

Molluscan fauna of Gueishan Island, Taiwan

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Abstract

This dataset records the occurrence and inventory of molluscan fauna on Gueishan Island, the only active volcanic island in Taiwan, based on the literature survey and field investigation conducted between 2011 and 2012. The literature review involved seven studies published from 1934 to 2003, which collectively reported 112 species from 61 genera and 37 families of Mollusca on Gueishan Island. Through our field investigation, we identified 34 species from 28 genera and 23 families. Fourteen of these species were new records on Gueishan Island: *Liolophura japonica*, *Lottia luchuana*, *Nerita costata*, *Nerita rumphii*, *Diplomatina suganikeiensis*, *Littoraria undulata*, *Solenomphala taiwanensis*, *Assimineia* sp., *Siphonaria laciniosa*, *Laevapex nipponica*, *Carychium hachijoensis*, *Succinea erythrophana*, *Zaptyx crassilamellata*, and *Allopeas pyrgula*. In Total, there are 126 species from 71 genera and 45 families of Mollusca on Gueishan Island. These data have been published through GBIF [http://taibif.org.tw/ipt/resource.do?r=gueishan_island] and integrated into the Taiwan Malacofauna Database (<http://shell.sinica.edu.tw/>).

Keywords

Mollusca, Gastropoda, Bivalvia, Cephalopoda, Polyplacophora, Taiwan, Gueishan Island

Project details

Project title: Investigation of molluscan fauna of Gueishan Island, Taiwan.

Personnel: Chih-Wei Huang (collection identifier, data collector, data manager, data publisher), Ta-Wei Hsiung (collection identifier, data collector, data manager), Yen-Chen Lee (collection identifier), Si-Min Lin (Project Director), Wen-Lung Wu (Project Director, data manager).

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Study area descriptions/descriptor: Gueishan Island is located about 10 km from Taiwan. The island was formed via volcanic activity about 1.65 Ma ago and experienced multiple volcanic eruption events until 20 ka ago (Juang et al. 2011). It is considered the only active volcanic island near Taiwan. The land area of the island is about 2.85 km², and the highest peak of the island is 398 meters above sea level. There are two lakes on the island, one of which consist of brackish water (Head Lake) and the other of freshwater (Tail Lake) (Figure 1). Humans colonized Gueishan Island in mid-19th century, by forming a small village. Later in 1977, all residents were moved back to Taiwan due to military requirements for the island. The fauna of this island were not investigated systematically until 2000, when the island came under the management of the Northeast and Yilan Coast National Scenic Area Administration, Tourism Bureau, MOTC and was open to tourists.

Design description: Island species are vulnerable to extinction due to their relatively small population size and limited access to resources. The number of species on an island represents a dynamic equilibrium between immigration and extinction. Volcanic islands provide particularly interesting cases of island biogeography, in that their biota is erased by volcanic activity and recolonized from neighboring regions. Species on Gueishan Island may have under gone several cycles of extinction after volcanic eruption, followed by recolonization from Taiwan when the sea-level dropped during glacial periods. Hu-

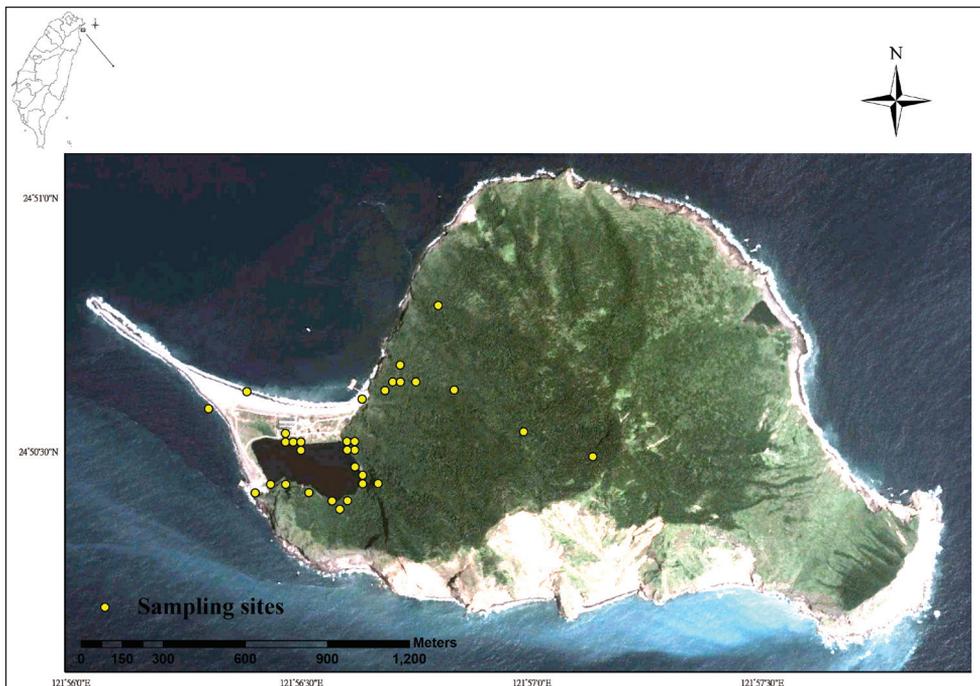


Figure 1. Location of Gueishan Island and field sampling sites of this study.

man activity may also have provided opportunities for colonization of mollusks, either intentionally or accidentally. Investigations of molluscan fauna have been previously conducted on Gueishan Island, but these did not involve a comprehensive examination of land snails. We performed a literature survey using diverse databases, in order to collect previously identified reports on molluscan fauna of Gueishan Island. In addition, we performed field sampling of mollusks in marine, freshwater and terrestrial environments during 2011 and 2012 to establish the inventory of molluscan fauna of Gueishan Island. We considered both the topography of the island and the habitats of mollusks during our field investigation. We focused on the terrestrial environment, as the majority of the earlier investigations examined non-terrestrial habitats. In total, our literature survey and field investigation identified 126 species from 71 genera and 45 families of Mollusca on Gueishan Island. This dataset provides basic information on the island's biodiversity.

Taxonomic coverage

General taxonomic coverage description: The coverage of this dataset includes 126 species from 71 genera and 45 families of Mollusks of marine, freshwater and terrestrial environments on Gueishan Island (Table 1). It includes Class Gastropoda (88.10%), Class Bivalvia (8.73%), Class Cephalopoda (1.59%), and Class Polyplacophora (1.59%). The top five representative families are Cypraeidae (20 species, 15.87%), Trochidae (13 species, 10.32%), Muricidae (11 species, 8.73%), Neritidae (8 species, 6.35%), and Littorinidae (5 species, 3.97%) (Figure 2).

Table 1. Species inventory of mollusks of Gueishan Island, Taiwan.

Taxa	References
CLASS POLYPLACOPHORA ORDER NEOLORICATA FAMILY CHITONIDAE	
† <i>Liolophura japonica</i> (Lischke, 1873)	§
<i>Liolophura</i> sp.	(Hwang and Lee 2003)
CLASS CEPHALOPODA ORDER OCTOPODA FAMILY ARGONAUTIDAE	
<i>Argonauta bians</i> (Lightfoot, 1786)	(Wu 2002)
<i>Octopus</i> sp.	(Hwang and Lee 2003)
CLASS BIVALVIA ORDER VENEROIDA FAMILY CORBICULIDAE	
<i>Corbicula fluminea</i> (Müller, 1774)	§ (National Museum of Marine Biology and Aquarium 2003)
FAMILY CARDIIDAE	
<i>Tridacna crocea</i> Lamarck, 1819	(Hwang and Lee 2003)
<i>Tridacna gigas</i> (Linnaeus, 1758)	(Hwang and Lee 2003)

<i>Tridacna maxima</i> (Roeding, 1798)	(Jung and Lai 1999)
ORDER UNIONOIDA FAMILY UNIONIDAE	
<i>Cristaria discoidea</i> (Lea, 1834)	(Hayasaka and Tan 1934)
ORDER ARCOIDA FAMILY ARCIDAE	
<i>Barbatia foliate</i> (Forsk. 1775)	(Hwang and Lee 2003)
ORDER OSTREOIDA FAMILY OSTREIDAE	
<i>Crassostrea gigas</i> (Thunberg, 1793)	(National Museum of Marine Biology and Aquarium 2003)
<i>Saccostrea mordax</i> (Gould, 1850)	(National Museum of Marine Biology and Aquarium 2003, Hwang and Lee 2003)
FAMILY PECTINIDAE	
<i>Chlamys irregularis</i> (Sowerby, 1842)	(Jung and Lai 1999)
ORDER PTERIOIDA FAMILY PTERIIDAE	
<i>Pinctada margaritifera</i> (Linnaeus, 1758)	(Jung and Lai 1999), Hwang and Lee 2003
<i>Pteria penguin</i> (Roeding, 1798)	Hwang and Lee 2003
CLASS GASTROPODA ORDER PATELLOGASTROPODA FAMILY PATELLIDAE	
<i>Cellana grata</i> (Gould, 1859)	§ (Jung and Lai 1999)
<i>Cellana toreuma toreuma</i> (Reeve, 1854)	§ (Jung and Lai 1999, Hwang and Lee 2003)
FAMILY LOTTIIDAE	
<i>Collisella heroldi heroldi</i> (Dunker, 1861)	(Hwang and Lee 2003)
† <i>Lottia luchuana</i> (Pilsbry, 1901)	§
<i>Notoacmea schrenckii schrenckii</i> (Lischke, 1868)	(Jung and Lai 1999, Wu 2002, Hwang and Lee 2003)
ORDER VETIGASTROPODA FAMILY HALIOTIDAE	
<i>Haliotis diversicolor</i> (Reeve, 1846)	(Jung and Lai 1999)
FAMILY TROCHIDAE	
<i>Calliostoma unicum</i> (Dunker, 1860)	(Jung and Lai 1999)
<i>Chlorostoma turbinatum</i> A.Adams, 1853	(Jung and Lai 1999)
<i>Chlorostoma argyrostoma argyrostoma</i> (Gmelin, 1791)	(Jung and Lai 1999, Wu 2002, Hwang and Lee 2003)
<i>Monodonta labio</i> (Linnaeus, 1758)	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Monodonta perplexa</i> Pilsbry, 1889	§ (Jung and Lai 1999, Hwang and Lee 2003)
<i>Stomatella planulata</i> (Lamarck, 1816)	(Jung and Lai 1999)
<i>Tectus conus</i> (Gmelin, 1791)	(Jung and Lai 1999)
<i>Tectus pyramis</i> (Born, 1778)	(Jung and Lai 1999)
<i>Trochus chloromphalus</i> A. Adams, 1853	(Jung and Lai 1999)
<i>Trochus hanleyanus</i> Reeve, 1842	(Jung and Lai 1999, Wu 2002, Hwang and Lee 2003)
<i>Trochus maculatus</i> Linnaeus, 1758	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Trochus sacellum</i> Philippi, 1854	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Trochus stellatus</i> Gmelin, 1790	(Jung and Lai 1999, Hwang and Lee 2003)
FAMILY TURBINIDAE	

<i>Astraliu haematragum</i> (Menke, 1829)	(Hwang and Lee 2003)
<i>Lunella coronate</i> (Gmelin, 1818)	(Hwang and Lee 2003)
ORDER NERITIMORPHA	
FAMILY NERITIDAE	
<i>Nerita albicilla</i> Linnaeus, 1758	(Jung and Lai 1999, Hwang and Lee 2003)
† <i>Nerita costata</i> Gmelin, 1791	§
<i>Nerita plicata</i> Linnaeus, 1758	§ (Jung and Lai 1999)
† <i>Nerita rumphii</i> Recluz, 1841	§
<i>Nerita chamaeleon</i> Linnaeus, 1758	(Hwang and Lee 2003)
<i>Nerita ocellata</i> Leguillou, 1841	(Jung and Lai 1999)
<i>Nerita polita</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Nerita undata</i> Linnaeus, 1758	(Jung and Lai 1999)
ORDER CAENOGASTROPODA	
FAMILY DIPLOMMATINIDAE	
† <i>Diplommatina suganikeiensis</i> (Pilsbry & Hirase, 1905)	§
FAMILY PLANAXIDAE	
<i>Planaxis sulcatus</i> (Born, 1778)	(Hwang and Lee 2003)
FAMILY POTAMIDIDAE	
<i>Batillaria zonalis</i> (Bruguere, 1792)	(National Museum of Marine Biology and Aquarium 2003)
FAMILY THIARIDAE	
<i>Tarebia granifera</i> (Lamarck, 1822)	§ (National Museum of Marine Biology and Aquarium 2003)
<i>Thiara scabra</i> (Muller, 1774)	§ (National Museum of Marine Biology and Aquarium 2003)
<i>Thiara tuberculata</i> (Muller 1774)	§ (National Museum of Marine Biology and Aquarium 2003)
FAMILY CYPRAEIDAE	
<i>Cypraea annulus</i> Linnaeus, 1758	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Cypraea arabica</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea asellus</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea capuserpentis</i> Linnaeus, 1758	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Cypraea caurica</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea chinensis</i> Gmelin, 1791	(Jung and Lai 1999)
<i>Cypraea clandestine</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea eglantine</i> Duclos, 1833	(Hwang and Lee 2003)
<i>Cypraea erosa</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea gracilis</i> Gaskoin, 1849	(Jung and Lai 1999)
<i>Cypraea helvola</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea labrolineata</i> Gaskoin, 1849	(Jung and Lai 1999)
<i>Cypraea lynx</i> Linnaeus, 1758	(Hwang and Lee 2003)
<i>Cypraea moneta</i> Linnaeus, 1758	§ (Jung and Lai 1999, Hwang and Lee 2003)
<i>Cypraea onyx</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea poraria</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea testudinaria</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea tigris</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea ziczac</i> Linnaeus, 1758	(Jung and Lai 1999)
<i>Cypraea errones</i> Linnaeus, 1758	(Wu 2002)
FAMILY OVULIDAE	

<i>Calpurnus verrucosus</i> (Linnaeus, 1758)	(Hwang and Lee 2003)
<i>Ovula ovum</i> Linnaeus, 1758	(Hwang and Lee 2003)
FAMILY LITTORINIDAE	
<i>Littoraria pintado</i> (Wood, 1828)	(Jung and Lai 1999)
† <i>Littoraria undulate</i> (Gray, 1839)	§
<i>Littoraria scabra scabra</i> (Linnaeus, 1758)	(Hwang and Lee 2003)
<i>Nodilittorina pyramidalis</i> (Quay & Gaimard, 1833)	§ (Jung and Lai 1999, Hwang and Lee 2003)
<i>Nodilittorina vidua</i> (Gould, 1859)	§ (Jung and Lai 1999, Hwang and Lee 2003)
FAMILY ASSIMINEIDAE	
† <i>Solenomphala taiwanensis</i> (Habe, 1942)	§
† <i>Assiminea</i> sp.	§
FAMILY BURSIDAE	
<i>Bursa granularis</i> (Roeding, 1798)	(Jung and Lai 1999)
FAMILY RANELLIDAE	
<i>Cymatium aquatile</i> (Reeve, 1844)	§ (Jung and Lai 1999)
<i>Cymatium mundum</i> (Gould, 1849)	(Jung and Lai 1999)
<i>Cymatium pileare</i> (Linnaeus, 1758)	(Jung and Lai 1999)
<i>Cymatium lotorium</i> (Linnaeus, 1758)	(Hwang and Lee 2003)
FAMILY COLUMBELLIDAE	
<i>Pyrene punctata</i> (Bruguiere, 1789)	(Jung and Lai 1999)
<i>Pyrene testudinaria testudinaria</i> (Link, 1806)	(Hwang and Lee 2003)
FAMILY FASCIOLARIIDAE	
<i>Peristernia nassatula</i> (Lamarck, 1822)	(Wu 2002)
FAMILY NASSARIIDAE	
<i>Nassarius glans</i> (Linnaeus, 1758)	(Jung and Lai 1999)
<i>Nassarius papillosus</i> (Linnaeus, 1758)	(Jung and Lai 1999)
<i>Telasco velatus</i> (Gould, 1850)	(Jung and Lai 1999)
FAMILY MURICIDAE	
<i>Chicoreus torrefactus</i> Sowerby, 1841	(Wu 2002)
<i>Chicoreus brunneus</i> (Link, 1807)	(Hwang and Lee 2003)
<i>Drupa morum</i> Roeding, 1798	(Jung and Lai 1999)
<i>Drupa ricina ricina</i> (Linnaeus, 1758)	(Jung and Lai 1999, Wu 2002, Hwang and Lee 2003)
<i>Drupa rubusidaea</i> Roeding, 1798	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Ergalatax contractus</i> (Reeve, 1846)	(Jung and Lai 1999, Hwang and Lee 2003)
<i>Mancinella mancinella</i> (Linnaeus, 1758)	§ (Jung and Lai 1999)
<i>Morula uva</i> (Roeding, 1798)	(Wu 2002)
<i>Purpura panama</i> (Roeding, 1798)	(Jung and Lai 1999, Wu 2002)
<i>Tenguella granulate</i> (Duclos, 1924)	§, (Jung and Lai 1999)
<i>Thais clavigera</i> (Kuster, 1860)	(Wu 2002, Hwang and Lee 2003)
FAMILY TURBINELLIDAE	
<i>Vasum ceramicum</i> (Linnaeus, 1758)	(Hwang and Lee 2003)

FAMILY CONIDAE	
<i>Conus flavidus</i> Lamarck, 1810	(Wu 2002, Hwang and Lee 2003)
<i>Conus lividus</i> Hwass, 1792	(Hwang and Lee 2003)
<i>Conus textile</i> Linnaeus, 1758	(Jung and Lai 1999, Wu 2002)
<i>Conus striatus</i> Linnaeus, 1758	(Wu 2002)
ORDER HETEROBRANCHIA	
FAMILY APLYSIIDAE	
<i>Aplysia juliana</i> Quoy & Gaimard, 1832	(Hwang and Lee 2003)
<i>Aplysia oculifera</i> Adams & Reeve, 1850	(Hwang and Lee 2003)
<i>Dolabrifera dolabrifera</i> (Rang, 1928)	(Hwang and Lee 2003)
FAMILY PHYLLIDIIDAE	
<i>Phyllidia pustulosa</i> Cuvier, 1804	(Hwang and Lee 2003)
<i>Phyllidia varicose</i> Lamarck, 1801	(Hwang and Lee 2003)
FAMILY SIPHONARIIDAE	
† <i>Siphonaria laciniosa</i> (Linnaeus, 1758)	§
FAMILY PLANORBIDAE	
† <i>Laevapex nipponica</i> (Kuroda, 1947)	§
FAMILY ELLOBIIDAE	
† <i>Carychium hachijoensis</i> Pilsbry, 1902	§
FAMILY VERONICELLIDAE	
<i>Vaginulus alte</i> (Ferussac, 1821)	§ (Wu 2002)
FAMILY SUCCINEIDAE	
† <i>Succinea erythrophana</i> Ancey, 1883	§
FAMILY CLAUSILIIDAE	
† <i>Zptyx crassilamellata</i> Kuroda, 1941	§
FAMILY ACHATINIDAE	
<i>Achatina fulica</i> Bowdich, 1822	§ (Wu 2002)
FAMILY SUBULINIDAE	
† <i>Allopeas pyrgula</i> (Schmacker & Boettger, 1891)	§
FAMILY PHILOMYCIDAE	
<i>Meghimatium bilineatum</i> (Benson, 1842)	(Wu 2002)
FAMILY CAMAENIDAE	
<i>Coniglobus melleus</i> (Pfeiffer, 1865)	(Kuroda 1938, Kuroda 1941)
FAMILY BRADYBAENIDAE	
<i>Acusta despecta</i> (Sowerby, 1839)	(Kuroda 1938, Kuroda 1941)
<i>Aegista mackensii</i> (Adams & Reeve, 1850)	§ (Jung and Lai 1999, Wu 2002)
<i>Aegista osbeckii</i> (Philippi, 1847)	§ (Kuroda 1938, Kuroda 1941, Wu 2002)
<i>Bradybaena similis</i> (Ferussac, 1822)	§ (Kuroda 1941)

†New records on Gueishan Island

§ Collected by our field sampling

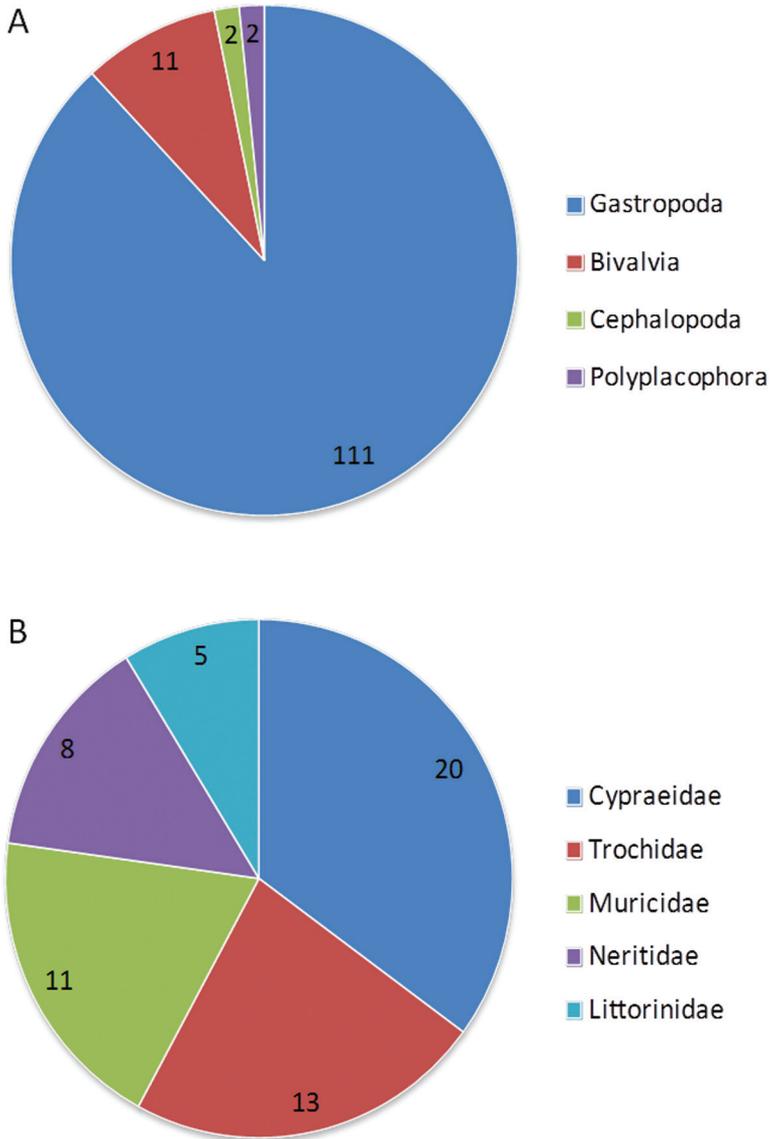


Figure 2. Taxonomic coverage. **A** Class **B** The top five representative families. Numbers in pie charts represent number of species.

Taxonomic ranks

Phylum: Mollusca

Class: Bivalvia, Cephalopoda, Gastropoda, Polyplacophora

Order: Arcoida, Caenogastropoda, Heterobranchia, Neoloricata, Neritimorpha, Octopoda, Ostreoida, Patellogastropoda, Pterioida, Unionoida, Veneroida, Vetigastropoda

Family: Achatinidae, Aplysiidae, Arcidae, Argonautidae, Assimineidae, Bradybaenidae, Bursidae, Camaenidae, Cardiidae, Chitonidae, Clausiliidae, Columbelloidae, Conidae, Corbiculidae, Cypraeidae, Diplommatinidae, Ellobiidae, Fasciolaridae, Haliotidae, Littorinidae, Lottiidae, Muricidae, Nassariidae, Neritidae, Octopodidae, Ostreidae, Ovulidae, Patellidae, Pectinidae, Philomycidae, Phyllidiidae, Planaxidae, Planorbidae, Potamididae, Pteriidae, Ranellidae, Siphonariidae, Subulinidae, Succineidae, Thiaridae, Trochidae, Turbinellidae, Turbinidae, Unionidae, Veronicellidae

Genus: *Achatina*, *Acusta*, *Aegista*, *Allopeas*, *Aplysia*, *Argonauta*, *Assiminea*, *Astraliium*, *Barbatia*, *Batillaria*, *Bradybaena*, *Bursa*, *Calliostoma*, *Calpurnus*, *Carychium*, *Cellana*, *Chicoreus*, *Chlamys*, *Chlorostoma*, *Collisella*, *Coniglobus*, *Conus*, *Corbicula*, *Crassostrea*, *Cristaria*, *Cymatium*, *Cypraea*, *Diplommatina*, *Dolabrifera*, *Drupa*, *Ergalatax*, *Haliotis*, *Laevapex*, *Liolophura*, *Littoraria*, *Lottia*, *Lunella*, *Mancinella*, *Meghimatium*, *Monodonta*, *Morula*, *Nassarius*, *Nerita*, *Nodilittorina*, *Notoacmea*, *Octopus*, *Ovula*, *Patella*, *Peristernia*, *Phyllidia*, *Pinctada*, *Planaxis*, *Pteria*, *Purpura*, *Pyrene*, *Saccostrea*, *Siphonaria*, *Solenomphala*, *Stomatella*, *Succinea*, *Tarebia*, *Tectus*, *Telasco*, *Tenguella*, *Thais*, *Thiara*, *Tridacna*, *Trochus*, *Vaginulus*, *Vasum*, *Zaptyx*.

Spatial coverage

General spatial coverage: The spatial coverage of the literature and our field investigation ranged from a latitude of 24°49'48"N to 24°51'0"N and a longitude of 121°55'48"E to 121°57'36"E. It includes the marine, intertidal, freshwater and terrestrial environment of Gueishan Island, Taiwan (Figure 1)

Coordinates: 24°49'48"N and 24°51'0"N Latitude; 121°55'48"E and 121°57'36"E Longitude

Temporal coverage:

1934–2012.

Methods

Sampling description:

Literature survey: We searched for publications (including journals, project reports, theses and books) associated with the molluscan fauna of Gueishan Island from the following databases: (1) the National Digital Library of Theses and Dissertations in Taiwan (<http://ndltd.ncl.edu.tw>) (this contains details of theses and dissertations pub-

lished since 1956, but did not contain publications relevant to this study); (2) the National Bibliographic Information Network (<http://nbinet3.ncl.edu.tw>) (this catalog integrates information from National Central Library and 74 other libraries containing all publications with a Taiwan ISBN and selected government project reports; three publications (Wu 2002, National Museum of Marine Biology and Aquarium 2003, Hwang and Lee 2003) from this database met our requirement); (3) the Government Research Bulletin (<http://grbsearch.stpi.narl.org.tw/GRB/>) (this contains government project reports made since 1993, but did not contain reports relevant to this study); (4) Google Scholar (<http://scholar.google.com.tw/>) (this contains a wide range of resources, from journals and books to webpages, and it provided two relevant journal articles (Chen and Fu 2007, Lee and Chen 2010)); (5) The Taiwan Malacofauna Database (<http://shell.sinica.edu.tw/>) (this database contains taxonomy, distribution and references of all mollusks occurred in Taiwan, and provided six relevant publications (Lee and Wu 1998, Jung and Lai 1999, Wu 2002, National Museum of Marine Biology and Aquarium 2003, Hwang and Lee 2003, Chen and Fu 2007)). In addition, three relevant publications (Hayasaka and Tan 1934, Kuroda 1938, Kuroda 1941) were identified from citations in Wu (2002). In total, we identified ten relevant publications. Three of these publications (Lee and Wu 1998, Chen and Fu 2007, Lee and Chen 2010) were excluded because they described specimens acquired from fishing ports that had been captured by shrimp fishing or bottom trawling boats near Gueishan Island, without information of the precise sampling location. The seven remaining publications were used to establish the occurrence and inventory data. Sampling sites, names of collectors and the scientific name of each species were recorded using Microsoft EXCEL 2010. All of the publications mentioned above can be accessed in the National Central Library and the National Taiwan Library.

