RESEARCH ARTICLE



Diversity and distribution of Chirostyloidea and Galatheoidea (Decapoda, Anomura) in the Southern Gulf of Mexico

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Academic editor:	S. De Grave	Received 8 June	e 2016	Accepted 5 July	v 2016	Published 2	3 August 2	2016
	http://	zoobank.org/82009	1DF-90D8-	-4185-8624-600B	274F9AE9)		

Citation: Vázquez-Bader AR, Gracia A (2016) Diversity and distribution of Chirostyloidea and Galatheoidea (Decapoda, Anomura) in the Southern Gulf of Mexico. ZooKeys 612: 1–30. doi: 10.3897/zookeys.612.9492

Abstract

We examined the diversity, abundance, distribution, and average size of squat lobsters collected during eight cruises conducted on the continental shelf and slope of the Gulf of Mexico (Mexican/USA border to the Caribbean Sea). Six species belonging to two genera of Chirostyloidea, and 25 species of four genera of Galatheoidea are reported. A total of 1513 specimens were obtained of which 95 were Chirostylidae, two Galatheidae, 285 Munidopsidae, and 1131 Munididae. Of the species collected, 13.8% were only known from Caribbean Sea. Three species of Chirostylidae—*G. salvadori, U. capillatus*, and *U. spiniger*—as well two of Munidopsidae, *M. bradleyi* and *M. riveroi*, are recorded for the first time in the Gulf of Mexico. The upper bathymetric range of one species and the lower one for eight species are extended. Biological and ecological traits of squat lobsters in the southern Gulf of Mexico are also provided.

Keywords

Chirostilydae, Galatheidae, Munididae, Munidopsidae, Gulf of Mexico, depth, distribution, abundance, new records

Introduction

Squat lobsters (Chirostyloidea and Galatheoidea) are abundant, speciose, and distributed worldwide (Fierro et al. 2008; Kilgoure and Shirley 2014; Konishi and Saito 2000;

de Melo-Filho 2006; de Melo-Filho and de Melo 1992; de Melo-Filho and de Melo 2001 a and b; Miyake and Baba 1970; Navas et al. 2003; Pequegnat and Pequegnat 1970). Schnabel et al. (2011a) and Schnabel et al. (2011b) recognized ca.1000 species (ca. 10% undescribed) that occur in all marine habitats, from the intertidal zone to more than 5400 m depth, including anchialine caves and hydrothermal vents. Recent molecular and phylogenetic studies of the Anomura have proposed significant changes in the phylogenetic relationships of squat lobsters. These recent studies indicate that the Chirostyloidea Ortmann, 1892, include the following families: Chirostylidae Ortmann, 1892, Eumunididae A. Milne-Edwards & Bouvier, 1900, and Kiwaidae Macpherson, Jones & Segonzac, 2005 (Schnabel and Ahyong 2010). The Galatheoidea Samouelle, 1819, comprises: Galatheidae Samouelle, 1819; Munididae, Ahyong, Baba, MacPherson & Poore 2010; Munidopsidae, Ortmann, 1898; and Porcellanidae Haworth, 1825 (Ahyong et al. 2010; Schnabel et al. 2011a). The Chirostylidae currently includes seven genera and over 200 species worldwide (Baba 2009; Baba and Lin 2008; Baba et al. 2008; Ahyong et al. 2009, Schnabel and Ahyong 2010), whereas the Galatheidae includes 11 genera and 95 species; the Munididae 20 genera and 395 species; and the Munidopsidae four genera and 250 species (Ahyong et al. 2011).

Squat lobsters are of ecological and economic interest because they play an important role in the marine food chain in coastal areas and sustain important fisheries in Central and South America and the Mediterranean Sea. However, overall studies of squat lobsters around the world have been mainly related to new species descriptions, and relatively few studies have made emphasis on their ecology and population structure (Creasy et al. 2000; Huguet et al. 2005; Kassuga et al. 2008; Maiorano et al. 2013).

In the southern Gulf of Mexico, Chirostyloidea and Galatheoidea species composition, distribution and abundance are poorly known compared to the northern Gulf. Though they are one of the most abundant and diverse groups just after penaeoids, information is restricted to a few species records (Escobar et al. 2008). In the last decade, several expeditions to study benthic biodiversity of the continental shelf and slope of the southern Gulf of Mexico have been conducted (Gracia et al. 2010; Vázquez-Bader and Gracia 2013; Vázquez-Bader et al. 2014). This paper represents the first attempt to contribute to the overall diversity, ecology, and knowledge of this group in this area. We provide data about specific composition, depth and geographic distribution, as well as basic biology and ecology traits of squat lobsters in the southern Gulf of Mexico.

Material and methods

All the material analyzed was collected during research cruises in the southern Gulf of Mexico onboard the R/V *Justo Sierra* of the Universidad Nacional Autónoma de México, on the continental shelf and slope of the Mexican Gulf of Mexico. Samples were obtained day and night with an otter trawl (18 m mouth aperture, 4.5 cm stretched mesh, 1.5 cm stretched mesh cod-end). Each tow lasted 30 min at a speed of 2.5–3.0 knots. We performed 273



Figure 1. Study area showing sampling stations by oceanographic cruise. Abbreviations: T = Tampico, V = Veracruz, TA = Tabasco, C = Campeche, Y = Yucatán, QR = Quintana Roo.

trawls between 300 and 1200 m during the following expeditions: BATO (spring 1998), BIOREPES1 (summer 2005), BIOREPES2 (spring 2007), BIOREPES3 (autumn 2008), COBERPES (summer 2009), and COBERPES 2011 (spring 2011), COBERPES 3 (Autumn 2011), and COBERPES 4 (Summer 2012). Additional material examined was collected from cruises SGM (between 15–100 m) in the Campeche Bank area (Fig. 1).

The catch of each haul was sorted by species and counted onboard. All material collected was determined to species level, preserved in ethanol (80%), and deposited in the Crustacean Reference Collection of the Laboratorio de Ecología Pesquera de Crustáceos, Instituto de Ciencias del Mar y Limnología, UNAM (EPC). For each specimen, we recorded cruise name and station number (stn.), and registered the geographic distribution according to a sector and subsector division within the Southern Gulf of Mexico (NNE = North northeastern; WNW = West Northwestern; SSW = South Sothtwestern; SSE = South Southestern; and ESE = East Southeastern) (Felder et al. 2009). We analyzed abundance, size and sex for each species (males = M and females = F). The carapace length (CL) was measured from the posterior border of the orbit to the mid-point of the posterodistal margin to the nearest 0.1 mm with a calibrated caliper. Differences in abundance by size and sex related to seasons (spring, summer and autumn) and 100 m depth intervals were analyzed for the most abundant species using a one-way ANOVA (STATISTICA version 12.0 StatSoft, Inc.). When ANOVA results were significant, post-hoc Tukey tests were used (Sokal and Rohlf 1995). Also, when sex ratio deviated from the expected proportion (1M: 1 F), we applied a two tail χ^2 test.

Results

Superfamily Chirostyloidea

We collected 95 individuals belonging to two genera and six species of Chirostylidae. Although all species occur throughout the Gulf of Mexico, only one had sample size large enough for a meaningful statistical analysis. Among the chryrostiloids examined we found approximately 31 individuals belonging to *Gastroptychus* that could not be clearly assigned any of described species of this genus. These specimens will be the object of a later study and are not considered herein in the total number for the family.

Gastroptychus salvadori Rice & Miller, 1991

Material examined. BIOREPES 2 stn.12, 1 ovigerous female.

Remarks. One ovigerous female was collected in June (CL 18.2 mm). This species was been reported for the Caribbean only by Baba et al. (2008). Thus, this is the first record for the Gulf of Mexico (SSW sector; off Alacranes Reef, Yucatán Peninsula). Also the upper bathymetric range is extended from 874 m to 650 m.

Gastroptychus spinifer (A. Milne-Edwards, 1880)

Material examined. BATO stn. 20, 3 males; stn. 32, 1 male; stn. 33, 1 ovigerous female; stn. 34, 2 ovigerous females.

Remarks. We collected only seven specimens (males CL 13.5–16.2; ovigerous females CL = 21.7–23.5 mm); 299–562.5 m. The ovigerous females distributed deeper (414.5–562.5 m) than males (299.0–311.8 m). These records are the first in the in SSW sector (Bank of Campeche), previous distribution was reported in NNE, NNW, and ESE of the Gulf of Mexico (Felder et al. 2009).

Uroptychus capillatus Benedict, 1902

Material examined. COBERPES 2011 stn. B1, 3 females, 1 ovigerous female; stn. B9, 6 males, 8 females, 4 ovigerous females.

Remarks. The 22 individuals occurred in front of Ría Lagartos, Quintana Roo between 976.0 and 1040.0 m. The overall sex ratio (1M: 2.66 F) deviates significantly from the expected ratio 1:1 ($\chi^2 = 4.545$ with 1 degree of freedom, two-tailed (P = 0.03). The carapace length size in males ranged from 4.7 to 10.2 mm, whereas females range was 6.3–10.00 mm and in ovigerous females was 8.3 to 11.2. The material examined increased the lower bathymetric limit to 1040 m from previous range (306–573 m, Baba et al 2008). Also, it is the first record for the sector SSE Gulf of Mexico. Previous records are only for the Caribbean (Baba et al 2008).

Uroptychus nitidus (A. Milne-Edwards, 1880)

Material examined. BATO stn. 29, 1 female; stn. 47, 1 female,1 ovigerous female; stn. 48, 1 female, 1 ovigerous female, stn. 53, 1 ovigerous female. BIOREPES 2 stn. 27, 1 male, 1 ovigerous female; stn. 28, 1 male; stn. 28b, 1 male, 1 ovigerous female; stn. 31, 1 female. BIOREPES 3 stn. A16, 1 ovigerous female; stn. C1, 6 males, 2 females, 3 ovigerous females. COBERPES stn. A6, 1 ovigerous female; stn. B10, 1 male; stn. B11, 1 male. COBERPES 2011 stn. B9, 15 males, 4 females, 5 ovigerous females, stn. D1b, 1 female, stn. D10, 1 female stn. C2, 1 male, 1 female, stn. D6b, 3 males, stn. C3, 3 males, 1 female.

Remarks. This species was the most abundant and frequent of the genus *Uroptychus* (n= 62 individuals). Specimens were collected off Laguna Madre, Tamaulipas; Términos Lagoon, Campeche; Carmen y Machona, Tabasco; N of Alacranes Reef, and Progreso, Yucatán; between 352 and 1044 m. The maximum abundances were found in spring (58.12%) and in sector ESE (61.3%) between 406.5–1044.0 m depth. The overall sex ratio favored males 1.18 M: 1 F, but it was not statistically significant ($\chi^2 = 0.581$, with 1 degree of freedom, two-tailed P= 0.45). Ovigerous females were present in spring, summer, and autumn.

The bathymetric range was different in summer (352.0–1144.0) and autumn (510.0–552.0 m). Females presented a slightly larger mean carapace length $\bar{x} = 8.9 \pm 3.45$ (min. 5.0. max 12.9 mm) than males $\bar{x} = 8.8 \pm 2.47$ (min. 3.8. max 14.8 mm) and ovigerous females $\bar{x} = 8.4, \pm 2.10$ (min. 4.8 max 12.8 mm). However, ANOVA analysis were only significant for males, $F_{depth} = 6.05$, p = 0.00; $F_{season} = 9.67$, p = 0.00. The Tukey post hoc test, showed that summer was significantly different from autumn and spring. The largest mean size was found in summer whereas the smallest one was observed in autumn (Fig. 2b). Significant differences were found between 800–899 and 1000–1099 m depth interval and the others. Also, a size increasing trend related to depth was apparent (Fig. 2a).

Uroptychus spiniger Benedict, 1902

Material examined. COBERPES 2011, stn. B9, 1 ovigerous female; COBERPES 4 stn. B10, 1 ovigerous female.

Remarks. The only two ovigerous females (CL 10.3–11.9 mm) were reported off Laguna Madre, Tamaulipas; and off Isla Holbox, Quintana Roo, in a 990–1040 m depth range. These findings represent the first record in the Gulf of Mexico (WNW and ESE). Also the lower bathymetric limit was extended 332 m from the previous 708 m reported by Baba et al. (2008) in the Caribbean.

Uroptychus uncifer (A. Milne-Edwards, 1880)

Material examined. COBERPES stn. A6, 1 ovigerous female.



Figure 2. Size distribution of *Uroptychus nitidus*, males: a depth interval b season.

Remarks. We collected only one ovigerous female in summer at 1144 m. (CL 12.6 mm); that constitutes the first record in the sector SSW Gulf of Mexico (off Carmen y Machona Lagoon, Tabasco) This single record increases 654 m the reported bathymetric range (155 to 490 m, Baba et al. 2008; Felder et al. 2009).

Superfamily Galatheoidea

We only collected two individuals of one genus and one species of Galatheidae family.

Galathea rostrata A. Milne-Edwards, 1880

Additional material examined. SGM 10 stn. 145.78, 2 males.

Remarks. *G. rostrata* was the only species collected of this family. The two individuals were found in front of Términos Lagoon, Campeche at 54 m depth (SSW). The two males (7.2–7.8 mm CL) were collected during autumn and constitute the first record in sector SSW.

Family Munididae

In this family we collected 1131 organisms belonging to two genera and nine species, of these, only five species had sample sizes large enough to stand statistical analyses.

Agononida longipes (A. Milne-Edwards, 1880)

Material examined. BATO stn. 24, 1 male, stn. 26, 1 ovigerous female, stn. 27, 2 females, 5 ovigerous females, stn. 29, 3 males, stn. 33, 2 males, 3 females, 1 ovigerous female; stn. 41, 5 males, 1 female, stn. 49, 1 male; stn. 54, 1 female. BIOREPES 1 stn. 12, 2 males, 3 females, 1 ovigerous female; stn. 26, 5 males; stn. 27, 7 males, 3 females; stn. 30, 62 males, 61 females; stn. 31, 5 males, 1 female, 10 ovigerous females. BIOREPES 2 stn. 2, 2 males, 2 females, 1 ovigerous female; stn. 4, 1 ovigerous female; stn. 14, 1 male; stn. 15, 7 males; stn. 18, 1 female, 5 ovigerous females; stn. 34, 1 male, 1 female, 1 ovigerous females. BIOREPES 3 stn. A2, 3 males, 3 females; stn. A10, 1 female; stn. A22, 1 male; stn. A23, 1 ovigerous female; stn. A24, 2 males, 1 female; stn. A25, 1 male; stn. B2, 1 male, 2 females, 1 ovigerous female; stn. B3, 1 male, 2 females; stn. B6, 1 male, 1 female, 1 ovigerous female 1; stn. B7, 5 males, 2 ovigerous females; stn. C2, 1 male, 3 females; stn. C5, 2 males, 4 females, 2 ovigerous females. COBERPES 1 stn. A9, 1 male, 1 female, 1 ovigerous female; stn. B9, 5 males, 4 females, 1 ovigerous female; stn. B14, 1 female, 1 ovigerous female; stn. $\Omega 2$, 11 males, 8 females, 9 ovigerous females; stn. $\Omega 15$, 2 males, 3 females; stn. E4, 1 female. COBERPES 2011 stn. E1, 2 ovigerous females; E7, 4 males. COBERPES 3 stn. α5, 1female; stn. B10, 2 males, 1 female. COBERPES 4 stn. A1b, females 1; A3, 1 male; stn. B15b, 7 males, 5 females; stn. B26b, 7 males, 7 females; stn. B27, 1 male; stn.C33b, 7 females; stn. C34, 4 males, 2 females.

Additional material examined. SIGSBEE 9 stn. A4, 8 males, 5 females, 1 ovigerous female, stn. A6, 15 males, 11 females, 5 ovigerous females, stn. A7, 11 males, 1 female, 1 ovigerous female, stn. A9, 11 males, 14 females, 4 ovigerous females. SIGSBEE 10 stn. C, 1 male, stn. D, 4 females, stn. E, 2 females, stn. F, 1 male, 1 ovigerous female.







Figure 4. Size distribution of Munida constricta, males and depth interval.

Remarks. This species presented a wide distribution in the southern Gulf of Mexico, in Yucatán, off Celestún; Tamaulipas, San Fernando River; Veracruz, Tamiahua Lagoon and Pánuco River; in Tabasco off Grijalva-Usumacinta Rivers; and Quintana Roo, off Holbox Island; from 110.5 to 1140.0 m depth. *A. longipes* was the most common and abundant species of squat lobsters throughout all cruises with 446 individuals. The overall sex ratio was 0.94 M: 1.0 F. The maximum abundance was observed in summer (77.8%; from 309.0 to 1140.0 m) and in the SSW sector (53.4%; 231.6–913.0 m). Ovigerous females (n= 58), exhibited larger mean CL $\bar{x} = 15.328 \pm 2.148$ (min. 10.7, max. 20.8 mm) than males (n= 216), CL $\bar{x} = 14.253 \pm 6.583$ (min. 2.0, max. 34.0 mm) and females (n= 172), CL $\bar{x} = 14.048 \pm 3.025$ (min. 7.61, max. 22.5 mm).

The ANOVA test showed that the mean CL in males, females, and ovigerous females were statistically different among seasons: F (2;207) = 8.48; p = 0.00; F (3;168) = 5.83; p = 0.00; F (2;55) = 6.94; p = 0.00, respectively. The largest sizes were present in spring, whereas the smallest were in summer (Figs 3b, d, e; Tukey Test). However, the mean CL among the depth strata were statistically different only in males and females: F (5;204) = 4.49; p = 0.00; F (3;168) = 5.83; p = 0.00, respectively. The largest males were collected in shallower depths (Fig. 3a), while the largest females were in deeper ones (Fig. 3c). The seasonal sex ratio approached the expected proportion (1M: 1F), except in autumn (0.68 M: 1F), but it was not statistically different (χ^2 = 1.524, p = 0.2170). Ovigerous females were present in spring, summer, and autumn, and the largest number was collected in summer between 269.0–913.0 m depth. The percentage of bopyrid infestation in each sex was relatively uniform (males = 5.8 and females 4.1). The CL size of parasitized individuals ranged from 1.9 to15.2 mm in males and 11.1 to15.4 mm in females.



Figure 5. Size distribution of *Munida evermanni*, males: **a** depth interval **b** season; ovigerous females **c** season.

Munida constricta A. Milne-Edwards, 1880

Material examined. BATO stn. 53, 3 males. BIOREPES 1: stn 6, 1 male; stn 42, 3 males, 1 female; stn. 47, 4 males, 2 females, 1 ovigerous female; stn 50, 2 males, 1 female; stn 54, 2 males, 3 females, 1 ovigerous female; stn 55, 8 males, 5 females. BIOREPES 2 stn 4, 1 male; stn. 11, 1 male; stn 12, 1 male, stn. 25, 13 males, 2 females; stn. 31, 3 males; stn. 37, 4 males. COBERPES 3 stn. B2, 2 males.

Remarks. We collected 62 individuals in the sectors SSW, SSE, and ESE; from 305.3 to 814.0 m depth. In Tabasco, this species was found off Carmen y Machona Lagoon; Yucatán at N of Alacranes Reef, and N of Celestún; and in Campeche, off Términos Lagoon. The highest abundance was found in summer (93.5%) at a 321.4–717.8 m depth range. *M. constricta* was mainly reported in sector SSE (79.1%, 536.0–717.0 m). The overall sex ratio was 3.2 M: 1F, $\chi^2 = 16.516$, p < 0.0001. Females exhibited larger mean CL $\bar{x} = 14.1 \pm 3.02$ (min.7.6- max. 22.5 mm) than males CL $\bar{x} = 13.7 \pm 2.516$ (min. 2.0, max. 21.7 mm). Only the CL size of males presented statistically significant differences (ANOVA: F (2; 45) = 6.08; p =0.00); the smallest sizes were found at shallower depths, whereas larger ones were observed at deeper depths (Fig. 4). The sex ratio in summer (3.8 M: 1 F) was significantly different from the expected proportion ($\chi^2 = 19.931$, 1 degree of freedom, two-tailed, P=0.0001). The two ovigerous females (CL=13.6–17.6 mm) were collected in autumn. We found only one female (CL=14.43 mm) infested with bopyrid. The material collected represents the first records in the sectors SSW, SSE, and ESE.

Munida evermanni Benedict, 1901

Material examined. BATO stn. 32, 1 male. BIOREPES 1 stn.5, 12 males, 6 females, 2 ovigerous females, stn 6, 19 males, 9 females, 9 ovigerous females 9, stn. 8, 2 males, 1 female, 1 ovigerous female, stn, 20 10 males, 3 females, 8 ovigerous females, stn 22, 2 males. BIOREPES 2 stn. 14, 12 males, stn. 16, 8 males, 1 female, 8 ovigerous females, stn. 18, 2 males, 1 female, 15 ovigerous females, stn. 21, 2 males, 1 ovigerous female. COBERPES 2011 stn. E1, 30 males, 29 ovigerous females. COBERPES 3 stn. B9, 2 males.

Remarks. This species was the third one in abundance with 197 individuals. They were collected in sectors SSW, WSW and SSE, from Yucatán: N of Celestún, N Alacranes Reef, Puerto Progreso to Campeche, off Términos Lagoon. The maximum abundance was observed in summer (68.5%; 257.4–863.0 m) mainly in the SSE sector (55.8%; 305.3–346.0 m). The overall sex ratio (1.07 M: 1 F) was not statistical significantly different. The mean CL size of ovigerous females was larger $\bar{x} = 14.6\pm1.569$ (min. 10.5, max. 18.3 mm) than males $\bar{x} = 13.6\pm2.189$ (min. 7.1, max. 18.0 mm) and females $\bar{x} = 13.5\pm2.747$ (min. 9.7, max. 19.4 mm). The smallest CL male sizes were observed in shallower depths, while the largest ones were found in deeper areas (F = 12.52; p = 0.00) (Fig. 5a). The smallest sizes were mainly reported in





spring and the largest in autumn (F = 8.69; p = 0.00) (Fig. 5b). The ovigerous females were collected in spring and summer, and we found a significant difference in CL by depth (F = 16.46; p = 0.00) (Fig. 5c). The sex ratio in spring and summer presented minimum differences that were not statistically significant. The material collected represents the first records in the sectors SSW, WSW, SSE. In addition, we increase the deeper bathymetric range to 863 m.

Munida forceps A. Milne-Edwards, 1880

Material examined. BATO stn. 11, 1 female, stn. 32, 1 male. BIOREPES 1 stn 15, 3 males, 3 females, 2 ovigerous females. BIOREPES 3 stn. A1, 2 ovigerous females, stn A 24, 2 males.

Additional material examined. MOPEED 1 stn. J1, 1 male. MOPEED 2 stn. J2, 2 males, 1 ovigerous female, stn. W1, 1 female. MOPEED 4 stn. W1, 1 male, stn. W2, 1 male. SGM 7 stn. GO8, 2 ovigerous females. SGM 8 stn. 6.7, 1 male. SGM 10 stn. 91.26, 1 male. SIGSBEE 9 stn. A9, 1 ovigerous female. SIGSBEE 10 stn F, 1 female.

Remarks. *M. forceps* was collected in the Campeche Bank, Campeche; Tuxpan, Veracruz; and off Alacranes Reef, Yucatán from 55 to 442.5 m. The highest abundance was observed in the SSW sector (77.8%, 55 to 269 m), mainly in summer (70.4%); the overall sex ratio was 0.93 M: 1 F. Females were larger $\bar{x} = 15.476 \pm 1.862$ (13.7–18.1 mm) than males $\bar{x} = 14.356 \pm 3.471$ (10.2–20.2 mm) and ovigerous females $\bar{x} = 13.776 \pm 4.524$ (7.6–20.5 mm). The ovigerous females were present in summer and autumn.

Munida iris A. Milne-Edwards, 1880

Material examined. BATO stn. 29, 2 males; stn. 33, 1 ovigerous female; stn. 41, 3 males, 2 females; stn. 49, 1 male; stn. 50, 2 males, 1 female; stn. 54, 1 male, 2 ovigerous females; stn. 59, 1 male, 1 ovigerous female. BIOREPES 1 stn, 12, 2 males, 2 ovigerous female; stn. 27, 33 males, 26 females, 42 ovigerous females; stn. 30, 2 males, 1 female; stn 34, 37 males, 1 female, 1 ovigerous female. BIOREPES 2 stn. 2, 1 female; stn 10, 1 ovigerous female. BIOREPES 3 stn. A1, 1 female; stn. A2, 1 ovigerous females; stn. A24, 1 male; stn. B2, 1 male; stn. B6, 1 male; stn. C5, 2 males, 2 females, 1 ovigerous female. COBERPES stn. B9, 2 males; stn. Ω 2, 1 male, 1 female. COBERPES 3 stn. B10, 2 males, stn B 15B, 1 ovigerous female. COBERPES 4 stn. B10, 2 males, 1 ovigerous female. COBERPES 4 stn. B15B, 1 male; stn. E7, 8 males, 1 ovigerous female. COBERPES 4 stn. B15B, 1 male; stn. C34B, 1 male.

Additional material examined. SIGSBEE 9 stn. A9, 1 male. MOPEED 2 stn. W1, 1 female.

