

## **Biology and Larval Diagnosis of Central European Neuroptera (A Review of Present Knowledge)**

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### **ABSTRACT**

The taxonomy of the imagines of Central European Neuropteroidea has been clarified for more than ten years whereas knowledge of the larval stages of most species is insufficient. Although the larvae of 75% of the species are mentioned in the literature, only 42% are adequately described. Over the last ten years the author has reared 65 species in all stages, so, at present, a total of 74% of the larvae of the Central European species can be accurately determined and 10 further species are partly described. The publication of a monograph on the Central European neuropteroid larvae is proposed.

### **INTRODUCTION**

Less than 5 % of the larvae of the world's approximately 6,500 species of Neuroptera have been described. In contrast to this, the identification of the larvae of the Central European species has been possible at least in general outlines at family level for more than 100 years.

BRAUER, REDTENBACHER and KILLINGTON gave larval diagnoses for at least 50% of the recent species. Since then, knowledge on the larvae of Sialidae (KAISER 1977), Raphidioptera (ASPÖCK et al. 1974 a, 1975), and Chrysopidae (GEPP 1983) has been fundamentally expanding. At present, publications on the larval stages of 90 Central European neuropteran species are available, and a further 16 species await publication.

### **SHORT HISTORICAL REVIEW**

Investigations on the larvae of Central European Neuroptera were initiated in the 19th century by BRAUER and REDTENBACHER. The clarification of the biology of **Mantispa styriaca** and the larval diagnosis of all the Central European myrmeleonids are still valid. After World War I WITHYCOMBE, with numerous individual biologies, and KILLINGTON, with his monograph on the British Neuroptera, set standards that have not been exceeded.

In the past decade adult megalopteran larvae (KAISER), raphidiopteran larvae (ASPÖCK & ASPÖCK), as well as chrysopterid larvae (GEPP) have been clarified.

More than 300 publications give complementary details about the larvae of a total of 90 Central European species of Neuroptera. The quality and completeness of the descriptions, however, varies considerably, so that there are at the most 50 species which can be considered as being adequately described.

Over the last 15 years the author has reared about 100 Central European species of Neuroptera in different larval instars, compiling observations on their biology, ecology and behaviour. He has numerous drawings and much data on larval instars of a total of 106 Central European species of Neuroptera at his disposal.

The neuropterous species and the state of description of their larval stages are listed below and the author's unpublished knowledge in this field is briefly discussed according to family groups.

### LIST OF SPECIES (after ASPÖCK, ASPÖCK & HÖLZEL 1980)

Table 1: Summary of the state of knowledge on the larvae of the Central European Neuroptera:

- 1 - larval stages unknown;
- 2 - described only superficially or in earlier stages;
- 3 - at least the last larval stage described;
- 4 - all stages described;
- 5 - unknown to the author or known only in early stages;
- 6 - at least the last larval stage at the author's disposal;
- 7 - all stages at the author's disposal.

## NEUROPTEROIDEA MEGALOPTERA

### Sialidae

<i>Sialis lutaria</i> (Linnaeus, 1758)	7
<i>Sialis morio</i> Klingstedt, 1932	3
<i>Sialis fuliginosa</i> Pictet, 1836	6
<i>Sialis nigripes</i> Pictet, 1865	3

### RAPHIDOPTERA

#### Raphidiidae

<i>Raphidia</i> ( <i>Raphidia</i> ) <i>ophiopsis</i> Linnaeus, 1758	3
<i>Raphidia</i> ( <i>Raphidia</i> ) <i>ulrikae</i> Aspöck, 1964	3
<i>Raphidia</i> ( <i>Dichrostigma</i> ) <i>flavipes</i> Stein, 1863	6
<i>Raphidia</i> ( <i>Phaeostigma</i> ) <i>notata</i> Fabricius, 1781	7
<i>Raphidia</i> ( <i>Magnoraphidia</i> ) <i>major</i> Burmeister, 1839	6
<i>Raphidia</i> ( <i>Ornatoraphidia</i> ) <i>etrusca</i> Albarda, 1891	6
<i>Raphidia</i> ( <i>Subilla</i> ) <i>confinis</i> Stephens, 1836	3
<i>Raphidia</i> ( <i>Puncha</i> ) <i>ratzeburgi</i> Brauer, 1876	7
<i>Raphidia</i> ( <i>Xanthostigma</i> ) <i>xanthostigma</i> Schummel, 1832	3
<i>Raphidia</i> ( <i>Xanthostigma</i> ) <i>aloyisiana</i> Costa, 1855	1
<i>Raphidia</i> ( <i>Atlantoraphidia</i> ) <i>maculicollis</i> Stephens, 1836	(3)
<i>Raphidia</i> ( <i>Raphidia</i> ) <i>ligurica</i> Albarda, 1891	(3)
<i>Raphidia</i> ( <i>Venustoraphidia</i> ) <i>nigricollis</i> Albarda, 1891	3

