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ANNALI
DEL MUSEO CIVICO DI STORIA NATURALE DI FERRARA

Proceedings of the Ninth International Symposium on Neuropterology

Ferrara, Italy, 20-23 June 2005

[with a Tribute to Maria Matilde Principi]

Edited by Roberto A. Pantaleoni, Agostino Letardi, Carla Corazza

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In copertina: elaborazione grafica del disegno originale di *Isoscelipteron fulvum* A. Costa, 1863 (Pantaleoni)

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The Editors would particularly like to thank Alessandro Molinu for the enormous amount of work done on text composition which he carried out with skill and patience.

R. A. Pantaleoni, A. Letardi & C. Corazza (eds), 2007 – *Proceedings of the IX International Symposium on Neuropterology, Ferrara, Italy, 20-23 June 2005 [with a Tribute to Maria Matilde Principi]*. In: Annali del Museo civico di Storia naturale di Ferrara, 8: I-XX, 1-204.

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by the Editors

During the eighth International Symposium on Neuropterology held in Texas in July 2003, no definite decision was made about where the next meeting would be held. It was only in the spring of 2004 that we were able to put ourselves forward as organizers of the IX Symposium. However, we set the condition that it would be held in 2005 to coincide with the 90th birthday of Maria Matilde Principi to whom the entire event would be dedicated.

So from 20 to 23 June 2005, in Ferrara, inside the historical monastery of San Gerolamo dei Gesuati, 48 specialists from 13 different countries in Europe, Asia and America came together.

Maria Matilde Principi participated in the first day's work. Young neuropterologists, still students, represented about one third of the participants.

As well as several opening speeches, during the Symposium there were 31 lectures, 15 poster presentations and the commemoration of our colleague Martin Meinander (Helsinki, Finland).

At the end of the work there was a short excursion (24-25 June) in the National Park of the Foreste Casentinesi, Monte Falterona, Campigna (Tosco-Emiliano Apennines) with the presence of most participants. A long excursion took place the following week in the National Parks of Abruzzo and Majella (Central Italy).

We judge the results obtained very positively. The topics covered in the lectures and posters were well distributed among all aspects of Neuropterology. There were sessions on morphology, systematics, biogeography, biodiversity, biology and applied entomology, as well as the opening session on historical aspects and on-line resources and the closing session dedicated to the specific problem of *Chrysoperla*.

The number of participants is probably the highest of those recorded in the previous Symposia. The number of countries represented, the number of presentations and the number of pages published is also satisfying.

We were helped by almost 50 referees from all over the world who, apart from very few exceptions, were chosen among non participants in the Symposium.

Ferrara was an enchanting site and the convivial moments (welcome party, social dinner and excursions) received high praise from participants.

Naturally, we can also make a list of the less successful aspects. The efforts made by the Organizing Committee to involve the many entomologists who, although not neuropterologists, have dealt with this group in their area of specialisation were only very partially successful. The publication of these proceedings is one year later than the foreseen date. The percentage of participants who submitted their papers for publication was entirely unsatisfactory.

In this volume (which follows the Proceedings of the VII Symposium as those from the VIII have never been published) we have chosen not to publish all the documentation relating to the meeting. This is already entirely reproduced on-line [http://www.isesardegna.it/sympneur].

Here we have included only some contributions, still unpublished, relating to the tribute to Maria Matilde Principi and the scientific contributions available to us. We have also used the pages which, for editorial reasons, would have remained blank to reproduce pages of Principi's works.

We wish our colleague Dušan Devetak, who has been elected to organize the X International Symposium on Neuropterology in 2008 in Slovenia, all the best for the work that awaits him.

Tribute to Maria Matilde Principi

The Prof. Maria Matilde Principi with Academic robe
(University of Bologna around the 1960)

Welcome Remark to the Ninth International Symposium on Neuropterology

by Roberto A. Pantaleoni, Senior Member of the Organizing Committee

Dear colleagues and friends, ladies and gentlemen,

on behalf of the Organizing Committee it gives me great pleasure to welcome you all.

The chairman of the session is Dr. Alessandro Bratti, he is the delegate of the town council, of which he is a valued member. He is also an entomologist at the University of Ferrara and he was a fellow student on my Ph.D. course, besides being an old friend, though not near at hand. Before calling on him to address the meeting allow me to thank a few people.

First of all, I would like to thank publicly Professor Maria Matilde Principi who agreed to be with us – who wanted to be with us – whose enthusiastic acceptance I found deeply touching. I thank her for all her work as a researcher, but above all, for all she has done as a teacher, a mentor and colleague. I thank her for the quality of the department where I was lucky enough to learn my profession, for the quality of the Ph.D. courses she directed and I had the good fortune to attend, for the quality of her scientific method, for her courteous but firm management of the department and for the respect she always showed towards others. I thank her also for being an example of how it is possible to keep one's integrity in the difficult, competitive and sometimes unprincipled world of the Italian university, where she was flexible and reasonable but without giving in to unwarranted pressure.

I am very proud of having been one of her students and I am even more proud of being the pupil Professor Principi entrusted with studying "her" Neuroptera.

I also wish to thank my friends of the International Association of Neuropterology for making the organization of this Symposium possible. Thank you for your good opinion, your faith in us and the freedom you gave us, inexperienced organizers, to arrange this important meeting.

I mustn't forget all the people on the Organizing Committee. The number of contacts I have made in these last few months has been much higher than those of recent years. I'll try to mention all of them. In primis Agostino Letardi, a close friend for many years now, and Rinaldo Nicoli Aldini, two of the three Italian neuropterologists presently working (I am the third!). All the staff of the Ferrara Museum of Natural History who have given us so much logistic and organizational support in this town. Our friends of the Società Naturalistica per gli studi sulla Romagna, whose work you will appreciate during the short excursion. The Associazione Romana di Entomologia and the Società Entomologica Italiana which have supported us, together with the most prestigious and exclusive Italian entomological institution: the Accademia Italiana di Entomologia. Finally, the University of Sassari, which is now my university, and the Alma Mater Studiorum, the University of Bologna.

Then there are my collaborators, young students who are entering the world of research in a country which allocates to research much less than the lowest indispensable amount. It is due to their light-hearted enthusiasm – extraordinary in a country like ours which has lost its future – that I was able to overcome so many disappointments and so many moments of weariness.

Before ending my first, and last, official speech as "Senior Member", it remains for me to thank the participants: all of you from all parts of the world who have honoured us with your presence here today.

I wish everyone a successful meeting and a happy stay in Ferrara.

Opening Address to the Ninth International Symposium on Neuropterology

by Maria Matilde Principi, Emeritus Professor of Alma Mater Studiorum Università di Bologna

Ladies and Gentlemen and all Colleagues,

I am happy to be here with you today and I would like to say how grateful I am to the Organizing Committee for giving me this opportunity. I also want to thank the Organizing Committee for dedicating this Symposium to me, which is a great honour for me. Finally, my heartfelt thanks go to Prof. Roberto A. Pantaleoni for his affectionate words of regard about me.

It is a great pleasure, as I said, to be here to meet colleagues I hadn't seen for years, as well as others I shared work relationships with, but never had the pleasure of meeting in person. Finally, I am pleased to meet the new generation of researchers working on Neuropterida I have had no scientific contact with, since I have not been engaged in research for over ten years.

I stopped working so many years ago not only for age reasons (I retired in 1990 at 75, and my last publication came out in 1995) but because in July 1993 my only sister (I have no other relatives living near me) suffered a stroke which left her paralysed on her left side. Since then, she has been living with me in Bologna and requires my constant presence and, although we do have some help, my assistance. My life has therefore changed completely and I have had neither the peace of mind nor the time to carry out any scientific activity. I miss it very much and, although at 90 years old, I wouldn't be able to do a great deal, I am sorry I can't make any further contributions to the knowledge of that fascinating world of the superorder of Neuropterida.

This superorder, on the threshold of holometabolism, owing to the habits of predatory insects, shows some morphological, physiological and ethological behaviours of great interest and is well worth while studying. Research in this field can be very rewarding.

Research today is aided by important works of systematics and knowledge of geographical distribution. However, it is very well-known that some groups, like, for example, the Chrysopids of the *Chrysoperla* and *Dichochrysa* genera, need further investigation. Fortunately taxonomic studies are now facilitated by new tools and techniques.

A study of morphological and anatomical conformations, although out of fashion nowadays, can lead to data useful for understanding the general morphology of Hexapods. Little is known about their complex glandular systems and our knowledge of these systems too often lacks an understanding of their function. In this case, too, modern technology can be of help.

Much still remains to be discovered about feeding habits, particularly of the adults. Examples of dietary specialization and the complexity of biological cycles, have been found in some case, as in Chrysopids, due to the antagonistic symbiosis between *Italochrysa italica* and the Ant *Crematogaster scutellaris*, and in Mantispids with the hypermetamorphosis.

A field which is almost completely unexplored is that one of the influence of environmental factors on the biological performance of these insects. Information about the diapause in the various stages of development is far from complete and much has still to be discovered about the action of the photoperiod on its induction, maintenance and end.

Unfortunately, funding plays a fundamental role in the kind of research carried out today. Financial aid, at least as far as the university and, in particular, the faculty of agriculture are concerned, is given mainly in finalized form. The opportunities to use Neuropterida in biological and integrated control have led to funds being made available and revival in research on some species of Chrysopids. Yet there is still much to be done in pure biology and our passion for research must not be curbed by economic factors. The eager desire to investigate the phenomena of the world around us must never be stifled.

At last, I wish you to carry out on the paths you have chosen, that may lead to thrilling answers.

My very best wishes for the success of this Symposium.

Alessandro Bratti, as Delegate of City Council of Ferrara, gives a plate to Maria Matilde Principi.

Maria Matilde Principi and the Italian Neuropterology

a speech by Roberto A. Pantaleoni

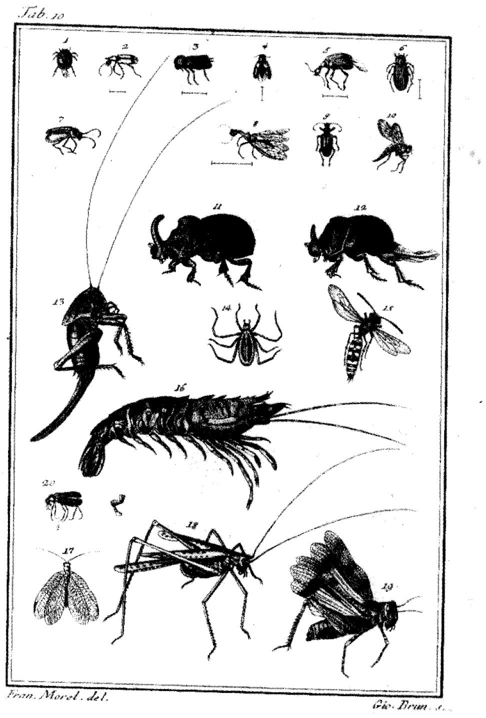
Italian neuropterology has its roots in the work of some great entomologists who were contemporaries of Karl Linnaeus (von Linné), but younger than him, all working in the second half of the 18th century. These were naturalists who bravely faced the whole animal kingdom or, when beginning to specialise, the whole Insecta class.

In the Italian regions which were then under the Austro-Hungarian empire, Giovanni Antonio Scopoli worked. He was an Italian speaker who was born in Trentino and died in Pavia, where he was a University Professor. In the Kingdom of Piemonte there was Carlo Allioni, a diligent correspondent of both Linnaeus and Fabricius. In the Great Dukedom of Tuscany lived Pietro Rossi, the first in the world to hold a University chair in Entomology at the University of Pisa.

These three naturalists, who we can say belonged to the 'European School', were flanked by scholars who formed an independent enclave, due to their geographical position and probably also to the political situation of the State they lived in. I'm talking about the 'Neapolitan School' whose founders were Vincenzo Petagna and Domenico Cirillo.

In Turin, in Piemonte, Allioni found a successor to continue his work in Giuseppe Gené. Actually Gené never published anything on Neuroptera but he sent important material to Rambur, including the Neuropterida that he had collected in Sardinia during the first entomological exploration of the island.

Among the few amateurs who published some news about Neuroptera at the beginning of the 19th century (Maironi da Ponte for the province of Bergamo, Ciro Pollini for Monte Baldo at Verona, Scinà for Palermo etc.) I would like to discuss those I consider to be two extremes.



Vincenzo Petagna (1792) – Institutiones entomologicae. 2 Vols. Typis Cajetani Raymundi, Neapoli, XII + 439 pp.; [I] + 441-718 + [10, index & legends] pp. + 10 tab.: plate 10, 8 *Raphidia ophiopsis*; 17 *Hemerobius Perla*.

The Jesuit abbot Raimondo (Ramòn) Maria De-Termeyer was an eighteenth century learned scholar with a passion for entomology. He was born to German parents in Cadiz in Spain and died in Faenza (Romagna, Italy). He described two new species of insect. One of the two species was *Lucanus minimus* a totally mysterious taxon that was surely an artefact, an assemblage of fragments which came from a Beetle and a Lacewing larva found together inside a spider's web.

Bernardino Angelini was an entirely different kind of amateur. He was born and died in the province of Mantova and often worked in the province of Verona. He wrote a sort of ante litteram monograph on the Italian Ascalaphids, in a modern style, or at least in full 19th century style. He described the *Ascalaphus siculus* and his *cotypi* are still preserved at the Natural History Museum of Verona.

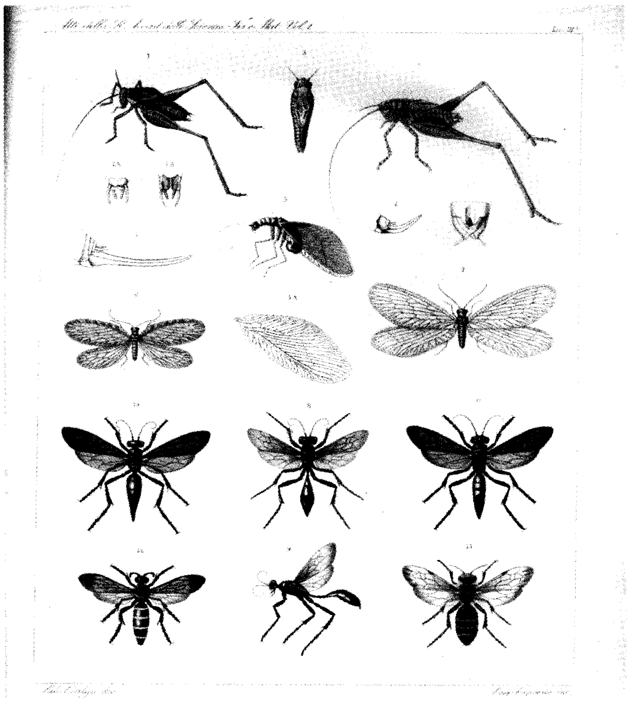
The Neapolitan school also had a great naturalist at the beginning of the 19th century. He was Oronz(i)o Gabriele Costa, a giant in zoology who only worked marginally on entomology. But it was Oronzio Gabriele's son, Achille Costa, who dominated the scene for most of the 19th century. Oronzio Gabriele's second son, Achille's brother, Giuseppe, left us a "Fauna Salentina" (Salento from Apulia).

Achille Costa was the zoologist who made the greatest contribution to entomological exploration of southern Italy and the Italian islands in the second half of the 19th century. Achille Costa was one of the few Italian entomologists to study Neuroptera. He devoted a volume of the Fauna del Regno di Napoli to this taxonomic group and wrote some important papers on these insects which he had collected in Calabria, particularly Aspromonte and Sila, and Sardinia.

In those times, there was every kind of problem for travellers. We only need to remember that banditry made almost every road in Southern Italy extremely dangerous. If we take this into consideration, the number of places that he personally visited is amazing!

I have personally reviewed his Neuropterological work and I can make an objective judgement. He was an ingenious naturalist, with an exceptional "taxonomic eye" but he believed that he was always able to study all of the insect orders, in many cases showing an evident lack in keeping himself up to date. As well as being a naturalist, Achille Costa was one of the first applied entomologists in Italy and he published, already in 1857, a famous manual of pest insects illustrated whit magnificent plates!

At the middle and end of the 19th century, many Italian authors discuss Neuropterida. They are above all local fauna lists which are more or less complete, in which almost always less than ten approximately identified species appear.



Achille Costa (1863) – Nuovi studii sulla entomologia della Calabria ulteriore. Atti della R. Accademia delle Scienze Fisiche e Matematiche Serie 1a Vol. I [fasc. 2], 80 pp., 4 pl.: plate III, 5/5A *Isoscelipteron fulvum*, n. sp.; 6 *Mucropalpus meridionalis*, n. sp.; 7 *Nevrorthus iridipennis*, n. sp..

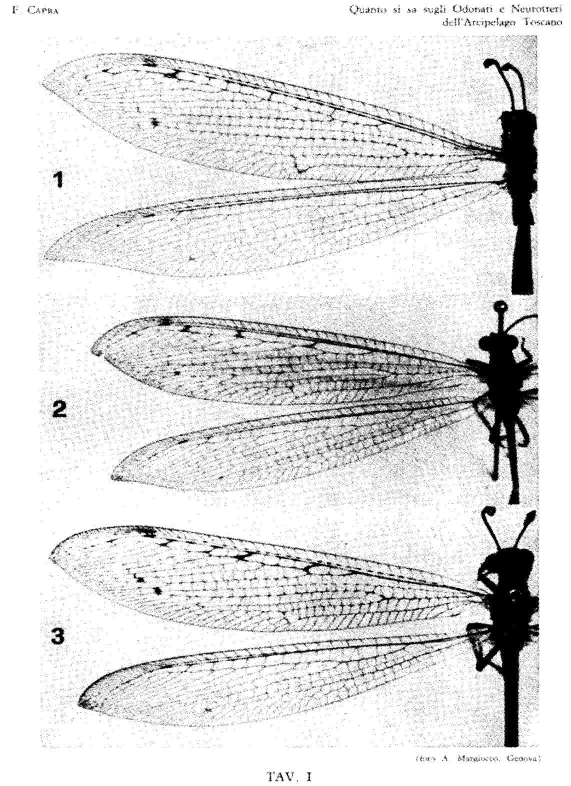
With the exception of Minà Palumbo, a Sicilian naturalist and physician, and some other Italian authors of central Italy (Dei, Spada), we have to deal with entomologists from the North of Italy, the culturally more advanced part of the country (Orseolo Massalongo, Disconzi, Tacchetti, Bettoni etc.). Similar works appears very later in less developed regions as Sardinia, where, after those of Carlini and Marcialis, Mola compiled a list again in 1916!

The beginning of the 20th century is an exceptional period for Italian entomology. The presence of men of the calibre of Antonio Berlese, Filippo Silvestri, Giovan Battista Grassi and, a few years later, Guido Grandi gave an incredible boost to our profession. Neuroptera were however strangely neglected. For this period, I will cite only two quite marginal names, although they did decisively influence the later years. Casually they are both from Romagna. Professor Carlo Fuschini taught entomology at Perugia and had Maria Matilde Principi among his students. He entrusted her with the study of Chrysopids for her graduation thesis. On the other hand, Pietro Zangheri was the prototype of a high level amateur naturalist. Almost all Italian amateur entomologists refer to him and his example in the second half of the 20th century.

The first real Neuropterologist to appear in Italy in the last century is Felice Capra. He was curator of the Genova Museum, an eclectic who wrote about Coleoptera, Orthopteroidea, Hymenoptera, but also Neuroptera, in particular about Myrmeleontidae.

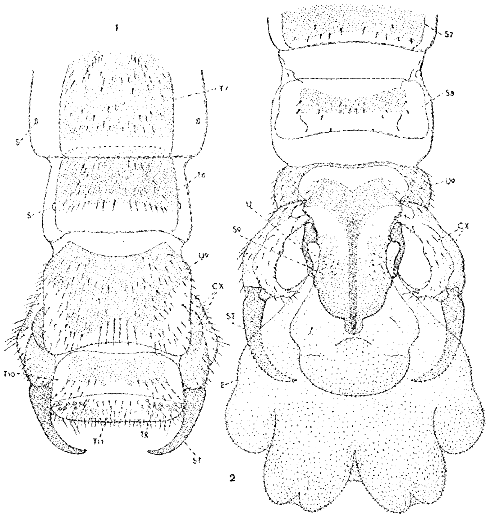
But the principal figure in Italian Neuropterology has been Maria Matilde Principi. Matilde Principi's work is a milestone in Neuropterology, one of the best examples of an exhaustive study of an order of insects. She is an author who has always combined absolute methodological rigour with precise and elegant language. Her original iconography is of the highest quality, her subjects are always carefully chosen and above all, her data are absolutely reliable, which means they are still valid today and her work continues to be consulted.

At the beginning of her career she used the "Italian" method of the biography of a chosen species which was illustrated in all its morphological, ethological and ecological aspects. In this way she accumulated a remarkable amount of information and at the same time made some exceptional discoveries. In 1940, when she was just twenty-five, Maria Matilde Principi published her first "Contributo allo studio dei Neurotteri italiani", the first of a series of papers which ended over fifty years later when their number reached almost forty. At the time she had recently arrived at the Entomology Department of the University of Bologna, which under the direction of Guido Grandi was gaining an international reputation.



Felice Capra (1976) – Quanto si sa sugli Odonati e Neurotteri dell'Arcipelago Toscano (Studi sulla Riserva Naturale dell'Isola di Montecristo. XIII). Lavori della Società Italiana di Biogeografia (Nuova Serie) 5: 541-560, 1 tav.: plate I, 1 *Creoleon corsicus* (Hagen, 1860) from Sardinia; 2 *idem* from Capraia; 3 *Cr. aegyptiacus* (Rambur, 1842) from Linosa.

After her first "contribution" on Chrysopids, there followed a second on Myrmeleontids. Then in the middle of the second World War she managed to find *Italochrysa italica* larvae and discover their antagonistic symbiosis with the Ant *Crematogaster scutellaris*. Next followed her contributions on *Chrysopa formosa* and its parasitoids, on *Synclisis baetica*, on the parasitoids of Chrysopids – with the discovery of *Chrysopophthorus chrysopimaginis*, a Braconid which attacks adults of some Chrysopid species - on *Chrysopa viridana*, on *Hypochrysa elegans*. In 1956 her 18th "Contribution" was published, the last of a series of "biographies", in which she illustrates a “homogeneous group of species” of Chrysopids belonging to the current genus *Dichochrysa*.



Raphidia etrusca Albarda. Fig. 1. Porzione caudale dell'addome di un maschio, vista dal dorso. Fig. 2. La stessa, vista dal ventre, con organo copulatore estroflesso: *CX*, gonocoxiti; *E*, organo copulatore; *S*, spiracoli tracheali; *S7, S8, S9*, regioni ventrali degli uriti 7°, 8° e 9°; *ST*, stili; *T7, T8, T10, T11*, regioni dorsali degli uriti 7°, 8°, 10° ed 11°; *TR*, tricobotri; *U*, uncini ventrali; *U9*, regione dorso-laterale del 9° urite.

Maria Matilde Principi (1958) – Neurotteri dei Monti Sibillini (Appennino umbro-marchigiano). Memorie del Museo Civico di Storia Naturale, Verona, Vol. VI, pp. 175-189, 3 figg.: figure at page 178.

Maria Matilde Principi was then forty years old and began to have an increasingly heavy workload of academic and teaching commitments. For more or less the next ten years she had only time to study also the chorology and systematic of Italian Neuropterida, obtaining her usual excellent results.

It was during this work that Maria Matilde Principi also studied Raphidioptera, excellently illustrating some Italian species and describing a new one.

But Maria Matilde Principi did not neglect to study morphology, as we can see in her masterpiece on the genital organs, or on the glandular structure present in the males of some species. In addition she preached – and taught to many of us – the necessity to work on a taxonomy which considered, along with the traditional adult morphology, also the larval morphology, ecology and ethology.

Maria Matilde Principi naturally has done more than I have just told you about. On this occasion I will only mention the long season of laboratory studies on the diapause of the species of *Dichochrysa*, on the use of Chrysopids in biological control programmes, on the introduction of the IPM in Italy.

M. M. Principi at work in her study at the “Istituto di Entomologia” in Bologna around 1950.

Finally, I certainly cannot forget her role as a teacher. It is unforgettable for me the moment when Prof. Principi gave me my degree at the University of Bologna. A wonderful day!

Today the Italian Neuropterologists ca only say: “Grazie Professoressa”!

Neuropterological papers of Maria Matilde Principi

edited by Roberto A. Pantaleoni & Alessandro Molinu

1. M.M.P., 1937. – Contributo allo studio dei Crisopidi più frequenti nell'Umbria. – R. Ossevatorio Fitopatologico Sezione: Entomologia agraria presso la Facoltà di Agraria di Perugia, Note ed Appunti Sperimentali di Entomologia Agraria, Fascicolo III, pp. 3-41, figg. 1-2.
2. M.M.P., 1940. – Contributi allo studio dei NEUROTTERI Italiani. I. *Chrysopa septempunctata* Wesm. e *Chrysopa flavifrons* Brauer. – Bollettino dell'Istituto di Entomologia della R. Università di Bologna, vol. XII, 1940, pp. 63-144, figg. I-XLV [pubblicato il 25 maggio 1940].
3. M.M.P., 1943. – Contributi allo studio dei NEUROTTERI Italiani. II. *Myrmeleon inconspicuus* Ramb. ed *Euroleon nostras* Fourcroy. – Bollettino dell'Istituto di Entomologia della R. Università di Bologna, vol. XIV, 1942-1943, pp. 131-192, figg. I-XXIII [pubblicato il 30 luglio 1943].
4. M.M.P., 1943. – La *Nothochrysa italica* Rossi ed i suoi singolari costumi (Neuroptera - Chrysopidae). – Bollettino della Società Entomologica Italiana, Volume LXXV, N. 9-10, 31 Dicembre 1943, pp. 117-118.
5. M.M.P., 1946. – Contributi allo studio dei NEUROTTERI Italiani. IV. *Nothochrysa italica* Rossi. – Bollettino dell'Istituto di Entomologia della Università di Bologna, vol. XV, 1943-1946, pp. 85-102, figg. I-VII [pubblicato il 20 agosto 1946].
6. M.M.P., 1947. – Contributi allo studio dei NEUROTTERI Italiani. V. Ricerche su *Chrysopa formosa* Brauer e su alcuni suoi parassiti. – Bollettino dell'Istituto di Entomologia della Università di Bologna, vol. XVI, 1947, pp. 134-175, figg. I-XXI [pubblicato il 15 giugno 1947].
7. M.M.P., 1947. – Contributi allo studio dei NEUROTTERI Italiani. VI. *Synclisis baetica* Ramb. (MYRMELEONIDAE - ACANTHACLISINI). – Bollettino dell'Istituto di Entomologia della Università di Bologna, vol. XVI, 1947, pp. 234-253, figg. I-X [pubblicato il 30 novembre 1947].
8. M.M.P., 1948. – Contributi allo studio dei NEUROTTERI Italiani. VII. Osservazioni su alcuni parassiti di Crisopidi. – Bollettino dell'Istituto di Entomologia della Università di Bologna, vol. XVII, 1948, pp. 93-121, figg. I-XIV [pubblicato il 10 novembre 1948].
9. M.M.P., 1949. – Contributi allo studio dei NEUROTTERI Italiani. VIII. Morfologia, anatomia e funzionamento degli apparati genitali nel gen. *Chrysopa* Leach (*Chrysopa septempunctata* Wesm. e *C. formosa* Brauer). – Bollettino dell'Istituto di Entomologia della Università di Bologna, vol. XVII, 1948-1949, pp. 316-362, figg. I-XXX [pubblicato il 31 dicembre 1949].
10. M.M.P., 1952. – Ricerche zoologiche sul Massiccio del Pollino (Lucania-Calabria). VI. Neurotteri. – Annuario dell'Istituto e Museo di Zoologia della Università di Napoli, Vol. IV, n. 10, Settembre 1952, pp. 1-22, figg. 1-5.
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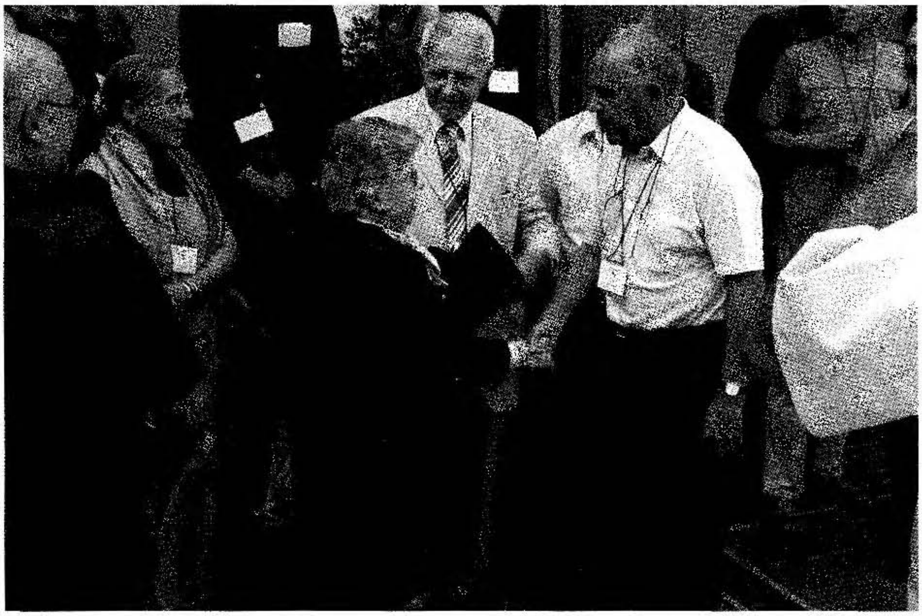
Some pages of Principi's papers are reproduced in this volume on pages 94, 116, 160, 166, 180, 196.

Some pictures from the Symposium



Maria Matilde Principi meeting the Participants.

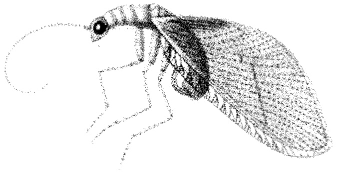
Maria Matilde Principi reading her speech.

Participant's Photo with Maria Matilde Principi
20 June 2005
Monastery of San Gerolamo dei Gesuati – Ferrara

1: Rinaldo Nicoli Aldini (Piacenza, Italy); 2: Alessandro Bratti (Ferrara, Italy); 3: Ferenc Szentkirályi (Budapest, Hungary); 4: Alessandro Minelli (Padova, Italy); 5: Hubert Rausch (Scheibbs, Austria); 6: Alexi Popov (Sofia, Bulgaria); 7: Verena Feuerstein (Göttingen, Germany); 8: Agostino Letardi (Roma, Italy); 9: Michael Ohl (Berlin, Germany); 10: Robert Güsten (Darmstadt, Germany); 11: Georgios Broufas (Orestiada, Greece); 12: Axel Gruppe (Freising, Germany); 13: Peter Duelli (Birmensdorf, Switzerland); 14: Sérgio de Freitas (Jaboticabal, São Paulo, Brasil); 15: Norman Penny (San Francisco, California, USA); 16: Roberto A. Pantaleoni (Sassari, Italy); 17: Ulrike Aspöck (Vienna, Austria); 18: Maria Matilde Principi (Bologna, Italy); 19: Horst Aspöck (Vienna, Austria); 20: Alinaghi Mirmoayedi (Kermānshāh, Iran); 21: Herbert Hölzel (Brückl, Austria); 22: Atsushi Mochizuki (Ibaraki, Japan); 23: Dominique Thierry (Angers, France); 24: David Faulkner (San Diego, California, USA); 25: Dušan Devetak (Maribor, Slovenia); 26: Kerstin Fischer (Graz, Austria); 27: Maria Pappa (Thessaloniki, Greece); 28: Dominique Zimmermann (Vienna, Austria); 29: Achille Loi (Sassari, Italy); 30: Antonio Sassu (Sassari, Italy); 31: Alessandro Molinu (Sassari, Italy); 32: Johannes Gepp (Graz, Austria); 33: Stefano Maini (Bologna, Italy); 34: Laura Loru (Sassari, Italy); 35: Johanna Villenave (Angers, France); 36: Michel Canard (Toulouse, France); 37: Mihaela Paulian (Bucuresti, Romania); 38: Franziska Anderle (Vienna, Austria); 39: Xenia Fois (Sassari, Italy); 40: Simone Cossu (Sassari, Italy); 41: John D. Oswald (College Station, Texas, USA).

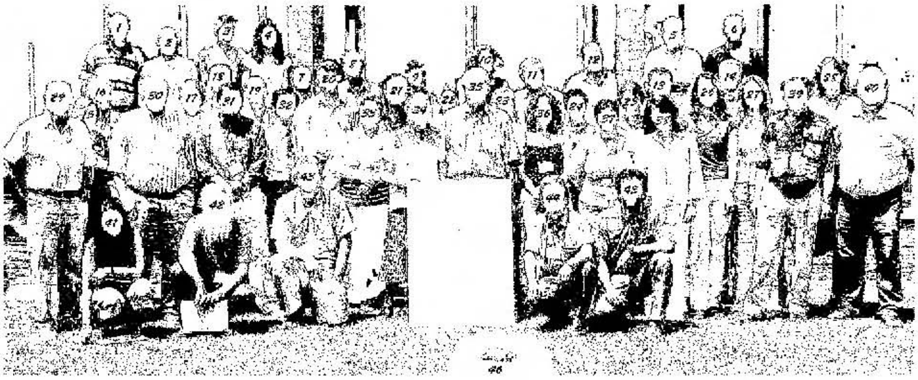
Contributions

IX INTERNATIONAL SYMPOSIUM ON
NEUROPTEROLOGY



Ferrara 2005
ITALY

Social photo of the IX International Symposium on Neuropterology
23 June 2005
Monastery of San Gerolamo dei Gesuati – Ferrara



1: Hubert Rausch (Scheibbs, Austria); 2: Simone Cossu (Sassari, Italy); 3: Valentina Zizzari (Siena, Italy); 4: Laura Loru (Sassari, Italy); 5: Stefano Maini (Bologna, Italy); 6: Achille Loi (Sassari, Italy); 7: Antonio Sassu (Sassari, Italy); 8: György Sziráki (Budapest, Hungary); 9: Axel Gruppe (Freising, Germany); 10: Verena Feuerstein (Göttingen, Germany); 11: Alinaghi Mirmoayedi (Kermānshāh, Iran); 12: Georgios Broufas (Orestiada, Greece); 13: Michele Loi (Sassari, Italy); 14: Agostino Letardi (Roma, Italy); 15: Renate Rausch (Scheibbs, Austria); 16: Peter Duelli (Birmensdorf, Switzerland); 17: David Faulkner (San Diego, California, USA); 18: Rinaldo Nicoli Aldini (Piacenza, Italy); 19: Ferenc Szentkirályi (Budapest, Hungary); 20: Alexi Popov (Sofia, Bulgaria); 21: Dominique Thierry (Angers, France); 22: Johanna Villenave (Angers, France); 23: Michel Canard (Toulouse, France); 24: Martha Reguero (Hidalgo, México); 25: Franziska Anderle (Vienna, Austria); 26: Kerstin Fischer (Graz, Austria); 27: Maria Pappa (Thessaloníki, Greece); 28: Dominique Zimmermann (Vienna, Austria); 29: Herbert Hölzel (Brückl, Austria); 30: Norman Penny (San Francisco, California, USA); 31: Atilano Contreras-Ramos (Hidalgo, México); 32: Atsushi Mochizuki (Ibaraki, Japan); 33: Mihaela Paulian (Bucuresti, Romania); 34: Ulrike Aspöck (Vienna, Austria); 35: Horst Aspöck (Vienna, Austria); 36: Maria A. Ventura (Ponta Delgada, Açores, Portugal); 37: Paula Lourenço (Ponta Delgada, Açores, Portugal); 38: Xenia Fois (Sassari, Italy); 39: Dušan Devetak (Maribor, Slovenia); 40: Roberto A. Pantaleoni (Sassari, Italy); 41: Carla Corazza (Ferrara, Italy); 42: Sérgio de Freitas (Jaboticabal, São Paulo, Brasil); 43: John D. Oswald (College Station, Texas, USA); 44: Johannes Gepp (Graz, Austria); 45: Alessandro Molinu (Sassari, Italy); 46: Ugo, the Tortoise of the Monastery (Ferrara, Italy).

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In memoriam Martin Meinander (1940-2004)

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On December 16th, 2004, the neuropterological scientific community was hit by a dreadful loss: Martin Meinander left us for ever. He was in the 65th year of his life. In May 2004, he suffered a stroke from which he never recovered.

Martin Meinander and we – my wife (Ulrike) and I – were all about the same age, about twenty, when we began more or less simultaneously to work on Neuropterida. It was thus inevitable that we would come into close contact with Martin. We maintained a copious correspondence with him, which we still possess, and our ways often crossed in many respects.

Thus, this obituary has a very personal touch, and it reflects a bit of history of neuropterology in the second half of the 20th century.

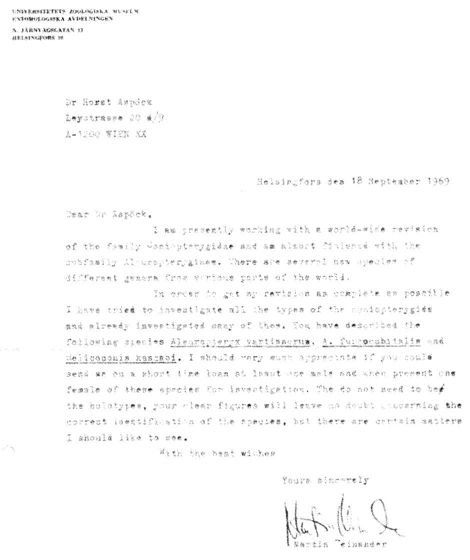
Martin Meinander was born in Grankulla in Finland on February 17th, 1940. His family was of Swedish origin. Already in childhood he developed a deep interest in insects, which was most probably induced by the famous entomologists Harald and Håkan Lindberg, with whom he had early contact within the family, and later supported and enhanced by the Finnish entomologist Harry Krogerus, who was his teacher in biology in the secondary school. In 1958 Martin Meinander began his studies in biology at the University of Helsinki where he obtained his MSc in 1964 and his PhD in 1972. During his University studies he was already employed as an amanuensis at the Zoological Museum, and after 1974 as a curator. In 1982 he became head of the Entomological Department of the Zoological Museum and in 1989 director of the Finnish Museum of Natural History. During this time he was also lecturer in zoology at the Department of Zoology of the University of Helsinki, and he taught many zoological field courses at the Tvärminne Zoological Station at the southern coast of Finland. He remained lecturer in zoology until his death.

Martin Meinander had also a strong interest for politics and was active in various official functions in the city of Helsinki since 1985. In 1996 he was elected as the Deputy Mayor of Helsinki. (For details of his curriculum, see Silfverberg, 2005).

Martin Meinander focused his entomological interests on Neuropterida already around 1960 and conducted investigations in most parts of Finland, from the southern coast to the northernmost areas in Lapland. In 1961 he joined Håkan Lindberg on an expedition to Morocco, and in 1964 he took part in the Finnish expedition to Sudan.

Between 1962 and 2002 he published more than 100 scientific papers. Most of them are devoted to Neuropterida, about 40 are centered on Coniopterygidae, the others are general reviews or concern in particular Sisyridae, Hemerobiidae, Chrysopidae or Nemopteridae, and several papers deal with Psocoptera, or Diptera (a list of Martin Meinander's publications can be found in Silfverberg, 2005, his neuropterological publications in Oswald, 2006).

At the beginning of the sixties the three of us were working on Coniopterygidae, and there was certainly some amount of



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ENTOMOLOGISKA AVDELNINGEN
N. JÄRNVÄGSGATAN 13
HELSINGFORS 10

Dr Horst Aspöck
Leystrasse 20 a/9
A-1200 WIEN XX

Helsingfors den 18 September 1969

Dear Dr Aspöck,

I am presently working with a world-wide revision of the family Coniopterygidae and am almost finished with the subfamily Aleuropteryginae. There are several new species of different genera from various parts of the world.

In order to get my revision as complete as possible I have tried to investigate all the types of the coniopterygids and already investigated many of them. You have described the following species Aleuropteryx vartianorum, A. furcocubitalis and Helicoconis kaszabi. I should very much appreciate if you could send me on a short time loan at least one male and when present one female of these species for investigation. The do not need to be the holotypes, your clear figures will leave no doubt concerning the correct identification of the species, but there are certain matters I should like to see.

With the best wishes

Yours sincerely

Martin Meinander

Fig. 1 – Martin Meinander's letter of September 1969 announcing his world-wide revision of the Coniopterygidae.

competition. In September 1969 Martin Meinander informed us that he was planning a world-wide revision of the family (Fig. 1). At that time my wife and I had already published several papers on Coniopterygidae and intended to continue this work on a broad basis. In August 1968 we attended the XIII International Congress of Entomology in Moscow in the former Soviet Union, where we met Dr. Edgar Riek from Australia. He offered us the whole Coniopterygidae collection of CSIRO for evaluation, and shortly later several big packages with the material arrived in Vienna. At the congress in Moscow we also met Prof. Olga Martynova, who generously offered us the entire material of Raphidioptera from Middle Asia and from the Caucasus region, which she was studying at that time, however, due to her advanced age with difficulties. For us, this was another great window to the world of snake-flies, which took – although as a source of great intellectual pleasure – a lot of our time, and after painful considerations and discussions we decided – with the agreement of Edgar Riek, who meanwhile had visited us in Vienna – to concede the Australian Coniopterygidae to Martin Meinander. He accepted with pleasure – thus the big Canberra collection could also be included in his world-wide revision. We focused on the Raphidioptera and on our book on the Neuropterida of Europe, which we completed a few years later.

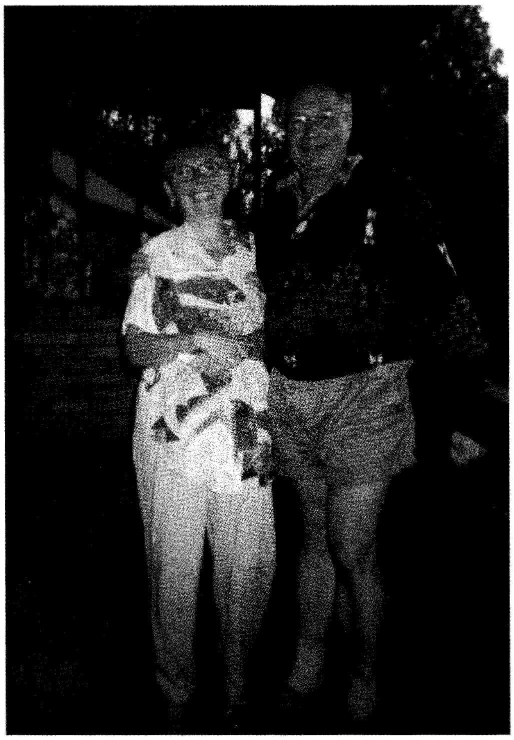

Fig. 2 – Kerstin and Martin Meinander, Helsinki, July 1997.

Martin Meinander's "Revision of the family Coniopterygidae" – his opus magnum – appeared in 1972. It contains lengthy chapters on the systematics of the family and summarizes the whole knowledge on the taxonomy, ecology, biology and distribution of the 238 recent species known at that time; 68 were described as new species, moreover, nine new genera

Fig. 3 – Neuropterologists on summit of the mountain Saana in July 1997. From left to right: Andrew Whittington, Peter Duelli, André Prost, Martin Meinander, Robert Güsten, Alexi Popov, Ulrike Aspöck, Horst Aspöck, William Shepard, Roger Forstmann (an ornithologist).

Fig. 4 – 1st Int. Symposium on Neuropterology, Graz, September 1980. From left to right: Peter Duelli, Victor Monserrat, Martin Meinander, Tim New, Sándor Újhelyi, Peter Ohm, Danny New.

Fig 5 – 2nd Int. Symposium on Neuropterology, Hamburg, August 1984. From left to right: Mervyn Mansell, Herbert Hölzel, Martin Meinander.

Fig. 6 – 4th Int. Symposium on Neuropterology, Bagnères-de-Luchon, June 1991. From left to right: Victor Monserrat, Phil Adams, Bert Hynd, Dušan Devetak, Michel Canard, Martin Meinander.

Fig. 7 – 5th Int. Symposium on Neuropterology, Cairo, April 1994. Phil Adams and Martin Meinander.

Fig. 8 – 6th Int. Symposium on Neuropterology, Helsinki, July 1997. From left to right: Martin Meinander, Kerstin Meinander, Norman Penny, John Oswald.

were erected. Another very important paper is an updated check-list of the Coniopterygidae of the world, published in 1990.

Martin Meinander attended most International Symposia on Neuropterology, and from 1994 to 1997, he was president of the International Association of Neuropterologists. In 1997 – at that time Deputy Mayor of the city of Helsinki – he organized the VI Symposium. The symposium took place in Helsinki from 13 to 16 July, 1997, with 43 neuropterists from 21 countries. The program was so dense that parallel sessions were necessary. Besides the scientific program we had a wonderful reception in his garden accompanied by his family (Fig. 2). Unforgettable was also the sunlight persisting long into the northern summer nights. A reception in the city hall was hosted by Martin in his position as the Deputy Mayor of Helsinki and (Martin was also responsible for the public transportation) a special guided tour through the city of Helsinki in a tramway exclusively reserved for the neuropterists.

After the symposium we all participated in a short excursion to the southern coast of Finland, and another lasting five days to Lapland. Unforgettable days, indeed! Near Kilpisjärvi (the lake where the boundaries of Finland, Norway and Sweden meet in one spot marked by a stone) is a mountain of 1024 m, the Saana, which we climbed up in the evening. At midnight a group of neuropterists trooped together at the top and watched the sun (Fig. 3). The harvest of the symposium in Helsinki was an impressive volume of Acta Zoologica Fennica with the Proceedings entitled "Neuropterology 1997" (Panelius, 1998).

Martin Meinander attended the first symposium in Graz (Austria) in 1980 (Fig. 4) the 2nd one in Hamburg (Germany) in 1984 (Fig. 5), the 4th in Bagnères-de-Luchon (France) in 1991 (Fig. 6), the 5th in Cairo (Egypt) in 1994 (Fig. 7), and after the Helsinki Symposium in 1997 (Fig. 8) the 7th one in Budapest (Hungary) in 2000. Comparing one of the photographs taken in Budapest in 2000 with those taken 20 years ago, he looks almost unchanged – always a smiling sunny boy.

Martin Meinander has left deep traces in neuropterology, particularly in two respects: First, any research on Neuropterida in Fennoscandia will always be linked with his basic paper on "The Neuroptera and Mecoptera of Eastern Fennoscandia" published already in 1962 when he was 22 years old. Secondly: His work on Coniopterygidae will be of importance for anybody working on these insects in any part of the world – even in far future.

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Ulisse Aldrovandi and Antonio Vallisneri: the Italian contribution to knowledge of Neuropterous Insects between the 16th and the early 18th centuries*

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The oldest evidence of neuropterous insects in Italian scientific literature dates back at least to the 15th–16th centuries and regards antlions. Documents concerning antlions and green lacewings are present in the outstanding corpus of watercolour illustrations of insects built up in the 16th century by the great naturalist from Bologna, Ulisse Aldrovandi (1522-1605), and then reproduced in his work *De animalibus insectis* (1602). His illustrations of some adult antlions and a green lacewing are among the earliest to be found in printed works. Between the 16th and the early 18th centuries, other Italian authors mention or deal with lacewings, mainly the outstanding scientist from Reggio, Antonio Vallisneri (1661-1730), who published bionomical and behavioural observations on antlions and green lacewings; he was the first to publish the life cycle of an antlion and to describe and illustrate the stalked eggs of green lacewings.

Key words – entomology, neuropterology, history, Italy, antlions, green lacewings, early authors.

Neuropterans in early literature and Italian scholars who dealt with them before Linné

It is well known that the earliest written references to neuropterous insects concern the most well known since time immemorial, antlions. The term "antlion", or its equivalents and variants in different languages, occurs in the texts of ancient civilizations even some centuries before Christ; but which animal or animals it referred to, we don't know with any certainty. The first author who wrote with certitude on "antlions" in the present meaning of the word seems to have been the German Albrecht von Bollstädt, Dominican, bishop of Ratisbon, Saint Albert the Great (ca 1193-1280) (Saitta, 1929); theologian, philosopher, naturalist, 'the universal teacher' of the thirteenth century. He spoke of flattened insects, similar to ticks, digging pits in the sand for hunting ants (Aldrovandus, 1602, p. 523; 1623, p. 207; Wheeler, 1930, p. 6; Kevan, 1992). Patron saint of naturalists, for this reason we can also consider him the specific patron of neuropterologists!

Antlions, animals which prey upon ants, and existing somewhere between reality and myth in ancient times, were the subject of early knowledge and beliefs perhaps partly referring to myrmeleontids; this idea survived in European culture over the Middle Ages, gradually freeing itself from uncertainty and legend and fi-

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* This contribution is dedicated to Prof. Maria Matilde Principi, Professor Emeritus in the Alma Mater Studiorum - Università degli Studi di Bologna, on the occasion of her 90th birthday (May 4th, 2005), as a sign of deep gratitude for her encouragement and help to the author at the beginning of his investigations on Neuropterida.

nally referring to well-defined insects.

Traces of these early vague ideas are to be found in Italian authors at least as early as the 15th century. Later, an important representative of 16th-century scientific humanism, Ulisse Aldrovandi, includes some neuropterous insects, not only antlions, in his work on insects, and illustrates them (Aldrovandus, 1602). About a century later, another great Italian scientist, Antonio Vallisneri, studied the life and behaviour of insects and gave an example of his observations describing the life cycle of an antlion (Vallisneri, 1700a) and the stalked eggs of a green lacewing (Vallisneri, 1717). Besides these two protagonists of the history of biological science and entomology, a few other Italian students working in other branches of science left more marginal evidence of an interest in these insects in the same period.

Thus, when we write of the Italian authors before Linné who studied the insects we now call neuropterans, we are referring to a period which lasted over two centuries, during which there was radical evolution in scientific thought and substantial changes in the way the study of nature was approached: from the inheritance of the Middle Ages, dogmatic and pervaded by myth, by way of the encyclopaedism of the late Renaissance, aimed at the complete recovery of classical knowledge and still subject to the authority principle, to the rise of the early scientific academies and the achievement of a new critical spirit and the experimental method, the basis of modern science and a prelude to the season of cataloguing and classifications of the Enlightenment.

This development of methods and concepts forms the background to the illustrations and writings I am going to present. These documents are evidence of centuries of interest in these insects in Italy, and they reflect at least some of the principal driving forces that historically have promoted the development of entomology itself: the simple desire to preserve and hand down forerunners' knowledge; the love of and wish to document the fascinating diversity of living beings, particularly insects with their metamorphoses; a practical and applied interest in nature in relation to man's activities, and possible advantages for him; the speculative desire to classify nature, to reach a systematic knowledge of the physical world; the goal of investigating and understanding structures, functions, behaviours, relations.

Late Middle Ages and height of the Renaissance: Decembrio and Cardano

In the works of at least two Italians before Aldrovandi, there is evidence of an interest in antlions: towards the end of the Middle Ages we find mention of them in the "*Codex animalium*", a handwritten bestiary by the learned humanist from Pavia, Pier Candido Decembrio (Petrus Candidus Decembrius) (1392-1477). This courtier and diplomat translated classical authors and wrote epigrams and tracts in prose (Viti, 1987). In the fourth volume of his richly illustrated work, dating back to approximately 1460 (the date of the drawings is uncertain), there is an illustration of a possible antlion larva, which the author refers to as the so-called "*Formicae Indicae*" (Decembrius, ca 1460). This illustration may be the first true image of an antlion larva, referred to with an early Latin name used for denoting the mythical "gold-digging" ants. This picture has undoubtedly something of the chimerical and fanciful: on the whole it resembles the tetrapod larva of an antlion, but the head with palps between the mandibles, and the four legs with strong claws, also recall the morphology of a male stag-beetle. In the codex, to one side of this image there is an illustration representing another meaning of "ant lion" in ancient times: a bigger ant which has another much smaller ant in its mouth (Bodenheimer, 1928-1929; Kevan, 1992).

At the height of the Renaissance, the antlion larva is quoted in the work of another student from Pavia, Gerolamo Cardano (Hieronymus Cardanus) (1501-1576) (Fig. 1), one among the more notable, eccentric and eclectic talents of the 16th century: he was physician, mathematician, physicist, astronomer, musician and philosopher. There are short entomological references mostly in his work *De subtilitate libri XXI*, published in Paris in 1551. In another work, the seventh book ("*De animalium*") of his *De rerum varietate* (1557), he also refers to antlions, following the description by Albert the Great, as being small animals, enemies of ants, like small grubs. They dig round pits in the sand, living in small holes at the bottom, where they catch ants for eating (Cardanus, 1557; see also Aldrovandus, 1602, p. 523; 1623, p. 207; Wheeler, 1930, p. 6). Cardano seems therefore to give a relatively accurate description of antlions, but he added nothing to what Albert the Great had already said three centuries before, as pointed out by Kevan (1992).

When we read certain ancient accounts of undefined insects digging pits in the sand we must remember, however, that they may refer to the larvae of vermileonid dipterans.

Scientific Humanism in the late Renaissance: Ulisse Aldrovandi

But it was due mainly to Ulisse Aldrovandi (*alias* Aldrovando; Ulysses Aldrovandus in his works in Latin) (Fig. 2), who died four hundred years ago, in 1605, that neuropterous insects were introduced into the scientific literature of the Renaissance. This encyclopaedic talent and very renowned naturalist, perhaps the greatest zoologist of the 16th century, was born in 1522 from a ruling family in Bologna – at that time in the Papal States – where he also died. His life was long and adventurous, ruled by his boundless passion for natural history. He studied law, philosophy

Fig. 1 – Portrait of Gerolamo Cardano (1501-1576), in the frontispiece of the first edition (Basel 1557) of his *De rerum varietate*.

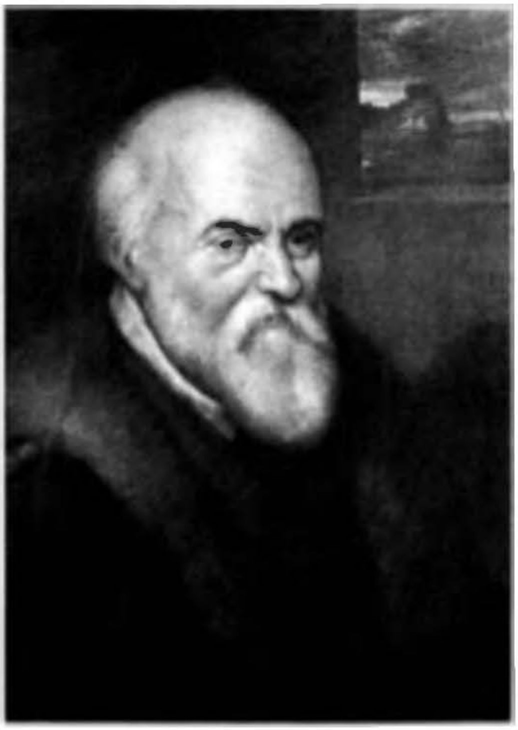

Fig. 2 – Portrait of Ulisse Aldrovandi (1522-1605) (B.U.B., Bologna).

and medicine and he graduated in philosophy and medicine at Bologna in 1553. He was professor for many years – teaching pharmaceutical botany, logic, philosophy, natural history – at Bologna University, and only late in life, when he was seventy-seven years old, he started the publication in Latin of his enormous work, the fruit of a life devoted to the collection of materials gathered together in a natural history museum – one of the first in the world – and to filing the great mass of naturalistic notions found in all his predecessors' works, from ancient times onwards. The many volumes of Aldrovandi's manuscripts and watercolour illustrations of animal and plant subjects pertinent to his observations are preserved in the University Library of Bologna (B.U.B.) and are a precious source of reference for deeper analysis of the way of thinking and working of this renowned scholar. Born in the land which had experienced first – in Magna Graecia and Sicily – the development of Greek, and then the flourishing of Latin civilisation, he was under the spell of classical studies, demonstrating this interest by writing in his youth of the monuments of ancient Rome; but what was most fascinating for him was classical scientific knowledge (he was principally a follower of Aristotelianism). The publication of his works was continued posthumously by relatives and pupils; fortunately for entomologists, however, one of his works published when he was still alive, and which therefore reflects faithfully his thought without interference by others, is the work which principally deals with entomology, the *De animalibus insectis libri septem*, published in Bologna in 1602 (Aldrovandus, 1602) (Fig. 3), and followed by several re-editions later (Frankfurt 1618, 1623; Bologna 1620, 1634, 1638-44). This encyclopaedic book summarises knowledge of insects since ancient times, and it is enriched with original observations by the author and with many illustrations; it represents the beginning of a new age for entomology (Berlese, 1909; Aldrovandi, 1929; Conci, 1975; Montalenti, 1978; Simonetta, 1994; Conci & Poggi, 1996; Simili, 2004; Nicoli Aldini, 2005).

Fig. 3 – U. Aldrovandi, *De animalibus insectis libri septem* (Bologna 1602) (private library, Bologna): frontispiece (photo R. Nicoli Aldini).

Of the many insects treated in the text and illustrated in woodcuts (*e.g.* see Figs 4 A-E), a few adult myrmeleontids and one chrysopid are recognisable. Aldrovandi's woodcuts, which are among the earliest printed illustrations of neuropterous insects (as well as of many other insects), are taken from the outstanding corpus of watercolour or wash drawings, more exact and helpful to us today in subject identification; Aldrovandi had some artists carry out these colour drawings earlier, as documentation of his research and collections; these documents (B.U.B., Ulisse Aldrovandi, Tavole di animali) (*e.g.* see Figs 5 A-D) date back to the second half of the 16th century; the preparatory writings of the book to be printed later date back to the same epoch. Adult antlions

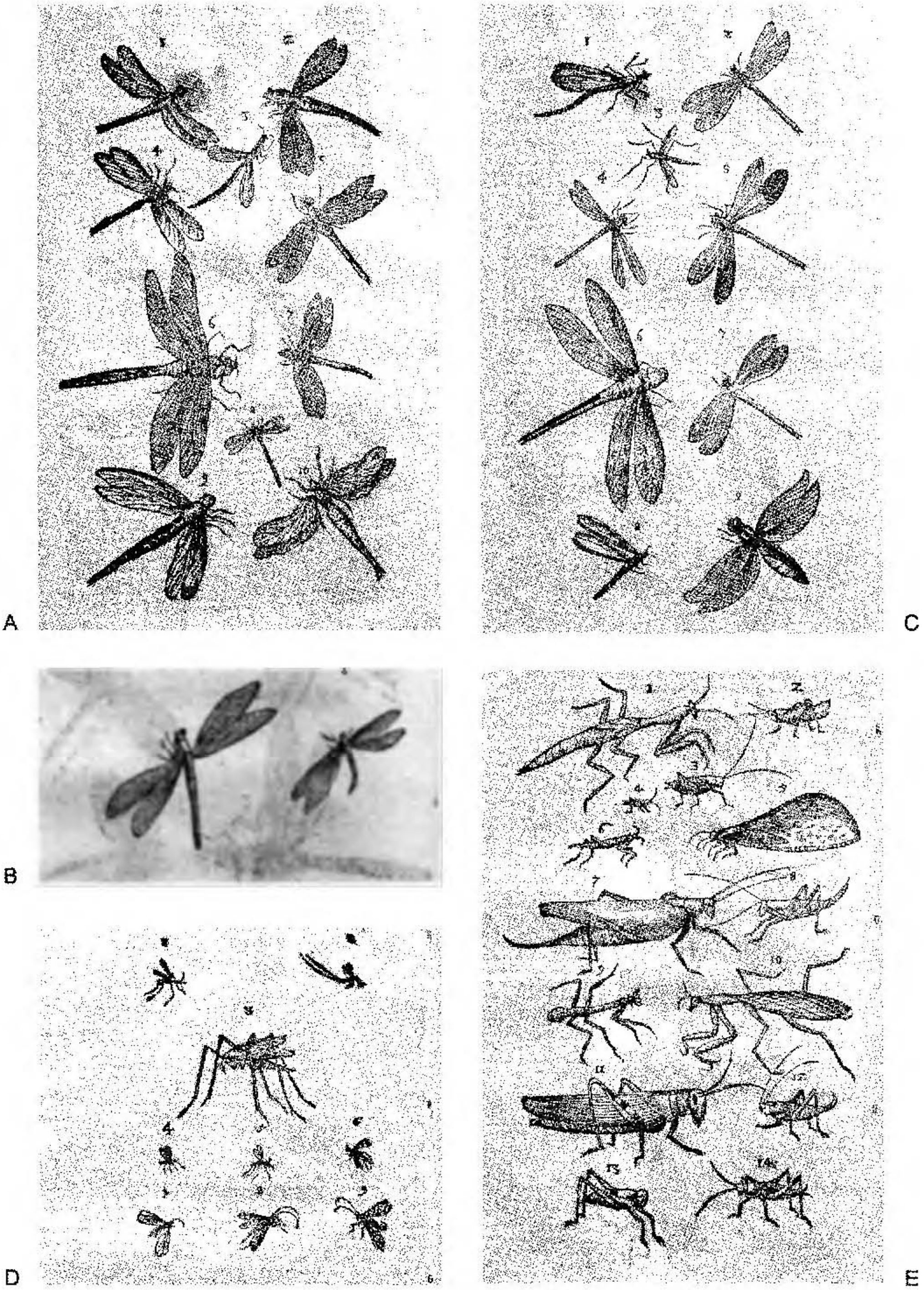

Fig. 4 – U. Aldrovandi, *De animalibus insectis* (Bologna 1602), woodcuts at pp. 303-305, 386, 414: **A**, p. 303 ("*Perlae*"); **B**, p. 304 ("*Perlae*"); **C**, p. 305 ("*Perlae*"); **D**, p. 386 (some "*Culices*"); **E**, p. 414 (some "*Locustae*") (photos R. Nicoli Aldini).

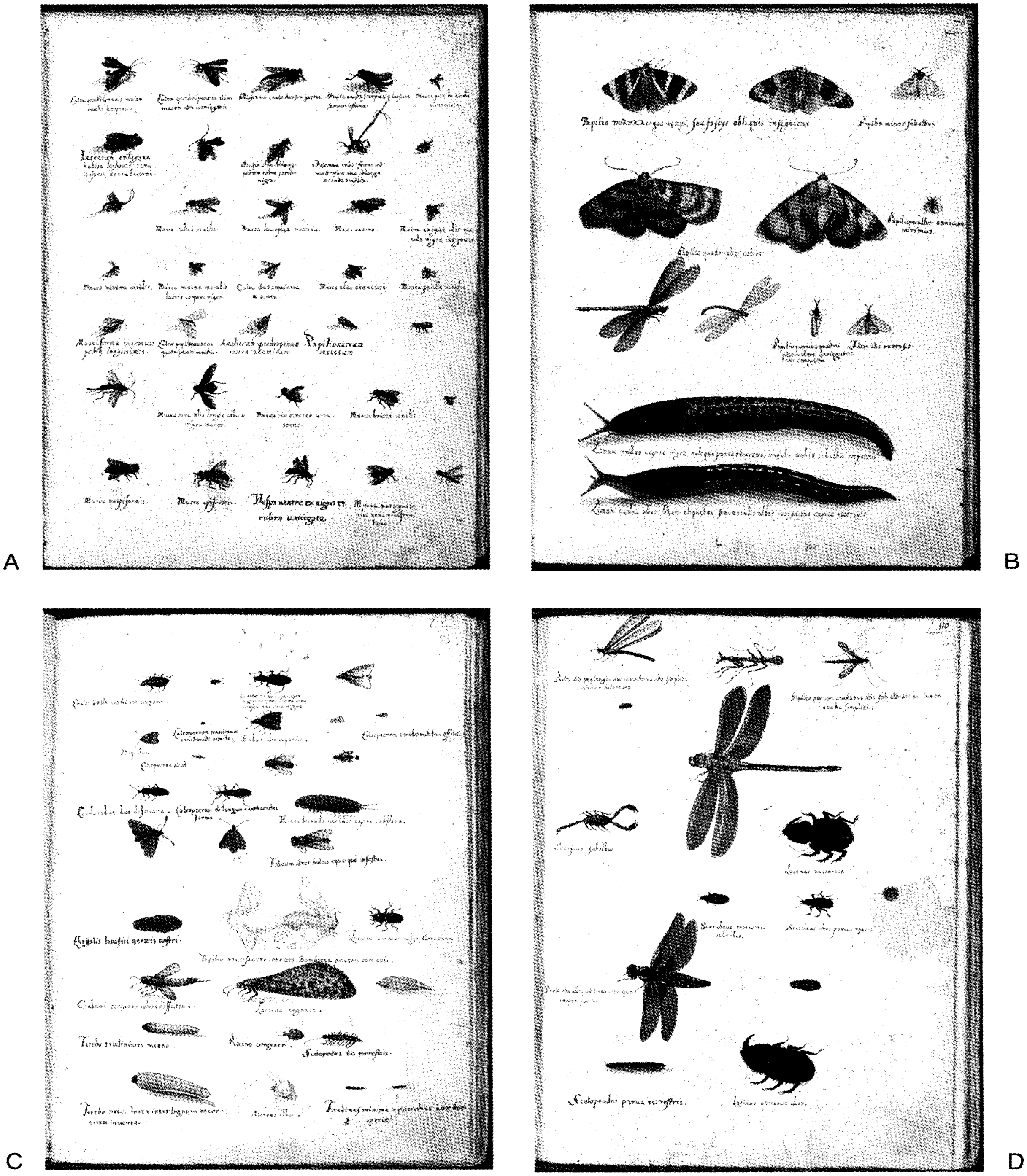

Fig. 5 – B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, carte 75, 76, 93, 110 (some of many Aldrovandi's plates with watercolour drawings of insects): **A**, c. 75; **B**, c. 76; **C**, c. 93; **D**, c. 110.

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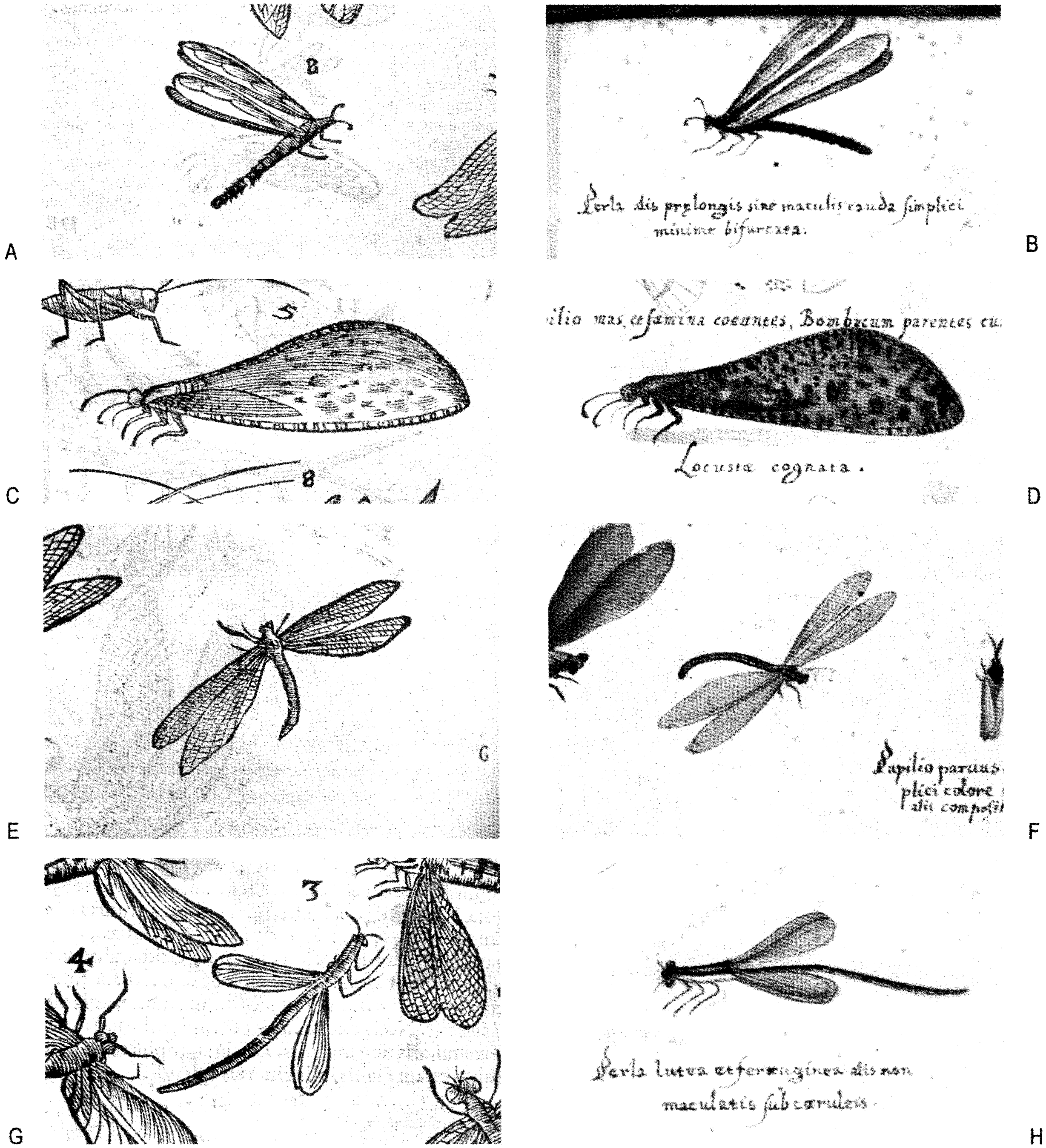

Fig. 6 – **A**, U. Aldrovandi, *De animalibus insectis* (Bologna 1602, p. 305, fig. 8): adult antlion (woodcut); **B**, adult antlion (watercolour painted before the woodcut in Fig. 6 A) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, detail of c. 110); **C**, U. Aldrovandi, *De animalibus insectis* (Bologna 1602, p. 414, fig. 5): adult antlion, probably of the genus *Palpares* (woodcut); **D**, adult antlion, probably of the genus *Palpares* (watercolour painted before the woodcut in Fig. 6 C) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, detail of c. 93); **E**, U. Aldrovandi, *De animalibus insectis* (Bologna 1602, p. 304, fig. on the right, without number): adult antlion (woodcut); **F**, adult antlion (watercolour painted before the woodcut in Fig. 6 E) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, detail of c. 76); **G**, U. Aldrovandi, *De animalibus insectis* (Bologna 1602, p. 303, fig. 3): damselfly, which in the woodcut resembles an adult antlion; **H**, the corresponding damselfy (watercolour painted before the woodcut in Fig. 6 G) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, detail of c. 92). (Figs 6 A, C, E, G: photos R. Nicoli Aldini).

are illustrated and briefly described in the *De animalibus insectis* among the "*Perlae*" (*i.e.* together dragonflies and damselflies); the term "*perlae*" refers to the pearly reflections from their wings. The *perla* more immediately recognizable as an antlion (maybe of the genus *Myrmeleon*) (Figs 4 C, 6 A) is briefly described in these words: "*Octava alvum habet obtusam, ac minime bifurcatam, toto corpore ferrugineo, alis candidis, a latere ferrugineis.*" ("[...] *a latere ferrugineo.*" in the 1623 edition) (1) (Aldrovandus, 1602, p. 304 and p. 305, fig. 8; 1623, p. 118 and p. 119 (bottom): *Perlae* fig. 8), and it corresponds to a watercolour, in the University Library of Bologna, of a specimen described as "*Perla alis praelongis sine maculis cauda simplici minime bifurcata*" (2) (B.U.B., U. Aldrovandi, Tavole di animali, tomo VII, c. 110) (Figs 5 D, 6 B). Another species (Figs 4 E, 6 C) seems to be of the genus *Palpares*; this attribution is easier if we refer to the watercolour drawings (B.U.B., U. Aldrovandi, Tavole di animali, tomo VII, c. 93) (Figs 5 C, 6 D), in which it is defined as "*Locustae cognata*" (3) – an attribution based perhaps on the head and mouthparts, and other similarities – and in the book is placed in a plate that illustrates grasshoppers and mantids, but the author writes that this insect is portrayed there by error and is to be placed among butterflies or moths: "*Papilionis icon est, quam supra dedimus inter papiliones*" (4), Aldrovandi writes (Aldrovandus, 1602, p. 414, fig. 5, and p. 415; 1623, p. 162 (on the right): *Locustae* fig. 5, and p. 164); however in the text and plates regarding these insects there is no trace of it. For two other printed illustrations of "*Perlae*" the watercolour drawings in Aldrovandi's "Tavole di animali" are enlightening in their interpretation: one insect ("*prior alas habet subflavas, et corpore toto flavo est exceptis zonis, quae sunt ferrugineae.*") (5) is represented without antennae (Figs 4 B, 6 E) (Aldrovandus, 1602, p. 304, and figure on the right, without a number, on the same page; 1623, p. 118 and p. 119 (on the right): *Perlae* fig. without number), but is a myrmeleontid (see B.U.B., U. Aldrovandi, Tavole di animali, tomo VII, c. 76, fig. without any caption, in the middle) (Figs 5 B, 6 F); another ("*Tertia alas habet breves, ad subcoeruleum inclinantes, alvum longissimam* [...]. *Antennas habet, admodum breves subflavas.*") (6) is represented in the woodcuts with distinct and relatively strong antennae (Figs 4 A, 6 G) (Aldrovandus, 1602, p. 303, fig. 3, and p. 304; 1623, p. 118 and 119 (top): *Perlae* fig. 3), but is clearly a damselfly if we consider the respective previous colour drawing (Fig. 6 H) (with the caption: "*Perla lutea et ferruginea alis non maculatis subcoeruleis*") (7) (B.U.B., U. Aldrovandi, Tavole di animali, tomo VII, c. 92).

While the antlion adults are associated to dragonflies and damselflies with the name of *perlae*, or - on second thoughts - to butterflies or moths in a single case with spotty-coloured wings, Aldrovandi deals at some length with the antlion larva, using both the Greek term "*Μυρμηκολέων*" (Myrmēcoléôn) and the Latin "*Formicoleo*" or "*Formicaleon*", in the part of his book covering ants, but without personal observations, reporting only what other authors wrote on this animal between reality and legend, citing Albert the Great and Cardano, to whom he gives more credit, then Saint Jerome and other authors. Aldrovandi, like his forerunners, did not know about the metamorphosis of antlions. We will have to wait for another century and the works of another Italian, Vallisneri, for an explanation of the life cycle of this insect. Here is a part of Aldrovandi's text about antlions (Aldrovandus, 1602, p. 523; 1623, p. 207; see also Wheeler, 1930, p. 6):

> "*Μυρμηκολέων, vel Formicoleo, Alberto Magno vocatur Insectum quasi inter Formicas leo, simulque Formica et leo, animal quidem parvum, sed Formicis adeo infestum, ut se in pulvere abscondens, semsphaericum sibi velut vallum e pulvere, munitionemque aedificans, Formicas frumenta gestantes aggressus interficiat ex insidiis. Alii aiunt esse quidem ex Formicarum genere, sed multo maiorem, et dum adhuc parvus est, et invalidus robore, pacem ac modestiam simulare; at ubi vires acceperit, pristina consortia despicere, et contra maiores tur-*

bas concitare. [...] *Cardanus sic meminit: Insidiatur Formicis animal Erucae parvae simile, sic interpretor Alberti, qui hoc vidit, verba: in sabulo foveam sibi fingens, haemisphaerii forma, in cuius apice quasi polus, foramen existit angustum ex quo improvisus insultat Formicis, easque devorat. hoc Formicaleon ab Alberto appellatur.* [...]" (8).

Aldrovandi goes on to quote other possible uses of the word antlion and mentions myrmecophagous mammals; but at this point it is interesting to note that, surprisingly, a faithful colour drawing of an antlion larva (probably *Myrmeleon* or *Euroleon*) is to be found in Aldrovandi's Tavole di animali, under the illustration of the adult *Palpares*, and this larva (B.U.B., U. Aldrovandi, Tavole di animali, tomo VII, c. 93) (Figs 5 C, 7 A) is defined as "*Ricino congener*" (9), probably with reference to its sucking mouthparts and the bulky, swollen abdomen recalling a tick; a resemblance already noted by Albert the Great for the antlion. But neither a woodcut from this picture, nor any reference in the text on ticks, are to be found in the *De animalibus insectis* for this insect, perhaps enigmatic for Aldrovandi.

Another very interesting neuropterological aspect of Aldrovandi's work is that a true green lacewing is briefly described and represented (Figs 4 D, 7 B) in a plate, among some "*Culices*" (Aldrovandus, 1602, p. 386, fig. 7, and p. 387; 1623, p. 136: *Culices* fig. 7, and p. 152). The green lacewing is also to be found in the previous papers of painted insects (Figs 5 A, 7 C), where it is defined as "*Culex papilionaceus quadripennis viridis*" (10) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, c. 75); in this case again, in the text of the printed book Aldrovandi corrected the erroneous location, referring this insect to the group of "*Perlae*". Aldrovandi writes:

> "*De septimo maxime dubito, num inter Culices sit referendus, nescioque qua incuria hic inter Culices positus. nam Perlis dictis minimis potius adscripserim. Culicibus vulgaribus sive lacustribus maior, corpore tenui, gracili, oblongo, viridi, linea ex luteo pallida medium dorsum intersecante, quae a capite incipit, et in caudam desinit, antennis mediocribus, absque oris aculeo, alis quaternis argentei splendoris, magnis.*" (11).

This is one of the earliest descriptions and illustrations of a green lacewing, possibly of the genus *Chrysoperla*, preceded only by the illustration published by Hoefnagel in 1592 (see Aspöck & Aspöck, 2007). If we take the latter lines of this piece, or those describing the adult antlions which are quoted above, we find, more than one and an half centuries before Linné (1707-1778), short descriptions of insects, comparable with those of the great Swedish naturalist (who appreciated Aldrovandi's work, quoted him here and there in his *Systema naturae*, and employed certain of his scientific names) (Linnaeus, 1758).

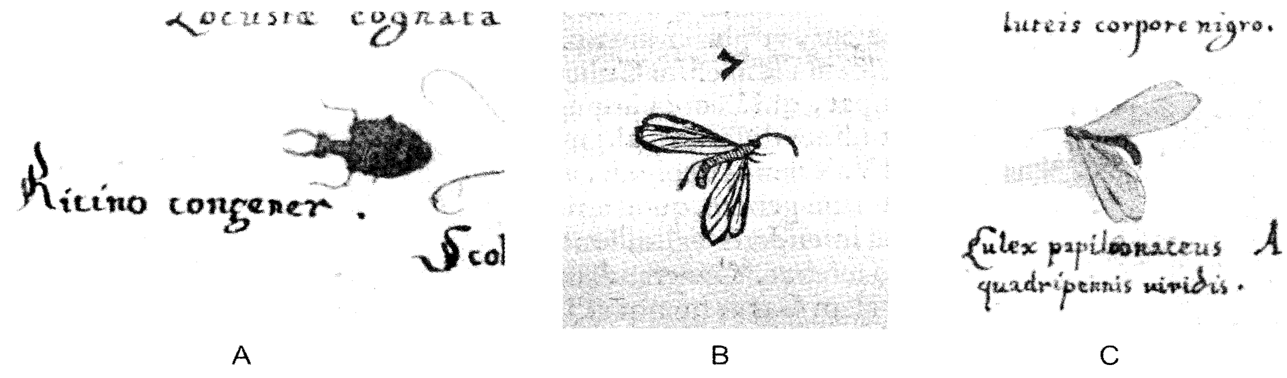

Fig. 7 – **A**, larva of myrmeleontid, probably of the genus *Myrmeleon* or *Euroleon* (watercolour) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, detail of c. 93); **B**, U. Aldrovandi, *De animalibus insectis* (Bologna 1602, p. 386, fig. 7): green lacewing (woodcut) (photo R. Nicoli Aldini); **C**, green lacewing (watercolour painted before the woodcut in Fig. 7 B) (B.U.B., Ulisse Aldrovandi, Tavole di animali, tomo VII, detail of c. 75).

Aldrovandi's doubts and afterthoughts on the classification of antlions and green lacewings reflect his changing ideas while he was collecting material, arranging it and later preparing the publication, and the difficulty he had describing these insects and including them in the major insect groups then recognized. We must remember, moreover, that he was working before the invention and diffusion of the microscope. Furthermore his classification of insects, while based on dichotomous method, rather than being an attempt at a systematic arrangement, is somewhat heterogeneous and based on various criteria, not only morphology but also including habitats and so on. We will still have to wait a long time for the systematic arrangements of Ray or Linné, and yet longer before finding the Neuroptera as a unitary-physiognomy group in systematics!

The analysis carried out here of Aldrovandi's neuropterological work aims to, partially, fill the gap it has sometimes recently been claimed exists in the progress of knowledge of these insects between the first half of the 16th century and the early 18th century (see Kevan, 1992; Letardi, 2004), especially in the light of the attention now being paid to the history of this knowledge.

17th and early 18th century: Antonio Vallisneri

A watercolour illustration of a neuropteran is also to be found in Lincei's naturalistic manuscripts and drawings up to the first decades of the 17th century, as Letardi (2004) has recently shown, publishing a figure of an antlion, perhaps *Megistopus flavicornis* (Rossi, 1790). The aims of the "Accademia dei Lincei", founded in Rome in 1603, shortly before Aldrovandi's death, by the young Roman prince Federico Cesi (1585-1630), were to gather students who would devote themselves to the study of nature with sagacity, rigour of method, a new critical approach, and enthusiasm for seeking the truth. Collecting ample documentation of animals, plants and minerals, as Aldrovandi himself had done, was an indispensable step in the realisation of subsequent printed illustrations. This document also testifies therefore to the interest for insects developed under the aegis of the Academy created by Cesi, precursor of modern botany and promoter of the *Theatrum totius naturae*, an encyclopaedic work which was never published, of which Cesi's famous *Apiarium*, together with Stelluti's *Melissographia*, was an early fruit. This work, finished in 1625, was also the first essay on insects (honeybees) described and illustrated using a microscope (Baccetti, 1993; Nicoli Aldini, 2002).