Remarks. This species was the second in abundance with 215 individuals collected off San Fernando River, Tamaulipas; Tuxpan, Veracruz; Campeche Bank, Campeche;

off Alacranes and Arenas Reef, Yucatán; sectors: WNW, WSW, SSW, ESE, SSE; 244.6-1040.0 m. The overall sex ratio was 1.26 M: 1F. The greatest abundance was found in summer (69.8%; 244.6–913.0 m) mainly in the ESE sector (54.9%; 249.9–452.0 m). The ovigerous CL mean was larger ($\bar{x} = 23.7 \pm 2.74$, min. 12.6, max. 26.3 mm) than females ($\bar{x} = 22.9 \pm 3.304$ min. 11.6, max. 27.7 mm) and males ($\bar{x} = 20.2 \pm 6.041$ min. 8.3, max. 30.9 mm). The ANOVA analysis of CL showed significant differences through depth strata in all sexes: males F (3; 97) = 162.55, p = 0.00, females F (2; 33) = 12.60, and ovigerous females F $_{depth}$ (3, 48) = 21.80, p = 0.00. Male and ovigerous female small sizes were found at shallow depth interval, whereas females were at deeper depth (Figs 6a, c, d). Only males presented significant size difference among seasons F (2;98) = 13.59; p = 0.00. Highest sizes were reported in autumn, whereas small ones were in summer (Fig. 6b). The differences of sex ratio in spring (1.07 M: 1F) and summer (2.3 M: 1F) were not statistically different compared to autumn (3.25 M: 1F; $\chi^2 = 4.765$, with 1 degree of freedom, two-tailed P = 0.0290). Ovigerous females were collected in spring, summer, and autumn; the greatest percentage (20.9%) was reported in summer in a 245-412 m depth range. Two males were infested with rhizocephalans (CL 21.3-24-9 mm), also one male (CL = 23.8 mm) and one female (CL = 30.3 mm) were infested with bopyrid.

Munida irrasa A. Milne-Edwards, 1880

Material examined. BIOREPES1 stn. 34, 11 ovigerous females; stn. 35, 1 male.

Remarks. *M. irrasa* occurred off Alacranes Reef, Yucatán; SSW, 443.7–829.0 m depth. The ovigerous females size ranged from 9.6 to 12.2 mm (summer at 443.7m), and the only male's CL size reported was 13.1 mm (summer at 829.0 m).

Munida microphthalma A. Milne-Edwards, 1880

Material examined. COBERPES stn. A6, 1 male.

Remarks. We collected only one male (CL=12.5 mm) in front of Carmen y Machona Lagoon, Tabasco; 1144 m, sector WSW.

Munida miles A. Milne-Edwards, 1880

Material examined. BATO stn. 10, 1 male, 1 ovigerous female, stn. 29, 1 male, stn. 54, 1 male, 2 ovigerous females, stn. 59, 1 male. BIOREPES 1 stn 12, 2 males, 2 females, 3 ovigerous females, stn 13, 1 male, 1 ovigerous female, stn 18, 1 female 1, stn 28 1 female, stn 31, 1 male. BIOREPES 2 stn 10, 1 male. COBERPES 2011 stn. B4, 1 male, 1 ovigerous female. COBERPES 3 stn B2, 1 female, stn. B10, 3 males, 1 female, 1 ovigerous female.

Remarks. *M. miles* was collected off Alacranes Reef, Yucatán; Campeche Bank, Campeche; San Fernando River, Tamaulipas; at 245.6–590.0 m. Although, it was

most abundant in sector SSW (89.7%; 327.5–590.0 m), mainly in summer (51.7%; 394.5–455.8 m). Sex ratio throughout seasons was similar and close to the expected proportion 1:1. The mean CL in ovigerous females was 18.7 mm, 18.1 mm for males and 14.1 mm for females. The ovigerous females (31.09% of the total collected) occurred in spring, summer, and autumn, but the maximum number was found in summer. Only one male was infested with a rhizocephalan parasite (CL= 18.9 mm). The material collected represents the first record in the sector SSW.

Munida valida Smith, 1883

Material examined. BATO stn. 10, 1 ovigerous female; stn. 35, males 1, females 1, ovigerous females 1; stn. 48, 1 male, 1 female; stn. 49, 2 males, 1 female; stn. 53, males 2, females 3. BIOREPES 1 stn. 42, 3 males, 3 females; stn 47, 5 males, 5 females; stn 48, 2 males, 1 female; stn 50, 3 males; stn 54, 1 male, 3 females; stn 55, 9 females. BIOREPES 2 stn. 10, 1 female; stn.11, 3 males, 1 ovigerous female; stn. 25, 2 males, females 2; stn. 37, 1 male, 1 female. BIOREPES 3 stn. A12, 6 males, 2 ovigerous females; stn. A13, 2 males; stn. A24, 2 males; stn. B1, 1 ovigerous female; stn. B5, 1 female, 1 ovigerous female; stn. C7, 2 males. COBERPES stn. A3, 2 males; stn. A12B, males 2; stn. B2, 1 male; stn. B12, 1 female; stn. B13, 1 male, 1 female; stn. B15, 1 male, 1 female; stn. Ω 1, 2 males; stn. Ω 6, 2 males; stn. Ω 7, 2 females; stn. Ω 8, 1 male; stn. Ω 14, 1 male; stn. Ω 15, 1 female. COBERPES 2011 stn. B2, 1 male; stn. C2, 1 female; stn. D11, 9 males, 8 females; 7 ovigerous females. COBERPES 3 stn. A10, 2 males, 1 female, 1 ovigerous female; stn. Ω 1, 2 males; stn. α 7, 1 female; stn. α 10, 2 males, 1 female, 1 ovigerous female; stn. B11, 2 males; stn. α 5, 2 males; stn. α 6, 1 male; stn. α 7, 1 female; stn. α 30 B, 2 males, 1 female; stn. B13, 2 males, 1 female; B12B, 1 female; stn. B13, 2 males; stn. α 5, 2 males; stn. α 6, 1 male; stn. α 7, 1 female; stn. α 30 B, 2 males, 1 female; stn. B13, 2 males, 1 female; B12B, 1 female; stn. B13, 2 males, 1 female; S12B, 1 female; stn. α 50 B, 2 males, 1 female; S12B, 1 female; stn. α 50 B, 2 males, 1 female; S12B, 1 female; stn. α 50 B, 2 males, 1 female; S12B, 1 female; stn. α 50 B, 2 males, 1 female; stn. α 50 B, 2 males.

Remarks. This species was frequent in the catches (i.e., 140 individuals), and was practically present in all sectors of the southern Gulf of Mexico: N Celestún, Holbox, Progreso, N Alacranes, Yucatán; Carmen y Machona Lagoons, Tupilco Lagoon, San Pedro and San Pablo Rivers, Tabasco; Coatzacoalcos, Veracruz; 359–1048 m. However, the greatest number was collected in the SSE (n=44, 536.0–700.0 m) and SSW (n=42, 317.5–780.0 m) sectors, particularly off rivers and lagoons. The major percentage of organisms (52.9%) was reported in summer (359.0 to 770.0 m), whereas less one was recorded in autumn (10.7%). Ovigerous females mean CL ($\bar{x} = 29.8\pm7.770$, min. 15.4, max. 41.7) was larger than males mean CL, ($\bar{x} = 27.3\pm7.629$ min. 9.7, max. 40.2), and females mean CL ($\bar{x} = 26.2\pm6.471$ min. 11.0, max. 44.0). The smallest size of males and females were found mainly at deeper strata. The ANOVA results were not significant for males CL: [F _{depth} (5; 65) = 1.22, p = 0.31; F _{season} (2, 68) = 0.07, p = 0.93], and females CL: [F _{depth} (3; 50) = 1.05, p = 0.37; F _{season} (2, 51) = 1.31, p = 0.27]. The sex ratio in autumn (2.4M: 1F) showed significant differences ($\chi^2 = 4.48$, p =0.03).

Ovigerous females (n= 15) were present in all seasons and almost in all sectors (except WNW) in a depth interval of 510 to 642 m. Four males (CL= 24.5-40.2 mm) and four females (CL= 21.1-44.4 mm) were infected with rhizocephalan. Also one male (CL= 24.3 mm) and one female (CL= 32.5 mm) were infected with bopyrid.

Family Munidopsidae

We collected 285 organisms belonging to two genera and 18 species of Munidopsidae. Only two species had sample size large enough to perform statistical analyses.

Galacantha spinosa A. Milne-Edwards, 1880

Material examined. BIOREPES 1 stn. 28, 1 male, stn. 48, 1 ovigerous female. BI-OREPES 2 stn. 5, 1 ovigerous female, stn. 7, 1 ovigerous female, stn 14, 1 ovigerous female, stn. 25, 3 males, stn. 36, 1 male, stn. 37, 1 male. BIOREPES 3 stn. A14, 1 male, 1 female, stn. A15, 3 males, 1 female. COBERPES stn. A6, 1 male, stn. α 5, 1 male, stn. α 7, 2 males, 1 ovigerous female, stn. α 8, 1 male, 1 ovigerous female. COBERPES 2011 stn. B2, 1 male, stn. C4, 1 male, 1 ovigerous female, stn. C5, 1 ovigerous female, stn D1, 2 males, 1 female, 1 ovigerous female. COBERPES 3 stn. B17, 1 ovigerous female, stn α 7, 2 males, 1 ovigerous female, stn. α 11, 2 males, 1 female, 1 ovigerous female, stn. α 7, 2 males, 1 ovigerous female, stn. α 11, 2 males, 1 female, 1 ovigerous female, stn. α 8, 1 male, 1 ovigerous female, stn. α 7, 2 males, 1 ovigerous female. COBERPES 3 stn. B17, 1 ovigerous female, stn α 7, 2 males, 1 ovigerous female, stn. α 11, 2 males, 1 female, 1 ovigerous female.

Remarks. *G. spinosa* was collected off Laguna Madre, Tamaulipas (WNW); Tuxpan, Veracruz (WSW), Términos Lagoon, and San Pedro and San Pablo rivers, Campeche (SSW); 640–1144 m. This species was most abundant in the SSW sector and in autumn (42.5% and 37. 5%, respectively). Overall sex ratio favored males 1.4: 1F, but this difference was not statistically significant. Females reached larger sizes $CL \bar{x} = 34.3 \pm 4.798$ (min. 27.0, max. 43.0 mm) than males $\bar{x} = 30.5 \pm 7.111$. (min. 14.8, max. 40.0). The ovigerous females (CL= 23.6 to 35.4 mm) occurred in spring, summer, and autumn at a 735–1016 m depth range. One female (CL= 20.5 mm) was infested by bopyrid. These are the first records in sectors WSW and WNW; also, we increase the deeper bathymetric limit to 1144 m.

Munidopsis abbreviata (A. Milne-Edwards, 1880)

Material examined. BIOREPES 2 stn. 27, 1 female, stn. 28, 1 ovigerous female.

Remarks. The only two females found (CL = 13.1, and ovigerous = 19.3 mm) were collected in summer. This constitutes the first record in the Gulf of Mexico, off Alacranes Reef, Yucatán; 828.9–965.3 m (sectors SSW and SSE). These records also increase the shallow bathymetric range to 829 m.

Munidopsis alaminos Pequegnat & Pequegnat, 1970

Material examined. BIOREPES 1 stn. 48, 1 male, 1 ovigerous female, stn. 25, 1 male. COBERPES stn. E2, 1 female. COBERPES 2011 stn. C4, 1 ovigerous female. COBERPES 3 stn. α 7, 1 female. COBERPES 4 stn. B14, 1 male, stn. A5, 1 female, 1 ovigerous female.

Remarks. The specimens collected in this study were found at San Fernando River, Tamaulipas; Grijalva-Usumacinta Rivers, Tabasco; off Tupilco Lagoon, Tabasco; off Holbox Island, Quintana Roo; in a 513–735 m depth range. The male CL size ranged from 9.8 to 13.9 mm, and the females size ranged from 7.0 to 11.3 mm. Ovigerous females (10.1 to 10.3 mm) were present in spring and summer at 700–735 m. This material constitutes the first record in the SWS (513.0- 640.0 m) and SSE (700.0 m) sectors. One male (CL=10.3 mm) was infested with bopyrid.

Munidopsis armata (A. Milne-Edwards, 1880)

Material examined. BIOREPES 2 stn. 23, 1 male. COBERPES stn. B8, 1 ovigerous female. COBERPES 2011 stn. B1, 2 males, 2 ovigerous females, stn. B9, 4 males, 2 females, 3 ovigerous females.

Remarks. We collected 15 individuals in front of Grijalva-Usumacinta Rivers, Tabasco; Campeche Bank, Campeche; at 560.0–1040.0 m. Females CL range was 10.8–10.9 mm, whereas the CL for males varied between 5.0–12.3 mm. The ovigerous females (CL = 8.9 to 11.9 mm) were collected in summer at 976.0–1040.0 m. It is the first time that this species is recorded in the SSE and SSW sectors. It was previously reported in sector ESE; Caribbean and South America (Felder et al. 2009).

Munidopsis bradleyi Pequegnat & Pequegnat, 1971

Material examined. COBERPES stn. Ω14, 1 male.

Remarks. This species was found off Tupilco, Lagoon, Tabasco, 573 m depth in the SSW sector. The only individual collected (CL= 25.1 mm) constitutes the first record for the Gulf of Mexico, it was previously recorded in the Caribbean Sea (Baba et al. 2008).

Munidopsis erinacea (A. Milne-Edwards, 1880)

Material examined. BATO stn. 42, 1 male. BIOREPES stn. 47, 11 males, 3 females, 7 ovigerous females 7, stn. 55, 1 ovigerous female. BIOREPES 2 stn. 4, 1 male 1, stn. 11, 2 males, stn. 24, 1 female, stn. 32, 1 male. BIOREPES 3 stn. B6, 2 males. COBERPES stn. A11, 1 female, stn. Ω 7, 1 female, stn. A12b, 1 male, 1 ovigerous female, stn B2, 1 ovigerous female, stn. B12, 1 male, stn Ω 7, 1 female, stn. Ω 14, 1 female. COBERPES 2011 stn. B2, 1 ovigerous female, stn. B4, 2 males, 1 female, 1 ovigerous female, stn. C2, 4 males, 4 ovigerous females, stn. C3, 2 males, 1 ovigerous female, stn. C4, 1 male, 1 female, stn. D1b, 1 female, stn. D6, 1 female, 1 ovigerous female, stn. D9, 11 males. COBERPES 3 stn. α 10, 1 male, stn. α 11, 1 ovigerous female, stn. B17, 1 male.

Remarks. It was collected off Soto la Marina River, Tamaulipas; San Pedro and San Pablo Rivers, Tupilco Lagoon, Tabasco; Términos Lagoon, Campeche; N Alacranes, Yucatán; (ESE, SSE, SSW, WSW); 406.0–820 m. *M. erinacea* was the sixth



Figure 7. Size distribution of Munida robusta, males: a depth interval b season.

species in terms of abundance (n= 72). The highest abundance was observed in the sector ESE during the spring season in a depth range of 700–799 m. The ANOVA analysis was made only for males (n= 37), but did not show significant differences by depth [F (3;32) = 1.1295; p = 0.3518] or season [F (2;33) = 3.0006; p = 0.0635]. The mean size of males was $\bar{x} = 14.0 \pm 3.954$ (6.0–21.4) at 406–780 m depth range. The mean size of females was $\bar{x} = 10.4 \pm 3.346$ (6.4–18.0) at 530–820 m depth. The mean size of ovigerous females was $\bar{x} = 12.7 \pm 2.431$ (8.3–17.1) at 530–820 m depth.

The ovigerous females were observed in all seasons; however, they were more numerous during spring in the ESE sector. Sex ratio was similar in all seasons (1M: 1F). Two individuals were infested by rhizocephalans (CL male=15.9 mm, female= 17.0), and one female (CL=13.1 mm) was infested by bopyrid.

Munidopsis latifrons (A. Milne-Edwards, 1880)

Material examined. COBERPES 2011 stn. D9, 1 female.

Remarks. Only one specimen was observed in southern Gulf of Mexico: Holbox Island, Yucatán (ESE), at 769 m depth. The female was collected in spring (CL = 5.3 mm).

Munidopsis longimanus (A. Milne-Edwards, 1880)

Material examined. COBERPES 3 stn. α 10, 1 male.

Remarks. We collected only one male during autumn (CL = 10.7 mm), off Grijalva-Usumacinta Rivers, Tabasco (sector SSW) at 780.0 m depth.

Munidopsis polita (A. Milne-Edwards, 1880)

Material examined. COBERPES 4 stn. C33B, 1 male.

Remarks. We collected only one individual during summer (CL = 6.4 mm); additionally, this record is the first one for the WSW sector (Off San Fernando River, Tamaulipas); 352.0 m depth.

Munidopsis ramahtaylorae Pequegnat and Pequegnat, 1971

Material examined. COBERPES stn. A6, 1 female.

Remarks. The only one female was caught in summer (CL= 10.7 mm) and constitutes the first record in the SSW sector (Grijalva-Usumacinta Rivers, Tabasco at 495 m).

Munidopsis riveroi Chace, 1939

Material examined. BIOREPES 3 stn. A10, 1 male.

Additional material examined. SIGSBEE 9 stn. A4, 1 ovigerous female.

Remarks. We collected two individuals off Laguna Madre, Tamaulipas; and off Tamiahua Lagoon, Veracruz (WSW) from 344.5 to 351.0 m depth. We captured one male (CL = 3.6 mm) in autumn and one ovigerous female in summer (CL = 7.4 mm). Both data represent the first record of the species in the entire Gulf of Mexico.

Munidopsis robusta (A. Milne-Edwards, 1880)

Material examined. BIOREPES 3 stn. A2, 4 males, 8 ovigerous females; stn A11, 1 female, 1 ovigerous female; stn. A12, 1 male; stn. B1, 2 ovigerous females; stn. B3, 1 male, 1 ovigerous female; stn. B4, 1 male; stn. B6, 10 males, 2 females, 7 ovigerous females. COBERPES stn. A4, 1 female, 1 ovigerous female; stn. Ω 15, 2 males, 1 ovigerous female. COBERPES 2011 stn. D7, 1 male. COBERPES 3 stn. α 7, 1 male. COBERPES 4 stn A3, 1 ovigerous female; stn A4, 2 males, 2 ovigerous females; stn A5, 11 males, 10 females; stn B15, 1 male; stn B15B, 9 males, 1 female, 10 ovigerous females; stn C35, 1 female.

Remarks. *M. robusta* was commonly captured in the Gulf of Mexico from the N Carolina–Florida Straits; Gulf of Mexico (all sectors); Caribbean Sea-Colombia (Ortega-Echeverría 2014); 110–4708 m (Felder et al. 2009). In the southern part, we collected this species, off N and S of Laguna Madre (sectors WNW, WSW); Soto La Marina and San Fernando River (WSW); Mecoacán Lagoon and Tonalá River (SSW); and Cabo Catoche (ESE), from 347.0 to 953.0 m depth. This species was the most abundant of the Munidopsidae family (n= 97 individuals). Many of them were collected in the WNW sector (53.9%; 401.3–546.0 m) during autumn (52.6%; 347.0 to 577.0 m). The CL mean size of ovigerous females was larger [$\bar{x} = 18.4\pm 2.129$ (14.0–22.6)] than males [$\bar{x} =$

16.9 ± 1.983 (10.7–20.1)]. The males' size was small at shallow depths and also during autumn ($F_{(depth)} = 5.434$, p = 0.0037, and $F_{(season)} = 8,956$, p = 0.0007) (Fig. 7a, b).

The overall sex ratio difference was not statistically different (χ^2 =0.051, p =0.8208); as it was observed among seasons. The ovigerous females occurred in spring, summer, and autumn in a depth interval of 347.0–546.0 m. Maximum number was reported in autumn. One male (CL=13.4 mm) was infested by bopyrid.

Munidopsis serratifrons (A. Milne-Edwards, 1880)

Material examined. BIOREPES 1 stn 28, 1 male. COBERPES 2011 stn D9, 1 male.
Remarks. This species has been reported in the Gulf of Mexico in Florida (NNW, ESE); Caribbean, Dominica, and Bermuda; 543–1967 m (Baba et al. 2008; Felder et al. 2009). Only two organisms of *M. serratifrons* were collected off Ría Lagartos, and Cabo Catoche, Yucatán (SSW, ESE) at a 614.0–769.0 m depth range. This species occurred in summer and spring. Male CL = 10.2, female CL = 9.8 mm.

Munidopsis serricornis (Lovén, 1852)

Material examined. BIOREPES 1 stn. 48, 2 males, 2 females, 1 ovigerous female. COBER-PES 2011 stn B9, 3 males, 1 female, 1 ovigerous female, stn D9, 2 males, 4 females.

Remarks. *M. serricornis* has been captured off Georgia; Gulf of Mexico (sector SE); West and East Atlantic; Indo West Pacific; 10?–2165 m (Felder et al. 2009). In the present study it was only collected in front of Ría Lagartos, Yucatán (ESE). Most of the individuals were collected in spring at 769.0–1040.0 m depth. The CL size ranges were: males (6.0–12.7mm), females (6.0–10.6 mm), and ovigerous females (7.8–10.7 mm). The two ovigerous females occurred in spring and summer (1040.0 and 700.0 m depth, respectively).

Munidopsis shulerae Vázquez- Bader, Gracia & Lemaitre, 2014

Material examined. BATO stn. 15, 1 male. BIOREPES 1 stn. 55, 1 male. BI-OREPES 2 stn. 25, 1 female, stn. 31, 1 female.

Remarks. This species has been reported in the northern and southern part of the Gulf of Mexico: Straits of Florida; off coast of Campeche, and the western Caribbean from 320 to 787 m (Vázquez-Bader et al. 2014). In the present study *M. schulerae* was collected off N Celestún, and N Alacranes, Yucatán (sector ESE) from 503 to 640 m depth. The two males analyzed had a CL size range of 6.8–10.5 and females 7.9–10.4 mm.

Munidopsis sigsbei (A. Milne-Edwards, 1880)

Material examined. BIOREPES 2 stn. 7, 1 male, stn. 8, 3 females, 1 ovigerous female, stn. 28, 1 female. COBERPES stn. B9, 1 male, 1 ovigerous female, stn. Ω10, 1 female.

COBERPES 2011 stn. B9, 2 males, 1 female, 2 ovigerous females. COBERPES 3 stn. α 1, 1 male. COBERPES 4 stn. A 6, 1 male, stn. B 9, 1 male, 2 ovigerous females.

Remarks. *M. sigsbei* presented a wide distribution: from the Gulf of Mexico to Brazil in depths of 500 to 2000 m (Kilgoure and Shriley 2014). Specimens of this study were collected in Yucatán: N Alacranes and N Celestún; Veracruz: off Coatzacoalcos River; and Tabasco: in front of San Pedro and San Pablo Rivers (sectors SSE and SSW). *M. sigsbei* was the third in terms of abundance (n = 19). Males had a CL range of 10.3–20.6 mm, females showed a 7.4–15.6 mm CL range, and ovigerous females a 10.8–15.3 mm CL range. Ovigerous females occurred in spring and summer.

Munidopsis simplex (A. Milne-Edwards, 1880)

Material examined. COBERPES 2011 stn. C5, 1 male.

Remarks. *M. simplex*, has been previously reported in all sectors of Gulf of Mexico; Caribbean Sea; Eastern Atlantic; from 116–3971 m (Felder et al. 2009); 458–1830 m (Baba et al. 2008); and 1000–3968 m (Kilgoure and Shirley 2014). Specimen in this analysis was found off Holbox Island, Yucatán (ESE) at 806 m depth. The only male (CL=17.9 mm) was collected in spring.

Munidopsis spinoculata (A. Milne-Edwards, 1880)

Material examined. BIOREPES 1 stn. 3, 1 female. BIOREPES 3 stn. D1, 1 female. COBERPES 1 stn. Ω 7, 1 male.

Remarks. The records for this species include Florida Straits; Gulf of Mexico (sectors: NNE, SW, and ESE); Caribbean Sea; 597–1738 m (Mayo 1974). In the southern Gulf of Mexico, we collected this species off Alacranes Reef; Tamiahua Lagoon, Tamaulipas; Grijalva-Usumacinta Rivers, Tabasco (sectors WSW, SSW) from 400.4 to 750.0 m depth. The only male had 10.2 mm CL; whereas females were 10.7–11.2 mm CL, respectively.

Discussion

A total of 1513 squat lobsters were collected: Chirostylidae (n= 95), Galatheidae (n= 2), Munidopsidae (n= 285), and Munididae (n= 1131) belonging to 6 species of Chirostyloidea and 27 of Galatheoidea. The low abundance of Chirostylidae may due to its specific habitat requirements (living associated with corals and other anthozoans, further than 1000 m) that are difficult to access and sample (Pequegnat 1983; Baba 2005; Le Guilloux et al. 2010; Schnabel et al. 2011b). However, *U. nitidus* was the most abundant and frequent species of the family. This was previously pointed out by other studies in the Gulf of Mexico (e.g., Kilgoure and Shirley 2014). However, the scarce abundance of Galatheidae could be an artifact of depth range sampled, as *G. rostrata*, mainly distributes at an upper depth range (< 200 m).

