HANDBOOK

FRESHWATER MOLLUSCS OF INDIA

By

N. V. SUBBA RAO

Zoological Survey of India, Calcutta

Edited by the Director

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FOREWORD

Freshwater molluscs include several species of socio-economic importance, as intermediate hosts of a number of disease-causing parasitic helminths and also as exploitable food resource of men and duckeries as well. Although they attracted the attention of several zoologists because of their medical and veterinary importance, leading to various investigations particularly during the first quarter of the present century, no reference book on Freshwater Molluscs of India has so far been available.

One of the major objectives of the Zoological Survey of India has been to undertake faunal exploration and prepare an inventory of each group of the Indian Fauna. It is the only Institute in India maintaining an extensive collection of molluscs and attending to different enquiries on their taxonomy. Dr. N. V. Subba Rao has been with the survey for nearly three decades and his well gained experience has found its expression through this book. I have an opportunity to observe him at close quarters and find that he has the potential to write a few more books for the benefit of students of Zoology, particularly malacology in India.

In this Handbook, Dr. Subba Rao has meticulously up-dated our knowledge of freshwater molluscs of India and neighbouring countries. The information presented in this work is of inherent interest and utmost value to the students of Zoology in general and of Malacology in particular. It is not only an useful identification manual of Indian freshwater molluscs but an important source of basic information of interest to the taxonomists, limnologists and helminthologists as well. I am happy that the Zoological Survey of India is bringing out this publication concurrent with its objectives.

I wish to congratulate Dr. Subba Rao for the onerous task he has undertaken in consolidating the knowledge of freshwater molluscs of the Indian region.

B. K. Tikader
Ex-Director,
Zoological Survey of India

PREFACE

MOLLUSCA is a large phylum, second only to Arthropoda in the number of species. The molluscs have colonised every possible habitat and are dominant in benthic communities of all aquatic ecosystems. The largest number of molluscs are found in the marine environment where some forms support valuable shell and pearl fisheries in addition to the lime industry. Species inhabiting the freshwater ecosystems are few in number and our knowledge of this group is rather limited. Experts as well as students dealing with freshwater molluscs are often handicapped by the absence of any worthwhile guide book on the subject. The present handbook by Dr. N. V. Subba Rao is aimed at filling this void and will serve as a useful guide to all those interested in any aspect of Malacology.

There are very few centres in India supporting active research in the molluscan taxonomy. Zoological Survey of India has been the foremost organisation actively engaged in this field right from the day of its inception in 1916. A number of distinguished malacologists such as Drs. N. Annandale, B. Prashad, H.S. Rao, H.C.Ray and a host of others worked in the laboratories of the Zoological Survey of India and have contributed profusely to our knowledge of freshwater molluscs of the Indian subcontinent. Dr. Subba Rao, the author, who has done extensive taxonomic work on terrestrial, freshwater and marine molluscs of India has presented in this book a comprehensive account of the freshwater molluscs of India and adjacent countries.

The present volume is nineth in the series of Handbooks published by the Zoological Survey of India. It gives detailed account of 285 species of freshwater molluscs reported from India, Pakistan, Bangladesh, Burma, Sri Lanka and other adjoining countries and draws our attention to hitherto unexplored areas of research and commercial potentialities of the molluscs with special reference to aquaculture for production of food and pearls. An extensive bibiliography and subject index are also provided in the book. It is hoped that this handbook on Freshwater Molluscs will serve as an useful identification guide and source of information to students and research workers of Malacology, Helminthology and Limnology.

Mohammad Shamim Jairajpuri
Director,
Zoological Survey of India.

AUTHOR'S PREFACE

From the time I joined the Mollusca Section in the Zoological Survey of India, in the year 1960, I have had to attend to several enquiries on molluscs received from the researchers in the Universities and other scientific institutions in India and abroad. In the process of attending to these enquiries I have noticed that there are several problems that need to be sorted out with regard to freshwater molluscs. The greatest problem that every one has been facing is the absence of a reliable and up-to-date identification guide to all freshwater molluscs of India. When I started working out, in a very casual way, on the preparation of such a book, I did not visualise that the task would be so stupendous. The taxonomy of several Indian molluscs is not thoroughly known. The ecology, biology and anatomy of only a few species have been investigated and thus making it difficult for their proper placement in the modern system of classification.

In the process of sorting out various nomenclatural problems and others associated with the preparation of this book considerable original research had to be undertaken. However, it should be admitted that the present work reflects the state of our knowledge of Indian freshwater molluscs bringing out several points which still need further study and elucidation.

Though initially the idea was to restrict the study to Indian species only, it was later enlarged to include species occurring in Bangladesh, Burma, Sri Lanka and Pakistan, for obvious reasons.

The book is intended firstly, to provide available information on taxonomy and distribution so as to inspire and facilitate further researches on ecology, physiology and other aspects of molluscan study. The state of art on each species and the bibliography provided at the end should be helpful to those who would like to undertake further investigations on molluscs. Although a few very recent important references have been included in the bibliography the cut off year for references in general should be 1980. Secondly, it is hoped that it would also serve the needs of students of Indian Universities, where molluscs are used as material for research and teaching. The keys and illustrations would be of particular help to get proper identification of their local fauna.

From the account presented here, it would be clear that most of the earlier work on freshwater molluscs was devoted to a few common species, especially gastropods. In some groups of molluscs no further investigations

were made after the original discovery or first discovery from India. Further, the systematics of many families are still in a confused state. When more intensive collection is made and types studied some of the species may become invalidated. To help any such future investigators type species of a genus and the type locality of each species are given wherever possible.

This present work wherein I have attempted to survey and consolidate the available information on freshwater molluscs of India is only an introduction to the subject which has to be pursued by detailed investigations.

N. V. SUBBA RAO

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ABBREVIATIONS used in the book

ANSP	:	Academy of Natural Sciences, Philadelphia
BM(NH)	:	British Museum (Natural History), London
LS	:	Linnean Society, London
MCZ	:	Museum of Comparative Zoology, Harvard
MHN	:	Museum D'Histoire Naturelle, Geneva
MNHN	:	Museum National D'Histoire Naturelle, Paris
USNM	:	United States Natural History Museum, Washington
Z S I	:	Zoological Survey of India, Calcutta
Regd. No.	:	Registered Number.

ILLUSTRATION CREDITS

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Figs. 4 to 6 redrawn after G. C. Mandal (1971).

Figs. 8 and 9 redrawn after B. Prashad (1925).

Figs. 10 to 14 redrawn after B. Chatterjee (1970).

Figs. 320 to 325 after Gude (1914).

CONTENTS

Foreword
Preface
Author's Preface
Acknowledgements
Abbreviations Used
Classification of Freshwater Mollusca
INTRODUCTION 1
General Organisation 2
Gastropoda 3
Bivalvia 19
Ecology 23
Collection and Preservation 26
Key to the families 29
SYSTEMATIC ACCOUNT 32
Family I. Neritidae 32
Key to genera 33
Genus 1. *Neritina* Lamarck 33
Key to subgenera
Subgenus *Neritina* s. str. 34
Species 1. *Neritina (Neritina) pulligera* Linnaeus 34
Subgenus *Vittina* Baker 35
Key to species 35
Species 2. *Neritina (Vittina) variegata* Lesson 35
3. *N. (V.) turrita* Gmelin ... 36
4. *N. (V.) smithi* Wood ... 36
5. *N. (V.) perottetiana* (Recluz) ... 36
Subgenus *Neripteron* Lesson 37
Species 6. *Neritina (Neripteron) auriculata* Lamarck 37
Subgenus *Dostia* Gray 37
Species 7. *Neritina (Dostia) violacea* (Gmelin) 37
8. *N. (D.) platyconcha* Annandale & Prashad 38
Genus 2. *Clithon* Montfort 38
Key to species 39
Subgenus *Clithon* s. str. 39
Species 9. *Clithon (Clithon) corona* (Linnaeus) 39
10. *C. (C.) bicolor* (Recluz) ... 39
11. *C. (C.) reticularis* (Sowerby) ... 40

Genus 3. *Neritodryas* Von Martens ... 40
Species 12. *Neritodryas subsulcata* (Sowerby) ... 40
Genus 4. *Septaria* Ferussac 41
Key to species 41
Species 13. *Septaria lineata* (Lamarck) ... 41
14. *S. porcellana* (Linnaeus) ... 42
Family 2. Viviparidae 42
Subfamily Bellamyinae 43
Key to genera 43
Genus 5. *Bellamya* Jousseaume 44
Key to species 44
Species 15. *Bellamya bengalensis* (Lamarck) ... 45
16. *B. crassispiralis* (Annandale) ... 47
17. *B. crassa* (Benson) ... 48
18. *B. dissimilis* (Mueller) ... 48
19. *B. micron* (Annandale) ... 49
Genus 6. *Cipangopaludina* Hannibal ... 49
Species 20. *Cipangopaludina lecythis* (Benson) ... 50
Genus 7. *Angulyagra* Rao 50
Key to species 51
Species 21. *Angulyagra microchaetophora* (Annandale) 51
22. *A. oxytropis* (Benson) ... 51
Genus 8. *Taia* Annandale 52
Key to species 52
Species 23. *Taia crassicallosa* Annandale and Rao 53
24. *T elitoralis* Annandale ... 53
25. *T intha* Annandale ... 53
26. *T naticoides* (Theobald) ... 54
27. *T shanensis* (Kobelt) ... 54
28. *T theobaldi* (Kobelt) 55
Family 3. Valvatidae 55
Genus 9. *Valvata* O.F. Mueller 55
Species 29. *Valvata piscinalis* (Mueller) ... 56
30. *V stoliczkana* Nevill ... 56
Family 4. Pilidae 56
Key to genera 57
Genus 10. *Pila* Roeding 57
Key to species 57
Species 31. *Pila globosa* (Swainson) ... 58
32. *P. nevilliana* (Annandale and Prashad) 59
33. *P. olea* (Reeve) 59
34. *P. scutata* (Mousson) ... 59

35. *P. theobaldi* (Hanley) ... 60
36. *P. virens* (Lamarck) ... 60
Genus 11. *Turbinicola* Annandale and Prashad ... 61
Species 37. *Turbinicola saxea* (Reeve) ... 61
38. *T aperta* (Philippi) ... 61
Family 5. Littorinidae 62
Subfamily Cremnoconchinae Preston ... 62
Genus 12. *Cremnoconchus* Blanford ... 62
Subgenus *Cremnoconchus* s. str. ... 62
Species 39. *Cremnoconchus (Cremnoconchus) syhadrensis* (Blanford) 63
Subgenus *Lissoconchus* Thiele 63
Species 40. *Cremnoconchus (Lissoconchus) carinatus* (Layard) 63
41. *C. (L.) conicus* Blanford ... 64
Family 6. Hydrobiidae 64
Subfamily Hydrobiinae 65
Genus 13. *Potamopyrgus* Stimpson ... 65
Subgenus *Indopyrgus* Thiele 65
Species 42. *Potamopyrgus (Indopyrgus) nevilli* Thiele 65
Subfamily Triculinae 65
Genus 14. *Tricula* Benson 66
Key to the species of *Tricula* ... 66
Species 43. *Tricula gravelyi* Prashad ... 67
44. *T gregoriana expansa* Rao ... 67
45. *T horae* Annandale & Rao ... 68
46. *T martini* Rao 68
47. *T montana* Benson ... 68
48. *T taylori* Rao 69
Subfamily Iravadiinae 69
Genus 15. *Iravadia* Blanford 70
Key to species 70
Species 49. *Iravadia annandalei* Preston ... 70
50. *I. ennurensis* Preston ... 71
51. *I. funerea* Preston 71
52. *I. princeps* Preston ... 71
Family 7. Bithyniidae 72
Key to subfamilies 73
Subfamily Bithyniinae s. str. 73
Key to genera 73
Genus 16. *Bithynia* Leach 73
Species 53. *Bithynia tentaculata kashmirensis* (Nevill) 74
54. *B. troscheli* (Paasch) ... 74

Genus 17. *Sataria* Annandale 74
Species 55. *Sataria evezardi* (Blanford) ... 75
Genus 18. *Gabbia* Tryon 75
Key to species 76
Species 56. *Gabbia orcula* Frauenfeld ... 76
57. *G. orcula* var. *producta* (Nevill) ... 77
58. *G. stenothyroides* (Dohrn) ... 77
59. *G. physcus* (Annandale) ... 78
60. *G. alticola* (Annandale) ... 78
61. *G. travancorica* (Benson) ... 78
Genus 19. *Digoniostoma* Annandale ... 79
Key to species 79
Species 62. *D. cerameopoma* (Benson) ... 79
63. *D. pulchella* (Benson) ... 80
64. *D. textum* Annandale ... 80
Genus 20. *Hydrobioides* Nevill 80
Key to species 81
Species 65. *Hydrobioides avarix* Annandale ... 81
66. *H. nana* Annandale ... 82
67. *H. nassa* (Theobald) ... 82
68. *H. turrita* (Blanford) ... 83
Subfamily Mysorellinae 83
Genus 21. *Mysorella* Godwin-Austen ... 83
Species 69. *Mysorella costigera* (Kuester) ... 84
Family 8. Stenothyridae 84
Key to genera 85
Genus 22. *Stenothyra* Benson 85
Key to species 85
Species 70. *Stenothyra blanfordiana* Nevill ... 87
72. *S. deltae* (Benson) 87
72. *S. echinata* Annandale and Prashad 88
73. *S. foveolata* Benson ... 88
74. *S. hungerfordiana* Nevill ... 88
75. *S. minima* (Sowerby) ... 89
76. *S. nana* Prashad ... 89
77. *S. ornata* Annandale and Prashad ... 90
78. *S. soluta* Annandale and Prashad ... 90
79. *S. woodmasoniana* Nevill ... 90
Genus 23. *Gangetia* Ancey 91
Species 80. *Gangetia miliacea* (Nevill) ... 91
Family 9. Thiaridae 92
Key to subfamilies 93

Subfamily Thiarinae s. str. 93
Genus 24. *Thiara* Röding 94
Key to subgenera 95
Subgenus *Thiara* s. str. 96
Key to species 96
Species 81. *Thiara (Thiara) scabra* (Müller) ... 96
82. *T (T.) amarula* (Linnaeus) ... 97
83. *T (T.) rudis* (Lea) ... 97
Subgenus *Stenomelania* P. Fischer 98
Key to species 98
Species 84. *Thiara (Stenomelania) punctata* (Lamarck) 98
85. *T (S.) plicaria* (Born) ... 99
86. *T (S.) aspirans* (Hinds) ... 99
87. *T (S.) torulosa* (Bruguiere) ... 100
Subgenus *Tarebia* H. and A. Adams ... 101
Species 88. *Thiara (Tarebia) granifera* (Lamarck) 101
89. *T (T.) lineata* (Gray) ... 101
Subgenus *Sermyla* H. and A. Adams ... 102
Species 90. *Thiara (Sermyla) riqueti* (Grateloup) 102
Subgenus *Melanoides* Olivier 103
Species 91. *Thiara (Melanoides) prashadi* Ray 103
92. *Thiara (Melanoides) tuberculata* (Müller) 103
93. *T (M.) tuberculata crebra* Lea ... 105
Subgenus *Mainwaringia* Nevill 105
Species 94. *Thiara (Mainwaringia) puludomoidea* Nevill 106
Subfamily Melanatriinae 106
Genus 25. *Sulcospira* Troschel 107
Species 95. *Sulcospira hügeli* (Philippi) ... 107
Genus 26. *Brotia* H. & A. Adams ... 107
Subgenus *Antimelania* Crosse and Fischer ... 108
Species 96. *Brotia (Antimelania) costula* (Rafinesque) 108
Subfamily Melanopsinae 109
Genus 27. *Faunus* Montfort 109
Species 97. *Faunus ater* (Linnaeus) ... 109
Subfamily Paludominae 110
Genus 28. *Paludomus* Swainson ... 110
Key to subgenera 111
Subgenus *Paludomus* s. str. 111
Species 98. *Paludomus (Paludomus) andersoniana* Nevill 111
99. *P. (P.) annandalei* Preston ... 112
100. *P. (P.) blanfordiana* Nevill ... 112
101. *P. (P.) burmanica* Nevill ... 112

102. *P. (P.) conica* Gray ... 113
103. *P. (P.) chilinoides* Reeve ... 113
104. *P. (P.) dhuma* Rao ... 114
105. *P. (P.) inflatus* Brot ... 114
106. *P. (P.) nana* Nevill ... 114
107. *P. (P.) obesus* (Philippi) ... 115
108. *P. (P.) ornatus* Benson ... 115
109. *P. (P.) palustris* Layard ... 115
110. *P. (P.) parvula* Rao ... 116
111. *P. (P.) pustulosa* Annandale ... 116
112. *P. (P.) reticulata* Blanford ... 117
113. *P. (P.) rotunda* Blanford ... 117
114. *P. (P.) stephanus* (Benson) ... 117
115. *P. (P.) regulata* (Benson) ... 118
116. *P. (P.) tanschauricus* (Gmelin) ... 118
Subgenus *Philopotamis* Layard ... 118
Species 117. *Paludomus (Philopotamis) bicinctus* Reeve 119
118. *P.(P.) nigricans* Reeve ... 119
119. *P. (P.) regalis* Layard ... 119
120. *P. (P.) sulcatus* Reeve ... 120
Subgenus *Tanalia* Gray 120
Species 121. *Paludomus (Tanalia) loricatus* Reeve 121
122. *P. (T.) neritoides* Reeve ... 121
123. *P. (T.) solidus* Dohrn ... 121
Subgenus *Stomatodon* Benson 122
Species 124. *Paludomus (Stomatodon) stomatodon* Benson 122
Subclass Pulmonata 123
Order Basommatophora 123
Family 10. Lymnaeidae 123
Genus 29. *Lymnaea* Lamarck 124
Key to species 124
Subgenus *Pseudosuccinea* Baker 126
Species 125. *Lymnaea (Pseudosuccinea) acuminata* Lamarck 126
126. *L. (P.) biacuminata* Annandale and Rao 128
127. *L. (P.) luteola* Lamarck ... 128
128. *L. (P.) ovalior* Annandale and Prashad 129
129. *L. (P.) horae* Annandale and Rao ... 130
130. *L. (P.) gedrosiana* Annandale and Prashad 130
131. *L. (P.) mimetica* Annandale ... 130
132. *L. (P.) shanensis* Annandale ... 131
Subgenus *Galba* Schrank 131
Species 133. *Lymnaea (Galba) bowelli* Preston ... 131

134. *L. (G.) laticallosa* Annandale and Rao 132
135. *L. (G.) hookeri* Reeve ... 132
136. *L. (G.) andersoniana* Nevill ... 132
137. *L. (G.) truncatula* (Mueller) ... 133
Subgenus *Radix* Montfort 133
Species 138. *Lymnaea (Radix) persica* Issel ... 133
139. *L. (R.) auricularia* (Linnaeus) ... 134
140. *L. (R.) brevicauda* Sowerby ... 134
141. *L. (R.) peregra* (Mueller) ... 135
Subgenus *Lymnaea* s. str. 135
Species 142. *Lymnaea (Lymnaea) stagnalis* (Linnaeus) 135
Subgenus *Stagnicola* Leach 136
Species 143. *Lymnaea (Stagnicola) tungabhadraensis* Ray 136
Family 11. Ancylidae 136
Genus 30. *Ferrissia* Walker 137
Key to species 137
Species 144. *Ferrissia baconi* (Bourguignat) ... 138
145. *F. ceylanica* (Benson) ... 138
146. *F. tenuis* (Bourguignat) ... 138
147. *F. verruca* (Benson) ... 139
148. *F. viola* Annandale and Prashad ... 139
Family 12. Planorbidae 140
Key to genera 141
Subfamily Bulininae 141
Genus 31. *Indoplanorbis* Annandale and Prashad ... 142
Species 149. *Indoplanorbis exustus* (Deshayes) ... 142
Genus 32. *Camptoceras* Benson 143
Key to species 143
Subgenus *Camptoceras* s. str. 144
Species 150. *Camptoceras (Camptoceras) austeni* Blanford 144
151. *C. (C.) terebra* Benson ... 144
Subgenus *Culmenella* Clench 145
Species 152. *Camptoceras (Culmenella) lineatum* Blanford 145
153. *C. (C.) subspinosum* Annandale and Prashad 145
Subfamily Segmentininae 145
Key to genera 146
Genus 33. *Hippeutis* Charpentier 146
Subgenus *Hippeutis* s. str. 146
Species 154. *Hippeutis (Hippeutis) fontanus* (Lightfoot) 146
Subgenus *Helicorbis* Benson 147
Species 155. *Hippeutis (Helicorbis) capitis* (Annandale) 147
156. *H. (H.) umbilicalis umbilicalis* (Benson) 148

Genus 34. *Segmentina* Fleming 149
Subgenus *Polypylis* Pilsbry 149
Species 157. *Segmentina (Polypylis) calatha* (Benson) 150
158. *S. (P.) taia* (Annandale and Rao) 150
159. *S. (P.) trochoidea* (Benson) ... 150
Subfamily Planorbinae s. str. 151
Genus 35. *Planorbis* Geoffroy 151
Species 160. *Planorbis (Planorbis) tangitarensis* Germain 152
161. *P. rotundatus* Poiret ... 152
Genus 36. *Gyraulus* Charpentier 153
Species 162. *Gyraulus barrackporensis* (Clessin) 153
163. *G. convexiusculus* (Hutton) ... 154
164. *G. euphraticus* (Mousson) ... 155
165. *G. labiatus* (Benson) ... 155
166. *G. ladacensis* Nevill ... 156
167. *G. pankongensis* (von Martens) ... 156
168. *G. rotula* (Benson) ... 157
169. *G. saltensis* Germain ... 157
170. *G. velifer* (Annandale) ... 158
Class Bivalvia 159
Order Arcoida 159
Family 13. Arcidae 159
Subfamily Anadarinae 159
Genus 37. *Scaphula* Benson 159
Species 171. *Scaphula celox* Benson ... 160
172. *S. deltae* Blanford ... 160
173. *S. pinna* Benson 160
Order Unionida 161
Family 14. Unionidae 161
Subfamily Unioninae 162
Key to genera 163
Genus 38. *Lamellidens* Simpson 164
Species 174. *Lamellidens consobrinus* Lea ... 164
175. *L. corrianus* Lea 165
176. *L. generosus* (Gould) ... 165
177. *L. indawgyiensis* Prashad ... 166
178. *L. jenkinsianus* (Benson) ... 166
179. *L. jenkinsianus daccaensis* (Preston) 167
180. *L. jenkinsianus obesa* (Hanley and Theobald) 167
181. *L. lamellatus* Lea 167
182. *L. marginalis* (Lamarck) ... 168

183. *L. phenchooganjensis* Preston ... 168
184. *L. scutum* (Sowerby) ... 169
Genus 39. *Arcidopsis* Simpson 169
Species 185. *Arcidopsis footei* (Theobald) ... 169
Genus 40. *Oxynaia* Haas 170
Species 186. *Oxynaia pugio* (Benson) ... 170
Family 15. Amblemidae 171
Subfamily Ambleminae 171
Genus 41. *Pseudodon* Gould 171
Subgenus *Pseudodon* s. str. 172
Species 187. *Pseudodon (Pseudodon) inoscularis* (Gould) 172
Subgenus *Trigonodon* Conrad 172
Species 188. *Pseudodon (Trigonodon) crebristriatus* (Anthony) 173
189. *Pseudodon (Trigonodon) peguensis* (Anthony) 173
Subgenus *Indopseudodon* Prashad 173
190. *Pseudodon (Indopseudodon) ava* (Theobald) 174
191. *Pseudodon (Indopseudodon) salwenianus* (Gould) 174
Genus 42. *Solenaia* Conrad 175
Species 192. *Solenaia soleniformis* (Benson) ... 175
Subfamily Parreysiinae 175
Genus 43. *Parreysia* Conrad 176
Key to subgenera 176
Subgenus *Parreysia* s. str. 176
Species 193. *Parreysia (Parreysia) annandalei* Preston 176
194. *P. (P.) bhamoensis* (Theobald) ... 177
195. *P. (P.) burmanus* (Blanford) ... 177
196. *P. (P.) choprae* Prashad ... 178
197. *P. (P.) corbis* (Benson) ... 178
198. *P. (P.) corrugata* (Mueller) ... 179
199. *P. (P.) corrugata laevirostris* (Benson) 179
200. *P. (P.) corrugata nagpoorensis* (Lea) 180
201. *P. (P.) cylindrica* Annandale and Prashad 180
202. *P. (P.) favidens* (Benson) ... 180
203. *P. (P.) favidens assamensis* Preston 181
204. *P. (P.) favidens chrysis* (Benson) ... 181
205. *P. (P.) favidens deltae* (Benson) ... 181
206. *P. (P.) favidens viridula* (Benson) ... 182
207. *P. (P.) feae* (Tapparone-Canefri) ... 182
208. *P. (P.) feddeni* (Theobald) ... 182
209. *P. (P.) gowhattensis* (Theobald) ... 183
210. *P. (P.) houngdaranicus* (Tapparone-Canefri) 183
211. *P. (P.) mandelayensis* (Theobald) ... 184

212. *P. (P.) olivacea* Prashad ... 184
213. *P. (P.) perconvexa* Preston ... 184
214. *P. (P.) rajahensis* (Lea) ... 185
215. *P. (P.) sikkimensis* (Lea) ... 185
216. *P. (P.) smaragdites* (Benson) ... 185
217. *P. (P.) tavoyensis* (Gould) ... 186
218. *P. (P.) triembolus* (Benson) ... 186
Subgenus *Radiatula* Simpson 187
Species 219. *Parreysia (Radiatula) andersoniana* (Nevill) 187
220. *P. (R.) bonneaudi* (Eydoux) ... 187
221. *P. (R.) caerulea* (Lea) ... 188
222. *P. (R.) caerulea gaudichaudi* (Eydoux) 188
223. *P. (R.) chaudhurii* (Preston) ... 189
224. *P. (R.) crispisulcata* (Benson) ... 189
225. *P. (R.) involuta* (Benson) ... 189
226. *P. (R.) khadakvaslaensis* (Ray) ... 190
227. *P. (R.) lima* (Simpson) ... 190
228. *P. (R.) nuttalliana* (Lea) ... 190
229. *P. (R.) occata* (Lea) ... 191
230. *P. (R.) olivaria* (Lea) ... 191
231. *P. (R.) pachysoma* (Benson) ... 192
232. *P. (R.) shurtleffiana* (Lea) ... 192
233. *P. (R.) theobaldi* (Preston) ... 192
Genus 44. *Scabies* Haas ... 193
Species 234. *Scabies crispata* (Gould) ... 193
Subfamily Rectidentinae 194
Genus 45. *Trapezoideus* Simpson 194
Species 235. *Trapezoideus exolescens exolescens* (Gould) 194
Genus 46. *Physunio* Simpson 195
Subgenus *Physunio* s. str. 196
Species 236. *Physunio (Physunio) ferrugineus* Annandale 196
237. *P. (P.) micropteroides* Annandale ... 196
Subgenus *Velunio* Haas 196
Species 238. *P. (Velunio) velaris* (Sowerby) ... 197
Family 16. Aetheriidae 197
Genus 47. *Acostaea* d'Orbigny 197
Subgenus *Pseudomulleria* Anthony ... 198
Species 239. *Acostaea (Pseudomulleria) dalyi* E.A. Smith 198
Family 17. Margaritiferidae ... 198
Genus 48. *Margaritifera* Schumacher ... 198
Subgenus *Margaritanopsis* Haas ... 199
Species 240. *Margaritifera (Margaritanopsis) laosensis* (Lea) 199

Order Veneroida ... ...
Family 18. Corbiculidae 199
Key to genera 200
Genus 49. *Corbicula* Megerle von Muehlfeld ... 200
Species 241. *Corbicula annandalei* Prashad ... 201
242. *C. arata* (Sowerby) ... 201
243. *C. assamensis* Prashad ... 201
244. *C. bensoni* Deshayes ... 202
245. *C. cashmiriensis* Deshayes ... 202
246. *C. iravadica* Blanford ... 203
247. *C. krishnaea* Ray 203
248. *C. noetlingi* von Martens ... 203
249. *C. peninsularis* Prashad ... 204
250. *C. solida* Clessin 204
251. *C. striatella* Deshayes ... 204
252. *C. subnitens* Clessin ... 205
253. *C. sylhetica* Preston ... 205
254. *C. tibetensis* Prashad ... 206
Genus 50. *Villorita* Griffith and Pidgeon ... 206
Key to species 207
Species 255. *V. corbiculoides* Prashad ... 207
256. *V. cornucopia* Prashad ... 207
257. *V. cyprinoides* (Gray) ... 208
Genus 51. *Batissa* Gray 208
Species 258. *Batissa inflata* Prime ... 209
259. *B. similis* Prime 209
Genus 52. *Geloina* Gray 209
Species 260. *Geloina bengalensis* (Lamarck) ... 210
261. *G. erosa* (Solander) ... 210
Family 19. Pisidiidae 211
Key to genera 211
Genus 53. *Sphaerium* Scopoli 211
Subgenus *Sphaerium* s. str. 212
Key to species 212
Species 262. *Sphaerium (Sphaerium) austeni* Prashad 212
263. *S. (S.) avanum* Theobald ... 213
264. *S. (S.) indicum* Deshayes ... 213
265. *S. (S.) kashmirensis* Prashad ... 213
266. *S. (S.) montanum* Tapparone Canefri 214
Genus 54. *Pisidium* Pfeiffer 214
Subgenus *Pisidium* s. str. 215
Species 267. *P. (P.) casertanum* (Poli) ... 215

Subgenus *Odhneripisidium* Kuiper ... 215
Species 268. *Pisidium (Odhneripisidium) annandalei* Prashad 215
269. *P. (O.) appressum* Prashad ... 216
270. *P. (O.) atkinsonianum* Theobald ... 216
271. *P. (O.) kuiperi* Dance ... 217
272. *P. (O.) stewarti* Preston ... 217
273. *P. (O.) yarkandense* Prashad ... 218
274. *P. (O.) zugmayeri* Weber ... 218
Subgenus *Afropisidium* Kuiper 218
Species 275. *Pisidium (A.) clarkeanum* G. & H. Nevill 218
276. *P. (A.) ellisi* Dance ... 219
277. *P. (A.) nevillianum* Theobald ... 219
278. *P. (A.) stoliczkanum* Prashad ... 220
Subgenus *Eupisidium* 220
Species 279. *P. (E.) mitchelli* Prashad ... 220
Family 20. Cultellidae 220
Genus 55. *Tanysiphon* Benson 220
Species 280. *Tanysiphon rivalis* Benson ... 221
Genus 56. *Neosolen* Ghosh 221
Species 281. *Neosolen aquaedulcioris* Ghosh ... 221
Family 21. Solecurtidae 222
Subfamily Novaculininae 222
Genus 57. *Novaculina* Benson 222
Species 282. *Novaculina andamanensis* Preston ... 223
283. *N. gangetica* Benson ... 223
FRESHWATER MOLLUSCS IN AQUACULTURE ... 225
Freshwater Pearls 230
Shell-fisheries of North Bihar 231
BIBLIOGRAPHY 233
Subject Index 275

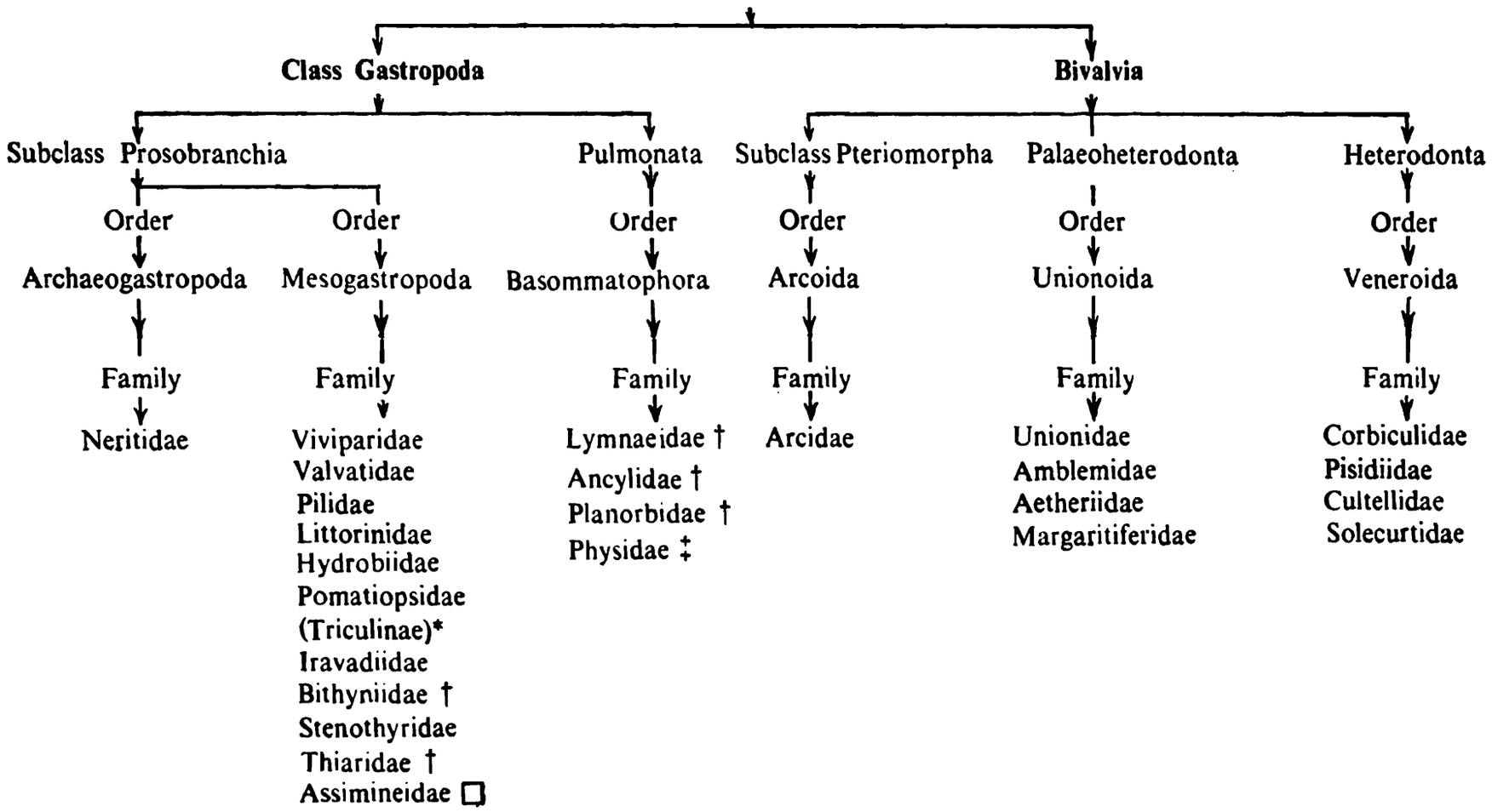
ADDENDUM 278

APPENDIX

List of Common Freshwater Molluscs of India ... 279

INDEX 283

CLASSIFICATION OF FRESHWATER MOLLUSCA



**Treated as Subfamily in the text

† Intermediate hosts for trematodes

□ Not dealt with in this book

‡ In India represented by fossil forms, but in Pakistan by the extant species, *Physa acuta* Draparnaud.

INTRODUCTION

The fresh water molluscs constitute an important part of the ecosystem. Their participation in the way of life of many organisms has made them significant partners in the ecological communities.

Not only many aquatic animals thrive on them, but they also serve as food for humans in many areas, in some cases attaining the level of delicacy. As vectors of trematode parasites they are instrumental in the transmission and spread of many diseases in livestock and humans, of which Schistosomiasis is reckoned as a potential threat to the human population of a large part of the globe. At the other end the larval bivalves are parasites on fishes. From the zoogeographical point of view some of the molluscs rank as excellent material.

Notwithstanding their role in aquatic ecosystem they were less explored ecologically and biologically. A perusal of the literature shows a paucity of information on several aspects of these molluscs of India. A good taxonomic account was given by different authors in the past, but at the same time much confusion was also created by the addition of several isolated and inadequately described species, the types of some of which are not available at present.

An array of literature is available on the freshwater molluscs of India. But neither a comprehensive account of the group in India as a whole is at hand nor an attempt has been made to study their occurrence, distribution and factors governing population density. The present work, it is hoped will fill up that long felt lacuna and inspire further investigations.

More than seventy years have elapsed since the publication of Preston's *Fauna of British India*—Freshwater Gastropoda and Pelecypoda. In the intervening period a vast amount of knowledge has accumulated on the freshwater molluscs. A number of new species, new excellent information on their biology, bionomics and distribution have been added. It is no easy task for the beginner to allocate his collected specimens to the particular genus, let alone the particular species. In recent years the problem has become almost acute. The present work serves as a guide and it is hoped, based on this to publish a revised fauna of freshwater molluscs of India in near future.

The author has examined large collections in the Zoological Survey of India and also has carefully gone through the literature. The first few

chapters give an idea about general structure, bioecology and the methods of collection and preservation. Keys have been provided to identify the families and the genera under the respective family. In the catalogue of species all those described from India and adjacent countries are included after ascertaining as far as possible the present status of each species. The families Thiaridae, Lymnaeidae, Planorbidae and Unionidae need further revision. A biosystematic approach is necessary to delineate each species and to show its exact systematic position. In the present state of knowledge it is difficult to provide keys to all the species. However, their salient diagnostic features and their known distributions are given.

The freshwater molluscs are distinguished into two natural groups, namely primary freshwater and secondary freshwater. The primary freshwater molluscs are confined exclusively to the freshwater habitats. There are many species which are distributed both in estuarine-and fresh-waters. Such genera as *Neritina, Clithon, Septaria, Scaphula* and *Novaculina* belong to this category. The genus *Thiara* is primarily freshwater with a tolerance to saline waters. The family Stenothyridae and subfamily Iravadiinae include primarily estuarine or saline water species, occasionally occurring in freshwaters. Among bivalves the genera *Villorita, Geloina, Batissa* and *Tanysiphon* are primarily estuarine, rarely occurring in freshwaters. These genera are however included here following Preston's fauna volume(1915). The family Assimineidae is excluded from the purview of this book.

Sincere attempts are made to bring an order in the taxonomy of molluscs. Yet much remains to be done. It is hoped that the present work would provide the necessary impetus and serve as a basic guide to all those concerned with Indian molluscs.

General Organisation

The freshwater molluscs have a shell, in which the soft parts are enclosed. Most species can be conveniently identified by their shell characters. However, in some groups the conchological characters have to be supplemented by their anatomical characters also. The more modern techniques like chromosome study, chromatography, and electrophoresis of blood and egg protein are yet to make a dent in molluscan taxonomy in India.

Gastropoda

Shell

The shell in gastropoda is a single, usually dextrally coiled spiral valve (Fig. 1). A sinistral shell occurs only in the genus *Camptoceras* amongst Indian species (Fig. 2d). The shell usually encloses the visceral mass and the foot when the animal is retracted into the shell. It has a large body whorl and a spire, including more than two whorls, terminating in an apex. The body whorl opens at the mouth or aperture, which is closed by a horny or calcareous operculum in prosobranchs (Fig. 3). The operculum is absent in basommatophoran pulmonates. When a shell is held in

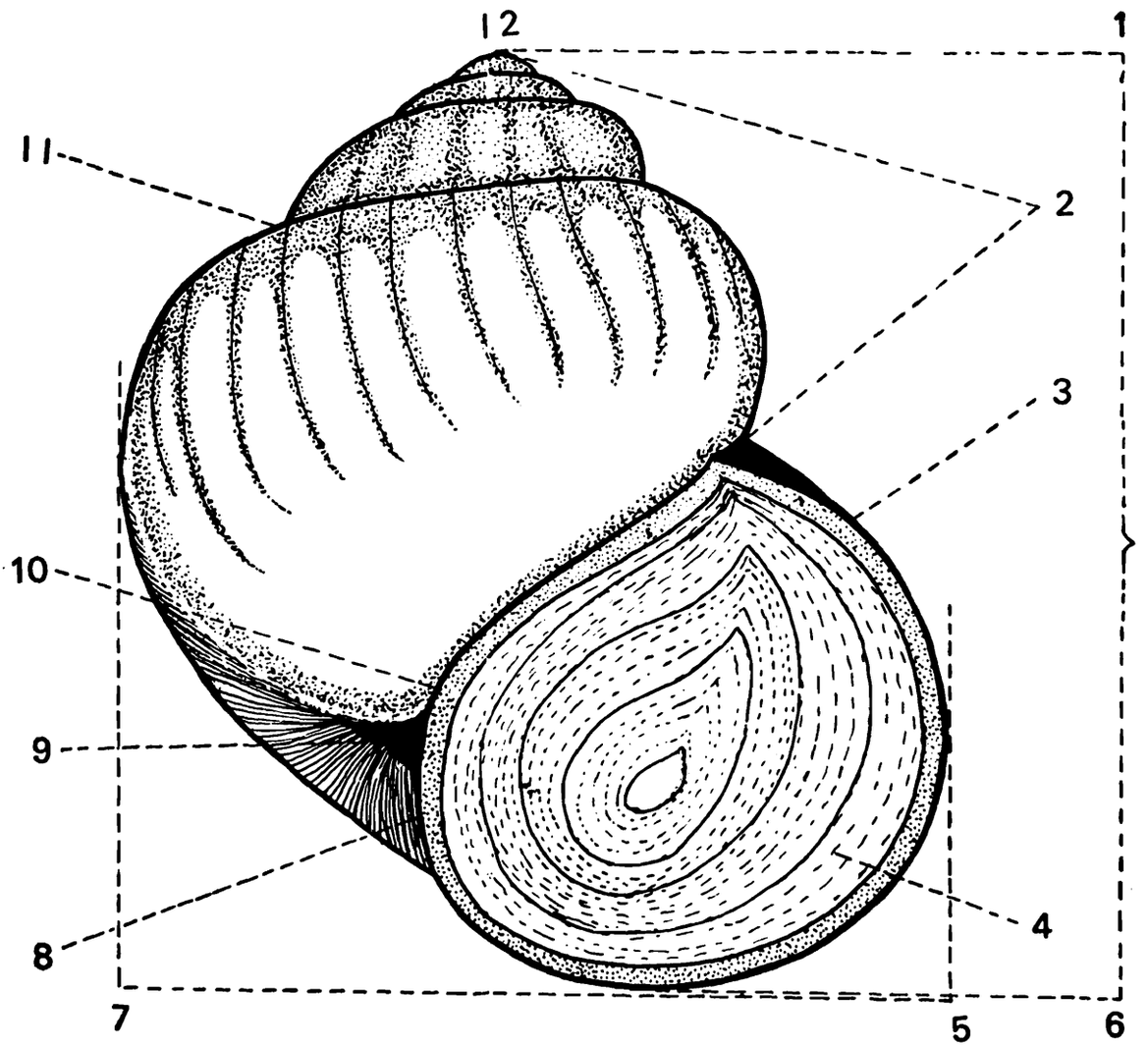


Fig. 1. *Shell terminology.* 1—6. Length of the shell; 2. Spire; 3. Outer lip; 4. Operculum; 7—5. width of the shell; 8. inner lip or columella; 9. umbilicus; 10. Parietal callus; 11. suture; 12. Apex.

hand with the apex pointing away and the aperture facing the observer the rim on the right side of the aperture is the outer lip and the left one is the inner lip or columella. The columella is (some times) hollow and when it is more spiral the central opening or umbilicus is seen. Sometimes the columella is strengthened by a callus deposit.

The shell of freshwater gastropods offers a great number of characters useful in taxonomy. The general shape, the presence or absence of operculum, the number, nature of coiling and shape of whorls, sculpture, the nature of umbilicus and columella, and the shape of the aperture in a shell are very important to a taxonomist.

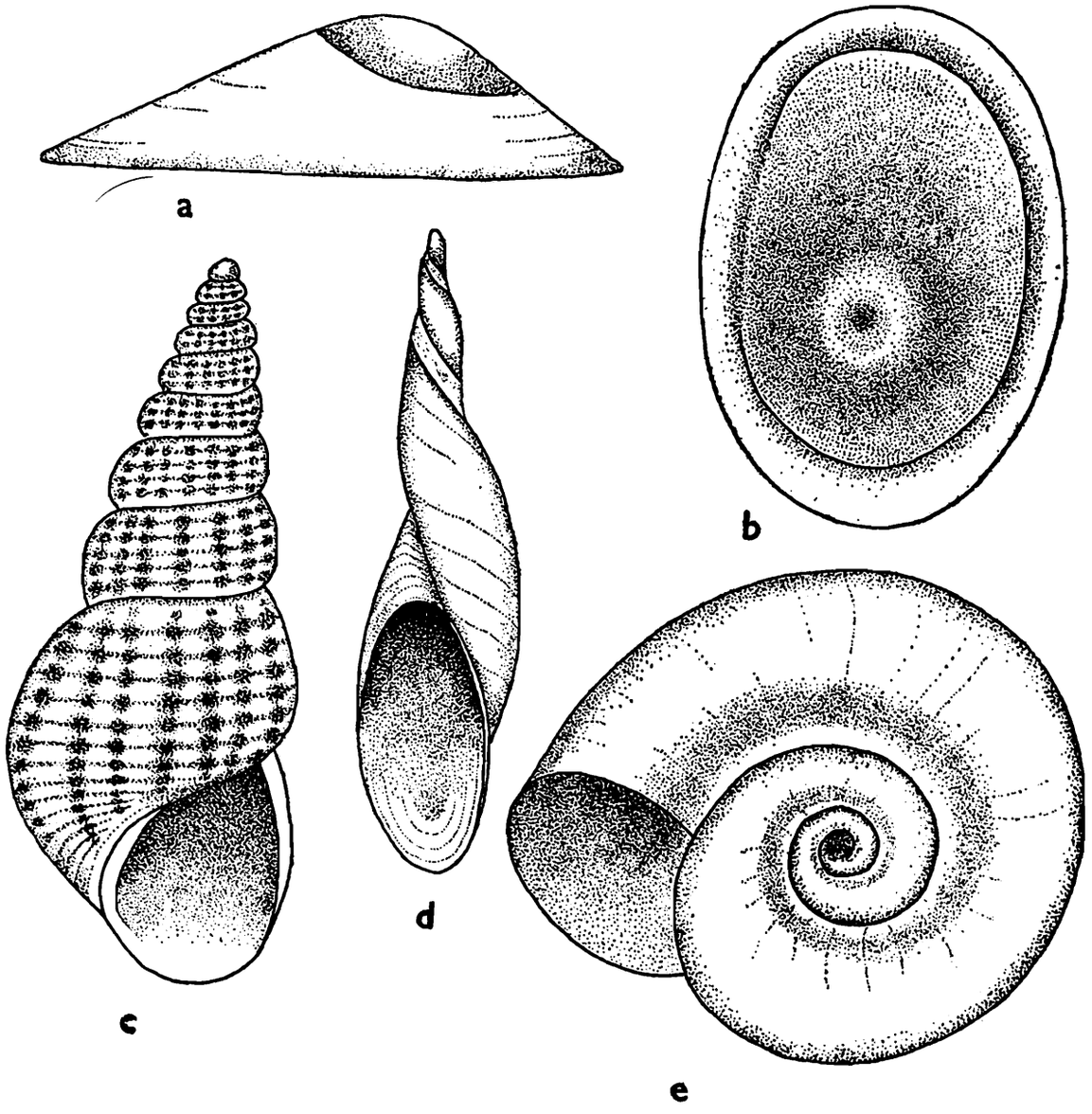


Fig. 2. *Shell shapes.* a—b. Limpet; c. Turreted; d. Sinistral; e. discoidal.

Broadly four different shell shapes (Fig. 2) are recorded from Indian freshwater molluscs.

1. The cup-or limpet-shaped shell with very faint traces of coiling. It is a distinguishing feature of the family Ancylidae and the genus *Septaria* of Neritidae (Fig. 2a, b)

2. Ovate or globose shell with a large body whorl and aperture, and a spire with two or three whorls is characteristic of a large number of gastropods (Fig. 1).

3. Turreted shell, where the shell with several whorls is drawn out in length as in the family Thiaridae (Fig. 2c)

4. Discoidal or planispiral shell, where all the whorls are in the same plane and coiled like a watch spring. It is the condition found in the majority of Indian planorbids (Fig. 2e).

Soft Parts

The body in a gastropod consists of a ventral flat muscular foot and a dorsal hump-like visceral mass. The head is distinct and bears a pair of tentacles, (Figs. 4-6), a mouth and a pair of eyes, situated on the inner base of each tentacle. The shape and size of the tentacles may also be used as characters in the identification. It may be broad and triangular (Lymnaeidae) or filiform and tapering (Planorbidae). The foot has a creeping ventral surface. It is divided into an anterior propodium, a middle mesopodium and a posterior metapodium; and operculum when present is attached to the dorsal part of the metapodium. The members of *Septaria* and ancylids attach themselves firmly to the substratum with the help of the large muscular foot acting as a sort of sucker.

The visceral mass is covered by the mantle or pallium and anteriorly encloses a cavity, the pallial or mantle cavity between it and the body. The edge of the mantle is generally smooth, but in the majority of thiarids it is provided with papillae or digitiform processes. The following organs of the pallial complex are found within the mantle cavity.

1. One or two ctenidia or gills.
2. A small comb-shaped organ, the osphradium attached to the mantle lobe.

3. Hypobranchial gland, a glandular organ, situated at the base of the posterior gill.
4. The terminal parts of the excretory, digestive and reproductive systems also form parts of the pallial complex. The rectum lies to the left of the ctenidium on the floor of the mantle cavity and opens out by the anus. The female genital duct lies left to the rectum and opens externally close to the anus. The anterior part of the excretory or renal organ opens into the posterior end of the mantle cavity by the renal aperture.

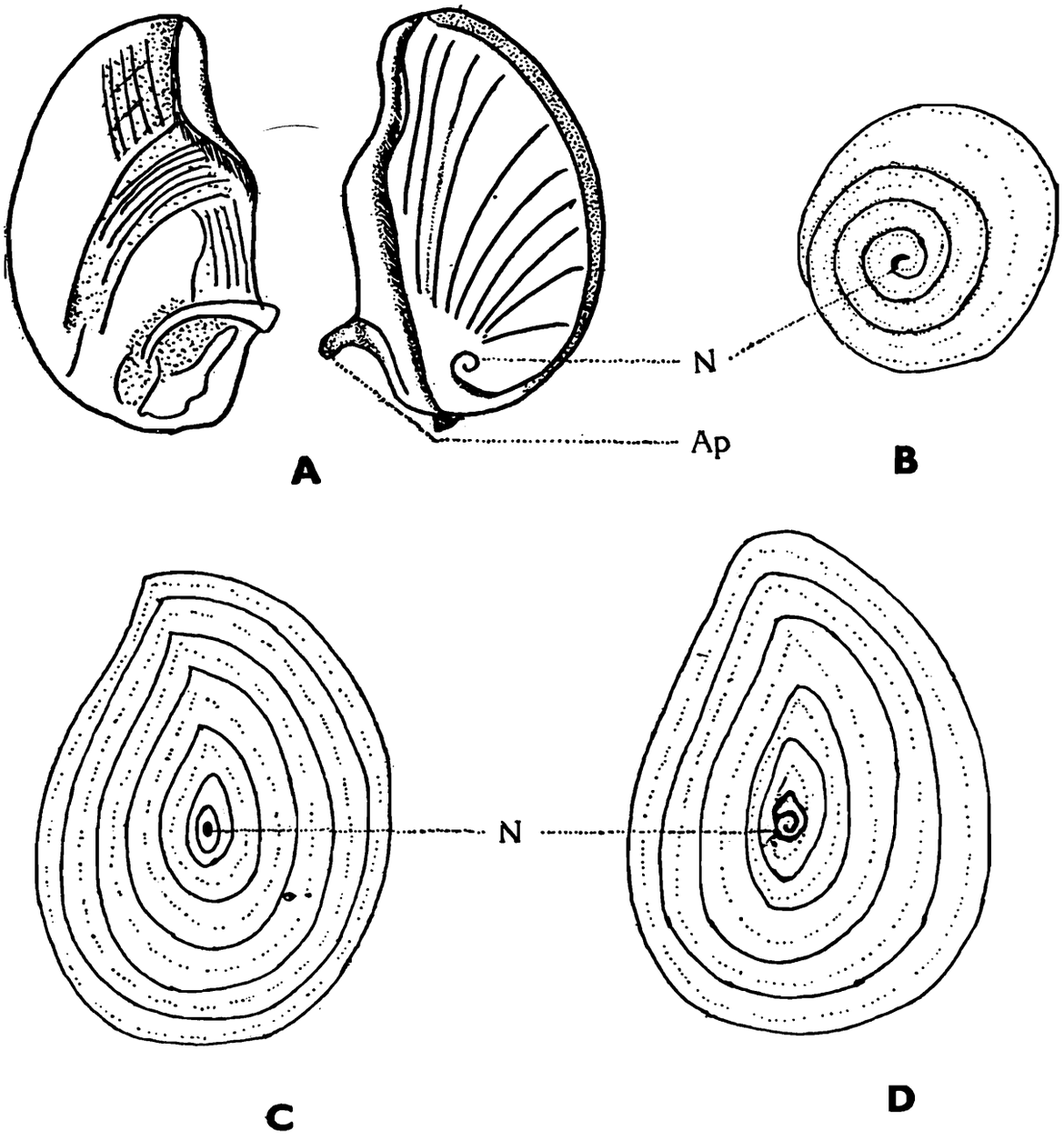


Fig. 3. *Types of opercula.* A. Paucispiral (with excentric nucleus); B. Multispiral; C. Concentric (with central nucleus); D. Concentric (with spiral nucleus).