Field Sampling: The topology of Gueishan Island and the types of mollusk habitat were considered for field investigation. Visual search was conducted for mollusks in intertidal, freshwater and terrestrial environments (Figure 1). The surface of rocks on the coastline and man-made concrete structures in port were searched for marine mollusks during low tide. Leaf litter and rocks under or near water around Tail Lake (the only freshwater habitat on island) were inspected for freshwater mollusks. We inspected from leaves, trunks, leaves litter, rocks and rotten woods for land snails along three trails: one trail around Tail Lake, another leads to the highest peak (401 Highland) on the island, and the other leads to the northern part of the island. We surveyed for land snails during their active periods: during and after rainfall, early morning, and night. At least one living individual or dead shells of each species was collected as voucher specimens. Living organisms were brought back to laboratory, fixed via freezing in a -80°C freezer, and subsequently transferred to 95% ethanol for long term preservation.

Quality control description: Latitude, longitude and altitude of sampling sites were recorded using Garmin *GPSmap 60CSx* with uncertainty of less than 10 meters. Sampling sites were georeferenced (WGS84). All the specimens collected during the field investigation were identified independently by Huang and Hsiung. Seven earlier studies described the molluscan fauna of Gueishan Island, but these publications lack

clear photos or other information for identifying specimens. Species identification was performed using the following guide books and publications about Taiwan malacofauna: Pace (1973), Lai (1990, 1998), Lee and Chen (2003), Wu and Lee (2005), and Hsieh et al. (2006). Newly recorded species were further confirmed by Dr. Yen-Chen Lee, a Mollusca specialist and postdoctoral researcher in the Biodiversity Research Center, Academia Sinica. Fourteen new recorded species were found to be native to Taiwan but previously unreported on Gueishan Island. The scientific names of all mollusks were checked against the Taiwan Malacofauna Database and World Register of Marine Species (<http://www.marinespecies.org/>).

Data resources

The data underpinning the analysis reported in this paper are deposited at GBIF, the Global Biodiversity Information Facility, http://taibif.org.tw/ipt/resource.do?r=gueishan_island

Datasets

Dataset description: This dataset incorporates seven publications (Hayasaka and Tan 1934, Kuroda 1938, Kuroda 1941, Jung and Lai 1999, Wu 2002, National Museum of Marine Biology and Aquarium 2003, Hwang and Lee 2003) associated with the molluscan fauna of Gueishan Island and field investigation results. The dataset includes sampling date, taxonomy information, GPS location, elevation, type of habitat, name of collector, method of collection, and literature record. Based on the literature published during the period between 1934 and 2003, 112 species from 61 genera and 37 families of Mollusca were recorded on Gueishan Island. Of the 34 species from 28 genera and 23 families identified during our 2011-2012 field investigation, fourteen species were new records on Gueishan Island. In total, our literature survey and field investigation documents 126 species from 71 genera and 45 families of Mollusca on Gueishan Island. The fourteen newly recorded species are: *Liolophura japonica* (Lischke, 1873), *Lottia luchuana* (Pilsbry, 1901), *Siphonaria laciniosa* (Linnaeus, 1758), *Nerita costata* Gmelin, 1791, *Nerita rumphii* Recluz, 1841, and *Littoraria undulata* (Gray, 1839), which were sampled from the marine environment; *Assiminea* sp. and *Laevapex nipponica* (Kuroda, 1947), which were discovered in a freshwater environment, Tail Lake; and *Solenomphala taiwanensis* (Habe, 1942), *Diplommatina suganikeiensis* (Pilsbry & Hirase, 1905), *Carychium hachijoensis* Pilsbry, 1902, *Zaptyx crassilamellata* Kuroda, 1941, *Allopeas pyrgula* (Schmacker & Boettger, 1891), and *Succinea erythrophana* Ancey, 1883 discovered in the terrestrial environment. This dataset provide basic information for the island's biodiversity and biogeography. This dataset will be maintained by the Malacology Lab, Biodiversity Research Center, Academia Sinica.

Object name: Darwin Core Archive Molluscan fauna of Gueishan Island, Taiwan

Character encoding: UTF-8

Format name: Darwin Core Archive format

Format version: 1.0

Distribution: http://taibif.org.tw/ipt/archive.do?r=gueishan_island

Publication date of data: 2012-12-21

Language: English

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Metadata language: English

Date of metadata creation: 2012-09-21

Hierarchy level: Dataset

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Gastrocopta (Mollusca, Gastropoda, Pupillidae) in the Pilbara region of Western Australia

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Abstract

Six species of *Gastrocopta* have been identified from the Pilbara region, Western Australia, by means of comparative analyses of shell and mtDNA variation. Three of these species, *G. hedleyi*, *G. larapinta* and *G. servilis*, have been recorded in the Pilbara for the first time. *Gastrocopta* sp. CW1 is probably new to science and might be endemic to the region. By contrast, *G. hedleyi*, *G. larapinta* and *G. mussoni* are shown to be widespread.

Keywords

Australia, Pupilloidea, Pulmonata, 16S, COI

Introduction

Gastrocopta Wollaston, 1878 is the most speciose pupillid genus in Australia with twelve recorded species (Pokryszko 1996). Its members are found throughout most of Australia except for the humid south-west and south-east corners of the continent (Solem 1991; Pokryszko 1996; Stanisic et al. 2010). The Australian taxa have most recently been revised based on comparative shell morphology by Solem (1986, 1989) and Pokryszko (1996). Both works disagree on some details, mainly the morphological separation of *Gastrocopta larapinta* and *Gastrocopta mussoni* and the taxonomic distinctness within the size-variable *Gastrocopta margaretae* complex. Molecular studies that might help to resolve the taxonomic discrepancies have remained unavailable.

Previous works have focussed mainly on the northern, eastern and southern parts of coastal Australia and to a lesser degree on the mid-west and central parts of Australia

(Pilsbry 1917; Iredale 1939; Solem 1986, 1989, 1991; Slack-Smith 1993; Pokryszko 1996; Köhler et al. 2012) while the fauna in Western Australia has remained poorly documented. In Western Australia most pupillid specimens have been collected along main roads of the more coastal areas and along major inland roads, but the interior of Western Australia has so far been widely neglected. Being of small size (maximum dimension less than 6mm) and cryptic in nature, pupillids are often ignored when documenting land snail diversity (Nekola 2009). The lack of specimens from inland areas of Western Australia has made it difficult to determine the relationships between west coastal specimens and those from central and eastern Australia.

Pilsbry (1917) in his world monograph on the subfamily Gastrocoptinae had little Australian material, except of a few types and vouchers received from Tate (from Central Australia) and Hedley (mostly from Eastern Australia). Solem (1986) was the first author to revise the Australian fauna more comprehensively. He examined the Pupillidae from the south and mid-west coasts of Western Australia and later (Solem 1989) the non-camaenid families (including Pupillidae) from the Kimberley, Northern Territory and Red Centre regions. A second major revision by Pokryszko (1996) extended the area of review in Western Australia only slightly, because only a small amount of additional material from the Western Australian Museum was studied (just 9 lots) and probably because the collection was little expanded since Solem (1986) examined the collections.

Since Pokryszko's (1996) revision, the Western Australian Museum collection of *Gastrocopta* in the Pilbara region has greatly expanded. Most of this collecting has been associated with expanding mineral operations in the region and improved vehicle access to remote areas. A Western Australian Museum fieldtrip during August 2009 visited the eastern Pilbara area, collected macro- and micro- non-marine molluscs and significantly increased the pupillid collection in that region.

This paper (1) presents new data on *Gastrocopta* in the Pilbara, establishing new records and range extensions; (2) tests the taxonomic significance of morphological characters commonly used for the identification and delimitation of species by using a mitochondrial phylogeny; (3) provides comparative remarks on shell morphology of *Gastrocopta* species; (4) indicates systematic issues that require clarification by further studies. For detailed comparative analyses of shell characters we refer to Pokryszko (1996) and Solem (1986, 1989).

Methods

All *Gastrocopta* material from the Pilbara in the malacological collections of the Western Australian Museum was examined. Additional specimens from the private collection of Mr Vince Kessner and from the collection of the Field Museum of Natural History, Chicago were also included. In total 545 *Gastrocopta* lots were studied with distributional maps being plotted by use of the online vector map software available at www.planiglobe.com.

Species identifications were based on shell characters, with particular emphasise on the size, shape and quantity of apertural barriers. Specimens were photographed

and measured using a Leica MZ16A microscope with Leica DFC500 camera. DNA was extracted from entire specimens taken from their shell by use of a QIAGEN DNA extraction kit for animal tissue following the standard procedure of the manual. Fragments of the mitochondrial 16S rRNA (16S) and of the COI genes were amplified by PCR using the primer pairs: 16Sar and 16Sbr (Palumbi et al. 1991), and L1490 and H2198 (Folmer et al. 1994), respectively. Reactions were performed under standard conditions with an annealing step of 60 s at 55 °C for 16S and at 50 °C for COI. Both strands of purified PCR fragments were cycle sequenced by use of the PCR primers. Electropherograms were manually corrected for misreads, if necessary, and forward and reverse strands were merged into one sequence file using CodonCode Aligner v. 3.6.1 (CodonCode Corporation, Dedham, MA). Sequences have been deposited in GenBank (COI: KC143966-KC143993, 16S: KC143994-KC144020). Sequence alignments were generated using MUSCLE as implemented in MEGA5 (Tamura et al. 2011). Uncorrected pair-wise genetic distances were calculated using MEGA5 under the option 'pair-wise deletion of gaps'. Prior to the model-based phylogenetic analyses, the best-fit model of nucleotide substitution was identified for each gene fragment using the model proposal function of MEGA5. To infer phylogenetic relationships, we performed Maximum Likelihood (ML) analyses using MEGA5 with Nearest-Neighbor-Interchange (NNI) as heuristic method and automatic generation of the initial tree. Two-hundred ML bootstrap replicates were performed to assess the topology support.

Abbreviations used for depositories of material are: FMNH, Field Museum of Natural History, Chicago, United States; VK, Vince Kessner Private Collection, Adelaide River, Australia; WAM, Western Australian Museum, Perth, Australia. For shell aperture barrier terminology we followed Pokryszko (1996), reproduced here in Fig. 1.

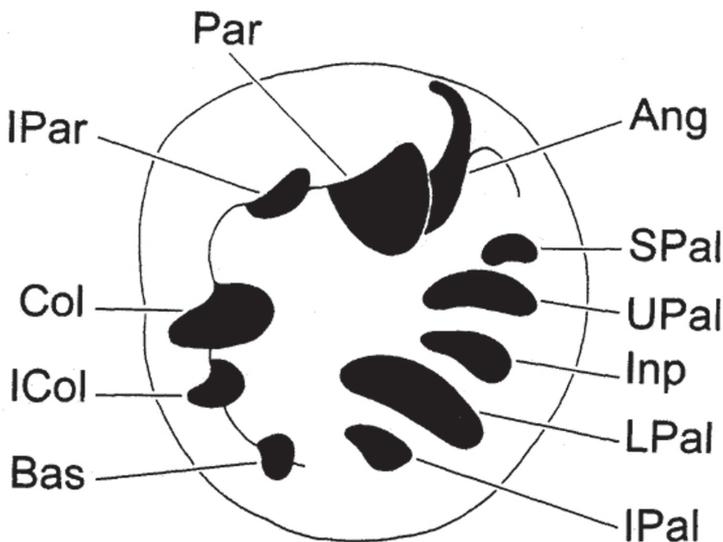


Figure 1. Apertural barriers of *Gastrocopta* (clockwise in aperture). **IPAR** Infraparietal Tooth **PAR** Parieto-angular Tooth **ANG** Angular Tooth **SPAL** Suprapalatal Tooth **UPAL** Upper Palatal Tooth **INP** Interpalatal Tooth **LPAL** Lower Palatal Tooth **IPAL** Infrapalatal Tooth **BAS** Basal Tooth **COL** Columellar Tooth.

Taxonomic part

Six species of *Gastrocopta* were recorded from the Pilbara region (Table 1). Four species are endemic to Australia, one species is introduced and one species requires further investigation (*Gastrocopta* sp. CW1). Another species, *G. bannertonensis* was only collected from the inner mid-west region of Western Australia and was not discussed in this paper.

1. *Gastrocopta hedleyi* Pilsbry, 1917

http://species-id.net/wiki/Gastrocopta_hedleyi

Fig. 2B

Gastrocopta hedleyi Pilsbry 1917 [in 1916-1918]: 166-167, pl. 27, figs 1–4; Solem 1991: 250; Pokryszko 1996: 1104, fig. 18; Stanisic 1998: fig. 17.42e; Stanisic et al. 2010: 102–103.

Australbinula hedleyi Iredale 1937a: 301.

Type locality. Narrabri, New South Wales.

Material studied. Western Australia: Abydos (64km W of Marblebar): 21.1343°S, 119.1259°E (WAM S64439). Burrup Peninsula: 20.6080°S, 116.7670°E (WAM S60089); 20.6141°S, 116.7548°E (WAM S60226); 20.6066°S, 116.7681°E (WAM S60227); 20.5833°S, 116.8000°E (WAM S60228, WAM S60230, WAM S60349, WAM S61117-21); 20.6102°S, 116.7607°E (WAM S60353); 20.6232°S, 116.7784°E (WAM S60402); 20.6166°S, 116.7833°E (WAM S60475); 20.6119°S, 116.7587°E (WAM S60477); 20.6238°S, 116.7777°E (WAM S60480); 20.6300°S, 116.7800°E (WAM S65167); 20.5858°S, 116.8044°E (WAM S65168). Cloud Break area: 22.2997°S, 119.3737°E (WAM S60416). Hope Downs: 23.0865°S, 119.3184°E (WAM S42661); 23.0379°S, 119.2124°E (WAM S42663); 23.0952°S, 119.2022°E (WAM S59553); 23.1030°S, 119.2917°E (WAM S59555). Kalgan

Table 1. Mean maximum shell height and width of *Gastrocopta* species from the Pilbara region.

Species	N	Mean max. shell height (mm)	Mean max. shell width (mm)
<i>Gastrocopta larapinta</i>	17	2.273	1.115
<i>Gastrocopta larapinta</i> (Kalgan Pool)	3	2.311	1.042
<i>Gastrocopta mussoni</i> (ovate)	7	2.278	1.251
<i>Gastrocopta mussoni</i> (cylindrical)	7	2.212	1.064
<i>Gastrocopta hedleyi</i>	14	2.017	1.014
<i>Gastrocopta margaretae</i> (Pilbara)	14	2.128	0.955
<i>Gastrocopta margaretae</i> (SWA)	13	2.466	1.128
<i>Gastrocopta</i> sp. CW1	14	1.664	0.895
<i>Gastrocopta servilis</i>	14	2.255	1.070

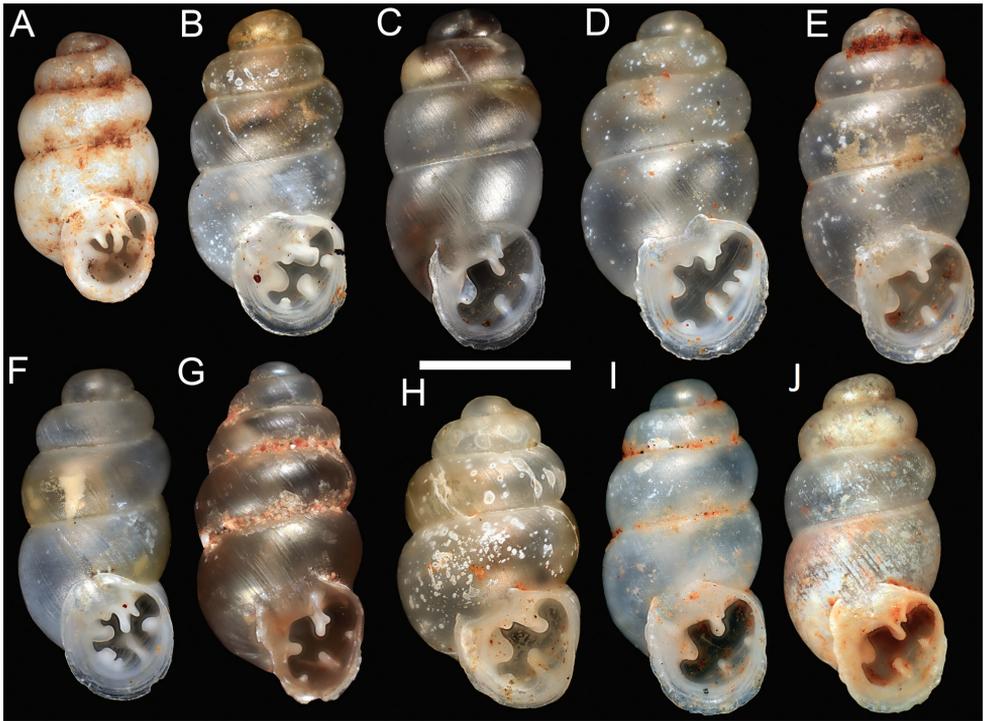


Figure 2. *Gastrocopta* species: **A** *Gastrocopta* sp. CW1 (WAM S60408, Exmouth) **B** *Gastrocopta bedleyi* Pilsbry, 1917 (WAM S61117, Burrup Peninsula) **C–E** *Gastrocopta larapinta* (Tate, 1896) **C** WAM S58005, Kalgan Pool **D–E** WAM S60368, Roy Hill Station **F** *Gastrocopta margaretae* (Cox, 1868) (WAM S42834, Bateman Sanctuary); **G** *Gastrocopta servilis* (Gould, 1843) (WAM S60237, Karratha) **H–J** *Gastrocopta mussoni* Pilsbry, 1917 **H** Ovate Form (WAM S42865, Roy Hill Station) **I** Cylindrical Form (WAM S59375, Phils' Creek) **J** Cylindrical Form (WAM S61070), Roy Hill Station). (Scale Bar = 1mm).

Pool area: 23.1872°S, 119.6958°E (WAM S58079); 23.1877°S, 119.6965°E (WAM S58091). Kangeenarina Gorge: 22.0588°S, 117.8549°E (WAM S60085). Karajini National Park: 22.4782°S, 118.5598°E (WAM S65307); 22.9797°S, 118.5891°E (WAM S65310); 22.8446°S, 118.5403°E (WAM S65314); 22.3714°S, 118.2989°E (WAM S65336). Marillana Station: 22.4285°S, 119.2043°E (WAM S81440). Mount Brockman area: 22.4815°S, 117.2384°E (WAM S83560). Mt Farquhar area: 22.4815°S, 116.8108°E (WAM S83564); 22.4932°S, 116.8679°E (WAM S83586). Nullagine area: 22.3848°S, 119.9696°E (WAM S58093); 22.3210°S, 119.4442°E (WAM S80958). Orebody 35°E (ca. 8km W of Newman): 23.4047°S, 119.6052°E (WAM S64713); 23.3943°S, 119.6316°E (WAM S64715-6, WAM S64718, WAM S64734, WAM S64753); 23.4108°S, 119.5715°E (WAM S64720); 23.3994°S, 119.5843°E (WAM S64722); 23.4045°S, 119.6211°E (WAM S64726); 23.4182°S, 119.5847°E (WAM S64730, WAM S64744); 23.4049°S, 119.6052°E (WAM S64732); 23.4045°S, 119.6247°E (WAM S64735); 23.4049°S, 119.6053°E (WAM S64737, WAM S64747); 23.4003°S, 119.6524°E (WAM S64740); 23.4137°S,

119.5826°E (WAM S64741); 23.4029°S, 119.6021°E (WAM S64742); 23.4003°S, 119.5721°E (WAM S64745); 23.3947°S, 119.5913°E (WAM S64750). ca. 35km E of Paraburdoo: 23.1300°S, 117.8984°E (WAM S41446); 23.1663°S, 117.9484°E (WAM S41447); 23.1670°S, 117.9597°E (WAM S41448). ca. 7.07.5km NW of Tom Price: 22.6500°S, 117.7185°E (WAM S42668); 22.6423°S, 117.7451°E (WAM S42672). Phil's Creek: 22.7319°S, 119.1940°E (WAM S59376). Sulphur Springs: 21.1475°S, 119.2269°E (WAM S60229). Wonmunna: 23.1216°S, 119.0498°E (WAM S65971); 23.1428°S, 119.0099°E (WAM S65976); 23.1266°S, 119.0470°E (WAM S65992, WAM S81027, WAM S81085); 23.1255°S, 119.0797°E (WAM S80937); 23.1287°S, 119.0904°E (WAM S80938); 23.1393°S, 119.0182°E (WAM S80939); 23.1220°S, 119.0611°E (WAM S80941); 23.1436°S, 119.0064°E (WAM S81001, WAM S81073); 23.1185°S, 119.0649°E (WAM S81004); 23.1592°S, 118.9928°E (WAM S81025, WAM S81062); 23.1632°S, 118.9770°E (WAM S81033, WAM S81054, WAM S81168, WAM S81176); 23.1615°S, 119.0020°E (WAM S81048, WAM S811056); 23.1185°S, 119.0649°E (WAM S81091); 23.1596°S, 118.9703°E (WAM S81052); 23.1283°S, 119.0736°E (WAM S81059); 23.1331°S, 119.0154°E (WAM S81103); 23.1356°S, 119.0463°E (WAM S81120); 23.1546°S, 118.9932°E (WAM S81122); 23.1314°S, 119.0774°E (WAM S81174). ca. 6km W of Wodgina Mine: 21.2383°S, 118.6519°E (WAM S65895); 23.1348°S, 119.0338°E (WAM S81074).

Distribution. This species has previously been recorded from northern New South Wales and from scattered localities in northern Queensland (Cape York Peninsula), central Australia (Glen Helen area) and northern Western Australia (King Leopold Ranges) (Pokryszko 1996). In addition, it is now recorded from the Hamersley Ranges, the Burrup Peninsula and a few isolated sites from approximately 100 km SSE of Port Hedland in the Pilbara region (Figure 3).

Comparative morphology. *G. hedleyi* shells are slightly smaller (shorter) than those of other *Gastrocopta* species (excluding *G. sp. CW1*) recorded from the Pilbara. They typically have (1) a large, usually rounded (sometimes acute) columellar tooth that is drooping at the anterior end (2) a high, strongly convergent upper palatal tooth (3) a long, high, strongly twisted parietoangular tooth that usually comes in close proximity to the upper palatal tooth (4) a prominent infraparietal tooth that is sometimes prolonged as thin ridge on parietal wall (5) often a strong basal tooth (6) very occasionally with a weak interpalatal tooth.

Some *G. hedleyi* shells (particularly more elongate specimens) can be difficult to separate from the ovate form of *G. mussoni* but (1) are smaller (slender) when sympatric (2) have a less rounded body whorl (3) have a more strongly sigmoid lower palatal tooth (4) have a larger upper palatal tooth that is usually strongly convergent with the lower palatal (5) have a longer, more strongly twisted parietoangular tooth (6) have a larger, more rounded columellar tooth that is usually drooping at the anterior end.

The cylindrical form of *G. mussoni* is also very similar to *G. hedleyi* but (1) has a lower, shorter and less twisted parietoangular tooth (usually at 45° angle in apertural

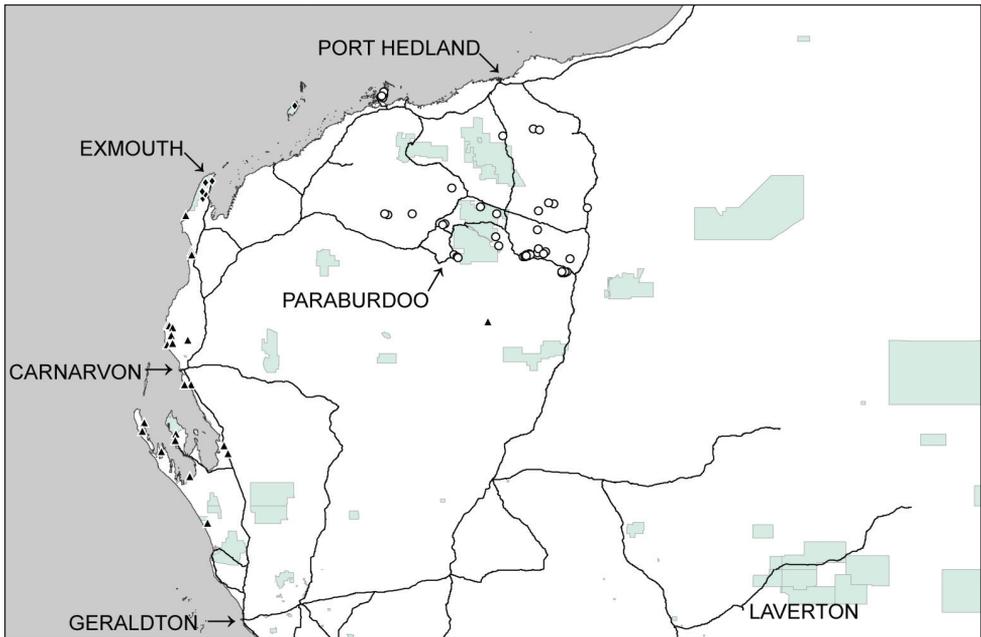


Figure 3. Distributional records of *Gastrocopta hedleyi* Pilsbry, 1917 (○), *Gastrocopta margaretae* (Cox, 1868) (▲) and *Gastrocopta* sp. CW1 (◆) in the Pilbara region. Shaded: Protected area.

view) (2) has a shorter and less sigmoid (usually straight) lower palatal tooth (3) generally lacks an infraparietal tooth (4) has a smaller upper palatal tooth (occasionally slightly convergent with lower palatal) (5) has a more acutely angled, slanted columellar tooth, rarely drooping at the anterior end.

Remarks. There is considerable variation in the shell size and barrier length of specimens identified as *G. hedleyi* during this study. Many specimens grouped as *G. hedleyi* from the eastern Hamersley Range (eg. Wonmunna, Kalgan Pool) have reduced barriers and often a lower parietoangular tooth (nearing 45° angle in apertural view) but a large series shows a progression to shells that typically possess a large, strongly convergent upper palatal tooth and a strongly twisted parietoangular tooth.

Solem (1989) mentioned that *G. hedleyi* was somewhat similar to *G. pilbarana*, although in that case he was actually referring to the ovate form of *G. mussoni* (see section on *G. mussoni*).

