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OBSERVATIONS ON *NOPHIS TEILLARDI* NAVAS (NEUROPTERA: MYRMELEONTIDAE), WITH DESCRIPTION OF THE LARVA1

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ABSTRACT

The larva of *Nophis teillardi* Navas, an eremic species that reaches its northernmost limit of distribution in Israel, is described for the first time. Life cycle, habitat preference and larval foraging behaviour are also described. *Thyridanthrax* sp. (Diptera, Bombyliidae) was found to parasitise the larva. *KEY WORDS:* Myrmeleontidae, *Nophis teillardi,* foraging behaviour, habitat preference, Israel, distribution.

INTRODUCTION

The ant-lion genus *Nophis* (Myrmeleontidae, Myrmecaelurini) was described by Navas in 1912 and redescribed by Holzel in 1969. It contains 3 species. The type species, *N. teillardi* Navas, 1912, was described from Algeria and is now known from Tunisia (L.A. Stange, personal communication), Egypt, Saudi-Arabia and Israel (Holzel, 1972, 1982; Simon, 1979). The two other species, *N. flava* and N. *lutea,* were described from Arabia (Holzel, 1972). However, *N. flava* is presently known also from Sudan and Sinai (Holzel, 1982).

Within the Myrmecaelurini, only the larva of *Myrmecaelurus trigrammus* (Pallas) has been described and figured by several authors (Steffan, 1975; Willmann, 1977; Aspock et al., 1980). Based on the study of larvae, Stange and Miller (1985) included the Myrmecaelurini in the Brachynemurini.

Publications dealing with myrmeleontid larvae were listed by Stange (1970), Heinrich and Heinrich (1984) and Mansell (1985). Recent papers on myrmeleontid larvae, not mentioned by these authors, are those of Furunishi and Masaki (1981), on Japanese ant-lions and the important, pioneering generic review of Stange and Miller (1985). Most of the available information deals with morphological and systematic aspects of the larvae. Biological data are scarce and primarily concerned with genera whose larvae are known to construct pits, which are easily found. The larva of *N.*

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teillardi does not construct pits. Nevertheless when active, it can be relatively easily detected in the field by its characteristic track. This enabled me to make biological observations that together with laboratory studies formed the present paper.

It is a pleasure to dedicate this paper to my teacher, Prof. J. Kugler, on the occasion of his seventieth birthday.

MATERIALS AND METHODS

During 1983-1985, larvae of *N. teillardi* were studied in sandy biotopes in the Coastal Plain of Israel as part of a comparative ecological investigation of ant-lion larvae. Most *N. teillardi* larvae were located by their characteristic tracks, but some were found by sifting sand under plants. Observations on the foraging behaviour, mainly of 3rd instar larvae, were made both in the field and in the laboratory. For behavioural observations larvae were kept in 40x40x23 cm styrofoam boxes with a 10 cm deep layer of sand, taken from the natural habitat of the larvae. For rearing purposes larvae in various stages of development were kept separately in plastic jars on a substrate of sieved sand and fed upon maggots of *Musca domestica*.