Another Italian scientist, Antonio Vallisneri (*alias* Vallisnieri, Valsinieri) (1661-1730) (Fig. 8), a physician and naturalist, is no less important than Aldrovandi in the history of biology and entomology. Born into a noble family in the fortress of Tresilico (now Trassilico), in the Garfagnana area, citizen of Reggio (now Reggio nell'Emilia) and subject of the Dukedom of the Family of Este, he started his university studies in Bologna, where he was a disciple of Marcello Malpighi (1628-1694), who left an indelible mark on his pupil. Vallisneri then graduated in Medicine at Reggio University, and practised medicine in Venice, Padua and Parma. During this period he devoted himself to intense naturalistic research, quickly achieving international scientific notoriety, and was soon called to teaching first practical medicine and then theoretical medicine at Padua University. He held the chair for thirty years (1700-1730), during which time he had to apply himself mainly to medical studies (Montalenti, 1937; Conci, 1975; Simonetta, 1994; Conci & Poggi, 1996). Of his scientific investigations, conducted with the benefit of a subtle mind and informed by Bacon's and Galilei's experimental dictates, many were entomological. His studies of insect generation are particularly worthy of mention: *Dialoghi sopra la curio-*

Fig. 8 – Portrait of Antonio Vallisneri (1661-1730) (after Conci & Poggi, 1996).

sa origine di molti insetti, published in Venice (Vallisneri, 1700b), and the *Esperienze, e osservazioni intorno all'origine, sviluppi e costumi di varj insetti*, published in Padua (Vallisneri, 1713), both also containing research aimed at refuting the theory of spontaneous generation. He made many other contributions, and produced reworkings, on entomological subjects. Vallisneri's scientific production is therefore very complex (Sabia, 1996; Generali, 2004); it is written almost exclusively in Italian. After his death, all his writings were collected and republished in three volumes (Vallisneri, 1733) under the care - at least nominally - of his young homonymous son Antonio, who was then professor of natural history at Padua University. At the present time the "Edizione Nazionale delle Opere di A. Vallisneri" is being edited and printed in Italy (since 2004, Prof. Dario Generali scientific co-ordinator, Leo S. Olschki publisher, Florence); the "Edizione" will also include the publication of the numerous manuscripts.

As regards neuropterans, the value of Vallisneri's research on the antlion did not fade over time (Réaumur, 1742; Linnaeus, 1758; Wheeler, 1930; Insom *et al.*, 1979; Letardi, 1998; and others); this is also the proper place to recall his early annotations concerning a chrysopid, quoted also by Linnaeus (1758, p. 549, under *Hemerobius perla*), despite an inaccurate reference. His notes were published in the Venetian magazine "*La Galleria di Minerva*" (Fig. 9): "Maniera rara, e curiosa d'un Insetto Anonimo nel collocare le sue uova" (Vallisneri, 1717, p. 152). This short text is here entirely reported, with the original typing:

"Fù portato li 25 Maggio al Vallisnieri un galantissimo Insetto volante, ch'egli ripone in una spezie di mezzo fra la Farfalla, e il Cevettone. Questi era tutto d'un elegantissimo color verde, eccettuati gli occhi tinti di color d'oro. Era corredato di quattro ali membranacee lucide e smeraldine, grandi a proporzione, le quali coprivano tutto il corpo. Quando si posa, stà coll'ali chiuse nel margine superiore, e aperte nell'inferiore, aguisa del tetto d'una Casa, dalle quali tutto viene difeso, e coperto, eccettuato il capo, e il collo, ed un'angolo nel principio del dorso. Piedi, ventre, Torace, dorso, collo, capo tutto tinto di verde. Gli occhi soli colorati d'oro. Porta il rostro in cima la bocca, e le antenne sul capo rivoltate in dietro, e interrotte da spessi nodi. Ecco la figura. Tav. j. Fig. 3. (c)

Rinchiuso in una scatola, vide la matina seguente cinquanta uova anch'esse verdi appiccate tutte al volto della medesima, e ne' dintorni delle parti, nel modo, che rappresenta la Fig. 4. T. j. (d)

Il filo, sul quale cadauna posava era duretto fatto d'una colla, o gelatina viscosa, che resisteva all'urto piegandosi, e poi tornando al suo luogo. Erano di figura alquanto ovata, e rassembravano tanti piccoli aghi col loro capo. Dopo ne trovò sopra foglie delle Rose, e sopra altre erbe, e ne darà un giorno ulteriore notizia. (c) Tav. I. Fig. 3. (d) Tav. I. Fig. 4." (12).

The drawing of the green lacewing provided by Vallisneri (Figs 10 A-C) is really rather rough in comparison with those to be found in previous or contemporary works by other authors (see Aspöck & Aspöck, 2007). His observations on this chrysopid were afterwards republished in the posthumous edition of the *Opere fisico-mediche* (Vallisneri, 1733, tomo III, p. 211), and we can also read a version of them in the first of the *Quaderni di osservazioni*, a manuscript dating back to the last years of the 17th century, and recently published (Pennuto, 2004, p. 62); in the manuscript the chrysopid is indicated as "insetto in forma di cevittone piccolo" and there is also a sketch of its pedunculate eggs. As regards the word "cevittone" or "cevettone", this is a vernacular and augmentative term derived from "civetta" (owlet), and used by Vallisneri to name the dragonflies, damselflies and other similar insects (corresponding therefore to Aldrovandi's *Perlae*; see also Conci & Nielsen, 1956, pp. 40-43). Like Aldrovandi, Vallisneri also saw a similarity or relationship between green lacewings, antlions, dragonflies and damselflies, even though he expressed some doubt regarding their affinities.

As far as myrmeleontids are concerned, Vallisneri's observations are to be found in his *Secondo dialogo* between Pliny and Malpighi, also published in the "*Galleria di Minerva*" (Vallisneri, 1700a, pp. 302-305), without illustrations. One of the aims of this "dialogue" – a literary genre common in scientific literature of the 17th and 18th centuries – was to refute the theory of spontaneous generation with evidence, as we can see in the contraposition between an ancient author (Pliny) and a modern one (Malpighi, teacher of Vallisneri himself). Through Malpighi, Vallisneri reports his own observations on the life cycle of the antlion and accurately describes the larva – which digs pits in dusty soils and has the characteristic forceps ("tanaglie"), whose functions are pointed out –, pupa, cocoon, adult and its emerging, the meconium produced by the adult, and erroneously interpreted as an egg; he provides other observations on the behaviour and the environment of this insect, whose surprising life is at first subterranean, then aerial. The person who sees an adult emerging from the soil, he says, could be mistaken, like the Ancients, and think that it is generated by the soil! His observations started from some larval pits found at the foot of an oak and in the bank of a ditch. He also reports larval movements backwards, the way it can dig an initial pit, its resistance to fasting, the castings. As regards larval feeding, he thinks it consists exclusively or principally in sucking prey's "linfa" (lymph, of ants or other small arthropods), and he supposes a correlation between the morphology of the forceps and ability to grasp victims of different shape and size. He also notes the location of the pits in relation to the cardinal points. By rearing larvae he experiments with the pupating in an artificial environment without dusty soil, in order to


LA GALLERIA
DI MINERVA
OVERO
NOTIZIE VNIVERSALI.
RETORICA, POETICA, POLITICA, ISTORICA, GEOGRAFICA,
TRATTE DA' LIBRI NON SOLO STAMPATI, MA DA STAMPARSI.
A PROFITTO DELLA REPVBBLICA DELLE LETTERE,
CONSACRATA
CARLO CONTARINI
Procurator di San Marco Dignissimo.
IN VENETIA. M.DC.XCVI.
Presso Girolamo Albrizzi.
CON LICENZA DE' SVPERIORI.

Fig. 9 – Frontispiece of a volume of the early periodical *La Galleria di Minerva*, published at Venice from 1696 to 1717 (after Sabia, 1996); this periodical published Vallisneri's observations on antlions and green lacewings.

Fig. 10 – **A**, A. Vallisnieri (“*La Galleria di Minerva*”, Venice 1717, tav. I), plate with illustration of a chrysopid and its stalked eggs; **B**, **C**, details of the same plate (by courtesy of Prof. D. Generali).

better observe silk reeling and metamorphosis. Furthermore, he dissects larvae and adults. He also writes that he has more than once observed adults laying eggs in dusty soils. He names the larva “verme formicario” (worm of ants), the pupa “ninfa”, the adult “cevettone”, a regional word whose meaning is reported above. The accurate description of the adult’s colouring, together with the bio-ethological data provided and the asserted larval place of origin, at least partially, in the surroundings of Bologna, suggest that his antlion could be identified today as a *Myrmeleon*, almost certainly *M. formicarius* Linnaeus, 1767.

Re-editions of this subject are to be found in Vallisneri’s works. A typographically unfortunate reprinting of the *Secondo dialogo* was published, indeed, in the same year (Vallisneri, 1700b), and the same is obviously comprised in the posthumous edition of the *Opere fisico-mediche* (Vallisneri, 1733, tomo I, pp. 32-75). In the first of his *Quaderni di osservazioni* (Pennuto, 2004, pp. 18-28) we can also read the detailed handwritten annotations which were of use for drafting the dialogue on the antlion.

It is needless to underline the importance, for the history of neuropterology, of the above findings of Vallisneri, the first author to the best of our knowledge to describe and illustrate the stalked eggs of chrysopids and to publish the life cycle of a myrmeleontid (and also the first to describe the holometabolous development of a neuropteran): he was conscious of this and he did not neglect defending the originality of his observations on antlions from supposed plagiarism – quarrels not rare between men of science – by the French anatomist François Poupart (1661-1709). In 1704, some years after the publication of Vallisneri’s text, Poupart presented a work on the antlion to the Science Academy of Paris, published in the same year (Poupart, 1704; Hagen, 1862-1863; Horn & Schenkling, 1928-1929), containing observations similar to Vallisneri’s together with a plate illustrating the antlion stages, and written seemingly in ignorance of the previous Italian work. Vallisneri did not fail to censure politely the presumed misdeed.

The matter is reported by Réaumur (1683-1757) in his *Mémoires*, at the beginning of his very ample and valuable work on the antlion (Réaumur, 1742: “Dixième Mémoire. Histoire des formicaleo"; see also Wheeler, 1930, p. 7, note 1; Albouy, 2001, p. 277 and subs.). Reaumur not only asserted convincingly that his compatriot had made his observations independently, but also reported that two other Frenchmen had anticipated Vallisneri in their observations on the insect, without publishing them. Quoting the forerunners in his memoirs, Réaumur correctly drew attention to their earlier contribution on the subject, pointing out that Poupart's observations differ from Vallisneri's because the former are more detailed and exact on certain aspects, less accurate as regards others. Poupart probably published first-hand data; in addition his notes and plate enable us to identify as *Euroleon nostras* (Geoffroy in Fourcroy, 1785) the species studied by him. For the posthumous edition of the *Opere fisico-mediche* (Vallisneri, 1733), Poupart's plate was then copied and published to illustrate the text by Vallisneri, even though the figures do not fully correspond to the species described by him (at least with regard to the adult, which could be a *Myrmeleon*, see above).

It seems worthwhile to reproduce here both the plate (Fig. 11) added to the "Secondo dialogo" in the posthumous edition of Vallisneri's work (Vallisneri, 1733), and that from the work of Poupart; the latter (Fig. 12) is taken from an Italian posthumous translation published in Venice (Poupart, 1750) of the Frenchman's *Histoire du formica-leo* of 1704; both plates also illustrate nymphs of dragonflies, which Poupart briefly mentions, and which also interested Vallisneri.

Two centuries later, ignoring any polemics, we can today recognise both authors as being almost simultaneously the first to disclose and reveal to the scientific community the basic features of the life cycle

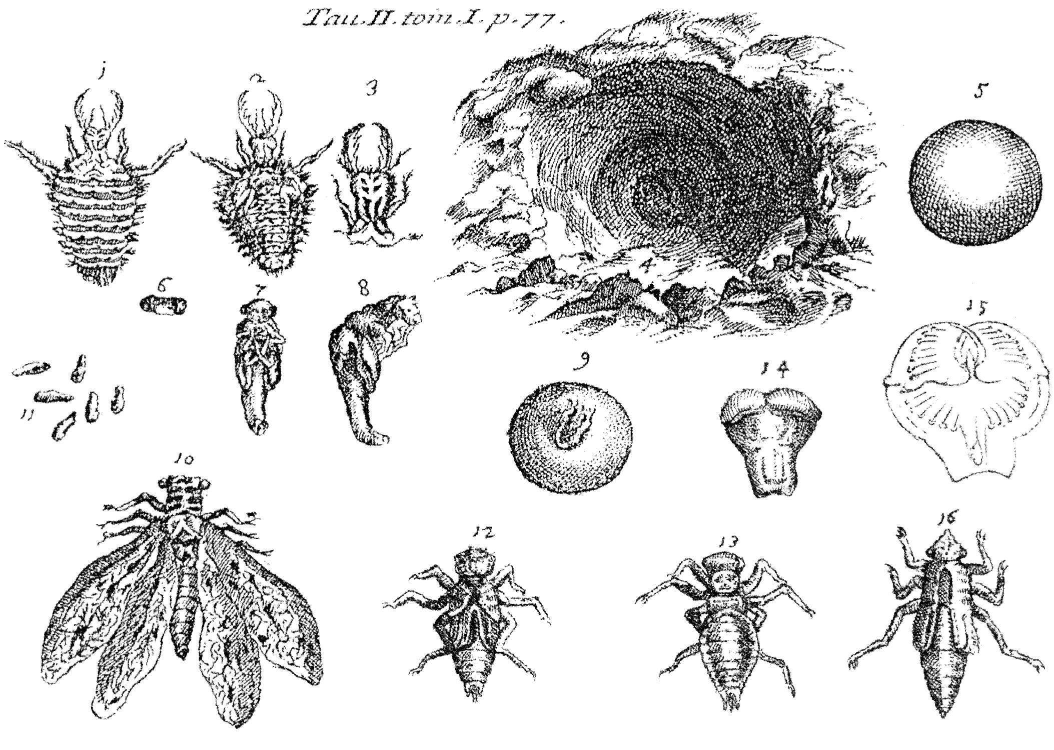

Fig. 11 – A. Vallisneri (*Opere fisico-mediche…*, Venice 1733, Tomo I, Tav. II): life stages and pit-trap of an ant-lion; the plate also illustrates some early stages of dragonflies and their details (numbers 12-16) (by courtesy of Prof. D. Generali); this plate was taken from that of Poupart, 1704.

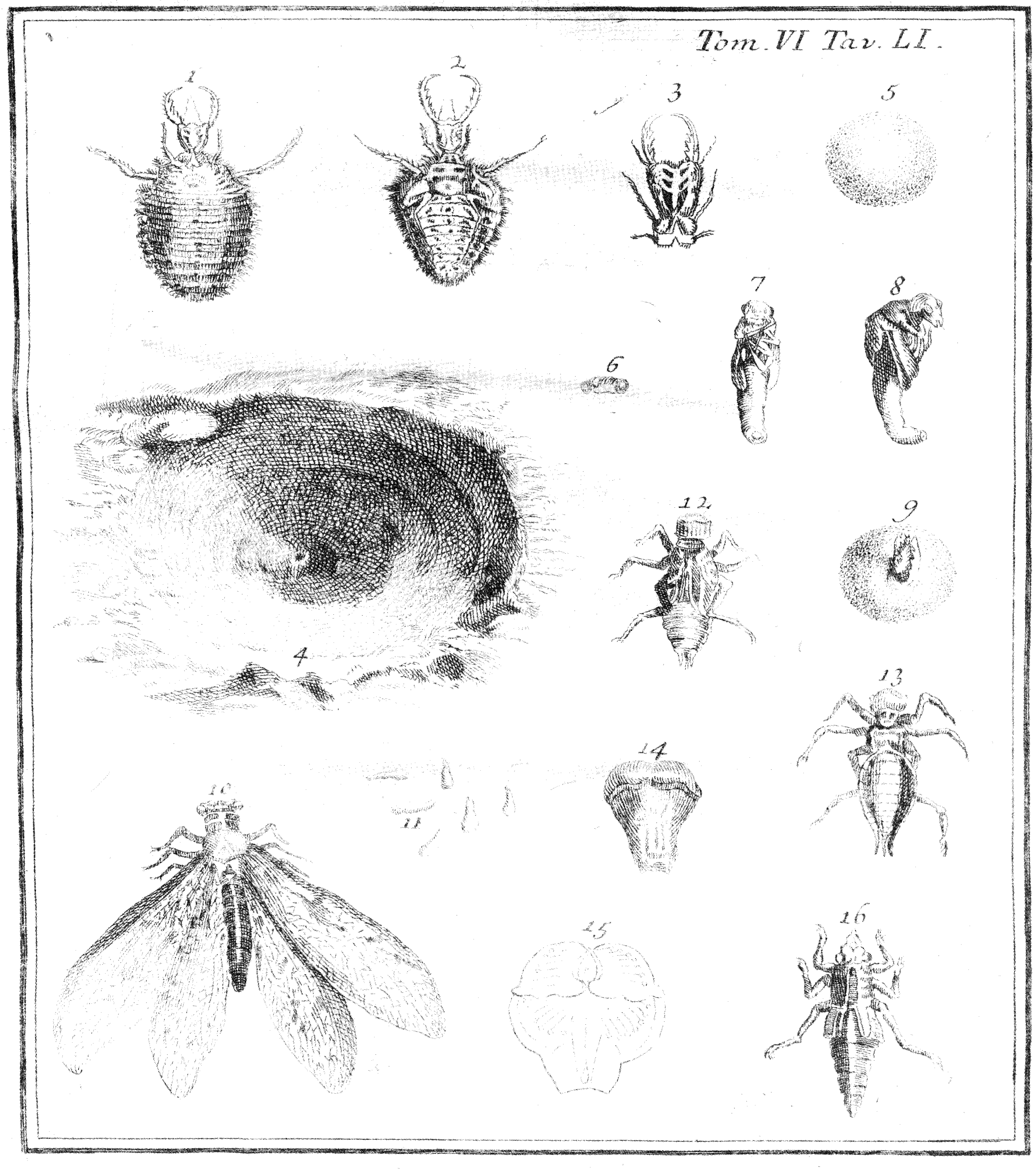

Fig. 12 – F. Poupart (*Memorie appartenenti alla storia naturale*…, Venice 1750, Tomo VI, Cl. II, Tav. LI): life stages and pit-trap of an antlion (*Euroleon nostras*) (the plate also illustrates some early stages of dragonflies and their details: numbers 12-16) in a posthumous Italian re-edition of his *Histoire du formica-leo* (Paris 1704): the original plate dating back to 1704 served as a model for that in the posthumous edition (1733) of Vallisneri's scientific work. (Private library, Bologna; photo R. Nicoli Aldini).

and the ethology of the most renowned insect among neuropterans.

Before Linné, Aldrovandi's and Vallisneri's work contributed therefore to the advance of knowledge on Neuroptera, and even in this minute part of their ample scope in the field of biological sciences, we can perceive interests, methodological approaches and objectives which marked and directed the development of science over national and historical boundaries.

A very important general contribution if we consider the impulse given by Aldrovandi to the applied and systematic studies of insects and his importance as a landmark for insect nomenclature, or by Vallisneri to the knowledge of insect morphology, bionomy, behaviour, environmental relations, and to the definitive refuting of the theory of spontaneous generation.

A contribution largely preceeding the great season of systematics of the 18th and 19th centuries, when in Italian countries, following in the wake of Linné, some outstanding zoologists and university professors such as Giovanni Antonio Scopoli (1723-1788) from Trentino at Idrija and Pavia, Pietro Rossi (1738-1804) from Tuscany at Pisa, and later Achille Costa (1823-1898) from Apulia at Naples, will also be working on neuropterous insects.

A contribution which deserves to be fully recognised.

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Notes

(1) "The eighth [*perla*] has a blunt abdomen without bifurcation, all the body being iron-coloured and the wings white, iron-coloured on the edge".

(2) "*Perla* with very long, spotless wings and simplex abdomen [or "tail"] without bifurcation".

(3) "Relative of the locust".

(4) "It is a figure of a butterfly or moth, which we gave above among them".

(5) "The first has yellowish wings and it is of completely yellow body, with exception of some iron-coloured areas".

(6) "The third has short wings tending to be bluish, very long abdomen [...]. It has extremely short, yellowish antennae".

(7) "Yellowish and iron coloured *perla*, with spotless and bluish wings".

(8) "Μυρμηκολέων, or *Formicoleo*, according to Albert the Great is the name of an insect which is like a lion among ants, at the same time both ant and lion, a small animal but so dangerous for the ants which, hiding itself in the dust and constructing a kind of round rampart forming a trench, attacks the ants while they are carrying grains of wheat and kills them insidiously. Other authors write that it is of the same

family as ants, but much bigger, and while it is still young and weak, it simulates peace and mildness; but when it has token strength, it disdains its former companions and rushes forward against bigger masses. […] Cardano recalls it as follows: an animal which resembles a small grub lays traps for ants, so I interpret the words of Albert, who saw it: it digs a round pit in the sand, at the bottom of which, as a pole, a narrow hole exists, from which it suddenly assails the ants and devours them. This is called *Formicaleon* by Albert. […]".

(9) "Of the same genus as the tick".

(10) "Green mosquito similar to a butterfly, with four wings".

(11) "As to the seventh [insect] I have the greatest doubts that it is referable to mosquitoes, and I do not know what carelessness led to it being placed here among them. In fact I should have referred rather to the smallest of the above-mentioned *perlae*. It is larger than the common or lake mosquitoes, with a delicate, long, thin, green body, with a dorsal median pale-yellow line that goes dorsally from the head to the abdomen, with modest antennae, without mouth sting, with four large and silvery shining wings".

(12) "On May 25 a very graceful insect was brought to Vallisnieri, who considered it a mid-way species between the butterfly and the "cevettone". This insect was completely coloured in a very elegant green, with exception of the eyes, which were gold-coloured. It was provided with four shining and emerald, proportionate membranous wings, which covered all its body. When the insect settles, it rests with wings close at their upper edge, and open at their lower edge, like the roof of house: the insect is completely protected and covered by these wings, with exception of the head, the neck, and an angle at the beginning of the back. Feet, abdomen, thorax, back, neck, head, are all green-coloured. Only the eyes are gold-coloured. It has the mouth on the tip of the snout, and the antennae turned backwards on the head, and interrupted with frequent nodes. Here is the figure. Plate j. Fig. 3. (c).

After closing it in a box, the morning after he saw fifty eggs, also green, all stuck to the reverse side of the same, and in the proximity of the sides, in the manner illustrated in the fig. 4, pl. j (d).

The thread on which each egg rested was rather hard, made of a glue, or viscous gelatin, which resisted to a blow by bending, and then returning to its place. They were quite ovate in shape, resembling many small pins with their head. Later he found similar eggs on the leaves of the roses, and on other plants, and one day he will report on them. (c) Plate I. Fig. 3. (d) Plate I. Fig. 4.".

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Illustrations of Chrysopidae in the early entomological literature

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Among the oldest illustrations of Neuroptera published in the scientific literature are those of green lacewings. Hoefnagel (1592), Aldrovandi (1602), Moufet (1634), Jonston (1653), Goedart (1667), Vallisnieri (1717), Merian (1717), Albin (1720), Frisch (1736), Réaumur (1734-1742), Bonnet (1745), Rösel von Rosenhof (1755), Schaeffer (1766) and others have published plain or coloured engravings of Chrysopidae, none of them can, however, be identified on a species level. The first illustration of a Chrysopid after Linnaeus (1758) was published by Scopoli (1763). It was only the German naturalist Wilhelm Friedrich von Gleichen, named Russworm (1717-1783) who published two papers in 1764 with magnificent, coloured copper engravings of a larva and of an adult which can be clearly identified. The larva is *Chrysopa pallens* (Rambur, 1838), the adult *Chrysoperla carnea* (Stephens, 1836). Most subsequent published illustrations in the 18th century were of poor scientific quality: Geoffroy (1764), Müller (1775), Barbut (1781), Rossi (1790), Petagna (1792), Olivier (1797), Panzer (1798). An outstanding exception is De Geer (1771), whose copper engravings of Chrysopidae were of surprisingly high quality. The first illustrations with truly correct wing venation were published in the first half of the 19th century; Curtis (1834) with the plate of *Chrysopa abbreviata* is a good example. The first culminations of illustrations of Chrysopidae are the study on Chrysopidae of Austria by Brauer (1851) and the monograph by Schneider (1851) with beautifully coloured lithographs. Many excellent illustrations of Chrysopidae were published in the past 160 years; but none of them has reached the unmatched quality and density of scientific information of the drawings of Chrysopidae made by M.M. Principi in the second half of the 20th century.

Key words – Chrysopidae, illustrations, engravings, 16th century, 17th century, 18th century, 19th century, 20th century.

Introduction

Besides antlions and adults of antlions, green lacewings are the most generally known Neuroptera. No doubt, almost everybody – even if not interested in nature – comes into contact with these insects, which are attracted by light and are often found in large numbers in houses, which are used as shelters by several species. The naturalists of antiquity must have certainly known them and, so too, must have early artists included them in their drawings and paintings. Thus, it is not surprising that illustrations of green lacewings appear very early in the entomological literature.

Characters of early illustrations

Illustrations of insects in the works of early authors were always made with the intention to grasp the general appearance. In the case of Chrysopidae this is rather easy: A slender insect, long antennae, four transparent wings, a lot of veins, and – in case of coloured illustrations – green. In other words: the old illustrations of Chrysopidae are terribly wrong – nevertheless they are usually easily recognizable as belonging to the family. The situation is similar to other Neuropterida, as has been shown in earlier papers on Raphidioptera (H. Aspöck, 1998), Mantis-

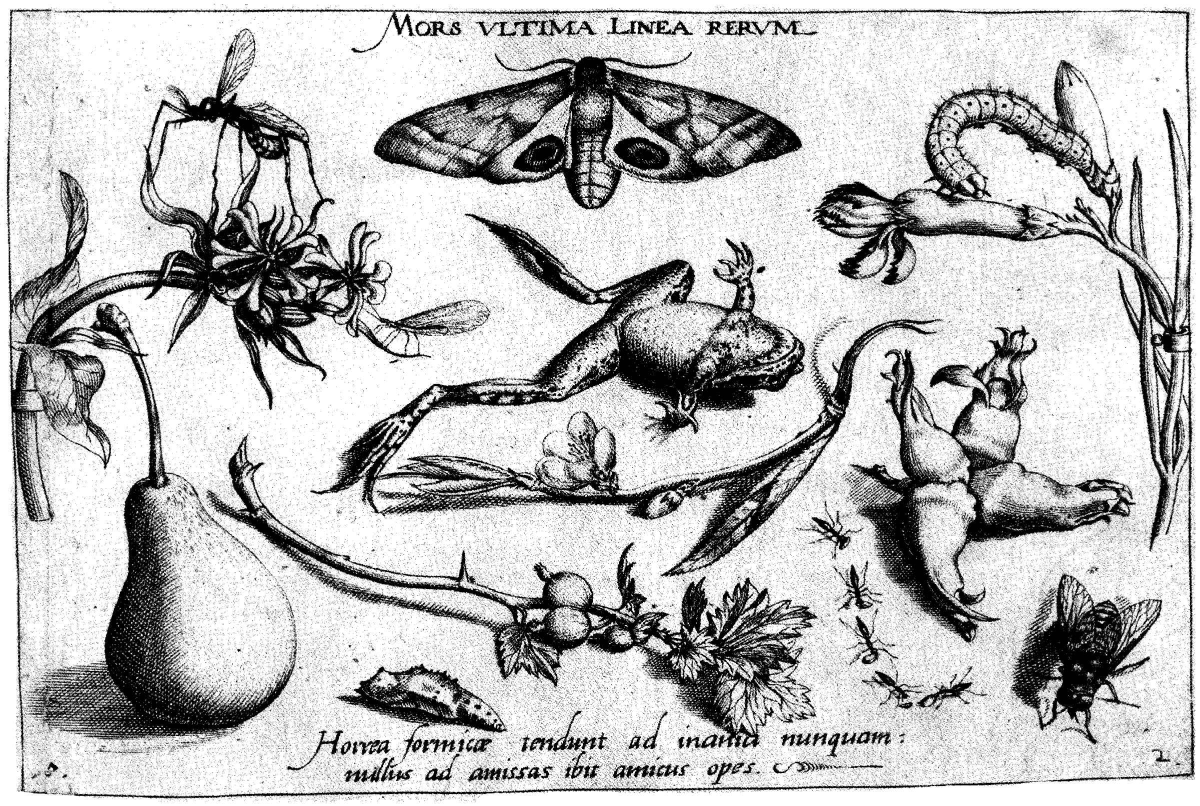


Fig. 1 – Georg Hoefnagel (1592): 2nd part, plate 5, showing a Chrysopid (left of frog) (Library H. & U. Aspöck).

pidae (H. Aspöck, 1999), Osmylidae (H. Aspöck, 2002), and Coniopterygidae (H. Aspöck & U. Aspöck, 2003).

Illustrations of Chrysopidae in the 16th century

Jacob Hoefnagel (1573-1632?) is probably the first author of a printed illustration of a Chrysopid. Plate 5 of the second part of the "Archetypa studiaque ...", based upon drawings of his father, Joris Hoefnagel (1542-1601), and published in 1592, contains an insect which is undoubtedly a Chrysopid, although a more precise assignment is absolutely impossible (Fig. 1); moreover, the wings are apparently attached to the body in an upside-down-inverted position. As far as we know, this is the only publication in the 16th century containing an illustration of a Chrysopid. Hoefnagel's "Archetypa" were published in several subsequent editions in the 17th and 18th century. Moreover, in 1630, Hoefnagel published 16 tables showing various arthropods, among them also (side-inverted) the Chrysopid of the "Archetypa". For details on Hoefnagel's work, see Vignau-Wilberg (1994).

Illustrations of Chrysopidae in the 17th century

The first printed illustration of a Chrysopid in the 17th century appeared in 1602 in Ulisse Aldrovandi's (1522-1605)

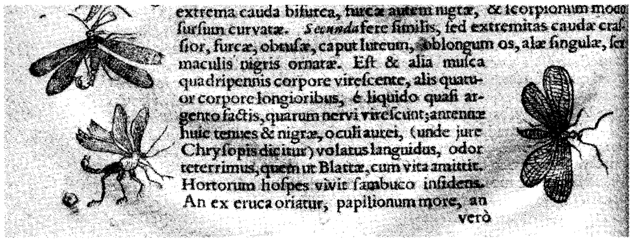

extrema cauda bifurca, furcæ autem nigræ, & ſcorpionum mod
ſurſum curvatæ. *Secunda* fere ſimilis, ſed extremitas caudæ craſ-
ſior, furcæ, obtuſæ, caput luteum, oblongum os, alæ ſingulæ, ſe
maculis nigris ornatæ. Eſt & alia muſca
quadripennis corpore vireſcente, alis quatu-
or corpore longioribus, è liquido quaſi ar-
gento factis, quarum nervi vireſcunt; antennæ
huic tenues & nigræ, oculi aurei, (unde jure
Chryſopis dicitur) volatus languidus, odor
teterrimus, quem ut Blattæ, cum vita amittit.
Hortorum hoſpes vivit ſambuco inſidens.
An ex eruca oriatur, papilionum more, an
verò

Fig. 2 – Thomas Moufet (1634): Detail of page 62, showing a Chrysopid (right) (Library H. & U. Aspöck).

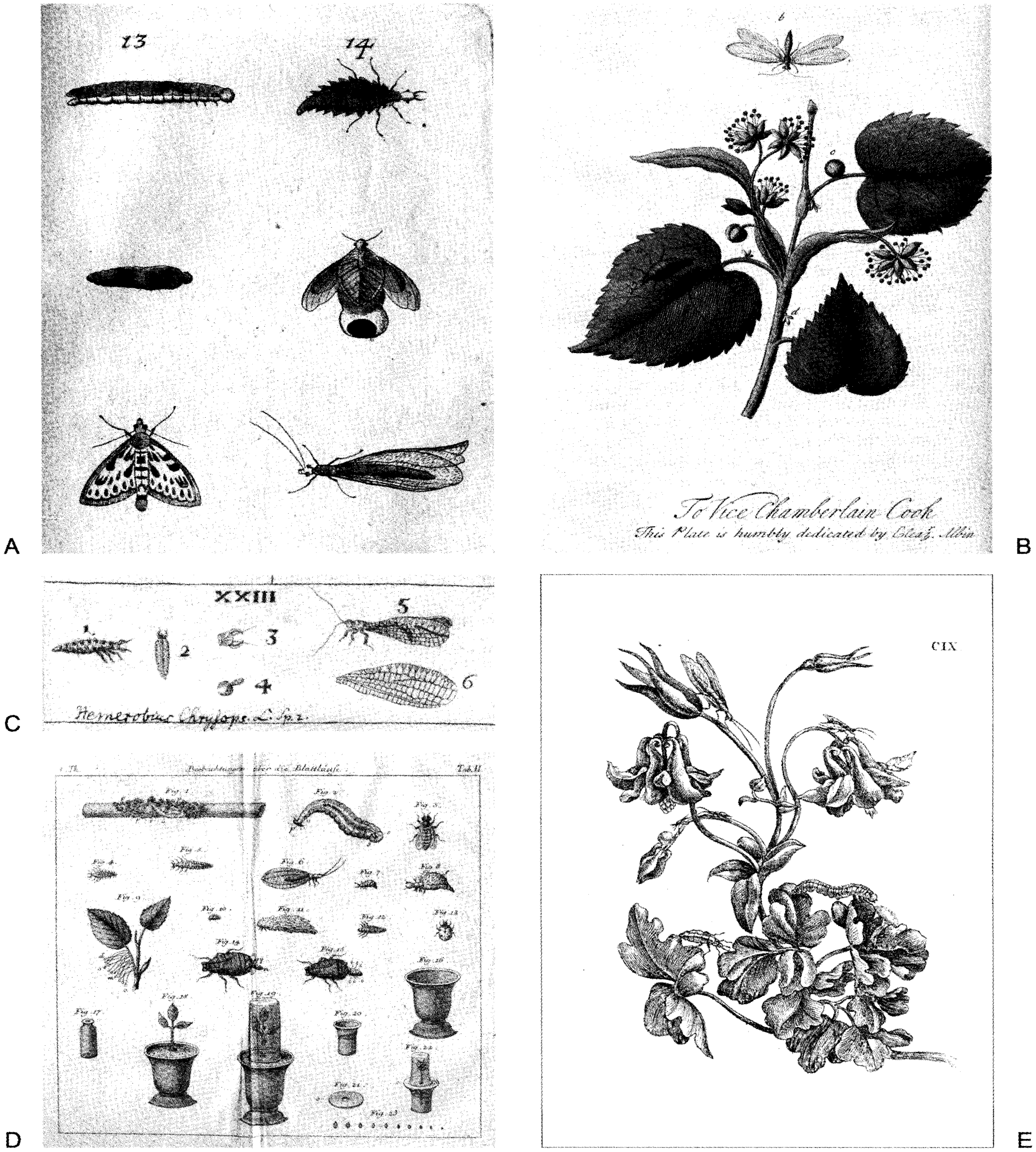


Fig. 3 – **A**, Jan Goedart (1669): 2nd volume, 7th plate, showing a naked Chrysopid larva (upper right) and an adult of a green lacewing (lower right) (Library H. & U. Aspöck); **B**, Eleazar Albin (1720): Plate 64, showing a naked larva (on the left leaf) and an adult (top) of a Chrysopid (Library H. & U. Aspöck); **C**, Johann Leonhard Frisch (1736): Detail of plate with green lacewings, showing various stages of Chrysopidae: larva, lateral (1) and ventral view (2), head (3), cocoon (4), adult (5), and fore-wing (6) (Library H. & U. Aspöck); **D**, Charles Bonnet (1773): Table II, showing various stages of Chrysopidae: larva (4), adult (6), a debris-carrying larva (7), the same enlarged (8), and stalked eggs on a plum leaf (9) (Library H. & U. Aspöck); **E**, Maria Sibylla Merian (1730): Figure CIX, exhibiting a larva (lower left) and an adult (upper left) of a Chrysopid (Library Natural History Museum Vienna).

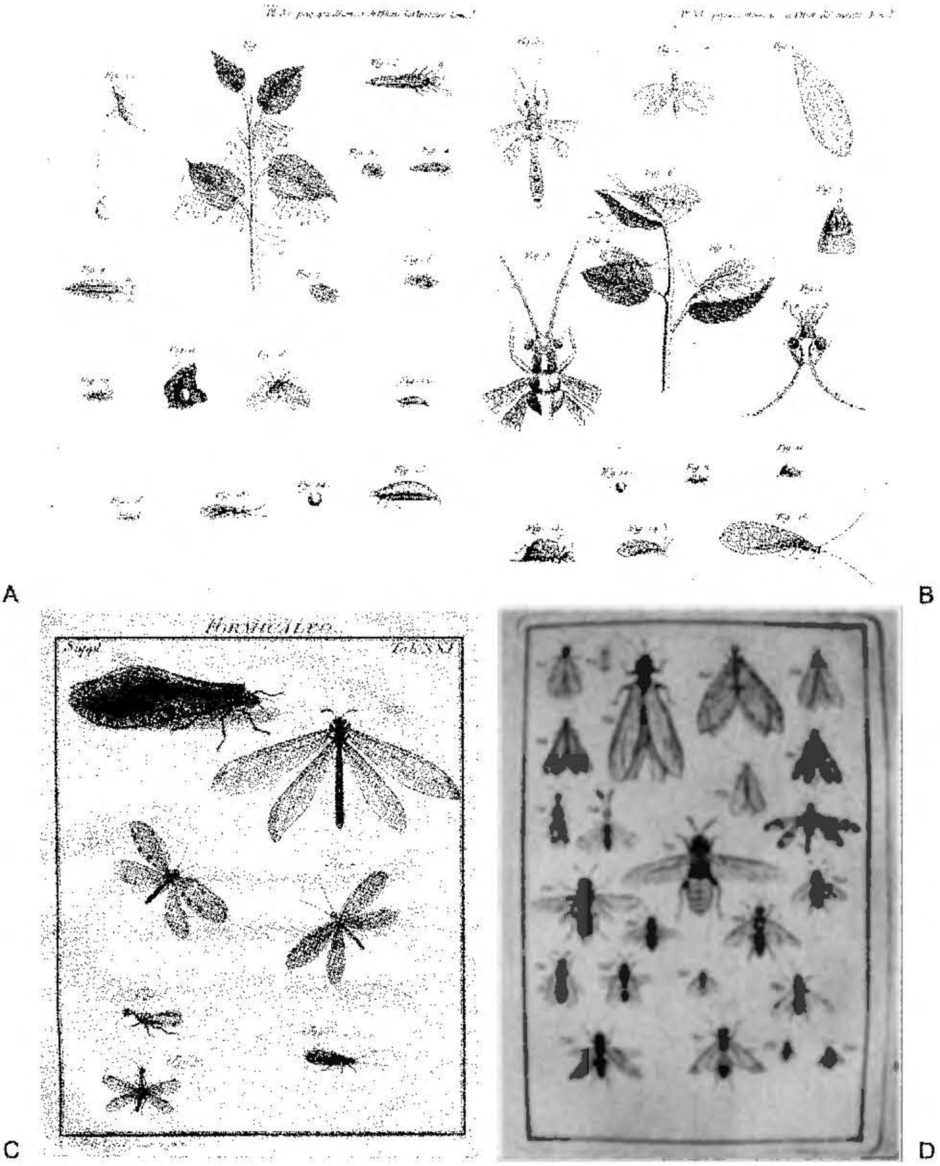


Fig. 4 – René Antoine Ferchault de Réaumur (1737): **A**, 3rd volume, plate 32, showing various stages of Chrysopidae: a twig of a plum-tree with stalked eggs (1), larger scale of a single egg (2), a naked larva, magnified (9) and natural size (10) (the other figures are Hemerobiidae) (Library Natural History Museum Vienna); **B**, 3rd volume, plate 33, showing various stages and details of Chrysopidae: fore-wing (1), adult (2), head, thorax, with wing bases and abdomen of an adult, enlarged (3), behaviour of an ovipositing female (4, 5, 6), ventral view of tip of a female abdomen (7), head of an adult showing the mouthparts (8), head and thorax with wing bases, greatly enlarged (9), a debris-carrying larva (10), the same after removal of the debris (11), cocoon (12), debris-carrying larva, magnified (13), adult reared from this larva, natural size (14) and magnified (15) (Library Natural History Museum Vienna); **C**, August Johann Rösel von Rosenhof (1755): 3rd volume, table XXI, with two Chrysopids (4, 5) (Library H. & U. Aspöck); **D**, Giovanni Antonio Scopoli (1763): Plate with Neuroptera, with "*Hemerobius flavus*" (= *Nineta flava*) (707), "*Hemerobius chrysops*" (= *Chrysopa perla* L. ?) (708), and "*Hemerobius perla*" (= *Chrysoperla carnea* Steph. ?) (709) (Library Natural History Museum Vienna).

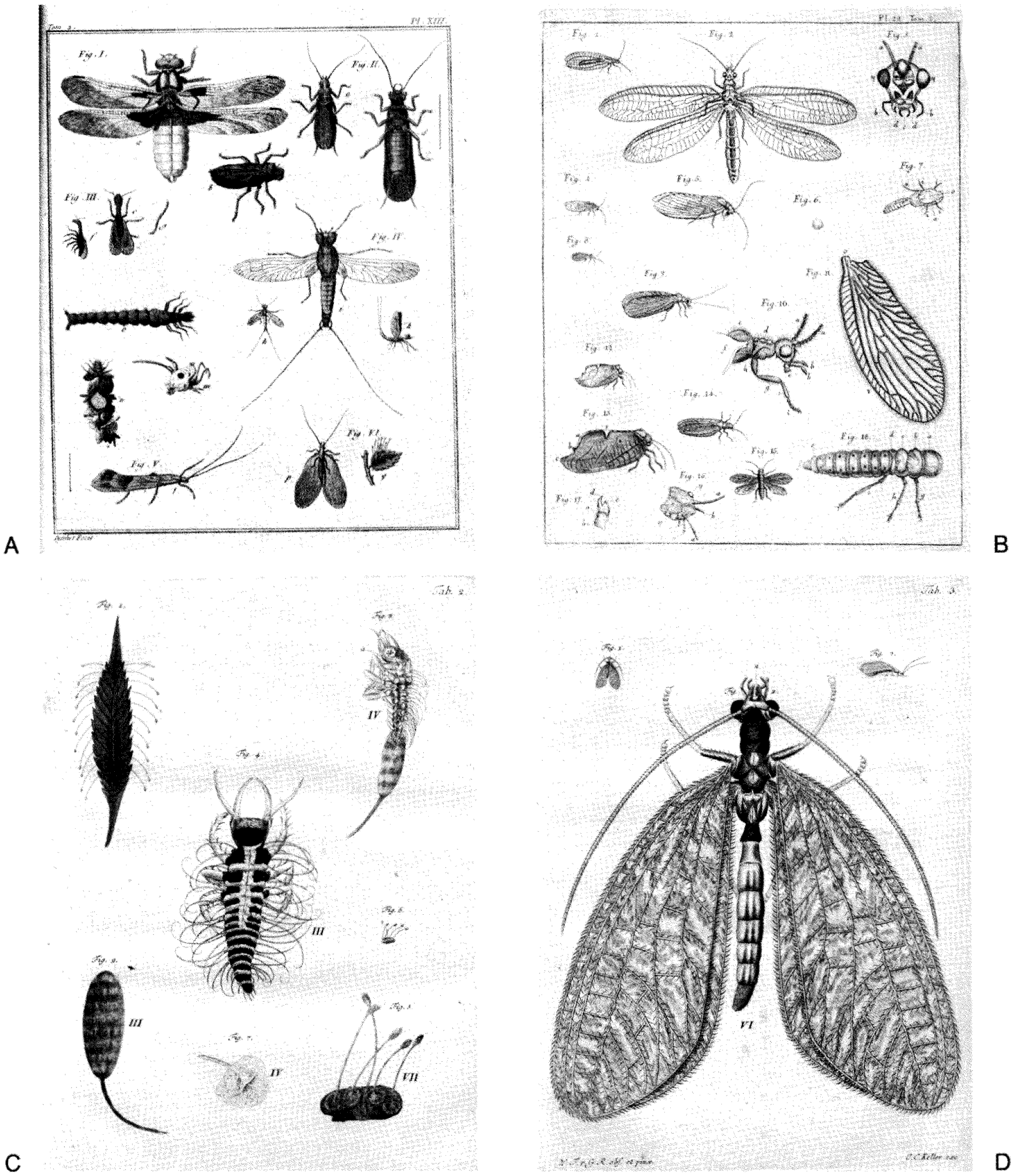


Fig. 5 – **A**, Étienne Louis Geoffroy (1799): Plate XIII, with stalked eggs and an adult of a Chrysopid (Library H. & U. Aspöck); **B**, Carl De Geer (1771): Volume 2, 2nd part, plate with Neuroptera: a Chrysopid ("*Hemerobius*"), sitting (1) and with spread wings (2), head, greatly enlarged (3) (Library H. & U. Aspöck); **C**, Wilhelm Friedrich von Gleichen, named Russworm (1764a): Plate, showing eggs and larvae of *Chrysopa pallens* (Rambur): A hemp leaf with eggs (1), a single egg, magnified (2), neonate larva hatching from the egg (3), first instar larva, one day old (4), eggs on a piece of skin of a plum, magnified (5), the same in natural size (6), lower part of the stalk of an egg showing the funnel-like base (7) (Library H. & U. Aspöck) (Prof. R. Pantaleoni is of the opinion that the larva is not *C. pallens*, but a *Chrysoperla* species.); **D**, Wilhelm Friedrich von Gleichen, named Russworm (1764b): Plate, with the insect named „die Hofdame" by the author (= *Chrysoperla carnea* Steph.). It is the first illustration of a Chrysopid which can be reliably identified on the species level (Library H. & U. Aspöck).

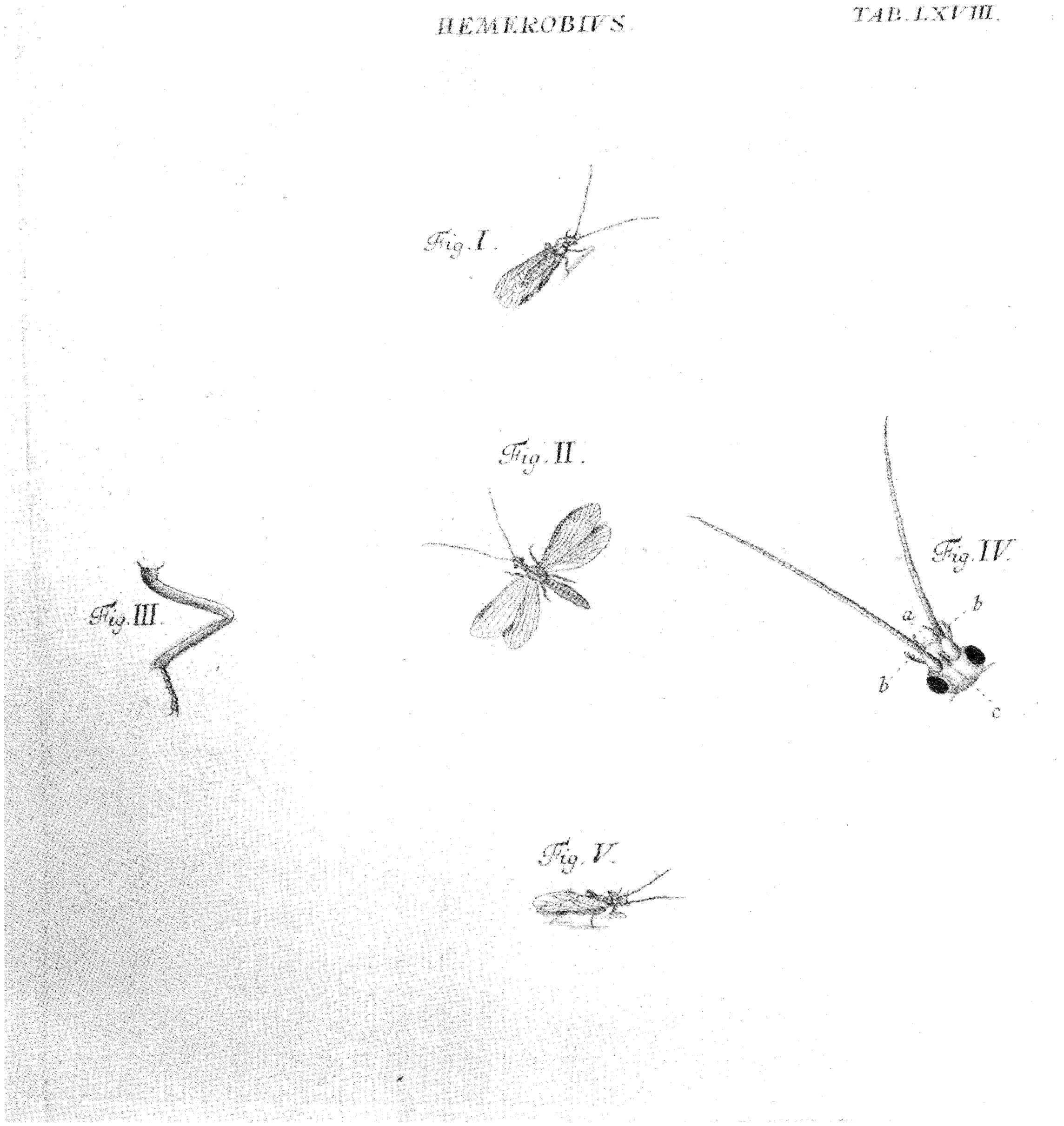
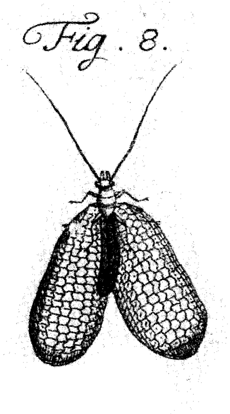


Fig. 6 – Jakob Christian Schaeffer (1766a): Plate LXVIII, showing a green lacewing (Schaeffer calls it simply “*Hemerobius*”) in various positions, and leg and head (Library H. & U. Aspöck).

famous work “De animalibus insectis ...”. Several subsequent editions were published, one of them in 1638 after Aldrovandi’s death, whereby the same woodcuts were used. On page 386 in the Liber tertius is an illustration (No. 7) of an insect which may – with some good will – be recognized as a Chrysopid. This is supported by Aldrovandi’s description of this insect in which he says that it has a delicate, slender, long, green body with a yellow stripe on the dorsum (“corpore tenui, gracili, oblongo, viridi, linea ex luteo pallida medium dorsum intersecante”). Determination at the species level is impossible (see also Nicoli Aldini, 2007).

In 1634, the “Insectorum sive minimorum animalium theatrum” by Thomas

Moufet (also Mouffet, Moffet, Moffett, Muffet, Mufet), an English naturalist, was published – 30 years after the death of its author.



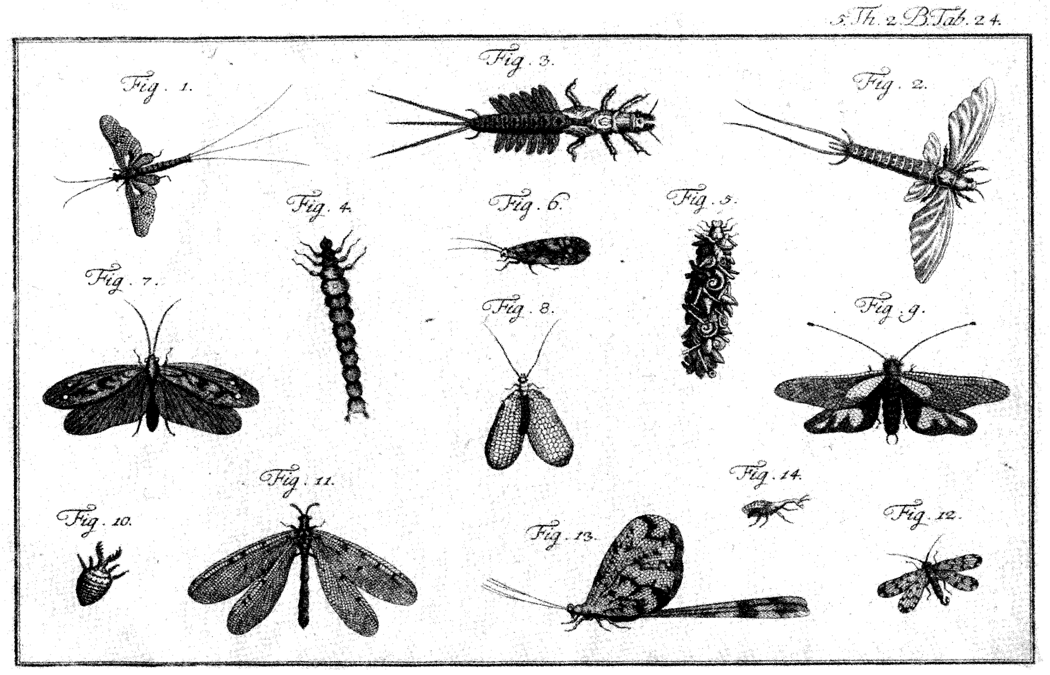


Fig. 7 – Philipp Ludwig Statius Müller (1775): 5th part, 2nd volume, plate 24, with Neuroptera, among them a Chrysopid (8), detail enlarged above (Library H. & U. Aspöck).

On page 62 is a woodcut of a Chrysopid (Fig. 2). The accompanying text says that this other fly ("alia musca") has four wings and a greenish body ("quadripennis corpore virescente, alis quatuor ..."), delicate black antennae ("antennae huic tenues et nigrae") and golden eyes ("oculi aurei"), therefore it is reasonable to call these insects Chrysopae ("unde jure Chrysopis dicitur"); and also the bad odour, like that of cockroaches, is mentioned ("odor teterrimus, quem ut Blattae, cum vita amittit"). Possibly the author had before him the species which we now call *Chrysopa perla* (Linnaeus, 1758) (or another species of the genus *Chrysopa*). The Latin edition was followed by an English translation published in 1658.

In 1653, another great book on insects appeared: "Historia naturalis de insectis ..." by the German Johann Jonston (1603-1675). A second edition was published in 1657. The book contains many woodcuts and among these are copies of drawings of Chrysopidae made by Moufet and Aldrovandi. Moreover, there are two very interesting drawings, each showing a Chrysopid larva, one of them being a debris-carrier (Jonston calls them "Vermes arboreae" and "Xylophthori").

In 1662, Jan Goedart (also Goedard, Goedardt, Goedaert), a Dutch naturalist, started to publish his "Metamorphosis ...

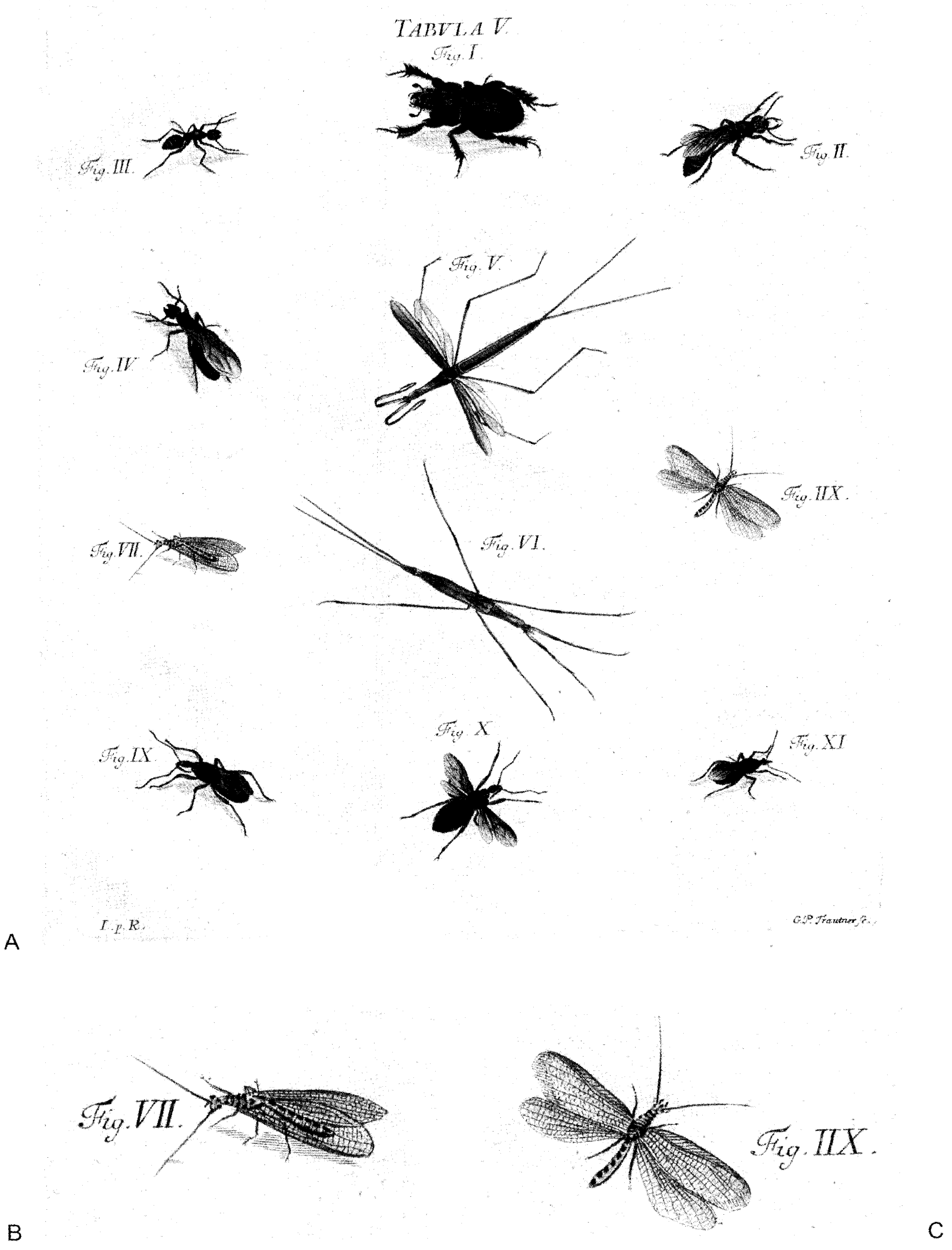


Fig. 8 – Georg Wolfgang Franz Panzer (1804): **A**, Plate V, with "*Hemerobius perla*"; **B** and **C**, details (Library H. & U. Aspöck).

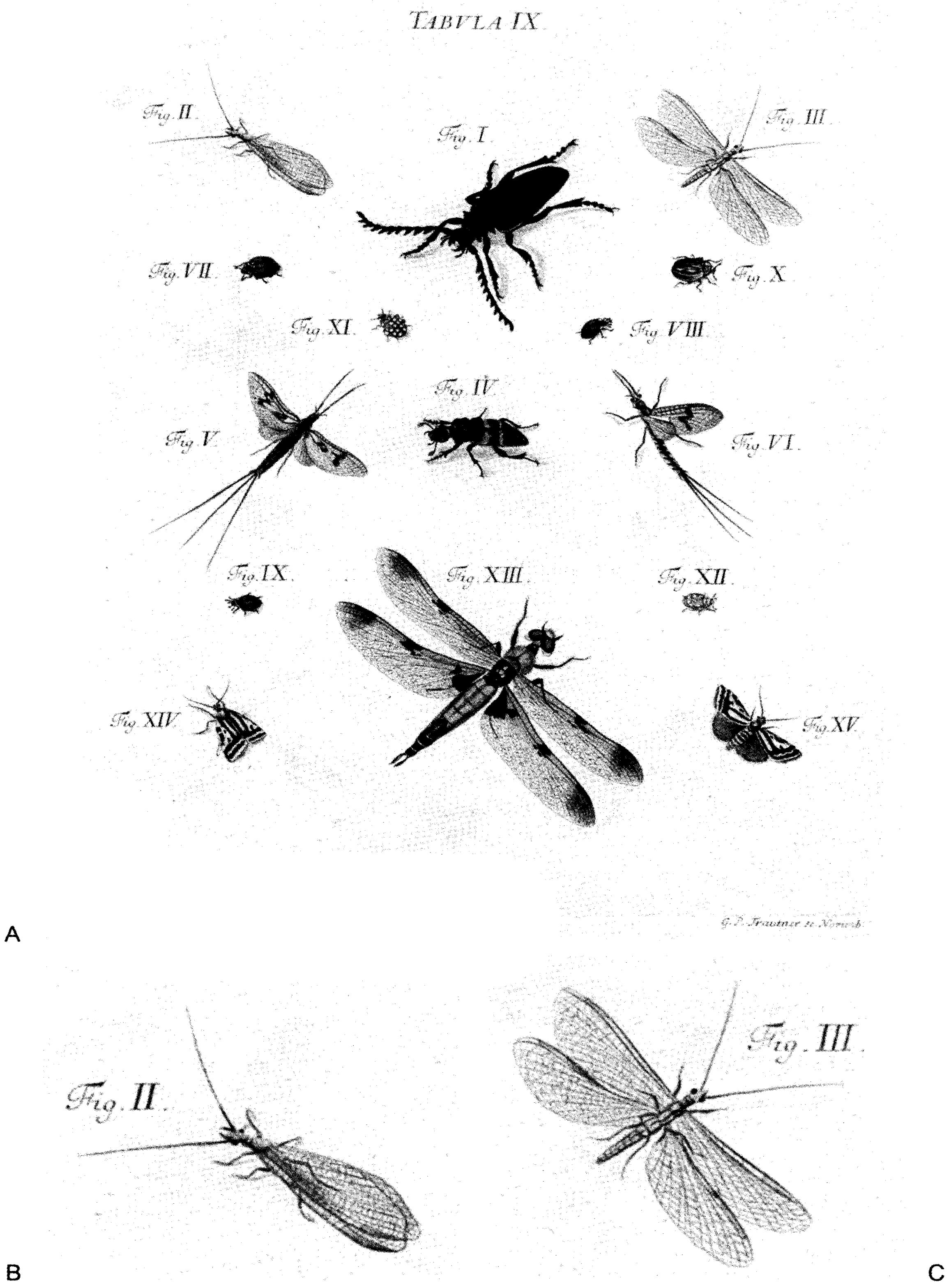


Fig. 9 – Georg Wolfgang Franz Panzer (1804): **A**, Plate IX, with "*Hemerobius albus*"; **B** and **C**, details (Library H. & U. Aspöck).

insectorum". This work (3 parts, usually bound as separate volumes, 125 plates) deals with the metamorphosis of insects, the copper plates (in some copies coloured) show many insects, adults as well as early stages. Goedart's work appeared in several editions in several languages (Latin, Dutch, French, and in part in English). On the (not numbered) 7th plate of the second volume (published in 1667) is a beautiful illustration of a larva and an adult of a Chrysopid (Fig. 3 A). Again, no precise identification is possible. At any rate, to the best of our knowledge this is the first coloured illustration of a Chrysopid in the entomological literature. Moreover, Goedart appears to be the first who published an illustration of a Chrysopid larva in connection with the adult thus demonstrating that he knew the development. The same drawings were published in a book by Goedart[ius] and Lister (1685).

Illustrations of Chrysopidae between 1700 and 1757

Before Linnaeus' 10th edition of his "Systema naturae" several authors published illustrations of Chrysopidae in the first half of the 18th century, some of them coloured and beautiful.

The first author in the 18th century who published an illustration of a Chrysopid is the great Italian naturalist Antonio Vallisnieri (1661-1730, sometimes also spelt as Vallisneri or Valsinieri). In 1717, an article appeared in which he described an adult of a green lacewing and the stalked eggs laid by it; both – adult and eggs – are shown in very simple figures (see Nicoli Aldini, 2007), but it seems to be the first publication in the entomological literature with an illustration of the stalked eggs of Chrysopidae.

In 1720, Eleazar Albin (ca. 1690-1759), an English painter and naturalist, published his splendid book "A natural history of English insects ..." mainly dealing with butterflies and moths. However, one plate (64) is solely devoted to green lacewings (Fig. 3 B). The larva, the cocoon, and an adult are shown. The accompanying text says that the "Hexapode Worm" was found on a lime-tree "at the latter End of July, and fed on small Flies, ... on the second of August it spun it self up in a white Silken Case ... and the 16th of May following came the Green-Golden-ey'd Fly ...". As might be expected, the species on Albin's table cannot be identified.

One of the outstanding authors in entomology in Germany in the first half of the 18th century was Johann Leonhard Frisch (1660-1743). Between 1720 and 1738 he published his famous book "Beschreibung von allerley Insecten in Teutschland..." in 13 parts with many plates showing many insects in various stages. In the fourth part (1st issue published 1722, second issue 1736) is a chapter dealing with the golden-eyed stinking fly ("Von der Goldäugigen Stinck-fliege"). The accompanying illustrations show larvae, the cocoon and an adult of Chrysopids (Fig. 3 C). The adult reminds one of *Chrysopa perla* and Frisch's descriptions of the bad odour and the dark green body of this insect would also apply to *Chrysopa perla*. The wing venation is more precise than in the earlier drawings, nevertheless the species cannot be identified.

Maria Sibylla Merian (1647-1717), a German, who spent a large part of her life in the Netherlands, is the author of at least two illustrations of green lace-wings. One was first published in 1717, it is apparently an original showing a naked larva and an adult of a green lace-wing, both cannot be identified on the species level. This engraving appears again in later books of M. S. Merian, and also in a posthumously (1730) published work (Fig. 3 E). In addition, this book contains an engraving of a bunch of flowers, and above it one finds surprisingly the drawings of the larva and adult of Chrysopids by Goedart (1667).

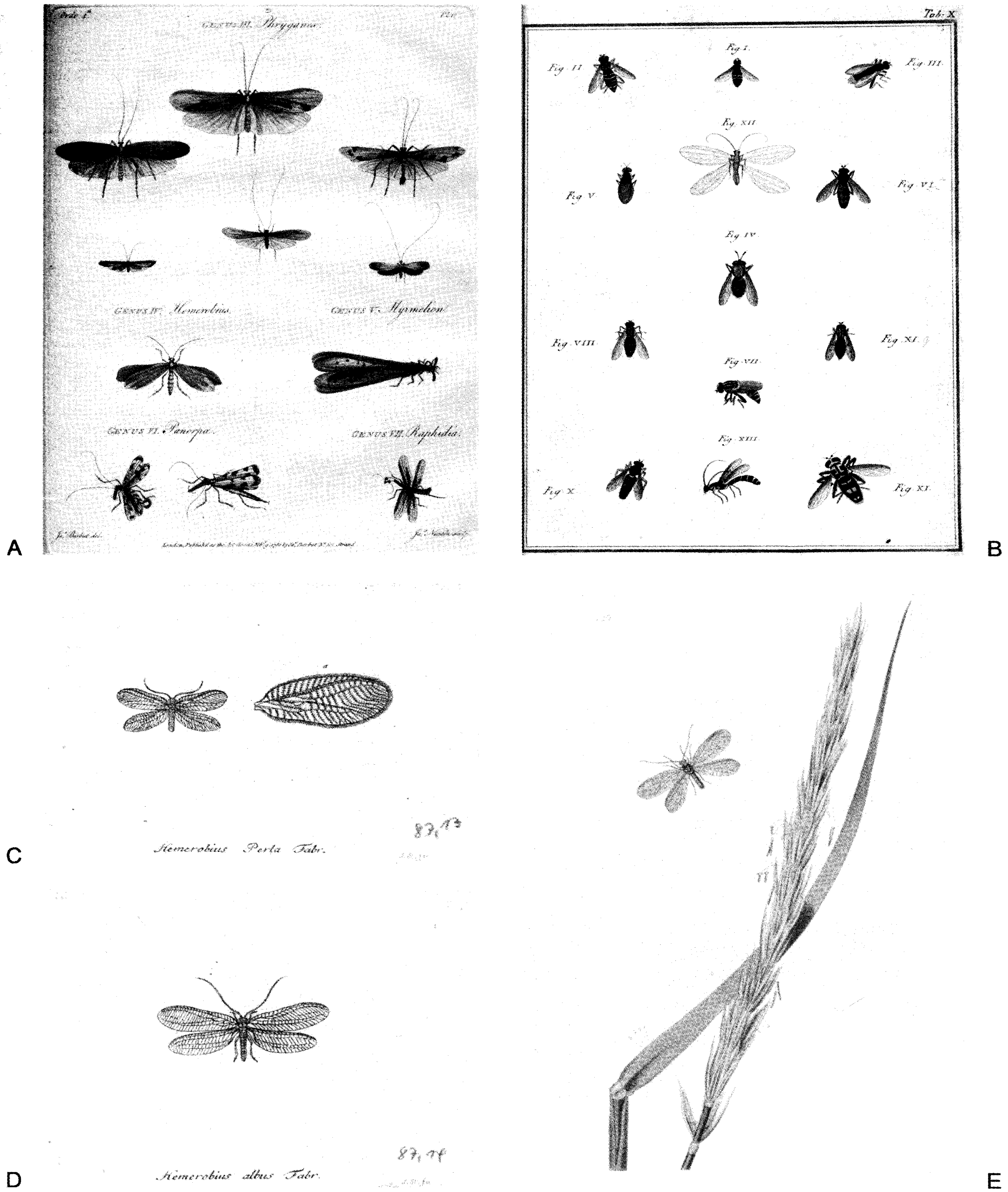


Fig. 10 – **A**, James Barbut (1781): Plate 12, showing a Chrysopid ("Genus *Hemerobius*") (Library H. & U. Aspöck); **B**, Pietro Rossi (1790): Plate 10, exhibiting "*Hemerobius italicus*" (= *Italochrysa italica*) (Library H. & U. Aspöck); **C**, Georg Wolfgang Franz Panzer (1801 - 1805): Heft 87, plate 13, showing a Chrysopid ("*Hemerobius Perla* Fabr.") (Library H. & U. Aspöck); **D**, Georg Wolfgang Franz Panzer (1801 - 1805): Heft 87, plate 14, showing another Chrysopid ("*Hemerobius albus* Fabr.") (Library H. & U. Aspöck); **E**, John Curtis (1834): Plate 520, showing an adult of *Chrysopa abbreviata* and morphological details (Library H. & U. Aspöck).

The engravings are very beautiful and of high artistic quality as are all drawings and paintings of this highly gifted woman.

The unsurpassed monument among the entomological books of the first part of the 18th century is the opus magnum "Mémoires pour servir à l'histoire des Insectes" by the French entomologist R. A. F. Réaumur (1683-1757). The work was published in a great edition in Paris from 1734 to 1742. A second edition in a smaller size, but otherwise identical and with folded plates, was published in Amsterdam in the years 1737-1748. The third volume contains several chapters dealing with Neuroptera; two of the several plates are devoted to Chrysopidae (Figs. 4 A, B). They show the stalked eggs on leaves, the larvae, the cocoon, adults, and morphological details. A huge amount of basic information on the biology and morphology is contained in these plates, the identification of a species is, however, impossible, the drawings of the wing venation are absolutely wrong.

The next pre-Linnaean author of illustrations of Chrysopidae is the French Swiss Charles Bonnet (1720-1797). In 1745 he published his famous "Traité d'insectologie ...". This book was translated by Johann August Ephraim Goeze (1731-1793) into German and was supplemented by his comments (1773). Fig. 3 D shows the plate with Bonnet's illustrations of Chrysopidae. Bonnet's book is a milestone in the biology of insects and his observations merit admiration. The drawings of the Chrysopidae are, however, poor and in many respects entirely wrong.

One of the greatest illustrators of insects was the German August Johann Rösel von Rosenhof (1705-1759). His "Insecten-Belustigung" is one of the greatest treasures of the entomological literature. In the third part (volume), which was published in 1755, there is a chapter on "Land-Libellen" (= terrestrial dragonflies) dealing with two green lacewings and a plate with two illustrations of green lacewings (Fig. 4 C). The general appearance of one of these (Rösel's Fig. 4) is beautiful and reminds one of a *Nineta* species, the wing venation, however, is entirely wrong and it is impossible to identify the species.

Albert Seba (1665-1736), a Dutch pharmacist and keen collector of all kinds of natural history specimens, particularly animals, is the author of a huge book with about 450 plates (1734-1765). In the 4th volume, published in 1765, and devoted to insects, on table XCVI, in the first row, is a peculiar green insect with four wings; this could be a Chrysopid.

Illustrations of Chrysopidae between 1758 and 1800

Linnaeus, in the 10th edition of his "Systema naturae", described *Hemerobius perla* – today *Chrysopa perla* –, but gave no illustrations. The first illustration of a Chrysopid after 1758 is that by the Italian and Austrian entomologist Giovanni Antonio (Johann Anton) Scopoli (1723-1788) in his "Entomologia Carniolica ..." (1763). Scopoli described three species of Chrysopidae, one of them for the first time – *Hemerobius flavus* (No. 707 in Scopoli's table). It is generally agreed that Scopoli's species is the species which we nowadays understand to be *Nineta flava*, but in reality the description and the drawing could apply to any other *Nineta*. At any rate, the drawings of *Hemerobius flavus* as well as those of the other two described and figured species (*Hemerobius chrysops*, *Hemerobius perla*) (Fig. 4 D) do not allow a decision on what they really are.

In 1764, the first edition of Étienne Louis Geoffroy's (1747-1810) "Histoire abrégée des insectes ... de Paris ..." appeared; a second edition with identical plates was published in 1799 and 1800. Plate XIII (Fig. 5 A) contains an illustration of the stalked eggs of Chrysopidae, a terrible drawing (moreover, terribly coloured) of an adult. None of the illustrations

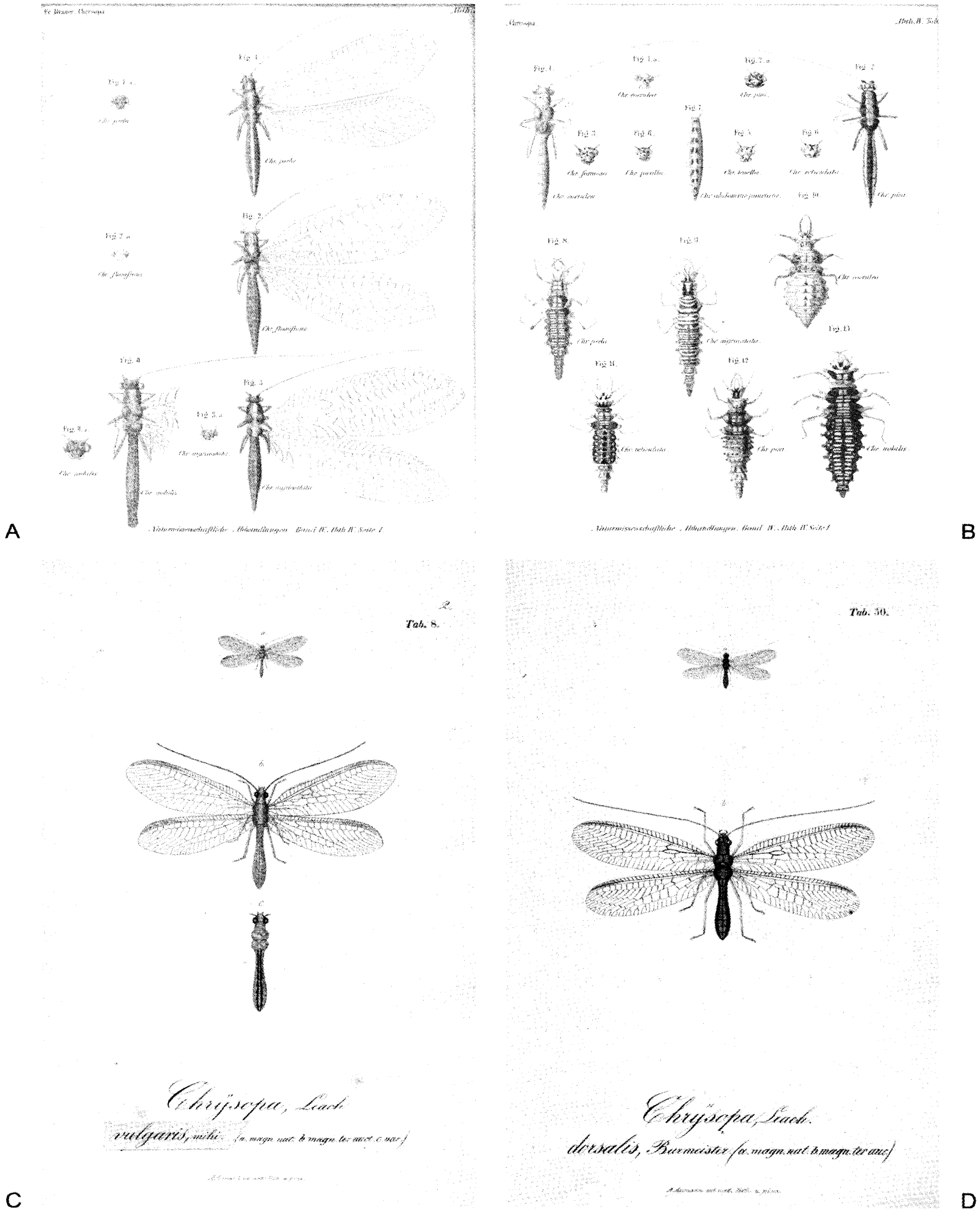


Fig. 11 – **A**, Friedrich Moritz Brauer (1851): Plate I (Library Natural History Museum Vienna); **B**, Friedrich Moritz Brauer (1851): Plate II (Library Natural History Museum Vienna); **C**, Wilhelm Gottlieb Schneider (1843): Plate 8, showing *Chrysopa vulgaris* (= *Chrysoperla carnea*) (Library H. & U. Aspöck); **D**, Wilhelm Gottlieb Schneider (1843): Plate 50, showing *Chrysopa dorsalis* Burm. (Library H. & U. Aspöck).

of Chrysopidae published until 1764 can really be identified on the species level.

In 1764, a peculiar man, Wilhelm Friedrich von Gleichen, named Russworm (1717-1783), a gifted German microscopist with an exciting biography, published two articles on Chrysopidae with beautifully hand-coloured copper engravings. The first ("Der Blattlausfreßer und seine Eier ...") contains a plate with drawings of eggs and larvae of Chrysopidae (Fig. 5 C), which can be identified as *Chrysopa pallens* (Rambur, 1842)[1]. The other publication ("Die Hofdame") is devoted to an adult of a Chrysopid which can today be identified as *Chrysoperla carnea* (Stephens, 1836) (Fig. 5 D). These are the first illustrations of Chrysopidae in the entomological literature which can be identified on the species level (H. Aspöck & U. Aspöck, 2005). Moreover, von Gleichen's illustration of *Chrysoperla carnea* is most probably the largest illustration (20 x 19 cm!) of a Chrysopid ever published. Nevertheless, the wing venation is largely wrong, and the identification of the species is mainly based on the colour and the circumstances of the finding. (The specimen was flying about in a warm room in a castle in Germany in January). Von Gleichen did not name his insects with scientific names according to the binary nomenclature (which became effective in 1758). He always used German names, otherwise he would have become the author of that lacewing which was described as *Chrysopa carnea* by James Francis Stephens 72 years later.

In 1766, Jacob Christian Schaeffer (1718-1790), a German parson and naturalist, published his famous "Elementa entomologica ...". The book contains a plate (LXVIII) devoted to a green lacewing (Fig. 6). The coloured drawings were done nicely, but are largely wrong. Another (augmented) edition of this work appeared in 1780; the first 135 plates where, however, identical with those of the first edition. Another famous book (with 280 plates!) published by Schaeffer in 1766 (-1779) is the "Icones Insectorum circa Ratisbonam indigenorum ...". A second edition with comments, but with the identical plates, was published by Panzer (1804). Two plates (V, Fig. 8, and IX, Fig. 9) show green lacewings. The figures are somewhat better than those in the "Elementa entomologica ...", and the specimens illustrated laterally may be recognized as *Chrysopa perla*, which was – in the case of Tabula IX – also Panzer's interpretation.

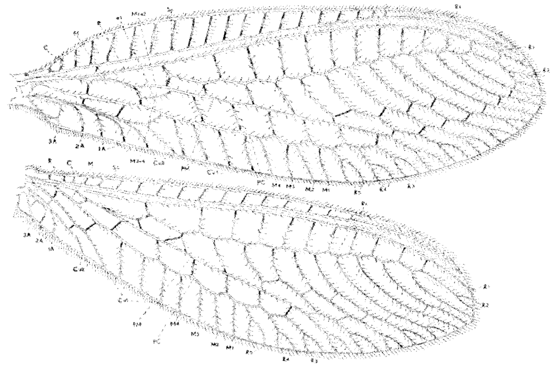


Fig. V.

Chrysopa flavifrons Brauer. – Adulto. — Ali di un maschio: c_1, prima cellula « intramediana »; *PC*, « pseudocubito »; *PM*, « pseudomedia ». (Le altre lettere corrispondono ai simboli normalmente usati per indicare le venature).

Fig. 12 – Maria Matilde Principi (1956): Figure V, showing the wing venation of *Dichochrysa flavifrons* (Brauer).

In 1771 (-1778), a very important book (in 7 volumes) appeared in Stockholm published by the Swedish entomologist Carl De Geer (1720-1778). The title is the same as with Réaumur's 1734 publication, and in many other respects the two works are similar. In the 2nd part of volume 2 there is a chapter, "Des Hémerobes", devoted to Neuroptera. It is supplemented by a beautiful copper plate which contains several illustrations of Chrysopidae and among these a beautifully drawn adult with largely correct wing venation (Fig. 5 B). De Geer's illustration of a Chrysopid, although an uncoloured copper engraving, is certainly the best compared to all others published before. De Geer's work was

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[1] R. Pantaleoni (pers. comm.) is of the opinion that the larva represents a *Chrysoperla* species.

translated and augmented by many very valuable and important comments by Johann August Ephraim Goeze (on the title page of this work spelt as Götze), already mentioned above as the translator of Bonnet. The plates in this edition (De Geer, 1779) are identical with De Geer's original edition.

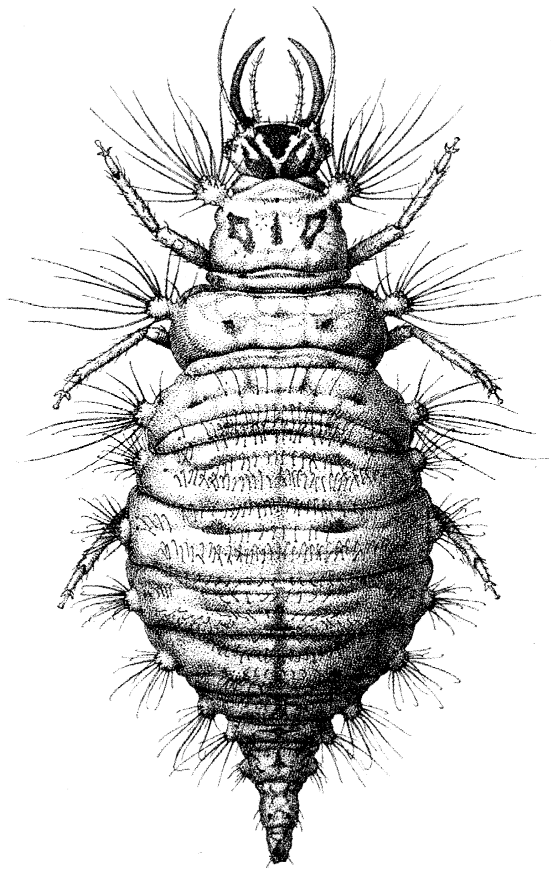

FIG. XVI.

Chrysopa flavifrons Brauer. – Larva matura.

Fig. 13 – Maria Matilde Principi (1956): Figure XVI, showing a larva (third instar) of *Dichochrysa flavifrons* (Brauer).

Less understandable is how Philipp Ludwig Statius Müller (1725-1776), a German, could publish a similarly awful illustration of a Chrysopid like that of Geoffroy (1764) in his "... vollständiges Natursystem ... " (1775) (Fig. 7).

A very poor illustration is also that in "Genera Insectorum" by the English author James Barbut (no biographic data available). The book appeared in 1781 (Fig. 10 A), 10 years after the outstanding work of De Geer.