The abundance and seemingly allopatric nature of *G. hedleyi* on the Burrup Peninsula is intriguing. The large numbers are presumably related to its' habitat requirement of either Fig tree, Cypress or Brigalow Stands among rocky substrates, and its' preference for high calcium soils (Pokryszko 1996). Away from the Burrup Peninsula, the distribution of *G. hedleyi* is somewhat patchy and is probably related to the isolated occurrence of its' preferred vegetative structures among rocks as well as less alkaline soils.

2. *Gastrocopta larapinta* (Tate, 1896)

http://species-id.net/wiki/Gastrocopta_larapinta

Fig. 2C–E

Pupa larapinta Tate 1896: 205–206, pl. 19, figs 19a–b.

Gastrocopta larapinta Pilsbry 1917 [in 1916–1918]: 168–171, pl. 30, figs 5–7, 9–11; Solem 1989: 490–491, figs 54–55; 1991: 249; Pokryszko 1996: 1109–1110, figs 19, 22.

Australbinula larapinta Iredale 1937a: 302; 1937b: 10.

Type locality. Central Australia.

Material studied. Western Australia: Cane River: 22.0298°S, 115.4296°E (WAM S42993). Central Pilbara: 22.3855°S, 117.4667°E (WAM S58492, WAM S65790); 22.3200°S, 117.6194°E (WAM S65778); 22.2675°S, 117.7197°E (WAM S65780); 22.1350°S, 117.4728°E (WAM S58493); 21.0216°S, 117.0560°E (WAM S65817); 20.7506°S, 117.0096°E (WAM S65797). Christmas Creek: 22.4061°S, 119.7376°E (WAM S65612); 22.3985°S, 119.7930°E (WAM S65604). Cloud Break area: 22.3210°S, 119.4442°E (WAM S34453, WAM S80956); 22.2688°S, 119.3147°E (WAM S61128); 22.3652°S, 119.3409°E (WAM S65150); 22.3985°S, 119.4748°E (WAM S65156); 22.3949°S, 119.5019°E (WAM 65161); 22.3527°S, 119.4189°E (WAM S65135). Collier Rocks: 20.4071°S, 116.8514°E (VK 30297). Cy Creek: 22.8183°S, 114.0609°E (WAM S34381). Du Boulay Creek: 21.1833°S, 116.1833°E (WAM S34569). Fortescue Marsh area: 22.2930°S, 119.0606°E (WAM S61996-7); 22.4646°S, 119.7726°E (WAM S64651, WAM S64654); 22.4430°S, 119.7785°E (WAM S64649); 22.4252°S, 119.7235°E (WAM S64635); 22.3125°S, 119.2348°E (WAM S64634, WAM S64637); 22.2875°S, 119.1701°E (WAM S64650); 22.2822°S, 119.1276°E (WAM S42923, WAM S64644, WAM S64652, WAM S64694). Hope Downs: 23.1030°S, 119.5821°E (WAM S59298); 23.0919°S, 119.1875°E (WAM S59550). Jumblebar: 23.3693°S, 120.1958°E (WAM S41346). Kalgan Pool area: 23.1877°S, 119.6965°E (WAM S58005); 23.1874°S, 119.6957°E (WAM S80939). Koodaideri Corridor West (90.4km NW of Tom Price): 21.8833°S, 117.7000°E (WAM S83434). Marillana Station: 22.6260°S, 119.2834°E (WAM S34638); 22.5840°S, 119.3114°E (WAM S34632, WAM S34472); 22.5739°S, 119.2562°E (WAM S34474); 22.5666°S, 119.2327°E (WAM S34637); 22.5663°S, 119.2308°E (WAM S34633); 22.6013°S, 119.2913°E (WAM S80924); 22.5625°S, 119.2311°E (WAM S80908); 22.1269°S, 119.2123°E (WAM S80911); 22.4080°S, 119.0067°E (WAM S80914); 22.4285°S, 119.2043°E (WAM S8143940); 22.3476°S, 119.1518°E (WAM S81433); 22.4295°S, 119.1923°E (WAM S81446). Millstream National Park: 21.2000°S, 117.2667°E (WAM S60343); 21.6000°S, 117.1000°E (WAM S 61044); 21.5833°S, 117.1000°E (WAM S 61048); 21.5833°S, 117.0833°E (WAM S60944-5); 21.5833°S, 117.0667°E (WAM S 60947); 21.4255°S, 117.0535°E (WAM S81213); 21.2039°S, 117.0440°E (WAM S81267). ca. 30km NNE of Newman: 23.1164°S, 119.8865°E (WAM S64469). ca. 65km NW of Newman: 22.9169°S, 119.2128°E (WAM S80937). ca. 108118km N of Newman: 22.3132°S, 119.8599°E (WAM S65534,

WAM S65673); 22.3134°S, 119.7886°E (WAM S65646); 22.2972°S, 119.8633°E (WAM S65530, WAM S65682); 22.2954°S, 119.8109°E (WAM S65652). North Star Mine: 21.2284°S, 119.0386°E (WAM S65720); 21.2104°S, 118.8769°E (WAM S65723). Phil's Creek: 22.7412°S, 119.1959°E (WAM S59388, WAM S80934); 22.7320°S, 119.1836°E (WAM S59374). ca. 100km S of Port Hedland: 20.6066°S, 119.5016°E (WAM S80942). ca. 200km SSE of Port Hedland: 22.1554°S, 119.0216°E (WAM S83486). Robe River area: 21.8063°S, 116.0774°E (WAM S42832). 6km SW of Redmont Airport: 22.0195°S, 118.9816°E (WAM S83423). NNE of Rocklea Homestead: 22.7882°S, 117.4974°E (WAM S80977). Roy Hill Station: 22.4898°S, 119.8951°E (WAM S34703); 22.4547°S, 119.8709°E (WAM S42924, WAM S60428-9, WAM S65389); 22.4943°S, 119.9217°E (WAM S60359, WAM S60368, WAM S60373, WAM S60378); 22.5383°S, 119.9424°E (WAM S42831, WAM S42833, WAM S60232, WAM S60857, WAM S60861); 22.4793°S, 119.9420°E (WAM S42925, WAM S60363, WAM S60426, WAM S60853, WAM S60860); 22.6394°S, 119.9642°E (WAM S60398); 22.5769°S, 119.9952°E (WAM S603667, WAM S608545, WAM S60859); 22.5771°S, 120.0247°E (WAM S60422); 22.7058°S, 119.7082°E (WAM S60392); 22.6430°S, 119.9599°E (WAM S60396); 22.6076°S, 119.9826°E (WAM S60388); 22.6593°S, 119.9198°E (WAM S60397); 22.6642°S, 119.9458°E (WAM S61066, WAM S61069); 22.6431°S, 119.9642°E (WAM S61075, WAM S61077); 22.6225°S, 119.9634°E (WAM S610723); 22.5050°S, 119.9143°E (WAM S64455). Running Waters (east of Nullagine): 21.6819°S, 121.1254°E (WAM S58039, WAM S58050); 21.6806°S, 121.1261°E (WAM S58032). 15km W of Shaw River Airport: 21.6123°S, 119.2642°E (WAM S83412). Wonmunna: 23.1220°S, 119.0611°E (WAM S81087, WAM S81182); 23.1356°S, 119.0463°E (WAM S81107, WAM S81125, WAM S81164); 23.1216°S, 119.0498°E (WAM S81096); 23.1201°S, 119.0484°E (WAM S65993, WAM S80904). ca. 18-23km SE of Wodgina Mine: 21.2273°S, 118.8336°E (WAM S646089); 21.2871°S, 118.8671°E (WAM S64604, WAM S64616). ca. 20km NNE of Wodgina Mine: 21.0260°S, 118.7024°E (WAM S64610). Yule River area: 21.6961°S, 118.8604°E (WAM S83372).

Distribution. This species has previously been recorded from central Australia (southern part of Northern Territory) with fewer records in north-western Queensland (Gregory River Basin); eastern coast of Queensland and a single record from the Oscar Ranges, in the southern Kimberley region of Western Australia (Pokryszko 1996). In addition, it is now recorded from throughout most of the Pilbara region, but is surprisingly absent from near coastal areas and islands (Figure 4).

Comparative morphology. The shells of typical *G. larapinta* specimens are distinguished from most other *Gastrocopta* species in the Pilbara by (1) their large size (2) usually the presence of three solid palatal teeth (the interpalatal tooth varying from a tiny callus to large tooth) (3) a short, solid parietoangular tooth that is usually deflected or curved moderately toward the columellar wall so that its anterior end is somewhat vertical in the apertural view (4) a long angular tooth that is generally fused (or connected via a translucent callus) to the parietoangular tooth, occasionally separate (particularly those that lack or have a small interpalatal tooth) (5) smaller, more rounded

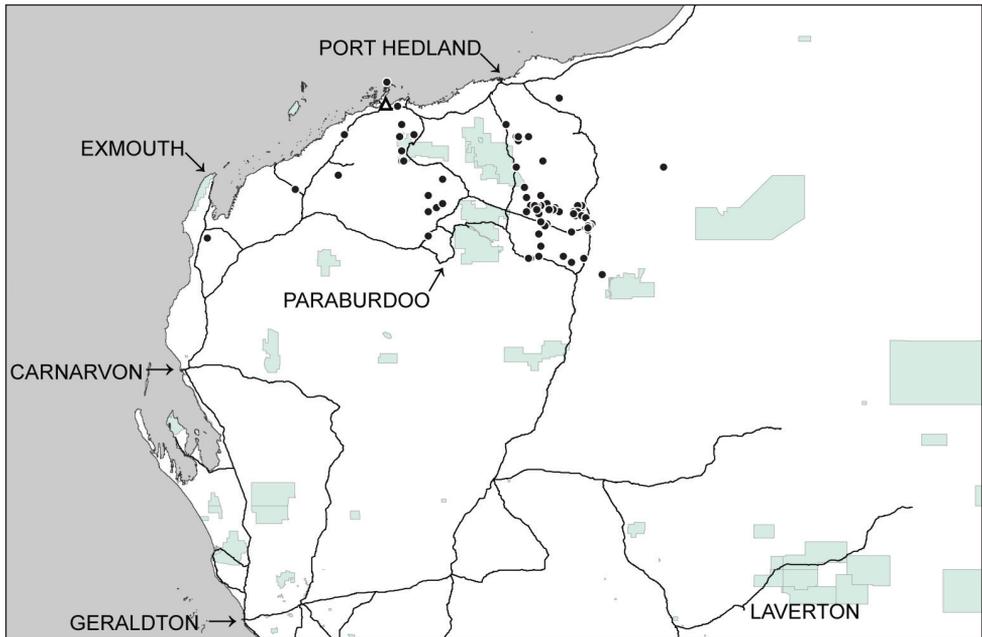


Figure 4. Distributional records of *Gastrocopta larapinta* (Tate, 1896) (●) and *Gastrocopta servilis* (Gould, 1843) (Δ) in the Pilbara region. Shaded: Protected area.

columellar tooth that curves or angles abruptly toward the columellar wall (6) usually the presence of an infraparietal tooth or basal tooth (or both).

Typical *G. larapinta* shells with a small interpalatal tooth (or very occasionally no interpalatal tooth) appear considerably more variable in apertural barrier structure (particularly in high calcareous soils), making their separation from the cylindrical and elongate-ovate forms of *G. mussoni* difficult. As such the following separation is tentative. *G. larapinta* shells are typically (1) slightly to moderately larger (obese) (2) have a slightly smaller, more rounded columellar tooth (3) usually a much shorter parietoangular tooth that is positioned lower in apertural view (4) generally possesses an infraparietal tooth (5) often a slightly lower, less convergent upper palatal tooth (6) usually a less sigmoid lower palatal tooth.

Remarks. The separation of *G. larapinta* (small or no interpalatal tooth) with the cylindrical and elongate-ovate forms of *G. mussoni* has proved extremely difficult and a more detailed molecular study is required to resolve this issue. Pokryszko (1996) separated these *G. larapinta* specimens from cylindrical *G. mussoni* based on shell size (smaller) and columellar tooth angle (less acute). However, from the small genetic data available and from examination of many shells, *G. larapinta* shells were slightly, to moderately more obese.

Some of those near west coast specimens (Cy Creek) included as cylindrical *G. mussoni* contained mixed lots of *G. larapinta* and *G. mussoni*. Interestingly, Pokryszko had identified a few of these larger Cy Creek specimens as *G. larapinta*, but included those records as *G. mussoni* in her publication. Pokryszko (1996) also noted in a large

lot of *G. mussoni* from central Australia (FMNH 201570) that some of the ovate *G. mussoni* were quite large (many having an interpalatal tooth) but we consider most of those to be *G. larapinta* with a small or no interpalatal tooth (see *G. mussoni* section).

It is possible Pokryszko (1996) was alluding to a slender form of *G. larapinta* when separating cylindrical *G. mussoni* and *G. larapinta* (no interpalatal tooth) but this does not reflect accurately in her identifications. During this study specimens from Kalgan Pool (WAM S58005) were unexpectedly grouped within the *G. larapinta* clade. These specimens, although slightly more slender, have proven difficult to separate from cylindrical *G. mussoni* specimens identified by Pokryszko (1996) as they (1) have a high, long, lamellate parietoangular tooth (2) have a separated angular tooth (3) have a slightly rounded to angled columellar tooth and (4) lack an infraparietal tooth. They may prove to be a subspecies of *G. larapinta* and in this sense, Pokryszko's (1996) separation of cylindrical *G. mussoni* and *G. larapinta* (no interpalatal tooth) was correct.

As there is doubt surrounding the distinguishing morphological characters of cylindrical *G. mussoni* and *G. larapinta* shells with a small or no interpalatal tooth, the above separation is tentative and a more detailed genetic investigation is required.

3. *Gastrocopta margaretae* (Cox, 1868)

http://species-id.net/wiki/Gastrocopta_margaretae

Fig. 2F

Pupa margaretae Cox 1868: 80, pl. 14, figs 20,20a.

Pupa wallabyensis Smith 1894: 97.

Gastrocopta margaretae Pilsbry 1917 [in 1916–1918]: 160–161, pl. 26, figs 7–8; Solem 1986: 99–101, figs 8–9,11–12, 1991: 249; Pokryszko 1996: 1096–1099, figs 6, 8–10.

Gastrocopta tatei Pilsbry 1917 [in 1916–1918]: 165–166, pl. 26, figs 9–10, pl. 30, fig. 12; Solem 1989: 491–492, figs 56–59; 1991: 249.

Gastrocopta wallabyensis Pilsbry 1917 [in 1916–1918]: 171–172; Solem 1986: 101–102, figs 13–15; 1991: 249.

Australbinula margaretae Iredale 1937a: 302, 1937b:11, pl. 1, fig. 4.

Australbinula wallabyensis Iredale 1937a: 302.

Australbinula tatei Iredale 1937a: 302, 1937b:10.

Gastrocopta pilbarana Solem 1986: 103–104, figs 16–20; 1991: 249.

Type locality. Wallaroo, South Australia.

Material studied. Western Australia: Bateman Sanctuary: 23.0552°S, 113.8234°E (WAM S42834). ~18km N of Boolathana Homestead: 24.4133°S, 113.7445°E (WAM S64708). Boolathana Station: 24.4127°S, 113.7631°E (WAM S64709). Bush Bay: 25.1175°S, 113.8063°E (WAM S42806); 25.1316°S, 113.7681°E (WAM S60355); 25.1136°S, 113.7311°E (WAM S64575); 25.1175°S, 113.8063°E (WAM S64577). Carrarang Station: 26.1666°S, 113.3500°E (WAM S34378). Cy Creek: 23.1000°S,

113.8000°E (WAM S34380). Dirk Hartog Island: 25.7166°S, 113.0667°E (WAM S14439); 25.8333°S, 113.0500°E (WAM S34398). Francois Peron National Park: 25.9760°S, 113.5707°E (WAM S60269); 25.9758°S, 113.5706°E (WAM S64706); 25.8752°S, 113.5497°E (WAM S61127). Lake Macleod area: 24.3449°S, 113.5194°E (WAM S65084); 24.3668°S, 113.5145°E (WAM S65093); 24.3544°S, 113.5098°E (WAM S65102); 24.4760°S, 113.5257°E (WAM S65108); 24.4598°S, 113.5013°E (WAM S65110); 24.3544°S, 113.5098°E (WAM S65121). 0.25 miles W of Nichol Springs: 24.1333°S, 118.4167°E (WAM S60270). ~25 miles N of turn off to Shark Bay on NW Coastal Highway: 26.0647°S, 114.3353°E (WAM S34459, WAM S60271, WAM S64585). 0.5 miles W of 512 mile peg on NW Coastal Highway: 26.1966°S, 114.3758°E (WAM S34379). Quobba Station: 24.4758°S, 113.4166°E (WAM S42829); 24.2448°S, 113.5353°E (WAM S61125); 24.1927°S, 113.4548°E (WAM S64576); 24.2233°S, 113.5036°E (WAM S64707). Salutation Island: 26.5333°S, 113.7667°E (WAM S34377). Winderabandi Point: 22.4929°S, 113.7258°E (WAM S60474). Zuytdorp: 27.2636°S, 114.0703°E (WAM S64710).

Distribution. This species has previously been recorded from the western and southern coastal areas of Western Australia, the southern regions of South Australia and the area near Alice Springs in the Northern Territory. There is also an isolated record from the King Leopold Range in the north of Western Australia (Pokryszko 1996). In the Pilbara it is confined to the near west coast with an isolated inland record from the Ashburton River (Figure 3).

Comparative morphology. Shells of *G. margaretae* are easily distinguished from other *Gastrocopta* species in the Pilbara by the presence of (1) a moderately to strongly folded columellar tooth (2) a generally large and transverse basal tooth (3) a high and long lower palatal tooth (4) an upper palatal tooth that is moderately to strongly convergent with the lower palatal (5) a weak to strong infraparietal tooth present.

Remarks. Solem (1986) maintained the separation of the west coast species *G. wallabyensis* from the south coast *G. margaretae* based on size (smaller) and length of apertural barriers (longer). He also described a new species, *G. pilbarana*, from the west coast but his separation of it from *G. wallabyensis* was vague. Solem later (1989) maintained the separation of the central Australian *G. tatei* from the above species but remarked it was somewhat similar to the west coast *G. wallabyensis*. Pokryszko (1996) later disagreed, synonymising all species with *G. margaretae*.

The few specimens sequenced from the south coast of Western Australia (WAM S32048, WAM S32052) could represent genetic isolation by distance or perhaps a different species from those on the west coast (WAM S42834) but more molecular data are required. The southern specimens are (1) much larger with reduced apertural barriers (2) more strongly rounded whorls (conical) and (3) consistently lack an infraparietal tooth. Specimens resembling the smaller west coast form (ie. long apertural barriers and weak to strong infraparietal tooth) have also been recorded from the south west area of Western Australia (Whisson, pers. comm.) where it is often sympatric with *Gastrocopta bannertonensis* (Gabriel, 1930). It is not known whether there is a

continuous distribution between the two areas. Until more detailed molecular work is undertaken we have maintained Pokryszko's (1996) systematic positions.

4. *Gastrocopta mussoni* Pilsbry, 1917

http://species-id.net/wiki/Gastrocopta_mussoni

Fig. 2H–J

Gastrocopta larapinta deserti Pilsbry 1917 [in 1916–1918]: 170–171, pl. 30, figs 1–3.

Gastrocopta mussoni Pilsbry 1917 [in 1916–1918]: 167–168, pl. 27, figs 5–6; Solem 1989: 494, figs 211–213, 1991: 249; Pokryszko 1996: 1105–1109, figs 20–21; Stanistic et. al. 2010: 102–103.

Australbinula helmsiana Iredale 1939: 8, pl. 1, fig. 2.

Australbinula mussoni Iredale 1937a: 301.

Gastrocopta deserti Solem 1986: 102–103, figs 13–15, 1988: 487–490, figs 48–53, 1991: 249; Slack-Smith 1993: 92.

Type locality. Calliungal (=Mt Morgan), Queensland.

Material studied. Western Australia: Angelo River: 23.4331°S, 118.7329°E (WAM S65935). Anketell Point area: 20.6356°S, 117.0398°E (WAM S59990); 20.6719°S, 117.0965°E (WAM S599912); 20.7025°S, 117.0473°E (WAM S80936). Area C: 22.9104°S, 118.9664°E (WAM S60417). Barrow Island: 20.7833°S, 115.4000°E (WAM S34384); 20.8649°S, 115.4069°E (WAM S34455); 20.6666°S, 115.4667°E (WAM S42879, WAM S60847); 20.7921°S, 115.4573°E (WAM S59636); 20.7858°S, 115.4573°E (WAM S59637); 20.7997°S, 115.4403°E (WAM S59640); 20.7069°S, 115.4194°E (WAM S59642); 20.7866°S, 115.4547°E (WAM S59644, WAM S60413); 20.7938°S, 115.4575°E (WAM S59651); 20.8644°S, 115.3428°E (WAM S59652); 20.8101°S, 115.4270°E (WAM S60410); 20.6666°S, 115.4667°E (WAM S42879, WAM S60847); 20.7977°S, 115.4064°E (WAM S65123, WAM S65126, WAM S65127, WAM S65164); 20.7684°S, 115.4673°E (WAM S65174). Cane River Conservation Park: 22.1694°S, 115.5606°E (WAM S42961); 22.4321°S, 115.2895°E (WAM S42967); 22.2685°S, 115.6470°E (WAM S42974); 22.0975°S, 115.4942°E (WAM S42976); 22.2075°S, 115.5260°E (WAM S42981); 22.1451°S, 115.7249°E (WAM S42987); 22.0298°S, 115.4296°E (WAM S42992); 22.0131°S, 115.6325°E (WAM S42998). Cape Preston area: 20.8435°S, 116.2016°E (WAM S59141). Chichester Ranges: 22.0525°S, 118.9883°E (WAM S60407); 22.0516°S, 118.9884°E (WAM S42711, WAM S42713, WAM S42759); 22.1508°S, 119.0179°E (WAM S42709); 22.0503°S, 118.9934°E (WAM S42717); 23.1164°S, 119.8865°E (WAM S64460). Christmas Creek area: 22.4170°S, 119.8941°E (WAM S65603); 22.4078°S, 119.8767°E (WAM S65605); 22.4061°S, 119.7376°E (WAM S65611). Cloud Break area: 20.3216°S, 119.4418°E (WAM S34460); 22.3210°S, 119.4442°E (WAM S42876, WAM S60403, WAM S80957); 22.3181°S, 119.3788°E (WAM S60267); 22.2935°S, 119.3872°E (WAM S61122);

22.2997°S, 119.3737°E (WAM S61123); 22.2881°S, 119.2360°E (WAM S65137°S, WAM S65143°S, WAM S65153); 22.3251°S, 119.4458°E (WAM S65139); 22.3527°S, 119.4189°E (WAM S65144); 22.3652°S, 119.3409°E (WAM S65148); 22.3894°S, 119.4380°E (WAM S65155); 22.3985°S, 119.4748°E (WAM S65157); 22.3949°S, 119.5019°E (WAM S65213). Cy Creek: 22.8183°S, 114.0609°E (WAM S34382). Dolphin Island: 20.4833°S, 116.8500°E (WAM S34385). Du Boulay Creek: 21.1833°S, 116.1833°E (WAM S34568). Finucane Island: 20.2982°S, 118.5572°E (WAM S16108). Fortescue Marsh area: 22.2822°S, 119.1276°E (WAM S42926, WAM S64694, WAM S646523); 22.2938°S, 119.0732°E (WAM S61991); 22.5098°S, 119.1274°E (WAM S61993°S, WAM S61995); 22.2872°S, 119.0301°E (WAM S646401, WAM S646556); 22.1322°S, 119.1983°E (WAM S64684); 22.2924°S, 119.0279°E (WAM S64687). East Hamersley Range: 22.8586°S, 119.6728°E (WAM S42921); 22.6335°S, 119.3289°E (WAM S64470). Hope Downs: 23.1474°S, 119.5191°E (WAM S42662); 23.1030°S, 119.2917°E (WAM S59548, WAM S59554); 23.0925°S, 119.2058°E (WAM S59551); 23.0878°S, 119.1609°E (WAM S59552). Jinayri area: 22.9219°S, 119.2036°E (WAM S42929); 23.0530°S, 119.2701°E (WAM S59239, WAM S592412, WAM S59244); 23.0129°S, 119.2371°E (WAM S59240, WAM S59243); 22.9058°S, 119.2000°E (WAM S59576, WAM S59596); 22.9275°S, 119.1275°E (WAM S59585); 22.9169°S, 119.2128°E (WAM S59587); 22.9219°S, 119.2036°E (WAM S59591); 23.0504°S, 119.2731°E (WAM S60406). Kalgan Pool area: 23.1877°S, 119.6965°E (WAM S439823). Kangeenarina Gorge area: 22.1186°S, 117.9427°E (WAM S61763); 21.8489°S, 117.3837°E (WAM S81210). Karratha area: 20.7166°S, 116.8500°E (WAM S60412); 21.4036°S, 116.9392°E (WAM S81217). SE of Karratha: 21.0698°S, 116.9702°E (WAM S81241, WAM S81246); 21.0300°S, 116.9997°E (WAM S81252, WAM S81271); 20.9853°S, 116.8811°E (WAM S81268). Lake Macleod: 24.3544°S, 113.5098°E (WAM S65120). Marillana Station: 22.5840°S, 119.3114°E (WAM S84075); 22.5663°S, 119.2308°E (WAM S34473); 22.5497°S, 119.2147°E (WAM S34476); 22.5851°S, 119.3142°E (WAM S34478). 22.5739°S, 119.2562°E (WAM S34634, WAM S80940); 22.5538°S, 119.2283°E (WAM S34635); 22.6260°S, 119.2834°E (WAM S34639); 22.5625°S, 119.2311°E (WAM S80907); 22.1269°S, 119.2123°E (WAM S80910); 22.5625°S, 119.2311°E (WAM S80913); 22.4080°S, 119.0067°E (WAM S80916); 22.6376°S, 119.3744°E (WAM S80917); 22.4285°S, 119.2043°E (WAM S81437); 22.3182°S, 119.1175°E (WAM S81442); 22.4295°S, 119.1923°E (WAM S81444). Meentheena Outcamp: 21.2671°S, 120.4570°E (WAM S58055); 21.2815°S, 120.4511°E (WAM S58099); 21.2816°S, 120.4508°E (WAM S58098). Millstream National Park: 21.6000°S, 117.1000°E (WAM S42838, WAM S42931, WAM S61043); 21.5833°S, 117.0833°E (WAM S42839, WAM S60943); 21.5833°S, 117.0667°E (WAM S60946); 21.4255°S, 117.0535°E (WAM S81212); 21.1781°S, 117.0461°E (WAM S81250); 21.2039°S, 117.0440°E (WAM S81301, WAM S81296). Mount Brockman area: 22.4815°S, 117.2384°E (WAM S83561). Mt Farquhar area: 22.4815°S, 116.8108°E (WAM S83563). Muiron Island: 21.6666°S, 114.3333°E (WAM S34383). Murray Hills: 22.1147°S, 118.5221°E (WAM S59996).

