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AUTECOLOGY AND BIOLOGY OF NEMOPTERA SINUATA OLIVIER (NEUROPTERA: NEMOPTERIDAE)

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Specimens of *Nemoptera sinuata* were reared from eggs to second instar larvae in captivity, and observations on imagos were carried out in the Struma Valley, Bulgaria. The adults occur in open sunny places in river gorges and feed only on pollen. They are most active at noon between the middle of May and the end of June. The males occur one week earlier than the females. The eggs are laid directly on the ground, most often in the morning. They are spherical (rare among Neuroptera), white, opaque, with one micropyle. Up to 70 eggs are laid by a female over a period of 10 days. The egg stage usually lasts from 23 to 25 days. The lid is cut off by an eggbreaker during hatching. The newly hatched larvae are 2.0–2.1 mm long, are terricolous and always buried themselves by digging to 1 cm in depth. The larvae rejected living or freshly killed arthropods, or roots and blossoms of plants. They were only observed to take water and vegetable sap. The longest surviving larva moulted in September (first instar lasts 72 days) and hibernated. It increased in length to 5 mm and died in April after being reared for nine months.

Key words: *Nemoptera sinuata*, imaginal ethology, feeding, oviposition, egg, hatching, larva

INTRODUCTION

Investigations on the autecology and the early stages of *Nemoptera sinuata* OLIVIER, which are reported here, were carried out more than 30 years ago. They included a rearing from imago to second instar larva. The observations and conclusions on the behaviour, feeding and habitat of the adults and the larvae were the subject of my thesis (POPOV 1967). These observations were not published because I expected to continue the rearing of a mature larva, prepupa and pupa.

At the time of the investigations there was no information on either the egg and larva, the biology and habits of the larva, or the feeding and behaviour of the imago. There were almost no detailed data on the whole family Nemopteridae *sensu* MONSERRAT (1996), now comprising 90 taxa. The development and the preimaginal stages of a number of species, mainly from the closely related family Crocidae distributed in the southern Hemisphere, has recently been investigated by MANSELL (1973, 1981, 1983*a, b* etc.) and of *Nemoptera bipennis* (ILLIGER) and all the Spanish representatives of both families by MONSERRAT (1983*a, b*, 1985*a*, 1996). A mature larva of *Nemoptera coa* (LINNAEUS) from Greece was reared to imago by TRÖGER (1993). Their results are very similar to my observations on

Nemoptera sinuata. The pollenophagy of the adults of *N. sinuata* was observed for the first time and my suggestion (POPOV 1967), that the structure of the mouthparts in the whole family Nemopteridae *sensu lato* proves feeding only on pollen, was confirmed by field observations of some authors, *e.g.* MONSERRAT (1985*b*) on *N. bipennis* and PICKER (1987) on *Palmipenna aeoleoptera* PICKER. Also my proposal (POPOV 1973) that Nemopterinae and Crocinae should be regarded as distinct families, if essential differences in all stages were confirmed after the discovery of the larvae of other genera, was realized by MONSERRAT (1996).

IMAGO

The observations on the imago of *N. sinuata* were carried out in 1965–1967 in the field in Kresna Gorge along the valley of Struma River in southwestern Bulgaria and in captivity in Sofia. For this purpose living nemopterids were transferred to broad glass tubes containing blooming flowers. They were reared between glass and cloth screen with blossoming plants in glass jars with water.

The imago of *N. sinuata* occurs in meadows and open sunny places with Mediterranean and Submediterranean vegetation in sheltered river gorges. The adults prefer the yellow blossoms or racemes of plants, such as *Achillea coarctata* POIR. (Asteraceae), *Alyssum murale* WALDST. et KIT. (Brassicaceae) and *Hypericum rumeliacum* BOISS. (Hypericaceae).

The flight period usually lasts from the middle of May to the end of June with the earliest and latest collecting dates May 2nd and July 8th. The phenological maximum is in the first ten days of June. The males occur one week earlier than the females.

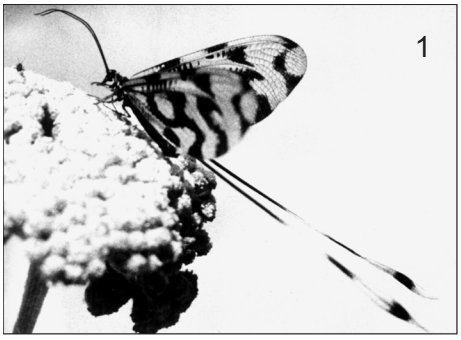
The flight of *N. sinuata* is easy and graceful, but slow. The flapping is done only with the forewings, while the hindwings remain static. The coloration of the wings provides effective camouflage and the adults are difficult to see. The imagos begin to fly in the morning and are most active at noon in sunny weather. In cloudy weather they remain perched on the blossoms with their forewings wide open and their hindwings directed at an angle of 40–45° and slightly twisted towards the ends. When it rains, they retreat below the blossoms with their forewings up above the back.