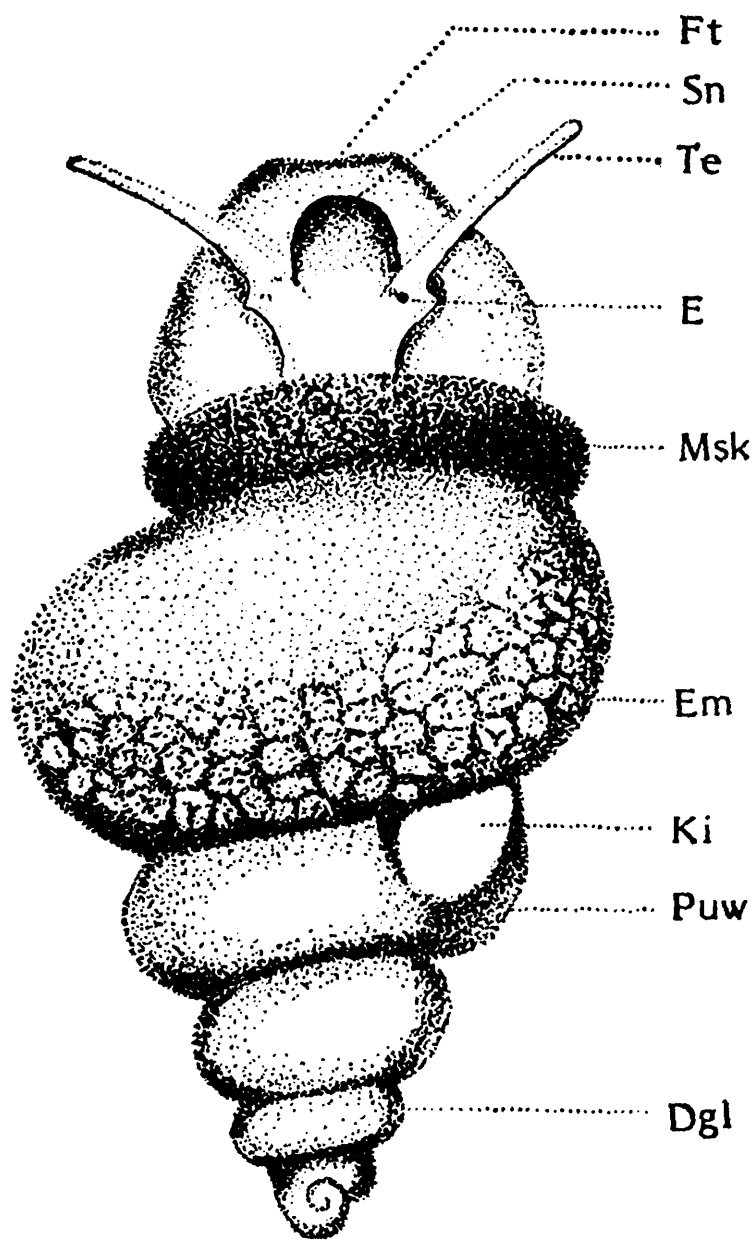


Fig. 4. *Bellamya bengalensis:* Animal on removal of shell. Ft.: Foot; Sn.: Snout; Te.: Tentacle; E.: Eye; Msk.: Muscular collar; Em.: Embryo; Ki.: Kidney; Puw.: Pulmonary wall; Dgl.: Digestive gland.

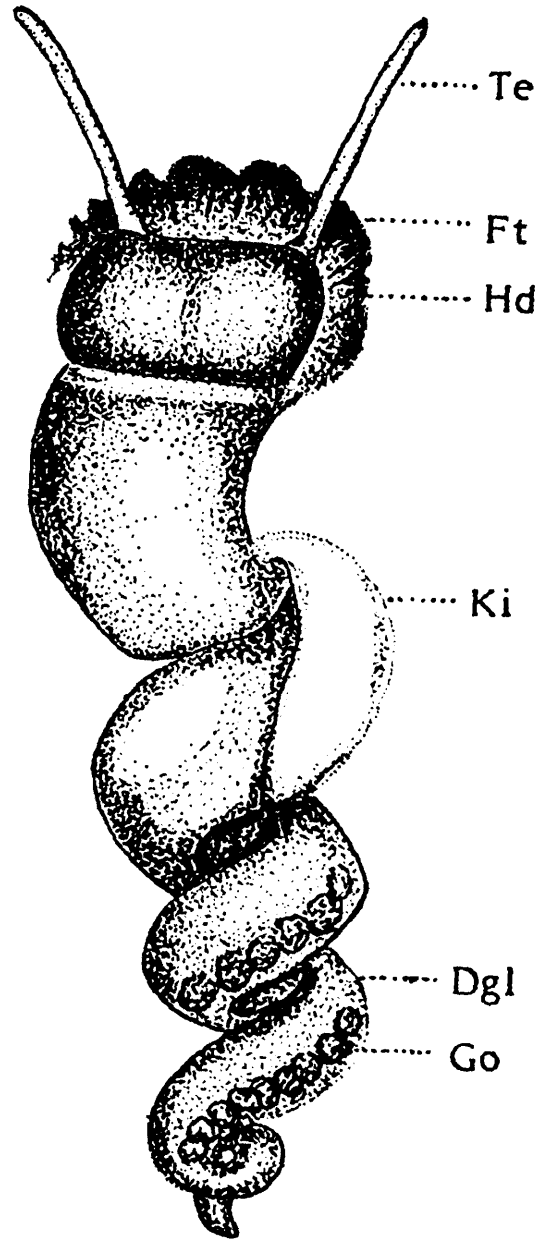


Fig. 5. *Brotia costula:* Animal on removal of shell. Te.: Tentacle; Ft.: Foot; Hd.: Head; Ki.: Kidney; Dgl.: Digestive gland; Go.: Gonad.

In prosobranchs the mantle cavity opens to the exterior through a large gulley at the anterior end while in the pulmonates, the opening is through a small, somewhat oval opening, the pneumostome on one side which in some cases may be drawn out into a siphon during respiration. True gills and hypobranchial glands are lacking in Pulmonata, but a lung adherent to the mantle is present. Respiration is aerial and carried out by the lung, formed by a separate invagination during early development. In early embryos the lung appears as a small chamber in the mantle cavity. Before the completion of the larval development the lung becomes adherent to the mantle. It is non-separable from the mantle in an adult snail and the latter appears as a highly vascularised structure. In ancylids and planorbids there is an accessory respiratory structure known as pallial gill or pseudobranch situated externally near the pneumostome.

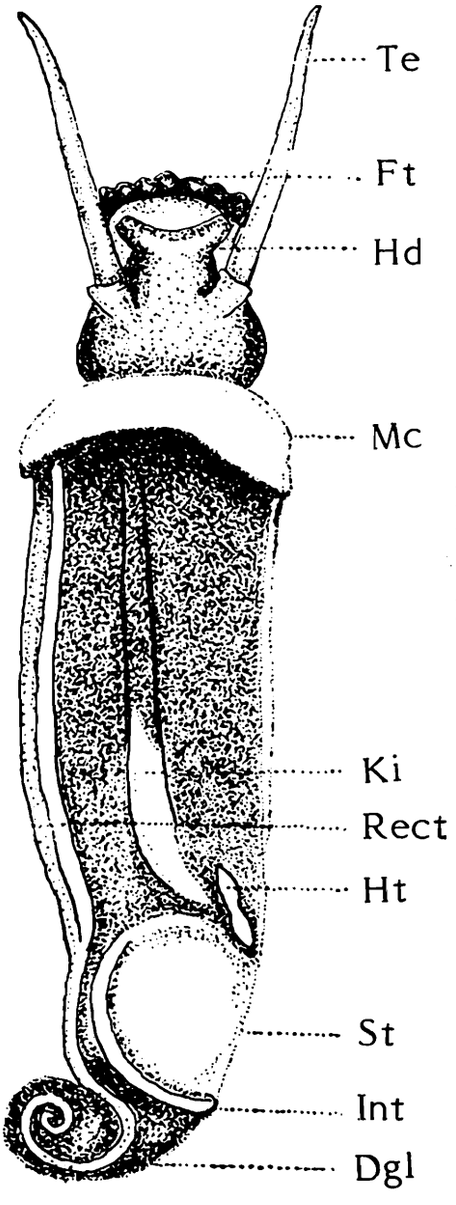


Fig. 6. *Indoplanorbis exustus*. Animal on removal of shell. Te.: Tentacle; Ft.: Foot; Hd.: Head; Mc.: Muscular collar; Ki.: Kidney; Rect.: Rectum; Ht.: Heart; St.: Stomach; Int.: Intestine; Dgl.: Digestive gland.

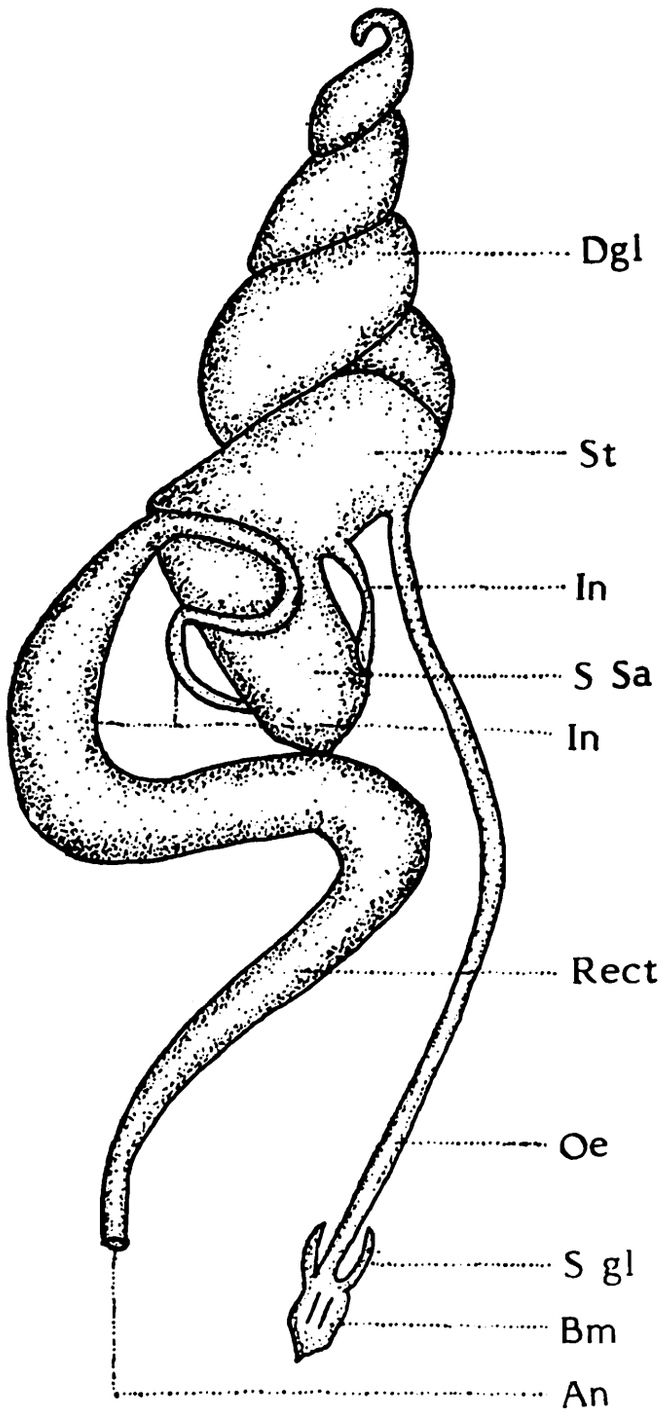


Fig. 7. *Thiara torulosa*. Digestive System. Dgl.: Digestive gland; St.: Stomach; In.: Intestine; S. Sa.: Salivary sac; Rect.: Rectum; Oe.: Oesophagus; S gl.: Salivary gland; Bm.: Buccal mass; An.: Anus.

Digestive system

Typically it consists of a mouth, the buccal mass, the oesophagous, the stomach, the intestine and the rectum (Fig. 7). All the fresh water molluscs of India are herbivores and the mouth is a simple structure situated on the anteroventral part at the snout. It leads into a buccal cavity enclosed in a buccal mass which has two characteristic organs—a paired or a single jaw and an odontophore containing a buccal cartilage and a radula. The radula is a ribbon-like structure covered with transverse rows of chitinous teeth. Each transverse row has a central or a rachidian tooth on either side of which there are symmetrically arranged lateral and marginal teeth. Each lateral tooth has two or three main cusps, namely endocone, mesocone and ectocone. Marginal teeth are obliquely arranged and bear several minute cusps. The number of radular teeth in a prosobranch is much less than that in a pulmonate but of usually larger size than in the latter. The number, arrangement and structure of teeth on the radula are of considerable systematic value.

The buccal mass leads into a tubular oesophagus, which in turn opens into the stomach. There are a pair of salivary glands arising from the postero-dorsal surface of the buccal mass. A pair of buccal glands are present in some prosobranchs. The stomach consists of an anterior globular and a posterior tubular region. In some pulmonates the anterior part of the stomach is partly or wholly muscularised to form a gizzard. The thin walled part behind the gizzard is known as pylorus, into which opens the caecum. In many prosobranchs, the stomach is evaginated anteriorly to form the style sac which contains a rod-like structure, the crystalline style. The stomach is connected to a coiled intestine. The digestive gland is very large and connected to the stomach by one or more digestive ducts.

Circulatory system

Heart: It is enclosed in the pericardium. It consists of one or two anterior auricles and a posterior ventricle in prosobranchs, but in pulmonates there is only a single auricle. The arterial system is well developed in pulmonates. Blood is discharged through aortae which branch off into a few large sinuses and numerous capillaries. (Fig. 8).

Respiratory system

In prosobranchs respiration is carried through ctenidia or gills situated in the mantle cavity. The ctenidium may be bipectinate, with two rows

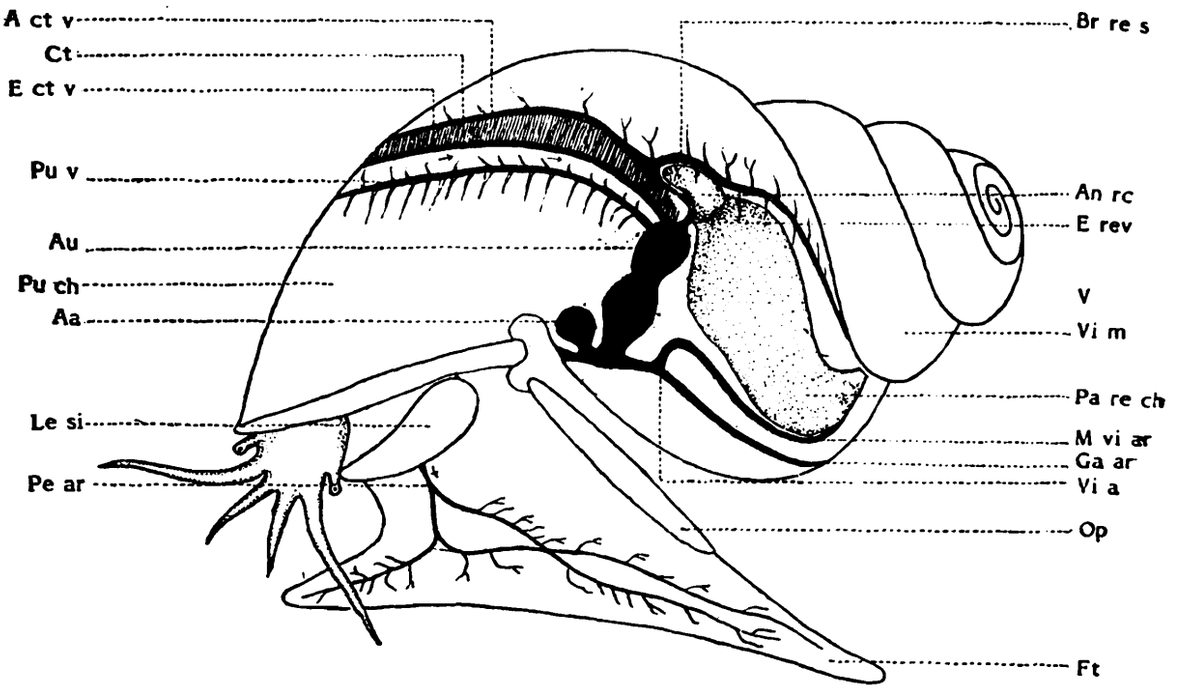


Fig. 8. *Pila globosa.* Diagramatic sketch (seen from left side) showing the position of heart and the principal vessels. A ct v: Afferent ctenidial vein; Ct.: Ctenidium; E ct v: Efferent ctenidial vein; Pu v: Pulmonary vein; Au: Auricle; Pu ch.: Pulmonary chamber; A a: Aortic ampulla; Le si: Left sinus; Pe ar: Pedal arteries; Br re s: Branchio renal sinus; An rc: Anterior renal chamber; E rev: Efferent renal vein; V: Ventricle; Vi m: Visceral mass; Pa re ch: Posterior renal chamber; M vi a: Main visceral artery; Ga ar: Gastric artery; Vi a: Visceral aorta; Op: Operculum; Ft: Foot.

of branchial filaments or monopectinate with one row of filaments as in *Pila*. Specific differences have been found in the gill-lamellae of viviparids.

Excretory System

Excretion is effected by a single kidney which is attached to the mantle close to the pericardium and communicates with it by a renopericardial aperture. The adult kidney is morphologically right or left one, depending on the direction of torsion, dextral or sinistral. The structure of the kidney can also serve as a taxonomic character.

Kidney is generally located in the visceral mass (e.g. *Bellamya*) or a small anterior part may project into the mantle cavity (e.g. *Brotia*).

The kidney is either divided into non-glandular accessory lobe and a glandular lobe as in *Brotia* or not divisible as in *Bellamya* and pulmonates.

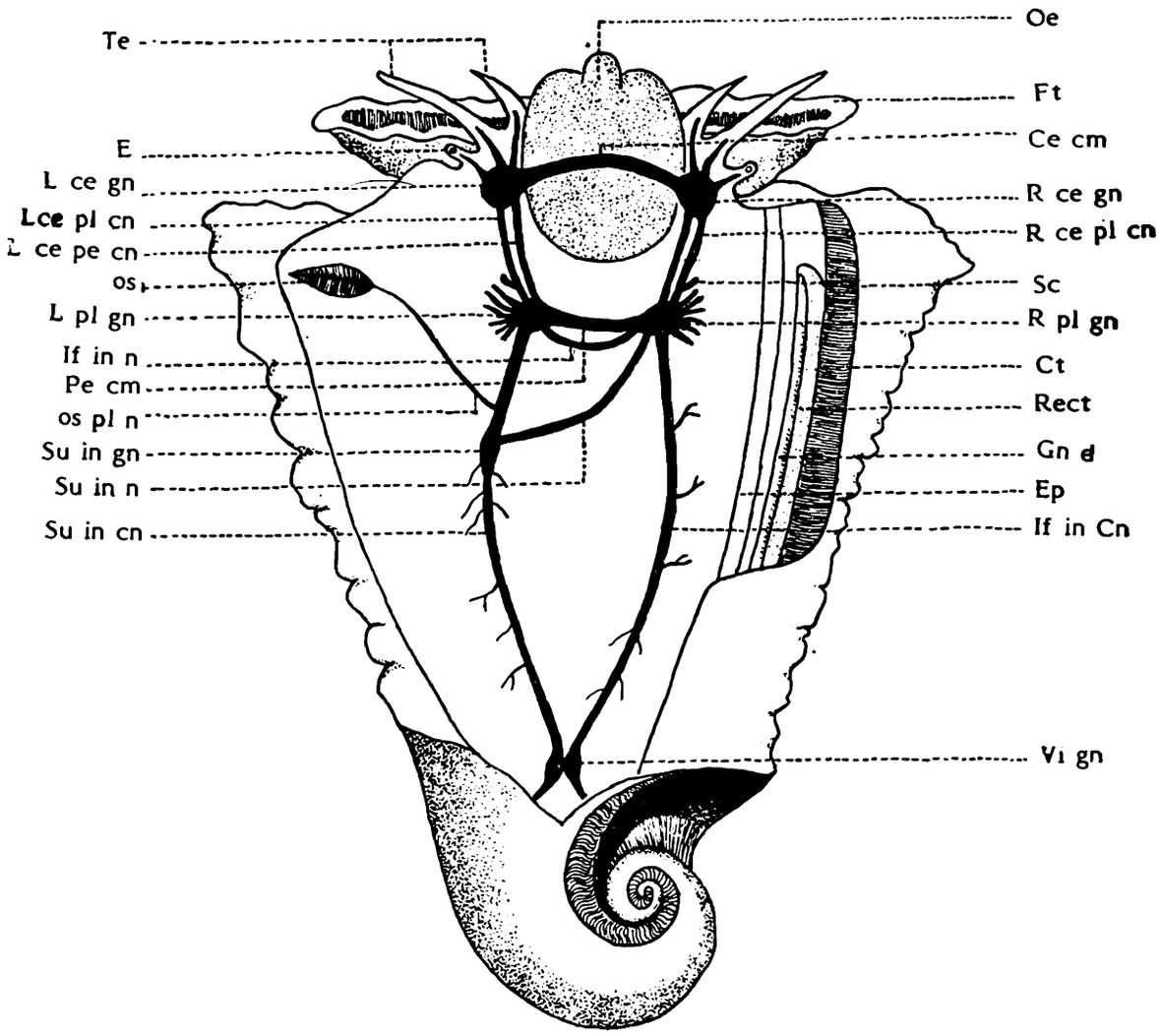


Fig. 9. *Pila globosa.* Nervous System. Te: Tentacle; E: Eye; L ce gn: Left cerebral ganglion; L ce pl cn: Left cerebro pleural connective; L ce pe cn: Left cerebro pedal connective; Os: Osphradium; L pl gn: Left pleural ganglion; If in n: Infra Intestinal nerve; Pe cm: Pedal commissure; Os pl n: Osphridial nerve; Su in gn: Supra intestinal ganglion; Su in n: Supra intestinal nerve; Su in cn: Supra intestinal connective; Oe: Oesophagus; Ft: Foot; Ce Cm: Cerebral commissure; R ce gn: Right cephalic ganglion; R ce pl cn: Right cephalic pleuro connective; Sc: Statocyst; R pl gn: Right pleural ganglion; Ct: Ctenidium; Rect: Rectum; Gnd: Genital duct; Ep: Epitaenia; If in cn: Infra intestinal connective; Vi gn: Visceral ganglion.

Nervous System

It consists of a series of paired ganglia, namely the cerebral, pleural, buccal and pedal, and unpaired visceral, supra oesophageal and suboesophageal ganglia, their commissures and connectives. (Fig. 9).

As a result of torsion, in prosobranchs, there is a crossing of visceral nerves into a figure of 8. The right one passes above the intestine forming supra-intestinal nerve and the left one passes below forming the infra-intestinal ganglion and nerve.

In pulmonates there is strong condensation of visceral loop and concentration of ganglia near the oesophagus.

Reproductive System

The sexes are separate in prosobranchs, but united in pulmonates. In some prosobranchs (Neritidae and Viviparidae) the males and females can be distinguished by the size and the presence of a penis. The gonad is always unpaired and is embedded in the digestive gland (Fig. 11, 12, 14) in the top whorls of the spire of the shell.

The male is provided with a penis (except in the ceritheaceans, which lack a penis) situated on the right side, behind the cephalic tentacle. The testis leads into a vas deferens or the male duct which bears a number of seminal vesicles. There may be a distinct prostate gland or a part of the vas deferens may serve as prostate gland (Fig. 10). The sperm duct lies on the floor of the mantle cavity and is connected to the base of the penis or to the male genital pore as the case may be.

The reproductive system in females is more complicated than in males. The oviduct is divided into the visceral oviduct and pallial oviduct. The latter acts as a brood pouch for the developing young in the case of ovo-viviparous forms. The seminal receptacle and bursa copulatrix are connected primarily to the oviduct at the junction of pallial and visceral portions.

In pulmonates the male and female organs open to the exterior through gonopores. The gonad consists of ovotestis which gives off the ovotestis duct which incompletely separates into a spermduct and oviduct. The sperm duct receives secretions from prostate gland and opens into the penial complex through the vas deferens. The penial complex or copulatory organ

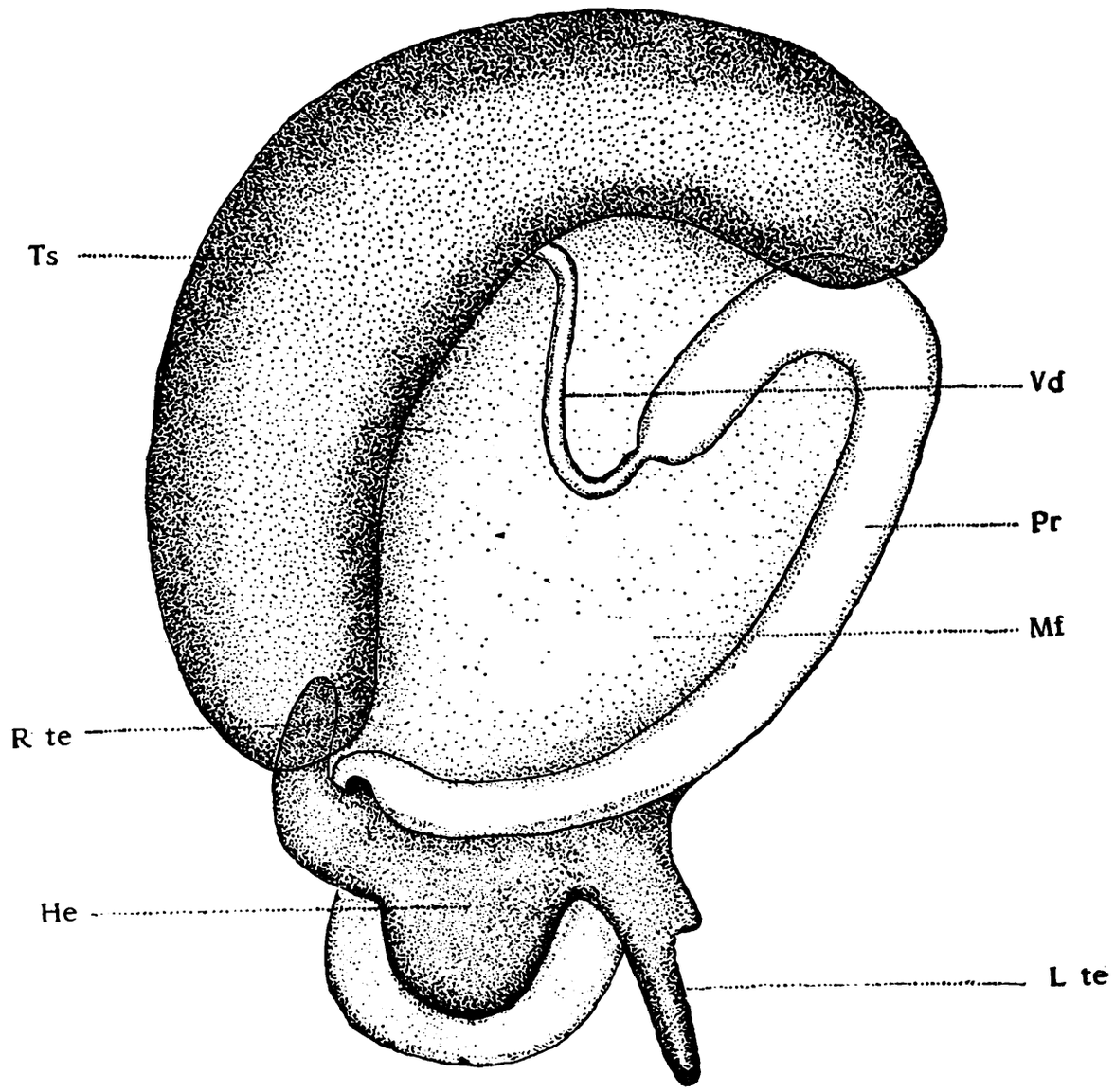


Fig. 10. *Bellamya bengalensis:* Male reproductive system (organs slightly displaced) Ts: Testis; R te: Right tentacle; He: Head; Vd: Vas deferens; Pr: Prostate; Mf: Mantle; L te: Left tentacle.

Fig. 11. *Brotia costula:* Female on removal of shell. Ov: Ovary; D gl: Digestive gland; St: Stomach; M el: Medial lamina; Rect: Rectum; Br P: Brood Pouch; He: Head; Te: Tentacle.

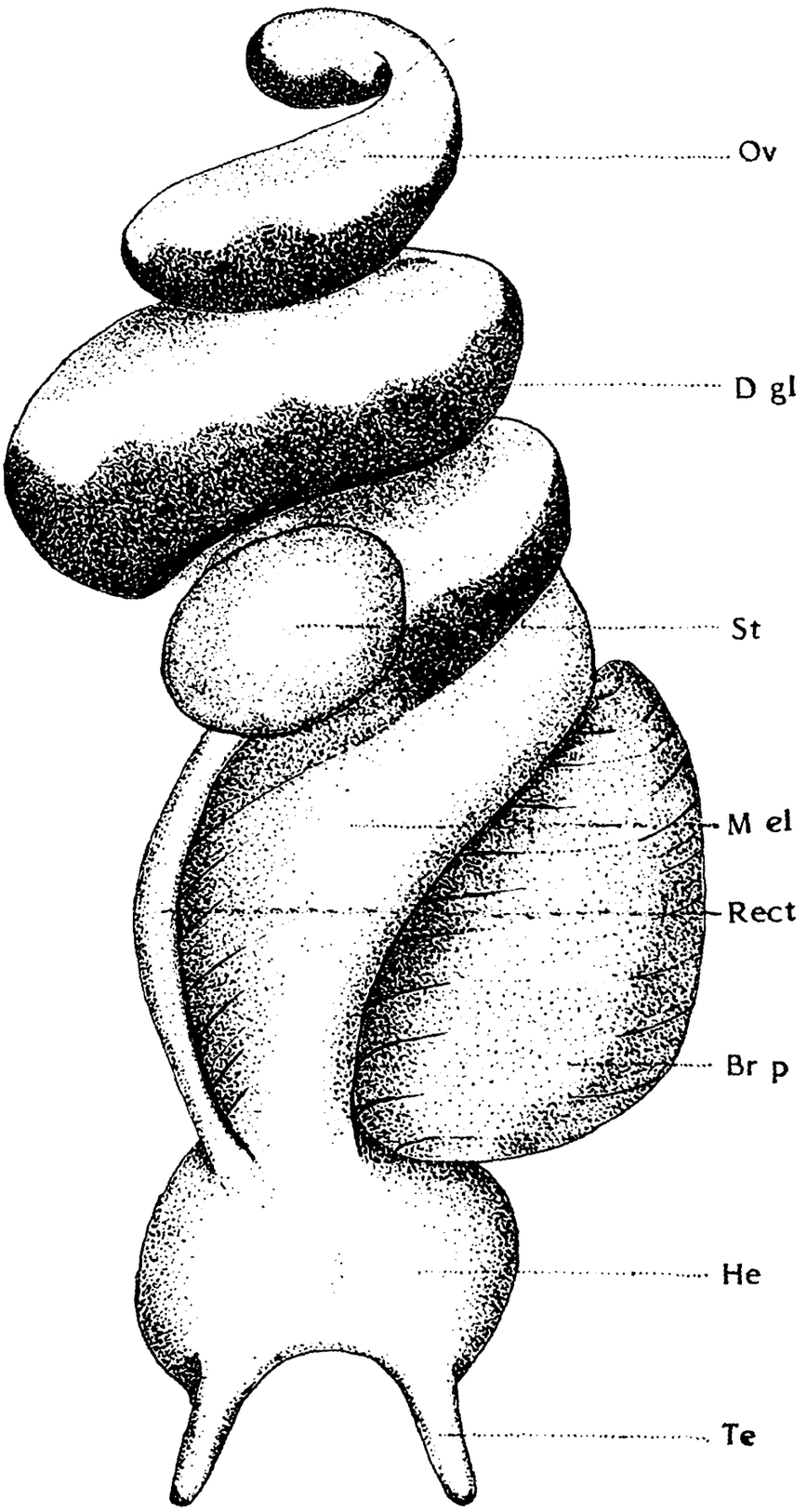


Fig. 11

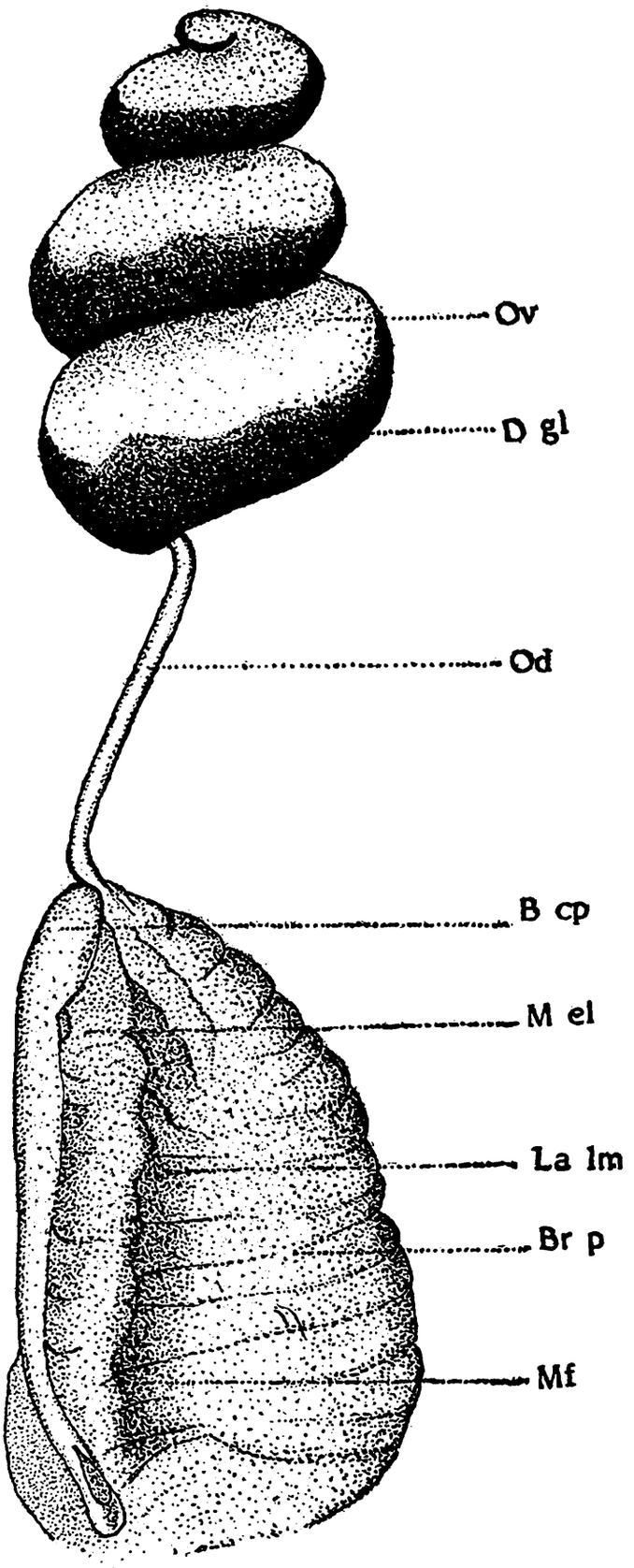


Fig. 12. *Brotia costula:* Female dissected. Ov: Ovary; D gl: Digestive gland; Od: Oviduct; B cp: Bursa copulatrix; M el: Medial lamina; La In: Lateral lamina. B P: Brood Pouch; Mf: Mantle.

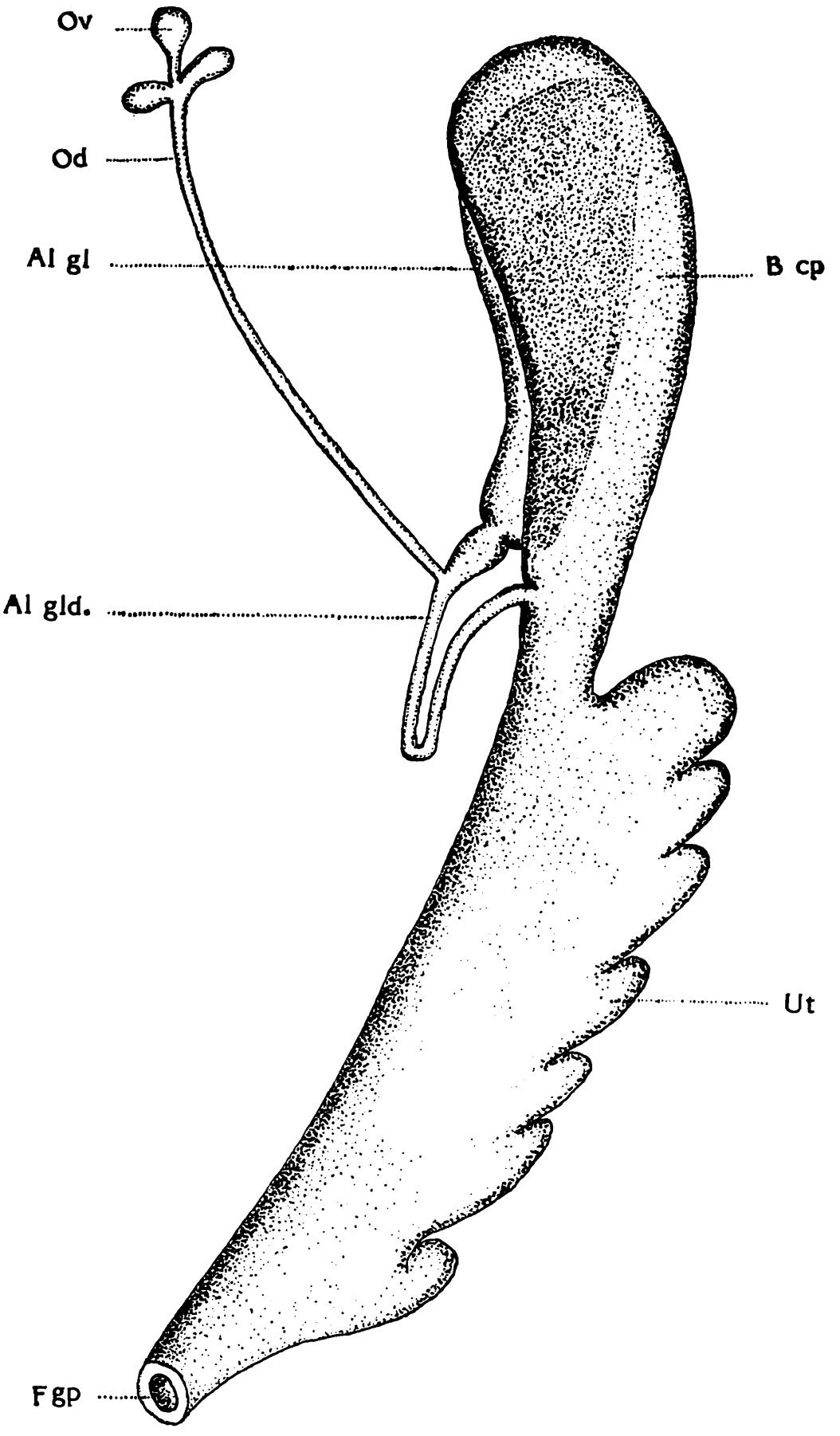


Fig. 13. *Brotia costula:* Female reproductive system. Ov: Ovary; Od: Oviduct; B cp: Bursa copulatrix; Al gl: Albumen gland; Al gl d: Albumen gland duct; Ut: Uterus; Fgp: Female genital pore.

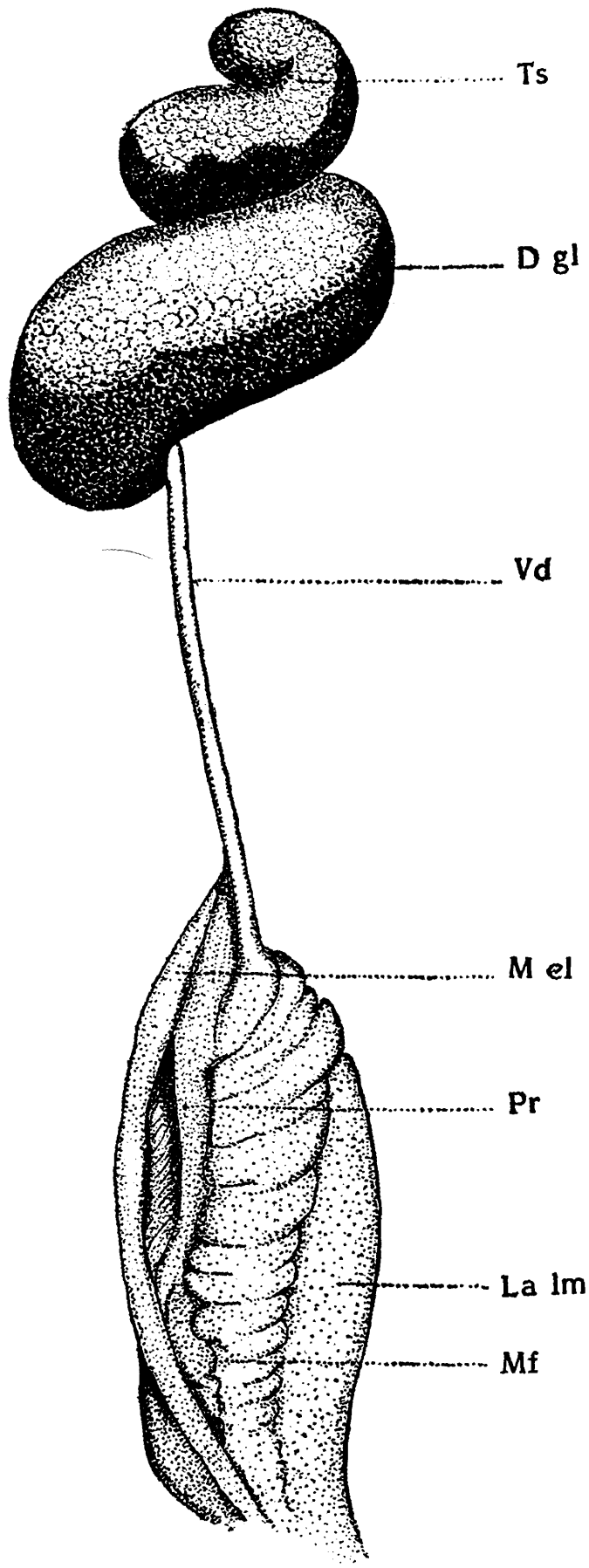


Fig. 14. *Brotia costula:* Male reproductive system. Ts: Testis; D gl.: Digestive gland; Vd: Vas deferens; M el: Medial lamina; Pr: Prostate; La ln: lateral lamina; Mf: Mantle floor.

consists of two parts, an upper part including vergic sheath and verge and a lower, muscular and bulky preputium connected with the genital atrium. The copulatory organ is a significant character in the taxonomy of planorbids. The oviduct receives secretions from a large albumen gland and extends as the uterus (Fig. 13). It receives secretions from the oothecal gland and genital atrium, the latter opening to the exterior through a gonopore. There is a seminal receptacle duct and sac connected to the vagina.

Bivalvia

In bivalves, as the name indicates, the shell consists of two calcified halves or valves and a typically wedge-shaped foot. The two valves are united dorsally by the hinge consisting of a system of teeth and sockets.

The shell is bilaterally symmetrical. The shell margins are distinguished into anterior, posterior, dorsal and ventral. Outer surface of the shell bears longitudinal or concentric growth striations. In some the umbonal region may be radially ribbed. On the inner surface each valve bears traces or impressions of ligament which opens the shell and adductor muscles which close it. The impression of posterior retractile is also seen. The edge of the mantle leaves its impression, which is called as pallial line. (Fig. 15).

The valves are closed or opened by one or two adductor muscles. Each valve is generally inequilateral. In some forms the right valve is attached to the substratum and hence inequivalve.

The body is laterally compressed and covered with a mantle consisting of two halves, one on either side. The body is not divisible into a head and a visceral hump. Tentacles, buccal mass, the eyes, jaws and radula are absent.

The foot (Fig. 16 A & B) is generally well developed and axe shaped (hence the name Pelecypoda), but in the attached forms it is obsolete in the adult.

The two mantle folds are united posteriorly but free along the ventral and anterior margins. Posteriorly the mantle cavity communicates with the exterior by two openings; the ventral or lower or branchial siphon through which water enters and the dorsal or upper or anal siphon through which the water is pumped out. These are also referred as inhalent and exhalent siphons (Fig. 16 A & B).

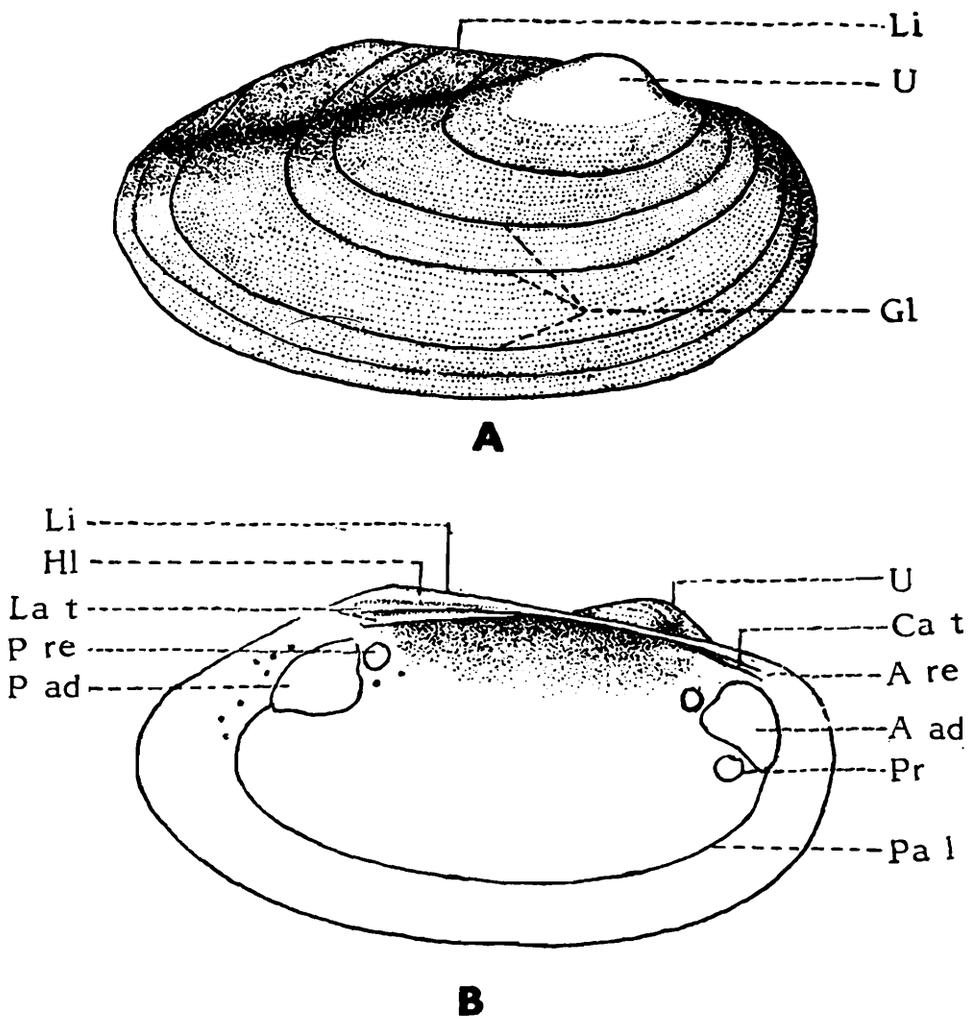
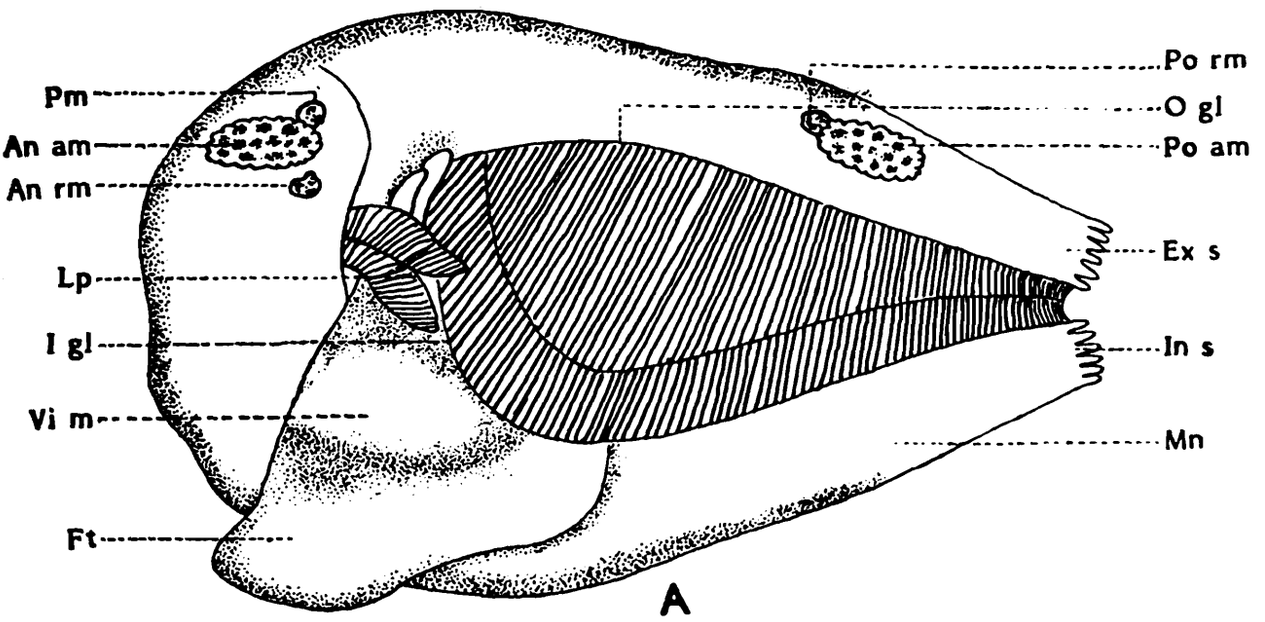
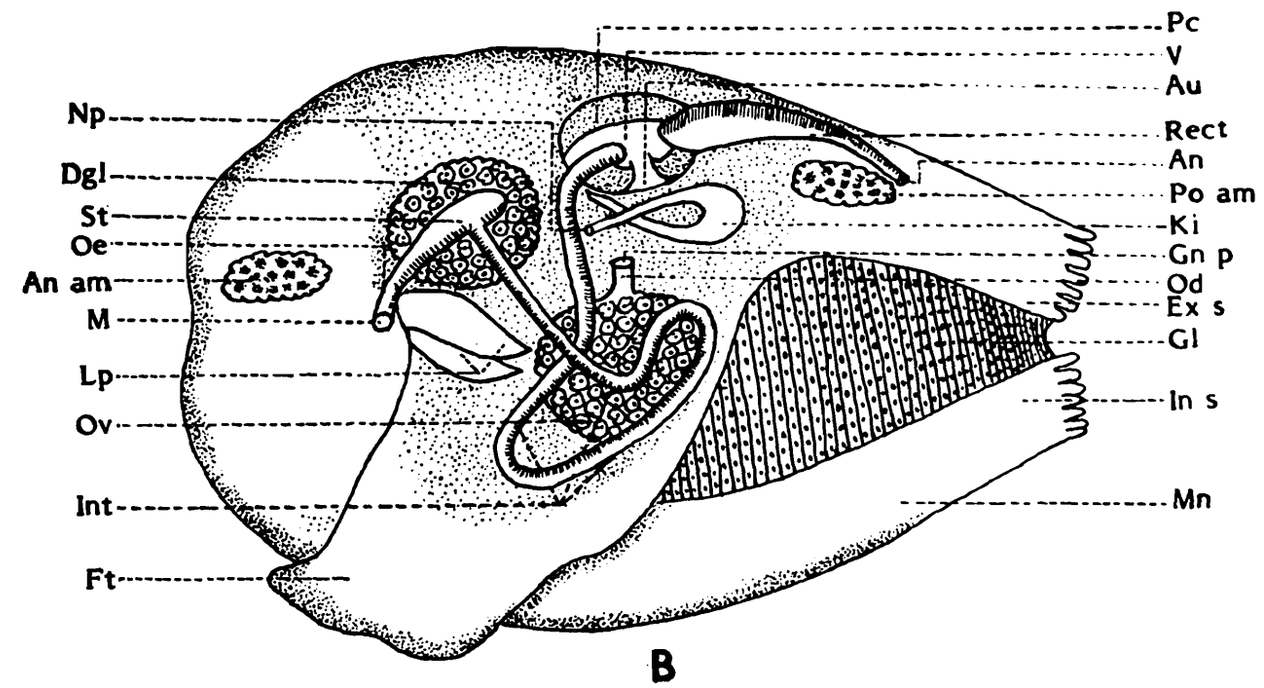


Fig. 15. *Lamellidens marginalis:* Shell, outer (A) and inner (B) views. Li: Ligament; U: Umbo; G l: Growth lines; Li: Ligament; Hi: Hinge line; La t: Lateral teeth; P re: Posterior retractor muscle scar; P ad: Posterior adductor muscle scar; U: Umbo; Ca: Cardinel teeth; A: Anterior retractor muscle scar; A ad: Anterior adductor muscle scar; Pr: Protractor muscle scar; Pa l: Pallial line.



