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Oligocene scorpion and insects (Plecoptera and Coleoptera) from the Los Ahuehuetes Locality, Puebla, Mexico

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Abstract. A scorpion prosoma, a plecopteran nymph, *Euperlida parvicercifera* Cifuentes-Ruiz gen. *et* sp. nov., and the elytra of an adult beetle (Coleoptera) are described from the Oligocene Coatzingo Formation, Puebla, Mexico. Specimens were found at the Los Ahuehuetes locality, Puebla, from where numerous plant remains have been previously described. A lacustrine paleoenvironment for these sediments is confirmed based on habitat of recent Plecoptera. This report represents the first record of Oligocene continental arthropods from Central Mexico, and the first for a fossil Plecoptera in this country. It is the first record for a Nearctic extinct genus of Perlidae.

Resumen. ESCORPIÓN E INSECTOS (PLECOPTERA Y COLEOPTERA) DEL OLIGOCENO DE LA LOCALIDAD LOS AHUEHUETES, PUEBLA, MÉXICO. El prosoma de un escorpión, la ninfa del plecóptero *Euperlida parvicercifera* Cifuentes-Ruiz gen. *et* sp. nov., y los élitros de un coleóptero adulto son descritos del Oligoceno de la Formación Coatzingo, Puebla, México. Los especímenes fueron encontrados en la localidad de Los Ahuehuetes, Puebla, de donde numerosos restos de plantas han sido previamente descritos. Un paleoambiente lacustre es confirmado en base al hábitat de Plecoptera recientes. Se trata del primer registro de artrópodos continentales del Oligoceno de la porción central de México, y el primer registro fósil de Plecoptera para este país. Es el primer registro de un género neártico extinto de Perlidae.

Key words. Scorpionida. Insecta. Oligocene. Puebla. Mexico.

Palabras clave. Scorpionida. Insecta. Oligoceno. Puebla. México.

Introduction

The fossil record of arachnids and insects in Mexico is rather scarce. An Upper Permian insect was described by Carpenter and Miller (1937) from Valle Las Delicias, Coahuila. Other reports include one spider, an odonate nymph from the Lower Cretaceous Tlayúa Formation of Tepexi de Rodríguez, Puebla (Feldmann *et al.*, 1998), and a pair of tipulid wings also found in that locality (Pantoja-Alor, 1992). Another odonate (zygopteran) nymph and a hemipteran have been reported from Lower Cretaceous (Albian) beds of the Sierra Madre Formation, Chiapas (Vega *et al.*, 2003, 2006). A Campanian assemblage of arthropods, consisting of a small spider, a dragonfly assigned to the Libelluloidea, and the latest record of the cockroach family Blattulidae, have been reported from the Cerro del Pueblo Formation in northeastern Mexico (Cifuentes-Ruiz *et al.*, 2006). Numerous Oligocene-Miocene arachnids and insects preserved in amber (*e.g.*, Petrunkevitch, 1963, 1971; Perrilliat, 1989; Zaragoza-Caballero, 1990; Poinar and Doyen, 1992; Santiago-Blay and Poinar, 1993; Poinar and Brown, 2002; Engel, 2004, among others) from the Simojovel de Allende deposits in central Chiapas were reported, including 15 orders and 81 insect families, all belonging to modern genera. More recently, a new species of *Epicauta* was described from Pliocene beds of Hidalgo (Zaragoza-Caballero and Velasco-de León, 2003).

The specimens here reported were collected at the Los Ahuehuetes locality, located at 18º35'15ºN and 97º55'30"W, approximately 4.5 km NNE from Tepexi de Rodríguez, Puebla (locality IGM-2573). This outcrop is part of the Coatzingo Formation, whose base is composed by chert and limestone, followed upwards by a sequence of fossiliferous volcanic ashes and fine sandstones. The age for this unit has not

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been formerly defined, but stratigraphic relationships, as well as palynological and paleobotanical evidence suggest that it is Lower Oligocene (Silva-Romo, 1998; Martínez-Hernández and Ramírez-Arriaga, 1996; Magallón-Puebla and Cevallos-Ferriz, 1994a). The paleoenvironment has been interpreted as a low energy lacustrine basin (Pantoja-Alor, 1992; Beraldi-Campesi, 2003).