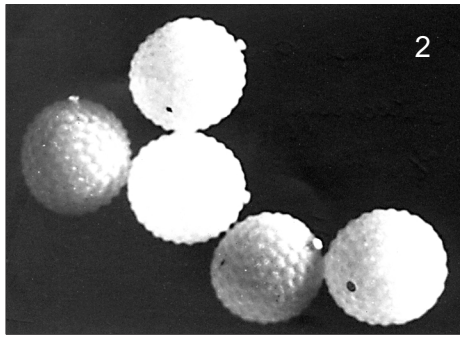
N. sinuata is a diurnal insect. It flies, feeds and lays eggs only during the day. When reared in a room or in a cage, the adults always fly and settle on more illuminated or sunlit spots.

The specimens reared under different conditions in captivity lived from 5 to 13 days. Taking into consideration that they were caught in the middle of the flight

period of the species in the same locality and that all females had already been fertilized and were laying eggs, it can be assumed that in the field the life span of the adults is nearly 20 days.

The observations in 1965 showed that the imago of *N. sinuata* feeds exclusively on pollen. It inserts its mouth parts into the floret cornet of *Achillea* and tears off the pollen bags. The clypeus and labrum of the insect become covered with pollen. The imago occasionally collects pollen with the tarsi of the forelegs, wiping the tarsi through its mouthparts and swallowing the pollen. The mouthparts of *N. sinuata* and Nemopteridae *s. l.* as a whole have a tearing function rather than chewing and are structured to feed only on pollen (Fig. 1). The main role in feeding is played by the maxillae and the labium, while the almost immovable mandibulae and labrum have no part at all. The maxillae move simultaneously and quickly up and down due to the strongly movable articulation between the stipes and the palpifer. The same movements are executed by the strongly elongated labium. During feeding the rostrum projects into the floret, opening it, and the distal parts of the maxillae and the labium, namely both galeae and both pairs of palpi, with their upward movements draw out the pollen grains from the bottom of the chalice to the mouth opening. The pollenophagy in *N. sinuata* was also confirmed by the analysis of the gut contents and the excrements of the imago. Both the proventriculus and the ventriculus were filled with whole grains, and the excrements with their shells, which are the same as the reference sample of pollen grains of *Achillea coarctata*. Thus the pollenophagy in nemopterids was recorded for the first time and accepted by analogy for the whole family because of the structure of the mouthparts. This was confirmed by the finding of pollen in the gut contents of a number of species by TJEDER (1967) and by observations on other species by other authors (see Introduction).





Figs 1–2. *Nemoptera sinuata*: 1 = feeding on a raceme of *Achillea coarctata*; 2 = eggs

EGG

The eggs are usually laid in the morning. The female, with half open wings and a drooping abdomen, perched on blossoms or racemes of plants, *e.g. Achillea*. An egg appears every two minutes and after 4–6 eggs the female moves on to another raceme. The eggs fall directly to the ground or on dry vegetation. They are not adhesive, but elastic and bounce when coming into contact with a hard surface, as for example a piece of wood.

The eggs (Fig. 2) are spherical, snow-white, opaque, lustreless, with a diameter of 0.83–0.90 mm and with one micropyle. It should be mentioned that the genus *Nemoptera* is one of the few genera among all Neuroptera with spherical shape to the eggs. The chorion is highly sculptured, with irregular hexagonal convexities on the surface, which touch one another. About 30 convexities have been counted on the periphery of the egg and about 180 convexities on the whole egg surface. When seen from above, the micropyle has the form of a disk; in profile it looks like a cornet with no opening in it.

According to the observations in the laboratory, the number of eggs laid by one female is up to 70. Eggs are laid for about 10 days during the total life span of 20 days of the female. Within the first five days the number gradually drops from 14 to 9 eggs per day.

The egg stage covers 20–26 days on the basis of the rearings in 1965–1967, most frequently 23–25 days at air temperatures of 19–27° in the laboratory. The duration of the egg phase depends on the temperature. For example, 16 eggs were put in a refrigerator for 10 days at 6° and the larvae were hatched with 12 days delay. While at 30–32° temperatures the hatching occurs after 19 days.

LARVA

After the fifteenth day the egg becomes light pink and then grey on one side. The embryo lies in the form of a semicircle in the egg. A polar lid with the micropyle in the centre is opened during hatching. The lid is cut off by an egg-breaker on the larval clypeus. The egg-shell breaks by pressure from the dorsal surface of the larva. The split becomes almost a complete circle and the lid separates without breaking from the egg. The larva pulls out the dorsal part of the thorax first, then the head in two or three minutes and the abdomen at the end. Filling its tracheae with air, the larva becomes bigger in one to two hours and begins to move slowly, until it hides.

