Nachrichtenblatt der Ersten Vorarlberger Malakologischen Gesellschaft	13	1 - 51	Rankweil, 20. Dez. 2005

Illustrated Checklist of large Freshwater Bivalves of the Ganga River System (Mollusca: Bivalvia: Solecurtidae, Unionidae, Amblemidae)

Illustrierte Check-Liste der Süsswasser-Grossmuscheln des Ganges Fluss-Systemes (Mollusca: Bivalvia: Solecurtidae, Unionidae, Amblemidae)

By Hasko Nesemann, Subodh Sharma, Gopal Sharma & Ravindra Kumar Sinha, Patna.

with 98 color paintings by Hasko Nesemann

Keywords: Bivalvia, *Novaculina, Lamellidens, Radiatula, Parreysia*, Ganga River Basin, India, Nepal, distribution, habitat, bio-indicator

Abstract:
Twenty-eight taxa of Unionacea and one endemic species of Solecurtidae were reported from the Ganga River System. Their distribution and habitats described, shell characters are briefly mentioned, supported by 98 figures of forms from different river types. Out of all Unionidae and Amblemidae seventeen taxa (= 60.7 %) are endemic to the Ganga River Basin. Eight species are belonging to the more widespread fauna of the oriental region. Furthermore eight species are classified as rare and endangered, since only one to three populations were discovered during extended fieldwork. The taxonomic position of eleven fossil species from the Miocene-Pliocene of Western-Central Nepal is discussed. The use of all available living taxa for the biological water quality assessment is proposed with giving indicator value based on the existing biotic score system.

Zusammenfassung:
Vom Einzugsgebiet des Ganges werden 28 Najaden (Arten und Unterarten der Überfamilie Unionacea) sowie eine endemische Striegelmuschel (Solecurtidae) nachgewiesen. Die Gesamtverbreitung und Lebensräume werden beschrieben und Schalenmerkmale kurz charakterisiert. 98 Farbabbildungen zeigen die ökologischen Anpassungen und Reaktionsformen aller vorliegenden Muscheln aus unterschiedlichsten Lebensräumen. Hierbei werden Fliesswasserarten aus Bächen den Formen grosser Flüsse und Stillwasserarten aus unterschiedlichen lenitischen Lebensräumen gegenübergestellt. Die Najadenfauna weist mit siebzehn auf das Gangesgebiet begrenzten Taxa einen hohen Endemismus (60,7 %) auf. Als endemische Muscheln sind anzuführen: *Lamellidens narainporensis, L. phenchoganjensis, L. mainwaringi, L. jenkinsianus jenkinsianus, L. jenkinsianus daccaensis, Radiatula lima, R. occata, R. keraudreni, R. gaudichaudi, "Radiatula" olivaria, Parreysia favidens favidens, P. favidens chrysis, P. favidens pinax, P. favidens deltae, P. sikkimensis, P. corrugata laevirostris.* Acht Arten sind in der orientalischen Faunenregion weiter verbreitet. Von diesen erreicht die von Iran bis nach Indien verbreitete *Lamellidens rhadineus* das Gebiet von Westen her, während *Lamellidens marginalis, L. corrianus, L. lamellatus, Radiatula andersoniana, R. bonneaudi, R. caerulea* und *R. pachysoma* eine östliche Gruppe mit grossen Verbreitungsgebieten bis zum Irrawadi Einzugsgebiet bilden. Acht Arten müssen als selten und gefährdet eingestuft werden, weil trotz intensiever Feldforschung nur mit ein bis drei Lebendvorkommen im Untersuchungsgebiet nachgewiesen werden konnten. Es sind namentlich *Lamellidens phenchoganjensis, L. rhadineus, L. lamellatus, Radiatula shurtleffiana, R. gaudichaudi, R. andersoniana, R. pachysoma* und *Parreysia*

viridula. Ihre Populationen, Lebensräume und wirbellose Begleitfauna werden genauer dargestellt. Die systematische Stellung von elf fossilen Najaden aus dem Miozän-Pliozän von West- und Zentral-Nepal wird diskutiert. Darunter befinden sich neben Formen mit grosser Ähnlichkeit zur rezenten Fauna zwei Vertreter der heute südost-asiatischen Gattungen *Physunio* und *Pilsbryoconcha*. Ihr ehemaliges Vorkommen im zentralen Ganges-Einzugsgebiet lässt auf wärmeres und feuchteres Klima im Jungtertiär schliessen.
Die Nutzung der untersuchten lebenden Muscheln zur biologischen Gewässergüte-Bestimmung wird vorgeschlagen. In Anlehnung an die bestehende NEPBIOS Methode, werden alle Arten entsprechend ihrer Ansprüche an biotische Parameter, insbesonders der organischen Verschmutzung, eingestuft. Als ökologisch intakte Fliessgewässer der Güteklasse II (Referenz-Stellen) werden Abschnitte mit noch reproduzierenden artenreichen Muschelbänken definiert.

Introduction:
Large Freshwater bivalves of the superfamily Unionacea are forming a dominating part of the benthic fauna of lowland waters. Because of their complex life-cycle, their parasitic larval stage on host fishes and their comparatively long life span, these invertebrates are especially useful longtime bio-indicators. Not only the presence of a species but furthermore the population structure allows easily to receive necessary information about the biological water quality. Thus, the occurrence of large freshwater mussels gives direct answer on the common questions during water and river quality monitoring likewise oxygen, organic load, healthy fish population and any form of direct human disturbance of the mussel's habitat. Due to river engineering, damming, water abstraction, sand-mining, sewage water, the use of pesticides and fertilizers in agriculture and over-fishing of rivers, most of the species are worldwide declining and natural habitats are becoming rare in many industrialized countries. Our knowledge of this remarkable group of Mollusca is quite deficient. The present study provides for the first time colored figures of available species, like for the North-American Species (CLARKE 1981, FULLER 1985). It should help and encourage the field biologists to make proper identification on species level.

Material and Methods:
Freshwater mussels were investigated in numerous water-bodies of Northern India, Nepal and Bangladesh between 1994 and 2005 in several hundred days of fieldwork. Collections were made by hand using hand-net or with the help of sediment-samples taken with metal-bucket as grab. The study area is situated between the lower Satluj River (N 31°00', E 75°54') and upper Yamuna River (N 28°50', E 77°10') in the West and the lower Hugli River (N 22°34', E 88°23') and the Northeastern Part of Bangladesh (Mymensingh N 24°45', E 90°27') in the East, the Damodar River (N 23°38', E 85°34') in the South and the Central Himalyas (N 28°17', E 83°58') in Nepal in the North.

Reference material: It is deposited in the scientific collections of the 1. Zoological Survey of India, Patna, Bihar (India), 2. Environmental Biology Laboratory, Department of Zoology, Patna University, Patna, Bihar (India), 3. Aquatic Ecology Center, Kathmandu University, Dhulikhel, Kavre (Nepal) and 4. Naturhistorisches Museum in Wien, Natural History Museum Vienna, (Austria).

Sketches were produced in 2004-2005 by H. Nesemann with water color as background, color pencil and ink pen for outlines. Instead of giving a long and difficult understandable text description of each taxon, the user may simply compare and identify with the help of the figures. For all available species and subspecies, shells of different habitats like large rivers and small running waters are figured to enable the demonstration of the particular ecological variability.

Results (Table 1)

The Unionacean fauna of South and Southeast Asia was compiled using the publications of Preston (1915), Haas (1969), Brandt (1974) and Subba Rao (1989). Additional information were included from Annandale & Prashad (1919), Gosh (1918, 1920), Nanzeen & Begum (1994), Nesemann, Sharma & Sinha (2003), Pfeiffer, Sharma & Dahal (1999), Prashad (1918, 1919, 1920, 1922), Sinha (1988), Sharan & Sinha, 1988), Subba Rao, Mitra & Manna (1989), Subba Rao, Mitra, Dey & Maitra (1995) and Thakur, Mitra & Maitra (1992). For the territory of India, Bangladesh, Nepal, Myanmar and Thailand, there are 119 living taxa known. A comparison of the species inventory is compiled in Table 1. Out of 51 taxa from the Indian subcontinent 39 taxa (= 76.5 %) are endemic. The present study deals with the fauna of the Ganga River System, which has a total number of 28 Unionacean taxa. Within this river basin 17 taxa (= 60.7 %) are endemic. Only 8 species are more widespread in the oriental region and not only restricted on the Gangetic watershed or the Indian subcontinent (*Lamellidens marginalis, L. corrianus, L. lamellatus, L. rhadineus, Radiatula caerulea, R. andersoniana, R. bonneaudi* and *R. pachysoma*). Three endemic species of the Indian fauna *Lamellidens consobrinus, Parreysia triembolus* and *Radiatula shurtleffiana* are also distributed outside the Ganga River Systems in neighboring watersheds. Independent from their full geographical distribution, the abundance of each taxon within the study area is of special interest. Eight species of the Gangetic fauna are classified as rare and endangered, because only one to three populations could be discovered during the extended fieldwork. These are namely *Lamellidens lamellatus, L. phenchooganjensis, L. rhadineus, Radiatula andersoniana, R. shurtleffiana, R. pachysoma, R. gaudichaudi* and *Parreysia viridula*. The habitat and the macrozoobenthic fauna of these rare bivalves is described more in detail.

The number of species and subspecies may increase in the near future, since several unidentified collections of *Radiatula* spec. and *Lamellidens* spec. have still to be worked out, they are not yet included.

Description of the Taxa (Plates I-XXVII)

Family Solecurtidae (= Novaculidae) (Plate I)

Marine origin, freshwater species are often named as marine relicts (Annandale 1922).

1. *Novaculina gangetica* Benson, 1830
Plate I Figs 1-4

Novaculina gangetica Benson, 1830, Gleanings in Science, Calcutta 2: 63.
Novaculina gangetica, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 229.
Novaculina gangetica, - Subba Rao, 1989, Freshwater Molluscs of India.: 223-224, Figs 637, 638.

Locus typicus: India, Ganga River.

Remarks on the examined material: Length 51,8 – 59,3 mm, height 17,7 –23,2 mm, width 11,5 –15,9 mm. Periostracum color usually light yellowish-brown, when the animals inhabit sand and silt. The color can change into dark brown in very large specimens of mud sediments.

Distribution: Endemic to the Ganga River System. Lower and Upper Gangetic Plains in Bangladesh, West Bengal, Bihar and Uttar Pradesh. It is known from the whole lower and middle reach upstream to Varanasi about 100 km after Mirzapur (Subba Rao 1989: 223). During our research on April 9th

2004, fragments of empty shells were collected from the Ganga River at Vindhyachal upstream Mirzapur (leg. Rajiv Kumar & Hasko Nesemann).

Habitat: *Novaculina gangetica* prefers soft sand and silt bottom of lotic reaches. It is burrowing therein in vertical direction, that usually only the posterior end can be seen on the sediment surface. Living animals remain fixed in the substrate even in strong water waves due to their very large extended foot.

The species inhabits pure freshwater as well as slightly brackish oligohaline water of the Hugli River downstream from Howra. It is able to colonize the littoral of the tidal zone. *Novaculina gangetica* is confined to the Ganga River habitat and may reach high density of individuals only in unpolluted beta-mesosaprobic habitats, where it is often associated with the polychaets *Nephthys oligobranchia*, *N. polybranchia* and the amblemids *Parreysia* spp. Therefore, it is a useful indicator for stable good ecological river-quality.

Family Unionidae (Plates II-XI)

2. *Lamellidens corrianus* (Lea, 1834)
Plate III Fig 2, Plate IV Fig 5

Unio corrianus Lea, 1834, Transactions of the American Philosophical Society 5, Ser. 2: p. 65, pl. 9, fig. 25
Lamellidens marginalis subsp. *Corrianus*, - Preston, 1915, The Fauna of British India including Ceylon and Burma, 183-184.
Lamellidens testudinarius (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 110-111.
Lamellidens corrianus, - Subba Rao, 1989, Freshwater Molluscs of India 165, Figs 386, 387.

Locus typicus: West Bengal, Kolkata.

Remarks on the examined material: Length 83,0 – 92,5 mm, height 40,0 – 45,4 mm, width 27,2 – 30,0 mm. Shell solid and thick with brown or dark brownish to blackish periostracum. Hinge plate with strong teeth, laterals linear. Ventral margin is slightly curved and convex.

Distribution: Upper and Lower Gangetic Plains in India, Nepal and Bangadesh. Lower Damodar River in Jharkhand.

Habitat: Sand, silt and mud substrate of large lowland rivers. *L. corrianus* prefers lotic water bodies with a very rich macro-zoo-benthic community. Ganga River at Patna and Fatuha in Bihar. Yamuna River at Allahabad in Uttar Pradesh. Damodar River downstream from Panchet dam in Jharkhand. Nepal, Rautahat, Kamdai Nadi and Dodi Nadi near Gaur. *L. corrianus* can be a very abundant species.

3. *Lamellidens consobrinus* (Lea, 1859)
Plate II Figs 1-4

Unio consobrinus Lea, 1859, Proceedings of the Academy of Natural Sciences, Philadelphia III: 331
Lamellidens marginalis subsp. *consobrina*, - Preston, 1915, The Fauna of British India including Ceylon and Burma, 180.
Lamellidens testudinarius (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 110-111.

Lamellidens consobrinus, - SUBBA RAO, 1989, Freshwater Molluscs of India 164, Figs 384,385.

Locus typicus: "China". PRESTON (1915) stated that the locality given by LEA is obviously a mistake. The taxon is widely distributed over India.

Remarks on the examined material: Length 57,3 – 85,3 mm, height 30,6 – 42,5 mm, width 17,4 – 30,0 mm. Shell solid and thick with dark brownish or even black periostracum. Outline of the shell elongated and sometimes kidney-shaped. Hinge plate with strong teeth, laterals almost significantly curved. Ventral margin linear or slightly concave.

Distribution: Upper and Lower Gangetic Plains in Uttar Pradesh, Bihar and Nepal, lower Damodar River in Jharkhand. *L. consobrinus* is spread widely throughout the Indian subcontinent (Subba Rao 1989), but it was not documented in the "Fauna of West Bengal" (Thakur, Mitra & Maitra 1992). Most probably it was overlooked or not clearly distinguished from *Lamellidens marginalis* due to the confusing species concepts of this genus proposed by Haas (1969).

Habitat: Sand, silt and mud substrate of lowland rivers. *L. consobrinus* has similar habitat preferences like *L. corrianus*, but it inhabits also smaller rivers. Lotic and lentic water bodies with a very rich macro-zoobenthic community. Ganga River at Patna and Fatuha in Bihar. Yamuna River at Allahabad, Gombti (Gomati) River upstream from Lucknow in Uttar Pradesh. Damodar River downstream from Panchet dam in Jharkhand. Nepal, Rautahat, Kamdai Nadi and Dodi Nadi near Gaur. *L. consobrinus* usually occurs in high abundances.

4. *Lamellidens narainporensis* Preston, 1912
Plate VI Figs 3, 4, Plate VII Figs 1-4

Lamellidens narainporensis Preston, 1912, Records of the Indian Museum, Calcutta, VII, p. 306
Lamellidens narainporensis, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 187-188, Figs 21.-1, 2.
Lamellidens testudinarius (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 110-111.
Lamellidens corrinanus (partim), - Subba Rao, 1989, Freshwater Molluscs of India: Figs 402,403.

Locus typicus: West Bengal, Murshidabad, Narainpur.

Remarks on the examined material: Length 36,4 – 78,4 mm, height 20,3 – 36,3 mm, width 12,5 – 22,2 mm. Shell solid and thick with dark red or even brownish periostracum. Outline of the shell elongated and oviform. Shell compressed. Hinge plate with thin teeth, laterals very long. Ventral margin is linear in adults. The umbones and cardinal teeth are shifted far towards the anterior end.

Distribution: Endemic to the Ganga River System. Upper and Lower Gangetic Plains in India and Nepal.

Habitat: Clay and mud substrate of lowland waters. The animals like burrowing in hard clay banks between the roots of trees. *L. narainporensis* prefers stagnant water bodies and inhabits also lentic zones of rivers. It is widely distributed, but occurs sporadically in ponds and rivers, mostly associated with *Radiatula caerulea*. Kumhrar pond at Patna, Ganga River at Bhagalpur in Bihar. Gombti (Gomati) River upstream from Lucknow, Ganga River at Chunarghat in Uttar Pradesh. Nepal, Rautahat, Kamdai Nadi near Gaur. *L. narainporensis* usually occurs in high abundances only in ponds, whereas the findings in rivers are often single specimens.

4. *Lamellidens mainwaringi* Preston, 1912
Plate III Fig 3, Plate IV Fig 6

Lamellidens mainwaringi Preston, 1912, Records of the Indian Museum Calcutta VII, p. 306
Lamellidens mainwaringi - Preston, 1915, The Fauna of British India including Ceylon and Burma: 190-192, fig. 24.
Lamellidens testudinarius (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 110-111.
Lamellidens corrianus (partim), - Subba Rao, 1989, Freshwater Molluscs of India: 165.

Locus typicus: West Bengal, Siliguri.

Remarks on the examined material: Length 56,3 mm, height 29,7 mm, width 18,0 mm. Shell ovate small, thick-shelled and heavy with strong developed hinge, periostracum dark brownish or black.

Distribution: Endemic to the Ganga River System. Terai region in Eastern Nepal and Northern West Bengal, endemic to the Mechi River Basin.

Habitat: Sand, gravel and mud of small lowland streams. *L. mainwaringi* is a typical running water species of the terai regions near the Himalayan foothills. It prefers forest streams, where it is often associated with *Radiatula lima* and *Parreysia sikkimensis*.

