

Title	A preliminary report on the freshwater molluscan fossils from Myanmar
Author(s)	Ugai, Hiroaki; Takai, Masanaru; Tsubamoto, Takehisa; Egi, Naoko; Maung-Maung; Chit-Sein; Thaung-Htike; Zin-Maung-Maung-Thein
Citation	Asian paleoprimateology (2006), 4: 205-220
Issue Date	2006
URL	http://hdl.handle.net/2433/199761
Right	
Type	Departmental Bulletin Paper
Textversion	publisher

A preliminary report on the freshwater molluscan fossils from Myanmar

Hiroaki Ugai¹, Masanaru Takai², Takehisa Tsubamoto³, Naoko Egi², Maung-Maung⁴,
Chit-Sein⁵, Thaung-Htike², and Zin-Maung-Maung-Thein²

¹*Goshoura Cretaceous Museum, Kumamoto 866-0313, Japan*

²*Primate Research Institute, Kyoto University, Inuyama, Aichi 484-8506, Japan*

³*Center for Paleobiological Research, Hayashibara Biochemical Laboratories, Inc., 1-2-3
Shimoishii, Okayama 700-0907, Japan*

⁴*Department of Geology, University of Mandalay, Mandalay, Myanmar*

⁵*Department of Geology, University of Yangon, Yangon, Myanmar*

Abstract

Three named species and nine indeterminate species of freshwater molluscan fossils are found from the Eocene, Mio-Pleistocene, and Holocene of central Myanmar. The Eocene fossils are found from the Pondaung Formation and consist of an indeterminate viviparid gastropod, indicating a shallow-water environment. The Mio-Pleistocene fossils were found from the Irrawaddy Beds and consists of *Melanooides* sp. indet., *Brotia costula*, *Indonaia?* sp. indet., *Radiatula* sp. cf. *Radiatula lima*, *Lamellidens* sp. indet., *Parreysia favidens*, and *P. pernodulosa*. The molluscan fauna of the Irrawaddy Beds is characterized by occurrence of comparative species in Myanmar and in South Asia, indicating that a similar water system with present one in that time. The Holocene fossils were found from the Buddaw Zinaw Cave deposit and consist of *Margarya* sp. and *Brotia costula*. Among the Holocene fossils, *Margarya* is a representative genus of the recent freshwater molluscan fauna of Yunnan (southern China), indicating that a water system extended between Yunnan and central Myanmar in that time.

Introduction

In Myanmar (= Burma), many Cenozoic freshwater molluscan fossils and living species have been reported from the Eocene to Holocene by several researchers. Eocene non-marine gastropods from the Kalewa coal-field in northern part of Myanmar were described by Kotaka and Uozumi (1962). Freshwater molluscan fossils of the Mio-Pleistocene Irrawaddy Beds were reported by Anandale (1919, 1923), Vredenburg and Prashad (1921), Prashad (1930a), and Gupta (1930). Freshwater gastropod fossils from cave deposits in the southern Shan States were reported by Bequaert (1943). Since Bequaert (1943), there is no study on freshwater molluscan fossils in Myanmar. On the other hand, taxonomy of Recent freshwater

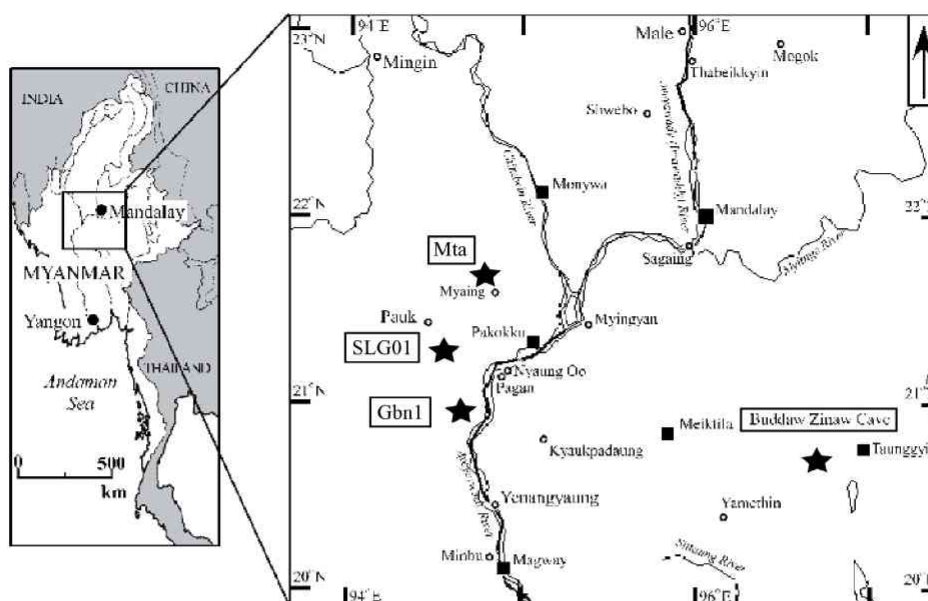


Figure 1. Local topographic map of central Myanmar, showing the fossil localities.

molluscs of Myanmar was studied by Preston (1908, 1912, 1915), Anandale (1918), Godwin-Austen (1919), Prasad (1920, 1930b), Rao (1928), Haas (1969), and Subba Rao (1989).

Material

Gastropods were found from the all fossil localities studied here. Bivalves were found from the Irrawaddy Beds localities. All materials are stored in the National Museum of the Union of Myanmar, in Yangon. Abbreviations: NMMP-KU, National Museum of Myanmar in Paleontology - serial specimen numbers catalogued by Kyoto University; and NMMP-KU-IR National Museum of Myanmar in Paleontology - serial specimen numbers catalogued by Kyoto University - Irrawaddy Beds.

Locality

Localities of fossils described in this paper (Figure 1) are as follows: (1) the Eocene Pondaung Formation, the Mta locality, Minthagya, Pagan, Mandalay Division (21°39'13.2" N and 094°49'11.4" E; Tsubamoto *et al.*, 2000, 2006); (2) the Mio-Pleistocene Irrawaddy Beds, SLG01 locality, Sulegon, Magway Division (21°21'03" N and 094°40'20" E), and Gbn01 locality, near Gwebin village, Satpyakingon, Seikpyu, Magway Division (20°58'52" N and 094°41'45" E); and (3) the Holocene Buddow Zinaw Cave deposit, the Buddaw Zinaw Cave, Shan State (20°41'53" N and 096°44'50" E). Comparative specimens of Recent species were collected from the northern shore side of Inle Lake, Shan State.