Numerous reports of well preserved plant macrofossils from this locality have been published. Most of them deal with the description of new taxa and discuss paleobiogeographic and stratigraphic implications (*e.g.*, Magallón-Puebla and Cevallos-Ferriz, 1994b, 1994c; Velasco-de León and Cevallos-Ferriz, 2000; Ramírez and Cevallos-Ferriz, 2000a, 2000b, 2002; Ramírez *et al.*, 2000; Calvillo-Canadell and Cevallos-Ferriz, 2002, 2005). Other remains include scarce fern fronds and an earthstar fungus (Magallón-Puebla and Cevallos-Ferriz, 1993).

This is the first report of a fossil Plecoptera for Mexico, and the second for an Oligocene nymph of the same family (Perlidae); a scorpion prosoma and the elytra of a beetle are also described. Their occurrence contribute to a better documentation and understanding of the paleoenvironment of this formation.

Specimens are deposited in the Colección Nacional de Paleontología, Instituto de Geología, UNAM, under IGM numbers for type specimens collection, and in the Colección Paleontológica de la Escuela Regional de Ciencias de La Tierra, Universidad Autónoma de Guerrero, under acronym ERCT.

Systematic paleontology

Class ARACHNIDA Lamarck, 1801
Order SCORPIONIDA Latreille, 1817
Family uncertain
Figure 1

Material examined. Specimen ERCT-1570, locality IGM-2573, Coatzingo Formation, Oligocene.

Description. Prosoma subtrapezoidal, anterior margin convex, posterior margin straight; irregular, microtubercled surface, more evident toward the anterior margin; median eyes raised, slightly longer than wide, one fifth of total carapace length, with distinct supraorbital carinae; median ocular area subrhomboidal, seven tenths of total carapace length.

Measurements (in mm). Specimen ERCT-1570 (cephalothorax): total length = 5.2; anterior width = 4.1; median width = 5.3; posterior width = 6.8; median eye length = 1.1, width = 1.0; median ocular area length = 3.5, width = 2.6.

Discussion. Santiago-Blay *et al.* (2001) assigned this specimen to the Family Vaejovidae, however, no taxonomically valuable characters, like the trichobotria or the coxosternal region (Polis, 1990) were preserved, making a reliable determination uncertain, even to the family level. Nevertheless, the great size of the median eyes is remarkable and apparently absent within extant genera (Francke, pers. comm., 2004).

Figure 1. Scorpion prosoma, specimen ERCT-1570, Los Ahuehuetes locality, Coatzingo Formation, Oligocene / *prosoma de escorpión, espécimen ERCT-1570, localidad Los Ahuehuetes, Formación Coatzingo, Oligoceno.*

Class INSECTA Linnaeus, 1758
Order PLECOPTERA Burmeister, 1839
Suborder ARCTOPERLARIA Zwick, 1973
Family PERLIDAE Latreille, 1802
Subfamily ACRONEURIINAE? Klapálek,1914
Tribe ACRONEURIINI? Klapálek, 1914

Euperlida Cifuentes-Ruiz gen. nov.