5. *Lamellidens jenkinsianus jenkinsianus* (Benson, 1862)
Plate IX Figs 1-3, Plate X Figs IV-VI

Unio jenkinsianus Benson, 1862, Ann. Mag. Nat. Hist. (3) 10: 185.
Lamellidens marginalis subsp. *jenkinsianus*, - Preston, The Fauna of British India including Ceylon and Burma, 184-185.
Lamellidens jenkinsianus, - Prashad, 1920, Records of the Indian Museum 19: 168-173, pl. 9, Figs 3, 4.
Lamellidens testudinarius (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 110-111.
Lamellidens jenkinsianus , - Subba Rao, 1989, Freshwater Molluscs of India: 166, Figs 390, 391.

Locus typicus: Assam, Brahmaputra River.

Remarks on the examined material: Large form of the Patna Secretariat Pond: Length 99,4 mm, height 51,3 mm, width 34,3 mm. Shell solid and (adult) very thick with dark brownish shining (!) periostracum. Hinge plate very strong with elongated pseudocardinal teeth. Umbones and pseudocardinal teeth shifted more towards the center than in *L. corrianus* and *L. consobrinus*. Nacre in large specimens often orange.

Distribution: Endemic to the Ganga and lower Brahmaputra River Systems. Lower and Upper Gangetic Plains in India and Bangladesh, Terai region in Central Nepal.

Habitat: Stagnant waters, large ponds with high natural organic load (eutrophication), occasionally found in rivers. Ponds of Patna in Bihar, Ganga River at Bithur in Uttar Pradesh, ponds of fish-farm near Hetauda in Nepal.

7. *Lamellidens jenkinsianus daccaensis* (Preston, 1912)

Parreysia daccaensis Preston, 1912, Records of the Indian Museum 7: 300.

Parreysia daccaensis, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma, 165-166, Fig. 16.
Lamellidens jenkinsianus subsp. *daccaensis*, - PRASHAD, 1920, Records of the Indian Museum 19: 173, pl. 9, Figs 5-8.
Lamellidens testudinarius (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 110-111.
Lamellidens jenkinsianus subsp. *daccaensis*, - SUBBA RAO, 1989, Freshwater Molluscs of India: 167, Figs 394-397.

Locus typicus: Bangladesh, Dacca.

Brief characters according to SUBBA RAO (1989: 167): Length 76,6 mm, height 47,35 mm. Shell much shorter, broader, more convex, much more swollen, umbones more distinct and convex, dorsal margin more arched than in the typical form.

Distribution: Endemic to the Gangetic delta. Lower Gangetic Plains in Bangladesh and India.

Habitat: Mostly confined to waters of the Gangetic delta, reported westwards as far upstreams as Bhagalpur in Bihar (Prashad, 1920).

8. *Lamellidens marginalis* (LAMARCK, 1819)
Plate V Figs 1-4, Plate VI Figs 1, 2

Unio marginalis LAMARCK, 1819, Histoire naturelle des animaux sans vertèbres 6: 79
Lamellidens marginalis, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma, 175-176.
Lamellidens testudinarius (partim), - HAAS, 1969, Tierreich, Superfam. Unionacea: 110-111.
Lamellidens marginalis , - SUBBA RAO, 1989, Freshwater Molluscs of India 168, Figs 404, 405.

Locus typicus: Bengal.

Remarks on the examined material: Length 71,6 – 102,0 mm, height 34,0 – 53,2 mm, width 21,4 – 31,4 mm. Shell fragile and thin with golden yellowish, yellow or light brownish periostracum. Hinge plate weak with thin teeth, ventral margin linear and almost parallel to the dorsal margin.

Distribution: Lower and Upper Gangetic Plains in India and Bangladesh, Terai region and Mid-mountains in Nepal up to elevation of 800 m above mean sea level.

Habitat: Living specimens were mostly observed in sand substrate. Various Lakes, oxbow-lakes, smaller rivers and streams, widespread but not everywhere common. *L. marginalis* is forming dense populations in the effluents of stagnant water bodies, e.g. Khudi Khola at Begnas Tal near Pokhara, Nepal.

9. *Lamellidens phenchooganjensis* PRESTON, 1912
Plate III Fig 1, Plate IV Fig IV

Lamellidens phenchooganjensis PRESTON, 1912, Records of the Indian Museum 7: 306.
Lamellidens phenchooganjensis, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma, 190, fig. 23..
Lamellidens testudinarius (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 110-111.

Lamellidens phenchooganjensis , - SUBBA RAO, 1989, Freshwater Molluscs of India 168, figs. 406, 407.

Locus typicus: Bangladesh, Phenchooganj.

Remarks on the examined material: Length 96,0 mm, height 41,0 mm, width 26,8 mm. Shell very elongated, thin, hinge reduced, pseudocardinal teeth are fused. Periostracum dark brown or black (? due to microhabitat).

Distribution: Endemic to the Ganga River System. Lower Gangetic Plains in Bangladesh and Bihar. Rare species of stagnant water bodies. Only one population was discovered during the present research.

Habitat: Mamu Bhanja Pokhra at Hajipur, 4th May 2004, Bihar. Black mud substrate under and near dense macrophytes in stagnant water of an oxbow-lake, formed by an old branch of the Gandak River. The habitat has a very rich faunal diversity.

L. phenchooganjensis lives in association with *Radiatula gaudichaudi, R. pachysoma, Lamellidens consobrinus* and a very elongated form of *L. marginalis*. The gastropod fauna consists of *Bellamya bengalensis, Pila globosa, Melanoides tuberculatus, Digoniostoma cerameopoma, D. pulchella, Radix luteola, Gyraulus euphraticus* and *Indoplanorbis exustus*. The annelids are represented with *Branchiura sowerbyi, Alboglossiphonia weberi, Placobdelloides fulvus, Hemiclepsis marginata asiatica* and *Hirudinaria manillensis*.

10. *Lamellidens lamellatus* (LEA, 1838)
Plate VIII Figs 1-4

Unio lamellatus Lea, 1838, Transactions of the American Philosophical Society 6: 19, pl. 6, fig. 16.
Lamellidens marginalis subsp. *lamellata*, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma, 180-181.
Lamellidens testudinarius (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 110-111.
Lamellidens lamellatus, - SUBBA RAO, 1989, Freshwater Molluscs of India 167-168, Figs 398, 399, 410, 411.

Locus typicus: Bengal.

Remarks on the examined material: Length of eight specimens varies between 56,2-81,5 mm, height 30,9-44,2 mm, width 18,7-21,6 mm. Shell moderately thin and solid, umbones always inflated, periostracum brownish.

Distribution: Lower Gangetic Plains in West Bengal, Lake of the Damodar River Basin in Jharkhand, Myanmar. Only one population was discovered during the present research.

Habitat: It is a rare and sporadic species. *L. lamellatus* was collected on 1st June 2004 from the Tenughat-Reservoir. It is a very clear and unpolluted oligotrophic reservoir in the Damodar River System. The animals inhabit gravel and sand substrate of the littoral zone.

They are associated with *Lamellidens consobrinus, Corbicula striatella, Bellamya bengalensis, Thiara lineata, Thiara scabra, Brotia costula, Melanoides tuberculatus, Digoniostoma pulchella, Lymnaea acuminata* and *Gyraulus convexiusculus*.

11. *Lamellidens rhadinaeus* Annandale & Prashad, 1919
Plate XI Figs 1-3

Lamellidens marginalis subsp. *rhadinaeus* Annandale & Prashad, 1919, Records of the Indian Museum 18: 59-62, Fig. 9, pl. III, Figs 9, 10, pl. VIII, Figs 8-11.

Locus typicus: Iran, Seistan, Helmand River.

Remarks on the examined material: Length 43,7- 71,0 mm, height 34,0 – 53,2 mm, width 21,4 – 31,4 mm. Thick-shelled with well developed hinge, ventral margin curved and anterior part tapered.

Distribution: Iran-Afghanistan, Seistan, Helmand River near Nasratabad. Satluj River Basin in Punjab, India. Two populations were discovered during the present research. It appears, that west-oriental *L. rhadineus* is a widespread and previously overlooked species. According to unpublished records, its distribution ranges from Teheran in Iran eastwards to the watershed between Indus and Ganga River Systems. Because of its geographical, ecological and conchological distinction from all other *Lamellidens* species, the taxon *rhadineus* will be herewith regarded as a good species.

Habitat: Sand and mud substrate of lentic water bodies within the Satluj River floodplain northwest from Lhudiana in Punjab. Specimens were collected on 23rd and 24th September 2001 from pools in the furcating zone of the main riverbed and from a temporarily flooded river channel. All waters are characterized by their high dynamic and perennial flow.

L. rhadineus lives here in association with *Radiatula caerulea, Corbicula striatella, Bellamya bengalensis, Melanoides tuberculatus, Indoplanorbis exustus, Gyraulus convexiuculus, G. labiatus, Radix luteola* and the leeches *Asiaticobdella fuscolineata* and *Poecilobdella granulosa*.

Family Amblemidae (Plates XII-XXVII)

Parreysia favidens should be regarded as a collective name of a species-complex or super-species. The hitherto known taxa are preliminarily classified as subspecies, when they have geographical distinction (= allopatric occurrence). Some can be taken as distinct species, when their geographical range is overlapping (= sympatric occurrence).

12. *Parreysia favidens favidens* (Benson, 1862)
Plate XXIII Figs 1, 2

Unio favidens Benson, 1862, Annals. Mag. Nat. History X: 188.
Parreysia (Parreysia) favidens, - Preston, The Fauna of British India including Ceylon and Burma 158-159.
Parreysia favidens, - Haas, 1969, Tierreich, Superfamilia Unionacea: 119.
Parreysia (Parreysia) favidens, - Subba Rao, 1989, Freshwater Molluscs of India, 180-181, Figs 466, 467, 484, 485.

Locus typicus: Uttar Pradesh, Ganga River, Bithur.

Remarks on the examined material: Length 43,0 – 71,3 mm, height 32,6 – 49,5 mm, width 21,7 – 28,4 mm. Shell rounded, thick shelled and heavy with very strong hinge plate bearing prominent and furcated pseudocardinal teeth and slightly curved lateral teeth. They are often divided into a variable

number of smaller accessory teeth in each valve. The hinge plate is slightly bent. The umbones are directed dorsally. Periostracum red-brownish.

Distribution: Endemic to the Ganga River System. Upper Gangetic Plains in Uttar Pradesh, Upper Ganga River before the confluence with Yamuna River.

Habitat: Sand, gravels, mud and silt of running lowland waters. Under good ecological conditions, *P. favidens favidens* may occur in high density of individuals.

The type locality was visited and investigated on 3rd April 2003 near the Brahmavrata Ghat at Bithur, 22 km upstream from Kanpur. The river has high current velocity of 0,8 m/second in the main channel. The dominating substrate is sand. The water is dark greenish brown with high content of Potamo-Plankton. The invertebrate fauna is remarkable dominated by very dense bivalve populations. The shells of all species are large forms, indicating optimal grow and life conditions. *Parreysia favidens favidens* is the most common species of the right erosion bank, others were identified as *Parreysia corrugata laevirostris, Radiatula caerulea, Radiatula* affinis *shurtleffiana, Lamellidens jenkinsianus jenkinsianus* (single specimen) and *Corbicula striatella*. On the left sedimentation bank "*Radiatula*" *olivaria* is abundant.

13. *Parreysia favidens chrysis* (Benson, 1862)
Plate XXIII Figs 3, 4, Plate XXIV Figs 1, 2

Unio favidens var. *chrysis* Benson, 1862, Annals. Mag. Nat. History X: 189.
Parreysia (Parreysia) favidens Var. *chrysis*, - Preston, The Fauna of British India including Ceylon and Burma 160, fig. 10.
Parreysia favidens, - Haas, 1969, Tierreich, Superfamilia Unionacea: 119.
Parreysia (Parreysia) favidens subsp. *chrysis*, - Subba Rao, 1989, Freshwater Molluscs of India, 181.

Locus typicus: Uttar Pradesh, Doroja River, Bareilly.

Remarks on the examined material: Length 52,3 – 57,8 mm, height 35,2 – 36,3 mm, width 23,9 – 26,4 mm. Shell elongated or rounded, thick shelled with strong hinge plate bearing prominent and furcated pseudocardinal teeth and curved lateral teeth. The hinge plate is significantly bent. The umbones in adult shells are very prominent and turned anterior. Periostracum brown, often yellowish brown.

Distribution: Endemic to the Ganga River System. Upper and Lower Gangetic Plains in Uttar Pradesh and Bihar, Yamuna River and Ganga River below the confluence. Damodar River in Jharkhand. *P. favidens chrysis* appears to be to most widespread and common taxon of the genus *Parreysia* within the Ganga River System.

Habitat: Gravel, between natural rocks, sand, mud and silt of various types of running water bodies, e.g. lowland streams, lowland rivers, large rivers and rivers originated from mid-mountains. This subspecies often occurs in large individual numbers and is always more abundant than *Parreysia corrugata laevirostris*.

14. *Parreysia favidens pinax* (Benson, 1862)
Plate XXV Figs 1-4

Unio pinax Benson, 1862, Annals. Mag. Nat. History X: 189.

Parreysia (Parreysia) favidens Var. *pinax*, - PRESTON, The Fauna of British India including Ceylon and Burma 160, Fig. 10.
Parreysia favidens, - HAAS, 1969, Tierreich, Superfamilia Unionacea: 119.
Parreysia (Parreysia) favidens pinax, - SUBBA RAO, 1989, Freshwater Molluscs of India, Figs. 456, 457.

Locus typicus: Uttar Pradesh, Gungun River, Moradabad.

Remarks on the examined material: Length 33,7 – 45,2 mm, height 25,4 – 30,3 mm, width 16,5 – 20,0 mm. Thick-shelled and heavy with strongly furcated and fused pseudocardinal teeth. Lateral teeth of right valve with two accessory teeth. Anterior part very short. The umbones in adult shells are more turned anterior, than in all other taxa of this genus. Periostracum dark brownish.

Distribution: Endemic to the Ganga River System. Terai regions in Uttar Pradesh, Bihar and Nepal. This subspecies is confined to the smaller river basins along the foothills of the Churia-Siwalik range.

Habitat: Gravel, sand and mud substrate of lowland streams and small lowland rivers, also abundant in running waters originated from mid-mountains up to elevations of 250 meters above mean sea level. During the present study, *P. favidens pinax* was found from a number of localities in the Western Zone of Nepal, where it appears to be locally abundant. Samir K. Sinha collected in April 2004 a number of shells of this subspecies from tributaries of the Gandak River in the Valmiki Tiger Reserve in northern Bihar.

15. *Parreysia favidens deltae* (BENSON, 1862)

Unio favidens var. *deltae* BENSON, 1862, Annals. Mag. Nat. History (3) 10: 189.
Parreysia (Parreysia) favidens Var. *deltae*, - PRESTON, The Fauna of British India including Ceylon and Burma, 159-160.
Parreysia favidens (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 119.
Parreysia (Parreysia) favidens subsp. *deltae*, - SUBBA RAO, 1989, Freshwater Molluscs of India, 181-182, Figs. 470, 471.

Locus typicus: Bangladesh, Jellinghy River.

Brief characters according to SUBBA RAO (1989: 182): Length 61,4 mm, height 43,5 mm Shell of rounded form, periostracum olive green and yellow, umbones with distinct rugae.

Distribution: Endemic to the Ganga, Brahmaputra and Mahanadi River Systems. Lower Gangetic Plains in West Bengal and Bangladesh, also known from Orissa. This subspecies could not be figured during the present investigation, since only a few old shell fragments, collected by Subodh Sharma in September 2005 from Bangladesh, were available.

16. *Parreysia triembolus* (BENSON, 1855)

Unio triembolus BENSON, 1855, Journal of the Asiatic Society of Bengal 35: 44.
Parreysia (Parreysia) tavoyensis Var. *triembolus*, - PRESTON, The Fauna of British India including Ceylon and Burma, 167-168.
Parreysia tavoyensis, - HAAS, 1969, Tierreich, Superfamilia Unionacea: 122-123.

Parreysia (Parreysia) triembolus, - SUBBA RAO, 1989, Freshwater Molluscs of India, 186, Figs. 506, 507.

Locus typicus: Madhya Pradesh, Narmada River.

Brief characters according to SUBBA RAO (1989: Figs 506-507): Length 47,6 mm, height 41,0 mm Shell very thick, umbones prominent and shifted anterior, posterior part angular.

Distribution: Rare species of the Lower and Upper Gangetic Plains and Brahmaputra River Basin, known from a few localities in Uttar Pradesh, West Bengal and Assam.

17. *Parreysia sikkimensis* (LEA 1859)
Plate XXVII Figs 1-4

Unio sikkimensis LEA, 1859, Proceedings of the Academy of Natural Sciences Philadelphia 3: 151.
Unio sikkimensis, - LEA, 1859, Journal of the Academy of Natural Sciences Philadelphia 4: 251, pl. 39, Fig. 131.
Parreysia (Parreysia) sikkimensis, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma.: 171.
Parreysia sikkimensis, - HAAS, 1969, Tierreich, Superfamilia Unionacea: 124.
Parreysia (Parreysia) sikkimensis, - SUBBA RAO, 1989, Freshwater Molluscs of India: 183, Figs 488, 489.

Locus typicus: Sikkim.

Remarks on the examined material: Length 30,5 – 36,2 mm, height 22,3 – 25,4 mm, width 13,0 – 16,0 mm. Shell thin and rounded, compressed, umbones less prominent. Periostracum is yellowish to brown. *P. sikkimensis* is distinguished from other species by its smaller size, its more central umbones and the less developed umbonal sculpture.