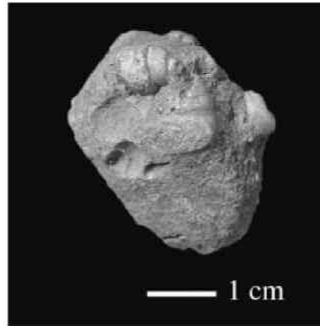


Figure 2. Viviparidae, NMMP-KU 0280, from the Pondaung Formation.

Eocene freshwater molluscs

The Pondaung Formation, which has been correlated to the upper middle Eocene (Tsubamoto *et al.*, 2002), has yielded 17 fragments of an indeterminate viviparid gastropod (NMMP-KU-0280; Figure 2). The Viviparidae is known as a freshwater gastropod that ranges from the Cretaceous to Recent (Wentz, 1938).

The occurrence of the Viviparidae in the Pondaung Formation indicates a shallow-water of river environment. In Asia, many species of a living viviparid genus *Bellamya* are widely distributed. Living species of this genus usually swarm on the sandy to muddy bottoms of stagnant waters such as pools and ponds of lowlands in China (Liu *et al.*, 1979; Qi, 1998). *Bellamya quadrata*, a living species from China, is known to become rare on the bottom of the lake and river of which depth exceed 2.5 m (Liu *et al.*, 1979).

Mio-Pleistocene freshwater molluscs

The Mio-Pleistocene Irrawaddy Beds have yielded four species of gastropods and eight species of bivalves. Fossils from the SLG01 locality were mostly identified with the Recent species in Myanmar and South Asia (Figure 3). On the other hand, fossils from mudstones in the Gbn01 locality were difficult to identify due to poor preservation (Figures 4, 5). The molluscan fauna of the Irrawaddy Beds is characterized by occurrence of two gastropods, *Melanooides* and *Brotia*, and three bivalves, *Radiatula*, *Lamellidens*, and *Parreysia* (Figures 3, 5).

The fossil gastropods from the Irrawaddy Beds are *Pila* sp., *Melanooides* sp., *Melanooides?* sp. indet., and *Brotia costula* (Rafinesque). These fossils indicate a gentle flow environment, based on comparative ecological studies of living species. The two gastropod genera, *Melanooides* and *Brotia*, are widely distributed in South and Southeast Asia (e.g., Preston, 1915; Brandt, 1974; Köhler and Glaubrecht, 2001). Living species of *Melanooides* make a swarm and inhabit near the banks of the river avoiding strong currents in the Maturinao River, Cebu Island, Philippines (Bandel and Riedel, 1998). *Brotia costula* (Rafinesque), a living species in Southeast Asia, is eurytopic, living in habitats ranging from narrowly tangled jungle creek and large rivers to stagnant waters (Köhler and Glaubrecht, 2001). Living species of *Brotia* inhabit in the similar ecological environment of the genus *Melanooides*.