One of the particularly important and famous entomological works of the last decade of the 18th century is the "Fauna Etrusca ..." (1790) by the Italian entomologist (according to Letardi, 1998 the first university professor of entomology in the world) Pietro Rossi (1738?-1804). Rossi described and figured *Hemerobius italicus* – today *Italochrysa italica* (Rossi, 1790) – but his illustration is extremely poor and in many respects wrong (Fig. 10 B). A second edition with the same illustrations appeared in Germany in 1795.

In 1792, Vincenzo Petagna (1734-1825?) published his "Institutiones Entomologicae". On table 10 is an engraving of a Chrysopid; Petagna calls it "Hemerobius Perla", but an identification is not possible.

The illustrations of Chrysopidae in the "Tableau encyclopedique ..." published by the French Guillaume Antoine Olivier (1756-1814) in 1797 were apparently copied from Rösel von Rosenhof (1755) and Rossi (1790).

Georg Wolfgang Franz Panzer (1755-1829), a German physician and naturalist, is the author of a large-scale work on the insects of Germany ("Faunae Insectorum Germanicae initia ...") published between 1793 and 1813 in 109 Heften, with more than 2500 small coloured copper engravings. Heft 87, published between 1801 and 1805, contains plates of two Chrysopidae, both are rather poor (Figs. 10 C, D).

First correct illustrations of Chrysopidae

At the beginning of the 19th century numerous illustrations of Chrysopidae existed, but none was correct. By far the best were still those of De Geer (1771).

In 1824, John Curtis (1791-1862) began with the publication of his "British Entomology ...", an outstanding work and a pleasure for the eyes even today. His figure of *Chrysopa abbreviata* (which he described as no. 520 in 1834) was the best illustration of a green lacewing published up to that time. It was meticulously drawn, and the wing venation is largely correct (Fig. 10 E).

This was the beginning of a new era in the illustration of Chrysopidae, which had its first culminations in the young Friedrich Moritz Brauer's (1832-1904) revision of the Chrysopidae of Austria (1851) (Figs 11 A, B) and the "Symbolae ad monographiam generis Chrysopae" (1851) by the German entomologist Wilhelm Gottlieb Schneider (1814-1889) (Figs 11 C, D). Since that time many excellent illustrations of Chrysopidae have appeared, but none has surpassed, not even reached, the drawings made by Maria Matilde Principi, whose 90th birthday we celebrated in 2005. Figures 12 and 13 (from Principi, 1956) are impressive examples for her many wonderful illustrations, which will remain milestones for ever.

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Grateful thanks to Wolfgang Brunnbauer (Librarian at the Natural History Museum Vienna) and Mag. Dominique Zimmermann for helpful search for illustrations of Chrysopidae in old and rare books, to Prof. Rinaldo Nicoli Aldini (Università Cattolica del Sacro Cuore, Piacenza) for valuable information on A. Vallisnieri's publications, to Prof. Roberto Pantaleoni for important critical comments and suggestions, to Mag. Franziska Anderle for technical assistance with the manuscript, and to Dr. John Plant for linguistic improvement.

The important bibliographies of Hagen (1862-1863), Bodenheimer (1928-1929), and Nissen (1969) were an indispensable source of bibliographic and biographic information. These authors – often consulted, but seldom cited – merit deepest admiration and gratitude for their long enduring and wonderful works.

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Larva of *Brucheiser penai* Riek, 1975 (Neuroptera Coniopterygidae)

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Description of the larva of a *Brucheiser* species is given on the first time. Morphological investigation of three larval specimens of *B. penai* Riek, 1975 confirmed the systematic position of Brucheiserinae within the family Coniopterygidae.

Key words – Coniopterygidae, Brucheiserinae, *Brucheiser penai*, larva, morphology.

Introduction

Navás (1927) described a rather unusual insect, *Brucheiser argentinus* on the basis of a single male specimen collected in Argentina. He placed this insect in the new family Brucheiseridae, and, because of the shape of the tarsi and wings, in the order Megaloptera. In the original description of the new genus *Brucheiser* Navás, 1927 the presence of lateral lobes on the fourth tarsal segment were mentioned and figured, a character which is typical in the Sialidae (Megaloptera).

Riek (1975) described a second *Brucheiser* species (*B. penai*) from Chile. After evaluating 18 characters, he concluded that Brucheiseridae was not a megalopterous family but belonged in the Neuroptera. This was based on head and prothoracic structures.

New (1989) lessened the taxonomic rank of this group to subfamily level, placed it within the family Coniopterygidae, and Meinander (1990) accepted his opinion. New did not give a detailed explanation of this alteration, but in his key for the Neuroptera families the low number of the basal costal crossveins is the common feature of *Brucheiser* and the (other) coniopterygids.

Sziráki (1996) examined a female specimen of *Brucheiser argentinus*, and confirmed that *Brucheiser* is a coniopterygid genus; typical "plicatures" were found on the abdomen, structures which were earlier known only in the subfamily Aleuropteryginae (Neuroptera Coniopterygidae). In addition, the structure of the sclerotized parts of the female internal genitalia agree with that of Aleuropteryginae.

Materials and methods

In the Neuroptera collection of the Smithsonian Institution, Washington three larval specimens of *Brucheiser penai* are housed, which were determined by Oliver Flint in 1980, and are preserved in alcohol. These larvae were collected on 30th of September 1980 by Luis E Peña G. in Chile at Cuesta de Pajonales, on the border between the Provinces of Huasco and Elqui, at about 75 km south of Vallenar. The site is in the Atacama Desert at 1400 m above the sea level. The type locality of *B. penai* is N. Cta. Pajonales, essentially the same site. Peña wrote Flint (letters of November 14, 1980, January 6, and March 1, 1981, Smithsonian Archives) that he found females of *Brucheiser* under the same stone that he found the larvae. He took 12 adults at this time in addition to these three larvae.

No other coniopterygid species is known

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from the collection area.

The larvae were examined in glycerol by stereo microscope at magnifications 80x and 120x, and for some details by light microscope at magnification 300x.

Results

The general appearance of the examined larvae is fusiform and slightly swollen (Fig. 1). Color of the thorax and abdomen (of the specimens preserved in alcohol) reddish-brown with greyish tint. Head and legs medium brown. Length of the body 3.2-4.2 mm.

Head capsule well sclerotized. Number of ommatidia: 5. Width of the head 0.5-0.6 mm. Length of the antennae 0.5-0.6 mm, of labial palpi 0.5 mm. Antenna is covered by ordinary hairs of different length and armed with an enlarged, straight seta near to the midlength. As regards the mouth parts, only the extreme tip of the jaws reach beyond the labrum – apart from its membraneous projection (Figs 3-4).

Legs rather long, and the first pair slightly longer than the others. First femur 0.8 mm, first tarsus 1.1-1.2 mm. Empodium between the tarsal claws short, funnel shaped (Fig. 2).

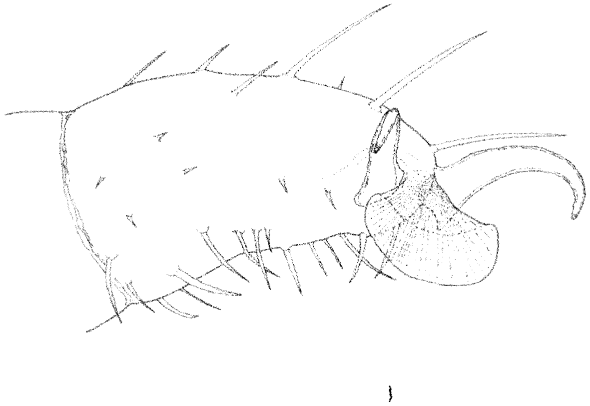

Fig. 2 – Larva of *Brucheiser:* Tarsus, latero-apical view.

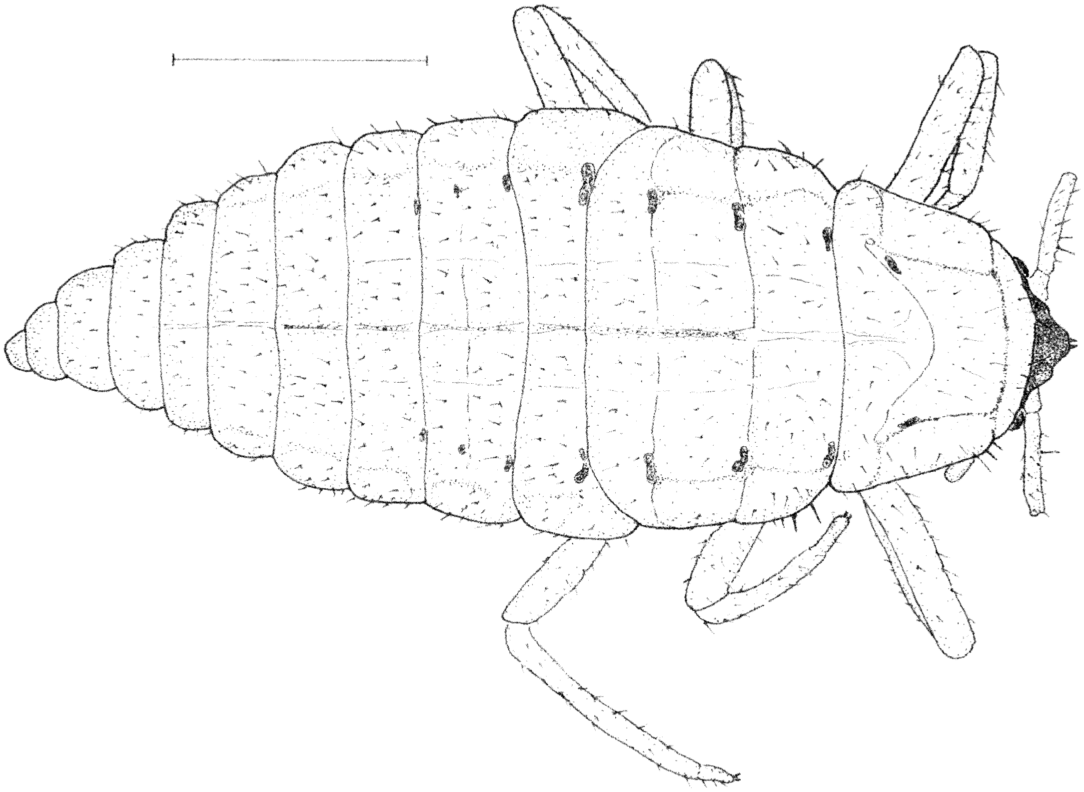

Fig. 1 – Larva of *Brucheiser penai*: Habitus. Scale: 1 mm.

Discussion

Structure of mouth parts and antennae, as well as the general appearance of the three neuropterous larvae are typical coniopterygid. The adults of the *Brucheiser* species are distinctly larger than the other coniopterygids. Because of some features of imagoes the genus *Brucheiser* was recently suspected of being a coniopterygid taxon (New 1989, Meinander 1990, Sziráki 1996). As the studied larval specimens (which were captured together with some adults of *Brucheiser penai*) are larger than the other known coniopterygid larvae, but they are clearly a kind of coniopterygid larvae, it seems to be sure that the insects at hand really belong to the above mentioned genus, and with high probability to the species *Brucheiser penai* as no other species of this genus is known from the Atacama Desert. Besides, no other Coniopterygidae are known from the given collecting locality, which is the locus

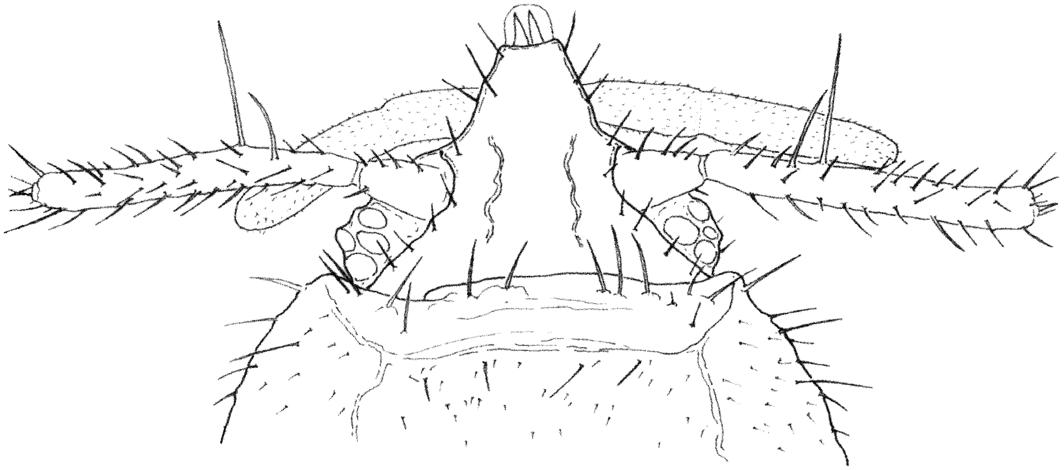

Fig. 3 – Larva of *Brucheiser penai*: Head, dorsal view.

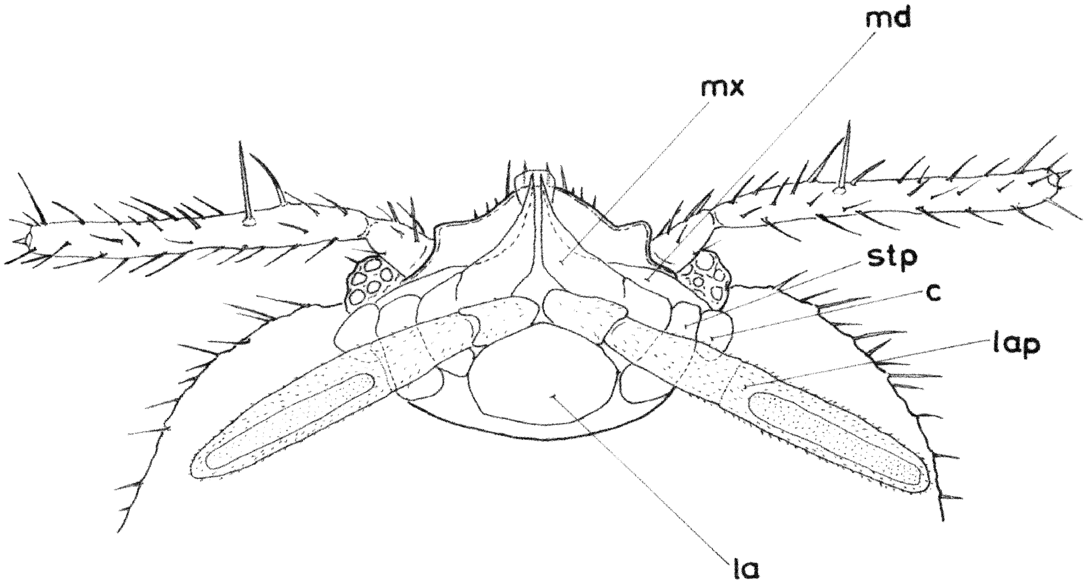

Fig. 4 – Larva of *Brucheiser penai*: Head, proximo-ventral view; c = cardo, la = labium, lap = labial palpus, md = mandibula, mx = maxilla, st = stipes.

typicus of *B. penai*. Our investigations confirm the systematic position of the subfamily Brucheiserinae within the family Coniopterygidae.

Set of the morphological characters of the larva of *B. penai* differs from either the typical Aleuropteryginae or Coniopteryginae larvae. The jaws of *Brucheiser* larvae are as short as in Coniopteryginae and in *Helicoconis* (Aleuropteryginae). Their labial palpi are long and slender as in *Aleuropteryx*, and their legs are long as in some Coniopteryginae.

Meinander (1972) stated that the empodium of the coniopterygid larvae is padlike, but in *B. penai* it is funnel shaped. The significance of this difference is uncertain, as this organ has not been discussed in such important publications as the paper of Meinander (1974) and Greve (1974), therefore our knowledge of this organ is insufficient for generalizations.

Regarding the comparative sizes of the studied larvae and of the adults of *B. penai* it is possible that our investigations were carried out on not fully developed specimens.

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New species of Brazilian Green Lacewings genus *Leucochrysa* McLachlan, 1868 (Neuroptera Chrysopidae)

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The Neotropical region has a very rich biodiversity on neuropteran insects, the Chrysopidae family being well represented by several genera and species. This study reports three new species of *Leucochrysa,* the largest genus in the familiy. *Leucochrysa* (*Nodita*) *anae* Freitas, *L.* (*Nodita*) *cidae* Freitas, *L.* (*Nodita*) *urucumis* Freitas were found in diverse Brazilian ecosystems.

Key words – Chrysopid taxonomy, biological control, *Bixa orellana,* Urucum, Bahia State, Brazil.

Introduction

Leucochrysa was described by McLachlan (1868). Later, those specimens which had a quadrangular intramedian cell were placed in *Allochrysa* by Banks (1903); however, Navás (1917) synonymized *Allochrysa* with *Leucochrysa* and placed those specimens with a triangular intramedian cell into the genus *Nodita*. Brooks & Barnard (1990) recognized the subgenus *Nodita* and *Leucochrysa* as parts of *Leucochrysa* genus based on their wing venation, the first one with triangular intramedian cell and the other quadrangular. *Leucochrysa* is represented in the Nearctic and Neotropical regions by 160 described species (Brooks & Barnard, 1990), Freitas & Penny (2001) added 23 new Brazilian species.

Leucochrysa green lacewings are small to large; the ground color is green; head, thorax and abdomen often marked with red-brown spots; male genitalia: tignum, gonapsis, median plate, entoprocessus and parameres absent; gonocornua present, arcessus large with a horn on the apex; pseudopenis absent. The stalked eggs are a characteristic of green lacewings. Larvae gibbous body heavily covered by long setae (as the trash carriers aspect larvae). A good description of the shape and the body morphology can be found in Mantoanelli *et al.* (2006). They described the larval morphology of *Leucochrysa* (*Leucochrysa*) *varia*. The *Leucochrysa* genus includes the subgenus *Leucochrysa* and *Nodita*. The male and female genitalia, wing venation share significant characteristics like as (i) black spots in the pterostigma (ii) gonarcus broad, transverse, gonocornua sometimes plate shaped, but always acute apex (iii) arcessus broad, large lateral lobes, dorsal crest sometimes apical forked, ventral hook hardly sclerotized. Therefore, they exhibit a great body color intraspecific variation like the spots dorsally distributed on the thorax and abdomen.

Important studies of Brazilian chrysopids were made by Adams & Penny (1987), which covered Chrysopini species; however, Leucochrysini were not discussed. The subgenus *Leucochrysa* (*Nodita*) contains about 183 described species and remains taxonomically as the most pro-

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blematic group (Freitas & Penny, 2001). This is a weakly known group as part of the Neotropical fauna. Frequently species such as *L.* (*N.) camposi* or *L.* (*N.) cruentata* are collected in citrus orchards. It seems that arboreal agroecosystems are their favourite habitat. As there is little information about the *Leucochrysa* fauna, we have carried out studies in many different ecosystems in order to know the Brazilian species. This paper is a new contribution for the increasing of the knowledge of the Brazilian *Leucochrysa* species. Three new species are described and the drawings of genital traits are provided.

Materials and methods

For this study 69 adults were collected in Urucum (*Bixa orellana* L., (1753)) (lipstick tree) crops from Vitoria da Conquista, Bahia State, Brazil (14° 53' S, 40° 48' W, alt. 915 m).

The material was collected using mango juice baited McPhail traps. The specimens were dried and pinned. To study the wings, they were detached from the body and mounted on microscope slides. Abdomens were macerated in warm 10% KOH, stained with Black Chlorazol. After the study, wings were glued to a small card on the pin below the specimen and the abdomens were placed in small vials of glycerin below each specimen. Drawings were made using dissecting and compound microscopes with camera lucida attachments. Inked drawings were then scanned, using Adobe Photoshop, and arranged into composite plates.

Types of designated new species will be deposited in the Museu de Zoologia/USP, São Paulo, SP, Brazil. Other examined material is deposited in the Sérgio de Freitas Collection (CSF), Departamento de Fitossanidade, Universidade Estadual Paulista, Jaboticabal, São Paulo.

The terminology used comes from Brooks & Barnard (1990).

Systematic treatment

Leucochrysa (*Nodita*) *anae* Freitas, **new species**

Diagnosis – This species has as distinctive characters the slender and curved gonocornua and the sclerotized ventral plate near the gonossacus. This characteristic is not found in other species. The spherical dark dorsal spots on the thorax are shared with the *L.* (*N.*) *ictericus* (Freitas & Penny 2001) and *L.* (*N.*) *parallela* (Freitas & Penny 2001), therefore their genital traits have significant differences.

Type – Male Holotype, deposited at Museu de Zoolgia/USP, São Paulo, Brazil, labeled "BRA-BA-Vitoria da Conquista, 11-12-03, A.E.L. Ribeiro".

This species is dedicated to Ana Elizabete Lopes Ribeiro who enthusiastically collected the specimens and did the local faunistic study on chrysopids.

Head – Yellow, frons and clipeus unmarked (Fig. 1A, B); gena lightly brown; vertex with dark stripes converging anteromedially between the antennae (Fig. 1A); antennal fossa dorsally dark. Maxillary and labial palpi pale. Scapes pale with diffuse reddish brown spots laterally and medially; pedicel pale; flagellum black (Fig. 1A).

Thorax – Pronotum yellow with red-brown stripes extended from the anterior to posterior margins (Fig. 1B); mesoprescutum pale with red marks in the antero-lateral margin; mesoscutum pale with dark red circular spot medially (Fig. 1A). Forewings: venation green except the costal and radial crossveins which are black in the middle part; inner and outer gradates black (Fig. 1C). Hind margin black. Length (1,73 cm): width (0,63 cm), ratio 2,75. Hindwing venation green except inner and outer gradates black; hind margin black. Length (1,53 cm): width (0,53 cm), ratio 2,8.

Abdomen – Pale green. Male genitalia: gonarcus thin, lateral arms small (Fig. 1D); conical gonocornua inside curved; arcessus long with a well developed median apical horn, flanked by rounded lobes (Fig. 1E); gonossacus anteriorly sclerotized (Fig. 1F), with long setae. Female genitalia: spermatheca short, ventral impression small (Fig. 1H); subgenitalia with posterior-lateral lobes and without anterior-medial projection (Fig.1I).

Other material examined – Brazil: Bahia: Vitoria da Conquista, 09 dezembro 2003, A.E.L. Ribeiro (11♂ 16♀ Paratypes) (CSF); 10 dezembro 2003 (9♂ 10♀ Paratypes) (CSF); 11 dezembro 2003 (8♂ 2♀ Paratypes) (CSF); 13 dezembro 2003 (2♂ Paratypes) (CSF); 06 janeiro 2004 (2♂ 1♀ Paratypes) (CSF).

Leucochrysa (*Nodita*) *cidae* Freitas, **new species**

Diagnosis – The distinctive characters of this species are a very broad gonarcus, median long plate on the arcessus with a dorsal forked process. Gonocornua plate shaped is a character shared by few other species, but the median dorsal forked process on the arcessus is very distinctive.

Type – Male Holotype, deposited at Museu de Zoolgia/USP, São Paulo, Brazil, labeled "BRA-BA-Vitoria da Conquista, 09-12-03, A.E.L. Ribeiro".

This species is dedicated to Maria Aparecida Castellani Boaretto who played an important part in knowing the species of green lacewings in Vitoria da Conquista, Bahia.

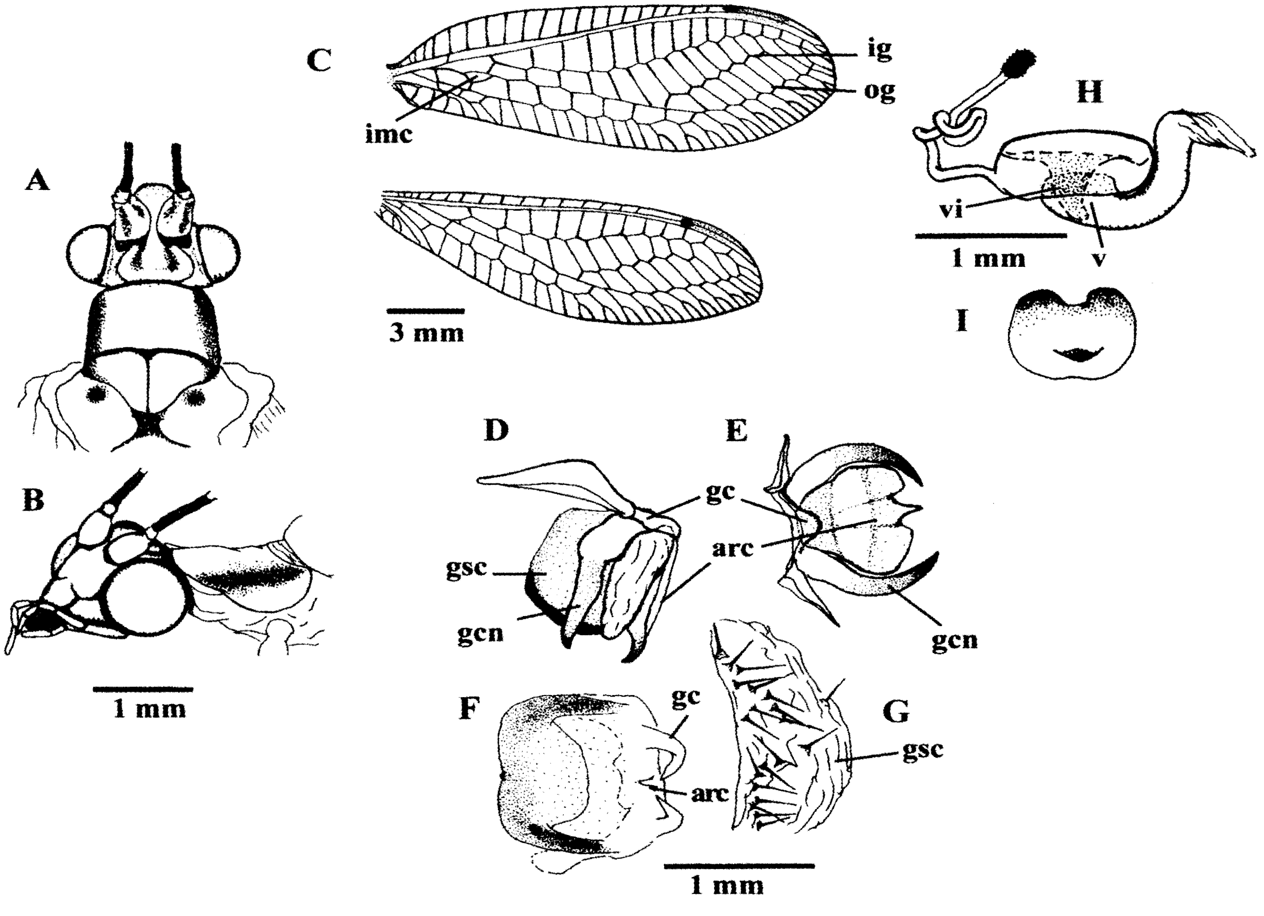

Fig. 1 – *Leucochrysa* (*Nodita*) *anae*, **new species**: **A**, Head and thorax in dorsal view; **B**, Head and thorax in lateral view; **C**, Wings; **D**, Male genitalia in lateral view; **E**, Male genitalia in dorsal view; **F**, Male genitalia in frontal view; **G**, Male genitalia: gonossacus; **H**, Spermatheca; **I**, Subgenitalia. imc = intramedian cell; ig = inner gradates veins; og = outer gradates veins; v = vela; vi = ventral impression; gsc = gonossacus; gc = gonarcus; arc = arcessus; gcn = gonocornua.

Head – Yellow, frons and clipeus unmarked; gena brown; vertex with dark stripes converging antero-medially between the antennae (Fig. 2A); maxillary and labial palpi pale. Scapes pale with lateral dark red stripes; pedicel pale with dark red spot; flagellum black.

Thorax – Pronotum yellow with red- brown stripes extended from the anterior to posterior margins (Fig. 2A); mesoprescutum pale with red dark median spots; mesoscutum pale with dark red elliptical spot medially. Forewings: venation green except the costal and radial crossveins which are black in the middle part; inner and outer gradates black (Fig. 2B). Hind margin black. Length (1,75 cm): width (0,58 cm), ratio 3,01. Hindwing venation green except inner and outer gradates black; hind margin black. Length (1,45 cm): width (0,48 cm), ratio 3,02.

Abdomen – Pale green. Male genitalia: gonarcus wide, lateral arms large (Fig 2C); flattened gonocornua apically horked (Fig. 2D); arcessus long with a well developed median apical horn, flanked by rounded lobes (Fig. 2E); median forked plate arise in the middle part of the arcessus (Fig. 2D, 2F); gonossacus with long setae (Fig. 2E). Female genitalia: spermatheca short, ventral impression small (Fig. 2G); subgenitalia with posterior-lateral lobes and a large anterior-medial projection (Fig. 2H).

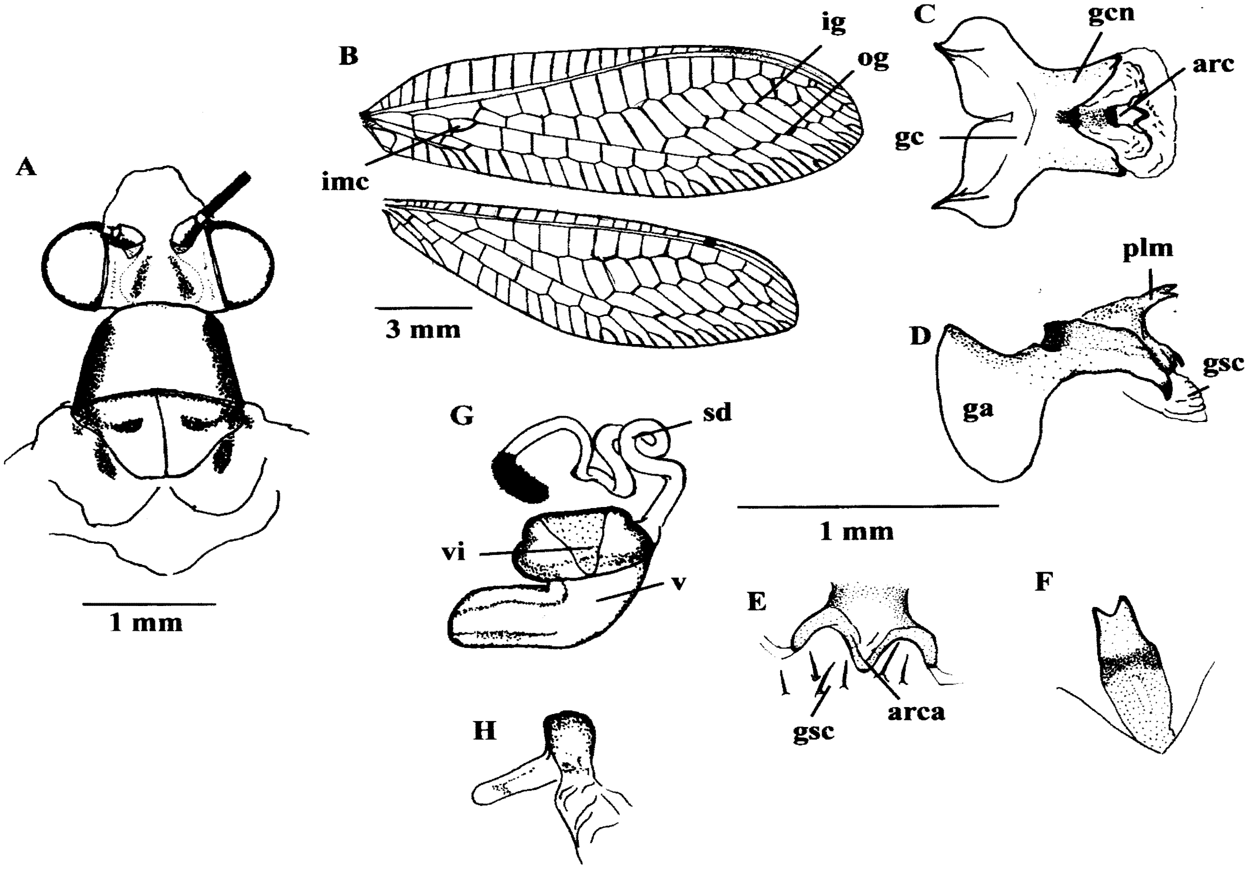

Fig. 2 – *Leucochrysa* (*Nodita*) *cidae*, **new species**: **A**, Head and thorax in dorsal view; **B**, Wings; **C**, Male genitalia in dorsal view; **D**, Male genitalia in lateral view; **E**, Arcessus apex and gonosetae; **F**, median plate of arcessus; **G**, Spermatheca; **H**, Subgenitalia. imc = intramedian cell; ig = inner gradates veins; og = outer gradates veins; v = vela; vi = ventral impression; sd = spermathecal duct; gsc = gonossacus; gc = gonarcus; arc = arcessus; gcn = gonocornua; plm = median plate of arcessus; arca = arcessus apex; ga = gonarcus arm.

Other material examined – Brazil: Bahia: Vitoria da Conquista, 09 dezembro 2003, A.E.L. Ribeiro (6♂ 10♀ Paratypes) (CSF); 10 dezembro 2003 (1♀ Paratypes) (CSF); 11 dezembro 2003 (1♂ 2♀ Paratypes) (CSF); 13 dezembro 2003 (1♂ Paratypes) (CSF); 20 Dezembro 2003 (1♂ Paratypes) (CSF).

Leucochrysa (*Nodita*) *urucumis* Freitas, **new species**

Diagnosis – The distinctive characters of this species are a median long plate on the arcessus. This crest is not shared with other *Leucochrysa*.

Type – Male Holotype, deposited at Museu de Zoolgia/USP, São Paulo, Brazil, labeled "BRA-BA-Vitoria da Conquista, 11-12-03, A.E.L. Ribeiro".

This name "urucumis" comes from the crop "urucum" in which the studied population was collected.

Head – Yellow, frons and clipeus unmarked; gena dark brown; vertex with dark brown stripes converging anteromedially between the antennae (Fig. 3A); maxillary and labial palpi pale. Scapes pale dorsally and laterally dark red spotted; pedicel pale with a dark red spot ring; flagellum black.

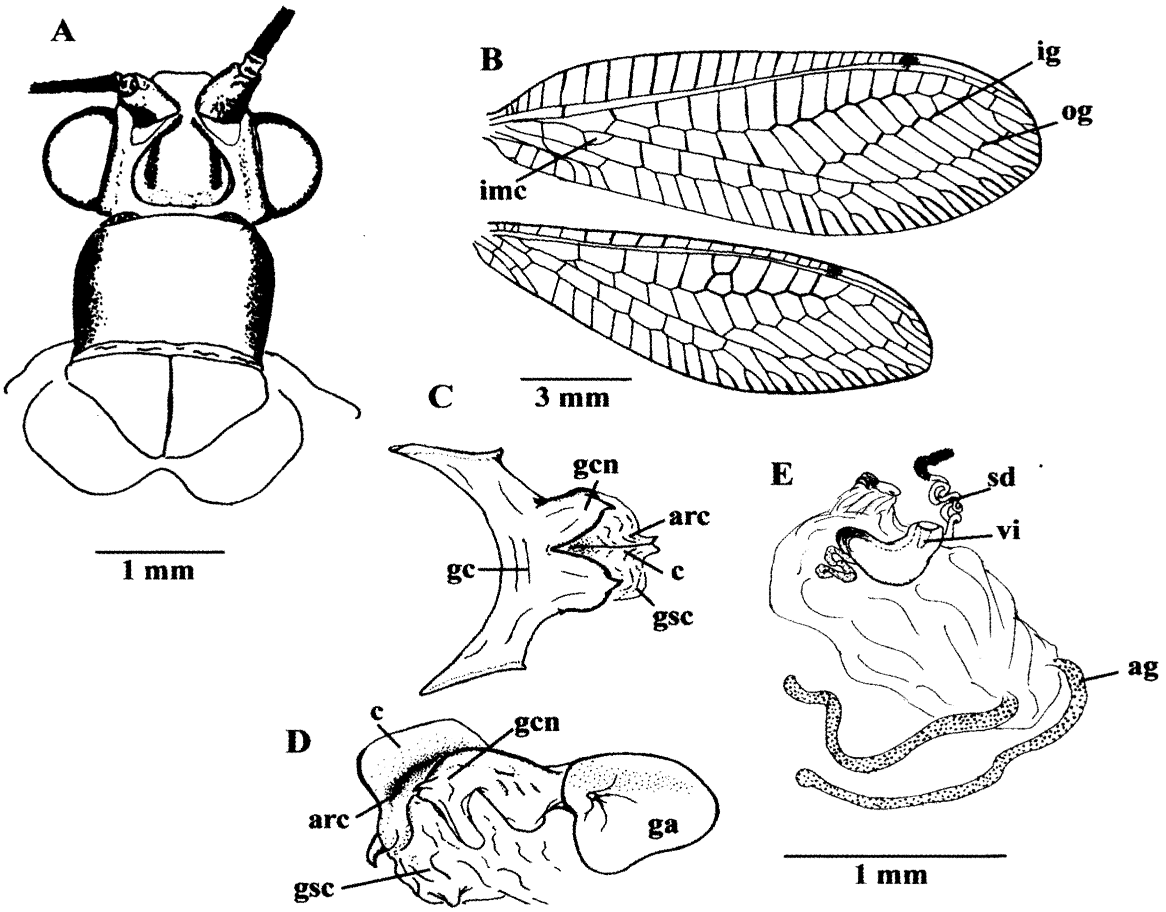

Fig. 3 – *Leucochrysa* (*Nodita*) *urucumis*, **new species**: **A**, Head and thorax in dorsal view; **B**, Wings; **C**, Male genitalia in dorsal view; **D**, Male genitalia in lateral view; **E**, Female genitalia. imc = intramedian cell; ig = inner gradates veins; og = outer gradates veins; vi = ventral impression; sd = spermathecal duct; ag = accessory gland; gsc = gonossacus; gc = gonarcus; arc = arcessus; gcn = gonocornua; ga = gonarcus arm.

Thorax – Pronotum yellow with red-brown stripes extended from the anterior to posterior margins; mesonotum without marks or spots (Fig. 3A). Forewings (Fig. 3B): venation green except the costal and radial crossveins which are black in the middle part; radial sector apex black; inner (7) and outer (9) gradates black. Length (1,58 cm): width (0,57 cm), ratio 2,77. Hindwing venation green except inner (5) and outer (7) gradates green; radial sector apex black; hind margin black. Length (1,33 cm): width (0,45 cm), ratio 2,95.

Abdomen – Pale green. Male genitalia: gonarcus wide, lateral arms large (Fig. 3C); flattened gonocornua apically horked; arcessus long with a well developed ventro-median horn, flanked by rounded lobes; dorsally with a well developed crest (Fig. 3D). Female genitalia: spermatheca short, ventral impression small, bursa convoluted and two thick accessory glands (Fig. 3E).

Other material examined – Brazil: Bahia: Vitoria da Conquista, 09 dezembro 2003, A.E.L. Ribeiro (2♂ 2♀ Paratypes) (CSF); 10 dezembro 2003 (2♀ Paratypes) (CSF); 11 dezembro 2003 (4♂ 5♀ Paratypes) (CSF).

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This project could not have been accomplished without the extensive help provided by the collecting efforts of Ana Elizabete Lopes Ribeiro and the enthusiastic entomologist Maria Aparecida Castellani Boaretto, from the Universidade Estadual do Sudoeste da Bahia.

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Morphology of the female terminalia of *Nymphes myrmeleonoides* Leach, 1814 (Neuroptera Nymphidae) and phylogenetic implications

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The female terminal structures of *Nymphes myrmeleonoides* Leach, 1814 (Nymphidae) are described in detail. Within Neuroptera the genitalia of Nymphidae are considered to be highly derived. However, all elements of the "orthopteroid" ovipositor are obviously present in *N. myrmeleonoides*. The ovipositor is short and is composed basically of the gonocoxites IX (+ valvulae III). A pair of sclerites (valvulae II) is present along the inner membranous sides. This pair of sclerites interlocks with a structure often called "subgenitale" (fused valvulae I). Similar structures exist in Chrysopidae and the arrangement may even be homologous with the olistheter of Raphidioptera. The valvulae I and II are missing in some other Neuroptera (e.g. Osmylidae). The interpretation of the subgenitale and the corresponding sclerites of *Nymphes* (and chrysopids) as ovipositor derivates sheds new light on the evolution of the ovipositor in Neuroptera and provides new views of their phylogeny.

Key words – Neuroptera, Nymphidae, *Nymphes myrmeleonoides*, ovipositor, morphology, phylogeny.

Introduction

Nymphidae is a small taxon consisting of approximately 35 extant species restricted to Australia, New Guinea and adjacent islands. It is considered to be the sister-group of Myrmeleontidae + Ascalaphidae + Nemopteridae (New, 1984; Oswald, 1998) or of Myrmeleontidae + Ascalaphidae (Mansell, 1992; Aspöck *et al.*, 2001) within the Myrmeleontiformia (Myrmeleontoidea *sensu* Mansell, 1992), one of the more species rich subtaxa within Neuroptera.

Contradictory interpretations of the neuropteran ovipositor structures exist in the literature and much controversy surrounds the homology of female genitalia. Morphological investigations of the ovipositor have been carried out predominantly for taxonomic reasons. Detailed morphological examinations exist only for a few neuropteran taxa. The first examination of the internal and external genitalia of Neuropterida was performed by Stitz (1909). Principi (1949) and Philippe (1972) described the morphology of the female genitalia of *Chrysopa*, that is characterized by a very short ovipositor. Investigations of taxa with a long ovipositor similar to that of the Raphidioptera are restricted to the external morphology. Ferris (1940) examined the ovipositor of *Plega signata* (Hagen, 1877) (Mantispidae) and Tjeder (1937) that of Dilaridae.

The overall similarity of the female genital structures of Neuroptera, Megaloptera and Raphidioptera was demonstrated by Mickoleit (1973a). He hypothesized a short ovipositor for the ground plan of Neuropterida and complete loss of the gonapophyses IX (valvulae II). The gonapophyses VIII (valvulae I) are assumed to have been lost in the ground plan of Neuroptera as well as that of Megaloptera. Alternatively, Mickoleit (1973a) discussed a long raphidiopteran-like ovipositor with valvulae I and valvulae II for the ground plan of Neuropterida. Although Mickoleit abandoned this theory for functional reasons, Achtelig (1978) supported the hypotheses after further investigations of Raphidioptera.

The short ovipositor of Nymphidae and other Myrmeleontiformia was assumed to be highly derived and for this reason considered to be less important for the understanding of the ground pattern of female genitalia in Neuroptera. However, examination of *Nymphes myrmeleonoides* Leach, 1814 (Nymphidae) showed that obviously all elements of an "orthopteroid" ovipositor are present and that it is not as derived as previously assumed.

Material and methods

The ovipositor morphology of *N. myrmeleonoides* was examined based on alcohol fixed material (70%) and macerated specimens that were studied in glycerine. Histological sections of *N. myrmeleonoides* and *Chrysoperla carnea* (Stephens, 1836) were made. For this purpose specimens were fixed in Bouin's solution, sectioned serially at 10µm and stained with "Nuclear Fast Red" and "Aniline Blue-Orange G" (Azan stain).

Females of *N. myrmeleonoides* were collected at Rocksberg near Brisbane (Queensland, Australia) in October 1997 by Ulrike Nolte. Specimens of *C. carnea* were collected at Göttingen (Germany) in February 2004 by Verena Feuerstein.

Results and discussion

The female external genitalia of *N. myrmeleonoides* (Figs 1 A and 1 B) consist primarily of a pair of so-called "gonapophyses laterales", a structure of segment IX present in all Neuropterida. It is interpreted as the gonocoxites IX + gonostyli IX (valvulae III) (Mickoleit, 1973a; Achtelig, 1978). In *N. myrmeleonoides* the gonocoxites IX + valvulae III are relatively short and joined to the sternum along almost the entire length. A pair of sclerites is present along the inner membranous sides of gonocoxites IX. This pair of sclerites interlocks with an unpaired sclerotized projection of the segment VIII, the so-called "subgenitale" (Figs 1 C and 2 A) - a structure invariably present in all nymphids (New, 1984).

Comparable structures exist in Hemerobiidae (e.g. *Wesmaelius*, Aspöck *et al.*, 1980) and Chrysopidae (e.g. *Chrysopa*, Principi, 1949; Philippe, 1972; *Chrysoperla*: Fig. 2 B). In Chrysopidae the "subgenitale" is a pair of lobes which articulate with a pair of sclerotized pockets like a snap-press button ("button-pression", Philippe, 1972).

Achtelig (1978) compared the arrangement of the sclerites found in Chrysopidae with the interlock of the long ovipositor of Raphidioptera (Fig. 3 C). In contrast to Smith (1969) and Mickoleit (1973a) he

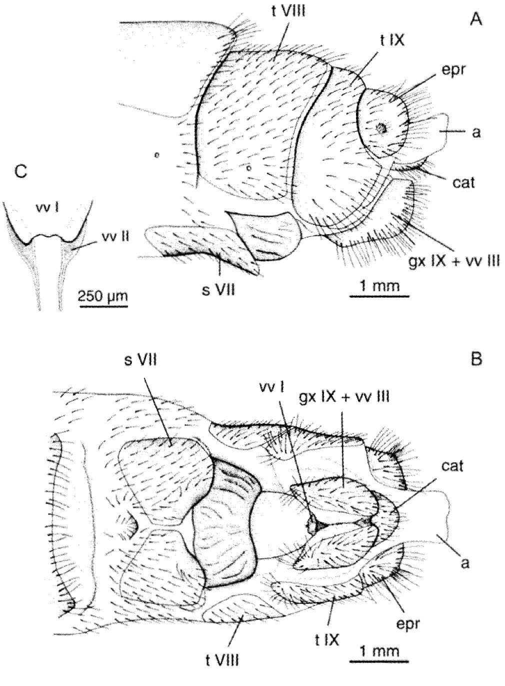

Fig. 1 – Female of *Nymphes myrmeleonoides*: **A**, lateral view of terminalia; **B**, ventral view of terminalia; **C**, fused valvulae I ("subgenitale") and valvulae II. a = anus; cat = cataprocessus; epr = ectoproct; gx = gonocoxite; i = interlock; vv = valvula; s = sternite; t = tergite.

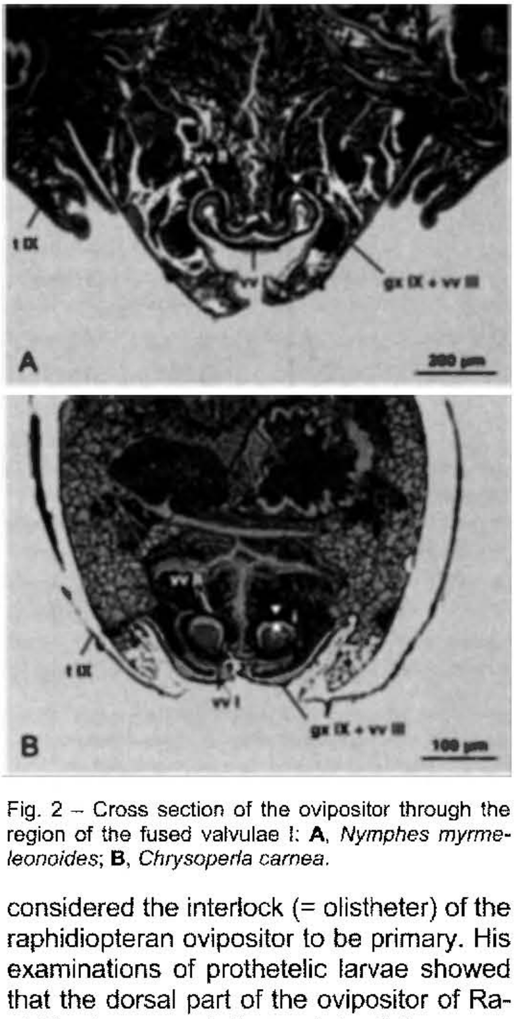

Fig. 2 – Cross section of the ovipositor through the region of the fused valvulae I: **A**, *Nymphes myrmeleonoides*; **B**, *Chrysoperla carnea*.

considered the interlock (= olistheter) of the raphidiopteran ovipositor to be primary. His examinations of prothetelic larvae showed that the dorsal part of the ovipositor of Raphidioptera, consisting mainly of the gonocoxites IX + valvulae III, also contains the valvulae II along their inner sides (Fig. 3 C). The valvulae II, which have the function of a rail, interlock on each side with the long fused unpaired valvulae I.

Extrapolating the situation of the ovipositor found in Raphidioptera to that of Chrysopidae Achtelig came to the conclusion that the lobes (subgenitale) of Chrysopidae are the reduced valvulae I and the snappress button interlock is a reduced olistheter (Fig. 3 B).

As a consequence the subgenitale of Nymphidae and Hemerobiidae may also be interpreted as the fused valvulae I. The sclerites along the inner sides of the gonocoxites IX are the valvulae II (gonapophyses IX) with the primary olistheter as the interlock between them and the valvulae I (Fig. 3). This leads to the conclusion that all elements of the orthopteroid ovipositor are not only present in the ground plan of Neuropterida, but also in the ground plan of Neuroptera.

The question as to the characteristic of the ovipositor in the neuropteran ground plan still remains unanswered. Assuming a primary olistheter a long raphidiopteran-like ovipositor seems probable for the ground plan of Neuropterida. Taxa with a long ovipositor must be examined in order to determine whether this also applies to Neuroptera. Tjeder (1937) described an unpaired subgenitale and a pair of rod-like appendages for Dilaridae which he homologized with the valvulae I and valvulae II. Mickoleit (1973a), who pointed out the similarity of the ovipositor of Dilaridae and Raphidioptera, discussed the rod-like appendages of Dilaridae as the valvulae I. Similar structures of the segment VIII have not been described for the long ovipositor of *Plega signata*

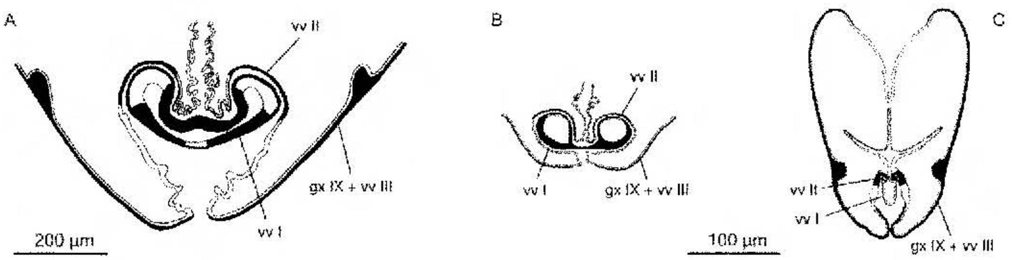

Fig. 3 – Schematic cross section of the ovipositor of (**A**) *Nymphes myrmeleonoides*, (**B**) *Chrysoperla carnea*, (**C**) Raphidioptera (after Mickoleit, 1973b). Emphasized structures show sclerotized part.

(Mantispidae) (Ferris, 1940). In accordance with Achtelig (1978) the presence of valvulae I and valvulae II in Neuroptera is considered to be plesiomorphic and can be found at least in Nymphidae and within Hemerobiiformia in Hemerobiidae and Chrysopidae. The structures discussed are apparently lacking in other Neuroptera, for example in Myrmeleontidae, Ascalaphidae and Coniopterygidae. They also seem to be absent in Osmylidae – a taxon which is supposed to have a plesiomorphic ovipositor with respect to the articulation of the gonocoxites IX with the tergite IX.

Additional investigation of the ovipositor is imperative and will certainly provide new information about its evolution and lead to new ideas concerning the phylogeny of Neuroptera.

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Observations on the larval morphology of the Antlion *Myrmeleon bore* (Tjeder, 1941) (Neuroptera Myrmeleontidae) and its life cycle in the Po Valley (northern Italy)

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Myrmeleon bore (Tjeder), an Eurasian antlion, has hitherto been recorded only in few localities of northern Italy, the southernmost part of its range. The author carried out observations in the Pavia province (western Po Valley) and rearings of this species, in order to obtain data concerning larval morphology, ecology and ethology, as well as to study its life cycle. Field observations and laboratory rearings indicate that the life cycle of *M. bore* in northern Italy may be completed in one year. The morphological characteristics of its three larval stages are noted and illustrated by SEM micrographs, discriminating them from those of the very similar and syntopic *M. inconspicuus* Rambur.

Key words – larval taxonomy, SEM, geographic distribution, voltinism, myrmeleontids.

Introduction

Myrmeleon bore (Tjeder, 1941) (Neuroptera: Myrmeleontidae), an Eurasian antlion, occurs in Europe mostly in the central and northern regions (Ohm, 1965; Aspöck *et al.*, 1980, 2001; Letardi, 1998; Röhricht, 1998); in Italy it has hitherto been recorded very rarely and only in the North (Aspöck & Aspöck, 1969; Nicoli Aldini, 1983; [Bernardi] Iori *et al.*, 1995; Hellrigl & Hölzel, 1996). Field studies in the Lomellina area (Province of Pavia, Lombardy) and laboratory rearings have been carried out by the author, since the seventies, for obtaining data on the ecology, behaviour and life cycle of this species. Observations have also been conducted using a scanning electron microscope in order to depict the morphological characteristics of its larval stages and differences between them and the corresponding stages of the very similar and syntopic *M. inconspicuus* Rambur, 1842. The mature larva of the latter was described masterfully by Principi (1943); taxonomical characteristics of the larva of *M. bore* were summarily presented by Friheden (1973), other illustrations are to be found in Dobosz (1993) and Ábrahám (1995).

Materials and methods

After the first findings of *M. bore* larvae in the Lomellina area, the research was widened to other stations in this region; moreover, some collections were examined to obtain further data on the presence and distribution of this antlion species in Italy.

The observations and samplings of larvae of *M. bore* and other antlions digging pits, were made in the Lomellina area during a period of nearly thirty years (1977 to 2005), in June-July and September-October. Laboratory rearings were conducted in Bologna, in an unconditioned environment.

Larval specimens were examined alive and shortly before death, as well as specimens preserved in ethanol 70-75%, dry specimens and cast skins from 1st and 2nd instar larvae, in order to study larval morphology. SEM micrographs were carried out in the Electron Microscope Laboratory of the Faculty of Agriculture, Università Cattolica, Piacenza, employing both non-metallized and metallized dry material, by means of a SEM Philips XL30 ESEM. Measurements of total larval length were conducted on live specimens; measurements of larval head (Fig. 3B) were conducted on specimens preserved in ethanol 70-75% (12 specimens for each stage of each species were examined), by means of a Leica Wild M 10 stereoscope, using an ocular micrometer. Other observations on larval morphology were carried out on prepared parts or appendages, previously clarified in KOH and mounted on slides in Faure's fluid. The "digging-setae" layout patterns of the 9th sternite and their relative frequencies were observed by examining a total of 263 *M. bore* larvae (L1: 69, L2: 150, L3: 44) (Tab. II) and 392 *M. inconspicuus* larvae (L1: 27, L2: 256, L3: 109). Detailed data on the latter species will be published in a future paper.

Results

Distributional data for *M. bore*

M. bore larvae were found in various localities of the southeastern Lomellina area (Pavia), both along river beds, and in some zones of the inland plain: a) Mezzana Rabattone, Po river; b) Pieve Albignola: Cascinotto Mensa, Po river; c) Pieve Albignola, Terdoppio stream; d) Pieve Albignola to Scaldasole: sandy banks and oak-wood borders near Cascina Rossa (now demolished) and Cascina Paralupo; e) Scaldasole, locality "I Dossi": borders of a small oak-wood; f) Alagna. In the collections of the Istituto di Entomologia, Università Cattolica, Piacenza, 3 adults of this species are preserved, labelled as follows: Cremona, Pizzighettone, farm "La Tencara", 19.VII.1970, light trap (1 female); Piacenza, 28.VII.1989 (1 male); Piacenza, Po river, VI.1991 (1 male). *M. bore* therefore, as published up to now, occurs in three Italian regions: Alto Adige (Aspöck & Aspöck, 1969; Hellrigl & Hölzel, 1996), Lombardy and Emilia (Nicoli Aldini, 1983, and present data) (Fig. 1).

Larval morphology of *M. bore*

1st instar larva (L 1)

Colouring – Basic colouring whitish straw, dorsally tending towards beige, with several brown or dark brown spots and blotches dorsally and ventrally (Fig. 2, Fig. 3A) (newhatched larva with only the cephalic and some, more or less evident, thoracic and abdominal spots). Head capsule dorsally almost entirely dark brown, due to the presence of large and confluent spots in the fronto-clypeal and epicranial areas (the epicranial spots extending to the sides); ocular tubercles black; head capsule also with a dark spot on each side posteriorly; ventrally yellowish brown with a pair of large and shaded brown spots in the hypostomal areas. Antenna dark brown. Mandible and maxilla iron-brown; labial palp with the last segment darker. Legs light, without spots, pretarsal claws of metathoracic legs clearly iron-coloured.

Size – Total length (including jaws) 3.8 (newhatched larva) to approx. 6 mm; morphometrical data of the head: Tab. I.

Relevant morphological features – Black setae, of various shapes and sizes, scattered almost all over the body; the fine structure of some of them from the anterior margin of the head, with longitudinal series of short spinules, is shown in Fig. 4A. Delicate white sinuous filaments (detail in Fig. 4C) dorsally scattered almost all over the body, lateroventrally over thorax and abdomen. Head capsule longer than broad, with maximum width at the ocular tubercles. Antenna (Fig. 4D) 11- to 15-segmented (scape stout, pedicel and apical flagellomere more or less elongate). Mandible falcate, tridentate, slender and finely sharp-

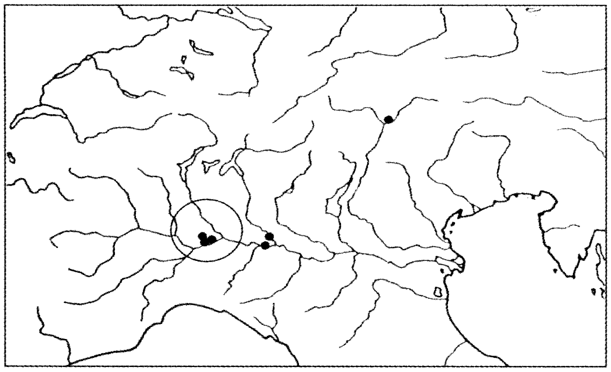

Fig. 1 – *Myrmeleon bore*, Italian distribution (bibliographic data and author's data); inside the circle: stations in the Lomellina area.

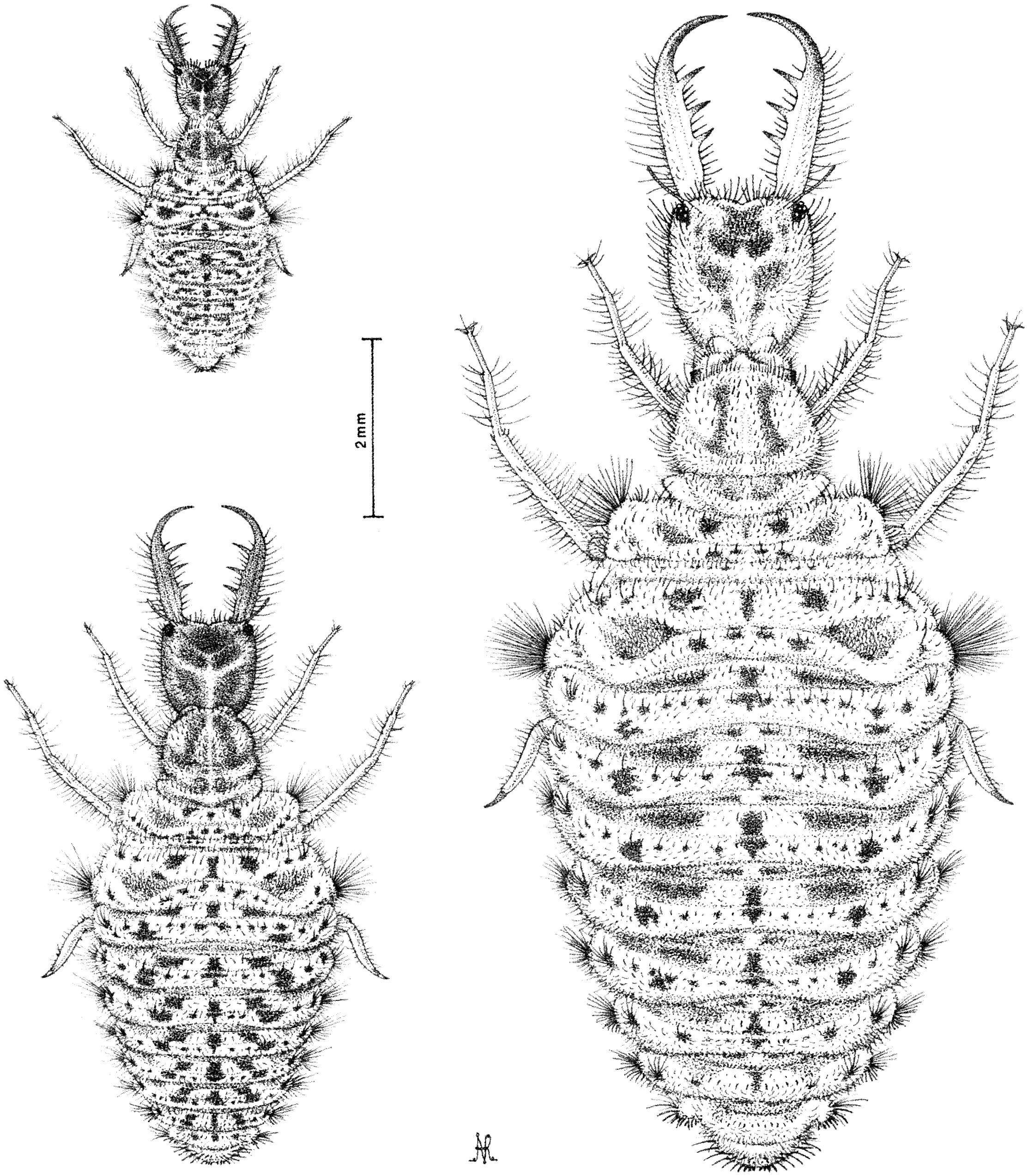

Fig. 2 – *Myrmeleon bore*: 1st, 2nd, 3rd instar larva (R. Nicoli Aldini *del.*).

ened, longer than the cephalic capsule; labium (Fig. 4E) with palps 3-segmented. Thoracic spiracle: Fig. 4F. "Digging setae" of the 9th sternite: Fig. 3C-D, Fig. 4G, Tab. II. Their most frequent pattern comprises 8 setae in the posterior row (4 on each side, forming the structure named "palette" by Steffan (1975), in which the most lateral seta is longer and sharpened), near the hind margin of the sternum; 4 setae in the row immediately in front; and 2 in front of them, in the discal area of the sternite, placed side by side or asymmetrically, more or less distant from each other. Sometimes there is only one or none of the latter.

Tab. I – *Myrmeleon bore* and *M. inconspicuus*, measurements of the head and number of antennal segments (12 specimens were measured and examined for each larval stage of each species).

	Myrmeleon bore			***Myrmeleon inconspicuus***		
Measurements (mm)	L 1	L 2	L 3	L 1	L 2	L 3
Head length (incl. jaws)	1.77-1.93	2.65-2.92	4.16-4.62	1.46-1.64	2.10-2.35	3.20-3.77
Length of the head capsule	0.84-0.92	1.28-1.45	2.06-2.26	0.68-0.81	1.05-1.17	1.62-1.90
Width of the head capsule	0.75-0.81	1.12-1.26	1.71-1.90	0.64-0.75	0.94-1.07	1.45-1.71
Number of antennal segments	11-15	8-14	9-15	11-15	13-16	10-15

Tab. II – *Myrmeleon bore*, layout patterns of “digging setae” on the 9th sternite, and their relative frequencies for each larval stage and for the whole number of larvae examined.

Layout patterns of the “digging setae”	**L 1** (69 larvae examined)	**L 2** (150 larvae examined)	**L 3** (44 larvae examined)	**L 1 + L 2 + L 3** (263 larvae examined)
2 (asymm.) – 5 – 7	-	1 (0.66%)	-	1 (0.38%)
2 (asymm.) – 3 – 8	-	1 (0.66%)	-	1 (0.38%)
0 – 4 – 8	5 (7.25%)	5 (3.35%)	-	10 (3.80%)
1 – 4 – 8	9 (13.04%)	11 (7.35%)	4 (9.09%)	24 (9.13%)
2 (asymm.) – 4 – 8	42 (60.87%)	109 (72.66%)	31 (70.46%)	182 (69.20%)
2 (symm.) – 4 – 8	11 (15.94%)	13 (8.66%)	4 (9.09%)	28 (10.65%)
3 (asymm.) – 4 – 8	-	7 (4.66%)	5 (11.36%)	12 (4.56%)
1 – 5* – 8	2 (2.90%)	3 (2.00%)	-	5 (1.90%)

* symmetric (*i. e.* in one row) or asymmetric but close to each other.

Tab. III – Morphological features discriminating *Myrmeleon bore* and *M. inconspicuus* larvae.

Species/Characteristics	***Myrmeleon bore***	***Myrmeleon inconspicuus***
SIZE	Slightly larger (see Tab. I for the head).	Smaller (see Tab. I for the head).
MANDIBLE	Relatively longer, more slender distally; in all stages, mandible a little longer than the head capsule.	Relatively shorter, less slender distally; only in L 1 mandible longer than the head capsule.
LABIAL PALP	3-segmented (see Fig. 4E).	4-segmented.
THICK CEPHALIC SETAE	With longitudinal series of short spinules (evident mainly in 1st instar larva, see Fig. 4A).	With longitudinal series of slightly longer and thinner spinules (evident mainly in 1st instar larva, see Fig. 4B).
NUMBER AND LAYOUT OF “DIGGING SETAE” ON THE 9TH STERNITE	Intermediate group forming a row of 4 setae (only exceptionally 5); anterior (discal) group comprising 0-3 setae (see Fig. 3C-F, Fig. 4G, and Tab. 2).	Intermediate group consisting of at least 6 setae (only exceptionally 5, not rarely 7, rarely 8-9) disposed in more or less regular row; anterior (discal) group comprising 0-7 setae disposed more or less irregularly (see Fig. 3G-I).

2nd instar larva (L 2) (main differences in comparison with L1)

Colouring – Dark colouring of the head capsule generally a little less wide than in L 1, with large dark spots dorsally (Fig. 2) and a dark spot on each side posteriorly; ventrally with a pair of oval dark spots.

Size – Total length (including jaws) approx. 6-8 mm; morphometrical data of the head: Tab. I.

Relevant morphological features – Maximum width of the head capsule a little behind the ocular tubercles. Antenna 8- to 14-segmented. Layout pattern of "digging setae" of the 9th sternite rather variable (Tab. II), their more frequent settings correspond to the 2 (asymmetric or symmetric) – 4 – 8 type.

3rd instar larva (L 3) (main differences in comparison with L 2)

Colouring – Head capsule dorsally with one frontoclypeal dark spot and some symmetric epicranial dark spots, less wide than in L 2 (Fig. 2); on each side with a dark spot posteriorly; ventrally with a pair of dark spots with shaded margins in the hypostomal areas. Antenna uniformly brown or yellow ochre, with the last segment darker; mandible yellow ochre, gradually darker in the points.

Size – Total length (including jaws) approx. 8.5-12.5 mm; morphometrical data of the head: Tab. I.

Relevant morphological features – Antenna 9- to 15-segmented (only 6 segments in both antennae, with various flagellomeres fused together, in an anomalous specimen). Spinosity of the ventral side of the mandible: Fig. 4H. Layout pattern of "digging setae" of the 9th abdominal sternum rather variable (Fig. 3E-F, Tab. II), their more frequent settings as in L 2.

Through the development from L1 to L3, therefore, the dark colouring of the head decreases in width; the mandible is dark in L1 and L2, lighter in L3. The head capsule modifies its shape a little and remains slightly shorter than the mandible. On the 9th sternite, the "digging setae" of the discal group tend to increase in number (in L3, not rarely 3 setae, placed asymmetrically, are to be found) (Tab. II).

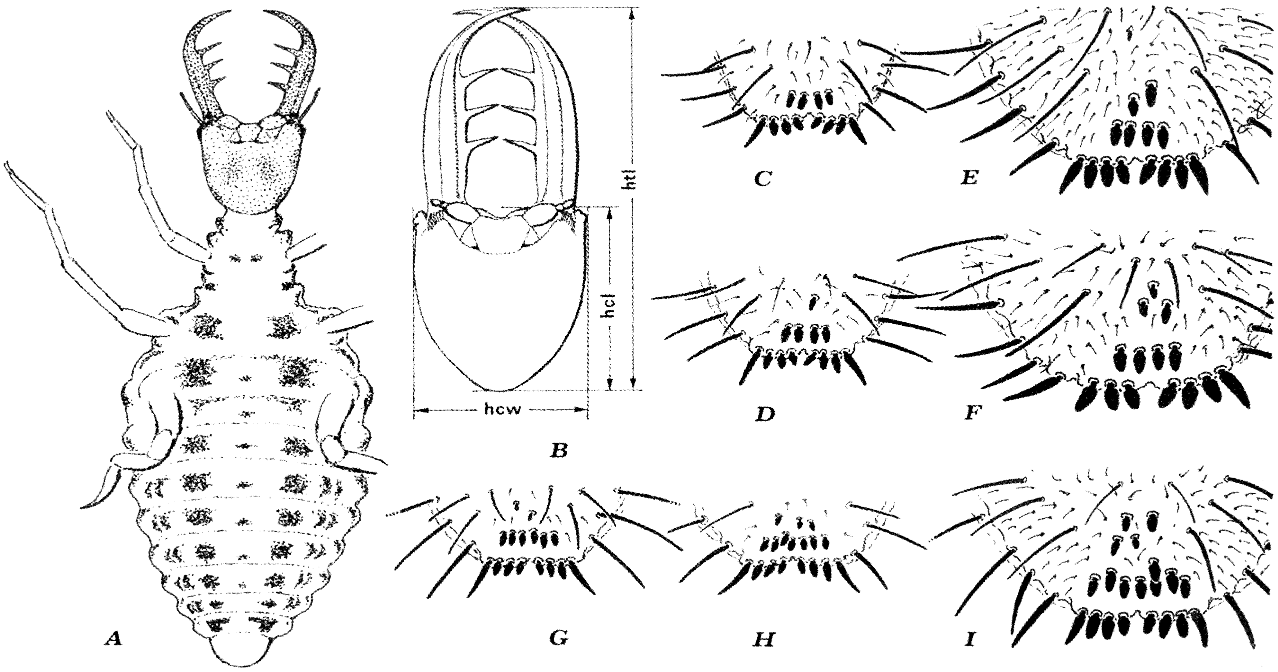

Fig. 3 – *Myrmeleon bore*: **A**, schematic distribution of ventral spots in 1st instar larva; **B**, technique of measurement of larval head (htl = total length of the head; hcl = length of the head capsule; hcw = width of the head capsule); **C**-**F**, some layout patterns of "digging setae" of 9th sternite in 1st (C: 0-4-8; D: 1-4-8) and 3rd (E: 2-4-8; F: 3-4-(7)8) instar larva. *M. inconspicuus*: **G**-**I**, idem in 1st (G: 2-6-8; H: 3-7-8) and 3rd (I: 4-8-8) instar larva. (Various magnification; R. Nicoli Aldini *del.*).

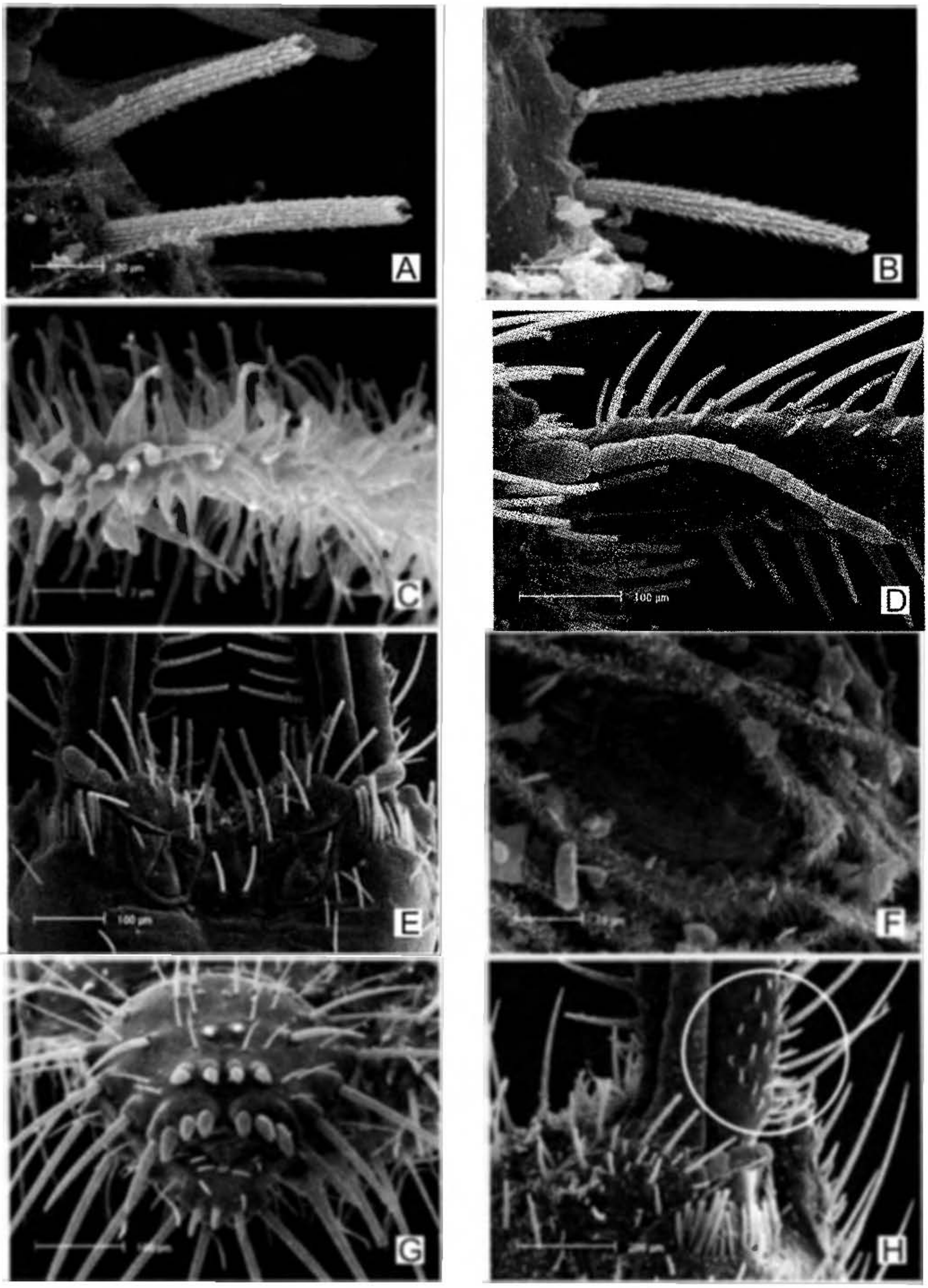

Fig. 4 – **A**, *Myrmeleon bore*, L 1: detail of two setae on the anterior margin of the frontoclypeal region; **B**, ditto of *Myrmeleon inconspicuus*, L 1; **C**, *M. bore*, L 1 (cast skin): detail of a delicate sinuous filament from the thoracic perispiracular region, at high magnification; **D**, *M. bore*, L 1: antenna. **E**, *M. bore*, L 1: labium; **F**, *M. bore*, L 1 (cast skin): thoracic spiracle; **G**, *M. bore*, L 1: 9th abdominal sternite; **H**, *M. bore*, L 3: ventral detail of mouthparts (inside the circle: spinosity of the ventral side of the mandible). (SEM photos).

Tab. IV – *Myrmeleon bore*, number and percentages of the three larval stages in three subsequent samplings made in the span of twelve months in the same poplar grove with sandy soil, at Pieve Albignola near Terdoppio stream (Province of Pavia), years 1983-1984.

Larval stage	**1.X.1983** (89 larvae)	**1.VII.1984** (25 larvae)	**28.IX.1984** (61 larvae)
L 1	23 (25.8%)	0 (0.0%)	31 (50.8%)
L 2	62 (69.7%)	2 (8.0%)	30 (49.2%)
L 3	4 (4.5%)	23 (92.0%)	0 (0.0%)

Almost all over the body, black setae of various shapes and sizes, as well as delicate white sinuous filaments, increase in number.

Some morphological characteristics discriminating between *M. bore* and *M. inconspicuus* larvae are summarized in Tab. I (head measurements) and Tab. III.

Bio-ecological notes, life cycle duration

Only a short account can be reported here. In the southern Lomellina area, *M. bore* occurs in various localities, in environments with suitable sandy soil: the banks of the Po river bed, the poplar groves near this major river and its tributaries, and the sandy banks (the typical "dossi" of the Lomellina area, with the surviving small oak-woods (*Quercus pedunculata*), associated with the invasive robinia (*Robinia pseudacacia*) and a few other species of trees) in the inland agricultural plain. In all these environments, this antlion is syntopic with *M. inconspicuus*, which is generally more abundant, only rarely the larvae of these two species were found in similar percentages. The pits of *M. bore* are located in the same places as those of *M. inconspicuus*, in bare soil or, especially for the pits of the 1st and 2nd instar larvae, which are closer together, near the base of herbs and small shrubs, in any case in sunny places. Syntopy with *Myrmeleon formicarius* Linné, 1767 and *Euroleon nostras* (Geoffroy in Fourcroy, 1785) (both, but especially the latter, scarcer than the other two species) was observed in some environments such as sandy banks in the inland plain, near small oak woods (Nicoli Aldini, 1983), and on a sandy slope far from rivers. These four species display partially different preferences in the location of their pits. The pits of *E. nostras*, for instance, are always found under overhangs – as has been well known for many years, see *e.g.* Steffan (1975), Yasseri & Parzefall (1996). It is likely that *M. bore* larvae, as well as those of *M. inconspicuus* (Steffan, *l.c.*), are able to survive the prolonged submersions of the sand banks of the Po river bed, which occur in some periods of the year.

Field samplings and laboratory rearings in climatic conditions similar to those of the natural habitat indicate that the life cycle of *M. bore* in the Po valley may be completed for the majority of the individuals in one year, compared with 2-3 years in central Europe (Hölzel, 1973; Gepp & Hölzel, 1996; Hölzel & Wieser, 1999). This fact in the Lomellina area is demonstrated by the high number of 3rd instar larvae of *M. bore* in July and their low number or absence in September-October, as well as by the very low number of 1st and 2nd instar larvae in July and their abundance in September-October (Tab. IV). Only a small number of larvae takes two years (personal observations), as has also been found for *M. inconspicuus* (Principi, 1943; Steffan, 1975; Pantaleoni, 1982; Nicoli Aldini, unpublished data). In the laboratory rearings, *M. bore* adults started to emerge in the first ten days of June, ending in the second ten days of August. During field research in the Lomellina area, in June-July adults of this species were never found (maybe they emerge later or are scarcer), whereas some specimens of *M. inconspicuus* were captured in July on herbaceous plants.

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Recent accounts on the systematics and biogeography of Neotropical Megaloptera (Corydalidae, Sialidae)

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The Neotropical fauna of Megaloptera is quite well known. However, gradually new taxa and new distribution data keep emerging. In Corydalinae (Corydalidae), there is a group of closely related *Chloronia* species of Andean affinity of which one has been described as new. In the Sialidae, a group whose taxonomy needs considerable attention in the region, two new species have just been described, from Brazil and Venezuela, respectively. Advances in the study of specimens are gradually clarifying the identity of Neotropical alderflies, but the study of a few types is still required. Comments on other members of the order are presented, including directions for further research on taxonomy and phylogeny.

Key words – Megaloptera, Corydalidae, Sialidae, systematics, biogeography, Neotropics.

Introduction

The alpha taxonomy of the Neotropical megalopteran fauna has recently reached a satisfactory level of knowledge (Contreras-Ramos, 1999a). However, refinement of data keeps producing new distribution data and, gradually, yet a few species new to science. Several new species have also been detected on the basis of female specimens, so their description has to await discovery of the corresponding males. Of both families, Corydalidae and Sialidae, the latter is the one in need of revisionary work in the region, although its taxonomy is being clarified partially as several species are being described or redescribed. Below, an account of the status of the systematics and distribution of the group is presented, with comments on possible directions for future research.

Materials and methods

This work is a summary of research that has taken place or is being developed in parts and presented in detailed publications elsewhere, by the author or by colleagues. In the end, actual field work and specimens conform the basis of this synthesis. Detailed credits of techniques, institutions, and curators, have been included in punctual contributions. The list of species in the tables is based on Contreras-Ramos (1999a).

Results

Corydalidae Chauliodinae – The taxonomy of this subfamily is quite stable (Tab. I). Its distribution is essentially restricted to the Chilean subregion, although one species is marginally present in northwestern Mexico from adjacent United States. Specimens of two species from southeastern Brazil are being studied by Dr. Adriano S. Melo (Universidade Federal do Rio Grande do Sul) and the author, and those results are forthcoming. These would be the first records of the subfamily in Brazil. A female specimen of *Dysmicohermes* Munroe, 1954, possibly of an undescribed species, has been recorded at the United States side of the border with Mexico, in Texas (Contreras-Ramos,

Table I – Fauna of Neotropical Megaloptera: Corydalidae Chauliodinae.

Species	Distribution	Selected references and comments
Archichauliodes chilensis Kimmins, 1954	Chile	Flint (1973). Genus also present in New Zealand and Australia. Larvae from Chile tentatively associated to genus.
Archichauliodes pinares Flint, 1973	Chile	Flint (1973).
Neohermes filicornis (Banks, 1903)	Mexico, United States	Flint (1965), Evans (1972), Contreras-Ramos & Harris (1998). Larva described.
Nothochauliodes penai Flint, 1983	Chile	Flint (1983). Monotypic genus, endemic.
Protochauliodes bullocki Flint, 1973	Chile	Flint (1973). Genus also present in Australia and western North America. Larvae from Chile tentatively associated to *P. cinerascens* and *P. humeralis*.
Protochauliodes cinerascens cinerascens (Blanchard, 1851)	Chile	Flint (1973).
Protochauliodes cinerascens fumipennis Flint, 1973	Chile	Flint (1973).
Protochauliodes cinerascens reedi Kimmins, 1954	Chile	Flint (1973).
Protochauliodes humeralis (Banks, 1908)	Chile	Flint (1973).

1995a). At this point, however, published records of this subfamily in the Neotropics sum up nine species and subspecies.

Corydalidae Corydalinae – The taxonomy of this subfamily is also fairly stable (Tab. II). Recently, the identity of *Chloronia bogotana* Weele, 1909 was clarified (Contreras-Ramos, 2004a), and a new species of the same genus from the Andes of Bolivia and Peru has been described (Contreras-Ramos, 2006a). Several unplaced female specimens from South America, evidence new species in *Chloronia* and *Corydalus*, but until males are found their identity will remain uncertain (Contreras-Ramos, 1998, 2004b). *Corydalus cornutus* (L. 1758), although collected in Texas, quite close to the Mexican border, has never been found in Mexico. A distinct larva of *Platyneuromus* points to a possible fourth species in this genus from western Mexico (Contreras-Ramos & Harris, 1998). In all, 54 species are currently recognized in the region, 18 in *Chloronia* Banks, 1908, 33 in *Corydalus* Latreille, 1802, and three in *Platyneuromus* Weele, 1909.