Table 1. Chirostyloidea and Galatheoidea species distribution in Gulf of Mexico, Caribbean, and Brazil. CAR = Caribbean; BRA = Brazil; NE = Northeast (nne = north northeast, ene = east northeast); NW = Northwest (nnw = north northwest; wnw = west northwest); SE = Southeast (sse = south southeast; ese = east southeast); SW = Southwest (wsw = west south west; ssw = south southwest).¹ = New record for Gulf of Mexico; Δ = New record for sector; + = Extension of bathymetric range.

			GU									
OPECIES	N	E	N	W	S	W	SE		CAR	BRA	DEPTH (m)	
SPECIES	nne	ene	nnw	wnw	wsw	ssw	sse	ese]			
E.picta	x		x	x				x	х		200-600	
G. affinis		х						x	х		78–635	
G. meridionalis										x	358-800	
G. salvadori ¹						Δ		Δ	х		650-874 +	
G. spinifer	x		x		Δ			x	х		212-2412	
U. aguayoi									х		528	
U. armatus									х		298	
U. brevis								x	х		457-1107	
U. capillatus ¹							Δ	Δ	х		306-1040 +	
U. fornicatus									х		555.6	
U. intermedius									х		298	
U. jamaicensis								x	х		677–1249	
U.minutus				x					х	x	46-137	
U. nitidus	x	х	x	x	x	x	х	x		x	161–1342	
U. princeps									х		514	
U. rugosus								x	х		174–549	
U. spiniger ¹				Δ				Δ	х		708–1040 +	
U. spinosus								x	х		265-421	
U. uncifer			x	x		Δ		x	х	x	155–1144 +	
G. rostrata	x	х	x	x		Δ	х	x			18–159	
A. longipes	x	х	x	x	x	х	х	x	х	x	40–1140 +	
A. schroederi								x	х		274–531	
A. caribensis						х			х		11.0-38.0	
M. affinis	x				x	х		x	х		42-914	
M. angulata	x	х	x	х	x	х	х	x	х	x	24-260	
M. atlantica										x	58–166	
M beanii	x								х		39–78	
M benedicti									х		174-430	
M chacei				x					х		393-446	
M coltroi										x	240-260	
M constricta	x	х				Δ	Δ	Δ	х	x	200–549 +	
M. elfina									x		670	
M evermanni			x		Δ	Δ	Δ	x	х		232-863 +	
M. flinti	x	х	x	x	x	x	х	x	х	x	11-641	
M forceps	x	х	x	x	x	x	х	x	х	x	40-950	
M. heblingi										x	83	
M iris	x	x	x	x	x	x	х	x	x	x	40-1303	
M. irrasa	x	х	x	x			х	x	х	x	38–914	
M. media						x		x	x		500–536	

		GULF OF MEXICO										
ODECIEC	N	E	N	W	S	W	S	E	CAR	BRA	DEPTH (m)	
SPECIES	nne	ene	nnw	wnw	wsw	ssw	sse	ese				
M. microphthalma	х	x	x	x	х	x	х	x	х	х	195–2412	
M. miles		x				Δ		x	х	х	68–659	
M. nuda		х							х		68–630	
M. petronioi										х	75	
M. pusilla	х	х	x	х	х	x	х	x	х	х	7–200	
M robusta									х	х	298	
M.santipauli								x		х	18-2360	
M- sculpta								x	х		179–284	
M. serrata									х		329-421	
M. simplex	х	х	x	х	х	x	х	x	х		16-440	
M. spinifrons	х							x		х	13–260	
M. stimpsoni	х							x	х		172-897	
M. striata								x	х		274–503	
M. subcaeca									х		842-1700	
M. valida	х	х	x	х	х	x	х	x	х	х	279–2297	
M. victoria										х	960	
G. rostrata	х								х	х	1600-3800	
G. spinosa			x			x		x	х		183–1144 +	
L. agassizii									х		300–1642	
M. abbreviata				x		Δ	Δ	x	х		860–1342 +	
M. abdominalis		х							х		350-720	
M. alaminos	х			x	Δ		Δ				428-842	
M.aries			x	x							71–5320	
M. armata						Δ	Δ	x	х		275-1446	
M. barbarae		х							х	х	185-200	
M. bermudezi		х		x					х		2434–5180	
M. bradleyi ¹						Δ			х		485-600	
M. brevimanus								x	х		366–906	
M. colombiana									х		4151-4153	
M. crassa		х						x	х		1026-5315	
M. cubensis								x	х		759–1144	
M. curvisostra									х		146-2430	
M. erinacea	х	х	x	x	х	x	х	x	х	х	238–1574	
M. espinis								x	х		779–897	
M. expansa								x	х		457-1107	
M. geyeri	х	х			х				х		2600-4151	
M. gilli								x	х		1638–2139	
M. glabra			x								510-622	
M. granulens									х		347-353	
M. gulfensis				x	x				x		1097-1400	
M. kucki		İ							İ		227	
M. latifrons								x	x		677-1107	
M. livida	x								x		2070-3496	
M. longimanus	х		x	x	x	x	x	x	x		292-1281	

	GULF OF MEXICO											
CDECIES	N	E	N	W	S	W	SE		CAR	BRA	DEPTH (m)	
SPECIES	nne	ene	nnw	wnw	wsw	ssw	sse	ese]			
M. nitida	x				x	x			х	x	592–3968	
M. penescabra				х							543-807	
M. platirostris								x	х		91-842	
M. polita			x	х	Δ	x		x	х	x	129–1170	
M. ramahtaylorae	x	х				Δ			х		200–668	
M. reynoldsi									х		4086-4277	
M. riveroi ¹					Δ				х	x	260-3822	
M. robusta	x	х	x	х	x	x	х	x	х		79–4708	
M. serratifrons			x					x	х		325-1966	
M. serricornis			x				х	x	х		200–2165	
M. sharrei									х		298-454	
M.shulerae	x	х	x	x		x		x			320–787	
M. sigsbei	x	x	x	x	x	x	x	x	х	x	500-2000	
M similis		х									1475–2438	
M. simplex	x	x	x	x	x	x	x	x	х		116-3971	
M.spinifer						x		x	x		203-880	
M. spinoculata	x			x	x	x		x	х		778–1738	
M. squamosa									x		212-500	
M. subspiniculata						x			х		457-823	
M. transtridens								x			1162–1475	
M. tridens								x	х		380-600	

A comprehensive analysis of the abundance showed that four species of the Munididae family contributed to 64.7% of the total organisms collected. These were in order of abundance: *A. longipes, M. iris, M. evermanni*, and *M. valida*. Some authors, like Creasy et al. (2000) and Kilgoure and Shirley (2014), also mentioned *A. longipes* as the most common and abundant species in the northern part of the Gulf of Mexico. Other species like *M. robusta, M. erinacea, M constricta*, and *U. nitidus*, although represent a low percentage (17.7%), were a common and frequent component in the capture. The highest abundance of many species occurred in front of river mouths or lagoons, particularly in the Campeche Bank and off Alacranes Reef areas.

Galatheoid and chirostyloid species occurs in a wide bathymetrical range, 0 to 5400 m, which indicates they have overlapping depth distribution ranges (Schnabel et al. 2011b). In this study we found differences in bathymetrical distribution among the families. The Munididae were mainly found in the 300–399 m depth interval, whereas the highest abundances of Munidopsidae and Chirostylidae were present in 400–499 m and 1000–1099 m, respectively. We extend the bathymetric range for nine species (shallower and deeper). We also extend the spatial range in three species of Chirostylidae (*G. salvadori*, *U. capillatus*, and *U. spiniger*). We reported for the first time three species of Munidopsidae (*M. bradleyi*, and *M. riveroi*) in the Gulf of Mexico (Table 1).

Only eight species had enough number to stand statistical analyses, the rest of the species presented, each one, an abundance minor than 30 individuals. However,

the ANOVA was only statistically significant for *U. nitidus, A. longipes, M. constricta, M. evermanni, M. iris,* and *M. robusta.* Males of *U. nitidus* and *M. evermanni* were larger in spring, whereas *M. iris and M. robusta,* were larger in autumn. In *A. longipes,* females presented the major size in the deeper strata, whereas in *M. iris* they were found in the shallower ones. Kilgour and Shirley (2014), mentioned that ovigerous females were significantly larger than females in: *U. nitidus, G. spinosa, M. abbreviata, M. alaminos, M. erinacea, M. robusta, M. sigsbei,* and *M. simplex.* In many of the species studied here, the largest ovigerous females occurred in the SSW and WSW sectors, which are subjected to the influence of rivers and lagoons.

The overall sex ratio difference was only statistical significant for two species: *M. constricta* and *U. capillatus*; while Bursey (1978); and Wenner (1982), reported significant differences in *A. longipes, M. valida, M. bairdii*, and *M. iris*.

In terms of seasonal occurrence, 58% of all species were present in summer, 30% in spring, and 12% in autumn. A high percentage of males and females (47.6%) occurred in summer, whereas ovigerous females (13.2%) occurred mainly in spring. However, ovigerous females were also collected during summer and spring, suggesting that families like Galatheoidea and Chirostyloidea do not have a marked seasonal reproduction, as pointed out by Kilgoure and Shirley (2014).

The incidence of parasitism in our study was low. Only eight species, that represents 4.7% of the total individuals of Galatheoidea were parasitized. Almost 88% of these individuals were infested by rhizocephalan barnacles, and 11% by bopyrid isopod, particularly in summer. *A. longipes* was the most heavily parasitized by rhizocephalan barnacles (3% of infestation incidence), all individuals were captured in only one station in the Alacranes Reef area. Pequegnat (1983) reported for this species one organism infected by bopyrid and one by rhizocephalan barnacle in the Northern Gulf of Mexico. In addition, she found other species like *M. iris* and *M. rostrata* infected with bopyirid and rhizocephalan, whereas Wenner and Windsor (1979) mentioned a 2.2–5.0% infestation incidence by bopyrid isopods in *M. iris*, but Williams and Brown (1972) reported 10% for the same species.

Global diversity studies of squat lobsters (Schnabel et al. 2011b) revealed that the Western Atlantic including the Caribbean, Brazil, and Gulf of Mexico, reported 10.2–12.1% of Chirostyloidea and 10.9–15.4 of Galatheoidea (Campos et al. 2005; Fierro et al. 2008; Felder et al. 2009; Kilgoure and Shirley 2014; de Melo-Filho 2006, de Melo-Filho and de Melo 2001 a, 2001 b; Navas et al. 2003; Ortega et al. 2014) (Table 1). Nevertheless, the global diversity records of these two groups are incomplete, 19–20% of Chirostylidae and 37–38% of Galatheidae species remain undescribed, particularly in tropical offshore areas (Appeltans et al. 2012). We reported 51.4% of Munidopsidae species, 33.3% of Munididae species, and 80% of Chirostylidae species recorded in this study were only reported in the Caribbean Sea.

At this moment, a total of 71 species has been reported for the entire Gulf of Mexico. Munididae were dominant in the SSW sector whereas Munidopsidae and Chirostylidae were more abundant in the ESE sector. The SE sector is the most important one with 54 species, NE with 35, NW 31, and SW with 26. In terms of biodiversity of the southern Gulf of Mexico we found in our study that the subsector ESE presented the higher number of species with restricted distribution and 18.3% of the total collected were only reported here, 2.8% in the SSW, and 1.4 in WSW. In the SE sector, 80% of the chirostylids and 25.6% of the munidopsids showed higher range restrictions, compared with 14.3% of muninids. According to Felder et al. (2009) and Baba et al. (2008), the NNE, NNW, and WNW had 7.0% of species with restricted distribution, but ENE had 5.6%. The high percentage of chirostylids restricted occurrence is perhaps related to its limited dispersal potential compared to the other galatheoids (Schnabel et al. 2011b); and also with the fact, that these species could have more specific habitat, as they are predominantly associated with corals and other anthozoans (Baba 2005).

Acknowledgements

We are grateful to Magaly Galván Palmerín and staff of Laboratorio de Ecología Pesquera de Crustáceos for their assistance in field and laboratory. To Arturo Ronquillo for his assistance in echosounders. Adolfo Gracia Vázquez is greatly appreciated for his support in figures elaboration. We also appreciate Rafael Lemaitre and Mary Wicksten comments that clearly enhanced the manuscript content. We thank the crew of the R/V *Justo Sierra* that participated in research cruises. This study was partially supported by a grant (IN223109-3) of the Dirección General de Asuntos del Personal Académico, UNAM.

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RESEARCH ARTICLE



Description of a new species of Gaeolaelaps (Acari: Laelapidae) from Iran

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Academic editor: Farid Faraji Received 24 June 2016 Accepted 6 August 2016 Published 23 August 2016
http://zoobank.org/40F43676-C973-44C0-A69C-35B40860C7F1

Citation: Saeidi Z, Nemati A, Khalili-Moghadam A (2016) Description of a new species of *Gaeolaelaps* (Acari: Laelapidae) from Iran. ZooKeys 612: 31–40. doi: 10.3897/zookeys.612.9678

Abstract

A new species of *Gaeolaelaps* (Acari, Mesostigmata, Laelapidae), *G. izajiensis* **sp. n.** is described based on the morphological characters of adult females which were collected from soil sample in the Izeh and Ghaletol regions of the Khuzestan province, Iran. It can be distinguished from the other members of the genus by some morphological characteristics of dorsal shield, form and reticulation of epigynal shield, the exopodal plates, and the peritremes.

Keywords

Chaetotaxy, Mesostigmata, mite, soil, taxonomy

Introduction

Mites of the family Laelapidae are ecologically divers and comprise parasites and predators which found in various habitats (Strong and Halliday 1994, Beaulieu 2009, Lindquist et al. 2009, Nemati and Mohseni 2013). They are good candidates for biological control of the pests which spend time in the soil or other plant growing media (Beaulieu 2009). The family increased in the size with around 90 known genera and

more than 1300 species (Beaulieu et al. 2011). *Gaeolaelaps* is a large cosmopolitan genus of the Laelapidae family which consists of more than 100 described species (Nemati and Mohseni 2013, Kazemi et al. 2014). Different types of the habitats were reported for the *Gaeolaelaps* mites including: soil, litter, nests and bodies of vertebrates and invertebrates (Bregetova 1977, Beaulieu 2009, Lindquist et al. 2009, Trach 2012). *Gaeolaelaps* species are typically known as small invertebrate predators, and collected from the bodies and nests of many arthropods including cockroaches, termites, mole crickets, beetles, ants, millipedes and mygalomorph spiders (Bregetova 1977, Rosario 1981, Tenorio 1982, Strong and Halliday 1994, Fain et al. 1995, Strong 1995, Beaulieu 2009, Faraji and Halliday 2009).

Twenty species of Gaeolaelaps have been reported from Iran of which nine were described as new for science (Nemati and Kavianpour 2013, Nemati and Mohseni 2013, Kavianpour et al. 2013, Kazemi et al. 2014, Kavianpour and Nemati 2014, Vatankhah et al. 2016). It is noticeable that the majority of these species (seven species) have been collected from soil (Nemati and Kavianpour 2013, Nemati and Mohseni 2013, Kavianpour et al. 2013, Kazemi et al. 2014, Kavianpour and Nemati 2014), one species (Vatankhah et al. 2016) has been described from the nest of Formica sp. (Hymenoptera: Formicidae) and one species from the body of a carabid beetle, Acinopus sp. (Coleoptera: Carabidae) which the later had been previously excluded from *Gaeolaelaps* by Kazemi et al. (2014). Four of these species including G. farajii Nemati & Mohseni, 2013; G. jondishapouri Nemati & Kavianpour, 2013; G. khajooii Kazemi, Rajaei & Beaulieu, 2014 and G. orbiculatus Nemati & Mohseni, 2013 were reported from the south of Iran (Khuzestan and Kerman provinces) while one species (G. ahangarani Kazemi & Beaulieu, 2014) has been described from the north (Mazandaran province) and three species (G. iranicus Kavianpour & Nemati, 2013, G. mossadeghi Kavianpour & Nemati, 2013 and G. lenis Vatankhah & Nemati, 2016) from the central part of Iran (Esfahan province). Here a further new species is described, which will be the tenth species from Iran; it was collected from the soils of Izeh and Ghaletol, Khuzestan province, Iran.

Materials and methods

Gaeolaelaps specimens were extracted from soil samples using Berlese funnels, placed in lactic acid at 55 °C for clearing and then mounted in Hoyer's medium as permanent microslides for microscopic examination. Taxonomically relevant structures of this species were illustrated with the use of a drawing tube and figures were performed with Corel X-draw software, based on the scanned line drawings. Measurements of structures are expressed as minimum-maximum ranges in micrometers. The dorsal setae notation, leg and palp chaetotaxy follows that of Lindquist and Evans (1965), Evans (1963a, b) and Evans and Till 1965 respectively. Terminology for idiosomal glands and lyrifissures follows Kazemi et al. (2014). Legs were measured dorso-medially excluding the stalk and pretarsus.

Reults

Genus Gaeolaelaps Evans & Till, 1966

Hypoaspis (Gaeolaelaps) Evans & Till, 1966: 160; Evans and Till 1979: 202.

Hypoaspis (*Geolaelaps*): Bregetova 1977: 499; Karg 1979: 79; Karg 1982: 237; Karg 1993: 136.

Gaeolaelaps: Casanueva 1993: 40; Beaulieu 2009: 35; Kazemi et al. 2014: 504. *Geolaelaps*: Rosario 1981: 46; Walter and Oliver 1989: 295.

Type species. *Laelaps aculeifer* Canestrini (1884), by original designation (Evans and Till 1966).

The genus definition of Kazemi et al. 2014 was followed (see notes in discussion).

Gaeolaelaps izajiensis sp. n.

http://zoobank.org/F8E6016A-33DA-4B04-97FB-67092192A3A9 Figures 1–13

Specimens examined and type deposition. Holotype female, Izeh, Khuzestan province, soil, coll. A. Nemati, 2013. Paratypes: two females, Ghaletol, Khuzestan province, soil, coll. Z. Saeidi, 2014. The holotype and two female paratypes are deposited in the Acarological Laboratory, Department of Plant Protection, Agricultural College, Shahrekord University, Shahrekord, Iran (APAS).

Diagnosis (adult female). Dorsal shield with constriction at lateral margins near setae s6 and distinct reticulation posterior to *j6* along with line reticulation in lateral margins of podonotal part, possesses 39 pairs of simple thin acicular setae; sternal shield with reticulation in lateral regions, epigynal shield with elongate and nearly quadrangle cells and abutting anal shield, exopodal plates fragmented between coxae II and IV; peritremes relatively long and extending to the posterior margin of coxae I.

Description of adult female. Three specimens measured, range is provided in µm.

Dorsal idiosoma. Idiosoma oval-shaped 431–442 long, 266–273 wide (at level of setae r3), dorsal shield with constriction at lateral margins near *s6* setae and distinct reticulation posterior to *j6* along with line reticulation in lateral margins of podonotal part, shield not covering whole dorsum (Fig. 1), 400–419 long from its anteromedian edge anterior to bases of setae *j1* to its posteromedian edge posterior to bases of setae *z5*, 240–247 wide at level of setae *r2-r3* (widest part), shield with 39 pairs of thin, small, simple acicular setae, 22 pairs on podonotal region (*j1–6*; *z1–6*; *s1–6*; *r2–5*) and 17 pairs on opisthonotal part (*J1–5*; *Z1–5*; *S1–5*) including *PX2–3* between *J* and *Z* series. Unsclerotised cuticle lateral of podonotal region including a smooth sub-triangular accessory shield (Fig. 1). Dorsal setae short (22–30), not reaching to following seta base in series. Setae *J3* located nearly far from *J4*, the distance of *J3-J4* is approximately five times *J3* length. Unsclerotised cuticle lateral of podonotal part with



Figures 1–5. *Gaeolaelaps izajiensis* sp. n. Female: 1 dorsal idiosoma 2 ventral idiosoma 3 Peritreme and sub-triangular accessory shield **4–5** the position of *Jv2*.

r6 (between *s6* and *S1*) and lateral of opisthonotal with *R1*, *R4*, *R6* and *R7*. *UR* seta located between *R4* and *R6*. Dorsal shield with 22 pairs of pores and pore-like structures, including *gd2* (posterolateral of setae *j4*) and *gd6* (posterior of *z6*) and one pair of poroids (*idR3*) on soft lateral cuticle near *R4* seta as shown in Figure 1.

Ventral idiosoma (Fig. 2). Base of tritosternum 25–30 long, 7–10 wide (at basal level), pilose laciniae free for 59–73 and fused basally for 7–9. Pre-endopodal area granulated, with a pair of slightly sclerotised pre-sternal plates. Sternal shield 120–127 long (along midline from anterior edge to its posterior margin), 98–110 wide (at level of projection between coxae II-III) and 81–88 at level of *st2*, smooth in median region and posterior part and reticulated in lateral margins, with distinct anterior and posterior margin irregular. Sternal setae smooth, *st1- st3* (20–23), *iv1* slit-like, located slightly behind *st1*, *iv2* pore-like, between *st2-st3*. Setae *st4* (16–19) and pore-like *iv3* located on integument behind posterior margin of sternal shield.



Figures 6–9. *Gaeolaelaps izajiensis* sp. n. Female: 6 hypostome 7 epistome 8 chelicera 9 palp (trochanter to tibia).



Figures 10–13. Gaeolaelaps izajiensis sp. n. Female: 10 Leg I 11 Leg II 12 Leg III 13 Leg IV.

Reticulate tongue-shaped epigynal shield with elongate and nearly quadrangle cells, 171–180 long at midline from anterior margin to posterior level and abutting anal shield, 73–83 wide at epigynal setae, ratio of length to width (L/W) 2.14–2.4, with one pair of simple acicular setae (st5 = 18-20). Paragenital pores (iv5) on soft integument posterior to epigynal setae, between epigynal margin and coxa IV. Anal shield subtriangular, reticulated, 54–60 long (at midline from the anterior margin to the posterior edge of the cribrum), 54–56 wide (at widest point), post anal seta (14–15) nearly equal to para-anal setae (15–17). Cribrum thin and extending posterolaterally to the level of post-anal seta insertion. Opisthogastric surface with: one pair of narrow and slightly elongate paragenital platelets; one pair of suboval metapodal plates (24– $26\times10-12$); one pair of minute platelets between paragenital and metapodal plates; eight pairs of smooth acicular setae: Zv1-3 and Jv1-5; and five pairs of pore-like structures, plus para-anal gland pores gv3 on lateral margins of anal shield. Jv2 located on soft opisthogastric cuticle bent down and Jv2 appeared on anterior margin of anal shield
as shown in Figures 2 and 5. Stigma located at anterior level of coxa IV. Peritremes narrow and long, extending anteriorly to posterior margin of coxae I with fusing at posterior margin of sub-triangular accessory shield, peritrematal plate wider in middle part, and with one glandular poroid *gp* and one lyrifissure *ip* (Fig. 3), separated from exopodal shield. Poststigmatal plate narrow and with two pore-like structures. Exopodal II-III small and subtriangular, along with two fragmented platelets at posterior part of coxa III. Exopodal III-IV narrow, angular and reached to the tip of endopodal III-IV at posterior level of coxa IV. Endopodal plates II/III incorporated to lateral margins of sternal shield, III-IV strip like extending to the posterior margin of coxa IV.

Gnathosoma. Hypostome (Fig. 6) with three pairs of smooth simple acicular setae; h1 (28–32), h2 (15–17) and h3 (17–19). Palpcoxal setae 17–19 long. Deutosternal groove with six rows of denticles (7–12). Corniculi horn-like, internal malae with median barbed extensions longer than fringed lateral lobes, labrum short and slightly pubescent. Epistome denticulate (Fig. 7). Chelicera (Fig. 8) with dorsal seta, small and setaceous pilus dentilis, lateral lyrifissure and arthrodial crownet-shaped, moveable digit (46–54) with two teeth; middle article from the basal level to the base of dorsal seta 78–85 ending in fixed digit (49–51) with five teeth in addition to terminal tooth. Palp chaetotaxy normal for Laelapidae mites (sensu Evans & Till, 1965), with simple setae except *al1* and *al2* of genu slightly thickened with blunt tip, palp apotele two-tined (Fig. 9).

Legs. Tarsi I-IV with claws and ambulacra. *leg I* 427–432, coxa 61–63, trochanter 39–44, basi-femur 20–24, telo-femur 61–68, genu 66–73, tibia 78, tarsus 90–95; *leg II* 317–329, coxa 37–39, trochanter 41–44, basi-femur 17–22, telo-femur 49–56, genu 46–54, tibia 46–49, tarsus: 73–78; *leg III* 249–259, coxa 22, trochanter 37–41, basi-femur 15–20, telo-femur 39, genu 24–32, tibia 37–41, tarsus 63–73; *leg IV* 383–417, coxa 34–37, trochanter 68–73, basi-femur 20–26, telo-femur 54–61, genu 49–56, tibia 54–61, tarsus 98–103. Legs I and IV longer than legs II and III. Chaetotaxy of all leg segments normal for *Gaeolaelaps* (sensu Faraji & Halliday, 2009). All leg setae smooth and pointed.