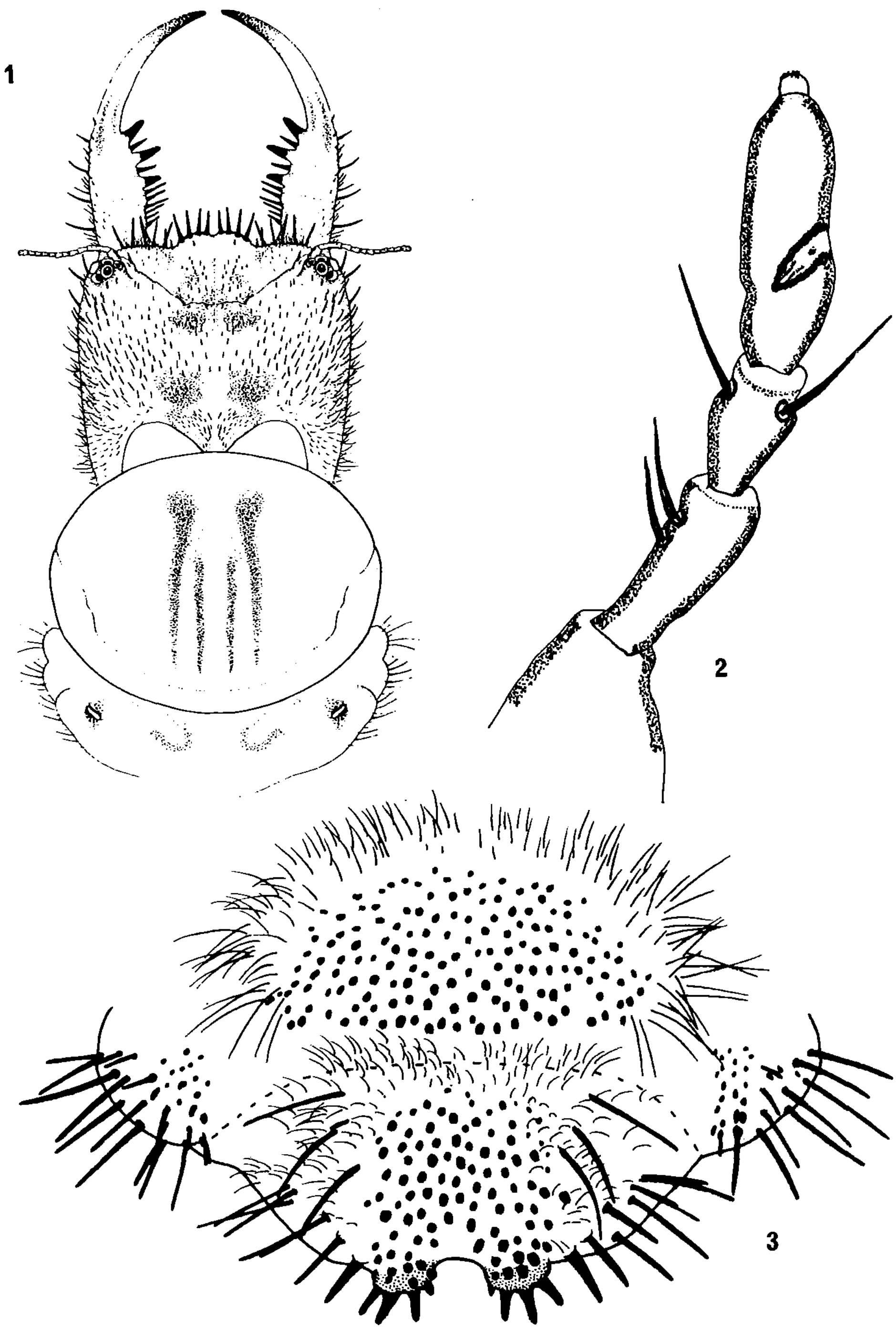
Terminology of larval morphology follows Henry (1976). Measurements follow Lucas & Stange (1981). SEM photographs were taken with Jeol 35 Scanning Electron Microscope. All photographs and drawings were taken of 3rd instar larvae. Specimens are deposited in the Entomological collection, Department of Zoology, Tel-Aviv University.

DESCRIPTION OF THIRD INSTAR LARVA

Measurements (n=40): Length of mature larva (excluding jaws): 10-13 mm. Width of head capsule: 1.9-2.0 mm. Length of jaw: 1.5-1.7 mm.

Color: Pale brown; head with two pairs of darker brown spots dorsally; the anterior pair partly united; clypeus with a dark brown area proximally; ventral surface of head cream-colored without spots; jaw reddish-brown, distal (3rd) tooth black, central (2nd) and proximal (1st) teeth mostly black; pronotum with four brown longitudinal stripes medially, more or less united anteriorly; mesonotum with two oval brown spots.