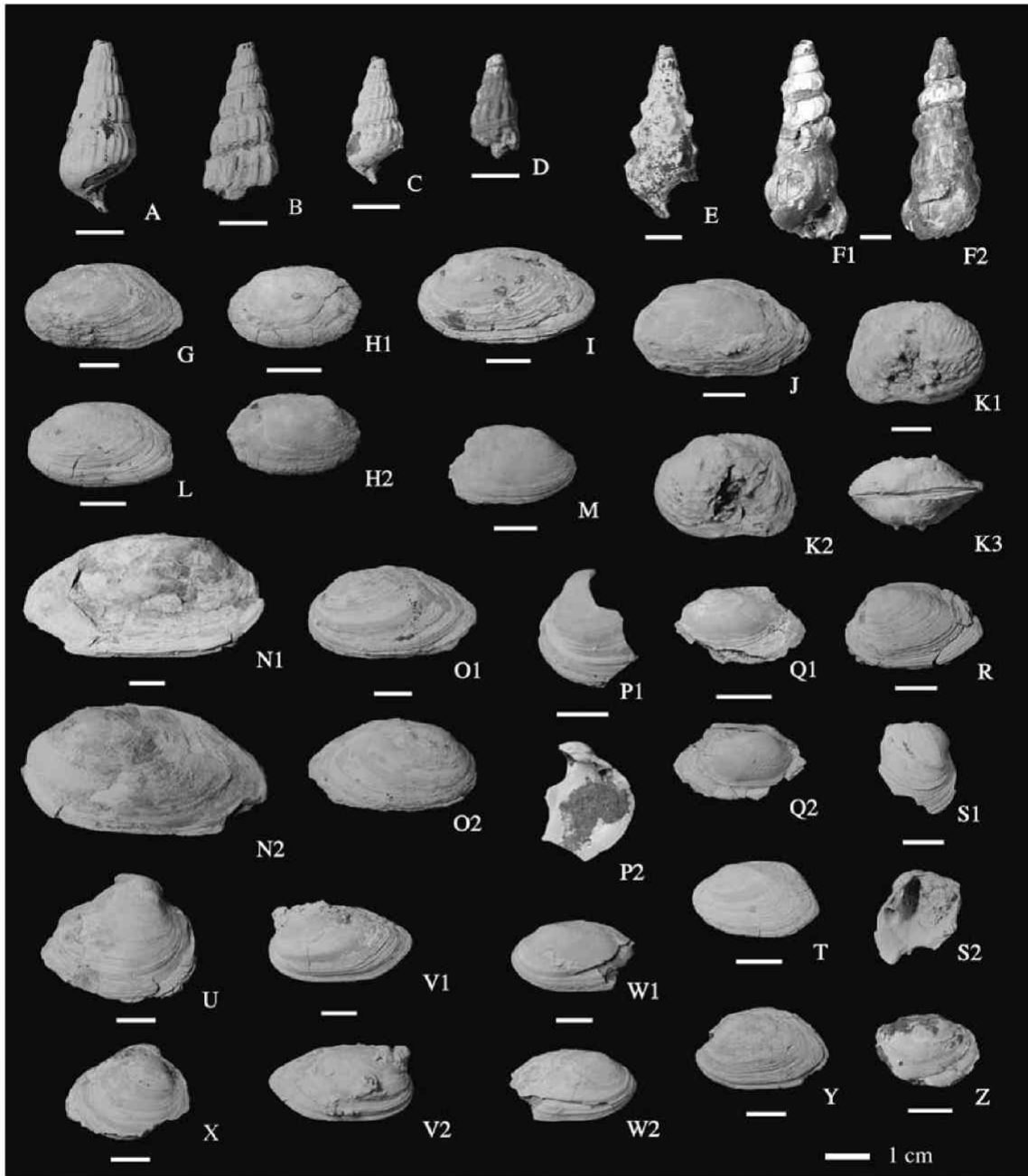


Figure 3. Molluscs from the Irrawaddy Beds in the fossil locality SLG01, Sulegon in Myitche Area, central Myanmar. **A-D**, *Melanoides* sp. indet.: **A**, **C**, apertural view, **B**, **D**, non-apertural view; **A**, NMMP-KU-IR0347-01, **B**, NMMP-KU-IR0347-02, **C**, NMMP-KU-IR0347-03, **D**, NMMP-KU-IR0363-01. **E-F**, *Brotia costula* (Rafinesque): **E** and **F1**, apertural view, and **F2**, dorsal view; **E**, NMMP-KU-IR0363-02, **F**, NMMP-KU-IR0363-03. **G-J**, **L**, **M**, **O**, **Q**, **R**, **T**, **V**, **W**, **Y**, **Z**, *Radiatula* sp. cf. *Radiatula lima* (Simpson): **G**, **H1**, **I**, **J**, **L**, **O1**, **Q1**, **R**, **T**, **V1**, **W1**, **Y**, **Z**, dorsal view of left valve, **H2**, **M**, **O2**, **Q2**, **V2**, **W2**, **Z**, dorsal view of right valve; **G**, NMMP-KU-IR0346-02, **H**, NMMP-KU-IR0346-03, **I**, NMMP-KU-IR0346-04, **J**, NMMP-KU-IR0346-05, **L**, NMMP-KU-IR0346-06, **M**, NMMP-KU-IR0370-04, **O**, NMMP-KU-IR0370-05, **Q**, NMMP-KU-IR0370-06, **R**, NMMP-KU-IR0370-09, **T**, NMMP-KU-IR0380-02, **V**, NMMP-KU-IR0380-03, **W**, NMMP-KU-IR0380-04, **Y**, NMMP-KU-IR0370-07, **Z**, NMMP-KU-IR0370-08. **K**, *Parreysia pernodulosa* Preston, NMMP-KU-IR0346-07: **K1**, dorsal view of right valve, **K2**, dorsal view of left valve, **K3**, umbonal view. **N**, *Lamellidens* sp. indet., NMMP-KU-IR0370-03; **N1**, dorsal view of right valve, **N2**, dorsal view of left valve. **P**, **S**, **U**, **X**, *Parreysia favidens* (Benson); **P1**, dorsal view of left valve, **P2**, internal view of left valve. **S1**, **U**, **X**, dorsal view of right valve. **S2**, internal view of right valve; **P**, NMMP-KU-IR0346-01, **S**, NMMP-KU-IR0370-01, **U**, NMMP-KU-IR0370-02, **X**, NMMP-KU-IR0380-01.

Freshwater molluscan fossils from Myanmar

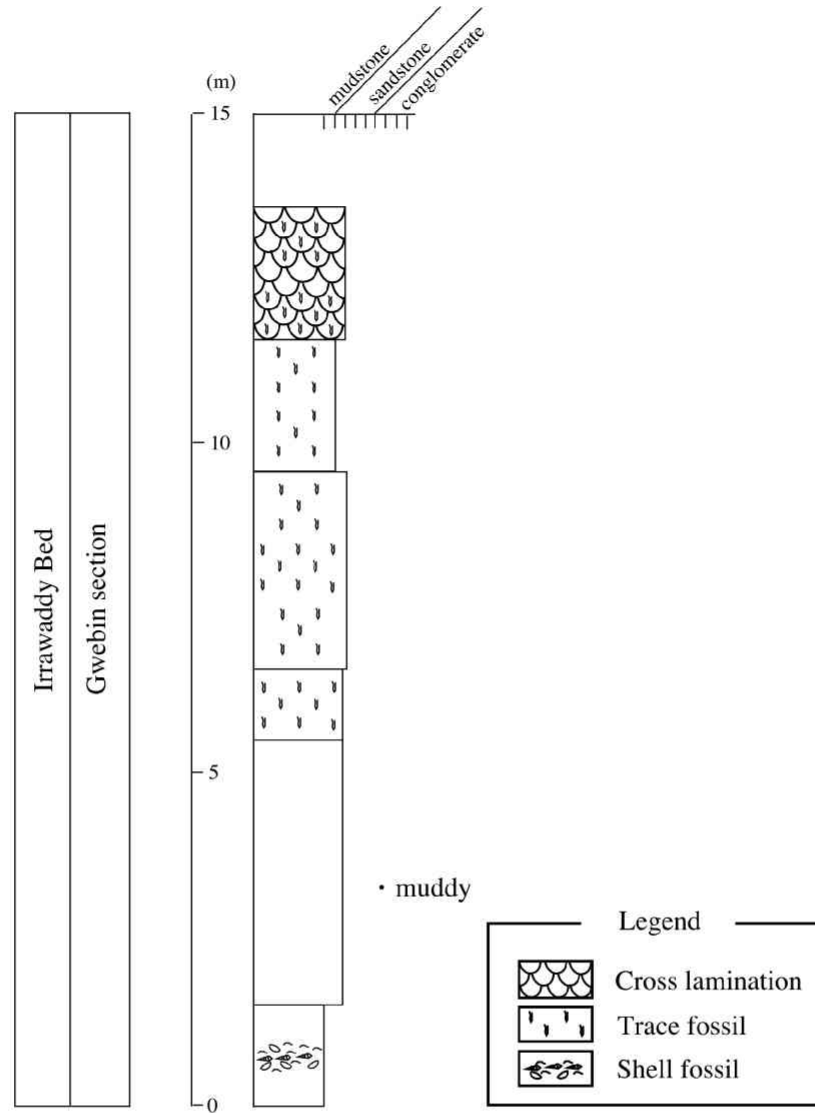


Figure 4. Columnar section of the Irrawaddy Beds in the fossil locality Gbn01, Gwebin Area in Seikpyu, central Myanmar.

The fossil bivalves from the Irrawaddy Beds are *Indonaia?* sp. indet., *Parreysia* sp. indet., *Parreysia?* sp. indet., *Lamellidens* sp. indet., *Radiatula* sp. cf. *Radiatula lima* (Simpson), *Parreysia favidens* (Benson), and *P. pernodulosa* Preston. Living species of the three bivalve genera, *Radiatula*, *Lamellidens* and *Parreysia*, are restricted in Myanmar and South Asia (e.g., Preston, 1915; Haas, 1969; Subba Rao, 1989). Ecology of a great majority of the South Asian freshwater Bivalvia is not known. Freshwater bivalves are common in stagnant water pools, ponds, lakes and flowing waters like perennial rivers and irrigation canals (Subba Rao, 1989). Subba Rao (1989) was reported that living species of *Radiatula lima* (Simpson), *Parreysia favidens* (Benson), and *P. pernodulosa* Preston are distributed in central Myanmar, Bangladesh and Eastern part of India. The molluscan fauna of the Irrawaddy Beds indicates that a similar water system with present one extended between South Asia and central Myanmar in that time.