Legs Chaetotaxy (Figs. 10–13): Leg I (Fig. 10): coxa 0 0/1 0/1 0; trochanter 1 0/2 1/1 1; femur 2 2/1 3/3 2; genu 2 3/2 3/1 2; tibia 2 3/2 3/1 2. Leg II (Fig. 11): coxa 0 0/1 0/1 0; trochanter 1 0/2 0/1 1; femur 2 3/1 2/2 1; genu 2 3/1 2/1 2(pv slightly thicker than other setae on the segment); tibia 2 2/1 2/1 2 (av and pv slightly thicker than other setae on the segment); tarsus 3 3/2 3/2 3 + mv, md (pl1, al1, pv1–2, av1–2, md and mv slightly thicker than other setae on the segment). Leg III (Fig. 12): coxa 0 0/1 0/1 0; trochanter 1 0/2 0/1 1; femur 1 2/1 1/0 1; genu 2 2/1 2/1 1; tibia 2 1/1 2/1 1; tarsus 3 3/2 3/2 3 + mv, md (the thickness of setae similar to those on tarsus II). Leg IV (Fig. 13): coxa 0 0/1 0/0 0; trochanter 1 0/2 0/1 1; femur 1 2/1 1/0 1; genu 2 2/1 1/0 1; genu 2 2/1 3/0 1 (av thicker than other setae on segment); tibia 2 1/1 3/1 2 (av and pv slightly thicker than other setae on segment). Leg IV (av and pv slightly thicker than other setae on segment). Leg IV (av and pv slightly thicker than other setae on segment). A slightly thicker than other setae on segment). Leg IV (av and pv slightly thicker than other setae on segment). The segment 1 2/1 1/0 1; genu 2 2/1 3/0 1 (av thicker than other setae on segment). The segment is the segment is the segment is the segment. All setae fine and needle-like unless otherwise noted.

Insemination structures. Not seen.

Male. Unknown.

Etymology. The name of the new species refers to Izaj, the ancient name of Izeh (a town in Khuzestan province, southwest Iran) where the holotype was collected.

Remarks. Gaeolaelaps izajiensis sp. n. is differentiated from all other members of the genus by the following combination of characters: dorsal shield with constriction at lateral margins near setae s6, with 39 pairs of simple thin acicular setae; reticulated epigynal shield with elongate and nearly quadrangle cells and abutting anal shield, exopodal plates fragmented between coxae III and IV; peritremes long and extending to the posterior margin of coxae I. Some species of Gaeolaelaps genus have long epigynal shield like: G. loksai (Karg, 2000), G. pinnae (Karg, 1987) and G. macra (Karg, 1978) in which the epigynal shield extending near anal shield with only one pair of opisthogastric setae between epigynal and anal shields. Gaeolaelaps macra and G. loksai have short peritremes which extended to near anterior and middle level of coxa I but has long dorsal setae which exceed the base of successive setae in series, seta J1 and some other opisthonotal setae barbed distally and *iv2* slit-like (Karg 1978, 1987, 2000).

Discussion

Gaeolaelaps has been defined in details by Beaulieu (2009) and Kazemi et al. (2014). The new species described in this paper is well accordance with definition of Kazemi et al. (2014) except for the characteristic no. 10 (p. 504). They stated that epigynal shield tongue or flask-shaped, not markedly broadened posteriorly, bearing one pair of simple setae, and not touching anal shield.

In some species of this genus (G. loksai (Karg), G. pinnae (Karg) and G. macra (Karg)) epigynal shield extending near subtriangular anal shield in which there is only one pair of opisthogastric setae between these two shields, but in fact none of Gaeolaelaps species has epigynal shield abutting subtriangular anal shield. Our new species has epigynal shield uniquely long and extended to the anal plate with one pair of setae (Jv2) located at posterior latero-corners of epigynal shield on unsclerotised cuticle of opisthogasteric area. In this paper, we have followed the definition of Kazemi et al. (2014) to consider our new species as a member of Gaeolaelaps with the following modification to the no. 10 characteristic (length of epigynal shield):

10. Epigynal shield tongue- or flask-shaped, not markedly broadened posteriorly, bearing one pair of simple setae, and not touching anal shield in most of the species except for G. izajiensis n. sp.

Acknowledgement

This study was supported by Shahrekord University (Grant no. 94GRD1M1969) and Agricultural and Natural Resources Research and Education Center, Chaharmahal va Bakhtiari, Iran, which is greatly appreciated. The authors wish to thank Dr. Farid Faraji, Dr. Bruce Halliday and Dr. Shahrooz Kazemi for their valuable and constructive suggestions.

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RESEARCH ARTICLE



Yamatochaitophorus yichunensis, a new species of aphid (Aphididae: Chaitophorinae) from northeast China

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Academic editor: R. Blackman Received 22 January 2016 Accepted 3 August 2016 Published 23 August 2016
http://zoobank.org/47AA2AAF-24F8-41E9-93C8-D2605FF3E3DE

Citation: Jiang L-Y, Chen J, Qiao G-X (2016) *Yamatochaitophorus yichunensis*, a new species of aphid (Aphididae: Chaitophorinae) from northeast China. ZooKeys 612: 41–49. doi: 10.3897/zookeys.612.7873

Abstract

Yamatochaitophorus yichunensis **sp. n.** is described from specimens collected in northeast China on *Acer tegmentosum* (Aceraceae). *Yamatochaitophorus* is also a new generic record for China. Type specimens are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China (NZMC) and the Natural History Museum, London, UK (BMNH).

Keywords

Aphididae, Chaitophorinae, China, new record, new species, Yamatochaitophorus

Introduction

The genus *Yamatochaitophorus* was erected by Higuchi (1972) for *Trichaitophorus albus* Takahashi, 1961, which was described from an unidentified *Acer* sp. in Japan. The alata and embryo of *Y. albus* were described by Chakrabarti and Mandal (1986) from several *Acer* spp. in India. The genus has until now been monotypic (Favret 2016). Here, a second species, *Yamatochaitophorus yichunensis* sp. n. is described based on the specimens collected in northeast China on *Acer tegmentosum* (Aceraceae); the genus is newly recorded in China.

In the Chaitophorinae, three genera are associated with the plant family Aceraceae; *Periphyllus* van der Hoeven, *Trichaitophorus* Takahashi and *Yamatochaitophorus* Higuchi.

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Yamatochaitophorus is closely related to *Trichaitophorus*, also distributed in Eastern Asia (China, Japan and India), but can be distinguished from *Trichaitophorus* by the larger number of marginal setae and fewer eye facets, as well as by the shape and length of the dorsal setae (Higuchi 1972; Chakrabarti and Mandal 1986). *Yamatochaitophorus* is similar to *Periphyllus* on the same host plants; cauda always rounded, anal plate entire, siphunculi with reticulations in alatae etc. However, it may be distinguished from *Periphyllus* by the following characters: eyes with approx. 25 facets (the latter: many eye facets), antennae 5-segmented in apterae (the latter: 6-segmented); first tarsal segments with 3 ventral setae (the latter: first tarsal segments with 5–7 ventral setae); body small, elongate oval, less than 1.36mm in apterae (the latter: body relatively large, mostly elliptical); without "aestivales" form in summer (the latter: with "aestivales" form, modified first-instar larvae of resting stage) (Higuchi 1972; Richards 1972; Junkiert et al. 2011).

Materials and methods

Reliable aphid taxonomy requires slide-mounted specimens that are undistorted, but with the body contents fully cleared to make it possible to see surface details clearly. Specimens were placed in a 10% solution of potassium hydroxide and heated for 10–20 minutes or until body contents have softened. They were taken successively through distilled water, 70% EtOH and 95% EtOH, then transferred to clove oil for a minimum of 5 minutes, and finally mounted in Canada balsam. The descriptions and drawings provided here were produced from slide-mounted specimens using a Leica DM4000B and drawing tube. The photomicrograph images were prepared with a Leica DM2500 using DIC illumination, and processed with Automontage and Photoshop software.

Specimens of *Yamatochaitophorus albus* from Japan and India were obtained on loan from the Natural History Museum, London, UK, (BMNH) for comparison with our material.

Aphid terminology in this paper generally follows that of Higuchi (1972) and Chakrabarti and Mandal (1986). The units of measurement in this paper are millimetres (mm). The holotype and some paratypes are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China (NZMC); the other paratypes are deposited in the Natural History Museum, London, UK (BMNH).

Taxonomy

Yamatochaitophorus Higuchi, 1972

Yamatochaitophorus Higuchi: Chakrabarti and Mandal 1986: 334; Remaudière and Remaudière 1997: 168; Blackman and Eastop 1994: 925.

Type-species. *Trichaitophorus albus* Takahashi, 1961; by original designation.

Generic diagnosis. Apterae: Head fused with pronotum. Eyes with approx. 25 facets or less. Antenna 5-segmented, occasionally 6-segmented, shorter than body. Antennal segments without secondary rhinaria. Ultimate rostral segment with 0–2 accessory setae. Dorsal body covered with O- or C-like tubercles, and dorsal setae of body long, thick, flattened with knobbed or blunt apices; ventral body with spinulose stripes. First tarsal segments with three setae. Abdominal tergites I-VII solidly fused, each with paired spinal and marginal setae. Siphunculi short, truncate, without reticulations. Cauda rounded, anal plate broadly rounded, genital plate transverse elliptical. In alatae (Chakrabarti and Mandal 1986): antenna 6-segmented, segment III with moderately protuberant rhinaria. Dorsal setae long and acute. Siphunculi with reticulation.

Yamatochaitophorus albus (Takahashi, 1961)

Table 1

Trichaitophorus albus Takahashi, 1961: 8.

Specimens examined. 1 apterous viviparous female, Japan: Suganuma (Tumma Pref.), 22 July 1967, on *Acer* sp., coll. H. Higuchi, leg. H. Higuchi (BMNH); 1 apterous viviparous female, India: Bhuinder (U.P.), 30 May 1980, on *Acer acuminatum*, coll. S. Saha, leg. S. Chakrabarti (BMNH) (Morphometric data of the specimen is in the table1).

Distribution. Japan, India, Siberia.

Host plants. Acer acuminatum, A. mono, A. ukurunduense, A. villosum and Acer sp.

Yamatochaitophorus yichunensis sp. n.

http://zoobank.org/4B15E539-219C-4529-A698-5FE963CC56CE Figures 1–30, Table 1

Specimens examined. Holotype: apterous viviparous female, China: Heilongjiang Province, Yichun City (Tangwanghe National Forest Garden, E 129.54°, N48.45°, Alt. 360 m), 21 July 2015, No. 35896-1-1-1, on *Acer tegmentosum*, coll. G.X. Qiao.

Paratypes: 8 apterous viviparous females, with the same collection data as holotype (NZMC); 2 apterous viviparous females, with the same collection data as holotype (BMNH).

Etymology. The specific name *yichunensis* is based on the type locality of the species.

Diagnosis. Body small, elongate oval, adults pale yellow in life. Dorsal body covered with O- or C-like tubercles. Antenna 5-segmented, half as long as body or shorter, with processus terminalis longer than the base of last segment. Ultimate rostral segment with 1 or 2 accessory setae. Embryo with long, thick and acute spinal setae similar to marginal setae.

Description. *Apterous viviparous female*: Body elongate oval, pale yellow in life (Figs 28–30). **Mounted specimens.** Whole dorsum pale (Fig. 15). For morphometric

	Yamatochaitophorus yichunensis	Yamatochaitophorus albus	
	sp. n.	(Takahashi)	
Characters	Apterous viviparous females	Apterous viviparous female	
	(n=11)	(n=1)	
Body length	0.800-1.360 (0.928)	1.300	
Body width	0.310-0.590 (0.391)	0.620	
Antenna	0.328-0.602 (0.396)	0.505	
Antennal segment I	0.035-0.050 (0.040)	0.055	
Antennal segment II	0.029-0.038 (0.032)	0.030	
Antennal segment III	0.090-0.224 (0.127)	0.104	
Antennal segment IV	0.050-0.095 (0.060)	0.060	
Antennal segment V	_	0.090	
Base of antennal segment V (VI)	0.055-0.075 (0.065)	0.075	
Processus terminalis	0.085-0.119 (0.080)	0.092	
Ultimate rostral segment	0.055-0.085 (0.065)	0.080	
Hind femur	0.124–0.224 (0.156)	0.214	
Hind tibia	0.214-0.383 (0.268)	0.348	
Second hind tarsal segment	0.075-0.100 (0.084)	0.100	
Siphunculus	0.015-0.050 (0.026)	0.050	
Basal width of siphunculus	0.020-0.040 (0.029)	0.065	
Distal width of siphunculus	0.015-0.040 (0.026)	0.045	
Cauda	0.040-0.050 (0.045)	0.055	
Basal width of cauda	0.060-0.090 (0.081)	0.095	
Basal diameter of antennal segment III	0.015-0.025 (0.019)	0.020	
Width of hind tibia at mid length	0.020-0.025 (0.023)	0.035	
Longest dorsal cephalic seta	0.070-0.095 (0.077)	0.109	
Longest marginal seta on abdominal tergite I	0.159-0.199 (0.170)	0.184	
Longest seta on abdominal tergite VIII	0.104–0.124 (0.111)	0.174	
Longest seta on antennal segment III	0.003-0.005 (0.004)	0.005	
Longest seta on hind tibia	0.020-0.040 (0.028)	0.070	

Table 1. Morphometric data for apterous viviparous females of *Yamatochaitophorus yichunensis* sp. n. (n = 11, with means in brackets) and *Y. albus* (Takahashi) (reliable morphometric data was only obtainable from one specimen, from India), the measurement is in mm.

data see Table 1. Dorsum with longitudinal spinal ridge, and covered with "O-"or "C-" like tubercles, ventral marginal area with spinulose stripes (Figs 1, 6–9, 15, 20). Dorsal setae of body thick, long or short, flattened with knobbed or blunt apices, with well-developed tubercles at bases (Figs 1, 4–9, 20–22); ventral setae very sparse, very short and fine-pointed 1/4-1/3 of length of dorsal setae.

Head. Frons convex, antennal tubercles poorly developed (Figs 1, 16); dorsum of head with short wrinkles (Figs 1, 16). Body dorsal setae long thick, flat at apices, with well-developed tubercles at bases (Fig. 4). Head with 4–5 long thick and 2–3 short dorsal setae between antennae, and two pairs of long thick and 0–2 short dorsal setae between eyes (Figs 1, 16). Eyes with approx. 25 facets. Antennae 5-segmented (Figs 2, 18), 0.41–0.50 times as long as body; length in proportion of segments : 22–42,



Figures 1–14. Yamatochaitophorus yichunensis sp. n. Apterous viviparous female: 1 dorsal view of head 2 antennal segments I–V 3 ultimate rostral segment 4 cephalic seta 5 marginal seta on abdominal tergite I 6 spinal setae and tubercles on abdominal tergite I in right, setal tubercles at base shown 7 tubercles on pleuro-marginal area on abdominal tergite IV 8 dorsal view of pronotum in right, dorsal setae, setal tubercles at base and tubercles shown 9 dorsal view of mesonotum in right, dorsal setae, setal tubercles at base and tubercles shown 10 siphunculi 11 cauda 12 anal plate 13 genital plate 14 embryo, dorsal setae shown.

18–33, 100, 41–59, 33–67+48–74, respectively, processus terminalis 1.07–1.60 times as long as the base of the segment. Segments III- V weakly imbricated. Antennal setae very short and blunt, setae on inside of segments I-II short, thick and flattened at apices; segments I–V with 4, 3, 1–5, 1, 1+0 setae, respectively; apex of processus terminalis with 2–4 setae. Longest setae on segment III 0.13–0.25 times as long as basal diameter of the segment. Primary rhinaria ciliated, secondary rhinaria absent (Figs 2, 18). Rostrum (Figs 3, 19) reaching mid-coxae; ultimate rostral segment wedge-shaped, 1.57–2.00 times as long as its basal width, 0.72–0.85 times as long as second hind tarsal segment, with 1 or 2 accessory setae.

Thorax (Fig. 15). Pronotum with 1 pair of long thick anterior spinal setae, 1–3 pairs of posterior spinal setae (of which 1 pair is long and thick) and 3–5 pairs of marginal setae (of which two pairs are long and thick) (Fig. 8); mesonotum with 3–5 pairs of spino-pleural setae (of which two pairs are long and thick) (Figs 9, 22); metanotum with 4–8 spino-pleural (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) (Figs 9, 22); metanotum with 4–8 spino-pleural (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) and 2–5 pairs of marginal setae (of which two pairs are long and thick) (Fig. 22). Legs normal.



Figures 15–27. *Yamatochaitophorus yichunensis* sp. n. Apterous viviparous female: 15 dorsal view of body 16 dorsal view of head, dorsal setae shown 17 cephalic seta 18 antenna 19 ultimate rostral segment 20 C- or O-like tubercles on abdominal tergites, 21 marginal setae on abdominal tergites III–IV 22 marginal setae on meso- and metanotum 23 siphunculus 24 cauda 25 anal plate 26 cauda and anal plate, mosaic-like ornamentation on distal ventral area of anal plate shown 27 genital plate. Scale bars: 0.10 mm.

times as long as antennal segment III. Hind tibia 0.26–0.32 times as long as body. Setae on legs long and pointed, length of setae on hind tibiae 1.00–1.60 times as long as middle diameter of the segment. First tarsal chaetotaxy: 3, 3, 3.



Figures 28–30. *Yamatochaitophorus yichunensis* sp. n. Apterous viviparous female: 28, 29 population colonising the underside of leaves 30 living aphid.

Abdomen. Abdominal tergites I-VII each with one pair of spinal and one pair of marginal long thick setae with flattened or expanded apices (the expanded part is membranous) (Figs 15, 21). In addition, abdominal tergite I with 3–10 spino-pleural and 1–5 pairs of marginal shorter setae (Figs 5–6, 20); tergite II with 7–8 spino-pleural and 2–3 pairs of marginal setae; tergite III with 3–8 spino-pleural and 1–5 pairs of marginal shorter setae (Figs 7, 21), respectively; tergite VI with 3–10 spino-pleural and 2–4 pairs of marginal shorter setae; tergital shorter setae; tergite VI with 3–10 spino-pleural and 2–4 pairs of marginal shorter setae; tergite S7, 21), respectively; tergite VI with 3–10 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII with 3–6 spino-pleural and 2–1 spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII spino-pleural and 2–4 pairs of marginal shorter setae; tergite VII spino-pleural and 2–1 spino-pleural and 2–4 pairs

2–3 pairs of marginal shorter setae; tergite VIII with 6–8 setae (Fig. 15). Length of longest marginal setae on tergite I 6.60–11.00 times as long as basal diameter of antennal segment III; dorsal setae on tergite VIII 4.60–7.00 times as long as basal diameter of antennal segment III. Spiracles oval, opened or closed; spiracular plates large, oval or round. Siphunculi (Figs 10, 23) short truncated, with weak transverse imbrications, without polygonal reticulation, flanges developed, 0.67–1.33 times as long as its basal width, about 0.40–1.00 time as long as cauda. Cauda (Figs 11, 24, 26) short, rounded, slightly constricted at base, with spinulose imbrications, 0.50–0.67 times as long as basal width, with 8–14 setae, among 6 long thick setae. Anal plate (Figs 12, 25, 26) broadly rounded, with spinulose short lines; with 15–20 setae, including two long thick setae; and distal ventral area of anal plate with mosaic-like ornamentation (Fig. 26). Genital plate (Figs 13, 27) transverse oval, with spinulose transverse lines; with two pairs of anterior setae, and 9–13 posterior setae. Four gonapophyses.

Embryo (Fig. 14): Dorsal setae of body long thick and acute. Head with two pairs of frontal setae and two pairs of mid-dorsal setae. Pro-, meso- and metanotum each with a single pair of spinal setae and two pairs of marginal setae. Abdominal tergites I-VII each with one pair of spinal and one pair of marginal setae; tergite VIII with two pairs of fine and short dorsal setae. Siphunculi short, truncated. Eyes with 6–7 facets.

Host plant. *Acer tegmentosum* (Aceraceae). The species infested the underside of leaves of the host plant, and population density was low, with less than 20 individuals dispersed on the underside of a leaf (Figs 28, 29).

Key to apterous viviparous females

Acknowledgements

The authors are grateful to F.D. Yang for making the slide mounts; to Paul Brown for arranging the loan of specimens of *Y. albus*. This work was supported by the National Natural Sciences Foundation of China (No. 31430078), the External Cooperation Program of BIC, Chinese Academy of Sciences (No. 152111KYSB20130012), and National Science Fund for Fostering Talents in Basic Research (No. J1210002).

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RESEARCH ARTICLE



Four new species of *Gasteruption* Latreille from NW China, with an illustrated key to the species from Palaearctic China (Hymenoptera, Gasteruptiidae)

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Academic editor: <i>M. Sharkey</i>	Received 3 July 2016	Accepted 2 August 2016	Published 23 August 2016
http://	lzoobank.org/088D3636-4D0	5D-423E-A0B5-11A5BEBFBC	686

Citation: Tan JL, Achterberg C van, Tan QQ, Chen XX (2016) Four new species of *Gasteruption* Latreille from NW China, with an illustrated key to the species from Palaearctic China (Hymenoptera, Gasteruptiidae). ZooKeys 612: 51–112. doi: 10.3897/zookeys.612.9751

Abstract

Four new species of the genus *Gasteruption* Latreille, 1796 (Hymenoptera: Evanioidea: Gasteruptiidae: Gasteruptiinae) are reported from NW China: three from Shaanxi province and one from Ningxia province. The new species (*G. bicoloratum* Tan & van Achterberg, **sp. n.**, *G. huangshii* Tan & van Achterberg, **sp. n.**, *G. pannuceum* Tan & van Achterberg, **sp. n.**, and *G. shengi* Tan & van Achterberg, **sp. n.**) and three newly recorded species (*G. sinepunctatum* Zhao, van Achterberg & Xu, 2012, *G. boreale* (Thomson, 1883) and *G. oshimense* Watanabe, 1924) are keyed and fully illustrated. In total, seven species are known from Shaanxi province, which is approximately half of the expected number. The East Palaearctic specimens provisionally identified as *G. tournieri* Schletterer, 1885, by Zhao et al. (2012) are included under *G. oshimense* Watanabe, 1924.

Keywords

Gasteruption, Heilongjiang, Inner Mongolia, key, Mongolia new species, new record, Ningxia, Shaanxi

Introduction

The family Gasteruptiidae is a small group of wasps comprising about 500 described species in two subfamilies, Gasteruptiinae (four genera) (Macedo 2009, 2011; Zhao et al. 2012) and Hyptiogastrinae (two genera) (Jennings and Austin 2002). Gasteruptildae are easily distinguished from the other apocritan hymenopterans by the elongated "neck" (propleuron), the swollen hind tibiae, and the highly attached and slender metasoma. Adults are free-living insects normally feeding on nectar from flowers with easily accessible nectar (especially families Apiaceae, Asteraceae and Euphorbiaceae), but likely at least some *Gasteruption* species feed on both nectar and pollen (Jennings and Austin 2004). Gasteruptiidae are also known by their hovering inspection flight in front of bee nests (van Achterberg 2013). The larvae feed on the larval food of solitary bees, after consuming the egg or larva of the bee (Malyshev 1966). They select bees of the subfamilies Apinae, Colletinae and Megachilinae nesting in stems or in wood, and less often in clay banks or other vertical soil substrates (Malyshev 1965; Zhao et al. 2012; van Achterberg 2013); as far as known, bees nesting in horizontal soil substrates are far less attacked. However, in Australia members of the Hyptiogastrinae do attend bee nests in flat ground (Houston 1987). There is only indirect evidence that Gasteruptiinae may attack wasp nests, especially of Crabronidae, Sphecidae and solitary Vespidae (Eumeninae) (Crosskey 1951; Gauld and Hanson 1995, Hanson and Gauld 2006; Jennings and Austin 1997a, 1997b, 2004). Metamorphosis takes place inside the host's nest where the gasteruptiid pupa hibernates until the next spring or summer (Malyshev 1968; He 2004; Jennings and Austin 2004). All known gasteruptiids from the Palaearctic Region belong to the subfamily Gasteruptiinae and to the genus Gasteruption Latreille, 1796. For identification the revision of the Chinese species (Zhao et al. 2012) and the yet unpublished revision of the East Palaearctic species (van Achterberg, in prep.) were used. According to Zhao et al. (2012) two species (G. angulatum Zhao, van Achterberg & Xu, 2012 and G. japonicum Cameron, 1888) are known from the NW Chinese province Shaanxi, which is 7% of the total of 28 species reported from China. Italy (about as varied in natural habitats as Shaanxi) is 50% larger than Shaanxi but has 20 species reported, which is about 60% of the total species known from Europe. In this paper we report five additional species, and from the comparison with Italy it may be deduced these seven are about half of the number to be expected.

Material and methods

The specimens were mainly collected by hand net or sweep netting, rarely in Malaise traps during 2015. Specimens from Shaanxi were directly stored in 70% ethanol, prepared using the AXA method (van Achterberg 2009; van Achterberg et al. 2010) and glued on card points; other specimens were directly pinned. Observations and descriptions were made with an Olympus SZX11 stereomicroscope and fluorescent lamps. Photographic images were made either with a Keyence VHX-5000 digital microscope



Figure A–B. Measurements (**A**) of the relative length of the propleuron (a) and length of the mesoscutum in front of the tegulum (b) and (**B**) the length and maximum width of the basal antennal segments; asc = antesternal carina.

or with an Olympus motorized stereomicroscope SZX12 and processed with Adobe Photoshop CS5, mostly to adjust the size and background.