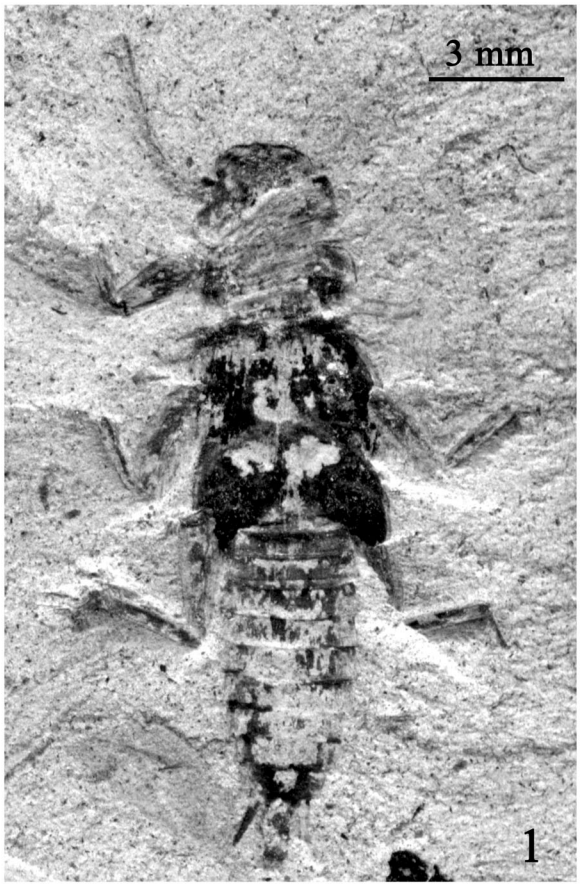
Type species. *Euperlida parvicercifera* Cifuentes-Ruiz sp. nov.

Diagnosis. Body length ca. 20 mm. Head rounded; long antennae; pronotum rectangular, posterior lateral border not expanded; medium sized, strongly divergent wing pads on meso and metathorax; stout profemur, short and slender tibiae; abdomen stout, slightly longer than thorax; ten recognizable abdominal segments; two short, acute cerci.

Etymology. The generic name refers to its certain taxonomical placement within Perlidae.

Euperlida parvicercifera Cifuentes-Ruiz
gen. et sp. nov.
Figures 2.1, 2.2

Material examined. Holotype IGM-6628, locality IGM-2573, Coatzingo Formation, Oligocene.



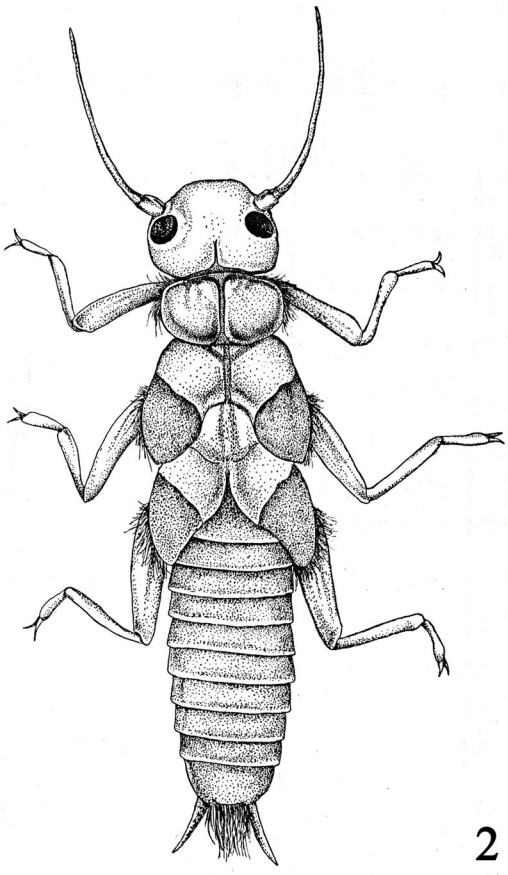


Figure 2. ***Euperlida parvicercifera*** Cifuentes-Ruiz gen. et sp. nov. **1,** Dorsal view of holotype IGM-6628, Los Ahuehuetes locality, Coatzingo Formation, Oligocene. 2, Reconstruction / ***1,*** *vista dorsal del holotipo IGM-6628, localidad Los Ahuehuetes, Formación Coatzingo, Oligoceno.* **2,** *reconstrucción.*

Diagnosis. As for the genus.