~60km NW of Newman: 23.0530°S, 119.2701°E (WAM S60235, WAM S60266, WAM S60405); 23.0878°S, 119.1609°E (WAM S59549); 23.0504°S, 119.2731°E (WAM S60404, WAM S60411); 22.9632°S, 119.2276°E (WAM S42928, WAM S60233). ~112km NNE of Newman: 22.3621°S, 119.9691°E (WAM S65650); 22.3132°S, 119.8599°E (WAM S 65672); 22.3871°S, 119.9664°E (WAM S 65694). ~110km N of Newman: 22.2954°S, 119.8109°E (WAM S65638); 22.3132°S, 119.8599°E (WAM S65672); 22.2972°S, 119.8633°E (WAM S65683). ~70km S of Newman: 23.7270°S, 119.7242°E (WAM S58073). North Star: 21.2523°S, 118.8334°E (WAM S65699); 21.1971°S, 118.8286°E (WAM S65706, WAM S65710); 21.2681°S, 118.9682°E (WAM S65713); 21.2104°S, 118.8769°E (WAM S65718); 21.2104°S, 118.8769°E (WAM S65719); 21.2319°S, 118.8263°E (WAM S65728). Nullagine area: 21.8221°S, 120.3409°E (WAM S61802). Orebody 35°E (ca. 8km W of Newman): 23.4108°S, 119.5715°E (WAM S64733); 23.3837°S, 119.6478°E (WAM S64748); 23.3712°S, 119.6127°E (WAM S64749); 23.3819°S, 119.6133°E (WAM S64751); 23.3970°S, 119.6138°E (WAM S64752). West of Pannawonica: 21.7000°S, 116.1667°E (WAM S42805); 21.8063°S, 116.0774°E (WAM S60268); 21.7202°S, 116.0705°E (WAM S60414, WAM S61034); 21.6298°S, 116.0206°E (WAM S60415). Point Quobba, near lighthouse: 24.4797°S, 113.4178°E (FMNH 201611); Phils' Creek area: 22.7320°S, 119.1836°E (WAM S 42878, WAM S 59372); 22.7316°S, 119.1931°E (WAM S 59371, WAM S59375, WAM S59383); 22.7351°S, 119.1856°E (WAM S59373); 22.7384°S, 119.1916°E (WAM S59377); 22.7412°S, 119.1959°E (WAM S59378); 22.7448°S, 119.1927°E (WAM S59379); 22.7412°S, 119.1959°E (WAM S59380); 22.7366°S, 119.1811°E (WAM S59381); 22.7316°S, 119.1798°E (WAM S59382). ~40km S of Port Hedland: 20.6095°S, 118.6661°E (WAM S81404). NNE of Rocklea Homestead: 22.8101°S, 117.4734°E (WAM S80990). Roy Hill Station: 22.6642°S, 119.9458°E (WAM S34588); 22.4943°S, 119.9217°E (WAM S42828, WAM SS60376); 22.4396°S, 119.9453°E (WAM S42837); 22.4898°S, 119.8951°E (WAM S42875, WAM S60234); 22.5383°S, 119.9424°E (WAM S42927); 22.7058°S, 119.7082°E (WAM S60393); 22.6347°S, 119.9698°E (WAM S60394); 22.8174°S, 119.9473°E (WAM S60395, WAM S60399); 22.5771°S, 120.0247°E (WAM S60421, WAM S60866); 22.4793°S, 119.9421°E (WAM S60427); 22.5039°S, 120.0210°E (WAM S60864); 22.5566°S, 119.9700°E (WAM S60865); 22.7489°S, 119.9221°E (WAM S61067); 22.7195°S, 119.9395°E (WAM S61068, WAM S61071); 22.6365°S, 119.9639°E (WAM S61070); 22.6431°S, 119.9642°E (WAM S61074, WAM S61076); 22.5050°S, 119.9042°E (WAM S64448); 22.5843°S, 120.0172°E (WAM S64453). Running Waters (east of Nullagine): 21.6819°S, 121.1254°E (WAM S58050); 21.6815°S, 121.1270°E (WAM S58059). W end of Telfer Road: 21.3290°S, 121.1390°E (WAM S58044). NW of Tom Price: 22.3734°S, 117.4631°E (WAM S34566); 22.1350°S, 117.4728°E (WAM S65775); 22.1519°S, 117.5428°E (WAM S65781); 22.2997°S, 117.6378°E (WAM S65787); 22.3855°S, 117.4667°E (WAM S65788). Weeli Wolli Creek: 22.6166°S, 119.4000°E (WAM S60231). Near Wodgina Mine: 21.1831°S, 118.6569°E (WAM S34567, WAM S65843, WAM S65869); 21.2871°S, 118.8671°E

(WAM S64618); 21.1789°S, 118.6463°E (WAM S65841, WAM S65855); 21.1737°S, 118.6503°E (WAM S65844); 21.2383°S, 118.6519°E (WAM S65903). Wonmunna: 23.1436°S, 119.0064°E (WAM S65977, WAM S81002, WAM S81026); 23.1355°S, 119.0384°E (WAM S65983); 23.1596°S, 118.9703°E (WAM S65979); 23.1632°S, 118.9770°E (WAM S65985); 23.1615°S, 119.0020°E (WAM S 65990); 23.1201°S, 119.0484°E (WAM S65993); 23.1287°S, 119.0904°E (WAM S 65996); 23.1283°S, 119.0736°E (WAM S65998); 23.1268°S, 119.0673°E (WAM S81032); 23.1309°S, 119.0689°E (WAM S81036, WAM S81167); 23.1428°S, 119.0099°E (WAM S81053); 23.1355°S, 119.0384°E (WAM S81081); 23.1169°S, 119.0396°E (WAM S81099); 23.1255°S, 119.0797°E (WAM S81094); 23.1216°S, 119.0498°E (WAM S81096, WAM S81171); 23.1393°S, 119.0182°E (WAM S81104); 23.1210°S, 119.0632°E (WAM S81109); 23.1356°S, 119.0463°E (WAM S 81110, WAM S81127); 23.1185°S, 119.0649°E (WAM S81114); 23.1255°S, 119.0797°E (WAM S81116); 23.1201°S, 119.0484°E (WAM S81119); 23.1331°S, 119.0154°E (WAM S81170); 23.1216°S, 119.0498°E (WAM S81178); 23.1220°S, 119.0611°E (WAM S81180). Yandi Mine: 22.8200°S, 119.2500°E (WAM S61774).

Distribution. This species has previously been recorded from central Australia (the southern part of Northern Territory), with a few records from the mid-west coast and northern Western Australia; northern Northern Territory; northern and north-eastern parts of Queensland and South Australia (Pokryszko 1996). In addition, it is now recorded from throughout most of the Pilbara region (Figure 5).

Comparative morphology. Cylindrical and elongate-ovate forms of *G. mussoni* can be mistaken for *G. larapinta* specimens (with a small or absent interpalatal tooth) but (1) are slightly to moderately slender (2) have a higher, usually longer parietoangular tooth (3) have a larger, more strongly slanted and acutely angled columellar tooth, with its posterior edge often forming a prominent wide ridge along the columellar wall (4) quite frequently have an upper palatal tooth that is slightly (occasionally moderately) convergent with the lower palatal (see also earlier section on *G. larapinta*). *G. mussoni* very occasionally possesses a small interpalatal tooth, usually located close to the upper palatal.

The typical ovate form of *G. mussoni* can be confused with *G. hedleyi* (particularly those with reduced apertural barriers) but (1) are larger (obese) when sympatric (2) have a less sigmoid lower palatal tooth and (3) have a smaller, less convergent upper palatal tooth (see also earlier section on *G. hedleyi*).

Remarks. There appears to be two size forms in *G. mussoni*, the larger ovate form and smaller, slender cylindrical form, and in agreement with Pokryszko (1996) both are confirmed as ecological phenotypes from the CO1 and 16S sequences. Based on specimens identified by Pokryszko (1996) and during this study, there is enormous variation in shell shape, shell size and apertural barrier structure between and including these two forms.

The ovate form of *G. mussoni* appears to be most common in the Pilbara. Prior to Pokryszko's 1996 publication, *G. pilbarana* Solem, 1986 was described from the Shark Bay area with an isolated record from the Chichester Range (north of Roy Hill). This

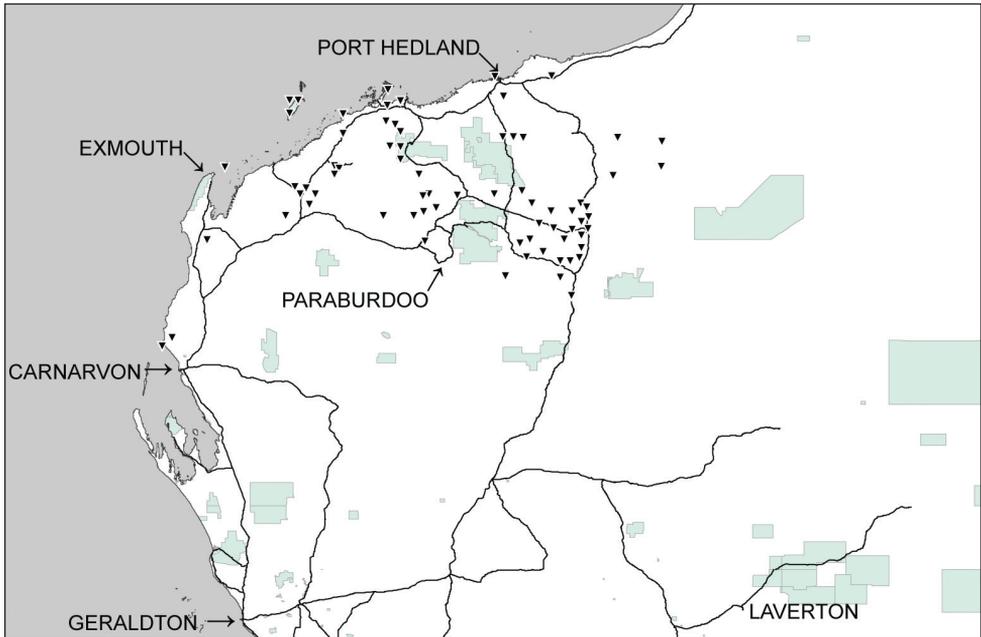


Figure 5. Distributional records of *Gastrocopta mussoni* Pilsbry, 1917 (▼) in the Pilbara region. Shaded: Protected area.

species was synonymised with *G. margaretae* (Cox, 1868) by Pokryszko (1996) although the Chichester Range paratype was not included in that study. This Chichester Range record is actually the ovate form of *G. mussoni*.

Some of those specimens tentatively identified as the elongate-ovate form of *G. mussoni* during this study (Wonmunna; Cy Creek; Cloud Break, Barrow Island) are (1) much larger (obese) than the usual elongate-ovate form (2) have the parietoangular tooth lower (45°) (3) usually have a supraparietal tooth and (4) quite frequently possess a small interpalatal tooth. These specimens may prove to be the somewhat variable *G. larapinta* with a small or no interpalatal tooth, but in the absence of a larger series of specimens and more detailed molecular data, we have left them as *G. mussoni*.

The nature of many cylindrical *G. mussoni* identified by Poykrosko (1996) and during this study requires more work. It is probable we have lumped the slender form of *G. larapinta* from Kalgan Pool (no interpalatal tooth) with cylindrical *G. mussoni*.

5. *Gastrocopta* sp. CW1

Fig. 2A

Gastrocopta pilbarana Slack-Smith 1993: 91.

Material studied. Western Australia: Barrow Island: 20.7069°S, 115.4194°E (WAM S59641). Cape Range No. 2 Deep Well: 21.9500°S, 114.0333°E (WAM S14132). Cape Range (cave): 22.1166°S, 113.9833°E (WAM S34394); 22.1500°S, 114.0000°E (WAM S34395, WAM S60409, WAM S60831); 22.0833°S, 113.9833°E (WAM S34396); 22.1833°S, 113.9833°E (WAM S80955). Exmouth rubbish tip: 21.9166°S, 114.1167°E (WAM S60408)

Distribution. This species is recorded from the Cape Range and from an isolated site on Barrow Island (Figure 3).

Comparative morphology. Shells of *Gastrocopta* sp. CW1 are easily recognized by their (1) small size (2) very solid, non-lamellate columellar tooth that projects horizontally from the columellar wall (shelf-like), slightly drooping at anterior end (3) long sigmoid lower palatal tooth (4) large, transverse upper palatal tooth (5) presence of a suprapalatal tooth.

Remarks. Solem (1989) identified specimens from the Kimberley and Northern Territory as *G. recondita* (Tapparone-Canefri, 1883) but in a later review, Pokryszko (1996) regarded that species as extralimital to Australia, describing the Australian representatives as a new sister species, *G. stupefaciens*.

G. sp. CW1. is very similar to *G. stupefaciens* and *G. recondita* but (1) is smaller (2) has longer apertural barriers and (3) has a thick, solid, non-lamellate columellar tooth and is here within regarded as a new species. Some of Solems' *G. recondita* specimens from limestone outcrops near Katherine (station WA-685) and Lake Argyle (station WA-248) have a similar columellar tooth structure and their relationship to *G. sp. CW1* needs further work.

Slack-Smith (1993) listed cavernicolus specimens from the Cape Range as *G. pilbarana* (which was later synonymised with *G. margaretae*) but those specimens were in fact *G. sp. CW1*. She suggested that although this population of snails was ameliorated with the limestone caves of the Cape Range, although it was not generally cavernicolus. The accumulation and breakdown of leaf litter within caves combined with calcareous rocks was deemed advantageous for snails. Solem (1991) discussed an affinity with limestone for his *G. recondita*. The few records of *G. sp. CW1* from the limestone dominated Barrow Island and Cape Range show similar requirements.

6. *Gastrocopta servilis* (Gould, 1843)

http://species-id.net/wiki/Gastrocopta_servilis

Fig. 2G

Pupa servilis Gould 1843: 356, pl. 6, fig. 14.

Pupa microsoma Tapparone-Canefri 1883: 107–8, pl. 2, figs 1–2.

Pupa lyonsiana Ancey 1892: *Fr.* 5, 713.

Gastrocopta lyonsiana Pilsbry 1917: 141–144, pl. 24, figs 1–4; van Benthem Jutting 1952: 355, fig. 34.

Gastrocopta microsoma (Tapparone-Canefri), Pilsbry 1917: 152, pl. 24, fig. 9; van Benthem Jutting 1964: 4–5

Gastrocopta servilis Solem 1989: 483–4, figs 38–41, 1991: 249; Shea 2006: 7, fig. 4; Stanisic et al. 2010: 104, fig. 123.

Type locality. near Matanzas, Cuba.

Material studied. Karratha area: 20.7385°S, 116.8357°E (WAM S9932, WAM S60237).

Distribution. This species has previously been recorded from just north of Broome (Quondong Point) across northern Australia to mid-eastern Queensland and offshore islands (Solem 1989, Shea 2006). In addition, it is now recorded from a single locality within the Karratha town site (Figure 4).

Comparative morphology. The shells of *G. servilis* are easily distinguished from other Pilbara *Gastrocopta* by their (1) strongly rounded whorls (2) short, straight columellar tooth which is perpendicular to the mid-columellar wall (3) very long angular tooth which is fused with the parietoangular tooth (4) weak to absent basal tooth and (5) weak to absent upper palatal tooth.

Remarks. *G. servilis* has been a recent introduction to the residential gardens of Karratha.

Molecular phylogeny

Two mitochondrial gene fragments, COI and 16S, have been analysed. The data sets contained 27 sequences of Western Australian *Gastrocopta* (five each of *G. bannertonensis* and *G. mussoni*, 12 of *G. larapinta*, two or three, respectively, of *G. margaretae*, and two of *G. hedleyi*) as well as 16 Genbank sequences of several American *Gastrocopta* species that stem from the study of Nekola et al. (2012). Two to three sequences each of *Vertigo* spp. and *Pupilla* spp. were used as out-group to root the trees. Maximum Likelihood analyses of the COI and 16S fragments resulted in identical tree topologies (Figs 6–7). All species as delineated by their shell formed monophyletic sequence clusters. The six Australian species formed a monophyletic crown group nested amongst a basal assemblage of American lineages. The species *G. hedleyi*, *G. mussoni* and *G. larapinta* are more closely related with each other as are *G. margaretae* and *G. bannertonensis*, which corresponds well with columellar tooth structure i.e. large and ascending versus small and short, respectively. Intraspecific evolutionary divergences were on average 1% (max. 4%) in COI as well as on average 1% (max. 2%) in 16S in all Australian species but *G. margaretae* (Tables 2–3). In *G. margaretae* intraspecific genetic distances were found to be significantly higher than in any other Australian species (16% in COI and 5.3% in 16S). Apart from *G. margaretae*, the intraspecific divergence was about an order of magnitude smaller than the observed interspecific distances of 5–26% (on average 18%) in COI and 2–14% (on average 9%) in 16S. Only in *G. margaretae* did the amount of intraspecific genetic differentiation overlap with the range of interspecific genetic distances.

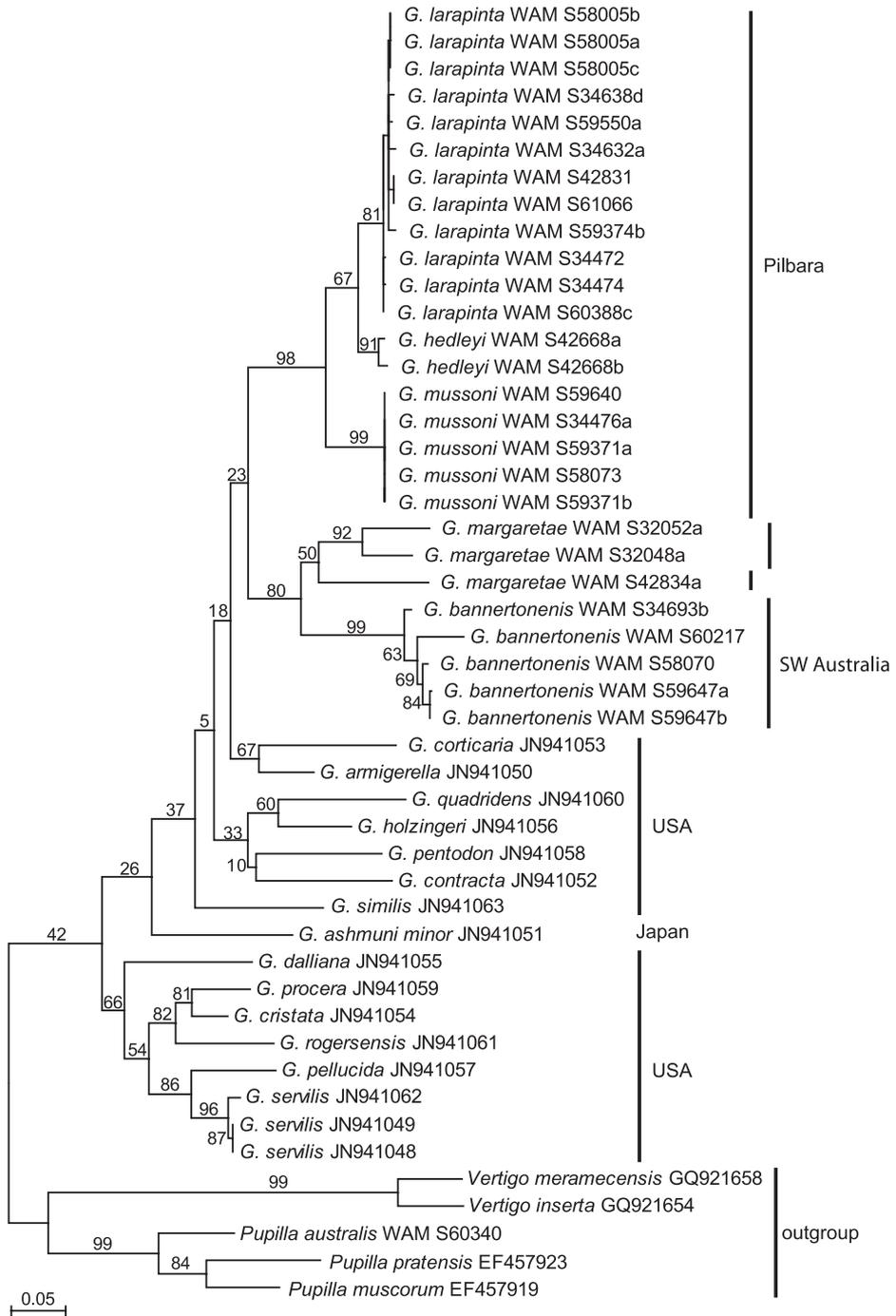


Figure 6. Maximum Likelihood phylogram for COI based on analysis of 27 new sequences of *Gastrocopta* from Western Australia and the 16 Genbank sequences made available by Nekola et al. (2012). Sequences of *Vertigo* spp. and *Pupilla* spp. were used as out-group to root the tree. Labels on branches indicate nodal support by 200 ML bootstrap replicates.

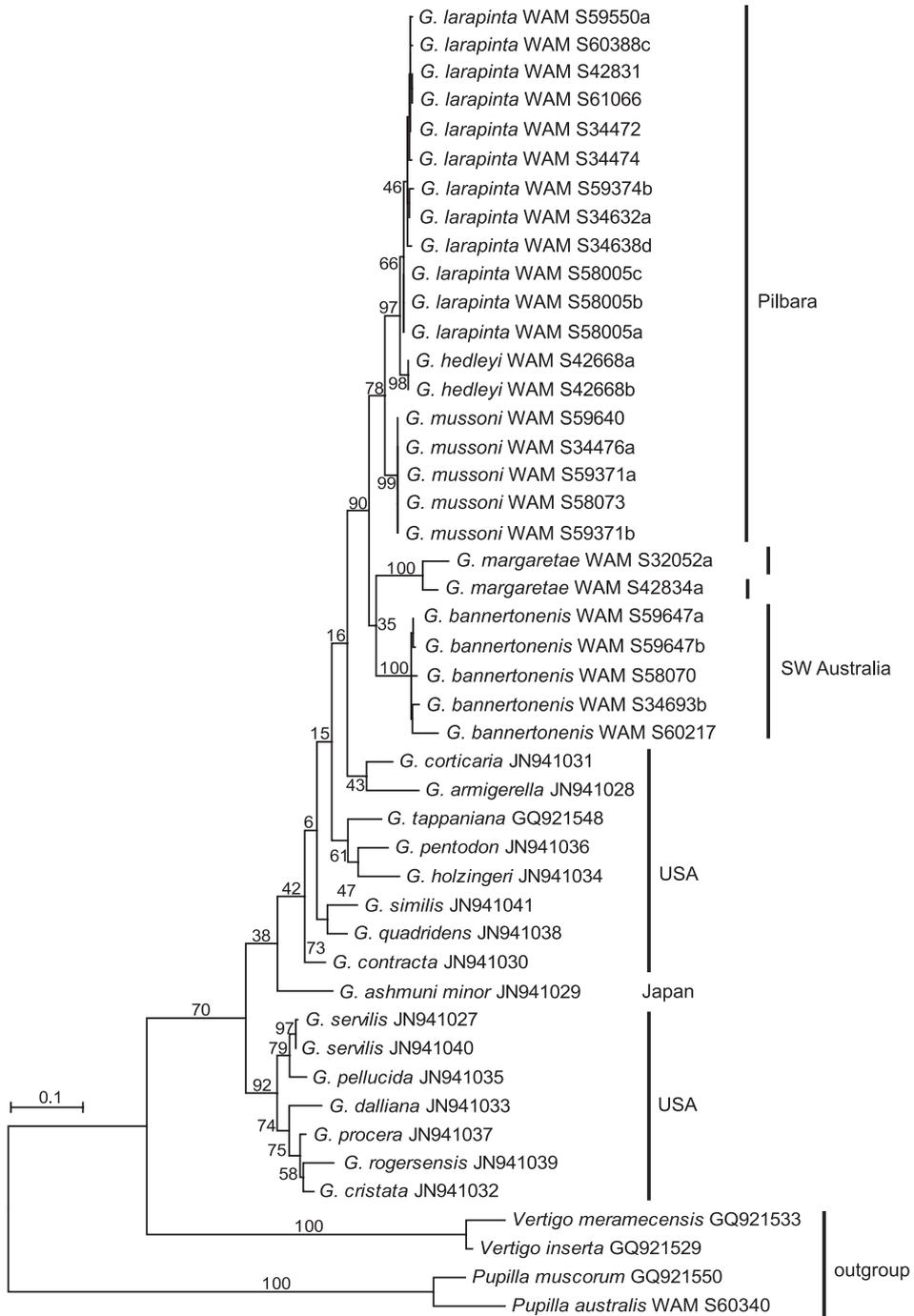


Figure 7. Maximum Likelihood phylogram for 16S based on analysis of 26 new sequences of *Gastrocopta* from Western Australia and the 16 Genbank sequences made available by Nekola et al. (2012). Sequences of *Vertigo* spp. and *Pupilla* spp. were used as out-group to root the tree. Labels on branches indicate nodal support by 200 ML bootstrap replicates.

Table 2. Average pair-wise genetic distances in COI. Shown are (p) uncorrected p-distances, and (TN93) corrected distances by using the model of Tamura-Nei (1993). The rate variation among sites was modelled with a gamma distribution (shape parameter = 0.4).

	Distance	<i>G. marg</i>	<i>G. bann</i>	<i>G. lara</i>	<i>G. muss</i>	<i>G. hedl</i>
<i>G. marg</i>	p	0.103	0.121	0.133	0.128	0.129
	TN93	0.160	0.195	0.218	0.202	0.204
<i>G. bann</i>	p		0.030	0.147	0.132	0.142
	TN93		0.036	0.263	0.211	0.244
<i>G. lara</i>	p			0.008	0.080	0.044
	TN93			0.008	0.113	0.052
<i>G. muss</i>	p				0.000	0.081
	TN93				0.000	0.115
<i>G. hedl</i>	p					0.012
	TN93					0.013

Table 3. Average pair-wise genetic distances in 16S. Shown are (p) uncorrected p-distances, and (TN93) corrected distances by using the model of Tamura-Nei (1993). The rate variation among sites was modelled with a gamma distribution (shape parameter = 0.4).

	Distance	<i>G. marg</i>	<i>G. bann</i>	<i>G. lara</i>	<i>G. muss</i>	<i>G. hedl</i>
<i>G. marg</i>	p	0.045	0.102	0.094	0.082	0.095
	TN93	0.053	0.139	0.126	0.103	0.126
<i>G. bann</i>	p		0.021	0.080	0.076	0.076
	TN93		0.024	0.106	0.096	0.099
<i>G. lara</i>	p			0.008	0.040	0.021
	TN93			0.008	0.046	0.023
<i>G. muss</i>	p				0.000	0.041
	TN93				0.000	0.046
<i>G. hedl</i>	p					0.000
	TN93					0.000

Discussion

Based on shell morphology, all *Gastrocopta* species recorded here (except *G. sp.* CW1) have relatively large distributional ranges. Although limited, the molecular data supports the shell-based delineation of the six species recognized herein. The molecular data also confirms the large distributional ranges of *G. larapinta* and *G. mussoni* by including samples from areas that are about 100 and 550 kilometres apart, respectively. The apparently widespread distribution of *Gastrocopta* species is probably due to the common ability in which a single *Gastrocopta* adult can self-fertilize their eggs and establish a new population (Nekola 2009). They also have the ability to be transported large distances, through either their small and light structure (via wind and water) and/or by their nature to mucous seal to objects such as bark, leaves and vertebrates (Slack-Smith 1993, Nekola 2009).