For comparison of head shapes it is essential that the middle of the vertex is in plane of objective of binocular microscope. For the other terminology, see Zhao et al. (2012) and van Achterberg (1988). Measurements are performed as indicated in Fig. A–B and in van Achterberg (1988). Additional non-exclusive characters in the key are between square brackets. The association of males with females is based on similarity. In the few cases in which no males were available, distinctive, and probably non-sexual, characters of the female were tentatively used for inclusion in the key. A new provincial record is indicated by an asterisk. The following abbreviations are used for the depositories:

ECHU	Entomology Collection, Hokkaido University, Sapporo;
NWUX	College of Life Sciences, Northwest University, Xi'an;
RMNH	Naturalis Biodiversity Center, Leiden;
ZJUH	Parasitic Hymenoptera Collection of the Zhejiang University, Hangzhou.

Results

Gasteruption Latreille, 1796

Gasteruption Latreille, 1796: 113; Zhao et al. 2012: 6–7 (diagnosis, references, key); van Achterberg 2013: 59 (illustrated key for the Netherlands); Jennings and Parslow 2014: 95; van Achterberg and Talebi 2014: 10 (illustrated key for Iran and Turkey); Žikić et al. 2014: 573. Type-species (designated by Latreille 1810): *Ichneumon assectator* Linnaeus, 1758.

Key to species of the genus Gasteruption Latreille from Palaearctic China

Ovipositor present (a); antenna with 14 segments (b) (females) 2



Ovipositor absent (aa); antenna with 13 segments (bb) (males); [if males are unknown the species is provisionally included, see Materials and Methods]......**32**











a b c d









Mesoscutum predominantly densely coriaceous, at most with some shallow punctures (aa); head truncate medio-posteriorly or nearly so (bb); head more protruding in lateral view (cc) and wider in anterior view (dd)......**8**











9 Mandible dark brown or reddish brown basally (a), rarely brownish yellow; basal depression of mandible rather large and deep (b); fifth (= pre-apical) sternite dark brown or blackish or narrowly pale medio-apically (c) **10**



Mandible pale yellow basally (aa); basal depression of mandible often smaller and shallower (bb); fifth sternite yellowish brown medio-apically (cc) 12



10 Vertex matt or with satin sheen and densely coriaceous (a); mesoscutum densely coriaceous and without indication of punctures (b); head gradually narrowed posteriorly in dorsal view (c); antero-ventral tooth of pronotum absent or indistinct (d); [third antennal segment 1.5–1.7 times as long as pedicellus; ovipositor sheath only with short fine setae]......11



Vertex shiny and punctulate (aa); mesoscutum with some fine punctures (bb); head directly narrowed posteriorly in dorsal view (cc); antero-ventral tooth of pronotum distinct (dd); [occipital carina distinct medio-dorsally]...... *G. latitibia* Zhao, van Achterberg & Xu, 2012













Head somewhat protruding below eyes (aa) and malar space 0.5 times length of second antennal segment and 0.4 times basal width of mandible and mandibular condylus below lower level of eyes (bb); hind basitarsus slender and entirely dark brown dorsally (cc); hind tibia ventrally paler than dorsally (dd); mesoscutum finely sculptured (ee) *G. bicoloratum* sp. n.





_

Vertex truncate medio-posteriorly (aa) or reversed U-shaped emarginate (aaa), shorter and moderately convex (bb); **if** vertex more or less emarginate and/or flat, then vertex finely sculptured, with satin sheen and shorter (cc); mesoscutum punctate, punctate-rugose or transversely wrinkled (dd)15



15 Head rather elongate and below eyes slightly enlarged, minimum length of malar space 0.3–0.4 times second antennal segment (a); head distinctly reversed U-shaped emarginate medio-posteriorly (b); mandible brown (c); hind tarsus brownish apically, paler than basally (d); [apex of ovipositor sheath ivory; first metasomal tergite orange or yellowish brown].....

......G. dimidiatum Semenov, 1892







Hind tibia distinctly inflated (aa); hind femur orange brown to dark brown (bb); middle lobe of mesoscutum punctate or punctate-rugose (cc); scapus ventrally paler than third antennal segment or both dark brown (dd)18





Middle lobe of mesoscutum coriaceous between punctures (aa); apex of ovipositor sheath blackish (bb); apical half of hypopygium brown (cc) or yellowish brown; [ovipositor sheath 4–6 times as long as hind tibia].....





Apex of ovipositor sheath mainly dark brown (aa), pale part at most 0.3 times as long as hind basitarsus; mesosoma densely setose laterally (bb); hind femur orange or reddish brown (cc); [head darker than mesoscutum anteriorly] .19























24 Pale apical part of ovipositor sheath 3.0–3.5 times as long as hind basitarsus (a); vertex shiny and largely smooth or finely punctulate (b); fourth antennal segment 1.7–2.3 times as long as third antennal segment (c); mesoscutum more or less coarsely spaced punctate or punctate-rugose medio-posteriorly (d)...... G. tonkinense Pasteels, 1958



Pale apical part of ovipositor sheath 0.3–3.2 times as long as hind basitarsus (aa); **if** 2.8–3.2 times (*G. japonicum*) then head dorsally with satin sheen and distinct fine sculpture (bb); fourth antennal segment 1.2–1.9 times as long as third antennal segment (cc); mesoscutum punctate, transverse rugose, punctate-rugose or partly reticulate medio-posteriorly (dd)......25



25 Hind femur and tibia widened (a); hind basitarsus robust (b); head slightly narrowed in dorsal view (c); head slender in anterior view (d) and face narrower than clypeus (e); hind basitarsus entirely dark brown (f); [ovipositor sheath about 1.4 times as long as body and 8.5 times as long as hind tibia]...

..... G. huangshii sp. n.















Pale apical part of ovipositor sheath 1.1–3.2 times as long as hind basitarsus (aa); occipital carina narrow lamelliform medio-dorsally (bb), if non-lamelliform (bbb) then mesoscutum very finely coriaceous or rugulose (cc)29











31 Mesoscutum moderately punctate (a); hind coxa rather robust basally (b); white or ivory apical part of ovipositor sheath 1.4–2.2 times as long as hind basitarsus (cc); [hind basitarsus often partly ivory]

..... G. japonicum Cameron, 1888





Males












35 Mesoscutum only coriaceous or finely rugulose medially (a), at most with a few shallow punctures; [*G. assectoides* provisionally included, ♂ unknown]**36**

















Fourth antennal segment 1.4–1.7 times as long as third segment (aa; unknown of *G. pannuceum*); face wide (bb)40



39 Fourth antennal segment about 3.5 times as long as third segment (a); second and third antennal segments robust (b); hind femur and tibia slender (c)..... G. sinepunctatum Zhao, van Achterberg & Xu, 2012







 Head moderately convex in lateral and anterior view (aa); head rather short in dorsal view (bb); hind coxa and tibia slender (cc)......41





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42 Frons and vertex shiny and smooth (a); mesoscutum rugose medio-posteriorly (b) and near notauli (c).......*G. latitibia* Zhao, van Achterberg & Xu, 2012















Hind tibia less inflated (aa); head slightly more narrowed posteriorly in dorsal view (bb); basal antennal segments slightly slimmer (c).... *G. bicoloratum* sp. n.



46 Mesoscutum distinctly more coarsely sculptured than vertex (a); head directly narrowed behind eyes (b); malar space short (c)



Mesoscutum slightly more coarsely sculptured than vertex (aa); head less narrowed behind eyes (bb); malar space more or less enlarged (cc) *G. boreale* (Thomson, 1883)





 Posteriorly vertex convex in lateral view and usually shorter (aa); sculpture of head dorsally variable (bb), if smooth (bbb) them more narrowed posteriorly (cc); mesosoma usually unicoloured (dd) or dorsally paler than laterally...... 48



























54 Hind tibia strongly inflated (a); third antennal segment less slender (b) *G. sinicola* (Kieffer, 1924)



Hind tibia moderately inflated (aa); third antennal segment slender (bb)..... *G. formosanum* Enderlein, 1913









- Occipital carina less or non-lamelliform (aa) and flat medio-dorsally (bb); mesoscutum more or less coarsely punctate (cc)......**5**7







Systematics

Gasteruption angulatum Zhao, van Achterberg & Xu, 2012 Figs 1–6

Gasteruption angulatum Zhao et al., 2012: 19–22 (description).

Material. 1 (NWUX), China: Shaanxi, Mt. Qin, Baolongyu, N34°03' E108°09', 10.vi.2015, 24.v.2015, Jiangli Tan.



Figures 1–6. *Gasteruption angulatum* Zhao, van Achterberg & Xu, 2012, male, Shaanxi. I habitus lateral 2 mesosoma dorsal 3 hind leg lateral 4 head dorsal 5 basal antennal segments 6 apex of metasoma lateral.

Gasteruption bicoloratum Tan & van Achterberg, sp. n. http://zoobank.org/1DBA37E4-2D61-4E7E-B5B3-19D3B311D73C Figs 7–22

Type material. Holotype, \bigcirc (NWUX), "China: Shaanxi, Foping, Yueba, Qinling Mts, N33°32' E107°49', 27.vi-1.vii.2015, 1095 m, Qingqing Tan". Paratypes: $4\bigcirc 3 \circlearrowleft$ (NWUX, RMNH), same data as holotype.

Comparative diagnosis. Runs in Zhao et al. (2012) to *G. oriplanum* Kieffer, 1911 (but the malar space is shorter in the new species and oblique in anterior view, not subparallel-sided below eyes in anterior view as in *G. oriplanum* and the mandibles are paler) or to *G. assectator* (Linnaeus, 1758). The pale fifth sternite of the female, the strongly narrowed head in dorsal view, the shorter ovipositor sheath (about 0.6 times hind tibia vs 0.9–1.3 times in *G. assectator*) and the yellowish mandible separate it from *G. assectator*. The new species is close to *G. flavimarginatum* van Achterberg, 2014, but it has a slightly longer malar space (short in *G. flavimarginatum*), the hind basitarsus slender and dorsally dark brown (rather robust and at least partly ivory dorsally) and the mesoscutum finely sculptured (coarser sculptured). The male differs by having the apex of the paramere dark brown, which is yellowish brown in *G. flavimarginatum*.

Description. Holotype, female, length of body 9.9 mm, of fore wing 4.9 mm.

Head. Vertex and frons with satin sheen, finely coriaceous, moderately convex and without a depression medio-posteriorly; head directly contracted behind eyes in dorsal view and temples nearly straight (Fig. 14); temple 0.9 times as long as eye in dorsal view; fourth antennal segment 1.2 times as long as third segment and 0.7 times as long as second and third segments combined, fifth antennal segment as long as third segment, third antennal segment 1.6 times as long as second segment (Fig. 8); occipital carina narrow and non-lamelliform medio-dorsally (Fig. 8); OOL 1.3 times as long as eye in frontal view (Fig. 13); malar space somewhat protruding below lower level of eyes (Fig. 13), its minimum width 0.4 times as long as second antennal segment and 0.35 times basal width of mandible and area behind incision nearly square (Fig. 8); clypeus only medio-ventrally shallowly depressed (Fig. 13); eye with numerous short setae.

Mesosoma. Length of mesosoma 1.6 times its height; propleuron robust and 0.8 times as long as mesoscutum in front of tegulae; pronotal side entirely coriaceous except for crenulated grooves and sparsely setose, without acute tooth antero-ventrally (Figs 8–10); antesternal carina narrow and hardly lamelliform; mesosternal sulcus wide and deep; mesoscutum and scutellum rather matt and superficially rugulose-coriaceous (Fig. 10); propodeum reticulate-rugose and without median carina.

Wings. First discal cell parallel-sided and with outer posterior corner rounded, and with vein 3-CU1 near its apical third (Fig. 11).

Legs. Hind coxa finely granulate-coriaceous; length of hind femur, tibia and basitarsus 3.9, 3.6 and 4.6 times their width, respectively; hind tibia strongly inflated (Fig. 15); middle tarsus 1.1 times as long as middle tibia; middle femur subparallel-sided and slimmer than fore femur.



Figure 7. Gasteruption bicoloratum Tan & van Achterberg, sp. n., female, holotype, habitus lateral.

Metasoma. Ovipositor sheath 1.2 mm, 0.1 times as long as body, 0.2 times as long as metasoma and 0.6 times as long as hind tibia; ovipositor sheath with dense cover of fine brownish and adpressed setae, its apical half slender; hypopygium shallowly emarginate medio-posteriorly.

Colour. Black; apical half of antenna largely brown ventrally; mandible pale brownish yellow (except narrow dark borders); clypeus latero-ventrally and humeral plate dark brown; tegulum, second-seventh metasomal tergites narrowly apically and widely laterally, sixth sternite widely apically and other sternites narrowly, trochantelli, hind femur apico-ventrally and hind tibial spurs yellowish brown; fore and middle tibiae basally and hind tibia baso-ventrally widely ivory; remainder of legs, veins and pterostigma dark brown; wing membrane subhyaline.

Male. Similar to female (including fine sculpture of mesoscutum: Fig. 18); third antennal segment 1.3–1.6 times as long as second segment; fourth antennal segment 1.3–1.5 times as long as third segment and 0.8 times as long as second and third segments combined, fifth antennal segment 1.3–1.4 times as long as third segment (Fig.



Figures 8–16. *Gasteruption bicoloratum* Tan & van Achterberg, sp. n., female, holotype. 8 head lateral 9 mesosoma lateral 10 mesosoma dorsal 11 fore wing 12 apex of metasoma lateral 13 head anterior 14 head dorsal 15 hind leg 16 ovipositor and ovipositor sheath lateral.



Figures 17–22. *Gasteruption bicoloratum* Tan & van Achterberg, sp. n., male, paratype. 17 habitus lateral 18 mesosoma dorsal 19 mesonotum dorsal 19 hind leg 20 head dorsal 21 basal antennal segments lateral 22 apex of metasoma lateral.

21); apical sternite entirely dark brown; paramere densely whitish setose and its apex dark brown (Fig. 22).

Variation. Body length of \bigcirc 8.7–10.3 mm, of \bigcirc 8.2–9.9 mm; length of ovipositor sheath 0.6–0.7 times hind tibia; minimum width of malar space 0.3–0.4 times as long as second antennal segment; tibiae and tarsi more or less yellowish brown ventrally; apical antennal segment more or less obliquely depressed.

Distribution. China (Shaanxi). Montane: 1095 m.

Biology. Unknown. Collected June-August.

Etymology. Named after the bicoloured hind tibia in both sexes ("bi" is Latin for "two").

Gasteruption boreale (Thomson, 1883)

Figs 23–32

- *Foenus borealis* Thomson, 1883: 849; Hedicke 1939: 7; Hedqvist 1973: 181, 182 (invalid lectotype designation); Wall 1994: 148. Synonymized with *G. assectator* (Linnaeus) by Schletterer (1889) and with *G. minutum* (Tournier) by van Achterberg and Talebi (2014).
- *Gasteruption boreale*; Schletterer, 1885: 303; Johansson and van Achterberg (submitted; references and synonymy).
- *Trichofoenus breviterebrae* Watanabe, 1934: 285; Hedicke 1939: 45. Synonymized with *G. assectator* (Linnaeus) by Pagliano and Scaramozzino (2000) and with *G. boreale* (Thomson) by Johansson and van Achterberg (submitted).

Type material. Holotype of *G. breviterebrae*, \bigcirc (ECHU), "[Russia,] Saghalien [= Sakhalin Oblast], K. Tamanuki/ Konuma, 23.v.1931", "Holotype *Trichofoenus breviterebrae* Watanabe, 1934, det. Konishi". Paratypes: 1 \Diamond (ECHU), "[Russia,] Saghalien, K. Tamanuki/ Nagahama, 28.vii.1927", "Paratype (Allotype) *Trichofoenus breviterebrae* Watanabe, 1934".

Additional material. China (Heilongjiang, ZJUH); Russia (Sakhalin).

Diagnosis. (after Johansson and van Achterberg submitted) Head in dorsal view subparallel-sided behind eyes (Fig. 30), elongate, about as wide as long; occipital carina indistinct medio-dorsally; frons with satin sheen; mesoscutum rather weakly rugulose-coriaceous or chagreened, similar as vertex (Fig. 24) and with satin sheen, in front of scutellum rather rugose (Fig. 26); mesosoma and head silvery pilose; mesosoma with a satin sheen, quite distinct from the rather fatty gloss present in *G. assectator* s.s.; whit-ish pubescence of eye of female (Fig. 29) mostly distinctly longer and denser than of *G. assectator* s.s.; antenna slightly shorter than in *G. assectator* s.s. with sixth segment about 1.5 times longer than wide and subapical segment about 1.2 times longer than wide; only apical half of hind coxa weakly striate dorsally; hind tibia and basitarsus with white or ivory ring (Fig. 27); metasoma mainly black with orange lateral patches on tergites 2–4, which might be partially reduced (Fig. 23); inner sides of tibiae often



Figure 23. *Gasteruption boreale* (Thomson), female, holotype of *G. breviterebrae* (Watanabe), habitus lateral.

red brown to orange with white or yellow basal patch indistinct on fore and middle tibiae; ovipositor sheath black or brown, 0.7-1.0 times as long as hind tibia, its apical half entirely with stout, rather scarce black bristles angled backwards at about 45° (Fig. 32). The male is difficult to separate from males of *G. assectator* s.s. and identification is not always possible with certainty. In most cases males of *G. boreale* have a slightly more elongate and subparallel-sided head in dorsal view, a less sculptured mesoscutum and a more or less enlarged malar space.

Distribution. China (*Heilongjiang, ZJUH); **Russia** (Sakhalin). New for China. **Biology.** Unknown. Collected May-July.

Gasteruption huangshii Tan & van Achterberg, sp. n. http://zoobank.org/6C7EC527-A23F-4AA1-B9A9-76E85FD24445 Figs 33–48

Type material. Holotype, \bigcirc (NWUX), "China: Shaanxi, Hanzhong, Liuba, Zhang Liang Temple, N33.68° E106.83°, 28.vii.2015, 1348 m, Jiangli Tan & Qingqing Tan". Paratypes (NWUX, RMNH): 5 \bigcirc , same data as holotype.



Figures 24–32. *Gasteruption boreale* (Thomson), female, holotype of *G. breviterebrae* (Watanabe). 24 head lateral 25 mesosoma lateral 26 mesonotum dorsal 27 hind leg 28 base of antenna 29 head anterior 30 head dorsal 31 fore wing 32 ovipositor and ovipositor sheath lateral.



Figure 33. Gasteruption huangshii Tan & van Achterberg, sp. n., female, holotype, habitus lateral.

Comparative diagnosis. The new species runs in the key by Zhao et al. (2012) to *G. japonicum* Cameron and *G. sinepunctatum* Zhao, van Achterberg & Xu, because of the very finely sculptured mesoscutum. It differs from both species by the trapezoid head in dorsal view (Fig. 40 vs Figs 55, 102), the distinctly widened hind tibia, fore and hind femora (Fig. 41 vs Figs 53, 103) and the slender head in anterior view (Fig. 39 vs Figs 54, 101). It shares with *G. praestans* Semenov-Tian-Shanskij & Kostylev, 1928, from Kazakhstan the widened hind femur and the sparsely punctate vertex. It differs by the ivory apical part of the ovipositor sheath (absent in *G. praestans*), the hind femur and basitarsus robust (slimmer), the mesoscutum finely coriaceous with fine punctures (coarsely and rather densely punctate) and the mesopleuron mainly coriaceous dorsally and posteriorly (reticulate).

Description. Holotype, female, length of body 12.5 mm, of fore wing 6.0 mm.

Head. Vertex and frons with satin sheen, finely and densely punctulate (but vertex with some fine additional punctures: Fig. 40), moderately convex and without a depression medio-posteriorly; head trapezoid and gradually narrowed behind eyes in dorsal view and temples convex (Fig. 40); temple 0.7 times as long as eye in dorsal view; fourth antennal segment 1.5 times as long as third segment and 0.9 times as long as second and third segments combined, fifth antennal segment 1.2 times as long as third segment (Fig. 33), third antennal segment 1.4 times as long as second segment; occipital carina narrow and narrowly lamelliform medio-dorsally (Figs 34, 40); OOL 1.3 times as long as diameter of posterior ocellus; face 2.7 times wider than high, 2.4 times wider than eye in anterior view (Fig. 39); minimum width of malar space 0.3 times as long as second antennal segment (Fig. 34); clypeus rather flat and with small round emargination medio-ventrally; eye glabrous.

Mesosoma. Length of mesosoma 2.1 times its height; propleuron rather robust and 0.9 times as long as mesoscutum in front of tegulae; pronotal side entirely punctulate (except for crenulated grooves and some fine punctures ventrally) and sparsely setose, with minute lobe-shaped tooth antero-ventrally (Fig. 35); antesternal carina narrow and hardly lamelliform; mesosternal sulcus narrow anteriorly and moderately wide posteriorly; mesopleuron mainly superficially coriaceous dorsally and posteriorly; mesoscutum and scutellum matt, very finely and superficially coriaceous with fine punctures and medio-posteriorly with some short grooves (Fig. 36); propodeum rugose anteriorly and coriaceous posteriorly.

Wings. First discal cell parallel-sided and with outer posterior corner rounded, and with vein 3-CU1 near apical third (Fig. 37).

Legs. Hind coxa very finely coriaceous-punctulate; length of hind femur, tibia and basitarsus 2.7, 3.5 and 4.1 times their width, respectively; middle tarsus 1.1 times as long as middle tibia; middle femur subparallel-sided and slimmer than distinctly widened fore femur.

Metasoma. Ovipositor sheath 15.3 mm, 1.2 times longer than body, 1.7 times as long as metasoma and 7.5 times as long as hind tibia, ivory apical part of sheath 1.8 times as long as hind basitarsus; apical half of hypopygium incised (Fig. 38).

Colour. Black; mandible dark brown with middle part brown; fore femur apically, fore and middle tibiae basally and apically, and hind tibial spurs yellowish brown; hind tibia ventro-basally ivory; tegulae and remainder of legs mainly dark brown; pterostigma dark brown; wing membrane subhyaline.

Male. Similar to female, but head behind eye slightly more contracted in dorsal view and somewhat shorter (Fig. 47); third antennal segment as long as second segment, fourth antennal segment 2.5–2.9 times as long as third segment and 1.3–1.5 times as long as second and third segments combined, fifth antennal segment 2.6–2.9 times as long as third segment (Fig. 46); mouthparts ivory; paramere densely whitish setose and its apex brownish yellow (Fig. 48).

Variation. Body length of male 8.7–9.9 mm; sculpture of mesosoma of male very fine and only slightly coarser coriaceous than of female.



Figures 34–42. *Gasteruption huangshii* Tan & van Achterberg, sp. n., female, holotype. 34 head lateral 35 mesosoma lateral 36 mesonotum dorsal 37 fore wing 38 hypopygium ventral 39 head anterior 40 head dorsal 41 hind leg 42 apex of ovipositor sheath.



Figures 43–48. *Gasteruption huangshii* Tan & van Achterberg, sp. n., male, paratype. 43 habitus lateral 44 mesosoma dorsal 45 hind leg 46 basal antennal segments 47 head dorsal 48 apex of metasoma lateral.

Distribution. China (Shaanxi).

Biology. Unknown, but the new species was collected together with a *Hylaeus* sp. **Etymology.** Named after Huang Shi Gong (supposed teacher of the early Han general Zhang Liang), because the specimens were collected outside the hall with Huang Shi Gong's statue at the Zhang Liang Temple.

Gasteruption japonicum Cameron, 1888

Figs 49-57

Gasteruption japonicum Cameron, 1888: 134; Zhao et al. 2012: 58–61. *Gasteruption sinense* var. *minus* Kieffer, 1924: 78; Zhao et al. 2012: 58 (synonymized with *G. japonicum*).

Material. 2♀ (NWUX, RMNH), China: Shaanxi, Hanzhong, Nanzheng, Liping National Forest Park, N32°44'04" E106°36'34", 22.vi.2015, c 1620 m, Jiangli Tan & C. van Achterberg; 1♀ (NWUX), China: Shaanxi, along the road from Hanzhong to Liping, N32.87° E106.71°, 4.ix.2015, c 1377 m, Jiangli Tan; 1♂ (NWUX), China: Hubei, Yichang, Yiling, Chentangping, Mal. trap, 17.v.-10.vii.2015, c 465 m, Haoliang Ni; 1♀ (NWUX), China: Shaanxi, Foping, behind Biological Station, Malaise trap, N33°39'29" E107°48'25", 29.v.-19.vi.2016, c 1710 m, JL. Tan & C. v. Achterberg.

Notes. The lectotype female of *Gasteruption rufescenticorne* Enderlein, 1913, is obviously different from the paralectotype male (e.g. head not emarginate medio-posteriorly and more narrowed, narrower occipital carina and different sculpture of mesoscutum) and is very similar to *G. japonicum*. The differences as indicated in the key could be part of gradual variation and after examination of more Japanese material its status may need reconsideration.



Figure 49. Gasteruption japonicum Cameron, female, Japan, habitus lateral.



