

Description of two new fossil Zygentoma from Mexico and the Dominican Republic

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Abstract

Two new in amber preserved Zygentoma are described, namely *Protolepisma tainicum* gen. n. sp. n. (Lepismatidae) from the Dominican Republic of Hispaniola Island, and *Paleograssiella chiapanicum* gen. n. sp. n. (Nicoletiidae) from the Chiapas State of Mexico. Dated at approximately 20–30 MY old, they represent, respectively, the second fossil Lepismatidae known from the Dominican deposits and the first fossil Nicoletiidae (Atelurinae) and only fossil Zygentoma known from Mexico.

Keywords Silverfish | new genera | Hispaniola | Mexico | Miocene-Oligocene

1. Introduction

Fossil Zygentoma are rare and are known from the mid-19th century, when *Lepidothrix pilifera* (Menge in Koch & Berendt, 1854) (Lepidotrichidae) and *Allacrotelsa dubia* (Koch & Berendt, 1854) (Lepismatidae) were described from specimens in Eocene Baltic amber (for synonymies, see Silvestri 1912 and Paclt 1967). These two species remained the only extinct silverfish known until the recent description of some 20–30 MY old Miocene-Oligocene Dominican amber species: four Nicoletiidae, namely one Atelurinae, *Archeatelura sturmi* (Mendes 1997a, 1997b), and the Subnicoletiinae *Trinemurodes antiquus*, *T. miocenicus* (Sturm & Mendes 1998) and *Hemitrinemura extincta* (Mendes & Poinar 2004), plus one Lepismatidae, the Ctenolepismatinae *Ctenolepisma (C.) electrans* (Mendes 1998).

The two Lower Cretaceous Brazilian silverfish specimens preserved in the Santana Formation sandstone (Sturm 1998) (Lepismatidae g. sp. from ‘Araripe’ – Upper Aptian, ca. 110 MY old) remain impossible to describe accurately due to their condition. More recently, the Lepismatinae *Burmalepisma cretacicum* Mendes &

Poinar, 2008 was described from one specimen preserved in 100–110 MY old Burmese amber. The above mentioned species comprise as a whole the true fossil Zygentoma known up to the present. Indeed, *Onycholepisma arizonae* from the Arizona onyx-marble (probably from the Oligocene), is too poorly described to be included in the order, while the ‘machilid’ *Onychomachilis fischeri*, from the same deposit and described in the same study (Pierce 1951), may be, as reported (Sturm & Machida 2001), a Nicoletiidae, despite its insufficient characterization. The taxonomic position of the Illinois (USA) Lower Carboniferous *Ramsdelepidion schusteri*, described by Kukalová-Peck (1987), remains uncertain, and based on the known morphological features it hardly integrates the Zygentoma as commented by Bechly & Stockar (2011).

Two new fossil species approximately of the same age, both preserved in *Hymenaea mexicana* (Leguminosae: Caesalpinoideae) amber from Oligocene-Miocene, are described below, with each sample represented by a single specimen. One of them is a Lepismatidae, a family characterized by the presence of compound eyes (though with a reduced number of ommatidia), absence of a female subgenital plate and male antennal pedicellus, as well

as unmodified terminal filaments. The other specimen is a Nicoletiidae, a family completely devoid of ocular structures, whose females have developed a subgenital plate and whose males often show a modified antennal pedicellus and sexually dimorphic terminal filaments. One further new genus from the Baltic amber is now under description.

2. Methods

The studied samples (Figs 1–3) are part of the co-authors amber collection maintained at Oregon State University (OSU). Sample T-1-5 is discoid, 20.8 mm × 18.0 mm × 5.2 mm and weighs 1.09 mg; it includes the lepismatid specimen, one acarid specimen, one pseudoscorpion specimen, two ants and the head of a third one (Ponerinae?) plus some mineral and plant debris. The other sample (T-1-5A), which is reshaped as a truncate pyramid, is 14.2 mm × 10.3 mm × 10.5 mm and weighs 0.68 mg, includes some plant debris only, as well as the nicoletiid, whose cephalic capsule is deformed (compressed). There are, furthermore, air bubbles, an inner crack and a few opaque inclusions, which compromises a detailed study of some body parts of the specimen.