Some of the species *G. hedleyi* and *G. sp.* CW1 are at the southern limits of their range. It is probable that *G. hedleyi* has arrived in the Pilbara as a result of dispersal

potential whereas *G. sp. CW1*, found only in the Cape Range in the Pilbara (and an isolated record from Barrow Island) might represent relictual populations from the Miocene. Both Cape Range and Barrow Island contain moist, well sheltered limestone gorges and caves.

Other recorded species represent a range extension from the red centre. These include *G. mussoni* and *G. larapinta* which are common in the Pilbara. This is not surprising given their affinity to arid or semi-arid environments, which persist throughout much of the Pilbara. Future collecting will no doubt show a mostly continuous distribution for these species between the Pilbara and the red centre.

The present COI and 16S molecular data set, although small (only 27 individuals sequenced) mostly supports the taxonomic revision of Pokryszko (1996) based exclusively on shell morphology (i.e. apertural barriers). However, more detailed molecular work is needed to sort out some systematic issues: (1) the relationship of the west coast and south coast populations of *G. margaretae* (2) the relationship of *G. sp. CW1* to similar specimens in the Kimberley region (3) the morphological separation of *G. larapinta* and *G. mussoni*.

The Australian species are less well differentiated by means of evolutionary divergence than the American *Gastrocopta* species, which are separated from each other by interspecific pair-wise Tamura and Nei (1993) distances of 7.8–28% (on average 20.4%) in COI and 2.3–22% (on average 13.9%) in 16S. Evolutionary divergences of the Australian *Gastrocopta* species are also lower than the genetic distances found in other Western Australian land snails, such as the Camaenidae. In this group interspecific sequences in COI were usually larger than 6% (e.g., Köhler 2011; Köhler and Johnson 2012) (16S distances were not compared because the analysed gene fragments differed in length).

There appears to be tremendous variation in shell shape and size between and within populations of some *Gastrocopta* species, and often this is associated with variation in apertural barrier structure. This can make separation of species difficult, particularly *G. larapinta*, *G. hedleyi* and *G. mussoni* which share similar apertural barrier structures. It is advisable to collect a large series of individuals so the wide variation in apertural barrier structures can be seen.

Conclusion

In summary, *G. hedleyi*, *G. larapinta*, *G. sp. CW1* and *G. servilis* are recorded from the Pilbara region for the first time. *G. servilis* has been a recent introduction to the residential gardens of Karratha. *G. hedleyi*, *G. larapinta* and *G. mussoni* were shown to be common across the Pilbara. *G. sp. CW1* may represent an undescribed species.

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The first euthemistid damsel-dragonfly from the Middle Jurassic of China (Odonata, Epiproctophora, Isophlebioptera)

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Abstract

Sinoeuthemis daohugouensis gen. et sp. n. is the first record of the isophlebiopteran family Euthemistidae from Middle Jurassic of northeast China, while previously this family was restricted to the early Late Jurassic Kazakhstan. This new finding allows us to emend the family diagnosis with hindwing characters. This new species shows a mixture of characters alternatively present in different genera of the two families Euthemistidae and Sphenophlebiidae.

Keywords

Euthemistidae, Sphenophlebiidae, gen. et sp. n., Middle Jurassic, China, mixture of characters

Introduction

The Mesozoic Isophlebioptera Bechly, 1996 is a very large clade subdivided into four subgroups: Euthemistidae, Parazygoptera, Selenothemistidae, and Isophlebiida. The family Euthemistidae Pritykina, 1968 comprises one genus and two species (both based on forewings). Our knowledge on the Euthemistidae remains indigent and its exact position is somewhat uncertain, even if it is probably very inclusive in the Isophlebioptera. Here we describe a new genus and a new species collected from the Jiulongshan Formation, Middle Jurassic of Daohugou, Inner Mongolia, China, where abundant well-preserved fossil insects are found, including 19 reported orders so far, and some of the observations are of great importance (e.g. Ren et al. 2009, 2010a, 2010b, 2010c; Gao et al. 2012; Gu et al. 2012; Shi et al. 2011). The new genus is closely related to the genus *Euthemis* Pritykina, 1968 and for the first time we show the hindwing characters of the family Euthemistidae. The new fossil has a mixture of characters alternatively present in different genera of the two families Euthemistidae and Sphenophlebiidae. Therefore, this new finding is of great importance for future clarification of the relationships between the Euthemistidae, Sphenophlebiidae, and other Parazygoptera. Furthermore, the new specimen expands the age and distribution of Euthemistidae from early Late Jurassic Karatau (Kazakhstan) to Middle Jurassic northeast China.

Material and method

The study is based on one specimen (No. CNU-ODO-NN2012004, positive imprint and negative imprint) housed in the Key Laboratory of Insect Evolution and Environmental Changes, Capital Normal University, Beijing, China. The specimen was examined with a Leica MZ12.5 dissecting microscope and illustrated with the aid of a drawing tube attached to the microscope. Line drawings were made using Adobe Photoshop CS graphic software.

We use the following standard abbreviations: AA, anal vein; AP, anal posterior; Ax0 Ax1 Ax2, primary antenodal cross-veins; CuAa, distal branch of cubitus anterior; CuAb, proximal branch of cubitus anterior; IR1, IR2, intercalary radial veins; MAa, distal branch of median anterior; MAb, posterior branch of median anterior; MP, median posterior; N, nodus; O, oblique vein; Pt, pterostigma; RA, radius anterior; and RP, radius posterior; ScP, subcosta posterior. We follow the taxonomy of Isophlebiida indicated by the phylogenetic system of Bechly (1996), but do not accept all the synapomorphies he proposed (see discussion below).

Systematic palaeontology

Order Odonata Fabricius, 1793

Clade Isophlebioptera Bechly, 1996

Superfamily Isophlebioidea Handlirsch, 1906

Family Euthemistidae Pritykina, 1968

<http://species-id.net/wiki/Euthemistidae>

Genus included. type genus *Euthemis* Pritykina, 1968 and *Sinoeuthemis* gen. n.

Emended familial diagnosis. Several long intercalary veins between IR1 and RP1, and between IR1 and RP2, as well as between RP3/4 and IR2, and between IR2 and RP2 (intercalaries parallel to main longitudinal veins without apparent origin on them, but originating in cross-venation); extremely narrow postdiscoidal area (in forewings and probably also in hindwings); not petiolate; numerous secondary antenodal crossveins between anterior wing margin and ScP distal of Ax2; discoidal cells opened in forewing and closed in hindwing; hindwing subdiscoidal area transverse, posteriorly closed, short and broad, with vein CuAb makes a strong angle with AA; hindwing gaff (basal CuA before its branching) not very long; RP2 aligned with subnodus; crossveins in hindwing postdiscoidal space are not very long and not oblique.

Genus *Sinoeuthemis* gen. n.

[urn:lsid:zoobank.org:act:1DE29A69-7318-4D84-B0EE-209593108C8A](http://species-id.net/wiki/Sinoeuthemis)

<http://species-id.net/wiki/Sinoeuthemis>

Diagnosis. Wings relatively short and very short CuA with weak posterior branches in both fore and hindwings.

Etymology. Named after *Sinica*, Latin name for China and *Euthemis*, the type genus. Gender feminine.

***Sinoeuthemis daobugouensis* sp. n.**

[urn:lsid:zoobank.org:act:6783C7B8-8791-48B0-9722-010427CECC6E](http://species-id.net/wiki/Sinoeuthemis_daobugouensis)

http://species-id.net/wiki/Sinoeuthemis_daobugouensis

Figure 1

Material. Holotype specimen No. CNU-ODO-NN2012004.

Diagnosis. As for the genus.

Description. A body with a thorax, abdomen, head, two legs and forewings and hindwing articulated. **Body** (Fig. 1; Fig. 2D,F) 53.0 mm long (from head to anal appendages); head 5.1 mm long, 5.2 mm wide, with broad eyes, 1.7 mm long, well separated, 1.0 mm apart in the mid level; thorax about 8 mm long, max width 6.5 mm;

abdomen about 3.8 mm wide in the mid part, slightly narrowed at the end; cercus and epiproct very short; there is no secondary genital structure on segment 2 and anal area rounded (female). **Forewing** (based on negative imprint, two forewing fragments combined; Fig. 2A,B), preserved with basal half, 22.4 mm long; no petiole (AA and AP separate at wing base); one row of cells between posterior wing margin and AA; AA parallel to MP + Cu; median and submedian areas free; a curved strong vein CuP between submedian and subdiscoidal areas, in a distal position just basal of arculus; subdiscoidal space free of cross-veins, transverse; discoidal space basally opened; RP+MA nearly straight, separated at nearly a right angle from RA in arculus; distance between base of RP and point of separation between MAa and MAb 0.4 mm, RP and MA well parallel; MAb 0.9 mm long, well aligned with distal free part of CuA; CuA separates from MP 4.3 mm from wing base and directed towards posterior wing margin for 0.6 mm; distal free part of CuA strong, CuA distally fused with AA; CuA divided into a very short CuAb directed towards posterior wing margin and CuAa basally more or less parallel to posterior wing margin and distally delimitating a short and narrow cubito-anal area, with 1-2 posterior branches and 1-2 rows of cells at its broadest part; apex of CuA slightly distal level of base of RP3/4; area between CuA and MP with one row of cells; distal of apex of CuA, area between MP and posterior wing margin very long and broad; MP nearly straight, certainly reaching posterior wing margin well distal of nodus level; MAa more or less parallel with MP, nearly straight in its preserved part; postdiscoidal area with one row of cells, 1.0 mm wide near discoidal cell and narrowing distally; Ax0 not preserved; Ax1 0.6 mm basal of arculus, disposed obliquely to ScP and R + MA, Ax2 2.4 mm distal of arculus, with inverted obliquity; eight preserved secondary antenodal cross-veins between C and ScP distal of Ax2; 13 visible secondary antenodal cross-veins between ScP and RA distal of Ax2; 15 preserved cross-veins in area between RA and RP between arculus and subnodus; base of RP3/4 5.0 mm distal of arculus, closer to arculus than to nodus; base of IR2 close to that of RP3/4, 3.8 mm distally; no visible antefurcal cross-vein in space between RP and MA basal of midfork (base of RP3/4); nodal structures not preserved; area between MA and RP3/4 narrow basally but distally widening. **Hindwing** (mainly based on right hindwing of positive imprint, combined with anal area of left hindwing on negative imprint; Fig. 2C,E) hyaline, more complete than forewing, 39.7 mm long, estimate 8 mm wide at the level of nodus; primary antenodal crossveins Ax0, Ax1 and Ax2 are well preserved; Ax1 nearly perpendicular to ScP; Ax2 slightly oblique; distance from base to Ax1 3.6 mm, to arculus 4.2 mm, to nodus 18.7 mm; distance from arculus to the first fork of RP 2.8 mm; Ax1 0.4 mm basal of arculus and Ax2 1.9 mm distal of arculus; nine secondary antenodal cross-veins between C and ScP, but 11 secondary antenodal cross-veins between ScP and RA, distal of Ax2; no petiole; anal area about 6 mm long, 1.7 mm wide, rather rounded elongate in shape, with two rows of irregular cells between AA and AP; no anal angle; no membranule; AA distally strongly bent towards posterior wing margin and nearly parallel with MP + CuA, distally fused with CuAb; median and submedian areas free; curved vein CuP slightly basal of arculus; subdiscoidal area transverse, posteriorly closed, short and broad, with one cross-vein, 1.3 mm long, 0.8



Figure 1. Photo of positive imprint of CNU-ODO-NN2012004. Scale bar represents 10 mm.

mm wide; discoidal cell basally closed, 1.6 mm long, 0.5 mm wide, free of cross-veins, length of proximal side, 0.8 mm; RP + MA separates at approximately a right angle from RA and strongly curved in arculus; RP separated from MA 0.3 mm distally; just distal of arculus base, MA basally strong and divided into MAa and MAb distally; MAb short, 0.8 mm long, aligned with distal free part of CuA; MP + CuA separated into MP and CuA at distal end of MAb; distal free part of CuA strong, separates from

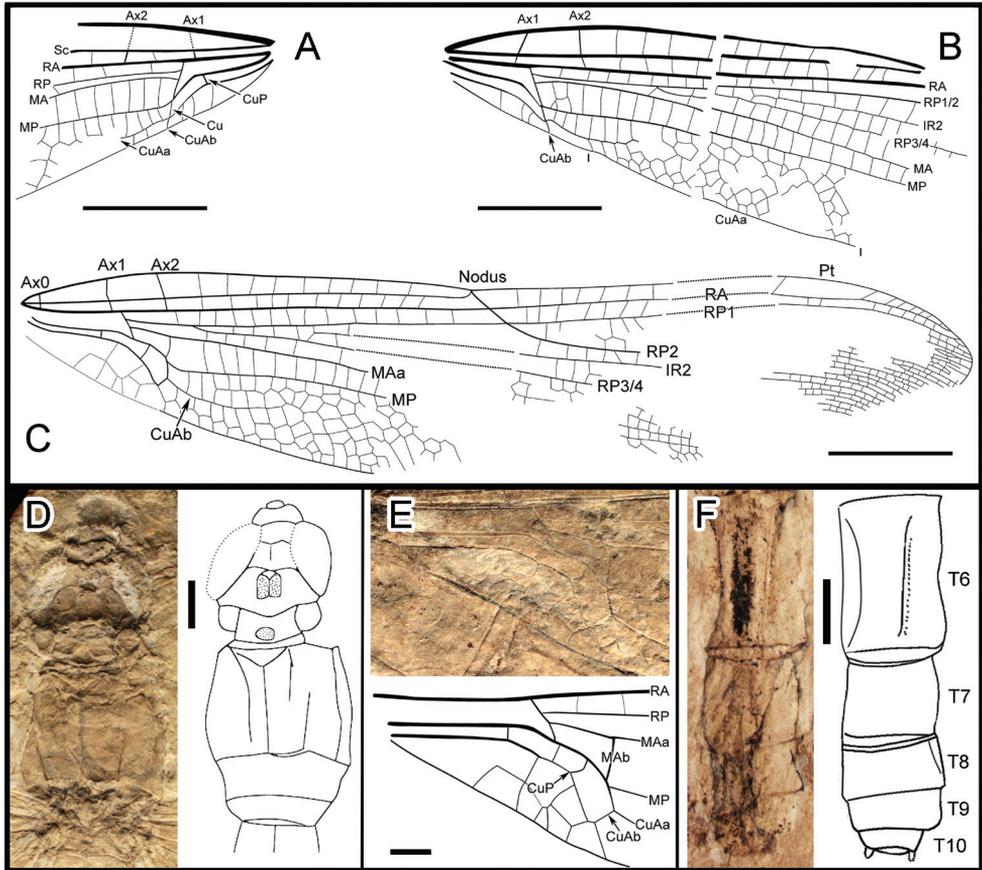


Figure 2. **A, B** Drawing of forewings, from negative imprint **C** Drawing of hindwing, from positive imprint, combined with anal area of the negative imprint (dotted line) **D** Detail photo and drawing of head and thorax, from negative imprint **E** Detail photo and drawing of hindwing anal area, from negative imprint **F** Detail photo and drawing of the lower part of abdomen, from positive imprint. Scale bars represent 5 mm in **A–C** and 1 mm in **D–F**.

MP 6.1 mm from wing base and extends towards posterior wing margin for 0.7 mm; CuA distally divided into CuAa and CuAb, CuAb short, 0.5 mm long, extending towards basal wing margin and meets main branch of AA; CuAa basally more or less parallel to posterior wing margin with two rows of cells between them; CuAa short, as long as in forewings, ending on posterior wing margin 5.8 mm from its base; area between CuAa and MP with one-two rows of cells, 0.9 mm wide; distal of end of CuAa, area between MP and posterior wing margin very long and broad; MP nearly straight, reaching posterior margin well distal of nodus level; MAa parallel with MP, nearly straight in its basal part, postdiscoial area mm wide, narrower distally; 14 cross-veins in area between RA and RP, between arculus and nodus; base of RP3/4 2.7 mm distal of arculus, closer to arculus than to nodus; base of IR2 close to that of RP3/4, 4.9 mm distally; no antefurcal cross-vein in space between RP and MA basal of midfork

(base of RP3/4); nodus oblique with subnodus aligned; more than seven postnodal cross-veins between C and RA and postsubnodal cross-veins between RA and RP1 not aligned with postnodals; pterostigmal brace probably not preserved; at least three cells below pterostigma; pterostigma sclerotized, long, 3.9 mm long, 0.8 mm wide; RP2 aligned with subnodus; oblique vein 'O' 4.3 mm and five cells distal of base of RP2; IR2 and RP2 nearly straight; area between MA and RP3/4 wider distally; area between RP3/4 and IR2 broadening distally; area between IR2 and RP2 with one row of cells and wider distally; several long intercalary veins between IR1 and RP1, and between IR1 and RP2 (but IR1 not clearly discernible), as well as between RP3/4 and IR2, and between IR2 and RP2 (these intercalaries are visible along posterior wing margin and parallel to the main longitudinal veins and have no apparent origin on them, but originate in the cross-venation).

Etymology. Named after Daohugou Village, from where the specimen was collected.

Type locality and horizon. Jiulongshan Formation, Middle Jurassic (Bathonian-Callovian boundary interval, ca 164–165 Ma); near Daohugou Village, Wuhua Township, Ningcheng County, Inner Mongolia, China.

Discussion

The hindwing subdiscoidal cell enlarged and with a bulged posterior margin, correlated with a unique course of the anal vein AA ("pseudo-anal-loop"), which is strongly bent towards the posterior wing margin at the CuP-crossing, is the main apomorphy of the Isophlebioptera Bechly, 1996. The RP2 aligned with subnodus excludes affinities with the Parazygoptera Bechly, 1997 (= Sphenophlebiidae Bechly, 1997 + Euparazygoptera Bechly, 1997), even if the absence of antefurcal crossvein in the space between RP and MA basal of midfork would be an apomorphy with the Euparazygoptera (= Asiopteridae Pritykina, 1968 + Triassolestoidea Tillyard, 1918). Within this last clade, affinities with the Asiopteridae are excluded because IR2 is not zigzagged. The Triassolestoidea (Cyclothemistidae Bechly, 1996 and Triassolestidae Tillyard, 1918) are also excluded because the subnodus is well aligned with nodus. Affinities with the Selenothemistidae Handlirsch, 1939 are excluded because the hindwing distal side (MAB) of the discoidal cell is shorter than twice as long as the basal side; the postdiscoidal space is very narrow; and the hindwing subdiscoidal cell has a different shape, not posteriorly rounded (Nel et al. 1993). Affinities with the Architemistidae Tillyard, 1917 are excluded because the crossveins in the hindwing postdiscoidal space are not very long and oblique, some antenodal crossveins are present between anterior wing margin and ScP, and the shape of the hindwing subdiscoidal cell is different.

The gaff is not as long as in the Isophlebioidea Handlirsch, 1906, except some species with reduced venation (*Zygokaratawia reni* Nel et al., 2008) (Nel et al. 2008). Furthermore *S. daohugouensis* shares with the Campterophlebiidae Handlirsch, 1920 the forewing discoidal cell basally opened but not the presence of antenodal crossveins between anterior wing margin and ScP (Li et al. 2012a, b), while the comparison

with Isophlebiidae Handlirsch, 1906 is just opposing, i.e. *Sinoeuthemis* contradicts to Isophlebiidae in the basally closed forewing discoidal cell, but they are sharing the character (except in *Walleria*) presence of antenodal crossveins between anterior wing margin and ScP (Nel et al. 2009).

The only remaining isophlebiopteran family is the Euthemistidae Pritykina, 1968 (*Euthemis* Pritykina, 1968, forewing characters only known). *Sinoeuthemis* shares with this group the following potential synapomorphies: ‘several long intercalary veins between IR1 and RP1, and between IR1 and RP2, as well as between RP3/4 and IR2, and between IR2 and RP2 (these intercalaries are parallel to the main longitudinal veins and have no apparent origin on them, but originate in the cross-venation)’. Such intercalaries are also present in the parazygopteran family Sphenophlebiidae Bechly, 1997 (*Sphenophlebia interrupta* Bode, 1953, *Mesoepiophlebia veronicae* Nel & Henrotay in Nel et al. 1993 and *Ensphingophlebia undulata* Bode, 1953, plus maybe *Proeuthemis pritykinae* Nel & Jarzembowski, 1996). Nevertheless the Sphenophlebiidae have their RP2 not aligned with subnodus, as already indicated above. Also the better known representatives of the Sphenophlebiidae (*Mesoepiophlebia* and *Proeuthemis*) have no secondary antenodal crossveins between anterior wing margin and ScP, unlike *Sinoeuthemis*, while this character remains uncertain in *Ensphingophlebia* and *Sphenophlebia* because the original descriptions of Bode (1953) remain doubtful. On the contrary, *Sinoeuthemis* and *Euthemis* share the presence of these antenodal veins and a non-petiololed forewing. A further apomorphy of *Euthemis*, an ‘extremely narrow postdiscoidal area’, is more uncertain in *Sinoeuthemis*, even if the preserved part of forewing postdiscoidal area suggests that it should be present in our fossil.

The structure of the hindwing subdiscoidal cell and vein AA in *Sinoeuthemis* is quite similar to that of *Mesoepiophlebia*, except that vein CuAb makes a strong angle with AA in the former but these veins are nearly aligned in the later genus. These structures are unknown in *Euthemis* as there is no hindwing reported. The greatest difference between *Sinoeuthemis* and *Euthemis* is the short and simple CuAa in the former while this vein is quite long with numerous posterior branches in the later. *Proeuthemis* has also a shortened CuAa but RP2 not aligned with subnodus and wings with petiole.

So it remains that *Sinoeuthemis* should be placed close to the Euthemistidae rather than to the Sphenophlebiidae, even if it shows a mixture of characters alternatively present in different genera in these two families.

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Two new species of *Dacne* Latreille (Coleoptera, Erotylidae) from China, with a key to Chinese species and subspecies of *Dacne*

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Abstract

Two new species *Dacne* (*Xenodacne*) *tangliangi* sp. n. and *Dacne* (*Xenodacne*) *hujiayaoi* sp. n. are described from China. A key to Chinese species and subspecies of genus *Dacne* Latreille is provided.

Keywords

Coleoptera, Erotylidae, *Dacne*, *Xenodacne*, identification key, new species, China

Introduction

The genus *Dacne* Latreille is considered to be one of the most primitive members of the subfamily Erotylinae (Wegrzynowicz 2002; Leschen 2003). Skelley (1997) reviewed this genus and later updated a world checklist and key (Skelley 2003). In general, little is known about *Dacne* in the Orient. Some work has been done in neighboring countries (Arrow 1925; Chûjô 1969; Chûjô and Chûjô 1988; Narukawa 1992; Chûjô and Lee 1993; Nikitsky and Kompantzev 1995), but nothing focuses specifically on China.

Previously, only two species and one subspecies have been reported from China, *Dacne* (*Dacne*) *picta* Crotch (1873) (Fig. 18), *Dacne* (*Dacne*) *japonica* Crotch (1873) (Fig. 16) and *Dacne* (*Xenodacne*) *zonaria taiwana* Chûjô (1976) (picture of this subspecies is not available for the present study)

In this work, two new species of the genus *Dacne* are described and illustrated: *Dacne* (*Xenodacne*) *tangliangi* sp. n. and *Dacne* (*Xenodacne*) *hujaiyaoi* sp. n. from Yunnan Province, China.

Material and methods

The specimens examined in this paper were collected in a wide variety of woodland fungi, in crevices under bark or in other retreats by splitting and sifting. For an examination of the male genitalia, the abdominal segments were detached from the body after softening in hot water. The aedeagi, together with other dissected parts, were mounted in Euparal (Chroma Gesellschaft Schmidt, Koengen, Germany) on plastic slides. Photos of sexual characters were taken with a Canon G9 camera attached to an Olympus SZX 16 stereoscope; habitus photos were taken with a Canon macro photo lens MP-E 65 mm attached to a Canon EOS7D camera.

The specimens treated in this study are deposited in the following public collections:

SHNU Department of Biology, Shanghai Normal University, P. R. China

FSCA Florida State Collection of Arthropods, USA [Paul E. Skelley]

Taxonomy

Key to Chinese species and subspecies of *Dacne*

Parts of the following key were taken from Skelley (2003).

- 1 Pronotal lateral margin thin for entire length; pronotum swollen anteriorly, projecting forward beyond anterior pronotal angles **2**
- Pronotal lateral margin thickened, often broader anteriorly; pronotal anterior margin normal, not projecting forward beyond anterior angles **3**
- 2 Pronotum with darkened disc *Dacne* (*Dacne*) *picta* Crotch
- Pronotum entirely orange *Dacne* (*Dacne*) *japonica* Crotch
- 3 Each elytron with one orange mark
..... *Dacne* (*Xenodacne*) *tangliangi* Dai & Zhao, sp. n.
- Each elytron with two orange markings **4**
- 4 Body shining; Legs black with tarsi dark brown
..... *Dacne* (*Xenodacne*) *zonaria taiwana* Chûjô
- Body indistinctly shining; legs reddish-brown
..... *Dacne* (*Xenodacne*) *hujaiyaoi* Dai & Zhao, sp. n.