Figures 50–57. *Gasteruption japonicum* Cameron, female, Japan. 50 head lateral 51 mesosoma lateral 52 mesonotum dorsal 53 hind leg 54 head anterior 55 head dorsal 56 fore wing 57 apex of ovipositor sheath.

Gasteruption oshimense Watanabe, 1934

Figs 58-67

Gasteruption oshimensis Watanabe, 1934: 283–284. *Gasteruption tournieri*; Zhao et al. 2012: 103–108.

Material. 2 (NWUX), China: Shaanxi, Zhashui, Huanghualing., N33.76° E108.85°, 23.vii.2015, c 1577 m, Jiangli Tan; 2 (NWUX), China: Shaanxi, Hanzhong, Liuba, Zibai Mt. Nat. Res., N33.66° E106.78°, 5.ix.2015, c 1627 m, Jiangli Tan; 3 6 (NWUX, RMNH), China: SE Shaanxi, Langoa near Ankang, N32°17'01" E109°03'46", c 1100 m, Jiangli Tan, Qingqing Tan & C. van Achterberg; 1 (NWUX), China: Shaanxi, Foping, behind Biological Station, Malaise trap, N33°39'29" E107°48'25", 29.v.-19.vi.2016, c 1710 m, JL. Tan & C. v. Achterberg.

Notes. The East Palaearctic specimens provisionally identified as *G. tournieri* Schletterer, 1885, by Zhao et al. (2012) are included here under *G. oshimense* Watanabe. The different shape of the head was noticed before, but also the hind tibia and hind basitarsus are slimmer and the sculpture of the mesoscutum is less developed. Most likely it concerns a separate species and because a valid name is available, this name (correctly spelled as *G. oshimense*) is used here. Especially the size of the males is very variable, e.g. length of body is 5.3–8.7 mm in the series from Langoa collected at the same spot and within one hour.



Figure 58. Gasteruption oshimense Watanabe, female, lectotype, habitus lateral (ovipositor sheath missing).



Figures 59–67. *Gasteruption oshimense* Watanabe, female, lectotype. 59 head lateral 60 mesosoma lateral 61 mesonotum dorsal 62 hind leg 63 head anterior 64 head dorsal 65 occipital carina dorsal 66 fore wing 67 apex of ovipositor sheath.

Gasteruption pannuceum Tan & van Achterberg, sp. n. http://zoobank.org/2E182575-5709-470C-81D6-435C2AE0C469 Figs 68–77

Type material. Holotype ♀ (NWUX), China: Shaanxi, Qinling Mts., Baolongyu, N34°03' E108°09', c 700 m, 10.vi.2015, 24.v.2015, Jiangli Tan.

Comparative diagnosis. Runs in Zhao et al. (2012) either to *G. varipes* (Westwood, 1851) (if the pale apical part of the ovipositor sheath is considered to be minor) or to *G. sinarum* Kieffer, 1911 (if the pale part is considered to be intermediate; Fig. 77). The new species differs from *G. varipes* by having the mesopleuron black and finely sculptured (orange brown and coarsely vermiculate-reticulate (rarely only weakly so)), the mesoscutum slender and finely rugulose (robust and coarsely rugose), the propodeum mainly coriaceous (coarsely vermiculate-rugose), a shorter ovipositor sheath (3 times hind tibia vs 5 times) and the mandible brownish yellow (blackish). The new species differs from *G. sinarum* by having a shorter ovipositor sheath (3.2 times hind tibia vs 4.8–6.0 times in *G. sinarum*), the mesoscutum without coarse punctures (present), the vertex shiny and largely smooth (with satin sheen and punctulate in *G. sinarum*) and the vertex distinctly convex (less so in *G. sinarum*). It shares with *G. parvicollarium* Enderlein, 1913, the convex vertex, but the new species has a longer ovipositor sheath (3.1 times hind tibia vs 1.2–1.7 times in *G. parvicollarium*), the mesoscutum transversely wrinkled (mainly coriaceous) and eyes more conspicuously setose.

Description. Holotype, female, length of body 10.0 mm, of fore wing 6.2 mm.

Head. Vertex and frons shiny and very finely punctulate, nearly smooth (Fig. 75), distinctly convex (Fig. 69) and without a depression medio-posteriorly; head trapezoid and directly narrowed behind eyes in dorsal view (Fig. 75); temple 0.7 times as long as eye in dorsal view; fourth antennal segment 1.1 times as long as third segment and 0.6 times as long as second and third segments combined, fifth antennal segment 1.2 times as long as third segment, third antennal segment 1.4 times as long as second segment; occipital carina narrow and non-lamelliform medio-dorsally (Figs 69, 75); OOL 1.5 times as long as diameter of posterior ocellus; face 3.5 times wider than high, twice wider than eye in anterior view (Fig. 74); minimum width of malar space 0.2 times as long as second antennal segment (Fig. 69); clypeus rather flat, slightly depressed ventrally and shallowly emarginate medio-ventrally; eye densely setose (Fig. 74).

Mesosoma. Length of mesosoma 2.1 times its height; propleuron rather robust and 0.9 times as long as mesoscutum in front of tegulae; pronotal side mainly coriaceous, but ventral half (except anteriorly) largely rugose and grooves crenulate and sparsely setose, with small blunt tooth antero-ventrally (Figs 70, 71); antesternal carina narrow and non-lamelliform; mesopleuron coriaceous and medially moderately rugose; mesosternal sulcus wide and crenulate; mesoscutum and scutellum with satin sheen, finely punctate-coriaceous, but middle lobe mainly transversely rugulose and medio-posteriorly broadly rugose (Fig. 71); propodeum mainly coriaceous but rugose anteriorly.



Figure 68. Gasteruption pannuceum Tan & van Achterberg, sp. n., female, holotype, habitus lateral.

Wings. First discal cell parallel-sided and with outer posterior corner rounded, and with vein 3-CU1 near its apical third.

Legs. Hind coxa very finely coriaceous; length of hind femur, tibia and basitarsus 4.8, 5.1 and 5.1 times their width, respectively; middle tarsus 1.2 times as long as middle tibia; middle femur subparallel-sided and slightly slimmer than fore femur; hind tibia weakly inflated (Fig. 76).

Metasoma. Ovipositor sheath 8.5 mm, 0.8 times longer than body, 1.1 times as long as metasoma and 3.2 times as long as hind tibia, ivory apical part of sheath 0.3 times as long as hind basitarsus; apical 0.3 of hypopygium incised (Fig. 73).

Colour. Black; mandible brownish yellow and basally slightly darkened; apical antennal segment, apex of ovipositor sheath, fore and middle tibiae basally and hind tibia ventro-basally ivory or pale brown; penultimate antennal segment brown; tegulae, pterostigma, remainder of legs and antenna, hind tibial spurs and remainder of legs mainly dark brown or blackish; wing membrane subhyaline.

Male. Unknown.

Distribution. China (Shaanxi).

Biology. Unknown.

Etymology. Named after the rugulose ("wrinkled") sculpture of the middle lobe of the mesoscutum: "pannuceus" is Latin for "wrinkled".



Figures 69–77. *Gasteruption pannuceum* Tan & van Achterberg, sp. n., female, holotype. 69 head lateral 70 mesosoma lateral 71 mesonotum dorsal 72 fore wing 73 hypopygium ventral 74 head anterior 75 head dorsal 76 hind leg 77 apex of ovipositor sheath.

Gasteruption shengi Tan & van Achterberg, sp. n. http://zoobank.org/F8DE70E2-B352-411C-994F-FAC3E62B80BF Figs 78–94

Type material. Holotype, \bigcirc (NWUX), "China: Ningxia, Pingluo, Mt. Shizui, 25.v.2015, Mao-Ling Sheng", "on *Hedysarum scoparium* Fisch ex Mey". Paratypes: 1 \bigcirc 1 \bigcirc (RMNH), "N. China: Ningxia, Mt. Shizui, 6.v.2009, M.-L. Sheng, RMNH'11"; 1 \bigcirc (NWUX), "China: Inner Mongolia, Otog Banner, Yikebulage, 31.iii.2015, Mao-Ling Sheng", "on *Tetraena mongolica* Maxim." [translation of Chinese labels].

Comparative diagnosis. Runs in Zhao et al. (2012) to *G. dimidiatum* Semenov, 1892, because of the emarginate head, the long and black ovipositor sheath, punctate mesoscutum and the finely sculptured propodeum. The new species differs from *G. dimidiatum* by having the head not prolonged below eyes in anterior view and malar space 0.2–0.3 times as long as second antennal segment (head shortly prolonged below eyes in *G. dimidiatum*; fig. 107 in Zhao et al. 2012, malar space 0.4 times as long as second antennal segment), first metasomal tergite black (orange or yellowish brown), basal half of hind coxa only coriaceous (transversely rugulose), apex of ovipositor sheath black (narrowly ivory), mesoscutum rather finely punctate (somewhat coarser punctate) and slightly wider hind tibia (slightly narrower). Males may be confused with *G. sinarum* Kieffer, 1911, the latter species has the hind coxa distinctly transversely rugose, the hind tibia is slim and the mesoscutum is more or less rugulose.

Description. Holotype, female, length of body 13.1 mm, of fore wing 5.9 mm. *Head.* Vertex and frons with satin sheen and very finely punctulate, but vertex posteri-

Head. Vertex and frons with satin sheen and very finely punctulate, but vertex posteriorly superficially coriaceous (Fig. 86), distinctly convex (Fig. 80) and without a depression medio-posteriorly; frons densely silvery setose anteriorly; head trapezoid and gradually narrowed behind eyes in dorsal view (Fig. 86); temple 0.7 times as long as eye in dorsal view; fourth antennal segment 1.4 times as long as third segment and 0.9 times as long as second and third segments combined, fifth antennal segment 1.1 times as long as third segment, third antennal segment 1.8 times as long as second segment; occipital carina narrow and hardly lamelliform medio-dorsally (Figs 80, 86); OOL 1.4 times as long as diameter of posterior ocellus; face 3 times wider than high, 2.2 times wider than eye in anterior view (Fig. 85); minimum width of malar space 0.2 times as long as second antennal segment (Fig. 80); clypeus rather flat, slightly depressed ventrally and distinctly emarginate medio-ventrally (Fig. 85); eye largely glabrous; head shallowly U-shaped emarginate posteriorly (Fig. 86).

Mesosoma. Length of mesosoma twice its height; propleuron rather robust and 0.8 times as long as mesoscutum in front of tegulae; pronotal side mainly superficially coriaceous, with grooves crenulate and largely densely silvery setose, with small acute tooth antero-ventrally (Fig. 80); antesternal carina narrow and non-lamelliform; mesopleuron coriaceous and largely densely silvery setose; mesosternal sulcus rather wide and crenulate; mesoscutum and scutellum with satin sheen, mesoscutum rather coarsely punctate but interspace mostly wider than diameter of punctures, interspaces superficially coriaceous, but middle lobe medio-posteriorly with few rugae (Fig. 82); scutellum mainly superficially coriaceous and with few small punctures; propodeum mainly coriaceous but medially with transverse crenulation connected to smooth median area.



Figures 78–79. *Gasteruption shengi* Tan & van Achterberg, sp. n., female holotype (78) and male paratype (79), habitus lateral.

Wings. First discal cell parallel-sided and with outer posterior corner rounded and with vein 3-CU1 near its apical third (Fig. 83).

Legs. Hind coxa very finely coriaceous and with satin sheen; length of hind femur, tibia and basitarsus 4.6, 4.7 and 5.3 times their width, respectively; middle tarsus 1.2 times as long as middle tibia; middle femur subparallel-sided and slightly slimmer than fore femur; hind tibia moderately inflated (Fig. 87).

Metasoma. Ovipositor sheath 14.4 mm, 1.1 times longer than body, 1.6 times as long as metasoma and 5.9 times as long as hind tibia, apex of sheath black; apical 0.5 of hypopygium incised (Fig. 84).



Figures 80–88. *Gasteruption shengi* Tan & van Achterberg, sp. n., female, holotype. 80 head lateral 81 mesosoma lateral 82 mesonotum dorsal 83 fore wing 84 hypopygium lateral 85 head anterior 86 head dorsal 87 hind leg 88 apex of ovipositor sheath.



Figures 89–94. *Gasteruption shengi* Tan & van Achterberg, sp. n., male, paratype from Inner Mongolia. 89 head lateral 90 mesosoma dorsal 91 hind leg 92 head dorsal 93 basal antennal segments 94 apex of metasoma lateral.

Colour. Black; mandible brown and basally slightly darkened; base and apex of fore and middle tibiae, most of fore and middle basitarsi and subbasal ring of hind tibia ivory or pale brown; tegulae, base and apex of fore and middle femora, remainder of fore and middle tarsi (but middle telotarsus dark brown), hind tibial spurs, second-fifth metasomal segments, apical half of hypopygium and lateral spots on sixth tergite brown; pterostigma, veins and clypeus ventrally dark brown; wing membrane subhyaline.

Male. Similar to female, but sculpture of mesoscutum coarser (Fig. 90), head less emarginate posteriorly and propodeum more or less reticulate; third antennal segment 1.3 times as long as second segment, fourth antennal segment 1.9–2.1 times as long as third segment and 1.1–1.2 times as long as second and third segments combined, fifth antennal segment 1.9–2.3 times as long as third segment (Fig. 93); mouthparts partly ivory; paramere greyish setose and its apex black (Fig. 94); hind tarsus mainly dark brown or blackish.

Variation. Body length of female 12.1–13.1 mm, of male 10.1–11.5 mm; length of malar space 0.2–0.3 times as long as second antennal segment; propleuron 0.8–0.9 times as long as mesoscutum in front of tegulae; ovipositor sheath 10.5–14.4 mm, 0.9–1.1 times longer than body, 1.4–1.6 times as long as metasoma and 4.1–5.9 times as long as hind tibia; occipital carina of female paratype narrow lamelliform medio-dorsally, mandible rather yellowish brown, hypopygium and sixth tergite entirely brown and seventh tergite laterally so, fore and middle legs (except coxae and trochanters) mainly brown, tegulae dark brown, hind femur brownish black and subbasal ring of hind tibia brownish.

Distribution. China (Ningxia, Inner Mongolia). **Biology.** Unknown.

Etymology. Named after the collector, Prof. Dr Mao-Ling Sheng, for his contribution of our knowledge of Chinese parasitoid Hymenoptera.

Gasteruption sinepunctatum Zhao, van Achterberg & Xu, 2012 Figs 95–104

Gasteruption sinepunctatum Zhao, van Achterberg & Xu, 2012: 85.

Material. 1^Q (NWUX), China: Shaanxi, Hanzhong, Liuba, Zibai Mt. Nature Reserve, N33.66° E106.78°, 5.ix.2015, c 1627 m, Jiangli Tan.

Note. Known in China from Jilin, Zhejiang, Taiwan and Tibet; new for Shaanxi.



Figure 95. Gasteruption sinepunctatum Zhao, van Achterberg & Xu, female, Shaanxi, habitus lateral.


Figures 96–104. *Gasteruption sinepunctatum* Zhao, van Achterberg & Xu, female, Shaanxi. 96 head lateral 97 mesosoma lateral 98 mesonotum dorsal 99 fore wing 100 hypopygium ventral 101 head anterior 102 head dorsal 103 hind leg 104 apex of ovipositor sheath.

Acknowledgements

Thanks are due to Prof. Mao-ling Sheng (Shenyang) for the much appreciated gift of material from Inner Mongolia and Ningxia to the first author and to Prof. Masahiro Ohara (Sapporo) for the loan of the Watanabe types. The research was supported jointly by the Foundation for Key University Teachers by the Ministry of Education (No. 2011697505), the National Natural Science Foundation of China (NSFC, No. 31201732, 31572300), the foundation of Shaanxi Educational Committee (No. 11JK0614), the Research Fund for the Doctoral Program of Higher Education of China (No. 20116101120001), the National Science Foundation for Fostering Talents in Basic Research of NSFC (No. J12100063) and the Opening Foundation of Key Laboratory of Resource Biology and Biotechnology in western China (Northwest University), Ministry of Education.

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RESEARCH ARTICLE



Descriptions of a new species of Foenatopus Smith from China and the male of Parastephanellus brevicoxalis (Hymenoptera, Stephanidae)

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Academic editor: M. Sharkey Received 7 July 2016 Accepted 11 August 2016 1	Published 23 August 2016
- http://zoobank.org/E6D8D404-00F7-4340-926D-1A5164CD10E1	

Citation: Chen H-y, van Achterberg C, Xu Z-f (2016) Descriptions of a new species of *Foenatopus* Smith from China and the male of *Parastephanellus brevicoxalis* (Hymenoptera, Stephanidae). ZooKeys 612: 113–123. doi: 10.3897/ zookeys.612.9781

Abstract

A new species of the stephanid genus *Foenatopus* Smith, *Foenatopus weii* **sp. n.**, is described and illustrated from Yunnan Province, China. A modified section of the identification key to species of *Foenatopus* is added to include the new species. The male of *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011 from Guangdong Province, China is also described and illustrated for the first time.

Keywords

China, Foenatopus, male, new species, Oriental Region, Parastephanellus brevicoxalis

Introduction

The family Stephanidae Leach, 1815 are a rare group of parasitoids (Hong et al. 2011). The Chinese Stephanidae were recently revised by Hong et al. (2011), and five genera and 21 species were recognized. However, one species of *Schlettererius* Ashmead, 1900

(Tan et al. 2015) and two species of *Pseudomegischus* van Achterberg, 2002 (Tan et al. 2015; Chen et al. 2016) were subsequently reported from China, suggesting that the actual number of Stephanidae occurring in China is still underestimated. During recent surveys of Chinese Hymenoptera some additional specimens of Stephanidae have been collected. Among them, a new species of *Foenatopus* is recognized and the male of *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011 is reported for the first time. Here the new species *Foenatopus weii* sp. n. and the male of *P. brevicoxalis* Hong, van Achterberg & Xu, 2011 are described.

Material and methods

Descriptions of the species have been made under an Olympus SZ61 stereomicroscope, with lighting achieved through a 27W fluorescent lamp. Digital images were taken with a digital microscope KEYENCE[®] VHX-5000 (Osaka, Japan), and plates were edited with the programs ACDSee 10.0 and Photoshop CS 8.0.1.

Morphological nomenclature follows van Achterberg (2002) and Hong et al. (2011).

The female holotype of *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011 is deposited in Zhejiang University (ZJUH). The remaining examined material is deposited in the Hymenopteran Collection, South China Agricultural University, Guangzhou, China (SCAU).

Taxonomy

Foenatopus Smith, 1861

Foenatopus Smith 1861: 58. Type species (by monotypy): *Stephanus indicus* Westwood, 1841.

Notes. The Chinese *Foenatopus* were recently revised by Hong et al. (2011). Eleven species of the genus are known from China after this study.

Foenatopus weii sp. n.

http://zoobank.org/261245ED-87D0-4FB7-B110-09EBBBC398A7 Figs 1–11

Material examined. Holotype, \bigcirc (SCAU), CHINA: Yunnan, Jinghong, Nanbanhe National Nature Reserve, 22°15'47.39"N, 100°36'3.22"E, 892 m, 19–23.VII.2011, Nasen Wei, yellow pan trap.

Etymology. Named after the collector Dr. Nasen Wei.



Figure 1. Foenatopus weii sp. n., holotype, female, dorsal habitus. Scale bar: 1 mm.

Diagnosis. Frons finely and transversely carinate-rugose (Fig. 2); vertex finely and transversely striate (Fig. 4); pronotum slender and mostly coriaceous, but anteriorly transversely rugulose (Figs 3, 5); scutellum (Fig. 5), propleuron and mesopleuron (Figs 3, 6) coriaceous; propodeum (Figs 5, 6) with medium-sized, circular foveolae and with coriaceous interspaces, inside of foveolae polished; fore wing with vein 2-CU1 absent (Fig. 9); most of mid tarsus ivory; subapical part of ovipositor sheath whitish (Fig. 11). This species is most similar to *Foenatopus flavidentatus* (Enderlein, 1913) but can be distinguished by the combination of the following characteristics: frons with two rather than three short longitudinal ivory streaks; pronotum entirely coriaceous (smooth posteriorly in *F. flavidentatus*); propodeum more spaced foveolate (reticulate-foveolate in *F. flavidentatus*); hind femur entirely black (hind femur chestnut brown and with two large ventral teeth yellowish in *F. flavidentatus*).

Description. Holotype. *Female*. Body length 12.2 mm; fore wing length 6.1 mm. *Colour*. Black (Fig. 1), except: frons laterally with short ivory streaks not reaching level of anterior coronal tooth (Fig. 2); temple brown with ivory streak along lower half of the eye, streak becoming narrow apically (Fig. 3); base of mandible yellow; most of mid tarsus ivory; subapical part of ovipositor sheath whitish (Fig. 11).

Head. Antenna with 33 segments; first flagellomere $3.0 \times as$ long as wide, and $0.6 \times as$ long as second flagellomere; three anterior coronal teeth large and acute, both posterior ones short and wider; frons finely and transversely carinate-rugose (Fig. 2); coronal area with some longitudinal carinae; vertex finely and transversely striate (Fig. 4); temple non-angulate, smooth and shiny (Fig. 3).



Figures 2–5. *Foenatopus weii* sp. n., holotype, female. 2 Head frontal 3 head and pronotum lateral 4 head dorsal 5 mesosoma dorsal. Scale bars: 1 mm.

Mesosoma. Pronotum (Figs 3, 5) slender and mostly coriaceous, but with transverse rugulae anteriorly; neck anteriorly deeply emarginated, neck at slightly lower level than middle part of pronotum (Fig. 3); anterior half of mesoscutum transversely coriaceous, posterior half with shallow and large foveolae; notauli and middle groove distinct; scutellum (Fig. 5), propleuron and mesopleuron (Figs 3, 6) coriaceous; propodeum (Figs 5, 6) with medium-sized, circular foveolae and with wide coriaceous interspaces, inside of foveolae polished; fore wing (Fig. 9) with vein 2-CU1 absent; pterostigma elongate and subparallel-sided, acute apically, 15.4 × as long as its maximum width and 3.1 × as long as vein r; vein r and vein SR1 obtuselyangled, vein r ends 0.2 × length of pterostigma behind level of apex of pterostigma; vein SR1 subparallel to costal margin; hind coxa transversely striate, basal third rugose; hind femur swollen, microreticulate, ventrally with two large acute teeth and with one smaller tubercle basally (Fig. 7); hind tibia coriaceous, $1.2 \times as$ long as hind femur, basal narrow part of hind tibia $1.2 \times$ as long as widened part, inner side of widened part basally distinctly depressed, followed by convex and setose area, apically densely setose.

Metasoma. First tergite transversely striate, $14.7 \times as$ long as its maximum width, $3.5 \times as$ long as second tergite and $1.1 \times as$ long as remainder of metasoma; basal 0.1 of second tergite rugose, remaining tergites largely smooth to weakly coriaceous; pygidial



Figures 6–11. *Foenatopus weii* sp. n., holotype, female. **6** Mesopleuron, metapleuron and propodeum lateral **7** hind leg **8** hind coxa lateral **9** fore wing **10** first tergite dorsal **11** apical ovipositor sheath. Scale bars: 1 mm.

area distinctly differentiated, pygidial impression reverse V-shaped; length of ovipositor sheath 0.7 \times as long as body length, length of subapical whitish band 1.9 \times length of dark apex (Fig. 11).

Male. Unknown.

Distribution. Oriental: China (Yunnan).

Biology. Collected in July. Host not known.

In the key to species of the genus *Foenatopus* by Hong et al. (2011), the new species can be included by replacing couplet 8 as follows:

8 Middle pale stripe of frons comparatively wide dorsally (Figs 124, 133 in Hong et al. 2011) and base of anterior tooth of corona yellowish-brown; pronotum often yellowish-brown or dark brown posteriorly and usually contrasting with black mesoscutum (Figs 127, 151 l.c.); teeth of hind femur completely to partly pale yellowish or ivory (Fig. 129 l.c.) F. flavidentatus (Enderlein, 1913) Middle pale stripe of frons absent (Fig. 2) or narrow dorsally (Fig. 76 l.c.) and base of anterior tooth of corona dark brown or black; pronotum black posteriorly and as black as mesoscutum (Figs 59, 78 l.c., also Fig. 5); teeth of hind femur often completely or largely black or dark brown (Figs 61, 71 l.c., 9 Pronotum with posterior half distinctly striate or carinate (Figs 175, 176 l.c.); face of female without distinct pale lateral stripes (Fig. 182 l.c.); frons comparatively coarsely sculptured (Fig. 182 l.c.) Pronotum with posterior half mainly reticulate-coriaceous (Fig. 5), at most with some short striae or carinae (Figs 50, 59, 68, 78 l.c.); face of female with distinct pale lateral stripes (Fig. 2); frons comparatively finely sculptured (Fig. 2) 10 10Middle stripe of frons abent (Fig. 2); anterior half of mesoscutum coriaceous (Fig. 5); propodeum (Figs 5, 6) with medium-sized, circular fovelae and with wide coriaceous interspaces F. weii sp. n. Middle stripe of frons present (Fig. 2); anterior half of mesoscutum striate (Fig. 5); propodeum strongly and densely reticulate-foveolate, the foveolae Ovipositor sheath completely black (Fig. 54 l.c.); anterior half of pronotum 11 in lateral view without transverse carinae and flat medially or slightly impressed (Fig. 51 l.c.); fore wing with vein 2-CU1 absent (Fig. 49 l.c.)..... F. brevimaculatus Hong, van Achterberg & Xu, 2011 Ovipositor sheath with ivory subapical band (Figs 62, 73 l.c.); anterior half of pronotum in lateral view with transverse carinae and depressed medially (Fig. 79 l.c.); fore wing with vein 2-CU1 weakly developed, 0.2 × as long as cu-a

Parastephanellus Enderlein, 1906

Parastephanus Enderlein, 1905: 474 (not Haeckel 1881). Type species (by original designation): *Stephanus pygmaeus* Enderlein, 1901.