The reshaped and polished amber samples were studied with two stereoscopic microscopes, Wild M5A and Leica M165C, and a light microscope Leitz SM-Lux, in both cases using a combination of illumination from above (Hund-Wetzlar apparatus optical tubes) and below. A camera lucida associated with the Leitz was used to create the figures. For the photos a Canon EOS-450D supported by a Macintosh iMac 27-inch LED 16:9 widescreen Computer was used.

3. Taxonomy

Family Lepismatidae

Subfamily Lepismatinae

Protolepisma gen. n.

Description. Male. Body covered with typical, uniform scales, the macrochaetae simple, apically pointed or bifid. Violaceous dark brown pigment present though not extended. Head wider than long, with macrochaetae on the frontal area and around the compound eyes, the setae neither arranged in tufts nor in rows. Antennae short, their specialized sensilla impossible to perceive.

Maxillary and labial palp without peculiar features; first one delicate and short, the second large and with dilated distal article, at least apparently with 2+3 large, compact papillae (of the labial palps, only the right one preserved). Thorax ovoid, wider than long, clearly detached from the abdomen base. Pronotum without anterior setal collar, the setae absent on the posterior border of pro-, meso- and metanotum. All anterior notal trichobothrial areas of the open type, the posterior areas open on the pronotum and closed on the meso- and metanotum, never clearly visible, but traceable. Marginal macrochaetae not arranged in combs. Thoracic sternites well developed, the prosternum not reduced. Legs without special features; femur and tibia with long and robust dark spines, tarsus 3-articulated, pretarsus simple and complete; empodium smaller than the lateral claws. Abdominal tergites II–VIII with 1+1 infralateral, 1+1 lateral and 1+1 sublateral isolated macrochaetae; urotergite I with infralateral and sublateral setae only, the IX glabrous; urotergite X longer than wide at the base and apically poorly excavated. Urosternites I–II with one median setal comb, III–VIII with 1+1 lateral, plus one median comb, the setae always in small numbers. Two pairs of stylets, on coxites VIII and IX. Paramera large, well developed, sacciform, almost attaining the level of the coxite IX inner process. Cerci and paracercum shorter than half the abdominal length, typical, their shape and chaetotaxy not modified.

Etymology. From the Greek, *Protos*: primitive, first one, and *Lepisma*, the nominate genus of the family; gender neuter.

Type-species. *P. tainicum* sp. n.; the genus is monotypic.

Discussion. Only one Lepismatidae was known until now from Dominican amber, *Ctenolepisma (C.) electrans* Mendes, 1998, a typical element of the Ctenolepismatinae (Mendes 1991), whose representatives are immediately distinguishable from the new genus in a number of features, namely: barbed macrochaetae, cephalic chaetotaxy, pronotum with a setal collar, number and arrangement of body macrochaetae and lack of paramera.

The smooth macrochaetae of *Protolepisma* gen. n. resemble, indeed, those of ten genera with recent representatives, namely *Afrolepisma*, *Allacrotelsa*, *Anallacrotelsa*, *Anisolepisma*, *Heterolepisma*, *Lepisma*, *Lepitrochisma*, *Neoasterolepisma*, *Tricholepisma* and *Xenolepisma*, though there are only three combs per tergite (except for the I and IX, as reported). Further, no barbed macrochaetae are present in the Myanmar amber *Burmalepisma* nor in the sandstone Lepismatidae g. sp. 'Araripe', from Brazil, both from the Cretaceous (Mendes & Poinar 2008, Sturm 1998).

The Australian *Anisolepisma* is completely different from the remaining listed genera, including the new one,

and it certainly does not belong to the same evolutionary line, due to the strongly modified thoracic sternites and the quite unique abdominal setation among other dissimilarities (Silvestri 1908b, Paclt 1967); its position in the family is now under revision (Smith *inf. pers.*).

The remaining genera share typical thoracic sternites with *Protolepisma* gen. n. However, the almost pantropical *Heterolepisma* is quite distinct, as it is the only one in this set to possess an anterior collar of macrochaetae on the pronotum and a not widened thorax, resulting in a much more linear design, which justified its inclusion in its own evolutive lineage, the Heterolepismatinae (Mendes 1991). The specialized sensilla in the maxillary palp, typical for this plesiomorphic genus, are almost certainly not present in *Protolepisma* gen. n. as no transformation could be observed in this palp.