Distribution: Endemic to the Ganga River System. Terai region and foothills of Eastern Nepal, Northern West Bengal and Sikkim, similar to *Lammelidens mainwaringi*. *Parreysia sikkimensis* (LEA 1859) was observed to be the most common member of this genus in Eastern Nepal in the Mechi River basin (PFEIFFER, SHARMA & DAHAL 1999).

Habitat: Sand, gravel and mud of small lowland streams. *P. sikkimensis* is a typical running water species of the terai regions near the Himalayan foothills. It prefers forest streams, where it is often associated with *Radiatula lima* and *Lamellidens mainwaringi*.

18. *Parreysia viridula* (BENSON, 1862)
Plate XXIV Figs 3, 4

Unio favidens var. *viridula* BENSON, 1862, Annals. Mag. Nat. History X: 189.
Parreysia (Parreysia) favidens var. *viridula*, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma: 160-161, Fig. 11.
Parreysia favidens (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 119.
Parreysia (Parreysia) favidens subsp. *viridula*, - SUBBA RAO, 1989, Freshwater Molluscs of India: 182, Figs 474, 475.

Locus typicus: Uttar Pradesh, Hamirpur.

Brief characters of the examined material: Length 41,9 – 44,2 mm, height 30,0 – 30,4 mm, width 19,5 – 21,0 mm. Shell similar to *P. favidens* but much shorter and umbones shifted more into the center. Periostracum dark with strong greenish brown color.

Distribution: Endemic to the Ganga River System. Lower and Upper Gangetic Plains in Uttar Pradesh, Bihar and Nepal. Rare and most probably overlooked species.

Habitat: Mud and silt substrate of lowland rivers with a very rich benthic fauna. Ganga River at Patna and Doriganj in Bihar, Kamdai Nadi and Dodi Nadi near Gaur, Nepal. *P. viridula* is nowhere abundant and was found only in small numbers of specimens.

19. *Parreysia corrugata laevirostris* (Benson, 1862)
Plate XXVI Figs 1-4

Unio laevirostris Benson, 1862, Annals. Mag. Nat. History X: 191-192.
Parreysia (Parreysia) corrugata Var. *laevirostris*, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 156-157.
Parreysia corrugata (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 118.
Parreysia (Parreysia) corrugata subsp. *laevirostris*, - Subba Rao, 1989, Freshwater Molluscs of India: 179, Figs 452, 453.

Locus typicus: Uttar Pradesh, streams near Chunar.

Remarks on the examined material: Length 49,5 –64,2 mm, height 30,8 – 41,2 mm, width 21,0 – 28,3 mm. Shell oval, thick shelled and heavy with strong hinge plates bearing furcated pseudocardinal teeth and straight lateral teeth. They are less prominent than in *P. favidens*. The hinge plate is not typically bent, like in *P. favidens*. Umbones less prominent, they are more directed dorsally.

Distribution: Endemic to the Ganga River System. Lower and Upper Gangetic Plains in northern India from Uttar Pradesh to Jharkhand, Terai region in Central Nepal.

Habitat: Gravel, between natural rocks, sand, mud and silt of various types of running water bodies, e.g. lowland streams, lowland rivers, large rivers and rivers originated from mid-mountains. This species is widely distributed within the Upper and Lower Gangetic Plains. It occurs in Nepal in elevation of more than 300 m above mean sea level in the Karna Khola upstream from Hetauda.

20. *Radiatula caerulea* (Lea, 1831)
Plate XIV Figs 1-4

Unio caeruleus Lea, 1831, Transactions of the American Philosophical Society 4: 95, pl. 13, fig. 25.
Nodularia (Nodularia) caeruleus, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 136-138.
Indonaia caerulea, - Haas, 1969, Tierreich, Superfamilia Unionacea: 113-114.
Parreysia (Radiatula) caerulea, - Subba Rao, 1989, Freshwater Molluscs of India 188, Figs. 516, 517.

Locus typicus: West Bengal, Hugli River.

Remarks on the examined material: Length 51,8 – 58,2 mm, height 21,8 – 29,6 mm, width 15,0 – 21,5 mm. Shell elongated and solid, umbones well developed, lateral teeth long and straight, dorsal and ventral margin almost parallel, periostracum dark greenish brown in adults.

Distribution: Northern Indian Subcontinent from Pakistan (Sindh) in the West to Assam and Myanmar in the East. Terai region in Nepal.

Habitat: *R. caelulea* is the less specialized and most widespread species. It colonizes gravel, sand and mud substrate of lowland streams and lowland rivers, also abundant in running waters originated from mid-mountains up to elevations of 250 meters above mean sea level. Occasionally, *R. caerulea* is common in large ponds with high nutrient and well oxygenated water.

21. *Radiatula keraudreni* (Eydoux, 1838)

Unio keraudreni Eydoux, 1838, Mag. Zool. CI, V: 8, pl. 118, fig.1.
Nodularia (Nodularia) caeruleus Var. *keraudrenii*, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 137-138.
Indonaia caerulea (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 113-114.
Parreysia (Radiatula) caerulea keraudreni, - Subba Rao, 1989, Freshwater Molluscs of India, 188-189, Figs. 520, 521.

Locus typicus: West Bengal, Chandannagar.

Remarks on the examined material: Length up to 55 mm, shell tumid and moderately thick, umbones with prominent sculpture, resembling elongated forms of *Radiatula lima*.

Distribution: Endemic to the Ganga River System. Damodar River Basin in Jharkhand and West Bengal.

Habitat: *R. keraudreni* is predominantly a running water species with very limited distribution in the middle and lower Damodar River System. It was investigated from 29th May to 5th June 2004 in six localities in Jharkhand and one locality in West Bengal. *R. keraudreni* usually forms monocultures in mixed gravel, sand and mud substrate, where it prefers lotic reaches and it also was observed between natural rocks in high water current. This bivalve is often associated with *Corbicula striatella* and the gastropods *Thiara scabra, T. lineata* and *Thiara (Sermyla) riqueti*.

22. *Radiatula gaudichaudi* (Eydoux, 1838)
Plate XVII, XXVIII Figs 1-6

Unio gaudichaudi Eydoux, 1838, Mag. Zool. CI, V: 8, pl. 118, fig.1.
Nodularia (Nodularia) caeruleus Var. *gaudichaudi*, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 137.
Indonaia caerulea (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 113-114.
Parreysia (Radiatula) caerulea subsp. *gaudichaudi*, - Subba Rao, 1989, Freshwater Molluscs of India, 188-189, Figs. 520, 521.

Locus typicus: Bengal.

Remarks on the examined material: Length 55,4-62,5 mm, height 26,5 – 28,2 mm, width 19,0 – 21,0 mm. Shell more elongated and larger than *Radiatula caerulea*, umbones more shifted anterior, periostracum of reddish brown color, nacre pinkish.

Distribution: Endemic to the Ganga and adjacent Mahanadi River Systems. Lower Gangetic Plains in West Bengal and Bihar. Only one locality of *R. gaudichaudi* could be studied during the present research.

Habitat: Mamu Bhanja Pokhra at Hajipur, May 2004, Bihar. Various sand and mud substrate in stagnant water of an oxbow-lake, formed by an old branch of the Gandak River. The habitat has a very rich faunal diversity. *Radiatula gaudichaudi* lives here in high densities of individuals associated with *Lamellidens phenchooganjensis*. For a detailed faunal composition of this locality see the list given above.

23. *Radiatula occata* (Lea, 1860)
Plate XII Figs 3, 4, Plate XIII Figs 1-4

Unio occatus Lea, 1860, Proceedings of the Academy of Natural Sciences Philadelphia 4: 307.
Nodularia (Nodularia) occata, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 138-139.
Indonaia occata, - Haas, 1969, Tierreich, Superfamilia Unionacea: 114-115.
Parreysia (Radiatula) occata, - Subba Rao, 1989, Freshwater Molluscs of India: 191, Figs. 426, 427, 526, 527.

Locus typicus: Bengal.

Remarks on the examined material: Length 48,0 – 55,5 mm, height 26,0 – 30,0 mm, width 15,5 – 18,8 mm. Shell short oval, very much compressed, umbones not inflated and almost flattened, anterior portion very short, rounded and dorsal margin here sharply bent into ventral direction. Lateral teeth rather short and straight. Periostracum is yellowish brown, even in adults lighter than in other members of this genus.

Distribution: Endemic to the Ganga River System. Lower and Upper Gangetic Plains in northern India and adjacent Terai region in Nepal.

Habitat: Sand, fine gravel or mud in silt of various running waters. *Radiatula occata* is a very common and widespread species of the terai in Nepal, often found together with *Radiatula lima* even in small streams. Its habitats are the middle reach of the Ganga River and numerous left tributaries coming from the Himalayan foothills. It is fairly abundant in West Bengal, Bihar and Nepal. Only one locality (Gombti River upstream from Lucknow) could be found in Uttar Pradesh. In the upper Gangetic Plains, *Radiatula occata* is replaced by *Radiatula shurtleffiana*.

24. *Radiatula shurtleffiana* (Lea, 1856)
Plate XII Figs 1, 2

Unio shurtleffianus Lea, 1856, Proceedings of the Academy of natural Sciences Philadephia. 8: 95.
Nodularia (Nodularia) shurtleffiana, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 138.
Indonaia caerulea (partim), - Haas, 1969, Tierreich, Superfamilia Unionacea: 113-114.

Parreysia (Radiatula) shurtleffiana, - SUBBA RAO, 1989, Freshwater Molluscs of India, 192, Figs. 512, 513.

Locus typicus: Maharashtra, Sina River, Ahmadnagar.

Remarks on the examined material: Length 49,3 mm, height 25,0 mm, width 16,2 mm. Shell elongated, very much compressed, umbones not inflated and almost flattened. Similar to Radiatula occata, but longer. Periostracum is brown to greenish..

Distribution: Rare running water species in Central to Western part of India and Western Nepal. Upper Gangetic Plains. Only three populations were discovered during the present research.

Habitat: Western Nepal, Rupandehi, Ghaghara Khola at Bangain, two specimens, 23rd February 1994, in association with numerous *Radiatula occata* and *Parreysia favidens pinax*, Uttar Pradesh, Ganga River downstream from Varanasi, 23rd November 2001, Ganga River at Chunarghat, 9th April 2004. Specimens were found in mixed silt and sand substrate of lotic places together with numerous other large bivalves.

Here *Radiatula shurtleffiana* lives in association with *Radiatula bonneaudi, Radiatula caerulea, "Radiatula" olivaria, Parreysia favidens chrysis, Parreysia corrugata laevirostris, Lamellidens narainporensis, Corbicula striatella, Corbicula bensoni, Scaphula celox*, the gastropods *Bellamya bengalensis, Mekongia crassa, Thiara lineata, Melanoides tuberculatus, Digoniostoma pulchella, Lymnaea acuminata, Physa mexicana*, the polychaets *Namalycastis indica, Nephthys oligobranchia* and the leeches *Alboglossiphonia weberi* and *Placobdelloides fulvus*.

25. *Radiatula lima* (SIMPSON, 1900)
Plate XV, XVI Figs 1-6

Nodularia (Radiatula) lima SIMPSON, 1900, Proceedings of the United States national Museum 22: 820.
Nodularia (Radiatula) lima, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma: 147-148.
Radiatula lima, - HAAS, 1969, Tierreich, Superfamilia Unionacea: 112.
Parreysia (Radiatula) occata, - SUBBA RAO, 1989, Freshwater Molluscs of India: 190, Figs. 528-531.

Locus typicus: Bengal.

Remarks on the examined material: Length 46,0 – 48,5 mm, height 25,0 – 28,8 mm, width 15,5 – 17,0 mm. Shell (and habitat) very similar to *R. occata*, but more tumid, umbones always slightly inflated and lateral teeth curved.

Distribution: Endemic to the Ganga and Brahmaputra River Systems. It is restricted on a comparatively limited area in Assam, Sikkim, West Bengal, Bihar, Uttar Pradesh (Haas 1969, Subba Rao 1989, Thakur et al. 1992) and Nepal. It inhabits the northern (left) tributaries of the Ganga River, wherein it occurs in elevation up to 800 meters above mean sea level.

Habitat: Mostly found in gravel and sand, occasionally in mud and silt substrate of different running waters.

26. *Radiatula pachysoma* (BENSON, 1862)
Plate XIX Figs 1-4

Unio pachysoma BENSON, 1862, Annals. Mag. Nat. History X: 186.
Nodularia (Nodularia) pachysoma, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma: 139-140.
Indonaia caerulea (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 113-114.
Parreysia (Radiatula) pachysoma, - SUBBA RAO, 1989, Freshwater Molluscs of India: 192, Figs 540, 541.

Locus typicus: Assam, Brahmaputra River.

Brief characters of the examined material: Length 48,0-55,5 mm, height 29,0 – 31,0 mm, width 20,4 – 21,2 mm. Shell elongated triangulate with wedge-shaped posterior end, umbones prominently inflated. Lateral teeth rather long and straight, periostracum deep greenish brown.

Distribution: Rare species of the lower Ganga and Brahmaputra Plains in Assam, West Bengal and Bihar. Also well known from Myanmar. It prefers the lentic habitats of stagnant large water bodies with rich benthic fauna.

Habitat: Sand and occasional mud substrate of stagnant water bodies, Zoopond in Patna (Nesemann, Sharma & Sinha, 2003), Mamu Bhanja Pokhra at Hajipur 4th May 2004. It is a rare stagnant water species, which may occur in high densities of individuals under optimal conditions.

27. *Radiatula bonneaudi* (EYDOUX, 1838)
Plate XX Figs 1-4

Unio bonneaudi EYDOUX, 1838, Mag. Zool. Paris Class. V: 10-11, pl. 119, Figs 1, 1a.
Nodularia (Nodularia) bonneaudi, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma, 140-141.
Indonaia bonneaudi, - HAAS, 1969, Tierreich, Superfamilia Unionacea: 115.
Parreysia (Radiatula) bonneaudi, - SUBBA RAO, 1989, Freshwater Molluscs of India: 187-188, Figs 510, 511.

Locus typicus: Myanmar, Pegu.

Remarks on the examined material: Length 46,0 – 61,0 mm, height 27,0 – 34,0 mm, width 16,3 – 21,3 mm. Shell ovale with less prominent umbones, posterior end carinate, lateral teeth almost curved, ventral margin often convex in juvenils and subadults, periostracum light yellowish to brown with a few fine green striae on the posterior part.

Distribution: Assam, Manipur, Myanmar. It is widely distributed in Burma, Assam (PRASHAD 1920), Manipur (Subba Rao 1989), Nepal, Bihar and Uttar Pradesh.

Habitat: Muddy substrate of lentic places in large lowland rivers and large ponds. *Radiatula bonneaudi* is a comparatively rare species which was found only in small numbers of individuals.

Several localities were discovered in the Lower and Upper Gangetic Plains, Nepal: Kailali, Tikapur, 2005, leg. P. B. Budha, Rautahat district, Jhaj Nadi near Gaur, 6th October 2005, Bihar: Patna,

Zoopond, May 2003 (NESEMANN, SHARMA & SINHA, 2003), Uttar Pradesh: Ganga River at Chunarghat, 9th April 2004.

28. *Radiatula andersoniana* (NEVILL, 1877)
Plate XXI Figs 1-4

Unio andersonianus NEVILL, 1877, Journal of the Asiatic Society of Bengal 46: 40.
Nodularia (Nodularia) andersoniana, - Preston, 1915, The Fauna of British India including Ceylon and Burma: 143.
Indonaia caerulea (partim), - HAAS, 1969, Tierreich, Superfamilia Unionacea: 115.
Parreysia (Radiatula) andersoniana, - SUBBA RAO, 1989, Freshwater Molluscs of India: 187, Figs 508, 509.

Locus typicus: Myanmar, Myadong.

Remarks on the examined material: Length 48,7 – 56,0 mm, height 26,6 – 28,6 mm, width 19,3 – 21,2 mm. Shell elongated, remarkable inflated, umbones prominent, lateral teeth straight, ventral margin forming a straight line, periostracum dark brownish to deep green. It can be distinguished from *R. caerulea* by its shorter and more tumid shell and it differs from *R. bonneaudi* by its thickness and by the typical dark brownish periostracum with prominent green striae.

Distribution: Myanmar, Assam, West Bengal (Subba Rao 1989), Bihar and Uttar Pradesh, widespread but rare species. Only two populations were discovered during the present study.

Habitat: Specimens inhabiting the sand substrate of the Zoopond in Patna, Bihar (NESEMANN, SHARMA & SINHA, 2003). Four living animals were found in sand substrate of the Yamuna River at Janghola near Palla, 22 km upstream from New Delhi on 1st April 2004 by Rajiv Kumar & Hasko Nesemann.

Here the riverbed consists of 80% instable sand, 10% silt and 10% mud. The water is clear with green-brown color and the current velocity is 0.4 m/second in the main channel. *Radiatula andersoniana* was found in association with *Parreysia corrugata* ssp., *"Radiatula" olivaria, Corbicula striatella*, the gastropods *Bellamya bengalensis, Melanoides tuberculatus, Lymnaea acuminta, Gyraulus convexiuculus, Physa mexicana* and the aquatic earthworm *Glyphidrilus gangeticus*. All molluscs are represented in large forms. Some lentic places are densely covered with the macrophytes *Eichhornia crassipes, Potamogeton crispus* and *Ceratophylum demersum*.

29. *"Radiatula" olivaria* (LEA, 1831)
Plate XXII Figs 1-3

Unio olivarius LEA, 1831, Transactions of the American Philosophical Society Philadelphia 4: 108, pl. 16, Fig. 31.
Nodularia (Nodularia) olivaria, - PRESTON, 1915, The Fauna of British India including Ceylon and Burma: 144-145.
Indonaia olivaria, - HAAS, 1969, Tierreich, Superfamilia Unionacea: 115-116.
Parreysia (Radiatula) olivaria, - SUBBA RAO, 1989, Freshwater Molluscs of India: 191, Figs 534, 535.