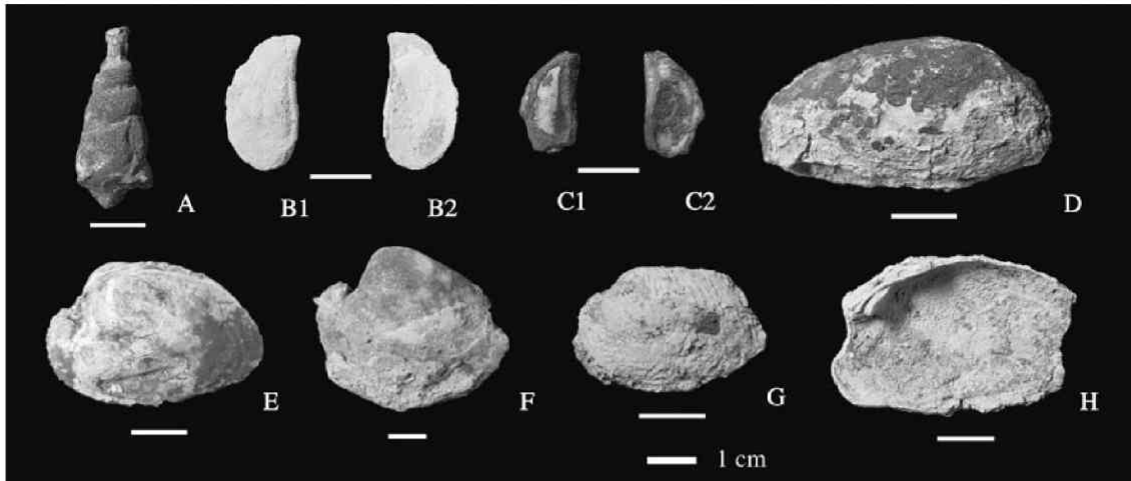


Figure 5. Molluscs from the Irrawaddy Beds in the fossil locality Gbn01, Gwebin Area in Seikpyu, central Myanmar. **A**, *Melanoides* ? sp. indet., NMMP-KU-IR0483-01, non-apertural view. **B-C**, *Pila* sp. indet.; **B1**, **C1**, internal view of the operculum, **B2**, **C2**, external view of the operculum; **B**, NMMP-KU-IR0483-02, **C**, NMMP-KU-IR0483-03. **D**, *Indonaia* ? sp. indet., NMMP-KU- IR0483-04, dorsal view of right valve. **E**, **F**, *Parreysia* sp. indet., dorsal view of internal mold of left valve; **E**, NMMP-KU-IR0482-01, **F**, NMMP-KU-IR0482-02. **G**, *Parreysia* ? sp. indet., NMMP-KU-IR0483-05, dorsal view of left valve. **H**, *Lamellidens* sp. indet., NMMP-KU- IR0483-06, internal view of right valve.

Holocene freshwater molluscs

The Holocene Buddow Zinaw Cave deposit has yielded two gastropod fossils, *Margarya* sp. and *Brotia costula* (Rafinesque) (Figure 6). Living species of the genus *Margarya* are inhabited in lakes of Yunnan Province of China (e.g., Liu *et al.*, 1979; Li, 1983, 1986, 1990; Qi, 1998). Li (1983) reported that *Margarya melanoides* Nevill from the late Holocene deposits in Er-Hai Lake of Yunnan (southern China) inhabited in the littoral zone about 0-0.5 m depth in this lake, but the detailed ecology of *Margarya* is poorly known. The molluscan fossils of the Buddow Zinaw Cave imply that its molluscan fauna is mostly composed of ancestral species of the Yunnan forms. The occurrence of the genus *Margarya* from the Buddow Zinaw Cave deposit implies a water system extended between Yunnan and central Myanmar at that time.

Systematic paleontology

Class Gastropoda Cuvier, 1797

Subclass Prosobranchia Milne Edwards, 1848

Order Mesogastropoda Thiele, 1929

Family Viviparidae Gray, 1847

Genus *Margarya* Nevill, 1877

Type species.—*Margarya melanoides* Nevill from the Recent of Yunnan, China

Geologic range.—Miocene to Recent.

Remarks.—Living species of the genus *Margarya* is inhabited in lakes of Yunnan Province in

China. Pliocene *Margarya* species were widely distributed in Asia.

Margarya sp. indet.

(Figure 6E-S)

Materials.—Fifteen specimens, NMMP-KU-TG 023-04 – 023-018 collected from the Buddaw Zinaw Cave, Shan State.

Locality.—Buddaw Zinaw Cave deposit.

Geologic age.—Holocene.

Diagnosis.—Shell large in size for the genus, convex rounded, one remarkable spiral ribs.

Remarks.—*Margarya* sp. indet. is frequently found from the Buddaw Zinaw Cave deposit in central Myanmar. This species is characterized by in having one remarkable spiral rib with nodules and seven or eight fine spiral ribs. Living species, *Margarya melanoides melanoides* Nevill is distinguished from present species in having one broad spiral rib with nodules and two remarkable spiral ribs on the spine. *M. melanoides monodi* Dautzenberg and P. Fischer has similar shell shape, but it can be distinguished from the present species in having six remarkable spiral ribs, and shell diameter gently increases. *M. melanoides obsolete* Dautzenberg and P. Fischer is distinguished from the present species in having smooth surface and strongly shouldered. *M. melanoides mansuyi* Dautzenberg and P. Fischer from the vicinity of Tseying, Yunnan Province, China (Yen, 1935) has similar shell shape, but it is distinguished from the present species in having deeper suture and four to six remarkable spiral ribs. This species is also known as Tertiary fossils. Pleistocene *M. margaryaeformis* from the Mong-tsu Basin in Yunnan, China (Mansuy, 1918) has smooth surface, and some specimens have few spiral riblets on the basal part of the body whorl. *Margarya* sp. from the Pliocene Tubusagawa Formation, Ohita Prefecture, Kyushu, Japan (Matsuoka and Kitabayashi, 2001), is distinguished from the present species in having deeper suture, larger shell width.

Family Ampullariidae Gray, 1847

Genus *Pila* Röding, 1798

Type species.—*Pila ampullacea* (Linnaeus) from Recent Asia

Distribution.—Tropical area of Africa and Asia, Australia and the Indo-Pacific islands.

Geologic range.—Cretaceous to Recent.

Pila sp. indet.

(Figure 5B-C)

Materials.—Two specimens, NMMP-KU-IR 0483-02 and 0483-03 collected from the fossil locality Gbn01, near Gwebin village, Satpyakingon, Seikpyu, Magway Division.

