Observations on the sticky trap predator *Zelus luridus* STÅL (Heteroptera, Reduviidae, Harpactorinae), with the description of a novel gland associated with the female genitalia[1]

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Abstract: The first instar nymph of *Zelus luridus* STÅL (Harpactorinae, Harpactorini) is shown here to use viscous substances, which are collected from the egg mass and applied to its appendages, to trap prey. In the adult of this species, glandular units in the legs are the source for a sticky cover on the fore tibia, which also assists in prey capture. Thus, a functional replacement of extrinsic sticky substances derived from the mother's secretion on the egg mass with intrinsic secretions derived from the insect itself takes place during the postembryonic development of *Z. luridus*. Structures on the legs, including a specialized type of hair, the sundew seta, potential olfactory sensilla and glandular units including external pores on the integument are examined and documented for the first instar nymph and the adult female of *Z. luridus*. The post-hatching behavior of the first instar nymph is documented, including the description of prey capture and behavior following the moult to the second instar. Two possible alternative sources for the secretion on the egg mass of the female are described in addition to the subrectal gland present in many Harpactorinae: Apart from paired glandular areas on the syntergite 9/10, a composite tubular gland associated with the syntergite 9/10 in the female of *Z. luridus* is described here for the first time.

Key words: Female genitalia, gland, Harpactorinae, prey capture, Reduviidae.

Introduction

Predatory Reduviidae, or assassin bugs, show a substantial range of methods to capture prey and a great diversity of structures involved in this activity. The taxon Phymatinae includes species that possess subchelate or even chelate raptorial legs (HANDLIRSCH 1897), in many Emesinae prey organisms may be secured between the spiny tibia and femur of the fore leg (WYGODZINSKY 1966), and the "fossula spongiosa" present in many taxa of Reduviidae is a flexible cushion-like structure on the tip of the tibia that assists in the handling of prey organisms (MILLER 1942; EDWARDS 1962). More unusual than these diverse types of raptorial legs are the preying methods of some Holoptilinae, where secretions are used to paralyze

ants before piercing them (JACOBSON 1911). In at least some Apiomerini, Ectinoderini and Harpactorini, sticky secretions that are either secreted by the insect itself (BARTH 1952; EDWARDS 1966), or acquired from plants with viscous exudates, are applied to the legs (ROEPKE 1932; EISNER 1988), and this sticky cover helps the reduviid to grasp and handle the prey organism.

BARTH (1952), in a very thorough histological study, documented specialized setae on the tibiae and femora of adult *Zelus leucogrammus* (PERTY) (Harpactorinae, Harpactorini) and glandular units that open on the integument. He assumed that the viscous secretions of these glands were held on the leg by the unique structure of these specialized hairs, which are smooth proximally

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[1]This paper is dedicated to Ernst Heiss in celebration of his 70th birthday.

but possess numerous small projections in their apical portion. EDWARDS (1966), also concentrating on adults and apparently unaware of the study by BARTH (1952), described the leg of *Zelus luridus* STÅL (as *exsanguis*; see HART (1986) for taxonomy of the genus *Zelus* in the United States). He noticed specialized setae of the type studied by BARTH (1952), named them sundew hairs (here referred to as "sundew setae"), and mentioned underlying glands, but assumed that they opened through a second type of setae, and not directly on the integument. SWADENER & YONKE (1973) described immature stages of *Zelus tetracanthus* STÅL (as *Z. socius*, see HART (1986) for taxonomy), and stated the adult legs of this species to be sticky, but made no observations on leg structure or preying behavior of the nymph. COBBEN & WYGODZINSKY (1975) noted specialized setae on the legs of nymphs of *Zelus tetracanthus* STÅL. More recently WOLF & REID (2001) added considerable knowledge on adults as well as nymphs of a closely related species, *Zelus longipes* (LINNAEUS). WOLF & REID (2001) documented sundew setae in adults and recently hatched nymphs, and found that ring-like invaginations, which they interpreted as pores of glandular units, were present in the adults, but not yet in the first instar nymphs. However, also first instar nymphs were found to possess a sticky cover on their legs. As to the origin of this sticky substance in the first instar nymph, WOLF & REID (2001) formulated the hypothesis that secretions deposited by the female on the egg mass might be its source. Unlike many other Reduviidae, which lay their eggs separately (DISPONS 1955), Harpactorinae often deposit egg masses of considerable size. Females are known to secrete cement-like or sticky substances on the egg mass during and after oviposition (KERSHAW 1909; MILLER 1956), the sources of which are assumed to be the subrectal glands known only in Harpactorinae (KERSHAW 1909; DAVIS 1969; COBBEN & WYGODZINSKY 1975).

As freshly hatched nymphs and adult females (dried and alcohol) of *Zelus luridus* became available, several questions could be addressed in the present study: Does the structure of different setae on the legs in first instar nymphs and adults of *Z. luridus* corre-spond to the situation described by WOLF & REID (2001) for *Zelus longipes*? Are the glandular units described in detail for adult *Z. leucogrammus* by BARTH (1952) and mentioned by EDWARDS (1966) for adult *Z. luridus* also present in freshly hatched nymphs? Does observation of live first instar nymphs corroborate the hypothesis concerning the origin of their sticky cover from the secretions on the egg mass? Which glands are associated with the female genitalia that might be responsible for the sticky cover on the egg mass?

Material and Methods

### Material and life observations on first instar nymphs

One female of *Zelus luridus* was collected in Cold Spring, New York, on June 21, 2004, on a mulberry tree. The female oviposited a batch of 37 eggs during the following night. Nymphs of this batch hatched on July 1, 2004, during 1 pm and 8 pm. Nymphs were preserved in absolute alcohol, as was the female. Several first instar nymphs were killed in alcohol immediately after hatching, i .e. before any sticky substance could be applied to the legs. The remaining nymphs were distributed into plastic containers with 3 to 6 specimens, and kept alive.