Sialidae – This is the least studied group of Megaloptera in the Neotropics (Tab. III). Several of the species have not been treated again after their original description. In fact, the generic position of the Neotropical species remains controversial. However, the alpha taxonomy of the group is beginning to be clarified and two species have been recently described (Contreras-Ramos, 2006b; Contreras-Ramos *et al.*, 2005). Also, a few redescriptions by the author are forthcoming. Nonetheless, a few species remain unstudied and the type of *Protosialis nubila* Navás, 1933 might be destroyed. Ten species of Sialidae have been described from the Neotropics.

Life history and phylogeny – Little has been studied of the life history of neotropical Megaloptera (e.g., Contreras-Ramos, 1999b; Contreras-Ramos & Harris, 1998). Now that the taxonomic identity of most species has been established, this is a promising field for description of immature stages, as well as determination of food habits, secondary production, mating behavior, and precise

Table II – Fauna of Neotropical Megaloptera: Corydalidae Corydalinae.

Species	Distribution	Selected references and comments
Chloronia absona Flint, 1992	Costa Rica	Flint (1992).
Chloronia antilliensis Flint, 1970	Dominica	Penny & Flint (1982).
Chloronia banksiana Penny & Flint, 1982	Venezuela	Penny & Flint (1982).
Chloronia bogotana Weele, 1909	Colombia	Contreras-Ramos (2004a). Redescription of a species with previous ambiguous identity.
Chloronia convergens Contreras-Ramos, 1995	Ecuador	Contreras-Ramos (1995b).
Chloronia corripiens (Walker, 1858)	Brazil	Penny & Flint (1982).
Chloronia gaianii Contreras-Ramos, 2002	Venezuela	Contreras-Ramos (2002).
Chloronia gloriosoi Penny & Flint, 1982	Costa Rica, Panama	Penny & Flint (1982).
Chloronia hieroglyphica (Rambur, 1842)	Brazil, French Guiana, Guyana, Peru	Penny & Flint (1982), Azevêdo (2003). Immature stages described.
Chloronia marthae Contreras-Ramos, 2002	Venezuela	Contreras-Ramos (2002). Possibly a variant, and thus junior synonym, of the widespread *C. mirifica*.
Chloronia mexicana Stitz, 1914	Costa Rica, Guatemala, Mexico	Penny & Flint (1982), Contreras-Ramos & Harris (1998), Contreras-Ramos (1999b). Larva diagnosed, life history notes available.
Chloronia mirifica Navás, 1925	Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Panama, Peru	Penny & Flint (1982), Contreras-Ramos (2004b).
Chloronia osae Flint, 1992	Costa Rica	Flint (1992).
Chloronia pallida (Davis, 1903)	Mexico	Penny & Flint (1982), Contreras-Ramos (1995b).
Chloronia pennyi Contreras-Ramos, 2000	Brazil	Contreras-Ramos (2000).
Chloronia plaumanni Penny & Flint, 1982	Brazil	Penny & Flint (1982).
Chloronia yungas Contreras-Ramos, 2006	Bolivia, Peru	Contreras-Ramos (2006a).
Chloronia zacapa Contreras-Ramos, 1995	Guatemala	Contreras-Ramos (1995b).
Corydalus affinis Burmeister, 1839	Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Venezuela	Contreras-Ramos (1998).
Corydalus amazonas Contreras-Ramos, 1998	Brazil	Contreras-Ramos (1998).
Corydalus armatus Hagen, 1861	Argentina, Bolivia, Colombia, Ecuador, Peru, Venezuela	Contreras-Ramos (1998).
Corydalus arpi Navás, 1936	Brazil, Venezuela	Contreras-Ramos (1998).
Corydalus australis Contreras-Ramos, 1998	Argentina, Brazil, Uruguay	Contreras-Ramos (1998).
Corydalus batesii MacLachlan, 1868	Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Suriname, Peru, Venezuela	Contreras-Ramos (1998), Azevêdo (2003). Immature stages and mating behavior described.
Corydalus bidenticulatus Contreras-Ramos, 1998	Mexico, United States	Contreras-Ramos (1998).

continues ...

Table II – Fauna of Neotropical Megaloptera: Corydalidae Corydalinae. Continued

Species	Distribution	Selected references and comments
Corydalus cephalotes Rambur, 1842	Brazil	Contreras-Ramos (1998).
Corydalus clauseni Contreras-Ramos, 1998	Colombia, Costa Rica, Ecuador	Contreras-Ramos (1998).
Corydalus clavijoi Contreras-Ramos, 2002	Venezuela	Contreras-Ramos (2002).
Corydalus colombianus Contreras-Ramos, 1998	Colombia	Contreras-Ramos (1998).
Corydalus crossi Contreras-Ramos, 2002	Venezuela	Contreras-Ramos (2002).
Corydalus ecuadorianus Banks, 1948	Ecuador	Contreras-Ramos (1998, 2004b).
Corydalus flavicornis Stitz, 1914	Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Panama, Peru, Venezuela	Contreras-Ramos (1998).
Corydalus flinti Contreras-Ramos, 1998	Venezuela	Contreras-Ramos (1998).
Corydalus hayashii Contreras-Ramos, 2002	Venezuela	Contreras-Ramos (2002).
Corydalus hecate MacLachlan, 1866	Brazil, Peru, Venezuela	Contreras-Ramos (1998).
Corydalus holzenthali Contreras-Ramos, 1998	Bolivia, Peru	Contreras-Ramos (1998).
Corydalus ignotus Contreras-Ramos, 1998	Brazil, French Guiana	Contreras-Ramos (1998), Azevêdo (2003). Immature stages described.
Corydalus imperiosus Contreras-Ramos, 1998	Argentina	Contreras-Ramos (1998).
Corydalus longicornis Contreras-Ramos, 1998	Argentina, Bolivia, Ecuador	Contreras-Ramos (1998).
Corydalus luteus Hagen, 1861	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, United States	Contreras-Ramos (1998), Contreras-Ramos (1999b). Life history notes available.
Corydalus magnus Contreras-Ramos, 1998	Costa Rica, El Salvador, Guatemala, Mexico	Contreras-Ramos (1998).
Corydalus mayri Contreras-Ramos, 2002	Venezuela	Contreras-Ramos (2002).
Corydalus neblinensis Contreras-Ramos, 1998	Venezuela	Contreras-Ramos (1998).
Corydalus nubilus Erichson, 1848	Brazil, French Guiana, Guyana, Venezuela	Contreras-Ramos (1998), Azevêdo (2003). Immature stages and mating behavior described.
Corydalus parvus Stitz, 1914	Ecuador, Peru	Contreras-Ramos (1998).
Corydalus peruvianus Davis, 1903	Argentina, Bolivia, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Panama, Peru, Venezuela	Contreras-Ramos (1998).
Corydalus primitivus Weele, 1909	Argentina, Bolivia	Contreras-Ramos (1998).
Corydalus tesselatus Stitz, 1914	Colombia, Venezuela	Contreras-Ramos (1998).
Corydalus texanus Banks, 1903	Guatemala, Mexico, United States	Contreras-Ramos (1998).
Corydalus tridentatus Stitz, 1914	Brazil	Contreras-Ramos (1998).
Platyneuromus honduranus Navás, 1928	Guatemala, Honduras, Mexico	Glorioso & Flint (1984).
Platyneuromus reflexus Glorioso & Flint, 1984	Guatemala, Mexico	Glorioso & Flint (1984).
Platyneuromus soror (Hagen, 1861)	Costa Rica, Mexico, Panama	Glorioso & Flint (1984), Contreras-Ramos & Harris (1998), Contreras-Ramos (1999b). Immature stages and mating behavior described.

Table III – Fauna of Neotropical Megaloptera: Sialidae.

Species	Distribution	Selected references and comments
Protosialis bifasciata (Hagen, 1861)	Cuba	Hagen (1861), Weele (1910). Redescription forthcoming.
Protosialis bimaculata Banks, 1920	Bolivia	Banks (1920).
Protosialis brasiliensis Navás, 1936	Brazil	Navás (1936), Contreras-Ramos (2006 b). Species redescribed.
Protosialis chilensis (McLachlan, 1870)	Chile	Flint (1973). Redescription forthcoming.
Protosialis flammata Penny, 1981	Brazil	Penny (1981), Azevêdo (2003). Immatures described. Adult redescription forthcoming.
Protosialis flavicollis (Enderlein, 1910)	Colombia	Enderlein (1910). Type specimen has not been located.
Protosialis hauseri Contreras, Fiorentin, Urakami, 2005	Brazil	Contreras-Ramos *et al.* (2005). Larval specimens available.
Protosialis mexicana (Banks, 1901)	Mexico, Panama	Weele (1910). Redescription forthcoming.
Protosialis nubila Navás, 1933	Brazil	Navás (1933). Type might be destroyed.
Protosialis ranchograndis Contreras-Ramos, 2006	Venezuela	Contreras-Ramos (2006 b).

ecological and geographical distributions of both adults and immatures. An exception to this lack of studies is the excellent master's thesis work by Azevêdo (2003) on the immatures of several species of Brazilian Amazonia. It is hoped that this work will be published soon. A phylogeny of *Corydalus* species has been proposed (Contreras-Ramos, 1998), and an updated one is under revision. Both, *Chloronia* and *Platyneuromus* lack formal phylogenetic analyses, as well as any of the Chauliodinae or Sialidae taxa in the Neotropics.

Discussion

As the taxonomy of a group is the first step in order to understand other aspects such as ecology, biogeography, or evolution, the neotropical Megaloptera are in fairly good shape to be subjected to studies of diverse sorts. An important goal would be, for instance, to describe the immature stages of the species, as well as to determine their precise distributions, both in a geographic and in an ecological context. Another interesting aspect would be the mating behavior of the different species in a comparative inter-specific and inter-generic context. Many more possibilities exist, and for this studies on northern temperate species could be taken as models.

Comparing the Nearctic versus the Neotropical faunas, 46 species are recorded from the former and 73 from the latter, although four species (one Chauliodinae and three Corydalinae) are shared between regions. Chauliodinae and Sialidae are more diverse in the Nearctic, with 18 and 24 species versus 9 and 10, respectively, in the Neotropics. However, Corydalinae is only represented by four species in the Nearctic, while 54 species of this group have been recorded in the Neotropics. The current proportion of New World Megaloptera species splits to about 38 % in the Nearctic and 62 % in the Neotropics.

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Hemerobiidae of the Afrotropical Region: a review of current knowledge

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Africa south of the Sahara has a comparatively small fauna of Hemerobiidae. Approximately 51 species in seven genera have so far been recorded from the Afrotropical Region. They are arranged into four subfamilies: Hemerobiinae, Sympherobiinae, Microminae and Notiobiellinae. Of the seven genera five are shared with the Western Palaearctic Region: *Hemerobius*, *Wesmaelius*, *Sympherobius*, *Psectra* and *Micromus*. The other two genera are either pantropical (*Notiobiella*) or endemic to Central Africa (*Anapsectra*). The majority of African species has only been recorded from the eastern parts of the continent, only 19 species have been found in Western Africa; 10 species occur in the Madagascan subregion and five species were also recorded from the Arabian peninsula.

Key words – Hemerobiidae, Afrotropical Region, distribution, biogeography

Introduction

The family Hemerobiidae – brown lacewings – contains approximately 550 species that are collectively distributed on all continents except Antarctica. Adults are generally believed to be predators, while all known larvae are strictly predaceous. Most species are arboreal and few are associated with low vegetation. Afrotropical Hemerobiids received little systematic attention before 1961, when Bo Tjeder's paper on the Hemerobiidae of Southern Africa was published. Tjeder recognized 22 species in seven genera, 10 species he described as new. In the following 40 years many papers, consisting largely of descriptive treatments and accounts of local and regional faunas were published. Most of these studies were carried out by V.J. Monserrat who examined most available African types and proposed many synonyms. At the same time he described six new African species. In the course of his studies he also published a systematic checklist of the Hemerobiidae of the world (Monserrat, 1990).

The most important paper on the Hemerobiidae of the world was published by Oswald (1993). In a revision and cladistic analysis of the world genera of Hemerobiidae he recognized nine subfamilies and 25 extant genera. Four of these subfamilies, Hemerobiinae, Sympherobiinae, Notiobiellinae and Microminae have been reported from Subsaharan Africa. A fifth subfamily, Megalominae, with only the genus *Megalomus* has been reported from Northwestern Africa, but is otherwise absent. Subsaharan Africa and the Western Palaearctic share five genera: *Hemerobius*, *Wesmaelius*, *Sympherobius*, *Psectra* and *Micromus*; two more genera are either pantropical (*Notiobiella*) or endemic to Central Africa (*Anapsectra*). To date, 51 species referred to these seven genera have been recorded from Subsaharan Africa.

This number compares well with the faunas of other regions. We now know 64 species in 7 genera in the Western Palaearctic Region (Aspöck *et al.*, 2001), 61 species in 6 genera, in America north of Mexico (Penny *et al.*, 1997), 111 species in ca. 20 genera in South America (Penny,

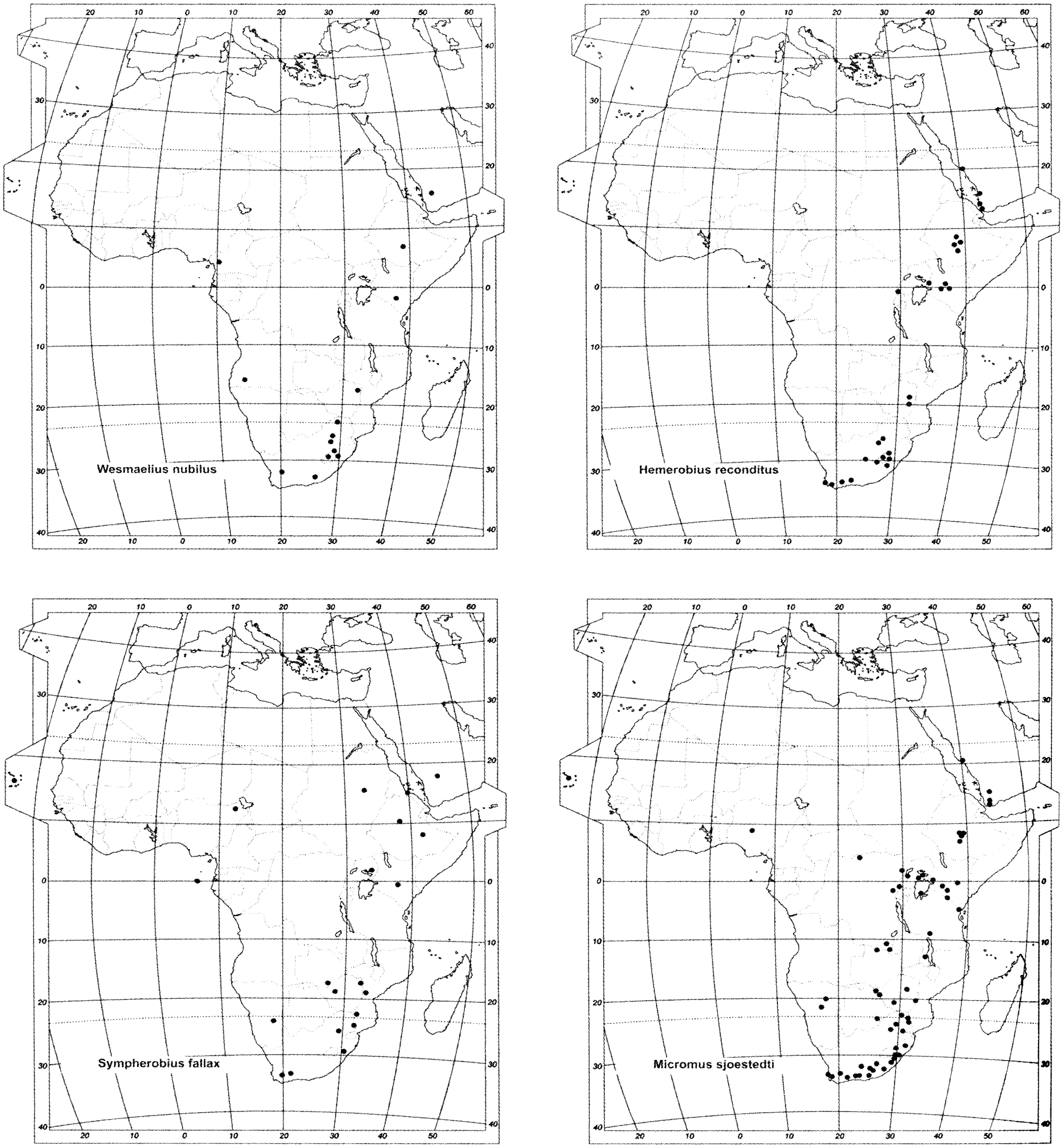

Fig. 1 – Recorded distribution of: *Wesmaelius nubilus*; *Hemerobius reconditus; Sympherobius fallax* (only Sub-saharan); *Micromus sjoestedti.*

1977), and 34 species in 10 genera in the Australian Region (New, 1988).

As I have already indicated (Hölzel & Ohm, 2002) the distribution of animals and plants on the African continent is influenced by the extensive area of lowland rainforest that covers West- and Central Africa along the equator. This is essentially a barrier that divides the continent into two different savannah areas (Illies, 1971). The only effective way for dispersal is through a small corridor in East Africa, between the large lakes and the high East African mountains and which eventually terminates in the Ethiopian highlands. It is therefore not surprising that the largest numbers of Hemerobiidae have been recorded from the eastern half of the continent.

Material

The basic information for the compilation of species in Table 1 originates from the following papers: Van der Weele (1909a, b), Navás 1910, 1914, 1924, 1929, 1930, 1934, 1936), Fraser (1951, 1952, 1955, 1957), Kimmins (1936, 1939, 1952, 1959), Tjeder (1961, 1963, 1976), Penny (1977), New (1988), Monserrat (1984, 1990a, b, c, 1991, 1992a, b, 1993, 2004), Monserrat & Deretsky (1999), Oswald (1993), Penny *et al.* (1997), Aspöck *et al.* (2001), Hölzel (1995, 1998, 2001, 2002), Hölzel & Ohm (1990, 2002), Hölzel *et al.* (1999), Ohm & Hölzel (1982, 1995, 1997, 1998).

Besides the published records, material collected by the author over the past 20 years in Africa has been included in this study.

Results

The following checklist demonstrates our present knowledge of the Afrotropical fauna of Hemerobiidae and indicates their known distribution. It shows that in the subfamily Hemerobiinae the majority of species has only been recorded in the east or southeast of the region. Only two species, *Hemerobius productus* and *Wesmaelius nubilus* have also been recorded in West Africa, the latter extending moreover to the Arabian Peninsula (Fig. 1). One undescribed species of the genus *Wesmaelius* occurs only on the Cape Verde Islands. *W. praenubilus* and *H. binigripunctatus* are endemic to the Mascarene Islands, *H. nairobicus* occurs on the Comoros as well as in Yemen, *H. reconditus* is recorded from the Cape in South Africa to the Western parts of the Arabian Peninsula (Fig. 1).

The only species of the subfamily Sympherobiinae, *Sympherobius fallax* shows panafrican distribution and also occurs in the Mediterranean Region and in Yemen (Fig. 1).

The subfamily Microminae contains a few interesting, widespread species. *Micromus timidus* is the most common species in Africa. It is distributed from West Africa over the whole region, the Madagascan subregion, to the Oriental and Australian Regions. *M. sjoestedti* occurs in the whole region, from the Cape Verde Islands in the West to the Arabian Peninsula in the East (Fig. 1). It is closely related to *M. canariensis* Esben-Petersen, 1936 on the Canary Islands and to *M. plagatus* in the Madagascan subregion. *M. africanus* is another widespread species over Subsaharan Africa and the Madagassis. Finally, *M. atlanticus* should be mentioned, it occurs on the island of St. Helena, far distant in the Atlantic Ocean. The species seems to be related to *M. africanus* (Tjeder, 1976).

The fourth subfamily Notiobiellinae contains three genera. One of them is *Anapsectra* with two endemic species, only once collected in Central Africa. Few records are available for species of the genus *Psectra*. *P. capensis* has been described from the Cape in South Africa and *P. mozambica* has only been found once in Mozambique. Some records from West and East Africa exist of *P. jeanneli*, the most interesting from the Cape Verde Islands (Fig. 2). Almost all 14 species of *Notiobiella* seem to be spread over the whole region as they are recorded both from West and East Africa. Three species, *N. nitidula*, *N. peterseni* and *N. rosea* have been recorded from the Madagassis, *nitidula* also from the Cape Verde Islands.

Conclusion

This study provides the first overview of the known Afrotropical species of the family Hemerobiidae. They are arranged into four groups on the basis of their current distribution. Group 1 shows the majority of species (25) recorded from East and

Hemerobiidae of the Afrotropical Region

1 = East and Southeast Africa; 2 = Madagascan subregion; 3 = Arabian peninsula; 4 = West Africa

Hemerobiinae Stephens, 1829				
Hemerobius Linnaeus, 1758				
abditus Tjeder, 1961	1			
anomalus Monserrat,1992	1			
aper Tjeder, 1961	1			
binigripunctatus Fraser, 1957		2		
ceraticus Navás, 1924	1			
deceptor Navás, 1914	1			
disparilis Navás, 1936	1			
elatus Navás, 1914	1			
falciger Tjeder, 1963	1			
nairobicus Navás, 1910	1	2	3	
natalensis Tjeder, 1961	1			
nemorensis Kimmins, 1952	1			
productus Tjeder, 1961	1			4
reconditus Navás, 1914	1		3	
(*abyssinicus* Esb.-Pet., 1928)				
(*errans* Navás, 1914)				
(*ellenbergeri* Navás, 1933)				
rudebecki Tjeder, 1961	1			
Wesmaelius Krüger, 1922				
barnardi Tjeder, 1961	1			
nubilus Kimmins, 1929	1		3	4
majusculus Kimmins, 1959	1			
obscuratus Navás, 1936	1			
praenubilus Fraser, 1961		2		
fumosus Tjeder, 1961	1			
Sympherobiinae Comstock, 1918				
Sympherobius Banks, 1904				
fallax (Navás, 1908)	1		3	4
(*amicus* Navás, 1915)				
(*smitheri* Nakahara, 1960)				
(*brincki* Tjeder, 1961)				
(*impar* Tjeder, 1961)				
(*nigricornis* Tjeder, 1961)				
Microminae Krüger, 1922				
Micromus Rambur, 1842				
atlanticus Tjeder, 1976				4
acutipennis Kimmins, 1956	1			
africanus v. d. Weele, 1910	1			4
(*ludicrus* Navás, 1933)				
(*lanceolatus* Navás, 1910)				
(*maculipes* Fraser, 1957)				
(*Stenomus nesaeus* Navás, 1922)				
berzosai Monserrat, 1992	1			
carpentieri Lestage, 1925	1			
oblongus Kimmins, 1935	1			
parallelus Navás, 1936	1			
plagatus Navás, 1934		2		
(*malgassicus* Fraser, 1951)				
(*zonarius* Navás, 1936)				
sjoestedti v. d. Weele, 1910	1	2	3	4
(*capensis* Esben-Petersen, 1920)				
(*braunsi* Navás, 1929)				
(*laxus* Navás, 1930)				
timidus Hagen, 1853	1	2		4
(*navigatorum* Brauer, 1867)				
(*vinaceus* Gerstäcker,1885)				
(*pusillus* Gerstäcker, 1894)				
(*sauteri* Esben-Petersen, 1912)				
(*weryae* Lestage, 1923)				
(*modestus* Navás, 1936)				
(*diminutus* Nakahara, 1956)				
(*delamarei* Auber, 1956)				
(*insulanus* Navás, 1925)				
(*insularis* Hagen, 1886)				
(*multinervosus* Fraser, 1955)				
(*parallelus* Fraser, 1957)				
Notiobiellinae Nakahara, 1960				
Anapsectra Tjeder, 1975				
berothoide Monserrat, 1992	1			
medleri Tjeder, 1975	1			4
Psectra Hagen, 1866				
capensis Kimmins, 1935	1			
jeanneli Navás,1914	1			4
(*antennata* Navás, 1931)				
(*congensis* Navás, 1931)				
mozambica Tjeder, 1961	1			
Notiobiella Banks, 1909				
africana Navás, 1929				4
barnardi Monserrat, 1984	1			4
bella Navás, 1930	1			4
costalis Banks, 1918				4
decora Kimmins, 1929	1			
hargreavsi Kimmins, 1936				4
mariliae Monserrat, 1984	1			4
nitidula Navás, 1910	1	2		4
peterseni Banks, 1932	1	2		
(*punctata* Tjeder, 1961)				
rosea Kimmins, 1933	1	2		4
semeriai Monserrat, 1984	1			4
turneri Kimmins, 1933	1			
ugandensis Kimmins, 1939	1			4
vicina Kimmins, 1936	1			

Addendum: Monserrat & Deretsky (1999) report on a single female in the collections of Zool. Museum, Berlin, that evidently belongs to the palaearctic genus *Drepanepteryx* Leach, 1815 and looks extremely similar to the European *Dr. algida* (Erichson in Middendorff, 1851). Supposedly it has been collected in tropical Africa (Cameroon, Lake Tschad). If these collecting data are correct the subfamily Drepanepteryginae should be added to the list of Afrotropical Hemerobiidae.

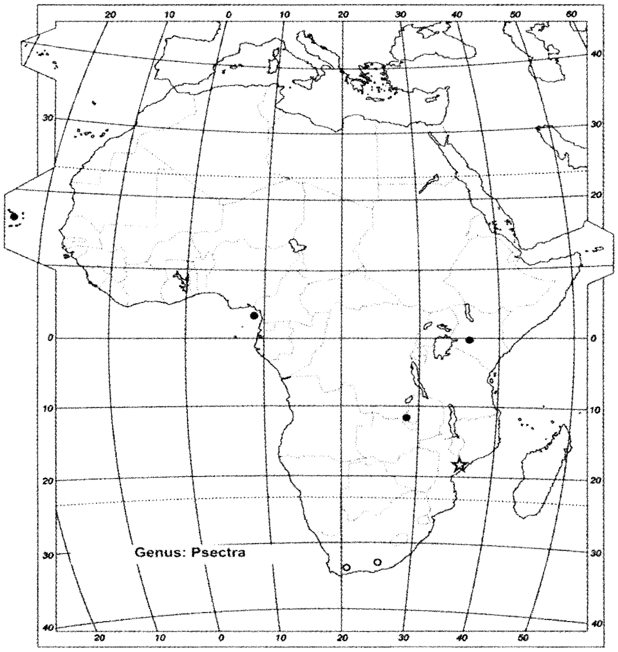

Fig. 2 – Recorded distribution of *Psectra capensis* = open circle, *Ps. jeanneli* = black circle, *Ps. mozambica* = star.

Southeast Africa, group 2 with 10 species recorded from the Madagascan subregion, group 3 with 5 species occurring on the Arabian Peninsula as well, and group 4 with 19 species recorded from West Africa.

The degree of exploration is by no means satisfactory. It is only in East- and South Africa that African and European entomologists have collected more material over the past few decades that could be evaluated. Recent collections have also been made in West Africa, on the Cape Verde Islands, in Senegal and in Equatorial Guinea. The present knowledge of the Neuroptera of the Arabian Peninsula is also satisfactory (Hölzel, 1998).

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Towards a global inventory of Mantispidae – the state-of-the-art in mantispid taxonomy

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The Mantispidae are a near-cosmopolitan family of Neuroptera with an attractive habitus and interesting behaviors. 410 species-group names are currently considered to be valid, but the true number of species is difficult to estimate. Some geographic areas such as Australia have been subject to modern revisions, but others with a remarkable high diversity, particularly Africa and southeast Asia, are still poorly documented. An analysis of the global distribution of the currently known species of Mantispidae identifies taxonomic and geographic research targets in order to develop sound genus concepts and a global species inventory as a primary step for further phylogenetic studies and biodiversity research in Mantispidae.

Key words – Neuropterida, Mantispidae, taxonomy, biogeography, biodiversity, species numbers.

Introduction

Mantispids are distinctive in having raptorial forelegs that insert at the apical end of a generally elongated prothorax. Their general appearance superficially resembles that of praying mantids (Mantodea), and, thus, mantispids are frequently called mantid flies. Most mantispid species are relatively small (forewing length <15 mm), although the largest have forewing lengths of more than 35 millimeters.

Mantispidae have an attractive habitus, interesting behaviors, and a relatively small number of species. However, even the taxonomy of Mantispidae, which is the prerequisite for any other kind of biological research, is only fragmentarily understood on a worldwide scale. Their phylogenetic position within the Neuroptera and the phylogenetic significance of the raptorial forelegs are still being disputed (e.g., U. Aspöck & Mansell, 1994; Willmann, 1990, 1994). Internal relationships among mantispid genera have not been formally and comprehensively analyzed (but see Lambkin, 1986a, b). Sound genus concepts have been developed only regionally (e.g., Lambkin, 1986a, b), and particularly the historical definitions of the large holding genus *Mantispa* and the absence of a modern re-analysis of genus limits on a worldwide scale is probably an impediment to a modern taxonomic treatment.

This paper is thought to summarize and re-analyze much of the information provided by Ohl (2004) in a catalog of the Mantispidae of the world. The goal of the paper is to identify areas of the world with a remarkable biodiversity of Mantispidae and poor taxonomic treatment in order to develop research plans for a global biodiversity assessment and taxonomic revision of the Mantispidae of the world.

Materials and Methods

I have recently published an annotated catalogue of the Mantispidae of the world (Ohl, 2004), which was based on an exhaustive examination of almost all publications with taxonomically relevant information on Mantispidae. The information in the catalog on geographic distribution of the species was ana-

Table I – Species distribution of Mantispidae per major biogeographic region. Only species-group taxa (i.e., species and subspecies) that are available, valid and extant, are included. Taxa occuring in more than one zoogeographical region are counted for all regions in which they are known to occur. Total numbers in bold are absolute numbers of valid species per genus. Abbreviations: AF = Afrotropical region, PA = Palaearctic region, NE = Nearctic region, NT = Neotropical region, OR = Oriental region, AU = Australasian region. Modified from Ohl (2004).

		Total	AF	PA	NE	NT	OR	AU
Symphrasinae		**32**						
	Anchieta Navás	**5**				5		
	Plega Navás	**14**			6	10		
	Trichoscelia Westwood	**13**				13		
Drepanicinae		**37**						
	Ditaxis McLachlan	**2**						2
	Drepanicus Blanchard	**5**				5		
	Gerstaeckerella Enderlein	**6**				6		
	Theristria Gerstaecker	**24**						24
Calomantispinae		**10**						
	Calomantispa Banks	**3**						3
	Nolima Navás	**7**			5	2		
Mantispinae		**334**						
	Asperala Lambkin	**2**					1	2
	Austroclimaciella Handschin	**9**		4			7	
	Austromantispa Esben-Petersen	**2**					1	2
	Buyda Navás	**2**				2		
	Campanacella Handschin	**1**					1	
	Campion Navás	**10**						10
	Cercomantispa Handschin	**16**	16					
	Climaciella Enderlein	**8**			1	8		
	Dicromantispa Hoffman	**5**			2	4		
	Entanoneura Enderlein	**7**	1			3	3	
	Euclimacia Enderlein	**31**		4			27	4
	Eumantispa Okamoto	**12**		4			9	2
	Haematomantispa Hoffman	**1**				1		
	Leptomantispa Hoffman	**3**			1	3		
	Madantispa Fraser	**3**	3					
	Manega Navás	**1**						1
	Mantispa Illiger	**123**	36	11	2	26	42	5
	Mimetispa Handschin	**1**					1	
	Nampista Navás	**1**		1				
	Necyla Navás	**15**	3	5			8	2
	Nivella Navás	**1**						1
	Orientispa Poivre	**12**		1			12	
	Paramantispa Williner and Kormilev	**3**				3		
	Paulianella Handschin	**2**	2					
	Perlamantispa Handschin	**10**	9	1				
	Pseudoclimaciella Handschin	**21**	21					
	Rectinerva Handschin	**1**	1					
	Sagittalata Handschin	**10**	7	1			2	
	Spaminta Lambkin	**2**						2
	Stenomantispa Stitz	**4**						4
	Toolida Lambkin	**1**						1
	Tuberonotha Handschin	**6**		1			6	1
	Xaviera Lambkin	**1**					1	1
	Xeromantispa Hoffman	**1**			1	1		
	Zeugomantispa Hoffman	**3**			1	3		
Total per geographic region			**99**	**33**	**19**	**95**	**121**	**67**
Total in Mantispidae		**410**						
			AF	PA	NE	NT	OR	AU

lyzed for the occurrence of species in the major geographic regions. All published keys on Mantispidae were checked against the catalogue for relevance, and based on this information, the state-of-the-art in mantispid taxonomy was summarized. Total numbers of published species records per politically delimited region (mostly country) worldwide were counted and were selectively mapped on the map of the earth (Fig.1). The northern part of the Palaearctic region, particularly Europe, and many small countries were omitted.

Results

Western Palaearctic – The western Palaearctic, as defined by H. Aspöck *et al.* (2001) to include Europe, northern Africa, the Arabian Peninsula, and western Asia to the eastern border of Iran, has 13 species of Mantispidae (Göbel & Ohl, unpublished data). The five European species were revised and critically discussed by H. Aspöck *et al.* (1980), U. Aspöck (1996), and U. Aspöck & H. Aspöck (1994), and this is probably close to the true species number in Europe.

The areas along the southern, eastern, and southeastern border of the western Palaearctic are still in need of comprehensive revisions. The status of some historical species names is unclear, but also new species can be expected. As an example, Hölzel (1998) listed two species from the Arabian Peninsula, but some historical names were ignored (e.g., *Necyla arabica* Navás), and recent findings have increased the total number to six, including one undescribed species (Göbel & Ohl, unpublished data). One species occurring in the Arabian Peninsula is *Mantispa nana* Erichson, which is widely distributed throughout continental Africa.

Eastern Palaearctic – Central Asia has probably only a limited number of species with close affinities to the species of the western Palaearctic, but still requires a taxonomic treatment. For example, information on Central Asian Mantispidae has been provided by Kozhanchikov (1949), Makarkin (1985), and Krivokhatsky (1995).

In the last years, studies on the Chinese Mantispidae have revealed a large number of new species mainly by the work of C.-k. Yang (e.g., Yang, 1988, 1992, 1999; Yang & Peng, 1998). China is not only geographically highly diverse, but it is also a transition zone between the Palaearctic and the Oriental region, and, thus, of particular significance for the biogeography of Mantispidae.

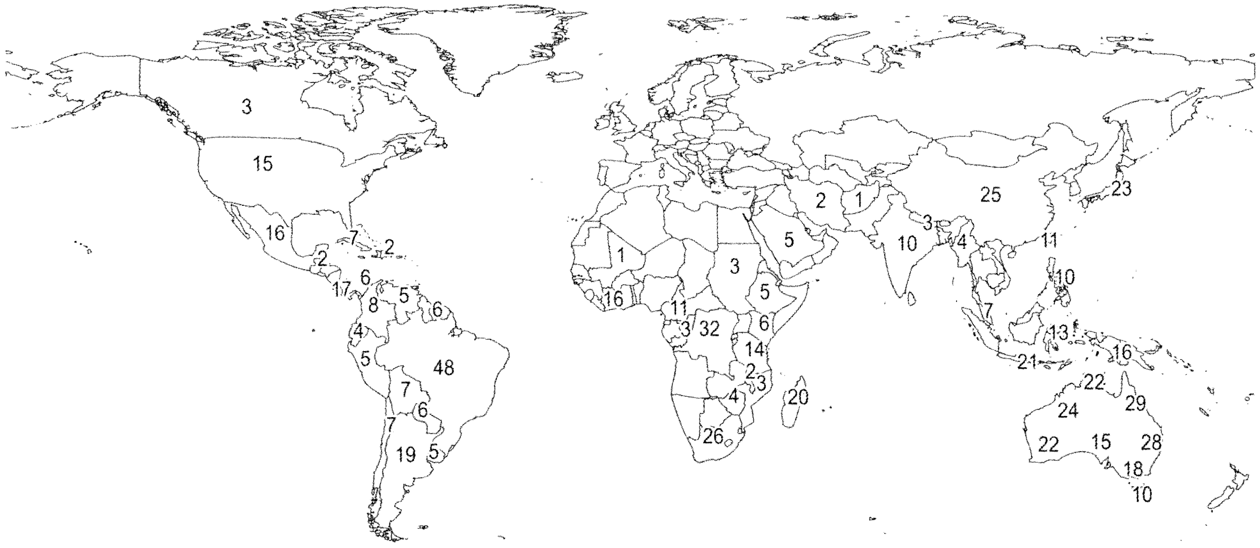

Fig. 1 – Political world map with published species numbers of Mantispidae. Numbers are omitted for Europe and most of the northern Palaearctic region (but see Results for more information).

The Japanese mantispid fauna has been quite comprehensively studied in the early 20th century, particularly by Miyake (1910), Okamoto (1910), Nakahara (1912), and Kuwayama (1925 ["1924-1925"]). These publications are still valuable, although many names are outdated.

India – The Neuropterida of India have been catalogued by Ghosh & Sen (1977), but comprehensive taxonomic treatments of Indian Mantispidae are missing, except for some isolated species descriptions mainly from the 19th century.

Australia – The approximately 60 species of Mantispidae from Australia have been monographed by Lambkin (1986a, 1986b; with supplements by Lambkin, 1987 and Lambkin & New, 1994), and catalogued by New (1996). Many of the species were previously placed in *Mantispa*, but Lambkin could show that true *Mantispa* do not occur in Australia. He described 25 new species and four new genera. It is quite unlikely that the true total number of mantispid species in continental Australia is markedly higher than Lambkin's revision indicated, but Australia is geographically and ecologically extremely diverse and locally poorly studied, so that undescribed species might still await discovery. Additionally, Lambkin (1986a, 1986b) left a few taxonomic problems (nomina dubia and probably mislabeled type species) unsolved, which might affect the total number of species in this area.

Southeast Asia including New Guinea – Southeast Asia is a geographically and ecologically highly complex area. Ohl (2004) listed 121 species of Mantispidae from the Oriental region (i.e., including India), but the majority of them is from southeast Asia. The mantispid species from this area have never been comprehensively treated. New (2003) gave an excellent introduction to the Neuroptera fauna of Malesia (which comprises southern Thailand, West and East Malaysia, the Philippines, Indonesia, and New Guinea) and catalogued the Neuroptera species recorded from there, including 63 species of Mantispidae.

Earlier, Handschin (1961) revised the genera *Euclimacia*, *Climaciella*, and *Entanoneura*, which were previously considered to be widely distributed throughout southeast Asia, Africa, and the New World. Handschin showed that only *Euclimacia* actually occurs in southeast Asia (and exclusively there), whereas the other two genera are New World elements. Among the southeast Asian Mantispidae with a relatively large body size, he documented a high amount of morphological diversity, which lead him to describe *Campanacella*, *Tuberonotha*, *Austroclimaciella*, and *Mimetispa*. Handschin provided a key to the southeast Asian genera of Mantispidae with larger body size, which is still a major source of diagnostic information. He also keyed the species of *Euclimacia* known to him, but this key is largely incomplete.

New (1998; reproduced in New, 2003) provided a key to the genera of Mantispidae from southeast Asia, which he regarded as tentative, because he did not resolve the taxonomically complex genus-group of *Mantispa*, *Mantispilla*, *Necyla*, and some probably undescribed genera. New (1998) ignored some of the characters already mentioned by Handschin (1961) as diagnostics on the genus level, which made his generic key arbitrary at some points. He illustrated wings of "anomalous mantispines" from New Guinea, which might represent undescribed species and genera.

In total, the taxonomy of the Mantispidae of southeast Asia and New Guinea is quite poorly understood. Some of the more recently described genera can be easily recognized, but the genus-group of the holding genus *Mantispa* and similar forms is still unresolved. The situation on the species-level is even worse, since no modern taxonomic revision for any of the mantispid genera in southeast Asia and New Guinea exists. Future studies will obviously result in new synonyms, but also in the discovery of new species.

Subsaharan Africa – The mantispid fauna of Africa south of the Sahara is of particular interest because of its rich diversity and its poor documentation and taxonomic status. It consists of 99 currently valid species according to Ohl (2004). Handschin (1959, 1960) redescribed many African species, described new genera and new species, and keyed the genus *Pseudoclimaciella*. His papers are still one of the major sources for African Mantispidae, but they are difficult to use for species identification. Poivre (e.g., 1981 ["1980"], 1982a ["1981"], 1982b, 1984) also described and redescribed African species. However, a comprehensive taxonomic treatment of the entire African region and even of limited parts of Africa is still lacking. A checklist of the Mantispidae of southern Africa has been recently compiled and lists 32 species for this region (Ohl & Harrison, unpublished data).

The Mantispidae of Madagascar have been treated by Paulian (1957) and Handschin (1963 ["1962"]), but these publications are incomplete and partly outdated. Some species known from Madagascar are widely distributed in continental Africa, but the status of some others is still unresolved. *Madantispa* Fraser is the only mantispid genus endemic to Madagascar and currently includes three species. The Neuropterida fauna of Madagascar is currently comprehensively studied by Norman D. Penny (see http://www.calacademy.org/research/entomology/Entomology_Resources/Faunal_Projects/madagascar_neuroptera/madanote-index.htm).

North, Central, and South America – The New World Mantispidae have been catalogued by Penny (1977; Neotropical region) and Penny *et al.* (1997; America north of Mexico). Penny (1982b) provided a generic level revision of the Mantispidae of the New World. A number of regional revisions are available, but most of them are incomplete or outdated. The Mantispinae were completely revised by Hoffman (1992), but this work is a Ph.D. dissertation, which remains only partially published (Hoffman in Penny, 2002). A large number of nomenclaturally relevant actions have been proposed by Hoffman, such as new species and new synonyms, but his results are not considered to be published and are not recognized as available under the current articles of the International Code of Zoological Nomenclature (ICZN, 1999; see also Ohl, 2004). However, Hoffman's work exemplifies how many synonyms can be expected in Mantispidae when revised on a broader geographic scale. Hoffman described 15 new species, but he proposed 56 junior synonyms, 33 of which are new. This decreases the total number of species in the Nearctic from 19 previously known species to eight, and from 95 previously known species to 40 in the Neotropics.

Revisionary works on the Symphrasinae, which are only known from South America, and the Drepanicinae, with the two South American genera *Drepanicus* and *Gerstaeckerella*, are only regional or outdated. For example, Penny (1982a) and Penny & da Costa (1983) keyed the Mantispidae of Brazil, and Rehn (1939) has revised the males of *Plega* in the America north of Mexico. The New World Symphrasinae and Drepanicinae are desperately in need of a taxonomic revision.

Discussion

Hagen (1866) presented a comprehensive listing of the genera and species of the world Mantispidae and listed four genera and 73 species known to him. The next recent catalogue of the Mantispidae of the world was published by Ohl (2004), and the numbers have increased to 44 currently valid genus-group names and 410 valid species-group names since Hagen's time. However, their taxonomy, phylogeny, and evolution are still only fragmentarily understood on a worldwide scale. A geographic analysis based on Ohl's (2004) catalogue identifies regions with high diversity and poor taxonomic treatment (Fig. 1). On a larger scale, southeast Asia with 121 described species and Africa south of the Sahara with 99 described species are only partially covered and are in desperate need of modern taxonomic analyses. The distribution of Ethiopian species throughout Africa has not been studied yet, but in southeast Asia, Malesia is obviously one of the hotspots in mantispid diversity.

Future taxonomic studies will undoubtedly require further changes in the generic placements of some taxa. Many mantispid species have been described primarily on the basis of differences in the details of coloration and wing venation (traits that are known to vary considerably in many species), and distribution. One can infer from the few comprehensive modern revisions available (e.g., Lambkin, 1986a, b; Hoffman, 2002), that many existing species-group names will eventually be relegated to synonymy when revisions of broad geographical scale are completed for poorly known regions. However, more detailed examination of other character systems, particularly male terminalia, will also undoubtedly lead to the discovery and description of many additional new species.

A general problem in mantispid taxonomy is that most species are essentially rarely collected, and many are known from the type specimens only. This is either because they are actually rare, i.e., the population density is extraordinarily low, or because the adults have a markedly short life-span. As a result, many species of mantispids, particularly those with large body size, are poorly represented in museum collections, which makes assessment of intraspecific versus interspecific variability difficult. In the few species with known biology, adult size variation can be significant, depending on the amount of larval food, i.e., the number of spider eggs in the cocoon parasitized by a mantispid (Redborg, 1998). This remarkable size variation and its allometric consequences seems to be a major source of difficulties in species delimitation in Mantispidae.

However, global collecting activities, improved collecting techniques, and increasing global cooperations among scientists result in a recent accumulation of much more material of Mantispidae and other insect groups than its was possible some decades ago. Newly collected specimens, frequently preserved in alcohol, permit to apply new methods, such as molecular systematics. Yet poorly studied character systems, such as internal soft tissue organs, are also new potential sources of relevant data revealed from newly collected material. Bringing together various methods and as many sources of information as possible are the prerequisite for what has been recently called integrative taxonomy (e.g., Dayrat, 2005; Wheeler, 2005; Ohl, in press). An integrative approach in mantispid taxonomy, in combination with much more material than was previously available, should be suitable for a deeper understanding of the world's biodiversity of Mantispidae.

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Survey towards an inventory of Italian Neuropterida

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A history is portrayed of efforts and events which have taken place in Italy in the last decade in order to form a database of information related to Italian Neuropterida. Particular emphasis is devoted to two recent initiatives, (i) the Checklist of the Species of the Italian Fauna and (ii) the Ckmap project, in which both the authors were involved. The major threat to these efforts could be the lack of an adequate amount of updating of the published database of knowledge concerning Neuropterida, a group of insects whose Italian distribution is known up to now in a quite heterogeneous way.

Key words – Checklist, Neuropterida, Italy, faunistics, chorology.

Introduction

Switching to computer and internet from paper and pencil, the matter of the faunistic database has dramatically changed. Not only technology but also the interest of community ecologists and other zoologists in species occurrence records and lists is rapidly increasing (Gotelli, 2004). On the other hand the national authorities acknowledged, now a long time ago, that biological diversity is a common concern of humankind and that its conservation is an appropriate objective (United Nations, 1993). So, although slower than hoped, in the last quarter of a century many projects have been born and a myriad of records and lists are now available on the Web.

Here we wish to describe the efforts of the scientific community and national authorities in order to list the Italian fauna and its distribution, with particular emphasis on Neuropterida.

The “Comitato Scientifico per la Fauna d’Italia” and the “Fauna d’Italia” book series

On April 18th, 1952, a meeting of Italian entomologists and zoologists, promoted by the Italian Academy of Entomology (“Accademia Nazionale Italiana di Entomologia”), together with the Italian Zoological Society (“Unione Zoologica Italiana”), was held in Florence, with the aim of organizing a new editorial initiative: a series of books concerning the Italian Fauna (“Fauna d’Italia”) (Anonimo, 1955). The famous entomologist Guido Grandi, who was at that time president of the Academy of Entomology, strongly supported the initiative: he had emphatically urged the Italian scientific community to start that series of books several times (Grandi, 1940).

The first issue of the “Fauna d’Italia” was published few years later (Conci & Nielsen, 1956) and, up to now, 40 volumes have been published, 29 related to arthropods (25 to insects in particular), 7 to vertebrates, and the remains to other animal groups.

In the initial meeting of the Scientific Committee for the Fauna of Italy ("Comitato Scientifico per la Fauna d'Italia"), a preliminary plan of the work was drafted, with a rough list of 24 issues which several specialists present at the meeting were willing to produce (Anonimo, 1955). In that list, two books related to Neuropterida were foreseen: one concerning myrmeleontids and ascalaphids (the author should have been Felice Capra, Civic Museum of Natural History "G. Doria", Genoa), the other concerning chrysopids (by Maria Matilde Principi, Institute of Entomology, University of Bologna). Neither would be realized! A book related to all of the Italian Neuropterida is, still, only in the minds of the two authors of this contribution.

Checklist of the Species of the Italian Fauna

An anecdotal description of the genesis of the "Checklist delle Specie della Fauna d'Italia" is reported in Minelli (1996). This idea was born in 1991 and it became a project through the financial support of the Nature Conservation Service (Ministry of the Environment). The project, developed through an agreement with the Scientific Committee for the Fauna of Italy, allowed for the first time in Europe (perhaps in the World) the complete inventory of the animal species of a whole country. 272 specialists from 15 countries participated in the project.

The work (Minelli *et al.*, 1993-95) was published in 110 issues (from number 33 to number 106 concerning insects). The complete work was printed in 24 volumes. The systematic sequence is strictly maintained at least within every issue up to the genus level, however, inside each genus, the species are often listed in alphabetical order. Species are uniquely identified by numerical codes. The very simple structure of the list includes: a) distribution of species in few and large geographical regions or marine areas (Fig. 1); b) status of endemic or threatened species; c) concise data on host species for parasites and nesting for birds; d) a minimum of notes and synonymy.

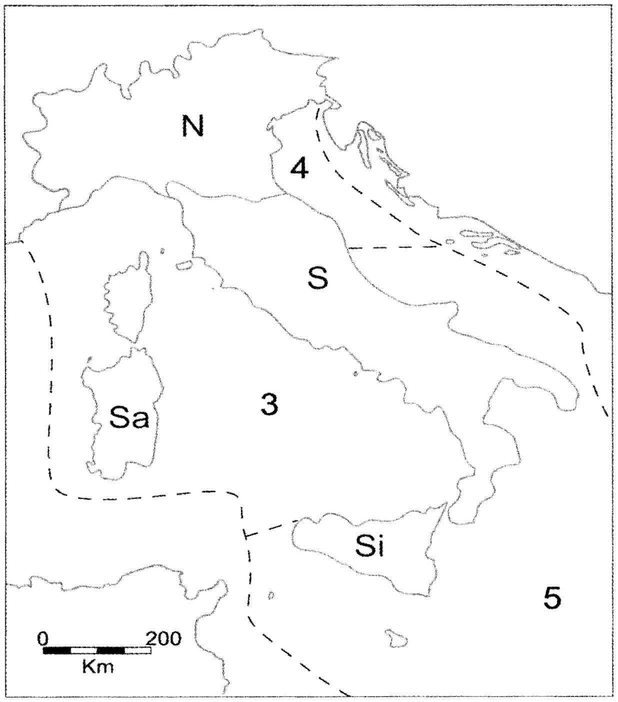


Fig. 1 – Geographical regions or marine areas utilized in the "Checklist of the species of the Italian fauna" (1993-1995).

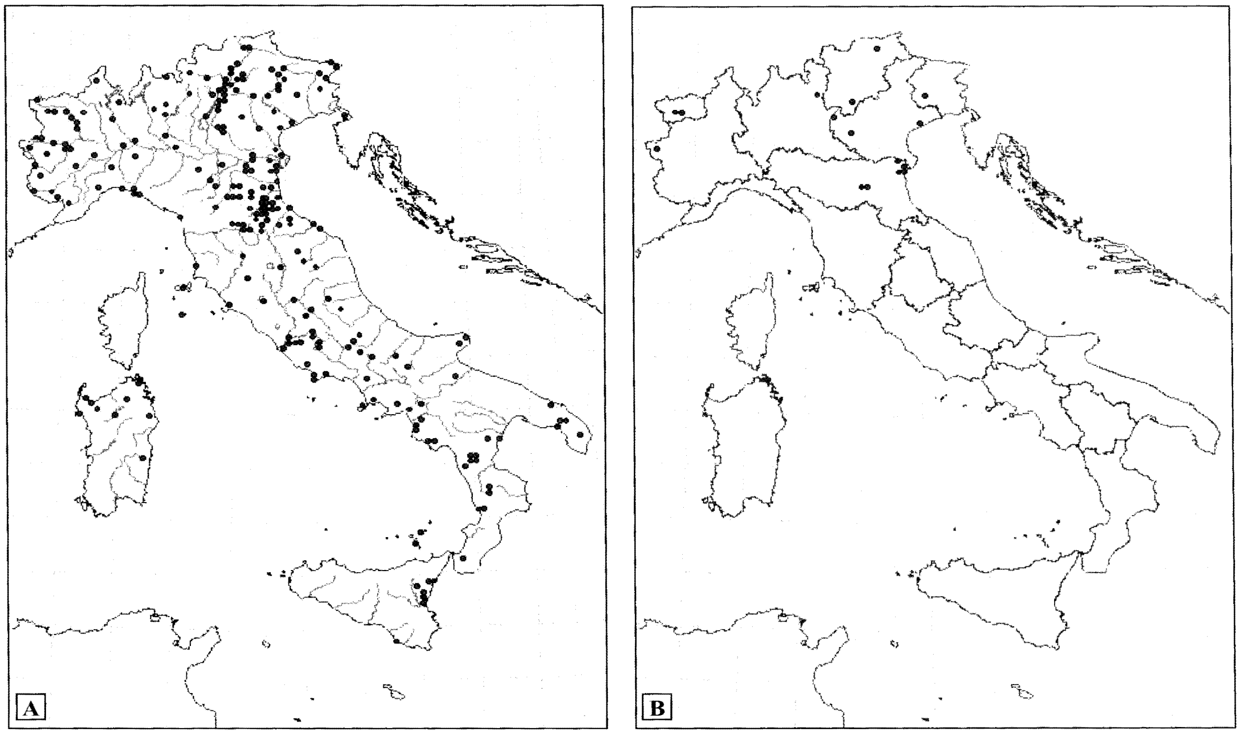
The species of the Italian fauna known up to the year of Checklist publication are 57.422 (including subspecies), of which 1.814 'protozoans' and 1.255 vertebrates, whereas the number of insects is 37.315 (Minelli, 1996) [a subsequent count, excluding subspecies, by Stoch (2000) provides slightly different figures].

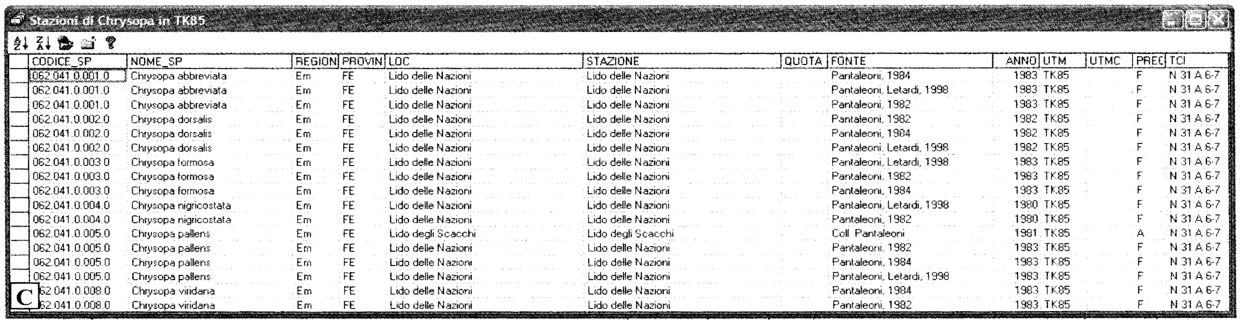
A Checklist of the Italian Neuropterida [as Neuropteroidea] was published in issue 62 together with Mecoptera, Siphonaptera, and Strepsiptera ([Bernardi] Iori *et al.*, 1995). Maria Matilde Principi and Roberto A. Pantaleoni were the authors for Neuropterida (in the same issue Agostino Letardi was the author for Mecoptera). 178 taxa were listed there, including two subspecies and two species whose presence in Italy was doubtful. At family level, the richest number of species was achieved by Hemerobiidae (44), *Hemerobius* Linnaeus, 1758 was the richest genus (15). On that occasion, the authors checked all the available published and unpublished data.

According to Ruffo & Stoch (2005), the Checklist will depreciate greatly if it is not updated continually, and if the information is not made public as soon as possible. To avoid these risks, the Checklist was at first transformed into a hierarchical database published on the Web in an On-line version 2.0 (Stoch, 2003). Moreover from 1999 up to 2004, the "Bollettino della Società Entomologica Italiana" has published 18 updates to the Checklist related to arthropods

Tab. I – List to the Genus/Subgenus level, and species number of Neuropterida in the Checklist of the species of the Italian fauna (1995). Genus/subgenus names are the same reported in the Checklist.

Megaloptera			
	Sialidae		
		Sialis	4
Raphidioptera			
	Raphidiidae		
		Phaeostigma s. str.	3
		Ph. (Pontoraphidia)	1
		Dichrostigma	1
		Tjederiraphidia	1
		Subilla	1
		Ornatoraphidia	1
		Xanthostigma	3
		Raphidia s. str.	4
		Italoraphidia	1
		Puncha	1
		Venustoraphidia	1
	Inocelliidae		
		Fibla s. str.	1
		Parainocellia s. str.	1
Planipennia			
	Coniopterygidae		
		Aleuropteryx	2
		Helicoconis s. str.	2
		H. (Ohmopteryx)	1
		Coniopteryx s. str.	3
		C. (Holoconiopteryx)	3
		C. (Metaconiopteryx)	3
		Parasemidalis	1
		Hemisemidalis	1
		Conwentzia	2
		Semidalis	3
	Osmylidae		
		Osmylus	1
	Nevrorthidae		
		Nevrorthus	2
	Sisyridae		
		Sisyra	3
	Berothidae		
		Isoscelipteron	1
	Mantispidae		
		Mantispa	1
		Perlamantispa	2
	Dilaridae		
		Dilar	2
	Hemerobiidae		
		Hemerobius	15
		Wesmaelius	11
		Sympherobius	7
		Psectra	1
		Megalomus	4
		Drepanepteryx	2
		Micromus	4
	Chrysopidae		
		Italochrysa	1
		Brinckochrysa	1
		Chrysopa	9
		Chrysoperla	3
		Chrysopidia (Chrysotropia)	1
		Cunctochrysa	2
		Mallada	11
		Nineta	5
		Peyerimhoffina	1
		Rexa	1
		Hypochrysa	1
		Nothochrysa	2
	Myrmeleontidae		
		Palpares	1
		Dendroleon	1
		Acanthaclisis	2
		Myrmecaelurus s. str.	1
		Cueta	1
		Myrmeleon s. str.	2
		M. (Morter)	3
		Euroleon	1
		Macronemurus	1
		Neuroleon	5
		Distoleon	2
		Nemoleon	1
		Nicarinus	1
		Creoleon	5
		Megistopus	2
		Gymnocnemia	1
	Ascalaphidae		
		Bubopsis	1
		Deleproctophylla	1
		Libelloides	7





Stazioni di Chrysopa in TK85

CODICE_SP	NOME_SP	REGION	PROVIN	LOC	STAZIONE	QUOTA	FONTE	ANNO	UTM	UTMC	PREC	TCI
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1984	1983	TK85		F	N 31 A 6-7
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, Letardi, 1998	1983	TK85		F	N 31 A 6-7
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1983	TK85		F	N 31 A 6-7
062.041.0.002.0	Chrysopa dorsalis	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1982	TK85		F	N 31 A 6-7
062.041.0.002.0	Chrysopa dorsalis	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1984	1982	TK85		F	N 31 A 6-7
062.041.0.002.0	Chrysopa dorsalis	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, Letardi, 1998	1982	TK85		F	N 31 A 6-7
062.041.0.003.0	Chrysopa formosa	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, Letardi, 1998	1983	TK85		F	N 31 A 6-7
062.041.0.003.0	Chrysopa formosa	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1983	TK85		F	N 31 A 6-7
062.041.0.003.0	Chrysopa formosa	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1984	1983	TK85		F	N 31 A 6-7
062.041.0.004.0	Chrysopa nigricostata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, Letardi, 1998	1980	TK85		F	N 31 A 6-7
062.041.0.004.0	Chrysopa nigricostata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1980	TK85		F	N 31 A 6-7
062.041.0.005.0	Chrysopa pallens	Em	FE	Lido degli Scacchi	Lido degli Scacchi		Coll. Pantaleoni	1981	TK85		A	N 31 A 6-7
062.041.0.005.0	Chrysopa pallens	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1983	TK85		F	N 31 A 6-7
062.041.0.005.0	Chrysopa pallens	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1984	1983	TK85		F	N 31 A 6-7
062.041.0.005.0	Chrysopa pallens	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, Letardi, 1998	1983	TK85		F	N 31 A 6-7
62.041.0.008.0	Chrysopa viridana	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1984	1983	TK85		F	N 31 A 6-7
62.041.0.008.0	Chrysopa viridana	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1983	TK85		F	N 31 A 6-7

Fig. 2 – **A**, Distribution of genus *Chrysopa* in Italy (hydrographical map); **B**, Distribution of *Chrysopa abbreviata* in Italy (administrative map with regional boundaries); **C**, Database of the UTM TK85 grid cell concerning genus *Chrysopa*.

(Minelli *et al.*, 1999). An On-line version (release 3.0) should permit a continual updating of the Checklist and its free consultation (Stoch *et al.*, 2004). Regrettably that last version was never released and the printed updates were postponed. Anyway, up to now, no update at all has been made related to Neuropterida.

The Ckmap (*Chec*k*list* *map*ping) project

On the basis of the scientific network created for the implementation of Checklist and its own development, the Nature Conservation Service (Ministry of the Environment), still in collaboration with the Scientific Committee for the Fauna of Italy, planned a data bank on the distribution of Italian Fauna. Two scientific institutions were responsible for the data collection: the Museum of Natural History of Verona and the Department of Ecology of the University of Calabria.

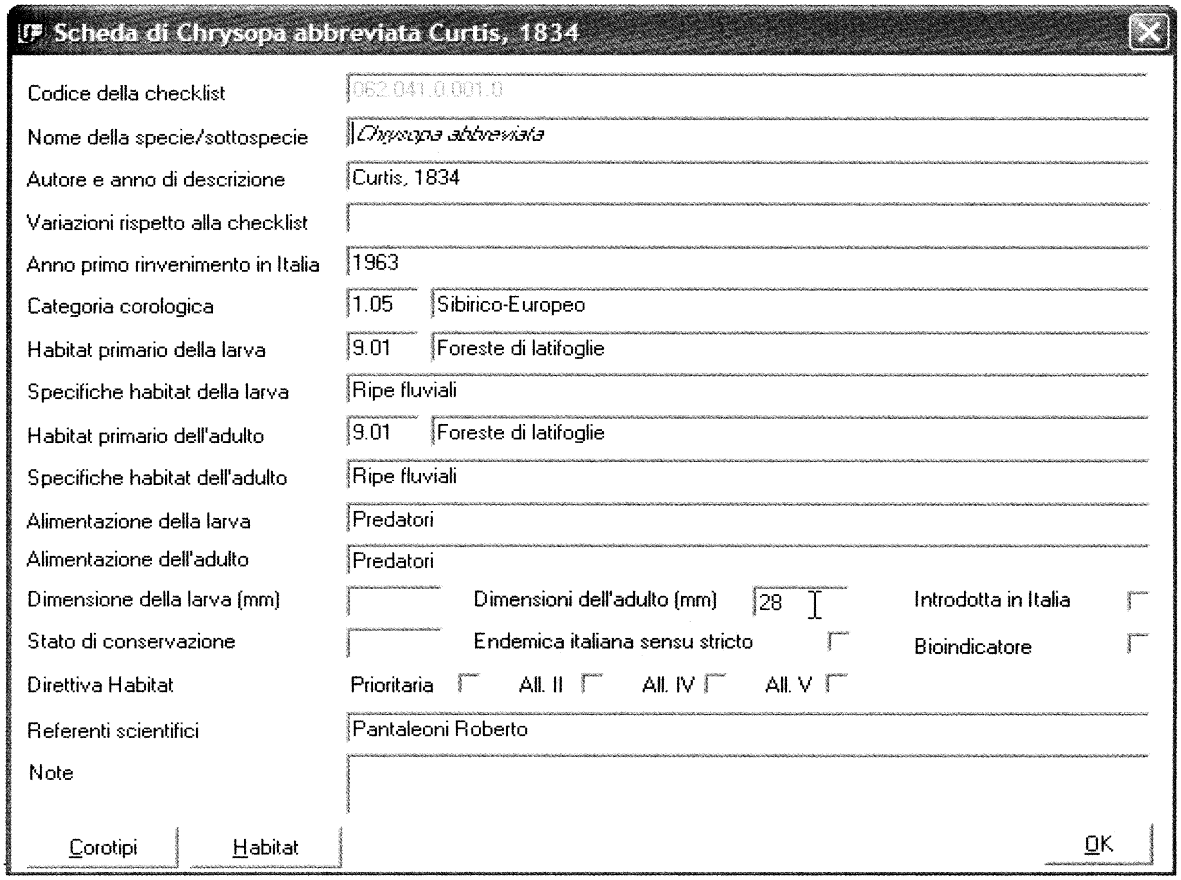
Many invertebrate taxa (orders and families), including about 10.000 species, were selected following Pearson's criteria (1995): well known distribution, taxonomic stability, no or small variation in distribution range with time, etc. Nevertheless the main criterion was the availability of experienced specialists (often the same as the Checklist network).

In this project, the specialists compiled three tables for each species: 1) a species-index card including taxonomic, chorological and ecological data such as habitat, food, conservation status, indicator value; 2) a distribution-table including all species records with coordinates added by a simplified software method, localities were automatically geo-referenced in the UTM grid (10 x 10 km grid cells); 3) a reference-table storing the list of literature sources and collections examined. The database was implemented on desktop computers using the software MS Access® 2000. The more recent software, named Ckmap2004, has some mapping tools for tracing distribution of taxa, overlaying geographical and thematic layers (e.g. administrative boundaries, natural reserve network, hydrography), etc. (Latella *et al.*, 2005).

At the end of the project approximately 500.000 records were stored in the database. Recently a book concerning the Ckmap project was published (Ruffo & Stoch, 2005), including a CD with the database source (Stoch, 2005). Regrettably, as for the On-line version 3.0 of the Checklist, this database too, and its related software Ckmap 2004 version 5.1, is not yet available on the internet.

Neuropterida in the Ckmap project

In the frame of Ckmap2004 software, data sets of 185 taxa of Neuropterida were implemented utilizing mainly reports


Scheda di Chrysopa abbreviata Curtis, 1834

Codice della checklist	062.041.0.001.0
Nome della specie/sottospecie	*Chrysopa abbreviata*
Autore e anno di descrizione	Curtis, 1834
Variazioni rispetto alla checklist	
Anno primo rinvenimento in Italia	1963
Categoria corologica	1.05 Sibirico-Europeo
Habitat primario della larva	9.01 Foreste di latifoglie
Specifiche habitat della larva	Ripe fluviali
Habitat primario dell'adulto	9.01 Foreste di latifoglie
Specifiche habitat dell'adulto	Ripe fluviali
Alimentazione della larva	Predatori
Alimentazione dell'adulto	Predatori
Dimensione della larva (mm)	
Dimensioni dell'adulto (mm)	28
Introdotta in Italia	☐
Stato di conservazione	
Endemica italiana sensu stricto	☐
Bioindicatore	☐
Direttiva Habitat	Prioritaria ☐ All. II ☐ All. IV ☐ All. V ☐
Referenti scientifici	Pantaleoni Roberto
Note	

Fig. 3 – Report card of *Chrysopa abbreviata*.

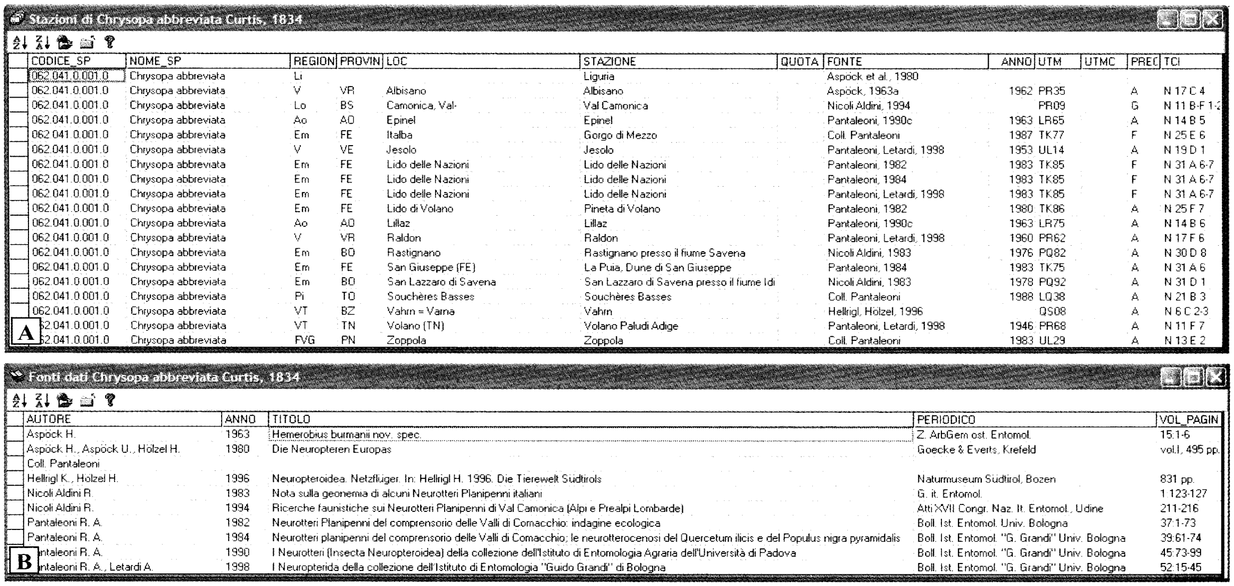
published or revised in the last two decades of the XX century by ourselves (Letardi, 2005). The filling in of species' distribution data was carried out by both of us (Pantaleoni did the Raphidioptera and, among the Neuroptera, Chrysopidae and Myrmeleontidae; Letardi did the Megaloptera and the remaining Neuroptera). Most of the reported data was personally checked by one of the two authors: old citations, particularly those referring to the families Chrysopidae and Hemerobiidae, were carefully screened, their assignment to the species currently considered as valid being often difficult, if not impossible in some cases. A lot of the material preserved in the main public and private Italian collections was included, thanks to study work carried out mainly during the past twenty years. The results of such studies had in most cases already been published, unpublished data therefore mainly accounted for only a small portion of total records.

A map of the Italian distribution of each genera can be generated (Fig. 2); local enlargements can be carried out; each point matches a specific 10 x 10 km grid cell. Clicking on a specific point, it is possible to have full information concerning the species of this genus collected in that specific grid cell. All these functions are effective for each single species; moreover, the tool could provide a summarizing chart of the available data concerning the species (Fig. 3), the bibliographic references, and a list of all the localities (Fig. 4). About 4.000 records of Italian Neuropterida have been scheduled in the database.

Conclusions

The "state of the art" of knowledge concerning the Italian Neuropterida resulting from this project is not quite homogeneous: only specific areas are well investigated, moreover in public and private collections only few families (i.e. Chrysopidae, Hemerobiidae, Myrmeleontidae and Ascalaphidae) are adequately represented. The recent additions to the Italian Raphidioptera (Letardi, 2004; Pantaleoni *et al.*, 2004; Rausch *et al.*, 2004) suggest that our degree of knowledge is far from exhaustive, in particular among certain families.

The Checklist and Ckmap projects represent a basic resource for taxonomic, systematic and ecological studies, unfortunately their level of public/free availability is up to now very low and no updates have



Stazioni di Chrysopa abbreviata Curtis, 1834

CODICE_SP	NOME_SP	REGION	PROVIN	LOC	STAZIONE	QUOTA	FONTE	ANNO	UTM	UTMC	PREC	TCI
062.041.0.001.0	Chrysopa abbreviata	Li			Liguria		Aspöck et al., 1980					
062.041.0.001.0	Chrysopa abbreviata	V	VR	Albisano	Albisano		Aspöck, 1963a	1962	PR35		A	N 17 C 4
062.041.0.001.0	Chrysopa abbreviata	Lo	BS	Camonica, Val-	Val Camonica		Nicoli Aldini, 1994		PR09		G	N 11 B-F 1-2
062.041.0.001.0	Chrysopa abbreviata	Ao	AO	Epinel	Epinel		Pantaleoni, 1990c	1963	LR65		A	N 14 B 5
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Italba	Gorgo di Mezzo		Coll. Pantaleoni	1987	TK77		F	N 25 E 6
062.041.0.001.0	Chrysopa abbreviata	V	VE	Jesolo	Jesolo		Pantaleoni, Letardi, 1998	1953	UL14		A	N 19 D 1
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1982	1983	TK85		F	N 31 A 6-7
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, 1984	1983	TK85		F	N 31 A 6-7
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido delle Nazioni	Lido delle Nazioni		Pantaleoni, Letardi, 1998	1983	TK85		F	N 31 A 6-7
062.041.0.001.0	Chrysopa abbreviata	Em	FE	Lido di Volano	Pineta di Volano		Pantaleoni, 1982	1980	TK86		A	N 25 F 7
062.041.0.001.0	Chrysopa abbreviata	Ao	AO	Lillaz	Lillaz		Pantaleoni, 1990c	1963	LR75		A	N 14 B 6
062.041.0.001.0	Chrysopa abbreviata	V	VR	Raldon	Raldon		Pantaleoni, Letardi, 1998	1960	PR62		A	N 17 F 6
062.041.0.001.0	Chrysopa abbreviata	Em	BO	Rastignano	Rastignano presso il fiume Savena		Nicoli Aldini, 1983	1976	PQ82		A	N 30 D 8
062.041.0.001.0	Chrysopa abbreviata	Em	FE	San Giuseppe (FE)	La Puia, Dune di San Giuseppe		Pantaleoni, 1984	1983	TK75		A	N 31 A 6
062.041.0.001.0	Chrysopa abbreviata	Em	BO	San Lazzaro di Savena	San Lazzaro di Savena presso il fiume Idi		Nicoli Aldini, 1983	1978	PQ92		A	N 31 D 1
062.041.0.001.0	Chrysopa abbreviata	Pi	TO	Souchères Basses	Souchères Basses		Coll. Pantaleoni	1988	LQ38		A	N 21 B 3
062.041.0.001.0	Chrysopa abbreviata	VT	BZ	Vahrn = Varna	Vahrn		Hellrigl, Hölzel, 1996		QS08		A	N 6 C 2-3
62.041.0.001.0	Chrysopa abbreviata	VT	TN	Volano (TN)	Volano Paludi Adige		Pantaleoni, Letardi, 1998	1946	PR68		A	N 11 F 7
62.041.0.001.0	Chrysopa abbreviata	FVG	PN	Zoppola	Zoppola		Coll. Pantaleoni	1983	UL29		A	N 13 E 2

Fonti dati Chrysopa abbreviata Curtis, 1834

AUTORE	ANNO	TITOLO	PERIODICO	VOL_PAGIN
Aspöck H.	1963	Hemerobius burmanii nov. spec.	Z. ArbGem ost. Entomol.	15:1-6
Aspöck H., Aspöck U., Hölzel H.	1980	Die Neuropteren Europas	Goecke & Everts, Krefeld	vol.I, 495 pp.
Coll. Pantaleoni				
Hellrigl K., Hölzel H.	1996	Neuropteroidea. Netzflüger. In: Hellrigl H. 1996. Die Tierewelt Südtirols	Naturmuseum Südtirol, Bozen	831 pp.
Nicoli Aldini R.	1983	Nota sulla geonemia di alcuni Neurotteri Planipenni italiani	G. it. Entomol.	1:123-127
Nicoli Aldini R.	1994	Ricerche faunistiche sui Neurotteri Planipenni di Val Camonica (Alpi e Prealpi Lombarde)	Atti XVII Congr. Naz. It. Entomol., Udine	211-216
Pantaleoni R. A.	1982	Neurotteri Planipenni del comprensorio delle Valli di Comacchio: indagine ecologica	Boll. Ist. Entomol. Univ. Bologna	37:1-73
Pantaleoni R. A.	1984	Neurotteri planipenni del comprensorio delle Valli di Comacchio; le neurotterocenosi del Quercetum ilicis e del Populus nigra pyramidalis	Boll. Ist. Entomol. "G. Grandi" Univ. Bologna	39:61-74
ntaleoni R. A.	1990	I Neurotteri (Insecta Neuropteroidea) della collezione dell'Istituto di Entomologia Agraria dell'Università di Padova	Boll. Ist. Entomol. "G. Grandi" Univ. Bologna	45:73-99
ntaleoni R. A., Letardi A.	1998	I Neuropterida della collezione dell'Istituto di Entomologia "Guido Grandi" di Bologna	Boll. Ist. Entomol. "G. Grandi" Univ. Bologna	52:15-45

Fig. 4 – **A**, Database of collecting places for *Chrysopa abbreviata*; **B**, Database of references for *Chrysopa abbreviata*.

been possible until now. Both the authors strongly expect that each on-line version will be put on-line in the near future, and that they will be continuously updated.

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cato e ogni tanto sollevato e riabbassato ritmicamente, mentre le ali sono leggermente allontanate e riavvicinate. Questi movimenti si possono ripetere ad intervalli per venticinque minuti. Finalmente, con notevoli sforzi viene emessa dall'apertura anale una massa baccelliforme, nera, compatta, lucida, lunga circa 2 mm., costituita dai residui dell'alimentazione larvale (¹). L'insetto è ora pronto per iniziare la sua vita di immagine.

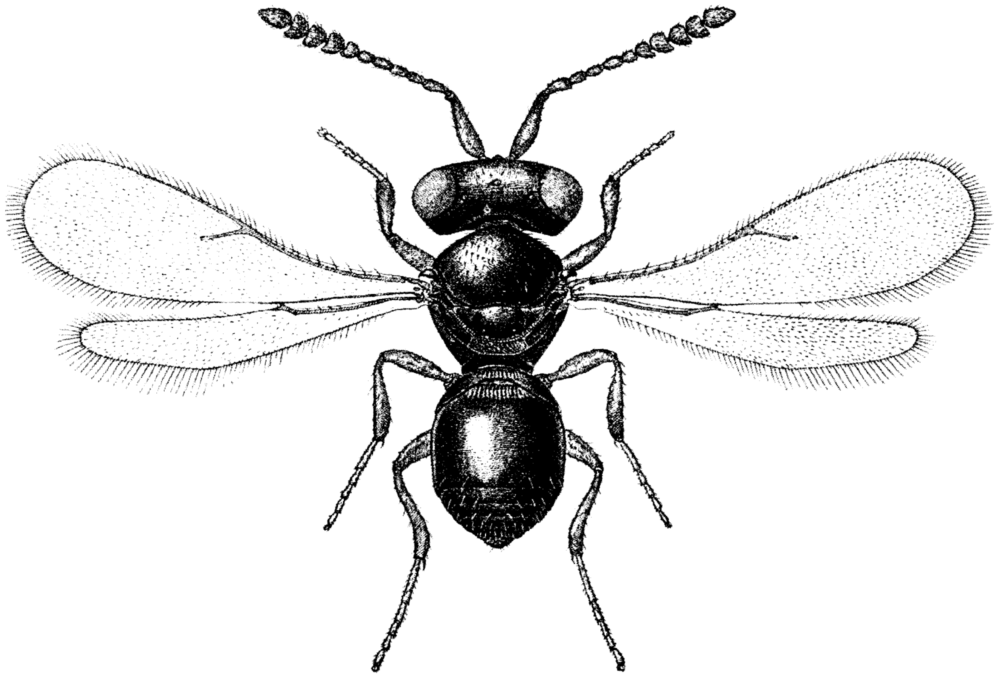

FIG. XXIX.

Telenomus acrobates Giard. - Femmina adulta.

Gli adulti di *C. septempunctata* fanno la loro comparsa nella prima quindicina di maggio. In Umbria, nell'anno 1937, vidi volare i primi esemplari il 15 maggio, mentre nei dintorni di Bologna, nel 1939, il 7 maggio feci la prima cattura costituita da una femmina non ancora fecondata. Fino a tutto agosto ho potuto poi, solo che mi riuscisse di individuare una pianta infestata dagli Afidi preferiti, trovare adulti senza una notevole discontinuità. Nell'anno 1939, in cui

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(¹) È noto che gli escrementi accumulati nell'intestino medio vengono evacuati dall'adulto, ancora avvolti dalla membrana peritrofica, subito dopo lo sfarfallamento.

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The Raphidioptera of the Apennines Peninsula: a biogeographical analysis*

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So far, 24 species of Raphidioptera – 21 of Raphidiidae/3 of Inocelliidae – have been found in Italy, 22 (20/2) of these on the mainland only. Five species (4/1) have been detected only in the northernmost parts (Southern Alps), 17 species (16/1) have been recorded from various parts of the Apennines Peninsula (AP). By far most of these are monocentric Adriatomediterranean faunal elements (8/1), 3 species of Raphidiidae are polycentric Adriatomediterranean-Balkanopontomediterranean faunal elements. Four species of Raphidiidae are endemic to the AP. Three of these species, each representing a systematically isolated monotypic genus confined to the south of the AP, are most probably ancient inhabitants of the AP and of Iberian origin: *Italoraphidia solariana*, *Calabroraphidia renate* and *Tjederiraphidia santuzza*. The fourth endemic species, *Phaeostigma (Pontoraphidia) grandii*, although more recent, is possibly a remainder of the old fauna of the Apulian platform. Of the remaining monocentric Adriatomediterranean elements only *Subilla confinis* shows an expansivity which has led to a (mainly postglacial) colonisation of larger parts of Central, western and eastern Europe. The others have hardly extended their distributions beyond the AP (*Raphidia ligurica*, *Parainocellia bicolor*) or they have colonised only small parts of the south of Central Europe, southern France, and northern Spain (*Phaeostigma italogallica*, *Xanthostigma aloysiana*, *X. corsica*). Regarding the polycentric species, two (*Ornatoraphidia flavilabris*, *Venustoraphidia nigricollis*) also inhabit many extramediterranean parts of Europe, but these colonisations occurred from the Balkan Peninsula (BP) and not from the AP. The remaining species (*Dichrostigma flavipes*, *Turcoraphidia amara*, *Raphidia mediterranea*, *Puncha ratzeburgi*) are recent invaders (during the Pleistocene) from the east and/or from the north. The Raphidioptera species presently inhabiting the AP exhibit extensive differences in age and origin reflecting the complex geomorphological history of the peninsula.

Keywords – Raphidioptera, Raphidiidae, Inocelliidae, Apennines Peninsula, Italy, biogeography, endemisms.

Introduction

The Raphidioptera of the Mediterranean parts of Europe have been intensively studied throughout the past decades, in particular, also those of the Apennines Peninsula (AP). Since the latest accounts and biogeographical analyses (H. Aspöck *et al.*, 1991, 2001; [Bernardi] Iori *et al.*, 1995), besides new records of several species, two surprising discoveries have been made on the mainland of Italy, one of them leading to the description of a new species belonging to a new genus (Rausch *et al.*, 2004; Fig. 1), the other

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* Gratefully, cordially, and respectfully dedicated to Professor Maria Matilde Principi on the occasion of her 90th birthday (May 4th, 2005). With her papers on Raphidioptera published during the 1950s and 1960s she has initiated a new era in Raphidioptera research. Her studies, descriptions, conclusions, and considerations, and, in particular, also her outstanding drawings have been of utmost influence for our further neuropterological work.