16. A. *Lamellidens marginalis:* Animal after removal of shell and a part of the mantle l obe. Pm: Protractor muscle; An am: Anterior adductor muscle; An rm: Anterior retractor muscle; Lp: Labial palp; I gl: Inner gill lamellae; Vi m: Visceral mass; Ft: Foot; Po rm; Posterior retractor muscle; O gl: Outer gill lamellae; Po am: Posterior adductor muscle; Ex S: Exhalent siphon; In S: Inhalent siphon; Mn: Mantle.



16. B: Dissected animal showing different internal organs. NP: Nephridium; D gl: Digestive gland; St: Stomach; Oh: Oesophagous: An am: Anterior adductor muscle; M; Mouth; Lp: Labial palp; Ov: Ovary; Int: Intestine; Ft: Foot; Pc: Pericardium; V: ventricle; Au: Auricle; Rect: Rectum; An: Anus; Po am: Posterior adductor muscle; Ki: Kidney; Gn P: Genital pore; Od: oviduct; Ex s: Exhalent siphon; Gl: Gill lamellae; In s: Inhalent siphon; Mn: Mantle.

Digestive System (Fig. 16B)

The mouth is situated anteriorly below the anterior adductor muscle. On either side of the mouth there are leaf-like structures, the labial palps. The palps are bilobed and lined with cilia on the surface. The cilia are responsible for creating currents in the water and guiding the food towards the mouth. The mouth leads directly into a short oesophagous which further leads into stomach. This opens into the intestine. The intestine takes a few turns and leads to the rectum. It passes through the ventricle of the heart and opens by anus into the exhalent siphon. The anus is situated behind the posterior adductor muscle. Close to the origin of the intestine, a tubular structure arises from the stomach. This is crystalline style sac and contains a homogeneous rod, the crystalline style, mucoprotein in nature. The tip of the style projects in the stomach through a narrow opening at the base of the sac. A pair of large digestive diverticula surrounds the stomach.

Circulatory System

It is of open type. It consists of a heart, enclosed in the pericardium. The heart has a median ventricle and two lateral auricles. From the ventricle arise anterior and posterior aortae which supply oxygenated blood to different parts of the body. Auricles are connected with the defferent branchial sinuses.

Respiratory System (Fig. 16A)

Respiration is carried on by a pair of gills or ctenidia. Each gill consists of a demibranch situated on either side of the foot. The gills are divided into a number of compartments or water tubes with a series of septa or partitions. The structure and shape of the gills vary from group to group and are conveniently used as taxonomic characters.

Excretory System

Excretory system consists of a pair of nephridia called organs of Bojanus. They are situated below the pericardium. Anteriorly they open into the pallial cavity and posteriorly into the pericardium. In addition to the nephridia the anterior pericardial wall is also modified to carry out the function of excretion.

Nervous System

It consists of pairs of ganglia, viz. cerebral, pedal and visceral' connected by commissures and connectives. As the distinct head is absent, the cerebral ganglia are also poorly developed. They are fused with the pleural ganglia to form cerebropleural ganglia.

Reproduction

The breeding habits and reproductive cycles of a few Indian freshwater bivalves were studied. Bivalves are in general dioecious (sexes separate). But functional or simultaneous hermaphroditism was noticed in Sphaeriidae and in a few species of Unionidae (Nagabhushanam & Lohgaonkar, 1978).

The gonads (Fig. 16B) are paired and situated in the coils on either side of the intestine. Gonoducts are paired and open into the pallial cavity by genital apertures in front of the renal opening.

The gonadal activity may be restricted to a certain period of the annual cycle as in *Parreysia corrugata'* (Lomte & Nagabhushanam, 1969) or it may extend throughout the year but with definite peaks as in *Lamellidens marginalis*, (Ghosh & Ghose, 1972) and *Lamellidens corrianus*, (Nagabhushanam & Lohgaonkar, 1978).

ECOLOGY

Ecology of a great majority of the Indian freshwater molluscs is not known. Biological studies are limited only to a few species. Biologically known species are viviparids, thiarids (=melanids) and pilids. (Annandale 1921; Annandale and Sewell 1921; Ramamoorthi, 1950, 1955; Jacob 1958; Prashad 1925, 1928; Muley 1977).

Freshwater molluscs are common in quiet water pools, ponds, lakes and flowing waters like perennial rivers, irrigation canals etc. The malacofauna of stagnant waters may be somewhat different from that of the streams. The streams in the hills and at a slightly higher elevations have a different fauna than those in the plains. In this respect the streams in the Western Ghats and Nilgiris are remarkable for their characteristic malacofauna. Snails belonging to the families Neritidae, Thiaridae, Ancylidae and Littorinidae inhabit streams and small rivers, whereas members of Viviparidae, Pilidae, Lymnaeidae and Planorbidae live in stagnant waters. Gastropods are generally found attached to submerged vegetation, rocks,

sticks etc. But bivalves live partly buried in the sand or mud. Similar to the gastropods, the bivalves exhibit variations in shell depending upon the ecology of the species and may produce ecophenotypes.

Under the tropical conditions the freshwater molluscs are usually faced with an annual dry season. Gastropods and bivalves show varying capacity to survive desiccation. Many snails can overcome this by aestivating either under dead vegetation or debris or by actively burrowing at least the aperture of the shell in the mud. Some of the snails are capable of anaerobic respiration. With the advent of favourable conditions the molluscs resume their normal activities. The discontinuous and transient nature of freshwater bodies leads to isolation of snails or bivalves into small local populations. Much remains to be worked on the ecology of Indian freshwater molluscs.

Gastropoda

In the majority, sexes are separate, dioecious or gonochoristic. Hermaphroditism or monoecious condition is known in pulmonates and in *Valvata* among prosobranchs. Natural parthenogenetic reproduction was observed in *Thiara* (*Melanoides*) *tuberculatus* (Mueller), *Thiara (Tarebia) lineatus* Gray and *Thiara* (*Thiara*) *scabra* (Mueller).

In the dioecious prosobranchs sexual dimorphism is hardly visible. Generally female has a larger shell than male. Sex is normally ascertained by the presence or absence of a penis. Males are either absent or rarely found in certain thiarids like *T*(*M*) *tuberculatus, T*(*T*) *lineatus* and *T*(*T*) *scabra.* In viviparids the males can be distinguished by their short, thick and curved right tentacle.

The duration of copulation is not known. Sperm received in copulation are stored in the seminal receptacle; in *Cremnoconchus,* where a seminal receptacle is absent, sperm is stored in the oviduct.

The number of eggs laid after mating and the time taken for hatching are variable depending upon the species. Very few species have annual life cycles with one breeding period; the majority breed throughout the year and the peak is reached soon after monsoon.

Pulmonates are hermaphrodites with synchronous ripening of male and female gametes and practice copulation. Certain species are functionally protandrous and pair when the male organs ripe. Elsewhere self-fertiliza-

tion was reported in Lymnaeidae, Planorbidae and Ancylidae. But so far no such phenomenon was reported from India. There is a controversy as to its occurrence in Planorbidae and Ancylidae.

In pulmonates and in some prosobranchs eggs are laid in capsules embedded in a jelly-like gelatinous substance which stick to the aquatic vegetation. The number of eggs in each capsule varies from species to species. In *Pila* a gelatinous mass containing 250-300 eggs is deposited in a depression excavated by the snail on the bank of a pond or tank. The mass is protected in the folds of the mantle of the snail until a calcareous shell is formed around each egg.

Among Prosobranchs a fairly good number of species are ovoviviparous. In viviparids and thiarids the eggs are retained in a special brood pouch or chamber. In some the pallial oviduct is modified to act as the "uterus" However, in some melanids there is a separate brood pouch. The eggs complete their development within the mother and the young ones hatch out in a form resembling that of the adult. In Viviparids the young are found in the uterus throughout the year but are released only in summer.

Freshwater gastropods have no planktonic larval stage. The majority hatch as young snails resembling the adults. *Thiara* (*Melanoides*) *crenulata* is the only freshwater snail where free swimming veligers were reported (Ramamoorthi, 1955).

Bivalvia

In India very scant attention was paid to the biology of bivalves. Our knowledge on this group is mainly due to the contributions of Prashad (1918, 1919).

Sexes are separate. Fertilization takes place in the branchial cavity and the fertilized ova pass into the spaces of the gill lamellae. The development takes place in the marsupium provided by the gills which may be either interlamellar occurring between inner and outer demibranch or either the inner or outer demibranch only. In unionid bivalves the embryo develops into a larva known as glochidium. The larva passes out by the exhalent siphon and gets attached to a fish where further development takes place. *Lamellidens marginalis* is a prolific breeder. A number of eggs are enclosed in a wedge-shaped capsule. Several capsules constitute one brood and the capsules are discharged. The capsules settle at the bottom

and the glochidium larvae hatch out (Ghose, personal communication). The parasitic life of the larva lasts for about ten weeks. When it is fully metamorphosed into an adult it detaches itself from the fish, drops down to the bottom and settles.

COLLECTION AND PRESERVATION

Method of Collection and Equipment

Freshwater snails are generally found adhering to the aquatic vegetation, floating objects or stones in stagnant waters. They are also common in paddy fields and irrigation canals. All the data pertaining to the snails viz: hydrographic information like the type of water body, temperature, nature of bottom and other ecological details are collected. A standardized data sheet for snails may be prepared as given by Malek and Cheng, 1974.

Periodical surveys are conducted covering at least one calendar year and the data are collected as indicated in the sheets. These data are then, analysed which would disclose the bionomics, life-cycle etc. of the mollusc.

The following articles are useful in the collection of the snails—1) a hand-net or water-net or a scoop-net, 2) a small piece of cloth, 3) a few cloth or polythene bags, 4) specimen bottles/tubes (assorted sizes), 5) a thermometer, 6) hip wading boots, 7) a pair of forceps, 8) enamel trays, 9) necessary chemicals, 10) field note book and data sheets, 11) labels.

A hand net is made of a fine mosquito net fixed to a round iron-ring and fitted to a wooden handle. A scoop-net is usually a metallic one with 30 cm. $\times$ 30 cm. frame of steel bars and wire netting and the scoop is 10 cm., deep with a 8 cm. wide blade soldered to the frame. A wooden handle is attached at the other end. The hand net or scoop net is dragged over the aquatic vegetation, and when it is filled with aquatic weeds, the contents are poured out on a spread-out cloth piece. The snails are picked up with a pair of forceps from the weeds.

While making collections the following precautions are taken:

i) Boots should always be used and one should not go bare footed.

ii) Hands and arms should be repeatedly cleaned with 70% ethanol, if bare hands are used.

FIXATION AND PRESERVATION

Histological Study

Snails are fixed, either in hot Bouin's fluid (sat. aq. Picric acid, 75 ml. Formalin, 25 ml. Glacial Acetic acid 5 ml.) or Ethanol Formalin-Acetic acid (AFA) 70% Ethanol 100 ml., Formalin 5 ml. and Glacial Acetic acid 5 ml.

Time of fixation varies from 20-24 hours. After fixation the snails are removed and thoroughly washed in running tap water and preserved in ethnol.

For Routine Studies

Preservation (Including Soft Parts)

Identification of a mollusc is not entirely based on shell characters alone, as it is usually believed. Especially for the members of the family Lymnaeidae, it is very difficult to identify them by shell characters alone. Morphological details like the structure of the radula, shape of the prostate gland etc., are also examined to arrive at an accurate identification of a species. It is needless to mention that the soft parts of the animal are preserved along with the shell.

The aquatic molluscs collected are placed in an enamel tray with source water. Finely powdered Menthol or Magnesium sulphate or Chloral hydrate should be sprinkled over the water surface and covered by a suitable lid. The specimens are left for 24 hours usually.

Nembutal (Sodium pentabarbitone) has been successfully used elsewhere. Specimens are placed in a 0.08% pure Nembutal and allowed to relax. Time required for this is dependent on the species and hence a close watch is kept during narcotisation. Urethane has also been successfully used for the purpose.

Preservation

Liquid

After narcotization, the snails may be preserved in 70% ethyl alcohol but not in formalin.

Dry Shells

While preserving some shells with the animal intact, it is a good practice to preserve a few dry shells separately. After narcotization, the animal is extracted from the shell with a pair of curved forceps. Empty shells may be boiled in water for about half an hour or so to remove any soft tissue sticking inside the shell. The shells may then further be cleaned with a smooth brush, and then dried in air. In case of operculate shells, operculum should be retained by pasting it to cotton wool plug inserted into the aperture of the shell.

Dry shells may be packed in cotton wool in small glass vials or tubes or card board boxes depending upon the size of the snail sample. Relevant data viz: field no., locality, date of collection, collector's name etc., should be provided with each sample.

Quantitative Studies

The population density of snails in a given area may be studied using any one of the following methods.

Quadrate Method

A metal ring or square is dropped in the area of study, and all the snails collected within that ring or square are collected and counted.

Standard Scoop or Dredge Method

A scoop or dredge of standard size is passed over the required area and number of snails collected in each operation be counted.

Counts per Unit Time

It involves counting the number of snails, collected systematically with sieves by one or more trained collectors in a measured or marked area of the biotope for a given length of time.

Palm-leaf Trap Method

Palm leaves are placed at regular intervals along the shore or bank of water body under study. After exposing for a definite period of time, the leaves are carefully removed and the snails sticking to them are counted. This method has been successfully followed in many Middle East countries during surveys of snails of *Biomphalaria* and *Bulinus*. It is interesting to note that where other methods have failed, this method has given better results.

Laboratory Rearing of Molluscs

Molluscs can be conveniently cultured in the laboratory, in glass aquaria or jars or in enamel trays and dishes. Natural conditions simulated in the laboratory produce good results. The parameters to be noted are vegetation, food, temperature and water composition. In this connection the data collected in the field are very useful.

Water, preferably, from the same pond may be used in the aquarium. If tap water is to be used it should be first allowed to stand for about a week, so that it gets dechlorinated. Providing vegetation in the aquarium helps oxygenation and removes carbon dioxide. It not only provides food for the snails, but also the necessary surface for egg-laying.

KEY TO THE FAMILIES

A key is provided to all the families so far recorded in India. When the specimens are allocated to a particular family, identification of the genus is to be made with the aid of the key given separately for each family. In the present state of our knowledge it is advisable to leave the problem of species identification to a specialist. Some idea can, however be obtained by looking into the illustrations given for each species.

1. Animal with a univalve shell 2 (GASTROPODA)

– Animal with a two valved shell .....14 (BIVALVIA)

2. Shell operculate 3

– Shell without a operculum 12

3. Operculum with two apophyses, shell with D-shaped mouth, columellar area expanded and with callus deposit .....NERITIDAE

– Operculum without apophyses, shell with round or oval mouth, columellar area not expanded and without callus deposit 4

4. Operculum with concentric growth lines 5

– Operculum with spiral growth lines 6

5. Operculum calcareous, shell globose and large; body whorl inflated and larger than the spire, animal with both gill and lung, long and filiform labial palps .....PILIDAE

– Operculum horny, shell pyramidal, whorls regularly increasing in size, animal with gill only, no labial palps .....VIVIPARIDAE,

6. Operculum circular and multispiral, animal hermophrodite .....VALVATIDAE

– Operculum ovate and paucispiral 7

7. Shell mostly turreted or when globose operculum completely closing the aperture, mantle border fringed, with a brood pouch .....THIARIDAE

– Shell globose, or conical, mantle border not fringed, no brood pouch 8

8. Animal with both gill and branchial chamber, found in hill stream .....LITTORINIDAE

– Animal with gill, generally found in stagnant fresh waters and often extending into brakish waters 9

9. Eyes at tip of tentacles, ciliated groove runs from mantle cavity down each side of foot to sole .....ASSIMINEIDAE

– Eyes at base of tentacles, no ciliated groove on side of foot 10

10. Operculum calcareous and concentric, as large as aperture and can not be withdrawn inside, verge bifurcate ..... BITHYNIIDAE

– Operculum corneous, smaller than aperture and can be withdrawn inside, verge not bifurcate 11

11. Shell compressed in its dorso ventral axis, operculum with two prominent ridges on the internal surface ..... STENOTHYRIDAE

– Shell elongate and turreted, operculum without ridges on the internal surface ....HYDROBIIDAE

12. Shell spirally coiled 13

– Shell limpet-shaped, without any spiral coils .....ANCYLIDAE

13· Shell extended and dextrally coiled, columellar axis typically twisted, animal with triangular tentacles .....LYMNAEIDAE

– Shell generally discoidal, or when extended sinistrally coiled, columellar axis not twisted, animal with filiform tentacles .....PLANORBIDAE

14 Shell internally nacreous 15

– Shell internally non-nacreous 18

15 Shell inequivalve, irregular, one valve fixed to the substratum, hinge edentulous .....AETHERIIDAE

– Shell equivalve, regular, valve not fixed to the substratum, hinge dentate 16

16. Mantle margin not united posteriorly to form separate anal openings, no distinct siphons .....MARGARITIFERIDAE

– Mantle margin united posteriorly to form one or more supra anal openings, mantle border thickened posteriorly showing the tendency towards the formation of distinct siphons 17

17. All four gills marsupial, beak sculpture radial and well developed .....AMBLEMIDAE

– Only the outer two gills marsupial, beak sculpture concentric-radial and rudimentary .....UNIONIDAE

18. Hinge linear with numerous lamelliform teeth and edentulous in the middle .....ARCIDAE

– Hinge with limited number of teeth but never edentulous 19

19. Shell rounded, triangular to oval, concentrically striated or ribbed 20

– Shell elongate-quadrate, umbones placed anteriorly, shell not ribbed 21

20. Ligament strong and external, shell thick and large, hinge straight with three cardinal teeth and strong serrated anterior and posterior lateral teeth .....CORBICULIDAE

– Ligament not very strong, generally internal, shell thin and small, hinge curved, with two small cardinal teeth and smooth lateral teeth .....SPHAERIIDAE

21. Shell thin, hinge with three cardinal teeth, siphons not very long .....CULTELLIDAE

– Shell thick, hinge narrow and weak, siphons very long .....SOLECURTIDAE

SYSTEMATIC ACCOUNT

Family 1 NERITIDAE

Shell dextral, globose, imperforate with a few whorls and a low spire, or limpet-shaped, aperture semiovate, large with an expanded and flattened columellar region, inner lip generally dentate. Operculum thick, semilunar and calcified.

Soft parts highly modified. Tentacles long and slender, eyes on pedicles at the external base of tentacles. A single large bipectinate gill. Radula a long ribbon and rhipidoglossate with the formula α—5—1—5—α. Right auricle reduced or often wanting. Sexes separate. Male with a cephalic penis on the right side, produces spermatophores, female with a crescent shaped ridge by the side of the right tentacle, oviparous, with a complicated reproductive system with two or three female gonopores. Eggs laid in calcareous capsules, development direct.

Marine, brackish and freshwaters, of all oceans and continents.

Important general references are those of Andrews (1937a, b), Baker (1923), Martens (1879, 1889), Reeve (1855-1856), Sowerby (1849, 1850),

Tryon (1888); on freshwater neritids, those of Benthem Jutting (1956), Pace (1973) and Starmuehlner (1970, 1974, 1976); on habits, reproductive organs Andrews (1933, 1935, 1937b), Baker (1923), Bourne (1908) Fretter (1946, 1965, 1966), Gilson (1896) and Lenssen (1899a, b).

Indian neritids were treated by Govindan (1974), Govindan and Natarajan (1972) and Subba Rao (1975).

The family is distinguished into two subfamilies namely, Neritinae and Neritopsinae; only the former is known from India. It includes four genera, namely *Neritina, Clithon, Septaria* and *Neritodryas.*

Key to genera

1. Shell symmetrical, limpet-like, without whorls, small apex, very wide aperture; operculum squarish, without apophyses and not closing the aperture ..... **Septaria**

– Shell asymmetrical, with one or more spiral whorls, aperture comparatively small, operculum semilunar with two apophyses at the posterior end and closing the aperture completely 2

2. Shell small, pea-shaped, surface more or less coarsely striated with growth lines, some times with spines, radula with anteriorly expanded central, supported by an extra lamella from the centre of the base, verge in the male and vaginal spout in the female more complex ..... **Clithon**

– Shell generally large and smooth, surface with very fine striae but never with spines, verge and vaginal spout not very complex..... 3

3. Operculum with longitudinally grooved rib, ridges ending in finger like projections at the free end, inner marginals with a few denticles (2—4), amphibious ..... **Neritodryas**

– Rib of operculum not grooved, inner marginals with several denticles, totally aquatic ..... **Neritina**

Genus 1. **Neritina** Lamarck, 1816

Lamarck, 1816, *Encycl, Method, Vers*, **2**, pl. 155.
Type species by subsequent designation *Nerita pulligera* Linnaeus, Children, 1823.

It is represented by a total of seven species in India, but only five species occur in coastal freshwater streams especially in the Andaman and Nicobar Islands.

Four subgenera namely, *Neritina* s. str., *Vittina* Baker, *Neripteron* Lesson and *Dostia* Gray are distinguished.

1. Shell globose or oval, spire pointed, columellar callus small and concave ..... **Vittina**

– Shell with a flat base, spire short or depressed, columellar callus broad 2

2. Peristome broad ending in two divergent "wings" or ,'auricles" at the upper and lower columellar sides, columellar edge attached to last whorl ..... **Neripteron**

– Peristome without "wings" or "auricles", collumellar edge not attached to last whorl 3

3. Shell dorsally rounded, spire hidden by the last whorl, last whorl inflated, operculum with well developed peg and rib ..... **Neritina**

– Shell dorsally strongly arched, spire vestigial and lateral, columellar callus extends as a transverse septum along the aperture of the shell; peg and rib comparatively less developed ..... **Dostia**

Subgenus **Neritina** s. str.

1. *Neritina (Neritina) pulligera* (Linnaeus, 1767) (Figs. 17-21)

Nerita pulligera Linnaeus, 1767, *Syst, Nat.,* ed. **12***:* 1253, no. 726. Type locality: "Rivers India".

Neritina pulligera: Van Benthem Jutting, 1956, *Treubia,* **23**(2): 307, fig. 24.

Distribution: India: Tamilnadu, Andaman and Nicobar Islands. Eastern Coast of Africa from Kenya to South Africa, Madagascar (Brown 1980). Thailand, Indonesia, Moluccas, Celebes; North Western Australia, New Guinea, New Caledonia, Fiji, Philippines.

Types: LS (London). Not found (Brandt, 1974).

Remarks: Shell very thick with a thick and wide columellar callus. Callus with fine granulations; bluish black on the outer half and gradually fades to the inner half. Outerlip thick with a deep orange band on its inner margin. Operculum with a sharp and longitudinally grooved sickle shaped rib and conical peg having a rounded top.

Pace (1973) gave a good general account of this species and hinted at the possibility of sexual dimorphism in the shells.

Subgenus **Vittina** Baker, 1923

It includes four species distinguished as follows:

Key to species

1. Shell with a short spire, fine longitudinal striae, colour uniformly shining black or olive ..... *N. perottetiana*

– Spire elevated, shell with coloured bands or stripes 2

2. Spire elevated and conical, columellar callus porcellanous white, operculum externally yellow ..... *N. turrita*

– Spire subconical, columellar callus with a coloured spot either on the upper or lower half, operculum externally black 3

3. Aperture yellowish white, columellar callus with an orange brown tint near the upper margin, spire prominent ..... *N. smithi*

– Aperture bluish white, columellar callus with an orange-red spot on the lower half of its outer margin, spire short but distinct..... *N. variegata*

2. **Neritina (Vittina) variegata** Lesson, 1831
(Figs. 22, 23)

Neritina variegata Lesson, 1831 *Voy. Coquille Zool.*, **2**: 378. Type locality: New Ireland.

Neritina variegata: Van Benthem Jutting, 1956, *Treubia* **23(2)**: 306, fig. 29.

Distribution: India: Andaman and Nicobar Islands; Indonesia, Moluccas, Australia, New Caledonia, New Guinea, New Ireland, Samoa, Fiji, Tahiti and Philippines.

Types: MNHN

Remarks: Shell oval with short but distinct spire. Surface smooth and polished with colour pattern of zigzag markings, network or with black spiral bands. Inner columellar edge generally straight with 8-11 weak denticulations.

Baker (1923) and Adam and Leloup (1938) described and figured the radular teeth.

3. **Neritina (Vittina) turrita** (Gmelin, 1791)
(Figs. 26, 27)

Nerita turrita Gmelin, 1791, *Syst. Nat.* ed. **13**: 3686, no. 71 Type locality: Islands of Antilles.

Neritina (Vittina) turrita: Starmuehlner, 1976, *Ann, Naturhist, Mus. Wien,* **80**: 514.

Distribution: India: Kamorta and Car Nicobar; Indonesia, Moluccas, New Guinea, New Caledonia, Marianas, Palaus, Carilines; Philippines.

Remarks: Starmuehlner (1976) studied the species from Pacific Islands. He gave good figures of radula, spermatophore and reproductive system.

4. **Neritina (Vittina) smithi** Wood, 1828
(Figs. 28, 29)

Neritina smithii Wood, 1828, *Index Test. Suppl.*, p. 26., pl. 8, fig. 11. Type locality: River Hooghly, Calcutta.

Neritina smithi: Tryon, 1888, *Man, Conch.* **10**: 37, pl. 10. fig. 96.

Distribution: India: Gangetic estuary. Burma: Irawaddy estuary.

Types: BM (NH).

Remarks: It is primarily a brackish water species occasionally extending into freshwaters. It is distinguished by its solid shell with peculiar molten lead grey or black colour pattern.

5. **Neritina (Vittina) perottetiana** (Recluz, 1841)
(Fig. 34)

Nerita perottetiana Recluz, 1841, *Revue Zool Soc. Cuvier.*, p. 337. Type locality: Nilgiri Hills, India.

Theodoxis perotetiana: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 5.

Distribution: Streams in the Nilgiri hills, Tamilnadu.

Types: MNHN

Remarks: Preston (1915) recorded its occurence in Sri Lanka (=Ceylon). But the latest work by Starmuehlner (1976) did not include this species.

Shell semiglobose and smooth. Inner columellar margin straight with 5-10 indistinct denticulations or sometimes smooth. Operculum thin and externally light grey.

Subgenus **Neripteron** Lesson, 1830

6. **Neritina (Neripteron) auriculata** Lamarck, 1826

(Figs. 38-44)

Neritina auriculata Lamarck, 1816, *Encycl, Meth. Vers., Planches,* pl. 455, fig. 6. Type locality: New Holland.

Neritina (Neripteron) auriculata: Starmuehlner, 1974, *Bull. Fish. Res. Stn.,* Sri Lanka, **25** (1-2): 108, figs. 5-8.

Distribution: India: Porto Novo, Andamans; Sri Lanka, Indonesia, Moluccas, New Ireland, Australia, New Caledonia, Philippines.

Types: MHN

Remarks: It inhabits both estuarine-and fresh-waters. Anatomical details were studied by Starmuehlner (1969, 1970); reproduction, breeding and other aspects concerning *N. layardi* (=*N. auriculata*) were investigated by Govindan and Natarajan (1972).

Subgenus **Dostia** Gray, 1840

7. **Neritina (Dostia) violacea** (Gmelin, 1791)

(Figs. 30, 31)

Nerita violacea Gmelin, 1791, *Syst. Nat.,* ed. **13**: 3686, no. 68. Type locality: Not mentioned.

Neritina violacea: Van Benthem Jutting, 1956, *Treubia,* **23**(2): 300, fig. 21.

Distribution: India: Andaman Islands, Andhra Pradesh, Goa, Gujarat, Kerala, Karnataka, Orissa, Tamilnadu and West Bengal; Sri Lanka, Burma, Thailand, Cambodia, Vietnam, Singapore, Indonesia, Timor, New Caledonia, Samoa, Fiji, Australia, Philippines and Japan.

Remarks: The shell is very much variable in shape, colour and structure. It generally occurs in river mouths and mostly in brackish waters At times it occurs in fresh or almost fresh water near the upper tidal limit.

The species was studied by many authors. Woodward (1892) studied the mode of growth and structure of shell. Radula was figured by Troschel (1866-1893), Annandale & Prashad (1919b) and Baker (1923). Govindan and Natarajan (1972) investigated its shell morphology, reproductive anatomy and breeding behaviour, Murthy and Balaparameswara Rao (1978) studied the effect of environment on its shell shape.

8. **Neritina (Dostia) platyconcha** Annandale & Prashad, 1919 (Figs. 35-37)

Dostia platyconcha Annandale & Prashad, 1919. *Rec. Indian Mus.*, **16**: 244. Type locality: Burdul, Kahaduk river, Khulna Dist., Bangladesh.

Distribution: Not known beyond type locality.

Type: Holotype, ZSI. Regd. No. M 11440/2.

Remarks: It is a brackish water species. Shell is thin and translucent. It is more spherical and dorsal side is less arched than in the previous species.

Genus 2. **Clithon** Montfort, 1810.

Montfort, 1810, *Conch. Syst.*, **2**: 326. Type species *Nerita corona* Linnaeus.

Members of this genus are generally fluviatile, extending into freshwater. They generally prefer streams with clear water and a stony bottom.

Shell coarsely or finely striated. Aperture small and with a narrow, concave columellar callus. Inner columellar margin finely denticulated, with a large superior tooth.

Although the genus is known by five species in India, only three are found occurring in the freshwater streams of the main land India and Andaman and Nicobar Islands. The other two species are marine extending into estuaries and back waters. They are however, not found in freshwaters and hence not included here.

Key to species

1. Shell very coarsely striated, spire distinct and projecting, inner columellar margin with more than 12 denticulations 2

– Shell finely striated, spire not prominent or entirely hidden by last whorl, inner columellar margin with less than 12 denticulations ..... *C. reticularis*

2. Shell olive-green with small dark squares, moderately sculptured, shell never with spines, outer margin of peristome not thickened ..... *C. bicolor*

– Shell dull yellowish or greenish, very coarsely sculptured, generally with spines, outer margin of peristome thickened; spire not produced ..... *C. corona*

Subgenus **Clithon** s. str.

9. **Clithon (Clithon) corona** (Linnaeus 1758) (Figs. 45, 46)

Neritina corona Linnaeus, *Syst. Nat.* ed. **10:** 777. Type locality: Rivers of Asia.

Clithon corona: Van Benthem Jutting, 1956, *Treubia,* **23**(2): 275, figs. 1 and 2.

Clithon (Clithon) corona: Starmuehlner, 1976. *Ann. Naturhist, Mus. Wien,* **80:** 494, figs. 2-5.

Distribution: India: Katchal (Nicobars); Indonesia, Moluccas, Flores, Timor, New Guinea, New Ireland, New Caledonia.

Types: L.S. (Lond.)

10. **Clithon (Clithon) bicolor** (Recluz, 1842) (Figs. 24, 25)

Nerita bicolor Recluz, 1842, *Proc. zool, Soc. Lond.,* p. 172. Type locality: Agoo (in a mountain stream), Philippines.

Theodoxus (Clithon) bicolor: Ray, 1947. *Rec. Indian Mus.,* **45** (4): 308.

Distribution: India: Andamans; Indonesia, Moluccas, Philippines, Formosa.

11. **Clithon reticularis** (Sowerby, 1838)
(Figs. 32, 33)

Neritina retifera Benson, 1936, *J. asiat. Soc. Beng.* **5**: 749 (Nomen nudum)

Neritina reticularis Sowerby, 1838, *Conch. Illustrations*, No. 51, fig. 44. Type locality: Calcutta.

Theodoxus reticularis: Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 6.

Distribution: India: Calcutta, Porto Novo.

Types: ?

Remarks: Shell finely striated, yellowish olive or green with oblique angulated red or black thin lines, often forming a coarse reticulation or network, a well developed tooth on the inner columellar margin.

Generally occurs in estuarine waters rarely extending into freshwater.

Genus 3. **Neritodryas** von Martens, 1869

Von Martens, 1869, *Sitz. Gesell. nature. Freunde Berlin.*, p. 21.

Type species: *Nerita cornea* Linnaeus.

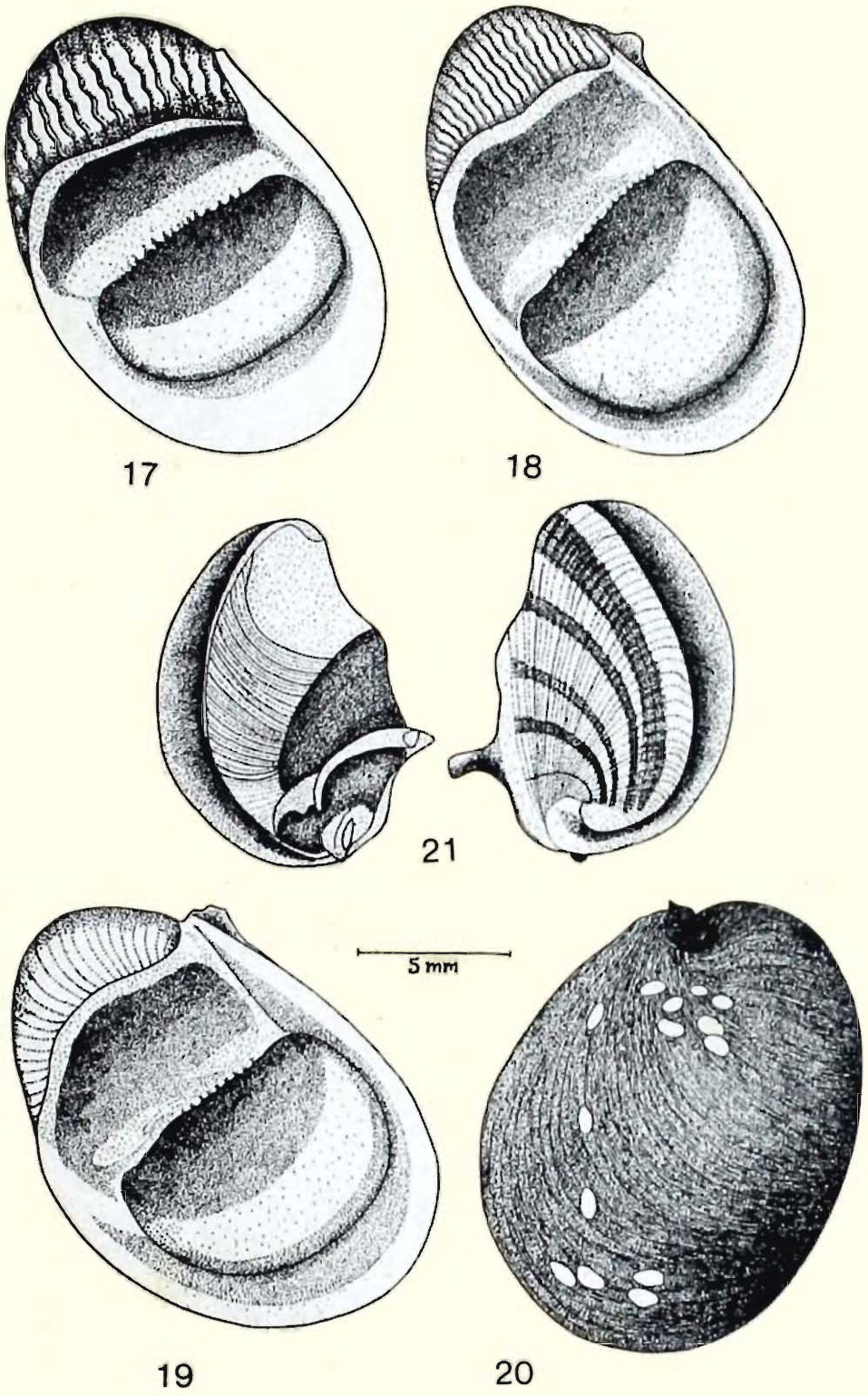
The genus is distributed throughout tropical Asia. The members are generally terrestrial and found adhering stones or other substrata by the sides of streams which are damp and moist.

12. **Neritodryas subsulcata** (Sowerby, 1836)
(Figs. 47, 48)

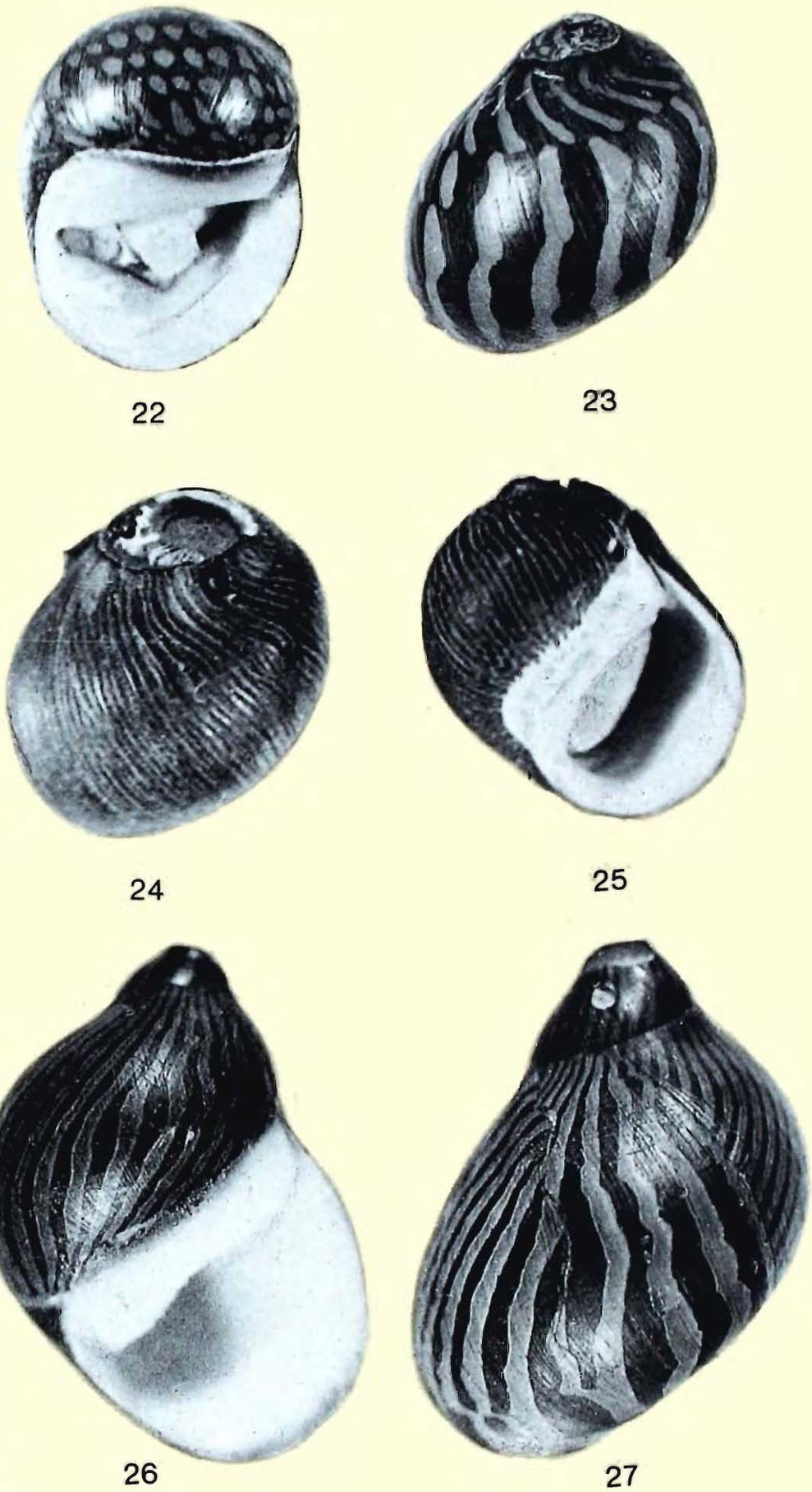
Neritina subsulcata Sowerby, *Conch. Illustrations* No. 50, fig. 50. Type locality: Philippine islands.

Neritodryas subsulcata: Van Benthem Jutting, 1956, *Treubia*, **23**: 294, fig. 18.

Distribution: India: Andaman and Nicobar Islands; Indonesia, Moluccas, New Hebrides, Fiji, Philippines.



Figs. 17-20. *Neritina pulligera*,28.8 × 25.9 mm., 31.6 × 27.2 mm., Andamans. 21. External and internal views of the operculum of the same species.



Figs. 22, 23. *Neritina variegata*, 14.65 × 10.9 mm.; 10.7 × 11.2 mm., Andamans. 24, 25. *Clithon bicolor*, 15.60 × 12.0 mm., Andamans. 26, 27. *Neritina turrita*, 31.0 × 20.05 mm., Car Nicobar.

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Figs. 28, 29. *Neritina smithii*,26.6 × 18.50 mm., 17.80 × 13.0 mm., Calcutta. 30, 31. *Neritina violacea*,27.35 mm., Coleron. 32,33. *Clithon reticularis*,11.50 × 18.25 mm.; 11.40 × 8.0 mm., Calcutta.

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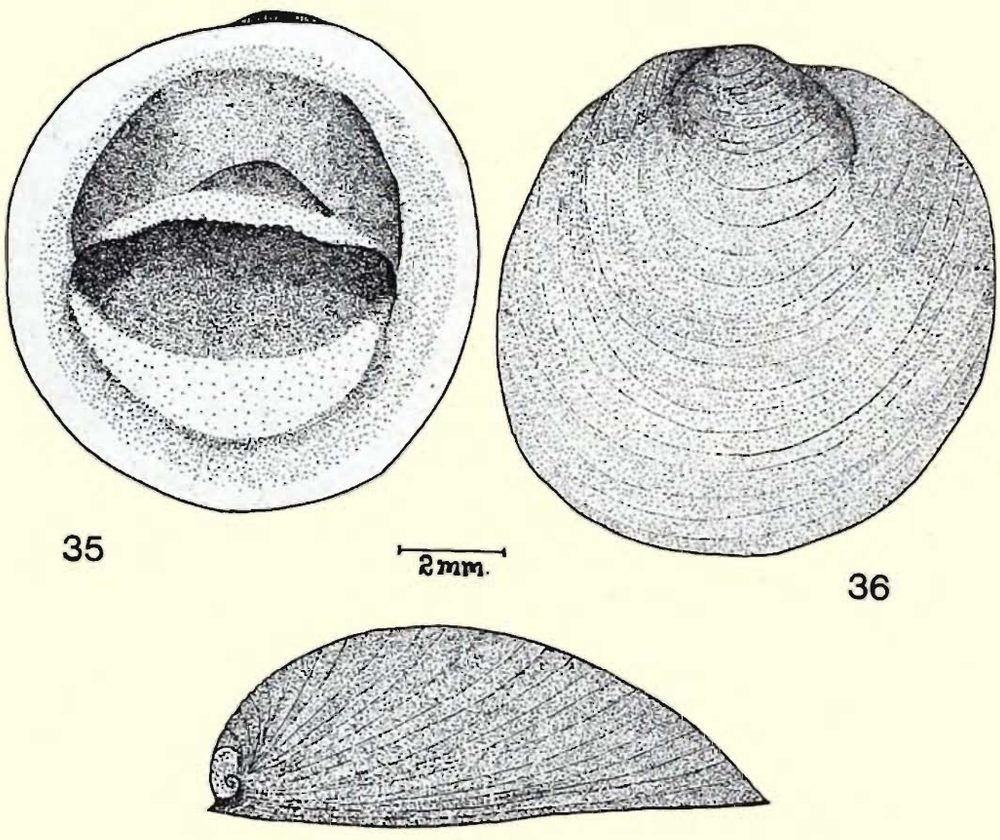

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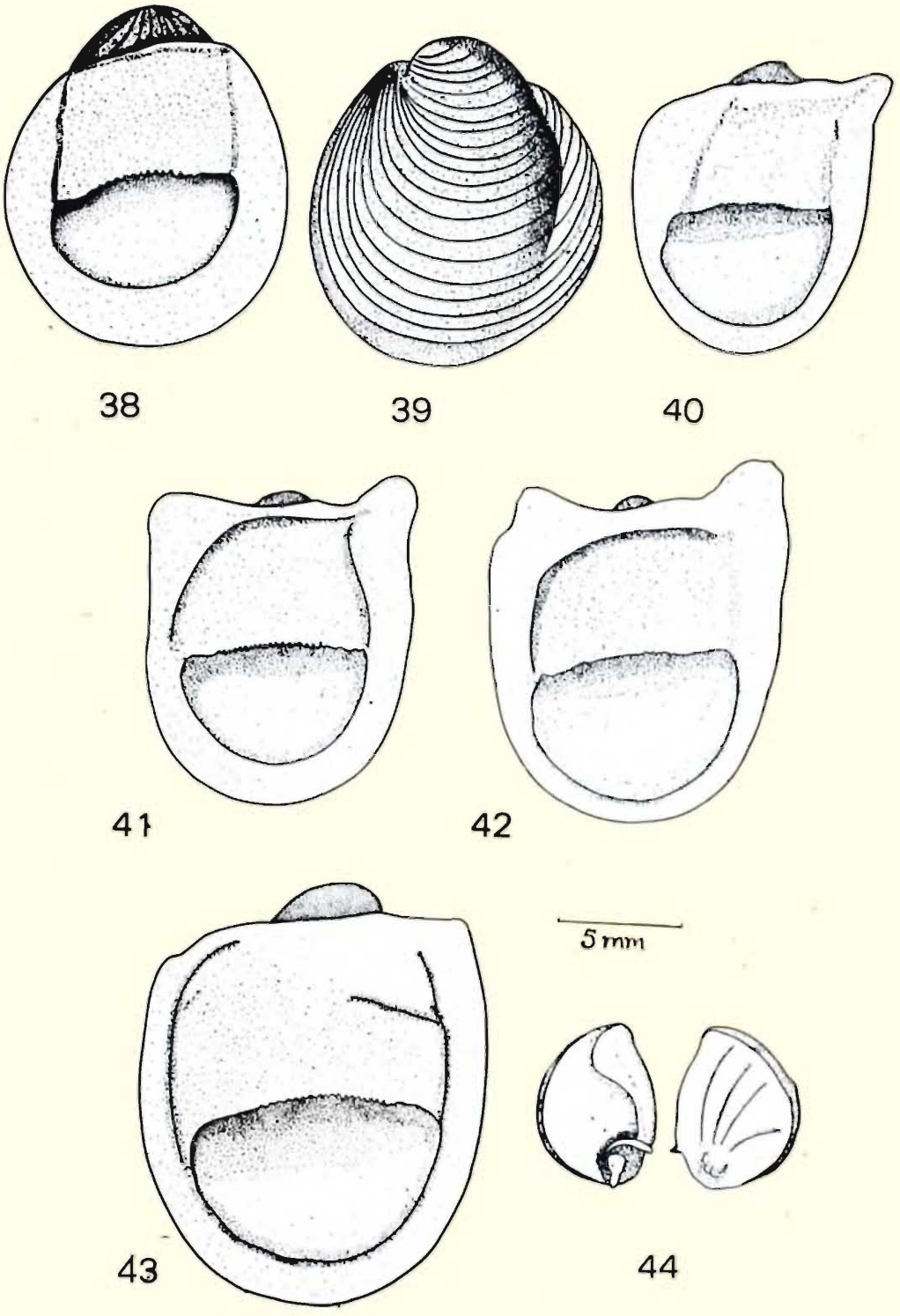
Figs. 34. *Neritina perottetiana*, 8.0 × 5.5 mm., Nilgiris. 35-37. *Neritina platyconcha*,Holotype, 10.55 × 9.40 mm., Bangladesh.



Figs. 38-43. *Neritina auriculata*, showing variation in 'auricle' (wing) development, Andamans.
44. Operculum of *N. auriculata*.