Head: (Fig. 1): Quadrate, approximately as wide as long; slightly broader anteriorly; middle of labral margin slightly protruding and slightly bilobed; each lobe bearing five, rarely four, long black setae. Dorsum with very short setae. Dolichasters absent. Ocular tubercle short, rounded, not protruding from lateral head margin. Ventral stemma far away from others, close to base of mandible, slightly smaller than dorsal stemmata. Antennal tubercle cylindrical; only 10-11 well differentiated segments; the second and last flagellomeres, each consisting of a number of united segments, are longer than the others. Jaws slightly longer than head; the narrow, distal part nearly equal in length to the swollen, tooth-bearing, basal part; three mandibular teeth; proximal tooth small; central tooth the longest; distal tooth proclinate at an angle of 45°; 6-9, usually 7 setae between base of mandible and 1st tooth; their lengths decline toward base; single seta, each, between 1st and 2nd tooth and between 2nd



Figs. 1-3. *Nophis teillardi*, 3rd instar larva. 1. Head capsule and anterior part of thorax. 2. Labial palp with part of the palpiger. 3. Sternite VIII + IX.

and 3rd tooth; external margin of mandible from base to about level of tooth 3 with about 5 long setae intermixed with numerous small and dense setae. Labial palp (Fig. 2) 3 segmented; longer than width of mandible at base; distal palpomere 3 times as long as wide.

Body: Elliptical in outline; pronotum more sclerotized than other parts, slightly wider than head, roughly oval. Scoli absent. Mesothoracic spiracles dorsolateral, small, nearly flat. Metathoracic spiracles dorsally oriented. All abdominal spiracles dorsolateral, very small.

Terminal segments (Fig. 3, 4, 5): Sternite VIII with long spines laterally, with an elliptical area of short and broad spines medially surrounded by a wreath of setae; without submedian teeth; sternite IX (Figs. 3, 4) with long spines laterally, with an area of short and broad spines medially that is narrower than the one on sternite VIII; sternite IX distally bilobed, lobes heavily sclerotized, each bearing three stout spines and some additional very short spines. Spinneret (Fig. 5) distally flattened. Anus elongate.

Ontogenetic Variation: The first instar larva of *N. teillardi* differs from the mature larva, in addition to size, mainly by its dark brown, shiny head and blackish ocular tubercles. Its maximal length (n=5) is about 5 mm, the head width is 0.7-0.9 mm, and the jaw length is 0.7 mm. The color of the second instar larva is intermediate between the first and third instars. Its maximal length (n=26) is about 8 mm, the head width is 1.0-1.2 mm, and the jaw length is 1.0-1.1 mm.