***Dacne* (*Xenodacne*) *tangliangi* Dai & Zhao, sp. n.**

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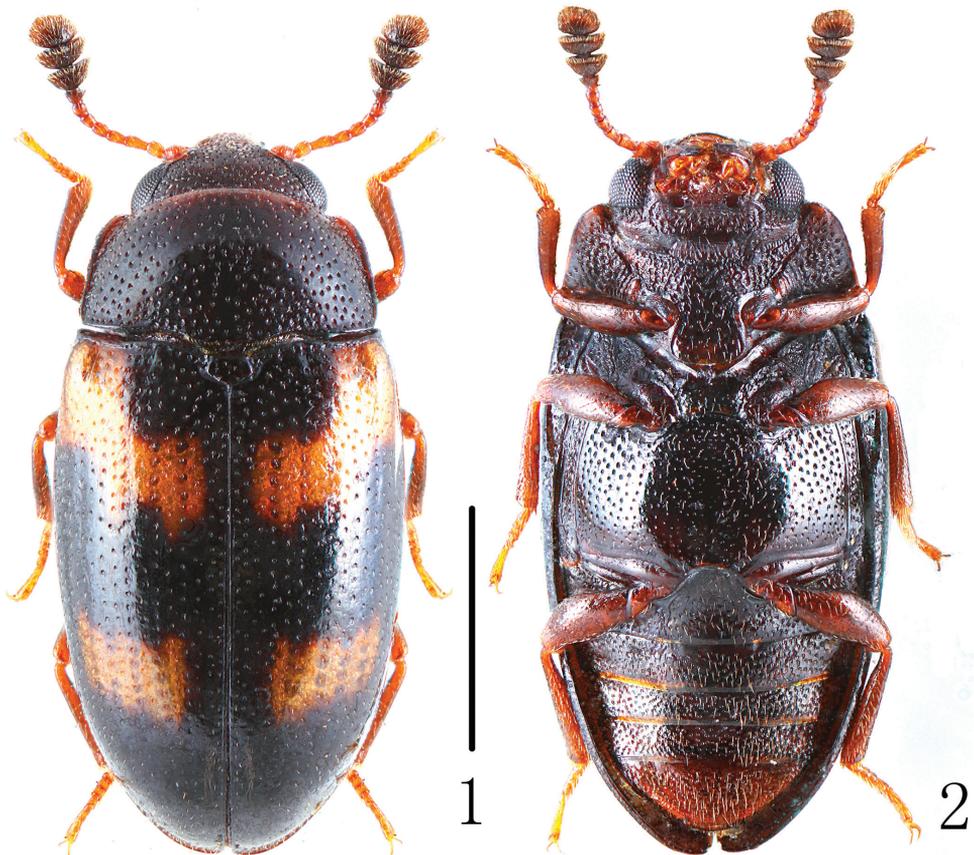
http://species-id.net/wiki/Dacne_tangliangi

Figs. 1, 2, 3–9, 19

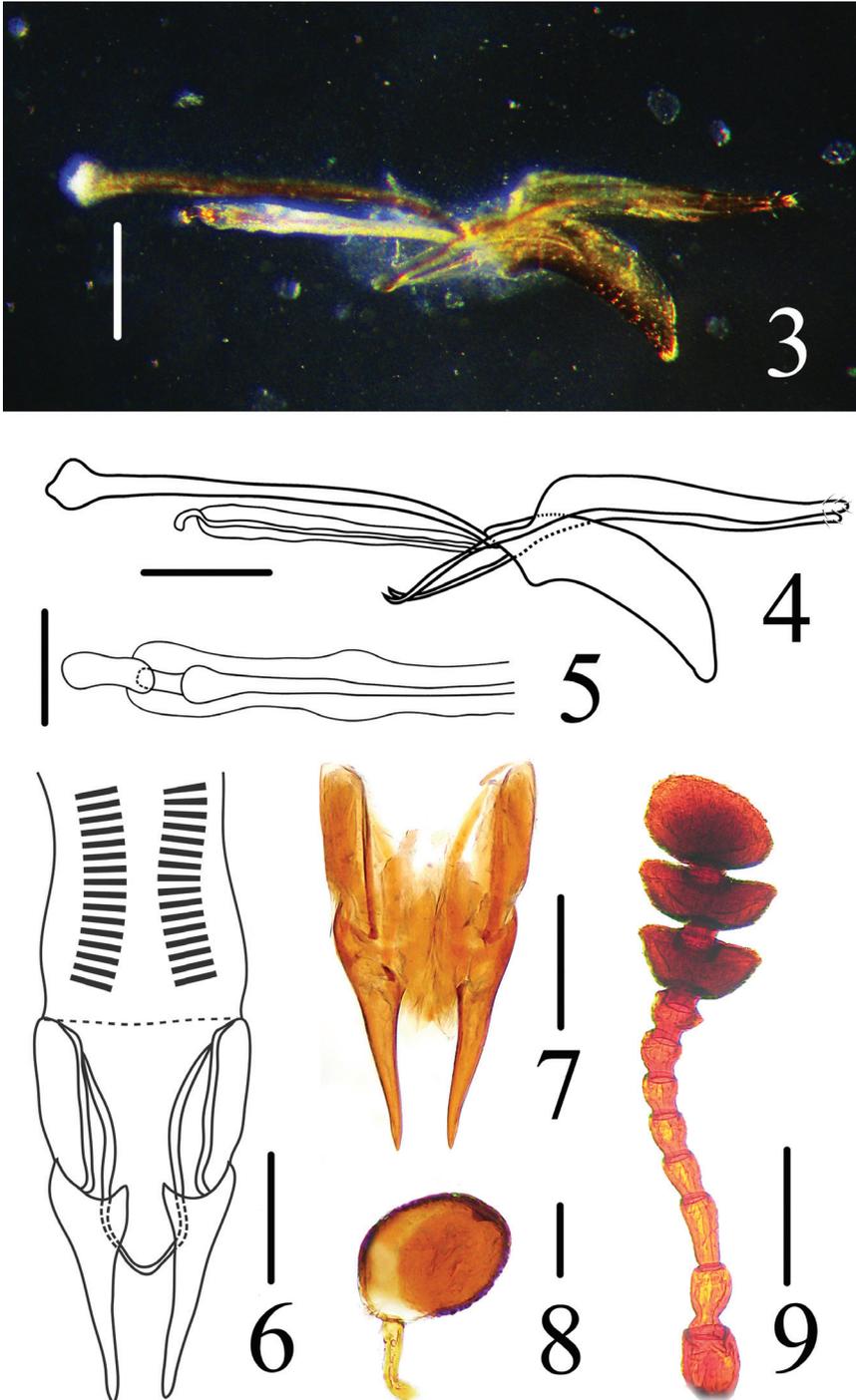
Type material. Holotype: CHINA: Yunnan Prov.: ♂, Nabanhe N.R., Benggangan, Nanmugahe, 22°06'N, 100°27'E, alt. 1700 m, 13.XI.2008, H Jia-Yao & TANG Liang leg. (SHNU). **Paratypes:** CHINA: Yunnan Prov.: 4♂♂, 4♀♀, same data as holotype (SHNU); 1♂, 1♀, same data as holotype (FSCA).

Description. Body (Fig. 1, 2) stout, elongate, length: 2.8–3.1 mm; width: 1.29–1.40 mm. Head and elytra black; pronotum general black with reddish-brown sides; legs, palpi and base of antennae reddish-brown; antennal club dark brown. Each elytron with two orange bands.

Head width between eyes = 4 times eye diameter in dorsal view; punctation coarse, sparse, separated by 3–4 puncture diameters; epistome truncate, lacking marginal line on anterior margin; stridulatory files not evident. Antennae (Fig. 9) long, extending behind



Figures 1–2. Habitus of *Dacne* (*Xenodacne*) *tangliangi* in dorsal and ventral view. Scale = 1 mm.



Figures 3–9. *Dacne (Xenodacne) tangliangi*. **3, 4** aedeagus in lateral views **5** internal sac and flagellum in dorsal view **6, 7** female genitalia in ventral views **8** female spermatheca **9** antenna. Scales = 0.05 mm(**5, 8**), Scales = 0.2 mm(**3, 4, 6, 7, 9**).

posterior border of pronotum; antennomere III about 1.4 times as long as IV; antennomere VIII slightly wider than VII, about 1.2 times as wide as long; antennomere IX trapezoidal; antennomere X transverse; antennomere XI almost elliptic; relative lengths of antennomeres II–XI: 12.5: 13.5: 8.5: 8.0: 8.0: 8.0: 8.0: 11.0: 11.0: 14.0. Maxillary and labial terminal palpomeres acuminate, sensory area restricted to apex. Mentum broad with anterior projection, almost triangular, slightly more than 2 times wider than long.

Pronotum arched, widest at base (pl/pw = 0.61–0.65); slightly narrowing toward apex; lateral margin thickened anteriorly; pronotal anterior margin normal, not projecting forward beyond anterior angles (typical for the subgenus *Xenodacne*). Pronotum distinctly punctured medially, finely and closely punctured laterally.

Prosternum with anterior edge straight, lacking marginal bead; posterior process broad, width more than diameter of procoxa; prosternal lines apparently lacking; punctures coarse and close, diameter = eye facet, separated by 1–2 puncture diameters. Abdomen with distinct coxal lines on first ventrite nearly attaining posterior margin. Legs with tibia not dilated at apex.

Scutellum pentagonal, finely and sparsely punctured.

Elytra margined basally; widest at middle, then gradually narrowing to apex; with fine punctures.

Male genitalia (Fig. 3, 4) moderately curved; median lobe short, apically pointed; median strut long, about 1.8 times as long as median lobe. Tegmen with parameres long, flattened, tightly fitting basal piece and each other. Internal sac simple (Fig. 5).

Female genitalia (Fig. 6, 7) with reduced stylus; coxite apically and curved terminally, chisel-like, length nearly equal to valvifer; paraproct narrowed apically; female spermatheca (Fig. 8) with head almost round shaped.

Distribution. China (Yunnan Province).

Diagnosis. *Dacne tangliangi* is most similar to *Dacne (Xenodacne) maculata* Chûjô due to similar form and color pattern of the body. *Dacne tangliangi* can be distinguished from *D. maculata* by the black pronotum, scutellum not transverse (length/width < 1.5), posterior band in elytron not extending to the border and occurs in southwest China. *Dacne maculata* has a reddish pronotum, scutellum transverse (length/width > 1.5), posterior band in elytron extending to the border and occurs in Japan and Siberia (Chûjô and Chûjô 1988).

Etymology. This species is named in honor of Mr. Liang Tang, collector of the new species and teacher of the senior author.

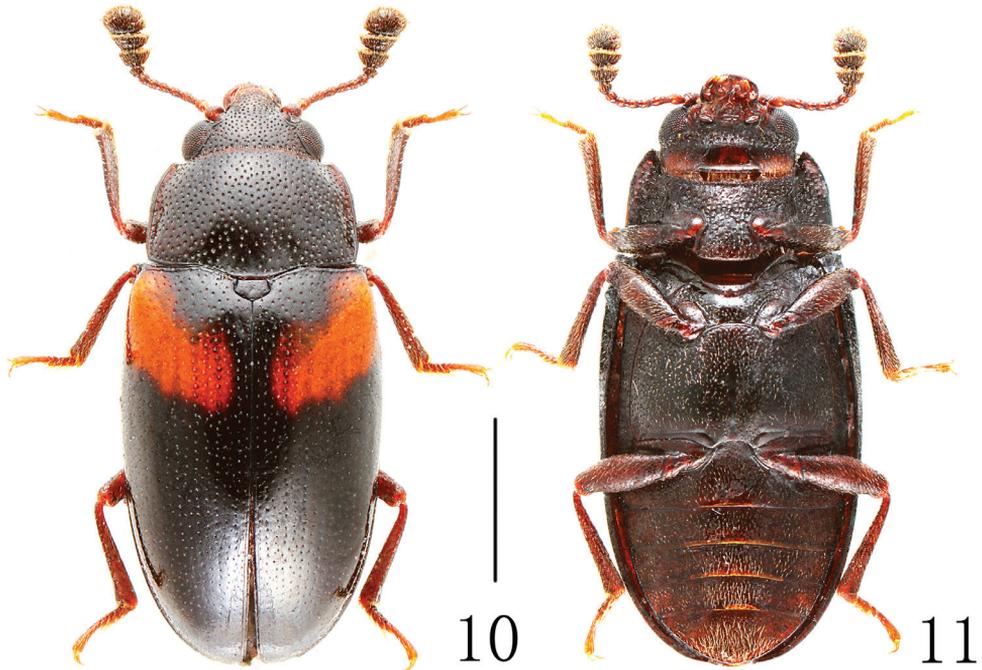
***Dacne (Xenodacne) hujiayaoi* Dai & Zhao, sp. n.**

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http://species-id.net/wiki/Dacne_hujiayaoi

Figs. 10, 11, 12–15, 17

Type material. Holotype: CHINA: Yunnan Prov.: ♂, Nabanhe N.R., Bengganhan, Nanmugahe, 22°06'N, 100°27'E, alt. 1700 m, 13.XI.2008, H Jia-Yao & TANG Liang leg. (SHNU).



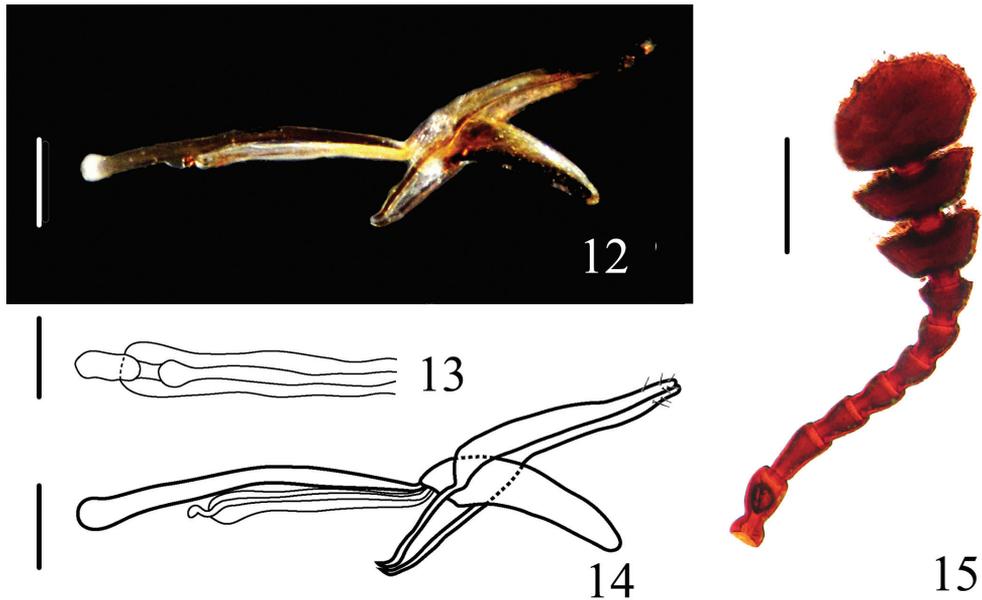
Figures 10–11. Habitus of *Dacne (Xenodacne) bujiayaoi* in dorsal and ventral view. Scale = 1 mm.

Description. Body (Fig. 10, 11) stout, elongate, length: 3.6 mm; width: 1.5 mm. Body black; legs, palpi and base of antennae reddish-brown; antennal club dark brown. Each elytron with one orange band.

Head width between eyes = 3.5 times eye diameter in dorsal view; punctuation coarse, separated by 1–3 puncture diameters; epistome truncate, lacking marginal line on anterior margin; stridulatory files not evident. Antennae (Fig. 15) long, extending behind posterior border of pronotum; antennomere III about 1.2 times as long as IV; antennomere VIII slightly wider than VII, about 1.5 times as wide as long; antennomere IX trapezoidal; antennomere X transverse; antennomere XI almost elliptic; relative lengths of antennomeres II–XI: 9.0: 11.5: 8.0: 8.0: 8.0: 8.0: 7.5: 10.0: 10.0: 17.0. Maxillary and labial terminal palpomeres acuminate, sensory area restricted to apex. Mentum broad with anterior projection, almost triangular, slightly more than 1.5 times wider than long.

Pronotum arched, widest at base ($pl/pw = 0.62$); slightly narrowing toward apex; lateral margin thickened anteriorly; pronotal anterior margin normal, not projecting forward beyond anterior angles (typical for the subgenus *Xenodacne*). Pronotum distinctly punctured medially, finely and closely punctured laterally.

Prosternum with anterior edge straight, lacking marginal bead; posterior process broad, width more than diameter of procoxa; prosternal lines apparently lacking; punctures coarse and close, diameter = eye facet, separated by 0.5–1.0 puncture diameters.



Figures 12–15. *Dacne* (*Xenodacne*) *hujiayaoi*. **12, 14** aedeagus in lateral views **13** internal sac and flagellum in dorsal view **15** antenna. Scales = 0.05 mm(**13**), Scales = 0.2 mm(**12, 14, 15**).



Figures 16–19. Habitus of Chinese species of *Dacne* in dorsal view (*Dacne zonaria taiwana* is excluded). **16** *Dacne* (*Dacne*) *japonica* **17** *Dacne* (*Xenodacne*) *hujiayaoi* **18** *Dacne* (*Dacne*) *picta* **19** *Dacne* (*Xenodacne*) *tangliangi*. Scale = 2 mm.

Abdomen with distinct coxal lines on first ventrite nearly attaining posterior margin.
Legs with tibia not dilated at apex.

Scutellum pentagonal, finely and sparsely punctured.

Elytra margined basally; widest at middle, then gradually narrowing to apex; with fine punctures.

Male genitalia (Fig. 12, 14) moderately curved; median lobe short, apically pointed; median strut long, about 1.6 times as long as median lobe. Tegmen with parameres long, flattened, tightly fitting basal piece and each other. Internal sac simple (Fig. 13).

Distribution. China (Yunnan Province).

Diagnosis. *Dacne hujiayaoi* is most similar to *Dacne (Xenodacne) zonaria* Lewis and its subspecies due to similar form and color pattern of the body. *Dacne hujiayaoi* can be distinguished from *D. zonaria* by body indistinctly shining, eyes large (head width between eyes = 3.5 times eye diameter in dorsal view), the reddish-brown legs and occurs in southwest China. *Dacne zonaria* has the body distinctly shining, eyes small (head width between eyes > 4 times eye diameter in dorsal view), the black legs and occurs in Japan, Korea, Siberia and Taiwan (Chûjô and Chûjô 1988).

Etymology. This species is named in honor of Mr. Jia-Yao Hu, collector of the new species and teacher of the senior author.

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An illustrated key to and diagnoses of the species of Histeridae (Coleoptera) associated with decaying carcasses in Argentina

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Abstract

A key to 16 histerid species associated with decaying carcasses in Argentina is presented, including diagnoses and habitus photographs for these species. This article provides a table of all species associated with carcasses, detailing the substrate from which they were collected and geographical distribution by province. All 16 Histeridae species registered are grouped into three subfamilies: Sapriniinae (twelve species of *Euspilotus* Lewis and one species of *Xerosaprinus* Wenzel), Histerinae (one species of *Hololepta* Paykull and one species of *Phelister* Marseul) and Dendrophilinae (one species of *Carcinops* Marseul). Two species are new records for Argentina: *Phelister rufinotus* Marseul and *Carcinops troglodytes* (Paykull). A discussion is presented on the potential forensic importance of some species collected on human and pig carcasses.

Keywords

Key, Histeridae, Sapriniinae, forensic, carcasses, Argentina

Introduction

Coleoptera is one of the major orders of insects represented on carcasses and its forensic importance has been frequently documented (Benecke 1988, Kulshrestha and Satpathy 2001, Schroeder et al. 2002). Among the most important families mentioned in the literature are: Dermestidae, Cleridae, Histeridae, Staphylinidae, Nitidulidae, Scarabaeidae, Tenebrionidae, and Trogidae (Mise et al. 2007, Ösdermir and Set 2009, Almeida and Mise 2009, Battán Horenstein and Linhares 2011). Members of these families are associated with carcasses due to different trophic roles of adults or their immature stages, which can feed on cadaveric tissues (necrophagous) or on other insects in the body, such as larvae of Diptera or other Coleoptera species (necrophilous).

Histeridae comprises 4252 species and 391 genera worldwide, grouped in 11 subfamilies (Mazur 2011), with 139 genera and 1047 species in the Neotropical region (Almeida and Mise 2009). They are mostly predators of soft-bodied insect larvae and eggs, particularly of cycloraphan Diptera, whose larvae develop on carcasses and dung of large mammals. The odoriferous products of microbial degradation attract both flies and histerids via olfaction (Kovarik and Catherino 2001).

Due to the fact that the Diptera colonize the body from the beginning of the decomposition process (Goff 1993), they have been the group most used for estimating Post Mortem Interval (PMI) within short periods after death. However, they have little usefulness after several weeks or months, when the body is in advanced stages of decomposition. Although histerids are less abundant than flies in the scavenger community, they complete its life cycle in the body (Aballay pers. obs.). Thus, histerids may be helpful when a long time has elapsed since death. Adult histerids reach their highest abundance in intermediate stages of decomposition such as Active and Advanced Decay (Ösdermir and Set 2009) and can cause a remarkable decrease in the number of immature stages of Diptera: Calliphoridae (Nuorteva 1970).

Histerid adults have been frequently mentioned in forensic studies on decomposing pig carcasses (Wolff et al. 2001, Centeno et al. 2002, Aballay et al. 2008, Özdemir and Sert 2009, Battán Horenstein and Linhares 2011, Battán Horenstein et al. 2012, Aballay 2012) and on human corpses (Arnaldos et al. 2005, Mariani et al. 2010, Aballay obs. pers.). The correct identification of insects and knowledge of their life history as well as the duration of each stage of development leads to accurately establishing the PMI (Turchetto and Vanin 2004). In South America, the usefulness of histerids as PMI indicators has not been established due to the absence of taxonomic keys that allow their determination, as well as minimal documentation of detailed life histories. In previous forensic studies in the continent, histerids were identified to family level (Mariani et al. 2010), most to generic level (Carvalho et al. 2000, Wolff et al. 2001, Mise et al. 2007, Segura et al. 2009, Battán Horenstein and Linhares 2011, Battán Horenstein et al. 2012) and a few to species level (Centeno et al. 2002, Oliva and Ravioli 2004, Aballay et al. 2008, Mise et al. 2010). A key to the main families of South American Coleoptera of forensic importance was recently published (Almeida and Mise 2009), which includes histerids mentioned for some South American countries.

In this key, only six genera and two species were determined for Histeridae, and it does not include most of the species collected in Argentina in decomposition assays (Aballoy et al. 2008). For these reasons, it is necessary to have a tool that allows determination of the necrophilous species of Histeridae.

The objective of this paper is to provide an illustrated key to the histerid species associated with decaying carcasses in Argentina to achieve their correct identification. Additionally, diagnoses for these species are presented.

Material and methods

A total of 7070 specimens were collected mostly during forensic studies on decomposing pig carcasses because it is the preferred animal model for forensic entomological studies (Goff 1993). These decomposition experiments were conducted in three Argentinean provinces with arid conditions: Mendoza, San Juan and Catamarca. Histerids were collected during the entire decomposition process on 16 pig carcasses. In Mendoza, the study was carried out at the campus of Instituto Argentino de Investigaciones de las Zonas Áridas, CCT CONICET-Mendoza (32° 53'53.3"S, 68°52' 26.2"W, 850 m altitude) collecting histerids on 12 pig carcasses, during the four seasons of the year. In San Juan, histerids were collected on two decomposing pig carcasses in summer at the campus of Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de San Juan (31°32'34.1"S, 68°34'38.2"W, 673 m altitude). In Catamarca, histerids were collected on two decomposing pig carcasses during spring in Antofagasta de la Sierra (26°01'32.3"S, 67°20'36.5"W, 3600 m altitude).

In addition specimens from decomposing pig carcasses were recorded in the provinces of Salta (24°54'40"S, 65°28'16"W, 1379 m altitude) and Jujuy (24°09'54.13"S, 65°18'37.73"W, 1383 m altitude), with mesic conditions. For collecting and conserving specimens the methodology followed was that by Centeno et al. (2002) and Aballoy et al. (2008, 2012).

Other Histeridae specimens were obtained using three kinds of collecting procedures, the first was conducted on human corpses at different places in Mendoza province authorized by the Medical Forensic Committee of Mendoza; the second was conducted in field trips in different Argentinean provinces on carcasses of cow (*Bos taurus*), horse (*Equus caballus*), donkey (*Equus asinus*), dog (*Canis familiaris*), snake (not identified), Geoffroy's cat (*Leopardus geoffroyi*), llama (*Lama glama*), guanaco (*Lama guanicoe*), vicuña (*Vicugna vicugna*), sheep (*Ovis orientalis*), fox (*Lycalopex griseus*), lesser rhea (*Pterocnemia pennata*), rat (*Eligmodontia typus*) all found outdoors; the third type of collection was using traps baited with rotting flesh of chicken, squid and sardine in different provinces of Argentina.

Voucher specimens are deposited in the entomological collections of the Instituto Argentino de Investigaciones de las Zonas Áridas (Mendoza, Argentina) and Museo Nacional de Historia Natural (Santiago, Chile).

Specimens were cleaned with water and detergent using a Haier ultrasonic cleaner. Diagnoses were made using a Bausch and Lomb stereomicroscope with magnification between 45 \times and 60 \times . Measurements (given in millimeters) were taken with an ocular micrometer. Body length was measured from anterior angle of pronotum to elytral apex, without including head and abdominal terga (propygidium and pygidium) and defined as follows: small 0.5–1.9 mm, medium 2.0–3.9 mm and large 4.0–8.0 mm. Body width was measured at maximum width of elytra, in humeral part. Terminology follows Lackner (2010). The main striae and parts of the body depicted in Figs 1 and 2 were taken from Lackner (2010). Digital photographs of the specimens were taken with a Canon S50 adapted to a Leica MZ6 stereomicroscope. Final images of the specimens (Figs 3–22) were produced with the image stacking freeware CombineZM (Hadley 2006).

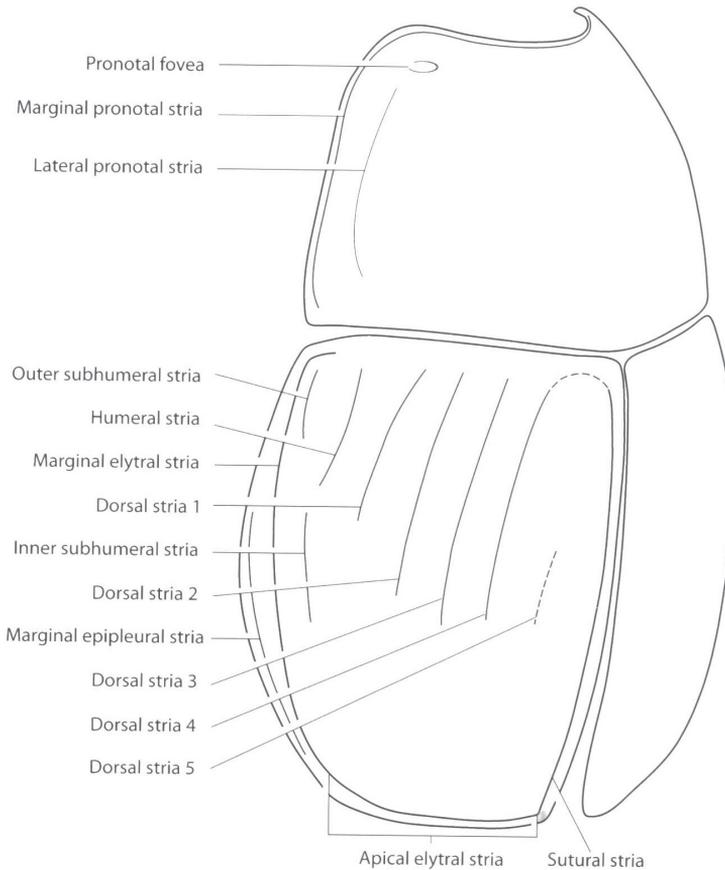


Figure 1. Sapriniinae, schematic. Pronotum and elytra, oblique lateral view (taken from Lackner 2010).

Results

The list of histerids of forensic importance in Argentina comprises 16 species distributed in 13 provinces (Table I). In order to enable a more accurate use of the key, diagnosis of each species with habitus photographs are provided.