All the other genera, none of which have recent Neotropical indigenous representatives, belong to the Lepismatinae. The monotypical Nearctic *Anallacrotelsa* (Mendes 1996), resembles the amphi-Atlantic *Allacrotelsa* (two living species, one southern Nearctic, the other Palearctic, plus a Baltic amber species) as they share 3+3 urotergal setal combs (though sometimes the inner one may be reduced) and 1+1 or 2+2 anterolateral tufts of macrochaetae on the pronotum – nothing similar occurs in *Protolepisma*. *Allacrotelsa* has also a median setal comb on urosternites I–VII, which is nonexistent in *Anallacrotelsa* and they are the only known Lepismatidae with pseudo-articulated, sub-cylindrical paramera (a feature unknown in *Protolepisma*, known by the female only).

Tricholepisma (with two Palearctic, one Indian and one South African species) and the monotypical eastern Afrotropical *Lepitrochisma* have a continuous row of posterior macrochaetae along the nota and urotergites (Mendes 1988), while the remaining genera share with *Protolepisma* gen. n. a glabrous posterior nota – although some rare *Neoasterolepisma* may possess a few sparse, minute posterior setulae. *Lepitrochisma* presents, further, a unique row of anterior and forwardly oriented macrochaetae on the pronotum, an exclusive urotergal infralateral setation and developed tarsal pulvilli.

A feature fundamental to the characterization of the remaining four genera is the type of specialized antennal sensilla (Mendes 1988), whose shape and presence are virtually impossible to trace in *Protolepisma*. Moreover, they all show a distinct urotergal setation: in *Xenolepisma* (one Southern African, two Oriental representatives) all notal trichobothrial areas are ‘closed’ that is, completely surrounded by scales, as opposed to the condition in all remaining cases, the new genus included. The type of notal trichobothrial areas separates the new genus from the western Palearctic *Lepisma* (three southwestern European species, being that *L. saccharina* Linnaeus,

1758 become synanthropic and cosmopolite) and from *Afrolepisma* (mainly Afrotropical, plus one species in India and other in Melanesia), with all the posterior areas being of the ‘closed’ type and clearly displaced inwardly (the one on the pronotum included). The *Lepisma* body is, otherwise, parallel-sided, with almost a non-detached thorax and the paramera are even more developed, exceeding or at least attaining the apex of coxites IX inner process while *Afrolepisma* lacks a median comb on urosternite I and has visibly less developed paramera. Finally *Neoasterolepisma*, clearly the most diverse, with more than thirty living species ranging along the peri-Mediterranean countries and throughout Africa, is distinguished from *Protolepisma* gen. n. by the more setated urotergites II–VIII (usually two infralateral plus 3 pairs of macrochaetae), a median setal comb on urosternites II only (the I is glabrous) and by the small to medium-sized paramera. The large development of the paramera in *Protolepisma* is, indeed, shared by *Lepisma* s.s. only, characterized by closed trichobothrial areas, different urotergal chaetotaxy and a different body shape, as mentioned above.

Regarding the Cretaceous taxa, the main dissimilarities relative to *Burmalepisma* concern the body shape, the lack of urosternal median combs on this genus and the distinct labial palp (Mendes & Poinar 2008); the two ‘Araripe’ sandstone Lepismatidae specimens are too poorly preserved to allow a detailed analysis of their morphological features (Sturm 1998); they are, however, much larger (11 and 14 mm of body length) than most of the representatives of the family, including *Protolepisma* gen. n. holotype.

Protolepisma tainicum sp. n. (Figs 1, 2, 4–9)

Material examined. 1 male holotype (T-1-5) in Dominican Republic amber (OSU) (Figs 1, 2).

Description. Male. Body length: 3.2 mm; thorax length: 1.1 mm; thorax width: 1.7 mm; antennae length: 1.6 mm; cerci length: 0.7 mm; total body length: 3.9 mm.

