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TORRIDINCOLIDAE: II. Description of the larva of *Satonius kurosawai* (SATÔ, 1982) (Coleoptera)

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Abstract

Third instar larvae of *Satonius kurosawai* (SATÔ) (Coleoptera: Torridincolidae) are described. They are characterized by a strongly flattened, ovoid body, 4 stemmata which are inserted on a distinct elevation, broad tergal extensions with lateral contact hairs on the thoracic segments, laterally inserted abdominal spiracular gills, and fixed urogomphi. *Satonius* ENDRÖDY-YOUNGA is the sistergroup of Torridincolinae. The ovoid body shape, a nearly semicircular thorax which is about as long as the abdomen, fused labral sensillae, and a strongly reduced trapezoid or triangular abdominal sternite IX are synapmorphies of *Satonius* and Torridincolinae. The monophyly of Torridincolinae is suggested by the reduced number of 3 stemmata and the presence of frayed setae on the labrum.

Key words: Coleoptera, Torridincolidae, *Satonius*, larva, phylogeny.

Introduction

Satonius kurosawai (SATÔ, 1982) was discovered in 1958 by Dr. Yoshiko Kurosawa in the Fukushima Prefecture in northeastern Japan (SATÔ 1982). It was the first known representative of Torridincolidae in Asia. However, the systematic affinity was unclear by that time. Torridincolidae was established as a family by STEFFAN (1964) based on an African species, *Torridincola rhodesica* STEFFAN, 1964.

Immature stages and adults of *Satonius kurosawai* live on wet rock surfaces covered with a thin film of water from seepages. Information on the morphology of the larva was not available so far, except for an illustration in a textbook on Japanese Coleoptera (SATÔ 1985).

The aim of this contribution is an improved knowledge of external and internal features of the larva, a phylogenetic assessment of the genus, and a key for larvae of the family Torridincolidae.

Material and methods

List of myxophagan larvae examined:

Torridincolidae: *Satonius kurosawai* (6 penultimate instars, 25 ultimate instars; Japan, Aichi Prefecture, Houraji-ko, 4.V.1997; leg. M. Satô).

Ytu zeus REICHARDT, 1973, *Iapir britskii* (REICHARDT & COSTA, 1967), *Delevea namibensis* ENDRÖDY-YOUNGA, 1997, *Torridincola rhodesica*, *Torridincola* sp. (undescribed species).

Hydroscaphidae: *Hydroscapha natans* LECONTE, 1874 sp.

Microsporidae: *Microsporus* KOLENATI, 1846 spp. (undetermined species from Arizona and Europe) (= *Sphaerius* WALTL., 1838)[1].

Specimens of *Satonius kurosawai* were embedded in Historesin, cut at 3 µm, and stained with methylene-blue and acid fuchsine. Scanning electronic microscopy was accomplished after specimens were dried (critical point method), and coated with gold.

Satonius kurosawai (SATÔ, 1982), ultimate instar

General appearance (Fig. 1): Body strongly flattened and ovoid, distinctly sclerotized dorsally. Thorax with very broad tergal extensions and long lateral contact hairs. Rounded laterally, nearly semicircular, about as long as the abdomen. Abdominal segments I-VII with lateral, segmented spiracular gills. Segment IX with fixed urogomphi.

Measurements: Head width: 0.44 mm; body length: 1.3 mm - 1.7 mm; body width: 0.8 - 0.9 mm. Penultimate instars differ from ultimate instar larvae in size (head width: 0.36 mm; body length: 0.96mm - 1.00 mm; body width: 0.75 mm).

Microsculpture: Parts of the dorsal surface of the head with small tubercles which are partly arranged as irregular rows. Tergites of thorax and abdomen mostly smooth, some areas slightly granulate.

Head capsule (Figs. 2 - 3): Transverse, approximately 1.4 times broader than long. Dorsal surface brown, distinctly sclerotized, ventral surface cream coloured. Distribution of setae as shown in Figs 2 and 3. Posterior area of vertex, anterior region of frons, and genal region anterior to antenna covered with small tubercles which are partly arranged in rows. Attachment area of dorsal tentorial arm with scale-like cuticular modifications. Four stemmata located on a distinct lateral prominence. Labrum free, attached to clypeus by a membranous fold. Clypeus large, separated from frons by a narrow membranous zone, with distinct, darkened anterior tentorial grooves. Frontal suture distinct, lyriform, anteriorly adjacent with the clypeofrontal membrane, not attaining antennal base. Frons distinctly extended posteriorly. Coronal suture very short. Distinct genal fold present lateral to maxillary groove. Maxillary articulating area and articulatory membrane well developed. Broad sclerotized gula inserted between posterior tentorial grooves, not clearly separated from submentum.