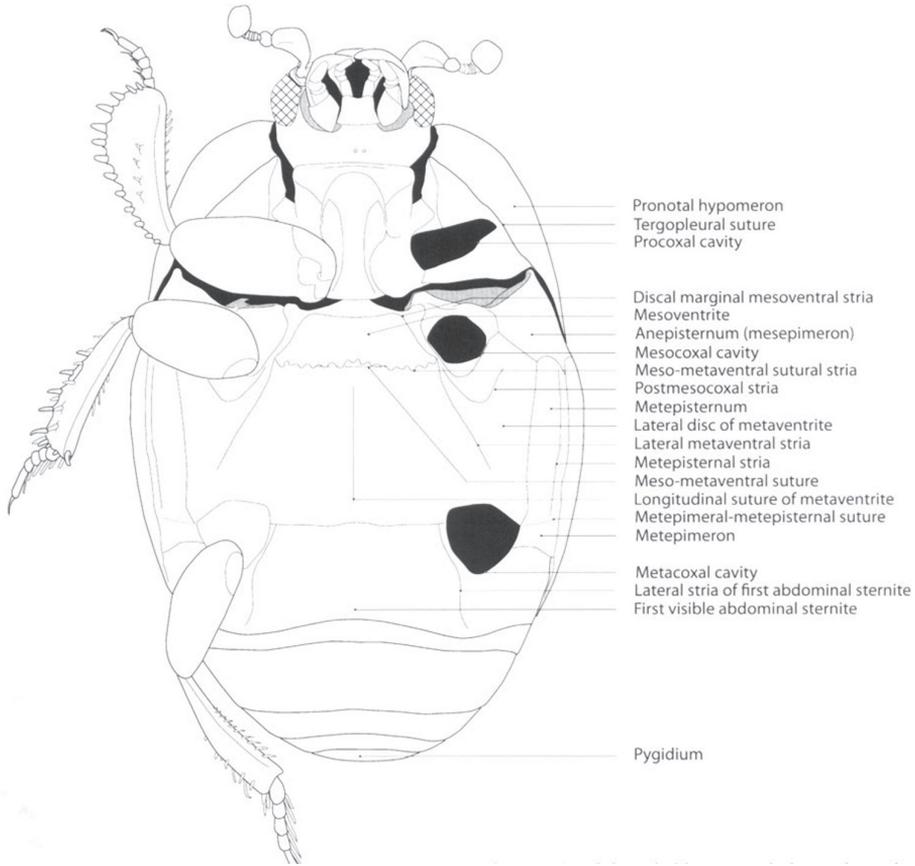


Figure 2. Sapriniinae, schematic. Habitus, ventral view (taken from Lackner 2010).

Key to species of Histeridae associated with carcasses in Argentina

- 1. Prosternal lobe present (Fig. 3) 2
- 1' Prosternal lobe absent (Fig. 4)..... 4
- 2. Labrum with setae (Fig. 5)..... *Carcinops (Carcinops) troglodytes* (Paykull)
- 2' Labrum without setae 3
- 3 Head prognathous, not retractile; mandibles long, prominent, as long as head; pronotum and elytra lacking punctures; length greater than 6.9 mm (Fig.6)..... *Holelepta (Leionota) reichii* Marseul
- 3' Head hypognathous, retractile; mandibles short, as long as half of head; pronotum and elytra with finer and sparse punctation; length less than 1.5 mm (Fig. 7)..... *Phelister rufinotus* Marseul
- 4 Pronotal hypomeron setose in dorsal view 5
- 4' Pronotal hypomeron glabrous in dorsal view 10
- 5 Elytron with five dorsal striae, the fifth between the fourth dorsal and sutural striae (Fig. 8) *Euspilotus (sensu stricto) lacordairei* (Marseul)

- 5' Elytron with four dorsal striae, fifth stria absent (Figs 9, 10, 13–15) 6
- 6 Elytron black, lacking spots (Figs 9, 10) 7
- 6' Elytron black with orange, yellow or white spots (Figs 13–15) 8
- 7 Outer margin of protibiae with teeth much expanded and 6 denticles (Fig. 11); elytron with coarse and dense punctation, with a shining area with finer and sparse punctation between the fourth dorsal and sutural striae, narrowed apically; length greater than 4.4 mm (Fig. 9)
..... *Euspilotus (sensu stricto) patagonicus* (Blanchard)
- 7' Outer margin of protibiae with teeth moderately expanded and 7-8 denticles (Fig. 12); elytron with very coarse and dense punctation, with a shining impunctate area between the fourth dorsal and sutural striae, wider apically; length less than 2.9 mm (Fig. 10) *Xerosaprinus (Xerosaprinus) diptychus* (Marseul)
- 8 Elytral spot with a digitiform projection towards apex (Fig. 13)
..... *Euspilotus (sensu stricto) richteri* Lewis
- 8' Elytral spot straight on distal edge (Figs 14–15) 9
- 9 Elytral spot with two digitiform projections anterad, the outer one close to but not reaching the basal edge (Fig. 14)
..... *Euspilotus (sensu stricto) lepidus* (Erichson)
- 9' Elytral spot with three digitiform projections anterad, away from basal edge (Fig. 15) *Euspilotus (sensu stricto) ornatus* (Blanchard)
- 10 Anterior half of elytron with very coarse and dense punctation, with a shining impunctate area between the fourth dorsal and sutural striae (Fig. 16)
..... *Euspilotus (Hesperosaprinus) caesopygus* (Marseul)
- 10' Anterior half of elytron with finer and sparse punctation, lacking shining impunctate areas (Figs 17–22) 11
- 11 Dorsal elytral striae 3–4 present, well demarcated on anterior half (Figs 17–20) 12
- 11' Dorsal elytral striae 3 absent or marked as a row of impressed punctures on basal area, stria 4 present or reduced to a rounded arch basally connected to the sutural stria (Figs 21–22) 15
- 12 Pronotum with a single fovea on each side close to anterior angles or with a longitudinal lateral depression on each side close to lateral margins with coarse and dense punctation (Figs 17–18) 13
- 12' Pronotum lacking fovea or longitudinal lateral depression (Figs 19–20) 14
- 13 Pronotum with a single depression on each side close to anterior angles, with coarse and dense punctation; distal half of elytra, propygidium and pygidium with ocellate punctation, a small puncture within a large puncture (Fig. 17)
..... *Euspilotus (Hesperosaprinus) strobili* (Steinheil)
- 13' Pronotum with a longitudinal lateral depression on each side, with coarse and dense punctation; distal half of elytra, propygidium and pygidium with regular punctation (Fig. 18) ... *Euspilotus (Hesperosaprinus) pavidus* (Erichson)

- 14 Elytron with inner subhumeral stria; length greater than 2.5 mm (Fig. 19) ..
.....*Euspilotus (Hesperosaprinus) modestus* (Erichson)
- 14' Elytron lacking inner subhumeral stria; length less than 2.2 mm (Fig. 20)....
.....*Euspilotus (Hesperosaprinus) parenthesis* (Schmidt)
- 15 Pronotum with marginal stria away from lateral margin; pygidium with a
transverse subapical groove not reaching lateral margins (Fig. 21).....
.....*Euspilotus (Hesperosaprinus) connectens* (Paykull)
- 15' Pronotum with marginal stria very close to lateral margin; pygidium with a
transverse subapical groove reaching lateral margins (Fig. 22).....
.....*Euspilotus (Hesperosaprinus) azureus* (Salberg)

Diagnoses of species

Carcinops (Carcinops) troglodytes (Paykull)

http://species-id.net/wiki/Carcinops_troglodytes

Figures 3, 5

Diagnosis. Small size (length: 2.1–2.3 mm, width: 1.4–1.6 mm). Body oval, elongated, parallel, black, shiny, with reddish legs. Pronotum with finer and sparse punctation, longer on lateral area, with a large puncture on medial part close to posterior margin. Pronotal hypomeron glabrous in dorsal view. Elytron with finer and sparse punctation in intervals; dorsal elytral striae 1–5 complete, well demarcated with punctures, sutural stria present, reduced on basal part. Pygidium without grooves. Protibiae with teeth expanded and 2 short, separated denticles and a long apical spur; proximal half of outer margin serrate, with small spurs.

Distribution. Cosmopolitan (Mazur 2011). **New record for Argentina.**

Hololepta (Leionota) reichii Marseul

http://species-id.net/wiki/Hololepta_reichii

Figure 6

Diagnosis. Large size (length: 6.9 mm, width: 5.3 mm). Body black, shiny, depressed, elongated, parallel, head prognathous, not retractile, mandibles long, prominent, as long as head. Pronotum lacking punctures, with marginal stria well demarcated, in males ending in a fovea on anterior angles. Pronotal hypomeron glabrous in dorsal view. Elytron lacking spot and punctures, with only two dorsal striae, first stria reduced to anterior half, second complete, almost reaching apex. Propygidium larger than pygidium, pygidium without grooves. Protibiae with four teeth, the two distal ones longer.

Distribution. Argentina, Brazil, French Guiana, Mexico and Central America (Mazur 1984, 2011).



Figures 3–4. Prosternum in ventral view. **3** *Carcinops (Carcinops) troglodytes* **4** *Euspilotus (Hesperosaprinus) modestus*.

***Phelister rufinotus* Marseul**

http://species-id.net/wiki/Phelister_rufinotus

Figure 7

Diagnosis. Small size (length: 1.5 mm, width: 1.3 mm). Body oval, black, shiny, with elytron reddish or black rufescent. Pronotum with finer and sparse punctation, larger on medial part close to posterior margin. Pronotal hypomeron glabrous in dorsal view. Elytron with finer and sparse punctation in intervals; dorsal elytral striae 1–4 complete, fifth present on distal half and with a large basal puncture; sutural stria present on distal half. Pygidium with finer and dense punctation and without grooves. Protibiae with outer margin not expanded and with 7 separated denticles.

Distribution. Brazil (Mazur 2011). **New record for Argentina.**

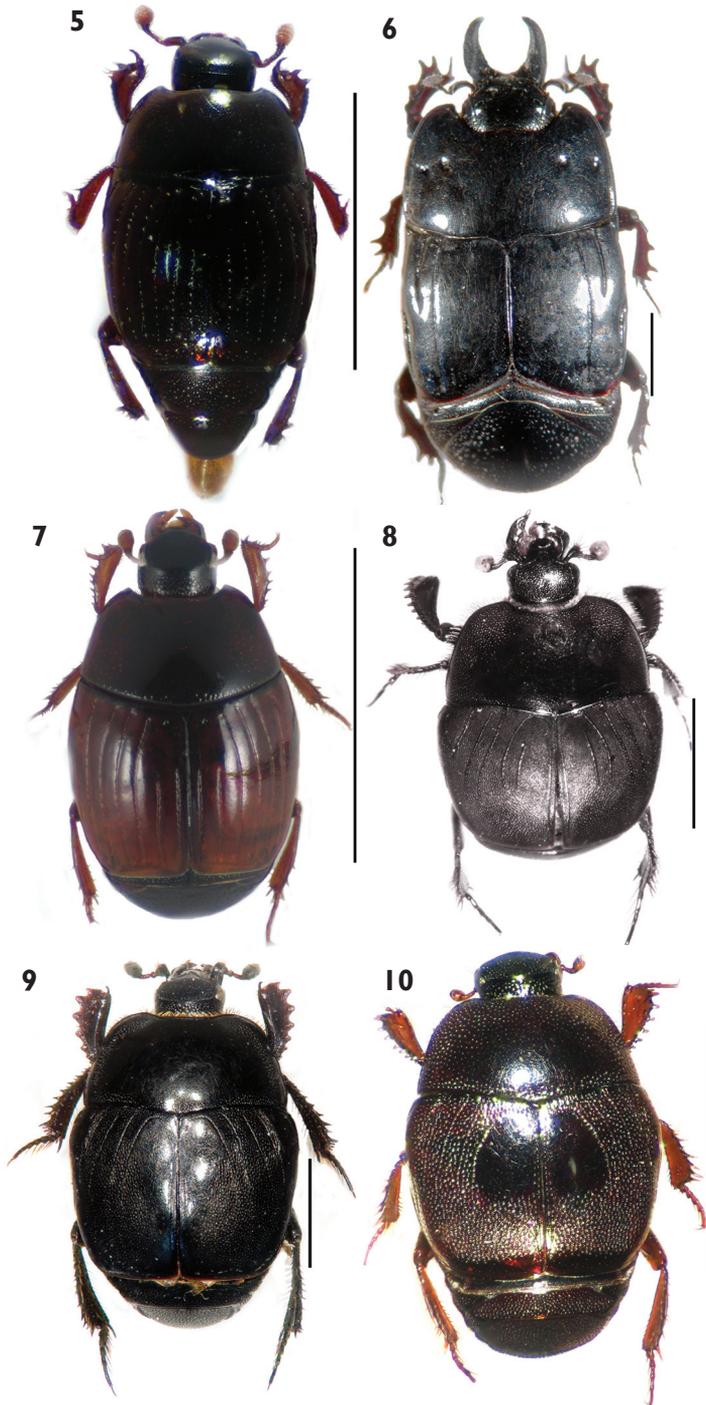
***Xerosaprinus (Xerosaprinus) diptychus* (Marseul)**

http://species-id.net/wiki/Xerosaprinus_diptychus

Figures 10, 12

Diagnosis. Small to medium size (length: 1.8–2.9 mm, width: 1.7–2.4 mm). Body oval, black to dark brown, shiny. Pronotum with coarse and dense punctation on anterior, lateral and basal areas, disc small, with finer and sparse punctation. Pronotal hypomeron setose in dorsal view. Elytron with coarse and very dense punctation seemingly rugose on distal half and on proximal half in intervals 1–3, with a smooth, shining area between the fourth dorsal stria, the sutural stria and the rounded arch; elytral dorsal striae 1–4 complete on anterior half, sometimes the first and third vestigial, fourth and sutural striae connected by a rounded arch. Pygidium without grooves. Protibiae with teeth moderately expanded and 7–8 denticles (Fig. 12).

Distribution. Mexico (Mazur 2011) and Argentina (Aballay et al. 2008, 2012).



Figures 5–10. Habitus in dorsal view. **5** *Carcinops* (*Carcinops*) *troglydytes* **6** *Hololepta* (*Leionota*) *reichii*. **7** *Pbelister rufinotus* **8** *Euspilotus* (s. str.) *lacordairei* **9** *Euspilotus* (s. str.) *patagonicus* **10** *Xerosaprinus* (*Xerosaprinus*) *diptychus*. Scale bars: 2 mm. Scale bars: 2 mm.

***Euspilotus (sensu stricto) lacordairei* (Marseul)**

http://species-id.net/wiki/Euspilotus_lacordairei

Figure 8

Diagnosis. Medium to large size (length: 3.4–4.5 mm, width: 3.3–3.8 mm). Body black reddish. Pronotum with coarse and dense punctation on anterior, lateral and basal areas, disc small, with finer and sparse punctation. Pronotal hypomeron setose in dorsal view. Elytron with coarse and dense punctation on distal half, projecting anterad in intervals 1–3, shortest in interval 4; with five dorsal striae well demarcated, 1–4 complete on anterior half, fifth reduced between the fourth dorsal and sutural striae, fourth and sutural striae connected by a rounded arch. Pygidium without grooves. Protibiae with expanded outer margin and 10–11 short, reddish denticles.

Distribution: Argentina, Bolivia and Chile (Mazur 2011; Aballay et al. 2008, 2012).

***Euspilotus (sensu stricto) patagonicus* (Blanchard)**

http://species-id.net/wiki/Euspilotus_patagonicus

Figures 9, 11

Diagnosis. Large size (length: 4.4–5.8 mm, width: 3.9–4.7 mm). Body black. Pronotum with large, shiny disc, with finer and sparse punctation, lateral and basal areas with coarse and dense punctation, with a punctate depressed area on anterior angles, without punctures behind anterior margin. Pronotal hypomeron setose in dorsal view. Elytron with coarse and dense punctation on distal half, projecting towards anterior half in intervals 1–4, not reaching inner subhumeral stria, the basal area of fourth and sutural striae, with a shining area with finer and sparse punctation between the fourth dorsal and sutural striae, narrowed apically; elytral dorsal striae 1–4 complete on anterior half, sutural stria sometimes absent in (on) basal part. Pygidium without grooves. Protibiae with teeth much expanded and 5–6 short denticles wider on base (Fig. 11).

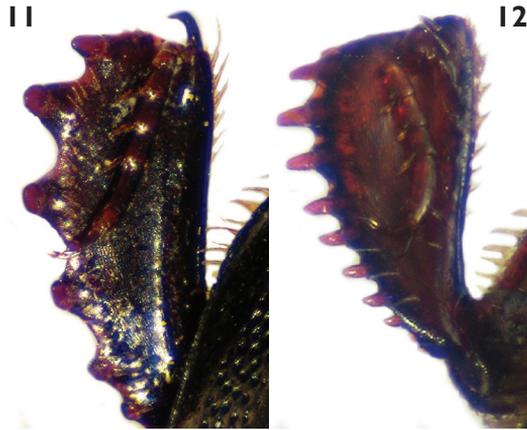
Distribution. Argentina, Bolivia and Chile (Mazur 2011).

***Euspilotus (sensu stricto) richteri* Lewis**

http://species-id.net/wiki/Euspilotus_richteri

Figure 13

Diagnosis. Medium size (length: 2.3–3.8 mm, width: 2.1–3.4 mm). Body black, elytron with yellow or white spot. Pronotum with finer and sparse punctation, with a longitudinal lateral area on each side with coarse and dense punctation reaching the marginal stria, with two rows of large punctures on base. Pronotal hypomeron setose in dorsal view. Elytron with punctation coarse and dense on posterior half, finer and sparser on anterior half between intervals 2, 3 and 4; elytral dorsal striae 1–4 complete



Figures 11–12. Protibia in dorsal view. **11** *Euspilotus* (s. str.) *patagonicus* **12** *Xerosaprinus* (*Xerosaprinus*) *diptychus*.

on anterior third, third stria sometimes reduced in basal area, fourth and sutural striae connected by a rounded arch; elytral spot with a digitiform projection towards apex, with two digitiform projections anterad, the outer one between the first and third dorsal elytral striae, the inner one between the fourth dorsal and sutural striae, sometimes between anterior margin, first and fourth dorsal striae and humerus with small yellow spots, making the anterior margin of the large elytral spot fuzzy. Pygidium: female with subapical groove V-shaped, male without grooves. Protibiae with outer margin expanded and 11–12 short, reddish denticles.

Distribution. Argentina, Chile and Paraguay (Mazur 2011).

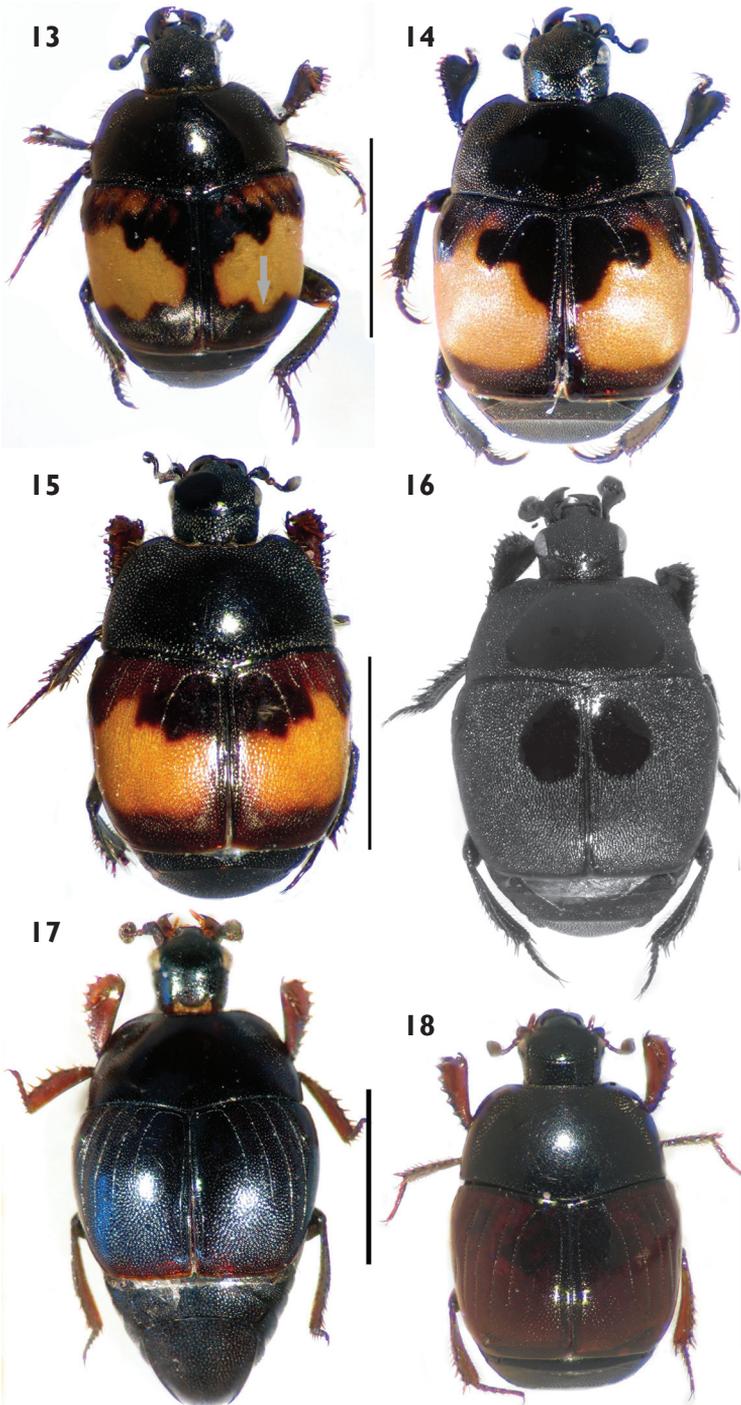
***Euspilotus* (sensu stricto) *lepidus* (Erichson)**

http://species-id.net/wiki/Euspilotus_lepidus

Figure 14

Diagnosis. Medium size (length: 2.3–3.3 mm, width: 1.86–2.3 mm). Body black, elytron with yellow or white spot. Pronotum with finer and sparse punctation, with a shining area on disc, with a longitudinal lateral area on each side with coarse and dense punctation, with two rows of large punctures on base. Pronotal hypomeron setose in dorsal view. Elytron with punctation coarse and dense on posterior half, finer and sparser on anterior half defining a shining area between intervals 2, 3 and 4; elytral dorsal striae 1, 2 and 4 complete on anterior half, third stria reduced to a short row of punctures on basal area, fourth and sutural striae connected by a rounded arch; elytral spot with distal margin straight and two digitiform projections anterad, the outer one between the first and second (or third) dorsal striae, the inner one towards the fourth dorsal elytral stria. Pygidium without grooves. Protibiae with outer margin expanded and 10–13 denticles.

Distribution. Argentina, Bolivia, Chile, and Peru (Mazur 2011).



Figures 13–18. Habitus in dorsal view. **13** *Euspilotus* (s. str.) *richteri* **14** *Euspilotus* (s. str.) *lepidus* **15** *Euspilotus* (s. str.) *ornatus* **16** *Euspilotus* (*Hesperosaprinus*) *caesopygus* **17** *Euspilotus* (*Hesperosaprinus*) *strobili* **18** *Euspilotus* (*Hesperosaprinus*) *pavidus*. Scale bars: 2 mm.

***Euspilotus (sensu stricto) ornatus* (Blanchard)**

http://species-id.net/wiki/Euspilotus_ornatus

Figure 15

Diagnosis. Medium size (length: 2.5–3.5 mm, width: 2.3–3.2 mm). Body black, elytron with yellow or orange spot. Pronotum: disc with finer and sparse punctation, lateral areas and base with coarse and dense punctation. Pronotal hypomeron setose in dorsal view. Elytron with punctation coarse and dense on posterior half, finer and sparser on anterior half defining a shining area between intervals 3 and 4; elytral dorsal striae 1–2 and 4 complete on anterior half, third interrupted, fourth and sutural striae connected by a rounded arch; elytral spot occupying the distal half of elytron with distal margin straight and three digitiform projections anterad, the outer one between the first and second dorsal striae, the medial one between the third and fourth dorsal elytral striae, and the inner one close to the sutural elytral stria. Pygidium without grooves. Protibiae with outer margin expanded and 8–10 short, reddish denticles.

Distribution. Argentina and Chile (Mazur 2011; Aballay et al. 2008, 2012).

***Euspilotus (Hesperosaprinus) caesopygus* (Marseul)**

http://species-id.net/wiki/Euspilotus_caesopygus

Figure 16

Diagnosis. Medium to large size (length: 3.2–4.3 mm, width: 2.7–3.7 mm). Body black. Pronotum with coarse and dense punctation, disc small, with finer and sparse punctation. Pronotal hypomeron glabrous in dorsal view. Elytron with coarse and very dense punctation seemingly rugose, dorsal elytral striae 1–4 absent or vestigial, sutural stria present, lacking rounded arch, with a shining area on anterior half between the fourth dorsal and sutural striae which presents a finer and sparse punctation visible only at 60× magnification. Pygidium: female with subapical groove, male without grooves. Protibiae with outer margin expanded and 10 short, reddish denticles.

Distribution. Argentina and Bolivia (Mazur 2011).

***Euspilotus (Hesperosaprinus) strobeli* (Steinheil)**

http://species-id.net/wiki/Euspilotus_strobeli

Figure 17

Diagnosis. Medium to large size (length: 3.5–4.0 mm, width: 2.9–3.9 mm). Body black to metallic blue. Pronotum with a large, shiny disc with finer and sparse punctation, with coarse and dense punctation on lateral area and in a single depression on each side close to anterior angles. Pronotal hypomeron glabrous in dorsal view. Elytron with finer and sparse punctation in the intervals on proximal half; distal half with coarse and dense ocellate punctation, a small puncture within a large puncture, with

a smooth, shining area between the fourth dorsal and sutural striae; elytral striae 1-2 almost complete, 3-4 reduced but surpassing the middle of elytron on posterior half, fourth dorsal and sutural striae connected by a rounded arch, lacking inner subhumeral stria. Pygidium with ocellate punctation and with a complete subapical groove in the middle with internal ramifications. Protibiae with outer margin expanded and 7–8 short, reddish denticles.

Distribution. Argentina and South Brazil (Mazur 2011).

Euspilotus (Hesperosaprinus) pavidus (Erichson)

http://species-id.net/wiki/Euspilotus_pavidus

Figure 18

Diagnosis. Medium size (length: 2.4–3.8 mm, width: 2.1–3.2 mm). Body black with elytron dark reddish. Pronotum with large, shiny, and smooth disc with finer and sparse punctation; anterior, lateral and basal areas with coarse and dense punctation, with two longitudinal, lateral, depressed punctate areas. Pronotal hypomeron glabrous in dorsal view. Elytron with coarse and dense punctation on distal third from interval 2 to sutural stria, on proximal half with finer and sparse punctation in intervals 1-4; elytral striae 1-2 almost complete, second longer than first, 3-4 surpassing the middle of elytron on posterior half, with inner subhumeral stria well demarcated, sometimes reduced. Pygidium with punctures, without grooves. Protibiae with outer margin expanded and 7–8 short, reddish denticles.

Distribution. Argentina, Bolivia, Brazil, French Guiana, Paraguay, Uruguay, Suriname, and Central America (Arriagada 1987; Mazur 2011; Aballay et al. 2008, 2012).