#### Inocelliidae

<i>Inocellia</i> ( <i>Inocellia</i> ) <i>crassicornis</i> (Schummel, 1832)	3
<i>Inocellia</i> ( <i>Parainocellia</i> ) <i>braueri</i> Albarda, 1891	3
<i>Inocellia</i> ( <i>Parainocellia</i> ) <i>bicolor</i> Costa, 1855	(3)

PLANIPENNIA

**Coniopterygidae**

<b>Aleuropteryx loewii</b> Klapalek, 1894	3
<b>Aleuropteryx juniperi</b> Ohm, 1968	3
<b>Helicoconis lutea</b> (Wallengren, 1871)	7
<b>Helicoconis hirtinervis</b> Tjeder, 1960	1
<b>Helicoconis eglini</b> Ohm, 1965	6
<b>Helicoconis pseudolutea</b> Ohm, 1965	1
<b>Coniopteryx</b> (Coniopteryx) <b>tineiformis</b> Curtis, 1834	3
<b>Coniopteryx</b> (Coniopteryx) <b>borealis</b> Tjeder, 1930	1
<b>Coniopteryx</b> (Coniopteryx) <b>parthenia</b> (Navás et Marcet, 1910)	7
<b>Coniopteryx</b> (Coniopteryx) <b>pygmaea</b> Enderlein, 1906	6
<b>Coniopteryx</b> (Coniopteryx) <b>aspoecki</b> Kis, 1967	6
<b>Coniopteryx</b> (Holoconiopteryx) <b>haemastica</b> McLachlan, 1868	1
<b>Coniopteryx</b> (Holoconiopteryx) <b>drammonti</b> Rousset, 1964	1
<b>Coniopteryx</b> (Metaconiopteryx) <b>esbenpeterseni</b> Tjeder, 1930	3
<b>Coniopteryx</b> (Metaconiopteryx) <b>arcuata</b> Kis, 1965	1
<b>Coniopteryx</b> (Metaconiopteryx) <b>lentiae</b> Aspöck et Aspöck, 1964	1
<b>Coniopteryx</b> (Metaconiopteryx) <b>tjederi</b> Kimmins, 1934	1
<b>Parasemidalis fuscipennis</b> (Reuter, 1894)	2
<b>Semidalis aleyrodiformis</b> (Stephens, 1836)	7
<b>Semidalis pseudouncinata</b> Meinander, 1963	3
<b>Conwentzia psociformis</b> (Curtis, 1834)	7
<b>Conwentzia pineticola</b> Enderlein, 1905	7
<b>Osmyliidae</b>	
<b>Osmylus fulvicephalus</b> (Scopoli, 1763)	7
<b>Sisyriidae</b>	
<b>Sisyra fuscata</b> (Fabricius, 1793)	7
<b>Sisyra terminalis</b> Curtis, 1854	3
<b>Sisyra dalii</b> McLachlan, 1866	1
<b>Sisyra jutlandica</b> Esben-Petersen, 1915	1
<b>Mantispidae</b>	
<b>Mantispa styriaca</b> (Poda, 1761)	7
<b>Hemerobiidae</b>	
<b>Drepanopteryx phalaenoides</b> Linnaeus, 1758)	7
<b>Drepanopteryx algida</b> (Erichson, 1851)	5
<b>Megalomus tortricoides</b> Rambur, 1842	1
<b>Megalomus hirtus</b> (Linnaeus, 1761)	7
<b>Megalomus tineoides</b> Rambur, 1842	1
<b>Megalomus pyraloides</b> Rambur, 1842	1
<b>Wesmaelius</b> (Wesmaelius) <b>concinus</b> (Stephens, 1836)	5
<b>Wesmaelius</b> (Wesmaelius) <b>quadrifasciatus</b> (Reuter, 1894)	7
<b>Wesmaelius</b> (Kimminsia) <b>fassnidgei</b> (Killington, 1933)	1
<b>Wesmaelius</b> (Kimminsia) <b>nervosus</b> (Fabricius, 1793)	3
<b>Wesmaelius</b> (Kimminsia) <b>helveticus</b> (Aspöck et Aspöck, 1964)	1
<b>Wesmaelius</b> (Kimminsia) <b>malladai</b> (Navás, 1925)	1
<b>Wesmaelius</b> (Kimminsia) <b>tjederi</b> (Kimmins, 1963)	1
<b>Wesmaelius</b> (Kimminsia) <b>subnebulosus</b> (Stephens, 1836)	7
<b>Wesmaelius</b> (Kimminsia) <b>ravus</b> (Withycombe, 1923)	3
<b>Wesmaelius</b> (Kimminsia) <b>balticus</b> (Tjeder, 1931)	1
<b>Hemerobius</b> (Hemerobius) <b>humulinus</b> Linnaeus, 1758	7
<b>Hemerobius</b> (Hemerobius) <b>perelegans</b> Stephens, 1836	3
<b>Hemerobius</b> (Hemerobius) <b>simulans</b> Walker, 1853	3
<b>Hemerobius</b> (Hemerobius) <b>stigma</b> Stephens, 1836	6
<b>Hemerobius</b> (Hemerobius) <b>pinii</b> Stephens, 1836	7
<b>Hemerobius</b> (Hemerobius) <b>contumax</b> Tjeder, 1932	6
<b>Hemerobius</b> (Hemerobius) <b>fenestratus</b> Tjeder, 1932	2