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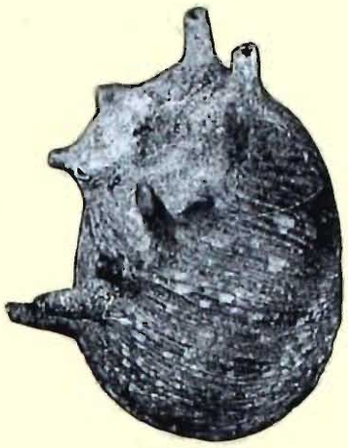

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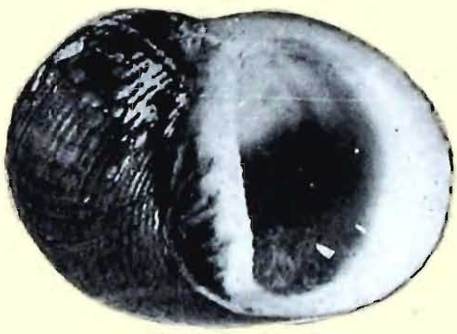

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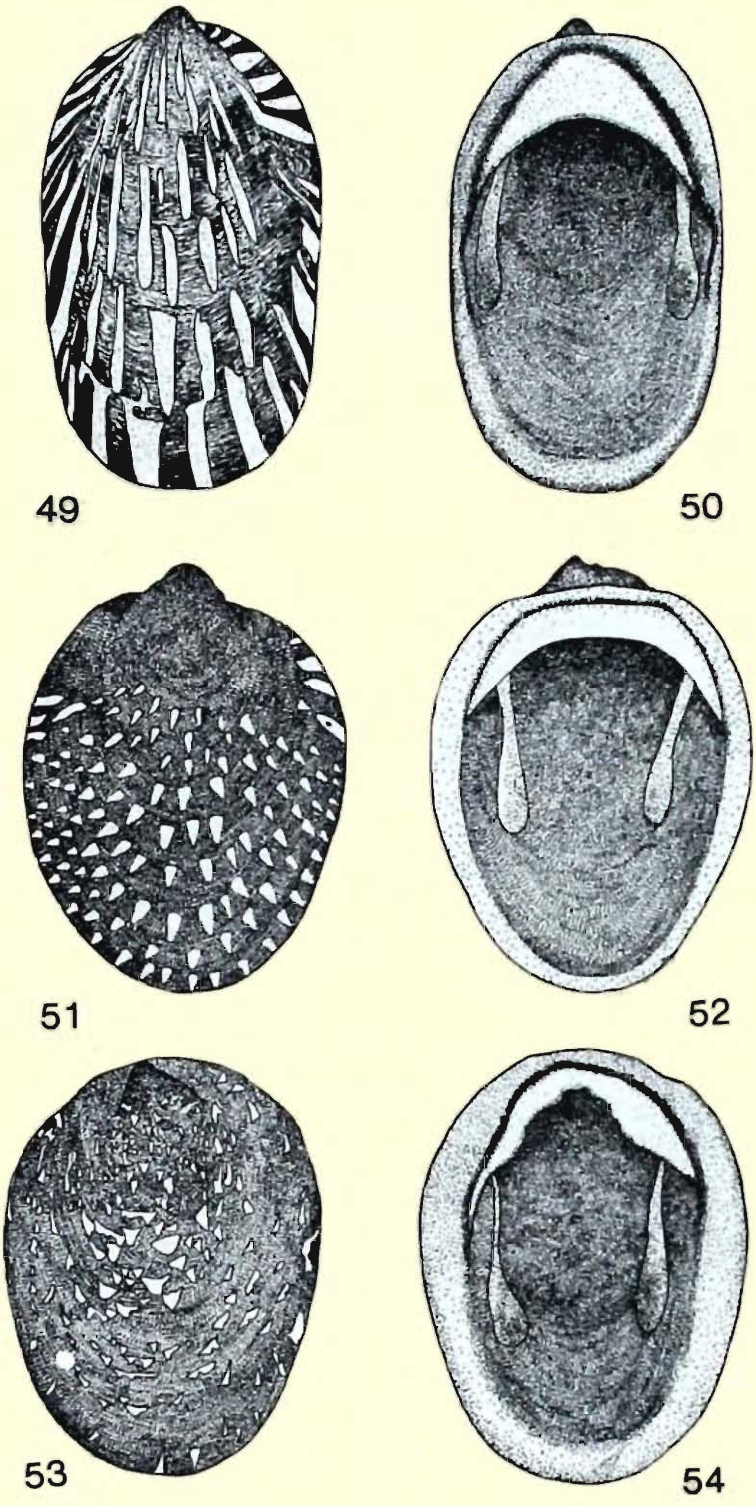
Figs. 45, 46. *Clithon corona*, 12.5 × 11.65 mm., 12.3 × 11.0 mm., Andamans. 47, 48. *Neritodryas subsulcata*, 29.4 × 22.5 mm., 28.85 × 21.65 mm., Camorta.



Figs. 49, 50. *Septaria lineata*, 25.10 × 15 mm., Calcutta. 51, 52. *S. porcellana*, 23.05 × 17.15 mm., 21.15 × 16.50 mm, Andamans. 53, 54. *S. dravadica* (=*S. lineata*).Holotype,16.55 × 12.45 mm.

Remarks: Shell blackish brown with yellowish-brown markings. Sculpture consists of conspicuous broad spiral ribs with distinct grooves in between and crossed by fine longitudinal striations. Aperture broad and bluish-white, columellar callus wide, bluish-white with clouded black penetrating from the outer margin. Operculum thick, externally black, nucleus white, internally orange brown, rib sickle shaped and strongly grooved, terminating in 8-10 finger-shaped lobes at the free end, peg strong and flattened.

Genus 4. **Septaria** Ferussac, 1807

Ferussac, 1807, *Essai d'une meth. Conch.*, p. 61.

Type species: *Patella borbonica* Bony de St. Vincent.

The genus is common in the coastal streams of the Indo-Pacific region. It is a very characteristic freshwater neritid in which the shell is modified to suit to the conditions of life in streams.

Two species are known from India.

Shell thick, apex generally projecting beyond the posterior margin ..... *S. porcellana*

Shell thin and transparent, apex not projecting beyond the posterior margin ..... *S. lineata*

13. **Septaria lineata** (Lamarck, 1816) (Figs. 49, 50, 53, 54)

Navicella lineata Lamarck, 1816, *Encycl. Meth. Vers., Expl. Planches.* pl. 456, fig. 2.

Septaria lineata: Starmuehlner, 1976, *Ann. Naturhist. Mus. Wien*, **80**: 544.

Distribution: India: Andaman and Nicobar Islands, Tamilnadu (Coleron river), West Bengal; Sri Lanka, Indonesia, Timor, Celebes, Moluccas, New Guinea, Fiji, Philippines.

Types: MHN

Remarks: It can also survive in saline waters. Baker (1923) figured its radula; while Andrews (1937a, b) gave a good description of the verge in male and ridge in female. Seshaiya (1934) described the style sac in *S.*

dravadica Prashad (=*S. lineata*). Govindan and Natarajan (1972) studied its shell morphology, reproductive anatomy and breeding behaviour.

14. **Septaria porcellana** (Linnaeus, 1758)
(Figs. 51, 52)

Patella porcellana Linnaeus, 1758, *Syst. Nat.*, ed **10**: 781. Type locality: "O. Indiae".

Septaria porcellana: Van Benthem Jutting, 1956, *Treubia*, **23**: 315, fig. 31.

Distribution: India: Andaman and Nicobar Islands; Sri Lanka, Singapore, Indonesia, Celebes, Moluccas, New Guinea, New Caledonia, Samoa, Tahiti, Philippines.

Remarks: Occurs in freshwater stream. Boutan (1893) gave an account of the nervous system.

Family 2. VIVIPARIDAE

"Pond snails"

Shell generally olive brown or green, moderately large, turbiniform, perforate or imperforate, whorls inflated, aperture ovate and slightly retracted below, shells of females larger than that of males, operculum horny, concentric with a subcentral nucleus.

Respiration entirely aquatic, monopectinate ctenidium or gill, viviparous and sexually dimorphic. In males the right tentacle stout, truncated and modified as a copulatory organ containing the penis, the left tentacle in male and both the tentacles in female long and slender. After copulation fertilization takes place internally. Pallial oviduct enlarged and acts as the uterus. It contains embryos in various stages of development. Young ones are shed into water.

Palaearctic, Ethiopian, Oriental, Australian and Nearctic Regions.

Annandale (1921f) discussed the systematics and ornamentation of the shell, while Sewell (1921) studied the anatomy and bionomics. Prashad (1928a, b) made a thorough study of structure of mantle and shell and of distribution, evolution and zoogeography of recent and fossil forms. Other significant contributions include Annandale (1920, 1921f, h 1924b), Haas (1939), Kobelt (1879, 1909) Reeve (1862-63) and Rohrbach (1937).

Divided into three subfamilies, namely Viviparinae Gill, 1863, Lioplacinae Gill, 1863 and Bellamyinae Rohrbach, 1937, the last mentioned confined to Ethiopian and Oriental regions.

Subfamily BELLAMYINAE

Includes all Indian viviparids. In males a big bean shaped complex of testis on the right side of the roof of the mantle cavity, females with complex seminal receptacle, shells unbanded in the embryonic stage.

The comparative anatomical studies by Rao (1925a) and the revisionary studies by Prashad (1928a, b) have to some extent helped in clearing the confusion at generic level. But the validity of many taxa at the specific and infra-specific level is still doubtful. Several varieties were described based on shell characters. A comprehensive and consolidated study of this group, which is beyond the scope of the present work, could provide better understanding of different taxa.

Four genera namely *Bellamya, Cipangopaludina, Angulyagra* and *Taia* are recognised. The last mentioned is restricted to Burma.

Key to genera

1. Shell smooth, without traces of distinct ridges or sculpture 2

– Shell ornamented with a number of well-developed spiral ridges, which may be continuous or broken up into nodular or squamous tubercles 3

2. Adult shell large, without any coloured bands, edge of mantle greatly thickened with a conspicuous sphincter muscle along it, superior margin of gill lamella usually thrown into folds, embryonic shell with three ridges bearing curved chaetae ..... **Cipangopaludina**

– Adult shell medium sized, with or without coloured bands, and when no bands the shell feebly ridged or keeled, edge of mantle not so thickened and without a conspicuous sphincter, superior margin of gill lamella never thrown into folds, embryonic shell with three primary ridges bearing chaetae and a number of secondary ridges ..... **Bellamya**

3. Shell thin and delicate, ridges continuous, colour uniform but ridges darker, embryonic shell without colour bands, margin of mantle with enlarged and highly vascular finger-shaped processes ..... **Angulyagra**

– Shell comparatively thick, ridges broken up into nodular or squamous tubercles, embryonic shell with three colour bands, margin of mantle with only minute triangular prominences ..... **Taia**

Genus 5. **Bellamya** Jousseaume, 1886

Jousseaume, 1886 *Bull, Soc. Zool. France,* **II:** 478.

Type species : *Paludina bellamya* Jousseaume.

Shell more or less oblong in outline, obtusely or strongly keeled at the periphery, scarcely convex or rather flattened whorls, thinner columellar margin. The adult shell usually without ridges or spines.

Head small in relation to the size of the animal, margin of the mantle moderately thick with three short processes corresponding in position to the three rows of chaetae on the embryonic shell.

Uterus usually with a large number of embryos in various stages of development.

Ethiopian and Oriental

Indian species were hitherto assigned to the genus *Viviparus.* Studies by Rohrbach (1937) had lead to the conclusion that the Oriental and African forms should be separated from the typical *Viviparus* and they bear close resemblance to *Cipangopaludina.* All the species which Prashad (1928) included under the groups *"Vivipari bengalensis"* and *"Vivipari dissimiles"* should be assigned to the genus *Bellamya.* It is represented by five species of which the validity of *B. micron* is not clearly established.

Key to species

1. Shell with dark spiral bands, suture not greatly impressed ..... ***B. bengalensis***

– Colour uniform without any bands in the adult shell, suture generally impressed 2

2. Shell globse, spire small and blunt ..... ***B. crassa***

– Shell ovate conical or high, spire elongated 3

3. Shell with deeply impressed sutures, body whorl generally with one slightly elevated peripheral ridge or broad and obscure pale spiral band ..... ***B. dissimilis***

– Body whorl with six rather delicate ridges ..... ***B. crassispiralis***

15. **Bellamya bengalensis** (Lamarck, 1882)

Paludina bengalensis Lamarck, 1822, *Hist. nat. Anim. sans Vert.*, 6;2): 174.

Vivipara bengalensis: Annandale, 1921, *Rec. Indian Mus.*, 22: 267.

Shell thin, more or less smooth, with three or more colour-bands, embryonic shell delicate and thin, with three primary rows of chaetae, low ridges, the lower most well developed, sometimes developing into a keel, secondary ridges bearing chaetae may develop between the primary ones.

In Chinsurah (and Pandua) areas of West Bengal the species is considered as a pest of *Azola pinnata,* a plant which is used as a biofertiliser in paddy field.

Remarks: Annandale (1921 f, h) studied the ornamentation of the shell and systematics, while Sewell (1921) discussed the anatomy and bionomics of the species. The former recognised 11 forms of this most common Indian species. These forms differ from each other only in the shell characters, but radula and soft parts are strikingly uniform. These differences are mainly due to the physical factors of the environment rather than to geographical isolation of the race (Annandale, 1921h).

Distribution: Common throughout India and Burma.

The following eight forms are recognised here:-

form *typica* (Lamarck). (Fig. 55)

The spire and body whorl of about equal height, whorls tumid, body whorl evenly convex in profile, not biangulate, umbilicus narrow, aperture subcircular with a narrow black margin. Dark bands variable and irregular, alternating broad and narrow bands.

Distribution: Throughout India.

Type: MHN

Parasites. Although it is a common mollusc, it is not important as an intermediate host. A few larval trematodes, were recorded viz. *Cercaria asiatica* Sinha and Prashad, 1964; *Thapariella anastomusa* Srivastava, *Cercaria thaparai* Rai, 1962, *Cercaria kumaunensis* Singh & Malaki, 1963.

form *mandiensis* (Kobelt, 1909.) (Fig. 56) *Nachr, Malak, Ges.*, **60:** 414. Type locality: Mandi, Kangra.

Spire more conical and a little narrower than in f. *typica*, aperture not quite so broad, but more projecting, umbilicus broader, well developed alternating broad and narrow spiral bands.

Distribution: Common in north-western India from Allahabad to Punjab and west to Bombay.

Types: ZSI Regd. No. M 5081/1.

Remarks: There is a doubt regarding its type locality—Mandi, given by Kobelt.

form *annandalei* (Kobelt, 1909) (Fig. 57) *Nachr, Malak, Ges.* **60:** 161, Type locality: Visakhapatnam, Andhra Pradesh.

Shell thin and translucent, whorls gradually increase in size, sutures shallow, aperture subrhomboidal and subangulate anteriorly.

Distribution: Andhra Pradesh, West Bengal, ("Pools of foul water used for domestic purposes"—Annandale, 1921h).

form *balteata* (Benson, 1836) (Fig. 63) *J. asiat. Soc. Beng.* pt. **2:** 745. Type locality: Silcuri, Cachar, Assam.

Shell narrow, whorls contracted, aperture ovoid, umbilicus closed.

Distribution: Sylhet valley, Assam or Bangladesh, eastern part of Brahmaputra valley, absent from Manipur (Annandale. 1921g).

Remarks: Resembles *f. annandalei* and f. *doliaris.*

form *colairensis* (Annandale, 1921) (Fig. 58). *Rec. Indian Mus.*, **22:** 275, pl. 1. figs. 5, 6. Type locality: Sriparptipada, Colair Lake, Andhra Pradesh.

Shell elongate, thin and translucent with relatively small almost circular aperture, pigmentation deep and dull.

Distribution: Restricted to type locality only

Types: Syntypes ZSI Regd. No. M 11691/2.

form *doliaris* (Gould, 1843) *Paludina doliaris* Gould, 1843 *Proc. Boston Soc. nat. Hist.:* 144. Type locality: Burma.

Shell with two spiral ridges or thickened dark bands on the body whorl.

Distribution: Burma

Remarks: The eastern forms *nepalensis, balteata* and *doliaris* intergrade into each other.

form *eburnea* (Annandale, 1921) (Fig. 59). *Rec. Indian Mus.* **22:** 274, pl. II, fig. 1-2. Type locality: Kaligiri (=Kanigiri) reservoir Nellore Dist. Andhra Pradesh.

Shell narrow and aperture smaller than in f. *typica*, whorls narrow but distinctly flattened outside the suture, body whorls showing a tendency to become biangulate; strong spiral sculpture. The aperture never with a black rim.

Distribution: Andhra Pradesh, extending as far north as Sambalpur, in Orissa. Occasionally in the Gangetic valley.

form *nepalensis* (Kobelt, 1909) (Fig. 62) *Nachr. Malak, Ges.*, **60** 441; pl. XXVII, fig. 10. Type locality: Nepal Valley.

Whorls more contracted and not so convex in outline, aperture narrower and more pointed above, umbilicus very narrow, dark bands incrassated.

16. **Bellamya crassispiralis** (Annandale, 1921) (Fig. 68)

Vivipara crassispiralis Annandale, 1921. *Rec. Indian Mus.*, **22:** 544, pl. iv, fig. 1. Type locality: Chakpi stream in the south of the Manipur valley near the Burmese frontier.

Type: ZSI Regd. No. M 11738/2

Remarks: Shell ovate conical, bluntly acuminate, whorls tumid, body whorl transverse and oblique, anterior margin strongly sinuate, with six rather delicate ridges; aperture small, suboval, evenly rounded below,

and obliquely and bluntly pointed above, outerlip thin, evenly and broadly arched columella, slightly laminated and retroverted umbilicus rimately perforate.

Distribution: Manipur Valley.

Nothing is known about its habitat.

17. **Bellamya crassa** (Benson, 1836) (Figs. 61, 62)

Paludina crassa (Hutton Ms.) Benson, 1836, *J. asiat. Soc. Beng.*, **5**: 745. Type locality: River Gomati, Jaunpur, U.P.

Types: ?

Shell olive brown, globose, without colour bands, spire small and blunt. shell surface sculptured with fine wavy spiral lines; aperture suboval, columella arched, anterior margin almost straight, outerlip arched, umbilicus rimately perforate.

Remarks: After its original discovery it was not reported by any author. Prashad (1928) refers it as a species belonging to *Vivipari Dissimiles* group.

It buries itself in the mud or sand in shallow water, often in large numbers, although there are favourable conditions. Other species of the genus are known to tide over the unfavourable conditions like drought etc. by burying themselves in the mud.

Distribution: Uttar Pradesh, River Gomati, Jaunpur; West Bengal: Ranaghat, Siliguri; Orissa; Assam: Cachar; Bangladesh: Hazrapur, Sylhet.

18 **Bellamya dissimilis** (Mueller, 1774) (Figs. 64-67)

Nerita dissimilis Mueller, 1774, *Hist. Verm. Test.*, pt. 2: 184. Type locality: Not given.

Paludina variata Frauenfeld, 1862, *Verhandl, Zool. bot. Gog.* Wien. p. 1163. Type locality: Pondicherry.

Types: Copenhagen Museum

Remarks: Shell small, high and narrow, spire swollen and suture deeply impressed, without dark spiral bands, body whorl with one slightly

elevated ridge or broad and obscure, pale spiral band. Rim of the aperture often black, operculum thicker and muscular scar better developed. Edge of the mantle smooth in the adult.

Distribution: Peninsular and northern India, and West Bengal.

19. **Bellamya micron** (Annandale, 1921) (Figs. 71, 72)

Vivipara micron Annandale, 1921, *Rec. Indian Mus.*, **22**: 550, fig. 5. Type locality: Manipur.

Type: ZSI Regd. No. M 11855/2

Distribution: Manipur

Remarks: The species was based on a single specimen. Unless fresh specimens are obtained it may be premature to comment on its validity. However, examination of a large number of collections of *B. dissimilis* have shown that *B. micron* may be a variant of the former.

Genus 6. **Cipangopaludina** Hannibal, 1912

Cipangopaludina Hannibal, 1912, *Proc. malac. Soc. Lond.*, **10**: 194. Type species: *Paludina malleata*; Reeve.

Lecythoconcha Annandale, 1920. *Rec. Indian Mus.*, 114, Type species: *Paludina lecythis* Benson.

Cipangopaludina: Brandt, 1974, *Archiv. Molluskenk.* **105**: 37.

Shell large, with broad swollen whorls, smooth, uniform colour without bands. Embryonic shell with three ridges bearing curved chaetae. Aperture large, subcircular or broadly ovate, columellar fold weakly developed, umbilicus narrowly perforate, outerlip thin.

Operculum with prominent concentric ridges, a deep funnel shaped, subcentral pit externally and correspondingly a smooth, prominent rounded boss internally.

Free edge of mantle greatly thickened and very muscular, three marginal processes in young, but none in the adult.

Manipur Valley, Burma, Thailand, Vietnam, China, Korea, Asiatic Russia, Japan, the Philippines and Java. Introduced into North America (Yen, 1943).

A single species in the Manipur valley, India.

20. **Cipangopaludina lecythis** (Benson, 1836) (Fig. 73)

Paludina lecythis Benson, 1836, *J. asiat. Soc., Beng.*, **5**: 745. Type locality: Manipur.

Lecythoconcha lecythis: Annandale, 1921, *Rec. Indian Mus.*, **22**: 553, pl. V, figs. 1-4, pl. vi, figs. 1, 2.

Types: ZSI Regd. No. M 2300.

Shell olive green when fresh, spire conical, apex acuminate, whorls tumid and flattened above, suture deep, aperture large and broadly oval, outer lip sharp and tinged with black, columella arched.

Distribution: Manipur valley through Upper Burma to the Southern Shan States, Yunnan and Vietnam.

Remarks: Shell more globose in female than in male. Operculum thin and transparent. Tentacles long and thin, foot very stout.

Depending on the ecological niche occupied by the species Annandale (1921g) recognised four phases; namely the open water phase, the marginal phase, the pond phase and the rice field phase.

Genus 7. **Angulyagra** Rao, 1931

Dactylochlamys Rao, 1925, *Rec. Indian Mus.*, **27**: 132.

Type species: *Paludina oxytropis* Benson. The generic name was preoccupied for a protozoan and hence a replacement name *Angulyagra*, Rao, 1931, *Rec. Indian Mus.*, **33** : 301 was suggested.

Shell large, conical, thin with prominent smooth and hollow spiral ridges on the surface, base flattened, uniform colour but the ridges darker, embryonic shell elongated with a well developed peripheral keel, umbilicus broadly rimate with a broad channel descending downward.

Assam and Burma, Malay Peninsula, Andalas, Java, Sulawesi, the Philippines, China and Japan (Prashad, 1928a).

Two species namely *A. microchaetophora* (Annandale) and *A. oxytropis* (Benson).

Key to species

Body whorl with three prominent ridges and three rather less prominent ridges below the peripheral keel ..... *A. oxytropis*

Body whorl as a rule without any definite trace of spiral ridges except the peripheral keel .....*A. microchaetophora*

21. **Angulyagra microchaetophora** (Annandale, 1921) (Fig. 69)

Vivipara microchaetophora Annandale, 1921, *Rec. Indian Mus.*, **22**: 546. fig. 4. Type locality: Dimapur, Nagaland.

Type: ZSI Regd. No. M 11856/2

Distribution: Nagaland, Assam.

Remarks: Shell small, thin, sharply acuminate, imperforate, a blunt peripheral ridge on the body whorl, outerlip sharp, columella strongly arched, spiral whorls with two fine spiral ridges.

Occurs in artificial ponds on floating grass-stems and longer parts of plants that float on the surface of water.

22. **Angulyagra oxytropis** (Benson, 1836) (Fig. 70)

Plaudina oxytropis Benson 1836, *J. asiat. Soc. Beng.*, **5**: 745.

Vivipara oxytropis: Annandale, 1921, *Rec. Indian Mus.*, **22**: 548, pl. iv. figs. 2—5.

Types: ?

Shell large, broadly conical, acuminate, narrowly perforate, prominent spiral ridges, outerlip thin but not sharp, broadly and regularly arched, with a distinct prominence at the termination of the peripheral ridge, spiral whorls with two smooth prominent spiral ridges.

Distribution: Manipur Valley.

Remarks: Annandale (1921g) recognised two phases, namely, typical phase from the Loktak Lake and a pond phase. The latter approaches. *A. microchaetophora.*

In female the shell is distinctly broader than in the male. They are also more abundant than males (Annandale, 1921).

Genus 8. **Taia** Annandale, 1918

Taia Annandale, 1918, *Rec. Indian Mus.*, **14**: 123, 168.

Type species: *Vivipara naticoides* Kobelt.

Shell conical-ovate or conoidal or conical, but never very thick, sculptured with spiral striae or ridges broken up into nodular or squamous tubercles, at least three such ridges on the body whorl, embryonic shell with three primary ridges, the lowermost i.e. peripheral well developed. Whorls 7 to 8, spire well developed; aperture subtriangular, columellar callus very broad and thick, extending over the umbilicus in the form of a convex ridge or flat plate. Operculum horny, pyriform, concave externally with a strong ridge along the inner margin.

Head larger than in *Bellamya* and eyes almost completely sessile, mantle edge more muscular with highly contractile lobes correlating with the shell sculpture, and a broad lobe corresponding to the thickened columellar callus; marginal teeth of radula very narrow, uterus with a small number of embryos, embryos more fully developed at birth than in *Bellamya.*

Streams, lakes and ponds. Endemic to Burma.

Annandale (1918a), Rao (1925b), Annandale & Rao, 1925 gave detailed accounts of the *Taia* genus.

Key to species

1. Shell somewhat globosely conoidal 2

– Shell elongate conoidal 3

2. Shell almost subumbilicate, spiral ridges never strongly developed and never regularly tubercular or squamous ..... *T. theobaldi*

– Shell entirely non umbilicate, spiral ridges almost absent or when present never with subspiniform scales ..... *T. naticoides*

3. Shell moderately elongated and thin ..... *T. shanensis*

Shell conical 4

4. Scales on body whorl spiniform, regular, shell not exceeding 32 mm. in length, narrowly conical ..... *T. intha*

Scales on body whorl subspiniform, shell less than 40 mm. thinner ..... *T. elitoralis*

23. **Taia crassicallosa** Annandale and Rao, 1925

Taia crassicallosa Annandale and Rao, 1925, *Rec. Indian Mus.*, **25**: 124 fig. 11-14. Type locality: Yawnghwe river near Tai-0, Yawnghwe State, S. Shan States, Burma.

Types: ZSI Regd. No. M 12462/2

Distribution: Burma.

Remarks: Shell globose, spire relatively short and broad, never exceeding the height of the body whorl, ridges well-developed, sometimes broken. squamous tubercles, columellar callus very prominent and greatly thickened.

It seems to be intermediate in some features between *T naticoides* and *T. elitoralis.*

24. **Taia elitoralis** Annandale, 1918
(Fig. 77)

Taia elitoralis Annandale, 1918, *Rec. Indian Mus.*, **14**: 134. Type locality: Inle Lake.

Types: ZSI Regd. No. M 11012/2.

Distribution: Inle Lake.

Remarks: Shell more elongate and slender than in any other form, scaly tubercles even on the penultimate whorl, other ridges more tuberculate, base of the gill filaments relatively broader.

25. **Taia intha** Annandale, 1918
(Fig. 78)

Taia intha Annandale, 1918, *Rec. Indian Mus.*, **14**: 135, Type locality: Inle Lake, Burma.

Types: ZSI. Regd. No. M 11004/2.

Distribution: Inle Lake.

Remarks: Shell very elongate, well developed ridge on the penultimate whorl, ridges tuberculate, peripheral ridge prominent with squamous tubercles projecting in the form of short spiniform processes, two ridges below the peripheral; embryonic shell banded.

26. **Taia naticoides** (Theobald, 1865)
(Fig. 76)

Paludina naticoides Theobald, 1865, *J. asiat. Soc. Beng.*, **34** (2): 274, pl. ix. fig. 1-3. Type locality: Upper Salween, Shan States.

Taia naticoides : Annandale, 1918, *Rec. Indian Mus.*, **14:** 126, pl. xv, figs. 16, 17, pl. xvi, figs. 3-6; pl. xviii, figs. 1-3.

Distribution: Burma.

Remarks: Shell not very elongate, with three very distinct colour bands, sculptured with three, low spiral ridges.

Two varieties are distinguished *T naticoides* var. *noetlingi* (Kobelt) and *lacustris* Annandale. The former differs from the typical form in having a more elongate shell, and in the prominent spiral ridges breaking up into tubercles. *T naticoides* var. *lacustris* is a fossil form and has a longer, narrower and less conical shell.

27. **Taia shanensis** (Kobelt, 1909)

Vivipara shanensis Kobelt, 1909, *Paludina*, in Martini & Chemnitz's *Syst. Conch. Cab.*, 411, pl. xxvii. figs. 4, 5. Type locality: Shan States.

Taia shanensis: Annandale, 1918, *Rec. Indian Mus.*, **14:** 129, pl. xv. figs. 14, 15, pl. xvi, fig. 10, pl. xviii, figs. 4-6.

Distribution: Burma.

Remarks: Shell globose-conoidal, relatively thin and brittle, and not very high, spiral ridges better developed, peripheral ridge consists of more or less regular and prominent subspiniform scales, two spiral rows of tuber-

cles above and two rather low ridges below, embryonic shells without bands, gill filaments relatively broad.

Occurs in foul water on the marginal zone of Inle Lake.

28. **Taia theobaldi** (Kobelt, 1909) (Fig. 74, 75)

Vivipara (*naticoides* var.?) *theobaldi* Kobelt, 1909, *Paludina,* in Martini & Chemnitz's *.Syst Conch. Cab.,* 151, pl. xxx, figs. 10, 11.

Taia theobaldi: Annandale, 1918, *Rec. Indian Mus.,* **14**: 126. pl. xv, fig. 18, pl. xvi, fig. 1, pl. xviii, figs. 15-17.

Distribution: Burma.

Remarks: Resembles *T naticoides* very much, but differs from it as follows: shell shorter, body whorl usually more swollen, columellar callus ridge-like in the young shells and the sharp outer edge when fully developed leaving a narrow umbilical opening, embryonic shells faintly banded.

Family 3. **Valvatidae**

Shell small to minute, almost circular, umbilicus distinct, deep and narrow, operculum horny, a pallial tentacle on the right side of the mantle and a protruding bipectinate gill on the left, hermaphrodite.

Very widely distributed in North America, Europe, northern Asia and Asia Minor, N. E. Africa (Brown. 1980). India—in Kashmir.

Only one extant genus *Valvata.*

Genus 9. **Valvata** O.F. Mueller, 1774

Valvata O.F. Mueller, 1774, *Verm. Terr. Fluv. Hist.* **2**: 198.

Type species: *Valvata cristata* Mueller.

Shell turbinate or subdiscoidal, with little exserted spire, whorls few, aperture oblique and circular, operculum multispiral.

Europe, Asia, North America and N. E. Africa (For details Brown 1980).

29. **Valvata piscinalis** (Mueller 1784)

Nerita piscinalis Mueller, 1774, *Verm. Terr. Fluv. Hist.*, **2**: 172. Type locality: Europe.

Valvata piscinalis: Rajagopal and Subba Rao, 1968, *Proc. Symp. Mollusca*, pt. 1, p. 98.

Distribution: India: Kashmir; Europe.

Remarks: Shell globose, brownish yellow, whorls 5 to 6, deeply, narrowly umbilicate, depressed at the apex, with dense, fine longitudinal striations and faint spiral ridges.

30. **Valvata stoliczkana** Nevill, 1878. (Fig. 79)

Valvata stoliczkana Nevill, 1878, *Sci. Results Second Yarkand Mission*, Mollusca, p. 12. figs. 34-36. Type locality: Yarkand.

Distribution: Yarkand.

Remarks: Umbilicus remarkably deep and narrow, whorls 4, slightly subangulate, with a faint depression near the suture, fine, close, regular and distinct striations, light glossy green.

Family 4. PILIDAE

"Apple-snails"

It includes apple-snails, characterised by a large perforate or imperforate shell with an inflated body whorl and a short spire. The shell generally green or olive-brown in colour. Operculum large, calcareous or corneous, and concentric with a subcentral nucleus.

The animal with a pair of filiform tentacles and a pair of long and filiform labial palps, simulating tentacles; a pair of nuchal lobes, the left one capable of rolling into a tube or siphon.

Amphibious in habit, with both aerial and aquatic respiration. The mantle cavity bears a long, monopectinate gill on one side and the other side modified into a pulmonary sac. Oviparous.

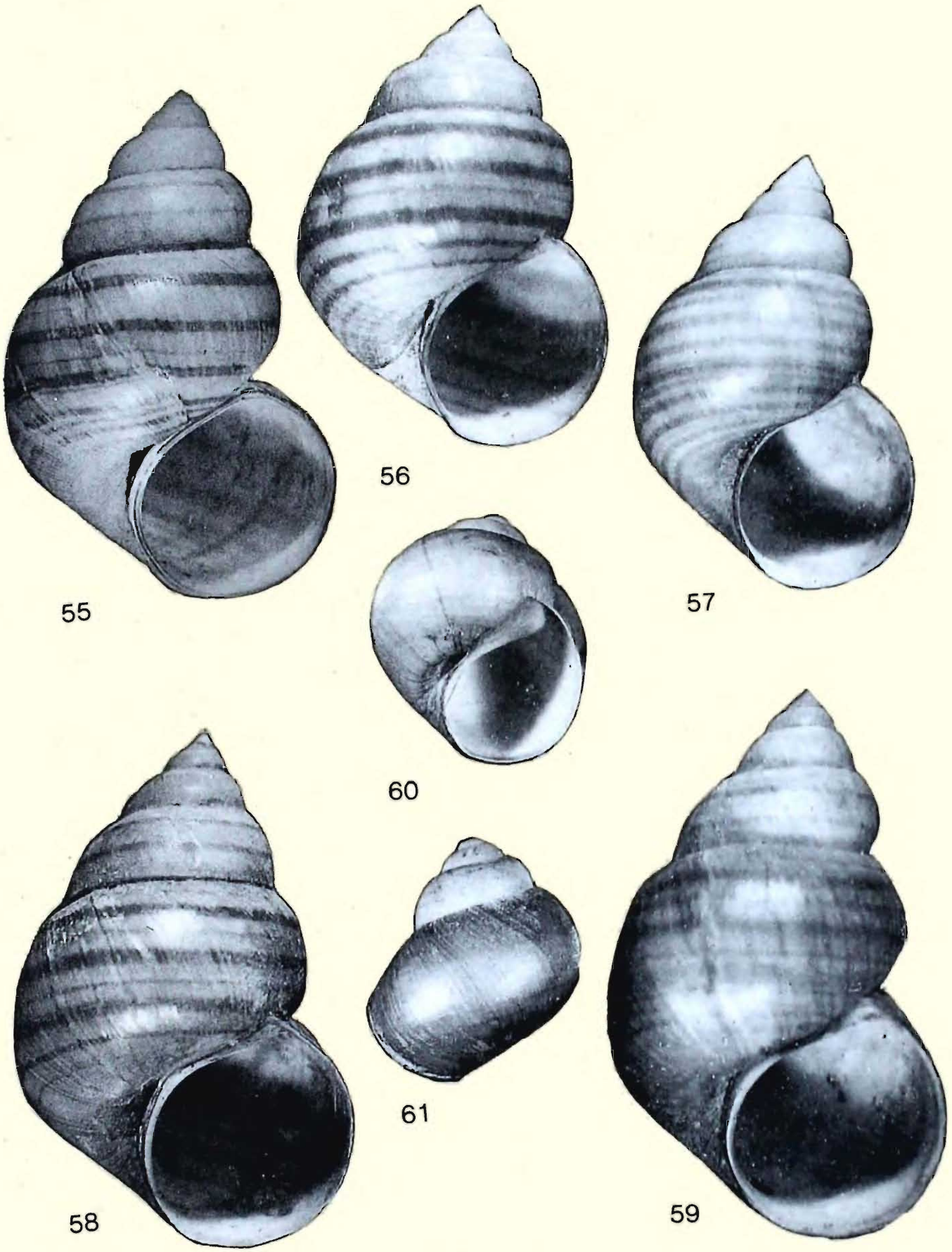


Fig. 55. *Bellamya bengalensis* f. *typica*, 29.5 × 19.45 mm., Bihar. 56. *B. bengalensis* f. *mandiensis* 29.00 × 19.15 mm., Panipat. 57. *B. bengalensis* f. *annandalei*, 28.62 × 19.28 mm., Bolarum tank, Secunderabad. 58. *B. bengalensis* f. *colairensis*, Syntype, 37.07 × 25.00 mm., Colair Lake, Andhra Pradesh. 59. *B. bengalensis* f. *eburnea*, 35.14 × 22.15 mm., Colair Lake. 60, 61. *B. crassa*, 19.60 × 18.0 mm; 19.20 × 17.75 mm., Orissa.

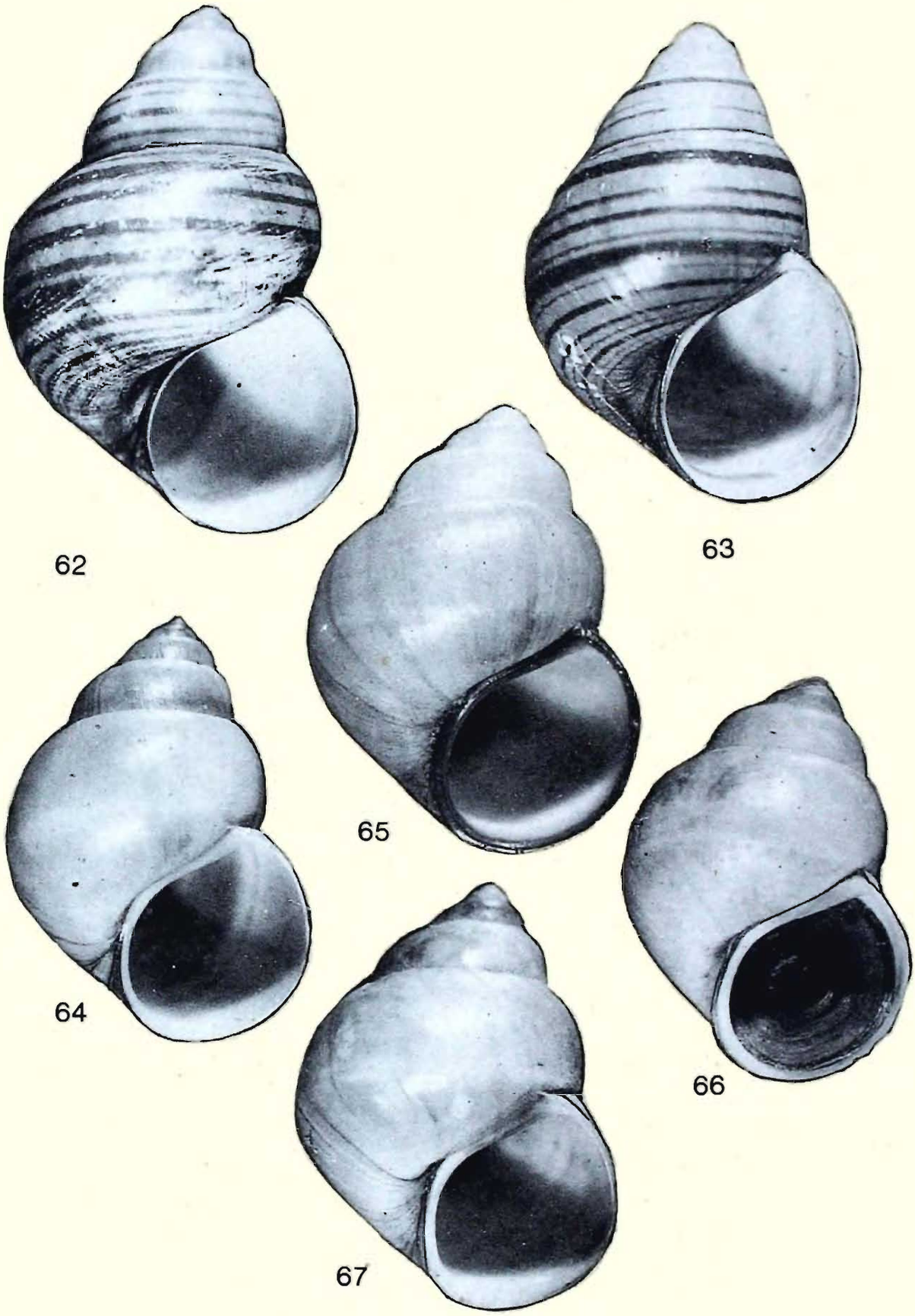
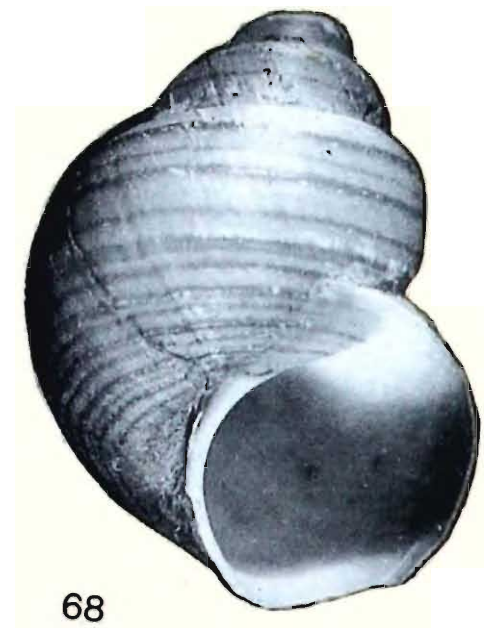
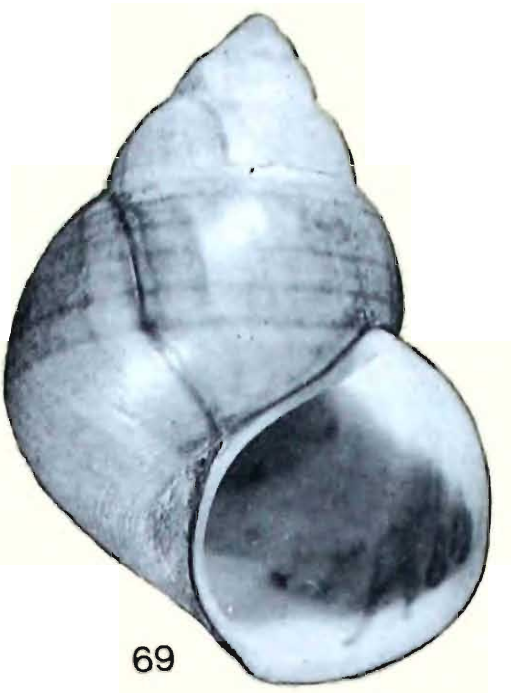


Fig. 62. *B. bengalensis* f. *nepalensis*, 31.0 × 21.16 mm., Nepal. 63. *B. bengalensis* f. *balteata*, 26.78 × 18.79 mm., Siliguri. 64. *B. heliciformis* (=*B. dissimilis*), 22.46 × 16.20 mm., Bangalore. 65. *B. variata* (=*B. dissimilis*), 24.86 × 17.52 mm., Tamilnadu. 66. *B. dissimilis* 24.86 × 17.52 mm., Ranchi, Bihar. 67. *B. olivacea* (=*B. dissimilis*) 25.86 × 18.76 mm., Lotus pond, Ellore, Andhra Pradesh.





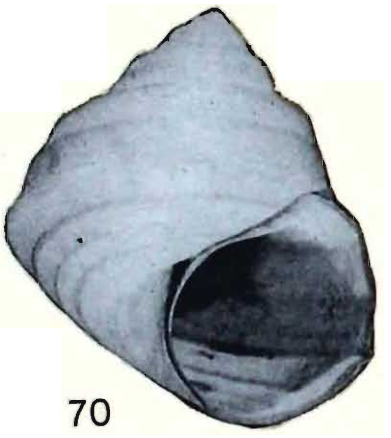


Fig. 68. *B. crassispiralis*, Syntype, 20.0 × 17.5 mm., Manipur. 69. *Angulyagra microchaetophora*, 29.66 × 21.00 mm., Dimapur. 70. *Angulyagra oxytropis*, 35.82 × 31.17 mm., Manipur. 71, 72. *Bellamya micron*, Holotype, 10.75 × 8.65 mm., Manipur. 73. *Cipangopaludina lecythis* 45.36 × 40.16 mm., Manipur. 74. *Taia theobaldi*, Syntype, 27.12 × 21.05 mm., Burma.

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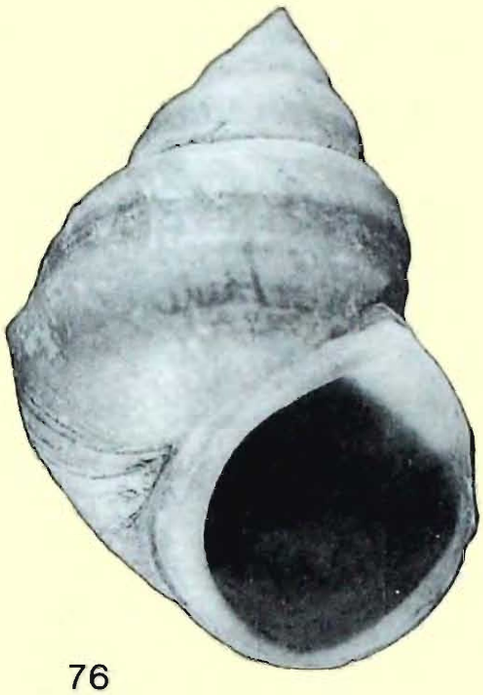

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Fig. 75. *Taia theobaldi niger* Syntype., 24.25 × 19.3 mm., Burma. 76. *Taia naticoides*, 31.06 × 21.16 mm., Burma. 77. *T. elitoralis*, 31.86 × 19.31 mm., Inle Lake, Burma. 78. *T. intha*, Syntype., 31.52 × 21.57 mm., Burma.

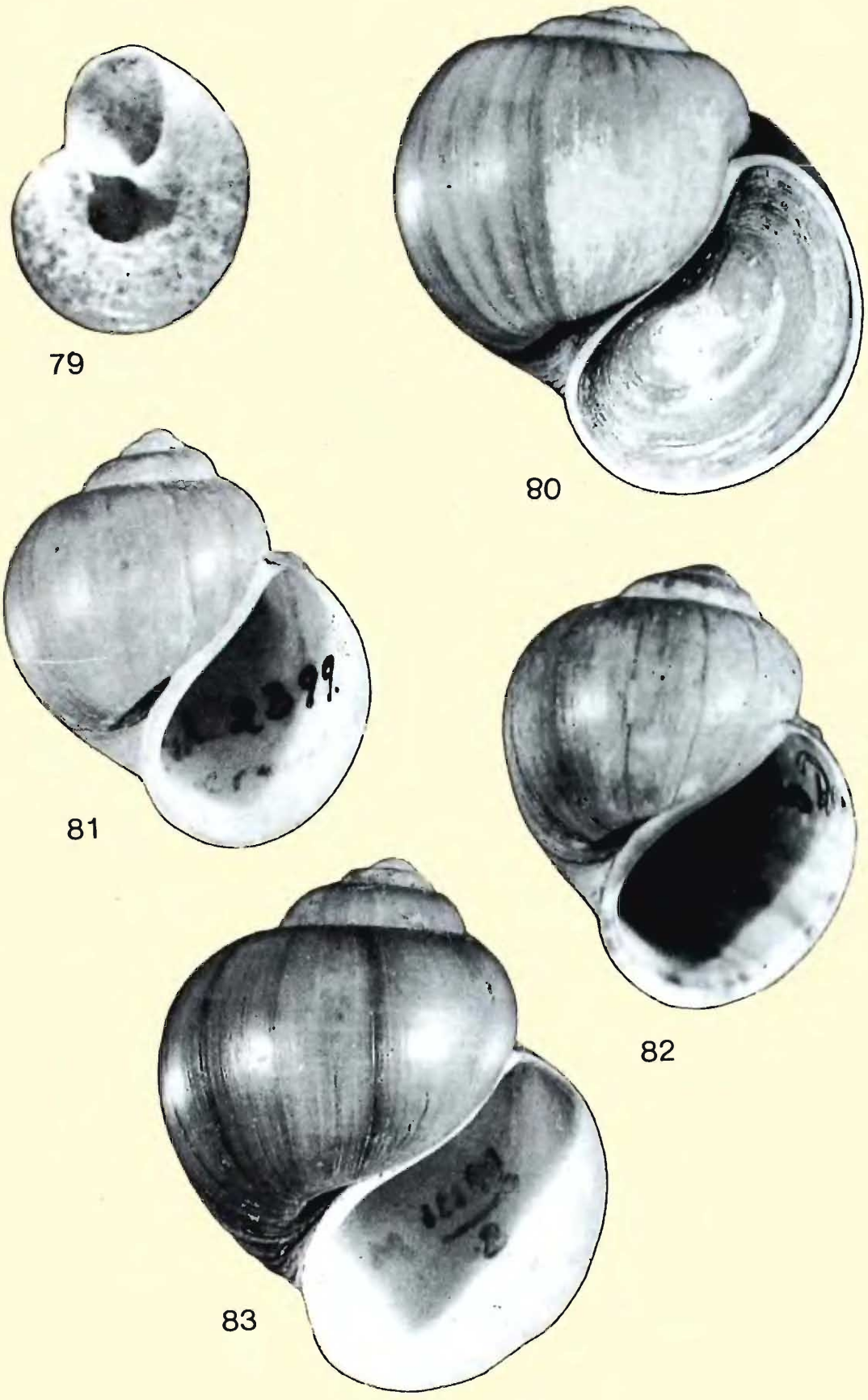
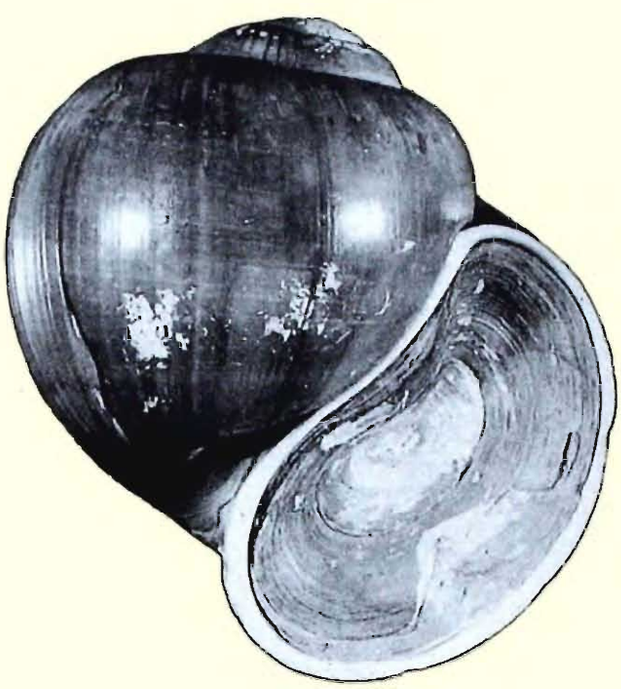


Fig. 79. *Valvata stoliczkana,* Holotype, 2.05 × 3.30 mm., Yarkand. 80. *Pila globosa,* 44.65 × 43.70 mm., Calcutta. 81. *P. globosa incrassatula,* Holotype, 31.80 × 28.05 mm., Calcutta. 82. *P. globosa minor* Syntype, 32.85 × 28.50 mm., Dum Dum, Calcutta. 83. *P. scutata,* 42.30 × 39.90 mm., Andamans.