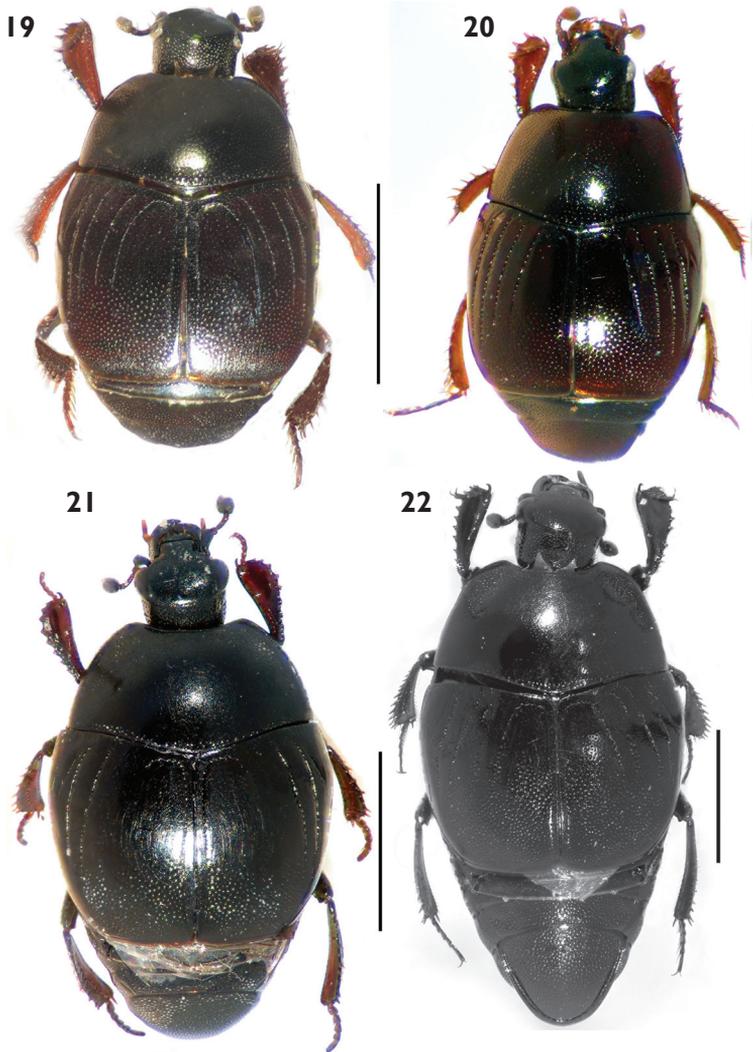
Euspilotus (Hesperosaprinus) modestus (Erichson)

http://species-id.net/wiki/Euspilotus_modestus

Figures 4, 19

Diagnosis. Medium to large size (length: 2.5–4.0 mm, width: 2.4–2.7 mm). Body black to reddish. Pronotum with fine and sparse punctation on disc, larger and deeper on lateral area. Pronotal hypomeron glabrous in dorsal view. Elytron with finer and sparse punctation in the intervals on proximal half; distal half with coarse and dense punctation, apically the punctures form elongate wrinkles; elytral striae 1-4 well demarcated, 1-2 surpassing the middle of elytron on posterior half, 3-4 reduced to anterior half; with inner subhumeral stria well demarcated. Pygidium with coarse and dense punctation, with two short transverse grooves or two longitudinal depressions. Protibiae with outer margin expanded and 8–9 short, reddish denticles, the basal fourth very small.

Distribution. Argentina, Brazil, French Guiana, Paraguay, Uruguay and Venezuela (Mazur 2011; Aballay et al. 2008, 2012).



Figures 19–22. Habitus in dorsal view. **19** *Euspilotus* (*Hesperosaprinus*) *modestus* **20** *Euspilotus* (*Hesperosaprinus*) *parenthesis* **21** *Euspilotus* (*Hesperosaprinus*) *connectens* **22** *Euspilotus* (*Hesperosaprinus*) *azureus*. Scale bars: 2 mm.

***Euspilotus* (*Hesperosaprinus*) *parenthesis* (Schmidt)**

http://species-id.net/wiki/Euspilotus_parenthesis

Figure 20

Diagnosis. Small to medium size (length: 1.7–2.2 mm, width: 1.3–1.8 mm). Body black reddish. Pronotum with fine and sparse punctation over the whole surface area, larger on lateral area. Pronotal hypomeron glabrous in dorsal view. Elytron with coarse and dense punctation on distal half, with finer and sparse punctation in the intervals

on proximal half; elytral striae 1–2 almost complete, 3–4 reduced but surpassing the middle of elytron on posterior half; lacking inner subhumeral stria. Pygidium with coarse and dense punctation with or without a short subapical groove, if present it is parenthesis-shaped and concave anterad, not reaching lateral margin of pygidium. Protibiae with outer margin expanded and 7–8 short, reddish denticles.

Distribution. Brazil (Mazur 2011) and Argentina (Aballay et al. 2008, 2012).

***Euspilotus (Hesperosaprinus) connectens* (Paykull)**

http://species-id.net/wiki/Euspilotus_connectens

Figure 21

Diagnosis. Medium to large size (length: 2.6–3.8 mm, width: 2.2–3.2 mm). Body black. Pronotum with a large, shiny disc with finer and sparse punctation, with coarse and dense punctation on lateral and basal areas and in a single rounded, shallow depression on each side close to anterior angles; with marginal stria away from lateral margin. Pronotal hypomeron glabrous in dorsal view. Elytron with proximal 2/3 lacking punctures, distal third with coarse and dense punctation between the second elytral dorsal and sutural striae; elytral dorsal striae 1–2 almost complete, second larger, third absent or reduced to a short row of punctures on basal area, fourth absent or reduced to a short row of punctures on basal area connected by a rounded arch with sutural stria. Pygidium with punctures and with a transverse subapical groove not reaching lateral margins. Protibiae with outer margin expanded and 7–8 short, reddish denticles.

Distribution. Argentina, Brazil and Uruguay (Mazur 2011).

***Euspilotus (Hesperosaprinus) azureus* (Sahlberg)**

http://species-id.net/wiki/Euspilotus_azureus

Figure 22

Diagnosis. Medium to large size (length: 2.9–5.5 mm, width: 2.5–4.7 mm). Body black or metallic blue. Pronotum with a large, shiny disc with finer and dense punctation visible only at 60× magnification, larger on lateral areas and in a single depression on each side close to anterior angles; with marginal stria very close to lateral margin. Pronotal hypomeron glabrous in dorsal view. Elytron with finer and sparse punctation in the intervals on proximal half; distal half with coarse and dense punctation between the second interval and sutural stria; elytral dorsal striae 1–2 almost complete, third absent or reduced to a short row of punctures on basal area, fourth complete on anterior half, fourth and sutural striae connected by a rounded arch. Pygidium with punctures and with a transverse subapical groove reaching lateral margins. Protibiae with outer margin expanded and 7–13 short, reddish denticles, the most basal ones very small.

Distribution. Argentina, Brazil and Venezuela (Mazur 2011).

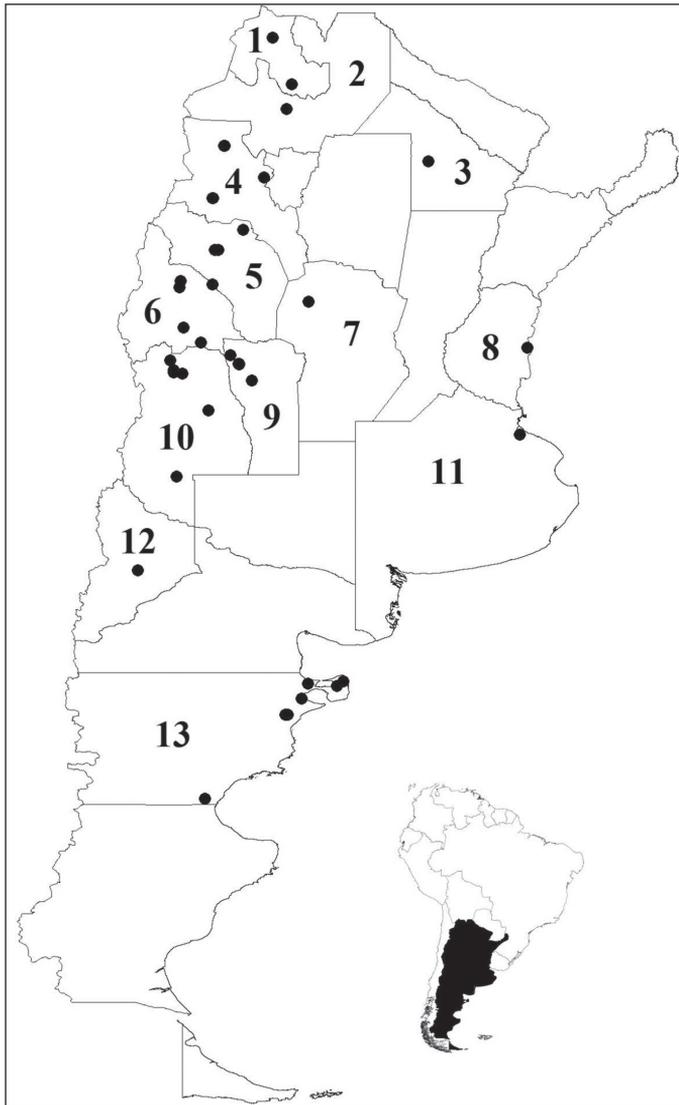


Figure 23. Geographical distribution of sixteen species of Histeridae in Argentina. Provinces: **1** Jujuy: *Euspilotus* (*Hesperosaprinus*) *caesopygus*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *lepidus* **2** Salta: *E.* (*H.*) *caesopygus*, *E.* (*H.*) *strobéli* **3** Chaco: *E.* (s. str.) *lacordairei* **4** Catamarca: *E.* (*H.*) *caesopygus*, *E.* (*H.*) *pavidus*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *richteri* **5** La Rioja: *E.* (*H.*) *caesopygus*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *lepidus*, *E.* (s. str.) *richteri* **6** San Juan: *E.* (*H.*) *modestus*, *E.* (*H.*) *parenthesis*, *E.* (*H.*) *pavidus*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *ornatus*, *Xerosaprinus* (*Xerosaprinus*) *diptychus* **7** Córdoba: *E.* (*H.*) *pavidus* **8** Entre Ríos: *E.* (*H.*) *pavidus* **9** San Luis: *E.* (*H.*) *caesopygus*, *E.* (*H.*) *pavidus*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *ornatus* **10** Mendoza: *Carcinops* (s. str.) *troglydites*, *E.* (*H.*) *azureus*, *E.* (*H.*) *caesopygus*, *E.* (*H.*) *connectens*, *E.* (*H.*) *modestus*, *E.* (*H.*) *parenthesis*, *E.* (*H.*) *pavidus*, *E.* (*H.*) *strobéli*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *lepidus*, *E.* (s. str.) *ornatus*, *E.* (s. str.) *patagonicus*, *E.* (s. str.) *richteri*, *Hololepta* (*Leionota*) *reichii*, *Phelister rufinotus*, *Xerosaprinus diptychus* **11** Buenos Aires: *E.* (s. str.) *patagonicus* **12** Neuquén: *E.* (s. str.) *patagonicus* **13** Chubut: *C.* (s. str.) *troglydites*, *E.* (*H.*) *modestus*, *E.* (s. str.) *lacordairei*, *E.* (s. str.) *ornatus*, *E.* (s. str.) *patagonicus*, *E.* (s. str.) *richteri*.

Discussion

The 16 Histeridae species collected in this study on carcasses in Argentina are grouped into three of the 11 subfamilies: Saprininae (twelve species of *Euspilotus* Lewis and one species of *Xerosaprinus* Wenzel), Histerinae (one species of *Hololepta* Paykull and one species of *Phelister* Marseul) and Dendrophilinae (one species of *Carcinops* Marseul).

Species of *Euspilotus*, *Xerosaprinus* and *Phelister* have been recorded as attracted by carcasses (Kovarik and Catherino 2001), and species of *Hololepta* and *Carcinops* are associated with rotting vegetation, especially cacti and bromeliads (Arriagada 1986, Kovarik and Catherino 2001). The species *Carcinops* (*Carcinops*) *troglydytes* has been found to be an effective natural enemy of synanthropic muscoid Diptera: *Musca domestica* Linnaeus (Muscidae) and *Chrysomya putoria* (Wiedemann) (Calliphoridae), and considered a potential biological control agent for the coleopteran *Alphitobius diaperinus* Panzer (Tenebrionidae) that develops in chicken droppings in Brazil (Lopes et al. 2006, Santoro et al. 2010); in Chile it was collected on dry goat's dung (Arriagada 1986). *Hololepta* (*Leionota*) *reichii* has been considered a predator of larvae and pupae of *Melipona compressipes manaosensis* Schwarz and *Melipona seminigra merrillae* Cockerell (Hymenoptera: Apidae) inside bee hives (Coletto-Silva and Freire 2006). In this study, *Carcinops troglydytes* was collected on pig and *Hololepta reichii* on human carcasses, in both cases with presence of Calliphoridae larvae.

Nine species of Histeridae constitute new records from the cadaveric fauna in Argentina: *Euspilotus caesopygus*, *E. connectens*, *E. lepidus*, *E. richteri*, *E. strobilis*, *E. azureus*, *Hololepta reichii*, *Phelister rufinotus* and *Carcinops troglydytes*. All of them were collected mostly on human and pig carcasses. The remaining seven species associated with carcasses listed in this key were recorded previously for the country in Buenos Aires (Centeno et al. 2002), Neuquén (Oliva and Ravioli 2004) and San Juan provinces (Aballay et al. 2008, 2012). Two species are new records for Argentina: *Phelister rufinotus* and *Carcinops troglydytes*.

Histeridae of forensic importance were already cited in the literature, for instance in Central Europe adults of *Saprinus planiusculus* Motschulsky and *S. semistriatus* (Scriba) are predictable at a specific time period in the cadaver succession because they have a short period of residency in the carcasses depending on their specialized feeding habits, therefore they are good tools for estimating PMI indicators (Matuszewski et al. 2010).

Operclippygus hospes (Lewis) was recorded from Brazil in buried bodies of rabbits in summer and autumn, and it was suggested that this species plays an important role in forensic entomology as a seasonal indicator (Corrêa et al. 2012).

Further research is necessary to establish the specific time period in the cadaver succession for which the species cited in the present article can be predictable and could be used to estimate PMI indicators based on succession patterns. In addition, immature stages can be useful in forensic entomology because they are reared within the body and collected in advanced stages of decomposition (Aballay pers. obs.) but the duration of larval development is variable and depends on the species (Kovarik and Catherino 2005).

Table 1. List of Histeridae species collected on vertebrate carcasses and from baited traps in Argentina and their geographic distribution by provinces. * = baited traps.

Species	N°	Substratum / carcasses	Province	Geographic Coordinates	Altitude (m)	Collector/ reference
<i>Carcinops</i> (s. str.) <i>trogloidytes</i>	4	Pig	Mendoza	32°53'49.3"S, 68°52'23.9"W	839	Aballay (2012)
<i>Carcinops</i> (s. str.) <i>trogloidytes</i>	4	Sheep	Chubut	43°16'18.2"S, 65°26'23.3"W	39	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>azureus</i>	192	Pig	Mendoza	32°53'58.4"S, 68°52'22.1"W	841	Aballay (2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	5	Pig	Mendoza	32°53'53.3"S, 68°52'26.2"W	850	Aballay (2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	2	Human,	Mendoza	32°32'07.5"S, 68°58'42.8"W	1424	Aballay F. (forensic cases)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	3	Pig	Jujuy	24°09'54.1"S, 65°18'37.7"W	1383	Quiroga N.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	1	Pig	Salta	24°54'40"S, 65°28'16"W	1379	Ayón R.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	121	Squid	La Rioja	29°10'45.3"S, 67°37'33.9"W	1806	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	4	Squid *	Catamarca	27°36'35.4"S, 67°41'48.5"W	1752	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>caesopygus</i>	1	Dog	San Luis	32°37'37.8"S, 66°54'35.5"W	744	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>connectens</i>	12	Pig	Mendoza	32°53'57.6"S, 68°52'32.4"W	847	Aballay (2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>modestus</i>	21	Human	Mendoza	32°49'18.4"S, 68°52'38.9"W	788	Aballay F. (forensic cases)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>modestus</i>	4	Cow	San Juan	31°59'51.1"S, 68°03'20.3"W	541	Arriagada G
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>modestus</i>	2	Pig	San Juan	31°32'34.1"S, 68°34'38.2"W	673	Aballay et al. (2008, 2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>modestus</i>	91	Pig	Mendoza	32°53'53.3"S, 68°52'26.2"W	850	Aballay (2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>modestus</i>	91	Sardine*	Chubut	43°16'37.1"S, 65°29'49.8"W	68	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>parenthesis</i>	2	Pig	San Juan	31°32'34.9"S, 68°34'35.9"W	674	Aballay et al. (2008, 2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>parenthesis</i>	30	Pig	Mendoza	32°53'49.3"S, 68°52'23.2"W	850	Aballay (2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	5	Human	Mendoza	32°56'14.2"S, 68°36'32.9"W	653	Aballay F. (forensic cases)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	63	Pig	San Juan	31°32'32.1"S, 68°34'44.8"W	675	Aballay et al. (2008, 2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	163	Pig	Mendoza	32°53'58.4"S, 68°52'22.1"W	841	Aballay (2012)
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	70	Donkey	Catamarca	26°59'22.1"S, 66°08'42.1"W	2121	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	15	Horse	San Luis	32°38'43.4"S, 66°53'52.7"W	717	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	45	Chicken *	Córdoba	30°44'39.8"S, 64°48'35.5"W	480	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>pavidus</i>	100	Cow	Entre Rios	32°08'39.1"S, 58°13'04.3"W	31	Arriagada G.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>strobili</i>	1	Pig	Salta	24°54'40"S, 65°28'16"W	1379	Ayón R.
<i>Euspilotus</i> (<i>Hesperosaprinus</i>) <i>strobili</i>	1	Cow	Mendoza	34°03'18.1"S, 67°49'13.8"W	537	Flores G.

Species	N°	Substratum / carcasses	Province	Geographic Coordinates	Altitude (m)	Collector/ reference
<i>Euspilotus (Hesperosaprinus) strobili</i>	1	Chicken *	Mendoza	34°03'25.1"S, 67°49'11.8"W	534	Arriagada G
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	25	Pig	San Juan	31°32'34.1"S, 68°34'38.2"W	673	Aballay et al. (2008, 2012)
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	2	Pig	San Juan	30°07'01.1"S, 68°39'43.9"W	1144	Aballay F.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	867	Pig	Mendoza	32°53'57.6"S, 68°52'32.2"W	850	Aballay (2012)
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	2	Horse	San Luis	32°38'34.4"S, 66°53'35.7"W	720	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	2	Cow	San Luis	32°22'08.2"S, 67°09'37.3"W	556	Aballay F.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	4080	Sardine*, Squid*	Chubut	43°16'37.1"S, 65°29'49.8"W	68	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	20	Rat	Chubut	42°24'11.1"S, 63°57'25.4"W	6	Cheli G
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	2	Lesser rhea	Chubut	42°20'21.8"S, 64°49'11.2"W	50	Flores G.;
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	2	Sheep	Chubut	42°20'28.8"S, 64°49'09.2"W	48	Flores G.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	5	Vicuña	Jujuy	22°44'52.4"S, 65°53'12.9"W	3667	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	166	Squid *	La Rioja	29°10'43.5"S, 67°31'49.9"W	1196	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	2	Donkey	Catamarca	26°59'22.1"S, 66°08'42.1"W	2121	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>lacordairei</i>	1	Snake	Chaco	26°30'16.3"S, 61°11'15.2"W	124	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>lepidus</i>	7	Pig	Jujuy	24°09'54.1"S, 65°18'37.7"W	1383	Quiroga N.
<i>Euspilotus</i> (s. str.) <i>lepidus</i>	55	Pig	Mendoza	32°53'49.3"S, 68°52'23.9"W	839	Aballay (2012)
<i>Euspilotus</i> (s. str.) <i>lepidus</i>	10	Squid *	La Rioja	28°34'17.9"S, 66°47'07.4"W	812	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>ornatus</i>	2	Pig	San Juan	31°32'34.9"S, 68°34'35.9"W	674	Aballay et al. (2008, 2012)
<i>Euspilotus</i> (s. str.) <i>ornatus</i>	48	Pig	Mendoza	32°53'58.4"S, 68°52'22.1"W	841	Aballay (2012)
<i>Euspilotus</i> (s. str.) <i>ornatus</i>	30	Rat	Chubut	45°49'04.7"S, 67°55'59.6"W	680	Cheli G.
<i>Euspilotus</i> (s. str.) <i>ornatus</i>	30	Sardine*	Chubut	43°16'30.1"S, 65°29'26.8"W	66	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>ornatus</i>	3	Geoffroy's cat	San Luis	33°08'07.5"S, 66°30'27.9"W	551	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>patagonicus</i>	4	Rat	Chubut	42°47'07.5"S, 65°00'43.8"W	9	Cheli G.
<i>Euspilotus</i> (s. str.) <i>patagonicus</i>	4	Guanaco	Mendoza	36°03'27.5"S, 68°47'11.1"W	1684	Flores G., Ruiz Manzanos E.
<i>Euspilotus</i> (s. str.) <i>patagonicus</i>	1	Pig	Buenos Aires	34°47'13.2"S, 58°26'33.1"W	17	Centeno et al. (2002)
<i>Euspilotus</i> (s. str.) <i>patagonicus</i>	1	Human	Neuquén	38°53'54.8"S, 69°56'54.2"W	962	Oliva and Ravioli (2004)

Species	N°	Substratum / carcasses	Province	Geographic Coordinates	Altitude (m)	Collector/ reference
<i>Euspilotus</i> (s. str.) <i>richteri</i>	178	Pig	Catamarca	26°01'38.2"S, 67°20'31.6"W	3595	Aballay (2012)
<i>Euspilotus</i> (s. str.) <i>richteri</i>	95	Llama	Catamarca	26°01'33.4"S, 67°20'42.5"W	3585	Aballay (2012)
<i>Euspilotus</i> (s. str.) <i>richteri</i>	85	Squid *	Catamarca	27°36'30.1"S, 67°41'04.7"W	1750	Arriagada G.
<i>Euspilotus</i> (s. str.) <i>richteri</i>	8	Pig	Mendoza	32°53'57.6"S, 68°52'32.4"W	847	Aballay (2012)
<i>Euspilotus</i> (s. str.) <i>richteri</i>	1	Rat	Chubut	42°16'10.4"S, 63°45'32.2"W	40	Cheli G.
<i>Euspilotus</i> (s. str.) <i>richteri</i>	76	Squid *	La Rioja	28°34'17.9"S, 66°47'07.4"W	812	Arriagada G.
<i>Hololepta</i> (<i>Leionota</i>) <i>reichii</i>	1	Human	Mendoza	32°56'14.2"S, 68°36'32.9"W	653	Aballay F. (forensic cases)
<i>Phelister rufinotus</i>	11	Pig	Mendoza	32°53'53.3"S, 68°52'26.2"W	850	Aballay (2012)
<i>Xerosaprinus diptychus</i>	72	Pig	San Juan	31°32'32.1"S, 68°34'44.8"W	675	Aballay et al. (2008, 2012)
<i>Xerosaprinus diptychus</i>	2	Horse	San Juan	30°13'52.3"S, 67°42'33.8"W	1261	Aballay F.
<i>Xerosaprinus diptychus</i>	2	Fox	San Juan	30°19'01.3"S, 68°41'42.3"W	673	Aballay F.
<i>Xerosaprinus diptychus</i>	114	Pig	Mendoza	32°53'49.3"S, 68°52'23.9"W	839	Aballay (2012)

Due to the limited information concerning development of larvae of Histeridae species (Kovarik and Catherino 2005), research studies should be conducted on their life cycle and to this end it is essential to achieve a correct identification of the adult necrophilous histerids. In this sense we consider that the present paper is a basic tool for undertaking these studies.

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Book review: FLIES – The Natural History and Diversity of Diptera

Stephen A. Marshall (2012) Firefly Press Ltd., 616 pp.

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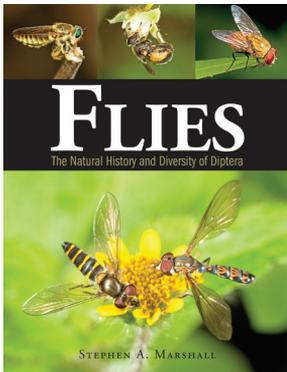
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*Human knowledge will be erased from
the world's archives before we possess the last word
that a gnat has to say to us.*

-Henri Fabre-



The new book, FLIES, tells us a lot about what gnats and their relatives have to tell us about nature, would we but listen attentively.

The author, Stephen Marshall, began his biological interests in beetles and then somehow went to the dark side, FLIES. This reviewer began his career in beetles and stayed put; that is what qualifies him as a reviewer of this simply superb book Steve Marshall has produced both in text and images. Why? It's in the subtitle: the Natural History and Diversity of Diptera, the key word being **diversity** by which Marshall means many different kinds. Beetles and parasitic wasps are universally touted as the

hyper-diverse and divergent groups of insects, so why does Marshall claim that Flies also exhibit such diversity in the natural world? In doing so, he sets himself apart from

what more focused Dipterists have usually done, that is stay the course, look at one genus, one family, one region at a time; not much diversity displayed on their watch, for sure. Marshall, on the other hand, took on the entire dipteran Order, globally, with hundreds of superb photos (adults and immatures) that he took in the field over years of searching out fly species richness. He added an up-to-date text covering all taxa of the entire Order at the subfamily and tribal levels with hundreds of examples and images named at the genus and/or species level.

Marshall's *FLIES* is written and imaged for both the academic and the enthusiastic layperson. It contains some 2000 color images of flies in their natural environment, nearly all taken by the author. He has selected (out of some 160,000 named species of flies), those that he finds especially fascinating and those essential for demonstrating global dipteran diversity in form and function. The latter, *form and function*, speak directly to the astounding diversity and divergence of dipterans and justify including them along with the celebrated richness and abundance of beetles and parasitic wasps. Marshall, in *FLIES*, has justified that leap with his broad coverage and excellent story telling about flies' lives.

Such dipteran diversity is a mixed blessing for the public and for scientists alike. Who wants to see a blow fly from your neighbor's garbage bin walking around on your chocolate cake, or a dozen mosquitos landing on you when you are trying patiently to photograph a hummingbird at a tropical flower in an Amazonian *Heliconia* patch? On the other hand, colorful hover flies on a yellow flower (Marshall's book cover jacket) are part of nature's exquisite beauty. While many groups of flies are vectors of devastating human and animal diseases and pests of crops and forests, others are important pollinators, recyclers, and beneficial control agents of insect pests. Marshall's text tells compelling stories about all these kinds of flies that are easily read by citizen naturalists and high-schoolers in science class, as well as professional biologists of all walks of study.

While Marshall's introduction claims that "flies rule!" and his book sets out to prove that claim, Coleopterists and Hymenopterists certainly will argue that point. However, this reviewer has to agree that in the Amazon Basin during the rainy season there is more fly abundance by far in the rain forest canopy than any other group of insects (except relatively species-poor but abundant ants). This is thanks to one family of dipterans, the fungus gnats, Mycetophilidae (see Marshall's pages 139-140) that emerge by the multimillions, as fungi reach their fruiting peak. While flies might not truly "rule," gnats do have a lot to say about temperate and tropical fly abundance, something that Henri Fabre would appreciate.

Without a doubt, Marshall sets high standards with this and his previous book, *Insects: Their Natural History and Diversity*, (also, Firefly Books). These treatments offer a challenge to entomologists of other ordinal taxa to produce similar books. Should that come to pass, and considering that insect and their relatives constitute three-fourths of life on earth, we humans would have a far better understanding of the natural world and our place in it.