Scales uniform, the dorsal surface brownish (golden?), ventrally lighter (silvery white?). Macrochaetae and spines brownish on the appendages, almost hyaline on the body and head. Violet-brown dark pigment on antennae, maxillary palps and terminal filaments, eventually present also along other body parts.

Head transverse, wider than long. Antennae short; if oriented backwards they barely exceed the posterior border of the thorax; distal chains of the flagellum composed of four divisions, their detailed chaetotaxy unknown, specialized antennal sensilla impossible to observe. Maxillary palp small and delicate, its distal

article ca. 1/5 longer than the preceding, cylindrical, ca. 5 times longer than wide, without special features (Fig. 4). Labial palp developed, with the distal article dilated (Fig. 5) and apparently (not clearly visible) with 3+2 large, typical, compact papillae.

Thorax wider than long; metanotum posterior border concave. Pronotum without anterior setal collar. Notal lateral macrochaetae not arranged in combs and no thoracal posterior macrochaetae. Trichobothrial areas as in the genus description, their characteristics sometimes impossible to appreciate in detail: anterior area of the pronotum triangular and wider than

deep, with a medium-size trichobothrium and a few setulae, the posterior area narrower but difficult to see circumstantially (although doubtlessly of the open-type, Fig. 6). Anterior areas of the meso- and metanotum triangular and clearly drawn back, shorter and wider than the corresponding pronotal area; remaining areas not visible though not of the open type. All thoracic sternites well developed. The prosternum not noticeably smaller than those of the remaining segments, sub-triangular and wider than long, with 1+1 combs positioned about 2/3 its length, and 1+1 antedistal combs. From the meso- and metasternum,

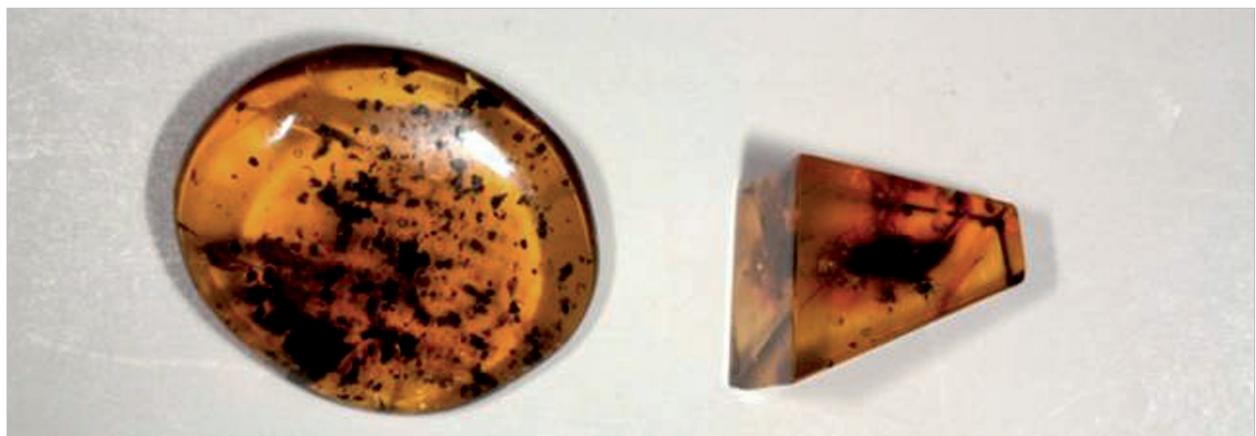


Figure 1. Studied amber fragments, including the holotype of *Protolepisma tainicum* gen. n. sp. n. (left, sample T-1-5) and that of *Paleograssiella chiapanicum* gen. n. sp. n. (right, sample T-1-5A). Photo: A. Bivar de Sousa.



Figure 2. *Protolepisma tainicum* gen. n. sp. n., holotype male, dorsal view. Photo: G. Poinar Jr.



Figure 3. *Paleogressiella chiapanicum* gen. n. sp. n., holotype male, ventral view. Photo: G. Poinar Jr.

both *in situ*, only the free distal area remains exposed; all combs with a reduced number of setae. Legs as usual (Fig. 7), without special characteristics; spines robust on the femur, as long as its diameter, longer on the tibia (eventually proportionally shorter due to the leg segments shrinking). Tarsus typical, the pretarsus simple; empodium claw-like, thin and shorter than the tarsal claws as in the genus description.