Tentorium (Figs. 7 - 9): Strong posterior arms arise from fissure-shaped posterior tentorial grooves anterior to foramen occipitale. Tentorial bridge broad and unusually strong (Fig. 7). Anterior arms well developed, slightly flattened in cross section. Dorsal arms present and strong, flattened, attached to dorsal wall of head capsule by means of fibrillar structures.

Labrum (Fig. 5): Connected with clypeus by a membranous fold. Moderately sized, not connected with genal fold laterally. Distribution of setae as shown in Fig. 5. Round, plate-like cuticullar sensilla at anteromedian margin fused. Flattened, frayed seta absent from anterolateral margin. A small seta with 3 indistinct apices is present close to the median line.

Labral musculature:

M. 7: M. labroepipharyngalis: not identified on available microtome sections.
M. 9: M. frontoepipharyngalis (Figs. 8 - 9).

A strong muscle; O (= origin): anterior frontal region, close to the median line; I (= insertion): medially on posterior margin of labrum.

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[1] The nomenclatoral stability within this family is threatened by the ruling of "OPINION 1331" (ICZN 1985). Subsequently, a proposal was made by M.A. Jäch (submitted to the ICZN on July 7th, 1997) to suppress "OPINION 1331" and to place the family-group name Sphaeriusidae ERICHSON, 1845 (type genus *Sphaerius* WALTL., 1838) on the Official List of Family-Group Names in Zoology.

Antenna (Figs. 2 - 3): 2-segmented, laterally directed. Antennomere II about 7.5 times longer than short basal segment. Sensorial appendage flattened, strongly reduced, inserted in a shallow excavation of the apical area of antennomere II.

Antennal musculature: Three slender muscles arise from the anterior tentorial arm.

M. 1, 2, 4: M. tentorioscapalis anterior, posterior, medialis. O: anterior tentorial arm; I: on scapal base

Mandible (Fig. 4): Fairly short, approximately triangular, with serrate apical and subapical teeth and large semimembranous pseudomola with posteriorly directed very short cuticular spines. Basal mola well developed, sclerotized.

M. 11: M. craniomandibularis internus (Figs. 7 - 9). Strongest muscle of the head capsule; O: extensive parts of the ventrolateral, dorsolateral and posterodorsal wall of the head capsule; I: adductor tendon.
M. 12: M. craniomandibularis externus (Figs. 7 - 9). Composed of several bundles; O: dorsolateral and lateral wall of the head capsule; I: abductor tendon.

Maxilla (Figs. 3, 6): Inserted in deep articulatory area. Cardo short and transverse. Stipes fairly long. Palpifer obsolete. Palp well developed, 3-segmented. Distal palpomere about as long as palpomeres I + II. Galea and lacinia fused, mala with fixed lateral tooth, several flattened, articulated teeth, and several mesal spines.

M. 15: M. craniocardinalis (Figs. 7 - 9). O: lateral wall of the head capsule; I: lateral condyle of the cardinal base.
M. 17: M. tentoriocardinalis (Figs. 7 - 9). O: posterior tentorial arm and tentorial bridge; I: ventral surface of cardo.
M. 18: M. tentoriostipitalis (Figs. 7 - 9). Composed of several strongly developed bundles; O: tentorial bridge and posterior tentorial arm; I: ventral surface and lateral edge of stipes.
M. 19: M. craniolacinialis (Figs. 7 - 9). O: laterally to M. 15; I: mesally on base of mala.
M 20: M. stipitolacinialis. O: lateral edge of stipes; I: mesal edge of mala.

Labium (Fig. 3): Submentum trapeziform, not separated from gula posteriorly. Mentum well developed, almost parallel-sided, very slightly rounded laterally. Prementum with small, 2-segmented palps and a ligular area with a dense field of sensorial papillae on either side. Large internal membranous sacs, probably gland reservoirs, are present in the submentomental region.