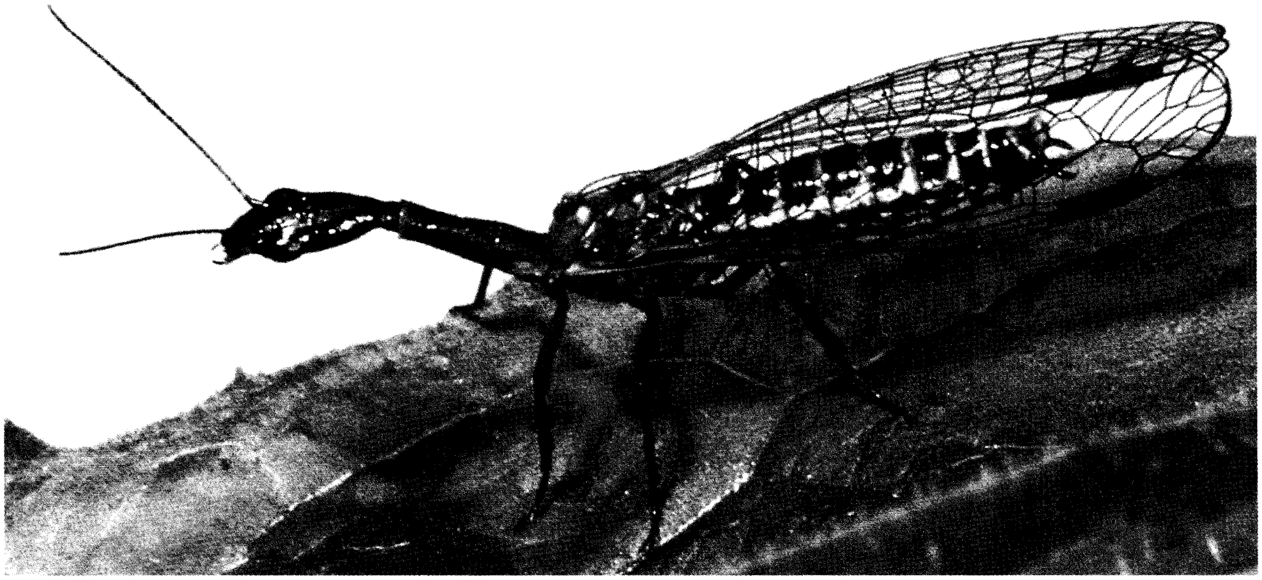

Fig. 1 – *Calabroraphidia renate* Rausch & H. Aspöck & U. Aspöck, 2004, ♂. Italia, Calabria, Cosenza, Sila Grande, near Viváio, 39° 23' 38" N / 16° 36' 24" E, 1300 m, 18 June 2005, H. & R. Rausch leg. (Photograph by Hubert Rausch).

representing a species and a genus so far only known from Pontomediterranean regions (Letardi, 2004), and, in addition, a spectacular new species has been detected in Sardinia (Pantaleoni *et al.*, 2005). Moreover, research on the palaeogeography and palaeoclimatology of the Mediterranean has made considerable progress so that the time has come to reconsider the genesis of the Raphidioptera fauna of the AP and to summarise our knowledge on snake-flies of this part of Europe in light of biogeography.

The Raphidioptera (snake-flies) with about 215 valid (and possibly 250 existing) species is the smallest and more ancestral order of the Holometabola. During the Mesozoic snake-flies occurred in a significantly greater diversity than today, and they also inhabited tropical regions (H. Aspöck, 1998, 2004; U. Aspöck & H. Aspöck, 2003, 2004, 2005a). Nowadays they are designated as living fossils, while their present distribution is restricted to arboreal parts of the Northern hemisphere.

The western Palaearctic harbours the highest number of species (about 110), however, most of them are restricted to small areas in mountain ranges of the peninsulas of Southern Europe, northwest Africa, Anatolia, and a few other parts of the Near East respectively. No snake-fly species exists with a distribution comprising all three south European peninsulas, and very few species occur in the AP as well as the Iberian Peninsula (IP) or the Balkan Peninsula (BP).

Snake-flies in general are characterised by an extremely low expansivity. The majority of species from both families on all continents inhabit small areas, in many cases just a few mountain ranges. Several species exist which have been recorded from a single mountain only (stationary species). Rarely do species occupy large distribution areas. Examples are, on one hand, a few Euro-Siberian elements with distributions covering large parts of Europe and northern Asia (they are particularly associated with the belt of the coniferous forests), and on the other hand, several Nearctic species occurring along the Rocky Mountains from the north of Mexico to the south of western Canada. So far it is unknown why so many Raphidioptera species are markedly stationary although it seems that identical or, at least suitable ecological conditions exist in adjacent regions.

The Raphidioptera of Italy also contain several extremely stationary species (*I. solariana*, *C. renate*, *T. santuzza*) as well as a number of species with very low (e.g. *Ph. grandii*) or modest expansivity (e.g. *Parainocellia bicolor*), but only one really expansive species (*Subilla confinis*).

The biogeographical terminology used in this article follows that in the Biogeography Glossary in H. Aspöck *et al.* (1991).

Annotated list of the Raphidioptera of Italy

At present, the following species have been found in continental parts of Italy; the list is made complete by the addition of comments on the snake-flies of the Italian islands. For distribution maps see H. Aspöck *et al.* (1991); additional records in Italy: Pantaleoni (1990a, 1990b); Letardi (1991, 1993, 1994, 2004); Pantaleoni *et al.* (1994); Hellrigl & Hölzel (1996); Letardi & Pantaleoni (1996); Pantaleoni & Letardi (1998); Güsten (1998a, b, c); Letardi & Maltzeff (2001); Nicoli Aldini & Baviera (2001); Rausch *et al.* (2004); Pantaleoni (2005).

Phaeostigma (Phaeostigma) notata (Fabricius, 1781)

Widely distributed in extramediterranean parts of Europe. Recorded in Italy only in the northernmost parts, i.e. in the Southern Alps.

Phaeostigma (Phaeostigma) italogallica (H. Aspöck & U. Aspöck, 1976)

Known only from the south of Italy and from southern France.

Phaeostigma galloitalica (H. Aspöck & U. Aspöck, 1976)

Recorded from the AP, southern France and Dalmatia.

Phaeostigma (Pontoraphidia) grandii (Principi, 1960)

Recorded only from the southern half of the

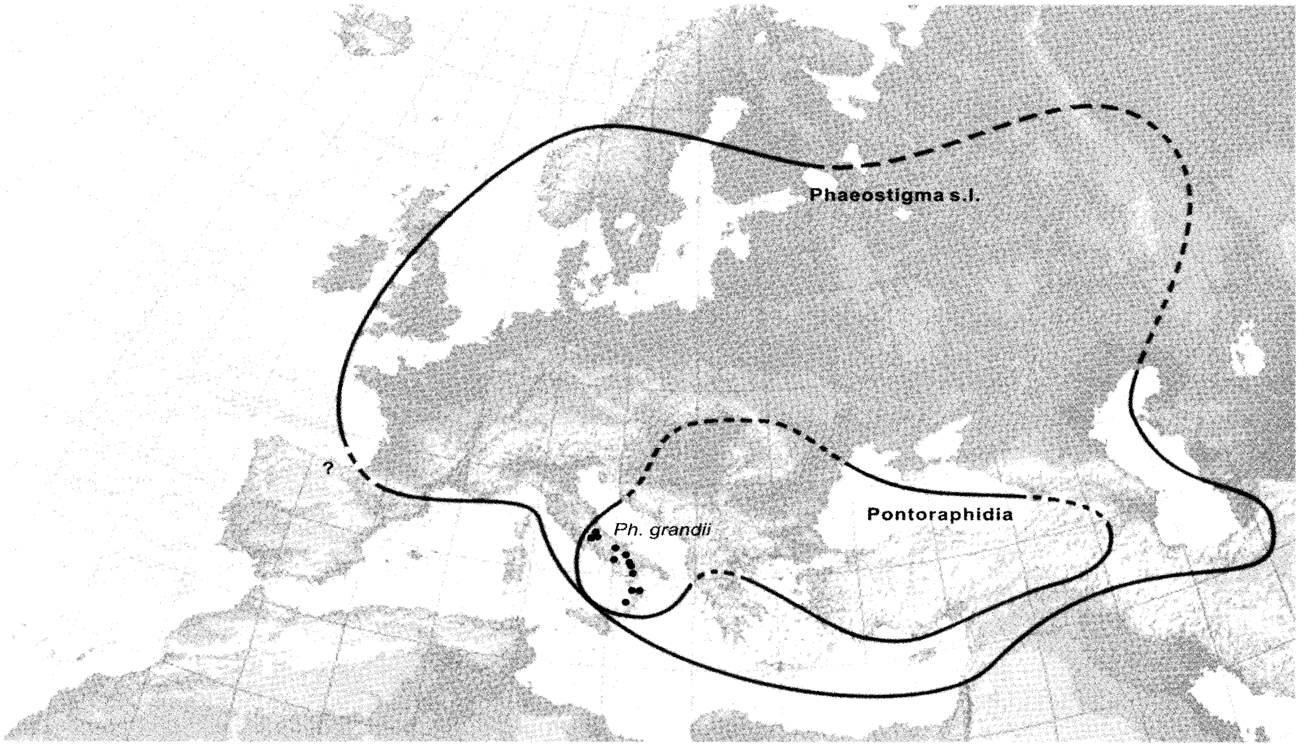

Fig. 2 – Documented distribution of *Phaeostigma (Pontoraphidia) grandii*, of the subgenus *Pontoraphidia*, and of the genus *Phaeostigma*.

AP (Fig. 2).

Dichrostigma flavipes (Stein, 1863)

Widely distributed in the BP and (mainly) eastern extramediterranean parts of Europe. Recorded in Italy only in the north and south to Tuscany and Marche (Bernardi Iori *et al.*, 1995).

Tjederiraphidia santuzza
(H. Aspöck & U. Aspöck & Rausch, 1980)

Known only from the Aspromonte (Fig. 3).

Turcoraphidia amara
(H. Aspöck & U. Aspöck, 1964).

In scattered populations in high altitudes, widely distributed in the BP, the Crimean peninsula and western Anatolia. Recently detected for Italy in the Majella Nat. Park (Abruzzo) (Letardi, 2004) (Fig. 3).

Subilla confinis (Stephens, 1836)

Widely distributed in extramediterranean parts of Europe. Several records in the southern half of the AP. Found probably in scattered populations throughout the whole peninsula. Letardi (1998) and Pantaleoni (1999) question whether the southern Italian populations might represent a distinct subspecies; so far this could not be verified by us.

Ornatoraphidia flavilabris (Costa, 1855)

Widely distributed in the BP, in the AP, in the south of France, and in southern parts of Central Europe.

Xanthostigma xanthostigma (Schummel, 1832)

Widely distributed in extramediterranean parts of Europe and in palaearctic parts of Asia as far as Sachalin. The only record for Italy is from Southern Tyrol (Alto Adige).

Xanthostigma corsica (Hagen, 1867)

In scattered populations widely distributed in the AP, Elba, Giglio, Sicily, Sardinia, Corsica, the south of France and the IP.

Xanthostigma aloysiana (Costa, 1855)

In scattered populations widely distributed in the AP, the south of Central Europe and of France, and the north of Spain.

Raphidia (Raphidia) ophiopsis Linnaeus, 1758

Widely distributed in extramediterranean parts of Europe and palaearctic Asia as far as Irkutsk. In Italy only in the northernmost parts (Southern Alps) (Hellrigl & Hölzel, 1996).

Raphidia (Raphidia) mediterranea
H. Aspöck & U. Aspöck & Rausch, 1977

Widely distributed in the BP, the southeast

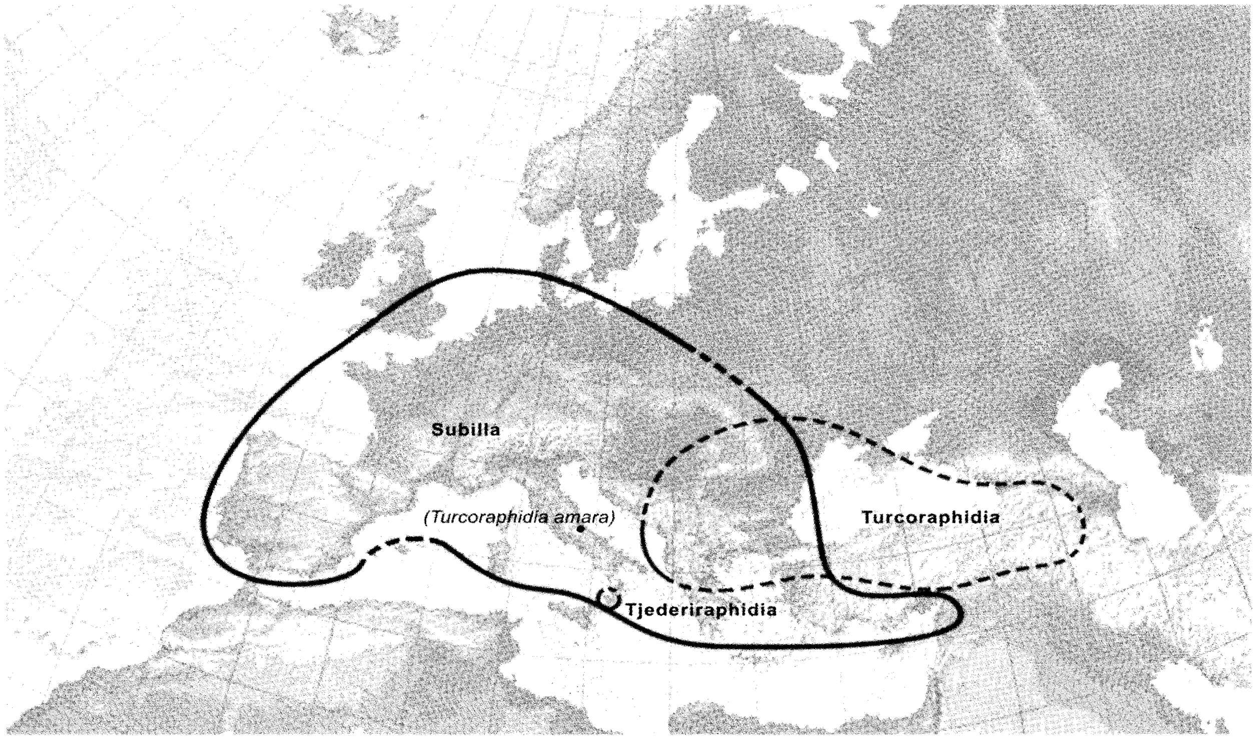

Fig. 3 – Distribution of the genera *Subilla*, *Turcoraphidia* (with the isolated record of *Turcoraphidia amara* in Italy), and *Tjederiraphidia*. – In the Apennines Peninsula and in Central Europe *Subilla* is represented by *S. confinis* only.

of extramediterranean Europe and western Anatolia. In Italy in isolated populations in Apulia (as far north as Gargano), Campania and Lazio.

Raphidia (Raphidia) ulrikae H. Aspöck, 1964

In scattered populations in various extramediterranean parts of Europe. In Italy only in the northernmost parts.

Raphidia (Raphidia) ligurica Albarda, 1891

In isolated populations in Piedmont, Calabria and the south of Switzerland.

Italoraphidia solariana (Navàs, 1928)

Restricted to the southern parts of the AP (Fig. 4).

Puncha ratzeburgi (Brauer, 1876)

Widely distributed in Central and eastern Europe, in isolated populations in the north of the BP and the AP, and southern France (Fig. 4).

Calabroraphidia renate

(Rausch & U. Aspöck & H. Aspöck, 2004)

The discovery of this species (Fig. 1) in a small area in the Sila Grande in 2003 (Rausch *et al.*, 2004) was quite a surprise. It was recaptured in 2005 (Rausch, pers. comm.) and 2006 (unpubl.) in a few localities in the Sila.

Venustoraphidia nigricollis (Albarda, 1891)

Widely distributed in Central and eastern Europe, the BP (north of the gulf of Corinth), and the AP as far south as the Aspromonte.

Inocellia crassicornis (Schummel, 1832)

Widely distributed in extramediterranean parts of Europe and the more northern parts of palaearctic Asia eastwards to Sachalin. In Italy restricted to the northernmost parts, known only from South Tyrol (Alto Adige).

Parainocellia bicolor (Costa, 1855)

Widely distributed in the AP and the south of France and southwestern parts of Central Europe.

The islands belonging to Italy, even the large ones (Sardinia, Sicily) harbour a surprisingly low number of Raphidioptera species. Besides *Xanthostigma corsica*, which has been recorded on several islands (see above), only the following two species have been found:

Subilla principiae

Pantaleoni & U. Aspöck & Cao & H. Aspöck, 2005

This species – one of the recent discoveries – has been found only in a *Quercus pubescens* habitat in the Gennargentu on Sardinia (Pantaleoni *et al.*, 2005).

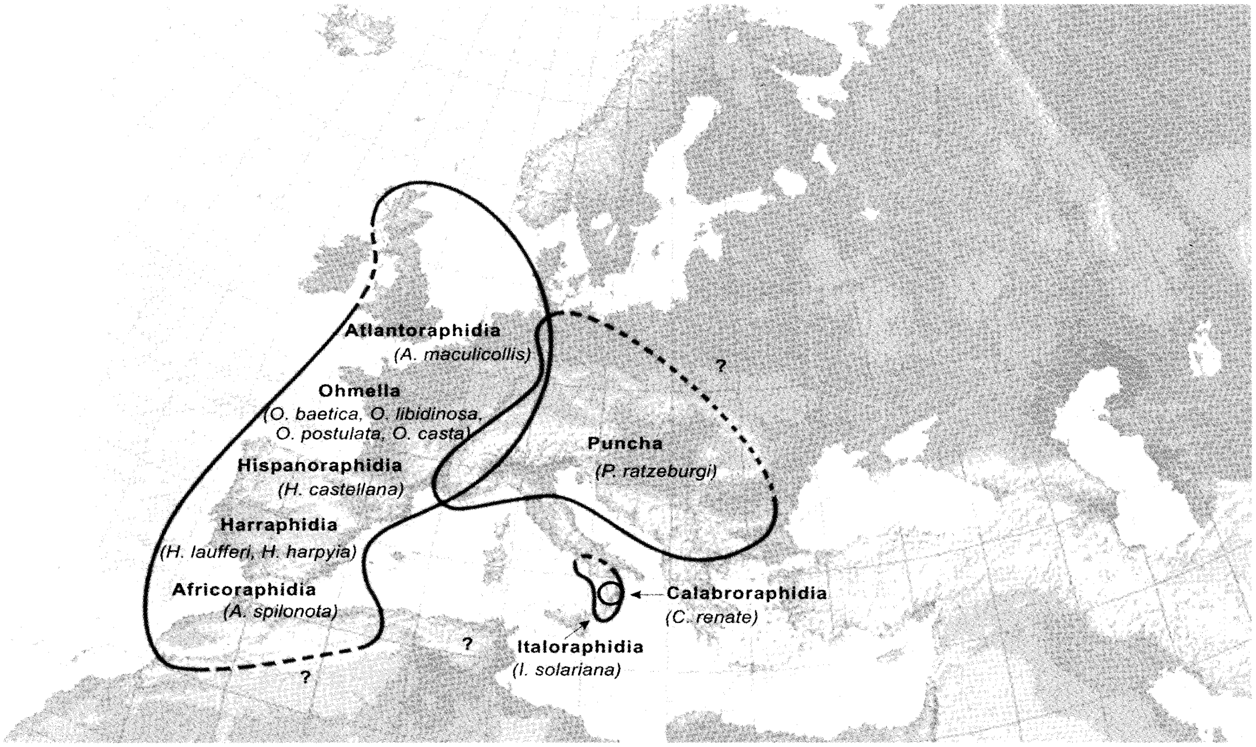

Fig. 4 – Distribution of the genera of group II of Raphidiidae.

Fibla (Fibla) maclachlani (Albarda, 1891)

Recorded only from Sicily, Sardinia and Corsica.

Present state of classification of Raphidioptera

As a precondition to understanding the chorological facts and biogeographical conclusions it would seem necessary to provide a condensed account of the confirmed or suspected relationships of the genera within the families of the Raphidioptera. The order comprises two extant families, Raphidiidae and Inocelliidae. They differ in many morphological and biological characters, presenting a number of striking autapomorphies (H. Aspöck *et al.*, 1991, 2001; H. Aspöck, 2002). Up to the present, the classification of each of the two families has been founded solely on morphological characters; an analysis of relationships based on molecular biology is, however, in progress.

The family Raphidiidae comprises 26 genera, which have been assigned to 7 presumably monophyletic groups (groups I-IV and groups VI-VIII; the dubious group V was revealed as part of group VI) (H. Aspöck *et al.*, 1991, 1998).

Group I comprises 12 Raphidiidae genera with a total of more than 90 species. It is the dominant group in Europe, the Caucasus region, Anatolia, other parts of the eastern Mediterranean, the Near East as well as the northern parts of Asia. In Italy this group is represented by the genera *Phaeostigma* Navás, 1909, *Dichrostigma* Navás, 1909, *Turcoraphidia* H. Aspöck & U. Aspöck, 1968, *Subilla* Navás, 1916, *Ornatoraphidia* H. Aspöck & U. Aspöck, 1968, *Xanthostigma* Navás, 1909, and *Raphidia* Linnaeus, 1758. The monotypic genus *Tjederiraphidia* H. Aspöck & U. Aspöck & Rausch, 1985, endemic to Calabria, was assigned – with some hesitation - to group I (H. Aspöck *et al.*, 1991). In the meantime, we have developed serious doubts regarding its systematic position, and we cannot exclude the possibility that in reality it is closer to group II.

Group II comprises 8 genera with a distribution confined to Europe and the northwest of Africa. Five of these, which have a distribution restricted to western Europe and the northwest of Africa, form a monophyletic clade within group II (Fig. 4). The remaining genera assigned to group II – *Puncha* Navás, 1915, *Italoraphidia* H. Aspöck & U. Aspöck, 1968, and *Calabroraphidia* Rausch & U. Aspöck & H. Aspöck, 2004 – differ in several striking characters and probably constitute the adelphotaxon to the rest of group II. All three occur in Italy, two of them (*Italoraphidia*, *Calabroraphidia*, both monotypic) are even endemic to the south of the AP (Fig. 4).

Group III consists of two markedly different genera, *Mauroraphidia* H. Aspöck & U. Aspöck & Rausch, 1983 (monotypic and endemic to the Atlas mountains) and *Venustoraphidia* H. Aspöck & U. Aspöck, 1968, with two species, one of them confined to the Peloponnisos, the other widely distributed in Central Europe, the BP and the AP.

Groups IV to VIII are not represented in Europe.

The relationships between these 7 groups of Raphidiidae have not yet been verified. The current classification is: (((((II + VII) + IV) + III) + I) + VI) + VIII, despite several weak points; the morphological findings urgently need molecular biological examination (which is currently in progress).

Of particular interest is the genus *Agulla* (group VII), which is restricted to North America and probably is the sister-group of group II. If this is true, the relationship must date back to the Mesozoic.

The Inocelliidae is a small family comprising 21 described valid species which have been assigned to 6 genera *Fibla* Navás, 1915, with four species, one of them endemic to the islands of Corsica, Sardinia and Sicily. *Parainocellia* H. Aspöck & U. Aspöck, 1968, widely distributed in several southern parts of Europe (including the AP and the BP), the eastern Mediterranean and Eastern Asia; five species have been described, one of them occurs throughout the whole mainland of Italy. *Inocellia* Schneider, 1843, with 6 species and widely distributed in large parts of Europe and Asia; one species has been found also in the northernmost parts of Italy. *Indianoinocellia* U. Aspöck & H. Aspöck, *Negha* Navás, and *Sininocellia* Yang do not occur in Europe.

The relationships within the family Inocelliidae have not yet been clarified. However, it seems clear that *Fibla* is the sister taxon to the remaining species, and that *Parainocellia* and *Inocellia* are probably sister groups.

Palaeogeography of the Apennines Peninsula

During the past three decades impressive progress has been made in our understanding of the genesis of the Mediterranean basin (Boccaletti *et al.*, 1990; Rögl, 1998; Popov *et al.*, 2005).

The AP is composed of several parts having different provenances and ages. The largest part can be traced back to lands which were primarily united with the Iberian land-mass, but which separated in the Oligocene and drifted eastwards in a rotating movement. In particular, this area encompasses large parts of the Apennines and parts of the present Calabria. Also Corsica, Sardinia, and northern parts of Sicily were once eastern parts of the Iberian land-mass which separated during the Oligocene – about 30 millions years ago – and drifted to the east.

In the east, the Apulian platform existed since the Mesozoic; it also rotated to the northeast during the Miocene and submerged under the Dinarides. Only a small narrow stripe has remained as a part of present-day Apulia and Calabria.

The famous Messinian salinity crisis – caused as a result of the closure of the Mediterranean Sea and its separation from the Atlantic Ocean in the late Miocene (about 6 millions years ago) – led largely to a desiccation of the Mediterranean Sea (lasting about 500.000 years) and to the formation of numerous land bridges and connections. Many of these – particularly those deeply below the old sea level – were, however, of only limited value for migration of animals and plants. They were basins with, at least, a partly lagoon-like character, high concentrations of salt (Sabhka facies) and high temperatures. Nevertheless, the Messinian crisis was of great significance for the faunal exchange within the ancient Mediterranean Sea and the continents.

Another important period for massive changes of land and water in the Mediterranean were the glacial periods of the Pleistocene. The sea level fell to about 100 – 130 m (for short periods possibly even more) below the present sea level. During this period, many land bridges emerged, which again facilitated migrations of organisms on a large scale. It is important to mention that the Northern Adriatic sea had largely dried out resulting in a faunal exchange between southeast Europe and the AP. Thus, it is easily understandable why the Raphidioptera fauna of the AP is markedly heterogeneous from a biogeographical, as well as from a systematic point of view.

Provenance of the Raphidioptera of the Apennines Peninsula

Adriatomediterranean species

Endemic species – Of the 22 species of Raphidioptera found on the mainland of Italy, four are endemic and restricted to the AP: *Italoraphidia solariana*, *Calabroraphidia renate*, *Tjederiraphidia santuzza*, and *Phaeostigma (Pontoraphidia) grandii*. Of these, *I. solariana*, *C. renate* and *T. santuzza* are representatives of monotypic genera with distinctly isolated systematic positions. *Italoraphidia* and *Calabroraphi-*

dia are probably related to *Puncha*, another monotypic genus which is distributed throughout large parts of Central and eastern Europe (Fig. 4).

The sister taxon of *Puncha* + *Italoraphidia* + *Calabroraphidia* is probably a group of genera occurring in the western Mediterranean (Fig. 4). Thus it is reasonable to assume that *Italoraphidia,* as well as *Calabroraphidia*, can be traced back to the ancient invaders coming from Iberia via the drifted platform which nowadays forms part of Calabria. This is comparable to the origin of *Fibla maclachlani* (occurring in Corsica, Sardinia and Sicily) and to *Subilla principiae* (most probably endemic to Sardinia), both of which are apparently ancient Tyrrhenian elements derived from Iberian ancestors.

The origin of *Tjederiraphidia* is not clear. Until now the genus was assigned to group I (see above), but this seems increasingly more doubtful, and it is quite possible that the genus is also an ancient element with ancestors of Iberian origin.

The fourth endemic species, *Ph. (P.) grandii*, belongs to a subgenus (*Pontoraphidia*) which altogether comprises four species and has a range of distribution covering – besides the south of the AP – parts of the southeast of Europe, northern Aegean islands, Anatolia, and the Caucasus region (Fig. 2). Thus, *Pontoraphidia* is of distinctly eastern origin and it cannot be doubted that (the ancestor of) *Ph. (P.) grandii* came from the east. It is certainly much younger than the other three endemic species dealt with above, but it is the sister taxon to the remaining three species of the subgenus and thus certainly is not a recent acquisition to the AP. *Ph. grandii* (or its immediate ancestor respectively) must have reached the peninsula before the glacial periods, i.e. prior to the Pleistocene. Possibly it is the sole remainder of the Raphidioptera fauna of the old Apulian platform.

Adriatomediterranean elements not restricted to the Apennines Peninsula – The origin and biogeographical assignment of these species (*Ph. italogallica*, *Ph. galloitalica*, *S. confinis*, *O. flavilabris*, *X. aloysiana*, *X. corsica*, *R. ligurica*, *V. nigricollis*, *P. bicolor*) is very different. The two species, *Ph. italogallica* and *Ph. galloitalica*, are related to *Phaeostigma (Ph.) notata* (Fabricius, 1781), a species with a large distribution in extramediterranean parts of Europe, moreover, to *Phaeostigma (Ph.) promethei* H. Aspöck & U. Aspöck & Rausch, 1983, restricted to the Caucasus, and to *Phaeostigma (Ph.) euboica* (H. Aspöck & U. Aspöck, 1976), endemic to mountains of Evia. It is likely that the evolution of these species took place in the BP during the Pleistocene and that *Ph. italogallica* and *Ph. galloitalica* (or their common ancestor) invaded the AP either from the north or from the east via the dried Adria.

Two species, *O. flavilabris* and *V. nigricollis*, occur also in large parts of the BP (moreover, in parts of Central Europe and in the south of France). Per definition they represent polycentric Adriato-Balkanpontomediterranean elements. Maybe they also reached the AP in the Pleistocene in a similar way as the *Phaeostigma* species. It is of interest that both of the two genera, *Ornatoraphidia* H. Aspöck & U. Aspöck, 1968, and *Venustoraphidia* H. Aspöck & U. Aspöck, 1968, comprise a second species, and both occur in very small mountain areas in Greece.

P. bicolor is a typical monocentric Adriatomediterranean faunal element with a distribution throughout the whole mainland of Italy, from the south of Calabria to the Southern Alps, but with very few records in adjacent parts of southern France and Switzerland. *P. bicolor* is the sister species to the closely related *P. braueri* (Albarda, 1891), which occurs in the southeast of Europe. Both are the sister group to *P. ressli* (H. Aspöck & U. Aspöck, 1965), the only Inocelliid species of Anatolia. No doubt, *P. bicolor* is of eastern origin and represents a comparatively recent acquisition to the Raphidioptera fauna of the AP. It is a reasonable assumption that *P. bicolor* (or its ancestor) reached the peninsula from the east in the Pleistocene.

The genus *Xanthostigma* with 5 known species, distributed from the north of the IP to the east of Asia, is most probably an ancient element of the Raphidioptera of the AP. It is likely that it invaded the peninsula from the north some time before the glacial periods, perhaps in the late Pliocene. Both species occurring in Italy, *X. corsica* and *X. aloysiana*, exhibit some degree of expansion by reaching the south of France and the north of the IP.

R. ligurica is a typical monocentric Adriatomediterranean faunal element with a somewhat isolated systematic position. The genus *Raphidia* (with 15 to 18 species, depending on the taxonomic status of some phena) is distributed throughout large parts of Central and southeast Europe, Anatolia, the Caucasus region and in the east as far as the Baikal lake. Thus, the most plausible assumption is that *R. ligurica* (or its ancestor) invaded the AP from the north or from the east before the Pleistocene, possibly during the late Pliocene.

One species remains to be discussed in this chapter: *Subilla confinis*. This species is an Adriatomediterranean faunal element showing a considerable expansivity. It has been found in various parts of the AP and is widely distributed in Central Europe extending to large parts of France, England and Romania. In the IP on one hand and in the BP and Anatolia on the other hand, altogether four other closely related species of the genus occur. It is suggested that all these 5 species evolved in the Pleistocene due to a splitting of a once continuous distribution area of the hypothetic stem species. The AP was colonised by *Subilla* from the north or from the east, possibly in the late Pliocene or early Pleistocene. It is of great interest that, besides the above mentioned 5 species (*confinis*-group), the genus *Subilla* comprises 5 more species which are characterised by more or less similar monstrous-like genitalia. One of these species is the recently discovered *S. principiae*, possibly endemic to Sardinia, the other four species are restricted to the eastern Mediterranean region (Rhodes, southern Anatolia). Pantaleoni *et al.* (2005) have hypothesised that *S. principiae* might be an old Tyrrhenian element of Iberian origin; there is indeed no plausible biogeographical argument which might support a close relationship between *S. principiae* and the other four species of this (probably not monophyletic) group. Molecular biological studies should help clarify the question.

Balkanopontomediterranean elements with recent immigration history

By "recent" we mean invasions to the AP that occurred during the Pleistocene via the Adria bridge.

As discussed above, *O. flavilabris* and *V. nigricollis* are of Balkan origin. Three additional species of Balkan origin invaded the AP recently, i.e. during the glacial period: *Dichrostigma flavipes*, *Raphidia mediterranea*, and *Turcoraphidia amara*.

D. flavipes occurs in Italy only in the northern parts (the southernmost records are in Tuscany and Marche), but the species is widely distributed in the BP north of Middle Greece (Sterea Ellas). Other species of the genus occur in eastern Europe, Anatolia, and the Near East.

R. mediterranea, although a species with a broad ecological spectrum, has been found only in a relatively small part of Italy, mainly in the southeast, but recently also in Lazio. Our previous assumption that it was introduced to Italy by human activities in historic or prehistoric times (H. Aspöck *et al.*, 1991; 2001) seems unlikely now as pointed out by Pantaleoni (2005). Presently, we believe that it has reached the AP via the dried out Adriatic Sea during (later periods of) the Pleistocene.

T. amara is another impressive example of a recent addition to the Raphidioptera of the AP from the BP via the Adriatic land bridge. *Turcoraphidia* is a genus with a distinct Pontomediterranean distribution (Fig. 3). Five species are currently known. *T. amara* has recently been found in the Majella National Park (Abruzzo) (Letardi, 2004).

Possibly also *Puncha ratzeburgi* reached the AP in the Pleistocene from the BP via the Adriatic land bridge, although it seems more likely that the species was a later immigrant (see below).

Extramediterranean (European or Eurosiberian) and/or Balkanopontomediterranean faunal elements with postglacial immigration

The distribution of few species in Italy is confined to the northernmost parts. Five of them – *Ph. notata*, *X. xanthostigma*, *R. ophiopsis*, *R. ulrikae*, and *I. crassicornis* – have only been found in Italy in the Southern Alps and may have persisted there throughout the later periods of the Pleistocene, at least throughout the last glacial period. Three of these (*X. xanthostigma*, *R. ophiopsis*, *I. crassicornis*) are Eurosiberian faunal elements with high expansivities and large distribution areas ranging throughout northern Asia and northern, eastern and Central Europe. They may have evolved in Europe or in northern Asia in the Pliocene.

Puncha, however, is a very old European monotypic genus and systematically isolated. It is nonetheless probably related to *Italoraphidia* and *Calabroraphidia* and is assigned to group II (see above). *P. ratzeburgi* is an Extramediterranean European faunal element which persisted south of the Alps during the last glacial period and possibly enlarged its distributional area in the AP somewhat to the south as far as Emilia Romagna.

Finally, it cannot be excluded that *D. flavipes* also immigrated (or partially so) into Italy from the north during postglacial periods.

Significance of the Apennines Peninsula for the Raphidioptera fauna of other parts of Europe

Compared to the BP, the AP has contributed only sparingly to the Raphidioptera fauna of other (particularly northern) parts of Europe. Most Adriatomediterranean species are either endemic or are characterised by an extremely low expansivity. Only a single species – *Subilla confinis* – has extended its distribution in the postglacial period and reached the northern borders of Central Europe (records in Denmark); moreover, its present distribution covers large parts of France, England and eastern Europe.

Few species (*Ph. italogallica*, *X. aloysiana*, *X. corsica*) have colonised parts of southern France and the north of the IP. It is unlikely that all these events should have occurred after the last glacial period. *X. corsica* e.g. may have reached the IP already in earlier periods in the Pleistocene.

In the Raphidioptera fauna of Central Europe, the Adriatomediterranean faunal elements play – with the exception of *Subilla confinis* – a rather insignificant role. There are a few records of *X. aloysiana*, *R. ligurica* and *P. bicolor* in the southernmost parts. The occurrence of *O. flavilabris* as well as *V. nigricollis* can most probably be traced back to postglacial immigrations from the BP rather than from the AP. *O. flavilabris* occurs in several parts of eastern Austria, but has not yet been found in the southwest of Central Europe. *X. aloysiana*, *R. ligurica*, *P. bicolor*, and *O. flavilabris* reach the northern borders of their ranges in the south of Central Europe, where they serve as bioindicators for climatically favoured and particularly rich, but vulnerable biocoenoses which merit protection (U. Aspöck & H. Aspöck, 2005b).

Outlook

The Raphidioptera fauna of Italy can be regarded as largely comprehended, although a few additional species so far recorded from regions outside the AP will certainly be found. It is, however, unlikely – although it cannot be excluded – that new species might be detected in isolated mountainous regions in higher altitudes.

Forthcoming biogeographical studies will particularly be based upon the results of molecular biological investigations. This concerns the clarification of the relationships of the genera (and subgenera) on one hand and the provenance of certain populations on the other hand.

Phylogeography will become an important tool also to clarify open questions on structure and biogeographical history of the snake-flies of Italy.

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Neuropterida of the Majella National Park (Italy)

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The Majella National Park, consisting of about 75,000 hectares, is a protected key-area situated at the heart of the central Apennines peculiar from several point of view of nature conservation. With the present contribution, the authors present a preliminary checklist of Neuropterida of the Majella National Park. Neuropterida were occasionally collected during a research project on Coleoptera carried out from July 2000 to January 2006, and with a specific survey in July 2005. A review of publications with distributional data is included.

Key words – Checklist, Neuropterida, Majella National Park, faunistics, chorology.

Introduction

In the last decade several contributions have been published about Neuropterida in Italian natural protected areas mainly in the Apennines (Letardi, 1998, 2002, 2004; Letardi & Maltzeff, 2001; Letardi & Migliaccio, 2002).

These researches have been carried out both for deepening knowledge concerning the Neuropterofauna of Apennines and for providing data about the existent biodiversity to the managing authorities of the protected areas. The territory of the Majella National Park, which is neighbours the recently investigated Abruzzo, Latium and Molise National Park (Letardi & Migliaccio, 2002), is peculiar for several point of view of nature conservation.

The Majella National Park, consisting of about 75.000 hectares, is situated at the heart of the central Apennines and covers a wide area which comprises the massif of the Majella, the Monti Pizzi - Mt. Secine chain and the massif of the Morrone. The whole area is principally made up of several mountain chains, rising from an altitude of 400-500 to 2.800 m above sea level, deeply engraved by valleys, often forming spectacular canyons. A vast plateau characterizes the rounded massif of the Majella above 2.000 m, with frequent phenomena of glacialism and karstification.

On the Majella there is clear evidence of the different covering of Apennine vegetation. At lower elevations there are woods formed of oaks, maples, hornbeams, lindens, manna-ashes, and holm-oaks. Higher up, towards 900-1.000 m the forest covering is made up of beech and mountain maple. Almost everywhere it is possible to see the yellow Laburnum, supporting the hypothesis that the word Majella could come from "maio", an old name the local population gave to this plant. In the beech altitudinal belt it has to keep account of the autochthonous nucleous of birch, in the Valle Fara S. Martino, and Austrian pine, in the Valle Serviera. In the Morrone, two distinct nucleous of fir are also present, possibily of relict origin. Up above, towards 1700 m, and only in the Majella, there are thick formations of high-

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mountain dwarf shrublands, chiefly with mountain pine of the variety *pumilio*.

In the frame of a wider survey of the entomocoenosis of the Park, made by one of us (A.B.B.), the opportunity was taken to deepen and collect the little and dispersal data about Neuropterida (Monserrat, 1980; Navás, 1913; Pantaleoni, 2005; Pantaleoni & Letardi, 1998) with the aim to realize a checklist of those insects of the Park territory and neighbourhoods.

Materials and methods

In order to produce a checklist of Neuropterida of the Majella National Park, the few bibliographic references have been collected and integrated with unpublished data of several public and private collections (collections of the University of Roma Tre; the Natural History Museum of Milan; the Natural History Museum of Venice; Civic Museum of Zoology of Rome; the Erdgenössische Technische Hochschule-Zen-trum, Zürich; Pantaleoni, pers. comm.; collection Terzani, Florence; collection Pessolano, Rome). Nevertheless, the majority of data has been collected during the surveys in the Park between 2001 and 2005, with several collecting methods (sweeping net, aerial trap, light trap, beating tray, and by rearing of the immature stages). Moreover, a specific survey has been conducted during the first three days of the Post IX International Symposium on Neuropterology long excursion by one of us (A. L.) together with four colleagues (Sergio De Freitas, John D. Oswald, Horst and Ulrike Aspöck) in several localities of the Park, collecting only with sweeping net.

In order to confront the checklist with the Neuropterofauna of the whole Abruzzo region, the basic information from the European monograph on Neuroptera has been used (Aspöck *et al.*, 1980), integrated with the following world monograph on Raphidioptera (Aspöck *et al.*, 1991), as result in the updated web resource on the Italian Neuropterida (http://neurotteri.casaccia.enea.it).

Numeric codes for genera and species have been derived from the project of the checklist of the Italian Fauna (http:// www.faunaitalia.it / checklist / introduction.html, see also [Bernardi] Iori *et al.*, 1995).

The systematic order used derives from the checklist of Italian Neuropterida ([Bernardi] Iori *et al.*, 1995) with few modifications; "*" symbol indicates species collected or cited in this area for the first time; "**" symbol indicates species new for Abruzzo; "***" symbol indicates species new for Italy; "?" symbol indicates determination which needs confirmation; "n" symbol indicates species collected near Park areas with similar ecological conditions.

Results

Checklist of Neuropterida of the Majella National Park

Megaloptera

Sialidae

001.0 *Sialis* Latreille, 1803
- 002.0 * *lutaria* (Linné, 1758)

Raphidioptera

Raphidiidae

002.0 *Phaeostigma* Navás, 1909 subg. *Phaeostigma* Navás, 1909
- 002.0 * *italogallica* (H. Aspöck & U. Aspöck, 1976)
- 003.0 * *notata* (Fabricius, 1781) **?**

003.0 *Phaeostigma* Navás, 1909 subg. *Pontoraphidia* H. & U. Aspöck, 1968
- 001.0 ** *grandii* (Principi, 1960)

007.0 *Ornatoraphidia* H. Aspöck & U. Aspöck, 1968
- 001.0 *flavilabris* (Costa, 1855)

007.1 *Turcoraphidia* H. Aspöck & U. Aspöck, 1968
- 001.0 *** *amara* (H. Aspöck & U. Aspöck, 1964)

008.0 *Xanthostigma* Navás, 1909
- 002.0 ** *corsica* (Hagen, 1867)

012.0 *Venustoraphidia* H. Aspöck & U. Aspöck, 1968
- 001.0 *nigricollis* (Albarda, 1891)

Inocelliidae

014.0 *Parainocellia* H. Aspöck & U. Aspöck, 1968 subg. *Parainocellia* H. Aspöck & U. Aspöck, 1968
- 001.0 * *bicolor* (A.Costa, 1855)

Neuroptera

Coniopterygidae

017.0 *Helicoconis* Enderlein, 1905 subg. *Ohmopteryx* Kis, 1970
- 001.0 * *pseudolutea* Ohm, 1965 **? n**

018.0 *Coniopteryx* Curtis, 1834 subg. *Coniopteryx* Curtis, 1834
- 001.0 ** *borealis* Tjeder, 1930
- 002.0 ** *pygmaea* Enderlein, 1906

020.0 *Coniopteryx* Curtis, 1834 subg. *Metaconiopteryx* Kis, Nagler & Mandru, 1970

001.0 *arcuata* Kis, 1965
024.0 *Semidalis* Enderlein, 1905
001.0 *aleyrodiformis* (Stephens, 1836)

Osmylidae

025.0 *Osmylus* Latreille, 1802
001.0 * *fulvicephalus* (Scopoli, 1763)

Mantispidae

029.0 *Mantispa* Illiger, 1798
001.0 * *styriaca* (Poda, 1761)
030.0 *Perlamantispa* Handschin, 1960
002.0 *perla* (Pallas, 1772) sensu Erichson, 1839

Hemerobiidae

032.0 *Hemerobius* Linné, 1758
004.0 * *gilvus* Stein, 1863
005.0 * *handschini* Tjeder, 1957
006.0 * *humulinus* Linné, 1758
009.0 ** *micans* Olivier, 1792
010.0 * *nitidulus* Fabricius, 1777
015.0 * *stigma* Stephens, 1836
033.0 *Wesmaelius* Krüger, 1922
010.0 ** *subnebulosus* (Stephens, 1836)
034.0 *Sympherobius* Banks, 1904
006.0 * *pellucidus* (Walker, 1853)
036.0 *Megalomus* Rambur, 1842
001.0 ** *hirtus* (Linné, 1761)
003.0 ** *tineoides* Rambur, 1842
004.0 *tortricoides* Rambur, 1842 **n**
038.0 *Micromus* Rambur, 1842
001.0 *angulatus* (Stephens, 1836) **?**
004.0 *variegatus* (Fabricius, 1793)

Chrysopidae

039.0 *Italochrysa* Principi, 1946
001.0 * *italica* (Rossi, 1790)
041.0 *Chrysopa* Leach, 1815
005.0 *pallens* (Rambur, 1838)
006.0 * *perla* (Linné, 1758) sensu Schneider, 1851
008.0 *viridana* Schneider, 1845
009.0 *walkeri* McLachlan, 1893
042.0 *Chrysoperla* Steinmann, 1964
001.0 gr. *carnea* (Stephens, 1836)
002.0 * *lucasina* (Lacroix, 1912)
003.0 ** *mediterranea* (Hölzel, 1972) **?**
004.0 ** *pallida* Henry et al., 2002
044.0 *Cunctochrysa* Hölzel, 1970
001.0 *albolineata* (Killington, 1935)
045.0 *Dichochrysa* Yang, 1991 (=*Mallada* Navás, 1925 partim)
001.1 ** *abdominalis* (Brauer, 1856)
002.0 *flavifrons* (Brauer, 1850)
007.0 * sp.pr. *picteti* (McLachlan, 1880)
008.0 *prasina* (Burmeister, 1839)
009.0 *ventralis* (Curtis, 1834)
011.0 *zelleri* (Schneider, 1851)
046.0 *Nineta* Navás, 1912
001.0 * *flava* (Scopoli, 1763)
002.0 * *principiae* Monserrat, 1980
003.0 * *inpunctata* (Reuter, 1894) **?**
047.0 *Peyerimhoffina* Lacroix, 1920
001.0 ** *gracilis* (Schneider, 1851) **n**
049.0 *Hypochrysa* Hagen, 1866
001.0 ** *elegans* (Burmeister, 1839)
050.0 *Nothochrysa* McLachlan, 1868
002.0 ** *capitata* (Fabricius, 1793)

Myrmeleontidae

051.0 *Palpares* Rambur, 1842
001.0 *libelluloides* (Linné, 1764)
054.0 *Myrmecaelurus* Costa, 1855 subg. *Myrmecaelurus* Costa, 1855
001.0 *trigrammus* (Pallas, 1781) **n**
057.0 *Myrmeleon* Linné, 1767 subg. *Myrmeleon* Linné, 1767
001.0 ** *formicarius* Linné, 1767
060.0 *Neuroleon* Navás, 1909
003.0 ** *microstenus* (McLachlan, 1898)
061.0 *Distoleon* Rambur, 1842
002.0 * *tetragrammicus* (Fabricius, 1798)

Ascalaphidae

069.0 *Libelloides* Tjeder, 1972
001.0 *coccajus* (Denis & Schiffermüller, 1775)
004.0 * *longicornis* (Linné, 1764)
006.0 *lacteus* (Brullé, 1832)

Discussion

According to the literature, in the area of the Majella National Park twenty species belonging to seven families of Neuropterida were recorded.

With the results of our study in this area, together with a study of some public and private collections, the Neuropterofauna of Majella rises to 59 species belonging to ten families. It represents more than 80% of the whole Neuropterofauna of Abruzzo: actually, according to our partially unpublished data, 70 species belonging to ten families inhabits the Abruzzo region.

The resulting Neuropterofauna is probably almost complete, taking into consideration the different environments in the territory of the Park. However, we consider that further research, also carried out with other techniques of collection (in particular with light traps), will increase the number of species, in particular within Coniopterygidae.

The Neuropterofauna of this area has been shown absolutely similar to analogous Apennine areas, in particular to the ones of the other protected areas in Central Italy, with some faunistic peculiarity like the presence of the raphidiid *T. amara*, with a trans-adriatic distribution. Moreover, this area represents the northern boundary limit of *Phaeostigma grandii*, an endemic raphidiid of the Italian Peninsula.

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Neuropterida of the Asinara Island (NW Sardinia, Italy)

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It had been impossible to conduct any detailed entomological survey on the Island of Asinara (North-West Sardinia, Italy) for a long time. This first became possible when, in 1997, the island was no longer used as a prison and the National Park of the Asinara was founded. After just over a year's research from September 2003 to October 2004, the list of collected Neuroptera, from the previously recorded 3 species, has reached about 20, *Chrysopa dorsalis* Burmeister,1839 (new to Sardinia), *Dichochrysa iberica* (Navás,1903), and *Hemerobius stigma* Stephens, 1836 (quite rare and stenotopic in Sardinia) were recognized on the coastal *Juniperus* formation of Cala Aréna. The finding of a small population of *Chr. dorsalis* is of particular interest as the adult specimens have similar chromatic habitus to *Chrysopa regalis*, Navás,1915, of the Iberian Peninsula.

Key words – Chrysopidae, Hemerobiidae, Coniopterygidae, Myrmeleontidae, Ascalaphidae.

Introduction

In 1885, the few inhabitants of Asinara, shepherds and fishermen, were forced to leave their homes and lands and transfer to the newly built village of Stintino. The island was turned into a penal colony and sanitarium. Consequently Asinara, the largest of the small islands surrounding Sardinia, was not freely accessible to the public until December 1997, when it became a National Park (Gutierrez *et al.*, 1998).

Even today, it is still complicated to carry out any detailed entomological survey on Asinara due to difficulties in moving round and logistic problems on the island. Entomological field trips are expensive and difficult even for Sardinian researchers.

On the other hand, Asinara is not exceptionally attractive from a naturalistic point of view. The island is paying for its disastrous environmental management in the past with the unsustainable burden of domestic and feral live-stock. Scrub vegetation shows signs of degradation all over. There is only one remaining tiny wooded area, a holm-oak grove in the north of the island (Elighe Mannu). Very few areas are uncontaminated and most of those are on the coast.

Asinara's entomological fauna is still practically unknown (Pantaleoni *et al.*, 1998). A recent checklist of the insects, built on published data, lists only 558 taxa (Nuvoli *et al.*, 2007) of which only 3 belong to Neuropterida.

However, as we have been able to go to Asinara with some frequency, we have been able to collect a small number of Neuropterida specimens belonging to twenty species.

Material and methods

We were able to have access to Asinara (Fig. 1) only on one extraordinary occasion in 1995, during a very short excursion in 2001 and with bi-monthly frequency throughout a year from September 2003 to October 2004.

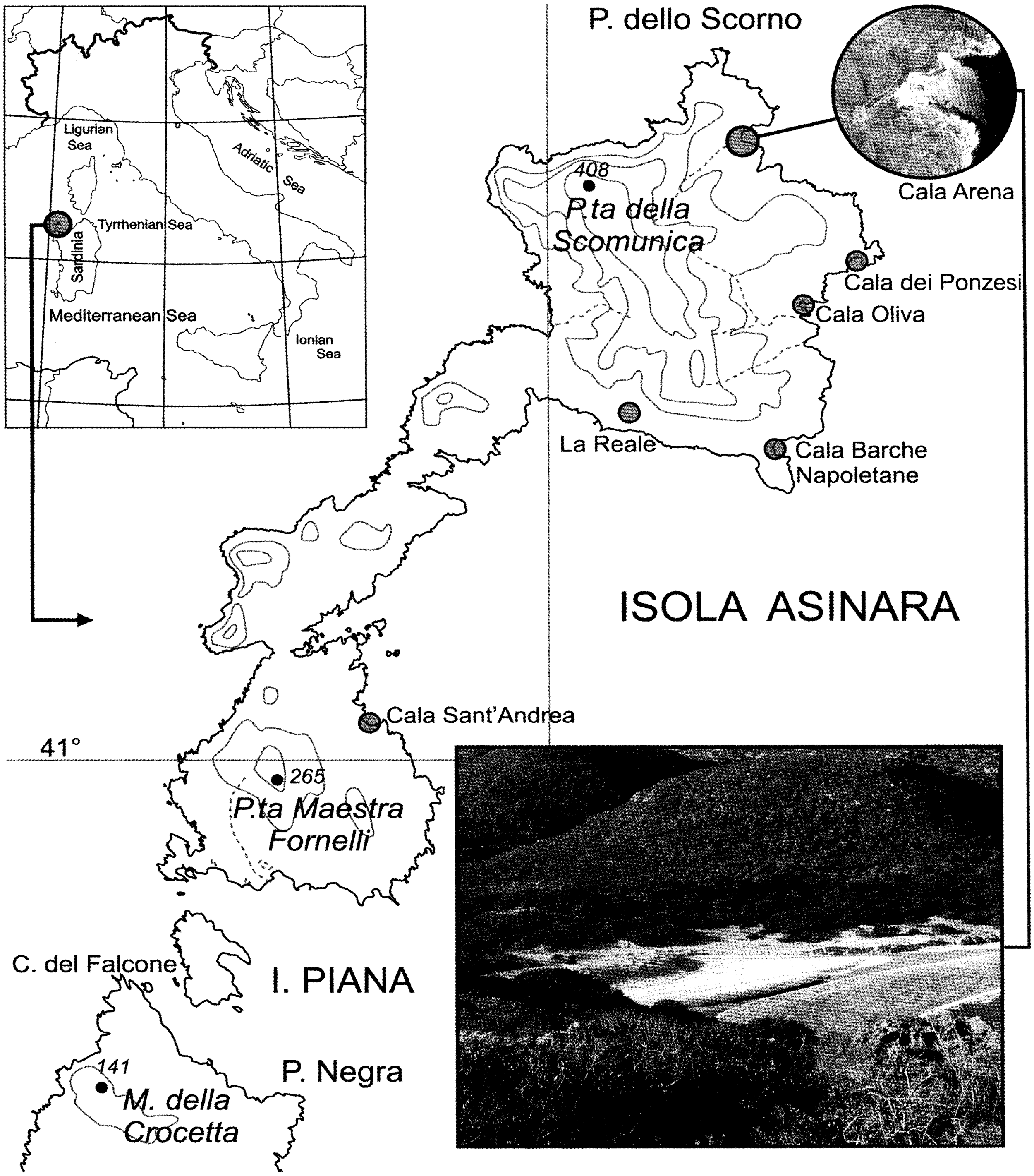

Fig. 1 – Map of Asinara with indications of its geographical position, collection localities, Cala Arena's aerial and landscape photos.

Unfortunately each time it was possible to visit only very few localities spending few hours on Neuropterida collection.

All the collected specimens are conserved in alcohol and preserved in Pantaleoni's collection.

List

Chrysopidae

Chrysopa dorsalis Burmeister, 1839
Cala Arena 1-2 VII 2004 4♂♂ 6♀♀ on *Juniperus*

The Asinara population includes specimens which have the typical characteristics of the species and others whose characteristics are like those of *Chrysopa regalis* Navás, 1915: the broad lines on the vertex becoming rather pale and thin and sometimes ending before they reach the posterior margin of the head; legs scarcely marked blackish; subcosta black at the base for only a fifth/half of the length of the wing; decoloration of the central part of the black stripe that almost covers the dorsal surface of the abdomen. The males tend to be darker than the females (Fig. 2).

Chrysopa formosa Brauer, 1850
Cala Barche Napoletane 15 V 2004 1♂; Cala Oliva 26 IX 2003 3♂♂ 4♀♀, 1 VII 2004 1♂ 2♀♀, 27 VII 2004 1♀

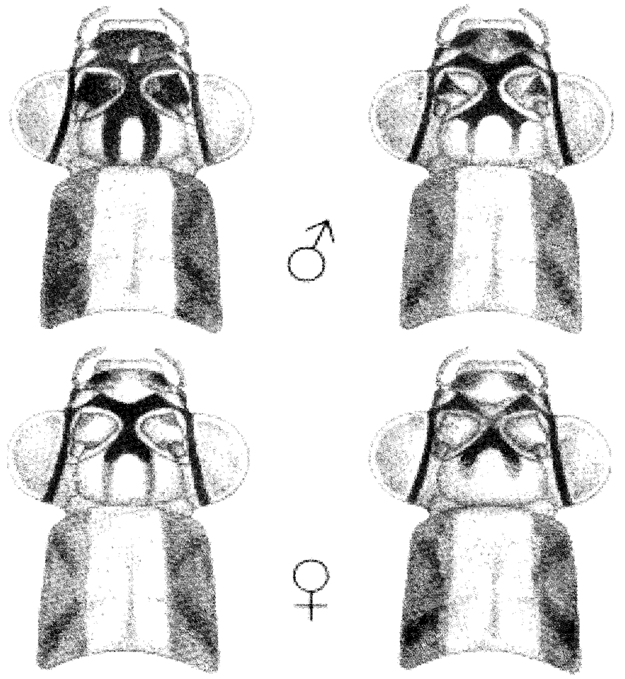

Fig. 2 – Head and prothorax of *Chrysopa dorsalis* from Asinara: darker (left) and paler (right) specimen; above males and below females. (Original draws by M. Mattei).

Dichochrysa clathrata (Schneider, 1845)
Cala Arena 19 VII 1995 1♂

Dichochrysa genei (Rambur, 1842)

Species recognised generically on "Asinara" by Navás (1928: 76).

Dichochrysa iberica (Navás, 1903)
Cala Arena 19 VII 1995 1♂ on *Juniperus*

Dichochrysa sp. pr. picteti (McLachlan, 1880)
Cala Arena 19 VII 1995 2♂♂ 5♀♀; Cala Oliva 26 IX 2003 2♀♀

Chrysoperla pallida Henry, Brooks, Duelli & Johnson, 2002
Chrysoperla lucasina (Lacroix, 1912)
Chrysoperla agilis Henry, Brooks, Duelli & Johnson, 2003
Cala Arena, Cala dei Ponzesi, Cala Oliva, Cala Sant'Andrea frequently in 2003 and 2004, many adults

We are not able to discriminate all the collected *Chrysoperla* specimens with certainty. However, on the basis of the songs observed in some male specimens, we can state that at least the three species listed above are present on Asinara.

Navás (1928: 76) recognised this species-group on "Asinara" under the name *Chrysopa vulgaris* Schneider, 1851.

Hemerobiidae

Hemerobius stigma Stephens, 1836
Cala Arena 19 VII 1995 1♂ on *Juniperus*

Coniopterygidae

Conwentzia psociformis (Curtis, 1834)
Cala dei Ponzesi 26 IX 2003 3♂♂, 28 VII 2004 on *Pistacia lentiscus* 4♂♂ 7♀♀, idem from cocoons 2♂♂

Semidalis aleyrodiformis (Stephens, 1836)
Cala dei Ponzesi 26 IX 2003 1♂, 28 VII 2004 on *Pistacia lentiscus* 1♂ 1♀

Semidalis pseudouncinata Meinander, 1963
Cala Arena 26 IX 2003 4♂♂ 5♀♀, 1-2 VII 2004 6♂♂ 6♀♀ on *Juniperus*

Myrmeleontidae

Synclisis baetica (Rambur, 1842)
Cala Arena, Cala dei Ponzesi, Cala Sant'Andrea frequently in 2003 and 2004, many larvae

Myrmeleon gerlindae Hölzel, 1974
La Reale 26 V 2001 1 larva (emerg. 1♂ VII 2002)

Myrmeleon inconspicuus Rambur, 1842
Cala Arena, Cala dei Ponzesi, Cala Sant'Andrea frequently in 2003 and 2004, many larvae

Macronemurus appendiculatus (Latreille, 1807)
Cala Arena 1-2 VII 2004 1♀

Distoleon tetragrammicus (Fabricius, 1798)
Cala Arena 1-2 VII 2004 1♀

Creoleon corsicus (Hagen, 1860)
Cala Arena 1-2 VII 2004 2♂♂

Ascalaphidae

Libelloides corsicus (Rambur, 1842)
Cala Arena 1-2 VII 2004 2♂♂ 5♀♀; Cala dei Ponzesi 28 VII 2004 1♀

Species recognised by A. Costa (1883: 17, 54-55) from the "collina che domina Cala d'Olivo" [hills over Cala d'Olivo].

Discussion and conclusions

Except three (to which we will refer later) all the species recognized from Asinara are common and widespread throughout Sardinia (Pantaleoni, unpublished data). Also *M. gerlindae*, of which we have only generic records in two lists (Pantaleoni, 1994; [Bernardi] Iori *et al.*, 1995), is in fact largely widespread on the main island (Pantaleoni, unpublished data).

On the other hand the absence of *Myrmeleon hyalinus* Olivier, 1811, from all of the beaches we have been able to study, is interesting. This species has been replaced by *M. inconspicuus* even in the micro-environments where it usually occurs in Sardinia: under bushes and trees on, or beyond, sand dunes (Pantaleoni, unpublished data).

One of the most interesting environments on Asinara is without doubt Cala Arena with its uncontaminated beach crowned by a well-preserved system of dunes surrounded by *Juniperus* formations of great importance (Fig. 1).

On the junipers we have found some Neuroptera normally linked to conifers. As well as the common *S. pseudouncinata* we have collected three species that are quite rare and stenotopic in Sardinia: *Chr. dorsalis, D. iberica* and *H. stigma*.

D. iberica was recorded only in the classical locality of Sorso, on the southern edge of the Gulf of Asinara (Grandi, 1957; Pantaleoni & Letardi, 1998), and for another unnamed locality on the oriental Sardinian coast (Aspöck *et al.*, 1980: II, 324). Very few further localities still remain unpublished (Pantaleoni, unpublished data). In Sardinia this species appears strictly confined to coastal *Juniperus* formation.

H. stigma was recognized in only two localities of northern Sardinia (Aspöck *et al.*, 1980: II, 297). *Chr. dorsalis* appears absolutely new to Sardinia, in fact the previous doubtful records are discussed and rejected by Pantaleoni (1999).

Both species are strictly allied to *Pinus* trees, particularly the Chrisopid, and their occurrence on *Juniperus,* if not surprising, is rather unusual.

In the case of *Chr. dorsalis*, not only the habitat is anomalous, but also the previous described adult habitus.

To the best of our knowledge (with few specimens of *Chr. regalis* examined by us) it is surely risky to advance any hypotheses. Nevertheless, in our opinion we have found a deeply isolated population of *Chr. dorsalis* that has been able to evolve its own peculiar ecological and chromatic traits. Also taking into consideration the rather unclear species rank of *Chr. regalis* (Aspöck *et al.*, 2001: 83), any relation with this taxon does not seem to be justifiable on a biogeographical basis.

Inevitably the list of the Neuropterida from Asinara will grow longer in the near future, after it has become easier to access and move around the island.

The finding of three species on Asinara which are rare or absent from Sardinia is due to the naturalistic value of the Cala Arena environment. We hope that this absolutely remarkable state of conservation will be taken into account in the management of the National Park.

Acknowledgements

The authors are indebted to their colleagues Michel Canard and Victor Monserrat who kindly provided them with some specimens of *Chrysopa regalis*. Logistic support from Corpo Forestale e di Vigilanza Ambientale of Sardinia and financial support from the Parco Nazionale dell'Asinara are gratefully acknowledged.

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poi anteriormente all'antenna, formare quivi il robusto condilo di articolazione dorsale della mandibola, e spegnersi dopo aver dato luogo ad un rinforzo abbracciante parzialmente la base del tubercolo portante

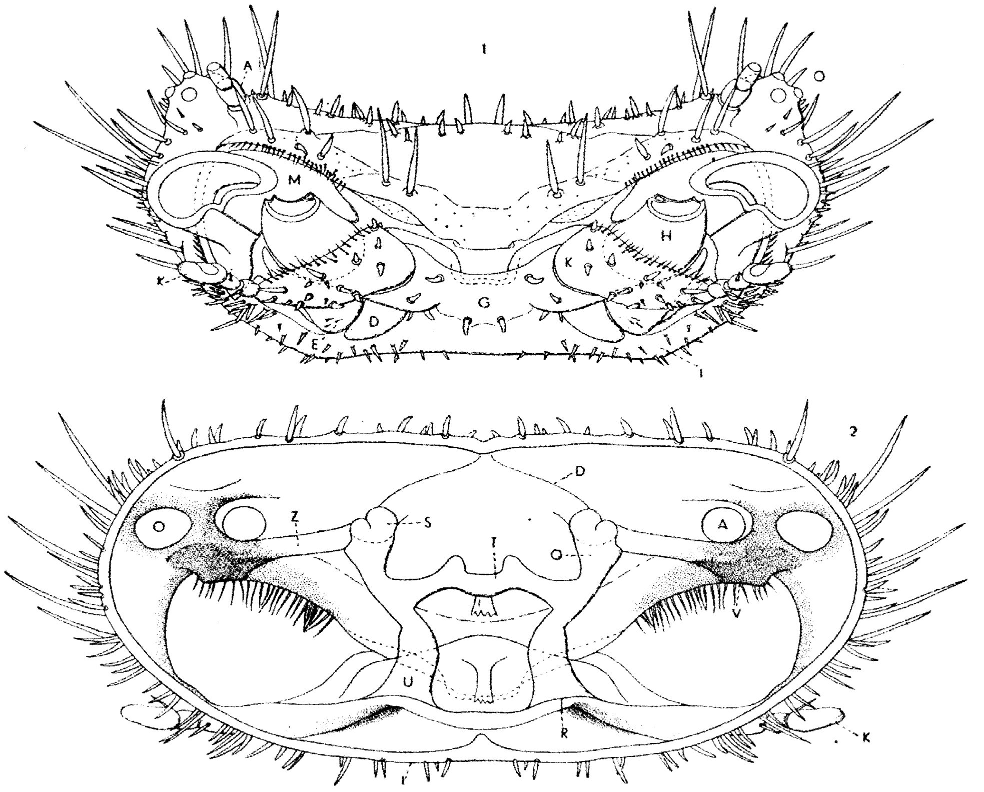

FIG. VI.

Myrmeleon inconspicuus Ramb. - Larva matura. — 1. Capo visto oralmente, con antenne, mandibole e lobi mascellari (i quali nel preparato si sono spostati dalla posizione fisiologica) troncati subprossimalmente. Le parti che normalmente combaciano e si incastrano tra di loro, determinando la chiusura fisiologica della bocca, appaiono allontanate l'una dall'altra: *A*, antenne; *D*, cardine delle mascelle; *E*, stipite delle mascelle; *G*, labbro inferiore; *H*, lobi mascellari; *K*, palpi labiali; *I*, regione ipostomale; *M*, mandibole; *O*, ocelli. - 2. Porzione anteriore del cranio, tagliata secondo un piano trasversale e veduta dall'interno: *A*, aree di articolazione delle antenne; *D*, suture divergenti; *K*, palpi labiali; *I*, ipostoma; *O*, cavità corrispondenti alle prominenze tubercoliformi portanti gli ocelli; *Q*, bracci anteriori del tentorio; *R*, aree di invaginazione dei bracci posteriori del tentorio; *S*, aree di invaginazione dei bracci anteriori del tentorio; *T*, formazione che unisce i bracci del tentorio di destra con quelli di sinistra; *U*, bracci posteriori del tentorio; *V*, condilo per l'articolazione dorsale delle mandibole; *Z*, apodemi antennali.

gli ocelli (fig. VI, 2). Il cranio è provvisto di numerosissime setole distribuite pressoché uniformemente su tutta la sua superficie. Di tali setole quelle inserite lateralmente ed anteriormente si presentano discreta-

M.M.P., 1943. – Contributi allo studio dei NEUROTTERI Italiani. II. *Myrmeleon inconspicuus* Ramb. ed *Euroleon nostras* Fourcroy. *Bollettino dell'Istituto di Entomologia della R. Università di Bologna*, 14: 131-192.

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Distribution of the families of Neuroptera with low species diversity in Bulgaria

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Bulgaria and Greece are the only countries in Europe where all twelve European families of Neuroptera occur. Eight of them can be characterized as families with low species diversity (1–4 species in Bulgaria and 2–19 taxa in Europe) and are represented in Bulgaria with 16 species altogether: Nevrorthidae, 1; Osmylidae, 1; Sisyridae, 4; Dilaridae, 1; Mantispidae, 3; Berothidae, 1; Nemopteridae, 1; Ascalaphidae, 4. Distribution in Bulgaria, habitats, maximum altitude and phenology of the treated species are outlined.

Key words – Neuroptera, Bulgaria, distribution, habitats, phenology.

Introduction

The richest fauna of Neuroptera in Europe is concentrated in the three South European peninsulas. Ranked by the species number, the first place is taken by the fauna of the Iberian Peninsula, followed by this of the Balkan Peninsula and of the Apennine Peninsula on the third place.

Twelve families are represented in European fauna. All these families are distributed in only two countries, Bulgaria and Greece. This is due to the absence of Nevrorthidae in the Iberian Peninsula and of Nemopteridae in the Apennine Peninsula because of historical and paleogeographical reasons, as well as to the absence of four families, thermophilous or with restricted ranges, in Central Europe and of six such families in North Europe. The comparison by regions in the European countries shows that the only territory in a country, where all twelve families occur, is the Bulgarian part of the Struma (Strimon) Valley with the adjacent areas: the middle course of the river (ten families), Sofia Plain (Sisyridae) and the mountains of Vitosha (Nevrorthidae and Sisyridae) and Osogovo (Nevrorthidae).

According to the species number, the families of Neuroptera divide into those with high[1] species diversity (four families: Chrysopidae, Hemerobiidae, Coniopterygidae and Myrmeleontidae; down to 47 species in Europe and 18 species in Bulgaria) and those with low species diversity (eight families; up to 16 species in Europe and 4 species in Bulgaria). When we arrange them under the species number, the difference between two next families is largest between the last family of the first group and the first family of the second group. The former is richer in species than the latter with 31 species or 2.9 times in Europe and with 14 species or 4.5 times in Bulgaria. If we compare the World fauna, the families determined here as those of high species diversity occupy again the first four places with richest fauna (Aspöck & Aspöck, 1999), although the difference between the two groups is not so distinct.

The aim of the present paper is to col-

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[1] These families can be accepted as those with high species diversity only if they are regarded within the boundaries of the order Neuroptera. Compared to the families of the other insect orders, they should be considered rather for families with medium species diversity.

lect all data on horizontal distribution of the species from the families with low species diversity in Bulgaria and to extract summarized information on their habitats, altitudinal distribution and phenology. Besides the published distributional data, all available collection in Bulgaria was identified or revised and the material of the treated families in them was accumulated and is preserved now in the National Museum of Natural History in Sofia.

List of species

Nevrorthidae

Nevrorthus apatelios Aspöck, Aspöck & Hölzel, 1977

Published data – VITOSHA MTS.: Boyana (Klapálek, 1895, 1917; Popov, 1990, 1993); Dragalevtsi (Klapálek, 1894, 1895, 1917; Popov, 1990, 1993). WESTERN RHODOPES: Batak; Devin; Chepelare; Smolyan (all according to Zelený, 1971).

Unpublished data – CENTRAL STARA PLANINA: Cherni Osam River, 9 km S of Cherni Osam Village, 800 m, 1 ♂, 22.7.1969, K. Kumanski. OSOGOVO MTS.: Bistritsa River above Garlyano, 900-1000 m, on *Alnus incana* and various deciduous tree species, also on light, 25 ♂♂, 5 ♀♀, 8–10.7.1965, on *Carpinus betulus*, 1 ♂, 19.7.2005, all A. Popov. Published preliminarily from these mountains by Popov (1991, 2000a).

See Fig. 1.

Navás (1935: Fig. 6–8) published drawings of male and female genitalia and mentioned that the figures of male genitalia are according to Esben-Petersen. In reality, this is a reproduction of drawings of Klapálek (1917: Fig. 9–11). Esben-Petersen has never published figures of *Neurorthus*. Navás (1935: Fig. 6–8) considered the figured species as *N. iridipennis* Costa, 1863 but it is in fact *N. apatelios*.

This is the only Balkan endemic species of Neuroptera in Bulgaria. The localities in Stara Planina Range, Rhodopes, and Greek island of Thasos (Malicky, 1984) outline the eastern border of the range. The easternmost locality is Cherni Osam.

The species is found in Bulgaria always on branches over the water of *Carpinus betulus* L. and other deciduous trees and of *Alnus incana* (L.) from the shrubs along mountainous streams at an altitude between 800 and 1100 m. Determinative for association of *N. apatelios* with the vegetation is not the species belonging to the trees and shrubs but their

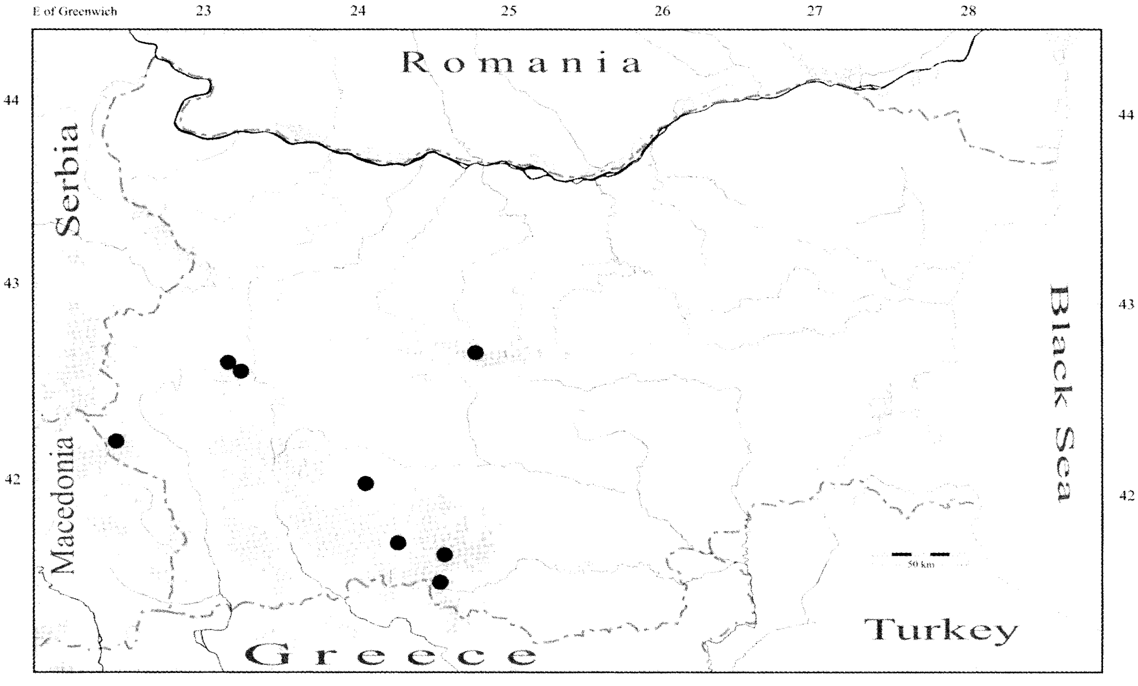

Fig. 1 – Distribution of *Nevrorthus apatelios* in Bulgaria. Areas above 1200 m altitude are shaded.

location along the riversides. Each locality in Bulgaria is isolated from the others. The species seems to be stenotopic regarding the characteristics and temperature of the cold fast-running streams and rivers (rhithral), which the larvae inhabit, and the narrow altitudinal range established so far in Bulgaria (in Greece it is found between 90 and 950 m, see Malicky, 1984).

One generation yearly. Known extreme dates of flight period: 6 July (Smolyan) and 3 August (Dragalevtsi). The dates of finding in Vitosha Mts. (first days of August) are the latest records of adults in the range (Popov, 1993).

Osmylidae

Osmylus fulvicephalus (Scopoli, 1763)

Published data – CENTRAL DANUBIAN PLAIN: Katunetz near Lovech (Popov, 1964). BLACK SEA COAST: Balchik; Pobiti Kamani site near Varna (both according to Popov, 1977); Varna (Buresch, 1936). WESTERN STARA PLANINA: Lakatnik and Bov in Iskar Gorge (both according to Zelený, 1971). CENTRAL STARA PLANINA: along Tazha River (Joost, 1973). EASTERN STARA PLANINA: Sliven and environs (Buresch, 1936; Joost, 1973). LYULIN MTS.: above Vladaya (Buresch, 1936); above Knyazhevo (Klapálek, 1895). VITOSHA MTS.: Studena (Popov, 1990); Cheren Kos site; Knyazhevo (both according to Zelený, 1971); Boyana; Bunkera site near Bistritsa (both according to Popov, 1990). SOFIA PLAIN: Sofia (Buresch, 1936). STRUMA VALLEY: Kresna Gorge (Popov, 2001); Sandanski (Joost, 1973); Petrich (Popov, 1993). SLAVYANKA MTS. (Popov, 1964). RILA MTS.: Raduil. RILA–RHODOPES: Belovo (both according to Buresch, 1936). WESTERN RHODOPES: Peshtera; Devin; Smolyan (all according to Zelený, 1971); Bachkovo (Buresch, 1936). EASTERN RHODOPES: Ardino (Zelený, 1971). STRANDJA MTS.: Kalovo (Popov, 1993).

Unpublished data – CENTRAL DANUBIAN PLAIN: Krushuna near Letnitsa. BLACK SEA COAST: Batovo near Dobrich. WESTERN PREDBALKAN: Drashan near Byala Slatina. WESTERN STARA PLANINA: Prevala near Chiprovtsi; Cherepish, Rebrovo and Kurilo (Novi Iskar) in Iskar Gorge; Kremikovtsi near Sofia. CENTRAL PREDBALKAN: Golyam Izvor near Teteven; Vetrintsi near Veliko Tarnovo. CENTRAL STARA PLANINA: Ribaritsa near Teteven; Oreshak and Cherni Osam near Troyan; Ostrets (Apriltsi); Etarat near Gabrovo. EASTERN STARA PLANINA: Kipilovo near Kotel; Kotel; Varbitsa. KRAISHTE: Rui Mts., Rui Chalet; Zemen. WESTERN SREDNA GORA: German; Kokalyane. CENTRAL SREDNA GORA: Panagyurishte. MALESHEVSKA MTS.: Gorna Breznitsa. BELASITSA MTS.: Belasitsa Chalet. PIRIN MTS.: Lilyanovo; below Popina Laka; Breznitsa; Kalimantsi.

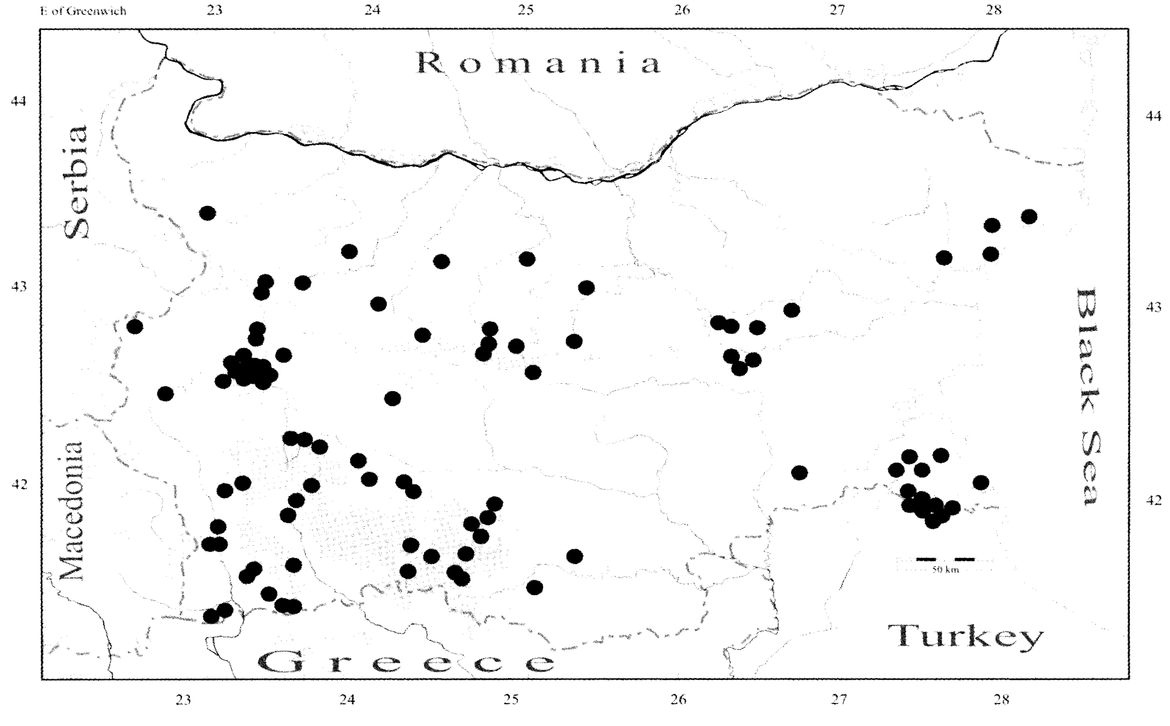

Fig. 2 – Distribution of *Osmylus fulvicephalus* in Bulgaria. Areas above 1200 m altitude are shaded.

RILA MTS.: above Blagoevgrad; Parangalitsa Reserve; Borovets; Kostenets Resort. RILA–RHODOPES: General Kovachev Railway Station; Yurukovo; Cherna Mesta. WESTERN RHODOPES: Tsepina Railway Station; Dobra Voda Chalet near Peshtera; Yagodina; Beden; Asenovgrad; Narechen; Persenk Mine; Chepelare; Smolyanski Ezera Chalet. EASTERN RHODOPES: Chernoochene. STRANDJA MTS.: Bolyarovo; Krushevets; Yasna Polyana; Mladezhko; Kovach site near Zvezdets; Katundere Valley near Zvezdets; Aidere Valley near Malko Tarnovo; Stoilovo; Vitanovo Reserve near Malko Tarnovo; Malko Tarnovo; Tsarnogorovo site near Malko Tarnovo; Slivarovo; Ahtopol.
See Fig. 2.

O. fulvicephalus is a common species in most regions of Bulgaria along fast-running and slowly-running waters on shrubs and trees, most often on *Salix* and *Ulmus*. It is a characteristic species of the rhithral and is found up to 1700 m (mainly below 1100 m). The high situated localities in Bulgaria are: Rui Chalet in Rui Mts. near the border with Serbia, 1700 m; Smolyanski Ezera Chalet in the Rhodopes, 1530 m; Borovets in Rila, 1400 m. The species occurs often in the zone of streams and brooks in the lower parts of the mountains and its abundance decreases strongly above 800 m because of climatic reasons. 87 % of the specimens in Bulgaria were collected below 800 m. Among the above mentioned localities are the first records for the Predbalkan (Western and Central), Sredna Gora (Western and Central), Kraishte, Western Frontier Mountains (Maleshevska Mts.), Belasitsa, Pirin and the southern part of the Black Sea Coast (Ahtopol).