Urotergal and urosternal setation as in the genus description, the macrochaetae shorter than 1/3 of the respective sclerite, the infralateral stronger than the remaining (Fig. 8). Urotergite X longer than wide and not excavated along the posterior border, with 2+2 posterolateral macrochaetae (Fig. 9). On the urosternites, the number of macrochaetae per comb always reduced though not clearly visible (apparently, no more than 5). Posterior ventral abdomen as in the genus description, the voluminous paramera sacciform, almost as large as the correspondent coxite inner process, though none of them are clearly and completely visible.

Etymology. The species is named after the Taino people, the Amerindian population inhabiting Hispaniola when Columbus arrived in the New World at the end of the fifteen century. The island is today shared between Haiti in the West and the Dominican Republic in the East.



Figures 4–9. *Protolepisma tainicum* gen. n. sp. n., holotype male. (4) Maxillary palp, (5) Labial palp, (6) Pro- and mesonotum, left side, dorsal, (7) Posterior leg (femur, tibia and tarsus), (8) Macrochaetae of a median urotergite, (9) Urotergite X. Scale bar = 0.1 mm.

Family Nicoletiidae

Subfamily Atelurinae

Paleograssiella gen. n.

Description. Male. Head exposed, completely visible dorsally, scaly, the setae restricted to the frontal area (laterally compressed in the only known specimen as result of fossilization). Antenna with a well developed inner distal pedicellar apophysis. Maxilla not especially elongated and the labium, at least apparently, typical with rounded posterolateral areas. Maxillary and labial palps well developed, with no special features. Nota scaly with smooth, thin, long macrochaetae, arranged in several, more or less regular, transverse rows, especially on the more lateral areas. Legs robust, the pretarsus with two long and thin lateral claws devoid of pulvilli and with one reduced, short, thin, unguiform empodium. Urotergites similar to the nota, scaly and with thin, long and simple macrochaetae arranged along several transverse rows on the laterotergites, with a tendency to become one ante-marginal row on the sagittal area; urotergite X not preserved. Ventral surface partially damaged, the vesicles and styli impossible to trace in the posterior segments, absent from urosternites I–V. Cerci in a very poor condition, only part of the basal division of the left one preserved, apparently with a few rare, short (or damaged?) pegs. The paracercus base (only the basal division preserved) with very robust dorsal and lateral dark pegs.

Etymology. From the Greek: *Palaios*, old, antique, and *Grassiella*, one of the eventually more similar recent genera; gender neuter.

Type-species. *P. chiapanicum*, in the monotypical genus.

Discussion. The only hitherto known fossil Atelurinae was *Archeatelura sturmi* Mendes, 1997 preserved in Oligocene–Miocene Dominican amber from the Fabaceae *Hymenaea protera* Poinar (Poinar 1991, Mendes 1997a, notes in Mendes, 1997b), and originally considered to date from 25–40 MY.

The new species is preserved in Chiapas amber, a fossil resin produced by *Hymenaea mexicana* Poinar & Brown 2002 and dating from Upper Oligocene to early Miocene (Poinar 1993, Poinar & Poinar 1999). Differences between *Paleograssiella* gen. n. and *Archeatelura* are the much larger size of the Mexican specimen, the much more developed pedicellar apophysis in the new genus, the lack of tarsal pulvilli, the reduced empodium and, mainly, the quite different body setation. Relatively to the recent Nicoletiidae, *Paleograssiella* gen. n. seems to approach a group of predominantly

Neotropical Atelurinae (in Mendes 2002 sense) recently united as the tribe Grassiellini (see Mendes 2012 for the tribes' characterization), which includes the genera *Allograssiella*, *Atelurina*, *Attatelura*, *Grassiella*, *Mesonychographis* and *Santhomesiella*, as well as the Oligocene *Archeatelura*.