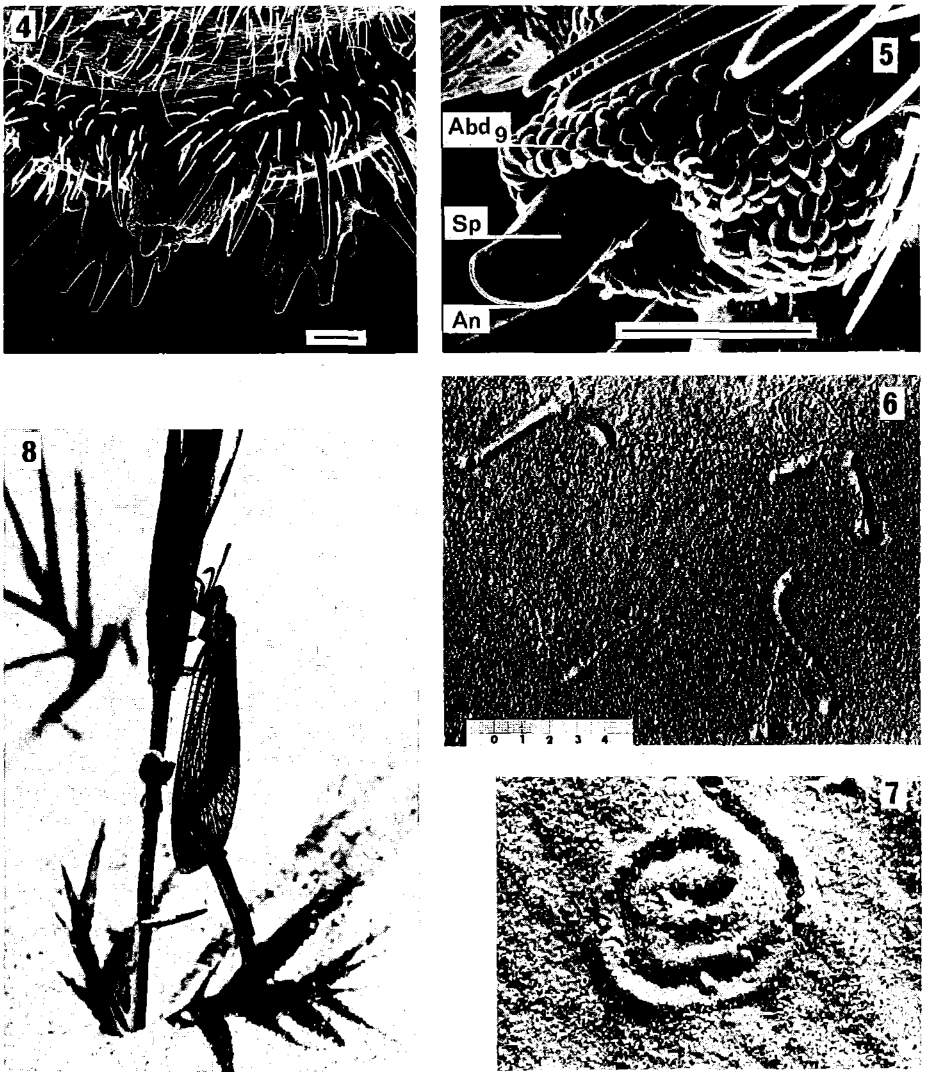
HABITAT PREFERENCE

Nophis teillardi is a psammophilic species that occupies various types of sandy soils. In the Southern Negev larvae were found in river beds with coarse sand and gravel. In the Northern Negev they were found in sandy loess. In the Coastal Plain larvae were most frequently found inhabiting semistable dunes with moderate vegetation cover. The predominant plant species in this habitat is *Artemisia monosperma* Del. (Asteraceae) (for fuller description of the habitat see Kutiel et al., 1979/80). Denser populations of about 4-5 larvae per m^2 were found on more stable soil, where shallow sand covered a hard pan of aeoleantic sandstone (Kurkar) or sandy loam soil (Hamra). In these areas larvae often inhabited a layer of loose sand that is 10 mm deep or less. The least populated habitat was the foot of moderate slopes of drifting dunes.

Regardless of the type of habitat, larvae were normally located in open area, under direct sunshine, away from vegetation or along its edge. Only rarely were they sifted from sand collected under plants. It is noteworthy, that larvae of *N. teillardi* were often found in the vicinity of nests of their main prey, ants of the genus *Messor* (*M. arenarius* (Fabricius) and *M. ebeninus* Forel). Sometimes they were found in the sand that had been carried out by the ants from the nests.

FORAGING BEHAVIOUR

The larva of *N. teillardi* is free-living in sand and does not construct pitfalls.



Figs. 4-8. *Nophis teillardi*. 4. SEM photograph of abdominal segment IX. Bar = 100 µm. 5. SEM photograph of abdominal segment IX with spinneret partly extruded. An = Anus, Sp = Spinneret, Abd 9 = Abdominal segment IX, Bar = 100 µm. 6. Tracks of 3rd instar larva formed during regular movement. 7. Spiral track of 3rd instar larva formed during the persue of prey; note the dead ant in the center. 8. Male, shortly after landing on a stem.

Moving occurs both forwards and backwards, creating a species-specific track pattern (Fig. 6). Backward movement beneath the surface leaves an S-shaped, furrow-like track, which alternates with the tracks of the abdomen and tarsi created during forward movement on the surface of the sand. When the larva stops moving, it pushes its head vertically above the surface, with rapid back and forth and lateral movements, thus forming a small and very shallow depression. Then it buries its head again beneath the surface of the depression and sometimes uses its anterior legs to complete the cover. Rapid movements of the erect antennae brush sand grains off the eye tubercles, exposing the dorsal stemmata and facilitating vision. The apex of the antenna usually remains uncovered, while the jaws are spread about 180° and are hidden beneath the sand.