To observe preying behavior of first instar nymphs, several specimens of *Drosophila melanogaster* were introduced into the plastic containers that held several nymphs. The moult to the second instar was observed for one nymph on July 13, 2004.

Hatching and post-hatching behavior of the first instar nymph of *Zelus luridus* were observed on a Nikon SMZ 1500. Photographs were taken using a Microptics System equipped with a Nikon D1X camera.

Scanning electron microscopy

First instar nymphs and the female were killed and preserved in absolute alcohol. The fore legs were removed, dried, coated with a DENTON VACUUM DESKII and observed on a HITACHI S-4700.
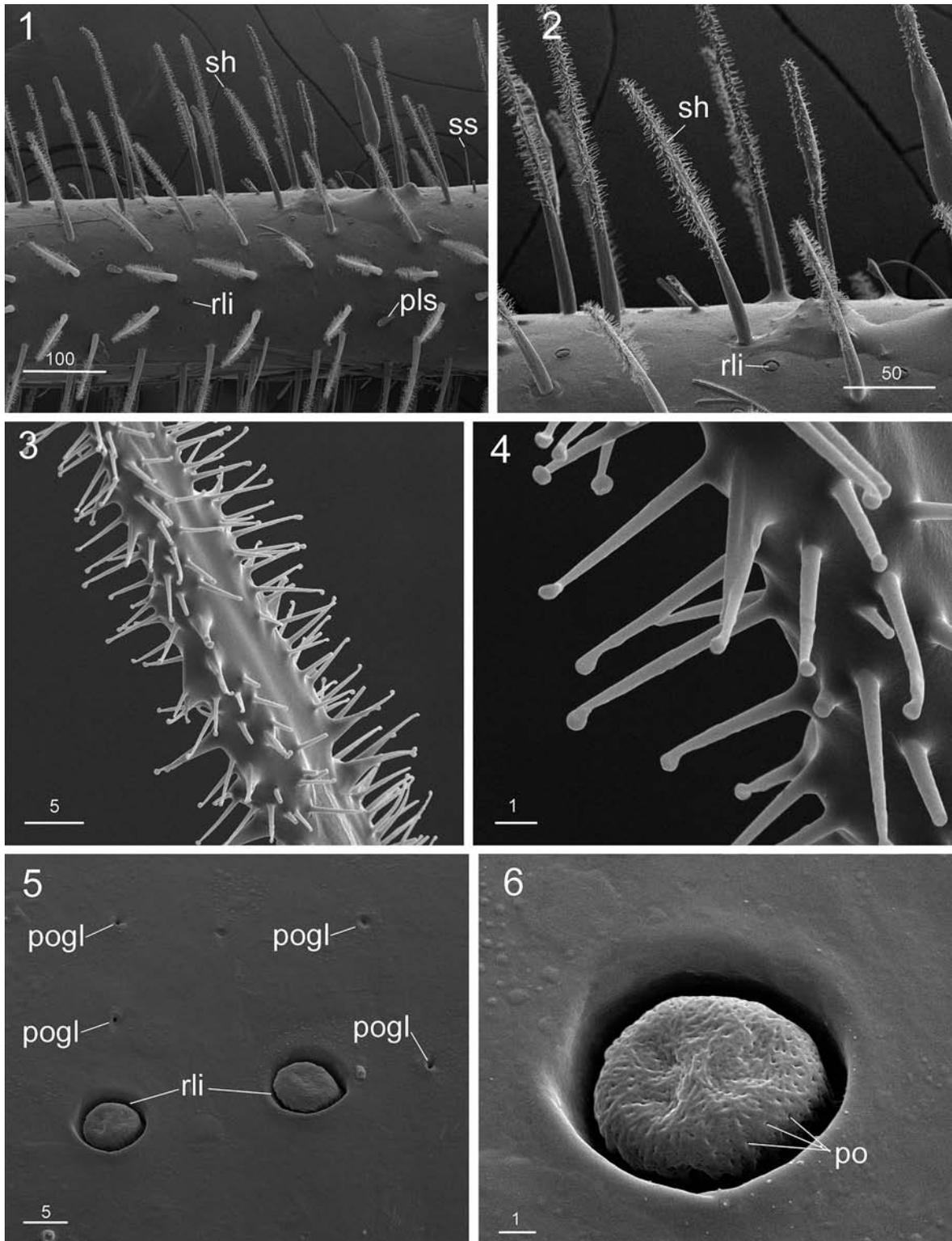
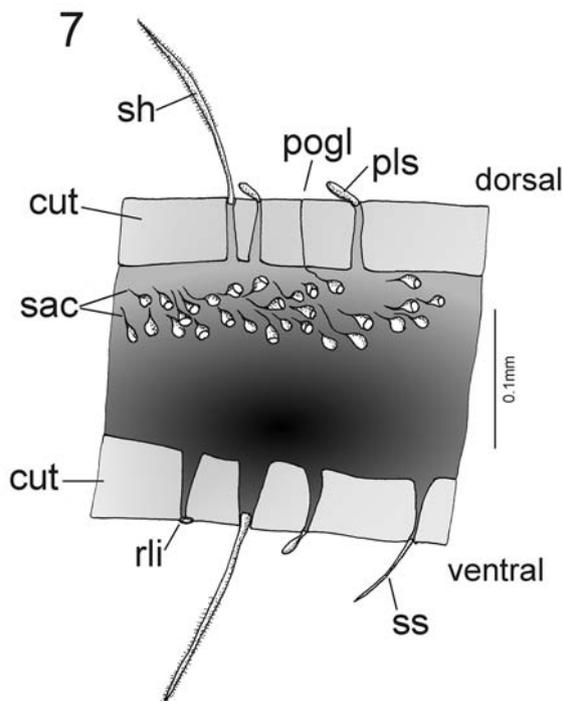**Figs 1-6**: The fore tibia in the female of *Zelus luridus*.
(**1**) Overview of the tibia showing sundew setae, peg-like setae, simple setae, and ring-like invaginations; (**2**) Sundew setae and ring-like invaginations; (**3**) Upper portion of a sundew seta with lateral projections; (**4**) Close-up of the upper portion of a sundew seta with lateral projections and their apical knobs; (**5**) integument of the fore tibia showing ring-like invaginations and pores, which are part of glandular units in the tibia; (**6**) ring-like invagination showing very small pores on the surface of the raised central area.
Scales in μm.