Locus typicus: Assam, Burill River.

Remarks on the examined material: Length 40,9 – 49,5 mm, height 22,3 – 28,0 mm, width 14,7 – 16,6 mm. Shell ovate, fragile and highly variable in form and size, periostracum light yellowish to ochre. Males and females can be easily distinguished by their shells, ventral margin more convex in females. No sculpture present.

Distribution: Endemic to the Ganga and lower Brahmaputra River Systems. *R. olivaria* is restricted on the Gangetic plain and mainly the Ganga River in Uttar Pradesh, Bihar and West Bengal.

Habitat: Instable sand substrate of lotic habitats in the main channel of Ganga and Yamuna Rivers. It prefers stretches with mineral sediment and tolerates only a fine detritus cover. "*Radiatula*" *olivaria* is an annual pioneer of such habitats, which cannot be permanently colonized by other large bivalves, except *Novaculina gangetica.* Therefore, *R. olivaria* appears to be one of the most pollution-sensitive species of all described taxa.

Fossil Unionacea species of Nepal (Table 2)

Closely related fossil species of Unionidae and Amblemidae are known from the middle Miocene-Pliocene Siwalik and Churia groups in Western and Central Nepal. *Lamellidens arungensis* Takayasu et al. (1995) and *Lamellidens* sp. (Gurung, 1998) (Takayasu et al. 1995, Gurung 1998) from the Narayani (Gandak) River System might be regarded as close relatives or ancestors of the living taxa. However, the very elongated *Lamellidens longiformis* Takayasu et al. (1995) has no similarity to any living member of this genus. It has better to be named as a fossil representative of the Southeast-Asian genus *Pilsbryoconcha* Simpson (1900) as new combination *Pilsbryoconcha longiformis* (Takayasu, Gurung & Matsuoka, 1995). Fossil species of Amblemidae are *Parreysia binaiensis* Takayasu et al.(1995) *Parreysia zigzagicostata* Takayasu et al. (1995) and *Parreysia chureii* Gurung (1998) with affinities to the living *Parreysia favidens* species-complex. The following species, described as *Indonaia jimuriensis* Takayasu et al. (1995) and *Indonaia tenella* Takayasu et al. (1995) are fossil relatives of the living *Radiatula caerulea*, *Radiatula lima* and *Radiatula occata.* Two further thick-shelled and rounded species, named as *Indonaia churia* Takayasu et al. (1995) and *Indonaia narayani* Takayasu et al. (1995) are clearly representing members of the genus *Parreysia*. From the zoogeographical point of view, the former presence of the two genera *Pilsbryoconcha* and *Physunio* is of special interest. The living species are limited to Thailand, Myanmar and Assam. The fossil occurrence in the northern Ganga River System indicates more humid and warmer climate in Pliocene era compared with the present situation.

Use of bivalves for biological water quality assessment (Table 3)

All species of large bivalves, especially the Unionaceans, are very useful indicator for monitoring of biological water quality and river quality classes due to their complex life cycle and long life span. The indicator value is based on their abundance and habitat preferences. Rare species and running water species have got a higher indicator value than common species or stagnant water species. All described taxa have their optimum in beta-mesosaprobic water quality of class II. Only a few habitat-indifferent and widespread taxa are able to tolerate higher organic pollution of water quality class III for longer duration. Most of the rare species are not only restricted on a medium level of organic load, they are more limited on special microhabitat and presence of host fishes. The presence of large colonies of Unionaceans in lowland rivers always indicates water quality class II or II-III in pre-monsoon. Water quality class I cannot be found in surface waters of the Gangetic Plains due to natural organic load. Out of all taxa three species with very specialized habitat preferences (*Novaculina gangetica, Lamellidens lamellatus* and "*Radiatula*" *olivaria*) are the most pollution-sensitive bivalves.

References

ANNANDALE, N. & B. PRASHAD (1919): The Mollusca of the inland waters of Baluchistan and Seistan. – Records of the Indian Museum XVIII: 17-62, pl. I-VIII.

ANNANDALE, N. (1922): The marine element in the fauna of the Ganges. - Bijderagen Dierkunde Amsterdam 22: 143-154.

BRANDT, R. A. M. (1974): The non-marine aquatic Mollusca of Thailand. – Archiv für Molluskenkunde 105: 1-423.

CLARKE, A. H. (1981): The Freshwater Molluscs of Canada. - National Museum of Natural Sciences, Ottawa, 446 pp.

FULLER, S. (1985): Freshwater Mussels of the Upper Mississippi River. - Wisconsin Department of Natural Resources, Madison, Wisconsin, 64 pp.

GHOSH, E. (1918): On the Anatomy of certain Indian Unionidae. - Records of the Indian Museum 15: 109-122, pl. XVI

GHOSH, E. (1920): Taxonomic studies on the soft parts of the Solenidae. – Records of the Indian Museum XIX: 47-78, pl. II, III.

GURUNG, D. & I. KOBAYASHI (1998): Shell micro-structure of the Late Miocene freshwater unionid Parreysia binaiensis (Mollusca: Bivalvia) from Nepal. - Science Reports of the Niigata University, Series E (Geology) 13: 43-54.

GURUNG, D. (1998): Freshwater molluscs from the Late Neogene Siwalik Group, Surai Khola, western Nepal. - Journal of the Nepal Geological Society 17: 7-28.

GURUNG, D., TAKAYASU, K. & K. MATSUOKA (1997): Middle Miocene-Pliocene freshwater gastropods of the Churia Group, west-central Nepal. - Palaeontological Research 1 (3): 166-179.

HAAS, F. (1969): Superfamilia Unionacea. Das Tierreich., pp 1-613, Der Gruyter, Berlin.

NAZNEEN, S. & F. BEGUM (1994): Distribution of molluscs in Layari River (Sindh), Pakistan. - Hydrobiologia 273: 95-100.

NESEMANN, H, SHARMA, G. & R. K. SINHA (2003): The Bivalvia species of the Ganga River and adjacent stagnant water bodies in Patna (Bihar, India) with special reference on Unionacea. - Acta Conchyliorum 7: 1-43, Ludwigsburg.

PFEIFFER, M., SHARMA, S. & B. M. DAHAL (1999): Age and Population Structure of Freshwater Mussels in the Lowland Rivers of Nepal. - Third International Conference on Science and Technology (March 8-11, 1999), Proceedings Vol. II, Royal Academy on Science and Technology, Kathmandu.

PRASHAD, B. (1918): Studies on the anatomy of the Indian Mollusca 2. The Marsupium and Glochidium of some Unionidae and on the Indian species hitherto assigned to the genus Nodolaria. – Records of the Indian Museum XV: 141-148.

PRASHAD, B. (1919): Studies on the Anatomy of Indian Mollusca. 3. The soft parts of some Indian Unionidae. - Records of the Indian Museum 16: 289-296.

PRASHAD, B. (1920): Notes on lamellibranchs in the Indian Museum. 2. *Lamellidens jenkinsianus* (Benson) and its subspecies. – Records of the Indian Museum XIX: 168-173, pl. IX.

PRASHAD, B. (1922): A revision of the Burmese Unionidae. – Records of the Indian Museum XXIV: 91-111, pl. II.

PRESTON, H. B. (1915): Freshwater Gastropoda + Pelecypoda. The Fauna of British India including Ceylon and Burma. pp. I-XI + 1-244, Francis & Taylor, London.

SHARAN, R. K. & R. K. SINHA (1988): Ganga Basin Research Project Buxar-Barh. Final Technical Report (July, 1985-June, 1988), pp. 1-88, Patna University, Patna. Ganga Project Directorate, New Delhi, Project No. J-13013/24/83-En-I.

SHARMA S. (1996): *Biological assessment of water quality in the rivers of Nepal* [thesis]. Wien: Universität für Bodenkultur. 257 + cxxxiv p.

SINHA, R. K. (1988): Benthic Macroinvertebrates. - In: Sharan, R. K. & R. K. Sinha: Ganga Basin Research Project Buxar-Barh. Final Technical Report (July, 1985-June, 1988), pp. 34-44, 2 plates, Patna University, Patna.

SUBBA RAO, N. V. (1989): Freshwater Molluscs of India. pp.1-289, Zoological Survey of India, Calcutta.

SUBBA RAO, N. V., MITRA S. C. & R. N. MANNA (1989): Mollusca (Freshwater). - Fauna of Orissa Part 2: 277-318, Zoological Survey of India, State Fauna Series No. 1.

SUBBA RAO, N. V., MITRA S. C., DEY, A. & S. MAITRA (1995): Mollusca. - Fauna of Meghalaya Part 8: 1-88, Zoological Survey of India, State Fauna Series No. 4.

TAKAYASU, K., GURUNG, D. & K. MATSUOKA (1995): Some new species of freshwater bivalves from the Mio-Pliocene Churia Group, west-central Nepal.- Transactions and Proceedings of the Palaeontological Society of Japan, New Series 179: 157-168.

THAKUR, D. K., MITRA, S. C. & S. MAITRA (1992): Land and freshwater molluscs - Part II. Fauna of West Bengal Part - 9 (Mollusca): 53-128, Zoological Survey of India, Calcutta.

Table 1: Inventory of Unionacea fauna in South and Southeast Asia, comparing the fauna of Thailand (Th.), Myanmar (My.) and the Indian subcontinent (In.S.) with Gangetic watershed (Ganga).

Unionacea	Genus	Species/Subspecies	Th.	My.	In.S.	Ganga
Etheriidae	*Acostea*	*dalyi*			x	
Margaritiferidae	*Margaritanopsis*	*laosensis*	x	x		
Amblemidae	*Pilsbryoconcha*	*lemeslei*	x			
		exilis exilis	x			
		exilis compressa	x			
	Pseudodon	*mouhoti*	x			
		inoscularis inoscularis	x	x		
		inoscularis callifer	x			
		inoscularis harmandi	x			
		inoscularis cumingi	x			
		crebristriatus		x		
		peguensis		x		
		ava		x		
		salwenianus		x		
		cambodjensis cambodjensis	x			
		cambodjensis tenerrimus	x			
		vondembuschianus ellipticus	x			
		vondembuschianus chaperi	x			
		vondembuschianus tumidus	x			
	Physunio	*superbus*	x			
		eximius	x			
		inornatus	x			
		micropterus	x			
		micropteroides		x		
		cambodiensis	x			
		modelli	x			
		ferrugineus		x		
		velaris			x	
	Hyriopsis	*bialatus*	x			
		delaportei	x			
		desowitzi	x			
		myersiana	x			
	Chamberlainia	*hainesiana*	x			
	Cristaria	*plicata*	x			
	Unionetta	*fabagina*	x			
	Harmandia	*munensis*	x			
	Ensidens	*ingallsianus ingallsianus*	x			
		ingallsianus dugasti	x			
	Uniandra	*contradens ascia*	x			
		contradens rusticoides	x			
		contradens tumidula	x			
		contradens rustica	x			
		contradens fischeriana	x			
		subcircularis	x			
	Trapezoideus	*exolescens exolescens*	x	x	x	
		exolescens pallegoixi	x	x		
		exolescens comptus	x			

Modellnaia	*siamensis*	x			
Solenaia	*soleniformes*			x	
Scabies	*crispata*	x	x	x	
	phaselus	x			
	nucleus	x			
Parreysia	*bhamoensis*		x		
	burmanus	x	x		
	choprae		x		
	feae		x		
	feddeni		x		
	houngdaranicus		x		
	mandelayensis		x		
	olivacea		x		
	perconvexa		x		
	smaragdites		x	x	
	tavoyensis		x		
	pernodulosa		x		
	vulcanus		x		
	annandalei			x	
	corbis			x	
	corrugata corrugata			x	
	corrugata laevirostris			x	x
	corrugata nagpoorensis			x	
	wynegungaensis			x	
	cylindrica			x	
	favidens favidens			x	x
	favidens assamensis			x	
	favidens pinax			x	x
	favidens chrysis			x	x
	favidens deltae			x	x
	viridula			x	x
	gowhattensis			x	
	rajahensis			x	
	sikkimensis			x	x
	triembolus			x	x
Radiatula	*andersoniana*		x	x	x
	bonneaudi		x	x	x
	caerulea		x	x	x
	substriata	x			
	pilata	x			
	humilis	x			
	keraudreni			x	x
	gaudichaudi			x	x
	khadakvaslaensis			x	
	pachysoma		x	x	x
	shurtleffiana			x	x
	theobaldi			x	
	involuta			x	
	chaudhurii		x		

		crispisulcata		x		
		lima			x	x
		occata			x	x
	"Radiatula"	*olivaria*			x	x
		nuttaliana			x	
Unionidae	*Lamellidens*	*consobrinus*			x	x
		corrianus		x	x	x
		generosus		x		
		lamellatus		x	x	x
		marginalis		x	x	x
		scutum		x		
		jenkinsianus jenkinsianus			x	x
		jenkinsianus daccaensis			x	x
		jenkinsianus obesa		x	x	
		indawgyiensis			x	
		phenchooganjensis			x	x
		narainporensis			x	x
		mainwaringi			x	x
		nongyangensis			x	
		rhadineus			x	(x)
	Arcidopsis	*footei*			x	
	Oxynaia	*pugio*		x		
4	22	119	**47**	**37**	**51**	**28**

Table 2: Fossil Unionacea and their proposed new generic names

Name of the original description	**Proposed generic position**
Lamellidens arungensis	*Lamellidens arungensis*
Lamellidens spec.	*Lamellidens* spec.
Lamellidens longiformis	*Pilbryoconcha longiformis* nov. comb.
Parreysia binaiensis	*Parreysia binaiensis*
Parreysia zigzagicostata	*Parreysia zigzagicostata*
Parreysia chureii	*Parreysia chureii*
Indonaia churia	*Parreysia churia* nov. comb.
Indonaia narayani	*Parreysia narayani* nov. comb.
Indonaia jimuriensis	*Radiatula jimuriensis* nov. comb.
Indonaia tenella	*Radiatula tenella* nov. comb.
Physunio chitwanensis	*Physunio chitwanensis*

Table 3: Newly proposed indicator value of large Freshwater mussels based on the NEPBIOS method of SHARMA (1996)

Family	Species/Subspecies	Indicator Value
Solecurtidae	*Novaculina gangetica*	8
Amblemidae	*Parreysia favidens favidens*	7
	Parreysia favidens chrysis	7
	Parreysia favidens pinax	7
	Parreysia favidens deltae	not classified
	Parreysia corrugata laevirostris	7
	Parreysia sikkimensis	7
	Parreysia triembolus	not classified
	Parreysia viridula	7
	Radiatula andersoniana	8
	Radiatula bonneaudi	8
	Radiatula caerulea	6
	Radiatula keraudreni	7
	Radiatula gaudichaudi	6
	Radiatula pachysoma	7
	Radiatula shurtleffiana	7
	Radiatula lima	7
	Radiatula occata	7
	"Radiatula" olivaria	8
Unionidae	*Lamellidens consobrinus*	7
	Lamellidens corrianus	7
	Lamellidens lamellatus	8
	Lamellidens marginalis	6
	Lamellidens jenkinsianus jenkinsianus	6
	Lamellidens jenkinsianus daccaensis	not classified
	Lamellidens phenchooganjensis	6
	Lamellidens narainporensis	6
	Lamellidens mainwaringi	7
	Lamellidens rhadineus	6

Adress of the Authors:
Hasko Nesemann, Subodh Sharma, Aquatic Ecology Centre, Kathmandu University, P.O. Box No. 6250, Dhulikhel, Kavre, Nepal.
Gopal Sharma, Zoological Survey of India, Gangetic Plains Regional Station, Road No. 11-D, Rajendra Nagar, Patna 800016, Bihar, India.
Ravindra Kumar Sinha, Environmental Biology Laboratory, Department of Zoology, Patna University, Patna 800005, Bihar, India.

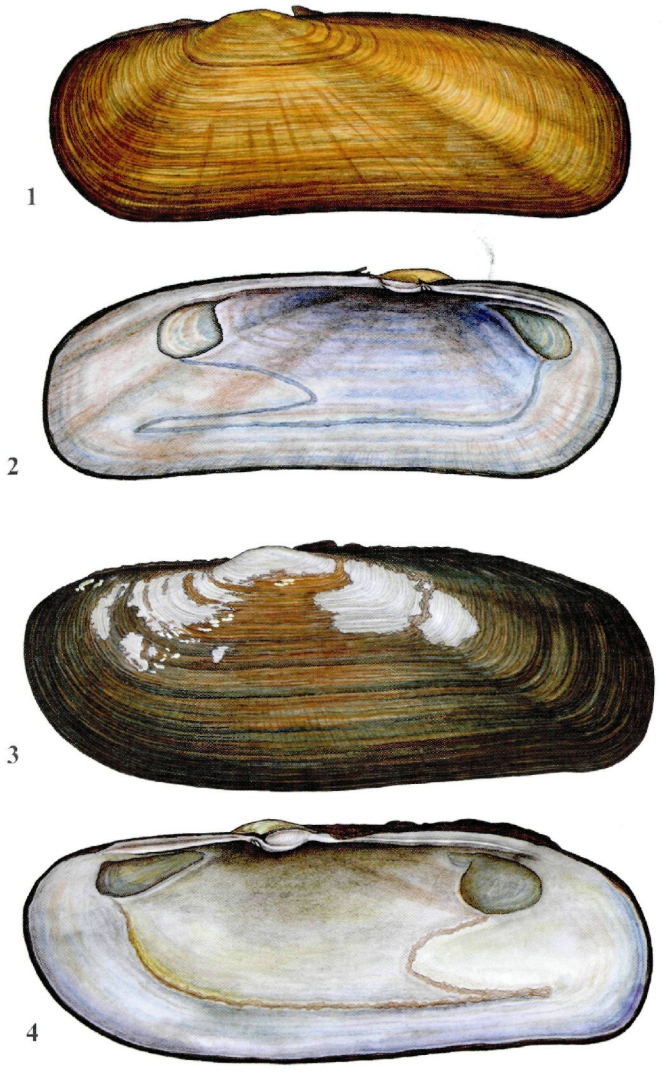


PLATE I. SOLECURTIDAE: NOVACULINA

Novaculina gangetica Benson, 1831, India, Bihar, Ganga River at Patna, (1, 2) common form of mixed sand-mud substrate in unpolluted lotic reaches, old royal palace, length 51.8 mm, (3, 4) thick-shelled form of black mud substrate inlentic reaches with high organic load, Mahendrughat, 59.3 mm.