One generation yearly. Extreme dates of flight period: 18 May (Lukovitsa Valley near Asenovgrad in the Rhodopes) and 22 August (Sredna Gora Range above Panagyurishte).

Sisyridae

Sisyra nigra (Retzius, 1783)
Published data – VITOSHA MTS.: Cherni Vrah Peak (Popov, 1990). SOFIA PLAIN: Ravno Pole near Sofia (Navás, 1925, 1935; Arndt, 1943).
Unpublished data – SOFIA PLAIN: stagnant waters along Stari Iskar River at Chepintsi near Sofia, 2 ♂♂, 2 ♀♀, 29–30.5.1974, 1 ♀, 3.6.1974, 2 ♂♂, 9.7.1974 and 1 ♀, 19.7.1978, all K. Kumanski. EASTERN STARA PLANINA: Sherba Game Reserve S of Grozdyovo, 1 ♀, 25.5.1970, A. Slivov. STRANDJA MTS.: Veleka River, Kachul site near Gramatikovo, 1 ♀, 18.6.1980, A. Popov.
See Fig. 3.

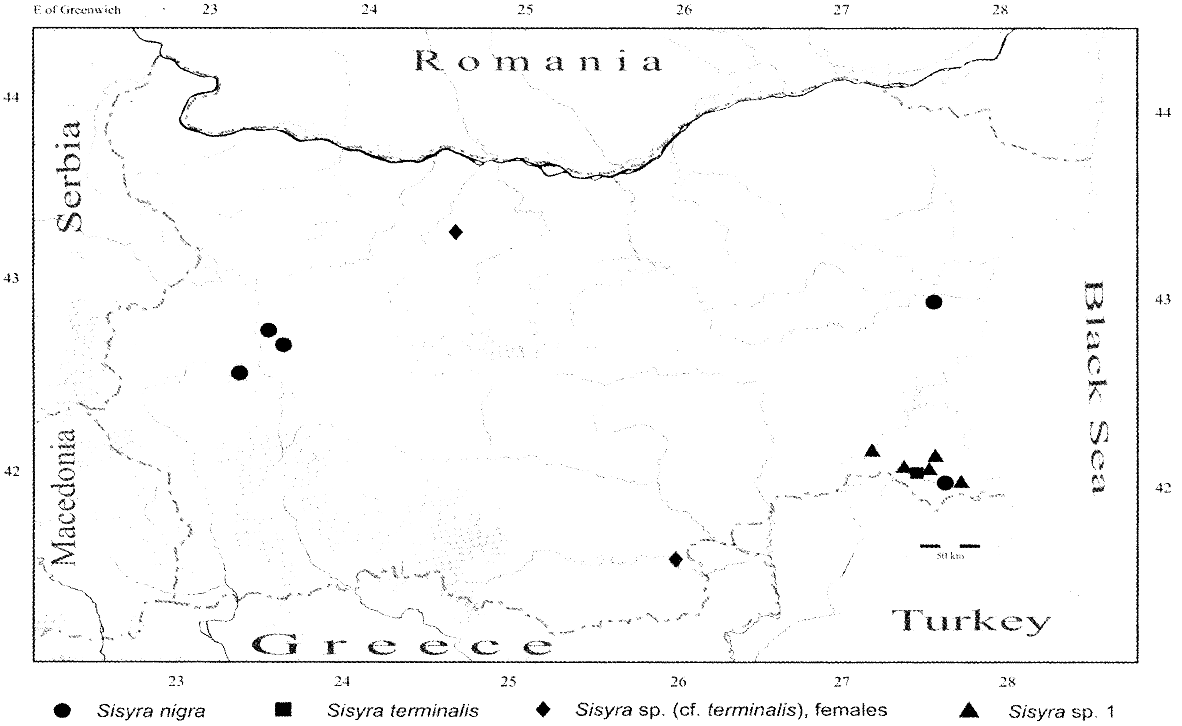

Fig. 3 – Distribution of the family Sisyridae in Bulgaria. Areas above 1200 m altitude are shaded.

This species occurs along stagnant waters (limnal). Half of the samples originate from the shores of an artificial basin near the dead waters along Stari Iskar River where it was found on marshy vegetation. A single specimen only was collected along running waters (potamal: Veleka River is slowly-running at Kachul site) together with *Sisyra* sp. 1. The surprising record of a female on a snow-drift 10 m below Cherni Vrah Peak, the highest peak of Vitosha Mts., impress with its high altitude (2270 m). The altitude is ca. 1000 m higher than the findings in the species range. Most likely the specimen has drifted there by wind. This record however indicates that *S. nigra* occurs perhaps in the peatbogs of the high mountain plateau of Vitosha (Popov, 1990).

Number of generations yearly in Bulgaria unclear. Two generations in Central Europe (Weissmair, 1994; Hölzel & Weissmair, 2002). The probable number of generations in Bulgaria is also two. Extreme dates of flight period: 18 May (Cherni Vrah) and 19 July (Chepintsi).

Sisyra terminalis Curtis, 1854

Unpublished data – STRANDJA MTS.: Veleka River, Kovach site near Zvezdets, 1 ♂, 8.8.1981, leg. K. Kumanski, det. H. Rausch. The above mentioned locality was preliminarily published without details by Popov (1998).

See Fig. 3.

Besides the mentioned male, in Bulgaria also females were found, most likely belonging to *S. terminalis*, in the following localities (Fig. 3): CENTRAL DANUBIAN PLAIN, Gortalovo near Pleven, Chernelka Gorge, 1 ♀, 24.6.1983, A. Popov; EASTERN RHODOPES, Arda Chalet near Dabovets, 1 ♀, 26.5.1990, S. Beshkov.

The locality in Strandja is the southernmost one and extends the knowledge of the species range. The single male is found along running waters (potamal: Veleka River is relatively fast running at Kovach site) together with *Sisyra* sp. 1. Both females are collected also along running waters, respectively along a small river and a dam lake.

Number of generations yearly in Bulgaria unclear. Two generations in Central Europe (Weissmair, 1994; Hölzel & Weissmair, 2002).

Sisyra sp. 1

Unpublished data – STRANDJA MTS.: Fakiiska River, 4 km N of Golyamo Bukovo near Sredets, 8 ♂♂, 3 ♀♀, 1 specimen without abdomen, 8.8.1981; Zelenkovska River, 10 km S of Yasna Polyana near Sozopol, 2 ♂♂, 4 ♀♀, 5.8.1981; Veleka River, Kovach site near Zvezdets, 6 ♀♀, 12.7.1975 and 5 ♂♂, 8 ♀♀, 8.8.1981; Zabernovska River near its outfall in Mladezhka River, S of Zabernovo, 1 ♀, 6.7.1981, all leg. K. Kumanski; Veleka River, Kachul site near Gramatikovo, 1 ♀, 18.6.1980, leg. A. Popov, all det. H. Rausch and W. Weissmair.

See Fig. 3.

The species is under description by Hubert Rausch and Werner Weissmair. It occurs along small and large rivers (potamal), sometimes together with single specimens of *S. nigra* and *S. terminalis* (see above).

Extreme dates of flight period: 18 June (Kachul) and 8 August (Golyamo Bukovo; Kovach).

Sisyra sp. 2

Also a species under description by Hubert Rausch and Werner Weissmair. It occurs in Southeastern Bulgaria.

Dilaridae

Dilar turcicus Hagen, 1858

Published data – STRUMA VALLEY: Kresna Gorge from Stara Kresna Railway Station to Kresna Town (Popov, 1964, 2001; Zelený, 1971). RILA MTS.: Kostenets (Zelený, 1971). EASTERN STARA PLANINA: Sliven (Popov, 1964).

Unpublished data – WESTERN STARA PLANINA: Lakatnik in Iskar Gorge, 5 ♂♂, 31.7.1965. CENTRAL STARA PLANINA: Etropole Monastery, 1 ♂, 9.7.1972, both H. Lukov; Sini Vir site near Etropole, 1 ♂, 12.8.1974, P. Beron. BELASITSA MTS.: Belasitsa Chalet, 1 ♀, 13.7.1978, A. Popov. STRUMA VALLEY: Zheleznitsa near Simitli, 3 ♂♂, 3 ♀♀, 7.6.1967, I. Buresch, A. Popov, 1 ♀, 3.6.1972, M. Josifov; Kozhuh Hill near Petrich, 3 ♂♂, 14.6.1982, 1 ♂, 10.5.1983, 5 ♂♂, 17.5.1983, 2 ♂♂, 10.6.1983, 1 ♂, 11.5.1988, all J. Ganev. PIRIN MTS.: Popina Laka, 3 ♂♂, 29.7.1969, A. Slivov; above Sugarevo near Melnik, 1 ♂, 23.6.2001; Pirin Village, 2 ♂♂, 22.6.2001, all S. Beshkov; Kalimantsi, Malaise trap, 1 ♂, 9–12.5.2002, M. Langourov. SLAVYANKA MTS.: 3 ♂♂, 17.6.1937, I. Buresch, 1 ♂, 1.7.1937, P. Drenski. WESTERN RHODOPES: Polkovnik Serafimovo near Smolyan, 1 ♂, 15–20.8.1970, S. Zagorchinov. EASTERN RHODOPES: E of Krumovgrad, 1 ♂, 22.7.1968, A. Slivov. STRANDJA MTS.: Krushevets, 7 ♂♂, 5.8.1981, E. Popova; 10 km S of Yasna Polyana, 1 ♂, 5.8.1981, V. Jordanova; Kovach site near Zvezdets, 1 ♂, 20.7.1973, A. Slivov; Katundere Valley near Zvezdets, 2 ♂♂, 11.7.1975, K. Kumanski; Zabernovska River near its outfall in Mladezhka River, 1 ♂, 2 ♀♀, 6.7.1981, E. Popova; Malko Tarnovo, 2 ♂♂, 30.7.1983, J. Ganev.

See Fig. 4.

D. turcicus is collected on herbaceous vegetation and on light. It has a preference for more humid habitats than the other species in Bulgaria from the families of southern origin anc terrestrial larvae treated in the present paper. Its surprising finding in Stara Planina Range and in its northern foots is very likely due to these heightened requirements of humidity. The species is reported for the first time for North Bulgaria and for the mountains of Pirin, Belasitsa, Slavyanka, Rhodopes and Strandja. *D. turcicus* is distributed in plains and lower parts of mountains mainly up to 700 m; higher it occurs on the warm slopes of Slavyanka (1100 m) and the southern parts of Pirin (1200 m: Popina Laka) and Rhodopes (1000 m: Polkovnik Serafimovo). The material from Slavyanka (with grey wings) differs from that from the other parts of the country (with yellow wings) but according to the male genitalia the two phena are conspecific. The specimens from Strandja are characterized by their considerably smaller size but also do not show differences in the male genitalia compared with the other populations.

One generation yearly. Extreme dates of flight period: 10 May (Kozhuh Hill) and 15 August (Polkovnik Serafimovo).

Mantispidae

Mantispa styriaca (Poda, 1761)

Published data – VITOSHA MTS.: Knyazhevo (Popov, 1990). STRUMA VALLEY: Kresna Gorge (Popov, 1998, 2001); Tisata Reserve (Popov, 2001). THRACIAN LOWLAND: Stara Zagora (Buresch, 1940).

Unpublished data – WESTERN DANUBIAN PLAIN: Vidin, 1 ♂, 1986, J. Ganev.

See Fig. 5.

This is a very rare species in Bulgaria. Only seven specimens are known from this country. *M. styriaca* is reported for the first time from North Bulgaria. It is found together and at the same time with *M. aphavexelte* near the outfall of Oshtavska River in Struma River in Kresna Gorge (Sheitandere site, 24.6.2001, S. Beshkov) and 2 km further north in one and the same place but in different time also with *M. perla* and *M. aphavexelte* (leg. H. Lukov on light). The photographed specimen, published by Josifov & Simov (2003) as *M. styriaca*, has a well-visible pale spot on the inner side of the fore femur and is in fact *M. aphavexelte*. Furthermore, the specimen does not originate from the Rhodopes where *M. styriaca* is not established so far.

The species inhabits meadows and open steppe habitats in lowlands and plains. It was collected on herbaceous vegetation, on *Vicia* or attracted to light and occurs up to 650 m (Knyazhevo near Sofia), mainly up to 300 m.

One generation yearly. Extreme dates of

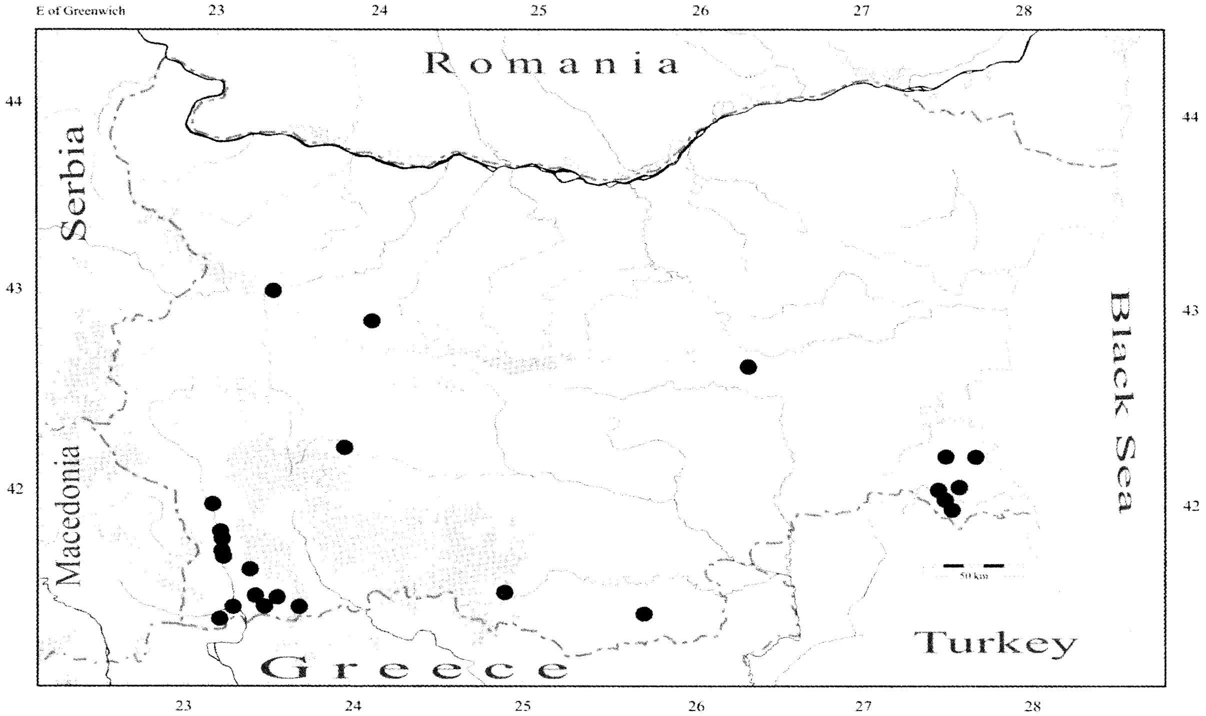

Fig. 4 – Distribution of *Dilar turcicus* in Bulgaria. Areas above 1200 m altitude are shaded.

flight period: 24 June and 10 August (both in Kresna Gorge). A typical summer species. Its later emergence is an adaptation which enables it to inhabit also Central Europe.

Mantispa perla (Pallas, 1772)

Published data – STRUMA VALLEY: Kresna Gorge (Popov, 1998, 2001). THRACIAN LOWLAND: Stara Zagora (Buresch, 1936).

See Fig. 5.

M. perla is one of the rarest neuropterous species in Bulgaria. Only two specimens were recorded so far. This is the species among Neuroptera not found for the longest time in this country, during the last 43 years. Nevertheless, it should not be considered extinct in Bulgaria. A lowland species collected on light up to 200 m in the beginning of June. It is a typical spring species also in the other parts of its range. The adults emerge earlier than those of *M. styriaca* and because of that the range of *M. perla* does not exceed in the north the borders of South Europe.

Mantispa aphavexelte Aspöck & Aspöck, 1994

Published data – WESTERN DANUBIAN PLAIN: Lom (Buresch, 1936). STRUMA VALLEY: Kresna Gorge; Kresna Town (both according to Popov, 2001). EASTERN STARA PLANINA: Sliven (Zelený, 1971; Popov, 1993). BLACK SEA COAST: Gyunduza Hill S of Varna–Asparuhovo (Popov, 1977). STRANDJA MTS. (Popov, 1964).

Unpublished data – CENTRAL DANUBIAN PLAIN: Bozhuritsa near Dolna Mitropolia, on light, 1 ♀, 25.6.1983; Chernelka Gorge at Gortalovo near Pleven, 1 ♂, 24.6.1983, both A. Popov; Nikolaevo near Pleven, 1 ♂, 5.6.1996, S. Yuzekchiev. OGRAZHDEN MTS.: Lebnitsa near Sandanski, on light, 1 ♀, 4.8.1986, J. Ganev. EASTERN RHODOPES: Madjarovo, 2 ♂♂, 2 ♀♀, 7.7.1992, S. Beshkov. BLACK SEA COAST: Varna Botanical Garden in Vinitsa, on light, 3 ♂♂, 1 ♀, 10–11.7.2002, D. Chobanov, B. Zlatkov; Sozopol, 1 ♀, 28.7.1979, A. Hoffer; Camping Perla near Primorsko, 1 ♂, 7.8.1998, S. Beshkov; Primorsko, 1 ♂, 1 ♀, 3.7.1979, A. Hoffer. STRANDJA MTS.: Krushevets near Sozopol, 1 ♀, 18.6.1985, V. Jordanova; Gramatikovo near Malko Tarnovo, 1 ♂, 6.6.1959, M. Josifov.

See Fig. 5.

Kresna Gorge is the only known locality in Bulgaria where all three mantispid species occur sympatrically. The species was found on *Achillea millefolium* L. in a meadow with tall herbage and prevalence of *Anchusa officinalis* L. and sparsely planted young apple-trees (Gyunduza near Varna according to Popov, 1977), only once on *Salix* (Chernelka Gorge), in dry sunny lowland grassy

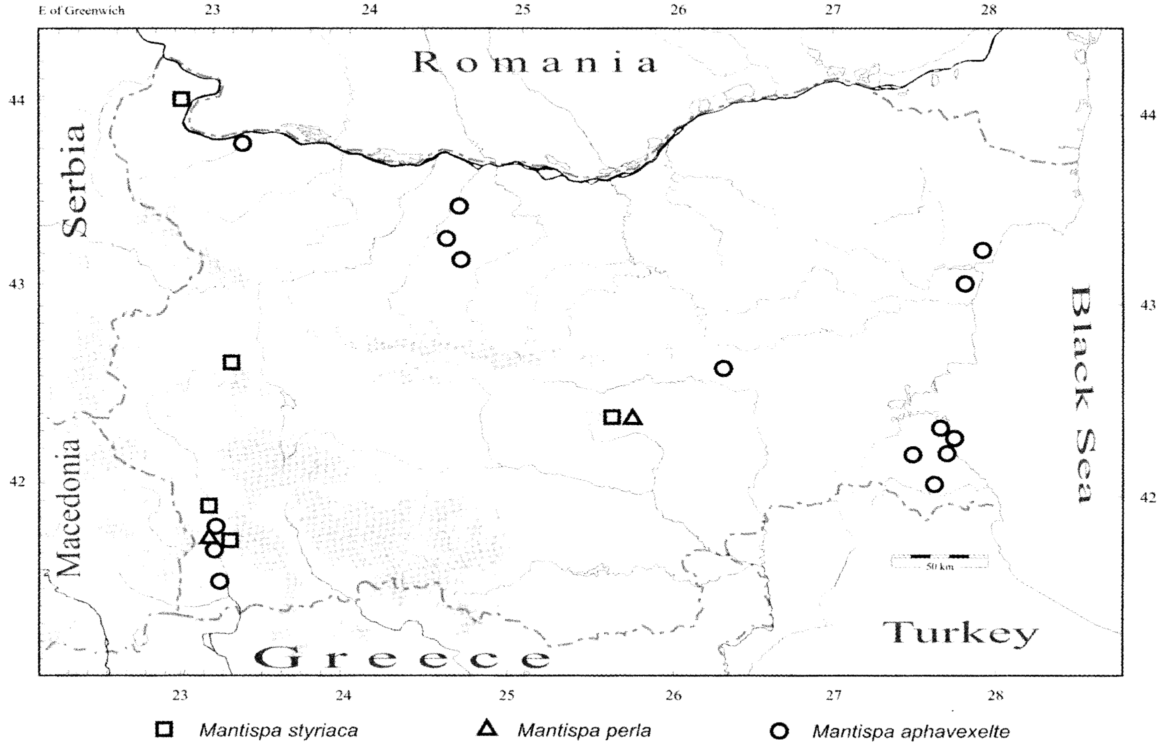

Fig. 5 – Distribution of the family Mantispidae in Bulgaria. Areas above 1200 m altitude are shaded.

areas and was collected on light up to 250 m (Gramatikovo in Strandja). All localities and areas excepting Kresna Gorge are first records (unpublished or misidentifications).

One generation yearly. Earliest date of flight period: 5 June (Nikolaevo near Pleven in North Bulgaria). Latest dates of flight period: 29 August and 1 October (both Kresnensko Hanche in Kresna Gorge). Occurrence of adults of the three species later than in August is not known so far. The record of 1 October either is a result of mislabelling or is a case of a specimen survived as an exception later than the normal period of flight. It is known that females of most Neuroptera live longer than the males and the specimen labelled as "1 October" is a female.

Berothidae

Isoscelipteron fulvum Costa, 1863

Published data – STRUMA VALLEY: Kresna Gorge (Popov, 2001). BLACK SEA COAST: Poda Protected Territory near Burgas; Alatepe Hill in Rosenets Park near Burgas (both according to Popov, 1964, 1977); Arkutino near Primorsko (Popov, 1977).

Unpublished data – BLACK SEA COAST: Aladja Monastery near Varna, 1 ♀, 10.8.1982, S. Zagorchinov; Priseltsi near Obzor, 1 ♀, 5.8.1987, S. Beshkov. STRUMA VALLEY: Kozhuh Hill near Petrich, 1 ♀, 3.9.1981, J. Ganev. PIRIN MTS.: above Sugarevo near Melnik, 1 ♂, 23.6.2001, S. Beshkov; Melnik, 1 ♂, 22.6.1957, S. Bocharov. EASTERN RHODOPES: Chorbadjiisko near Momchilgrad, on *Quercus*, 1 ♂, 1 ♀, 22.6.1969; Avren near Krumovgrad, on *Quercus*, 1 ♀, 21.6.1969, both A. Slivov; Meden Buk near Ivailovgrad, 1 ♀, 20.9.1995; Belopolyane near Ivailovgrad, 1 ♂, 21.9.1995. SAKAR MTS.: Dositeevo near Harmanli, 1 ♀, 14.9.1986, all S. Beshkov.

See Fig. 6.

The localities on the Black Sea Coast are the northernmost ones of the family in the Eastern Hemisphere. All specimens originated from the warmest and very dry parts of South Bulgaria and only along the Black Sea Coast this species has dispersed in North Bulgaria. Among the mentioned localities are the first records in North Bulgaria and in the mountains of Pirin, Rhodopes and Sakar where the species occurs only in their lower parts. *I. fulvum* is found on *Quercus* and attracted to light. The habitat represents typical pseudomaquis in arid areas with sparse oak trees. A lowland species distributed up to 800 m (above Sugarevo) but mainly up to 400 m (Melnik; Avren).

One generation yearly. Extreme dates of flight period: 2 June (Kresna Gorge) and 21 September (Belopolyane). *I. fulvum* and *Manti-*

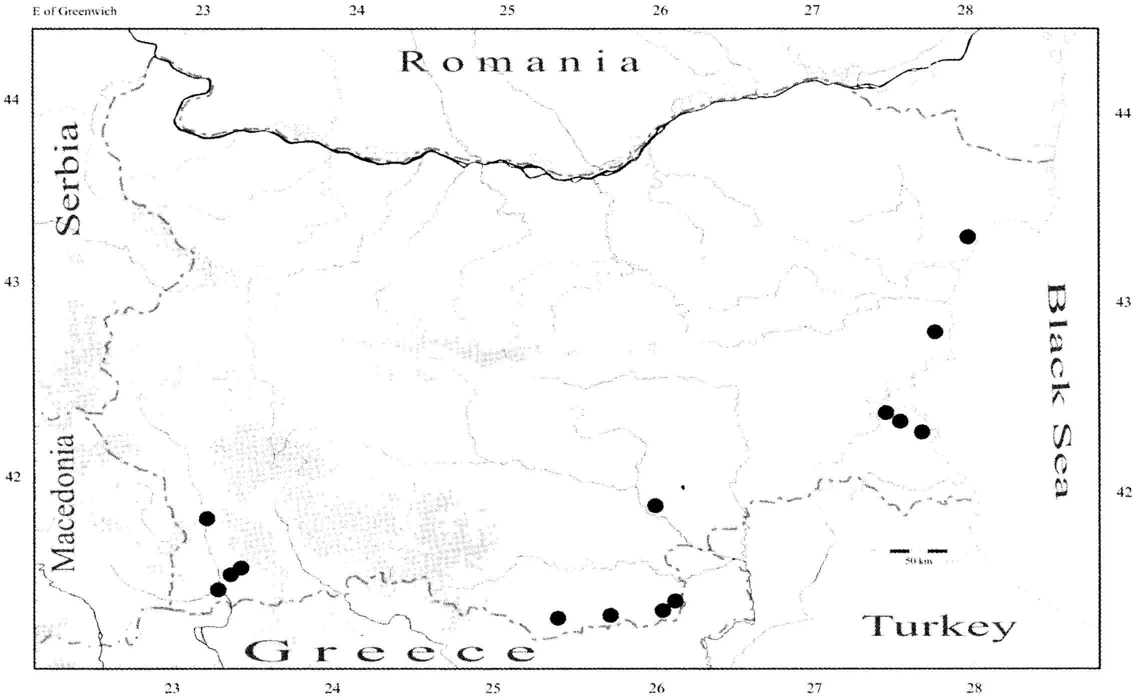

Fig. 6 – Distribution of *Isoscelipteron fulvum* in Bulgaria. Areas above 1200 m altitude are shaded.

spa aphavexelte are the species with longest period of flight and with latest dates of adult ocurrence from the families with low species diversity in Bulgaria.

Nemopteridae

Nemoptera sinuata Olivier, 1811

Published data – MALESHEVSKA MTS.: Gorna Breznitsa (Popov, 1963). STRUMA VALLEY: Kresna Gorge from Krupnik and Mechkul to Kresna and Vlahi (Zukowsky, 1935; Buresch, 1936; Popov, 1971, 2001, 2002); Sandanski (Popov, 1971; Zelený, 1971); Levunovo (Buresch, 1936); Parvomai near Petrich (Prostov, 1963); along Strumeshnitsa River (Popov, 1963); Petrich; Marino Pole (both according to Popov, 1971). BELASITSA MTS. (Zelený, 1971). SLAVYANKA MTS.: above Petrovo. WESTERN RHODOPES: Sestrimo; Chepinska River Gorge; Dorkovo near Velingrad (all according to Buresch, 1936); Peshtera (Popov, 1963, 1993); Vacha Valley, 10 km S of Krichim (Popov, 1963); Devin (Popov, 1971); Asenovgrad and environs (Buresch, 1936, 1940; Zelený, 1971; Popov, 1993); Bachkovo (Popov, 1963, 1971). EASTERN RHODOPES: Byal Kladenets near Studen Kladenets Dam Lake; Madjarovo and environs; Ivailovgrad Dam Lake; Kamilski Dol near Ivailovgrad (all according to Zaharov, 1968). THRACIAN LOWLAND: Konstantinovo Railway Station near Simeonovgrad; Harmanli (both according to Popov, 1971). CENTRAL STARA PLANINA: above Enina near Kazanlak, 650 m (Dimitrov, 2004). EASTERN STARA PLANINA: Sliven and environs (Zaharov, 1968; Popov, 1971, 1993); Sinite Kamani Nature Park; Kutelka Peak; Karandila Resort; 400-700 m (all according to Popov, 1971). STRANDJA MTS.: N of Malko Tarnovo (Popov, 1971); Gramatikovo (Popov, 1963).

Unpublished data – SAKAR MTS.: Mramor near Topolovgrad, 2 ♂♂, 1 ♀, 2.6.1982, A. Popov.

See Fig. 7.

Localities in Stara Planina Range are the northernmost ones in the species range. *N. sinuata* occurs only in South Bulgaria in warm pseudomaquis, rich in herbaceous vegetation, in valleys and gorges usually up to 600–700 m (as an exception up to 1100 m in Slavyanka: Trana site above Petrovo). On one hand, valleys protect adults from winds since they are not good fliers because of modified hindwings; on the other hand, they ensure higher humidity. The humidity requirements of *N. sinuata* are lower than these of *Dilar turcicus* but higher than those of the other species of treated families with terrestrial larvae. For that reason, *N. sinuata* inhabits sunny meadows where most often perches on racemes of *Achillea coarctata* Poir.

The populations in valleys are relatively isolated one from another. A perfect isolation

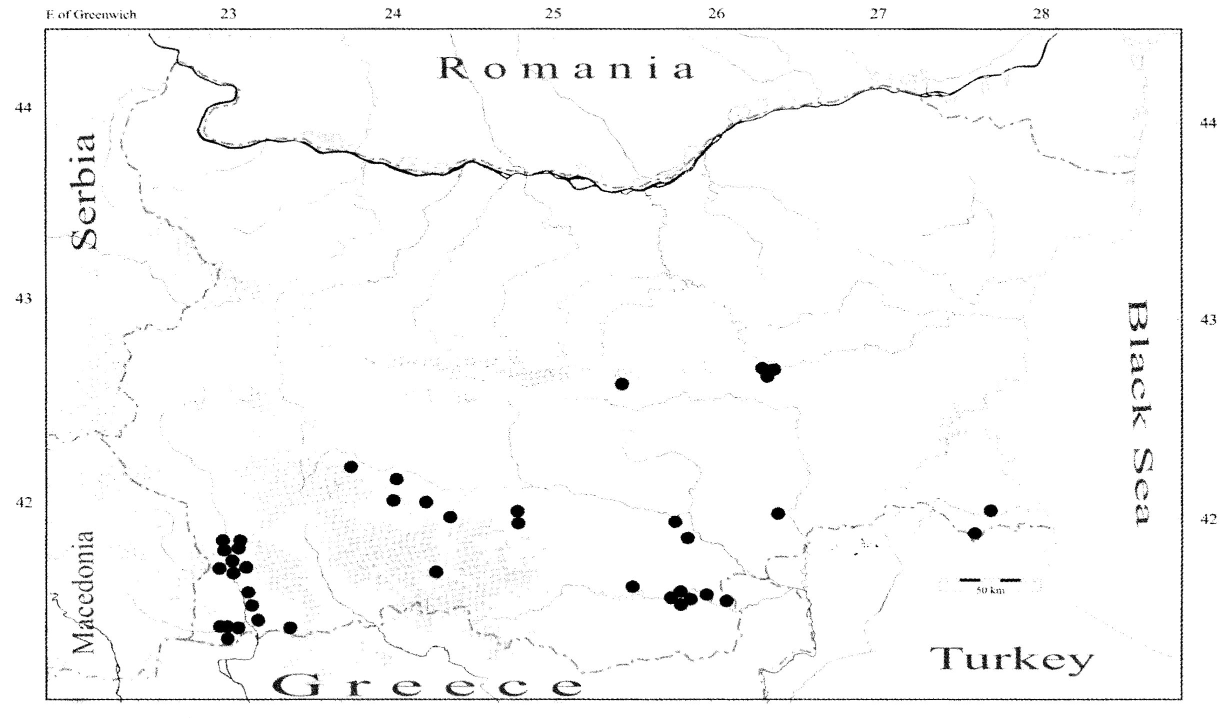

Fig. 7 – Distribution of *Nemoptera sinuata* in Bulgaria. Areas above 1200 m altitude are shaded.

exists between the populations of Struma Valley, Rhodopes and Strandja. Typical cases of relict populations are these in Enina Gorge and the slopes above Sliven, both in Stara Planina Range, the northernmost populations in the range of the species. They are located more than 75 km one from another and 70 km away from the other populations. The population in Sakar is also small, as both in Stara Planina; this one in Strandja however, more than 90 km distant from the others, covers larger area.

Two-year development cycle. Extreme dates of flight period: 2 May (Asenovgrad) and 15 July (Enina Gorge). The spring occurrence of *N. sinuata* is an adaptation of this thermophilous species for living in habitats in which the vegetation develops in early spring.

Ascalaphidae

Bubopsis andromache Aspöck, Aspöck & Hölzel, 1979

Published data – STRUMA VALLEY: Kozhuh Hill near Petrich (Popov, 2004).

See Fig. 8.

This is one of the rarest species of Neuroptera in European mainland where it is found only three times. The Bulgarian locality is the northernmost one in the range (Popov, 2004). For the habitat see Popov (2004).

Deleproctophylla australis (Fabricius, 1787)

Published data – STRUMA VALLEY: Novo Konomladi near Petrich (Popov, 2004). BLACK SEA COAST: Ropotamo River (Chládek, 1983).

See Fig. 8.

D. australis occurs together with *Bubopsis andromache* on the volcanic hill Kozhuh in Struma Valley. For information about other records in the area of Kozhuh and Novo Konomladi (observed or collected but not preserved specimens) and about the habitat see Popov (2004).

Libelloides lacteus (Brullé, 1832)

Published data – EASTERN PREDBALKAN: Patleina site near Preslav (Táborský, 1936). EASTERN STARA PLANINA: Kotel (Popov, 1964). SLAVYANKA MTS. (Táborský, 1936; Popov, 1993). WESTERN RHODOPES: Asenovgrad (Popov, 1964).

Unpublished data – WESTERN RHODOPES: Besapara Hills near Byaga, 2 ♂♂, End of April 2000, V. Gashtarov; Bachkovo Monastery near Asenovgrad, 400 m, 2 ♀♀, 22.5.1940, 600 m, 1 ♂, 1 speci-

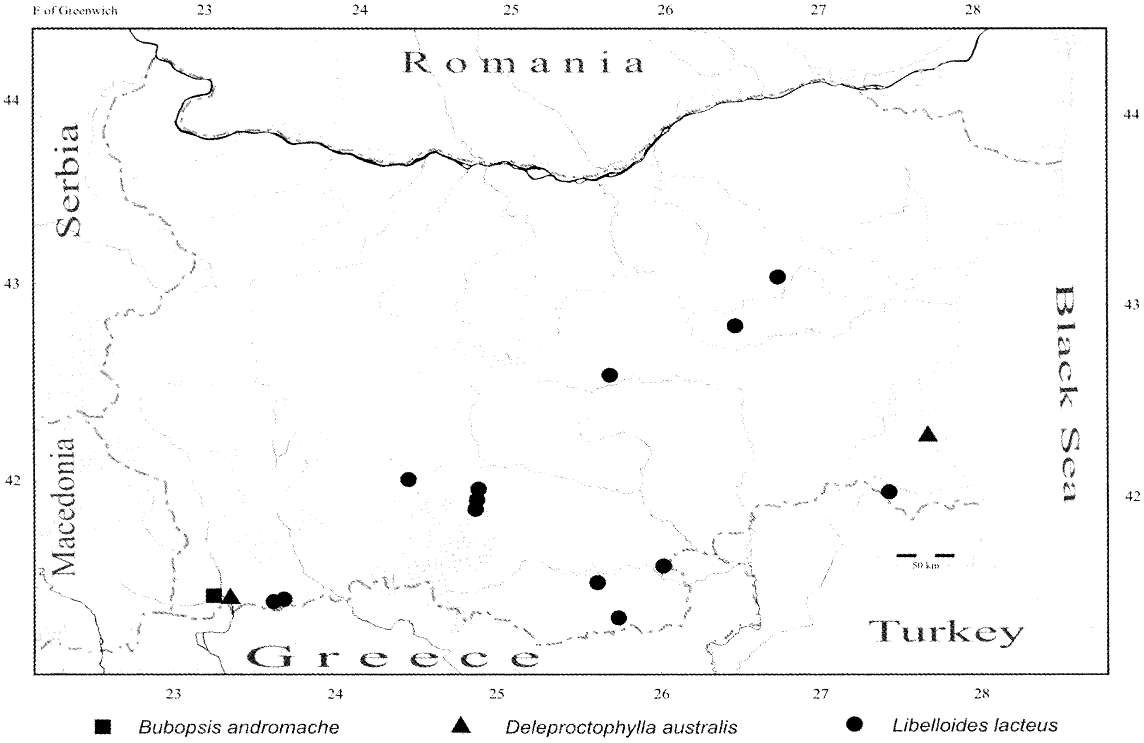

Fig. 8 – Distribution of *Libelloides lacteus* and the genera *Bubopsis* and *Deleproctophylla* (Ascalaphidae) in Bulgaria. Areas above 1200 m altitude are shaded.

men, 2.6.1940, all I. Buresch. EASTERN RHODOPES: Studen Kladenets Village in Arda Valley, 1 ♂, 23.4.1990, 1 ♀, 23.5.1990, both S. Beshkov; Avren near Krumovgrad, 1 ♀, 12.6.1995, E. Kozhuharova; Arda Chalet near Dabovets, 1 ♂, 27.4.1990, S. Beshkov. KAZANLAK PLAIN: Vetren near Maglizh, 1 specimen, 10.5.1924, I. Buresch. STRANDJA MTS.: Katundere Valley near Zvezdets, 14 ♂♂, 15 ♀♀, 30.5.1982, A. Popov. Preliminary published from these localities without details by Popov (2004).

See Fig. 8.

This species occurs in meadows on herbaceous vegetation mainly in South Bulgaria and usually up to 600 m. It is found higher only in Slavyanka (1450–1550 m, Livada site; 1100 m, Trana site above Petrovo). For the habitat see Popov (2004).

Two-year development cycle. First date of flight period: 23 April (Studen Kladenets). Last dates of flight period: 26 and 15 June. The specimens from these last dates of occurrence are found in the mentioned localities with highest altitude: respectively Trana and Livada sites in Slavyanka, the southernmost mountain in Bulgaria, one of the two mountains in this country located as islands in the proper Mediterranean Subregion. A typical spring species. Adults emerge earliest among all species treated here.

Libelloides macaronius (Scopoli, 1763)

Published data – CENTRAL DANUBIAN PLAIN: Pleven. EASTERN DANUBIAN PLAIN: Kubrat (both according to Popov, 2004). WESTERN STARA PLANINA: Cherepish (Buresch, 1936); Lakatnik; Kurilo (Novi Iskar); Voinyagovtsi. CENTRAL PREDBALKAN: Dermantsi near Lukovit (all according to Popov, 2004); Veliko Tarnovo and environs (Buresch, 1936; Táborský, 1939). CENTRAL STARA PLANINA: above Beli Osam (Popov, 2000a); Krastets near Tryavna. EASTERN STARA PLANINA: above Sliven; Kotel; Krasimir near Dalgopol (all according to Popov, 2004); Banya near Obzor (Popov, 1977; Pieper & Willmann, 1980). KRAISHTE: Tsegrilovtsi near Tran (Popov, 2004). LYULIN MTS.: Sv. Kral Monastery (Buresch, 1936; Táborský, 1939; Popov, 1964). VITOSHA MTS.: Bosnek (Popov, 1990); Starcheski Polyani site above Vladaya (Buresch, 1936); above Planinets Chalet; Kopitoto site; Boyana. STRUMA VALLEY: Simitli. PIRIN MTS.: Dobrinishte; below Gotse Delchev Chalet; Lilyanovo near Sandanski; Karlanovo near Melnik; Melnik (all according to Popov, 2004). SLAVYANKA MTS.: above Petrovo (Drenovski, 1939; Popov, 2004). RILA MTS.: Dupnitsa (Buresch, 1936; Táborský, 1939); Damga Peak (Popov, 2000b); Borovets and environs (Buresch, 1936; Táborský, 1939); Dolna Banya; Kostenets Resort (both according to Popov, 2004). RILA–RHODOPES: Golyamo Belovo (Buresch, 1936; Táborský, 1939). WESTERN RHODOPES: Pesh-

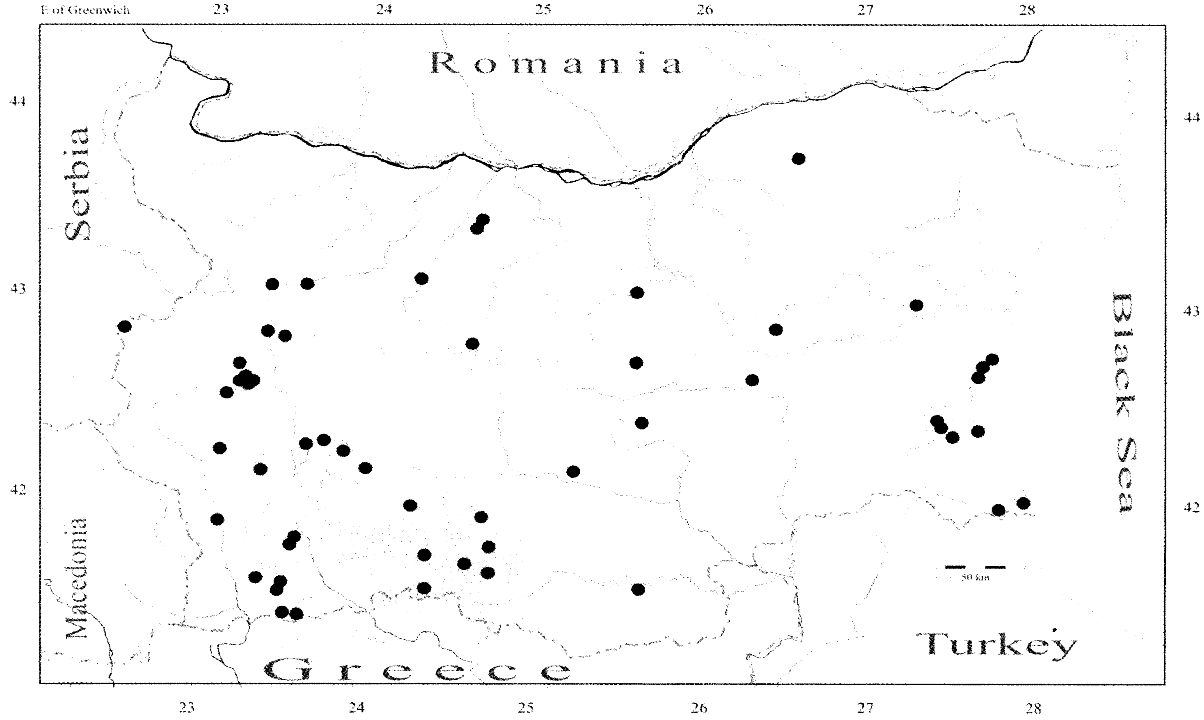

Fig. 9 – Distribution of *Libelloides macaronius* in Bulgaria. Areas above 1200 m altitude are shaded.

tera; Devin; Trigrad; Shiroka Laka; Rozhen Pass; Persenk Mine near Chepelare (all according to Popov, 2004); Byala Cherkva Resort (Buresch, 1936). EASTERN RHODOPES: Studen Kladenets Village (Popov, 2004). THRACIAN LOWLAND: Chirpan; Stara Zagora (both according to Nedelkov, 1909). BLACK SEA COAST: Sveti Vlas near Nesebar (Popov, 1977); Slanchev Bryag (Popov, 1993); Burgas (Buresch, 1939); Poda Protected Territory near Burgas; Ravna Gora near Sozopol (both according to Buresch, 1936); Sozopol (Popov, 1993); Sinemorets (Popov, 1977). STRANDJA MTS.: between Malko Tarnovo and Ahtopol (Popov, 2004).

Unpublished data – CENTRAL DANUBIAN PLAIN: Kashin near Pleven, 1 ♀, 5.7.1996, T. Ljubomirov.

See Fig. 9.

L. macaronius occurs in entire Bulgaria in steppe and forest-steppe areas up to 1600 m (Rila, Rhodopes and Slavyanka). For information about the habitat see Popov (2004).

Two-year development cycle. Extreme dates of flight period: 7 June (Ravna Gora near Sozopol) and 16 August (Krastets in Stara Planina). The later emergence of *L. macaronius* in comparison with the spring species *L. lacteus* and *Nemoptera sinuata* is an adaptation for living also of colder habitats in the mountains.

Conclusion

The families with low species diversity in Bulgaria (also in Europe) are: Nevrorthidae, Osmylidae, Sisyridae, Dilaridae, Mantispidae, Berothidae, Nemopteridae and Ascalaphidae. So far, 16 species of these families are established in Bulgaria: Sisyridae and Ascalaphidae (four species each), Mantispidae (three species) and remaining families (one species each).

Comparison between the families with low (small families) and those with high species diversity (large families) regarding share of the Bulgarian species in the European or Balkan fauna shows different tendencies. Concerning the number of European species used for the conclusions below, we follow Aspöck *et al.* (2001), with alterations. Share of the Bulgarian species in the European fauna is low (30%) in the small families because of the combination of following facts: the Western Mediterranean species of Dilaridae, Nemopteridae and Ascalaphidae are many more than the Eastern Mediterranean; the Holomediterranean species are less than the Mediterranean ones of the secondary centres; the Mediterranean species s.l. prevail strongly in Europe. In the large families, share of the Bulgarian species in the European fauna is higher (48%) because of two reasons: the species with wide ranges are more than the species with restricted ranges; ratio of the expansive Mediterranean species (the four families) and these of northern origin (mainly Hemerobiidae) compared to all species is higher and many of them occur in Bulgaria. On the contrary, share of the Bulgarian species in the Balkan fauna is higher in the small families than in the large families. Nearly entire Balkan fauna of the small families is represented in Bulgaria. Only one nemopterid and one ascalaphid from the Balkan mainland and one mantispid from the islands around the Peninsula are not distributed in Bulgaria and they are not species of northern origin. In the large families, the difference comes not so much from the species of northern origin, which occur in the Balkan Peninsula but do not reach Bulgaria, e.g. *Hemerobius fenestratus* Tjeder, 1932, *Megalomus hirtus* (Linnaeus, 1761), many as from the species inhabiting only the warmest parts of the Peninsula and also not reaching Bulgaria, e.g. *Dichochrysa genei* (Rambur, 1842), *Rexa raddai* (Hölzel, 1966), *Suarius nanus* (McLachlan, 1893), *Semidalis pseudouncinata* Meinander, 1963.

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The biodiversity of Green Lacewings (Neuroptera Chrysopidae) in a mosaic ecosystem in southern France

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Collections of chrysopids occurring in a mosaic-like ecosystem were carried out in southern France, Tarn valley. Comparative discrete samples were taken from five habitats of a karstic region, lying in succession from river banks to dry calcareous table-lands. Adults were collected by hand-net, sweeping low vegetation and beating bushes and trees, during a short period (end of July) in two consecutive summers. Qualitative and quantitative approaches (biodiversity index, graphic interpretation of a Correspondence Analysis on the data) revealed proper patterns of assemblages occurring in distinct but close biotopes. Such differences in green lacewing representation in habitat sub-units are of consequent consideration in appraising the fauna of complex ecosystems. This efficient approach which is based on a restricted sampling during a very short period, could be helpful for management plans or environmental survey.

Key words – Chrysopidae, green lacewing, diversity, dominance, complex ecosystem, habitat, environmental protection.

Introduction

The biodiversity, most often reduced by authors to the simple enumeration of species, is currently used to appraise the impact of human activities on natural or semi-natural biotopes (e.g. Thierry *et al.*, 2005) and to justify measures for environmental protection. Studies are predominantly carried out on large geographical units, depending on floristic and faunistic surveys. This approach does not necessarily include considerations on habitat structure, especially when different ecosystems overlap in mosaic-like landscapes.

Another way to assess the biological diversity somewhere involves sampling a restricted group of species and then calculating indices that reflect their actual diversity. Aspöck (1992) noted that the richness and the specific composition of Neuropteridan assemblages constitutes a good indicator of the biodiversity in many terrestrial ecosystems. Chrysopidae appear suitable for such consideration. More than 60 species occur in Europe (Aspöck *et al.*, 2001), the taxonomic diagnosis of which is largely reliable. Their main biological characters have been described and summarized in recent papers (e.g. Canard, 1998, 2005). Their distribution together with their autoecology (Aspöck *et al.*, 1980, 2001) allows ecologists to undertake realistic studies on communities. Cohorts of green lacewings overlap in summer and utilise various trophic levels: all larvae are eurytrophic predators into a single level, adults are either carnivorous or glyco-palynophagous. They thus occupy different ecological niches in the herbaceous layer and more often in the arboreal canopy. Quantitative biodiversity indices may indeed reveal this interactive species assemblage.

A rapid sampling was carried out in the

suitable period for green lacewings and based on the life history of the insects to give an instantaneous and practical view of abundance and biodiversity.

The present study reveals qualitative and quantitative differences between contiguous and intermingled habitats.

Material and methods

The work was carried out in a karstic area of southern France near Millau (44° 06' N / 03° 05' E). It is a transitional ecosystem between the west-Mediterranean landscapes and those of temperate forests. The geomorphological structure of a calcareous table-land, the Mediterranean type climate together with human activities form strongly contrasted biocenotic units, in which the vegetation cover is sometimes organized in mosaic-like sub-units. The collecting sites spread out from the plateau where a dry semi-natural lawn of *Festuca* spp. grows (code Natura 2000: 62-10) (Anonymous, 1997), broken only by discontinued trees like calcarophilous oaks *Quercus* spp., up to the shaded side of the Tarn valley crowded with chestnut trees *Castanea sativa* (code Natura 2000: 92-60). This region has not been subjected during recent decades to the drastic changes induced elsewhere by industrial crop development and by accelerating urbanization.

Adult green lacewings were collected by day, by hand-net, randomly sweeping low herbaceous vegetation and by beating bushes and the lower part of tree canopies. The hand-net diameter is 44 cm.

Samples were made in six habitats (Table I) on July 1995 and 1996. Sampling duration in each habitat lasted according to volume of vegetation directly available and to number of specimens caught, at least for one hour and never for more than three and a half hours.

Indices were established in order to describe the assemblage structures: 1) the relative abundance of species taxa (or taxonomic richness S) and of the specimens (Q) constitute a first rough piece of information on dominance; 2) the standard Shannon's diversity index (H') ranging from 0 to log S and being maximal in stable ecosystems; 3) the Hurlbert's equitability index (Eh) which varies from 0 to 1, being nil when the quasi-totality of the specimens caught belongs to a single species, and reaches one when each species is represented by the same number of individuals.

Tab. I – Main characteristics of the habitats. + and – mean high and weak value appraisal, respectively.

Habitats	**A**	**B**	**C**	**D**	**E**	**F**
Date of sampling	20/7/1995 25/7/1996	21/7/1995	22/7/1995	18/7/1995	19/7/1995	18/7/1995
Approximate special scale (%) in sampling area	20	5	<1	45	20	10
Topographic situation (m)	200-400	200	600-700	600-700	200-400	700-800
Geomorphology	Adret	Tarn river flooding area	«Sotch»	Causse	Ubac	Causse
Vegetation cover	arborescent	ripisylve	arborescent	lawn	maquis	arborescent
Main species of arborescent vegetation	*Castanea sativa*	*Salix* sp + *Populus* sp + *Fraxinus*	*Fraxinus excelsior* + *Ulmus*	*Quercus pubescens*	*Quercus pubescens* + *Rosa* sp	*Pinus sylvestris*
Edaphic moisture	-	+	+	-	-	-
Atmospheric moisture	+	+	-	-	-	-
Atmospheric temperature	-	-	+	+	+	+
Density of specimens	-	+	+	-	-	-
Species diversity	+	-	-	+	+	-
Equitability	+	-	-	+	+	-

In addition, a table [habitat/species] is built with number of specimens collected, rare species being excluded. A typological analysis of the various habitats proceeding from this table was established by a correspondence analysis (Manly, 2005). A graphic interpretation would be assessed according to the method proposed by Dervin (1990). This interpretation is confirmed by automatically classifying hierarchic ascending onto the coordinates of items on the main axes (Roux, 1985).

Results

Faunistics – The numbers of chrysopids recorded by species and the duration of sampling in each habitat appear in Table II. No specimen was caught in the low vegetation. Only the arboreal and bushy layers yielded 362 specimens belonging to 12 species, 7 of which represented by more than 10 individuals, so-called 'the main species'. Among these, the genus *Dichochrysa* is dominant, which constitute 62% of the total. Following are the *Chrysoperla* spp. of the *carnea*-complex *sensu* Thierry *et al.,* (1992, 1998) (25%), namely *Ch. affinis*, *Ch. carnea,* and *Ch. lucasina* and then, *Chrysopa viridana* (11%). Five other species were casual, represented by few individuals.

Quantitative analysis – The general features of the assemblages displayed differences according to the nature of the different habitats. A contingency χ^2 test on the main species indicated that species and habitats were correlated (χ^2_{30ddl} = 440.14). Figure 1 shows that the green lacewings were more numerous in de-

Tab. II – Numbers of specimens of Chrysopidae collected according to habitat and species, durations of sampling and taxonomic richness.

	Habitats							Total
	A		B	C	D	E	F	
Year of sampling	**1995**	**1996**	———		**1995**	———		
Species								
Chrysopa viridana Schneider 1845	13	8		5	8	5		**39**
Chrysopa walkeri McLachlan 1893						2		**2**
Chrysoperla carnea (Stephens, 1836)	3	2	3		1	1	1	**11**
Chrysoperla affinis (Stephens, 1836)	8	3	3	6	3	2	2	**27**
Chrysoperla lucasina (Lacroix, 1912)	2	1	1	27	4	5	12	**52**
Dichochrysa flavifrons (Brauer, 1850)	14	5	25	3	2	4		**53**
Dichochrysa inornata (Navás, 1901)			82	2				**84**
Dichochrysa picteti (McLachlan, 1880)			1	2				**3**
Dichochrysa prasina (Burmeister, 1839)	1	1	2	69	9	5	1	**88**
Dichochrysa zelleri (Schneider, 1851)				1				**1**
Cunctochrysa albolineata (Killington, 1935)	1							**1**
Nineta principiae Monserrat 1980				1				**1**
Total of specimens (Q)	42	20	117	116	27	24	16	**362**
Sampling duration (hours)	3	1	3.5	2.5	2	5	3	**20**
Taxonomic richness (S)	7	6	7	9	6	7	4	**12**

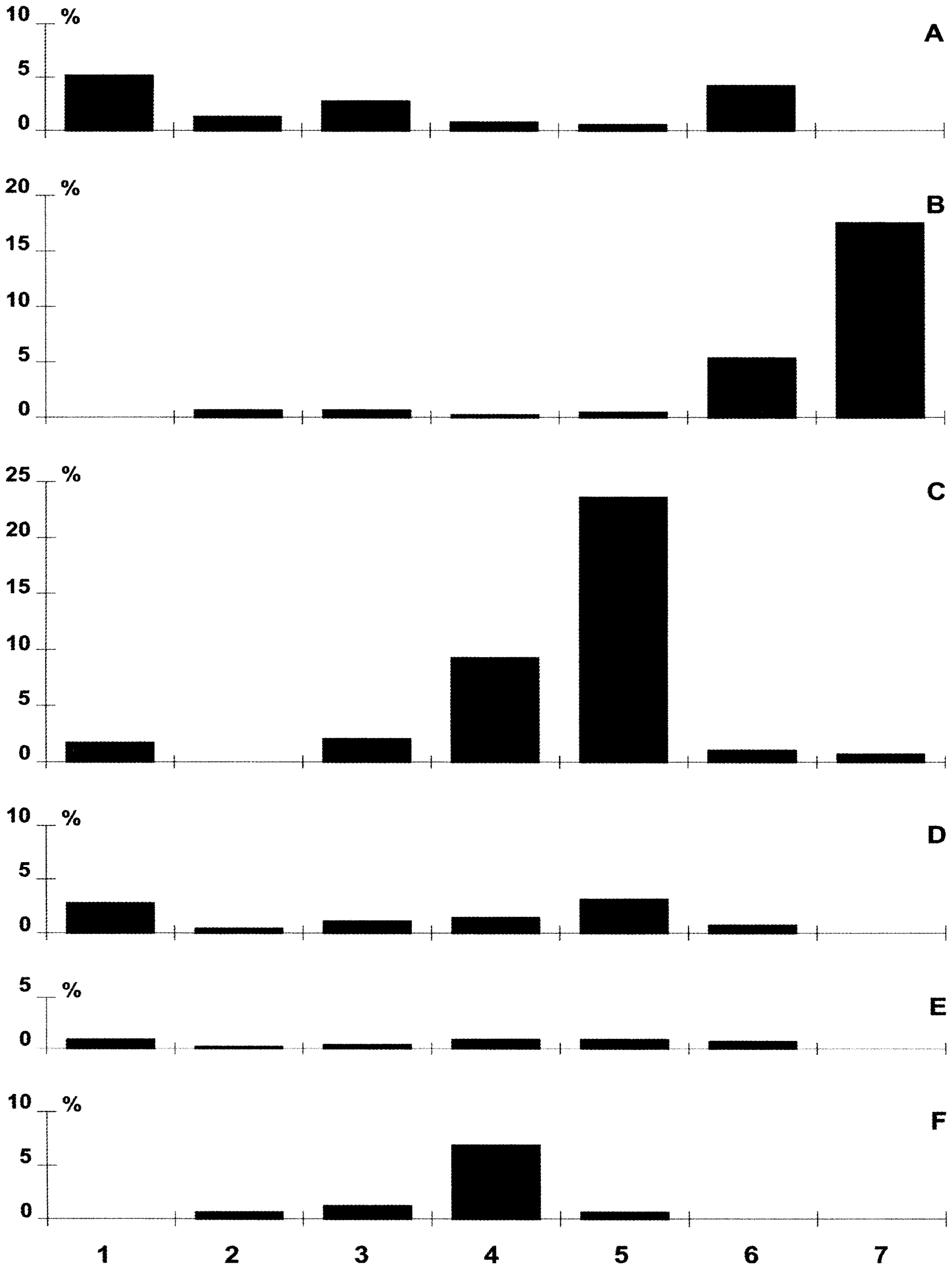

Fig. 1 – Distribution of the seven more common species of Chrysopidae. Percentages are calculated based on the total captures and adjusted to one hour sampling in each habitat. 1 = *Chrysopa viridana*; 2 = *Chrysoperla carnea*; 3 = *Chrysoperla affinis*; 4 = *Chrysoperla lucasina*; 5 = *Dichochrysa prasina*; 6 = *Dichochrysa flavifrons*; 7 = *Dichochrysa inornata*.

Tab. III – Frequency (%) of the dominant taxon (Qd) related to the total main species size, diversity index (H') assorted with its minimal (Hmin) and maximal (Hmax) values, and equitability index (Eh) in each habitat.

	Habitats					
	A	B	C	D	E	F
Qd	0.36	0.71	0.62	0.33	0.23	0.75
H'	2.3	1.3	1.9	2.3	2.2	1.2
H'max	2.8	2.8	3.0	2.6	2.8	2.0
H'min	1.0	0.4	0.5	1.1	1.5	1.0
Eh	0.7	0.4	0.5	0.8	0.9	0.2

ciduous arboreal vegetation of the wetlands, such as the ripisylve (B habitat) and wet hollows (sotchs), on the table-land (C habitat). However, the individuals collected in each case belonged almost exclusively to two species of *Dichochrysa*. The specific diversity (H') and the equitability (Eh) were rather low when reported for all the species (Table III). In the coniferous woods occurring in the higher dry biotopes (F habitat), the occurrence of green lacewings was much lower and included one main dominant species: *Ch. lucasina*. The specific richness and the equitability were both lower than in all other surveyed habitats. In the deciduous arboreal vegetation of dry habitats, the abundance was low (A habitat) or very low (D and E habitats), but the specific richness and the equitability were higher. Assemblages were indeed more well-balanced than in the other habitats.

The diagrams of the correspondence analysis (Fig. 2c) show that most correlations between species and habitats manifest in the F1/F2 plan. The main plan F1xF2 gives evidence for isolation of B habitats in which the assemblage is strongly dominated by *D. inornata* associated with *D. flavifrons* (Fig. 2a). A, D et E habitats were closely related, characterized by a high frequency of *Ch. viridana*, dominant in A habitat and associated in each case to *D. flavifrons* in A and *D. prasina* in D and E habitats. Besides, C and F habitats contained *D. prasina* followed by *Ch. lucasina* (C) and by *Ch. lucasina* followed by *Ch. affinis* (F).The third axis F3 explains only 14.9 % of the full inertia, i.e. less than the threshold of 20 % given according to the method proposed by Dervin (1990). Nevertheless, we will take into account this axis because 82.6 % of relative inertia of F habitat comes from this axis. The two first groups as identified in the main plan must also be investigated through the plan F1/F3 (Fig. 2b). Thus, the F3 axis clearly maintains as separate the F habitat associated with *Ch. lucasina* and the C habitat near by *D. prasina.*

The automatic classification achieves four classes:

— class 1: A, D, and E habitats harbouring *Ch. viridana*, *Ch. carnea*, *Ch. affinis* and *D. flavifrons*;

— class 2: B habitat, *D. inornata*;

— class 3: F habitat, *Ch. lucasina*;

— class 4: C habitat, *D. prasina*.

Discussion and conclusion

Differences in assemblage structures might be interpreted to reflect association between ecological traits of the recorded species and the various abiotic and biotic characters of the habitats.

The ripisylve harbouring willows, poplars and ashes in the Tarn flood-plain (B habitat) is typified by abundance of *D. inornata*; this observation agrees with what is known of its ecological requirements for wet and dense vegetation (Aspöck *et al.*, 1980; Monserrat & Marìn,1994). Five other occurring species are widely distributed in all European arboreal areas. *Dichochrysa picteti*, a thermophilous element of dry biotopes, was only found here as a single male specimen. The groves of deciduous trees which grow around the sotchs on the calcareous

Fig. 2 – Factorial Analysis of Multiple Correspondence: projection of species and habitats on the F1/F2 (**a**) and F1/F3 (**b**) plans. Percentages of total inertia explained by the axes (**c**).

plateau (C habitat) are characterized by the strong dominance of *D. prasina*. Nevertheless, *D. inornata* is present because of the edaphic moisture, but in much lower number than in the previous habitat. The warmth of such an habitat is inferred by the occurrence of *Ch. viridana*, *D. picteti* and especially of *D. zelleri*. *Ch. lucasina* is also included in the same thermophilous species group as attested by its wide distribution all around the Mediterranean Basin and its scarceness northwards (Henry *et al.,* 1996; Thierry *et al.,* 1996). However, the strong dominance of *D. prasina* possibly reflects a relative increasing mirroring a seasonal decline of other multivoltine species such as *Chrysoperla* spp. often abundant in same habitats.

The number of green lacewings in the F habitat is low so that the assemblage structure cannot be validly assessed. However, *Ch. lucasina* which is a main constituent of the C habitat is globally the most abundant of the chrysopids of the table-land, whilst it was rarely found in or even absent from the valley specimen collections (B habitat). That confirms the affinity of this species to warm habitats.

A, D and E habitats differ from one another in their sun exposure and the nature of vegetation cover; however, they display a rather homogeneous assemblage in which *Ch. viridana* is always well represented, together with a species of *Dichochrysa*: either *flavifrons* in A or *prasina* in D and E. Amongst the three habitats, A is the coolest and the least dry because it belongs to arboreal slopes open to N-NW where chestnut trees are common. The low incidence of *Ch. viridana*, the occurrence of other possibly thermophilous species, the casual occurrence of *Cunctochrysa albolineata* and the related decrease of both *D. prasina* and *Ch. lucasina* as in E habitat, all agree with this relative coolness. In contrast, D and E habitats located in more open, warmer and drier sites on the plateau and on the slopes open to N-NW harbour many more *D. prasina* and *Ch. lucasina*, indicating one more time their ability to colonize warm habitats. E habitat harbours in addition *Ch. walkeri*, a thermophilous chrysopid associated with herbaceous vegetation.

We note the abundance of *D. flavifrons* wide-spread in very distinct habitats. More investigations are needed again this eurytope species which could be a complex of biotypes with different ecological traits.

Our samples are restricted to adults collected over a very short period. They give by the way an instantaneous view of the abundance and on the diversity of the studied assemblages. Therefore, this rapid sampling still reveals objective and actual differences in the assemblages of several habitats within a mosaic-like ecosystem. This not time-consuming method should be useful for practical studies on landscape management.

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Neuropterida (Insecta Endopterygota) of the Nature Reserve Eichkogel (Lower Austria): arguments for protecting an insular biocoenosis in the South of Vienna*

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The nature reserve Eichkogel (300 m – 366 m), Lower Austria, located at the eastern edge of the Alps and characterized by Pannonian, Continental and Submediterranean influences, is of particular importance as a refugium for thermo- and xerophilic plants and animals. Between May and October 2004, with additional samplings in May and July 2005, 572 adult Neuropterida and 5 larvae were collected. Furthermore, material from the Eichkogel in the collections of the Natural History Museum Vienna (NHMW), of Horst & Ulrike Aspöck (HUAC) and Hubert & Renate Rausch (HRRC) has been included. A total of 47 species are recorded from the Eichkogel, representing the Neuropterida families Raphidiidae, Inocelliidae, Sisyridae, Coniopterygidae, Mantispidae, Hemerobiidae, Chrysopidae, Myrmeleontidae and Ascalaphidae. Some of them are of particular interest to nature conservation.

Key words – Neuropterida, Raphidioptera, Neuroptera, Eichkogel, thermophilic species, nature conservation.

Introduction

Compared to other insect groups (Coleoptera, Lepidoptera), Neuropterida are rarely used as bioindicators. Nevertheless, in conservation assessment some of them are of great value, e.g. as indicators for dry and warm habitats. One of such xerothermic biotopes is the Eichkogel (366 m) in the south of Vienna. As a foothill of the Alps it is located near Mödling, Lower Austria, along the 'Thermenlinie', a geological rupture zone between the Alps and the Viennese Basin. Due to its unique position and the Pannonian-Continental climate influences with hot dry summer, cold winter and a long vegetation period (Foelsche, 2005), an Illyric-Mediterranean and Pontic-Pannonian fauna and flora can be found in this area next to Central European elements.

The Eichkogel is mostly based on Upper Tertiary unconsolidated sediments, relics of the Pannonian Sea, with deep dark soil. On the hilltop fresh water calcareous sediments provide a basis for flat Rendzina soil. Such a high diversity in soil types allows the development of various plants and animals, leading to an immense biodiversity. Moreover, the inhomogeneous structure of the Eichkogel with fosses, swales and shrubs as well as extensive meadow and forest areas meets microclimatic conditions for many species. The predominant vegetation types are forest and forest steppe communities with the Downy oak (*Quercus pubescens* Willdenow) and the Austrian pine (*Pinus nigra* Arnold), further dry and semi-dry grasslands, especially rock grasslands. Originally, the Eichkogel was entirely covered

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* The study was part of the diploma thesis of Franziska Anderle.

with oaks (German 'Eiche' meaning: oak), but as it served as watch hill in the early 19th century some parts of the Eichkogel had been deforested. Later on, pines were planted in order to extract resin (Kriechbaum *et al.*, 1999).

As it serves as a refugium for many thermo- and xerophilic species – most of them deserving protection – 34 ha (0,34 km²) of the Eichkogel were declared as a nature reserve in 1961, extended to 68 ha (0,68 km²) in 1991 (Paar *et al.*, 1993). Especially with respect to its entomofauna, the Eichkogel is of international importance and therefore well-investigated. And yet, only few attempts have been made for recording Neuropterida in this area, mainly by Horst & Ulrike Aspöck and Hubert & Renate Rausch.

This paper aims at appreciating the value of this nature reserve as a refugium for interesting as well as endangered species of Neuropterida and probably making a case for some protecting actions in the future.

Materials and methods

Adult Neuropterida were collected between May and October 2004, with two additional samples in May and July 2005. Eight sites in the north, south, west, and on the hilltop were selected to be sampled by net sweeping, in August 2004 and July 2005 two resp. three light traps were set up. Larvae of Myrmeleontidae were detected in their sand pits. With the exception of some females of Coniopterygidae the material has been determined up to species level, using Aspöck H. *et al.* (1980), Aspöck H. *et al.* (1991) and Aspöck H. *et al.* (2001) as basic literature. Material from the Eichkogel in the Natural History Museum Vienna (NHMW) and the collections Horst & Ulrike Aspöck (HUAC) and Hubert & Renate Rausch (HRRC) has been included.

Results

577 specimens were sampled in 2004/2005 representing 39 species and 9 families of the orders Raphidioptera (77 specimens, 5 species) and Neuroptera (500 specimens, 34 species). These data were supplemented by material of the collections NHMW, HUAC and HRRC by 7 further species. Moreover, Klapálek (1899) noted a record of *Chrysopa hungarica* (Chrysopidae) from the Eichkogel (Zelený, 1971). Thus, the total amount of Neuropterida recorded on the Eichkogel can be added up to 47 species: 5 species of the order Raphidioptera, both Raphidiidae and Inocelliidae (Tab. I), and 42 species of the order Neuroptera; representing the families Coniopterygidae, Sisyridae, Mantispidae, Hemerobiidae, Chrysopidae, Myrmeleontidae and Ascalaphidae (Tab. II).

Tab. I – Species of the order Raphidioptera occurring in the nature reserve Eichkogel (1 = collected by the authors in 2004/2005, 2 = coll. NHMW, 3 = HUAC & HRRC).

Raphidiidae			
Ornatoraphidia flavilabris (Costa, 1855)	1		
Dichrostigma flavipes (Stein, 1863)	1	2	3
Puncha ratzeburgi (Brauer, 1876)	1	2	3
Xanthostigma xanthostigma (Schummel, 1832)	1		
Inocelliidae			
Inocellia crassicornis (Schummel, 1832)	1	2	3

The predominant families regarding number of species are Hemerobiidae (17 spp.) and Chrysopidae (14 spp.). Regarding number of specimens collected in 2004/2005 the predominant families are Chrysopidae (339 specimens = 59%), Hemerobiidae (89 specimens = 15%) and Raphidiidae (76 specimens = 13%). The most abundant species are *Chrysoperla carnea,* Chrysopidae (238 specimens = 41%), *Dichrostigma flavipes*, Raphidiidae (69 specimens = 12%) and *Chrysoperla lucasina*, Chrysopidae (40 specimens = 7%).

8 of these 47 species (= 17%) are classified as endangered in Gepp (1994), some of them deserve closer attention regarding distribution and life history, respectively:

Ornatoraphidia flavilabris (Costa, 1855), Raphidiidae – *O. flavilabris* is an Adriato-Balkano-Pontomediterranean faunal element, reaching its distributional boundary in the north eastern parts of Austria. Further, it occurs in the south east of Austria, on the Balkan Peninsula, Italy and the south of France. This species inhabits dry pine forests and, in Central Europe, the edges of warm mixed forests in particularly xerothermic biotopes. Its terricolous larvae live in the rootstock detritus of various shrubs and below stones next to shrubs (Aspöck H. *et al.*, 1974; Aspöck H. *et al.*, 1991).

Mantispa styriaca (Poda, 1761), Mantispidae – This only representative of Mantispidae in Central Europe has originally been described from Styria/Austria and can be found in small areas on south slides (Gepp, 1976). In Austria, *M. styriaca* is known from Carinthia, Styria, Burgenland, Upper and Lower Austria. Its mosaic-like distribution in the north of Europe is very enigmatic. The northernmost and at the same time oldest records from Berlin or Magdeburg could have never been verified again, also in other parts of Germany the species has not been found for many years (Saure, 2003). What causes the decline of *M. styriaca* in Germany and where its distributional range ends in the north, we don't exactly know. Anyway, this species is a very sensitive indicator for microclimatic changes, which it registers a long time before we do (Aspöck U., 1996).

M. styriaca was the first Mantispid species of which larvae have been described as well as their remarkable life cycle (Brauer, 1869; Aspöck H., 1999). They undergo a so-called hypermetamorphosis, a form of complete insect metamorphosis in which at least one of the instars in the life cycle differs considerably from the others (Pinto, 2003). The first instar larvae are active, do not feed and, after hibernation, enter spider egg sacs (Lycosidae, Drassidae) (Schremmer, 1959), while the second instar larvae are grublike, less

Tab. II – Species of the order Neuroptera occurring in the nature reserve Eichkogel (1 = collected by the authors in 2004/2005, 2 = coll. NHMW, 3 = HUAC & HRRC).

Chrysopidae			
Hypochrysa elegans (Burmeister, 1839)	1		
Chrysopa perla (Linnaeus, 1758)	1	2	3
Chrysopa dorsalis Burmeister, 1839	1	2	3
Chrysopa hungarica Klapálek, 1899			
Chrysopa phyllochroma Wesmael, 1841	1		3
Chrysopa viridana Schneider, 1845	1		
Chrysopa pallens (Rambur, 1838)	1	2	
Dichochrysa flavifrons (Brauer, 1850)	1	2	3
Dichochrysa prasina (Burmeister, 1839)	1	2	3
Chrysoperla carnea (Stephens, 1836)	1		
Chrysoperla mediterranea (Hölzel, 1972)	1		
Chrysoperla lucasina (Lacroix, 1912)	1		
Chrysoperla pallida Henry *et al.*, 2002	1		
Cunctochrysa albolineata (Kill., 1935)	1		
Hemerobiidae			
Hemerobius humulinus Linnaeus, 1758	1	2	3
Hemerobius stigma Stephens, 1836	1		3
Hemerobius pini Stephens, 1836	1		
Hemerobius contumax Tjeder, 1932			3
Hemerobius nitidulus Fabricius, 1777	1		3
Hemerobius handschini Tjeder, 1957	1	2	3
Hemerobius micans Olivier, 1792	1		3
Hemerobius lutescens Fabricius, 1793		2	
Wesmaelius concinnus (Stephens, 1836)			3
Wesm. subnebulosus (Stephens, 1836)	1		
Wesmaelius ravus (Withycombe, 1923)			3
Sympherobius elegans (Stephens, 1836)	1	2	
Symph. pygmaeus (Rambur, 1842)	1		3
Sympherobius pellucidus (Walker, 1853)	1		
Micromus variegatus (Fabricius, 1793)	1		3
Micromus angulatus (Stephens, 1836)	1		
Micromus lanosus (Zelený, 1962)	1		
Sisyridae			
Sisyra nigra (Retzius, 1783)	1		
Coniopterygidae			
Aleuropteryx loewii Klapálek, 1894	1		
Helicoconis lutea (Wallengren, 1871)			3
Coniopteryx pygmaea Enderlein, 1906	1		
Con. esbenpeterseni Tjeder, 1930			3
Coniopteryx lentiae Asp. & Asp., 1964			3
Semidalis aleyrodiformis (Steph., 1836)	1		3
Mantispidae			
Mantispa styriaca (Poda, 1761)	1	2	3
Myrmeleontidae			
Euroleon nostras (Geoffroy in Fo., 1785)	1		
Distoleon tetragrammicus (Fab., 1798)	1		
Ascalaphidae			
Libelloides macaronius (Scop., 1763)	1		

mobile and live on young spiders inside the egg sac (Brauer, 1869; Wachmann & Saure, 1997). In Neuroptera, only Mantispidae and Berothidae (Tauber & Tauber, 1968) are known to have true hypermetamorphosis.

A considerable variation in body size (8,5 mm to 19,0 mm) in adults of *M. styriaca* has been observed. These differences could be correlated neither with sex nor with date of collection and will be discussed below.

Chrysopa hungarica Klapálek, 1899, Chrysopidae – Only two records of *C. hungarica* are known from Austria, both from the Eichkogel: the first record traced back to Klapálek (1899), mentioned also in Zelený (1971). More recently, Gepp (1983) succeeded in rearing *C. hungarica* from egg to L2. Since then it has not been detected again in Austria. *C. hungarica* is known from Switzerland, former Czechoslovakia, Hungary, Slovenia, Romania, Albania, and Turkey. This extremely stenotopic species develops in thermo- and mesophilic, steppe-like biotopes. Population densities in Europe are consistently low (Aspöck H. *et al.*, 1980).

Chrysopa viridana Schneider, 1845, Chrysopidae – This highly thermophilic species is distributed in the western Palaearctic with low population densities. In Austria, *C. viridana* is only known from Carinthia, Vienna and Lower Austria (Hölzel *et al.*, 1980). It lives in various deciduous shrubs and trees, but prefers *Quercus* sp. (Aspöck H. *et al.*, 1980).

Chrysoperla mediterranea (Hölzel, 1972), Chrysopidae – The holarctic *Chrysoperla carnea* group is a complex of many cryptic sibling species, whose members are reproductively isolated by substrate-borne vibrational songs (Henry *et al.*, 2002). A European member of the *C. carnea* group is *C. mediterranea*, which is known from Spain, France, Switzerland, Italy, Slovakia, Hungary, Poland, Greece, Macedonia and North Africa (Aspöck H. *et al.*, 2001) and reaching its distributional boundary north of the Alps. This is the first record of *C. mediterranea* on the Eichkogel. In Austria, records only exist from Carinthia, but considering the *carnea* group problem this species can be assumed to be more widespread in Austria.

C. mediterranea is delimited by its dark green body coloration, narrow wings and a minute basal dilation of the pretarsus. However, the proportion of these claw shapes change throughout Europe. Populations in the eastern parts of the distribution range show a larger dilation to the claw than specimens from western parts (Henry *et al.*, 1999). The dark green body coloration of *C. mediterranea* specimens is corresponding to their ecology, as they are associated with conifers, usually strictly limited to pine trees (Duelli, 1987).

Distoleon tetragrammicus (Fabricius, 1798), Myrmeleontidae – Widespread in the Mediterranean region, *D. tetragrammicus* occurs in Central Europe in isolated, xerothermic biotopes. In Austria, this species is known from Carinthia, Styria, Burgenland, and Lower Austria (Hölzel *et al.*, 1980). Their non-pitbuilding larvae prefer dry and warm pine and deciduous forests (Gepp & Hölzel, 1989).

Libelloides macaronius (Scopoli, 1763), Ascalaphidae – Due to its distinctive and striking appearance this highly thermophilic species is of great value for nature conservation both as flagship species and as target species (Gepp, 1999). The Pontomediterranean *L. macaronius* reaches its western distributional boundary north of the Alps (Aspöck H. & Aspöck U., 1964). Possibly the geographic vicariant *L. longicornis*, which occurs in south western parts of Europe, and *L. macaronius* are both subspecies of one and the same species (Aspöck H. *et al.*, 2001).

Discussion

In specific areas of Austria, as in the nature reserve Eichkogel, some Mediterranean insects reach their distributional boundary. Those warm and dry habitats with highly sensitive species deserve particular attention and protection (Aspöck U. & Aspöck H., 2005). On the Eichkogel protective measures are taken adapted to some target species, but due to their lack of publicity Neuropterida have been neglected so far. Nevertheless, brightly coloured Ascalaphids, like *Libelloides macaronius*, may capture public interest (New, 1998) as well as *Mantispa styriaca* or *Ornatoraphidia flavilabris*.

The *Pinus nigra* population on the Eichkogel has been forested (previously it was completely covered with oaks) and therefore is not pristine. As a consequence, it was taken into consideration to remove *P. nigra* from the Eichkogel. But as many Neuropterida species (*O. flavilabris*, *I. crassicornis*, *A. loewii*, *H. nitidulus*, *H. handschini*, *W. concinnus*, *W. ravus, C. mediterranea, …*) are associated with these conifers and some of them – e.g. *O. flavilabris*, *A. loewii*, which are registered as endangered (Gepp, 1994) – are of particular interest to nature conservation, the Pine population should be preserved.

Regarding the size variation in *Mantispa styriaca*, the host species seems to be of importance. Rogenhofer (1862) obtained a specimen from the egg sac of *Clubiona* sp., a 'wrong' host species, which was only half of the normal size (Brauer, 1869). In *Mantispa uhleri* Banks a direct relationship exists between the amount of food ingested by the larvae and the body size of the resulting adult (Redborg & MacLeod, 1985). The ability of Mantispids to reach maturity with an exceptionally wide range of food supplies causing size variation is supposed to be an adaptation to their parasitoid life history.

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Distribution of Neuropterida in beech dominated forests in southern Germany

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The community of Neuropterida was used to test the hypothesis that species richness as well as abundance increases with the complexity of a habitat. Arthropods were captured with flight interception traps at various height levels in hardwood forests in the Steigerwald, Germany. The neuropterid community consisted of 31 species and was predominated by *Hemerobius micans*. Compared to results from more diverse mixed forests the number of species was low. In respect to abundance, we found most specimens in traps in strata of high leaf densities.

Key words – Raphidioptera, Neuroptera, beech forest, spatial distribution, neuropterid community, habitat complexity, diversity, vertical stratification.

Introduction

The spatial distribution of arthropod species and specimens in a habitat is clearly known to be unequal. The 'habitat heterogeneity hypothesis' assumes that highly structured habitats provide more niches and thus increase species diversity (Bazzas, 1975, Tews *et al.*, 2004).

The complexity of forest stands is mostly described through tree species composition, gaps within the stand, the supply of light, the amount of dead wood, regeneration etc., factors which are mostly defined with respect of forestry purposes. Thus, their importance for insect communities needs to be proved for any target taxon. We tested the 'habitat heterogeneity hypothesis' using neuropterid data from an inventory of arthropods captured with flight interception traps in the Steigerwald, Germany.

Materials and methods

The "Northern Steigerwald" is a forest area of about 10,000 ha, located in northern Bavaria (N 49° 50'; O 10° 29'), dominated by hardwood with the beech tree (*Fagus sylvatica*) as the predominant species. "*Luzulo-Fagetum*" and "*Galio odorati-Fagetum*" are the main plant communities. The average daily temperatures range from 7 to 8 °C and annual precipitation is between 700 and 800 mm. Sampled stands have a mean canopy closure of 70% (65% beech, 5% oak), whereas the understorey is dominated by beech with a mean density of 30%.