Occurrence.—Irrawaddy Beds

Geologic age.—Mio-Pleistocene

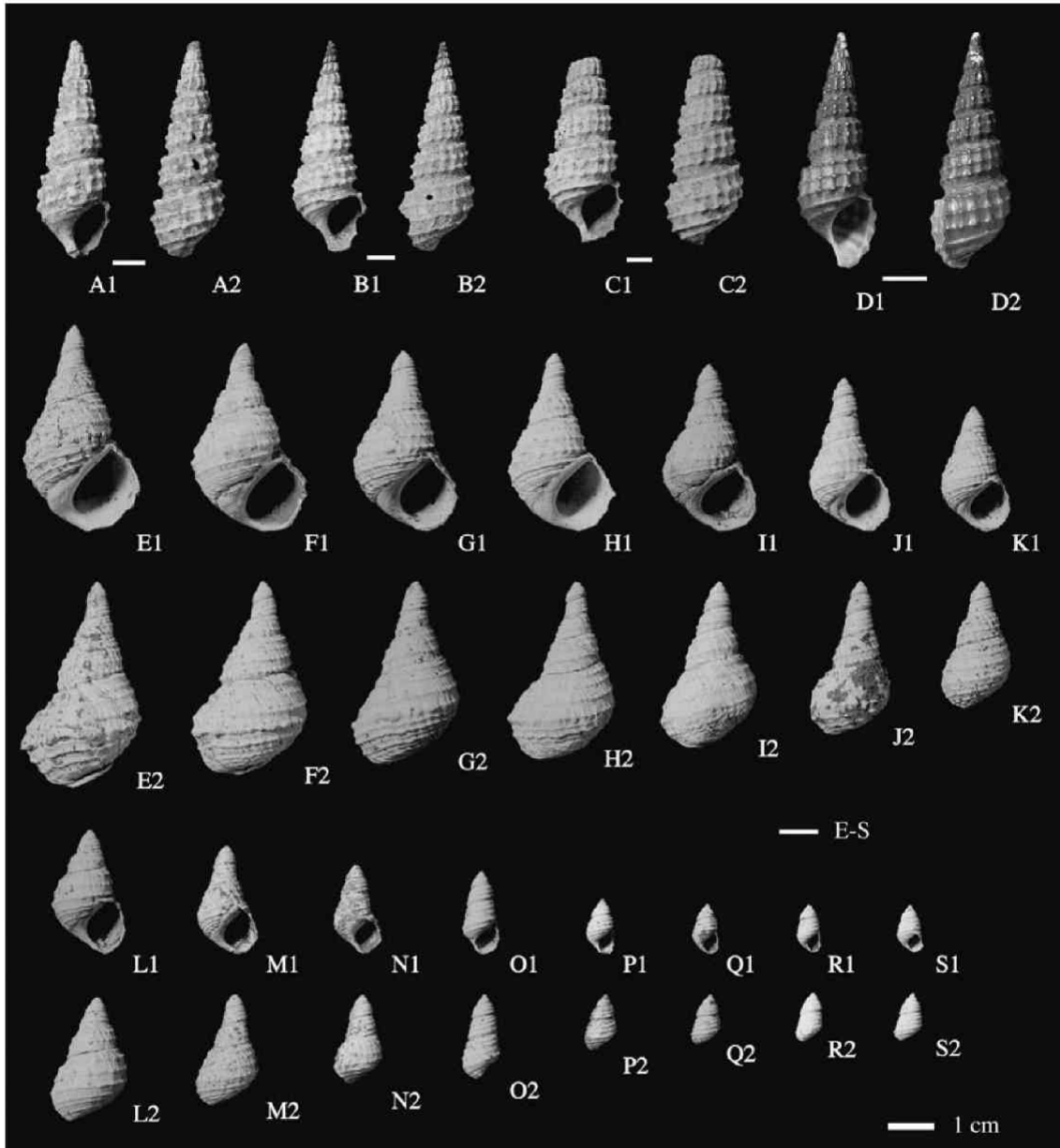


Figure 6. Gastropoda from the Buddow Zinaw Cave deposit. **A-D**, *Brotia costula* (Rafinesque); **A1, B1, C1, D1**, apertural view, **A2, B2, C2, D2**, dorsal view; **A**, NMMP-KU-TG023-01, **B**, NMMP-KU-TG023-02, **C**, NMMP-KU-TG023-03, **D**, NMMP-KU-TG024. **E-S**, *Margarya* sp.; **E1, F1, G1, H1, I1, J1, K1, L1, M1, N1, O1, P1, Q1, R1, S1**, apertural view, **E2, F2, G2, H2, I2, J2, K2, L2, M2, N2, O2, P2, Q2, R2, S2**, dorsal view; **E**, NMMP-KU-TG023-04, **F**, NMMP-KU-TG023-05, **G**, NMMP-KU-TG023-06, **H**, NMMP-KU-TG023-07, **I**, NMMP-KU-TG023-08, **J**, NMMP-KU-TG023-09, **K**, NMMP-KU-TG023-010, **L**, NMMP-KU-TG023-011, **M**, NMMP-KU-TG023-012, **N**, NMMP-KU-TG023-013, **O**, NMMP-KU-TG023-014, **P**, NMMP-KU-TG023-015, **Q**, NMMP-KU-TG023-016, **R**, NMMP-KU-TG023-017, **S**, NMMP-KU-TG023-018.

Remarks.—This species is rarely found from the Irrawaddy Beds in the locality Gbn01. The present species might be identified with the genus *Pila* based on the oval to elongate-lunar calcareous operculum, which is thick and somewhat concave on its external surface.

Family Thiariidae Gray, 1847
Subfamily Thiarinae Gray, 1847

Genus *Melanoides* Olivier, 1804

Type species.—*Melanoides tuberculata* (Müller) from Recent Southeast Asia.

Geologic range.—Jurassic to Recent.

Remarks.—The genus *Melanoides* is inhabited in rivers and lakes of South to East Asia.

Melanoides? sp. indet.

(Figure 5A)

Material.—A specimen, NMMP-KU-IR 0483-01 collected from the fossil locality Gbn01, near Gwebin village, Satpyakingon, Seikpyu, Magway Division.

Occurrence.—Irrawaddy Beds

Geologic age.—Mio-Pleistocene

Remarks.—This species is rarely found from the Irrawaddy Beds in the locality Gbn01. The present species might be identified with the genus *Melanoides* based on the conically turreted in outline.

Melanoides sp. indet.

(Figure 3A-D)

Materials.—Four specimens, NMMP-KU-IR 0347-01, 0347-02, 0347-03, and 0363-01 collected from the fossil locality SLG01, Sulegon, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—This species is rarely found from the Irrawaddy Beds in the locality SLG01. The present specimens are identified as the genus *Melanoides* based on the conically turreted in outline and in having periphery marked by lunate spiral ribs.