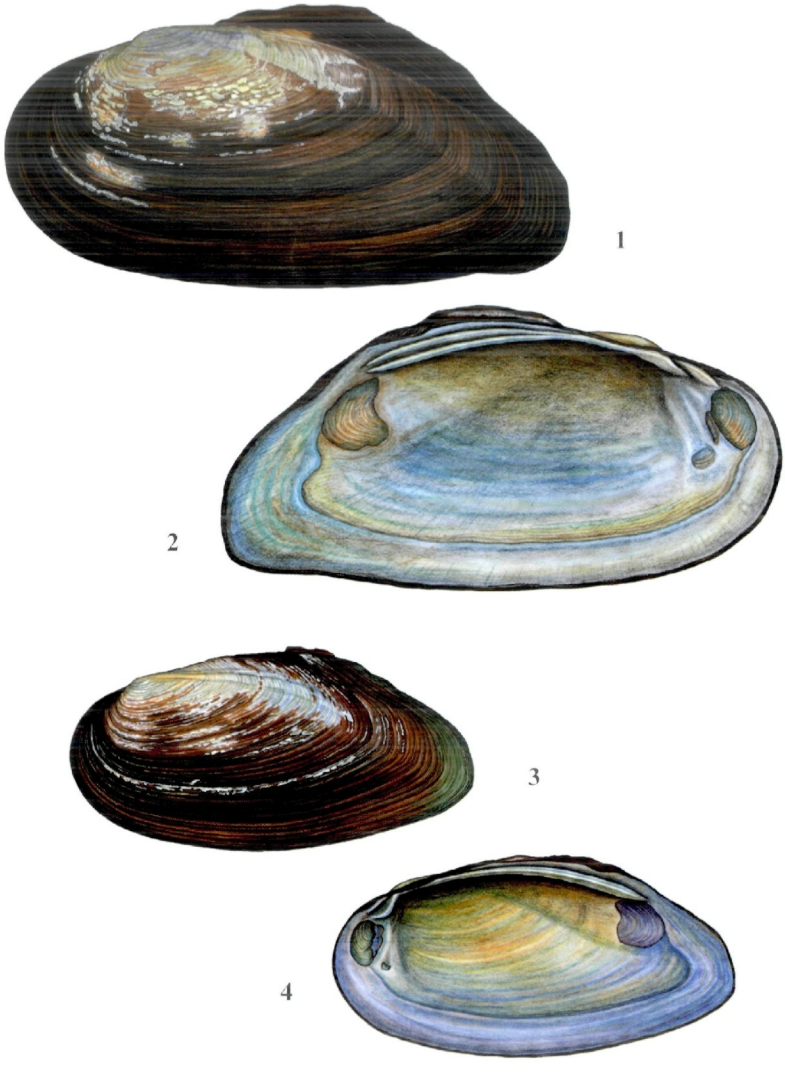
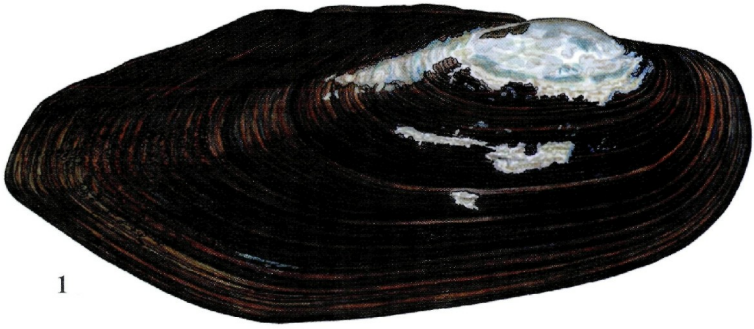
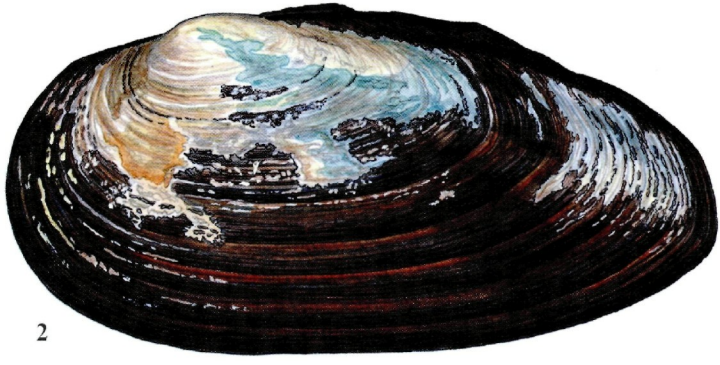


PLATE II. UNIONIDAE: LAMELLIDENS

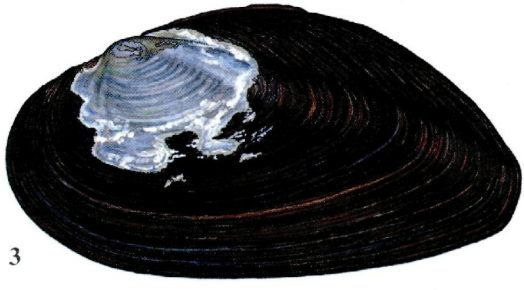
Lamellidens consobrinus (Lea, 1859), (1, 2) India, Bihar, Ganga River, Patna, old royal palace, form of mud-silt substrate, lotic habitat, erosion bank with artificial rock substrate, unpolluted reach, length 76.7 mm, (3, 4) Uttar Pradesh, Gombti (Gomati) River upstream from Lucknow, small form of lentic reaches from sand substrate in a slowly running rain-feeded lowland river, 57.3 mm.



1



2



3

Plate III. UNIONIDAE: LAMELLIDENS

Lamellidens phenchooganjensis Preston, 1912, length 96.0 mm (1, 4), India, Bihar, Mamu Bhanja Pokhra near Hajipur, large form from black mud substrate of an oxbow lake (former branch of Gandak River)

Lamellidens corrianus (Lea, 1834), 92.5 mm, (2, 5), Ganga River, Patna, old royal palace,

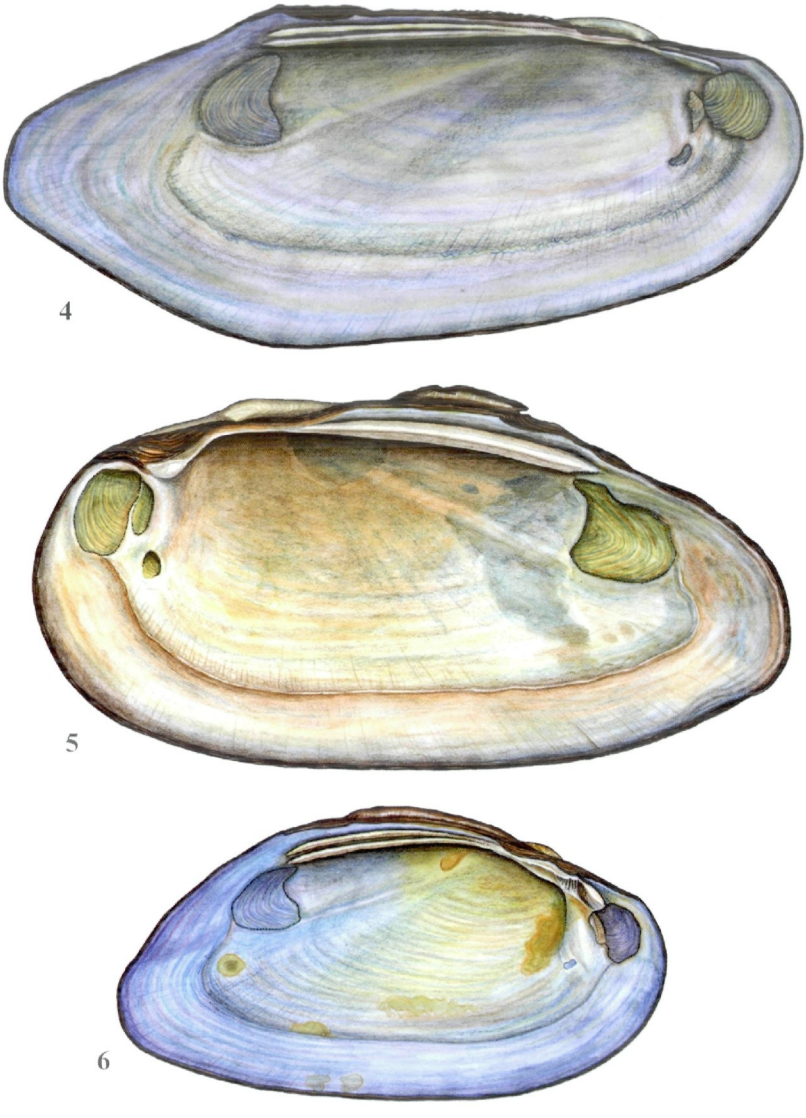


PLATE IV. UNIONIDAE: LAMELLIDENS

form of mud-silt substrate, lotic habitat, erosion bank with artificial rock substrate, unpolluted reach, *Lamellidens mainwaringi* Preston, 1912, (3, 6) 56.3 mm, Nepal, Jhapa, Birtamod, Kali Khola, forms of small lowland streams (*Shorea robusta* tropical moist deciduous forest) with mud, sand and gravel substrate and remarkable natural organic load (CPOM).

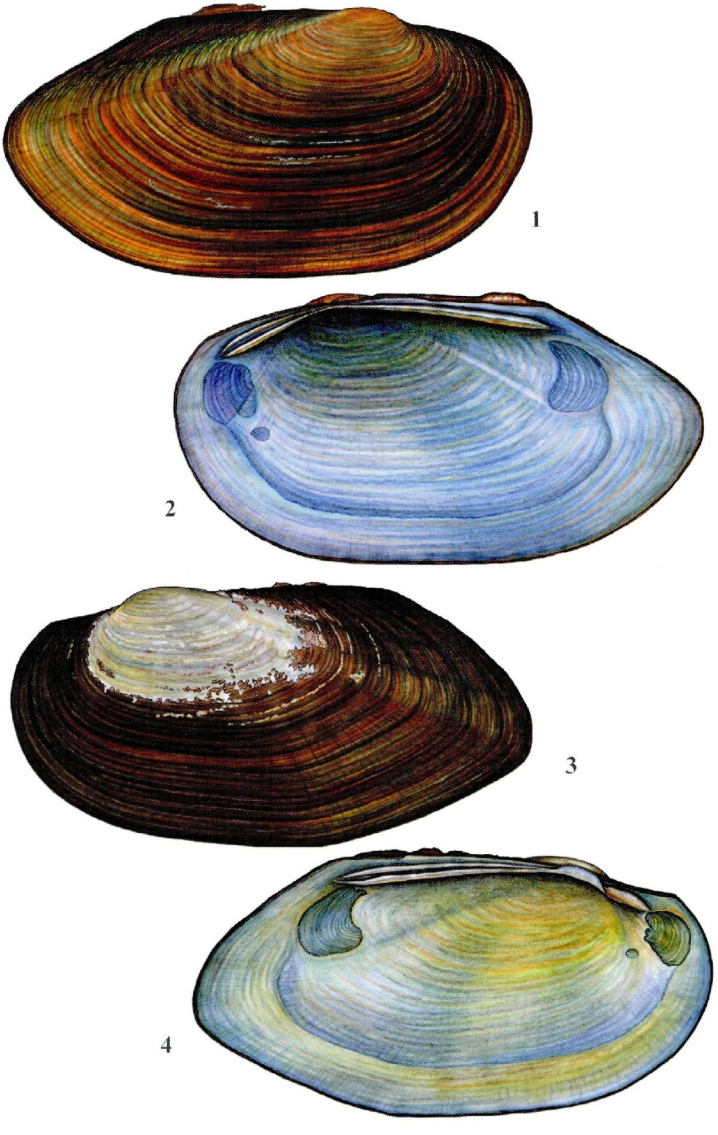


PLATE V. UNIONIDAE: LAMELLIDENS

Lamellidens marginalis (Lamarck, 1819), (1, 2) length 102.0 mm, India, West Bengal, Salt Lake near Kolkata, (3, 4) 89.9 mm, Nepal, Pokhara Valley, Kaski, Begnas Tal effluent Khudi Khola at Begnas.

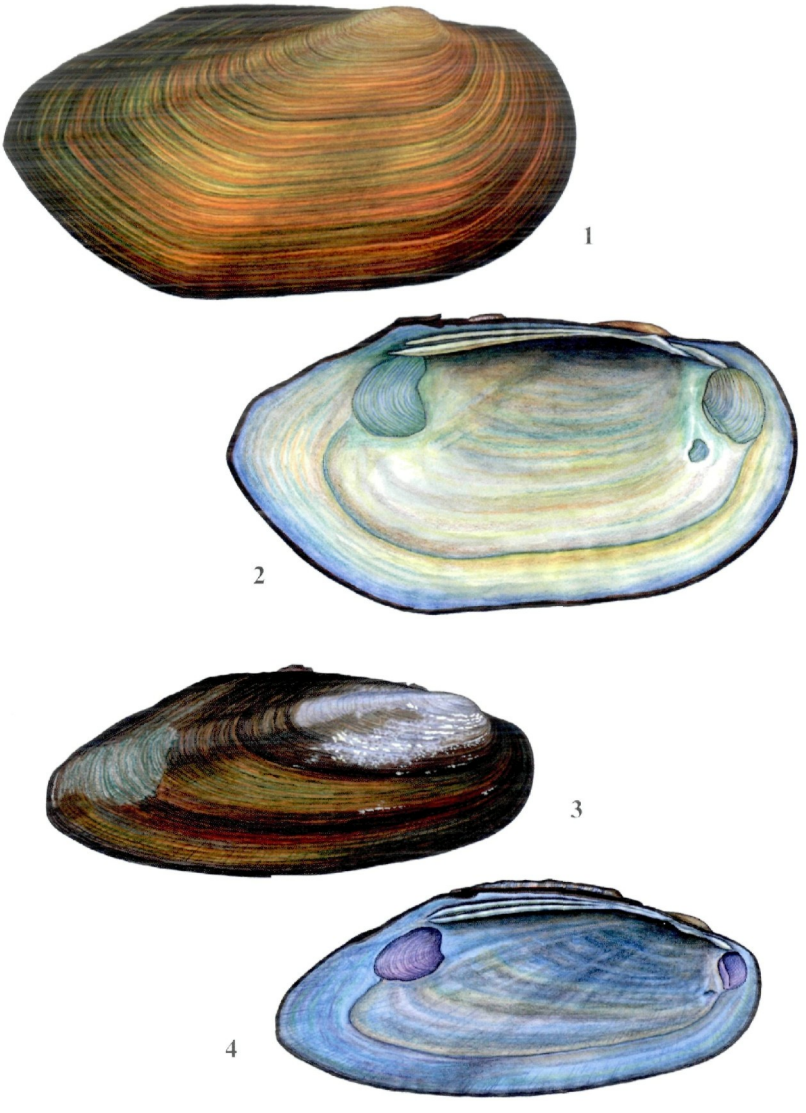


PLATE VI. UNIONIDAE: LAMELLIDENS

Lamellidens marginalis (Lamarck, 1819), (1, 2) length 79.6 mm, India, Bihar, Ganga River upstream from Danapur, form of sand substrate in lentic eutrophic reach near the confluence of floodplain water bodies. Lamellidens narainporensis Preston, 1912, (3, 4) 53.5 mm, Patna, Kumhrar pond, form of steep loamy bank, found burrowing between the roots of trees.