Description. Left antenna slender and elongate, one fifth body length; basal segment quadrangular. Head rounded, about one tenth body length, and four fifths maximum width. Labrum at the most anterior border of the head. Pronotum rectangular, twice as broad as long, slightly broader than head, four fifths maximum width; anterior and posterior angles rounded. Mesonotum width about nine tenths maximum width; maximum width at metanotum. Medium sized wing pads, subtriangular, round apex. Hind wing pads diverging from long axis of body, attaining second abdominal segment. Fore and hind wing pad surface with lighter coloration at the middle. Profemur stout, half of total leg length, three times as long as broad; tibiae shorter and narrower than femora, two thirds femora length, almost half femora width. Right fore leg missing. Right metatarsus without visible joints or claws; its length, one third femur length; its width, one eighth femur width. Abdomen stout, telescoped, nearly as long as thorax, its length about one half body length, sides slightly arcuate. Ten visible abdominal segments, six times as wide as long. Sixth segment the widest, last segment the narrowest, with an apparent short, broad, and irregular median projection, slightly longer than left cercus. Left cercus short and acute; nearly as long as tarsus. Only a slight impression of the right cercus is visible.

Measurements (in mm). Slight differences among dimensions of some paired structures are due to taphonomic processes (*i.e.*, burial position). Specimen IGM-6628: total length = 26.8; left antenna length = 5.0; head length = 2.6, width = 3.7; pronotum length = 2.0, width = 3.9; mesonotum length = 2.9, width = 4.5; metanotum length = 3.5, width = 4.8; abdomen length = 9.4, width = 3.3; left cerci length = 1.4, width = 0.3; left profemur length = 2.2, width = 0.9; left mesofemur length = 2.9, width = 0.9; left metafemur length = 3.0, width = 0.8; left protibia length = 1.7, width = 0.5; left mesotibia length = 2.0, width = 0.3; left metatibia length = 2.3, width = 0.3; right mesofe-

mur length = 3.0, width = 0.5; right metafemur length = 3.1, width = 0.6; right mesotibia length = 2.3, width = 0.3; right metatibia length = 2.3, width = 0.3; right metatarsi length = 1.1, width = 0.1; left mesothoracic wing pad length = 2.8, width = 2.0; left metathoracic wing pad length = 3.2, width = 3.0; right mesothoracic wing pad length = 3.0, width = 1.9; right metathoracic wing pad length = 2.7, width = 1.7.

Etymology. The specific epithet refers to the short, acute cerci.

Discussion. The specimen corresponds to a carbonaceous compression. Despite the incompleteness or lack of preservation of important characters such as the gills or the impossibility to see them due to the position in which the nymph was preserved, the presence of a relatively long antenna, wing pads, and two abdominal caudal filaments (Arnett, 1993), allows to refer the fossil nymph as a juvenile stonefly.

Although typical diagnostic characters at the family level, such as mouth parts or gills are not visible, there are several features like the shape and size of the head, wing pads, body pattern (Peckarsky *et al.*, 1990), as well as the foreleg and pronotum shape (Hamada and Couceiro, 2003) allowing its identification within Perlidae. Similar wing pad divergence is found in Perlodidae, although the large size of the head and the small size of pronotum in this family prevent its recognition as a bona fide member. Placement of the specimen in other families seems also improbable mostly because the general body pattern do not match at all: *e.g.*, size and shape of head; size, shape and divergence of wing pads; size and shape of body. Rounded shape of nymphal wingpads and an ellipsoid pronotum are characters typically present in perlodids-perlids the former (Zwich, 2000), and in perlids the latter (Olifiers *et al.*, 2004), and are evident in the specimen too.