Light microscopy of macerated specimens

The detached fore leg of the alcohol preserved female and several first instar nymphs were macerated in KOH (approx. 10 %), stained with Chlorazol black and observed using a NIKON Eclipse 80i. The abdomen of one dried female (American Museum of Natural History: "L. Toxaway, N.C.; Collection of Mrs. A.T. Slosson, Ac. 26226) was removed, macerated in KOH, and the female external and internal genitalia were dissected, stained and set up for observation on a microscopic slide in glycerin. In specimens macerated with KOH, the epidermis including its gland cells is destroyed. How-

Fig. 7: Optical section as seen in the light microscope through part of the fore tibia of the female of *Zelus luridus*, showing three types of hairs, a ring-like invagination, and numerous saccules of glandular units inside the tibia including one pore that opens on the exterior surface of the cuticle.

Results

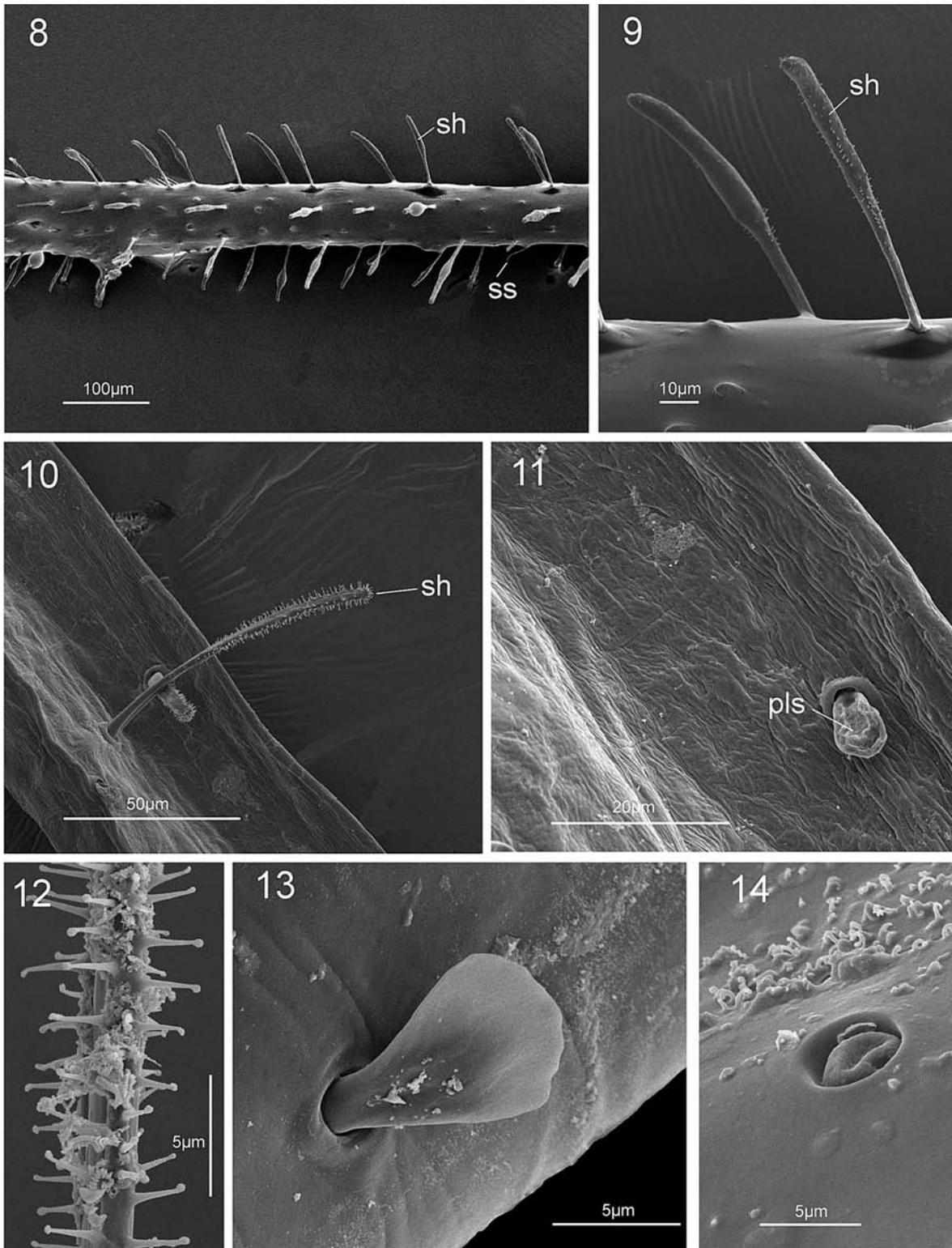### The fore tibia of the adult and first instar nymph of *Zelus luridus*

Sundew setae, peg-like setae, and simple setae

The tibia of the fore leg in the adult of *Zelus luridus* is beset with large numbers of sundew setae, and smaller numbers of both peg-like setae and simple setae (Fig. 1). The sundew setae are ~ 150-200 µm long, have a smooth lower portion and an upper portion that is equipped with laterally projecting spines. The spines taper toward the apex and end in a knob (Figs 2-4). Sundew setae are also abundant on the fore tibia of the first instar nymph. The hairs are ~ 70 µm long and thus much shorter than those in the adult. Only the sundew setae in nymphs killed immediately after hatching were clean (Fig. 10), those of older first instars nymphs were covered with a sticky substance that concentrated on the upper portion of the sundew setae that is covered with the lateral projections (Fig. 9). Comparison of the sundew setae of a first instar with the adult female shows that the lateral projections in the adult are more abundant and longer than those in the nymph (Figs 3, 12). Sundew setae in the first instar nymph are not restricted to the fore tibia, but also occur on the tibia of the other pairs of legs, on all femora, and in smaller numbers on the scapus and pedicellus of the antenna, and on head, thorax and abdominal dorsum.