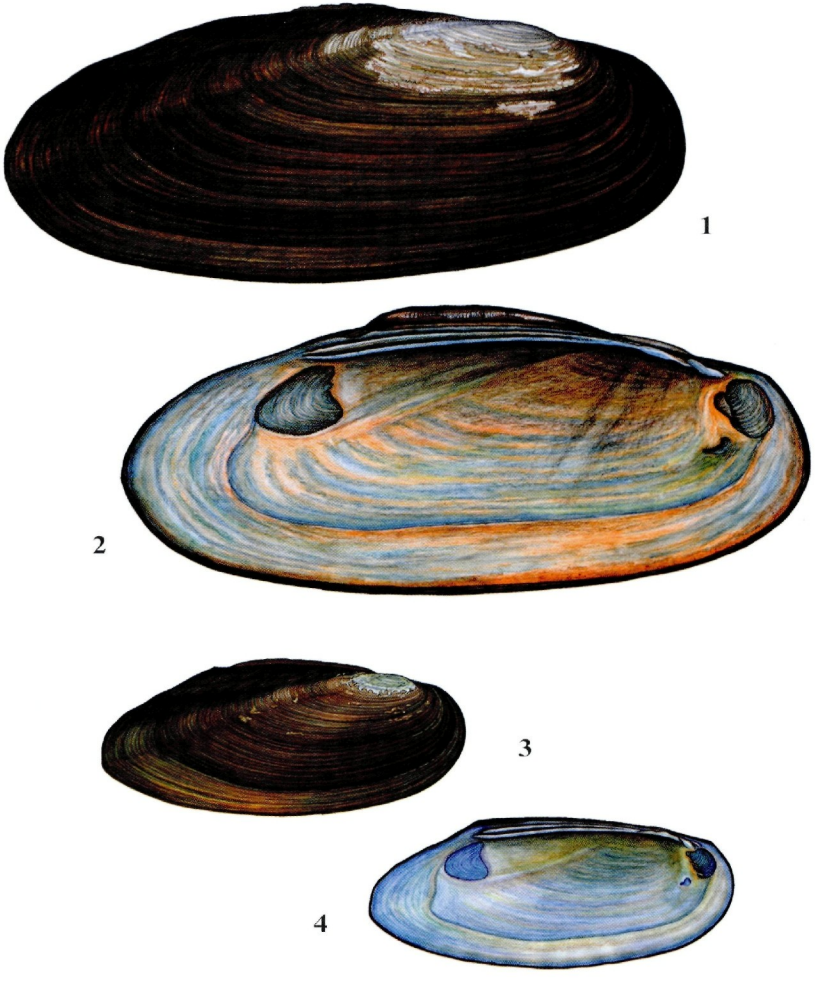


PLATE VII. UNIONIDAE: LAMELLIDENS

Lamellidens narainporensis Preston, 1912, (1, 2) length 68.4 mm, India, Uttar Pradesh, Ganga River near Chunarghat, downstream Mizrapur, large form inhabiting mud and silt substrate of lotic reaches in large river habitat, (3, 4) 36.4 mm, Gombti (Gomati) River upstream from Lucknow, small form of lentic reaches from sand substrate in a slowly running rain-feeded lowland river.

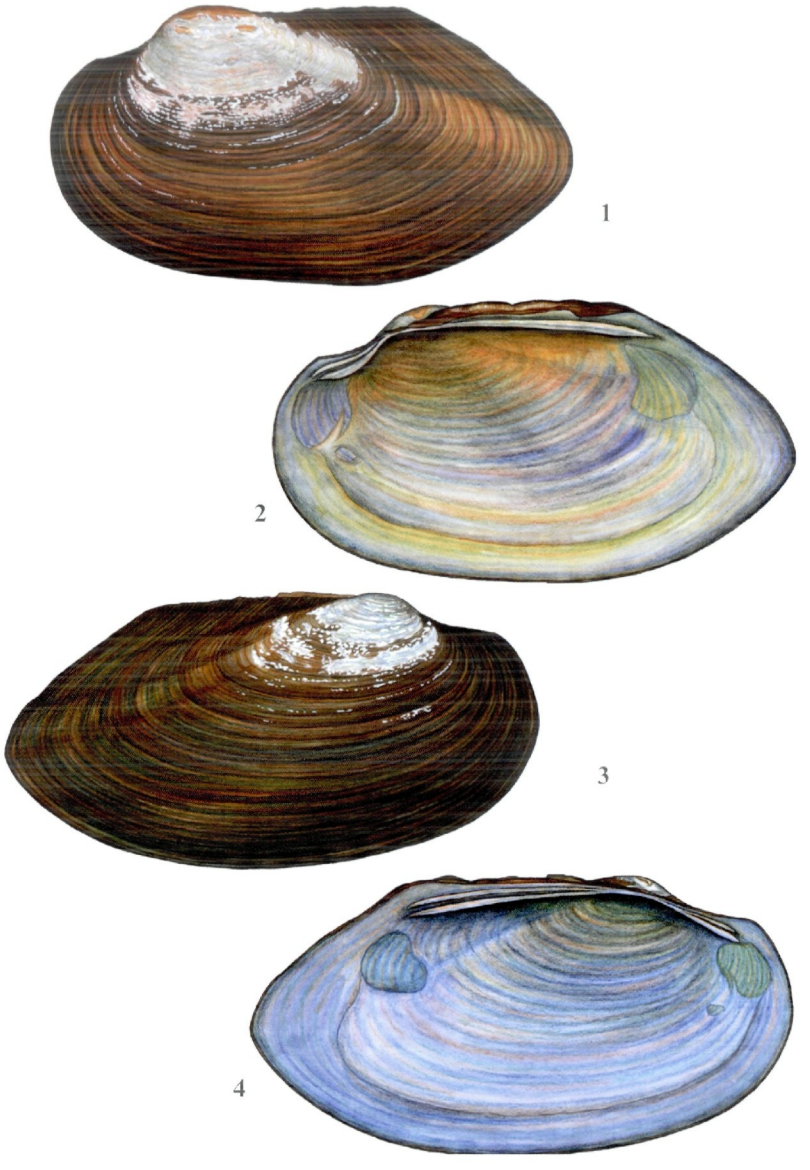


PLATE VIII. UNIONIDAE: LAMELLIDENS

Lamellidens lamellatus (Lea, 1838), India, Jharkhand, Damodar River basin, Tenughat Reservoir, forms of gravel substrate from littoral of oligotrophic lake-like reservoir, (1, 2) length 56.2 mm, (3, 4) 60.7 mm.

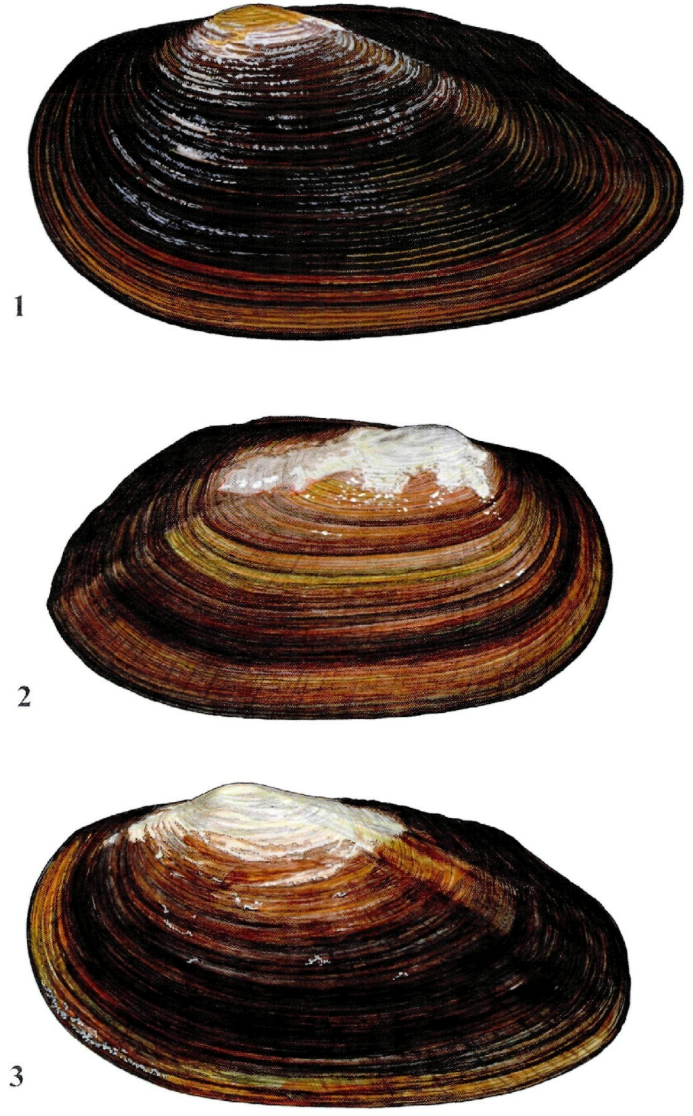
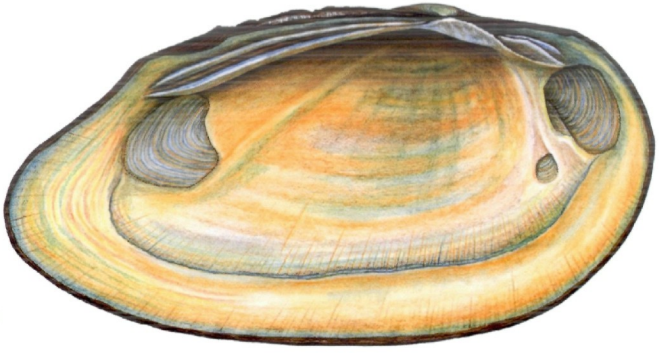


PLATE IX. UNIONIDAE: LAMELLIDENS

Lamellidens jenkinsianus jenkinsianus (Benson, 1862) India, Uttar Pradesh, Ganga River, Bithur upstream from Kanpur, (1, 4) very large and thick-shelled form of sand-mud substrate in lotic zone with high organic load, length 96 mm, (2, 5) Bihar, Patna, Zoopond, medium-sized form of lentic sand substrate.



4

5

6

PLATE X. UNIONIDAE: LAMELLIDENS

Lamellidens jenkinsianus jenkinsianus (Benson, 1862), Nepal, Makwanpur, Hetauda, Fishpond near Karni Khola, very large form inhabiting mud substrate of eutrophic lentic zones.

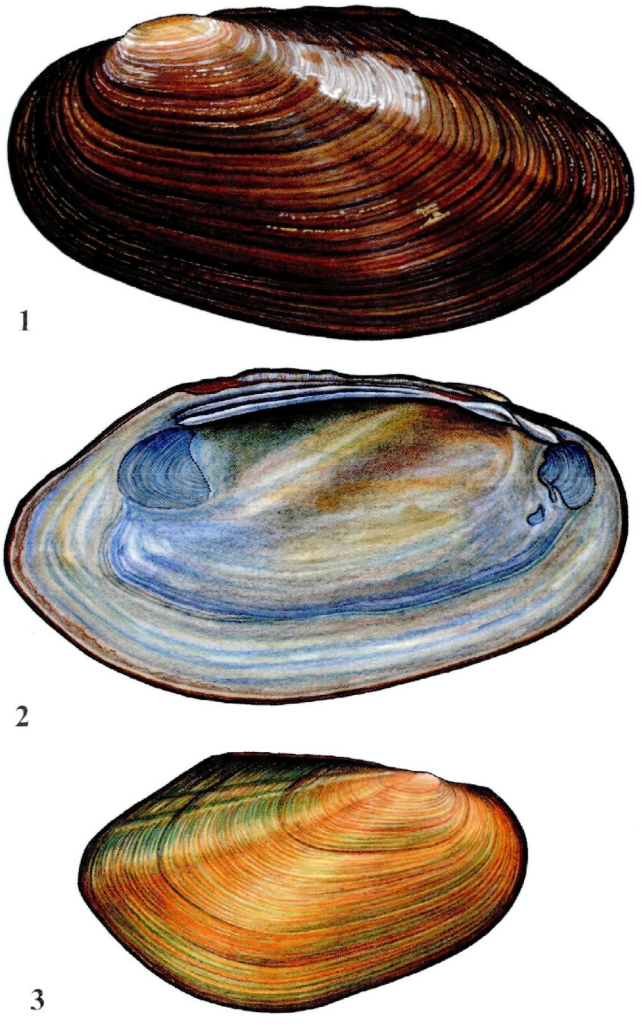


PLATE XI. UNIONIDAE: LAMELLIDENS

Lamellidens rhadineus Annandale & Prashad, 1921, (1, 2) length 70.0 mm, India, Punjab, Satluj River flood-channel northwest of Ludhiana, form of temporary running water from mud substrate of a stagnant pool, (3) 43.7 mm, Satluj River pool, juvenile shell from sand substrate.

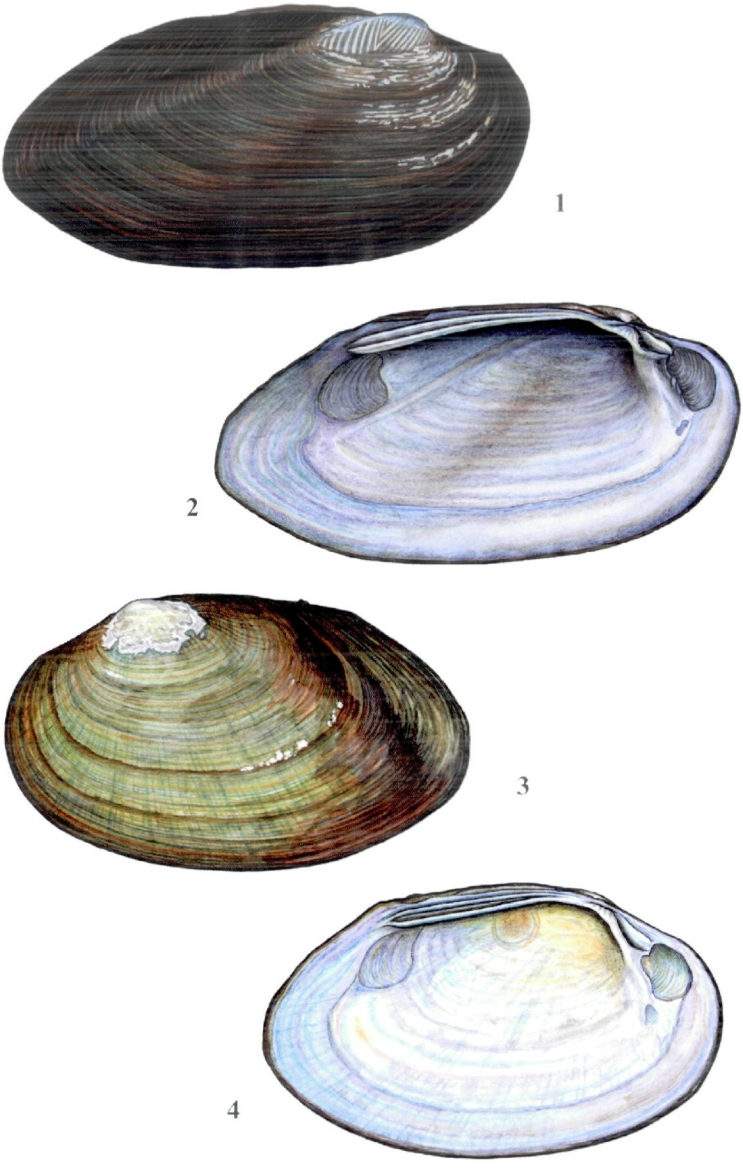


PLATE XII. AMBLEMIDAE: RADIATULA

Radiatula shurtleffiana (Lea, 1856), (1, 2) length 49.3 mm, Uttar Pradesh, Ganga River at Chunarghat downstream from Mirzapur, form inhabiting mud and silt substrate of lotic reaches in large river habitat, Radiatula occata (Lea, 1860), (3, 4) 39.2 mm, Nepal, Sunsari, Pakali Khola in Itahari, form of sand substrate inhabiting a small lowland stream.

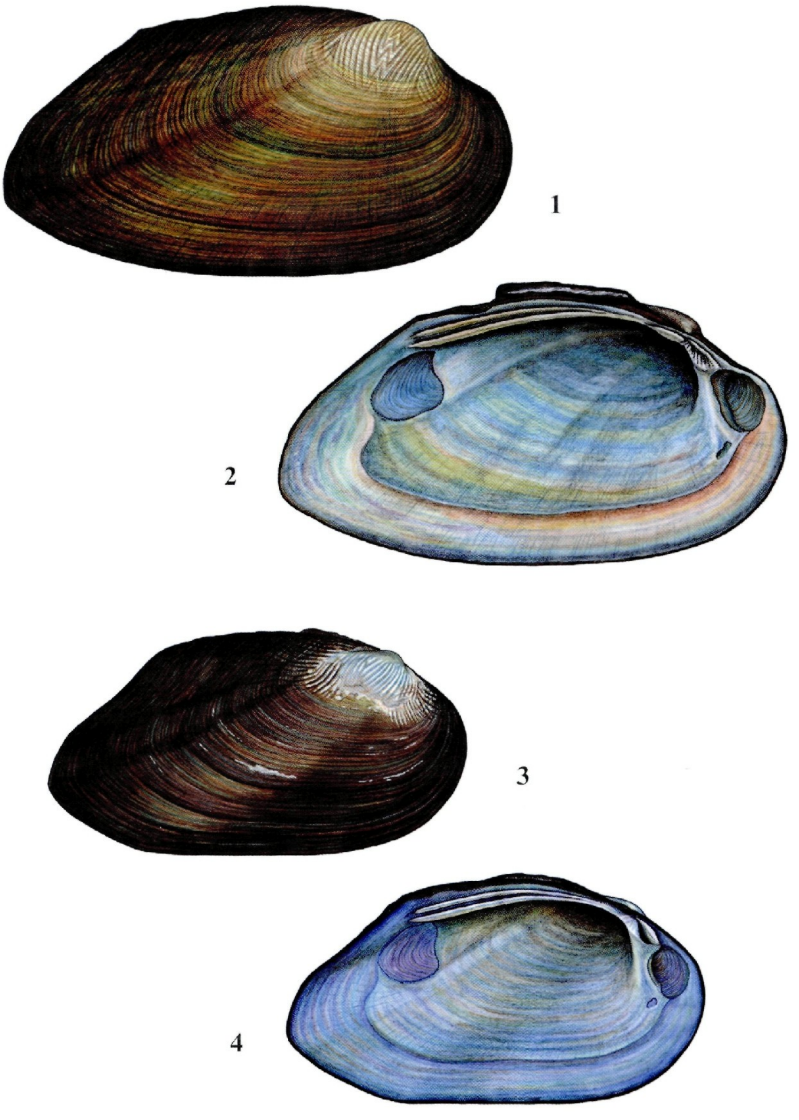


PLATE XIII. AMBLEMIDAE: RADIATULA

Radiatula occata (Lea, 1860), (1, 2) length 42.8 mm, India, Bihar, Ganga River, Patna, old royal palace, form of silt and mud sediment of large rivers, (3, 4) 36.4 mm, Uttar Pradesh, Gomti (Gomati) River upstream from Lucknow, small form of lentic reaches from sand substrate in a slowly running rain-feeded lowland river.