The first record of the Order Plecoptera belongs to the Permian, and the one for the Family Perlidae to the Cretaceous (Carpenter, 1992). Stoneflies of Paleogene age are rare, all belonging to living families (Sinitshenkova, 2002). Several larvae and adults of Perlidae are described from Baltic amber and attributed to the recent genus *Perla* Geoffroy (Carpenter, 1992). The only known record from the Neotropics, specifically from the Dominican amber, is *Dominiperla antigua*, and corresponds to an adult specimen (Stark and Lentz, 1992). A larva from the Oligocene of Southwestern Montana (USA), attributed to *Acroneuria* Pictet, and an immature stonefly from Lower Miocene of Northern Bohemia, Czech Republic, *Perla* cf. *burmeisteriana* Claassen have been also reported (Prokop, 2002).

The majority of North American extant stonefly genera is endemic to the Nearctic Province with a second component being common to the East Asiatic fauna (Illies, 1965). The number of currently recognized Nearctic perlid genera is 15 (Stewart and Stark, 1993), while in the Neotropics, 10 perlid genera and approximately 280 species are considered valid (Stark, 2001).

On the other hand, extant fauna of Plecoptera in Mexico includes North American boreal and austral elements of tropical origin, including 47 species within 12 genera and 7 families. Nearctic affinities are found in 25 species, included in the following genera: *Bisancova*, *Haploperla*, *Cultus*, *Malenka*, *Capnia*, *Mesocapnia*, *Isoperla*, *Capnura*, *Paraleuctra*, *Amphinemura*, and *Pteronarcys* belonging to Capniidae, Leuctridae, Nemouridae, Chloroperlidae, Perlodidae, and Pteronarcyidae (Baumann and Kondratieff, 1996). The Neotropical element of Mexican Plecoptera is represented by 30 species in a single genus: *Anacroneuria* (Perlidae) (Stark and Kondratieff, 2004). All Mexican Plecoptera are only known from the adult stage (Baumann and Kondratieff, 1996).

The habitus of the specimen herein described indicates a rather Nearctic element of Perlidae. Shape, size, and proportion of wing pads differ between *Euperlida* Cifuentes-Ruiz gen. nov. and *Anacroneuria* Klapálek (Neotropical), and although proportion of pronotum and shape of its posterior lateral borders coincide (Dorvillé and Froehlich, 1999; Hamada and Couceiro, 2003), fore and hind wing pads in *Anacroneuria* are not subtriangular or posteriorly prominent as in *Euperlida* Cifuentes-Ruiz gen. nov.

Habitus features like shape, size, and proportion of pronotum and wingpads in *Euperlida* Cifuentes-Ruiz gen. nov. resemble those in *Eccoptura* Klapálek and *Acroneuria* Pictet, both Nearctic genera. *Eccoptura* has the general habitus of *Acroneuria*, but is readily identified by the distinctive color pattern (Stewart and Stark, 1993). The medial portion of fore and hind wing pads in the specimen shows a lighter coloration respect to their sides and apexes. Since patterns of dark and light spot coloration are commonly visible in fossil specimens (*e.g.*, Prokop, 2002), this finding could indicate a stronger resemblance with *Eccoptura*.

The fossil nymph shows a rounded head and a rectangular pronotum with the posterior lateral border not expanded. Apparently both, the fore and hind wing pads, diverge strongly from long axis of body. The apex of the metathoracic wing pads attains the second abdominal segment. The preserved left foreleg shows a stout femur and a short and slender tibia. The total length of the body also matches the size reported within *Eccoptura* (Stewart and Stark, 1993). Nevertheless, no extant New World perlid genus presents short cerci (Stewart and Stark, 1993; Zwick, 2000; Hamada and Couceiro, 2003). Short and acute cerci in the specimen isolate it from any other extant genus within Perlidae. Within Plecoptera, cer-

ci length is, in some cases, a taxonomically important character at the genus or family level; sometimes it is sexually dimorphic too (Zwick, 2000). Although short cerci with blunt apexes are found in some species of Nemouridae and Leuctridae (Harper and Stewart, 1984), this is not the case in Perlidae. Therefore, *Euperlida* Cifuentes-Ruiz gen. nov. differs from other known stoneflies in the shape and size of cerci. Its rather stout abdomen is remarkable too.