Family Pachychilidae Troschel, 1857

Genus *Brotia* H. Adams, 1866

Type species.—*Brotia pagodula* (Gould) from Recent Southeast Asia.

Geologic range.—Cretaceous to Recent.

Remarks.—Living species of the genus *Brotia* is inhabited in rivers and lakes of South to Southeast Asia. This genus is characterized by a long turreted shell and a spire that is smooth or sculptured with spiral ridges and/or axial ribs and ornamented with tubercles or spines.

Brotia costula (Rafinesque, 1833)

(Figures 3E, F, 6A-D)

Melania costula, Rafinesque, 1833, p.166.

Melania variabilis, Molet, 1891, p.233.

Brotia variabilis, Bequaert, 1943, p.433.

Brotia variabilis, Solen, 1966, p.15.

Materials.—Six specimens, NMMP-KU-IR 0363-02 and 0363-03 collected from the fossil locality SLG01, Sulegon, Magway Division, NMMP-KU-TG 023-01 – 023-03 collected from the Buddaw Zinaw Cave, Shan State, and NMMP-KU-TG 024, a recent living specimen collected from the northern shore side of Inle Lake, Shan State.

Occurrence and Geologic age.—Mio-Pleistocene Irrawaddy Beds (NMMP-KU-IR 0363-02 and 0363-03), Holocene Buddaw Zinaw Cave deposit (NMMP-KU-TG 023-01 – 023-03).

Remarks.—*Brotia costula* (Rafinesque) is frequently found from the Irrawaddy Beds in the locality SLG01. This species has some larger spine of the shoulder than living species. However, living species of this genus have large morphological variations, such as development of spines, in their own habitat (Brandt, 1974). Specimens from the locality SLG01 can be identified with the recent species based on their turreted shell form and shape of the lunate spiral ribs.

Class Bivalvia Linnaeus, 1758

Subclass Palaeoheterodonta Newell, 1965

Order Unionida Stoliczka, 1871

Family Unionidae Fleming, 1828

Genus *Lamellidens* Simpson, 1900

Type species.—*Unio marginalis* Lamarck from the Recent of eastern India.

Geologic range.—Eocene to Recent.

Remarks.—Shell elongated elliptical and pointed behind. Surface ornamented with growth lines and consisting of growth lines. Right valve provided one lamellar pseudocardinal tooth and one long posterior lateral tooth. Left valve provided two lamellar pseudocardinal teeth and two posterior lateral teeth.

Lamellidens sp. indet.

(Figures 3N, 5H)

Materials.—Two specimens, NMMP-KU-IR 0483-06, collected from the fossil locality Gbn01, near Gwebin village, Satpyakingon, Seikpyu, and NMMP-KU-IR 0370-03, collected from the fossil locality SLG01, Sulegon, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—Living species of the genus *Lamellidens* widely distributes in India and Myanmar. Fossil species of this genus have been reported from Myanmar and India (Vredenburg and Prashad, 1921; Prashad, 1927, 1930a; Annandale, 1923). Specimen of the locality Gbn01 is identified as this genus in having one lamellar pseudocardinal tooth. *Lamellidens* sp.

indet. from the locality SLG01 has elongated elliptical shell. This shell is pointed behind and is ornamented with con marginal growth lines and consisting of growth lines.

Genus *Radiatula* Simpson, 1900

Type species.—*Unio crispisulcatus* Benson from the Recent of Myanmar.

Geologic range.—Pliocene to Recent.

Remarks.—Shell elliptical and pointed behind. Surface ornamented with growth lines and consisting of growth lines and radial or V-shaped ribs. Right valve provided one short thin trapezoidal pseudocardinal tooth and one rather long posterior lateral tooth. Left valve provided two trapezoidal pseudocardinal teeth and two posterior lateral teeth.

Radiatula sp. cf. *Radiatula lima* (Simpson, 1900)

(Figure 3G-J, L, M, O, Q, R, T, V, W, Y, Z)

Material.—Fourteen specimens, NMMP-KU-IR 0346-02 - 0346-06, 0370-04 - 0370-06, 0370-09, 0380-02 - 0380-04, 0370-07 and 0370-08, collected from the fossil locality SLG01, Sulegon, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—Living species of the genus *Radiatula* widely distributes in India and Myanmar. Fossil species of this genus have not been reported from Myanmar and India. Specimens of the locality SLG01 are comparable with the living species, *Radiatula lima* (Simpson), in having prominent umbo, trapezoidal pseudocardinal tooth and radial and/or V-shaped ribs. However, the materials from the locality SLG01 have a characteristic shell that has a pointed posterior end and an anterior margin leaning to anterior. These shell characters might suggest a presence of a new species.

Genus *Indonaia* Prashad, 1918

Type species.—*Unio caeruleus* Lea from the Recent of India.

Geologic range.—Pleistocene to Recent.

Remarks.—Shell elongate and pointed behind. Surface ornamented with growth lines. Right valve provided two short thin trapezoidal pseudocardinal tooth and one rather short posterior lateral tooth. Left valve provided two trapezoidal pseudocardinal teeth and two posterior lateral teeth.

Indonaia? sp. indet.

(Figure 5D)

Material.—A specimen, NMMP-KU-IR 0483-04 collected from the fossil locality Gbn01, near Gwebin village, Satpyakingon, Seikpyu, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—Living species of the genus *Indonaia* widely distributes in India and Myanmar. Fossil species of this genus have not been reported from Myanmar and India. Specimens of the locality Gbn01 might be identified as the genus *Indonaia* in having elongated shell. However, in the specimen, the ventral part is missing. It is possible to be another species and genus of Unionidae.

Genus *Parreysia* Conrad, 1853

Type species.—*Unio multidentatus* Philippi (= *Parreysia corrugata* (Müller)) from the Recent of India and Myanmar.

Geologic range.—Mioocene to Recent.

Remarks.—Shell is heavy, inflated, and subrhomboidal. Surface ornamented with growth lines, zigzag sculpture on the umbonal area and sometime radial spines. Pseudocardinals are heavy, irregular, and striated.

Parreysia sp. indet.

(Figure 5E-F)

Materials.—Two specimens, NMMP-KU-IR 0482-01 and 0482-02 collected from the fossil locality Gbn01, near Gwebin village, Satpyakingon, Seikpyu, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—NMMP-KU-IR0482-01 has a cast of the pseudocardinals. This specimen can be identified as the genus *Parreysia* in having striated, heavy pseudocardinals and subrhomboidal shell. NMMP-KU-IR0482-02 has a cast of large beak cavity. This character indicates that this bivalve had an inflated and heavy shell. This specimen can be identified as a species of the genus *Parreysia*.

Parreysia? sp. indet.