Peg-like setae (Figs 1, 11, 13) are rather rare in both the adult female and the first instar nymph. The surface of the peg-like seta is smooth and it does not possess any pores or other ornamentation as seen from the close-up examination of the first instar nymph (Fig. 13). Simple setae occur in small numbers on the fore tibia of the adult female and on the first instar nymph (Figs 1, 8).

Ring-like invaginations

Ring-like invaginations (sensu WOLF & REID 2001) are abundant on the fore tibia of the adult of *Z. luridus* (Figs 1, 2). The invagination has a diameter of ~ 8µm, the central raised area a diameter of ~ 6µm. Observation of the ring-like invagination at high resolution reveals (Figs 5, 6) that the

ever, the sclerotized components of glandular units, termed the ductule, which comprises the receiving canal, the saccule, and the conducting canal, is retained and thus observable. Drawings were made using a camera lucida attachment on the NIKON microscope.

Terminology and Abbreviations

The terms for different types of setae – peg-like setae and simple setae – are used according to WOLF & REID (2001). As the fine structure of the "sundew hairs", termed by EDWARDS (1966) and referred to as such by WOLF & REID (2001), suggests that these hairs are also setae, I suggest calling them "sundew setae". The term "ring-like invaginations" coined by WOLF & REID (2001) is used here, even though hypotheses for a possible function of these structures differ (pores of glands [WOLF & REID 2001] vs. sensory structures [this paper]).

Abbreviations. bc, bursa copulatrix; cut, cuticle; gl synt 9/10, gland on syntergite 9/10; gla synt 9/10, glandular area on syntergite 9/10; lsp, lateral spermatheca (pseudospermatheca); mo, median oviduct; pls, peg-like seta; po, pore; pogl, pore of a glandular unit; rli, ring-like invagination; sac, saccule of a ductule; sus, sundew seta; spph, spermatophore; srgl, subrectal gland; ss, simple seta; synt 9/10, syntergite 9/10; vf1, vf2, valvifer 1 and 2; vv1-3, valvula 1, 2, and 3.

Figs 8-14: The fore tibia in the first instar nymph of *Zelus luridus*. (**8**) Overview of the tibia showing sundew setae and one simple seta; (**9**) sundew setae with sticky cover after the nymphs has applied secretions from the eggs mass; (**10**) clean sundew seta of first instar nymph killed immediately after hatching; (**11**) peg-like seta; (**12**) close-up of the upper portion of a sundew seta with lateral projections ending in a knob; (**13**) close-up of peg-like seta; (**14**) ring-like invagination.

raised center consists of coarse cuticle with numerous very small pores of less than 0.1 µm in diameter. Ring-like invaginations also occur on the fore tibia of the first instar nymph of *Z. luridus* (Fig. 14), even though in fewer numbers than in the female. The invaginations in the nymph have the same dimensions and characteristics as those in the adult. The observation of ring-like invaginations also in the first instar nymph contradict WOLF & REID (2001), who stated them to be present only in the adult.

External pores and ductules of internal glandular units

In addition to the ring-like invaginations, a second type of pores is present on the fore tibia of the adult, which was not mentioned by WOLF & REID (2001): Numerous simple circular pores of ~ 0.5 μm are spread over the cuticle (Fig. 5). Light microscopical observation revealed that these pores are connected through a cuticular canal to glandular saccules that constitute part of ductules and thus glandular units abundant in the tibia of the adult female (Fig. 7). Neither SEM nor light microscopical observation revealed pores or glandular units in the fore tibia of the first instar nymph.

Observations on the post-hatching behavior of the first instar nymph of *Zelus luridus*

The female deposited an egg mass comprising 37 eggs during the night of the 21st of June 2004 (Fig. 15). Each egg was coated with a thin film of sticky substance. No additional copious layer of sticky substance seems to have been applied to the entire egg mass. The nymphs hatched 11 days later during a period of approximately 7 hours. After hatching, which usually lasted 10 to 20 minutes, the almost transparent nymphs moved away from the egg mass. After approximately 30 minutes, the color pattern started to appear, which consists in the first instar nymph of dark annulations on the femora and tibia and dark coloration of the tarsi as well as dark annulations on the antennae. As soon as the coloration started to appear, the nymphs moved back to the egg batch, from which more nymphs were still hatching (Fig. 16). The nymphs then started to dip the tip of their right and left fore tibiae alternatingly into the secretion around the hatched or unhatched eggs at the margin of the egg batch (Fig. 16). The threads of secretion between the egg mass and the tip of the tibia were clearly observable (Fig. 17). Subsequently, the nymphs started to spread the sticky substance on the other appendages (Fig. 18). The sticky substance derived from the egg mass was visible as small translucent droplets that adhere to the upper portion of the sundew setae on tibia and femur of the legs (Figs 16, 18). The nymphs touched the tibia of the other leg and the fore femora of the same leg with the sticky tip of the fore tibia. Besides, the tip of the fore tibia was stroked against the dorsal side of the middle femur, the middle tibia against the hind femur and hind tibia, the hind tibia on the middle femur, and sporadically also the scapus of the antenna was touched with the sticky fore legs. Occasionally, the tips of the fore femora were rubbed against each other. In a few instances, nymphs also touched the legs of another nymph that was also engaged in applying the sticky substance to its appendages. As soon as part of the appendages were covered with sticky material, some of the nymphs moved away from the egg batch and continued to spread the substances to as yet uncovered appendages, but occasionally returned to the batch to acquire new supplies of viscous secretion.