Parastephanellus Enderlein, 1906: 301. Type species (by original designation): *Stephanus pygmaeus* Enderlein, 1901.

Notes. At present five species of *Parastephanellus* are known from China with four species are only described from females or males. Here the male of *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011 is described.

Parastephanellus brevicoxalis Hong, van Achterberg & Xu, 2011 Figs 12–21

Parastephanellus brevicoxalis Hong, van Achterberg & Xu 2011: 39.

Material examined. Holotype, \bigcirc (ZJUH), CHINA: Zhejiang, Wuyanling Provincial Nature Reserve, 29. VII.2005, Peng Xu, No. 200605074. Other material. 1 \bigcirc (SCAU): CHINA: Guangdong, Nanling National Nature Reserve, 6.X.2004, Zaifu Xu.

Description. Male. Body length 9.6 mm; fore wing length 5.3 mm.

Colour. Black (Fig. 12), except: frons yellowish-brown; coronal teeth, vertex medio-longitudinally and narrow area of vertex behind eyes dark brown, remainder of vertex reddish-brown; temple yellowish-brown with yellow streaks along eye; base of mandible yellow; palpi, scape, pedicel yellowish-brown; propleuron largely dark brown; fore leg, tibiae and tarsi of mid and hind legs yellowish-brown; hind trochanter and base of second tergite reddish-brown; wing membrane subhyaline; pterostigma and wing venation dark brown.

Head. Antenna with 28 segments (Fig. 13); frons coarsely reticulate-rugose (Fig. 14); three anterior coronal teeth acute, both posterior ones wide and arcuate, sculpture on coronal area from rugose anteriorly to longitudinally short carinate; behind level of coronal area with three strong, transverse straight carinae, followed by transversely rugose area, rugae coarse anteriorly, finer laterally near eye and posteriorly, striae posteriorly weaker and approximately extending to occipital carina (Fig. 15); temple smooth and shiny, relatively broad; gena round (Fig. 15).

Mesosoma. Neck (Fig. 16) short and robust, anteriorly distinctly emarginate, medio-posteriorly smooth, and with pairs of oblique lateral carinae, neck at much lower level than remainder of pronotum; pronotal fold and concavity absent; middle of pronotum steeply elevated and subvertical to neck, weakly transversely striate; posterior pronotum not differentiated from middle part, weakly striate dorsally and more or less smooth apically (Fig. 16), pronotal lobe with oblique striae; lateral oblique groove of pronotum narrow and indistinct, ventral area below it distinctly obliquely striate (Fig. 16); propleuron largely coriaceous, smooth medially; mesos-



Figure 12. *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011, male, dorsal habitus. Scale bar: 1 mm.



Figures 13–15. *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011, male. 13 Antenna 14 head frontal 15 head dorsal. Scale bars: 1 mm.



Figures 16–21. *Parastephanellus brevicoxalis* Hong, van Achterberg & Xu, 2011, male. 16 Mesosoma dorsal 17 hind femur and tibia lateral 18 hind coxa dorsal 19 hind coxa lateral 20 first tergite dorsal 21 wings. Scale bars: 1 mm.

cutum foveolate, anterior 0.2 and area between foveolae striate, latero-posteriorly somewhat rugose; notauli and median groove distinct and formed by some foveolae or crenulae; axilla rugose-foveolate; scutellum (Fig. 16) laterally densely foveolate and medially rugulose; mesopleuron rather robust, dorsally flat and largely smooth, convex ventral part shallowly rugose and pubescent, anteriorly pubescence denser and rugae coarser than posteriorly; convex part of metapleuron irregularly rugose and sparsely setose, ventral part below it rugulose; propodeum irregularly foveolate, foveolae changing from circular to suboval, area in between and inside foveolae rugulose, foveolae laterally and apically somewhat coalescent and reticulate (Fig. 16); fore wing (Fig. 21) with vein 1-M 1.9 \times as long as vein 1-SR and 1.2 \times vein m-cu; vein cu-a slightly postfurcal and subvertical; vein 2-SR 1.7 × as long as vein r; vein r ends at level of apex of pterostigma; vein r and vein 1-M distinctly curved; vein 1-SR 1.4 × as long as parastigmal vein; vein 3-CU1 basal 0.2 tubular, remainder largely nebulous, apically distinctly curved; hind coxa (Figs 17-19) robust, antero-dorsally rugose, anterior 0.6 of outer side distinctly compressed and sculpture changing from rugose to microreticulate, posterior part of hind coxa coarsely transversely striate; hind femur (Fig. 17) considerably swollen, densely and finely aciculate, ventrally with 2 large teeth and some denticles in between; hind tibia (Fig. 17) about $1.2 \times as$ long as hind femur, basal narrow part about $1.4 \times as$ long as widened part, outer side of hind tibia distinctly obliquely carinate, narrow part of inner side coriaceous, widened part of inner side distinctly depressed basally and densely bristly setose apically; basitarsus rather robust, ventral length about 3.8 × as long as its apical width.

Metasoma. First tergite 7.5 × as long as its maximum width, $2.6 \times$ as long as second tergite and $0.8 \times$ as long as remainder of metasoma, densely coarsely and rather regularly transversely striate, basal 0.1 rugose and with 2 distinct, short longitudinal carinae, apically narrowly smooth; basal 0.2 of second tergite with several short longitudinal carinae, remainder of tergite smooth; remainder of tergites densely finely microaciculate; pygidial process distinct and tubular apically.

Distribution. Oriental: China (Zhejiang, Guangdong).

Biology. Collected in July and October. Host not known.

Remark. The male is similar to the female, except: body smaller (female body length 16.2 mm); head paler; antenna with 28 segments (33 segments in female); propleuron largely coriaceous, smooth medially (coriaceous and microreticulate in female); vein 1-M 1.9 × as long as vein 1-SR and 1.2 × as long as vein m-cu (vein 1-M 1.25 × as long as vein 1-SR and 0.9 × as long as vein m-cu in female); vein r ends at level of apex rather than behind of pterostigma; first tergite elongate, considerably longer than second tergite.

Acknowledgements

We are very grateful to Prof. Dr. Mingyi Tian (South China Agricultural University, Guangzhou, China) for providing imaging systems. We are very indebted to subject editor Dr. Michael Sharkey and to reviewer Dr. Alejandro Zaldivar-Riveron for their useful suggestions which improved the manuscript. This study is partly supported by the National Basic Research Program of China (No. 2013CB127600).

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RESEARCH ARTICLE



Two new species of Coleoxestia Aurivillius, 1912 from Brazil (Coleoptera, Cerambycidae, Cerambycinae, Cerambycini)

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Academic editor: Ann Ray		Received 21 January 2016 Accepted 9 August 2016 Publis	shed 23 August 2016
	ttp://zoobank.org/539607B9-4D1E-4249-8970-C4555513CD57		

Citation: Galileo MHM, Santos-Silva A (2016) Two new species of *Coleoxestia* Aurivillius, 1912 from Brazil (Coleoptera, Cerambycidae, Cerambycinae, Cerambycini). ZooKeys 612: 125–132. doi: 10.3897/zookeys.612.7851

Abstract

Two new species of *Coleoxestia* Aurivillius, 1912 are described from Brazil: *C. apeara*, and *C. moromokoi*. Both are included in a previous key.

Keywords

Amazonian region, Central Brazil, Neotropical Region, Sphallotrichina, taxonomy

Introduction

Currently *Coleoxestia* Aurivillius, 1912 contains 45 species distributed from North (Mexico) to South America (Monné 2015). Eya and Chemsak (2005a, 2005b) revised the species from Mexico and Central America, recognizing 12 species in the region. Martins and Monné (2005) revised the species from South America, recording 35 species in the continent.

Material and methods

Photographs were taken with a Canon EOS Rebel T3i DSLR camera and Canon MP-E 65mm f/2.8 $1-5\times$ macro lens and focus stacking system by Zerene Stacker AutoMontage software. Measurements were taken in "mm" using a micrometer ocular Hensoldt/Wetzlar - Mess 10 in the Leica MZ6 stereomicroscope, also used in the study of the specimen.

The collection acronym used in this study is as follows:

INPA Coleção Sistemática de Entomologia, Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil.

Systematics

Cerambycini Latreille, 1802 Sphallotrichina Marins & Monné, 2002

Coleoxestia apeara sp. n.

http://zoobank.org/FA534F2D-C744-4460-8A5E-97DEE28B3FD8 Figs 1, 2, 3, 4

Description. Holotype male. Integument dark brown, almost black; mouthparts brown, with yellowish areas; sensorial area of antennomeres dark reddish brown; femora mostly reddish brown, with base and apex dark brown; ventrites gradually lighter from I to V.

Head. Frons coarsely, confluently punctate laterally; diamond-shaped, tumid area close to clypeus coarsely, sparsely punctate; with short, sparse, white setae (sparser on diamond-shaped area) interspersed with some long setae close to antennal tubercle. Area between antennal tubercles deeply sulcate. Area between upper eye lobes and middle of vertex coarsely, confluently punctate; area of vertex close to margin of prothorax coarsely, abundantly punctate (punctures smaller than area closer to eyes); with very short and sparse setae, except for long, yellowish, erect setae close to upper eye lobes. Longitudinal sulcus distinct from clypeus to area between antennal tubercles. Area behind upper eye lobes coarsely confluently punctate toward eye, somewhat finer toward prothorax; with short, sparse setae. Area behind lower eye lobes coarsely, abundantly punctate close to prothorax, smooth on entire superior area close to eye, coarsely, confluently, shallowly punctate on narrow band close to inferior area of eye, smooth between this band and punctate area close to prothorax. Antennal tubercles coarsely, moderately abundantly punctate toward antennal socket, sparser toward sulcus between tubercles. Genae finely, confluently punctate, with short, sparse setae (denser close to eye), except for narrow, smooth, glabrous area close to apex; apex



Figures 1–8. 1–4 *Coleoxestia apeara*, holotype male: 1 dorsal view 2 ventral view 3 lateral view 4 head, frontal view 5–8 *Coleoxestia moromokoi*, holotype male: 5 dorsal view 6 head, frontal view 7 lateral view 8 ventral view.

projected forward, subacute. Gula finely, transversely sulcate. Submentum opaque, microsculptured, coarsely, shallowly, sparsely punctate (punctures laterally confluent); with short, yellowish, moderately abundant setae interspersed with long setae (more abundant laterally). Postclypeus finely, abundantly punctate centrally, smooth laterally; with short, sparse setae on punctate area, with one long seta each side. Basal half of labrum coplanar with clypeus, finely, sparsely punctate, with short sparse setae, with tuft of very long setae laterally; distal half distinctly inclined, finely, abundantly punctate, with long, abundant setae. Distance between upper eye lobes 0.35 times length of scape; distance between lower eye lobes in frontal view 0.85 times length of scape. Antennae as long as 1.15 times elytral length; reaching elytral apex at base of antennomere XI. Scape slightly, gradually enlarged toward apex; finely, abundantly punctate; with short, sparse setae interspersed with some long setae. Antennomere III distinctly enlarged from base to apex, flattened from inner to outer surface; sensorial area wide, very distinct dorsally and ventrally, carinate on distal outer half; inner surface shiny; outer apex rounded. Antennomeres IV-X parallel-sided, with sensorial area wide and very distinct (gradually wider toward X), carinate on outer surface from base to apex; inner surface gradually more microsculptured from IV to X; distinctly flattened from inner to outer surface. Antennomere XI narrowed on distal third; entirely microsculptured. Antennal formula (ratio) based on antennomere III: scape = 0.61; pedicel = 0.15; IV = 0.77; V = 0.86; VI = 0.86; VII = 0.82; VIII = 0.78; IX = 0.78; X = 0.77; XI = 1.15.

Thorax. Prothorax slightly wider than long (largest width 1.1 times length); laterally with three gibbosities (central ones largest). Pronotum coarsely, abundantly punctate (punctures confluent on some areas), except for smooth central, longitudinal callosity on basal half, and subsmooth area close to anterior margin; with very short and sparse setae; with some long setae laterally on basal half. Sides of prothorax coarsely, densely, confluently punctate, except for anterior area with punctures smoother and less distinct; with very short, sparse setae interspersed with some long setae. Basal half of prosternum smooth, glabrous centrally, coarsely, abundantly punctate, with short, sparse setae laterally; anterior half transversely sulcate, coarsely, sparsely punctate on its basal third, smooth toward anterior margin, with short, sparse setae. Prosternal process smooth, glabrous centrally, with very short, abundant setae laterally; horizontal apex cordiform. Mesosternum microsculptured, coarsely, sparsely punctate; with short, abundant pubescence (not obscuring integument). Mesepimera and mesepisterna with short pubescence, not obscuring integument. Mesosternal process without tubercle, pubescent. Metepisterna with short pubescence, not obscuring integument. Metasternum finely, moderately sparsely punctate throughout, interspersed with coarse, sparse punctures each side of longitudinal sulcus; with short, abundant setae laterally, gradually sparser toward center, interspersed with long, sparse setae (more abundant each side of longitudinal sulcus). Scutellum with short, moderately sparse setae. Elytra. Shiny, finely, abundantly punctate, gradually finer toward apex; nearly all punctures with microscopic seta; apex somewhat obliquely truncate; outer angle with long, curved spine (outer side accompanying elytral curvature); sutural angle with distinct spine (shorter than that on outer angle). Legs. Apices of meso- and metafemora with rounded lobe.

Abdomen. Ventrites finely, sparsely punctate (slightly denser on V); ventrites I–IV laterally pubescent, with short sparse setae on remaining surface, interspersed with long setae centrally; ventrite V with short and long setae more abundant than on remaining ventrites; apex of ventrite V widely truncate.

Dimensions in mm (male). Total length, 23.5; length of prothorax at center, 3.8; largest width of prothorax, 4.2; anterior width of prothorax, 3.2; posterior width of prothorax, 3.6; humeral width, 5.5; elytral length, 16.8.

Type material. Holotype male from BRAZIL, *Distrito Federal*: Brasília (Fazenda Água Limpa, Universidade de Brasília, 1050 m, 15°56'49"S / 47°56'15"W), 25.III.2008, J. A. Rafael & F. F. Xavier Filho col. (INPA).

Etymology. Tupi, apéara = surface. It refers to the surface of the pronotum coarsely punctate, without striae.

Remarks. *Coleoxestia apeara* sp. n. belongs to the group of species without striae on pronotum and with antennomeres distinctly explanate laterally. Only *C. cinnamomea* (Gounelle, 1909), *C. exotica* Martins & Monné, 2005, and *C. ebenina* Melzer, 1935 share both features with the new species. It differs from *C. cinnamomea* as follows: integument dark brown, almost black; elytral punctures finer; antennae in male surpassing elytral apex by antennomere XI. In *C. cinnamomea* the integument is from orangish to reddish-brown, the elytral punctures are fine, but distinctly coarser than in the new species, and the antennae in male surpass elytral apex by antennomeres X and XI. It can be separated from *C. exotica* by the elytra shiny (opaque in *C. exotica*) and by the basal antennomeres distinctly wider (narrower in *C. exotica*). It differs from *C. ebenina* mainly by the elytra shiny (more opaque in *C. ebenina*) and distinctly punctate (without distinct punctures in *C. ebenina*).

Coleoxestia apeara sp. n. can be included in the alternative of couplet "19" from Martins and Monné (2005) (translated; modified):

19(18)	Elytra shiny, not shagreened
_	Elytra more opaque, shagreened
18'(19)	Antennomere III filiform; pronotum distinctly transversely rugose. C. spini-
	pennis (Audinet-Serville, 1834)
_	Antennomere III notably enlarged toward apex; pronotum without trans-
	verse wrinkles. Brazil (Distrito Federal) C. apeara sp. n.

Coleoxestia moromokoi sp. n.

http://zoobank.org/14318E30-C234-4C2B-A9A6-DF13749A852D Figs 5, 6, 7, 8

Description. Holotype male. Integument black; mouthparts brown, with yellowish areas; antennae gradually dark-brown toward distal antennomeres; coxae brown; trochanteres and base of femora reddish-brown; remaining surface of femora orangish with black apex.

Head. Frons finely, moderately abundantly punctate on slightly tumid area close to clypeus, denser toward base of antennal tubercles; with deep pit each side close to clypeus; sides with carina between tumid area and antennal tubercles; with very short and sparse setae. Area between antennal tubercles sulcate. Area between upper eye lobes finely, abundantly punctate laterally, almost smooth centrally, mainly toward vertex; with moderately short, erect setae close to eyes. Vertex moderately coarsely, abundantly punctate; with very sparse, minute setae. Longitudinal sulcus slightly distinct from clypeus to antennal tubercles, becoming carina-shaped up to middle of upper eye lobes. Area behind upper eye lobes with sculpture as on vertex; with moderately short setae close to eyes and minute, very sparse setae on remaining surface. Area behind lower eye lobes longitudinally, widely sulcate close to eyes (almost smooth on this region), moderately coarsely, abundantly punctate toward prothorax. Antennal tubercles finely, sparsely punctate; with minute, sparse setae. Genae finely, moderately abundantly punctate; with minute, sparse setae. Gula shiny, smooth. Submentum microsculptured; with transverse row of coarse punctures close to gula; with short, moderately abundant setae interspersed with some long setae. Postclypeus moderately coarsely, confluently punctate centrally, smooth laterally; with very sparse, minute setae. Basal half of labrum coplanar with clypeus, and distal half distinctly inclined; coplanar region with long setae laterally. Distance between upper eye lobes 0.3 times length of scape; distance between lower eye lobes in frontal view 0.6 times length of scape. Antennae as long as 1.3 times elytral length; almost reaching elytral apex. Scape almost parallel-sided; finely, moderately abundantly punctate (mainly on basal third); with minute, sparse setae. Outer apex of antennomeres III–IV nodose; outer apex of antennomeres V–X dentate. Antennal formula (ratio) based on antennomere III: scape = 0.85; pedicel = 0.20; IV = 0.88; V = 0.94; VI = 0.88; VII = 0.88; VIII = 0.82; IX = 0.85; X = 0.82; XI = 1.23.

Thorax. Prothorax slightly wider than long (largest width 1.1 times length); laterally with three, slightly distinct gibbosities (central ones more distinct). Pronotum coarsely punctate on wide, longitudinal band each side of smooth central region, interspersed with fine, sparse punctures (area with coarse punctures slender middle, not reaching anterior margin); coarsely, confluently punctate laterally at basal 4/5; between these two coarsely punctate area with wide band with sparse, coarse and fine punctures; anterior fifth with transverse, well-marked sulcus and fine, sparse punctures; with minute and sparse setae (slightly more distinct laterally). Sides of prothorax coarsely, moderately abundantly punctate on wide central region (punctures confluent on some regions); with minute and sparse setae; with some long setae centrally close to pronotum; basal area smooth; anterior fifth with irregular sculpture. Prosternum finely, sparsely punctate on basal half (sparser centrally), with very sparse, minute setae; anterior half with two transverse sulci (the most distal distinctly narrow). Prosternal process glabrous centrally, with short, abundant setae laterally; horizontal apex somewhat rounded. Mesosternum with short, abundant setae (not obscuring integument). Mesepimera and mesepisterna with pubescence slightly denser than on mesosternum. Mesosternal process without tubercle, pubescent; apex deeply emarginate centrally. Metepisterna with short pubescence, not obscuring integument. Metasternum finely,

sparsely punctate throughout; with short, moderately abundant setae on narrow lateral band and transverse area close to metacoxae; remaining surface with short, sparse setae interspersed with some long setae. Scutellum finely, abundantly punctate laterally, smooth centrally; with short setae laterally. **Elytra.** Shiny, finely, abundantly punctate throughout (punctures finer toward apex); apex somewhat obliquely truncate; outer angle with long spine; sutural angle with spine very distinct, but shorter than that of outer angle. **Legs.** Apices of meso- and metafemora with rounded lobe.

Abdomen. Ventrites finely, sparsely punctate; with short, sparse setae interspersed with some long setae; apex of ventrite V subrounded, slightly emarginate centrally.

Dimensions in mm (male). Total length, 15.10; length of prothorax at center, 2.40; largest width of prothorax, 2.75; anterior width of prothorax, 2.15; posterior width of prothorax, 2.30; humeral width, 3.30; elytral length, 10.4.

Type material. Holotype male from BRAZIL, *Amazonas*: Ipixuna (Rio Liberdade, Estirão da Preta, 07°21'46.7"S / 71°52'07.1"W), 11-15.V.2011, J. A. Rafael, J. T. Câmara, R. F. Silva, A. Somavilla, and C. Gonçalves col. (INPA).

Etymology. Tupi, moro = color; mokôî = two. Allusive to the femora orange with black apex.

Remarks. Coleoxestia moromokoi sp. n. belongs to the group of species with femora reddish or orangish, distinctly contrasting with dark apex, and with elytral apex bispinose: C. anthracina Martins & Monné, 2005; C. brevipennis (Bates, 1870); C. femorata (Gounelle, 1909); C. guttula Martins & Monné, 2005; C. polita (Waterhouse, 1870); C. sanguinipes (Bates, 1884); C. tupunhuma Martins & Monné, 2005. Coleoxestia moromokoi sp. n. differs from all these species by the pronotum not transversely rugose, while in these other species it is distinctly rugose.

Coleoxestia moromokoi sp. n. can be included in the alternative couplets "14" from Martins and Monné (2005) (translated):

Acknowledgements

We thank José Albertino Rafael (INPA), who sent the specimen for study to the late Ubirajara R. Martins.

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RESEARCH ARTICLE



Molecular systematics of the Labeonini inhabiting the karst regions in southwest China (Teleostei, Cypriniformes)

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Academic editor: D. B.	sloom	Received 6 May 2016	Accepted	18 July 2016		Published 23	August 201	16
http://zoobank.org/40139EDC-438D-4C99-B45A-CF19EF551741								

Citation: Zheng L-P, Chen X-Y, Yang J-X (2016) Molecular systematics of the Labeonini inhabiting the karst regions in southwest China (Teleostei, Cypriniformes). ZooKeys 612: 133–148. doi: 10.3897/zookeys.612.9085

Abstract

The major phylogenetic pattern of the cyprinid tribe Labeonini has been revealed by previous molecular studies; however, the relationships within a clade that mainly inhabits the karst regions, which we refer to as the "karst group", in southwest China remain unresolved due to the low taxon sampling. This group includes more than 50% of the genera and species of Labeonini in China. Moreover, more than 90% of the genera of this group are endemic to China. In addition, some new genera and species of Labeonini have been discovered from these karst regions, but their taxonomic validity and phylogenetic position have not been examined. In this contribution, partial sequences of four nuclear (exon 3 of recombination activating protein 1, rhodopsin, early growth response protein 2B gene and interphotoreceptor retinoid binding protein gene) and three mitochondrial genes (cytochrome b, cytochrome oxidase subunit I and 16S ribosomal RNA) from 36 ingroup taxa and 25 outgroup taxa were analyzed to provide a hypothesis of the phylogenetic relationships within the labeonins of the karst regions in China. We propose that the monophyly of Parasinilabeo, Ptychidio, Rectoris and Semilabeo are supported. A new genus, Prolixicheilus, is erected for Pseudogyrinocheilus longisulcus. Cophecheilus bamen is the sister to Prolixicheilus longisulcus. Ptychidio, Pseudocrossocheilus, Semilabeo, Rectoris and Stenorynchoacrum are closely related with high support values. Sinocrossocheilus, Pseudogyrinocheilus, Paraqianlabeo, Hongshuia, Discogobio and Discocheilus form a clade together with high support. Considering molecular results and morphological differences, Parasinilabeo longicorpus and Ptychidio macrops might be the synonyms of Parasinilabeo assimilis and Ptychidio jordani respectively. Comprehensive taxonomic revisions of the two genera Parasinilabeo and Ptychidio may be necessary.