Sixty-nine sample plots were randomly selected using the forest inventory net in beech stands (100 to 350 years old) on sandy soils in that area. Forest structural data (presence of conifers, dead wood, canopy gaps, amount and height of regeneration) was collected using GPS supported measurements of spots with fixed-radius (r = 17.82 m). One flight interception trap (window 40x60 cm, funnel at the bottom only) 1.5 m above ground was used at each plot for sampling of flight active arthropods. These traps were not assigned to individual trees. Additionally, 109 flight interception traps were installed in ranges from 2 to 36 m on beech (82 traps, 2-36 m above ground) and oak trees (*Quercus petraea*) respectively (27 traps, >10 m above ground). The traps were emptied monthly between April and October 2004. The capture of flight interception traps represent "a density of activity" and not an "abundance" in the ecological sense. However, in this study, we define the term "abundance"

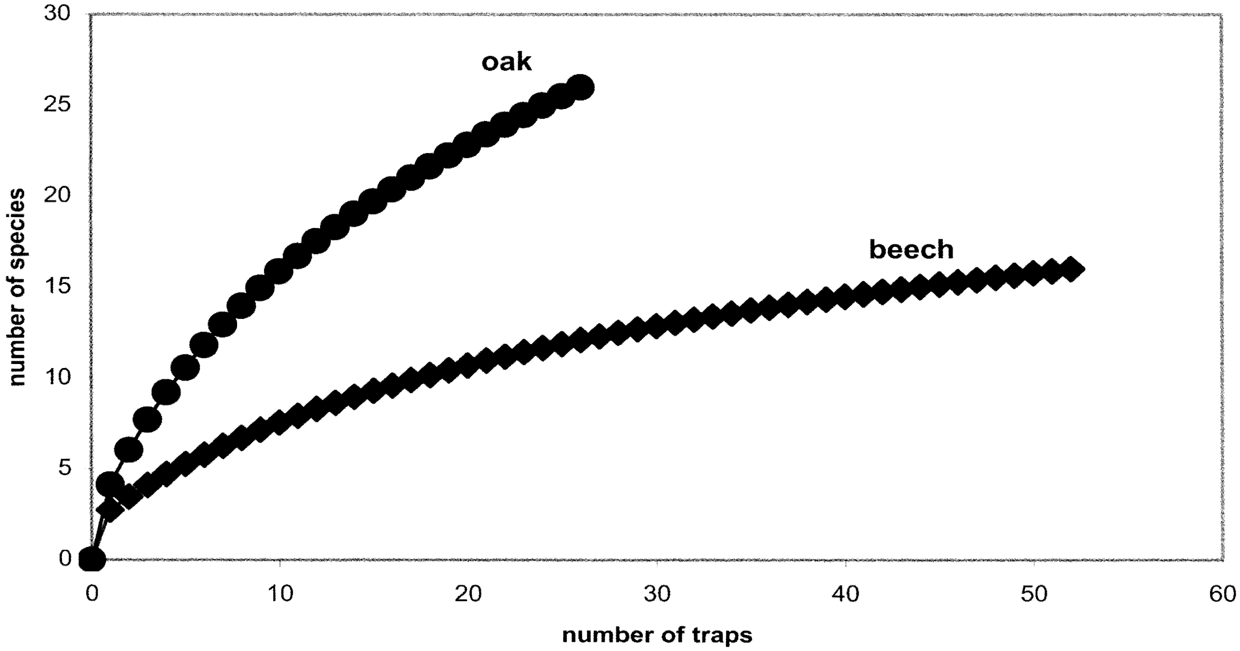

Fig. 1 – Species accumulation curves of Neuropterida on beech (diamonds) and oak trees (circles) in Steigerwald. Data of beech are derived from traps in the tree crown only (> 10 m).

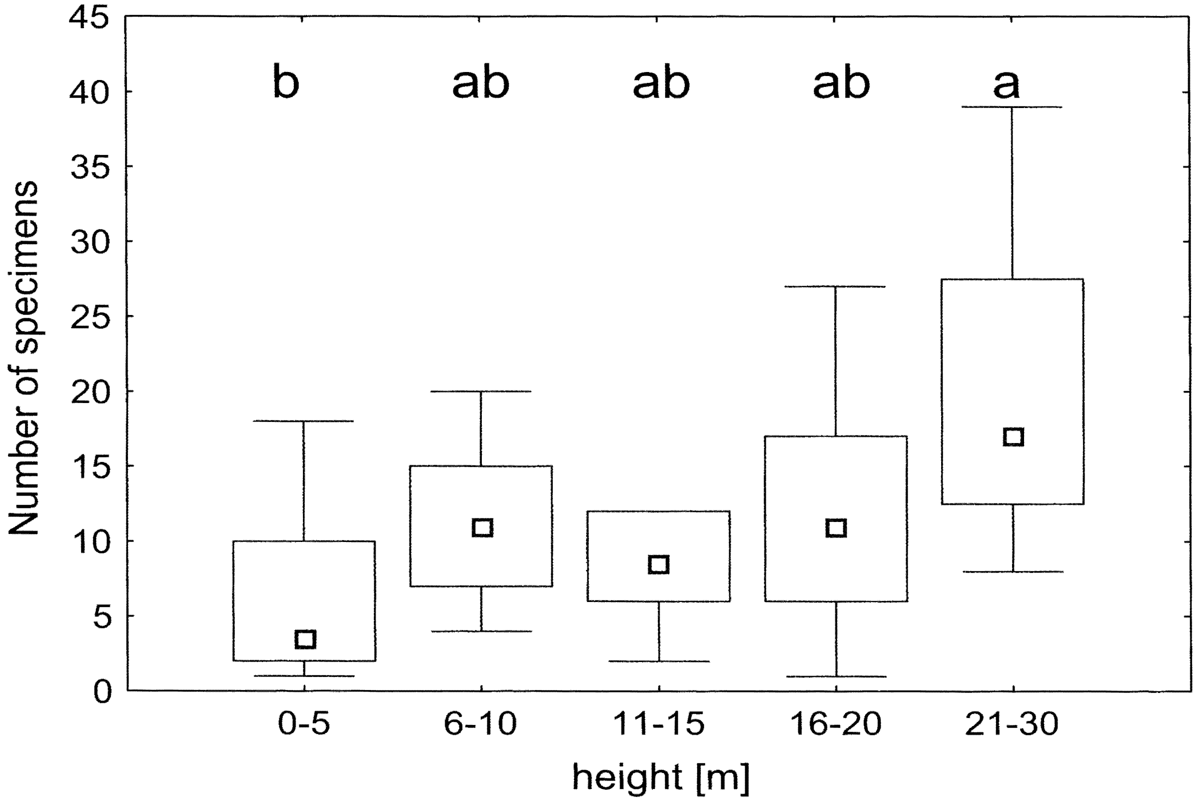

Fig. 2 – Average number of specimens (Median) captured with flight interception traps at different heights in tree crowns of beech. Different letters indicate significant differences between height levels (ANOVA, p=0.05).

as "the number of specimens captured".

We performed Kruskal-Wallis ANOVA statistic to compare means of groups. The Indicator Analyses and the Cluster Analysis were carried out by performing the statistic program PCOrd 4.2 (McCune & Mefford, 1999). The "Rarefraction method" according to Shinozaki (1963) was applied for the quantitative comparison of species counts on beech and oak trees, but only for the data of traps in the crown stratum (> 10 m). This method allowed the comparison of species numbers despite different sample sizes. The Poisson Regression for the plot habitat parameters was calculated using the program R 2.1.1 (Ihaka & Gentleman, 1996). This method searches with multivariate analysis for a set of parameters in the environmental variables that may explain best the target variable.

Results

Neuropterid communities on beech and oak – A total of 1,098 adult Neuropterida of 31 species were captured in this study on beech and oak trees. The predominant species was *Hemerobius micans* with 86% of all captured specimens (beech 90.0%, oak 78.1%), followed by *Chrysoperla carnea* (total 3.8%, beech 2.9%, oak 5.8%), *Sympherobius pellucidus* (total 1.5%, beech 1.2%, oak 2.0%) and *Dichochrysa flavifrons* (total 1.0%, beech 0.7%, oak 1.7%). The proportion of all other species was less than 1% (Appendix I).

The communities on beech exhibited a lower total number of species (21) than on oak (25), although on beech the number of traps used was higher (82 versus 27 on oak) (Fig. 1). Tourists, i.e. species which are supposed to be strongly associated to coniferous trees, occurred in samples of both tree species similarly (beech: *Raphidia ophiopsis*, *Wesmaelius concinnus*, *Coniopteryx pygmaea*, oak: *Drenanepteryx algida*, *Hemerobius nitidulus*, *H. stigma*, *Wesmaelius concinnus)*. Indicator values (IV) calculated for the more abundant species (> 5 specimens) in the crown stratum were significant for *Semidalis aleyrodiformis* for oak (IV = 16.1; p = 0.031) and *Hemerobius micans* for beech (IV = 26.8, p = 0.050).

Vertical distribution – The vertical distribution of Neuropterida on beech and their abundance at five height levels are shown in Appendix II. *Hemerobius micans* was the predominant species at all height levels (0-5 m 86.4%, 6-10 m 90.2%, 11-15 m 90.5%, 16-20 m 89.2%, 21-30 m 92,3%). Most other species occurred in the traps of a particular height level with only one or two specimens, except *Chrysoperla carnea*, *Hypochrysa elegans*, *Sympherobius elegans* and *S. pellucidus*. Most specimens of the latter three species were found in 16-20 m, whereas *Chrysoperla carnea* was most abundant between 6 and 15 m (Appendix II).

Although the abundance exhibited significant differences only between the lowest and highest level (Fig. 2), the dendrogram of faunistical similarity indicated a strong differentiation between the communities at the two uppermost and the lower levels (Fig. 3).

Influence of light supply – The effect of stand structure on the abundance of Neuropterida was analysed by "sample plot approaches". A different supply of light at the stratum close to the forest ground did not influence the counts of specimens in the traps (K-W-test $H_{df=2, n=65} = 1.66$, p= 0.4359; Fig. 4). Moreover, no significant effect of dead wood or presence of conifers in the vicinity of traps was detected by a Poisson regression.

Discussion

For the temperate zone little is known about the vertical intraforest or tree crown distribution of arthropods (Schowalter & Ganio, 1998; Gruppe *et al.*, in press). Regarding Neuropterida, results were presented by Saure & Kielhorn (1993) from *Quercus* in northern Germany and Schowalter & Ganio (1998) from coniferous tree species in Washington, USA.

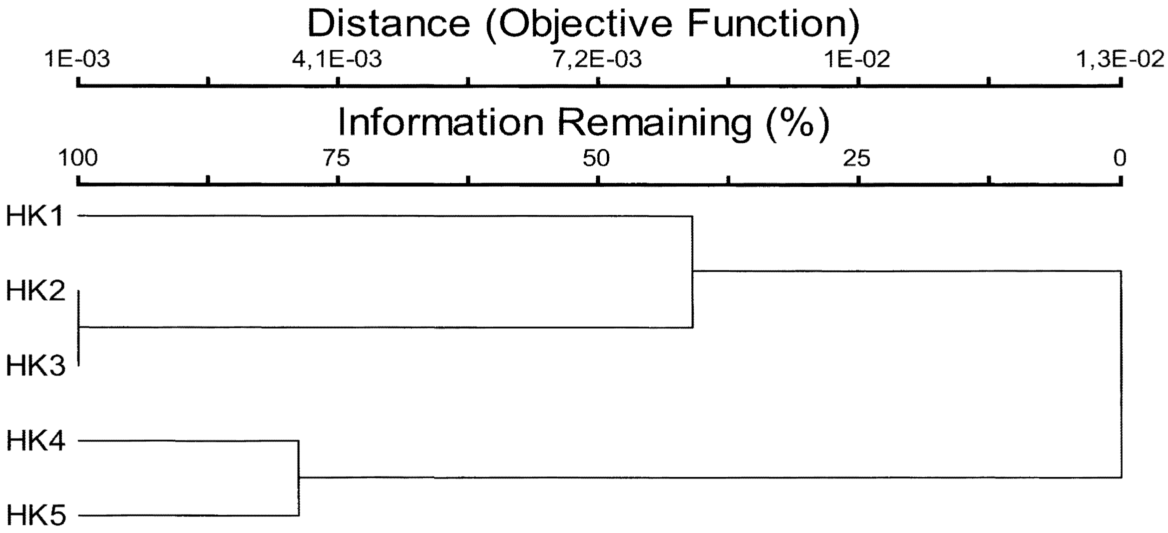

Fig. 3 – Dendrogram of the faunistical similarity (Soerensen values) of neuropterid communities at different heights in beech. (HK1 = 0-5 m; HK2 = 6-10 m; HK3 = 11-15 m; HK4 = 16-20 m; HK5 > 20 m).

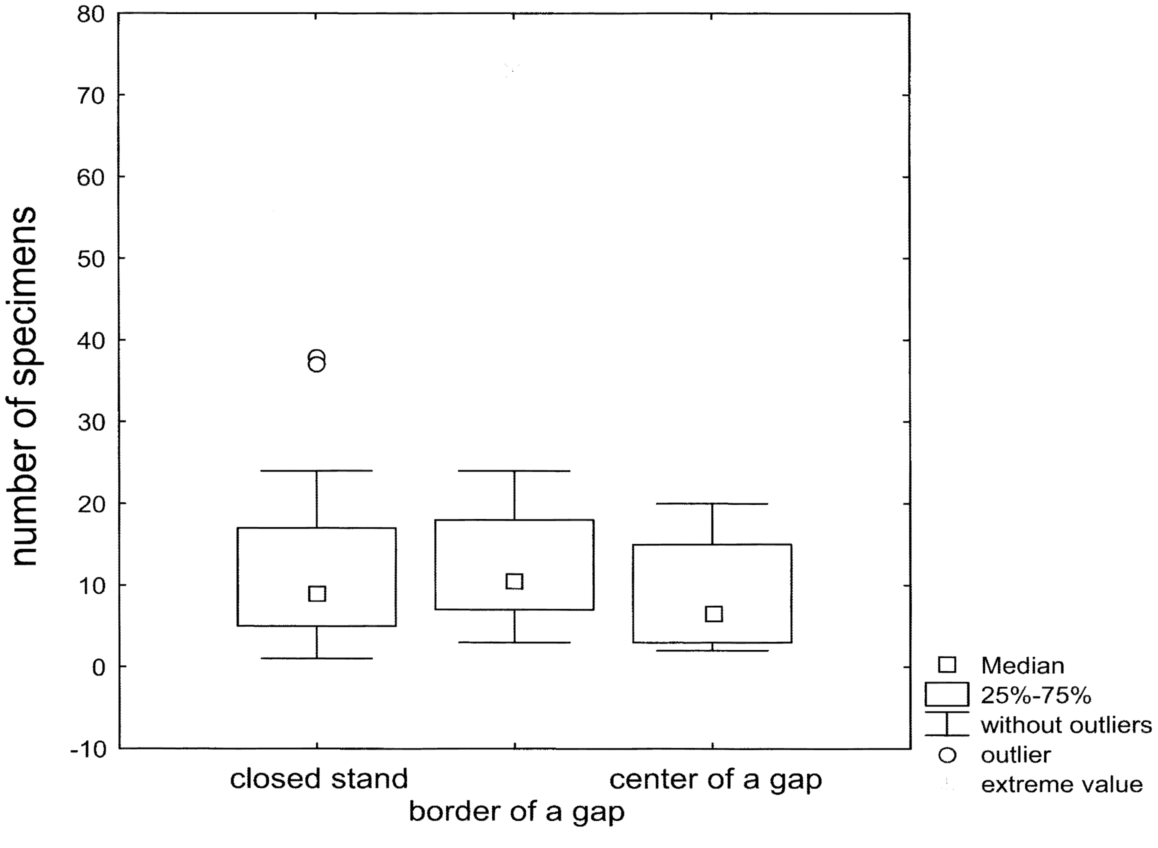

Fig. 4 – Numbers of neuropterid specimens captured in flight interception traps in a beech forest in Steigerwald close to the ground (trap height 1.5 m). Outliers are defined as values outlying of box value + 1,5 * (upper box value – lower box value). Extreme values are defined as values outlying of box value + 2 * 1,5 * (upper box value – lower box value).

Data from *Fagus* were published by Duelli *et al.* (2002) from Switzerland. In all three studies different collecting devices were used which makes data hardly comparable (Basset *et al.*, 1997; Bußler *et al.*, 2004). In the present study we describe the vertical distribution of Neuropterida on a tree exemplarily for *Hemerobius micans* which contributed to a proportion of about 90% of all Neuropterida. Most specimens were captured in the tree crown, i.e. higher than 10 m above ground, and the communities differed highly between crown and ground level. Duelli *et al.* (2002) also captured most species in the forest interior at the highest level (28 m), and Gruppe & Schubert (2001) confirmed that neuropterids prefer the canopy in closed forests more than strata which are closer to the ground. However, Schowalter & Ganio (1998) reported that Neuroptera which were caught with direct sampling methods, were only present in the lower and middle stratum of tree crowns, and Saure & Kielhorn (1993) captured more specimens with colour pan traps in 5 m versus 15 m (337 at 5 m vs. 220 at 15 m), even though the counts of species were smaller in the low level (16 at 5 m vs. 19 at 15 m).

We have found the euryoecious *Chrysoperla carnea* most abundant between 6 and 15 m and captured it in association with *Dichochrysa abdominalis*, *Hemerobius humulinus*, *Wesmaelius concinnus*, and *Semidalis aleyrodiformis* only in the lower strata (up to 10 m). Gruppe & Schubert (2001) found that *Dichrostigma flavipes* was the only species which was more abundant rather at ground level than in tree crowns. In contrast to our results, Saure & Kielhorn (1993) found several species to be more abundant in the lower stratum.

The neuropterid communities inhabiting beech and oak crowns of hardwood forests in the 'Northern Steigerwald' were poor in species numbers compared to other forest stands in Central Europe. In mixed forests in Southern Bavaria (Germany) Schubert & Gruppe (1999) and Goßner (2004) recorded 27 and 24 species respectively for beech compared to 21 in this study, and 33 and 26 for oak compared to 25. Duelli *et al.* (2002) found 13 species of Coniopterygidae, 18 species of Chrysopidae, 26 species of Hemerobiidae, and 3 species of Raphidioptera in a mixed beech forest in Switzerland but the study was focused on the communities of forest edges and not in that of the interior closed forest stands. The community on oak trees in Surrey, Great Britain, consisted of 23 species sampled by insecticide knock-down technique (Barnard *et al.* 1986). In his review of host plant association of Neuroptera in Europe, Szentkirályi (2001) listed in total 17 species of Chrysopidae and 27 of Hemerobiidae for beech and 29 species of both Chrysopidae and Hemerobiidae for oak. However, these numbers of species were summarised from different studies using various sampling methods and designs.

The poorness in species numbers of the communities which were caught on oak and beech may be due to the uniform character of the hardwood forests in which the samples were taken. The stands were more or less open, predominated by beech (65% coverage) with minor admixture of oak (5% coverage). Conifers occurred rarely in the stands (Müller, 2005). In contrast, stands sampled by Gruppe & Schubert (2001) and Goßner (2004) were more closed and consisted of hardwood and coniferous trees in different admixtures as well.

The abundance of Neuropterida in the forest stand was independent of most tested environmental and structural parameters. Neither light supply which is usually strongly correlated with temperature (Geiger, 1965), nor differences in the tree structure (Müller, 2005) significantly influenced the distribution of adult Neuropterida.

In general, the insect species diversity is positively correlated to the heterogeneity of a habitat (Tews *et al.*, 2004, Lassau *et al.*, 2005). From our results and data published earlier (Gruppe & Schubert, 2001, Goßner, 2004) we can verify this for the diversity of Neuropterida at the level of forest stand (highly structured mixed forest stands vs. homogenous hardwood forests). Diversity of structures at the scale of single trees seem to have no effect on abundance. However, at the scale of different height levels within trees, the crown stratum harbours more specimens than lower strata. In terms of complexity tree crowns are highly complex due to the high amount of leaves and this seems to be a keystone structure with regards to the abundance of Neuropterida, as reviewed by Tews *et al.* (2004) for species diversity in general.

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Appendix I – List of neuropterid species and their abundance in flight interception traps in Steigerwald in 2004. Notice the different numbers of traps used in beech and oak.

	Beech	Oak	Total
No. of traps	82	27	109
Raphidioptera Raphidiidae			
Dichrostigma flavipes (Stein)	2	1	3
Phaeostigma major (Burmeister)	1		1
Phaeostigma notata Fabricius		3	3
Raphidia ophiopsis Linnaeus	1		1
Subilla confinis (Stephens)	2	1	3
Xanthostigma xanthostigma (Schummel)	1	3	4
Neuroptera Chrysopidae			
Nothochrysa fulviceps (Stephens)		1	1
Hypochrysa elegans (Burmeister)	6	3	9
Chrysopidia ciliata (Wesmael)		2	2
Chrysoperla spp.	2		2
Chrysoperla carnea (Stephens)	22	20	42
Chrysoperla pallida Henry et al.	3		3
Cunctochrysa albolineata (Killington)	3	1	4
Dichochrysa abdominalis Brauer	1	1	2
Dichochrysa flavifrons (Brauer)	5	6	11
Dichochrysa prasina (Burmeister)	1	1	2
Dichochrysa ventralis (Curtis)		1	1
Nineta flava (Scopoli)		3	3
Nineta principiae (Monserrat)	1		1
Neuroptera Hemerobiidae			
Drepanepteryx algida (Erichson)		1	1
Hemerobius humulinus Linnaeus	1		1
Hemerobius micans Olivier	677	271	948
Hemerobius nitidulus Fabricius		1	1
Hemerobius stigma Stephens		1	1
Sympherobius elegans (Stephens)	7	2	9
Sympherobius klapaleki Zelenỳ		1	1
Sympherobius pellucidus (Walker)	9	7	16
Sympherobius pygmaeus (Rambur)		4	4
Wesmaelius concinnus (Stephens)	1	1	2
Neuroptera Coniopterygidae			
Coniopteryx pygmaea Enderlein	1		1
Coniopteryx spp. (females)	3	2	5
Conwentzia psociformis (Curtis)	1	2	3
Semidalis aleyrodiformis (Stephens)	1	7	8
no. of species	21	25	31
no. of specimens	752	347	1099
average no. of specimens per trap	9.2	12.9	

Appendix II – List of neuropterid species and their abundance in flight interception traps in different heights in beech crowns at Steigerwald. Notice the different numbers of traps in different heights.

Trap height	0-5 m	6-10 m	11-15 m	16-20 m	21-30 m	summ
No. of traps	11	19	13	28	11	82
Raphidioptera Raphidiidae						
Dichrostigma flavipes (Stein)	1		1			2
Phaeostigma major (Burmeister)				1		1
Raphidia ophiopsis Linnaeus				1		1
Subilla confinis (Stephens)				1	1	2
Xanthostigma xanthostigma (Schummel)				1		1
Neuroptera Chrysopidae						
Hypochrysa elegans (Burmeister)	1			4	1	6
Chrysoperla sp.		1			1	2
Chrysoperla carnea (Stephens)	2	6	9	3	2	22
Chrysoperla pallida Henry et al.				1	2	3
Cunctochrysa albolineata (Killington)				1	2	3
Dichochrysa abdominalis Brauer	1					1
Dichochrysa flavifrons (Brauer)	1	2		1	1	5
Dichochrysa prasina (Burmeister)				1		1
Nineta principiae (Monserrat)					1	1
Neuroptera Hemerobiidae						
Hemerobius humulinus Linnaeus		1				1
Hemerobius micans Olivier	57	110	114	240	156	677
Sympherobius elegans (Stephens)	2		1	4		7
Sympherobius pellucidus (Walker)	1		1	7		9
Wesmaelius concinnus (Stephens)		1				1
Neuroptera Coniopterygidae						
Coniopteryx pygmaea Enderlein				1		1
Coniopteryx spp. (females)				1	2	3
Conwentzia psociformis (Curtis)				1		1
Semidalis aleyrodiformis (Stephens)		1				1
no. of species	8	6	5	15	8	21
no. of specimens	66	122	126	269	169	752
average no. of specimens per trap	6.0	6.4	9.7	9.6	15.4	9.2

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Overwintering stages of *Sisyra iridipennis* A. Costa, 1884 (Neuroptera Sisyridae)

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Sisyra iridipennis has a Western Mediterranean distribution throughout the Iberian Peninsula, Maghreb and Sardinia. Little is known about its life history. To determine the overwintering stages of this species, a series of surveys were carried out at Riu Bunnari (Sassari, NW Sardinia). In the period between November and February, *S. iridipennis* was found exclusively as a first instar larva. This spongillafly lives in environments characterized by strong summer dryness, in which the host sponge *Ephydatia fluviatilis* (Linnaeus,1758) (Porifera Spongillidae) exhibits a summer quiescence. It is possible that the life history strategy utilised by *S. iridipennis* has evolved to track this commonly occurring poriferan.

Key words – *Sisyra*, freshwater sponges, life cycle, Mediterranean.

Introduction

The Sisyridae is a small family of Neuroptera containing about fifty species in four genera among which *Sisyra* is cosmopolitan (Tauber *et al.*, 2003). The larvae are aquatic obligate predators of freshwater sponges (New, 1986).

Despite being one of the few freshwater invertebrate groups uniquely dependent on Porifera as a food source, there has been little research on sisyrid biology. Parfin and Gurney (1956) summarise most early information; Brown (1952) first described the complete sisyrid life cycle. More recent information is supplied by H. Aspöck *et al.* (1980, 2001), Evans & Neunzig (1984), Pupedis (1985), New (1986), Elliott (1996), Meinander (1996), Weißmair (1999), Hölzel & Weißmair (2002).

Sisyra nigra (Retzius, 1783) [= *fuscata* (Fabricius, 1793)], *S. vicaria* (Walker, 1853) and *S. terminalis* Curtis, 1854 as well as *Climacia areolaris* (Hagen,1861) are the only species whose life cycles are well known. They all have a "northern" distribution: Holarctic in *S. nigra*, East-Nearctic in *S. vicaria* and *Cl. areolaris*, and European in *S. terminalis*.

Sisyra iridipennis A. Costa, 1884 has a Western Mediterranean distribution throughout the Iberian Peninsula (Monserrat, 1986), Maghreb (McLachlan, 1898; Aspöck & Hölzel, 1996; Güsten, 2003) and Sardinia (Costa, 1884a, b; Weißmair, 1999). Little is known about the life history of *S. iridipennis*. The fact that it is found in environments characterized by strong summer dryness, in which the potential host sponge *Ephydatia fluviatilis* (Linnaeus,1758) (Porifera Spongillidae) exhibits a summer quiescence (Pronzato & Manconi, 1994), raises the interesting question of the nature of the life history strategy utilized by the sysirid to track this commonly occurring poriferan. As a start to addressing this question, we first looked at the overwintering strategy of *S. iridipennis*.

During the two winters of 2003 - 2004 and 2004 - 2005, we sampled the host sponge in a short stretch of Riu Bunnari, near Sassari (NW Sardinia), in order to confirm the identity of the overwintering spongillafly and determine the life stage present during the winter months.

Materials and methods

Sampling was carried out, at more or less monthly intervals, in a short stretch (about 200 m in length) of the Riu Bunnari between November and May in 2003-2004 and 2004-2005 (see Fig. 2).

This river, about 12 km in length, is situated near Sassari (NW Sardinia) (Fig. 1). Its macrozoobenthic communities was studied by Manconi *et al.* (1995). Despite the presence of many signs of human impact, benthic invertebrate populations in the river do not appear to be greatly affected by pollution (Mascolo & Loru, 2000). Water flow is at its highest in winter. In summer a significant portion of the water flow becomes hyporheic but the loss of all surface flowing water is an extremely rare catastrophic event.

During the period of our surveys the sponge was active exhibiting a "fleshy" body. Because the number of sponge colonies was low and the individual colony sizes were small

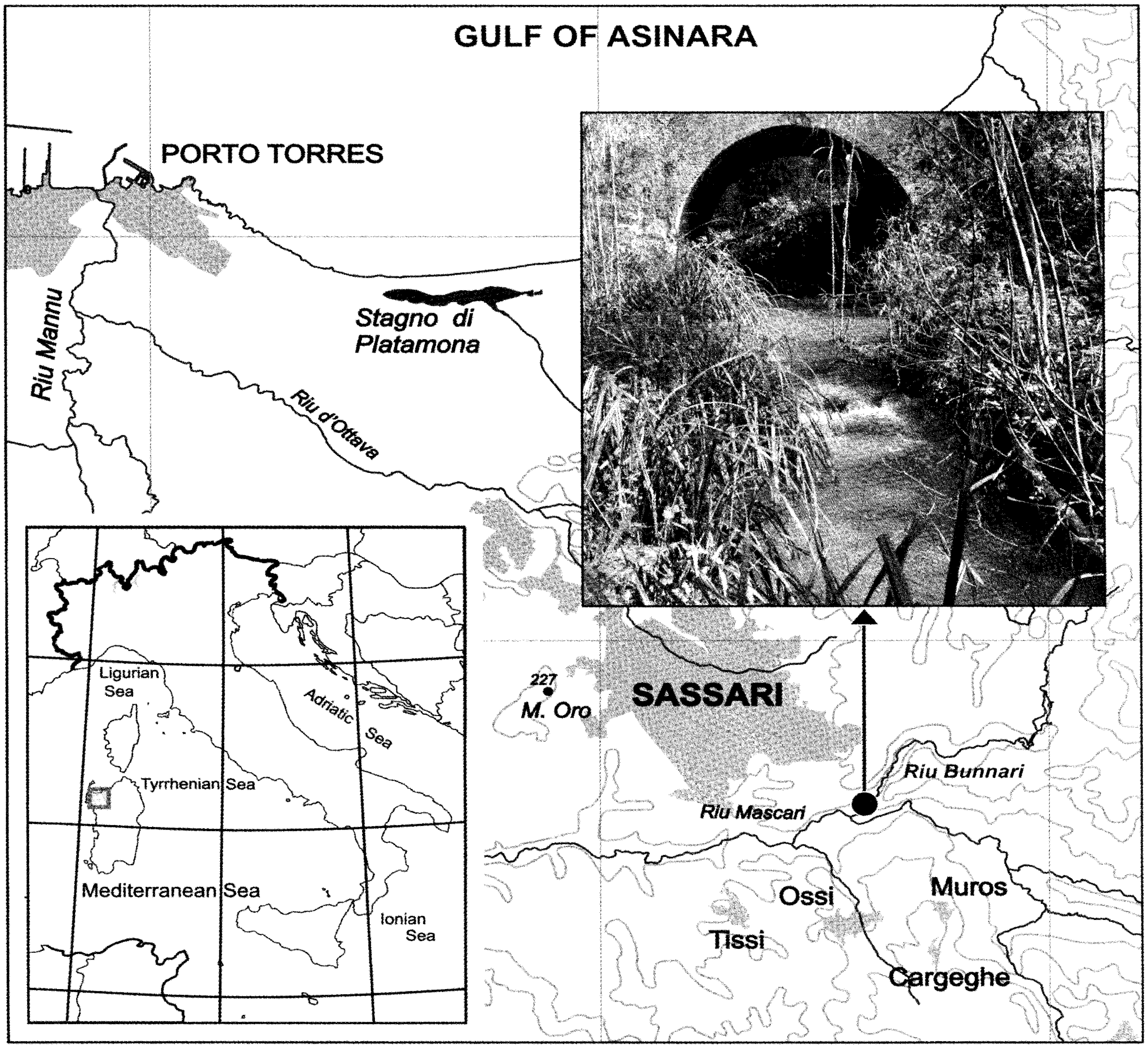

Fig. 1 – Map of the Riu Bunnari region marked with the location and photograph of the sampling site in winter.

(diameter of the largest reached only 5 cm), only a portion (between ¼ to ½) of 3 - 5 colonies were taken during each sampling trip. The small amount of samples was assumed not to affect sisyrid and sponge populations and hence future sampling. The fragments of sponge were sampled with a spatula and placed in a container with habitat water.

In the laboratory the habitat water was withdrawn from the sponge colony causing the sisyrid larvae to leave the colony whereupon they were collected and recorded.

As only second and third instar larvae are identifiable to the species level, some first instar larvae were reared to the next stadium, using techniques described in Weißmair (1999). The identification of larval stadia and spongillafly species was made according to Weißmair (1999).

The sponge fragments were prepared for identification as in Pronzato & Manconi (1989) and identified following Pronzato & Manconi (2001).

Voucher specimens of the sisyrid larvae and the identification slides of the sponge colonies have been deposited in the collections of the Civico Museo di Storia Naturale di Ferrara.

Results

Figure 2 shows the results of the study. The total number of larvae collected was 81, 60 as first instars, 18 as second instars and 3 as third instars. The sponge collected was always *E. fluviatilis*. In the period between November and February, *S. iridipennis* is found exclusively as a first instar larva. From the beginning of March, in addition to first instars, second instar larvae are found. From mid May only third instar larvae are found.

Discussion

Overwintering stages of only few species of spongillafly are well known: the Holoarctic *S. nigra*, the Palearctic *S. terminalis* and the Nearctic *S. vicaria* and *Cl. areolaris*.

Killington (1936) recorded the first data about the overwintering stage of *S. nigra*, subsequently confirmed by Elliott (1996) and Hölzel & Weißmair (2002). This species spends the winter in the prepupal stage within the cocoon and pupates in the following spring. In England, a small number of individuals may bypass hibernation and continue on to pupate into adults; these adults will produce a second generation that grows rapidly and in turn overwinters in the prepupal stage.

The first data about the overwintering of *S. terminalis* in the larval stage date back to Withycombe (1923) but he makes this observation generically about the genus *Sisyra*, since he did not manage to distinguish between larvae of *S. terminalis* and *S. nigra.* The biology of *S. terminalis*

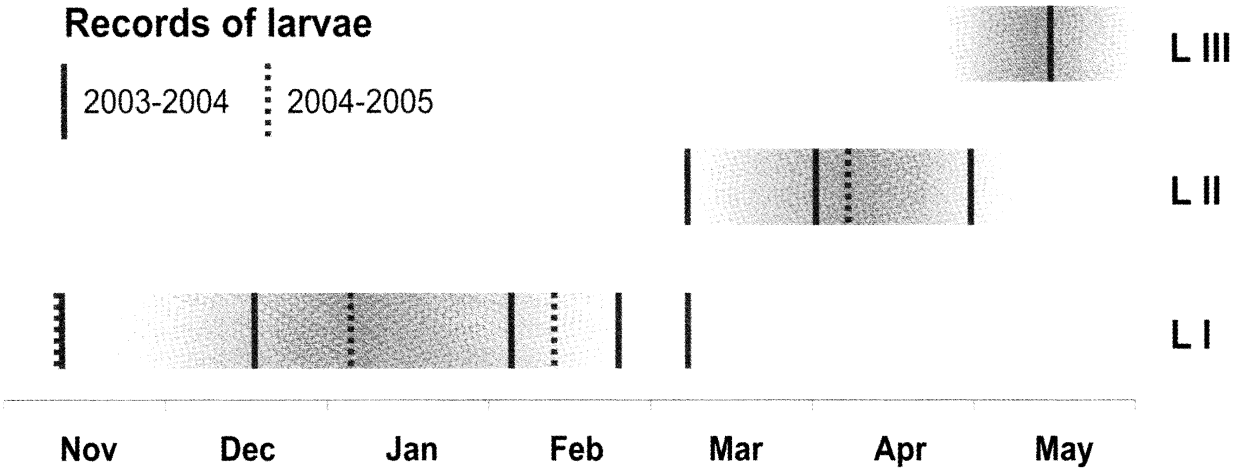

Fig. 2 – Records of spongillafly larvae in Riu Bunnari (NW Sardinia) during the winters of 2003-2004 and 2004-2005.

was clarified later by Weißmair (1994) and Hölzel & Weißmair (2002). Larvae derived from eggs laid early are able to complete their development, overwintering in the prepupal stage whereas larvae derived from eggs laid later (August), overwinter in the I or II larval stadium. In spring the overwintering larvae continue their development and then pupate together with those which overwinter as prepupa. Consequently all adults emerge at the same time.

Prior to Pupedis (1985) the only information about the overwintering stages of *Cl. areolaris* dated back to Roback (1968) and White (1976) who found larvae during the winter. Pupedis (1985) confirmed these observations demonstrating that this species spends the winter as diapausing larvae in the second stadium. A small number of individuals overwinter as first or third instars. In spring, rising water temperature induces growth and moulting; however, migration out onto land for pupation does not occur until the photoperiod lengthens to a certain value. This synchronizes individuals of the spring generation so that they emerge simultaneously. The number of yearly generations varies for *Cl. areolaris* with longitude and depending upon the local environmental conditions.

Pupedis (1985) also determined the overwintering stage of *S. vicaria*. This species spends the winter as a terrestrial, pharate first instar within the eggshell. The eggs are laid on permanent structures overhanging the water. In spring the first instar larvae hatch, fall into the water, and seek out the new sponge colonies. The larvae develop rapidly and adults start to appear in the middle of June. In Connecticut the first generation adults lay diapausing eggs, only a few females may produce non diapausing eggs and consequently a possible second yearly generation. More southerly populations of *S. vicaria* do appear to be multivoltine.

In regards to the life cycles of Tropical sisyrids, the only data available concerns *S. indica* Needham, 1909 and is supplied by Needham (1909) who relayed the following original observations from Dr. Annandale: “this species is common in the canals of *Spongilla carteri* [Carter, 1859], one of our most abundant freshwater sponges in India. I have only found the larvae between August and March, that is to say, in the rains and cold weather, but the sponge as a rule dies in the hot weather”.

It is apparent from the results of our survey that most if not all individuals of *S. iridipennis* overwinter in the first larval stadium. The first instars do not exhibit any obvious external development during the five winter months; second instars are found only after March. Even if we cannot completely exclude that a small portion of the population overwinters in other stages, we think this hypothesis is rather improbable on the basis of our knowledge about the environmental conditions and the life cycle of *E. fluviatilis*.

Freshwater sponges are able to get through periods of drought or freezing by producing resistant bodies known as gemmules; the fleshy portion of the colony is lost or greatly reduced during the process of gemmulation. Gemmules represent the quiescent phase of the sponge life cycle. When favorable environmental conditions return, the gemmules, either as a group or individually, give rise to a new sponge colony. Gemmulation is a seasonal process that, in temperate regions, usually occurs in late summer or at the beginning of autumn. Gemmules are consequently present during the winter (hibernation). On the other hand, in dry regions the opposite can happen: gemmulation occurs during the spring so that gemmules are present in summer (aestivation). *E. fluviatilis* populations hibernate in sites north of the 40°N parallel and aestivate south of it. *E. fluviatilis* is the only species known, up until now, to exhibit a life cycle inversion, but it is possible that other cosmopolitan species have the same behaviour (Pronzato & Manconi, 1994). On the basis of morphometrical

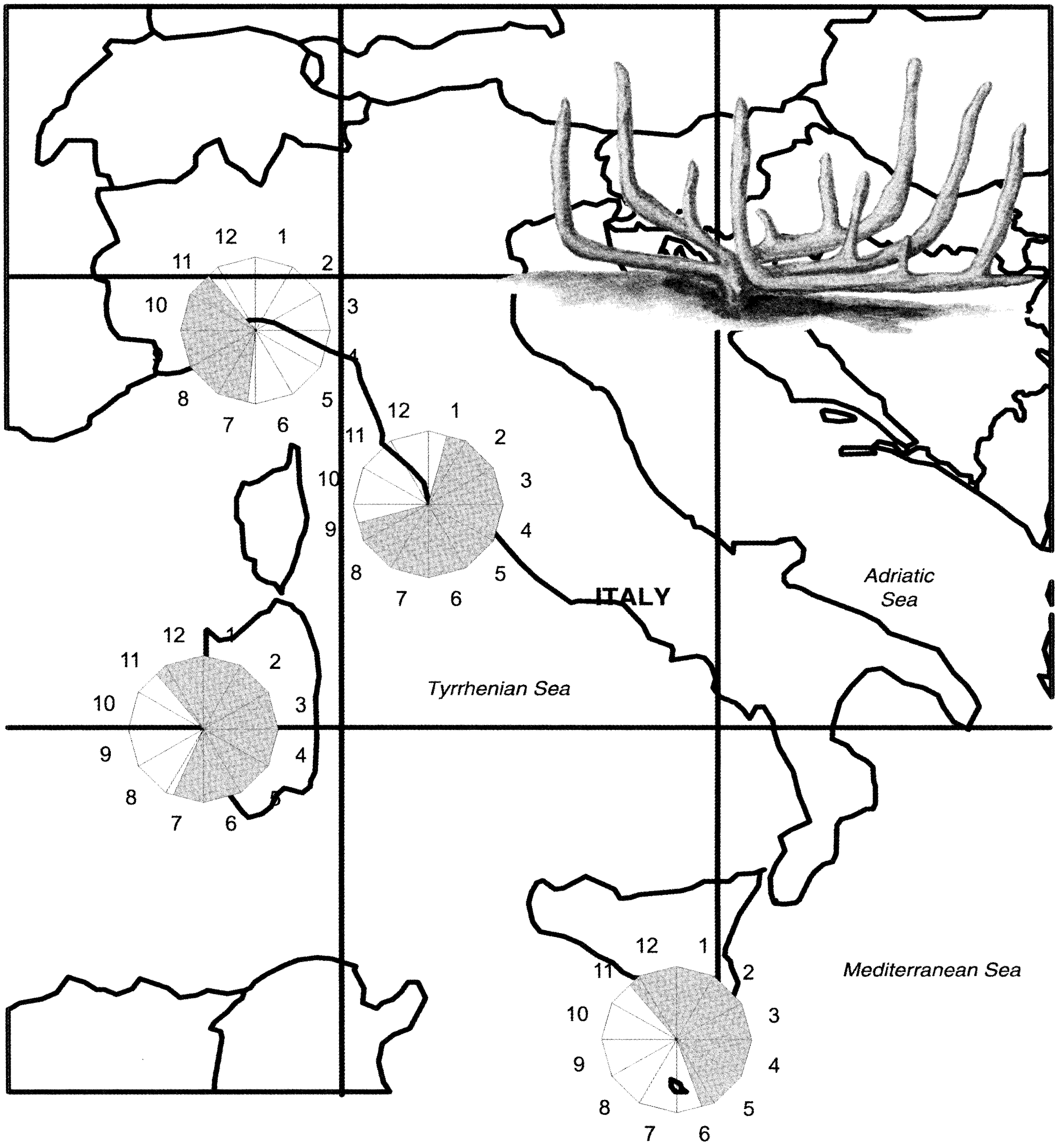

Fig. 3 – Life cycle in different populations of *E. fluviatilis*. Coloured sectors represent the presence of active sponges while numbers represent months. In the period represented by empty sectors the sponge is in quiescence and gemmules are present. The sponge figure is only illustrative and does not represent the aspect of the species in every considered habitat. The active phase of the sponge is preceded by a hatching process and followed by a gemmulation process which both last a few weeks. The border between coloured and empty sectors is therefore approximate (data from Pronzato *et al.*, 1988).

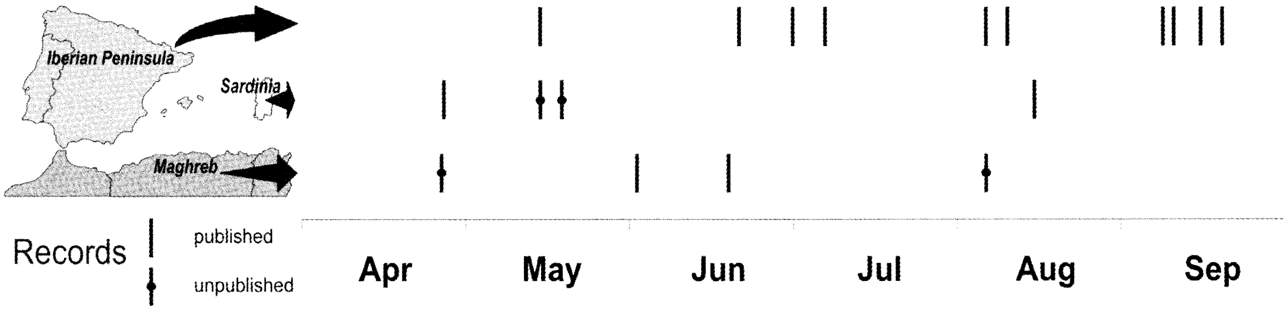

Fig. 4 – Adult records of *S. iridipennis*.

data this species was split, by Ezcurra de Drago (1975), into two subspecies, *E. fluviatilis fluviatilis* (Linnaeus, 1758) living in northern habitats and *E. fluviatilis ramsay* (Haswell, 1882) living in southern ones. The existence of two morphological taxa is consistent with the data on life cycle inversion.

The life cycle of *E. fluviatilis* is well known in Italy (Figure 3). In Sardinia, *E. fluviatilis* starts gemmulation in July; the subsequent aestivation period in the gemmule stage lasts from August to late September. The hatching process begins in October and the active sponge is present from November (Pronzato & Manconi, 1994).

In Sardinia other sponge species with a non-inverted life cycle are also present: *Ephydatia muelleri* (Lieberkühn, 1855) and *Spongilla lacustris* (Linnaeus, 1759) (Pronzato & Manconi, 2001).

From the data in our possession, it is possible to hypothesize the following spongillafly life-cycle. First-instar larvae of *S. iridipennis* establish themselves on *E. fluviatilis* in autumn when the sponges reactivate. They spend the whole winter in quiescence, or possibly diapause, sheltering in the sponges and resuming their development in March. It may be possible that a small portion of the population may overwinter in either the third or second stadium.

In figure 4 the records of adult captures, obtained from published and unpublished data, are plotted. Published records are from Monserrat (1986), Monserrat & Marin (1995) for the Iberian Peninsula, McLachlan (1898) and Güsten (2003) for Maghreb, Costa (1884a, b) for Sardinia. The first adults emerge at the end of April; subsequent adult emergence appears to be concentrated in May, the end of June and the beginning of August.

There is a complete lack of information concerning the fate of *Sisyra* populations in August and in September. In this period *E. fluviatilis* is quiescent and present only as gemmules. Many hypotheses about the life history stages employed by sisyrids during this period are possible: aestivation as eggs, larvae, prepupae or adults or development on other sponge species in permanent rivers.

While we have determined a portion of the life history strategy of *S. iridipennis*, it is still necessary to continue our research with sampling throughout the year to clarify many unknown aspects of the life history of *Sisyra iridipennis*.

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poco più di due volte la loro larghezza massima, molto più brevi della lunghezza del cranio, arcuate in maniera non molto accentuata, subdistalmente attenuate piuttosto bruscamente. Subprossimalmente ed aboralmente si trovano due setole denticolate. È costante, come nel gen. *Chrysopa*, la presenza della serie lineare dei quattro sensilli dor-

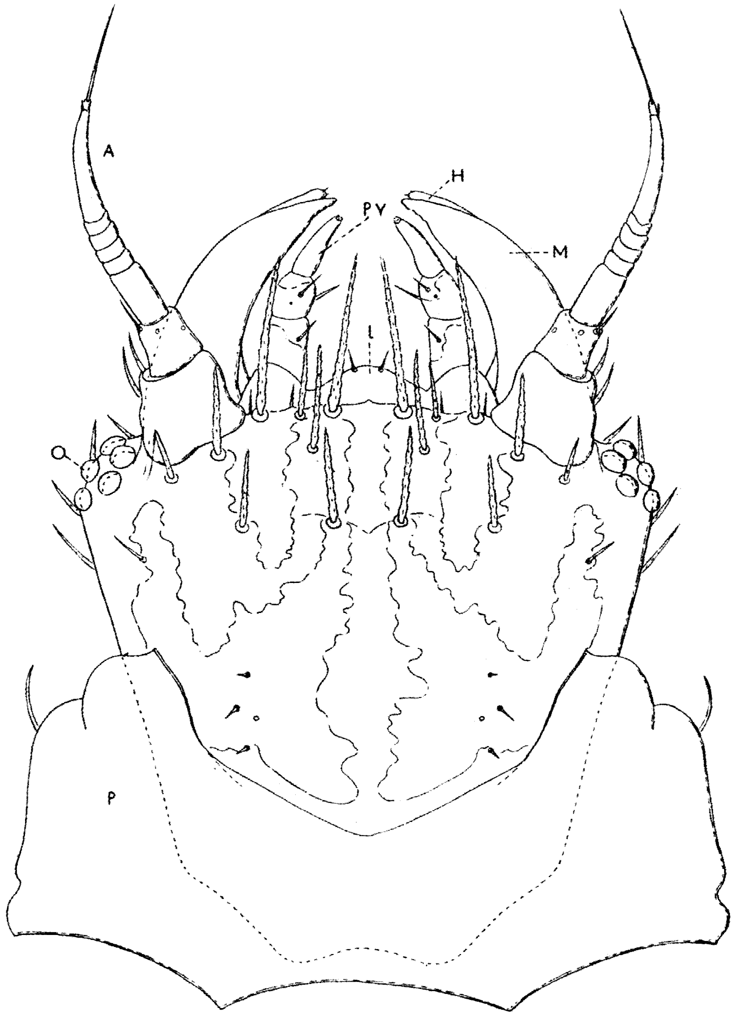

FIG. III.

Nothochrysa italica Rossi. - Larva. — Capo visto dal dorso: *A*, antenne; *H*, lobo mascellare; *L*, labbro superiore; *M*, mandibole; *O*, ocelli; *P*, protorace; *PY*, palpi labiali.

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Capture success in pit-building Antlion *Euroleon nostras* (Geoffroy in Fourcroy, 1785) (Neuroptera Myrmeleontidae) depends on the presence of pits, sand particle size and transmission of vibratory signals: a mini-review

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Antlion larvae build inverted conical pits on the sand surface to capture their prey. This review examines the role of the pits, sand particle size and transmission of vibratory signals in prey capture behaviour of *Euroleon nostras*. First the effect of the pits on the prey escape-time and on the number of escaped ants is discussed. Then the role of sands with different particle sizes is presented. The number of pits and the pit diameter depend on substrates with a certain particle size. The most convenient substrate for prey capture and the pit formation is sand with particle size of 0.23-0.54 mm. Finally biophysical properties of vibrations produced during locomotion of prey animals are evaluated. Characteristics for these signals are low intensities, acceleration values around 1 mm/s^2, and frequencies up to 4.5 kHz.

Key words – antlion, capture success, *Euroleon nostras*, Myrmeleontidae, sand particle size, substrate vibration.

Introduction

Most antlion larvae (Neuroptera Myrmeleontidae) are sand-dwelling insects, but only a few antlion species build pitfall traps, which is considered to be the most specialized strategy within the family Myrmeleontidae for capturing prey (Gepp & Hölzel, 1989; Mansell, 1996, 1999).

Pit-building behaviour and prey capture has been known for a long time (e.g. Youthed & Moran, 1969; Topoff, 1977; Klein, 1982; Lucas, 1982; Griffiths, 1986; Napolitano, 1998). The antlions wait at the bottom of the pit for prey, with only the front of the head and mandibles visible. The antlion detects its prey – a small arthropod – from a distance of a few centimetres by sensing the vibrations that the prey produces whilst walking on the sand surface (Devetak, 1985; Mencinger, 1998). When the prey slides into the trap, the antlion attempts to capture it and inserts its mandibles. If the antlion does not succeed in grasping the prey at its first attempt or if the prey escapes the antlion and tries to climb out of the trap, the antlion tosses sand with violent flicks of its head till the prey slides back to the antlion where it is caught.

The analytical approach in the study of predatory behaviour of antlions dates back to 1916 when Doflein published his famous book on antlion biology, behaviour and reflexes. Since 1916, a series of papers has been published dealing with the topics (for reviews see Gepp & Hölzel, 1989; Lucas, 1989; Mansell, 1996; Napolitano, 1998; Morrison, 2004).

In pit-building antlions, various factors affect capture success. Capture success is a function of the relative size of predator and prey (Griffiths, 1980) and is influenced by pit size, pit morphology and number of pits (Griffiths, 1986). Prey-capture success also depends on prey and predator movement. In the antlion species *Euroleon nostras* (Geoffroy in Fourcroy, 1785), the usual pit-building strategy is involved, although this antlion occasionally encounters and grasps its prey without building a pit (Devetak, 2005).

In the present paper the following questions regarding predator-prey interactions in pit-building antlions are addressed: (i) which signals are important in detection and recognition of prey, and (ii) which factors influence capture success.

The role of a pit and the presence of an antlion

Lucas (1989) suggested the following functions of the pit: the pit funnels prey to the bottom of the pit to the predator, and the pit also retards the escape of prey, and therefore increases the amount of time the prey is available for capture. Besides these, there are several other advantages to constructing a pitfall trap as a predation strategy: (i) the need to hunt or pursue prey is reduced, thereby conserving energy; (ii) the pit is a selective device for prey of a suitable size, large prey would be able to escape and energy is not wasted on futile efforts; (iii) it affords protection as large species falling into the pits cause the larva to retreat; (iv) fast-moving prey can be intercepted by the pit; and (v) prey can be subdued rapidly as it is disorientated upon falling into the pit (Mansell, 1996). In different antlion species, capture success is a function of the relative sizes of predator and prey (Griffiths, 1980) and is influenced by pit size, pit morphology and number of pits (Griffiths, 1986).

Devetak (2005) studied the success of the pit-building predation strategy compared with non pit-building predation in *Euroleon nostras*. Prey escape-time is measured by introducing ten ants into one of four different treatment arenas. The first treatment lacks pits and antlions, the second includes ten antlions that did not build pits, the third comprises eight artificially constructed pits, and the fourth is a treatment of eight antlions in pits and two without pits. When antlions are present without constructing pits, they impede the dispersal of prey. The mean escape-time for one half of the released ants is twice as long with antlions present as without them. Escape-times for all released ants are statistically different in three treatments (Fig. 1). When pits are present, escape-time for one half of the released ants is more than 10 times as long as when pits are absent. The time taken for one half of the released ants to escape from artificial pits is three times that from non pit-building antlions. In the treatment with the pits occupied by antlions, escape-time is four times longer than in the treatment with similar sized artificial pits. It is concluded that not only a pit, but also the presence of antlions influences capture success.

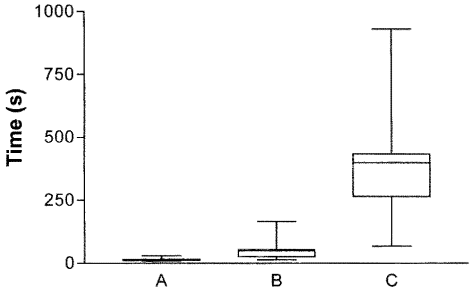

Fig. 1 – Escape-time for 10 ants for three treatments (A-C). A – treatment with plain sand (control treatment); B – treatment with ten antlions without pits; C – treatment with eight artificial pits. Lines across boxes are medians, lower and upper boundaries are first and third quartiles, and adjacent whiskers are lowest and highest values.

The role of substrate particle size

The larvae of the antlion *Euroleon nostras* build a pit in sand or loose soil which is protected against rainfall. Antlions require dry substrates with a certain particle size. In natural habitats, pit-building antlions are capable of discriminating between areas of sand differing in particle size, building pits in fine sand and avoiding coarser sand (Youthed & Moran, 1969; Kitching, 1984; Lucas, 1986; Loiterton & Magrath, 1996; Botz *et al.*, 2003; Devetak *et al.*, 2005). As antlion larvae rarely relocate their pits and thus are sedentary predators, habitat selection at oviposition by the female becomes an important factor governing larval spatial distribution (Matsura *et al.*, 2005).

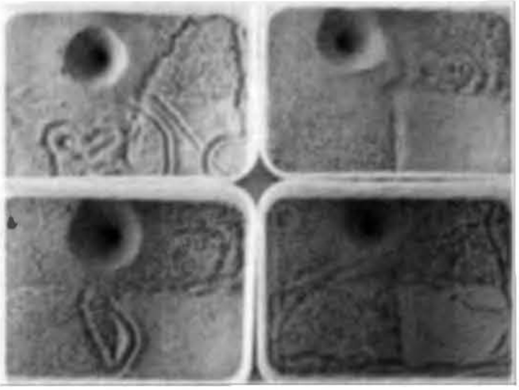

Fig. 2 – Four treatments of substrate-choice experiment testing third-instar larvae after 72 hours. Left upper quadrant of each tray contains sand with particle sizes 0.23-0.54 mm (G2), right upper quadrant contains sand with particle sizes 1-1.54 mm (G4), left lower quadrant was filled with sand with particle sizes 0.54-1 mm (G3) and right lower quadrant with sand with particle sizes 0-0.23 mm (G1). Pits in all trays were constructed in G2.

In experiments when four sand fractions with certain substrate particle size are offered to *Euroleon nostras*, the larvae prefer a sand fraction with a particle size of 0.23-0.54 mm (Fig. 2). In four-substrate-choice tests in which the coarsest sand grain fraction is 1-1.54 mm, only third-instar larvae construct pits occasionally in this fraction (Devetak *et al.*, 2005). Pit-building decision in a certain sand fraction in *Euroleon nostras* depends on larval instar (Devetak *et al.*, 2005). First-instar larvae avoid buildling pits in coarser substrates and this could be explained with small dimensions of this larval instar. The larger the instar, the more readily it builds a pit in coarser sand. Halloran *et al.* (2000) found that twice as many antlions of the species *Myrmeleon crudelis* in coarser substrate relocated their pits than those in fine substrate. Larger sand particles are probably more difficult to handle for antlions, and thus they require more time to build functional pits. The number of pits and the pit diameter are different when larvae are kept in sands with different particle sizes. The largest pits are constructed in sand with a particle size of 0.23-0.54 mm; here also the greatest number of pits is noted.

How might substrate particle size influence prey capture success? Particle size affects pit diameter and thus directly affects capture success. Pits constructed in fine-grained sand are bigger. Lucas (1982) demonstrated that increasing sand particle size facilitates the escape of ants from the pits of American species of the genus *Myrmeleon*. Ants escape faster from pits dug in coarse-grained sand than from pits dug in fine-grained sand (Farji-Brener, 2003). The pits of two Australian antlions (*Myrmeleon diminutus* and *M. pictifrons*) are lined with fine sand particles (<0.3 mm diameter) and this improves capture success by delaying the escape of prey and increasing the number of falls to the pit vertex during escape (Allen & Croft, 1985). Substrate particle size has a significant effect on the angle of the pit wall (Allen & Croft, 1985; Botz *et al.*, 2003); a steeper wall retards the escape of ants.

Vibratory signals in prey capture behaviour

In solid substrates insects can locate their prey visually or can receive prey's odours or detect mechanical signals produced by the prey during locomotion. Larval antlions use both visual and vibratory cues for prey localization (Fig. 3). Up to date, there is no direct evidence for olfactory cues used in prey detection. Mencinger (1998) elucidated the role of substrate vibrations *versus* vision in prey detection in *Euroleon nostras*. When the eyes of the antlions are covered with a paint to exclude visual stimuli the antlions still respond with a normal predatory behaviour to the presence of a prey without seeing it.

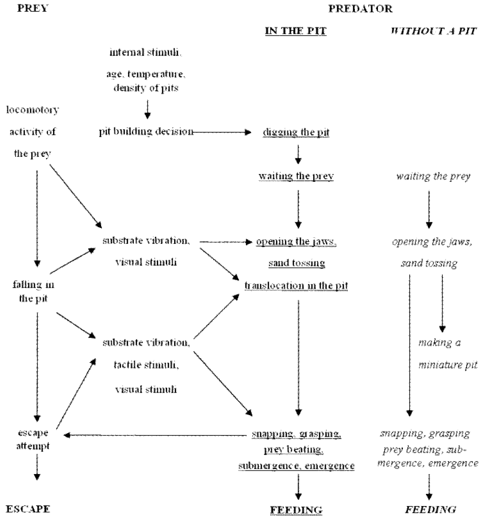

Fig. 3 – The role of tactile stimuli, substrate vibration and visual stimuli in predator-prey interaction in the pit-building antlion species *Euroleon nostras*. Sequence of behaviours of a predator waiting in the pit and without a pit is shown.

An antlion locates and recognizes its prey by sensing the vibratory signals that the prey produces during movement on the sand surface (Devetak, 1985; Mencinger, 1998). Tactile stimuli become important when a physical contact between the antlion and its prey occurs.

In sand, the antlion *Euroleon nostras* detects its prey on a maximal distance of only 20 cm. A number of factors limit long-distance transmission of vibratory signals. Because insects are much smaller than the sandy surfaces they vibrate, the amplitude of vibratory signals is low at the source. Damping of vibrations in sand further reduces amplitude of the signals (Aicher & Tautz, 1990). Substrate vibrations elicit prey capture behaviour of antlions, namely opening/closing the jaws, sand tossing and grasping the prey. Substrate vibrations produced by ants, beetles, bugs, woodlice and other prey animals are recorded accelerometrically. Vibratory signals produced by a firebug (*Pyrrhocoris apterus*) falling on its back and crawling are characterized with low frequencies, with peak values between 0.2 and 1 kHz (Fig. 4). As acceleration values (peak level) of the signals of locomotion of a firebug, recorded at a distance of ca. 2-5 cm from the accelerometer, were below 1 mm/s^2, it is assumed that antlions are extremely sensitive to substrate vibrations.

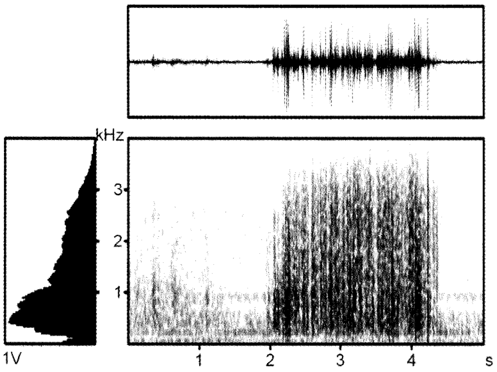

Fig. 4 – Vibratory signals of a firebug (*Pyrrhocoris apterus*), falling on its back and crawling on sand surface: *upper trace* – oscillogram; *lower trace* – sonogram; *left* – frequency spectrum. The frequency spectrum of the crawling signals has its most prominent peak between 0.2 and 1 kHz. Time in seconds.

Antlions are a good example of arthropods highly dependent on physical characteristics of their surrounding medium. Thus future research should be directed towards elucidation of the role of the sandy medium for the physical shape of the pits and transmission of the mechanical signals (vibrations, tactile stimuli) important in prey capture behaviour.

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cata dall'Imenottero. Tale spoglia, ridistesa ed esaminata accuratamente mi ha permesso di identificare la specie dell'ospite, la quale è risultata essere la *Chrysopa flavifrons* Brauer (¹) (²).

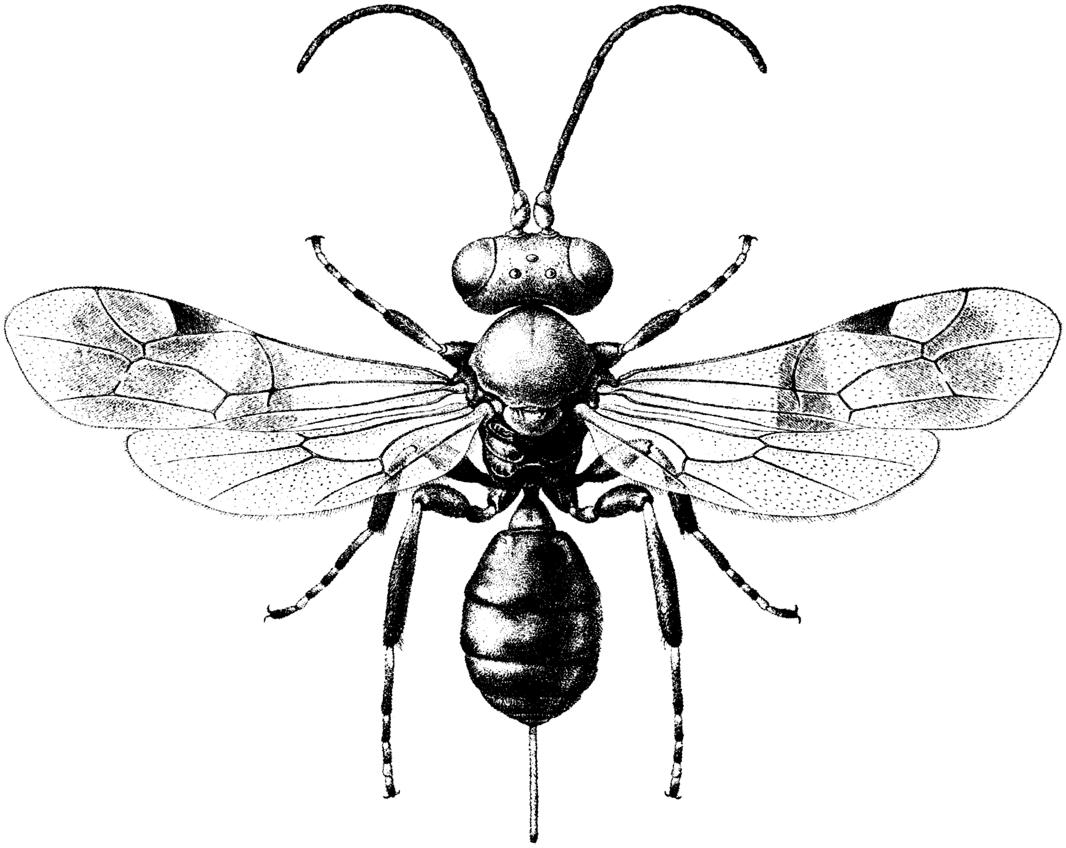

FIG. VI.

Hemiteles sp.

(¹) In un prossimo lavoro di morfologia comparata delle larve delle Crisope italiane, esporrò quali sono le caratteristiche che servono ad individuare le diverse specie.

(²) Sempre nel parco delle Cascine di Firenze, ma in una località a circa 500 m. da quella sopra ricordata ed una settimana più tardi, ho trovato, fissati alla pagina inferiore di foglie di Alloro e di Viburno di una siepe composta da tali arbusti (l'Alloro era infestatissimo da uno Psillide, la *Trioza alacris* Flor. ed il Viburno da un Tisanottero per ora non identificato), parecchi bozzoli di Crisopa mascherati da frammenti vari, che presentavano quasi tutti presso un polo un piccolo foro subcircolare, come il bozzolo di cui ho riferito sopra. Due erano ancora intatti. Nell'interno di quelli con il foro vi era un setto

M.M.P., 1948. – Contributi allo studio dei Neurotteri Italiani. VII. Osservazioni su alcuni parassiti di Crisopidi. *Bollettino dell'Istituto di Entomologia della Università di Bologna*, 17: 93-121.

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Monitoring of Antlions (Neuroptera Myrmeleontidae) by light trapping: influence of weather elements on daily and seasonal flight patterns

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A long-term light trapping monitoring program has been conducted for antlions in a sand dune area of the Kiskunság National Park in Hungary. The aims of this study were to analyse (a) how the night-flying activity of antlions was influenced by some weather variables; (b) to describe the effects of the weekly temperature and rainfall on the seasonal flight patterns of antlions. For the analyses daily catches of antlions and daily weather variables were used from the period of 2000-2004. The studied species were *Myrmeleon inconspicuus*, *Myrmecaelurus trigrammus*, *Creoleon plumbeus*, and *Nohoveus punctulatus*. The nocturnal air temperature threshold for antlion flight was 13-14°C. The intensity of flight activity increased as air temperature rose, with most adults (>70%) flying when the temperature was between 17 and 24°C at 22 h. Light winds (0.1-2.5 msec^{-1}) promoted antlion flight and it became sporadic when the wind speed was higher than 3 msec^{-1}. More than 70% of antlion specimens were captured on rainless days. Amounts of daily rainfall below 2 mm did not limit flight strongly. The flight patterns fluctuated synchronously with weekly time series of aerial temperatures. Higher frequency of rainfall between April and mid-June delayed the mass flight of antlions by one month.

Key words – antlions, Myrmeleontidae, light trapping, flight activity, weather variables.

Introduction

A long-term insect monitoring program has been conducted in Hungary using light trapping. The purpose of the project is to describe and analyse, at various temporal scales, the flight patterns of insects in relation to habitat and climatic changes (Szentkirályi, 2002). Parts of the Kiskunság National Park consist of extended protected sand dune areas supplying many suitable habitats for antlion assemblages with 11 species recorded (Gepp & Hölzel, 1989; Szentkirályi *et al.*, 2001).

Generally only a few antlion adults fly outside the boundaries of their larval habitats and then only sporadically. So, although they can be quantitatively collected by light trap, this method works only inside their typical habitats. However frequent sampling by light traps provides data suitable for analysing the effects of weather on daily and seasonal flight activity. Seasonal flight patterns of some common Hungarian antlion species have been analysed previously using light-trap data by Szentkirályi *et al.* (2001), Szentkirályi and Kazinczy (2002). Our paper presents here preliminary results on the effects of some weather variables on the daily and seasonal flight of the most abundant antlion species captured by light trapping in the study area.

The aims of our study were (a) to analyse the possible effects of various

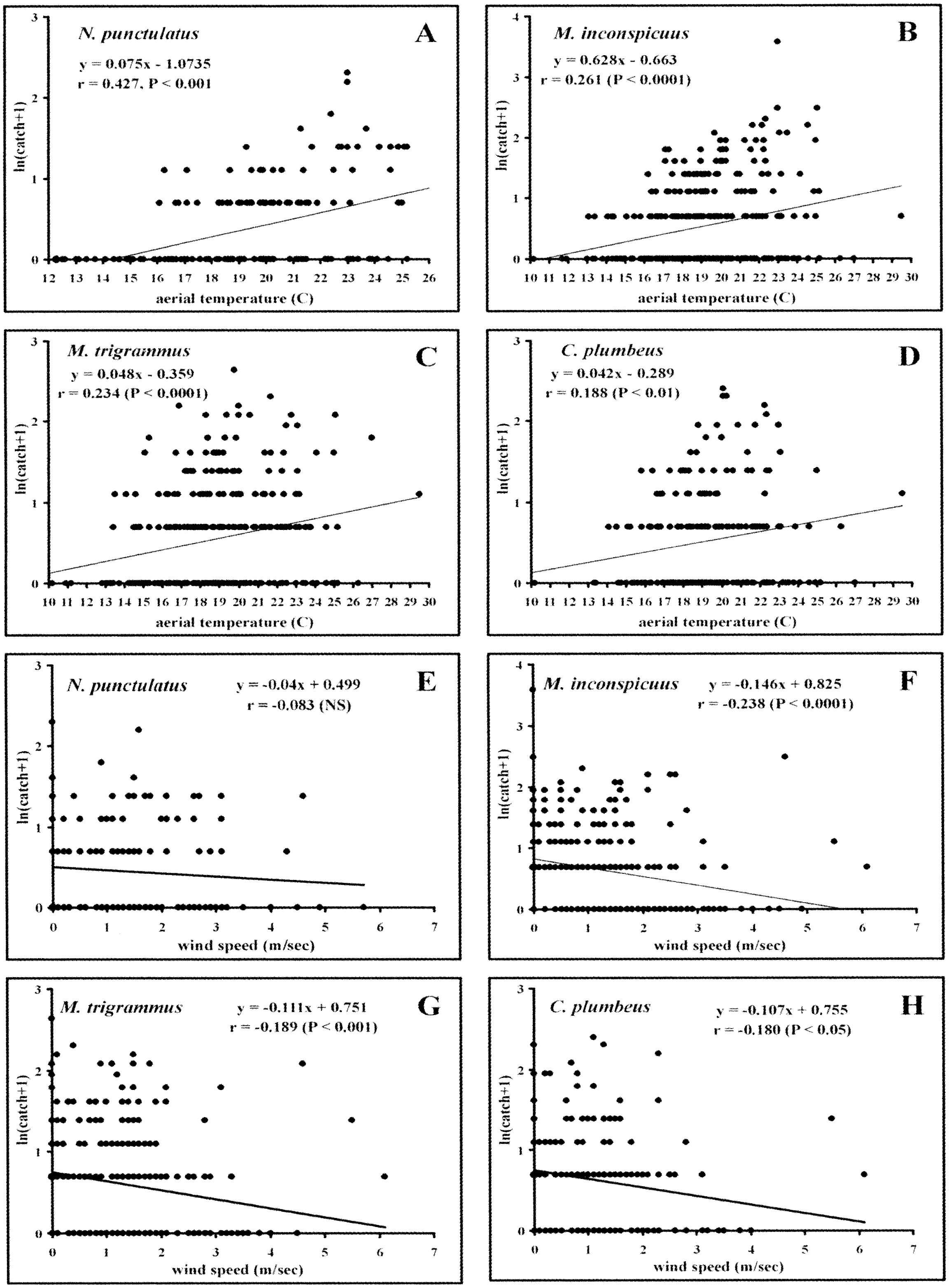

Fig. 1 – Catches of the four most abundant antlion species plotted against aerial temperature and wind-speed measured at 22 h (light trapping data set: 2000-2004).

weather elements on the night-flying activity of the most abundant antlion species; (b) to show any effect of weather on the seasonal flight patterns of antlions.

Materials and methods

Collecting site and characteristics of light trapping – The trap was set up in 1998 on a sand dune in a nature reserve area of the Kiskunság National Park (46.87°N, 19.42°E) in Hungary.

A Jermy-type light trap was used with three baffles around the bulb. The light source was a compact fluorescent lamp (Philips PL-T 42W/830/4p) producing white light at 2 m above the ground. The killing agent was chloroform vapour.

Daily trapping was done from April to October. A meteorological recording tower was set up at a distance of 250 m from the light trap in 2000. For analysis we used weather variables recorded automatically at 2 m height.

Antlions fly most actively between sunset and midnight with a maximum around 22-23 h (Gepp & Hölzel, 1989). Laboratory experiments with some species confirm that antlions usually fly before midnight (Ábrahám, 2003). So weather measurements at 22 h UTC were used for the analysis.

Variables and statistical analyses – The number of daily captured adults were used in the daily activity analysis. Antlion imagines do not swarm in mass, which is reflected in low and sporadic numbers in light trap catches in the early and late periods of seasonal flight. Consequently, we have excluded these zero catches from our analyses.

The weather parameters, from 2000-2004, were nocturnal air temperature, wind velocity (recorded at 22 h), and daily precipitation (2001-2004). For analyses these were exclusively taken from the actual period of flights and used as all have the potential to effect flight behaviour.

The seasonal flight activity patterns were measured using standard weekly total catch for 2002-2004. Weekly rainfall totals and means of daily maximum, minimum, and average air temperatures were used as potential factors influencing seasonal flight.

To show any trend in the effect of weather characteristics on daily activity level we used linear and non-linear regression analysis of daily catches against the weather variables. The daily catches were transformed to ln(number + 1) prior to analysis. We also calculated the number of individuals caught in various ranges of the values of weather variables to characterise changes in flying activity. The rate of seasonal synchrony between series of catches and weather data was calculated by the cross-correlation function, CCF (STATISTICA, StatSoft Inc., 2000).

Results

Influence of weather on daily flight activity – Four antlion species were found in the catches in sufficient numbers (N) for activity analysis: *Myrmeleon inconspicuus* (Rambur, 1842) (N=426), *Myrmecaelurus trigrammus* (Pallas, 1781) (N=395), *Creoleon plumbeus* (Olivier, 1811) (N=237), and *Nohoveus punctulatus* (Steven, 1822) (N=141). The transformed daily catches plotted against the increasing values of weather variables are presented in Figs 1-2. Among various types of functions the linear regression produced the best fits and significant correlation coefficients.

As expected, increasing evening air temperature significantly increased the flight activity of each antlion species but only slightly (Fig. 1, A-D). Nocturnal flight started regularly only above a specific temperature threshold, which varied between 13 and 16°C (Tab. I). Most individuals of the species studied flew on evenings with temperatures between 17-24°C. A high proportion of individuals (74 to 84%; Tab. I) were caught in mass flights occurring between these temperatures.

Increasing wind speed significantly, slightly decreased capture rates of antlions, except one (Fig. 1, E-H). Surprisingly, only a small proportion of the adults (16-24%) flew on calm nights (Tab. I). Mass flights of individuals (60-75% of total catches) were recorded in weak wind with a speed range of 0.1-2.5 msec^{-1}. The flight frequency of each species decreased

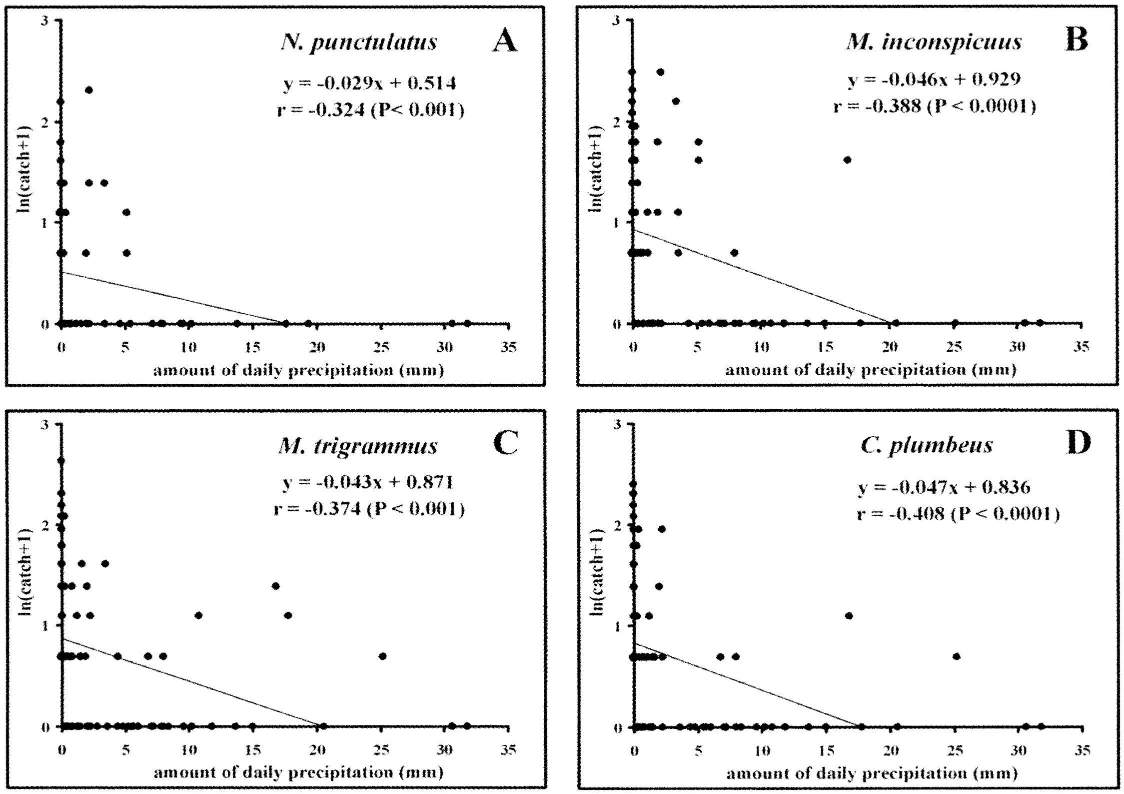

Fig. 2 – Catches of the four most abundant antlion species plotted against increasing amount of daily precipitation (light trapping data set: 2001-2004).

greatly above 3 msec^{-1} wind speed (see Fig. 1, E-H).

Rainfall generally inhibited the flying of antlions. The majority, 70-83%, of captured specimens flew on rainless days (Tab. I). If there was rain during the daytime, antlions were mainly caught when precipitation was low (0.1-2.5 mm) (Tab. I). On rainy evenings, flight only ocurred if the rain fell as a single short shower. With increasing daily rainfall the flight activity of all species decreased significantly (Fig. 2, A-D). Above 8 mm of daily rainfall captures became few with only one or two individuals caught (Fig. 2).

Influence of weather on seasonal flight activity – Table 2 and 3 present the results of correlation analysis to study the weather effects on the flight patterns of antlions. Positive correlations were found between weekly catches of the three most abundant species and the mean aerial temperatures (Tab. II). This suggests that increasing weekly mean, maximal, and minimal temperature increased weekly capture rates, i.e. flight activity. Significant ($P<0.05$) correlation values above 0.5 were mainly detected using the weekly mean or minimal temperatures. The mean maximum temperature is usually a daytime characteristic, so its effect is likely to be less than the other two temperatures measures which use values recorded during nocturnal flights. The majority of higher correlation values (range: 0.57 – 0.84) occurred in 2002 and 2004, while maximum temperature only had a correlation >0.5 with catches of *M. trigrammus* and *C. plumbeus* in 2003 (Tab. II). This annual variation in correlation can be attributed to the very dry, hot summer in 2003, in contrast to the other two years. In cooler seasons due to the longer periods unfavourable to flight, the

Tab. I – Characteristics of the flight of most abundant antlion species and of the nocturnal/daily weather elements influencing the flying activity (2000-2004).

Species	Aerial temperature at 22 h			Wind speed at 22 h			Daily precipitation	
	Lower temperature limit of flight (°C)	Temperature range of mass flight (°C)	Catching rate of mass flight (%)	Catching rate in calm (%)	Wind speed range of mass flight (msec^{-1})	Catching rate of mass flight (%)	Catching rate on rainless days (%)	Precipitation range of frequent flight (mm)
NPUN	16	18-24	74	21	0.1-2.0	60	70	0.1-3.5
MINC	13	17-24	84	23	0.1-2.5	70	76	0.1-2.5
MTRI	13	17-24	80	16	0.1-2.0	75	83	0.1-2.0
CPLU	14	18-23	80	24	0.1-2.0	71	82	0.1-2.5

Abbreviations: NPUN = *N. punctulatus*, MINC = *M. inconspicuus*, MTRI = *M. trigrammus*, CPLU = *C. plumbeus*.

Tab. II – Values of Pearson correlation coefficient calculated between weekly light trap catches of antlions and the weekly characteristics of some meteorological elements from three seasons between 2002 and 2004.

Species	Weekly average of daily air temperature (°C)									Weekly amount of precipitation (mm)		
	Tmax			Tmin			Tave					
	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004
M. inconspicuus	0.37	0.11	0.39	0.79c	0.21	0.75c	0.71c	0.13	0.84c	-0.14	0.44	-0.13
M. trigrammus	0.34	0.51a	0.39	0.57a	0.33	0.64b	0.58a	0.46	0.59a	-0.15	0.16	0.06
C. plumbeus	0.12	0.65a	0.45	0.58a	-0.03	0.40	0.47	0.32	0.41	-0.06	0.20	0.01

Abbreviations & symbols: Tmax = daily maximum temperature, Tmin = daily minimum temperature, Tave = daily mean temperature; a: P<0.05, b: P<0.01, c: P<0.001.

Tab. III – Values of cross correlation function between series of weekly light trap catches of antlions and the weekly characteristics of meteorological elements at 0 week lag in a dry (2003) and a wet (2004) season.

Species	Weekly average of daily air temperature (°C)				Weekly amount of precipitation (mm)	
	Tmax		Tmin			
	2003	2004	2003	2004	2003	2004
M. inconspicuus	0.466a	0.556a	0.514a	0.622a	0.417	-0.210
M. trigrammus	0.447a	0.494a	0.440a	0.587a	0.175	0.080
C. plumbeus	0.550a	0.310	0.059	0.400	-0.130	0.040
N. punctulatus	0.207	0.468a	0.111	0.452a	-0.390	0.240

Abbreviations & symbols: Tmax = daily maximum temperature, Tmin = daily minimum temperature; a: P<0.05.

dependence of flight activity on temperatures was stronger as shown by the greater correlation values. Two years with contrasting summer climate were chosen for the analysis to demonstrate the synchrony between antlion flights and temperatures: 2003 (warm and dry) and 2004 (cool and wet). The mostly significant ($P<0.05$) and positive CCF values without any lag (Tab. III) referred to the synchronous fluctuations between time series in both seasons: for all the four antlion species the largest proportion of adults flew on weeks with greater maximum and minimum temperatures.

Catching rates did not show significant dependence on weekly rainfall for any of the antlion species (Tab. II). Correlation values were low (<0.2) with one exception in 2003 and the expected negative relationship was detected only in half of the cases. This result was also supported by the low and non-significant CCF values at no lag (see in Tab. III). Though weekly antlion catches were not significantly influenced by the rainfall pattern, it could strongly shift the temporal allocation of flight pattern. A good example was supplied by the flight pattern of *M. trigrammus* and rainfall distribution over a dry (2003: precipitation from Apr to mid-Jun: 41 mm) and a wet (2004: precipitation from Apr to mid-Jun: 265 mm) season. Due to the continuously rainy spring in 2004, the start of mass flight was delayed from mid-June in 2003 to one month later.