<b>Hemerobius</b> (Hemerobius) <b>atrifrons</b> McLachlan, 1868	7
<b>Hemerobius</b> (Hemerobius) <b>nitidulus</b> Fabricius, 1777	3
<b>Hemerobius</b> (Hemerobius) <b>schedli</b> Hölzel, 1970	1
<b>Hemerobius</b> (Hemerobius) <b>handschini</b> Tjeder, 1957	1
<b>Hemerobius</b> (Hemerobius) <b>micans</b> Olivier, 1792	7
<b>Hemerobius</b> (Hemerobius) <b>lutescens</b> Fabricius, 1793	6
<b>Hemerobius</b> (Hemerobius) <b>gilvus</b> Stein, 1863	1
<b>Hemerobius</b> (Brauerobius) <b>marginatus</b> Stephens, 1836	3
<b>Micromus</b> (Micromus) <b>variegatus</b> (Fabricius, 1793)	7
<b>Micromus</b> (Nesomicromus) <b>angulatus</b> (Stephens, 1836)	7
<b>Micromus</b> (Nesomicromus) <b>paganus</b> (Linnaeus, 1767)	7
<b>Micromus</b> (Nesomicromus) <b>lanosus</b> (Zeleny, 1962)	1
<b>Psectra diptera</b> (Burmeister, 1839)	2
<b>Symphherobius</b> (Sympherobius) <b>pygmaeus</b> (Rambur, 1842)	3
<b>Symphherobius</b> (Sympherobius) <b>elegans</b> (Stephens, 1836)	3
<b>Symphherobius</b> (Niremberge) <b>fuscescens</b> (Wallengren, 1863)	6
<b>Symphherobius</b> (Niremberge) <b>pellucidus</b> (Walker, 1853)	3
<b>Symphherobius</b> (Niremberge) <b>klapaleki</b> Zeleny, 1963	1
<b>C h r y s o p i d a e</b>	
<b>Nothochrysa fulviceps</b> (Stephens, 1836)	7
<b>Nothochrysa capitata</b> (Fabricius, 1793)	7
<b>Hypochrysa elegans</b> (Burmeister, 1839)	6
<b>Nineta flava</b> (Scopoli, 1763)	7
<b>Nineta gadarramensis</b> (Pictet, 1865)	7
<b>Nineta vittata</b> (Wesmael, 1841)	7
<b>Nineta carinthiaca</b> (Hölzel, 1965)	7
<b>Nineta inpunctata</b> (Reuter, 1894)	7
<b>Nineta pallida</b> (Schneider, 1851)	7
<b>Chrysotropia ciliata</b> (Wesmael, 1841)	7
<b>Chrysopa perla</b> (Linnaeus, 1758)	7
<b>Chrysopa walkeri</b> McLachlan, 1893	7
<b>Chrysopa dorsalis</b> Burmeister, 1839	7
<b>Chrysopa hungarica</b> Klapalek, 1899	6
<b>Chrysopa abbreviata</b> Curtis, 1834	7
<b>Chrysopa formosa</b> Brauer, 1850	4
<b>Chrysopa phyllochroma</b> Wesmael, 1841	7
<b>Chrysopa commata</b> Kis et Ujhelyi, 1965	7
<b>Chrysopa viridana</b> Schneider, 1845	4
<b>Chrysopa nigricostata</b> Brauer, 1850	7
<b>Chrysopa septempunctata</b> Wesmael, 1841	7
<b>Anisochrysa flavifrons</b> (Brauer, 1850)	7
<b>Anisochrysa inornata</b> (Navás, 1901)	7
<b>Anisochrysa prasina</b> (Burmeister, 1839)	7
<b>Anisochrysa ventralis</b> (Curtis, 1834)	7
<b>Tjederina gracilis</b> (Schneider, 1851)	7
<b>Chrysoperla carnea</b> (Stephens, 1836)	7
<b>Cunctochrysa albolineata</b> (Killington, 1935)	7
<b>M y r m e l e o n i d a e</b>	
<b>Dendroleon pantherinus</b> (Fabricius, 1787)	6
<b>Acanthaclisis occitanica</b> (Villers, 1789)	3
<b>Myrmecaelurus trigrammus</b> (Pallas, 1781)	3
<b>Myrmeleon</b> (Myrmeleon) <b>formicarius</b> Linnaeus, 1767	7
<b>Myrmeleon</b> (Morter) <b>hyalinus</b> Olivier, 1811	3
<b>Myrmeleon</b> (Morter) <b>inconspicuus</b> Rambur, 1842	4
<b>Myrmeleon</b> (Morter) <b>bore</b> (Tjeder, 1941)	1
<b>Euroleon nostras</b> (Fourcroy, 1785)	7
<b>Distoleon tetragrammicus</b> (Fabricius, 1798)	7
<b>Creoleon lugdunensis</b> (Villers, 1789)	3