The larva usually remains motionless in this position from 8 to 24 hours, but some larvae remained stationary for 3 days before changing their site. Prey passing within a few millimeters from the ambushing larva is immediately caught by the jaws and dragged down and backward into the sand in a spiral movement. After being sucked out, the prey is usually discarded at the center of the spiral (Fig. 6). Larvae were never observed pursuing their prey by moving forward. In the field, 90% of the prey captured were ants of the genus *Messor*.

In the laboratory, slight vibrations of the sand produced by a thin brush (imitating the movement of an insect), caused the larva to suddenly project its jaws above the sand surface and quickly close them in an effort to catch prey. At the same instant the larva burrowed rapidly deeper into the sand. If the vibrations continued, the larva protruded its whole head above the surface, in an attempt to locate the prey.

PREDATORS AND PARASITES

Little direct evidence is available concerning predators and predation of ant-lion larvae. Examination of stomach contents of fringe-toed lizards, *Acanthodactylus scutellatus* (Audouin), showed remnants of the larvae of 3 species of ant-lions, including one 3rd instar larva of *N. teillardi* (Avital, personal communication). Faecal analysis of the skink *Chalcides sepsoides* (Audouin) also revealed remnants of an *N. teillardi* larvae.

3rd instar larvae were occasionally found to carry tiny (0.8 mm), elongate bombyliid larvae on their bodies. The parasitoid (usually one per host) remained inactive throughout the larval development of the ant-lion and renewed its activity only after cocoon formation and pupation. Flies that emerged from infested cocoons were identified by Prof. O. Theodor, the Hebrew University, Jerusalem, as an undescribed species of *Thyridanthrax* (Diptera, Bombyliidae).

THE ADULT

In the field adults were observed during daytime resting on thin, vertical stems at the lower parts of plants. The male (Fig. 8) is easily recognized in the field by its long abdomen which is bent ventrally like a siphon in segments 5-6. The male clings to the stem with his legs, his wings are placed at each side of the stem and his long abdomen drooping, with the bend supported by the stem and the apical half of the abdomen slightly diverging from it. The female's position is similar, but her entirely straight abdomen droops vertically. Compared with many other species (Simon, unpublished data) adult life-span is long. In the laboratory females lived up to 30 days. Specimens of *N. teillardi* from the study area at the Coastal Plain have a darker appearance in comparison to specimens from North-Africa (Hölzel, personal communication) and also from specimens collected in the southern parts of Israel.

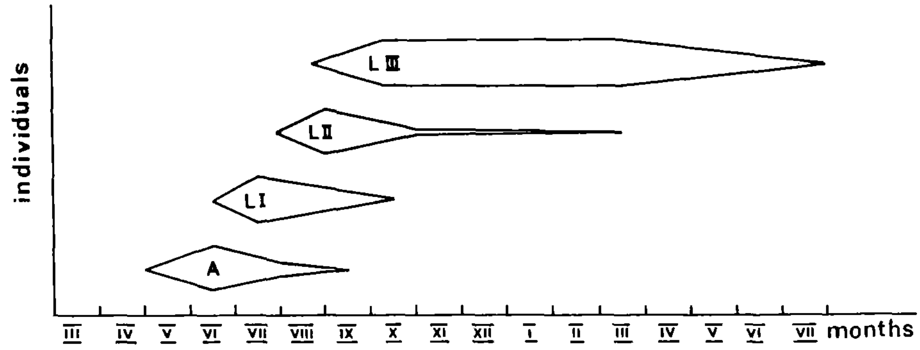


Fig. 9. *Nophis teillardi*, annual cycle: Schematic representation of seasonal occurrence of adults and immature stages. A = Adult, L I, II, III, = 1st to 3rd Larval instars

DISTRIBUTION AND PHENOLOGY

In Israel the distribution of *N. teillardi* extends from northeastern Sinai through the South and Central Coastal Plain as far north as Caesarea (32 31 N, 34 53 E) and also to the Southern and Northern Negev.