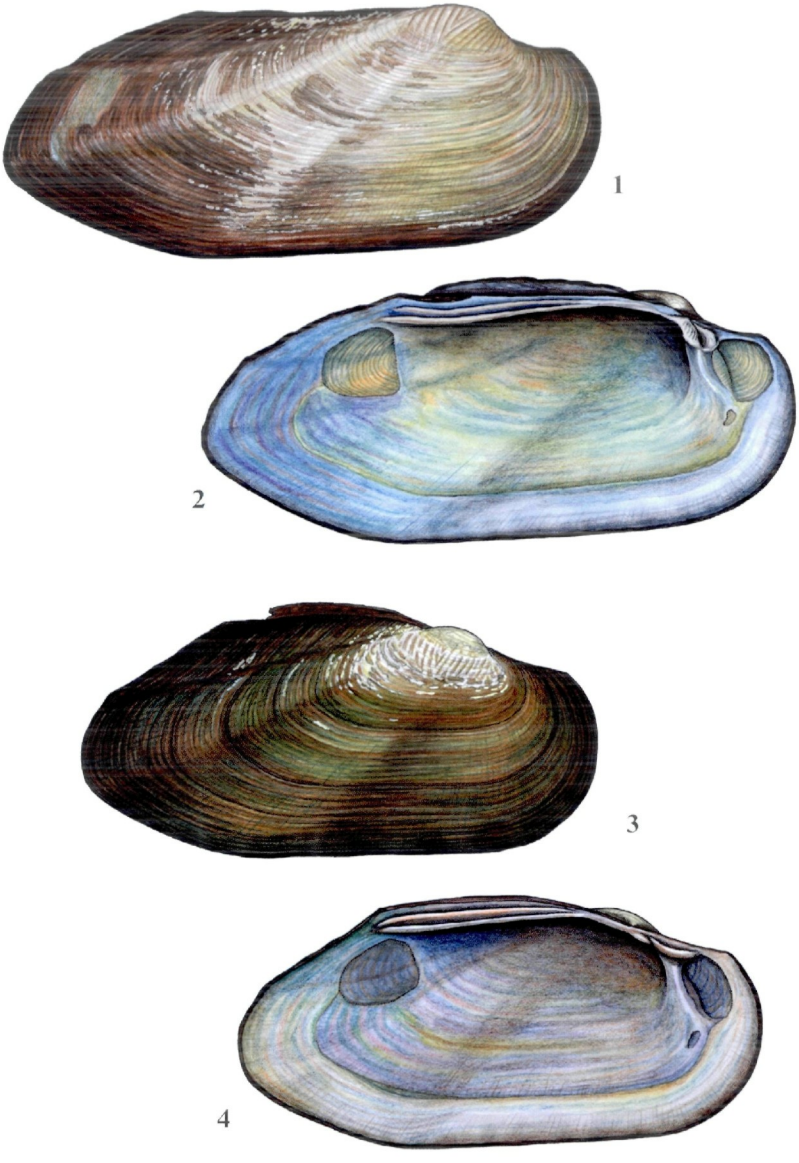


PLATE XIV. AMBLEMIDAE: RADIATULA

Radiatula caerulea (Lea, 1831), (1, 2) 51.5 mm, India, Bihar, Patna, Kumhrar pond, form of steep loamy bank, found burrowing between the roots of trees, (3, 4) 47.2 mm, common and widespread form of lowland rivers, Ganga River, Patna, old royal palace.

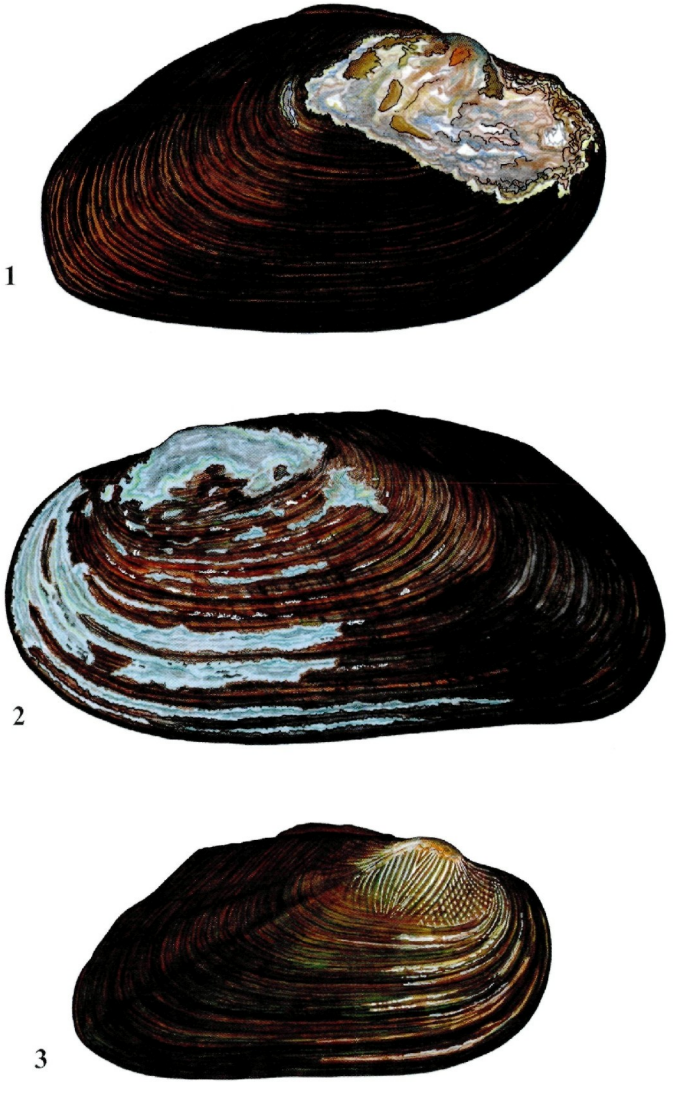


PLATE XV. AMBLEMIDAE: RADIATULA

Radiatula lima (Simpson, 1900), three different forms from running waters, (1, 4) length 41.4 mm Nepal, Jhapa, Deune Khola near Birtamod, form of small lowland stream in Shorea robusta forest, inhabiting instable sand substrate, (2, 5) 48.0 mm, Nepal, Pokhara Valley, Kaski, Begnas Tal effluent Khudi Khola at Begnas, large thick-shelled form of an eutrophic lake effluent with high organic load and plankton.

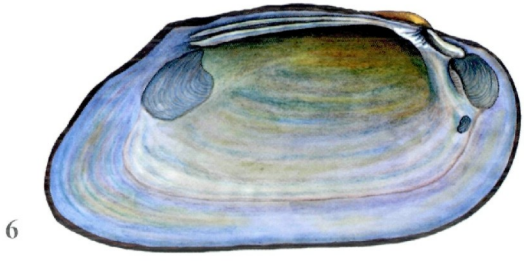
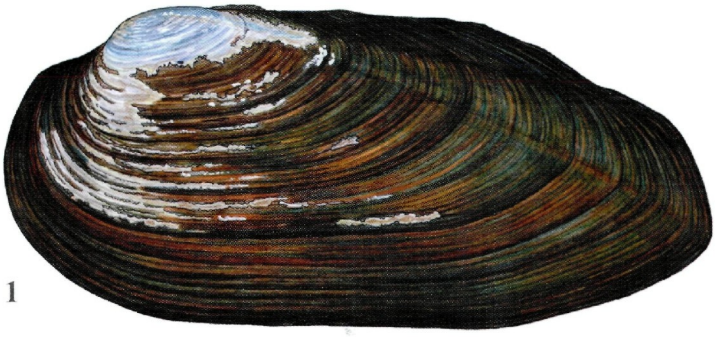
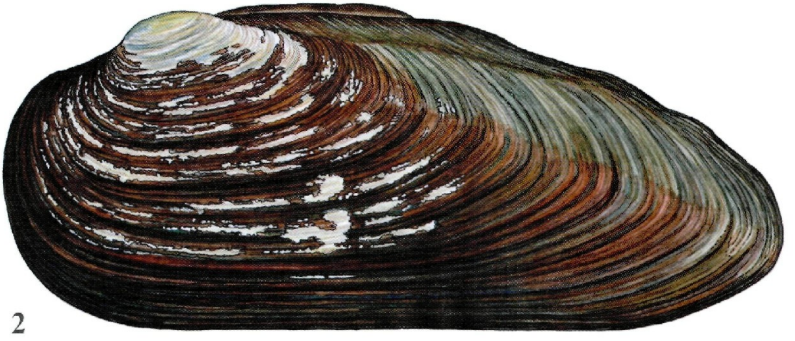


PLATE XVI. AMBLEMIDAE: RADIATULA

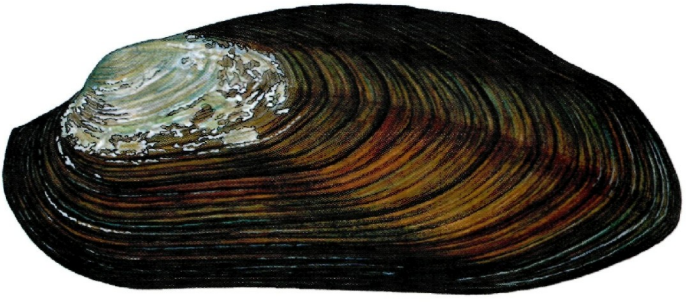
Radiatula lima (Simpson, 1900), (3, 6) length 36.7 mm, India, Uttar Pradesh, Gombti (Gomati) River upstream from Lucknow, small form of lentic reaches from sand substrate in a slowly running rain-feeded lowland river.



1



2

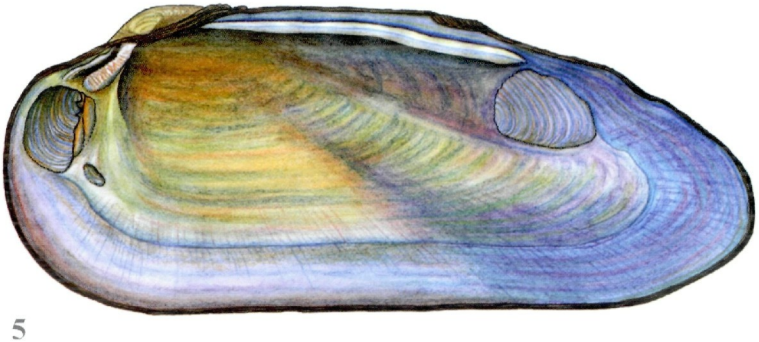


3

PLATE XVII. AMBLEMIDAE: RADIATULA

Radiatula gaudichaudi (Eydoux, 1838) India, Bihar, Mamu Bhanja Pokhra near Hajipur, three forms from black mud, loam and sand substrate of an oxbow lake (former branch of Gandak River).

4



5

6

PLATE XVIII. AMBLEMIDAE: RADIATULA

Radiatula gaudichaudi (Eydoux, 1838), (1, 4) length 55.4 mm, (2, 5) 62.5 mm, (3, 6) 56.3 mm.

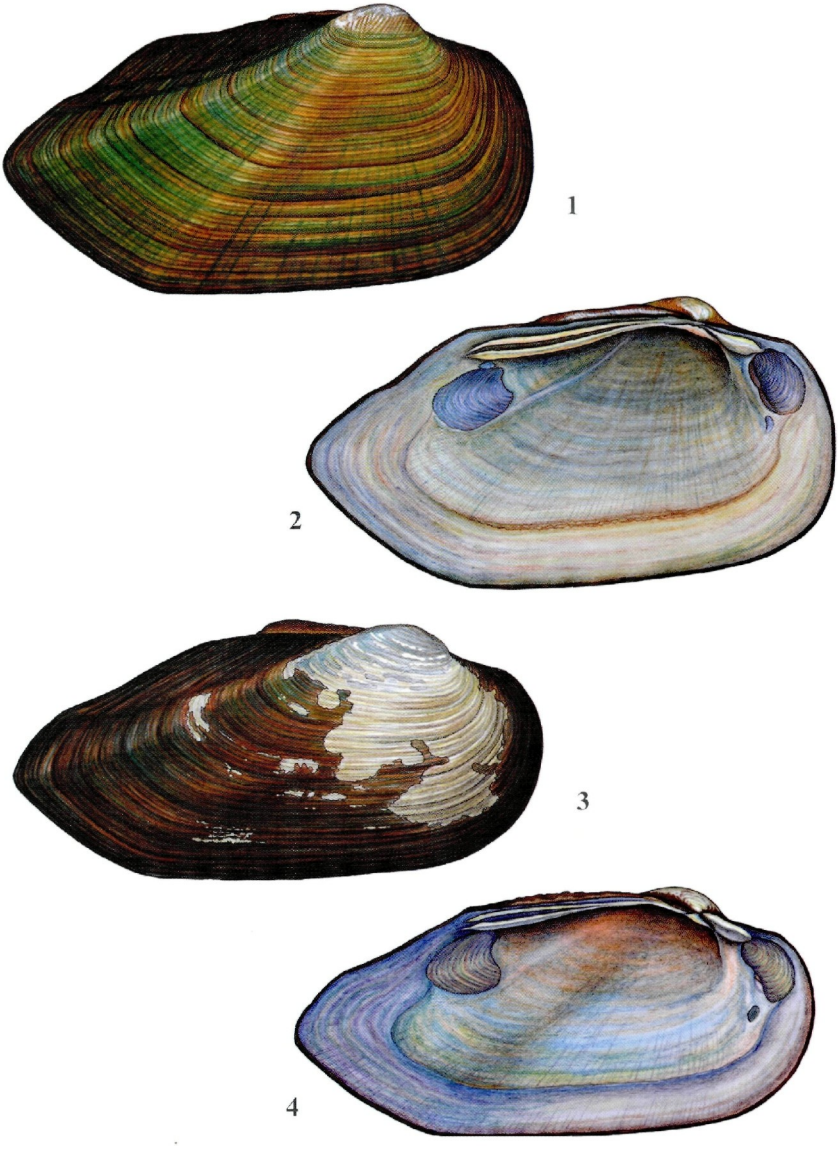


PLATE XIX. AMBLEMIDAE: RADIATULA

Radiatula pachysoma (Benson, 1862), (1, 2) length 49.5 mm, India, Bihar, Patna, Zoopond, form of lentic sand substrate, (3, 4) 48.0 mm, Mamu Bhanja Pokhra near Hajipur, form from black mud substrate (former branch of Gandak River).

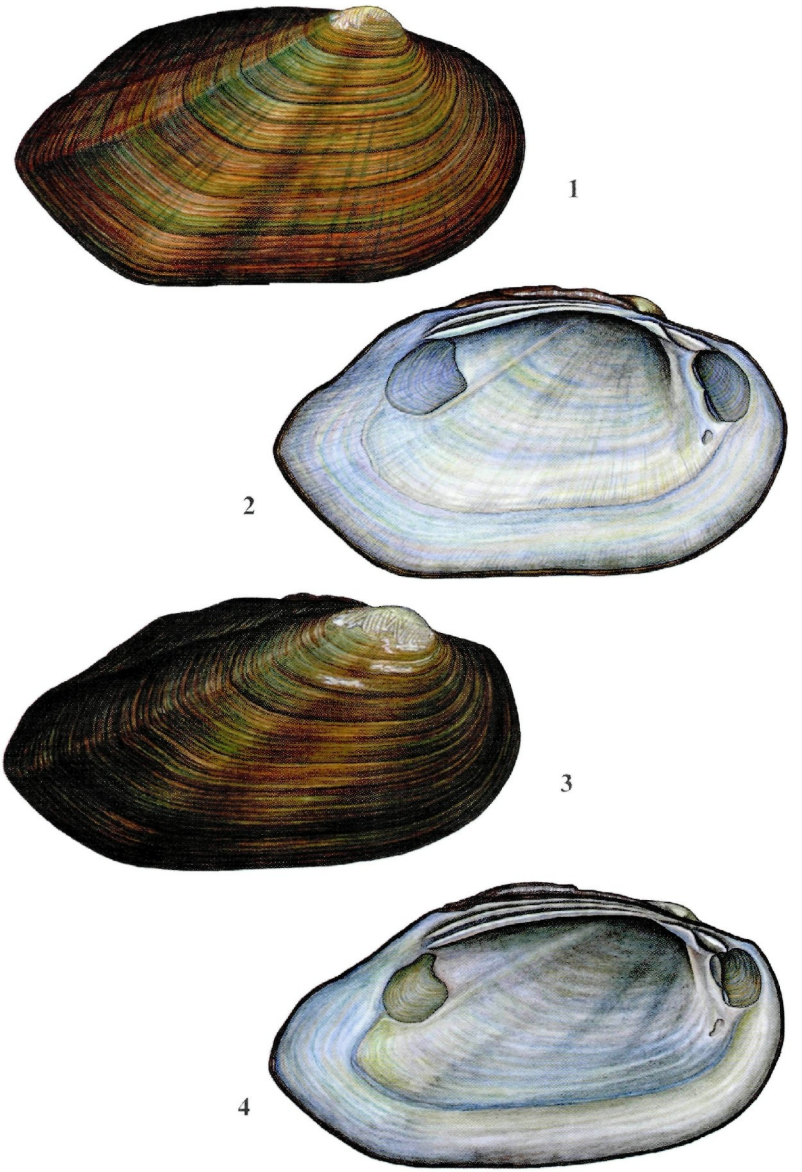


PLATE XX. AMBLEMIDAE: RADIATULA

Radiatula bonneaudi (Eydoux, 1838), (1, 2) length 49.1 mm, India, Bihar, Patna, Zoopond, form of sand substrate in an eutrophic lentic water body, (3, 4) 49.0 mm, Uttar Pradesh, Ganga River at Chunarghat downstream from Mirzapur, form inhabiting mud and silt substrate of lotic reaches in large river habitat.