<b>Megistopus flavicornis</b> (Rossi, 1790)	3
<b>Ascalaphidae</b>	
<b>Libelloides coccajus</b> (Denis et Schiffermüller, 1775)	7
<b>Libelloides longicornis</b> (Linnaeus, 1764)	4
<b>Libelloides macaronius</b> (Scopoli, 1763)	6

	Number of species	State of investigation	With descriptions of the larval stages
Sialidae	4	4	100 %
Raphidiidae	13	12	92,3 %
Inocelliidae	3	3	100 %
Coniopterygidae	22	14	63,6 %
Osmylidae	1	1	100 %
Sisyridae	4	2	50 %
Hemerobiidae	41	27	65,9 %
Chrysopidae	28	28	100 %
Mantispidae	1	1	100 %
Myrmeleionidae	11	11	100 %
Ascalaphidae	3	3	100 %
	131	106	80,9 %

Table 2: Survey of the knowledge on the larval stages of Neuroptera, arranged in family groups.

## DISCUSSION OF THE FAMILIES

### Sialidae

The egg clutches and later larvae instars of the Central and Northern European sialids became distinguishable through KAISER's (1961 and 1977) illustrated publications. Young larvae and pupae remain problematical.

### Raphidiidae

12 of the 13 Central European raphidiid species were described in their larval stages by ASPÖCK et al. (1974 a + b, 1975). At least the later instar larvae permit an identification to species.

### Inocelliidae

The descriptions of the later larval stages of 2 of the 3 Central European inocelliid species were published by ASPÖCK et al. (1974 a + b).