Prey catching behavior of the first instar nymph

Specimens of *Drosophila melanogaster* were introduced into cages with unfed first instar nymphs. Apparently aware of the presence of the small flies, the reduviid nymphs raised their fore legs in such way that the fore tibiae pointed out obliquely in front of the nymph. After a short while, a fly became attached to the fore tibia of a nymph and the tibia was moved towards the body. The nymph then extended the labium to get hold of the fly and presumably inserted the stylets, since movements of the fly ceased immediately.

Observation on the post-moulting behavior of one second instar nymph

After moulting to the second instar, the single nymph observed showed a behavior that resembled the behavior of recently hatched first instar nymphs: The freshly moulted nymph started to touch the exuvia with the tip of the fore tibiae and then repeated the process of applying sticky substance to its appendages described above for the first instar nymph.
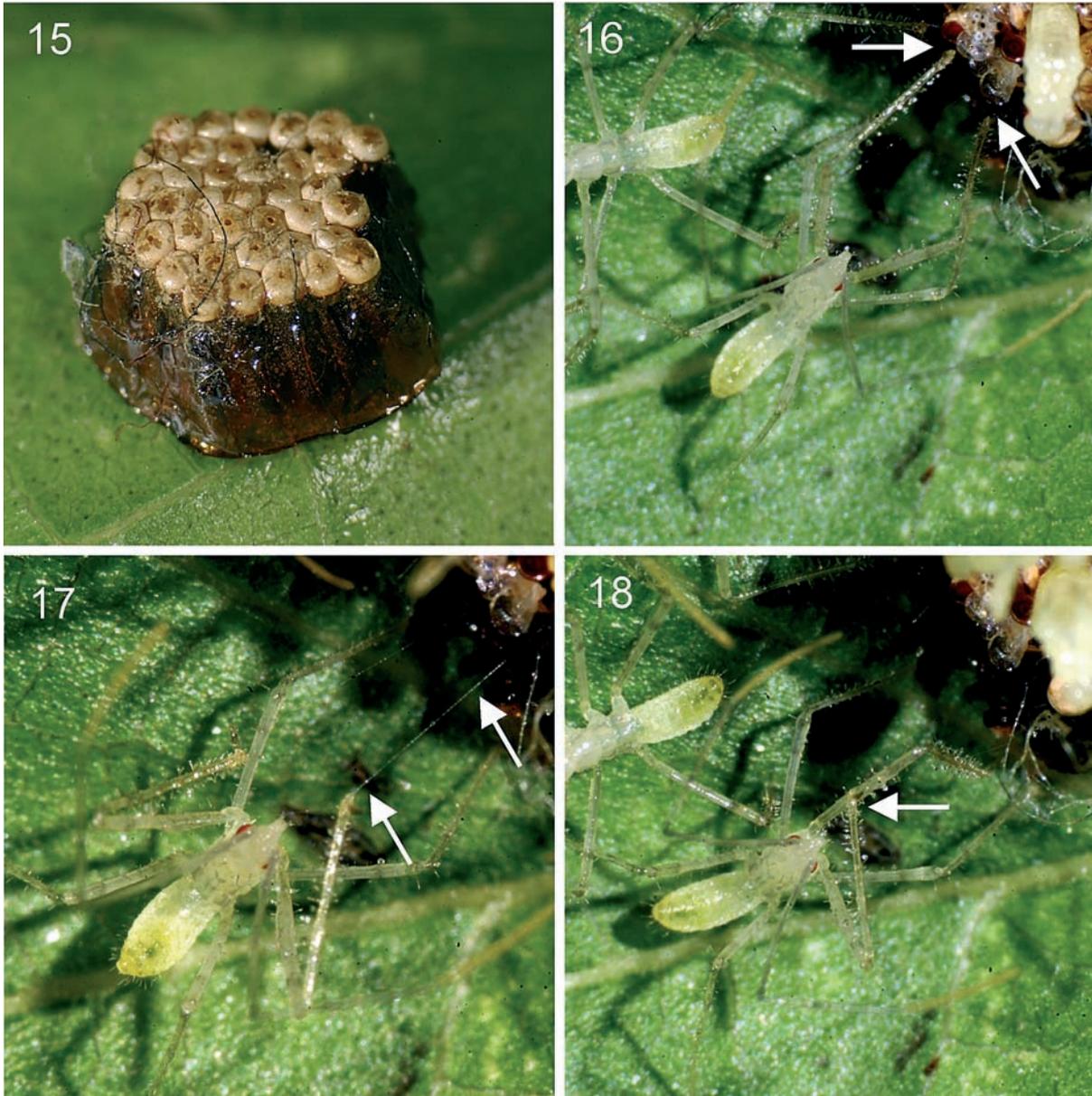
Female genitalia of *Zelus luridus* with description of a new composite gland and undescribed paired glandular areas on syntergite 9/10

Since the sticky cover of the egg mass in *Zelus luridus* is apparently derived from the female, closer examination of the female genitalia including associated glandular structures seemed desirable. The external female genitalia comprise segments 8 and 9 and their appendages, i.e. the valvifers of the 8th and 9th segment, and the valvulae 1 to 3 (Fig. 19). Tergites 9 and 10 are fused in *Zelus luridus*. This sclerite is here referred to as syntergite 9/10 and it forms a cover for the genitalic appendages (Figs 19, 21). The anus opens ventral to the syntergite 9/10.

The ectodermal portion of the internal female genitalia consists of a large, membranous median bursa copulatrix that narrows anteriorly into the median oviduct (Fig. 20). Unlike in many other Reduviidae, the paired lateral spermathecae are not attached to the median oviduct but insert in the anterior portion of the bursa copulatrix (Fig. 20). As in other Harpactorinae (DAVIS 1969), the median spermatheca or vermiform gland is absent in *Zelus luridus*.