The newly hatched larva is 1.7–1.8 mm long or 2.0–2.1 mm long including the jaws. It is dorsally grey, with an oblong transverse dark spot on both sides of the median line of every thoracic and abdominal segment and a large, almost black spot on the head. The body densely is haired with long and short setae: macrotrichia, dolichasters and micrasters. The length of some of the macrotrichia is equal to almost one third of the body length. The head is trapezium-shaped to rectangular, 0.38 mm long and 0.55–0.65 mm wide, and occupies together with the jaws more than one third of the body in length. The slowly movable head moves only in a vertical direction. The jaws are large, broad, gradually curved inwards, sharply-pointed at the apices, with a flat and rounded outer margin covered with long macrotrichia, with 9 short dolichaster-like setae on the inner margin. The eye spot consists of 7 stemmata. Antennae are composed of one small basal segment and one large, curved, rounded and dilated segment. Palpi labiales are very short, four-segmented. Legs are short, with hard spines. The abdomen is broad and ten-segmented. The first instar larva of *N. sinuata* from Bulgaria is very similar to that of *N. bipennis* reared by MONSERRAT (1996). The former differs from the latter in the shape of the black spot on the head and in its wide and short abdomen.

I could not find any living larvae in the field, to define their habitat. When reared in captivity in 9 microhabitats (soil, sand, peat, leaves, etc.), the larvae always buried themselves by digging to 1 cm depth. They are consequently assumed to be terricolous.

For the entire duration of rearing (9 months) no answer was found to the question of how the larvae feed. They were offered the common caterpillars of *Plodia interpunctella* (HÜBNER), larvae of *Tenebrio molitor* LINNAEUS, imagos of *Drosophila* FALLÉN, *Musca domestica* LINNAEUS, *Sitophilus granarius* (LINNAEUS), as well as field-collected Collembola, Acarina, Psocoptera, Psyllina, Formicidae and various families of Diptera. The larvae of *Nemoptera* paid no attention either to living, or to freshly killed small arthropods, or to cut out pieces of those with body fluids. The result was also negative with Enchytraeidae, *Tubifex* LAMARCK, segments of Lumbricidae, living snails, as well as with mellow roots of herbaceous plants or their blossoms. The larvae were only observed to dip the apices of their jaws into drops of water and into the sap of newly cut carrots or potatoes. The typical predatory feeding habit as well as the parasitic one is not characteristic at least for the first instar larva of *N. sinuata*. The hypothesis of MONSERRAT and MARTINEZ (1995) on possible myrmecophily of Nemopteridae *s. str.* in the larval stage seems quite probable bearing in mind the rejection of a wide range of prey by the larvae of *N. sinuata* in Bulgaria and of *N. bipennis* and *Lertha sofiae* MONSERRAT in Spain, as well as the experiments for harvesting of eggs and eventually of young larvae by some ant species in their nests. The successful feeding of

the third instar larva of *Nemoptera coa* in captivity by TRÖGER (1993) only appears to contradict the hypothesis. Feeding on ant larvae may be necessary and obligatory for only the first and eventually the second instar larvae of *Nemoptera*.

The longest reared larva moulted on 23rd September; the instar lasts 72 days. The second instar larva has a more elongated body, darker coloration and a relatively smaller head, corresponding to one fifth of the body. Every segment has a small tubercle laterally with tufts of black macrotrichia.

The larvae move slowly and clumsily, and only forwards. They cover about 6 cm over 30 seconds. The larvae always try to bury themselves, going forward with their head. When touched, they become immovable and appear to be dead. This lasts from half a minute to one minute or rarely two minutes.

The longest living larva was left to hibernate at the end of November. A small bowl with sand was put in a bigger bowl with regularly moistened sand at temperatures between +5° during the night and 10° during the day. The larva spent the winter in the sand in the form of a crescent without making any nest around itself. After being taken out of the sand, it would become active after several minutes. After the hibernation, it still did not accept food. The larva died on 9th April next year after being reared for nine months. Although no feeding was observed, the larva increased in size from 2 mm at hatching to 4.1 mm at moulting to 4.8 mm before hibernation and to 5 mm in the end of its life.

In conclusion, the known first half of the life cycle afforded an opportunity to speculate on the development of *N. sinuata*. It probably passes through a second moulting at the beginning of summer, hibernation of the third larva, forming of a cocoon in April and emerging of the imago after one month total duration of the prepupal and pupal stages.

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This report was presented on the Sixth International Symposium on Neuropterology held in Helsinki in 1997. Only an abstract of it has been published in the Proceedings of the Symposium (POPOV 1998) because I intended to include the original data in a detailed comparative review on the eggs, larvae and development of nemopterids. As that has not been realized, the full report is published in the present volume.

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