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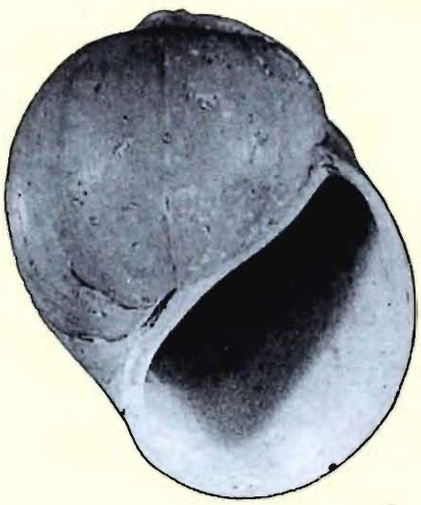

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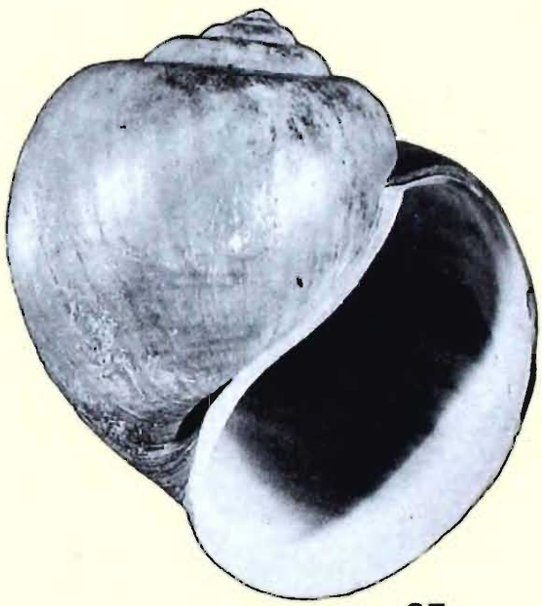

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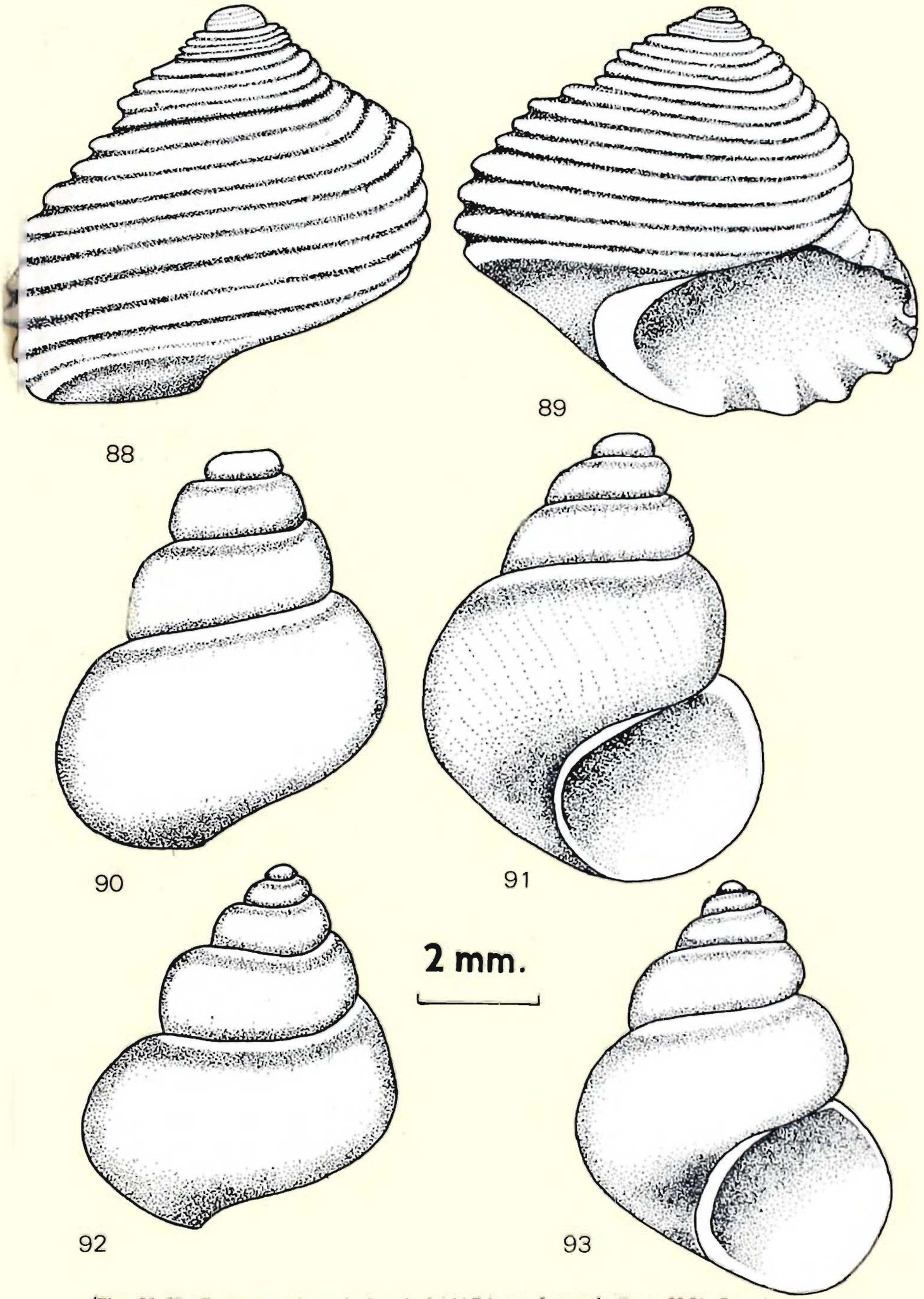
Fig. 84. *Pila theobaldi*, 86.05 × 84.65 mm., Burma. 85. *P. nevilliana*, Syntype, 37.3 × 33.15 mm., Tranquebar. 86. *Turbinicola saxea*, 24.15 × 20.95 mm., Khandalla. 87. *Pila virens*, 64.30 × 60.35 mm., Madras.



Figs. 88, 89. *Cremnoconchus syhadrensis*, 6.4 × 7.1 mm.. Lonovala, Pune. 90,91. *C. carinatus*, 10.25 × 9.10 mm.; 11.68 × 9.8 mm., Mahabaleshwar, Pune. 92, 93. *C. conicus*, 7.55 × 6.35 mm., 7.65 × 6.15 mm., Pune.

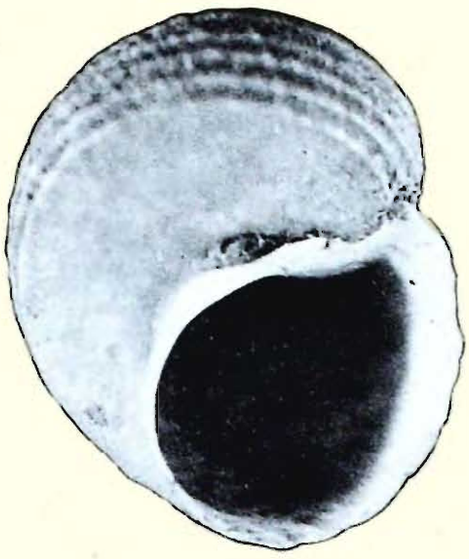


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Fig. 89a, b. *Cremnoconchus syhadrensis*, Lonovala, Pune.

Asia, Africa and America. Common in freshwater ponds, tanks, streams and paddy fields.

Prashad (1925) made a revision of Indian Pilidae. The functional anatomy of the mantle cavity, kidney, gut, blood and reproductive systems of pilid gastropods were studied by Andrews (1964, 1965a, b) and Pain (1972).

Two genera are represented in India; *Pila* is a common one and *Turbinicola* is a hill-stream form with very restricted distribution.

1. Shell large or very large, globose, aperture large, expanded, surface of shell smooth, body whorl inflated, umbilicus open, lateral teeth with five cusps, third or central one the largest and innermost reduced, the lung less capacious, its opening small ..... **Pila**

   Shell comparatively small, regularly ovate, aperture relatively high and narrow, surface of shell malleated with minute spiral and longitudinal striae, umbilicus closed, lateral and marginals with two cusps, inner one vestigial and the outer expanded and obliquely truncate, lung more capacious, its opening larger ..... **Turbinicola**

Genus 10. **Pila** (Bolten) Roeding, 1798

Pila (Bolten) Roeding, 1798, *Museum Boltenianum*, pt. 2, p. 145 (in part)
Type species: *Helix ampullacea* S. D. Dall, 1904, *J. Conch.*, **11**: 53.

Asia and Africa.

Prashad (1925) revised the genus and recognised eight species and six varieties occuring in India, Sri Lanka and Burma. He reported *P. layardi* (Reeve) and *P. robsoni* from Sri Lanka. But in a more recent paper Starmuehlner (1974) concluded that only one species, namely *Pila globosa* is represented in Sri Lanka. In the present state of our knowledge it is not possible to come to any conclusion with regard to Indian species. However, it may be mentioned that four species, namely *P. globosa, P. virens, P. scutata* and *P. theobaldi* are easily distinguishable.

The species are known by their shell characters which are generally variable. The anatomical details of all the species are not known and it is imperative that the key is based on shell characters of the adult.

1. Shell globose, and spacious, upper surface of whorls obliquely flattened, suture not deep, spire depressed ..... *P. globosa*

   Shell ovoid or semiglobose, suture deeply impressed, spire elevated 2

2. Suture canaliculate with a distinct carination of the whorls on the outside, spire prominent and conical ..... *P. virens*

   Suture without a distinct carination, spire distinct and more elongated 3

3. Shell smaller, whorls descending step-like, colour bands showing through the aperture of the shell, umbilicus narrow ..... *P. scutata*

   Shell larger, whorls globose, aperture without colour bands, umbilicus widely open ..... *P. theobaldi*

31. **Pila globosa** (Swainson, 1822)
(Figs. 80-82)

Ampullaria globosa Swainson, 1822, *Zool, Illustrations,* Vol. 2, pl. cxix. Type locality: "Rivers of India."

Type: BM (NH).

Distribution: India: Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Orissa and Assam. Not recorded from Punjab and Himachal Pradesh.

Remarks: The species has been the centre of investigation by several workers. Bahl (1928) investigated the reproductive processes and development. Some of the important investigations were: Bhargava (1968) on the structure of heart, Ghosh E. N. (1912) on nervous system, Prashad (1925) on biology and anatomy and Ranjha (1942) on embryology. There were several publications dealing with different aspects of its physiology, including aestivation: Bhargava (1964), Brahmanandan (1976), Chatterjee (1960), George & Desai (1955), Krishnamoorthy (1968), Nayeemunnis (1978), Raghupathiramireddi (1967), Raghupathiramireddi & Swami (1961, 1964, 1968), and Saxena (1955, 1956a).

The species is known by its two varieties, viz. *incrassatula* Nevill, 1877 (Fig. 81) and *minor* Nevill, 1877 (Fig. 82). They are so far reported from ponds around Calcutta, in West Bengal.

Parasites. The following larval trematodes were recorded: *Artyfechinostomum sufratyfex, Diplodiscus* sp. Anjaneyulu, 1967, *Echinostoma cercaria* Ganapati & Rao, 1968, *Cercaria andhraensis* Ganapati et al 1969; *Cercaria pigmentata* Rao et al, *Xiphidocercaria* sp., Sen, 1949.

32. **Pila nevilliana** (Annandale and Prashad, 1921) (Fig. 85)

Pachylabra nevilliana Annandale and Prashad, 1921, *Rec. Indian Mus.* **22**: 11, fig. 2. Type locality: Tranquebar.

Type: ZSI Regd. No. M 11864/2.

Distribution: Not known beyond type locality.

Remarks: The species is known by its type series only. It is doubtfully placed next to *P. virens* (Prashad, 1925). When compared with *P. virens* the shell is stouter, body whorl more transverse, suture more oblique, sculpture coarser and less regular.

33. **Pila olea** (Reeve, 1856)

Ampullaria olea Reeve, 1856, *Conch. Icon.*, **10**, *Ampullaria*, sp. no. 102, pl. xxi, fig. 102. Type locality: Not mentioned.

Type: BM (NH)

Distribution: Cachar, Assam.

Remarks: Allied to *P. virens* and may be a variety of it (Prashad, 1925).

34. **Pila scutata** (Mousson, 1848) (Fig. 83)

Ampullaria scutata Mousson, 1848, *Mitth. Naturf. Ges. Zurich*, **1**: 268. Type locality: Java.

Pila conica: Prashad, 1925, *Mem. Indian Mus.*, **8**: 79. pl. xv. figs. 4-8.

Pila scutata: Benthem Jutting, 1956, *Treubia*, **23**(2): 332, figs. 37-40.

Distribution: The typical form is widely distributed extending from Andaman & Nicobar Islands to Celebes and north to the Philippines. Not found in Moluccas or New Guinea (Benthem Jutting, 1956).

Remarks: Annandale (1920) and Benthem Jutting (1956) gave good descriptions of the species. The latter provided a note on the spawning also.

Prashad (1925) recognised two varieties namely *compacta* Reeve, 1856 and *gracilis* Lea, 1856. The former is distinguished from the typical form by its thicker and stouter shell with strong vertical striations, broader columellar callus and more ovoid mouth. The variety *compacta* was originally recorded from Burma only but later it was recorded from Andamans also (Subba Rao et al, 1979). The variety *gracilis* is restricted to Burma. Excepting in size the two varieties are hardly distinguishable.

35. **Pila theobaldi** (Hanley, 1875)
(Fig. 84)

Ampullaria theobaldi Hanley, 1875, *Proc. zool. Soc. Lond.*, p. 608. Type locality: Bhamo, Burma.

Pila theobaldi: Prashad, 1925, *Mem. Indian Mus.*, **8**: 77, pl. xv, fig. 3.

Distribution: Confined to Burma (Prashad, 1925)

Remarks: It is the largest apple snail. It grows to 85 mm. in total height. It differs from the closely allied *P. virens* in size, more globose, more impressed suture and very open umbilicus.

36. **Pila virens** (Lamarck, 1822)
(Fig. 87)

Ampullaria virens Lamarck, 1822, *Hist. nat. anim. sans Vert.*, **6** (2): 179. Type locality: Not mentioned.

Ampullaria maura Reeve, 1856, *Conch. Icon.*, **10**, *Ampullaria*, sp. no. 57, pl. xiii, fig. 57.

Pila virens: Prashad, 1925, *Mem. Indian Mus.*, **8**: 75, pl. xiv, fig. 13.

Type: MHN.

Distribution: It is a common species in South India and Maharashtra.

Remarks: The species is very variable in its colour and shape of the spire. It is so variable that at times it becomes difficult to distinguish it from the other common species, *P. globosa*. This is more particularly true when the collections originate from Orissa, West Bengal and Assam.

The physiology, especially pertaining to aestivation was investigated by Meenakshi (1951, 1954, 1955a—c, 1956a—c, 1957, 1964), Rammoorthi (1955, 1958a, d, 1959a, b, 1960), Shylaja and Alexander (1975).

Genus 11. **Turbinicola** Annandale and Prashad, 1921.

Turbinicola Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 9.

Type species: *Ampullaria nux* (= *Ampullaria saxea*) Reeve.

Members of this species are restricted to hill streams in Western Ghats, India and Burma.

The animal in general resembles that of *Pila*, but its habitat has brought in certain changes in its anatomy. The branchial and pulmonary chambers of the mantle cavity are distinctly separated by a well-developed epitaenia. The lung is also comparatively well-developed and more efficient. Gill is not used for aquatic respiration as much as in *Pila*.

The genus includes two species, one Indian and the other Burmese. The latter is known by shell characters only; it is more globose, generally smooth and larger than the Indian species.

37. **Turbinicola saxea** (Reeve, 1856).
(Fig. 86)

Ampullaria saxea Reeve, 1856, *Conch. Icon.*, **10**, *Ampullaria*, pl. xxii, fig. 108. Type locality: Streams near Khandalla (Prashad, 1925).

Turbinicola saxea: Prashad, 1925, *Mem. Indian Mus.*, **8**: 87, pl. xiv, figs. 10—12.

Type: BM (NH).

Distribution: Hill streams around Khandalla and Igatpuri, Western Ghats.

38. **Turbinicola aperta** (Philippi, 1849)

Ampullaria aperta Philippi, 1849, *Zeitschr. Malakzool.* **6**: 18. Type locality:?

Turbinicola aperta: Prashad, 1925, *Mem. Indian Mus.*, **8**: 88, pl. xv. figs. 1, 2.

Distribution: Hill-streams in Burma.

Family 5. LITTORINIDAE

"Periwinkles"

Shell thick, turbinate, imperforate, whorls more or less rounded, smooth or spirally striate, axially furrowed or nodulose, aperture ovate, operculum horny and paucispiral.

Mainly marine, but extending to estuaries and also in freshwater. Very common in the intertidal zone in the Indo-Pacific region and also in eastern Pacific, Atlantic and Antarctic seas.

Only one freshwater genus *Cremnoconchus* Blanford, 1869.

Subfamily CREMNOCONCHINAE Preston, 1915.

Shell ovate, depressedly turbinate, with large aperture.

Freshwater. India.

Genus 12. **Cremnoconchus** Blanford, 1869.

Cremnobates Blanford, 1863, *Ann. Mag. nat. Hist.*, (3) **12**: 184 (non Swainson, 1865) Preoccupied for a fish.

Cremnoconchus Blanford, 1869, *Ann. Mag. nat. Hist.*, (4) **3**: 343. Type species: *Cremnoconchus syhadrensis* Blanford, O.D.

Shell globose or turbinate, smooth or with spiral striae, periostracum thick, aperture subovate, operculum paucispiral.

Animal with a short and thick snout, tentacles very long, mantle margin with fine finger like processes, penis large.

Hill streams of Western India.

Subgenus **Cremnoconchus** s. str.

Shell broad, stout, sculptured with strong spiral ridges, below flat, with fine striae.

39. **Cremnoconchus (Cremnoconchus) syhadrensis** (Blanford, 1863) (Figs. 88, 89, 89a, b.)

Cremnobates syhadrensis Blanford, 1863, *Ann. Mag. nat. Hist.*, (3) **12**: 184, pl. iv. figs. 1—7 Type locality: Syhadri hills, Khandala, Pune district (Subba Rao & Mitra, 1979).

Cremnoconchus syhadrensis Blanford, 1869. *Ann. Mag. nat. Hist.*, (4) **3**: 343. Subba Rao and Mitra, 1979, *Rec. zool. Surv. India*, **75**: 24.

Distribution: Western Ghats and Igatpuri (Blanford, 1870)

Remarks: Shell globose, whorls $4\frac{1}{2}$, periostracum olive green to brown, perforate, body whorl large, sutures distinct, sculptured with distinct spiral granular ridges in the upper half and fine spiral striae in the lower half, aperture oval, columella slightly reflected, with callus, outerlip thin, a broad white band in between two brown bands inside the aperture.

Foot short, mantle margin free, with a gill and a branchial chamber. Sexes separate.

Subgenus **Lissoconchus** Thiele, 1931.

Shell higher than broad, without any spiral ridges or striae, spire conical, body whorl slightly or prominently keeled.

40. **Cremnoconchus (Lissoconchus) carinatus** (Layard, 1854) (Figs. 90, 91)

Anculotus carinatus Layard, 1854, *Proc. zool. Soc. Lond.*, p. 94. Type locality: "Streams in the Mahakeshwar" (= Mahabaleshwar) hills.

Cremnoconchus carinatus: Blanford, 1870, *J. Asiat. Soc. Beng.*, **39** (2): 12, pl. 3, fig. 5.

Types: BM (NH).

Distribution: Mahabaleshwar hills, Maharashtra.

Remarks: Shell ovately conical, spire short and exserted, whorls inflated, sharply keeled in the middle, minute longitudinal striations, colour olive-yellow, marked with two indistinct broad, brown bands, seen distinctly in the aperture, columellar side slightly callus and white.

41. **Cremnoconchus (Lissoconchus) conicus** (Blanford, 1870) (Figs. 92, 93)

Cremnoconchus conicus Blanford, 1870, *J. Asiat. Soc. Beng.*, **39** (2): 10, pl. 3, fig. 3. Type locality: Torna hills, near Pune.

Distribution: Torna hills, near Pune, Maharashtra.

Remarks: Shell ovately conical, spire conical, sutures distinct, angle at the periphery slightly marked in the typical form but distinct in the variety *canaliculatus*.

Judging from the figures and description given by Blanford (1870) *C. conicus* should be synonymous with *C. carinatus* Layard. According to him "perhaps all three forms (refers to *C. carinatus, C. conicus* and its var. *canaliculatus*) should be considered as varieties of one species, for which, however the name *carinatus,* which is not very appropriate even for full grown specimens of the Mahabaleshwar hills can scarcely be retained with propriety"

Family 6. HYDROBIIDAE*

Shell elongate conical, rarely higher than 10 mm., smooth, narrowly umbilicate to imperforate, aperture ovate. Operculum horny (corneous), usually paucispiral.

Snout long, terminally a little divided, foot broad and simple, not divided, anteriorly truncate and posteriorly rounded.

Radula 2:1:1:1:2. Central broader than long, with cusps on the basal edge.

Oesophagous without gland, stomach with crystalline style. Verge slightly to the right of mid dorsum and without a flagellum.

Sexes separate and development direct.

World-wide. Marine, brackish and freshwater and a few extending on to land.

Three subfamilies viz. Hydrobiinae, Triculinae, and Iravadiinae, each represented by a single genus.

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* The name is tentatively used. Iravadiinae is elevated to a family by recent authors. Triculinae is a subfamily under Pomatiopsidae and the position of *P. nevilli* is not known.

Annandale (1920) dealt with different Indian genera in the family Hydrobiidae and pointed out the deficiencies in the Preston's Fauna Volume.

Subfamily HYDROBIINAE

Genus 13. **Potamopyrgus** Stimpson, 1865

Subgenus **Indopyrgus** Thiele, 1928

Shell smooth, radula with finely toothed central. Similar to *Amnicola.*

42. **Potamopyrgus (Indopyrgus) nevilli** Thiele, 1928.

Potamopyrgus (*Indopyrgus*) *nevilli* Thiele, 1928, *Zool, Jahrbuch.*, (*Syst. Abth.*), **55**: 373, pl. 8, fig. 7. Type locality: Andamans.

Types: Berlin Museum.

Distribution: Not known beyond Andamans (Except type no other material is known).

Remarks: Shell oval, smooth, spire short and blunt, body whorl large, aperture slightly oblique, oval, margins thickened. Operculum thin, horny and spiral.

Subfamily TRICULINAE Annandale, 1924

Shell small or of moderate size, rarely 10 mm. in height, elongate with a number of whorls. Operculum thin, transparent and paucispiral.

Radula with relatively broad denticulations, Rachidian or central with two or three lateral denticulations on either side.

Foot simple, undivided and not produced anteriorly.

Snout comparatively short and broad, tentacles filiform. Gill filaments usually prolonged across the roof of the mantle cavity to the anal border, true gills comparatively reduced in length but expanded and bear long cilia. Verge without a lateral appendage.

Among stones or weeds in very shallow waters of mountain streams or at the edge of rivers.

India, Sri Lanka, Upper Burma, Thailand and China.

Genus 14. **Tricula** Benson, 1843

Tricula Benson, 1843, *Calcutta J. nat. Hist.*, **3**: 467.

Type species: *Tricula montana* Benson. Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 3.

Shell small, thin and elongate, surface smooth and glossy, narrowly perforate or imperforate, columellar callus poorly developed and outer lip thin; aperture ovate to subquadrate, operculum thin, horny and paucispiral.

Foot elongate, truncate anteriorly and rounded posteriorly, central tooth of radula without basal denticulations, verge without lateral process. Mountain streams of Central, North and North east India, North and East Burma, South-east Asia-Malaysia, Laos, Cambodia and the Philippines.

The genus is regionally known by six species, two from India and four from Burma.

Recent studies have shown that the genus includes 20 to 25 species and has a wider distribution. Davis (1960, 1976, 1979, 1980a, b) and Davis et al (1983, 1984) have made important contributions to our knowledge on the anatomy of *Tricula*.

Key to the species of **Tricula** (After Rao, 1928).

1. Out line of the shell conspicuously broken by the suture 2

   Outline of the shell not conspicuously broken by the suture 5

2. Outline of aperture rounded, outerlip uniformly thickned ..... *T. gravelyi*

   Outline of aperture oval, outerlip not uniformly thickned 3

3. Shell with rather narrow whorls, when viewed ventrally the anterior margin of the aperture projecting considerably in advance of the outline of the bodywhorl ..... *T. montana*

   Shell with broad whorls, ventrally anterior margin of aperture not projecting conspicuously 4

4. Shell opaque and coloured when fresh, outerlip thickened ..... *T. martini*

   Shell hyaline when fresh, outerlip not very much thickened ..... *T. gregoriana expansa*

5. Shell height exceeding 5 mm, aperture elliptical and produced above and below ..... *T. taylori*

   Shell height not exceeding 5 mm, aperture oval and not so produced ..... *T. horae*

43. **Tricula gravelyi** Prashad, 1921
(Fig. 98)

Tricula gravelyi Prashad, 1921, *Rec. Indian Mus.*, **22**: 69, figs. lc, ld. Type locality: Still creek, amongst small islands in the bed of the Narmada river, at Hoshangabad, Madhya Pradesh.

Types: ZSI Regd. No. M 11895/2. (Syntypes).

Distribution: Not known beyond type locality.

Remarks: Shell elongate oval with obtuse apex, whorls $5\frac{1}{2}$ to $6\frac{1}{2}$, increase regularly, suture oblique, deeply impressed but not canaliculate, aperture smaller than in *T montana.*

Found attached to weeds. It is the only species found in still creeks in the plains, while all the other species occur "in weedy streams at moderate altitudes"

44. **Tricula gregoriana expansa** Rao, 1923
(Figs. 101, 102)

Tricula gregoriana expansa Rao, 1928, *Rec. Indian Mus.*, **30**: 437, text-fig. 11. Type locality: Mongyu, Shan states.

Types: ZSI Regd. No. M 12808/2 (Syntypes).

Distribution: Burma

Remarks: Shell elongate ovate, polished, 6—$6\frac{1}{2}$ whorls, aperture broadly ovate, columellar callus slightly reflected over the umbilicus.

Found sticking to the weeds in streams.

45. **Tricula horae** Annandale & Rao, 1925
(Figs. 95, 103, 104)

Tricula horae Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 116. fig. 6. Type locality: He-Ho Gorge.

Types: ZSI Regd. No. M 12460/2. (Syntypes).

Distribution: Burma.

Remarks: Shell narrowly ovate, whorls $5\frac{1}{2}$ to 6, apex blunt, body whorl occupying nearly half the length of the shell, columellar callus well developed in the form of a narrowly flattened ridge continuous at the lip and closing the umbilicus.

Rao (1928) expressed a doubt regarding the occurrence of this species and its variety, viz. *T horae var. major* in the living condition.

46. **Tricula martini** Rao, 1928
(Fig. 99)

Tricula martini Rao, 1928, *Rec. Indian Mus.*, **30**: 434, text. fig. 9. Type locality: At Kutkai, in a small channel flowing into the Nam Geng river, S. Shan states.

Types: ZSI Regd. No. M 12807/2 (Syntypes).

Distribution: Burma.

Remarks: The species is similar to *T gregoriana* but differs from it in having a thicker shell, a deeper suture and more convex whorls. Shell lemon yellow to brown.

47. **Tricula montana** Benson, 1843
(Figs. 96, 97)

Tricula montana Benson, 1843, *Calcutta J. nat. Hist.*, **3**: 467. Type locality: Bhimtal, Nainital, Uttar Pradesh. Prashad, B. 1921. *Rec. Indian Mus.*, **22**: 67. figs. la, lb.

Distribution: India: Bhimtal, U.P., Jhiri Valley, Assam; Central Sri Lanka.

Remarks: Shell conically ovate, twice as long as broad, apex obtuse, whorls $5\frac{1}{2}$—6, increase irregularly, sutures oblique, curved and somewhat canaliculate.

"On stems and leaves of an aquatic plant in a stream flowing through the marsh at the head of the Bhimtal Lake."

Prashad (1921) could not collect any specimen from the type locality, when he visited the place in August, 1920. The species has been rediscovered recently and its anatomy has been studied (Davis et al. 1986).

48. **Tricula taylori** Rao, 1928.
(Fig. 100)

Tricula taylori Rao, 1928, *Rec. Indian Mus.*, **30**: 432, Text fig. 7. Type locality: A small stream on the Reservoir road in Lashio, N. Shan States.

Types: ZSI Regd. No. M 12806 (2 (Syntypes).

Distribution: Burma.

Remarks: Shell larger than in all the species of *Tricula,* whorls 6—$7\frac{1}{2}$, whorls evenly increasing, the body whorl oblique and narrow at the begining but broadens out distally trumpet-like, body whorl with a slight peripheral keel giving it an angular appearance in ventral view, columellar callus thick and unusually broad, a distinct narrow channel runs from the more or less closed umbilicus to the anterior end of the shell.

Subfamily IRAVADIINAE Thiele, 1928

Shell small, periostracum brown, whorls with strong spiral ridges, aperture oval, peristome thick, with an external varix, columellar margin weak above, operculum horny, not spiral, nucleus nearer to the inner margin, two transverse ridges on the inner side.

Radula with a short and broad central, with additional cusps on either side of basal corners, laterals long.

Mostly estuarine. India and Burma.

A single genus.

Genus 15. **Iravadia** Blanford, 1867

Iravadia Blanford, 1867, *J. Asiat. Soc. Beng.*, **36** (2): 56.

Type species: *Iravadia ornata* Blanford.

Shell imperforate, turreted with spiral ridges, thick, covered with periostracum, aperture oval.

Four species from the Indian region and all known by their Types. They may all turn out to be one and the same species. However, a provisional key is given below to distinguish them from each other. Brackish-water.

1. Shell very much elongated, whorls five or more 2

   Shell stunted and fusiform, whorls generally three ..... *I. funerea*

2. Sculptured with very distinct regular spiral lirae, interstices crossed by fine transverse striae 3

   Sculptured with spiral lirae, interstices not very deep, transverse striae almost obsolete ..... *I. annandalei*

3. Spire very much pointed, lower margin of columella produced ..... *I. princeps*

   Spire comparatively less pointed, lower margin of columella not much produced ..... *I. ennurensis*

49. **Iravadia annadalei** Preston, 1916.
(Figs. 105, 106)

Iravadia annandalei Preston, 1916, *Rec. Indian Mus.*, **12**: 31, fig. 8, 8a. Type locality: Ennur back-waters.

Type: ZSI Regd. No. M 10051/2. (Holotype).

Distribution: Cochin and Ennur backwater.

Remarks: Differs from *ennurensis* in its more slender form, more acute lirations and obsolete, transverse striae, aperture smaller, whorls 6.

50. **Iravadia ennurensis** Preston, 1916.
(Figs. 107, 108)

Iravadia ennurensis Preston, 1916. *Rec. Indian Mus.*, **12**: 31, fig. 7, 7a. Type locality: Ennur backwater, Madras.

Type: ZSI Regd. No. M 10050/2 (Holotype).

Distribution: Not known beyond type locality.

Remarks: Shell cylindrically fusiform, whorls 5, sculptured with regular revolving spiral lirae crossed by fine transverse striae, suture impressed, finely lirate above, parietal callus restricted and well defined.

51. **Iravadia funerea** Preston, 1916.
(Figs. 109, 110)

Iravadia funerea Preston, 1916, *Rec. Indian Mus.*, **12**: 30, fig. 6, 6a. Type locality: Cochin backwater, near Ernakulam.

Type: ZSI Regd. No. M 10052/2 (Holotype)

Distribution: Not known beyond type locality.

Remarks: Shell ovately fusiform, whorls 3, sculptured with coarse spiral lirae showing traces of transverse striations, suture impressed, columellar margin vertically descending, parietal callus restricted and well defined.

52. **Iravadia princeps** Preston, 1915
(Figs. 111, 112)

Iravadia princeps Preston, 1915, *Rec. Indian Mus.*, **11**: 480, fig. 2, 2a. Type locality: Canal near Chingrighatta, outskirts of Calcutta.

Type: ZSI Regd. No. M 9741 (Holotype).

Distribution: Known from type locality only.

Remarks: Shell elongately fusiform, whorls 7, sculptured with fine, acute regular and slightly distant spiral lirae, interstices occupied by very fine transverse riblets, suture impressed, columellar margin porcellanous, narrowly outwardly expanded and reflexed.

Family 7. BITHYNIIDAE

Shell ovate to elongate-turreted, narrowly umbilicate to imperforate, moderately convex whorls. Aperture ovate to round, some times expanded basally, peristome continuous and thickened, columellar fold ridgelike. Operculum as large as aperture, thick, calcareous and concentric with a small subcentral, spiral nucleus.

Tentacles long with thickened bases bearing eyes on lateral side. *Radula 2:1,* central tooth of the radula with or without a series of latero-basal denticulations on either side.

Sexes separate. Verge located on the dorsal side of the neck, curved, fleshy and bifid. A long finger like appendage on the inner concave part. A small, cupshaped skin flap attached to the right side of the head just behind the right tentacle.

Freshwater streams, stagnant water pools and paddy fields.

Europe, Asia, Africa, Australia and North America.

Pace (1973) reviewed the validity of the nomenclature of this family. Benthem Jutting (1956) used the family name Bulimidae. Important contributions include Annandale (1920a, 1924), Annandale and Prashad (1921a, 1924), Annandale, Prashad and Kemp (1919), Abbott (1948), and Walker (1925, 1927).

Represented by five genera namely, *Bithynia, Digoniostoma, Gabbia Sataria* and *Mysorella.*

Godwin-Austen (1919a) while describing the new genus *Mysorella* suggested that it should be placed in a separate family. But Annandale (1920) preferred to treat it under a separate subfamily *Mysorellinae* as distinct from the other subfamily *Bithyniinae,* which includes the other four genera.

Key to subfamilies

Shell not very thick, smooth to the naked eye or with fine spiral ridges; ovate or globose, columellar fold ridge-like, central tooth with a series of latero-basal denticulations on either side ..... BITHYNIINAE

Shell rather thick, with strong spiral ridges, turbinate, columellar fold not ridge-like, central tooth without latero-basal denticulations but with a single downwardly directed blunt process on either side ..... MYSORELLINAE

Subfamily BITHYNIINAE (BULIMINAE)

Annandale (1920*b*) included four genera namely *Bithynia, Digoniostoma, Sataria* and *Gabbia* in this subfamily.

Key to genera

1. Operculum with a distinct but paucispiral figure situated near the middle of the lower part, transparent, columellar fold ridge-like but by no means prominent, groove running from the umbilicus absent ..... **Gabbia (=Alocinma)**

   Operculum concentric, thick with central or subcentral nucleus, internally smooth, columellar fold ridge-like and prominent, a well defined groove running downwards from the umbilicus 2

2. Shell generally more elongate, smooth or with microscopic spiral striae 3

   Shell trochiform with fine but distinct spiral grooves ..... **Sataria**

3. Outer lip thin, not produced or angulate at its inner extremity ..... **Bithynia**

   Outer lip slightly thickened, produced and angulate or subnagulate at its inner extremity ..... **Digoniostoma**

Genus 16. **Bithynia** Leach, 1818

Bithynia Leach, 1818 in Abel's *Narrative of Journey into interior of China*, p. 362. Type species: *Helix tentaculata* Linnaeus, 1758.

Shell elongate-conical and acuminate. Whorls convex, usually perforate but constricted, a well defined groove extending obliquely downwards from the umbilicus to columellar fold, a sharp and prominent ridge forming a wall along the inner margin of the groove. Operculum not very thick, externally with coarse concentric ridges, nucleus central or sub-central, internally almost smooth.

The denticulations of the lateral teeth greatly enlarged, denticulations of marginals minute and sharp.

Mainly Palaearctic but extending into Kashmir and neighbouring countries.

Two species were reported from Kashmir but only one is definitely known.

53. **Bithynia tentaculata kashmirensis** (Nevill, 1884)

Bithynia tentaculata var. *kashmirensis* Nevill, 1884, *Hand List Moll. Indian Mus.*, **2**: 39
Type locality: Srinagar, Kashmir.

Bulimus tentaculatus (Linnaeus) var. *kashmirensis;* Rajagopal and Subba Rao, 1968, *Proc. Symposium Mollusca.* Mandapam, pt. 1, p. 99.

Types: ZSI Regd. No. 2236

Distribution: Kashmir (common in paddy fields). Salt Range, Punjab.

Remarks: Shell conically ovate, greenish brown, whorls five, smooth, convex, apex rather sharp, umbilicus minute or almost closed, aperture pyriformly ovate, lip generally dark-edged, scarcely reflected. Operculum with a central nucleus.

54. **Bithynia troscheli** (Paasch, 1842)

Paludina troscheli Paasch, 1842 *Archiv. fur Naturgeschaft*, 1842, p. 300, pl. 6, figs. A-D.

Bithynia troscheli: Preston, 1915, *The Fauna of British India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 77.

Distribution: Europe; Kashmir.

Remarks: Its occurrence in Kashmir is doubtful. There are no recent records or collections to prove its occurrence there.

Shell small, ovately fusiform, suture rather deep, aperture ovate.

Genus 17. **Sataria** Annandale, 1920

Sataria Annandale, 1920. *Rec. Indian Mus.*, **19**: 45.
Type species: *Bithynia evezardi* Blanford.

Shell moderately small and thick, trochiform, whorls swollen, perforate, a broad and deep oblique groove extending down the umbilicus, peristome

continuous, internally thickened, prominent and produced to a point both above and below, sculpture of fine but distinct spiral grooves. Operculum calcareous, stout, smaller than the aperture, externally with strong concentric ridges, central nucleus, internally convex and smooth.

Central tooth with a quadrate process on the disc, denticulations of the teeth blunt.

Western Ghats.

55. **Sataria evezardi** (Blanford, 1880)
(Figs. 117, 118)

Bythinia evezardi Blanford, 1880, *J. Asiat. Soc. Beng.*, **49** (2): 220. Type locality: Lanaoli, between Bombay and Pune. Nevill, 1881, *J. Asiat. Soc. Beng.*, **50** (2): 157, pl. 6, fig. 13.

Types: ?

Distribution: Maharashtra: Khandala and Mahabaleshwar.

Remarks: Whorls 4 to 5, rounded, spire conical, sutures deeply impressed, sculptured with regular, close and impressed spiral lines. Aperture oval, subangulate at the anterior and posterior ends, peristome simple, straight, obtuse, umbilicus distinct.

Genus 18. **Gabbia** Tryon, 1865

Gabbia Tryon, 1865, *Amer. J. Conch.*, **1**: 216.

Type species: *Gabbia australis* Tryon.

Alocinma Annandale and Prashad, 1919, *Rec. Indian Mus.*, **18**: 23 (as subgenus of *Amnicola*).

Type species: *Amnicola* (*Alocinma*) *sistanica* Annandale and Prashad, 1919.

Shell more or less globose, with somewhat tumid whorls, body whorl large, sutures wide, imperforate or subumbilicate, columellar fold ridge-like but not prominent, no well defined groove extending down the umbilicus. Operculum thick and calcareous but usually hyaline or subhyaline, distinctly spiral and with a slightly cocentric nucleus, but ornamented round the margin with concentric lines.

Foot relatively short projecting very little beyond the shell, rounded or pointed posteriorly and angulate anteriorly, snout long and narrow.

Radula similar to that of *Amnicola.* Central tooth with a distinct quadrate projection on its disc, with very few laterobasal denticulations at some distance from lateral margins.

Verge (penis) almost in the middle of 'neck; large and flattened.

India, Australia, Africa and Mesopotamia. All species of so-called *'Gabbia'* reported to occur in Africa are now classified in a distinct genus, *Gabbiella* Mandahl-Barth (Brown, personal communication, and Brown 1980).

Key to species

1. Shell globose, thick, body whorl proportionately swollen, columellar callus well developed 2

   Shell ovately fusiform, not so thick, body whorl not much swollen, columellar callus not much developed 3

2. Aperture somewhat contracted (body whorl smooth) ..... *G. stenothyroides*

   Outerlip slightly produced outwards (body whorl with raised ridges) ..... *G. physcus*

3. Shell narrowly umbilicate ..... *G. alticola*

   Shell imperforate 4

4. Shell with rounded whorls and deep sutures, columellar margin descending at an angle ..... *G. orcula*

   Shell with obliquely rounded whorls and shallow sutures, columellar margin ridge-like and descending almost straight ... *G. travancorica*

56. **Gabbia orcula** Frauenfeld, 1862

Bithynia orcula Frauenfeld, 1862, *Verhandl. Zool. Bot. Geschaft,* p. 1154. Type locality: "in Cuming's Sammlung Von Ganges, Ranewalla, Ceylon, Barrackpore". Hanely and Theobald 1876, *Conch. Indica.* pl. XXXVIII, figs, 9, 8.

Amnicola (*Alocinma*) *orcula:* Annandale, 1921 *Rec. Indian Mus.,* **22**: 540.

Types: ?

Distribution: Assam, West Bengal, Bihar, Uttar Pradesh, Punjab, Rajasthan and Maharashtra.

Remarks: Shell globosely conic, almost imperforate, smooth, whorls four, slightly rounded, body whorl swollen, columellar margin a little reflected. Sewell (1922) recorded a few cercariae from this species but there are no subsequent records.

57. **Gabbia orcula** var. **producta** (Nevill, 1884) (Fig. 142)

Bithynia orcula var. *producta* Nevill, 1884, *Hand list Moll. Indian Mus.*, **2**: 37. Type locality: Not mentioned.

Alocinma orcula var. *producta:* Ray and Mukherjee, 1963, *Rec. zool. Surv. India*, **61**: 420, pl. 19, figs. 1, 1a.

Types: No designation was made.

Distribution: Assam, West Bengal, Bihar, Uttar Pradesh, Punjab, Rajasthan, Maharashtra, Andhra Pradesh.

Remarks: Shell much narrower and more elongate than in the typical form.

58. **Gabbia stenothyroides** (Dohrn, 1857) (Figs. 143, 144)

Bythinia stenothyroides Dohrn, 1857, *Proc. zool. Soc. Lond.*, 1857, p. 123. Type locality: "Ceylon, Nilgheries." Hanley and Theobald, 1876, *Conch. Indica*, pl. 38, figs. 7 & 10.

Distribution: India: Pune, Nilgiris, South Arcot, Tiruchirapalli, Madras; Sri Lanka.

Remarks: Shell ovate, whorls 4—5, convex, smooth, body whorl proportionately larger, spire comparatively short, broadly conical, mouth somewhat contracted.

It bears some resemblance to *Gabbia orcula.* Annandale (1920*b*) was right when he assigned this to the subgenus *Alocinma* (=*Gabbia*). On examining the collection in ZSI, it has been found that it should be included in the genus *Gabbia.*

59. **Gabbia physcus** (Annandale, 1918)
(Fig. 127-129)

Hydrobioides physcus Annandale, 1918, *Rec. Indian Mus.*, **14**: 921, pl. xiii, figs. 8, 8a, 9. pl. xiv, figs. 5, 5a. Type locality: Inle Lake, S. Shan States.

Types: ZSI Regd. No. M 11113/2. (Syntypes)

Distribution: Burma

Remarks: Shell thick, globose, subumbilicate with the spire short and pointed, whorls $4\frac{1}{2}$, body whorl relatively very large and swollen, aperture with the outer lip slightly produced outwards, not much thickened, varix not well-defined, runs a short distance above the lip but not parallel to it.

60. **Gabbia alticola** (Annandale, 1918).
(Figs. 147, 148)

Amnicola alticola Anandale, 1918, *Rec. Indian Mus.*, **14**: 122, pl. xiv, figs. 6, 6a. Type locality: Inle Lake, S. Shan States.

Types: ZSI Regd. No. M 11110/2. (Syntypes)

Distribution: Burma.

Remarks: Shell ovately fusiform, sculptured with close-set longitudinal striae, whorls swollen, suture impressed, narrowly unbilicate, aperture large, strongly rimate and projecting, columella arched, operculum testaceous, with 4 distinct whorls.

61. **Gabbia travancorica** (Benson, 1860)
(Figs. 145, 146)

Bithynia travancorica Benson, 1860, *Ann. Mag. nat. Hist.*, (3) **6**: 259. Type locality: Quilon. Hanley and Theobald, 1876. *Conch. Indica*, pl. 38, figs. 2, 3.

Type: Cambridge University Museum.

Distribution: South India: Andhra Pradesh (Visakhapatnam) and Kerala (Quilon).

Remarks: Shell conically globose, whorls $4\frac{1}{2}$, sutures impressed, imperforate, aperture oval, columellar margin ridge-like.

Genus 19. **Digoniostoma** Annandale, 1920

Digoniostoma Annandale, 1920, *Indian J. Med. Res.*, **7**: 104. Type species: *Paludina cerameopoma* Benson.

Shell elongately ovate, or pyramidal, whorls convex, body whorl relatively large and inflated, finely striated, narrowly perforate, aperture rounded, peristome continuous, somewhat expanded at the base, columellar callus thick, broad, prominent and with laminated appearance.

Operculum calcareous, spirally coiled in the centre, periphery concentrically ridged, nucleus almost central.

Central tooth with small cusps in basal corners.

Generally in fresh strangnant waters like pools, ponds and lakes or small sluggish streams.

India, Southern China, Siam, Malay Archipelago, New Guinea and the Philippines.

Key to species

1. Lip at the base of columella prominently produced, spire shorter than the body whorl 2

   Lip at the base of columella not much produced, spire longer than the body whorl ..... *D. pulchella*

2. Shell oval, sutures not much impressed ..... *D. textum*

   Shell elongated, sutures impressed ..... *D. cerameopoma*

62. **Digoniostoma cerameopoma** (Benson, 1830) (Fig. 121)

Paludina cerameopoma Benson, 1830, *Gleanings in Science*, Calcutta, **2**: 125. 1855. *J. Asiat, Soc. Beng.*, **24**: 131. Type locality: Ditch at Nanda, Madhya Pradesh.

Type: Cambridge University Museum.

Distribution: India: Assam, West Bengal, Bihar, Madhya Pradesh, Rajasthan, Punjab: Pakistan.

Remarks: Shell oblong-ovate, whorls five, regularly and rather rapidly increasing, sculptured with very fine, weak spiral striae and weak growth lines, suture well impressed, umbilicus moderately narrow and deep, peristome continuous and slightly reflected, aperture oval and oblique. Operculum calcareous, concave, nucleus subcentral.

63. **Digoniostoma pulchella** (Benson, 1836).
(Figs. 113, 114, 119, 120)

Paludina pulchella Benson, 1836, *J. Asiat, Soc. Beng.*, **5**: 746. Type locality: Mirzapore, U.P. Hanley and Theobald, 1876. *Conch. Indica,* pl. 38, figs. 5, 6.

Type: Cambridge University Museum.

Distribution: Throughout India extending to plains of Assam in east, and Jammu in north-west. Also Andamans, Burma and Malay Archipelago.

Remarks: Shell elongate, spire longer than the body whorl, sutures depressed, umbilicus almost closed, aperture oval.

64. **Digoniostoma textum** Annandale, 1921
(Figs. 115, 116)

Digoniostoma textum Annandale, 1921, *Rec. Indian Mus.*, **22**: 541, figs. 1, 2. Type locality: Manipur.

Types: ZSI Regd. No. M 11860/2.

Distribution: Manipur valley.

Remarks: Whorls $4\frac{1}{2}$, spire shorter than the body whorl in dorsal view, suture oblique, not very much impressed, aperture narrowly oval, posteriorly the outerlip meets the columellar callus at an angle slightly greater than a right angle, columellar margin arched, prominent and thick, umbilicus almost closed. Operculum large, moderately thick, internally convex and granular.

Genus 20. **Hydrobioides** Nevill, 1884

Hydrobioides Nevill, 1884, *Hand List Moll. Indian Mus.*, **11**: 42.

Type species: *Bithynia turrita* Blanford.