The subrectal gland, which was initially described by KERSHAW (1909) in the harpactorine *Sycanus croceovittatus* and observed by DAVIS (1969) in other Harpactorinae, is present in *Zelus luridus* as a pair of large membranous lobes. The lateral lobes are

Figs 15-18: Egg mass and post-hatching behavior of the first instar nymph of *Z. luridus*. (**15**) egg mass comprising 37 eggs covered with a translucent sticky secretion; (**16**) nymph touching the sticky cover of the egg mass with the tips of its fore tibiae; (**17**) thread of sticky substance from the egg mass develops as the nymph folds back the fore tibiae; (**18**) nymph applies the sticky secretion from the egg mass to the fore femur of the opposite leg by tapping it with the apex of the sticky fore tibia.
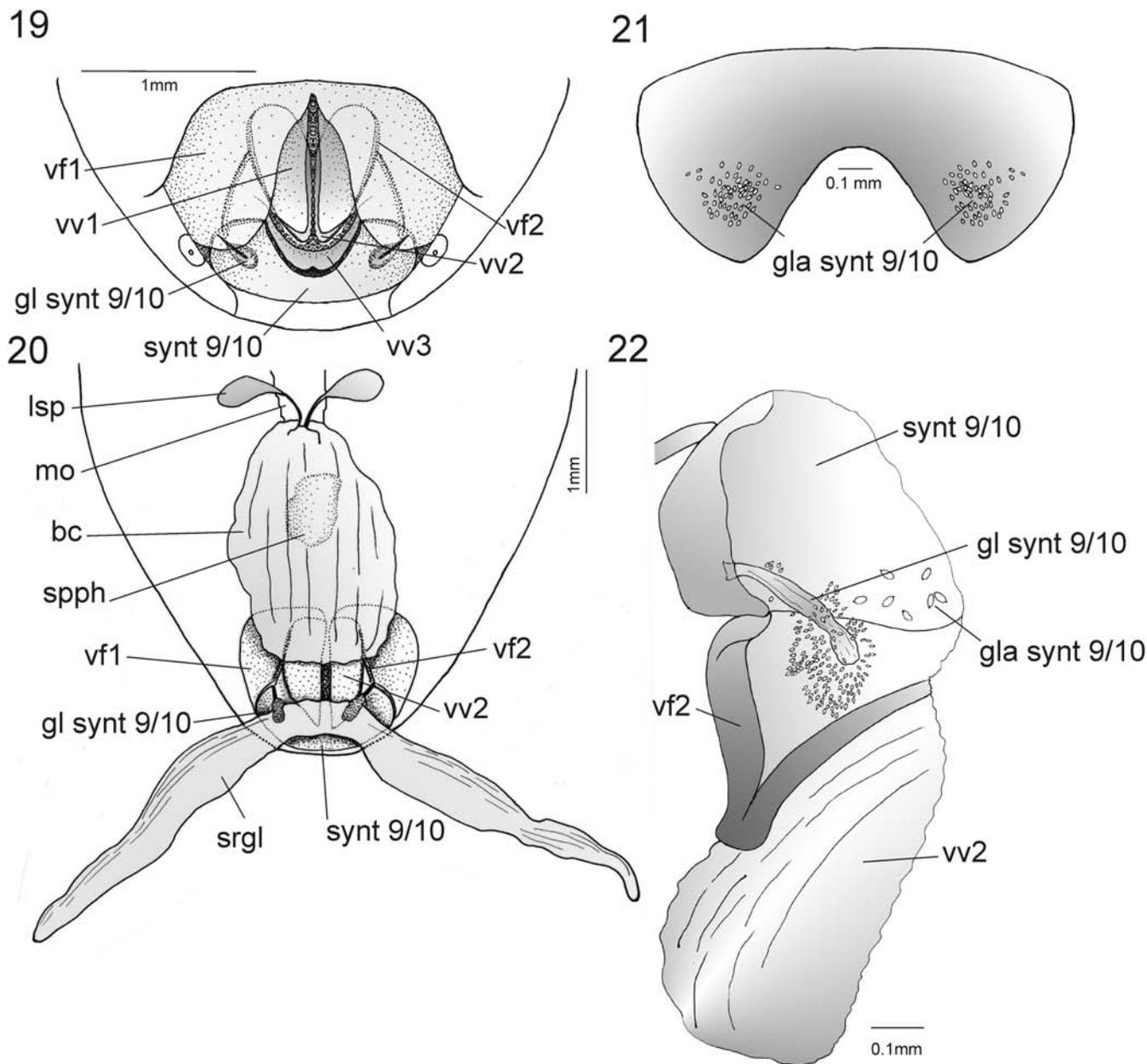
Figs 19-22: Female genitalia and associated glandular structures in the female of *Z. luridus*. (**19**) Female external genitalic structures in ventral view, showing valvifers, valvulae, and the syntergite 9/10, indicated are also the paired lateral glands associated with syntergite 9/10; (**20**) ectodermal internal genitalic structures, including bursa copulatrix with median oviduct and lateral spermathecae, subrectal gland and novel gland associated with syntergite 9/10, the substance inside the bursa is here interpreted as spermatophore; (**21**) syntergite 9/10 with paired lateral glandular areas, represented by numerous saccules; (**22**) tubular gland associated with syntergite 9/10, showing numerous glandular units as indicated by their saccules.

united medially, and they open through a common opening ventral to the anus and dorsal to the valvulae 3. The surface of the subrectal gland consists of a thin and heavily wrinkled membranous layer. Unpublished SEM examination of the macerated subrectal gland in another Harpactorinae, *Rhynocoris iracundus*, failed to reveal pores in this membrane. The same result was obtained from light microscopical observation of the subrectal glands in *Zelus luridus*. Furthermore, no ductules were observed during light microscopical observation of the subrectal glands in *Z. luridus*. Thus, the subrectal gland unlike many other glandular structures in Reduviidae, e.g. the metathoracic or abdominal glands (STADDON 1979), seems to lack glandular units with sclerotized components.