(Figure 5G)

Material.—A specimen, NMMP-KU-IR 0483-05, collected from the fossil locality Gbn01, near Gwebin village, Satpyakingon, Seikpyu, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—NMMP-KU-IR0483-05 is small (shell length about two centimeters) and with strong zigzag sculptures. These features are indicated to the young stage of Unionidae. Two genera *Parreysia* and *Radiatula* have zigzag sculptures on the umbonal area. The genus *Parreysia* have stronger zigzag sculptures rather than the genus *Radiatula*. NMMP-KU-IR0483-05 is likely to be a species of the genus *Parreysia*.

Parreysia favidens (Benson, 1862)

(Figure 3P, S, U, X)

Parreysia favidens var. *assamensis*, Preston, 1912, p.299.

Parreysia annandalei, Preston, 1912, p.302.

Parreysia (*Parreysia*) *favidens* var. *assamensis*, Preston, 1915, p.161, fig.12.

Parreysia (*Parreysia*) *annandalei*, Preston, 1915, p.173, figs.18.1-3.

Parreysia favidens, Haas, 1969, p.119.

Parreysia (*Parreysia*) *annandalei*, Subba Rao, 1989, p.176, figs.444, 445.

Parreysia favidens, Subba Rao, 1989, p.180, figs.466, 467, 484, 485.

Parreysia (*Parreysia*) *favidens assamensis*, Subba Rao, 1989, p.181, figs.468, 469.

Materials.—Four specimens, NMMP-KU-IR 0346-01, 0370-01, 0370-02, and 0380-01, collected from the fossil locality SLG01, Sulegon, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—*Parreysia favidens* (Benson) is a living species distributes in India (Subba Rao, 1989). Specimens from the locality SLG01 have deep beak cavity and rounded ubrhomboidal shell with commarginal growth lines on the smooth surface. Two living subspecies of *Parreysia favidens*, *P. f. deltae* (Benson) and *P. f. viridula* (Benson), have zigzag sculptures on the shell surface around the umbo. The fossil materials have smooth surface around the umbonal area and rounded ubrhomboidal shell. This species can be identified as *P. f. assamensis* Preston that is synonymous with *P. favidens* sensu stricto by Haas (1969).

Parreysia pernodulosa Preston, 1912

(Figure 3K)

Parreysia pernodulosa, Preston, 1912, p.300.

Parreysia pernodulosa, Preston, 1915, p.164, fig.15.1-3.

Parreysia pernodulosa, Haas, 1969, p.120.

Material.—A specimen, NMMP-KU-IR 0346-07, collected from the fossil locality SLG01, Sulegon, Magway Division.

Occurrence.—Irrawaddy Beds.

Geologic age.—Mio-Pleistocene.

Remarks.—The restricted living species, *Parreysia pernodulosa* Preston, distributes in Myanmar (Preston, 1912, 1915). The specimen from the locality SLG01 have heavy rounded shell, three finny pointed spins on the two radial ribs, one deep notch tending from beak to ventral margin and zigzag sculptures on the shell surface around the umbo. This species can be identified as *Parreysia pernodulosa* by its shell ornaments.

Acknowledgments

We are grateful to the Myanmar Government for allowing us to study the fossils. We sincerely thank officers of the Union of Myanmar for their guidance and help in the field. We also sincerely thank staffs of the Primate Research Institute, Kyoto University, and mayor of the Goshoura Town, Kumamoto Prefecture for allowing us to go to the field. I wish to express my thanks to Dr. Keiji Matsuoka of the Toyohashi Museum of Natural History for allowing me to use his literature in his care. Financial supports were provided by the MEXT Overseas Scientific Research Fund (09041161, 14405019, 16405018) and by the MEXT Grant-in-Aid for COE Research (10CE2005) and for the 21st Century COE Program (A14 to Kyoto University).

References

- Adams, H. (1866) Description of a new genus and a new species of mollusks. *Proceedings of the Zoological Society of London* 1866:150-151.
- Anandale, N. (1918) Aquatic molluscs of the Inle Lake and connected waters. *Records of the Indian Museum* 14:103-182.
- Anandale, N. (1919) The gastropod fauna of old lake-beds in Upper Burma. *Records of the Geological Survey of India* 50:209-240.
- Anandale, N. (1923) Fossil molluscs from the oil-measures of the Dawna Hills, Tenasserim. *Records of the Geological Survey of India* 55:97-104.
- Bandel, K. and Riedel, F. (1998) Ecological zonation of gastropods in the Matutinao River (Cebu, Philippines), with focus on their life cycles. *Annales de Limnologie* 34:171-191.
- Bequaert, J. (1943) Fresh-water shells from cave deposits in the southern Shan States, Burma. *Transactions of the American Philosophical Society, New Series* 32(3):431-436
- Brandt, R.A.M. (1974) The non-marine aquatic mollusca of Thailand. *Archiv für Molluskunde* 105:1-423.
- Cuvier, G. (1797) *Tableau élémentaire de l'histoire naturelle des animaux*. Baudouin: Paris. xvi+710pp.
- Conrad, T.A. (1853) Synopsis of the family of Naiades of North America; with notes and a table of some of the genera and subgenera. *Proceedings of the National Academy of Science, Philadelphia* 6:243-269.
- Fleming, J. (1828) *A history of British animals, exhibiting the descriptive characters and systematical arrangement of the genera and species of quadrupeds, birds, reptiles, fishes, mollusca and radiata of the United Kingdom; including the indigenous, extirpated, and extinct kinds; together with periodical and occasional visitants*. Bell and Bradfute: Edinburgh. xxiii+554pp.
- Godwin-Austen, H.H. (1919) Description of a new species of *Margaritanopsis* (Unionidae) from the southern Shan States, with notes on *Solenia soleniformis*. *Records of the Indian Museum* 16:203-206.
- Gray, J., E. (1847) A list of the genera of Recent mollusca, their synonyms and types. *Proceedings of the Zoological Society of London* 15:129-219.
- Gupta, B.B. (1930) Two new species of *Unio*. *Records of the Geological Survey of India* 58:210-213.
- Haas, F. (1969) *Superfamilia Unionacea. Das Tierreich* 88, Walter de Gruyter & Co.: Berlin, 663pp.
- Köhler, F. and Glaubrecht, M. (2001) Toward a systematic revision of the Southeast Asian freshwater gastropod *Brotia* H. Adams, 1866 (Cerithioidea: Pachytilidae): an account of species from around the South China Sea. *Journal of Molluscan Studies* 67:281-318.
- Kotaka, T. and Uozumi, S. (1962) Variation and dimorphism of *Pachymelania* (Gastropoda) from the Eocene of Burma. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series*