M. 28: M. submentopraementalis. O: anterior submental area; I: dorsally on premental margin.
M. 29, M. 30: M. tentoriopraementalis inferior and superior (Figs. 7 - 9). Two fairly thin bundles; O: basal part of posterior tentorial arm; I: ventrolaterally on premental base.

Epipharynx: Semimembranous, densely covered with very short hairs anteriorly. Fused with the hypopharynx posteriorly, thus forming a closed prepharnygeal tube (Figs. 8 - 9).

M. 43: M. clypeobuccalis (Fig. 9). Several strong bundles; O: clypeus; I: roof of prepharyngeal tube.

Hypopharynx: Unusually high and parallel-sided in cross section, semimembranous dorsally, with strong lateral sclerotizations. Very short hairs, similar to those found on the epipharynx are present anteriorly.

M. 41: M. frontohypopharyngalis (Fig. 8). O: anterolateral region of frons; I: on dorsolateral folds of pharynx, laterally to the anatomical mouth.
M. 42m: M. tentoriohypopharyngalis medialis: absent.
M. 42l: M. tentoriohypopharyngalis lateralis: absent.

Pharynx (Fig. 7): Moderately wide, with distinct dorsolateral, ventrolateral, and ventral folds.

Posteriorly adjacent with a wide oesophagus.

M. 44: M. clypeobuccalis: absent.
M. 45: M. frontobuccalis anterior. 4 strong bundles, posterior 3 bundles with common origin; O: 3 bundles medially from posteriormost part of frons, 1 bundle from anterior frontal area, mesally to M. 41; I: dorsolateral folds and dorsal surface of anterior pharynx, posterior to anatomical mouth.
M. 46: M. frontobuccalis posterior. Several thin bundles with common origin; O: posteriormost part of frons, lateral to M 45; I: dorsally on posterior pharynx.
M. 48: M. tentoriobuccalis anterior: absent.
M. 51: M. verticopharyngalis: absent.
M. 52: M. tentoriopharyngalis. O: posterolaterally from tentorial bridge; I: ventral folds of posterior pharynx

Cerebrum and suboesophageal ganglion (Figs. 7 - 8): Cerebrum large in relation to head size, located in posteriormost region of head capsule. Anterolateral extensions separated from mesal part by the dorsal tentorial arms. Suboesophageal ganglion very large, almost completely shifted to the prothorax.

Prothorax (Fig. 1): Pronotum distinctly widening posteriorly, more than 3 times broader than long at posterior margin. Rounded laterally, with long lateral contact hairs. Small tubercles present laterally and medially. Pleura well developed, notopleural suture distinct. Ventral side largely unsclerotized, with paired anterior semimembranous bulges and 2 similar median elevations. Legs 5-segmented, moderately long. Tibiotarsus with a single, strong but fairly short claw with a subproximal short seta.

Mesothorax (Fig. 1): Tergum slightly broader and shorter than pronotum. Laterally and medially covered with small tubercles. Pleura similar to prothorax. Sternum broad, unsclerotized, with one median semimembranous bulge. Legs as described in previous section.

Metathorax (Fig. 1): Tergum as broad as mesonotum. Lateral edge almost straight, slightly shorter than edge of mesonotum. Other structures as described in previous sections.

Abdominal segment I (Fig. 1): Tergum as broad as metanotum and slightly shorter, with distinct lateral processus and a pair of moderately long, 2-segmented spiracular gills. Surface of gills without plastron meshwork, opening subapical. Three setae inserted at posterior margin of lateral process. Small tubercles present medially on tergal surface. Sternum sclerotized, as broad and as long as tergum, with scattered small tubercles.

Abdominal segments II-VII (Fig. 1): Segments slightly narrowing towards abdominal apex. Otherwise as described in section 1.3.1.

Abdominal segment VIII (Fig. 1): Narrower than segment VII, lateral processus posteriorly directed, outer margin parallel-sided.

Abdominal segment IX (Fig. 1): With moderately long fixed urogomphi (Fig. 1). Sternum reduced to a fairly small trapezoid plate.

Abdominal segment X (Fig. 1): Represented by a pair of ventral flaps posterior to sternite IX.

Phylogenetic position of *Satonius kurosawai*

This phylogenetic assessment is based upon an evaluation of 55 larval features of 3 families (Microsporidae, Hydroscaphidae, Torridincolidae) and seven genera of Myxophaga (BEUTEL, MADDISON & HAAS 1998). The analysis (PAUP) resulted in 2 trees of 110 steps length.