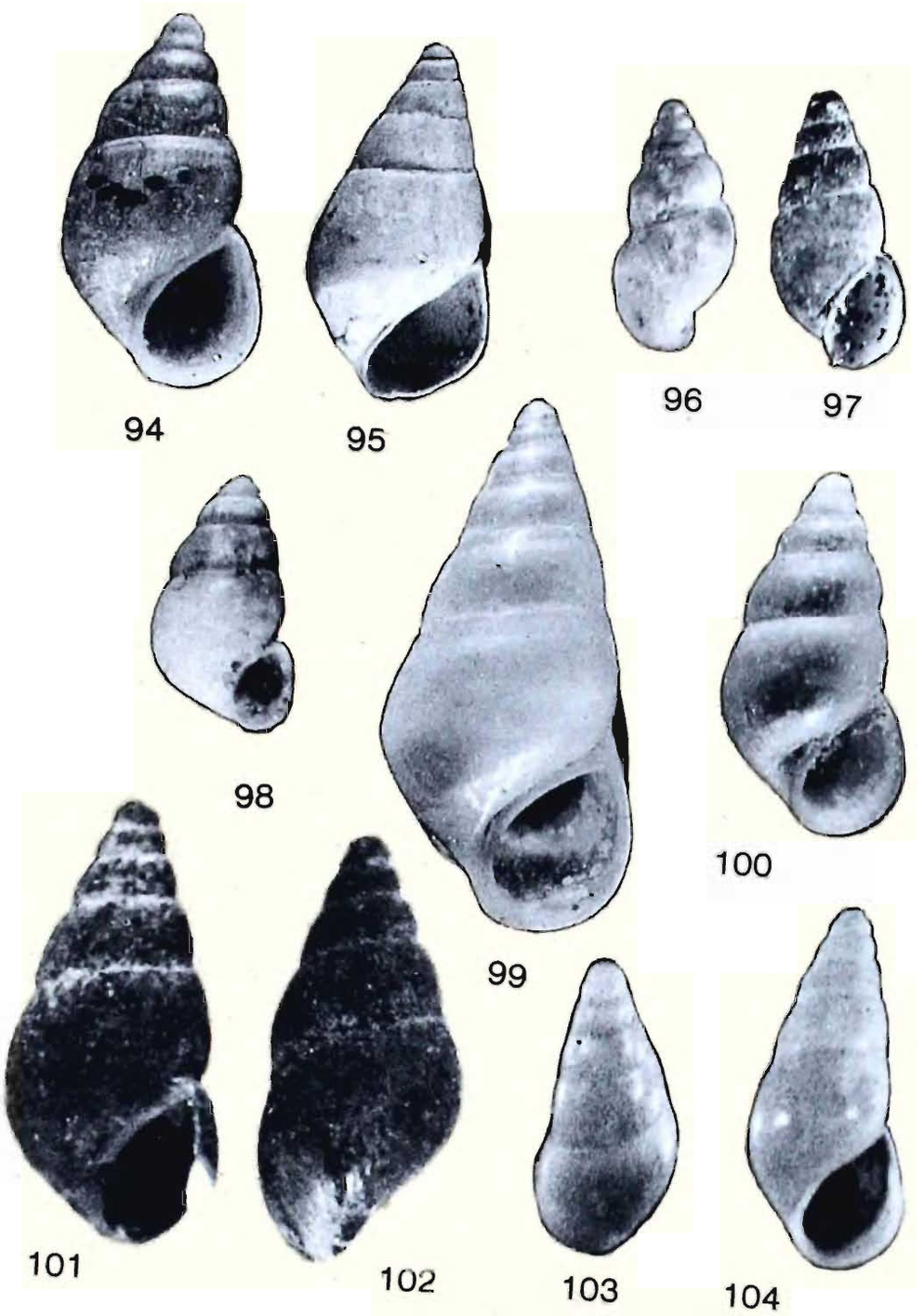
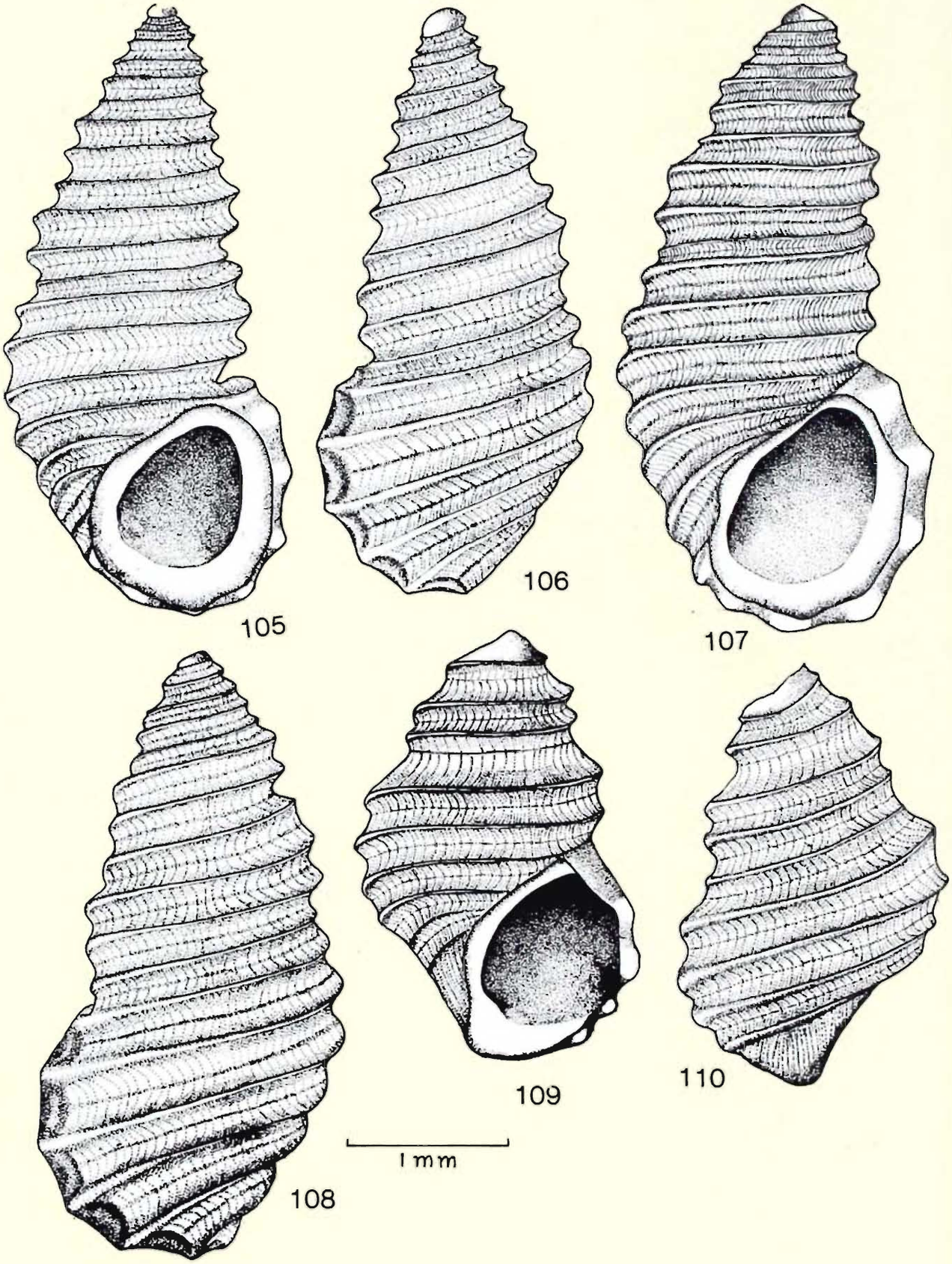
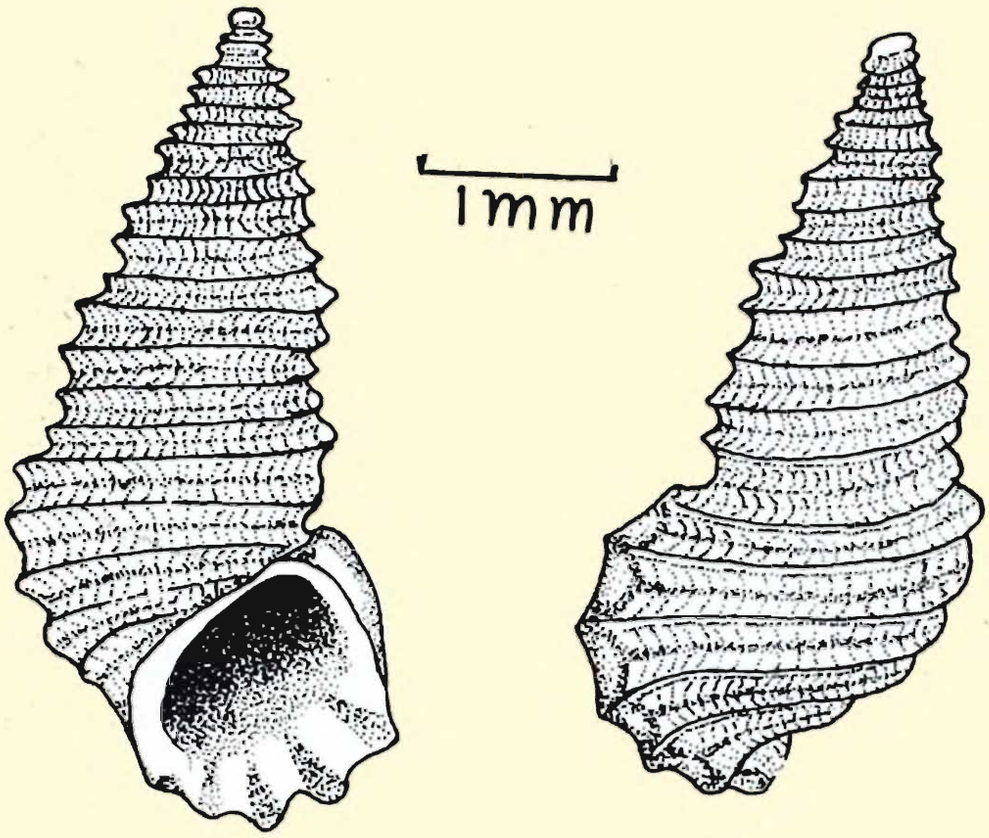


Fig. 94. *Tricula gregori expansa*, Lectotype, 4.20 × 2.10 mm., Burma. 95. *Tricula horae major* Lectotype, 3.90 × 2.10 mm., Burma. 96, 97. *T. montana*, 3.55 × 1.60 mm.; 3.65 × 1.60 mm., Nainital. 98. *T. gravelyi*, Lectotype, 2.51 × 1.25 mm., Hoshangabad. 99. *T. martini*, Lectotype, 4.0 × 1.9 mm., Burma. 100. *T. taylori*, Lectotype, 5.60 × 2.65 mm., Burma. 101, 102. *T. gregoriana*, Holotype, 3.50 × 1.50 mm., Awa bend, Burma. 103, 104. *T. horae*, Lectotype, 2.90 × 1.30 mm., Burma.



Figs. 105, 106. *Iravadia annandalei*, Holotype, 4.0 × 1.65 mm., Ennur backwater. 107, 108. *I. ennurensis*, Holotype, 4.40 × 1.65 mm., 109, 110. *I. funerea*, Holotype, 2.95 × 1.55 mm., Ennur backwater.



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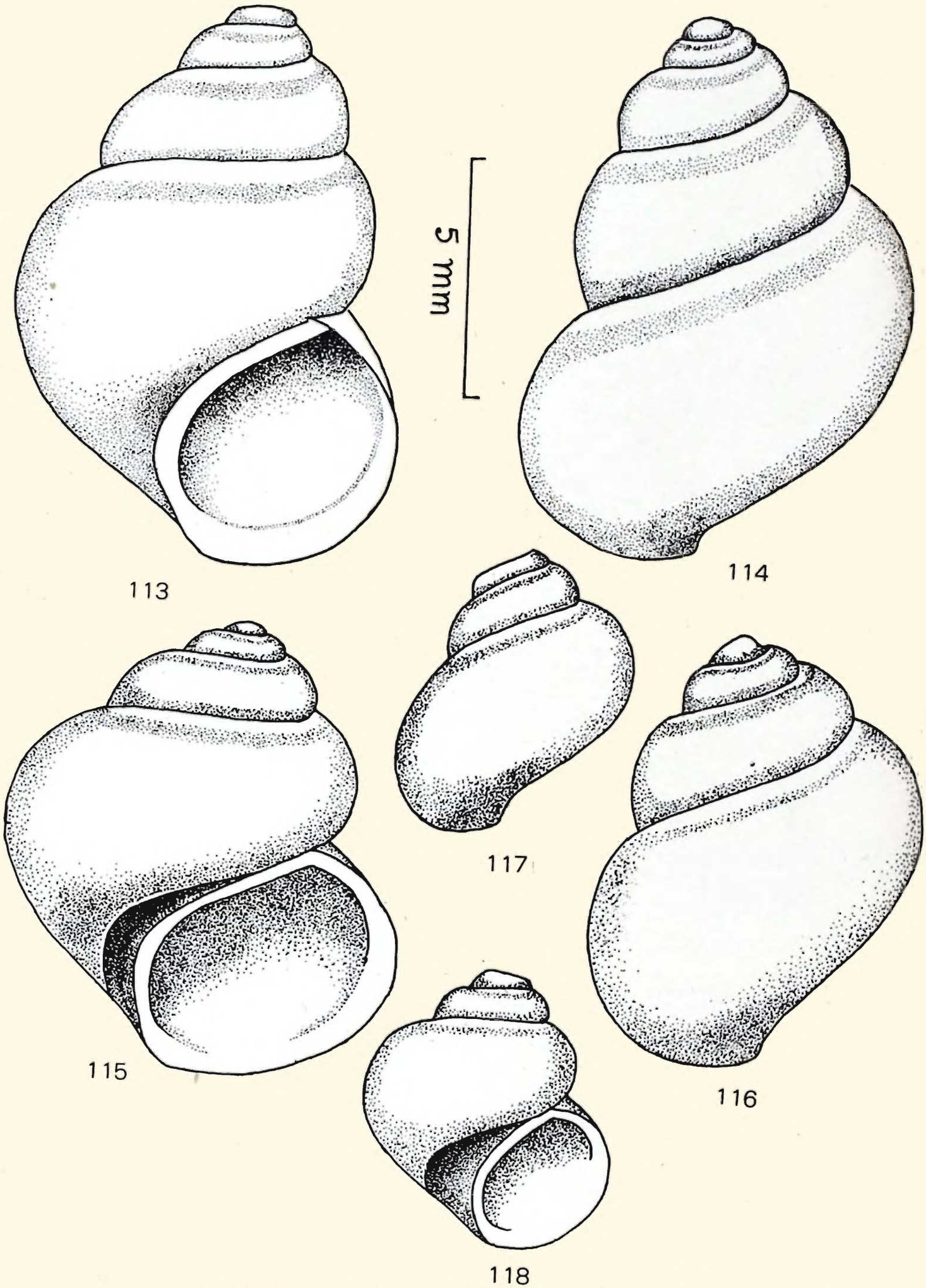
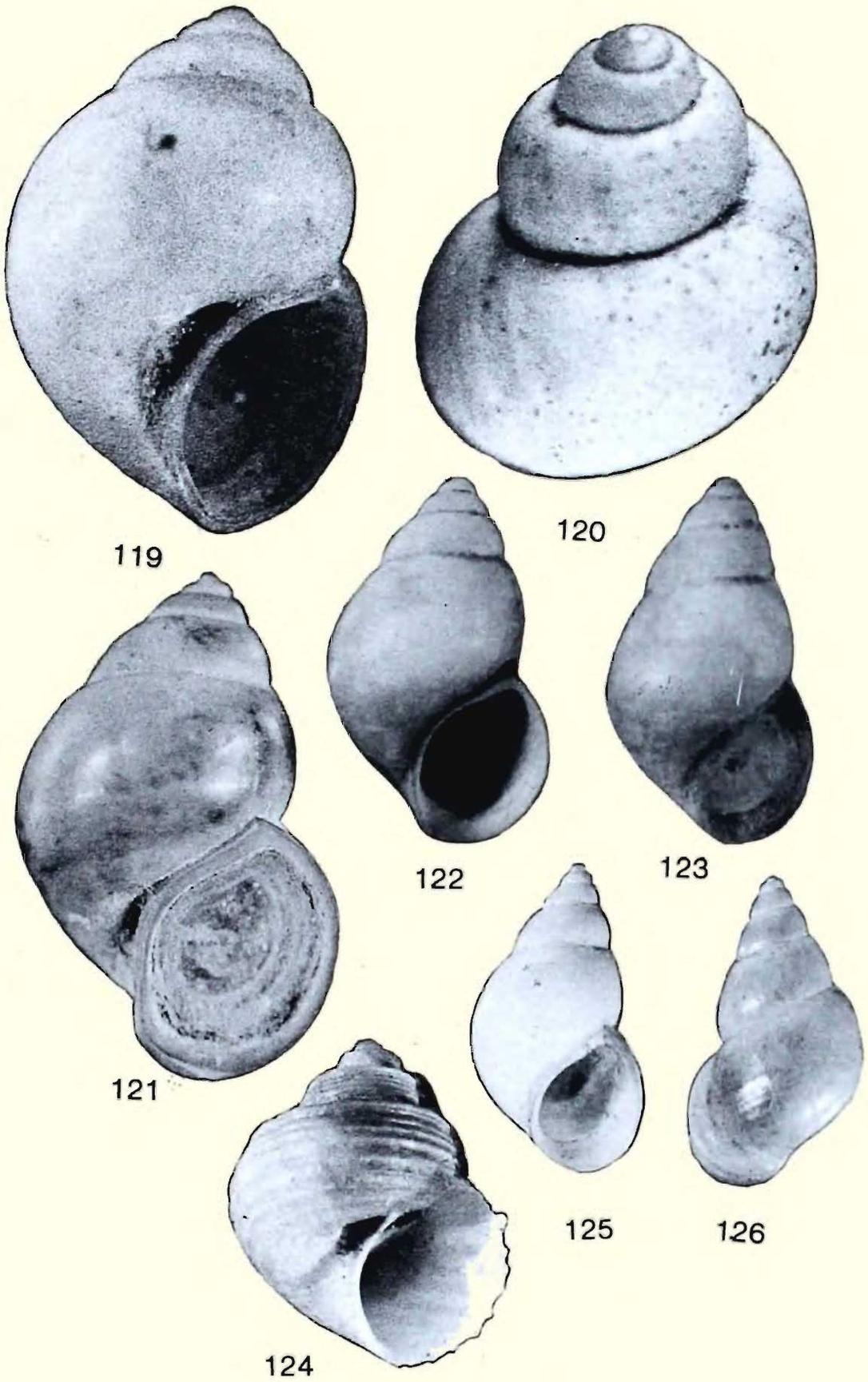
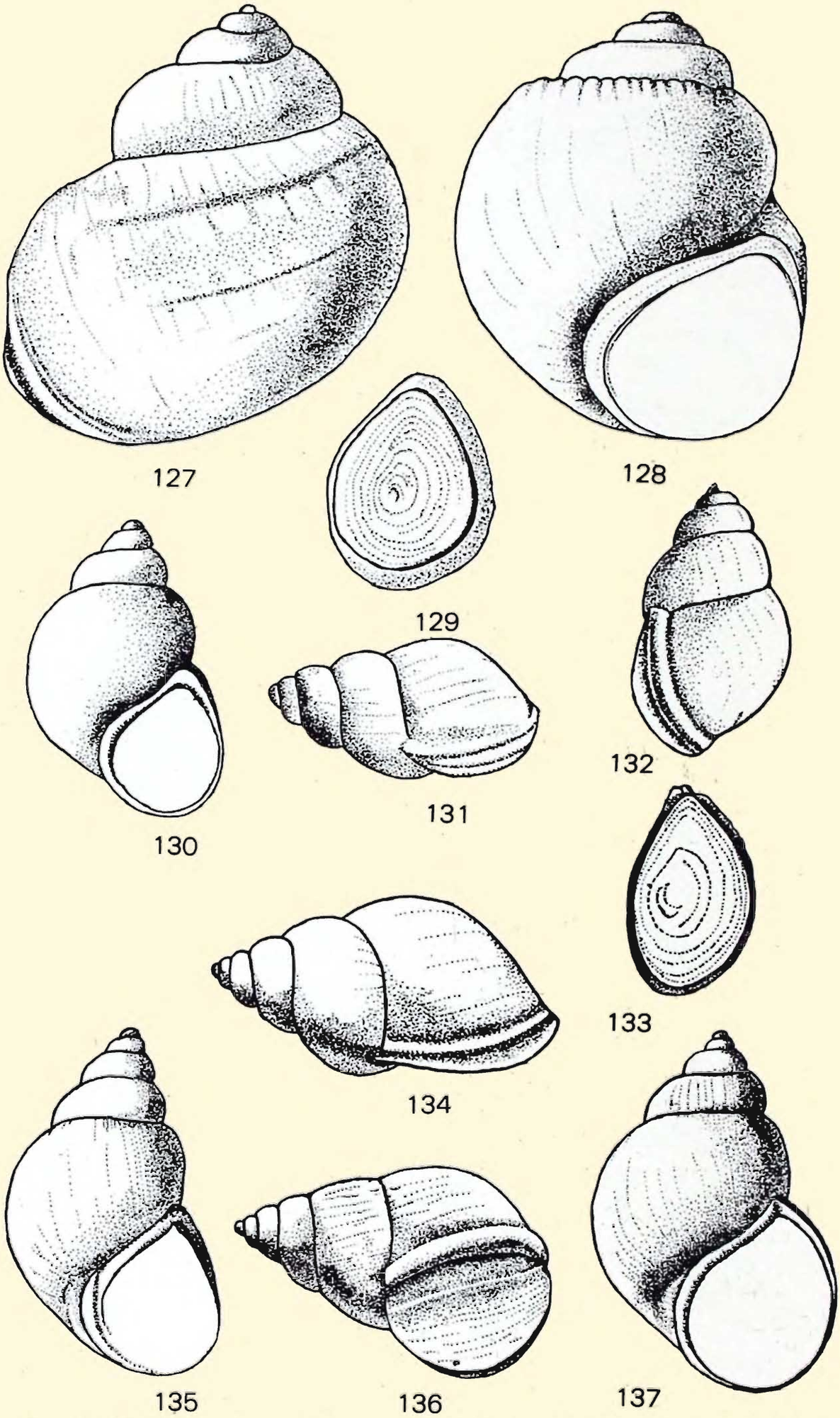
111, 112. *I. princeps*, Holotype, 6.85 × 2.90 mm., Outskirts of Calcutta.



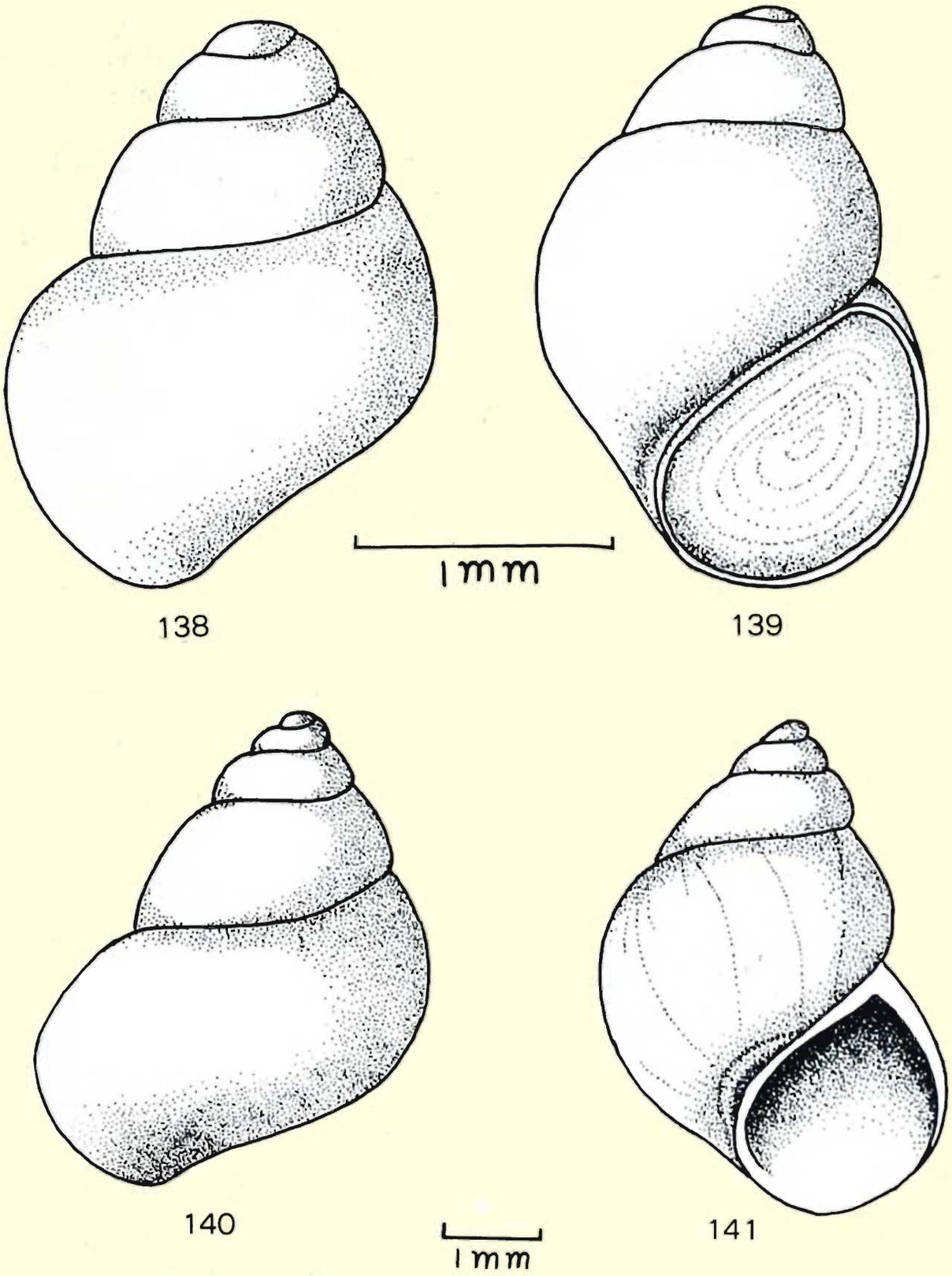
Figs. 113, 114. *Digoniostoma pulchella*. 115, 116. *D. textum*, Syntype, 6.0 × 4.35 mm., Manipur. 117, 118. *Sataria evezardi*, 4.10 × 2.85 mm., Pune.



Figs. 119, 120. *Digoniostoma pulchella*, 6.45 × 4.65 mm.; 7.10 × 4.70 mm., Pune. 121. *D. cerameopoma*, 7.50 × 5.37 mm., Patna. 122, 123. *D. iravadica*, 8.10 × 5.60 mm. 124. *Mysorella costigera*, 5.22 × 3.68 mm., Bangalore. 125, 126. *Hydrobioides nassa*, 9.08 × 4.19 mm.; 9.25 × 5.00 mm., Burma.



Figs. 127, 128. *Gabbia physcus*, Holotype, 7.00 × 6.25 mm., Inle Lake. 129. Operculum of *G. physcus*. 130, 131. *Hydrobioides nassa* f. *distoma*, 8 × 5 mm., He-Ho Plain. 132. *Hydrobioides nassa* f. *typica*, 7.5 × 4.50 mm., Yaunghwe. 133. Operculum of *H. nassa lacustris*. 134, 137. *H. nassa rivulicola*, Holotype, 7.30 × 4.85 mm, Thamakan, Burma. 135, 136. *H. nassa lacustris*, Syntype, 9.70 × 5.80 mm., Inle Lake.



Figs. 138, 139. *Hydrobioides nana*, Holotype, 2.25 × 175 mm., Inle Lake. 140, 141. *H. avarix*, Syntype, 6.60 × 4.30 mm., Fort Stedman, Inle Lake.

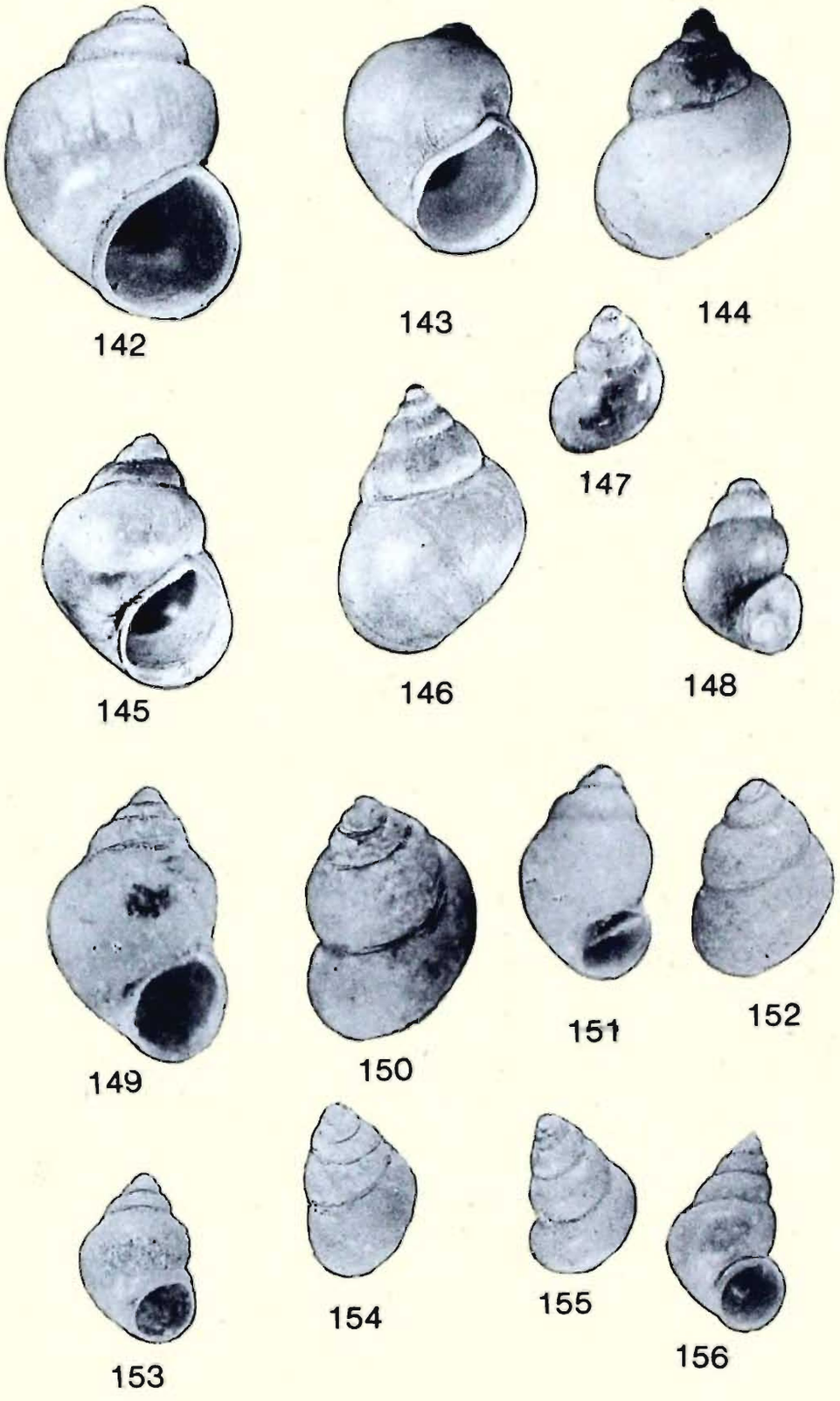


Fig. 142. *Gabbia orcula producta*, 6.48 × 4.78 mm., Pune. 143, 144. *G. stenothyroides*, 7.80 × 4.81 mm., Mysore. 145, 146. *G. travancorica*, 5.73 × 4.38 mm.; 5.78 × 4.78 mm., 147, 148. *G. alticola*, Syntype, 3.15 × 1.90 mm.; 3.58 × 2.26 mm., Burma. 149, 150. *Stenothyra blanfordiana*, 2.80 × 1.65 mm.; 2.30 × 1.60 mm., Chilka Lake. 151, 152. *Stenothyra minima*, 3.10 × 1.05 mm., Chilka Lake. 153, 154. *Stenothyra orissaensis*, Holotype, 2.50 × 1.45 mm.; 2.75 × 1.50 mm., Satpara, Lake Chilka. 155, 156. *S. trigona*, Holotype, 2.35 × 1.20 mm., 2.72 × 1.30 mm., Barkul, Lake Chilka.

Shell thick and imperforate, aperture large, ovoid or subtriangular, columellar callus stout and runs continuous at both ends with the thickening of the outerlip, a strong longitudinal ridge or varix on the outer surface of the body whorl near the outer lip; operculum calcified, thick and surrounded by a membraneous margin, nucleus central and with numerous well defined concentric striae.

Penis bifid. A deep but narrow groove on the sole of the foot parallel to and close behind the anterior margin.

Although Annandale (1918) gave it a generic rank, Thiele (1928) considered it to be a subgenus of *Bithynia*.

Burma and Thailand.

Represented by four species.

Key to the species (after Annandale, 1918)

1. A ridge or varix running on the outer surface of the body whorl ..... *H. nassa*
   No varix 2
2. Shell not more than 3 mm. long ..... *H. nana*
   Shell more than 4 mm. long 3
3. Shell twice as long as broad ..... *H turrita*
   Shell comparatively smaller ..... *H. avarix*

65. **Hydrobioides avarix** Annandale, 1918
(Figs. 140, 141)

Hydrobioides avarix Annandale, 1918, *Rec. Indian Mus.*, **14:** 120. pl. xiv, figs. 1, 2, 2a—2c.
Type locality: Near Fort Stedman.

Type: ZSI Regd. No. M 11127/2

Distribution: Burma, Laos and Thailand. So far it is not recorded from India.

Remarks: Shell moderately thick, with longitudinal striae, peristome thickened, without a varix or ridge on the body whorl.

Brandt (1974) synonymised the species with *H. nassa* (Theobald)

66. **Hydrobioides nana** Annandale, 1918
(Figs. 138, 139)

Hydrobioides nana Annandale, 1918, *Rec. Indian Mus.*, **14**: 121, pl. xiv, fig. 3. Type locality Fort Stedman, Inle Lake.

Types: ZSI Regd. No. M 11289/2

Distribution: Burma

Remarks: Shell conoidal, thick, transparent, smooth and polished, whorls 4, swollen, spire blunt, aperture large and ovate.

67. **Hydrobioides nassa** (Theobald, 1865)
(Figs. 125, 126, 130-137)

Bithinia nassa Theobald, 1865, *J. Asiat, Soc. Beng.* **34** (2): 275. Type locality: Shan States, Burma.

Hydrobioides nassa: Annandale, 1918, *Rec. Indian Mus.*, **14**: 118, pl. xiii, figs. 1—7, pl. xiv. figs. 4, 4a.

Distribution: Burma, Laos, and Thailand.

Remarks: Shell variable, four forms recognised depending on the structure and position of the ridge, viz. f. *typica*, varix runs parallel to the lip and separated from it by a broad groove, no trace of an intermediate ridge; f. *lacustris*—shell more pointed and narrow, varix does not run parallel to the lip but rather across the arc it forms: widely separated from the edge of the mouth, intermediate space not a groove but distinctly convex;

f. *distoma*—Shell small, varix prominent and close to the aperture.

f. *rivulicola*—Shell thinner than any other form, varix very low, margin of aperture not very much thickened.

Brandt (1974) synonymised *H. avarix* Annandale with this species.

68. **Hydrobioides turrita** (Blanford, 1869)

Fairbankia? turrita Blanford, 1869, *Proc. zool. Soc. Lond.*, p. 446. Type locality: Kyoukpong, Irawaddy river.

Hydrobioides turrita: Annandale, 1918, *Rec. Indian Mus.*, **14**: 117.

Distribution: Burma

Remarks: Shell solid, spire elongate and conical, suture impressed, aperture ovate.

Subfamily MYSORELLINAE

Genus 21. **Mysorella** Godwin-Austen*, 1919

Mysoria Godwin-Austen, 1919, *Rec. Indian Mus.*, **16**: 211. *Mysorella*, 1919, *Rec. Indian Mus.*, **16**: 430 (Previous name preoccupied for Insecta, hence a replacement name was suggested).

Type species : *Bithynia costigera* Kuester var *curta* Nevill.

Shell ovately conical or depressedly conical, solid, with a large rounded body whorl, and moderately elevated spire, sculpture of distinct spiral ribs, three above and two below the periphery being prominent, aperture subcircular and oblique, perforate, without any groove, columellar side thickened, peristome simple. Operculum calcareous, not very thick, subcircular, concave, nucleus small with indication of spiral origin, internally convex and smooth.

Central tooth of the radula smaller than others and without basal denticulations.

Southern part of Peninsular India and Sri Lanka.

A single species

* Thiele (1931) wrongly attributed the authorship to Annandale.

69. **Mysorella costigera** (Kuester, 1852)
(Fig. 124)

Paludina costigera Kuester, 1852, in Martini & Chemnitz, *Syst. Conch. Cab.*, 1 (21): 33, pl. 7, figs. 18, 19. Type locality: Bengal.

Bithynia (? Fossarulus) costigera: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 78.

Distribution: India: Tamil Nadu (Madras), Pondicherry, Karnataka; Sri Lanka. It does not occur in Bengal, as erroneously reported by earlier authors.

Remarks: Shell ornamented with five strongly raised spiral ridges and finer and weaker spiral ridges in between them. Shell uniformly pale horny brown.

Annandale (1920) distinguished two varieties, a typical form frequenting muddy bottom, in plains of Madras and Sri Lanka and the var. *curta* Nevill, 1884, a shorter shelled form found among stones in Bangalore, at an altitude about 3000 ft.

Godwin-Austen (1919) figured the type, operculum and radula of specimens from India, while Starmuehlner (1974) gave figures of operculum and radula of specimens from Sri Lanka. Seshaiya (1930) studied the anatomy.

Family 8. STENOTHYRIDAE

Shell minute, rarely more than 5 mm. high, ovate or subcylindrical, compressed in its dorso ventral axis, whorls moderately convex, body whorl more or less descending to the small, subcircular aperture, surface smooth but often ornamented with minutely punctated spiral lines, rarely with fine spines, narrowly umbilicate to imperforate. Operculum calcareous to horny, externally paucispiral, internally with two prominent transverse ridges.

Radula similar to that of Bithyniidae, Teeth relatively broader, laterals and marginals less differentiated. 2: 1: 1: 1: 2.

Rostrum cylindrical, extremely mobile and extensile. Tentacles filiform, eyes on slightly raised bases. Foot long and narrow, spindle shaped, anteriorly truncate and posteriorly pointed.

Penis nearly cylindrical and without a lateral process.

India, Iran to Indonesia and from Australia to the Philippines and Japan, Western Pacific Islands.

Annandale and Prashad (1921) treated it as a subfamily of Hydrobiidae. It is mainly estuarine and so far none of the species excepting *S. deltae* are reported from freshwater in India. Pace (1973) briefly mentioned the views expressed by different authors on the systematic position of this group. Following many recent authors it is given a full family rank here.

Two genera, namely *Stenothyra* Benson, 1856 and *Gangetia* Ancey, 1890 are included in this family.

Key to genera

1. Mouth very small, not at all prominent, separated from the outer edge of shell above by a well-defined triangular area ..... **Stenothyra**

   Mouth larger and slightly prominent, less regular in outline, separated from the outer edge of shell above by a small and ill-defined area ..... **Gangetia**

Genus 22. **Stenothyra** Benson, 1856

Stenothyra Benson, 1856, *Ann. Mag. nat. Hist.*, **18**: 496.

Type species: *Nematura deltae* Benson, 1836.

Shell small but relatively thick, ovate or sybcylindrical, whorls at least 4 (4-6), with sculpture of minutely punctated spiral lines, occasionally with small spines, aperture oval or subcircular, peristome continuous, uniform and hardly thickened. Operculum horny, brittle, internally with two transverse ridges or smooth, polished and convex.

Foot usually produced into a filament posteriorly.

India, Burma, Malay Archipelago, Southern China, Formosa, Philippines, Japan and Australia. Majority of the species are from brackishwater.

Annandale and Prashad (1921) revised the genus and recognised twelve species.

Key to species (After Annandale and Prashad, 1927)

1. Shell bearing a spiral row of large spines on some of the whorls in addition to the microscopic sculpture 2

   Shell without any definite spines, with or without a definite spiral sculpture 3

2. Spines restricted to basal whorls of the spire only, the whorls evenly inflated and not keeled ..... *S. echinata*

   Spines present on almost all the whorls including the body whorl, the whorls especially those of the spire ridged or keeled in the middle ..... *S. ornata*

3. Shell elongate ovate, nearly cylindrical 4

   Shell ovate or ovoid, never elongate cylindrical 5

4. Shell rather small and narrow ($2\frac{1}{2} \times 1\frac{1}{8}$ mm), subperforate, rimate; whorls of the spire increase regularly and with microscopic sculpture ..... *S. hungerfordiana*

   Shell much larger ($4\frac{1}{2} \times 3$ mm), imperforate; whorls of the spire increase irregularly, with relatively large pits on the surface of the shell ..... *S. monilifera*

5. Aperture large, more than 1/3 the size of the body whorl 6

   Aperture small, less than 1/3 the size of the body whorl 8

6. Body whorl not at all flattened on the ventral surface, and with a very small boss separating the mouth from the body whorl ..... *S. soluta*

   Body whorl distinctly flattened on the ventral surface, at least in its anterior half and with a well developed boss separating the mouth from the body whorl 7

7. Shell subventricose, ovate; with a short spire, spiral whorls increasing irregularly; body whorl greatly swollen, aperture biangulate suboval ..... *S. blanfordiana*

   Shell elongate ovate, spire more produced, spiral whorls increasing regularly, body whorl less tumid, aperture nearly circular or having only a faint notch above ..... *S. minima*

8. Shell without any spiral pitted sculpture ..... *S. woodmasoniana*

   Shell with a definite spiral pitted sculpture 9

9. Shell minute, 2 mm long, with a very short spire and bluntly rounded apex ..... *S. nana*

   Shell relatively large, with a prominent conical spire and an acuminate apex 10

10. Shell globose conical, body whorl large and swollen, with a well developed boss ..... *S. deltae*

Shell ovate, acute, body whorl smaller and not greatly swollen, with a much smaller boss ..... *S. foveolata*

70. **Stenothyra blanfordiana** Nevill, 1880

(Figs. 149, 150, 159, 160)

Stenothyra blanfordiana Nevill, 1880, *J. Asiat. Soc. Beng.*, **49** (2): 160. 1881, *J. Asiat. Soc. Beng.*, **50** (2): 156, pl. 7, fig. 10. Type locality: Chilka Lake, Orissa.

Stenothyra chilkaensis Preston, 1914, *Rec. Indian Mus.*, **10**: 300, fig. 1. Type locality: Barkul, Chilka Lake.

Stenothyra obesula Preston, 1915, *Rec. Indian Mus.*, **11**: 292, fig. 4. Type locality: Southernmost island of Manikpatna, Chilka Lake.

Stenothyra blanfordiana: Prashad, 1921, *Rec. Indian Mus.*, **22**: 129

Types: ZSI Regd. No. M 11888/2 (Syntypes).

Distribution: Port Canning, Chilka Lake and Madras.

Remarks: Shell subventricose, whorls $4\frac{1}{2}$, spire not very much elongated, whorls increase irregularly, body whorl tumid and subangulate. Operculum oval, semitransparent, spiral of a few whorls, nucleus central, on the inner side three ridges, one semicircular and two short ones with a single S-curvature.

71. **Stenothyra deltae** (Benson, 1836)

(Fig. 166a)

Nematura deltae Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 782. Type locality: Gangetic Delta.

Stenothyra deltae: Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 131, text fig. 2.

Types: BM (NH).

Distribution: India: West Bengal-Port Canning, Calcutta (Chandpal Ghat).

Remarks: Body whorl flattened ventrally, sculptured with spiral punctured lines, aperture very small, subcircular with merely the trace of a notch above, periostracum thick and often with spiral rows of spines.

72. **Stenothyra echinata** Annandale & Prashad, 1919
(Figs. 157, 158)

Stenothyra echinata Annandale and Prashad, 1919, *Rec. Indian Mus.* **16:** 247, pl. xx, fig. 5. Type locality: Edge of river Pussur at Khulna, Bangladesh.

Type: ZSI Regd. No. M 11439/2 (Holotype)

Distribution: Not known beyond type locality.

Remarks: It is closely allied to *S. deltae* but distinguished from it by its smaller size, narrower and less inflated body whorl characterised by the row of spines on the basal part of the spire, but larger and relatively broader aperture.

73. **Stenothyra foveolata** Benson, 1856

Stenothyra foveolata Benson, 1856, *Ann. Mag. nat. Hist.*, (2) **17:** 497. Type locality: "in Gange fluvio, prope Sikrigali". Hanley and Thoebald, 1876, *Conch. Indica,* pl. 37, fig. 3. Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22:** 132.

Type: ?

Distribution: Ganges near Sikrigali, near Bhagalpur ; West Bengal.

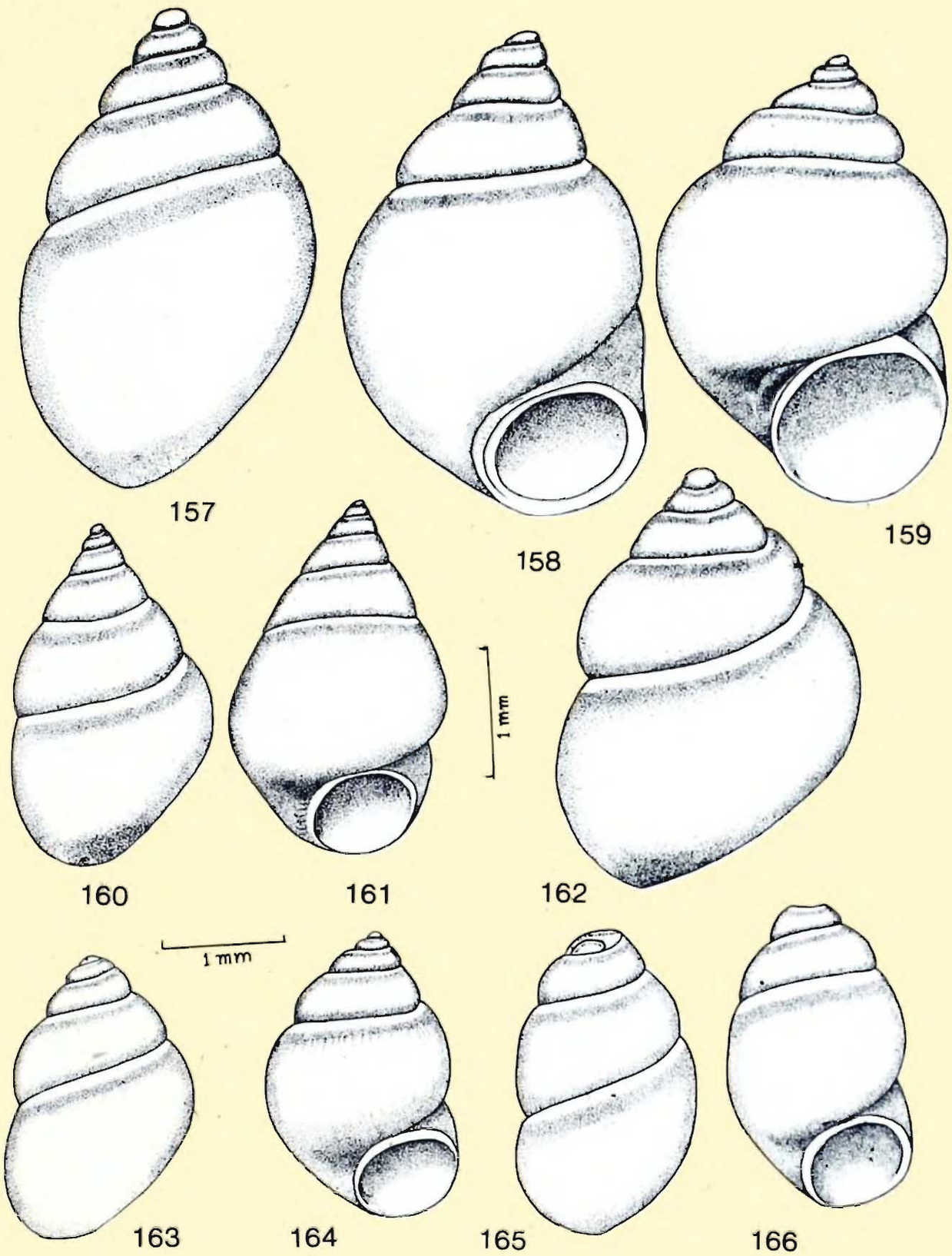
Remarks: Shell ovately conical, apex acute, sutures shallow, whorls 5, convex, sculptured with spiral pits or punctate markings, aperture oblique-ovate.

74. **Stenothyra hungerfordiana** Nevill, 1880
(Figs. 165, 166)

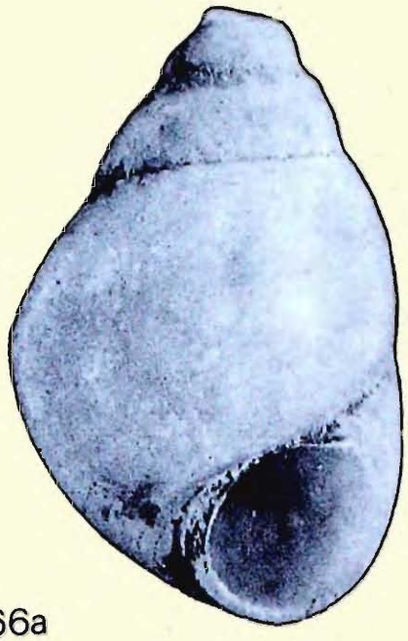
Stenothyra hungerfordiana Nevill, 1880, *J. Asiat. Soc. Beng.*, **49**(2): 159. Type locality: Andamans. Nevill, 1881, *J. Asiat. Soc. Beng.*, **50:** 156, pl. VII, fig. 9. Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22:** 127.

Type: ZSI Regd. No. M 16906/2 (Holotype)

Distribution: Andamans.

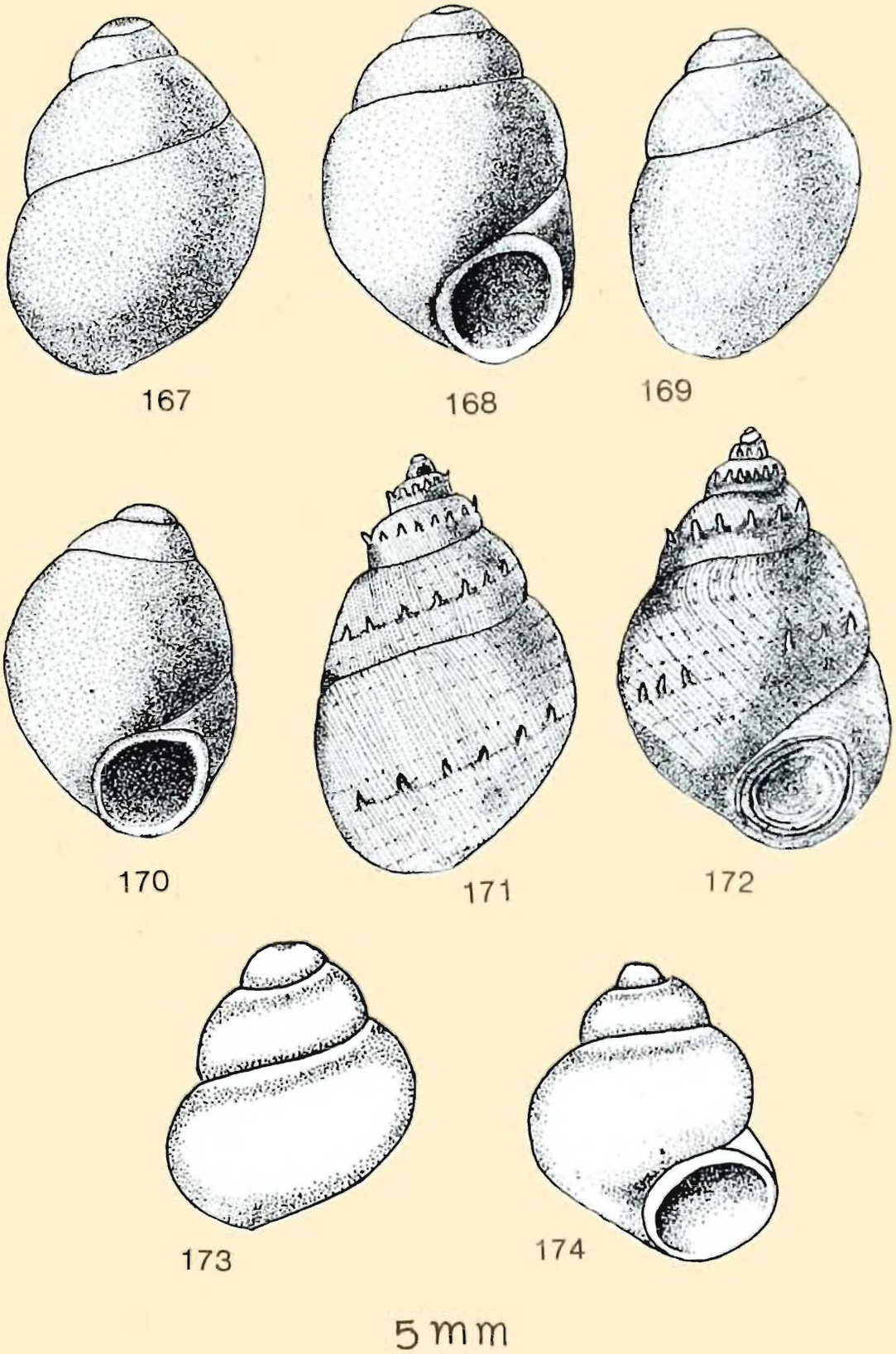


Figs. 157, 158. *Stenothyra echinata*, Holotype, 3.85 × 2.40 mm., 159, 160. *S. blanfordiana*, Holotype, 3.30 × 2.15 mm., Chilka Lake, figs drawn at different enlargements. 161, 162. *S. woodmasoniana* 2.75 × 1.45 mm., Port Canning. 163, 164. *S. minima*, 3.10 × 1.05 mm., Chilka Lake. 165, 166. *S. hungerfordiana*, Holotype, 1.80 × 1.30 mm., Andamans.

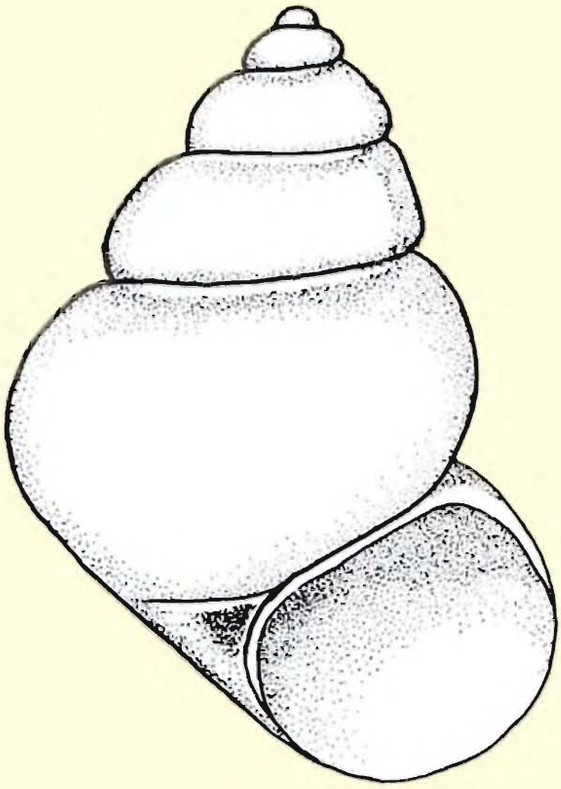


166a

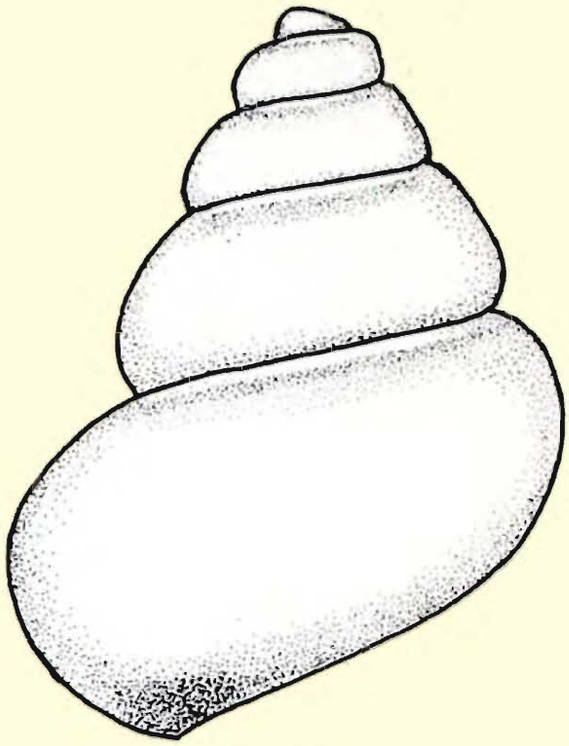
Fig. 166a. *Stenothyra deltae*. 6.0 × 4.10 mm., Port Canning.