- 47:301-309.
- Li, Z. (1983) The horizontal and vertical distribution of Gastropoda in Late Holocene Epoch's sediments of Er-Hai Lake, Yunnan. *Transactions of the Chinese Society of Malacology* 1:191-196.
- Li, Z. (1986) Study on the morphological variation of *Margarya melanoides* and *M. monodi* from Dian-Chi, Yunnan. *Transactions of the Chinese Society of Malacology* 2:65-70.
- Li, Z. (1990) Studies on the ancient snail shell-mounts in the Dian Chi Lake region, Yunnan Province. *Transactions of the Chinese Society of Malacology* 3:152-155.
- Linnaeus, C. (1758) *Systema Naturae per Ragna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis. Tomus I. Editio Decima*. Laurentius Salvius: Stockholm. 824pp.
- Liu, Y., Zhang, W., and Wan, E. (1979) *Monograph of economical animals of China. Freshwater mollusca*. Academic Sinica: Beijing. 133pp.
- Mansuy, H. (1918) Paludinidae Fossils du bassin lacustre de Mong-Tseu Yunnan. *Bulletin du Service geologique de l'Indochine* 5:1-15.
- Matsuoka, K. and Kitabayashi, E. (2001) Fossil freshwater mollusks from the Tsubusagawa Formation in Ajimu Basin, Oita Prefecture, Japan. *Research Report of the Lake Biwa Museum* 18:42-50.
- Milne Edwards, H. (1848) Note sur la classification naturelle des mollusques gastéropodes. *Annales des Sciences Naturelles Zoologiques* Ser.3 9:102-112.
- Morlet, L. (1891) Contributions a la faune malacologique de l'Indo-Chine. *Journal de Conchyliologie* 39:230-254.
- Nevill, G. (1877) List of the mollusca brought back by Dr. J. Anderson from Yunnan and Upper Burma, with description of new species. *The journal of the Asiatic Society of Bengal* 46:14-41.
- Newell, N.D. (1965) Classification of the Bivalvia. *American Museum Novitates* 2206:1-25.
- Olivier, G. A. (1804) Voyage dans l'Empire Othoman, l'Egypte et la Perse, fait par ordre du Gouvernement, pendant les six premières années de la République 3. Agasse: Paris. 69pp.
- Prashad, B. (1920) Notes on Lamellibranchs in the Indian Museum. *Records of the Indian Museum* 19:165-174.
- Prashad, B. (1927) On some fossil Indian Unionidae. *Records of the Geological Survey of India* 60:308-312.
- Prashad, B. (1930a) On some Undescribed freshwater molluscs from various parts of India and Burma. *Records of the Geological Survey of India* 63:428-433.
- Prashad, B. (1930b) Pelecypoda of the Indawgyi Lake and its connected freshwater areas in the Myitkyina District, Upper Burma. *Records of the Indian Museum* 32:247-255.
- Preston, H.B. (1908) Descriptions of new species of marine and freshwater shells in the collection of the Indian Museum, Calcutta. *Records of the Indian Museum* 2:45-48.
- Preston, H.B. (1912) A catalogue of the Asiatic naiads in the collection of the Indian Museum, Calcutta, with descriptions of new species. *Records of the Indian Museum* 7:279-308.
- Preston, H.B. (1915) *The fauna of British India including Ceylon and Burma, Mollusca (Freshwater Gastropoda & Pelecypoda)*. Taylor and Francis: London. 244pp.
- Qi, Z. (1998) *Economic Mollusca of China*. China agricultural publishing company: China. 317pp.
- Rao, H.S. (1928) The aquatic and amphibious mollusca of the northern Shan States, Burma. *Records of the Indian Museum* 30:399-468.
- Rafinesque, C.S. (1833) On 5 new fresh water shells, of Bengal and Assam in Asia. *Atlantic Journal and Friend of Knowledges* 5:165-170.
- Röding, P., F. (1798) *Museum Boltenianum, pars secunda continens Conchylia sive Testacea univalvia,*

- bivalvia & multivalvia. Johan Christi Trapii: Hamburg. viii+199pp.
- Prashad, B. (1918) Studies on the anatomy of Indian mollusca 2. The marsupium and glochidium of some Unionidae and on the Indian species hitherto assigned to the genus Nodularia. *Records of the Indian Museum* 14:141-148.
- Simpson, T. C. (1900) Synopsis of the naiads, or pearly fresh-water mussels. *Proceedings of the United States Natural Museum* 22(1205):501-1044.
- Solen, A. (1966) Some non-marine mollusks from Thailand, with notes on classification of the Helicarionidae. *Spolia zoologica musei Hauniensis* 24:1-110.
- Stoliczka, F. (1871) Cretaceous fauna of southern India, v. 3, The Pelecypoda, with a review of all known genera of this class, fossil and Recent. *Records of the Geological Survey of India, Palaeontology, Indica* ser. 6 3:1-537.
- Subba Rao, N.V. (1989) *Handbook freshwater molluscs of India*. Zoological Survey of India: Calcutta. 288pp.
- Thiele, J. (1929) *Handbuch der systematischen Weichtierkunde 1 (Loricata and Gastropoda)*. Verlag von Gustav Fischer: Jena. vi+778 pp.
- Troschel, F. H. (1857) *Das Gebiss der Schnecken, zur Begründung einer natürlichen classification 1*. Nicolaische Verlags-Buchhandlung:Berlin. 252pp. (1856-61)
- Tsubamoto, T., Egi, N., Takai, M., Shigehara, N., Aye-Ko-Aung, Tin-Thein, Aung-Naing-Soe, and Soe-Thura-Tun (2000) A preliminary report on the Eocene mammals of the Pondaung fauna, Myanmar. *Asian Paleoprimateology* 1:29-101.
- Tsubamoto, T., Egi, N., Takai, M., Shigehara, N., Suzuki, H., Nishimura, T., Ugai, H., Maung-Maung, Chit-Sein, Soe-Thura-Tun, Aung-Naing-Soe, Aye-Ko-Aung, Tin-Thein, Thaug-Htike, and Zin-Maung-Maung-Thein (2006) A summary of the Pondaung fossil expeditions. *Asian Paleoprimateology* 4:1-66.
- Tsubamoto, T., Takai, M., Shigehara, N., Egi, N., Soe-Thura-Tun, Aye-Ko-Aung, Maung-Maung, Danhara, T., and Suzuki, H. (2002) Fission-track zircon age of the Eocene Pondaung Formation, Myanmar. *Journal of Human Evolution* 42:361-369.
- Vredenburg, E. and Prashad, B. (1921) Unionidae from the Miocene of Burma. *Records of the Geological Survey of India* 51:371-374.
- Wentz, W. (1938) Gastropoda in Schindewolf. *Handbuch der paläozoologie* 6:1-1639.
- Yen, T. (1935) On some Tertiary Gastropods of Yunnan. *Bulletin of the Geological Society of China* 14:315-337.