The remaining known Atelurinae may be excluded from this comparison, as their males are devoid of antennal pedicellar apophysis (tribes Atopatelurini and Dionychellini), or they lack the modified chaetotaxy on the paracercum base (Atelurini). The exclusively Southern African termitophilous Dinatelurini show, otherwise, a modified body shape, a distinct type and distribution of setae and scales, usually a different modified pedicellar apophysis and in most cases, a morphologically modified paracercum (Wygodzinsky 1970), making them quite isolated geographically and morphologically impossible to confuse with any other group.

Concerning the recent Grassiellini, *Paleograssiella* differs from all known genera by the long notal and urotergal macrochaetae and their arrangement, as well as by the very thin, long tarsal claws and the delicate and minute empodium. The Afrotropical *Mesonychographis* possesses a quite unique well developed empodium, with a dorsal crest of setulae (Silvestri 1908a), but in all the remaining genera of the tribe, the empodium is simple and usually well developed; if reduced as in *Atelurina* (monotypical, known from the Eastern Brazil based on one female only – Wygodzinsky 1943), then the lateral claws have pulvilli, the maxillary palp is shortened, the maxilla is greatly elongated, the labial palp apical article is enlarged and the head partially concealed by the anterior border of the pronotum.

Paleograssiella chiapanicum sp. n. (Figs 1, 3, 10–17)

Material examined. 1 male holotype (T-1-5A) in Mexican amber from Chiapas (OSU) (Figs 1, 3).

Description. Body length: 6.8 mm; thorax length: 3.2 mm; thorax width: 2.1 mm; antenna length: 3.3 mm.

Head laterally compressed (if not distorted, it should be somewhat wider than long), covered by scales, the setae restricted to the frontal area. Antennae slightly longer than the thorax (entire?); scapus sub-cylindrical, short; pedicellus longer than wide with a very developed apophysis, which almost attains the level of the third flagellum division; pedicellus with an inner ventral tuft of quite strong, large macrochaetae (Fig. 10); chaetotaxy of flagellum not possible to observe in detail. Mandibles not well visible although the exposed area is as usual. Maxillae not elongate; maxillary palp typical (Fig. 11), long and thin (eventually somewhat distorted

due to the amber preservation), its distal article ca. 1/3 longer than the preceding and ca. 5 times longer than wide. Labium not distinctly visible, though apparently with posterolateral round areas; labial palp well developed,

thin, with almost cylindrical distal article (Fig. 12). Thorax large, attaining ca. half the body length, with scales and with several transverse rows of thin, elongated smooth macrochaetae (Fig. 13), as in the genus description.



Figures 10–17. *Paleograssiella chiapanicum* gen. n. sp. n., holotype male. (10) Antennal pedicellus, (11) Maxillary palp, (12) Labial palp, (13) Macrochaetae of metanotum, (14) Median leg, detail of pretarsus, (15) Hind leg, tibia and visible part of tarsus, (16) Preserved area of the left cercus, ventral, (17) Base of paracercum (only preserved division), ventral oblique. Scale bars = 0.1 mm.

Legs robust. Tibia with dark spines attaining or even surpassing its diameter (they are strong and long, despite the eventual tibia shrinking due to the amber fossilization), 5–6 spines in the apical area, 2–3 in the median-proximal region; tibial epiphysis pointed and very large. Tarsus with four tarsomers; the first article distal ventral area, with 1–3 spines similar to those on the tibia; praetarsus with two lateral well developed and clearly arched claws and a greatly reduced, claw-like empodium (Figs 14–15). Urotergites as the nota, scaly and with some transverse rows of thin, long, smooth macrochaetae, less numerous on the middle dorsal area. Urotergite X not preserved. Urosternal surface damaged, the preserved urosternites with long smooth macrochaetae similar to those on the body dorsal surface; at least urosternite I–V devoid of stylets and of vesicles. Genitalia not preserved, and so, paramera morphology unknown. Cerci (only the left one is partially preserved, though in very poor condition, Fig. 16) with a large basal division and with 1–2 also poorly preserved inner pegs only. Paracercum with strongly sclerotized pegs symmetrically arranged in two or more rows along the basal and only preserved division (Fig. 17).

Etymology. The new species is named after the Tepechiapan people, considered to be the original human population inhabiting the recent Mexican State of Chiapas.

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