External and internal morphological features (*e.g.*, head ridges, gills, and genitalia) cluster perlids into two subfamilies and six tribes (Zwick, 2000). Such structures are neither visible nor preserved in the specimen, therefore *Euperlida parvicercifera* Cifuentes-Ruiz gen. et sp. nov. could only be tentatively assigned to Acroneurinae and Acroneuriini, where similar extant genera are currently placed (*i.e. Eccoptura* and *Acroneuria*).

Biogeographical conclusions about floristic features at Los Ahuehuetes mention a high-latitude North American composition with Mexican endemics (Ramírez and Cevallos-Ferriz, 2002). It seems that the finding of *Euperlida parvicercifera* Cifuentes-Ruiz gen. et sp. nov. documents at least some Nearctic influence in the fauna of the place at that time, however, only further records could provide information about the endemism of the taxon herein proposed.

Additionally, the importance of this record resides in the fact of being the first report of a stonefly fossil for Mexico, and in its striking palaeoecological implications. Immature Plecoptera are aquatic, living in clear, cold, unpolluted rivers, streams and lakes, with high oxygen levels required during their development (Baumann, 1987). Nymphs can occur abundantly in warmer lowland streams and rivers (Baumann and Kondratieff, 1996), bearing gills of different structure and disposition (Sinitshenkova, 2002). The finding of this type of insect confirms the interpretation of the place as a lacustrine environment or a low energy fluvial environment, where evaporation was greater than precipitation, rendering a tropical xeric area where a community similar to that of a tropical dry forest established and served as shelter for animals like the ones here described (Ramírez and Cevallos-Ferriz, 2000a, 2000b; Beraldi-Campesi, 2003).

Order COLEOPTERA Linnaeus, 1758
Family uncertain
Figure 3.1

Material examined. Specimen IGM-6629, locality IGM-2573, Coatzingo Formation, Oligocene.

Diagnosis. Elytra long, convex, tubercled, base emarginated with anterior intersegmental membrane fragment visible; suture raised, continuous.