Monophyly of Torridincolidae (plesiomorphic states in parentheses):

- stemmata inserted on distinct elevation (elevation indistinct or absent)
- distal antennomere strongly elongated (distal antennommere less than 4 times longer than scapus)
- sensorial appendage of antennomere II embedded in apical excavation (sensorial appendage elongated, fully exposed)
- apex of maxilla with an external fixed tooth and several flattened and articulated teeth (apex of mala simple, without articulated teeth)
- labial gland reservoir present (absent)
- abdominal segment X transformed into paired flaps (segment X uropod-like)

Monophyly of Torridincolidae excl. *Delevea*:

- body ovoid (body subparallel or parallel-sided)
- thorax and abdomen about equally long (abdomen distinctly longer than thorax)
- disc-shaped labral papillae fused (labral papillae separate)
- sternite IX strongly reduced, trapezoid or triangular (broad, well developed)

Monophyly of Torridincolinae sensu ENDRÖDY-YOUNGA (1997) (= Torridincolidae excl. *Delevea* and *Satonius*):

- 3 stemmata (4 stemmata)
- labrum with frayed setae (without frayed setae)

Larval key to torridincolid genera

1 Body subparallel, thorax distinctly shorter than abdomen ..... *Delevea*

- Body disc-shaped, rounded laterally, thorax about as long as abdomen 2

2 Urogomphi absent, spiracular gills inserted on dorsal surface of abdominal tergites ..... *Torridincola*

- Urogomphi present, spiracular gills inserted laterally 3

3 Legs long, distinctly visible in dorsal view, lateral contact hairs absent ..... *Iapir*

- Legs shorter, not visible in dorsal view, lateral contact hairs present 4

4 4 stemmata, labrum without frayed setae, maxillary palp well developed, 3-segmented ..... *Satonius*

- 3 stemmata, labrum with 3 pairs of frayed setae, maxillary palp strongly shortened, appears 1-segmented ..... *Ytu*

Conclusions

Several larval apomorphies indicate clearly that *Satonius* belongs to Torridincolidae. However, the subfamily Deleveinae, erected by ENDRÖDY-YOUNGA (1997) for the genera *Delevea* and *Satonius*, is paraphyletic. *Satonius* is not the sistergroup of *Delevea* but the sistergroup of the monophyletic subfamily Torridincolinae (sensu ENDRÖDY-YOUNGA 1997). The larvae of *Satonius* are very similar to those of the Brazilian genus *Ytu*. However, they can be distinguished by the number of stemmata, presence or absence of frayed setae along the labral margin, and the shape of the maxillary palp.