## Coniopterygidae

The coniopterygids, with their minute larvae, are the family of Central European Neuroptera of which we have least scientific knowledge. Although the genera can be identified by their antennae (GEPP & STÜRZER, unpublished), the species-rich group of **Coniopteryx** in particular is still difficult to survey in its larval stages. Only 9 out of 23 species (39.1 %) have been described in the third instar. The rearing of larvae is difficult because of long egg stages, susceptibility to desiccation and food specialization.

## Osmylidae

The biology, larval morphology, and some facts relating to the ecology of **Osmylus fulvicephalus** - the only Central European osmylid species - are largely clarified. A monographic presentation is being prepared.

## Sisyridae

Of the 4 Central European sisyrid species, 2 have been described as larvae (a monographic presentation is being prepared).

Laboratory breeding of sisyrids is extremely difficult (oviposition!) and for many years their existence in nature has been threatened by water pollution and river channeling.

## Mantispidae

Since BRAUER (1852), the larva of the only Central European species, **Mantispia styriaca**, has been known to be a kleptoparasite in cocoons of wolf spiders. Later BRISTOWE (1932) and SCHREMMER (1959, 1983) published further observations.

## Hemerobiidae

Research on hemerobiid larvae has stagnated almost completely since KILLINGTON's monographs (1936 and 1937). The main reasons for this are the great variety of species on the one hand, and on the other hand the difficulty of interpreting the variability of the larval habitus in the field. Nearly 55 % of the Central European species are described in their larval stages. The species of **Symphorobius** can only be reared with great difficulty beyond the first instar. Under laboratory conditions the species of **Wesmaelius** and **Eumicromus** usually die in their egg stages. The species of **Megalomus** can hardly ever be induced to oviposit. Field captures of **Drepanopteryx algida** are rare during the oviposition period. The genus **Hemerobius** is relatively well known - clear characteristics for the identification of the 14 species are, however, lacking.

## Chrysopidae

The larval stages of chrysopids have been largely investigated - yet detailed results of the author's research are still unpublished. An identification key including several colour photographs already exists for living larvae of all the Central European species (GEPP 1983), another for alcohol-preserved larvae is in preparation. Complementary research on **Hypochrysa elegans** (1st and 2nd instar), **Chrysopa formosa** (2nd instar), and **Chrysopa hungarica** (3rd instar) would be desirable.

## Myrmeleonidae

A differentiation of the Central European ant-lions has been possible since REDTENBACHER's (1884) work. In this respect, STEFFAN (1965 and 1969) and WILLMANN (1977) must be mentioned as other important authors. Recent rearings confirm the former findings and, at the same time, give insight into extraordinarily interesting biologies.

## Ascalaphidae

All 3 species of Central European ascalaphids are known in their larval stages (ROUSSET 1973, PIEPER & WILLMANN 1980, GEPP, unpublished). Their biologies and

ecological differentiation have, however, been poorly investigated to date.

## PROSPECTS

Within the next few years some proposed monographs (ASPÖCK, ASPÖCK & RAUSCH: Raphidiopteren der Erde; GEPP: Biologie der Neuropteren Mitteleuropas; HÖLZEL: Aquatische Neuropteren) will contribute to the present knowledge of the larval stages of Central European neuropterans. Characteristics, biological references, and comments on the ecological requirements will be available for the larvae of all common Central European species of Neuroptera. Moreover, illustrated publications will facilitate identifications for applied pest control purposes.

In contrast to this, we are still far from a satisfactory situation regarding the prey spectra, parasites and ecological parameters. Knowledge of these, however, is an essential prerequisite for evaluating the efficiency of entomophagous neuropterans. Therefore, in order to complete our knowledge, future research work on the Neuroptera of Central Europe will have to place emphasis on several areas:

- a) clarification of the larval biology, and identification of still unknown larval stages;
- b) completion of the knowledge on relevant species for applied control;
- c) natural prey spectra;
- d) parasite complexes.

Including the unpublished knowledge, 8 of the 11 recent Central European families can be judged as being well investigated. With respect to their larval stages, the species-rich families Coniopterygidae and Hemerobiidae are mainly considered as poorly studied.

In general, our knowledge of the biologies of the Central European species of Neuroptera is based on laboratory observations. Their field ecology and natural behaviour in the biotope are relatively poorly known.

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