N. teillardi is a univoltine species, showing considerable overlap of the different larval instars (Fig. 9). First and second instar larvae found in summer (from early May to early October) hatched from eggs deposited in the same year. The number of third instar larvae observed in the field reached its peak during the end of the summer (mid September and early October) matching a decline in the number of second instar larvae. Of 29 larvae collected at one site near Herzliyya in the beginning of October, 22 were third instar, 6 were second instar and only one was a first instar larva. The winter is spent in the third larval instar and only rarely in the second instar. Adults first appear in the field in early May. There was a clear peak in the number of adults observed in the field during June, and the population size declined to almost zero at the end of July. However, some adults were found sporadically as late as September. Third instar larvae that were kept in the laboratory under natural lighting had a delayed cocoon formation of about 2 months, and most adults emerged in August. Pupal duration (in room temperature of 26 ± 2°C) was 38-42 days (n = 7).

DISCUSSION

In the sandy study areas of the Coastal Plain of Israel, 15 myrmeleontid species have been recorded, and the larvae of 10 species have been collected (Simon, unpublished). The mature larva of *N. teillardi* differs from all other species by its humpbacked appearance, light brown color, relatively short jaws with swollen proximal part (Fig. 1) and bilobed fossorial appendage on sternite IX. Moreover, its track is also characteristic (Fig. 7).

The distribution of *N. teillardi* is typical West-Eremian (Saharo-Arabian) (Hölzel, 1972). The deep northern penetration of this species into the mediterranean area, along the sandy biotops of the Coastal Plain, represents a well known phenomenon in the zoogeography of Israel (Por, 1975).

In comparison to other psammophilous larvae (Simon, unpublished) *N. teillardi* occupies very shallow sands. This ability is probably a result of its being more thermophilic than other species. While in deeper sand thermoregulation by vertical movement is an efficient strategy (Heinrich & Heinrich, 1984), in shallow sand it is difficult to thermoregulate by using this technique, and the larva is exposed to higher temperatures during daytime. An advantage to living in shallow sands could be the following: after the beginning of the rains in autumn, the larvae are trapped in the wet sand and become inactive. It was observed that during the intervals between the rains, when the sand becomes dry and loose again, larvae inhabiting shallow sands renew their activity earlier than larvae inhabiting deeper sands. The same advantage could be gained by larvae inhabiting open areas instead of shady locations, at the edge of vegetation. Heinrich and Heinrich (1984), studying the ecology of *Myrmeleon immaculatus* DeGeer, mentioned that after getting wet the larvae rebuilt their pits and resumed trapping faster, if their pits were located in the open.

Larval body position during ambush, albeit without constructing a pit, was described by Stange (1970) and Heinrich and Heinrich (1984). The present description of *N. teillardi* behaviour differs from the previous descriptions mainly in the fact that the ambushing larva of this species brushes away the sand grains from its dorsal stemmata by rapid movements of the antennae. This observation indicates that not only vibrations or tactile stimuli may influence prey capture by the ant-lion larva but visual identification could also be involved. This could probably explain why in most free living ant-lion larvae the eyes are borne on prominent tubercles. In the pit building species these have become reduced and the eyes are often sessile on the head (Mansell, 1985).

My observations conclude that *N. teillardi* larvae are selective predators, preying mostly on ants of the genus *Messor*. As mentioned previously larvae were routinely observed in the vicinity of *Messor* nests, sometimes in the sand carried out by the ants. Although suspected, no clear evidence has yet been found for positive association between the ant-lion larvae and the nest location. Predator-prey relationship is known among neuropteran larvae and ants within the Chrysopidae (Principi, 1946). On the other hand, Heinrich and Heinrich (1984) mentioned that ant-lion larvae of *M. immaculatus* DeGeer, a pit constructing species, made no apparent attempt to place their pits near entrances to ant nests.

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