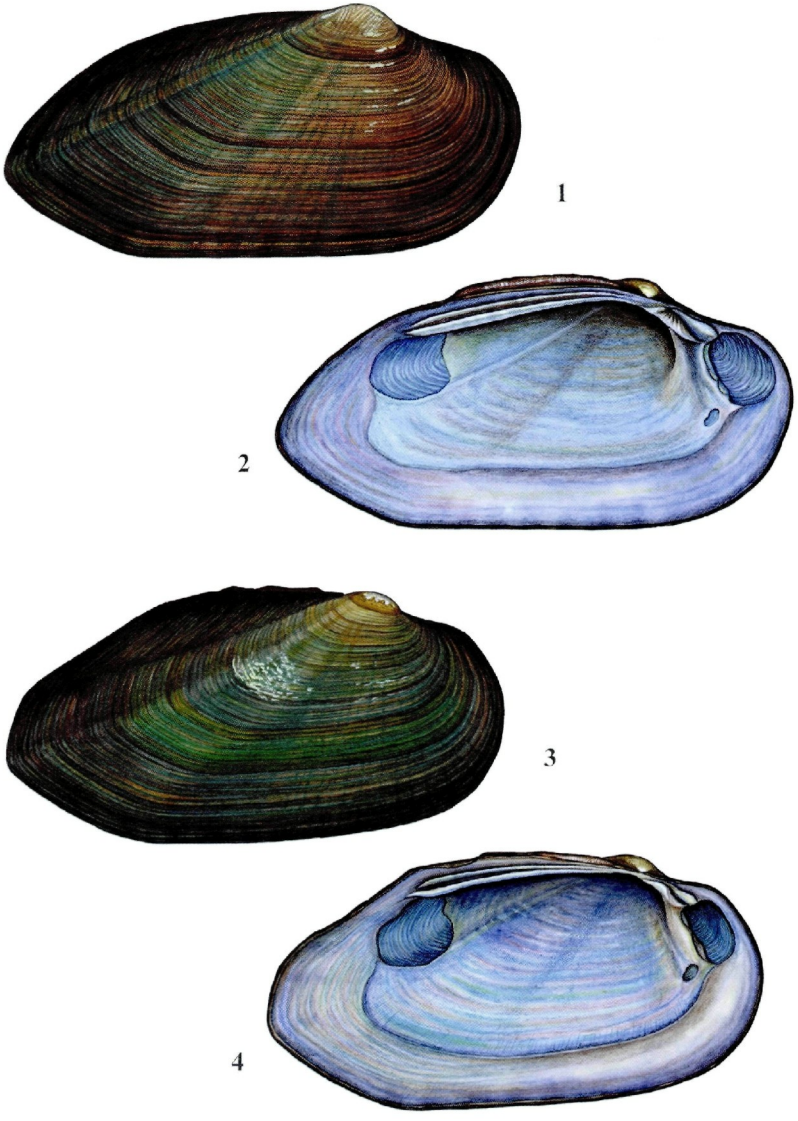
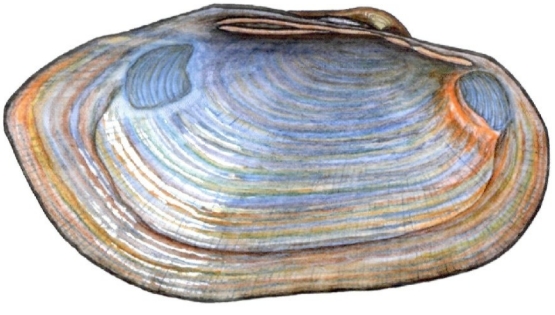


PLATE XXI. AMBLEMIDAE: RADIATULA

Radiatula andersoniana (Nevill, 1877) length 55.5 mm, (1, 2) India, Bihar, Patna, Zoopond, form of sand substrate of an eutrophic lentic water body, (3, 4) 54.0 mm, Uttar Pradesh, Yamuna River at Janghola near Palla, 22 km upstream from Delhi, form of sand substrate of a slowly running branch of lowland river.

1



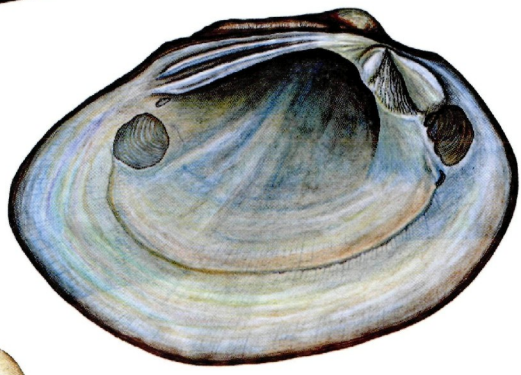
2

3

PLATE XXII. UNIONACEA incertae sedis

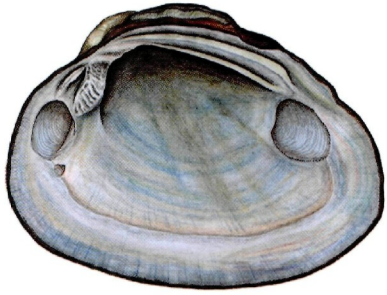
"Radiatula" olivaria (Lea, 1831), India, Bihar, Ganga River upstream from Patna, (1, 2) female shell, length 38,2 mm, (3) male shell, 35.6 mm, forms of instable sand substrate of the river bottom.

1



2

3



4

PLATE XXIII. AMBLEMIDAE: PARREYSIA

Parreysia favidens favidens (Benson, 1862), India, Uttar Pradesh, Ganga River, Bithur upstream from Kanpur, topotype material from the type locality, (1, 2) very large and thick-shelled form of sand-mud substrate in lotic zone with high organic load, length 71.3 mm, *Parreysia favidens chrysis* (Benson, 1862), Bihar, Ganga River, Patna, old royal palace, (3, 4) form of mud-silt substrate, lotic habitat, erosion bank with artificial rock substrate, unpolluted reach, length 48.2 mm.

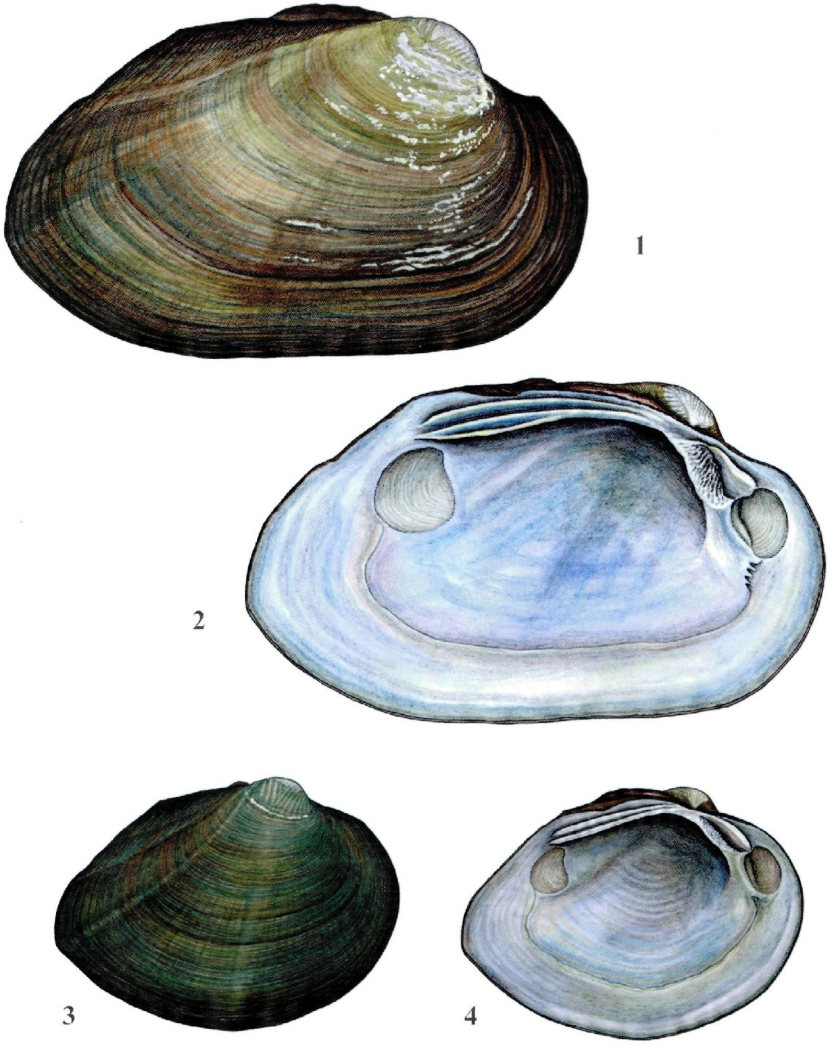
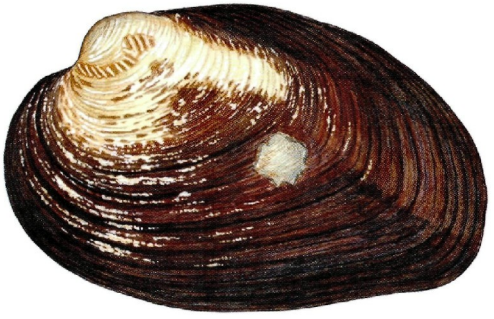


PLATE XXIV. AMBLEMIDAE: PARREYSIA

Parreysia favidens chrysis (Benson, 1862), Bihar, Ganga River, Patna, Mahendrughat, (1, 2) elongated form of black mud substrate in lentic reaches with high organic load, Mahendrughat, 59.7 mm
Parreysia viridula (Benson, 1862), Bihar, Ganga River, Doriganj upstream from Patna, (3, 4) form of mud-silt substrate, unpolluted reach, length 35.6 mm.



1

2

3

4

PLATE XXV. AMBLEMIDAE: PARREYSIA

Parreysia favidens pinax (Benson, 1862), Nepal, Rupandehi, Ghaghara Khola near Bangain, Tinau River System, length (1, 2) 40.7 mm, (3, 4) 35.9 mm.

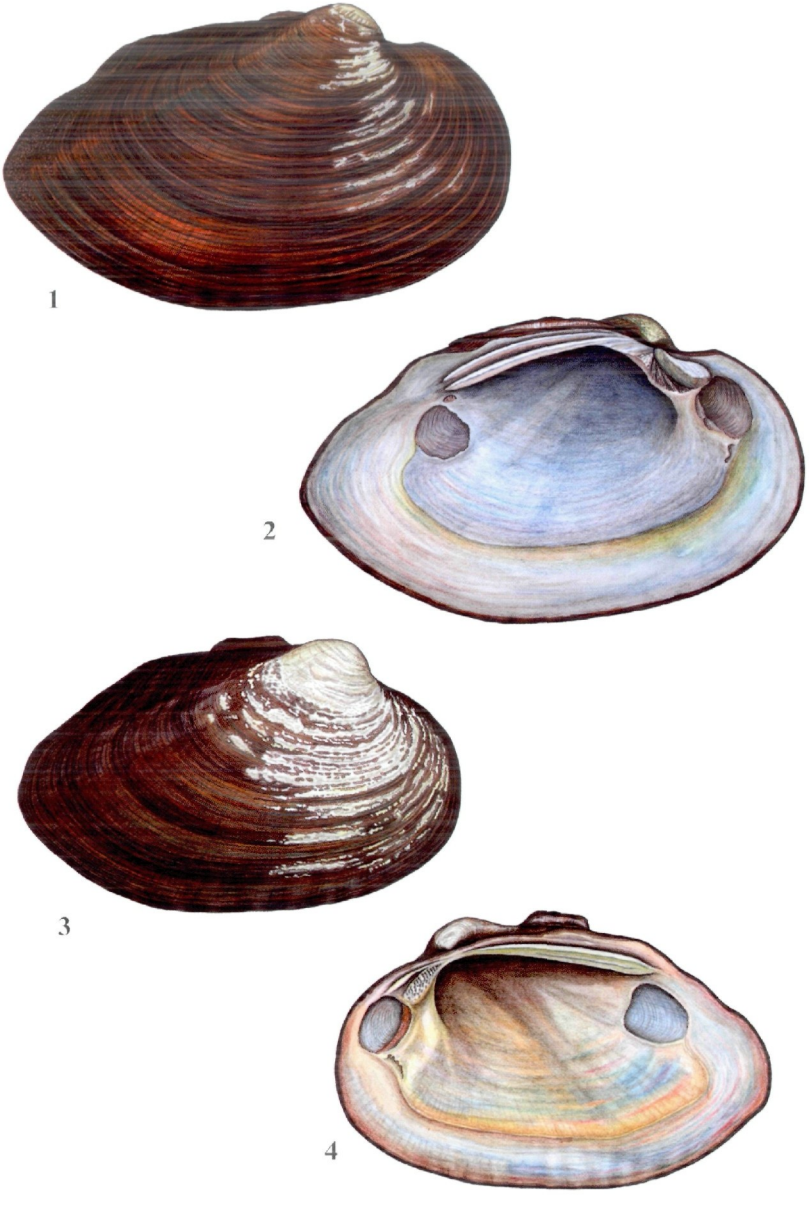


PLATE XXVI. AMBLEMIDAE: PARREYSIA

Parreysia corrugata laevirostris (Benson, 1862), India, Uttar Pradesh, Ganga River, Bithur upstream from Kanpur, (1, 2) very large and thick-shelled form of sand-mud substrate in lotic zone with high organic load, length 64.2 mm, (3, 4) Bihar, Ganga River, Patna, old royal palace, form of mud-silt substrate, lotic habitat, erosion bank with artificial rock substrate, unpolluted reach, length 55.3 mm.

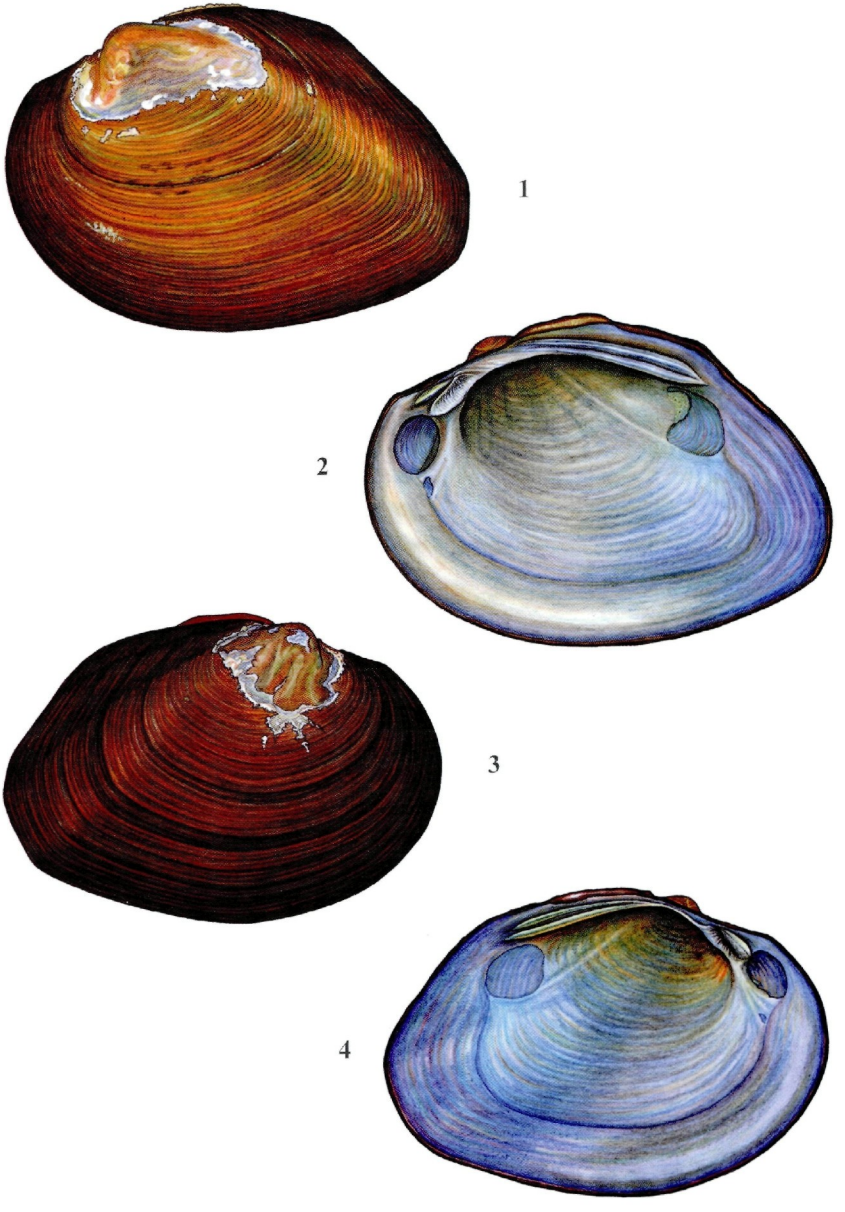


PLATE XXVII. AMBLEMIDAE: PARREYSIA

Parreysia sikkimensis (Lea, 1859), Nepal, Jhapa, Birtamod, (1, 2) Debaniya Khola, length 36.2 mm, (3, 4) Deune Khola, length 34.2 mm, forms of small lowland streams (Shorea robusta tropical moist deciduous forest) with mud, sand and gravel substrate and remarkable natural organic load.