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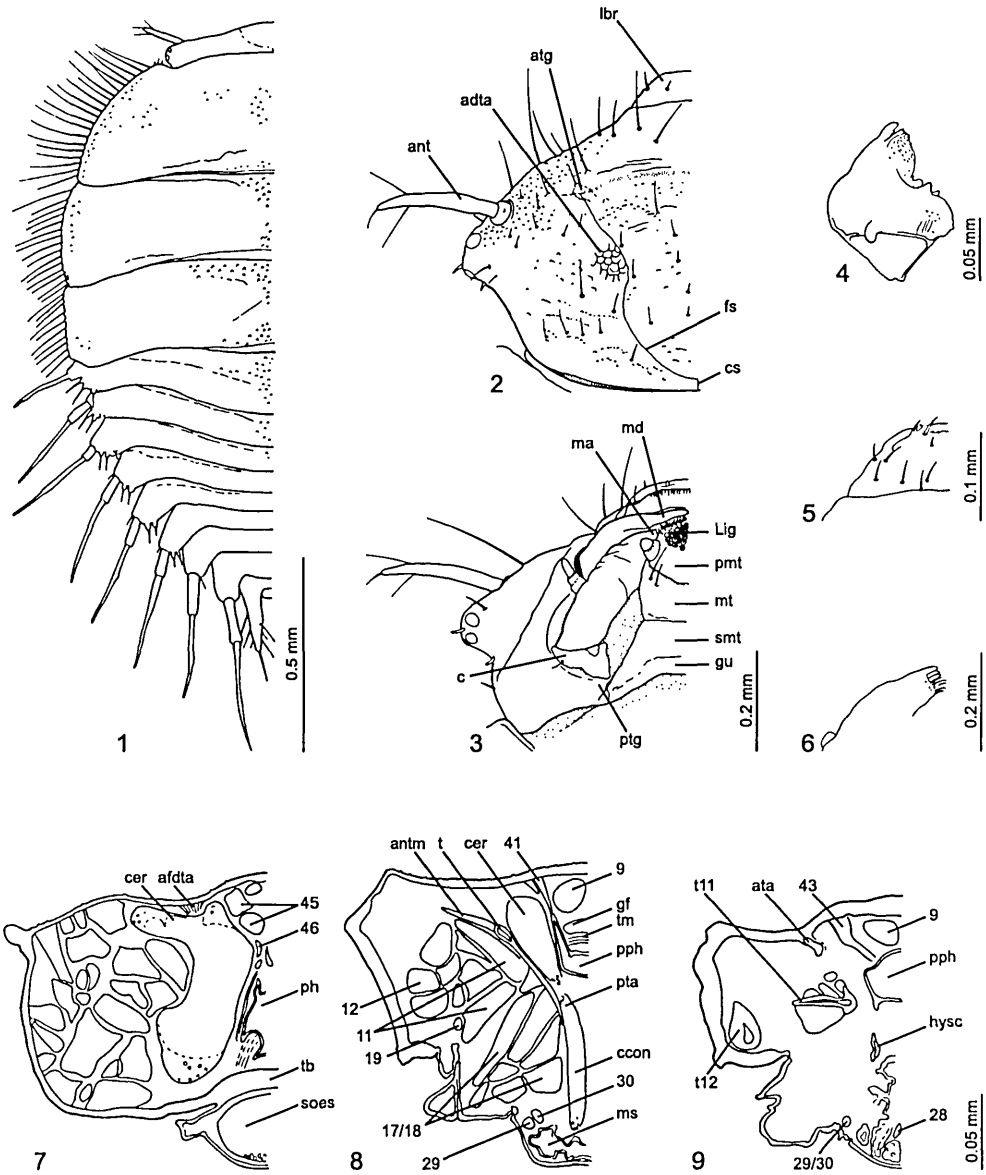

Figs. 1 - 9: *Satonius kurosawai*, 1) 3rd instar larva, dorsal view; 2) head, dorsal view; 3) same, ventral view; 4) mandible, ventral view; 5 - 7) head, cross sections; 5) posterior pharyngeal region; 6) region of the anatomical mouth; 7) prepharyngeal region.

Abbreviations: Figs. 2, 3: **adta** - attachment area of dorsal tentorial arm, **ant** - antenna, **atg** - anterior tentorial groove, **c** - cardo, **cs** - coronal suture, **fs** - frontal suture, **gu** - gula, **lbr** - labrum, **lig** - ligula, **ma** - mala, **md** - mandible, **mt** - mentum, **pmt** - praementum, **ptg** - posterior tentorial groove, **smt** - submentum.

Abbreviations: Figs. 7 - 9: **afdta** - attachment fibrillae of the dorsal tentorial arms, **antm** - antennal muscle, **ata** - anterior tentorial arm, **ccon** - circumoesophageal connective, **cer** - cerebrum, **dta** - dorsal tentorial arm, **gf** - ganglion frontale, **hysc** - hypopharyngeal sclerite, **ms** - membranous sacs, **ph** - pharynx, **pph** - prepharynx, **pta** - posterior tentorial arm, **soes** - suboesophageal ganglion, **t11** - tendon of M. craniomand. int., **t12** - tendon of M. craniomand. ext., **tb** - tent. bridge, **tm** - transverse muscle, 9 - M. frontoepipharyngalis, 11 - M. craniomandibularis internus, 12 - M. craniomandibularis externus, 15 - M. craniocardinalis externus, 17 - M. tentoriocardinalis, 18 - M. tentoriostipitalis, 19 - M. craniolacinialis, 28 - M. submentopraementalis, 29 - M. tentoriopraementalis inferior, 30 - M. tentoriopraementalis superior, 41 - M. frontohypopharyngalis, 43 - M. clypeopalatalis, 45 - M. frontobuccalis anterior, 46 - M. frontobuccalis posterior, 52 - M. tentoriopharyngalis.

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