Discussion

As expected, increasing temperatures increased flight activity of antlions, while rising wind speed and increasing rainfall reduced it. The lower temperature threshold of flight was 13-14°C, while increased activity was found above 20°C. 70-80% of antlions were caught on such warm evenings. Unexpectedly, the majority (60-75%) of adults flew at 0.1-2.0 msec^{-1} wind-speeds, which suggests that weak winds enhance the flight of antlions, with their large wings and slow flight speed, but wind speeds above 3 msec^{-1} inhibited them. Antlions did not fly much on rainy days and 70-83% of them swarmed on rainless evenings. An amount of rain not exceeding 2-3 mm a day did not impede the flying, but above this amount it became sporadic. On rainy evenings the catches were very small excepting when rain fell in a short single shower.

Flight patterns were synchronous with mean temperatures. Negative impact of rain was not detected, but a rainy spring can shift antlions' flight later by prolonging larval development via inhibiting feeding.

These results on the impacts of weather are preliminary, further monitoring is required.

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A historical perspective on nomenclature within the genus *Chrysoperla* Steinmann, 1964 in Europe: the *carnea*-complex (Neuroptera Chrysopidae)

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Eight species of *Chrysoperla* occur in Europe. Four of them belong to the complex of *Chrysoperla carnea* sensu lato, so-called "the common green lacewings". The discrimination of these sibling species was clearly established by means of courtship song analysis or molecular biology, but it remains sometimes difficult with respect to morphological characters. Various names have been laid out for more than 20 years to denominate these species morphologically very closely related. A review of the taxa used without any coherence by authors is presented chronologically and discussed. In conclusion, the west-European *Chrysoperla* fauna includes four well-defined species and four other valid species within the *carnea* group, namely:

Chrysoperla carnea (Stephens, 1836) = Cc2 in term of song species
Chrysoperla affinis (Stephens, 1836) = Cc4
Chrysoperla lucasina (Lacroix, 1912) = Cc1
Chrysoperla agilis Henry, Brooks, Duelli & Johnson, 2003 = Cc3.

Key words – *Chrysoperla*, common green lacewing, *Chrysoperla carnea*, *carnea* complex, sibling species, song species, European fauna.

Introduction

The genus *Chrysoperla* Steinmann, 1964 includes 36 species distributed throughout the world but with a preponderance of Holarctic regions (Brooks, 1994). Europe harbours at least eight species, the identity of which is sometimes difficult to ascertain due to the tenuousness of discriminant characters and the confusing situation in the terminology used by authors. The keys available do not allow us to reach a good result in identifying the species: Hölzel (1972) and Aspöck *et al.* (1980) achieve in three species, Séméria & Berland (1988) in one only, Brooks (1994) in four species relative to Europe and Thierry *et al.* (1998) in six species.

Unambiguous species

Chrysoperla mutata (McLachlan, 1898) – Was briefly described long ago either as a possible new species or only as a variety of *Chrysopa vulgaris* Schneider, 1851 (later synonymized with *carnea* Stephens, 1836 sensu lato) from specimens found at Biskra (Algeria). "It differs in most of the nervules being blackish ... and the gradate series entirely blackish". Based on the groups established by Brooks (1994) with respect to the male genitalia structure, *Ch. mutata* belongs to the *pudica*-group, separated by having complex spinellae on gonosetae formed by 5 or more spines on each tubercle and small entoprocessus. All other seven species of European *Chrysoperla* lack spinellae and show entoprocessus large and crescentic. Among them, three species are easily characterized by the shape of the pretarsal claws which have a basal dilation roughly triangular (vs quadrangular in the others).

Chrysoperla renoni (Lacroix, 1933) – Was identified on some specimens collected in the department of Deux-Sèvres in western France. The taxon rose from a short description based on characters of coloration of the head, the venation, strait wings and pretarsal claws lowly dilated in basis, long, thin and not very incurved. This species was long ignored and/or forgotten up to its synonymization to *carnea* s.l. established by Aspöck *et al.* (1980). It was later re-instated by Leraut (1991) who gave a more substantial description featuring an abundant hyalin ciliation on both the body and wings. Leraut designated a lectotype stored in the Muséum National d'Histoire Naturelle, Paris (MNHN).

Chrysoperla mediterranea (Hölzel, 1972) – Was differentiated by the dark green body ground colour, the size and shape of wings and the triangular dilation of claws. It was described from a series of several specimens collected in the Mediterranean zone, the holotype coming from Bizerte (Tunisia).

Chrysoperla ankylopteryformis Monserrat & Díaz-Aranda, 1989 – Was recognized as new from few specimens collected in southern Spain, based on the shape of its claws showing a triangular basal dilation, the pale ground coloration, the abundant ciliation on wings and on the body, and the particular development of the costal area of the forewing which gave rise to the name of the species looking like an examplar of the Afrotropical genus *Ankylopteryx* Brauer, 1854.

The *carnea*-complex

All the four previous species are easily recognizable. The problem remaining to be clarified concerns the four others constituting the *carnea*-complex in which claws bear a quadrangular basal dilation. Their terminology is still confusing. Since its original description as *Chrysopa carnea* by Stephens, 1836 – and later its junior synonym *Ch. vulgaris* created by Schneider, 1851 – the common green lacewing was elsewhere regarded as the commonest (if not the only?) European chrysopid. Such a reduction was due to a supposed widespread distribution (see e.g. Aspöck *et al.*, 2001) and its ability to colonize almost all places involved with human activity. The variability that some searchers felt was only manifested by a lot of names (more than 80) given to possible subspecies and/or varieties. However, the common green lacewing was considered a single species occurring from the northern polar circle to Mauritania and Sudan, and from the alpine zone to the sea level.

From the end of the 70's, this chrysopid was revealed to be an assemblage of kindred species, in North-America and few time later, in the Palaearctics (Henry, 1979). The diversity within the whole was first manifested by analysing the courtship song, the tremulation pattern in each species providing convincing evidence that these species are valid biologically. Such a behavioural barrier constitutes a key element amongst various factors able to secure the species isolation. Further electrophoretic (e.g. Bullini *et al.*, 1983; Cianchi & Bullini, 1992; Mouloud *et al.*, 2002; Lourenço *et al.*, 2002) and genetic studies (Thierry, 1991) also demonstrated the occurrence of several species.

Chrysoperla carnea sensu lato has been the subject of lots of papers. In the early publications, only the single original (collective) name was used together or instead of the synonymous taxon *vulgaris*. However, for more than 20 years, various denominations have appeared relative to common green lacewings. It is thus sometimes difficult to recognize what species was actually involved in each case. In order to clarify that, we sum up the names used by several authors and what they imply about European populations in relation with publication dates. The present review is aimed to achieve in a consensus about the terminology of the *carnea*-complex, respecting nomenclature rules. It is then restricted to species of common green lacewings showing a quadrangular basal enlargement of claws.

The diversity in nomenclature within the *carnea*-complex

Names recently used by various authors about the *carnea*-complex constituent species in Europe appear below in the Table I. In the four first columns, the courtship song patterns are noted, as made up in the provisional system given by Duelli (1995); the successive equivalences with binary names assigned by authors who wrote about the topic are given function of publication dates.

Discussion

Owing to the fact that the specific binary name *Chrysoperla carnea* belongs most often to the complex of sibling species, it is confusing. Indeed, constituents can be separated by analysing their courtship songs. But such an operating method needs live specimens of both sexes to achieve its right identity. Besides, the candidate specimens to determination must be recently emerged and not yet paired, and the determinator must be fitted with sophisticated apparatus and have a good practice of the technics. The result is therefore inaccessible in many instances by this method. That is why the direct link between a song type and its actual nomenclature remains an obligatory constraint dependent on morphological characters.

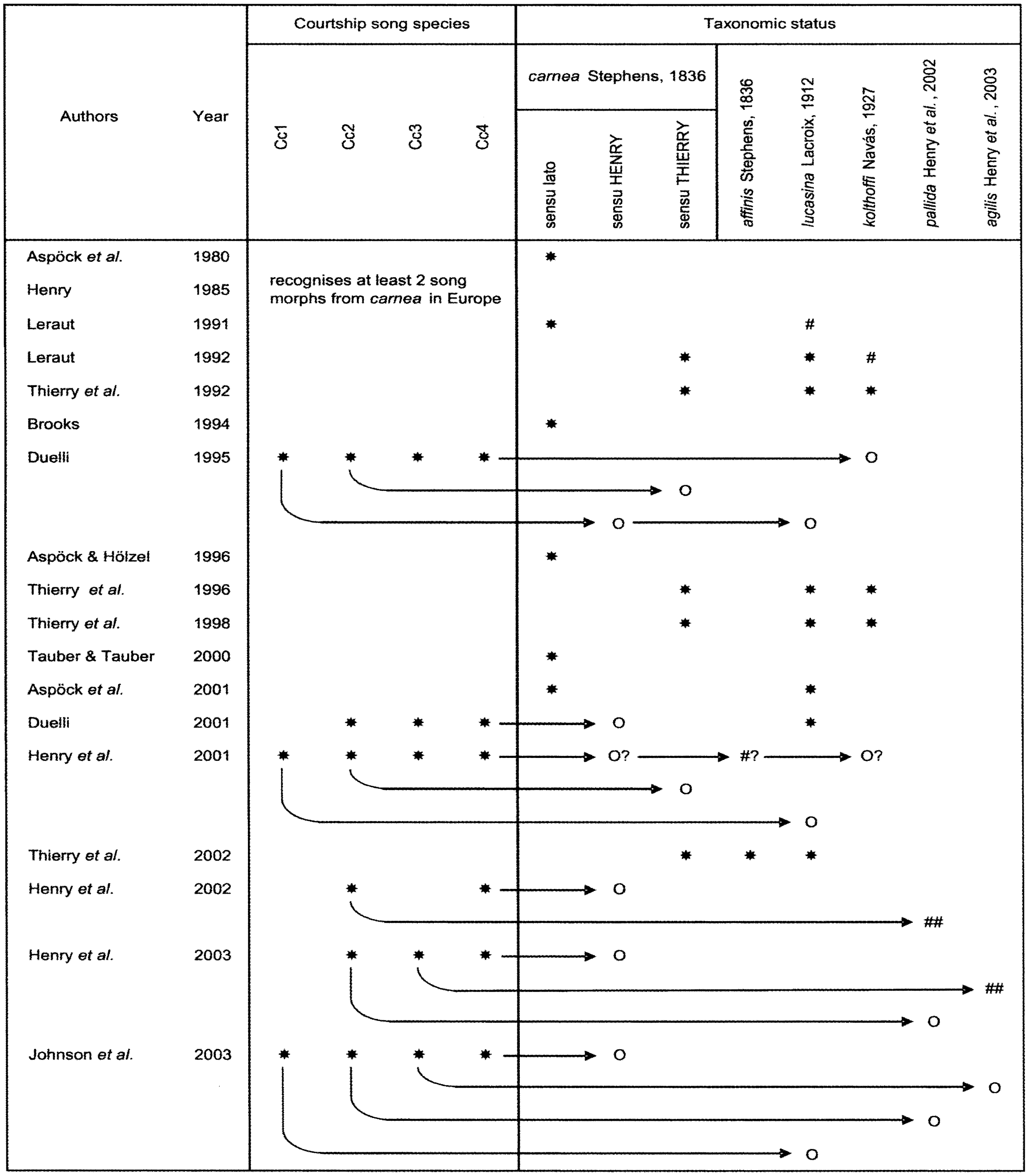
One taxon, *Chrysoperla lucasina* (Lacroix, 1912) was described from Frenda (Algeria) and a lectotype designated by Leraut (1991) is stored in the MNHN, Paris. This species, synonymized with *carnea* by Aspöck *et al.* (1980), thus reinstated as bona species by Leraut (1991), is now consensually accepted without any reserve, clinging to the song species Cc1 (Henry *et al.*, 1996). This chrysopid is unambiguously identifiable by its conspicuous brown stripe on the pleural zone of first abdominal segments featured first by Thierry *et al.* (1992). Unfortunately, due to the recurrent difficulty to preserve soft tissues of the abdomen in many specimens, this characters sometimes is not easily and safely visible.

The song species Cc3 is well-defined by its typical courtship song and has been recently formally described as *Chrysopa agilis* Henry, Brooks, Duelli & Johnson, 2003. However, its morphological characterization is not so evident, so that it may be ignored and/or misidentified by collectors with one of the two other species with which it has partially common characters.

The two song species Cc2 and Cc4 were the most ambiguous, despite the recent attempt made by Henry *et al.* (2002). Examination of the type specimen series deposited in the British Museum of Natural History, London (BMNH) was done by Leraut (1991) and lectotypes were then designated for *Ch. carnea* and *Ch. affinis* Stephens, 1836. The taxon *Chrysoperla kolthoffi* (Navás, 1927) used by some researchers was originally described from China and the type was deposited in the MNHN. It was synonymized with *carnea* by Tjeder (1936), raised to valid species by Leraut (1991) and synonymized again with *Chrysoperla nipponensis* (Okamoto, 1914) by Brooks (1994). It would not occur in West Palaearctic zone so that this name must not be used until further information is provided about Asian green lacewings.

We consider the further assignation of Cc4 to *carnea* by Henry *et al.* (2002) and the consequent description of a new species, *Ch. pallida* Henry, Brooks, Duelli & Johnson, 2002, as based on incorrect arguments:

Tab. I – Names recently used by authors about the *carnea*-complex constituent species in Europe. # means re-instated status of a species and # #, the description of a new species; arrows indicate the taxonomic equivalence given by the author(s).



Authors	Year	Courtship song species				Taxonomic status							
						carnea Stephens, 1836			*affinis* Stephens, 1836	*lucasina* Lacroix, 1912	*kolthoffi* Navás, 1927	*pallida* Henry *et al.*, 2002	*agilis* Henry *et al.*, 2003
		Cc1	Cc2	Cc3	Cc4	sensu lato	sensu HENRY	sensu THIERRY					
Aspöck *et al.*	1980					✱							
Henry	1985	recognises at least 2 song morphs from *carnea* in Europe											
Leraut	1991					✱				#			
Leraut	1992							✱		✱	#		
Thierry *et al.*	1992							✱		✱	✱		
Brooks	1994					✱							
Duelli	1995	✱	✱	✱	✱ →						O		
			↳					→ O					
		↳					→ O			→ O			
Aspöck & Hölzel	1996					✱							
Thierry *et al.*	1996							✱		✱	✱		
Thierry *et al.*	1998							✱		✱	✱		
Tauber & Tauber	2000					✱							
Aspöck *et al.*	2001					✱				✱			
Duelli	2001		✱	✱	✱ →		O			✱			
Henry *et al.*	2001	✱	✱	✱	✱ →		O? →		#? →		O?		
			↳					→ O					
		↳								→ O			
Thierry *et al.*	2002							✱	✱	✱			
Henry *et al.*	2002		✱		✱ →		O						
			↳									→ ##	
Henry *et al.*	2003		✱	✱	✱ →		O						
				↳									→ ##
			↳									→ O	
Johnson *et al.*	2003	✱	✱	✱	✱ →		O						
				↳									→ O
			↳									→ O	
		↳								→ O			

re-instated status

description of new species

→ O taxonomic equivalence of song species

- A supposed mislabelling resulting in a mixing of specimens in the series remains unlikely. Indeed, the references of Kimmins (1964) given in Henry *et al.*'s text (2002: 173) only reports on Trichoptera, genus *Athripsodes* Billberg, 1820, not on lacewings.
- The statement that almost no research published under the specific name *carnea* was done on Cc2 is made a priori, as well as the affirmation that "most of the numerous agro-environmental and biological studies on *Ch. carnea* in Europe are referable to Cc4 because Cc2 does not occur in agricultural biotopes" (Henry *et al.*, 2002: 188); in the same paper (p. 187), the authors also wrote that "*Chrysoperla affinis* is clearly Cc4 in all respects as are the remaining five specimens of the type series". They also wrote in the authorized "Lacewings in the crop environment" (Henry *et al.* 2001) "the most obvious candidate in Britain to Cc4 differs from the lectotype of *Ch. carnea* (Stephens) in having darker coloured setae and narrow basal dilation of the claw which make it similar to the lectotype of *Ch. affinis* (Stephens)" and "Cc2 (slow motorboat) is probably Leraut/Thierry's *carnea* s. str., at least in part, while Cc4 (motorboat) corresponds most closely to Leraut/Thierry's *kolthoffi*" (p. 36). Missing voucher specimens, we cannot ascertain whether observations and experiments were relative to one or another actual species. The most of previous works really concerned crop field studies and were carried out by researchers of northern and northwestern Europe. It is obvious that Cc2 might be more scarce than Cc4, bearing in mind that Cc2 lives essentially in the canopy of trees whilst Cc4 (together with Cc1 = *Ch. lucasina*) colonizes mainly the herbaceous layer (Duelli, 2001; Canard *et al.*, 2002). The dominance of Cc4 – i.e. of *Ch. affinis* – in crop fields and its greater frequency pointed out in relative papers is then a consequence of topics and of authors' origin, namely the low vegetation in mild Europe. Besides, many old papers more often report to *Ch. vulgaris* than to *Ch. carnea.* That is why common green lacewings must be only taken in many ancient references as *carnea* sensu lato without any more precision. Willingness to enter actual names for common green lacewings cited in former publications to the current terminology is simply hazardous, incorrect and probably impossible.
- The argument based on the coloration of the original specimens of *Ch. carnea* is difficult to correlate precisely with one of the sibling species which turns colour in diapause. Stephens himself avowed a variability ("bright rosy or flesh-colour"). It was demonstrated later that this character depends statistically on intensity of diapause (Honěk, 1973), habitat and date of collection through diapause completion in Cc2 and Cc4 and on sex in Cc4 (Thierry *et al.*, 1995).

Confusion still exists in the identification of some of the components of the *Ch. carnea* complex occurring in Europe (Saure, 1999). We need a consensus on terminology consonant with the universally used Linnean system. It would appropriately facilitate not only the work of entomologists, but also of owners of mass rearing facilities and practitioners involved in biocontrol using common green lacewings (Tauber *et al.*, 2000).

Conclusive opinion

In conclusion, the west-European fauna includes four species in the *Ch. carnea* group having a quadrangular enlargement of claws, namely:

- *Chrysoperla carnea* (Stephens, 1836) as the lectotype is labelled and stored in the BMNH, = Cc2 in term of song species,
- *Chrysoperla affinis* (Stephens, 1836) as the lectotype is labelled and stored in the BMNH, = Cc4 in term of song species,
- *Chrysoperla lucasina* (Lacroix, 1912) as the type is labelled and stored in the MNHN, = Cc1 in term of song species,

– *Chrysoperla agilis* Henry, Brooks, Duelli & Johnson, 2003 as the type is labelled and stored in the BMNH, = Cc3 in term of song species.

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rigidamente connesse, come sarà tra poco ripetuto, mediante un apodema laterale, con le produzioni endoscheletriche dipendenti da una formazione trasversa, sclerificata, che si dispone, a mo' di barra, tra le placche stesse, differenziando in vicinanza della base di ciascun uncino un piccolo processo odontoide. Tale barra proietta infatti internamente un apodema laminare, il quale a ciascuna estremità si continua con due vistosissime produzioni endoscheletriche aliformi, pressochè perpendicolari alla barra stessa (¹), in corrispondenza della loro origine connesse, come è stato detto sopra, con l'apodema delle placche

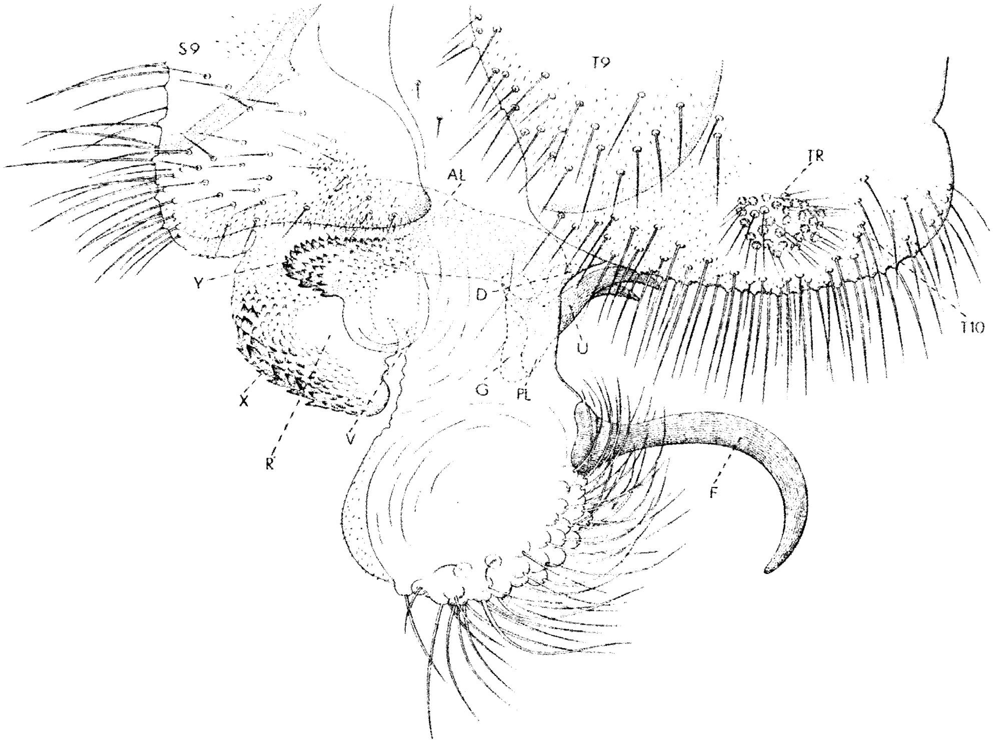

FIG. VII.

Chrysopa septempunctata Wesm. — Porzione caudale dell'addome del maschio con organo che viene evaginato al momento della copula (visto di fianco): *AL*, produzione endoscheletrica aliforme; *D*, apodema; *F*, processo uncinato; *G*, apodema laterale delle placche sopportanti gli uncini; *PL*, placche sopportanti gli uncini; *R*, prominenza dorsalmente alla quale è situato lo sbocco del canale eiaculatore; *S9*, 9° urosterno; *T9*, *T10*, terghi degli uriti 9° e 10°; *U*, uncini; *V*, sbocco del canale eiaculatore; *X*, rilievo a forma di U (è visibile solo una branca) provvisto di microprocessi appuntiti; *Y*, uno dei due rilievi laterali alle branche del rilievo ad U, ugualmente provvisto di microprocessi appuntiti.

(¹) In alcuni esemplari tali apodemi aliformi sono più estesi, più sclerificati ed orientati un po' diversamente,

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Wing morphological variation of *Chrysoperla externa* (Hagen, 1861) (Neuroptera Chrysopidae) from Brazil

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Green lacewings are voracious predators of crop pests. The most common species in Brazilian ecosystems is *Chrysoperla externa*. It can be found frequently associated with many kinds of insect and mites species in crop systems. Although species identification must be done on genital traits, many entomologists use morphological characteristics for quick naming. This procedure causes some mistakes because most of the time the intraspecific variability is unknown. The differences in morphological characteristics were studied for populations collected in different places to understand how genetic variability is manifested. Wing morphology was studied and the intraspecific variation is presented.

Key words - *Chrysoperla externa*, intraspecific variation, green lacewings, Biological control, wings.

Introduction

Correct species identification has been carried out by looking at the external morphological characteristics and examining the genital traits. However, each species can show intra-population and/or inter-population variations. The members are not identical copies such as in the cloning process, because genetic variation is preserved by sexual reproduction. Genetic variability is manifested in different ways. Mayr (1977), says that clinal variation is gradual and continual in contiguous populations. These can be observed in butterfly populations (Spomer *et al.*, 1993). The sub-population in different localities always produces the geographical variation (Mayr, 1977).

The choosing of a specific habitat can emphasize local differences. The size and the geographical distribution can determine how it is possible to have a large number of ecological variants. This situation is explained by the Ludwig theorem (Mayr, 1977). The population structure and necessary local adaptation takes the geographical variation as a universal fact, however it can not always be manifested (Mayr, 1977). The absence of variation can be explained as (Mayr, 1977): a. the distribution area is too small; b. the dispersion ways are extensive because the species is panmitic (it is a unique deme); c. the phenotype is conserved, probably due to homeostasis; d. the genotype is stable, there is loss of mutation capacity. Presence and the inversion frequency, chromosome fusion and the supranumeracy are the phenomena subject to geographical variation. It is common sense that the variations at a generic level are not adaptative but under the evolutionist concept, the specific variation is a product of natural selection (Mayr, 1977).

The external aspect of the body is the first step in population characterization. The morphometer is an important tool in studying evolutionary biology and ecology (LaBarbera, 1989). It focuses on the similarities between groups. The identity of two popula-

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tions can be seen by the isonomy of the measured characteristics. There are three types of similarities (LaBarbera): a. physical similarity – it is size dependent; b. geometric similarity – each series has a multiplicative ratio for the body measurements; c. functional similarity – the constancy or variation of the shape or volume of the structure can correspond to the function.

Chrysoperla externa (Hagen, 1861) – The *Chr. externa* is the most common Brazilian green lacewing. It can be found in almost all crops and has a large geographical distribution. It is largely reported in many Neotropical countries such as, the USA, Mexico, Guatemala, Honduras, Cuba, Haiti, Colombia, Venezuela, Ecuador, Peru, Paraguay, Chile, Argentina (Brooks, 1994).

The genus *Chrysoperla* is represented by the species *Chr. externa*, *Chr. defreitasi* Brooks, 1984, *Chr. raimundoi* Freitas & Penny, 2001, *Chr. genanigra* Freitas, 2003 (Freitas, 2003). These species are very close and most of the time they can be separated only by the genital trait examination. With this study we intend to show the species wing variation between populations from different localities.

Materials and Methods

A total of 931 individuals of *Chr. externa* from seven states and thirty eight counties (Tab. II) were collected with entomological nets and deposited in the Plant Health Department (UNESP-Jaboticabal, SP).

For the general characterization of the species, all 931 specimens were considered and thirty-five wing characteristics were taken into consideration or measured (Tab. I) not considering the origin of the specimens. To detect the difference between some populations, only ten specimens from each locality were examined (we adopted this procedure because some populations samples were so small). The selection of the localities was based on their extension and on the presence of the largest populations (more than 10 specimens). The localities selected: Itiquira, Pontes e Lacerda (Mato Grosso), Cachoeira Alta (Goiás), Júlio de Castilhos (Rio Grande do Sul), Águas da Prata, Birigui, Espírito Santo do Pinhal, Guaira, Jaboticabal (São Paulo), Assú, Mossoró, Mojeiro (Rio Grande do Norte), Sete Lagoas (Minas Gerais).

Tab. I – Wing morphological characters used to evaluate the populational variation of *Chrysoperla externa.*

Distal width (DW): wing width at the level of the inner gradate base
Basal width (BW): wing width at the level of the intramedian cell base
Length (L): distance between the junction point of the radial and subcostal veins until wing apex
Distance between the intramedian until the wing apex (DA)
Distance between the inner gradates until the wing apex (DIA)
Distance between the wing apex until the imaginary intersection of pseudomedian with the wing margin (DAP)
Width of the intramedian cell base (BCI)
Intramedian cell height (IH)
Costal cells number (CCN)
Costal setae coloration
Inner gradates meets the pseudomedian vein or not
Inner gradates incrassated
Gradates coloration
Marginal cells number (MC)
Intramedian cell base length
Intramedian cell height
Hind wing distal width
Hind wing length
Inner gradates number (IG)
Outer gradates number (OG)
1A forked or not
Anal-vein color
Shape of the costal crossveins
Wing apex shape
Shape of the C1 e C2 cells
Shape of DCC
Intermedian veins colors
Shape of radial sector vein
Radial veins number
Radial sector base coloration
Basal costal crossveins shape
Radial crossveins shape
Subcostal crossvein presence
Costal veins coloration
Radial veins coloration

Tab. II – States and Counties where the studied specimens of *Chrysoperla externa* were collected. ( ) - number of specimens.

States	Counties
São Paulo	Águas da Prata (23), Barretos (4), Birigui (19), Brodósqui (27), Campinas (3), Catanduva (1), Catiguá (1), Elisário (1), Espírito Santo do Pinhal (39), Guairá (13), Guatapará (3), Ibirá (1), Itápolis (1), Jaboticabal (322), Limeira (1), Luiz Antonio (20), Luzitania (3), Monte Alto (27), Monte Azul Paulista (5), Olímpia (1), Ribeirão Preto (1), Santa Rita do Passa Quatro (1), São Miguel Arcanjo (1), São Simão (14), Taiúva (13), Taquaral (12), Taquaritinga (100).
Rio Grande do Norte	Assú (11), Mogeiro (13), Mossoró (30).
Goiás	Cachoeira Alta (53).
Mato Grosso	Corumbá (1), Itiquira (116), Pontes e Lacerda (22).
Minas Gerais	Lavras (3), Timoteo (Parque do Vale do Rio Doce) (1), Sete Lagoas (8).
Santa Catarina	São Joaquim (2).
Rio Grande do Sul	Júlio de Castilhos (11).

Tab. III – Average value (mm) of the measured characters in the *Chrysoperla externa* populations collected in Brazilian different areas (Based on all 931 studied specimens).

Character	Average	S	%
Wing length – L	11,56 (9,72-13,46)	0,79	72,18
Distal width – DW	3,67 (2,62-4,36)	0,30	56,53
Basal width – BW	2,54 (2,08-3,06)	0,21	67,98
Distance between the intramedian cell until the wing apex – DA	8,71 (7,19-10,11)	0,60	71,07
Intramedian cell base width – IBW	0,23 (0,07-0,52)	0,05	13,95
Intramedian height – IH	0,61 (0,48-0,76)	0,06	63,55
Dist. between the IG until the apex - DIP	2,88 (1,85-4,72)	0,37	39,18
Dist. between the IG until the margin - DIA	4,42 (3,02-5,45)	0,44	55,60
Dist. between the apex until the psm – DAP	2,02 (1,3-2,98)	0,20	43,53
Length of the hind wing – LP	10,33 (8,67-12,29)	0,74	70,53
Width of hind wing - WP	3,12 (2,49-3,81)	0,28	65,30
Costal cells number – CCN	21 (12-25)	2,00	48,00
Inner gradates number *GIN	6 (5-7)		
Outer gradates number *GEN	6 (5-8)		
Radial cells number *RCN	11 (9 – 13)		
Median cells number *MCN	8 (7 - 10)		

* Countable dates.

Measurement was made on detached wings mounted on slides and we used a stereoscope Wild MZ11,5 equipped with a digital camera and using the measure module of the IM50 software.

Statistical analysis was performed using the SAS (Proc GLM) Version V.8.0.1 (SAS Institute 2000).

Results and discussion

General characterization – The anterior wings had variations in the measured characteristics, venation distribution and shape (Tab. III). The longitudinal veins are very characteristic. The subcostal (Sc) runs beside the costal vein reaching it before the acute wing apex. The pterostigma is green. Numerous crossveins (12-23) add the costal to sub-costal forming the Costal cells (12-25 cells); the basal crossveins are sinuous. The radial vein forks in its third basal part giving origin to the R_1 arm which runs parallel to the sub-costal and forks at the apex. Basally a crossvein connects one to another (Sc-R_1). The Radial Sector (Rs) arises and runs in a zig-zag shape until the wing apex, producing a series of cells called Radial cells (Rc) (9-13). Two series of crossveins connect the branches of the Rs, they are named Inner gradates (IG) and Outer gradates (OG). There are 5-7 inner gradates and 5-8 outer gradates.The R's branch veins fork after the gradates crossveins and reach the costal vein. The Median veins (M_1 M_2) are added in the basal part and configure the Intramedian Cell (Im) which has an ellipsoid shape; the cell base (ImB) has 0,23 mm (0,07-0,52) and the height (HI) 0,61 mm (0,48-0,76). The base length configures the shape of the Im. Sometimes its appearance is like an ellipse. After the Im the median veins come to the distal margin. Some fragments are superimposed forming the Pseudomedian vein (PSM). By the same way the Pseudocubital (PSC) is formed. The median and cubital vein branches form the eight Marginal cells (Mc) (7-10). The anal veins are weak, short and run to the ventral margin. The costal vein is covered by oblique setae. They can be black colored (90,55%) or amber (9,45%). The anterior wing length is 9.72 to 13.46 mm, the width is 2.62 to 4.4 mm.

The hind wing is 10,33 mm (8,67 – 12,29), being 0,89 times the anterior wing length. The shape factor is given by the ratio between the length and the width. The anterior wing is 3 times longer than it is wide.

Wing variation between populations (based on all 931 specimens) – The shape of the anterior wing is uniform, however the Pontes e Lacerda (3,22) and Itiquira (3,21) populations showed significant differences from the others (Tab. IV). Therefore, they are wider than the others. The distal width is 1,47 times bigger than the basal width. However the same ratio for the Itiquira population is 1,32, which gave the rectangular shape to the wing (Tab. IV).

The results show that there are no significant differences between the populations (Tab. V).

The wing length, which is the main size-dependent characteristic, did not show enough variations to separate the populations, except for the Assú and Mossoró populations that were shorter compared to the others (Tab. V).

The number of Costal cells is proportional to the wing length. The specimens from Julio de Castilhos, that showed the biggest wing, had 22,2 costal cells (Tab. VI). There is no proportion between the Radial and Median cell numbers as well as the Gradates crossveins with the wing length (Tab. VI). There are similarities

Tab. IV – Average value of the ratios between wing length/distal width (L/DW), Distal width/Basal width (DW/BW) and Length/Distance of the intramedian cell apex until wing apex (L/DA), in the fore wings of specimens from different populations of *Chrysoperla externa*.

County	State	L/DW	DW/BW	L/DA
Pontes e Lacerda	MT	3,217b	1,467a	1,310a
Itiquira	MT	3,321a	1,316a	1,334a
Cachoeira Alta	GO	3,118a	1,493a	1,310a
Julio de Castilhos	RS	3,095b	1,425a	1,310a
Águas da Prata	SP	3,047a	1,472a	1,312a
Birigui	SP	3,161a	1,486a	1,325a
Espirito sto Pinhal	SP	3,180a	1,479a	1,325a
Guairá	SP	3,125a	1,428a	1,309a
Jaboticabal	SP	3,110a	1,458a	1,343a
Mojeiro	RN	3,089a	1,457a	1,315a
Mossoró	RN	3,103a	1,448a	1,300a
Assú	RN	3,040a	1,453a	1,345a
Sete Lagoas	MG	3,061a	1,415a	1,336a

Means followed by the same letters in the column do not differ by the Tukey-test at 5% probability.

Tab. V – Average value (mm) of the characters measured on wings from different populations of *Chrysoperla externa* (Based on 10 specimens for each locality).

County	State	L	DW	BW	DA	BCI	IH	DIA	DIP	DAP
Pontes e Lacerda	**MT**	11,69ab	3,63ab	2,48 b	8,93ab	0,25ab	0,63ab	4,43abc	2,73a	1,97abc
Cachoeira Alta	**GO**	11,70ab	3,75ab	2,51ab	8,93a	0,25ab	0,59 b	4,50ab	2,89ab	1,99abc
Julio de Castilho	**RS**	12,21a	3,94a	2,77a	9,32a	0,23ab	0,61ab	4,38a	3,27 c	2,20ab
Itiquira	**MT**	11,47abc	3,45 b	2,62ab	8,59abc	0,23ab	0,60 b	4,42abc	2,85ab	1,96abc
Esp. St. do Pinhal	**SP**	11,47abc	3,61ab	2,44 b	8,65abc	0,19 b	0,59 b	3,98abc	2,81ab	2,02abc
Birigui	**SP**	11,70ab	3,70ab	2,49ab	8,83ab	0,23ab	0,58 b	4,42abc	2,76a	2,14abc
Guaira	**SP**	11,56abc	3,70ab	2,59ab	8,82ab	0,21ab	0,61 b	4,63ab	2,98ab	1,83abc
Mojeiro	**RN**	11,33abc	3,67ab	2,52ab	8,61abc	0,19 b	0,61ab	4,55ab	2,88ab	2,12abc
Mossoró	**RN**	10,58 c	3,41 b	2,35 b	8,14 bc	0,19 b	0,56 b	4,03 bc	2,63a	1,77 bc
Sete Lagoas	**MG**	12,00a	3,92a	2,77a	8,99a	0,24ab	0,69a	4,78a	2,69a	2,30a
Jaboticabal	**SP**	11,53abc	3,71ab	2,54ab	8,58abc	0,24ab	0,64ab	4,33abc	2,75a	2,09 b
Águas da Prata	**SP**	11,59abc	3,80ab	2,58ab	8,83ab	0,28a	0,60 b	4,48ab	3,42 c	2,09abc
Assú	**RN**	10,75 bc	3,48 b	2,39 b	7,99 c	0,24ab	0,59 b	3,86 c	2,69a	1,69 c

* numbers followed by the same letters in the column do not have significative difference at the level of 95% according Tukey-test.

** Wing length (L) – Distance between the junction point of the radial and subcostal veins until wing apex; Distal width (DW) – wing width at the level of the inner gradate base; Basal width (BW) – wing width at the level of the intramedian cell base; Distance between the intramedian cell until the wing apex (DA); Width of the intramedian cell base (BCI); Intramedian cell height (IH); Distance between the inner gradates until the wing apex (DIA); Distance between the base of inner gradates until the margin along the pseudo median (DIP); Distance between the wing apex until the imaginary intersection of pseudomedian with the wing margin (DAP).

Tab. VI – Avarage value of the countable wing characters of the different populations of *Chrysoperla externa* (Based on 10 specimens for each locality).

County	State	L	CCN	IGN	OGN	RCN	MCN
Pontes e Lacerda	MT	11,69	21,2 (19 – 24)	6,2 (6 – 7)	6,9 (6 – 8)	10,6 (10 –12)	8
Itiquira	MT	11,47	21,8 (21 – 24)	6,0 (4 – 7)	6,5 (4 – 8)	10,1 (7 – 11)	8
Cachoeira Alta	GO	11,70	20,0 (18 – 23)	5,7 (5 – 6)	6,0 (5 – 7)	10,3 (9 – 11)	8
Julio de Castilhos	RS	12,21	22,2 (21 – 24)	6,2 (5 – 7)	6,7 (6 – 7)	11,4 (11 – 12)	8
Águas da Prata	SP	11,59	20,2 (16 – 23)	6,1 (5 – 8)	6,5 (5 – 8)	11,0 (10 – 12)	8
Birigui	SP	11,70	21,1 (18 – 23)	5,9 (5 – 7)	6,2 (6 – 7)	10,9 (10 – 12)	8
Espírito sto Pinhal	SP	11,46	19,4 (18 – 20)	5,7 (5 – 6)	6,2 (6 – 7)	10, 4 (9 – 11)	8
Guairá	SP	11,56	21,0 (18 – 24)	5,9 (5 – 7)	6,4 (6 – 8)	10,5 (8 – 12)	8
Jaboticabal	SP	11,53	21,2 (19 – 23)	6,1 (5 – 9)	6,8 (6 – 10)	10,9 (10 – 13)	8
Mojeiro	RN	11,33	20,1 (19 – 24)	6,2 (6 – 7)	6,6 (6 – 7)	11,1 (10 – 12)	8
Mossoró	RN	10,58	20,0 (18 – 22)	5,9 (5 – 7)	6,1 (6 – 7)	10,4 (10 – 11)	8
Assú	RN	10,75	19,8 (18 – 22)	5,3 (5 – 6)	5,5 (5 – 6)	10,2 (10 – 11)	8
Sete Lagoas	MG	12,00	21,9 (21 – 24)	7,0 (6 – 8)	7,7 (7 – 8)	11,7 (11 – 12)	8

Costal cells number (CCN); Inner and Outer Gradates vein (IGN and OGN); Radial cells number (RCN); Marginal cells number (MCN).

Tab. VII – Average value of the (mm) character measured in the hind wings of different population of *Chrysoperla externa*.

County	State	LP	WP
Pontes e Lacerda	MT	10,47 ab	3,10 abc
Itiquira	MT	10,29 ab	3,09 abc
Cachoeira Alta	GO	10,54 ab	3,17 ab
Julio de Castilhos	RS	11,06 a	3,37 a
Águas da Prata	SP	10,55 ab	3,44 ab
Birigui	SP	10,50 ab	3,16 ab
Espírito sto Pinhal	SP	10,29 abc	3,10 abc
Guairá	SP	09,27 abc	3,13 abc
Jaboticabal	SP	10,36 ab	3,07 abc
Mojeiro	RN	10,34 ab	3,11 abc
Mossoró	RN	09,36 c	2,76 c
Assú	RN	09,64 bc	2,96 bc
Sete Lagoas	MG	10,60 ab	3,26 ab

* numbers followed by the same letters in the column do not have significative difference at the level of 95% according the Tukey-test.

** Hind wing Length (LP); Hind wing width (WP).

between the populations, but the Mossoró specimens are a quite different from the others in the hind wing measurements (Tab. VII).

Based on our results, we can conclude, that observations are not enough to separate the populations examined and they can be accepted as intra population variations and not as geographical variations. Considering that the populations were from extremely different localities (north and south of Brazil) and climactic situations it is possible to conclude also that the dispersion ways for *Chr. externa* are extensive. We can consider the panmictic conditions for this species despite its very large geographical distribution. The other hypothesis is that the phenotype is stable, probably the absence of large variation is due to development homeostasis, thus the capacity to produce a normal phenotype despite the disturbance of the development or environment.

Chrysoperla externa (Hagen, 1861) wing diagnosis – Green venation with innumerable black setae; anal veins mainly black but green ones are possible; oblique black setae on the costal vein, green ones are not common. Fore wing: acute apex; 1A (anal) vein forked; basal costal crossveins sinuous; quadrangular cubital 1 e 2 cells; distal cubital cell closed; two series of green gradates; intermedian veins green; green zig-zag radial sector; green radial sector base; radial crossveins green straight; basal crossvein costal present; inner gradates meet the pseudomedian; length 11,56 mm (9,72-13,46); distal width 3,67 mm (2,62-4,36); basal width 2,54 mm (2,08-3,06); distance between the intramedian cell apex to wing apex 8,71 mm (7,19-10,11); intramedian cell base width 0,23 mm (0,07-0,52); intramedian cell height 0,61 mm (0,48-0,76); distance between the gradate base and the wing apex 2,88 mm (1,85-4,72); distance between the wing apex and the imaginary intersection of pseudomediam with the distal margin 2,02 mm (1,30-2,98); costal cells number 21 (12-25); inner gradates number 6 (5-7); outer gradates number 6 (5-8); radial cells number 11 (9-13); median cells number 8 (7-10). Hind wing: length 10,33 (8,67-12,29); distal width 3,12 mm (2,49-3,81).

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Laboratory evidence for phenological adaptation in two insular populations of *Chrysoperla agilis* Henry, Brooks, Duelli & Johnson, 2003

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Holarctic *Chrysoperla carnea* is a complex of sibling species known as the "*Chrysoperla carnea* complex", whose diverse courtship songs have led to the recognition of several cryptic species, including *C. agilis* Henry *et al.*, 2003. The geographic range of *C. agilis* is westerly limited by Madeira and Azores. The climatic differences between the two archipelagos led us to investigate whether populations of the species have differentially adapted to local conditions. After considering the climatic conditions of the archipelagos, we chose 24 and 28 °C to evaluate a large set of life cycle parameters. Our results indicate that the Azorean population performs well under both temperatures, whereas the one from Madeira had a clear preference for 24 °C. The performance of both populations appears to be linked with local climatic conditions. Also, the Azorean population showed an overall greater breeding potential, perhaps linked to climatic instability of its environment.

Key words – *Chrysoperla agilis*, insular populations, acclimatisation, fitness.

Introduction

The Azores is the most isolated and youngest archipelago of the Macaronesia biogeographic region (Beyhl *et al.*, 1995), immediately followed by Madeira. The native entomofauna of both archipelagos have a predominantly Palaearctic origin (Wallace, 1872; Bivar de Sousa, 1985), and thus it is not surprising that *Chrysoperla agilis* Henry, Brooks, Duelli & Johnson, 2003, a part of the Palaearctic *Chrysoperla carnea* (Stephens, 1836) complex, exists on both archipelagos (Ventura *et al.*, 2005). According to Balletto *et al.* (1990), Madeira may have served as a stepping-stone to the Azores colonization, a hypothesis corroborated by Ohm (1973) and Ventura *et al.* (2005), who mention the biogeographical affinities between the Neuropterological fauna of both archipelagos.

C. agilis geographic range is westerly limited by these mid-Atlantic islands, and reaches as far as southern Switzerland (north) and northern Iran (east) (Henry *et al.*, 2003). Globally it can be found in all Mediterranean Europe with a mild climate. The Portuguese Macaronesian archipelagos have temperate mild climates, denoting a great influence from the surrounding Ocean; however, the Azores is located further to the north (38° 31' 60" N) compared to Madeira (32° 43' 33" N), being subject to great instability and frequent storms due to the encounter of polar and tropical air masses (Agostinho, 1938).

Azorean populations of *C. agilis* came from mainland Europe; still, their routes and dates of arrival remain uncertain. An acclimatisation process, involving an evolutionary response of an organism, can

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last a few generations. Some authors (e.g. Thomson *et al.*, 2001) refer the phenomena as a more or less quick physiological response to a sudden change in environmental patterns. Either way it is expected that local populations have already adopted different strategies to face local climates that, although close in average temperature at sea level, are quite different in terms of stochastic. Tauber & Tauber (1982) also refer that local populations of Nearctic *Chrysopa* (=*Chrysoperla*) *carnea*, have traits that adapt them to meet the physical and biotic requirements of their local environments.

In geographically widespread ectotherms, variation in life history traits may be caused, at least in part, by differences in maintenance metabolism of individuals (e.g. vertebrates: Huey & Pianka, 1977; Clarke & Johnston, 1999; invertebrates: Acar *et al.*, 2001), which in turn reflect different life strategies both for vertebrates *(e.g. Angilletta, 2001) and invertebrates like insects (e.g. Sheldon & MacLeod,* 1974).

One of the environmental factors that changes with latitude (and elevation) is temperature and Huey & Berrigan (2001) clearly state its impact on Darwinian fitness of ectotherms, reflecting mostly the effects on developmental and reproductive rates (e.g. Butler & Ritchie, 1970; Obrycki & Tauber, 1981; Lee & Ahn, 2000; Saethre & Hofsvang, 2002). It is often assumed that growth trades-off with reproduction (e.g. Roff, 2000), enhancing the importance of these two parameters on an ectotherm life cycle. Thus, an understanding of the effects of thermal environment on individuals may aid in the explanation of geographic differences in life history and properties of populations (Beaupre, 1995).

Our main goal was to evaluate, under controlled conditions, the consequences of a possible acclimatisation on two populations of *C. agilis* that inhabit temperate insular ecosystems, with similar average temperatures but very different in terms of predictability. Evaluating population fitness (Futuyma, 1998) we are able to predict the influence of the habitat on the species. Temperatures were chosen to characterize the summer conditions on the archipelagos and also the reproductive season for these insects. We wanted to test the hypothesis that even small differences in latitude and length of reproductive season, and unstable climatic conditions, may reflect on fitness parameters of geographic populations of a multivoltine insect species such as *C. agilis.*

Material and methods

The Portuguese Macaronesian Archipelagos – In Table I we present the most important features that characterise the archipelagos, where the two populations used in the essays came from. Table I presents the geographic location of the archipelagos in the North Atlantic Ocean, particularly of the islands *where we collected the specimens, and respective climates. Both populations were* mostly collected in the same type of habitat, *Zea mays* L. cultures, and were reared according to the techniques and biotic and abiotic conditions described in Ventura (2003).

Bioassays – Insects used in the bioassays were all from second and third lab generations. The bioassays for each population, were conducted under two temperatures (24 and 28 °C ± 0.5 °C) to simulate the optimal range of temperatures for the reproductive season of both populations, at these latitudes. Insects were reared in individual glass vials until adult emergence and larvae fed *ad libitum* on *Ephestia kuehniella* Zeller 1879 (Lepidoptera Pyralidae) eggs. Each group of 100 insects/temperature was put inside an acrylic box (35 X 23.5 X 14 cm), and kept inside Sanyo® chambers with RH 75 ± 5%, photoperiod 16:8 h (L:D), and 1200 lux of maximum light intensity. Biological parameters recorded were: developmental time for each larval stage in days; daily mortality; pupae weight after immobilisation in the cocoon; imago weight after release of meconium; gender [sex-ratio evaluated through the formula n.° ♀♀ / n.° (♂♂ + ♀♀)]. Weights were measured with an analytical scale IT® with 10^{-4} mg precision.

For F1 generation we coupled 30 males

Tab. I – Some important features that characterise the Azores and Madeira archipelagos.

FEATURES	Madeira Archipelago	Azorean Archipelago
Island of origin of the populations	Madeira	São Miguel
Latitude / Longitude	32° 50' N / 17° 00' W	37° 46' N / 25° 29' W
Annual average temperature (T) (sea level)	20 °C	17.5 °C
Annual average relative humidity (RH)	70%	80%
Distance between the archipelagos	950 Km	
Distance to nearest point in Europe	978 Km	1300 Km

and 30 females, fed them on a mixture of commercial pollen, honey, yeast extract and distilled water in equal parts, and put them into round acrylic boxes (10 X 3.5 cm) inside the same climate chambers and keeping the same abiotic conditions. Daily, and for a period of 30 days, eggs were collected and individualised in Elisa® wells and, after 5 days inside the couples' chamber, they were grouped into sterile (unfertile), dead embryos and fertile eggs (originating living larvae). Biological parameters of the couples included: sexual maturation period (number of days to first egg-laying); total of eggs laid within the 30 days; total of larvae obtained within the 30 days; fecundity (eggs/female/day); fertility (fertile eggs/female/day); oviposition period within the 30 days (unless female died).

Experimental Design

$X_{(ij)k} = \mu + T_i + P_j + TP_{ij} + e_{(ij)k}$

Factors involved in the analysis:

T=Temperature with two levels: 24 and 28 °C;

P=Population (geographic origin) with two levels: Madeira and Azores.

Our alternative hypothesis concerning the populations' fitness at each temperature tested, were:

HA (24 °C): μ Azores > μ Madeira

HA (28 °C): μ Azores < μ Madeira

Since we are dealing with ectothermic animals, we also expect to find significant differences between temperatures.

Data were analysed by two-way ANOVA ($p<0.05$) with software GMAV5© for Windows® (Underwood, 1997). When variance homogeneity did not apply, data were transformed according to software specifications. Sex-ratio and percentage data were compared through chi square test ($\alpha=0.05$) using PopTools® from Excel®, and its applicability was based on Zar (1984).

Results

C. agilis populations behaved differently according to temperature tested and geographic origin of the population. Developmental time, for instance, showed significant differences due to temperature, geographic origin of the population and their interaction (Tab. II; Figs 1 and 2).

In general, the population from Madeira took longer time to complete its development at both temperatures, with a greater difference at 24 °C.

Biomasses and sex-ratios showed no influence due to any of the experimental factors but the same does not apply when it comes to mortality. The population from Madeira had a significantly higher global mortality at 28 °C (24°: 4.5%; 28°: 17.6%) also when compared to the population from the Azores (Chi square test; $p<0.05$), which had a low mortality at both temperatures (24°: 6.1%; 28°: 3.1%).

Although the population from Madeira takes significantly more time to mature at both temperatures (Tab. III), this reflects an independent effect from each factor and never an interaction (F=1.20; d.f. 1,119; p=0.276). When it comes to oviposition ability, and except for fecundity and fertility, there is always a significant interaction between temperature and population (total of eggs: F=16.52; d.f. 1,119; p=0.0001; total of larvae: F=10.35; d.f. 1,119; p=0.0017). While the Azorean population has a similar behaviour at both temperatures, the Madeira one shows a

Tab. II – Statistical parameters of the two-way Anova conducted on the developmental time (days) of the insects.

Develop. Stage	Factors	Two-way ANOVA F	d.f.	p
Larval Life	Population	281,25	1, 239	0,0000
	Temperature	249,14	1, 239	0,0000
	Pop. x Temp.	107,29	1, 239	0,0000
Larvae to Adult	Population	705,77	1, 239	0,0000
	Temperature	933,38	1, 239	0,0000
	Pop. x Temp.	138,42	1, 239	0,0000
Total Development	Population	687,26	1, 239	0,0000
	Temperature	582,60	1, 239	0,0000
	Pop. x Temp.	137,66	1, 239	0,0000

significant reduction of its oviposition ability at 28 °C (Tab. III) and similar values to its congener at 24 °C. These values are obviously also reflected on fecundity and fertility parameters as shown on graphics of figures 3 and 4.

The graphics clearly show a fecundity and fertility that reaches a peak within the first 10 days of oviposition, when both populations show similar behaviour at 24° temperature but, at 28°, the Madeira population has a great decrease on its oviposition ability (Figs 3 and 4). The interesting thing is that when it comes to egg viability, Madeira population has a better fitness with significantly lower amount of sterile eggs and dead embryos (Tab. IV) and, at 28 °C, these are even significantly reduced when compared to the other temperature. This means that lower oviposition ability of Madeira population at 28 °C is due to the amount of eggs laid rather than their reduced viability.

Discussion

Longer developmental times in the southern population from Madeira (Tab. I; Figs 1 and 2) corroborate Sheldon & MacLeod (1974), who hypothesised that southern populations have less accelera-

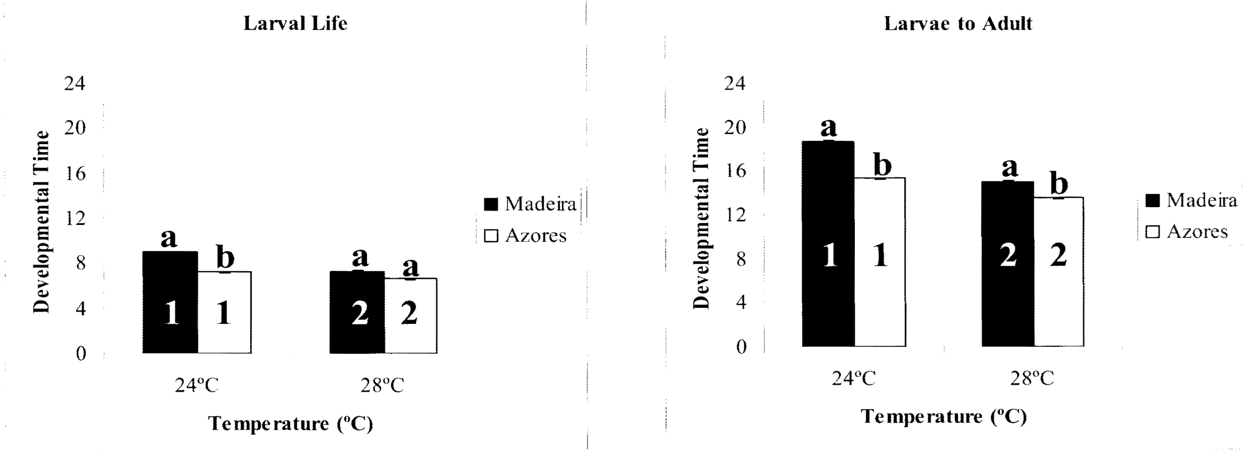

Fig. 1 – Developmental time in days ($\overline{X}$ ±SE) of the larval period (3 instars) (Larval Life), and from first instar to emergence of the adult (Larvae to Adult); different letters indicate significant differences between populations and different numbers indicate significant differences between temperatures (p<0.05).

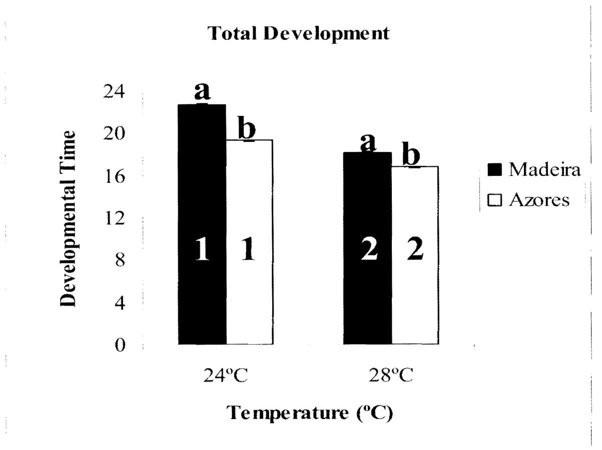

Fig. 2 – Developmental time in days ($\overline{X}$ ±SE) of the insects from egg to the adult emergence; different letters indicate significant differences between populations and different numbers indicate significant differences between temperatures (p<0.05).

ted developmental rates in relation to northern populations at the same temperature, since they experience a longer-growing season thus not needing a rapid growth rate to complete the life cycle to the point where new generations are added. The significant interaction between temperature and geographic origin of the population is also in accordance with Sheldon and MacLeod (1974) results, who stated that the geographic origin of the population has a great influence on its developmental response to temperature. Like us, they also found an interaction between geographic origin and temperature, in the sense that the effect of one factor depends on the levels of the other (Tab. II).

Our results, however, contradict Angilletta's (2001) hypothesis developed for lizards, which states that southern populations have a faster development and an earlier sexual maturation when compared to northern ones due to the higher temperatures experienced throughout the year, which favours a higher metabolic rate (Beaupre, 1995). But we must not forget that lizards depend greatly on diurnal temperatures for their activity, something that does not apply to insects that have a more heterothermic strategy, allowing them to have a nocturnal activity. This is actually the case concerning the *Chrysoperla carnea* group (Duelli, 1984).

It is also interesting to note that although both "temperature" and "population" had a significant effect on the sexual maturation period (Tab. III), there was no significant interaction between the variables, which is a similar result to the one obtained by Saethre & Hofsvang (2002) with two populations of the codling moth at various temperatures, although working with eastern *vs* western populations. The same applies to other important reproductive parameters like fecundity and fertility. Thus, reproductive response is correlated with temperature as expected, but is also correlated with the geographical origin of

Tab. III – Reproductive parameters of F_1 generation ($\overline{X}$ ±SE); different letters report to significant differences among populations and different symbols report to significant differences between temperatures (two-way Anova; p<0.05).

Population	Azores		Madeira	
Temperature (ºC)	24	28	24	28
sexual maturation period (days)	3,17 ± 0,39a*	2,30 ± 0,16a#	3,97 ± 0,18b*	3,69 ± 0,66b#
Fecundity (eggs/♀/day)	23,58 ± 1,96a*	23,28 ± 1,79a*	20,16 ± 1,46a*	9,82 ± 2,72b#
Fertility (larvae/♀/day)	20,54 ± 2,01a*	20,19 ± 1,93a*	19,10 ± 1,41a*	8,89 ± 2,70b#
total of eggs laid (30 days)	530,00 ± 56,73a*	521,30 ± 58,89a*	530,40 ± 38,61a*	196,90 ± 34,47b#
total of larvae (30 days)	469,17 ± 55,44a*	451,67 ± 57,59a*	502,03 ± 38,62b*	181,07 ± 34,82b#

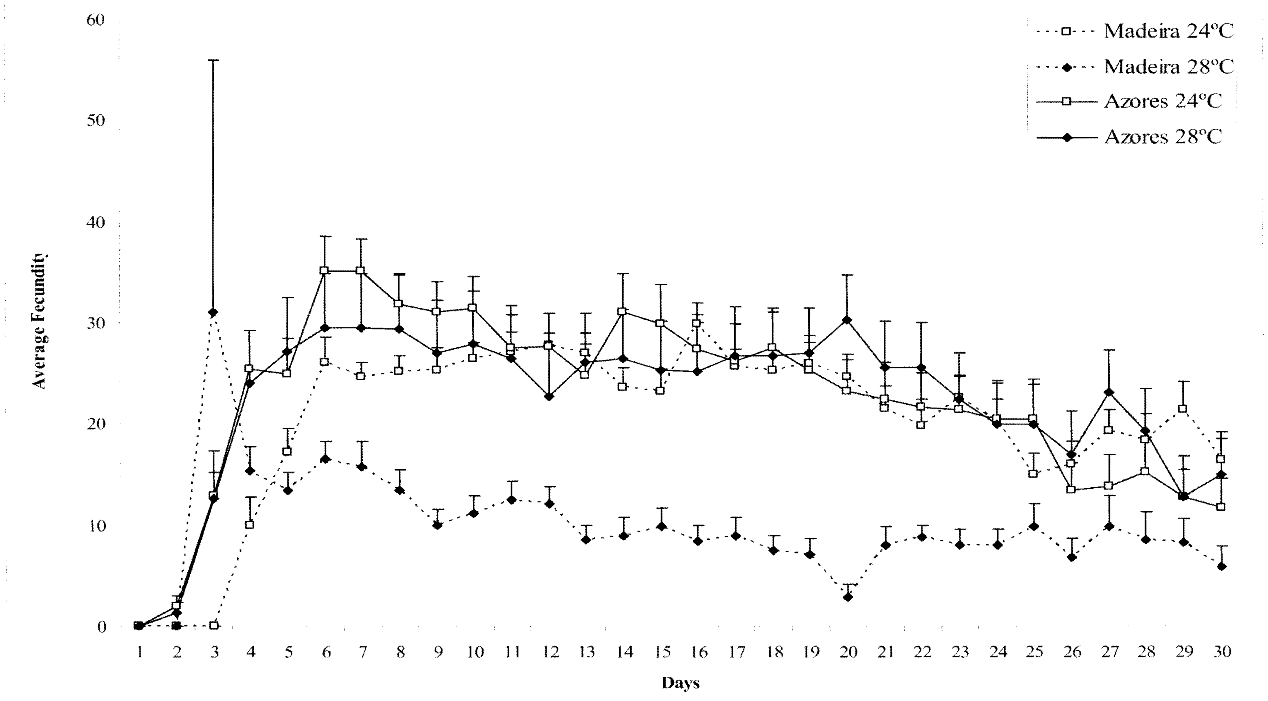

Fig. 3 – Average fecundity of F_1 females ($\overline{X}$ ±SE) during first 30 days of oviposition.

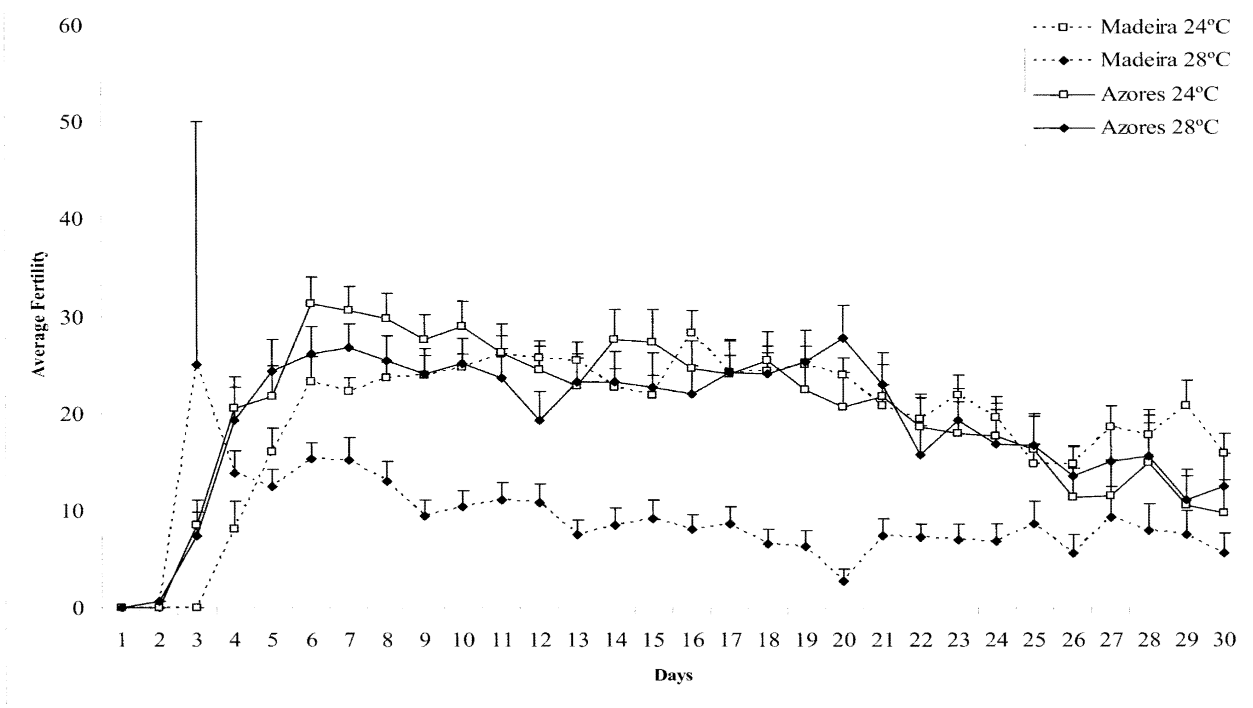

Fig. 4 – Average fertility of F_1 females ($\overline{X}$ ±SE) during first 30 days of oviposition.

Tab. IV – Egg viability of F_1 generation ($\overline{X}$ ±SE); different letters report to significant differences among populations and different symbols report to significant differences between temperatures (two-way Anova; p<0.05).

Population	Eggs	Temperature (°C) 24	28
Azores	Sterile	43.10 ± 5.10 a*	57.17 ± 12.09 a#
	Dead Embryo	17.73 ± 2.70 a*	12.47 ± 1.91 a#
Madeira	Sterile	17.93 ± 2.33 b*	12.34 ± 2.89 b#
	Dead Embryo	9.9 ± 2.7 b*	3.48 ± 0.66 b#

the population, without a relation between both factors. This agrees with the studies conducted by Tauber & Tauber (1986, 1987), on the inheritance of the responses underlying interpopulation differences in the ecological traits of the Nearctic *Chrysoperla carnea* species-complex. They concluded on the existence of a genetic variation among geographical populations of the same species, determining the requirements for reproduction.

Although we have neglected the critical photoperiod used by ectothermic animals in temperate environments as a cue to determining time horizons for seasonal synchronization of generations (Gotthard, 2001), this cue is approximately the same for the two latitudes considered and, for *Chrysopa oculata* Say, corresponds to a photophase of 13 h (Nechols *et al.*, 1987).

An interesting result is that our study contradicts the conclusions drawn by Tauber *et al.* (1987) with respect to different geographic continental populations of *C. oculata*. These authors suggest that thermal requirements for development are genetically variable but geographically stable, due to constraints imposed by a multivoltine cycle that may interfere in the magnitude and projection of natural selection and insect physiology. If we compare the results obtained for the populations from latitudes close to ours (30° 34' N and 42° 26' N), we realise that for 24 and 26.7 °C they had a maximum difference of 0.8 days in developmental duration, whereas we have differences of 3.42 days at 24 °C and 1.35 at 28 °C (Fig. 2). Since our populations were both subjected to the same photoperiod, our results may reflect a stochastic characteristic of insular climates as opposed to continental, particularly felt in the Azores. Local populations may then be forced to develop some traits that will enable them to face unexpected adverse weather conditions, which may lower their chances for survival.

In fact, the population from Madeira had a clear preference for 24 °C, demonstrating a good level of acclimatisation to the mild temperatures of the archipelago. The greater thermal tolerance showed by the Azorean population, on the other hand, may point to a better acclimatisation to the greater climate instability of the Azorean archipelago, corroborated by developmental and reproduction data. To a faster pre-imaginal development and sexual maturation period in the Azorean population, corresponds equal oviposition ability at 24 °C and a greater one at 28 °C (with similar results between temperatures). This may be a response to the climate instability that characterises the Azorean archipelago. Since both regions have the same critical photoperiod (Nechols *et al.*, 1987), the climate can explain the rush of the Azorean specimens in reaching maturity and leaving progeny, along with the low mortality rate verified at both temperatures. However, the greater viability of Madeira offspring (lower number of sterile and unfertile eggs) (Tab. IV) is again a consequence of an optimal response to 24 °C by this population.

Another possible explanation for the differences between populations, and for the significantly lower mortality of the Azorean population at 28 °C, may be that, unlike the Madeira population, *C. agilis*

Azorean population arrived more recently to the archipelago, probably brought by commercial trades with Europe's mainland. Thus it still keeps a greater tolerance to higher summer temperatures that characterise its southern European source (Henry *et al.*, 2003).

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mediali, subanteriori (assenti nelle due specie prima nominate); due assai lunghe, postantennali; due, pure assai lunghe, dorsali, mediali e posteriori alle precedenti; quattro, piuttosto brevi, dorsali, distribuite pressochè sulla stessa linea trasversale dove si trovano le due mediali posteriori; sei brevissime, dorsali e posteriori, riunite in due gruppi di tre per parte; quattordici ocellari, distribuite sette per parte, di cui quattro dorsali e tre ventrali (ventralmente ve ne possono essere in più una o due per parte, talora anche solo da una parte). Infine il tegumento del cranio, oltre alle sei microformazioni circolari pigmentate distribuite due ai lati, subanteriormente, e quattro al dorso (due submedialmente e anteriormente e due medialmente e posteriormente), ed alle quattro microformazioni subellittiche ventrali, distribuite due per parte presso gli ocelli, è provvisto, su tutta la faccia dorsale, di numerosi peluzzi sopportati da una larga base membranosa circolare. Antenne prive di caratteri degni di rilievo. Branche del forcipe succhiante lunghe circa quanto il cranio, o poco di più. Mandibole e mascelle rappresentate dalla fig. VII, con chetotassi senza caratteri degni di rilievo rispetto a quanto è stato osservato nelle altre specie. Il labbro

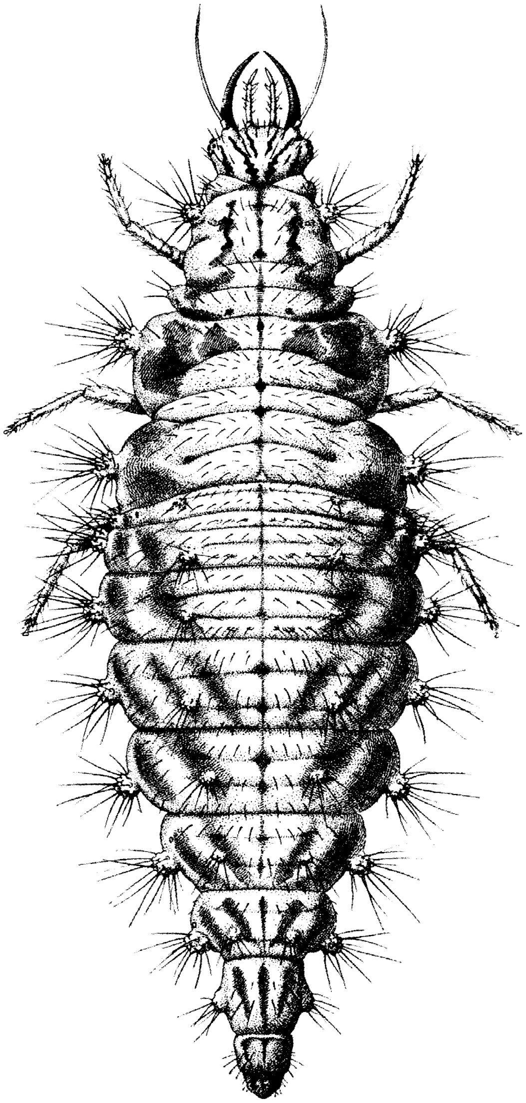

FIG. VI.

Chrysopa viridana Schn. — Larva matura.

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Is the introduction of the biological control agent, *Chrysoperla carnea* (Stephens, 1836), risky or beneficial?

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The non-target impact of introduced exotic natural enemies on native ecosystems is a matter of concern on the part of a number of prominent ecologists and conservation biologists. Several case studies are being carried out to design a new assessment method and guidelines for using exotic biological control agents in a safe manner in the Japanese environment. In this paper, we review several studies on the non-target effects of the exotic green lacewing, *Chrysoperla carnea*, which has recently been introduced in Japan, and discuss its risks and benefits. Classification of the *C. carnea* group is very complex and challenging. Several cryptic species are divided by courtship song. Courtship song analysis has revealed that the imported green lacewing is the true *C. carnea*. The Japanese indigenous green lacewing was originally classified as *C. carnea*, but was later revised to *C. nipponensis*, since its courtship song differs from that of other *carnea* group species. To determine the potential ecological risk of releasing an exotic green lacewing in Japan, laboratory studies were conducted on intraguild predation and interspecific hybridization. The results suggested that larval size determines any asymmetry in predation and that, at the species level, the competitive relationship can be regarded as symmetric. Interspecific hybrids were obtained under laboratory conditions, and fully viable and fertile F1 and F2 generations were produced. However, interspecific crosses showed lower fertility than conspecific crosses, suggesting that various mechanisms, such as different courtship songs, may act as a barrier to interspecific mating. The use of the green lacewing for biological control has proved beneficial in Integrated Pest Management programs. However, more information on non-target effects needs to be accumulated, and the establishment of the exotic *C. carnea* and their cryptic species which may be imported, labeled as *C. carnea*, must be monitored.

Key words – *Chrysoperla carnea, C. nipponensis*, environmental risk assessment, intraguild predation, interspecific hybridization.

Introduction

Natural enemies have been used to control pests in many countries to reduce the use of chemical pesticides. In Japan, the introduction of exotic natural enemies started in 1911, to suppress exotic pests. Thirty-six species have been introduced and 8 species have become established. Since 1998, biological control agents have been imported as biological pesticides to control both exotic and indigenous pests. More recently, serious concerns over the non-target impact of introduced exotic natural enemies on native ecosystems have been raised by a number of prominent ecologists and conservation biologists (Follett & Duan, 2000; Wajnberg *et al.*, 2001; Louda *et al.*, 2003). However, in many countries, there are still numerous importation programs of biological control agents that have not been subjected to non-target evaluations. In 1999, the Ministry of the Environment of Japan published their "Guidelines on the Introduction of Environmental Impact Assessment of Biological Control Agents", to ensure that only environmentally safe biological control agents are imported. [The flow chart for the assessment is summarized in Mochizuki (2004)]. The assessment method in the guideline is qualitative, and there are problems with insect classification and standards of judgment for their introduction. Several case studies have been carried out with the aim of designing new assessment methods and guidelines for the safe use of exotic biological control agents in the Japanese environment. In this paper, we review the case studies featuring the non-target effects of the exotic green lacewing, *Chrysoperla carnea* (Stephens, 1836), which has recently been introduced in Japan, and discuss its risks and benefits.

Problems with classification

Characterization and identification of biological control agents is the most important and fundamental step in environmental risk assessment. The green lacewing, *Chrysoperla carnea* (Stephens, 1836), which is frequently used for biological control in many countries (Tauber *et al.*, 2000), was long assumed to be a single morphologically identical species with a Holarctic distribution (Tjeder, 1960). However, there is some evidence that it is not a single species, but instead a complex of several species, characterized by different male courtship songs (Henry *et al.*, 1993, 2001). In Japan, the indigenous, widely-distributed green lacewing was originally categorized as *C. carnea* (Tsukaguchi, 1985), but later revised to *C. nipponensis* (Okamoto, 1914) by Brooks (1994) based on external morphological differences such as the color of the gradate crossveins, which are black in *C. nipponensis* and green in *C. carnea*. Its courtship song also differs from the other *carnea* group species (Henry & Wells, 2004; Taki *et al.*, 2005). In 1996, the green lacewing designated as *C. carnea* was imported from Germany on a test basis. It was registered as a biological pesticide in 2001, and is now on the market in Japan. Courtship song analysis demonstrated that the imported green lacewing was the true *C. carnea* (Henry, personal communication). The introduced green lacewing should therefore be treated as a different species to the indigenous type.

Potential risks of releasing exotic green lacewing

Potential risks arising from the release of exotic biological control agents were summarized by van Lenteren *et al.* (2006), who said the most important risks were environmental risks, which include the possibility of global or local extinction of a native species; large reductions in either the distribution or abundance of native organisms; interference in the efficacy of native natural enemies of pests via intraguild interactions or competitive displacement; the vectoring of pathogens harmful to native organisms; and loss of biodiversity and identity of native species via hybridization between close relatives.

Evaluating environmental risks is very difficult in biological control, due to a lack of information on non-target effects and no critical assessment method.

To obtain information on interference in the efficacy of the indigenous green lacewing, *C. nipponensis*, via intraguild interactions or competitive displacement with exotic *C. carnea*, Mochizuki & Mitsunaga (2004) studied intraguild predation between exotic and indigenous green lacewings under laboratory conditions. Larval predation outcomes between individuals were symmetrical at the same developmental stage and asymmetrical between different stages. At the species level, the competitive relationship by predation between the two species can be considered symmetric. Intraguild predation among predaceous insects is largely dependent on the predator's mobility, size, and feeding specificity (e.g., Lucas *et al.*, 1998; Sengonca & Frings, 1985). The size was the most important factor in determining the symmetry of the intraguild predation between the larvae of *C. carnea* and *C. nipponensis* (Mochizuki & Mitsunaga, 2004). Populations of *C. nipponensis* are not likely to be decreased by intraguild predation with *C. carnea* unless there are extremely large mass releases of *C. carnea* in a small arena, or unless *C. carnea* were to become established in Japan and adopt a different development rate or seasonal cycle. The lower development threshold of *C. carnea* was about 10 °C (Volkovich, 1998). The data on *C. nipponensis* was very similar at 10.2 °C (Fujiwara and Nomura, 1999). Developmental periods from egg to adult and preoviposition time were not significantly different between the species in the laboratory at 25 °C (Naka *et al.*, 2005). These data will be useful for the prediction of development rate or seasonal cycles of *C. carnea* if it becomes established in Japan.

To investigate the possible loss of biodiversity and identity of native species via hybridization between close relatives, Naka *et al.* (2005) studied hybridization between exotic and indigenous green lacewings under laboratory conditions. When *C. carnea* and *C. nipponensis* were brought together in a small cup, they readily hybridized and produced fully viable and fertile F1 and F2 generations. However, the rate of interspecific hybridization resulted in lower fertility (≤ 41.3%) than the rate of conspecific crossing in *C. carnea* (90%), and in *C. nipponensis* (70%). Albuquerque *et al.* (1996) showed low fertility in interspecific hybrids between *Chrysopa quadripunctata* Burmeister, 1839 and *C. slossonae* Banks, 1924 under laboratory conditions, although other studies of green lacewings, particularly those in the *C. carnea* group, have reported highly fertile F1 and F2 hybrids and backcrosses between close relatives [*C. plorabunda* (Fitch, 1855) x *C. downesi* (Smith, 1932), reported by Tauber & Tauber (1977); *C. johnsoni* Henry, Wells & Pupedis, 1993 x *C. plorabunda*, reported by Wells (1993), Henry (1993) and Henry *et al.* (1993)]. Under no-choice mating conditions, the barriers to prezygotic reproductive isolation appear to be broken in some insects (e.g., dos Santos *et al.*, 2001). The high fertility in both *C. plorabunda* x *C. downesi* and *C. plorabunda* x *C. johnsoni* may result from breakdown of the prezygotic barriers caused by the experimental conditions. The low fertility of the interspecific hybrids between *C. carnea* and *C. nipponensis* may show the existence of postzygotic barriers, as in the case between *C. quadripunctata* and *C. slossonae*, where reproductive isolation is dependent on a negative effect on the sperm (Albuquerque *et al.*, 1996).

In green lacewings, Wells & Henry (1994) showed courtship songs to be an important barrier to interspecific hybridization. Notably, the courtship songs of the *C. carnea* group are quite elaborate and identically expressed in both sexes. Mating will not occur under natural conditions unless the participants engage in a prolonged and accurately matching duet (Wells & Henry, 1992). The courtship songs of *C. carnea* and *C. nipponensis* are quite different (Henry *et al.*, 2002; Henry & Wells, 2004; Taki *et al.*, 2005). The rate of interspecific hybridization between *C. carnea* and *C. nipponensis* is likely to be lower in the wild than under laboratory conditions. In some orthopteran cryptic species, it has been shown that courtship songs are the only differences that separate the species (Walker, 1964). Comparable observations have been reported in several similar species, such as the ground crickets *Allonemobius fasciatus* (De Geer, 1773) and *A. socius* (Scudder, 1877), and water bugs of the family Corixidae (Howard, 1986; Jansson, 1979). In closely related species, differences in courtship songs appear to be the chief cause of the low success of hybridization.

Towards the future

In Japan, studies on the environmental risks of exotic biological control agents have only just started. Concerning the green lacewings, it is necessary to study the interactions between these species in greater detail (e.g., comparisons of each species' propensity to prey on other species versus cannibalizing its own siblings, and the propensity of each species to prey on other species in the presence of real insect prey) and to look at whether *C. carnea* can become established in Japan. The ecological data for *C. carnea* in Europe before 2002 may be that of the *carnea*-group, since the true *C. carnea* was distinguished from other cryptic species and described only recently (Henry *et al.*, 2002). However, knowledge on ecology and biology has been accumulated on both *C. carnea* and individual cryptic species (e.g., McEwen *et al.*, 2001). In Japan, a sibling species of *C. nipponensis*, type B, was by Taki *et al.* (2005). However, type discovered B has a very localized distribution and can be easily distinguished from the widely-distributed *C. nipponensis* by the larval head markings. The data collected as *C. carnea* in Japan can thus be treated as data on *C. nipponensis*. More knowledge will be needed on the non-target effects of the exotic *C. carnea* becoming established in Japan.

Van Lenteren *et al.* (2003) showed a risk assessment method based on the risk evaluation system for biological control agents proposed by Hickson *et al.* (2000). In their system, five groups of risks are considered related to the release of exotic biological control agents: establishment, dispersal, host specificity, direct effects and indirect non-target effects. Van Lenteren *et al.* (2003) calculated the risk index value of *C. carnea,* which arrives at an intermediate point; they said that species with intermediate risk indices will result in advice to obtain additional information before a conclusion can be drawn concerning release. *C. carnea* has the potential to become established in more than 50% of non-target habitats in Japan, since it is warmer than in Europe. The index point will be the same in Japan.

The biological control agents *Aphidius colemani* and *Aphidoletes aphidimyza* are also on the market in Japan. The risk index of *A. colemani* is also categorized as being intermediate, but lower than that of *C. carnea* (van Lenteren *et al.*, 2003). The risk of *A. aphidimyza* is not yet known, but its effects on aphid control are unstable (Nemoto, personal communication). It would be difficult to find alternative, low-risk biological control agents for *C. carnea.* It is better to use native natural enemies which carry either no risk or a predictably small level of risk. Since the production costs of native species would be prohibitively expensive in Japan, importation of the more commonly reared *C. carnea* is at present the only low-cost solution for mass-release of green lacewings for biological control. The use of natural enemies has numerous environmental benefits, such as reducing pollution by chemical pesticides. A risk-benefit analysis, however, must be carried out. Currently, the introduced *C. carnea* is not found naturally in the field. In Europe, several cryptic song species (*carnea* group) co-exist (Henry *et al.*, 2002); these too, could have been imported to Japan in some shipments. They cannot be easily distinguished from each other. It is therefore necessary to develop a new technique for distinguishing between these cryptic species and to monitor how many biological species have been imported from Germany, labeled as *C. carnea*, with the potential to become established in Japan. This will be the focus of future studies on the impact that imported *C. carnea* may have with respect to potential competition and hybridization with the indigenous *C. nipponensis*.

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