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Keywords

China, karst regions Labeonini, molecular systematics, taxonomic revision

Introduction

Fishes of the tribe Labeonini (Cypriniformes: Cyprinidae) are adapted to riverine environments. Labeonini used here is equal to Labeoninae in Zheng et al. (2010, 2012). They have evolved a diverse mouth morphology. The diversity of these morphological characters has been used to identify genera and generate hypotheses of phylogeny (Zhang 1994, 1998a, b, 2005; Zhang et al. 2000). Therefore, the species of Labeonini with similar oral morphology were thought to be closely related by these morphological studies. As the development of molecular techniques has advanced, the results of previous morphological phylogenetic studies have been challenged. Recent molecular studies demonstrated a different phylogenetic pattern of Labeonini from that derived from morphology. Species with similar morphology were not closely related to each other in the molecular studies (Yang et al. 2010; 2012; Zheng et al. 2010; 2012). The relationships within Labeonini were basically consistent in the aforementioned molecular studies. However, the relationships within the terminal clade of Labeonini were unresolved due to a low taxon sampling. This terminal clade is equal to the Clade F in Zheng et al. (2010). This clade mainly inhabits the karst regions in China's southwestern provinces: Yunnan, Guizhou and Guangxi, which is characterized by a mass of underground rivers and caves. Therefore, we define it as the karst group herein. The karst group included 52 species within 14 genera, accounting for 57% of the species and 55% of all the genera of the Labeonini in China. Moreover, more than 90% of the genera of this group are endemic to China (Table 1). Yang et al. (2010) refer to a single species in each of 7 genera inhabiting the karst regions, and Zheng et al. (2010, 2012) to 23 species distributed over 12 genera. Yang et al. (2012) dealt with the same genera as Zheng et al. (2010, 2012) adding three more species. It is obvious that previous studies suffered from low taxon sampling, leading to yet unresolved specific phylogenetic relationships within the karst group.

Several new genera, such as *Qianlabeo* Zhang & Chen, 2004, *Hongshuia* Zhang, Qing & Lan, 2008, *Cophecheilus* Zhu, Zhang, Zhang & Han, 2011, *Sinigarra* Zhang & Zhou, 2012, *Stenorynchoacrum* Huang, Yang & Chen, 2014, and *Paraqianlabeo* Zhao, Sullivan, Zhang & Peng, 2014, and some new species, such as *Parasinilabeo longicorpus* Zhang, 2000, *Parasinilabeo longibarbus* Zhu, Lan & Zhang, 2006, *Parasinilabeo longiventralis* Huang, Chen & Yang, 2007, and *Pseudogyrinocheilus longisulcus* Zheng, Chen & Yang, 2010, have been described since 2000. All descriptions were based on morphological characters, in particular on the structural morphology of the mouth. These recently described genera and species are all distributed in karst regions in southwest China. The phylogenetic positions of some new genera and species have not yet been examined. Studies of Labeonini indicated that these morphological characters evolved homoplastically (Zheng et al. 2012). Therefore, the phylogenetic positions of the new genera and species need to be further examined.

Genus name	Number of species	Distribution		
Discocheilus Zhang, 1997	2	China		
Discogobio Lin, 1931	16	China (13), Vietnam (3)		
Hongshuia Zhang, Qing & Lan, 2008	3	China		
Parasinilabeo Wu, 1939	6	China		
Pseudocrossocheilus Zhang & Chen, 1997	6	China		
Pseudogyrinocheilus Fang, 1933	2	China		
Ptychidio Myers, 1930	3	China		
Qianlabeo Zhang & Chen, 2004	1	China		
Rectoris Lin, 1935	5	China		
Semilabeo Peters, 1881	2	China		
Sinocrossocheilus Wu, 1977	2	China		
Stenorynchoacrum Huang, Yang & Chen, 2014	1	China		
Cophecheilus Zhu, Zhang, Zhang & Han, 2011	2	China		
Paraqianlabeo Zhao, Sullivan, Zhang & Peng, 2014	1	China		
Sum	52			

Table 1. List of genera and species of Labeonini inhabiting the karst regions of China.

This contribution reconstructs the phylogenetic tree based on extensive sampling and multiple molecular markers in order to demonstrate the phylogenetic relationships of the karst group.

Materials and methods

Sample collection

At least two specimens of each species were sequenced and analyzed, and all the specimens of the same species shared a common haplotype or clustered into a lineage. Each species is represented by one specimen (two for *Parasinilabeo longicorpus*). A total of 37 specimens representing 36 species and 13 genera of the karst group were used in this work. Eleven species of Cyprininae were selected as distant outgroups and 14 species of Labeonini were selected as hierarchical outgroups, following Mayden et al. (2009) and Zheng et al. (2010). Species identification and collection localities are given in Suppl. material 1. All voucher specimens sequenced for use in this study are deposited in the Kunming Institute of Zoology, the Chinese Academy of Sciences.

DNA extraction, PCR amplification and sequencing

The genomic DNA was extracted from fin clips preserved in 95% ethanol. Three mitochondrial genes (cytochrome b, cytochrome oxidase subunit I, and 16S ribosomal RNA) and four nuclear genes (exon 3 of recombination activating protein 1 (RAG1), Rhodopsin (RH), early growth response protein 2B gene (EGR2B) and interphotoreceptor retinoid binding protein gene (IRBP)) have been used in this study. The primers for mitochondrial genes for PCR amplification have been given in Zheng et al. (2010), and nuclear genes followed Chen et al. (2008). Sequencing was performed directly using the corresponding PCR primers. PCR products were purified via spin columns. Purified PCR products were sequenced in both forward and reverse directions using the sequencing services of BigDye Terminator v3.1 on an ABI PRISM 3730 following the manufacturer's instructions. All sequence accession numbers are given in Suppl. material 1.

Statistical analyses

Sequences were aligned using ClustalX v1.83 (Thompson et al. 1997) and manually checked for inconsistencies. To test for the possible saturation of substitution types, the number of transitions (Ti) and transversions (Tv) versus the F84 distance were plotted for our sequences in DAMBE (Xia and Lemey 2009). The base compositional bias using a chi-square test with the BaseFreq function implemented in PAUP* 4.0b 10 (Swofford 2002).

Phylogenetic analyses

Phylogeny reconstruction was carried out with Bayesian (BI) and maximum likelihood (ML) approaches. The most appropriate evolutionary model was selected by Modeltest v3.7 (Posada and Crandall 1998) for BI and ML using Akaike information criterion (AIC, Nylander et al. 2004) before phylogenetic analyses. Bayesian analysis was conducted using MrBayes 3.1.2 (Huelsenbeck and Ronquist 2001). Four chains (three hot, one cold) were run for 10,000,000 generations, sampling trees every 100 generations and with the first 25,000 generations discarded as burn-in. Convergence was confirmed by ascertaining that the average standard deviation of split frequencies was below 0.01. Six data partitioning strategies were adopted in the Bayesian analysis on the combined data set, with the number of data partitions ranging from 1 (all genes evolve under a single evolutionary model) to 11 (partitions for each of the 2 protein coding genes plus 5 separate partition for 16S rRNA, RAG1, RH, EGR2B and IRBP) (Table 2). The program PartitionFinder was used to select the partition scheme and evolutionary models for our sequences (Lanfear et al. 2012). Partitioning strategies were compared by Bayes factors, which represent the ratio of the harmonic mean likelihoods of the two analyses being tested in MrBayes 3.1.2. For each run, the harmonic mean likelihoods were calculated using the 'sump' command. A value greater than 5 for In Bayes factor was considered as strong evidence against the alternative topology tested (Kass and Raftery 1995). The optimal partition selected by Bayes factor was used

#	Partition strategy	Partition identity
P1	All data combined	COI+Cyt <i>b</i> +16S+RAG1+RH+EGR2B+IRBP
Р5	By mitochondrial and nuclear genes	COI+Cyt <i>b</i> +16S; RAG1; RH; EGR2B; IRBP
P6	Based on the analysis of our combined dataset using PartitionFinder	Cyt <i>b</i> 1+RAG1; Cyt <i>b</i> 2+COI 3+16SrRNA +EGR2B; Cyt <i>b</i> 3; COI 1+RH; COI 2; IRBP
P7	By gene	COI; Cyt b; 16S; RAG1; RH; EGR2B; IRBP
Р9	By separating codon positions 1 & 2 and codon position 3 of protein-coding gene, non- coding mitochondrial gene and nuclear gene	COI 1 2; COI 3+Cyt <i>b</i> 1 2; Cyt <i>b</i> 3; 16S; RAG1; RH; EGR2B; IRBP
P11	By codon position of protein-coding mitochondrial gene, non-coding mitochondrial gene and nuclear gene	COI 1; COI 2; COI 3; Cyt <i>b</i> 1; Cyt <i>b</i> 2;Cyt <i>b</i> 3; 16S; RAG1; RH; EGR2B; IRBP

Table 2. Partitioning strategies used in this study.

in Maximum Likelihood analysis. Partitioned ML analysis employing separate models was performed using GARLI 2.0 (Zwickl 2006) with model parameters optimized during the run. Nodal support was assessed by 1000 bootstrap replicates and then the resulting bootstrap trees were imported into PAUP* 4.0b 10 (Swofford 2002) to obtain the bootstrap values and a majority-rule consensus topology.

BI and ML tree were tested using the Shimodaira–Hasegawa (SH) test (Shimodaira and Hasegawa 1999) in PAUP* 4.0b 10, using 1000 bootstrap replicates with RELL optimization. The RELL approximation is used to avoid the re-estimation of the parameters in the bootstrap replicates (Buckley et al. 2001).

Results

Sequence analyses

A total of 402 nucleotide sequences were used in this study, of which 106 sequences were obtained from this study and 296 downloaded from the GenBank. No signal of saturation was observed among sequences (Suppl. material 2). A total of 6600 bp nucleotides were used in the analyses, including 837 bp of COI, 1098 bp of Cyt b, 1151 bp of 16S rRNA, 1465 bp of RAG1, 488 bp of RH, 751 bp of EGR2B and 810 bp of IRBP. Mean base composition of the combined dataset is as follows: A, 0.2821; C, 0.2844; G, 0.1913, and T, 0.2422. No significant compositional biases existed in either ingroup or outgroup taxa (P=1.00>0.05). Nucleotide substitution models selected by AIC under different partition models are presented in Table 3. The mean ln likelihood (ln L) and Bayes factor comparisons are presented in Table 4. The partitioned scheme separated by codon positions 1 and 2 and codon position 3 of protein-coding gene, non-coding mitochondrial and nuclear gene (P9) was selected as the best-fit partition scheme.

Gene	Model
COI	GTR+I+G
COI 1st position	GTR+I+G
COI 2nd position	НКҮ
COI 1st and 2nd position	GTR+I+G
COI 3rd position	GTR+I+G
Cyt b	GTR+I+G
Cyt b 1st position	GTR+I+G
Cyt <i>b</i> 2nd position	GTR+I+G
Cyt <i>b</i> 1st and 2nd position	TIM+I+G
Cyt <i>b</i> 3rd position	TIM+G
16S	GTR+I+G
RAG1	SYM+I+G
RH	K81uf+I+G
EGR2B	TrN+I+G
IRBP	TrNef+I+G
models selected by partitionfinder	
Cyt <i>b</i> 1st position +RAG1	SYM+I+G
Cyt <i>b</i> 2nd+COI 3 rd position +16SrRNA +EGR2B	GTR+I+G
Cyt <i>b</i> 3rd position	GTR+G
COI 1st position +RH	TIM+I+G
COI 2nd position	HKY+I
IRBP	TrNef+I+G

Table 3. Nucleotide substitution models selected by AIC under different partition models.

Table 4. Comparison of likehood scores after different partitioning strategies and estimation of Bayes factors. Bayes factors are calculated as 2(Px-PY).

Partition	-lnL	Р5	P 7	P11	P1	P6
Р9	86281.43	711.74	1527.96	7810.76	8932.12	16455.34
P5	86637.30		816.22	7099.02	8220.38	15743.6
P7	87045.41			6282.8	7404.16	14927.38
P11	90186.81				1121.36	8644.58
P1	90747.49					7523.22
P6	94509.10					

Phylogenetic analyses

The SH test did not reject any hypotheses of BI or ML (P>0.05). Relationships of all taxa derived from partitioned ML and Bayesian analyses of sequences were nearly identical. Thus, the ML tree is presented here together with the nodal support values generated by ML bootstrap analysis and Bayesian posterior probabilities (BPPs), respectively (Fig. 1). All phylogenetic analyses show that the group of the labeonins in the karst regions of China is divided into four lineages (Fig. 1).



Figure 1. Phylogenetic tree derived from a partitioned Maximum Likelihood analysis of the combined data set. The nodal numbers are ML bootstrap values and Bayesian posterior probabilities, respectively. Only values above 50% are given.

- 1) *Pseudogyrinocheilus longisulcus* Zheng, Chen & Yang, 2010 forms the sister taxon to *Cophecheilus bamen* Zhu, Zhang, Zhang & Han, 2011, and together they form the first lineage Clade I.
- 2) The monophyly of *Parasinilabeo* is not rejected and all the species of *Parasinilabeo* form the second lineage Clade II.

- 3) The species of *Ptychidio*, *Pseudocrossocheilus*, *Semilabeo*, *Rectoris* and *Stenorynchoacrum* form a monphyletic group, and the third lineage in our study. The monophyly of *Ptychidio*, *Pseudocrossocheilus*, *Rectoris* and *Semilabeo* are not rejected by all analyses, while *Stenorynchoacrum xijiangensis* Huang, Yang & Chen, 2014 forms the sister taxon to *Rectoris*.
- 4) Sinocrossocheilus, Pseudogyrinocheilus, Paraqianlabeo, Hongshuia, Discogobio, and Discocheilus form the forth lineage (Clade IV), which can be further divided into three subclades (Clade IV A-C). Within Clade IV, Sinocrossocheilus, Pseudogyrinocheilus and Paraqianlabeo form Clade IV A. The monophyly of Hongshuia is supported and all the species of Hongshuia form Clade IV B. Discocheilus and Discogobio form Clade IV C together.

Taxonomic revision

Pseudogyrinocheilus longisulcus was described as a new species of *Pseudogyrinocheilus* because it shares similar mouth morphology with *Pseudogyrinocheilus prochilus* (Sauvage & Dabry de Thiersant, 1874) (Zheng et al. 2010). However, the molecular results show that *P. longisulcus* and *P. prochilus* are located into two distant lineages. It is indicated that the oral morphological character evolved convergently and the allocation of this species need to be revised. Therefore, we erect a new genus for *P. longisulcus*.

Prolixicheilus gen. n. http://zoobank.org/3CB3F6C1-5F77-403B-85D5-60D6F14FCEEA

Type species. Pseudogyrinocheilus longisulcus Zheng, Chen & Yang, 2010 (Fig. 2A).

Etymology. From the Latin adjective *prolixus*, meaning broad, stretched far out, and the Greek noun *cheilos* meaning lip, an allusion to the broad lips of the type species. Gender masculine.

Diagnosis. *Prolixicheilus* can be distinguished from all other genera of labeonins by its peculiar morphology: papillate rostral fold and lower lip, evaginating and triangular; rostral fold pendulous, expanded ventrally, posterior margin non-fimbriate; lower lip with a straight posterior margin; upper lip vestigial; postlabial grooves prolonged, and extended anteromedially close to anterior end of middle lower lip, but not meeting with its counterpart; posterior margin of lower lip free; lateral-line scales 40–42; a longitudinal dark stripe along lateral line on flank; body laterally compressed.

Remarks. *Prolixicheilus* can be easily distinguished from *Pseudogyrinocheilus* by the following combination of characteristics: postlabial grooves prolonged, and extended anteromedially close to anterior end of middle lower lip, but not meeting with its counterpart (only restricted at corners of mouth); posterior margin of lower lip free (vs. connected with chin); lateral-line scales 40–42 (vs. 45–49); a longitudinal dark stripe along lateral line on flank (vs. absent); body laterally compressed (vs. cylindrical). In addition, although *P. longisulcus* and *Cophecheilus bamen* are genetically closely related, *P. longi-*



Figure 2. Ventral view of the mouth morphology. **A** *Pseudogyrinocheilus longisulcus* **B** *Pseudogyrinocheilus prochilus* **C** *Cophecheilus bamen*.

sulcus is readily distinguished from the species of *Cophecheilus* by the following combination of characteristics: rostral fold and lower lip evaginating (vs. not evaginating); rostral fold pendulous, expanded ventrally (vs. not pendulous, rostral cap with a shallow, arched, subdistal depression extending nearly the full length of its ventral edge); rostral fold and lower lip broad and fully papillated (vs. only margin papillated); posterior margin of lower lip free (vs. connected with chin); lateral-line scales 40–42 (vs. 43–48).

Distribution. *Prolixicheilus longisulcus* has been only recorded in an unnamed stream in Lutong Village, Jingxi Co., Guangxi. The stream belongs to Zuojiang River, a tributary of Pearl River.

Discussion

Phylogenetic relationships

Previous studies on the molecular systematics of Labeonini included low taxonomic sampling of species from the karst regions of China. This and the close genetic relationships within this group are reflected by relatively low node values (Yang et al. 2010, 2012; Zheng et al. 2010, 2012) thereby indicating that the relationships within this group of labeonins have not been resolved satisfactorily. Moreover, the phylogenetic position of *Parasinilabeo*, *Ptychidio*, *Semilabeo*, *Rectoris* and *Stenorynchoacrum* were in a state of flux. Our results are very different from that of previous studies mentioned above and this group of Labeonini can be further divided into four clades with strong support. The monophyly of *Parasinilabeo*, *Ptychidio*, *Rectoris* and *Semilabeo* are firstly verified in this study, and the phylogenetic position of the genera listed above reach a definite conclusion.

In previous studied of the Labeonini, mouth morphology was used as an important character for taxonomy and phylogeny. Zhang (1994, 1998a) thought *Pseudogyrinocheilus*, *Semilabeo* and *Discocheilus* formed a monophyletic group, and that *Parasinilabeo* was closely related to both *Pseudogyrinocheilus* and *Semilabeo*. He also considered that *Sinocrossocheilus* was closely related to both *Pseudocrossocheilus* and *Rectoris* because these species share the same mouth structures, and he suggested that the four discbearing genera *Discocheilus*, *Discogobio*, *Garra* and *Placocheilus* formed a monophyletic group (Zhang 1998b, 2005).

The molecular results presented here show that species with similar morphological characters do not cluster in the phylogenetic tree. For example, *Ptychidio, Semilabeo, Stenorynchoacrum, Rectoris* and *Pseudocrossocheilus* form clade III. However, the margin of rostral fold of *Pseudocrossocheilus, Rectoris* and *Ptychidio* is crenulated with a deeply indented distal margin, and that of *Semilabeo* and *Stenorynchoacrum* is smooth or only with a median incision. *Pseudogyrinocheilus prochilus* does not have an oral disc on the lower lip, but form clade IV with disc-bearing species or species with a disc similar structure on the lower lip. *Paraqianlabeo striatus* Zhao, Sullivan, Zhang & Peng, 2014 has a well-developed upper lip, but other species included in the same clade have not. This indicates that the phylogenetic relationships of these species cannot be inferred by a few oral morphological characters.

Phylogenetic positions of recently described genera

Hongshuia, *Cophecheilus*, *Sinigarra*, *Stenorynchoacrum* and *Paraqianlabeo* were described recently (Zhang et al. 2008; Zhu et al. 2011; Zhang and Zhou 2012; Huang et al. 2014; Zhao et al. 2014). The phylogenetic positions of *Cophecheilus* and *Sinigarra* have never been verified. Zhu et al. (2011) thought *Cophecheilus* is likely located in the basal position of the Garraina (*Garra* + *Garra*-like cyprinids). Our molecular results show that *Cophecheilus bamen* and *Prolixicheilus longisulcus* form a clade, which is the sister to all other members of the karst group.

Zheng et al. (2010) tried to elucidate the phylogenetic position of *Stenorynchoacrum*. Insufficient samples and relatively low node support resulted in an inconclusive phylogenetic position. Our results suggest that the species of *Rectoris* form a monophyletic group, and that *Stenorynchoacrum xijiangensis* forms the sister taxon to *Rectoris* with strong support. Although *Stenorynchoacrum* and *Rectoris* are genetically closely related, *Stenorynchoacrum* is morphologically distinct from the species of *Rectoris* by the following combination of characteristics: middle part of rostral cap undeveloped, narrow, only covering the base of the upper jaw, both sides of rostral cap well-developed and extending upward (vs. rostral cap developed, covering upper jaw completely); lower lip modified into fleshy pad (vs. lower lip not modified) (Fig. 3).

The validity of *Hongshuia* has been discussed by Zheng et al. (2010), and its independent generic position has been supported therein. However, its phylogenetic position was uncertain because of the relatively low node support. Our results strongly support that *Hongshuia* is closely related to *Discogobio* and *Discocheilus*. These three genera share a fleshy central pad on the lower lip, and they are genetically closely related (Fig. 4). *Paraqianlabeo striatus* forms the sister taxon to *P. prochilus*, and then forms a lineage together with *Sinocrossocheilus labiatus* Su, Yang & Cui, 2003. *Paraqianlabeo striatus* can be easily distinguished from *P. prochilus* by upper lip present (vs. absent), rudimentary sucker present (vs. absent), and mental grooves present (vs. absent). Spe-



Figure 3. Ventral view of the mouth morphology. A Stenorynchoacrum xijiangensis B Rectoris posehensis.



Figure 4. Ventral view of the mouth morphology. A Hongshuia megalophthalmus B Discogobio brachyphysallidos C Discocheilus wuluoheensis.

cies with disc or fleshy central pad on the lower lip (with the exception of *P. prochilus*) form clade IV in our molecular results.

In addition, Zhang and Zhou (2012) erected *Sinigarra* as a new genus because the authors considered the mental adhesive disc of *Sinigarra* more primitive compared to that of *Garra*, *Discogobio*, *Discocheilus* and *Placocheilus*. In fact, *Garra* is not a monophyletic group and the species allocated into *Garra* nowadays have been divided into several groups (Zheng et al. 2010; Yang et al. 2012). Due to the extensive distribution and complex mouth morphology, the taxonomy of *Garra* and its related genera is confused and awaits a comprehensive revision. *Sinigarra napoensis* Zhang & Zhou, 2012 shares the notch on the posterior margin of oral sucking disc with *Garra micropulvinus*. Zhou, Pan & Kottelat, 2005. Our results showed that *S. napoensis* forms the sister taxon to *G. micropulvinus*. The notch on the posterior margin of the oral sucking disc could be a homologous character for this group of fish (Fig. 5).



Figure 5. Ventral view of the mouth morphology. A Sinigarra napoensis B Garra micropulvinus.

Taxonomy of Parasinilabeo

Parasinilabeo mutabilis was described by Wu (1939) and was placed in the synonymy of Parasinilabeo assimilis Wu & Yao in Wu (1977). The genus Parasinilabeo has been a monotypic genus until 2000. Five new species, namely Parasinilabeo longicorpus, Parasinilabeo maculatus Zhang, 2000, Parasinilabeo microps Su, Yang & Cui, 2001, P. longibarbus, and P. longiventralis, have been successively described subsequently (Zhang 2000; Su et al. 2001; Zhu et al. 2006; Huang et al. 2007). The molecular results showed that the species of *Parasinilabeo* form a monophyletic lineage. In addition, *P. longicor*pus and P. assimilis form a lineage together. Parasinilabeo longicorpus was described as a new species because it was distinguished from *P. assimilis* by a more slender body (body depth 14.7-18.9 % of standard length vs. 23.3-26.3) and a lower caudal peduncle (caudal-peduncle depth 8.9–11.8 % of standard length vs. 12.1–14.1) (Zhang 2000). With the exception of the metric differences, there are not any other stable characters that can be used to effectively distinguish specimens. Moreover, the genetic distance of Cyt b gene between P. assimilis and P. longicorpus is 0.016, which is lower than the distance between P. assimilis and P. longibarbus (0.078) and that between P. assimilis and P. longiventralis (0.019). This low level of genetic variation is consistent with the morphological evidences. Therefore, *P. longicorpus* might be the synonym of *P. assimilis* and the comprehensive revision of this genus is needed.

Taxonomy of Ptychidio

Ptychidio macrops Fang, 1981 was closely related to *Ptychidio jordani* Myers, 1930 in our results. *Ptychidio macrops* was distinguished from *P. jordani* by a larger eye (more than 25% of head length vs. less), shorter tassel (less than eye diameter vs. longer) and
shorter rostral barbels (reaching anterior margin of eyes vs. reaching beyond). This situation is similar as that of *P. longicorpus* and *P. assimilis*. With the exception of the metric differences, there are not any other stable characters that can be used to effectively distinguish specimens. Moreover, the genetic distances of Cyt *b* gene between *P. jordani* and *P. macrops* is 0.011, which is lower than the distance between *P. jordani* and *Ptychidio longibarbus* Chen & Chen, 1989 (0.028). Similarly, in view of the close genetic relationship and the morphometric differences, *P. macrops* might be the synonym of *P. jordani* and the comprehensive revision of this genus is needed.

Acknowledgements

We are grateful to Rick Winterbottom and Marco Endruweit for suggestions and comments of this manuscript. We thank Jian Yang and Jia-Hu Lan for assisting in sample collections, and Guo-Hua Yu for advising and consulting. This work was supported by National Natural Science Foundation of China (31201707), and the Western Light Doctor Program of the Chinese Academy of Sciences.

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Supplementary material I

Table S1

Authors: Lan-Ping Zheng, Xiao-Yong Chen, Jun-Xing Yang

Data type: molecular data

- Explanation note: Taxa included in this study and accession numbers of sequences in GenBank.
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Supplementary material 2

Figure S1

Authors: Lan-Ping Zheng, Xiao-Yong Chen, Jun-Xing Yang

Data type: figure

- Explanation note: Scatter plots for the number of transitions and tranversions versus the F84 distance of all sequences.
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