However, two glandular structures comprising ductules were found in this study to be associated with the female genitalia of *Zelus luridus*. The ventrolateral parts of syntergite 9/10 show paired, well defined areas, which are beset with ductules. These ductules are characterized by saccules of ~ 30 µm length (Fig. 22). The pores of these glandular areas on the outside of syntergite 9/10 could not be traced.

In addition, paired composite glands comprising a tubular collecting canal and numerous ductules with small saccules were

found in *Zelus luridus* beneath the syntergite 9/10 (Figs 19, 20). The gland's collecting canal opens onto the anterior margin of the tergite 9/10, just dorsal to the articulation of the syntergite with the valvifers 2 (9th segment). The wrinkled membranous surface of the collecting canal is beset with numerous ductules. The saccules are ~ 10 µm long, and thus much smaller than the saccules of the syntergite 9/10 glandular areas described above.

Paired sternal glandular areas between sternite 7 and valvifers 1 are absent in *Zelus luridus*. These glands were reported to be present in many Reduviidae, but absent in Harpactorinae (WEIRAUCH 2004).

Discussion

Sticky substances, which are used by the first instar nymph of *Zelus luridus* to trap prey, originate from the sticky cover of the egg batch. In the adults of *Zelus leucogrammus* and *Zelus luridus*, on the contrary, glandular units in the fore tibia are the source for the sticky cover of the fore tibia, which assists in trapping prey organisms (BARTH 1952; EDWARDS 1966). The secretion, which the female of *Zelus luridus* deposits on the eggs and which the freshly hatched first instar nymph applies to its legs, is thus replaced functionally with the secretion of the glandular units in the leg during a later developmental stage.

WOLF & REID (2001) were unable to find ring-like invaginations – abundant on the fore tibia of the adult – on the legs of the first instar nymph of *Zelus longipes*. Since these authors interpreted ring-like invaginations as pores of glandular structures, they in consequence claimed the absence of glands in the first instar nymph of *Z. longipes*. According to this observation and interpretation, WOLF & REID (2001) then predicted the use of sticky substances derived from the egg mass in prey capture by the first instar nymph of *Zelus longipes*, and they suggested the subrectal gland of the female as a potential source for the viscous substances. The present study, using *Zelus luridus*, not *Zelus longipes* as a model, helps to clarify several points, which remained unresolved in the study of WOLF & REID (2001) and which

were laid out as open questions above: The types of setae and their fine structure in the first instar nymph and the female in *Z. luridus* correspond largely to the one presented by WOLF & REID (2001) for *Z. longipes*. The observation of numerous glandular units – the potential source of the sticky cover of the legs – in the fore tibia of adult *Z. luridus* by EDWARDS (1966) was corroborated in this study and their pores were identified on the surface of the tibia. The first instar nymph of *Z. luridus* was found to lack glandular units of this type in the fore tibia. First instar nymphs of *Z. luridus* were observed to gain a sticky substance from the egg mass, to spread it over their legs and to use this sticky cover during prey capture.

The subrectal gland of female Harpactorinae, which is also present in *Zelus luridus*, is not the only gland associated with the female genitalia and thus not the only potential source for the sticky cover of the egg mass: Apart form paired glandular areas on syntergite 9/10, a composite gland associated with syntergite 9/10, which comprises numerous glandular units and a common collecting canal, was discovered in the present study.

The leg of *Zelus luridus* compared to the leg of *Z. longipes*

Sundew setae are numerous on the fore tibia of first instar nymph and adult of *Z. longipes* (WOLF & REID 2001) and *Zelus luridus* and comprise a smooth lower portion and an upper portion that is beset with lateral projections. In both species, the sundew setae are considerably longer in the adult than in the first instar nymph. In *Z. luridus* the projections are also more numerous and longer in the adult than in the nymph.

In first instar nymphs that were allowed to cover themselves with viscous substance from the egg mass, the secretion seems to adhere mainly to the upper portion of the sundew seta that is equipped with lateral projections (Fig. 9). This result agrees with observations on *Z. longipes* (WOLF & REID 2001) and the hypothesis on the function of the sundew setae as holding devices for viscous substances as originally proposed by BARTH (1952).

At least in the first instar nymph of *Z. luridus*, sundew setae are not restricted to

the fore tibia or to the legs, but also occur on other parts of the body, including the proximal antennal segments, head and thorax. Additional observations are needed to trace the fate of the sundew setae through the developmental stages.

The peg-like setae observed in the first-instar nymph and adult of Z. *luridus* correspond to those described by WOLF & REID (2001) in Z. *longipes*. The absence of pores on the shaft of these setae as indicated by WOLF & REID (2001) was corroborated in Z. *luridus* (Fig. 13). In contrast to what WOLF & REID (2001) found in Z. *longipes*, simple setae are present in Z. *luridus* also in the first instar nymph, even though only in small numbers.

The major discrepancy between the observation and interpretation of leg structures by WOLF & REID (2001) on Z. *longipes* and the results presented here lay in the ring-like invaginations and the ductules of glandular units and their associated pores. According to the results presented here, the latter – the glandular units and their pores – are probably responsible for the viscous cover in the adult leg. The ring-like invaginations in Z. *luridus* seem structurally similar to those in Z. *longipes*, but they were here shown to possess numerous very small pores on their raised central region. However, unlike in Z. *longipes*, where the ring-like invaginations were said to be restricted to the adult stage (WOLF & REID 2001), also the first instar nymph of Z. *luridus* possesses ring-like invaginations. Furthermore, the proposed function of the ring-like invaginations as pores of glandular structures proposed by WOLF & REID (2001) appears unlikely for two reasons: Judging from external appearance in the SEM, ring-like invaginations have properties of chemoreceptive sensilla, i. e. multiple very small pores on the seta, and they may represent olfactory sensilla. Furthermore, the only type of glandular units observed inside the tibia of Z. *luridus* is connected to small pores that open on the integument (Figs 5, 7). The glandular units, which are only present in the adult, are very likely responsible for the secretion of the viscous substance in the adult. A drawback of the interpretation of the ring-like invaginations as sensilla and not as gland pores is the fact that olfactory sensilla on an appendage that is covered with extrinsic viscous substance or intrinsic secretion are potentially useless. However, the ring-like invaginations may have a function while acquiring the sticky cover, not after the fact.