Figs. 167, 168. *Stenothyra atomus*, 1.40 × 0.80 mm., Arakan, Burma. 169, 170. *S. nana*, 2.20 × 1.9 mm., Chandpal, Calcutta. 171, 172. *S. ornata*, Holotype, 5.0 × 3.20 mm., Dhapa, near Calcutta. 173, 174. *S. soluta*, Holotype, 3.90 × 2.95 mm., Port Canning.



175



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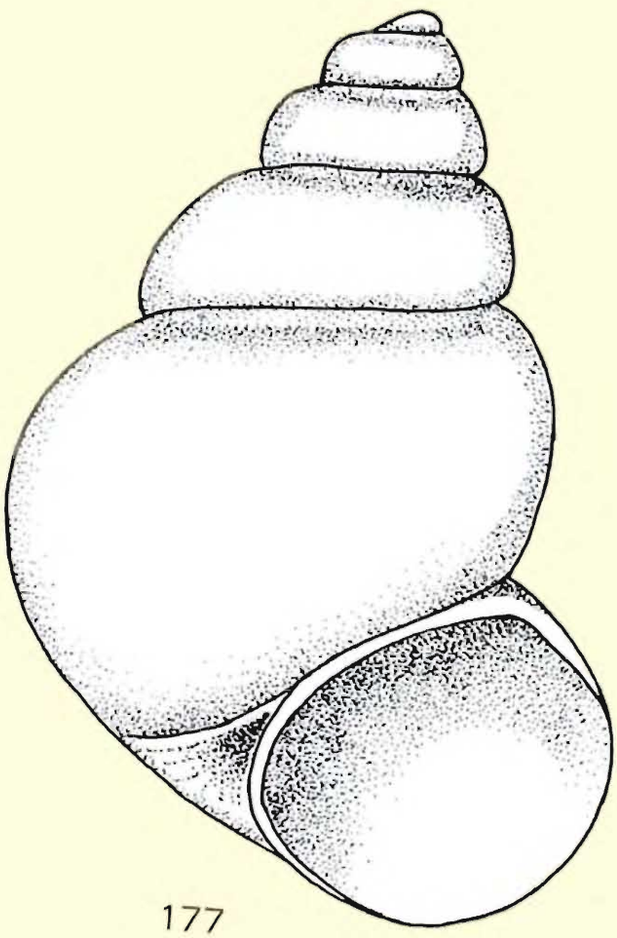
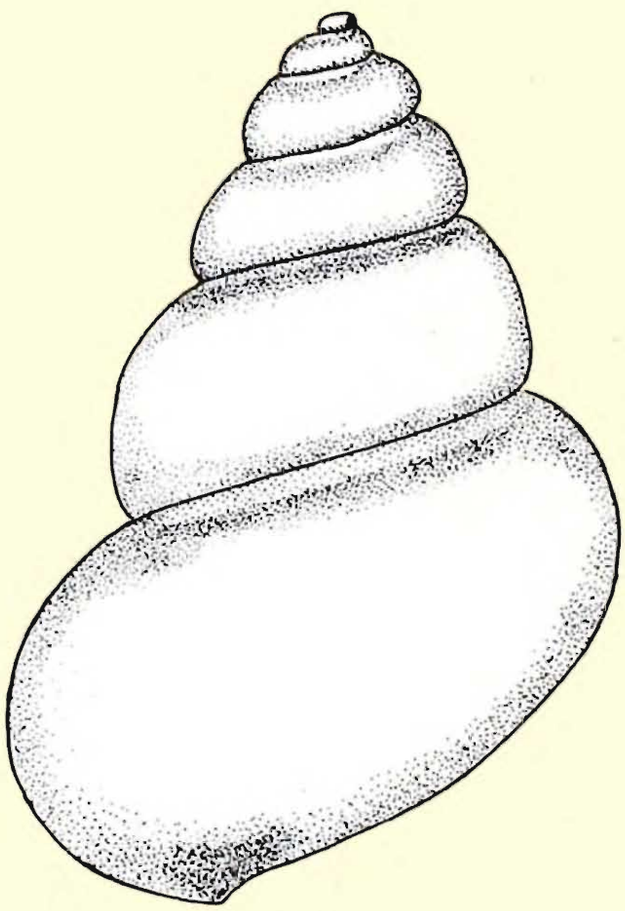
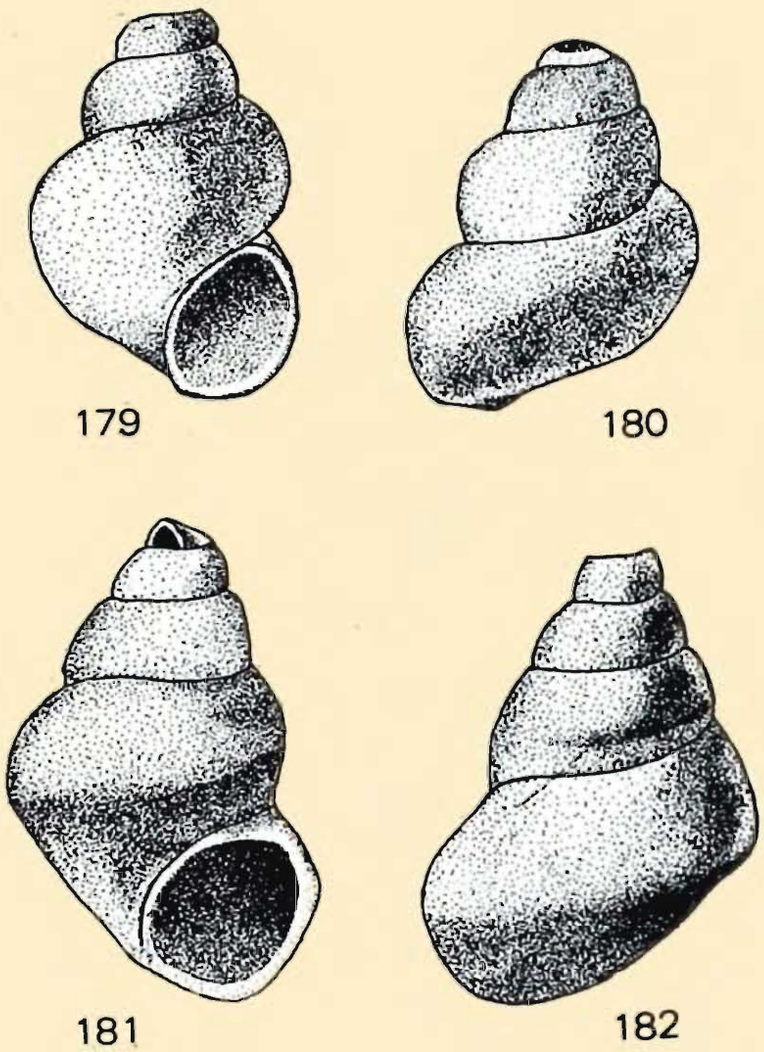


177



178

Figs. 175, 176. *Gangetia miliacea*, Syntype,2.55 × 165 mm.; 2.35 × 1.40 mm., Port Canning.
177, 178. *Gangetia miliacea*, 2.80 × 1.80 mm., Gangetic Delta.



Figs. 179, 180. *Gangetia miliacea* var. *subangulata*, Syntype, 2.25 × 1.40 mm., Port Canning.
181, 182. *G. miliacea* var. *gibbosula*, Holotype, 1.65 × 1.25 mm., Port Canning.

Remarks: Apex obtuse, whorls sculptured with minute, distinct, close punctations, whorls unusually convex, body whorl remarkably long, compressed, slightly flattened and ovate, suture distinct, and on the body whorl distinctly marginate below.

75. **Stenothyra minima** (Sowerby, 1837)
(Figs. 151-154, 163, 164)

Nematura minima Sowerby, 1837, *Ann. Mag. nat. Hist.* (Charlesworth's series) **1**: 217, fig. 22b. Type locality: Western India.

Stenothyra orissaensis Preston, 1914, *Rec. Indian Mus.*, **10**: 300, fig. 2. Type locality: Lake Chilka, Orissa.

Stenothyra minima: Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 129.

Types: BM (NH)

Distribution: Kathiawar, Bombay, Chilka Lake and Sri Lanka.

Remarks: Shell small, narrowly perforate, ovately turbinate, whorls 5, regularly increasing, smooth, body whorl convex and rapidly descending in front.

It resembles *S. blanfordiana* very closely but can be distinguished from it by the regularly increasing spiral whorls.

76. **Stenothyra nana** Prashad, 1921
(Figs. 169, 170)

Stenothyra nana Prashad, in Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 130, pl. XVI, figs. 5, 6. Type locality: Chandpal, Calcutta.

Types: ZSI Regd. No. 2196.

Distribution: Calcutta, Ranong harbour in Thailand (Brandt, 1974).

Remarks: Whorls 4, increase very rapidly, suture faintly impressed, regular and somewhat oblique, body whorl large, subrhomboidal in dorsal view, but nearly flat in the anterior 2/3 of its length ventrally, imperforate but with prominent boss or lamellae.

77. **Stenothyra ornata** Annandale and Prashad, 1921.
(Figs. 171, 172)

Stenothyra ornata Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 126, pl. XVI, figs. 1, 2. Type locality: Brackish water pool at Dhapa near Calcutta.

Type: ZSI Regd. No. M 11565/2

Distribution: Calcutta.

Remarks: Shell imperforate, apex acutely pointed, whorls $5\frac{1}{2}$, spiral whorls distinctly keeled in the middle, keel continues on to the body whorl, spiral rows of blunt, flattened and blackish spines on last four whorls.

78. **Stenothyra soluta** Annandale and Prashad, 1919.
(Figs. 173, 174)

Stenothyra soluta Annandale and Prashad, 1919, *Rec. Indian Mus.*, **16**: 247, pl. XX, fig. 6. Type locality: A creek in the Gangetic Delta at Basanti.

Type: ZSI Regd. No. M 11442/2

Distribution: Gangetic Delta.

Remarks: Shell globose, thick, spire flattened, concave at the apex, whorls very distinct and swollen, body whorl proportionately short and stout, not flattened on the ventral surface, aperture large, oval, rounded posteriorly, very prominent and with the peristome thick and somewhat plicated concentrically.

79. **Stenothyra woodmasoniana** Nevill, 1880.
(Figs. 161, 162)

Stenothyra woodmasoniana Nevill, 1880, *J. Asiat. Soc. Beng.*, **49** (2): 159. Type locality: Port Canning. 1881, *J. Asiat. Soc. Beng.*, **50** (2): 156, pl. VII, fig. 8.

Type: ZSI Regd. No. 2197 (Syntypes)

Distribution: Gangetic Delta.

Remarks: Shell ovately conical, spire very acute and concavely excavated, whorls 5-6, body whorl subangulate, flattened round the umbilical region, shell almost smooth or may appear malleated under large magnification.

Genus 23. **Gangetia** Ancey, 1890.

Gangetia Ancey, 1890, *Bull. Soc. Malacol. Fr.*, **7**: 162.

Type species: *Hydrobia* (*Belgrandia*) *miliacea* Nevill.

Astenothyra Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 133 (as subgenus).

Type species: *Hydrobia* (*Belgrandia*) *miliacea* Nevill.

Body whorl convex, aperture larger than in *Stenothyra,* ovate and slightly prominent. No definite triangular area between the aperture and outer edge of body whorl.

Foot not produced posteriorly.

India, Burma, and Gulf of Oman.

Only one species known from India.

80. **Gangetia miliacea** (Nevill, 1880).
(Figs. 155, 156, 175-182)

Hydrobia (*Belgrandia*) *miliacea* Nevill, 1880, *J. Asiat. Soc. Beng.*, **49** (2): 161. Type locality: Port Canning, West Bengal.

Stenothyra (*Astenothyra*) *miliacea:* Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 134, text fig. 3.

Type: ZSI Regd. No. M 11865/2. (Figs. 175, 176)

Distribution: Gangetic Delta and Gulf of Oman.

Remarks: Annandale and Prashad (1921) recognised three varieties namely, f. *typica*, var. *subangulata* Prashad (Figs. 179, 180) and var.

gibbosula Prashad (Figs. 181, 182). In the typical form aperture is evenly rounded and body whorl is smooth. The body whorl is distinctly keeled in var. *gibbosula* where as it is smooth in *subangulata.* The latter can however be differentiated from the typical form by its subangulate aperture.

Common among weeds in brackish water pools at Port Canning.

Family 9. THIARIDAE

"Melanids"

Shell high, elongate turreted to ovate-conical, whorls rounded with moderate or impressed sutures, sculpture smooth to spiral or longitudinal ridges, ribs, knobs or tubercles, imperforate, aperture generally narrowly ovate and somewhat canaliculate. Operculum smaller than aperture, dark brown, corneous and multispiral with a central or subcentral nucleus or paucispiral with an excentric nucleus.

Animal with a short, broad snout slightly bifurcate and laterally "keeled", eyes on short stalks near the external base of tentacles. Mantle margin smooth or papillate. Foot small and squarish.

Radula with the formula 2: 1: 1: 1: 2, cutting edges of teeth with a few or numerous cusps.

Either oviparous or ovoviviparous with a brood pouch for the eggs to hatch, birth pore situated on the right side of the neck, males rare in many species; in one species *T (M.) torulosa* males common and free veligers produced.

Tropics to temperate regions. Asia, Africa, Central and South America, islands of the Pacific and the Caribbean Sea.

Prefers streams or rivers, stagnant ponds or lakes, some tolerate brackish waters.

Important contributions on this group include Annandale (1920*c*—generic revision), Brot (1874—systematics), Jacob (1953, 1958, 1959*a,b*—cytology), Meenakshi (1955*d*—physiology), Muley (1975—1978, physiology and biology), Muley and Nagabhushanam (1975, 1977—ecology and reproductive physiology), Nagabhushanam and Kulkarni (1972—physiology).

Nagabhushanam and Muley (1974, 1975, 1977—neurosecretion), Natarajan (1968*a*—cytology), Ramamoorthi (1949, 1950, 1955—embryology), Seshaiya (1929*a*, 1934*b*, 1935, 1936*a,b*—anatomy).

Taxonomy of the group was discussed by Morrison (1954) and Davis (1969). But it is still in a confused state. Some authors have adopted an excessive degree of splitting resulting in many genera and species. The system of arrangement proposed by Abbott (1948) and adopted by Pace (1973) is followed here at the generic level. Morrison (1954) elevated the status of subfamily Pleurocerinae to the family level and included the genus *Paludomus* in it. According to Morrison (1954) there are three distinct families namely Thiaridae, Pleuroceridae and Melanopsidae, But many earlier authors gave them subfamily ranks in the family Thiaridae. Regarding the inclusion of *Paludomus* in a separate family Davis (1969) expressed a different opinion and was inclined to include it in the family Thiaridae.

Following Thiele (1929) the Indian species are grouped under four subfamilies namely Thiarinae, Melanopsinae, Melanatrinae and Paludominae.

Key to Subfamilies

1. Shell generally rounded or ovately conical, aperture ovate and proportionately larger ..... **Paludominae**

   Shell elongate or turreted, aperture more or less vertical and proportionately smaller 2

2. Shell very much elongate, usually with more than 12 whorls, mantle margin smooth 3

   Shell moderately elongate, usually not more than 12 whorls, mantle margin with about 14 or more papillae ..... **Thiarinae**

3. Shell with a sinus in upper and lower corner of aperture, operculum with a few whorls and a basal nucleus ..... **Melanopsinae**

   Shell without a sinus, operculum multispiral with a central or subcentral nucleus ..... **Melanatrinae**

Subfamily THIARINAE

Shell imperforate, with thick periostracum, ovately conical to an elongately turreted shape, smooth or spirally sculptured, tuberculated or spiny. Aperture more or less elongately ovate, acutely angulated above, usually indented below, operculum oblong with a terminal nucleus.

Mantle margin with about 14 papillae, the farthest four to the left being largest (Abbott, 1948). Formerly it was believed that no males were present in the species (Morrison, 1954). However, many recent authors have reported males in species like *Thiara scabra, Thiara tuberculata* and others. It is confirmed by Pace (1973). In certain species males are very rare, but in a few, like *Thiara plicaria* (Born) and *T torulosa* (Bruguiere) they are common.

Most species are parthenogenetic and ovoviviparous. Free veligers are produced in at least two species, namely *T torulosa* (Bruguiere) (Seshaiya, 1936, 1940*b*; Ramamoorthi, 1950, 1955; Jacob, 1959*a*) and *T plicaria* (Born) (Pace, 1973).

Freshwater rivers, streams, lakes and ponds often extending into brackish waters.

Asia, Africa, Central and South America, Islands of the Caribbean and Pacific Sea.

There is difference of opinion regarding the status of taxa included in this subfamily. Morrison (1954) included seven genera in the sub family. Pace (1973), following Abbott (1948), preferred to have less splitting and relegated all the genera except *Brotia* (which was not treated in his work) to subgeneric rank. The same arrangement is adopted here. All the Indian species are grouped in one genus *Thiara,* which is distinguished into six subgenera.

Genus 24. **Thiara** Roeding, 1786.

Thiara Roeding, 1798, *Museum Boltenianum,* **2**: 109.

Type species: *Helix amarula* Linnaeus, the other species mentioned by Roeding being nomen nuda (Abbott, 1949).

Shell generally measures 3 to 5 cms. in length, whorls varying in number from 8 to 15, sutures deep to moderately deep or shallow, sculpture also variable, spiral striae to beaded, and a few species with spines, aperture more or less vertical, without any sinus or siphonal canal, operculum pear shaped; with an excentric nucleus at the narrow, basal end.

Mantle edge bears 10 to 14 papillae, ovoviviparous with neck brood pouch.

Tropical and subtropical Africa and Asia, extending as far north as Formosa and the Ryukyu Island and south up to Northern Australia. Abundant in India, Malay Archipelago, Philippines and on various Pacific Islands.

The Indian species are grouped under six subgenera, namely *Thiara* s.str. *Melanoides, Stenomelania, Tarebia, Sermyla* and *Mainwaringia.*

Key to subgenera

1. Height of body whorl considerably more often exceeding the height of the spire, sculptured with conspicuous nodules, granules or axial ridges 2

   Spire proportionately larger than the body whorl, sculptured with axial and spiral ridges but never with spines 4

2. Shell generally spinous or sharply nodulose, whorls angular between suture and the periphery, spiral whorls descending in steps, pagoda-like ..... **Thiara s. str.**

   Shell granulose or tessellated with nodules or with contrasting sculpture on the body whorl, whorls round between suture and the periphery, spiral whorls gradually increasing 3

3. Body whorl with axial ridges on the upper portion strongly contrasting with the spiral ridges on its lower part ..... **Sermyla**

   Shell coarsely sculptured with elevated axial and spiral ridges giving a strong nodulose or granular appearance or with fine dark brown lines coinciding with spiral ridges ..... **Tarebia**

4. Shell conical, with minute scattered hairs or chaetae ..... **Mainwaringia**

   Shell elongated, without hairs 5

5. Shell very slender, very much elongated, more than 12 whorls in a full grown adult, spire attenuate and sharply pointed, sculptured with spiral striae only ..... **Stenomelania**

   Shell neither very slender nor much elongated, generally not more than 12 whorls, sculptured with spiral striae crossed by axial striae giving a tubercled appearance ..... **Melanoides**

Subgenus **Thiara** s.str.

Key to the species of **Thiara** s.str.

1. Whorls increasing regularly, sculptured with axial ribs and strong spiral ridges ..... *T. rudis*

   Whorls descending step like, with a crown of spines below the sutures 2

2. Shell almost smooth, spire very much shorter than the body whorl ..... *T. amarula*

   Shell with spiral ridges, spire generally almost as high as body whorl ..... *T. scabra*

81. **Thiara (Thiara) scabra** (Mueller, 1774)
(Figs. 185, 186, 189)

Buccinum scabrum Mueller, 1774. *Hist. Verm. Terr. Fluv.*, **2**: 136. Type locality: Tranquebar.

Melania acanthica Lea, 1850, *Proc. zool. Soc. Lond.*, p. 194.

Thiara (Thiara) scabra: Pace, 1973. *Malac. Review* Suppl. 1: 52, pl. 12, figs. 1, 2 pl. 13, fig. 3.

Distribution: India: Throughout, except Kashmir. Elsewhere: Coasts of Indo Pacific, from Zanzibar to New Hebrides, north to the Philippines, various Pacific islands.

Remarks: Whorls regularly increasing in size, sutures distinct, whorls often shouldered above and rounded below the row of spines, shell sculptured with characteristic vertical ribs bearing prominent spines directed obliquely outward, surface with rough spiral striations, on the body whorl near the umbilical region striations form strong ridges.

It prefers slow or fast moving streams but may also occur in ponds.

The species is very variable. A complete synonymy is given by Benthem Jutting (1956). In India it was known by names like var. *elegans* (Benson) and *T acanthica* (I & H Lea) (Preston, 1915, Ray, 1947). Nevill (1884) described many varieties and subvarieties.

Males are very rare in this species (Muley, 1977; Pace, 1973). Jacob (1959a) however found no males. It is doubtful whether the males produce any viable sperms. Muley (1975—78), Muley and Nagabhushanam (1975, 1977) investigated the breeding biology, physiology etc. of this species.

82. **Thiara (Thiara) amarula** (Linnaeus, 1758)
(Figs. 203, 204)

Helix amarula Linnaeus, 1758, *Syst. Nat.* ed. **10**: 774. Type locality: "Asiae fluvitis".

Thiara amarula: Starmuehlner, 1976, *Ann. Naturhist. Mus. Wien.*, **80**: 558, figs. 63-66, pl. 15, fig. 166.

Distribution: India: Great Nicobar; Mauritius; Indonesia: Sumatra, Java, Amboina; Fiji, New Caledonia and the Philippines.

Remarks: Shell large and black, spire generally decollated, body whorl proportionately longer than the spire, body whorl with crown of spines near the periphery and suture, between the suture and crown of spines flattened body whorl almost smooth except a few spiral striations near its umbilical region.

Mantle edge bears 15-25 papillae. Only females known (Starmuehlner, 1969).

83. **Thiara (Thiara) rudis** (Lea, 1850)
(Fig. 199)

Melania rudis Lea, 1850, *Proc. zool. Soc. Lond.*, p. 186, Type locality: Amboina.

Thiara rudis: Benthem Jutting, 1956, *Treubia*, **23**(2): 389, fig. 83.

Type: AMNH.

Distribution: India; Sri Lanka; Burma; Kampuchea; Indonesia; Sumatra, Java, Amboina, Batjan, Halnahera; Philippines.

Remarks: Shell thick, subcylindrical, with a high spire, sculptured with axial ribs and spiral ridges, formed into nodules, sometimes strongly developed subsutural nodules just below the suture, spiral ridges often in the beaded form.

Subgenus **Stenomelania** P. Fischer, 1885

Shell subulate, elongate, spire attenuate and pointed, entirely smooth or with spiral threads or rows of beads, but not with spines, columella thin and without callus.

Mantle margin with papillae as in *Thiara* s.str., no brood pouch (Abbott, 1948), but present according to Morrison (1954).

South east Asia, Malay Archipelago, Pacific Islands and the Philippines.

Key to the species of **Thiara (Stenomelania)**

1. Shell sculptured with strong spiral ridges broken into rectangular nodules, strongest just below the suture ..... *T. torulosa*

   Shell with not very strong spiral striae, or at most some vertical ridges or folds on the apical whorls 2

2. Shell very slender, spire attenuate, sharp 3

   Shell broader, spire not attenuate and not so sharp ..... *T. punctata*

3. First few whorls of the spire strongly folded, lower ones smooth or with spiral striae ..... *T. plicaria*

\- Shell throughout with fine spiral lines, in the body whorl and a few spiral whorls the central region is often smooth, the striae occuring only in the subsutural region and below the periphery ..... *T. aspirans*

84. **Thiara (Stenomelania) punctata** (Lamarck, 1822)

(Figs. 210, 211)

Melania punctata Lamarck, 1822, *Hist. Nat. Anim, sans Vert.*, **6** (2): 165. Type locality: ?

Tiara (*Radina*) *clavus* Preston, 1915 *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda); p. 12.

Melanoides (*Stenomelania*) *punctata:* Starmuehlner, 1976, *Ann. Naturhist. Mus. Wien.*, **80:** 586, figs. 98—108, pl. 17, figs. 197—201.

Types: MHN.

Distribution: India: Andaman and Nicobar Islands. Malay Archipelago; Indonesia: Java, Moluccas; New Guinea, Bismarck Archipelago, Solomon Islands, New Hebrides and the Philippines.

Remarks: Shell turret-elongated, body whorl broad, spire not very much attenuate, whorls flat, shell smooth, whorls 14-16, regularly increasing in size, sutures not deep, aperture pointed above and rounded below, operculum horny, pear shaped to oval, with excentric nucleus situated at the lower left corner.

85. **Thiara (Stenomelania) plicaria** (Born, 1780)

Helix plicaria Born, 1780, *Test. Mus. Caes, Vindob,* p. 389, pl. 16, fig. 14. Type locality:?

Thiara (*Stenomelania*) *plicaria:* Pace, 1973, *Mal. Review* Supplement, **1:** 65, pl. 12, fig. 9, pl. 13, fig. 6.

Melanoides (*Stenomelania*) *plicaria*: Starmuehlner, 1976, *Ann. Naturhist. Mus. Wien,* 80: 580, figs. 87-97, pl. 16, figs. 182-194.

Distribution: India: Andaman and Nicobar Islands. Madagascar, Malay Archipelago, Philippines to Fiji Islands and on the north extending upto Ryukyu Islands

Remarks: Shell long and slender, whorls numerous and flat, tapering to a fine and acute apex, spiral whorls a little convex, spiral sculpture strongest on the base and near the sutures, the initial whorls with strong vertical plicae. Aperture vertical, outerlip slightly sinuous and protruding in the middle

86. **Thiara (Stenomelania) aspirans** (Hinds, 1874)

(Fig. 206)

Melania aspirans Hinds, 1847, *Ann. Mag. Nat. Hist.* 1847: 8. Type locality: Fiji.

Melania charon Preston, 1908, *Rec. Indian Mus.*, **2**: 196, pl. 15, fig. 22. Type locality: Andaman Islands.

Melanoides (*Stenomelania*) *aspirans:* Starmuehlner, 1976, *Ann. Naturhist. Mus. Wien.*, **80**: 577, pl. 16, fig. 180a, b; pl. 17, figs. 195, 196.

Distribution: India: Andaman and Nicobar Islands; Bismarck Archipelago, Solomon Island, New Hebrides, New Caledonia, Fiji and Samoa

Remarks: Shell high, turreted, extremely attenuate, with more than 12 whorls, sculptured with spiral ridges on the upper and basal part of the whorls leaving the central part smooth, suture margined by a somewhat stronger ridge. Whorls mostly eroded, regularly increasing in size, aperture nearly vertical, pointed above, rounded or almost straight below

87. **Thiara (Stenomelania) torulosa** (Bruguiere, 1789)

(Fig. 202)

Bulimus torulosus Bruguiere, 1789, *Encycl. Meth. Vers.*, **1**: 332. Type locality:?

Tiara (*Radina*) *crenulata* Preston, 1915, *Fauna Brit. India, Mollusca* (Freshwater Gastopoda and Pelecypoda), p. 11.

Thiara (*Stenomelania*) *torulosa:* Pace, 1973, *Mal. Review,* Supplement **1**: 66.

Distribution: India: Andamans, Visakhapatnam, Porto Novo; Madagascar, South-east Asia, Malaysia, Philippines, Taiwan and Solomon Islands

Remarks: Shell elongate turreted, whorls 12-14, thick with strong spiral sculpture broken up by transverse lines into rectangular nodules, aperture pyriform, pointed above and rounded below, columellar side somewhat twisted and curved to the right, outer lip crenulated

Seshaiya (1935, 1936*a,b* 1940) studied the ecology, anatomy and biology of the species. Ramamoorthi (1950, 1955) investigated the histology of the brood pouch, embryology and larval development. Meenakshi (1954) and Jacob (1959a) studied the physiology of digestion and reproduction (including chromosomes) respectively.

Van Benthem Jutting (1956) gave a detailed synonymy of this species.

Subgenus **Tarebia** H. & A. Adams, 1854.

Tarebia H. & A. Adams, 1854, *Genera Recent Moll.*, **1**: 304.

Type species: *Tarebia semigranosa* von dem Busch, 1842, SD Morrison, 1952.

Shell ovately-fusiform, whorls granulose or tessellated with nodules, outer lip sinuated below, interior of aperture often with spiral grooves.

Represented by two species, namely *T granifera*, with distinct spiral rows of granules and another *T lineata* without any granules, but with distinct dark spiral bands.

88. **Thiara (Tarebia) granifera** (Lamarck, 1822).

(Figs. 212, 213)

Melania granifera Lamarck, 1822, *Hist. nat. Anim. sans Vert.*, **6**(2): 167. Type locality: ?

Thiara (Tarebia) granifera; Pace, 1973. *Mal. Review* Supplement **1**: 62, pl. 12, fig. 3, pl. 13, fig. 4.

Tarebia granifera: Starmuehlner, 1976, *Ann. Naturhist. Mus. Wien,* **80**: 569, figs. 72-75, pl. 16, figs. 175-179.

Distribution: India: West Bengal, Madhya Pradesh, Bihar; Madagascar, Malaysia, Philippines, Formosa and Pacific Islands. Introduced into United States of America (Abbott, 1952).

Remarks: Shell elongately conical, sculptured with distinct spiral rows of nodules, spire sharp with flat whorls, height of body whorl more than half the total height of the shell.

Abbott (1952) made an exhaustive study on the anatomy, habitat and bionomics of this species.

89. **Thiara (Tarebia) lineata** (Gray, 1828).

(Fig. 191)

Helix lineata Gray, 1828, in *Wood's Index Test. Suppl.*, p. 24, fig. 68. Type locality: Ganges.

Tiara (Tarebia) lineata: Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 34.

Type: BM (NH).

Distribution: India: West Bengal, Bihar, Madhya Pradesh, Uttar Pradesh, Maharashtra, Assam; Bhutan; Burma; Sri Lanka.

Remarks: The species was often synonymised with *T granifera* (Lamarck) or treated as its variety (Van Benthem Jutting, 1956). But it is readily distinguished from the former by the absence of rows of nodules and presence of distinct dark spiral lines.

Subgenus **Sermyla** H. and A. Adams, 1854

Sermyla H. and A. Adams, 1854, *Genera Recent Moll.*, **1**: 296.

Type species: *Melania tornatella* Lea, 1850.

Shell with a relatively shorter spire than body whorl, arcuate, axial ridges on the upper portion strongly contrasting with the spiral ridges on the basal part of body. Aperture almost vertical, pointed above and rounded below.

90. **Thiara (Sermyla) riqueti** (Grateloup, 1840)
(Fig. 190)

Melania riqueti Grateloup, 1840, *Act. Soc. Linn. Bordeaux*, **11**: 433, pl. 3, fig. 28. Type locality: Bombay.

Thiara (*Melanoides*) *riqueti:* Pace, 1973, *Mal. Review*, Supplement **1**: 64, pl. 12, fig. 4, pl. 13, fig. 5.

Distribution: India: Bombay, Quilon, Cochin and Trivandrum. South east Asia, Malaysia, China, the Philippines, Taiwan, Japan: Ryukyu Islands and Australia.

Remarks: Shell small, moderately elongate, sculpture of undulating axial ridges and spiral ridges, axial ridges dominant above the periphery and the spiral ridges below it on the body whorl. Whorls about 8, regularly increasing, suture distinct.

Van Benthem Jutting (1956) gave a complete synonymy.

Subgenus **Melanoides** Olivier, 1807

Melanoides Olivier, 1807, *Voyage a* 1 *'Emp. Ottoman,* **2**: 40.

Type species: *Melanoides fasciolata* Olivier = *Nerita tuberculata* Mueller, 1776.

Shell small or of moderate size with a number of regularly increasing whorls, spire usually twice the length of the aperture or more, sculpture of axial and spiral striae or thin ribs often producing a more or less granular appearance. Aperture small, ovoid and not greatly produced in front, columellar callus moderate, the columella slightly bent and not produced anteriorly, the lip slightly or not at all thickened. Operculum relatively large with the posterior extremity pointed, paucispiral, with a basal nucleus sometimes almost approaching the subspiral condition. Ovoviviparous and parthenogenetic.

North, East and South Africa, Arabia, Persia, India, Sri Lanka, North Australia, Burma, Malaysia, Malay Archipelago, the Philippines and various Pacific Islands.

91. **Thiara (Melanoides) prashadi** Ray, 1947

Melanoides prashadi Ray, 1947, *Rec. Indian Mus.*, **45**(1): 304, text fig. 2. Type locality: Stream S. W. of Golf course, Aberdeen, Port Blair, Andamans.

Type: ZSI Regd. No. M 15940/2. (Not found)

Distribution: Not known beyond type locality.

Remarks: Shell smooth, pure olive-green, spire acuminate, whorls regularly increasing in size, first few spirally striated, but striations disappear on the later whorls, aperture small, triangularly ovate, columella white, thick, outer lip slightly expanded and produced below with an obtuse angle.

92. **Thiara (Melanoides) tuberculata** (Mueller, 1774)

(Figs. 183, 184)

Nerita tuberculata Mueller, 1774, *Hist. Verm. Terr. Fluv.*, **2**: 191. Type locality: Coromandel Coast.

Melania pyramis Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 354. Type locality: Ganges.

Melanoides (*Melanoides*) *peddamunigalensis* Ray and Ray Chowdhuri, 1969, *Proc. zool. Soc. Calcutta*, **22**: 48, pl. 4, figs. 12-17. Type locality: Peddamunigal, Nagarjunakonda, Nalgonda Dist. A.P.

Melanoides (*Melanoides*) *tuberculatus:* Starmuehlner, 1976, *Ann. Natur Hist. Mus. Wien.*, **80**: 591.

Distribution: Throughout India except Kashmir. North and South Africa. (For details of its distribution on the African continent—see Brown, 1980, p. 94), Eastern Mediterranean countries, South east Asia, Southern China, Malaysia, Malay Archipelago, North Australia, various Pacific Islands and north to the Ryukyu Islands of Japan, New Hebrides.

Remarks: It has a wide-range of distribution and variation. Shell with a high spire and moderately large body whorl, whorls evenly rounded, dark red-brown dots and flames, either irregularly distributed or longitudinally arranged on the shell surface, sculptured with vertical ribs and spiral striae, distinct and raised on the upper whorls, but flater on the lower ones.

Mantle edge bears 10-12 appendages, exterior surface of mantle not pigmented. Only females known.

It is a common melanid occuring in streams, rivers, irrigation canals and stagnant water ponds, often extending into brackish waters.

It was known by several names. Starmuehlner (1976) gave a complete synonymy. In India it was described under the names like *M. pyramis* (Hutton) (Fig. 184), *M. tigrina* (Hutton) and their varieties. Many of the names given by Preston (1915) may turn out to be synonyms of this species.

Ray and Roychowdhuri (1969) described *Melanoides peddamunigalensis* from Andhra Pradesh. It falls well within the variation of this species. An extensive collection of this and other thiarids from different parts of India and their intensive study may reveal the extent of variation exhibited by this and other species. As mentioned by Pace (1973) the fact that most thiarids are parthenogenetic requires special taxonomic considerations. There is a possibility for the existence of two or three subspecies of *T tuberculata.*

Seshaiya (1936), Ramamoorthi (1950, 1955), Jacob (1959a, b), Subba Rao and Mitra (1982) studied the biology. Recent studies by Berry and Kadri (1974) include investigations on reproduction.

Parasites—Several cercariae were recorded: *Cercaria indica* III-VII, XI, XIII-XVI, XVIII, XIX, XXXIV, XLVI, XLVII, LVI & LVIII (Sewell, 1922); *Cercaria* sp. (Lal & Gupta, 1952; Lal & Premvati, 1955), *Cercaria aciculata, C. bristiae, C. bristpennata, C. claudiglandula* (Gupta & Taneja, 1963 etc) *C. cordata, C. cruciata, C. deschiensi, C. dissimilis, C. fulvior, C. fulvaculata, C. gomtiensis, Neopronocephalus triangularis, C. kukrailensis* Thapar, 1969, *C. bhimtalensis* Malaki & Singh, 1963, *C. naukuchiensis* Gupta & Taneja, 1969, *C. pinjorensis* Gupta & Taneja, 1969. Avian parasites like *Stellantchasmus falcatus, Transversotrema patialensis* Murty & Rao, 1968.

93. **Thiara (Melanoides) tuberculata crebra** Lea, 1850
(Figs. 187, 188, 195, 196)

Melania crebra Lea, 1850, *Proc. zool. Soc. Lond.*, 1850: 193. Type locality-Philippines.

Distribution: Andaman and Nicobar Islands, the Philippines.

Remarks: It differs from the typical form in being broader, width usually more than 1/3 of the total height, whorls comparatively less rounded, sculptured with broad equidistant spiral ridges, raised axial ridges present only on the apical whorls often continuing on to the body whorl.

Melanoides tigrina raoi Ray, 1947 (Figs. 195, 196) may be a synonym of this

Subgenus **Mainwaringia** Nevill, 1884

Mainwaringia Nevill 1884, *Hand List Moll. Indian Mus.*, **2**: 286.

Type species: *Mainwaringia paludomoidea* Nevill.

Shell conical and imperforate, spire acuminate, columella strongly arched, not greatly incrassate, outer lip sharp, sculptured with deep cut spiral striae, a thin epidermis with minute scattered hairs or chaetae. Operculum horny, extremely thin, paucispiral, with the excentric nucleus.

Foot pointed and produced into a short filamentous process posteriorly, a distinct mid-dorsal groove on posterior part of the foot extending on to the terminal process.

Lower part of the Gangetic Delta.

94. **Thiara (Mainwaringia) paludomoidea** Nevill, 1884.
(Figs. 214, 215)

Melania (*Mainwaringia*) *paludomoidea* Nevill, 1884, *Hand List Moll. Indian Mus.*, **2**: 286. Type locality: Matlah river near Port Canning. Annandale and Prashad, 1919, *Rec. Indian Mus.*, **16**: 252, pl. XX, fig. 8.

Type: ZSI Regd. No. 1183 (Syntypes)

Distribution: Gangetic delta.

Remarks: Shell conically produced, suture distinct, shell bright yellowish-brown, body whorl with three distinct, broad, dark brown bands, showing clearly through the aperture, sculptured with spiral striae, which become prominent just below the suture, surface covered with rather long and well developed hairs.

Foot small, tentacles long and slender, snout prominent, blunt and slightly notched in front, foot and tentacles translucent white, with black pigment at the tips, snout brownish.

On trunks and aerating roots of mangrove trees submerged at high tide, in the Mutlah river at Port Canning.

Subfamily MELANATRIINAE

Shell rounded to tower-shaped form, smooth or with varied sculpture, spirally striated, ribbed or tuberculated, columellar margin thick, more or less arched. Aperture generally angular below. Operculum round, multi-spiral with a central or nearly central nucleus.

Margin of the mantle smooth, with a small fleshy, cup shaped fold on the right side opposite the anal opening.

Genus. 25. **Sulcospira** Troschel, 1858

Sulcospira Troschel, 1858, *Gebiss Schnecken*, **1**: 117.

Type species: *Melania huegeli* Philippi.

Shell ovoid conical, not slender as in *Thiara* or *Brotia*, yellowish-green or brown, spirally grooved, especially on the basal region of whorls, lustreless. Aperture oval, somewhat expanded at base, but never with a siphonal canal. Operculum multispiral with a central nucleus. Female ovoviviparous.

India and Indonesia

95. **Sulcospira huegeli** (Philippi, 1841) (Fig. 200)

Melania huegeli Philippi, 1841, *Abbild, Beschreib. Conch.*, **1**: 61, pl. 2, fig. 8. Type locality: New Holland?

Melania blisteri Ray, 1953, *Rec. Indian Mus.* **50** (1): 112, pl. 1, figs. 1-6 & 1a-6a Type locality: Coromandel Coast.

Distribution: Assam: Khasi hills, Garo hills; Karnataka: Upper Cauvery River, Bangalore; Kerala: Wynaad, Cochin hills.

Remarks: Shell ovoid conical, whorls 5-6, regularly increasing in size, spire generally decollated, dark brown, body whorl large, almost equal to the height of the spire, shell smooth, spiral striae below the periphery of the body whorl, aperture vertical and produced at the base.

Melanoides blisteri Ray differs from the typical form only in the presence of blisters, which might have been caused due to the ecological factors.

Genus 26. **Brotia** H. Adams, 1866

Brotia H. Adams, 1866, *Proc. zool. Soc. Lond.*, p. 150.

Type species: *Melania pagodula* Gould, 1847 by Monotypy.

Acrostoma Brot, 1874, Martini and Chemnitz's *Syst. Conch. Cab.*, **1** (24): 17.

Type species: *Melania huegeli* Philippi.

Shell large up to 5 or 8 cms. shell high-conoid or turreted with many whorls, spire longer than the body whorl, apex of the shell asymmetrical,

coated with a dark brown, almost black epidermis, axial ribs heavy and clear, columellar angle of the lip of the aperture produced slightly forward or round. Operculum round, multispiral, central or nearly central nucleus.

Snout broad and protrusible, tentacles long and slender. Foot short and broad.

Mainly parthenogenetic. Males were recorded by Davis (1971). Brood pouch is same as in *Thiara*.

India, Indo-China, Malaysia, Malay Archipelago and the Philippines.

Subgenus **Antimelania** Crosse and Fischer, 1892

Antimelania Crosse and Fischer, 1892, *Miss. Mex.*, **7** (2): 313.

Type species: *Melania variabilis* Benson, 1836 (=*Melania costula* Rafinesque, 1833)

Aperture more or less regularly rounded at the base but not projecting as in *Brotia* s. str.

96. **Brotia (Antimelania) costula** (Rafinesque, 1833)
(Figs. 192—194, 197, 198)

Melania costula Rafinesque, 1833, *Atlantic Journ.* no. 5: 166. Type locality: Gomti river at Jaunpur, Uttar Pradesh.

Brotia costula: Van Benthem Jutting, 1956, *Treubia*, **23** (2): 374, fig. 76.

Distribution: India: Gangetic Plain, West Bengal, Manipur, Assam, Sibsagar, Garo Hills, Damuda Hill, Garam Pani, Kaziranga; Burma; Malay Archipelago; Indonesia.

Remarks: Shell elongate, whorls 12-14, regularly increasing, sculptured with spiral ridges or nodules, prominent axial ribs, often with spines.

It is very much variable and thirteen varieties and subvarieties have been identified by different authors. Annandale (1921) recognised three varieties namely *laevis* Annandale, *semilaevigata* Nevill and *subspinata* Annandale from Manipur. Other important varieties of this species are *echinata* (Benson), *intermedia* (Brot), *subspinosa* (Nevill) and *subtuberculata* (Nevill). As Annandale (1921) himself remarked these varieties are by no

means constant. Unless a thorough revision is made it is impossible to classify them as ecological or geographical subspecies. Davis (1971) studied the systematics of *Brotia costula episcopalis*. The subspecies probably extends from Malaysia to Assam through Burma. There may be another subspecies in the Indo-gangetic plains. It occurs in muddy water and on muddy bottom of rivers and stagnant water.

In ponds, generally do not prefer swift flowing streams.

Parasites. Cercaria indica VI, VII and VIII were recorded (Sewell, 1922).

Subfamily MELANOPSINAE

Shell usually elongated, ovately conical with moderately low spire except in *Faunus*. Shell surface smooth or sculptured, columellar margin more or less twisted, lower margin of aperture distinctly channelled. Operculum elongate oval with a terminally placed nucleus.

Mantle margin smooth, oviparous.

Genus 27. **Faunus** Montfort, 1810

Faunus de Montfort, 1810, *Conch. Syst.*

Type species: *Strombus ater* Linnaeus.

Shell elongate with fine, pointed apex, whorls several and flat, finely striated axially and spirally. Aperture oval, with an anterior canal at the base, and posteriorly with a sinus, columella smooth, arched, extending into a parietal callus. Operculum elongate ovate, nucleus excentrical.

India, Sri Lanka, Malay Archipelago, the Philippines, New Guinea and New Hebrides.

97. **Faunus ater** (Linnaeus, 1758)

(Figs. 208, 209)

Strombus ater Linnaeus, 1758, *Syst Nat.* ed **10**: 746. Type locality: "Asiae paludibus"

Faunus ater: Van Benthem Jutting, 1956, *Treubia*, **23** (2): 380, fig. 78.

Distribution: India: Goa, Nicobars; Sri Lanka, Mauritius, Malay Archipelago, the Philippines, New Guinea and New Ireland.

Remarks: Shell with a long spire, whorls flat and sutures shallow, whorls 18 to 20, regularly increasing, the first 5 or 6 whorls strongly striated. Aperture broadly oval with sinus at upper and lower ends.

Occurs in slightly brackish water.

Subfamily PALUDOMINAE

Shell round or oval, smooth or with spiral sculpture, strong periostracum, aperture proportionately large, ovate, notched or obliquely grooved below, operculum round with concentric ridges.

Mantle margin with 20 to 25 small, equal-sized fleshy protruberances or papillae.

Oviparous. An egg-laying groove on the right side of the foot.

Occurs in fast and slow-moving hill streams.

Sri Lanka, South India, Assam (Brahmaputra Valley), Burma and Sumatra extending on the west to Africa and east to New Guinea.

Genus 28. **Paludomus** Swainson, 1840

Paludomus Swainson, 1840, *Treatise on Malacology,* 1840: 340.

Type species: *Melania globulosa* Gray.

Shell strong, oblong-globose, aperture larger than the spire, inner lip or columella very thick.

Sri Lanka, South, South-west and North-east India, Burma.

Starmuehlner (1977) treated the genus and its species occuring in Sri Lanka.

Four subgenera are recognised.

Key to subgenera

1. Shell with an elevated spire, columella narrow and not very flat 2

   Shell with a low or depressed spire, columella broad and flat 3

2. Operculum with a submedian nucleus displaced to the left, growth striae subspiral rather than concentric, on the inner surface distinctly marked, stair-step like growth lines ..... **Paludomus** s. str.

   Nucleus subbasal and dextral, growth striae paucispiral ..... **Philopotamis**

3. Columella with a prominent tooth like projection on its anterior part, operculum with an excentric nucleus ..... **Stomatodon**

   Columella without any tooth or projection, operculum with a dextral and lateral nucleus ..... **Tanalia**

Subgenus **Paludomus** s.str.

The species generally occur in slow flowing streams in Sri Lanka and Indo Malayan region.

It is the most common of all the subgenera and is represented by 19 species.

98. **Paludomus andersoniana** Nevill, 1877
(Fig. 223)

Paludomus andersoniana Nevill, 1877, *J. Asiat. Soc. Beng.*, **46** (2): 35. Type locality: Upper Burma. Nevill, 1881, *J. Asiat. Soc. Beng.*, **50** (2): 160, pl. 5, fig. 2.

Type: ZSI Regd. No. M 16917/2 (Holotype)

Distribution: Burma.

Remarks: Shell large and globose, spire produced and pointed, body whorl with four dark black bands, the second one from top broader than others, whorls seven, sculptured with superficial broad spiral ridges, only the subsutural ridge distinct and a little prominent. Operculum internally with a remarkably raised nuclear portion, and distinct, minute granular region.

99. **Paludomus (Paludomus) annandalei** Preston, 1909
(Fig. 218)

Paludomus annandalei Preston, 1909, *Rec. Indian Mus.*, **3**: 278, fig. 1. Type locality : Tenmalai, Western Ghats (W. side).

Types: ZSI Regd. No. M 4610/1 (Holotype), M 17433/3 (Paratypes—2).

Distribution: Western Ghats, India.

Remarks: Shell conoidal, apex eroded, dark olivaceous brown, sculptured with coarse spiral striae below the sutures and on the basal part of the whorls, interstices with punctate appearance, sutures slightly impressed, columella arched, hardened into a nodule at the point of meeting the outer lip.

100. **Paludomus (Paludomus) blanfordiana** Nevill, 1877
(Figs. 222, 239)

Paludomus blanfordiana Nevill, 1877, *J. Asiat. Soc. Beng.*, **46** (2): 37. 1881, *J. Asiat. Soc. Beng.*, **50** (2): 159, pl. 5, figs. 3, 3a. Type locality: Ava, Burma.

Paludomus rotungensis Preston, 1915, *Rec. Indian Mus.*, **8**: 539, fig. 3, 3a. Type locality: Upper Rotung.

Distribution: India: Assam-Gauhati; Meghalaya: Siju Cave, Garo Hills. Burma: Pegu, Arakan.

Remarks: Shell ovately-globose, body whorl inflated, colour dark yellow, often coated with black encrustation, sculptured with fine spiral striae and longitudinal growth striae, body whorl with three characteristic chocolate-brown coloured broad bands, which also show through the aperture, aperture oval, margin of columellar callus tinged with chocolate brown colour.

101. **Paludomus (Paludomus) burmanica** Nevill, 1877

Paludomus burmanica Nevill, 1877, *J. Asiat. Soc. Beng.*, **46** (2): 36. Type-locality: Yaylaymaw, U. Burma. Nevill, 1881, *J. Asiat. Soc. Beng.*, **50** (2): 162, pl. 5, fig. 4.

Types: ZSI Regd. No. M 10919/2 (Syntypes)

Distribution: Burma.

Remarks: Shell small, spire depressed, decollated, sculptured with irregular striae, three dark black bands, the upper one exceedingly broad, covering nearly half of the whorl, columellar callus a little broad and thick.

102. **Paludomus (Paludomus) conica** (Gray, 1834) (Figs. 227, 228)

Melania conica Gray, 1834, *Griffith Cuvier, Moll.*, pl. 14, fig. 5.

Distribution: India: Meghalaya-Teria Ghat, South Jaintia Hills, Garo Hills, Kopili River, West Khasi Hills; Sibsagar (Assam); Bhutan; Bangladesh.

Remarks: Shell globose conical, whorls 5, smooth for the most part excepting for one broad or three to four spiral ridges in the sutural region, colour yellowish brown to dark-brown, often ornamented with dark spiral bands as in *P. blanfordiana.*

103. **Paludomus (Paludomus) chilinoides** Reeve, 1847 (Figs. 225, 226)

Paludomus chilinoides Reeve, 1847, *Conch. Icon.*, **4**: pl. 2, f. 7a, pl. 3, f. 7b, 7c. Type locality: "Bed of the Mahawelle Ganga, near Kandy, Ceylon".

Paludomus (*Paludomus*) *chilinoides:* Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka,* **25** (1 & 2): 133.

Types: BM (NH).

Distribution: Low and Upland of Sri Lanka.

Remarks: Shell rather thin, ovate, spire small, whorls five, depressed around the upper part, yellowishbrown to olive, one or more rows of spots or zigzag lines, columellar callus thick and expanded.

Starmuehlner (1974) gave a detailed synonymy and account of its anatomy and ecology.