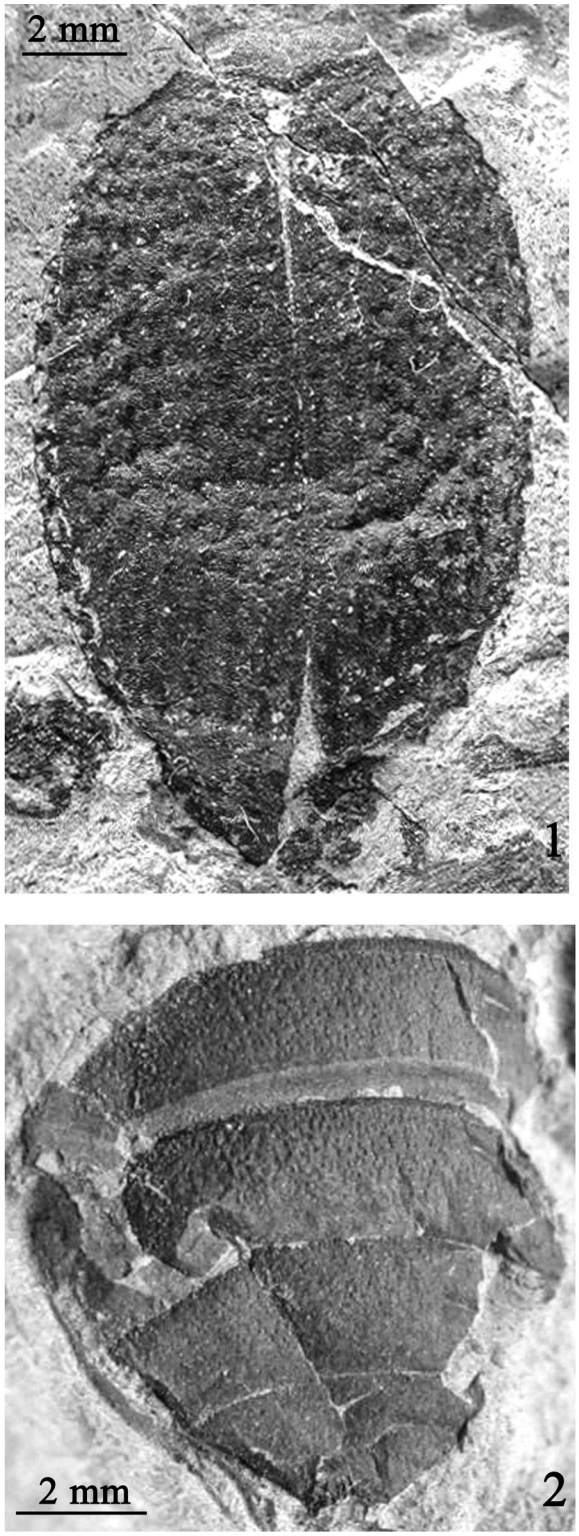


Figure 3. 1, Dorsal view of a coleopteran, showing elytra and intersegmental membrane fragment, specimen IGM-6629. **2,** Ventral view of the apical portion of coleopteran abdomen, specimen IGM-6672. Los Ahuehuetes locality, Coatzingo Formation, Oligocene / **1,** *vista dorsal de un coleóptero, mostrando los élitros y un fragmento de la membrana intersegmental, espécimen IGM-6629.* **2,** *vista ventral de la porción apical del abdomen de un coleóptero, espécimen IGM-6672. Localidad Los Ahuehuetes, Formación Coatzingo, Oligoceno.*

Description. Remains of elytra and intersegmental membrane of mesothrorax. Shape oval, stout. Intersegmental membrane fragment length about one twentieth specimen maximum length. Elytra length almost four times their width, sides evenly rounded, base broadly emarginate; surface catenate, sculptured with eight longitudinal rows of prominent convex tubercles slightly larger toward the median part, tubercles in contact with raised suture, continuous with apical margin; apex pointed.

Measurements (in mm). Total length = 19.6; anterior part of mesothorax length = 1.1, width = 4.2; left elitra length = 18.5, width = 5.8; humeri of elytra width = 3.2; median part of elytra width = 11.7; apex of elytra width = 4.7.

Discussion. Extinct species from Tertiary strata have been doubtfully assigned to extant genera without considering the inherent constraints of generic assignations based on isolated elytra (Carpenter, 1992). Visible features on the elytra above described, (*i.e.*, tubercled sculpture), could be present throughout the order; from a general approach, shape, size, and surface relief could remind of *Zopherus* Gray (Zopheridae), as well as several tribes within Tenebrionidae (*e.g.*, Cryptoglossini: Pimeliinae). Beetle's bodies in these groups are moderate to large, most often apterous with fused elytra, and with glabrous to rugose-tuberculate surface (Triplehorn, 1972; Aalbu *et al*., 2002).

An incomplete coleopteran abdomen (figure 3.2, specimen IGM-6672) was found at the same locality; intersegmental membranes are visible, but insufficient to allow a more precise identification.

Seventy-three families of Oligocene beetles have been reported, and several hundred species have been described (Rasnitsyn and Quicke, 2002), though the majority of the descriptions are in need of revision. Some Oligocene amber inclusions of beetles that belong to Elateridae, Platypodidae, Dermestidae, Alleculidae, Chrysomelidae and Cantharidae are mentioned in a list of Mexican fossil types (Perrilliat, 1989). This is the first coleopteran impression described for this age in Mexico.

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