Viscous cover in the first and second instar and the adult

The post-hatching behavior of nymphs of Z. *luridus* documented in this study shows that the sticky cover of the nymph is derived from the egg mass. Interestingly, this sticky cover seems to be transferred also to the second instar, since a freshly hatched second instar nymph was observed to collect and apply the viscous substance from its own exuvia. A follow up study investigating gland and hair morphology as well as behavior in the five nymphal instars may reveal at what stage the egg mass derived sticky cover is replaced by an intrinsic sticky cover, i.e. one that is secreted by the bug's own glandular units. Unclear also is, how long the sticky egg mass cover preserves its viscous characteristic. The observed moult to the second instar and use of the sticky cover of the exuvia took place more than 3 weeks after oviposition. Thus it can be assumed that the stickiness lasts at least for that period of time.

Observation of the prey capture of *Drosophila melanogaster* by first instar nymphs in this study corroborates the hypothesis that the sticky cover of the legs assists during this behavior. However, other possible functions of the secretion cannot be ruled out: Apart from fastening the egg mass to the substrate, the viscous cover is also thought to protect the eggs against parasitoids (ALDRICH 1988) and it may prevent the eggs from desiccation. Transferred to the first instar nymph, the sticky cover might then also protect the nymph from predation through other insects. This hypothesis would also account for the presence of sundew setae on parts of the body unlikely involved in prey capture, such as those on the dorsal surface of the head.

Glandular structures associated with the female genitalia as potential source for sticky egg mass cover

All Harpactorinae – and this includes *Zelus luridus* – lack the median spermathecal gland (DAVIS 1969), which is responsible for the production of egg cement in other groups of Reduviidae, e.g. in Triatominae (LOCOCO & HUEBNER 1980a, 1980b). The subrectal gland has been proposed in the past to be the source for the viscous cover for the egg mass in many Harpactorinae (COBBEN & WYGODZINSKY 1975; WOLF & REID 2001). The subrectal gland occurs in most Diaspidini, Harpactorini and Tegeini among Harpactorinae (DAVIS 1969; own unpublished observation). The ultrastructure of the possibly aberrant eversible subrectal gland of *Arilus carinatus* (Harpactorini) was described by BARTH (1961). Light microscopical observation in this study failed to identify ductules of glandular units on the subrectal glands of *Zelus luridus*, and further investigation into the fine structure of this gland and its potential function seems desirable. In this study, I propose two alternative possibilities for the source of the sticky egg cover in Harpactorinae: The female of *Zelus luridus* possesses paired glandular areas in the posterio-ventral portion of the syntergite 9/10, the secretions of which may play a role in mating or oviposition behavior. The same realm of possible functions also applies to the composite tubular gland associated with syntergite 9/10, which was first described in this study. Further investigation into the functional morphology of oviposition in Harpactorinae as well as comparative morphological studies across Harpactorinae will help to elucidate the functions of the three glandular structures associated with the female genitalia in *Zelus luridus*.

Systematic perspective

The use of a sticky substance in prey capture of early instars of *Z. luridus* (Harpactorini, Harpactorinae) is paralleled in a striking way by the prey capture behavior of *Apiomerus flaviventris* (Apiomerini, Harpactorinae), where the first instar nymphs also collect sticky secretions from the egg mass to catch their prey (EISNER 1988). However, in contrast to the situation in *Z. luridus*, the sticky secretion on the egg mass in *A. flaviventris* is not derived from the mother itself, but collected by her from plants with viscous exudates and then applied to the egg mass (EISNER 1988). Observations on additional species of Apiomerini and Harpactorini together with a phylogenetic analysis of Harpactorinae are the next steps in order to gain an understanding of the evolution of sticky trap behaviour in the immatures of this group of Reduviidae.

Acknowledgements

Zusammenfassung

Im vorliegenden Beitrag wird gezeigt, dass Nymphen des ersten Nymphenstadiums von *Zelus luridus* STÅL (Harpactorinae, Harpactorini) klebrige Substanzen vom Gelege absammeln und auf die Beine auftragen, um sie dann beim Beutefang einzusetzen. Schon bekannt war hingegen, dass Drüseneinheiten in den Beine der Imagines von Arten der Gattung *Zelus* eine klebrige Substanz sezernieren, die ebenfalls beim Beutefang eingesetzt wird und dies wird hier fuer *Z. luridus* bestätigt. Während der Postembryonalentwicklung von *Z. luridus* werden somit extrinsische klebrige Substanzen, die von der Mutter stammen, funktionell durch eigen produzierte klebrige Drüsensekrete ersetzt. Beinstrukturen, darunter spezialisierte Haare, Sensillen und Drüseneinheiten, werden hier für das erste Nymphenstadium und die Imago untersucht und dokumentiert. Das Verhalten der Nymphen des ersten Nymphenstadiums nach dem Schlüpfen, Beutefang und Häutung zum zweiten Stadium werden beobachtet. Zusätzlich zu den subrektalen Drüsen, die bei den Weibchen zahlreicher Harpactorinae bekannt sind, werden hier zwei bislang nich dokumentierte Drüsen beschrieben, die als mögliche Quellen für die Sekretion auf dem Gelege in Frage kommen: Neben paarigen Drüsenbereichen auf den Syntergiten 9/10 wird hier für *Z. luridus* eine tubuläre Drüse beschrieben, die mit dem Syntergit 9/10 assoziiert ist.

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