104. **Paludomus (Paludomus) dhuma** Rao, 1925
(Fig. 229)

Paludomus dhuma Rao, 1925, *Rec. Indian Mus.*, **27**: 97, fig. 1. Type-locality: Edge of a stream near Thazi railway station, Lower Burma.

Types: ZSI Regd. No. M 12485/2.

Distribution: Burma.

Remarks: Shell thick, uniform dark smoke colour, whorls 4-5, rapidly increasing, young shells with three brown coloured spiral bands visible through the innerside of the aperture, sculptured with indistinct vertical and spiral striae, columellar callus fairly thick and smooth, outer lip thin and sharp.

It may be conspecific with *P. andersoniana* Nevill.

105. **Paludomus (Paludomus) inflatus** Brot, 1880
(Figs. 244, 245)

Paludomus inflata Brot, 1880, in Martini and Chemnitz, *Syst. Conch. Cab.*, **1** (25): 44, pl. 18, figs. 25, 26. Type locality:?

Paludomus (*Paludomus*) *inflatus:* Starmuehlner, 1974, *Bull. Fish. Res. Stn. Sri Lanka*, **25** (1): 139, pl. VIII, fig. 78.

Distribution: India: Kerala (Western Ghats), Amerghat; Tamilnadu—Tinnevelley; rare in Eastern Sri Lanka.

Remarks: Shell globose, spire elevated, apex mostly decollated, body whorl abruptly enlarged and globular, flat below the suture and arched later, sculptured with distinct unequal spiral furrows, aperture broad and ovate.

106. **Paludomus (Paludomus) nana** Nevill, 1881
(Fig. 231)

Paludomus andersoniana subsp. *peguensis* subvar. *nana* Nevill, 1881, *J. Asiat. Soc. Beng.*, **50**:160. Type locality: Pegu, Lower Burma.

Paludomus nana: Rao, 1929, *Rec. Indian Mus.*, **31**:292, text fig. 6.

Types: ZSI Regd. No. M 12847/2.

Distribution: Burma.

Remarks: Shell with rapidly increasing whorls, suture transverse and lightly impressed, aperture acuminate above and relatively rounded below, columellar callus broad and somewhat flattened.

107. **Paludomus (Paludomus) obesus** (Philippi, 1842) (Fig. 232)

Melania obesa Philippi, 1842, *Abbild, Beschreib, Conch.*, **2**: 170, *Melania* pl. 4, fig. 3. Type locality: "Patria: Nova Hollandia"

Distribution : Maharashtra: Bombay, Khandala, Ahmednagar and Ratnagiri.

Remarks: Annandale (1919) mentioned it as a widely distributed species. But from the collections studied it is evident that it is restricted to streams in Western India.

108. **Paludomus (Paludomus) ornatus** Benson, 1856 (Fig. 220)

Paludomus ornata Benson, 1856, *Ann. Mag. nat. Hist.* (2) **17**: 496. Type locality: Upper Burma.

Distribution: India: Brahmaputra valley; Burma: Pegu, Upper Burma.

Remarks: Shell ovately conical, whorls 6, spire acuminate, shell smooth except for 2 or 3 spiral ridges in the sutural region, below the suture flat, aperture ovate, inside with three dark bands, columella arched and thick, straight below, outerlip sharp, angular above and then almost straight.

109. **Paludomus (Paludomus) palustris** Layard, 1854 (Figs. 250, 251)

Paludomus palustris Layard, 1854, *Proc. zool. Soc. Lond.*, 1854: 89, Type locality: "Grassy margins of a tank of Anorajahpura, Ceylon".

Paludomus (*Paludomus*) *palustris*: Starmuehlner, 1974, *Bull. Fish. Res. Stn, Sri Lanka*, **25** (1 & 2): 139, pl. VII, fig. 79.

Distribution: North Central Province of Sri Lanka.

Remarks: Shell ovate, spire exserted, whorls 3-5, rounded and flat, sculptured with close, minutely granular striae.

110. **Paludomus (Paludomus) parvula** Rao, 1929
(Fig. 233)

Paludomus parvula Rao, 1925, *Rec. Indian Mus.*, **31**: 293, text fig. 7. Type locality: Burma.

Types: ZSI Regd. No. M 12849/2 (Holotype), M 12850/2 (Paratypes)

Distribution: Burma.

Remarks: Shell regularly ovate, decollate, sculptured with distinct spiral ridges, suture oblique and well-defined, aperture acuminate above and narrowly rounded below, with four broad brown bands in the interior of the aperture.

It is perhaps a variety of *Paludomus regulata* Benson.

111. **Paludomus (Paludomus) pustulosa** Annandale, 1925
(Fig. 234)

Paludomus pustulosa Annandale, 1921, *Rec. Indian Mus.*, **22**: 563, fig. 11 A,B. Type locality: Stream in the south part of the Manipur valley.

Types: ZSI Regd. No. M 11858/2

Distribution: Manipur.

Remarks: Shell ovate, thick and uniformly black, with a tumid body whorl, sculptured with coarser longitudinal lines, interior of shell olivaceous sometimes with traces of two or three broad chestnut bands.

112. **Paludomus (Paludomus) reticulata** Blanford, 1870

(Fig. 237)

Paludomus reticulata W.T. Blanford, 1870, *J. Asiat. Soc. Beng.*, **39** (2): 9, pl. 3, fig. 1. Type locality: North Cachar, Assam.

Remarks: Shell globose, whorls 3-4, sutures impressed, sculptured with reticulate spiral striations, which form regular axial granules or reticulations.

It resembles *P. loricatus* in the presence of granular spiral ridges but differs from it in the general shape and nature of granules.

113. **Paludomus (Paludomus) rotunda** Blanford, 1870

(Fig. 238)

Paludomus rotunda W.T. Blanford, 1870, *J. Asiat. Soc. Beng.*, **39** (2): 10, pl. 3, fig. 2. Type locality: "Travancore."

Distribution: Kerala: Western Ghats: Tamilnadu: Balarangam, Anamullay and Madurai Hills.

Remarks: Shell small, oval, decollated, only two whorls seen, irregular spiral striae, aperture suboval, columella arched, callus broad, outer lip sharp.

114. **Paludomus (Paludomus) stephanus** (Benson, 1836)

(Figs. 240, 241)

Melania stephanus W.H. Benson, 1836, *J. Asiat. Soc. Beng.*, **36**: 747. Type locality: Sylhet, Bangladesh. Hanley and Theobald, 1876, *Conch. Indica*, pl. 122, fig. 10.

Distribution: India: Meghalaya, Khasi Hills; Bangladesh: Sylhet.

Remarks: Shell ovately conical, whorls rapidly increasing, body whorl very much inflated, spire short, decollated, whorls conspicuously shouldered bearing a crown of short and pointed spines, aperture oval, columella very much arched and produced below, outer lip angularly arched.

115. **Paludomus (Paludomus) regulata** Benson, 1856
(Fig. 236)

Paludomus regulata Benson, 1856, *Ann. Mag. nat. Hist.*, (2) **17**: 496. Type locality: Thyet-Myo, Burma. Hanley and Thoebald, 1876, *Conch. Indica*, pl. 108, fig. 5.

Distribution: Burma.

Remarks: Rao (1928) was of the opinion that *Paludomus andersoniana* should be treated as a synonym of *P. regulata.*

116. **Paludomus (Paludomus) tanschauricus** (Gmelin, 1771)
(Figs. 221, 252, 253)

Helix tanschaurica Gmelin, 1791, *Syst. Nat.* ed. **13**: 3655. Refers to Chemnitz's *Syst. Conch. Cab.* **9**: 174, figs. 1246, 1247.

Paludomus acutus Reeve, 1862, *Proc. zool. Soc. Lond.*, 1852: 127. Type locality: Near Pondicherry.

Paludomus tanjoriensis H.F. Blanford (emend), 1863, *Trans. Linn. Soc. Lond.*, p. 173, pl. 27, figs. 2a-e.

Paludomus (Paludomus) tanschauricus: Starmuehlner, 1974, *Bull. Fish Res. Stn., Sri Lanka*, **25** (1-2): 140, pl. VIII, fig. 80.

Distribution: India: Maharashtra: Pune; Kerala: Courtallum, (Travancore, Malabar); Tamilnadu: Pulney Hills, Trichinopoly, Madras; Andhra Pradesh: Kadapa (=Cuddapah); Northern Sri Lanka.

Remarks: Shell conical, with 6-8 convex whorls, first few whorls with keeled spiral ridges, colour yellowish-brown with dark brown spots running in lines and waves, aperture ovate, posteriorly pointed.

Seshaiya (1934) gave a detailed account of the anatomy of this species.

In slow-moving streams and in temporary streams (Sri Lanka Starmuehlner, 1977).

Subgenus **Philopotamis** Layard, 1855

Philopotamis Layard, 1855, *Ann. Mag. Nat. Hist.*, (2) **16**: 134.

Type species: *Paludomus sulcatus* Reeve.

It is distinguished from the other subgenera of the genus by its opercular characters. It is restricted to fast flowing torrents and mountain streams of S. W. Sri Lanka and Sumatra (Starmuehlner, 1977). Although we have only one species in India represented by a few specimens, an intensive collection in the hill streams of Western Ghats may throw more light on the occurrence of this subgenus in India. According to Starmuehlner (1977) it is endemic to Sri Lanka.

117. **Paludomus (Philopotamis) bicinctus** Reeve, 1852 (Fig. 224)

Paludomus bicinctus Reeve, 1852, *Proc. zool. Soc. Lond.*, 1852, p. 129. Type locality: Mountain stream of Ceylon.

Paludomus (Philopotamis) bicinctus: Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka* **25** (1 & 2): 142, pl. VIII. fig. 82.

Distribution: Sri Lanka: Eastern, Central and Uva Province.

Remarks: Shell oblong globose, spire small, whorls three, penultimate whorl big and ovate, sculptured with delicate spiral striae, two broad, indistinct chestnut brown bands on the inner surface of the aperture.

118. **Paludomus (Philopotamis) nigricans** Reeve, 1847 (Fig. 219)

Paludomus nigricans Reeve, 1847, *Conch. Icon.*, **4:** pl. 2, f. 6. Type locality: "Ceylon, in mountain streams at 6000 ft. elevation".

Paludomus (Philopotamis) nigricans: Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka,* **25** (1 & 2): 143, pl. VII, fig. 84.

Distribution: Sri Lanka: Highland of Central Province.

Remarks: Shell oval, spire rather prominent and exserted, whorls 2-4, smooth or delicately granulated, adult specimens dark brown to blackish, young ones reddish brown with indistinct chestnut brown bands.

Starmuehlner (1974) briefly remarked on its anatomy and bioecology.

119. **Paludomus (Philopotamis) regalis** Layard, 1854 (Fig. 235)

Philopotamis regalis Layard, 1854, *Proc. zool. Soc. Lond.*, 1854: 93. Type locality: "Stream in the Cnia Corle, Western Province, Ceylon".

Paludomus (Philopotamis) regalis: Starmuehlner, 1974, *Bull. Fish. Res. Stn., Srl Lanka,* **25** (1 & 2): 144, pl. VIII, fig. 88.

Distribution: Sri Lanka: Southern and Western Province.

Remarks: Shell oblong ovate, spire short and exserted, whorls rounded, sculptured with close, superficial spiral ridges and minute longitudinal striae, a peripheral row of close set, short and sharp angular spines.

120. **Paludomus (Philopotamis) sulcatus** Reeve, 1847
(Fig. 243)

Paludomus sulcatus Reeve, 1847, *Conch. Icon.*, **4**: pl. 2, fig. 8a, pl. 3, figs. 8b, 8c. Type locality: Stream at Ratnapoora, Ceylon.

Paludomus (Philopotamis) sulcatus: Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka,* **25** (1-2): 145, pl. IX, fig. 89.

Types: BM (NH).

Distribution: India: Kerala; Sri Lanka.

Remarks: Shell ovate, spire prominent but generally eroded, whorls 3-5, rounded, suture impressed, sculptured with spiral grooves, colour brownish, aperture subtriangularly ovate, angulate posteriorly. Operculum subtriangularly ovate, nucleus subbasal and dextral.

The collections from Travancore were identified as *P. travancorica* Blanford, 1880. If the identification is correct it should become a synonym of *P. sulcatus.*

Subgenus **Tanalia** Gray, 1847

Tanalia Gray, 1847, *Proc. zool. Soc. Lond.*, p. 153.

Type species: *Nerita aculeata* Chemnitz

It is highly endemic to high lands of Southern and Southwestern Sri Lanka, in fast flowing torrents and mountain streams (Starmuehlner, 1977). As in the case of the subgenus *Philopotamis* it is also represented by a single species in India. More collections are needed to find out the actual distribution of this subgenus in India.

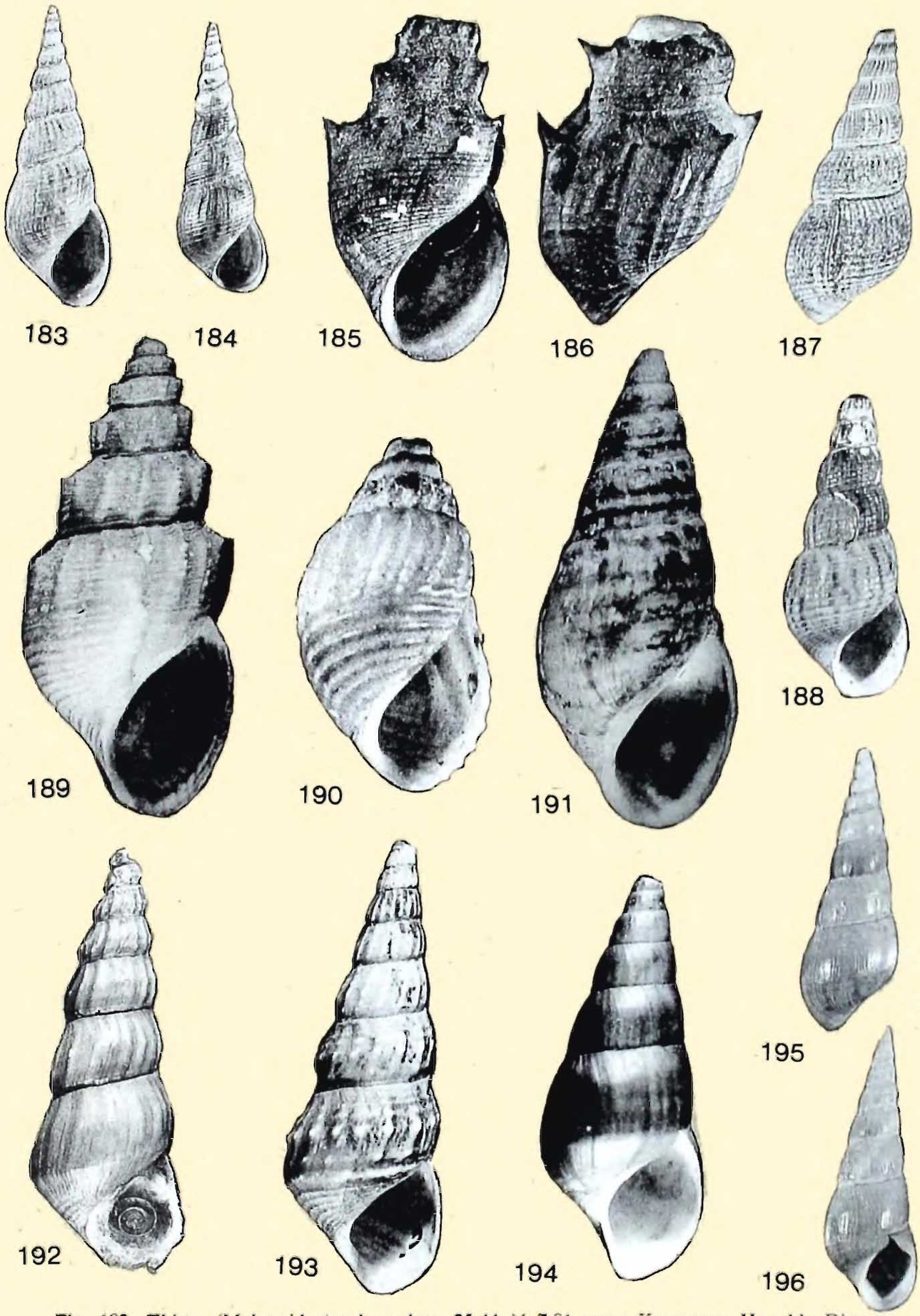
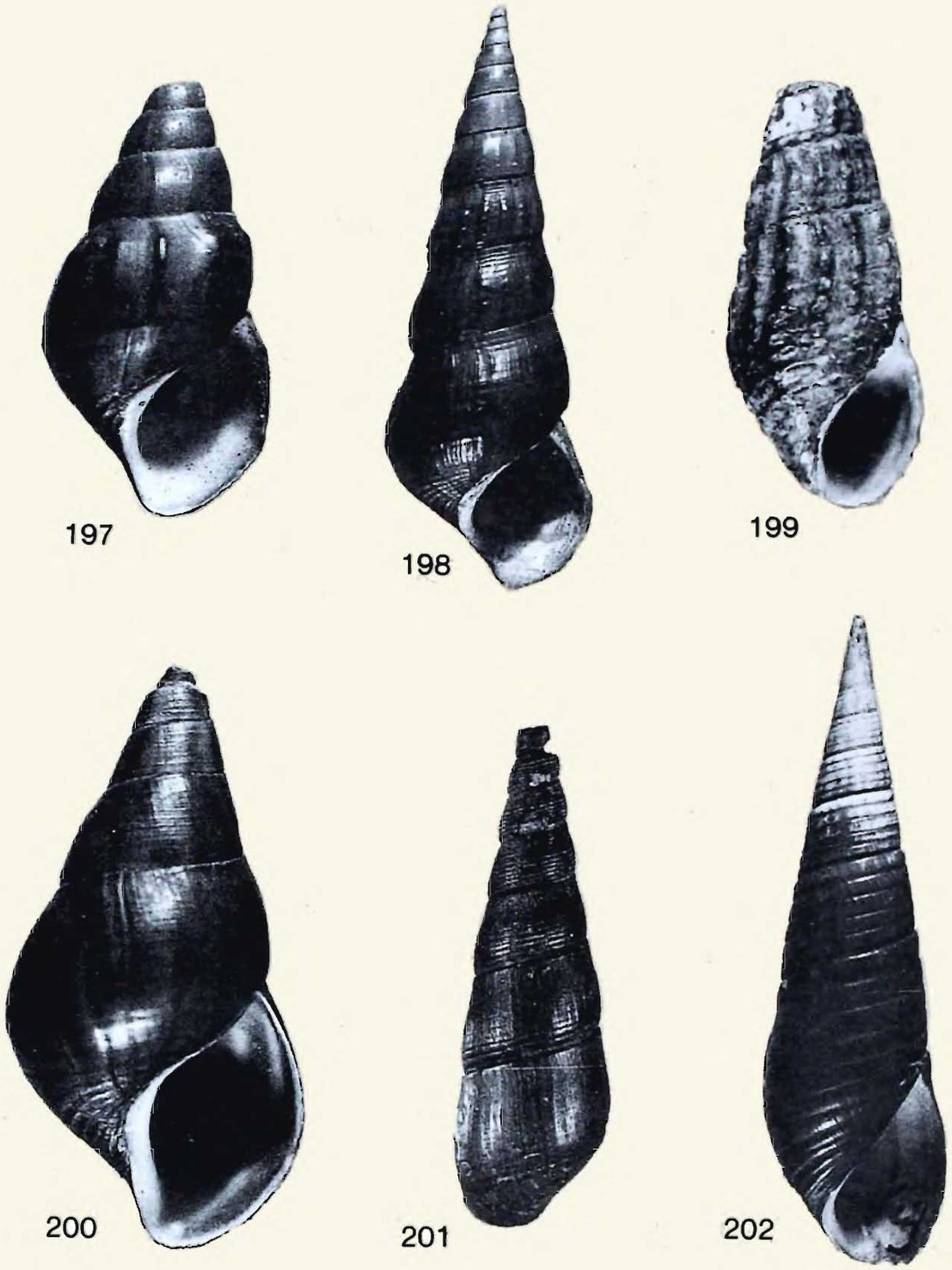
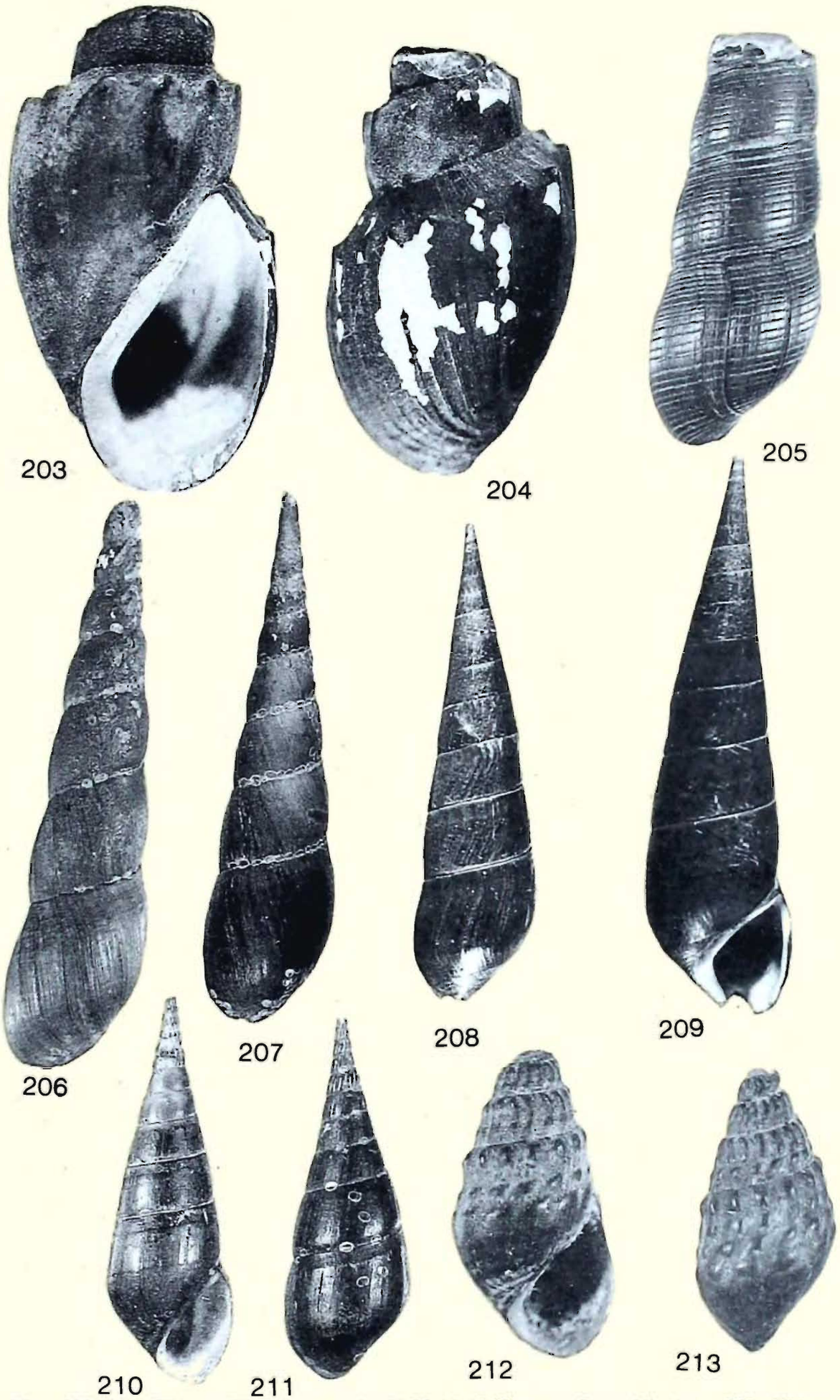


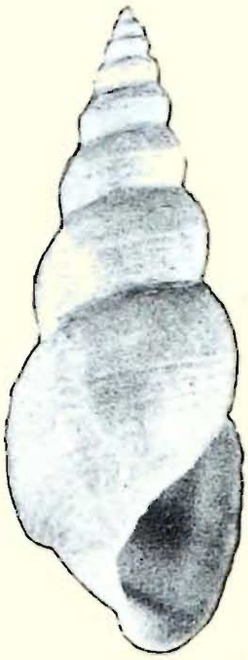
Fig. 183. *Thiara (Melanoides) tuberculata*, 25.44 × 7.81 mm.; Konnagar, Hooghly Dist., 184. *T. (M.) pyramis*, 26.43 × 9.1 mm.; Himachal Pradesh. 185, 186. *Thiara (Thiara) scabra*, 23.75 × 10.23 mm.; Mutha river, near Pune. 187, 188. *T. (Melanoides) tuberculata crebra*, 24.90 × 9.10 mm.; Andamans, 189. *Thiara (Thiara) scabra*- Juvenile shell, 10.23 × 4.86 mm.; Pune, 190. *T. (Sermyla) riqueti*, 9.55 × 5.13 mm.; Ratnagiri. 191. *Thiara (Tarebia) lineata*, very much enlarged 11.64 × 5.48 mm.; Kanha water works, Nagpur. 192, 193. *Brotia costula*, Juvenile shells, 12.58 × 7.61 mm.; 16.68 × 10.18 mm.; Calcutta. 194. *Brotia costula* var. *laevis*, (Full grown), 43.95 × 17.5 mm.; Meghalaya. 195, 196. *Thiara (Melanoides) tigrina raoi* Holotype.



Figs. 197, 198. *Brotia costula* — juvenile shells in two different stages of growth, 28.58 × 14.04 mm.; 55.14 × 19.58 mm.; Imphal, Manipur. 199. *Thiara (Thiara) rudis*, 15.90 × 6.81 mm.; Tenasserim, Burma. 200. *Sulcospira huegeli*, 40.1 × 20.50 mm.; Kerala. 201. *Thiara (Melanoides) nevillei*, 25.30 × 8.80 mm.; Andamans. 202. *Thiara (Stenomelania) torulosa*, 60.56 × 15.96 mm.; Andamans.



Figs. 203, 204. *Thiara (Thiara) amarula*, 31.30 × 18.25 mm.; Great Nicobars. 205. *Thiara multistriata*, 25.15 × (decollated), 9.90 mm.; Andamans. 206. *T. (Stenomelania) charon* (=*T. (M.) aspirans*), 48.85 × 11.40 mm.; Andamans. 207. *T. (M.) fucata*, 41.15 × 9.35 mm.; Nicobars. 208, 209. *Faunus ater*, 60.46 × 16.35 mm.; Nicobars. 210, 211. *T. (Stenomelania) punctata*, 37.85 × 10.85 mm.; 39.80 × 12.25 mm.; Katchal. 212. 213. *Thiara (Tarebia) granifera*, 11.00 × 6.75 mm.; Calcutta.



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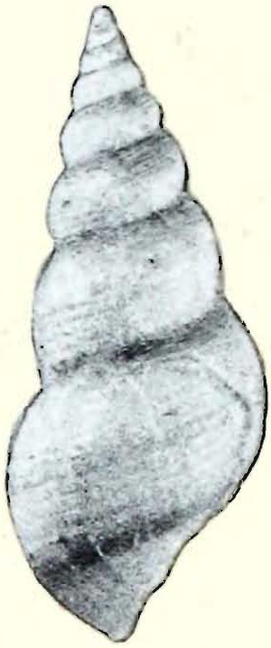

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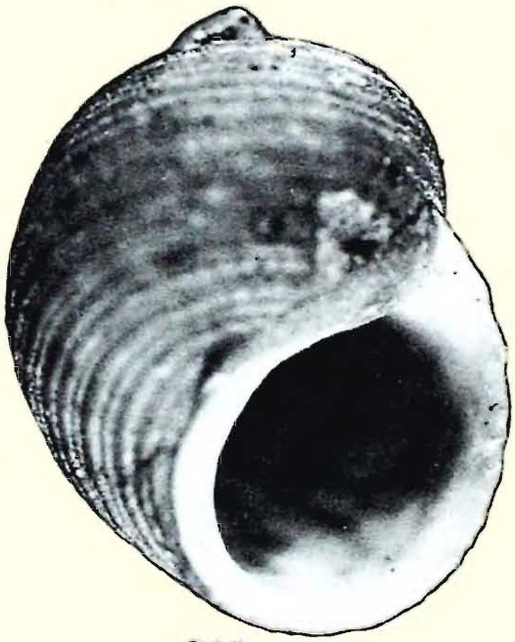

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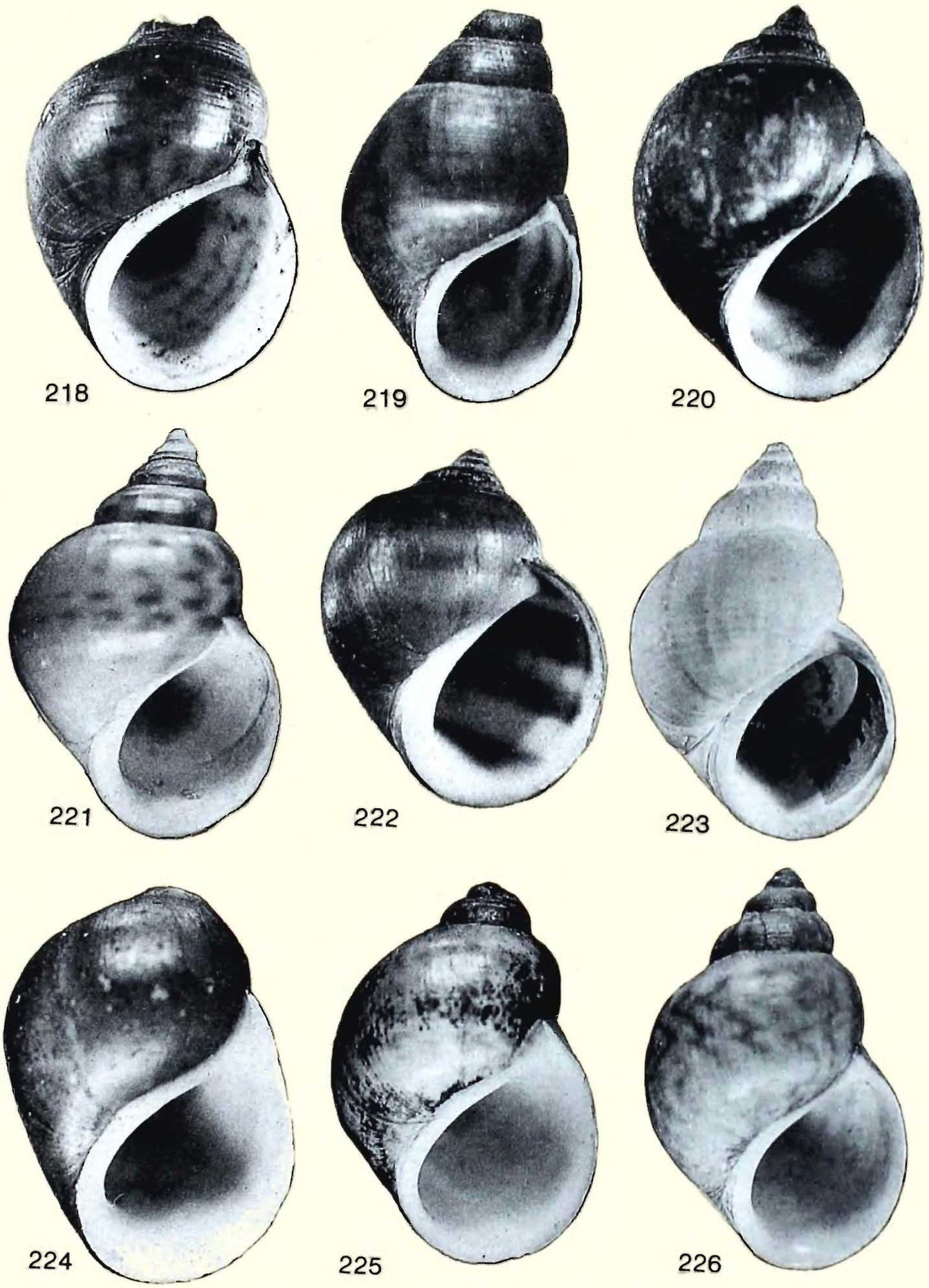
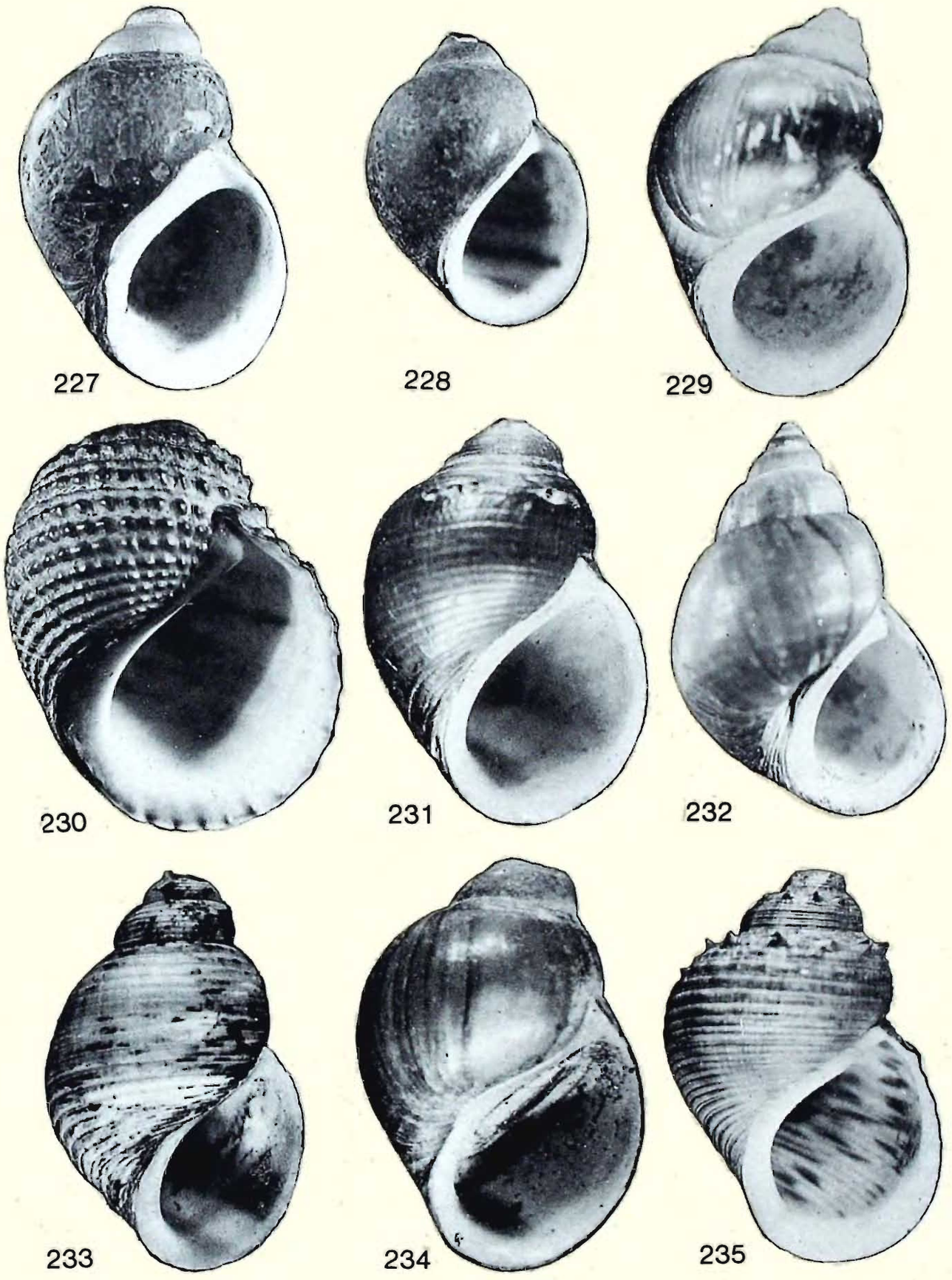
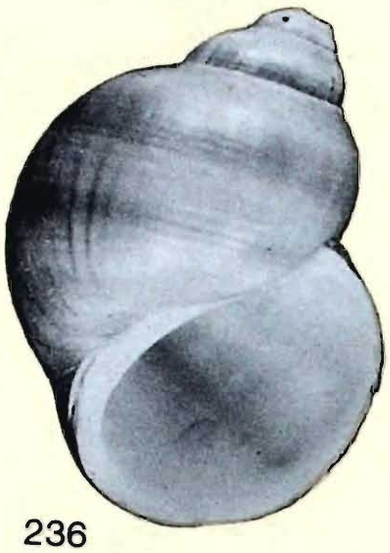
Figs. 214, 215. *Mainwaringia paludomoidea*, Syntype, 9.75 × 3.95 mm., Port Canning, W.B.
216, 217. *Paludomus solidus*, 11.15 × 9.15 mm., Sri Lanka.



Figs. 218. *Paludomus annandalei*, Holotype, 24.20 × 20.0 mm., Kerala (Travancore). 219. *P. nigricans*, 15.65 × 9.55 mm., Sri Lanka. 220. *P. ornata*, 15.25 × 9.65 mm., Burma. 221. *P. acuta tanschaurica*, 16.60 × 4.65 mm., Madras. 222. *P. blanfordiana*, Syntype, 16.85 × 12.0 mm., Ava, Burma 223. *P. andersoniana*, 31.85 × 21.80 mm., Burma. 224. *P. bicincta*, 18.05 × 12.70 mm., Sri Lanka. 225. *P. chilinoides*, 18.75 × 12.15 mm., Sri Lanka. 226. *P. chilinoides laevis*, 21.80 × 12.90 mm., Sri Lanka.



Figs. 227. *Paludomus conica*, 22.40 × 14.25 mm., Assam. 228. *Paludomus conica*, 29.25 × 17.90 mm., Assam. 229. *P. dhuma*, 22.75 × 14.60 mm., Thazi stream. 230. *P. loricata*, 37.95 × 29.0 mm., Sri Lanka. 231. *P. nana*, Syntypes, 15.0 × 9.72 mm., Pegu, L. Burma. 232 *P. obesus*, 13.85 × 8.15 mm., Bombay. 233. *P. parvula*, Paratypes, 15.30 × 9.60 mm., Burma. 234. *P. pustulosa* Paratype, 12.30 × 8.15 mm., Manipur. 235. *P. regalis*, 30.60 × 18.90 mm., Sri Lanka.



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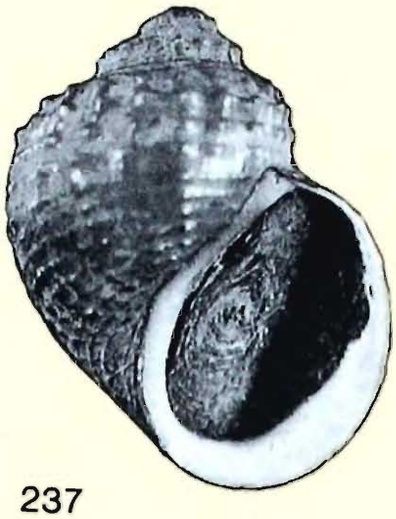

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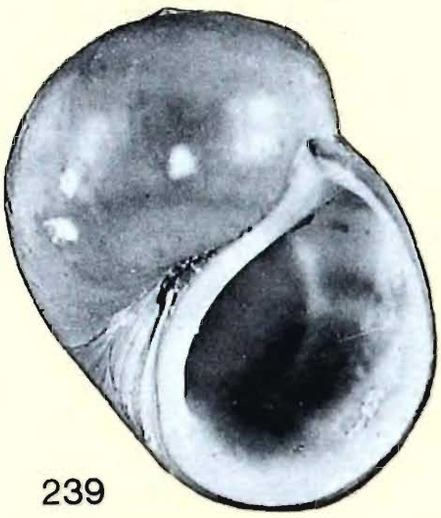

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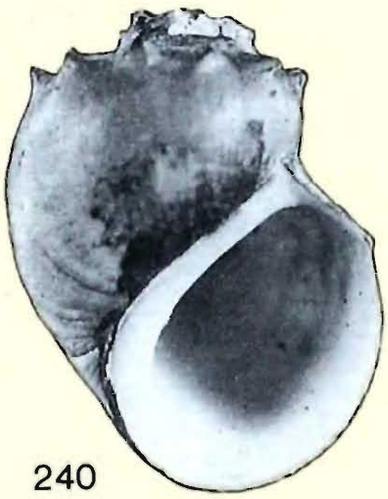

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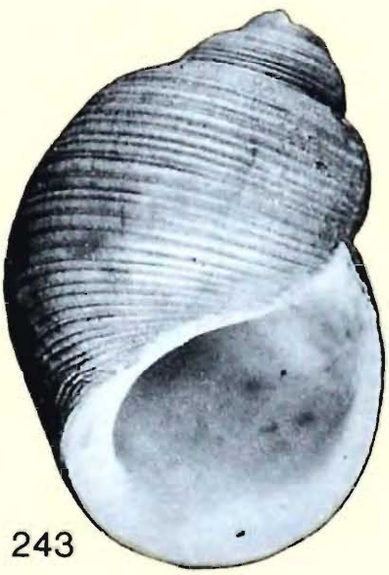
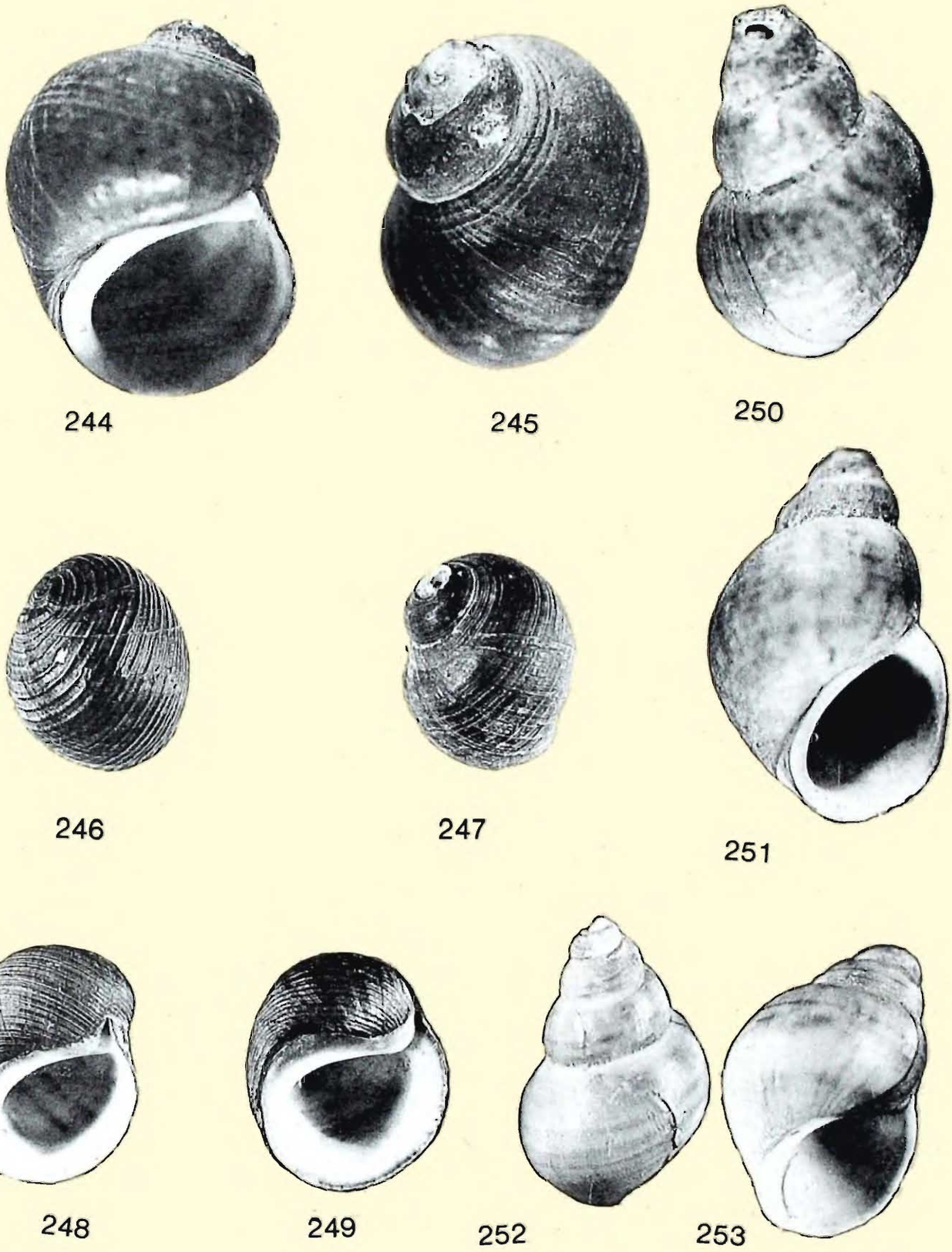


243

Figs. 236. *P. regulata*, 26.50 × 16.85 mm., Burma. 237. *P. reticulata*, 19.20 × 12.15 mm., Jaintia. 238. *P. rotunda*, 11.20 × 8.25 mm., Kerala (Travancore). 239. *P. rotungensis*, Holotype, 6.70 × 5.0 mm., Upper Rotung. 240, 241. *P. stephanus*, 24.75 × 17.0 mm.; 20.0 × 14.50 mm., Assam. 242. *P. stomatodon*, 12.35 × 9.40 mm., Kerala. 243. *P. sulcata*, 26.85 × 17.50 mm., Sri Lanka.



Figs. 244, 245. *P. inflatus*, 20.70 ×14.45 mm., Tamil Nadu. 246-249. *P. neritoides*, 31.95 × 28.05 mm.; 25.90 × 22.90 mm., 250, 251. *P. palustris*, 17.25 × 11.40 mm., Sri Lanka. 252, 253. *P. tanjorensis*, 14.10 × 7.80 mm., Madras.

121. **Paludomus (Tanalia) loricatus** Reeve, 1847
(Fig. 230)

Paludomus loricata Reeve, 1847, *Conch. Icon.*, **4**, *Paludomus* sp. no. 1, pl. 1, figs. la, b, c. Type locality: In rapids flowing from Adam's Peak, Ceylon.

Paludomus (*Tanalia*) *loricatus:* Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka,* **25** (1-2): 146, pl. IX, figs. 92-99, pl. X, figs. 100-104.

Distribution: India: Assam; Sri Lanka. In slightly acidic and slow-flowing mountain streams (Starmuehlner, 1977).

Remarks: It is represented by a single shell in the collection. Shell black-brown, oblong-ovate, spire eroded, sculptured with characteristic nodulose spiral ridges.

Starmuehlner (1974) dealt in detail on the intraspecific variations.

122. **Paludomus (Tanalia) neritoides** Reeve, 1847
(Figs. 246-249)

Paludomus neritoides Reeve, 1847, *Conch. Icon.*, **4**: pl. 1, fig. 3. Type locality: In the bed of a river at Ambegamon, Ceylon.

Paludomus (*Tanalia*) *neritoides:* Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka,* **25** (1 & 2): 150, pl. X, figs. 108—110. pl. XI, figs. 111-120, pl. XII, figs. 121-123.

Distribution: Sri Lanka: South west parts.

Remarks: Shell oblong ovate, neritoid in shape, body whorl large, spire often depressed or exserted, sculptured with spiral ridges, aperture large with broad columellar callus, stained with purple black or blackish brown.

Starmuehlner (1974) gave details of its anatomy, ecology and an exhaustive synonymy.

123. **Paludomus (Tanalia) solidus** Dohrn, 1857
(Figs. 216, 217)

Paludomus solidus Dohrn, 1857, *Proc. zool. Soc. Lond.*, 1857: 124. Type locality: Not mentioned.

Paludomus (*Tanalia*) *solidus:* Starmuehlner, 1974, *Bull. Fish. Res. Stn., Sri Lanka,* **25** (1 & 2): 154, pl. XII, figs. 143, 144.

Distribution: Sri Lanka: South east of Uva Province.

Remarks: Shell globose, spire short and pointed, whorls rounded, regularly increasing, sculptured with rather distant obtuse ridges and delicate vertical striations. Colour yellowish-brown, with wavy jet-brown bands seen distinctly on the inside of the aperture. Columella flat with an outer brownish edge.

Subgenus **Stomatodon** Benson, 1862

Stomatodon Benson, 1862, *Ann. Mag. nat. Hist.,* (3) **10:** 414.

Type species: *Paludomus stomatodon* Benson.

Shell ovately conical, with a rather low spire, aperture posteriorly angular, columellar margin broad and with a distinct tooth anteriorly.

It is restricted to streams in Western Ghats, Kerala.

124. **Paludomus (Stomatodon) stomatodon** Benson, 1862
(Fig. 242)

Paludomus (*Stomatodon*) *stomatodon* Benson, 1862, *Ann. Mag. nat. Hist.,* (3) **10**: 415. Type locality: Mountain streams near Cottayam (= Kottayam), Kerala.

Paludomus (*Stomatodon*) *stomatodon:* Satyamurti, 1960, *Bull. Madras Govt. Museum,* (*New Series*), *Nat. Hist. Sec.,* **6** (4): 50, pl. VI, figs. 2a, 2b.

Distribution: Kerala: near Kottayam.

Remarks: Shell with a large and inflated body whorl, spire short and depressed, sutures well impressed, faint or often obsolete spiral striations, aperture ovate and angular posteriorly, columellar callus broad as in neritids and bears a prominent tooth-like projection on its anterior part, often with a blackish brown tinge on the upper part of the columellar callus. Operculum horny, dark brown with excentric nucleus.

Subclass PULMONATA

Order BASOMMATOPHORA

Family 10. LYMNAEIDAE

The shell dextral and ovately oblong, size varies from 5 mm to 50 mm., spire pointed and of variable height, columellar axis typically twisted. Tentacles flattened and triangular, no pseudobranch, stomach divisible into three parts, the anterior oval crop, the middle stomach proper enclosed by the highly muscular bilobed gizzard, and the posterior tapering pylorus, penis long and devoid of flagellum.

World-wide, inhabits almost all types of freshwater habitats.

The genus *Lymnaea* exhibits a greater degree of plasticity and individual variations. Obviously all the earlier studies based on morphological species concept have created confusion by adding a large number of new species, varieties and forms. Hubendick (1951) made a revisionary study of recent Lymnaeidae using the biological species concept. The shell form, the distal part of the genitalia, radula and the structure of the prostate were the characters employed in his study. His revisionary studies have reduced the number of species from over a thousand to forty. In this connection the observations made by Burch and Lindsay (1973) who have tried various techniques ranging from classical conchology to breeding studies are interesting. According to them "Classical taxonomic divisions within the family based on shell characters are more reliable than radular teeth or characters of the reproductive tracts (as previously used) i.e. our immunological studies correlated best with shell characters."

As far as recent Lymnaeidae is concerned Annandale and Rao (1925) made a revision and their conclusions are reliable to a large extent. Their observations showed that in Indian lymnaeids much value could not be attached to anatomical and other characters. As such the findings of Hubendick (1951), who did not study much Indian material, could not be completely relied upon with regard to Indian species.

There are differences of opinion regarding the taxonomic grouping of species into genera. Some include all the species in a single genus

Lymnaea recognising several subgenera in it, while others prefer to elevate all the subgenera to the generic level. Under the present confused state of Lymnaeid taxonomy it is proposed to follow the earlier Indian works and recognise one genus namely *Lymnaea.*

The works pertaining to two common Indian species, namely *Lymnaea acuminata* and *Lymnaea luteola* include: Agarwal, (1977 on growth in *L. acuminata*; Brahmachary et al (1968, 1970, 1971*a-c*, 1977) on embryology; Dasgupta (1973, 1978), biology of parsitised individuals; Dasgupta and Ghoshe (1977), physiology; Dutt & Bali, (1977), life history studies; Michael (1966), development; Nagabhushanam & Azantunnisa (1977), temperature tolerance; Patnaik (1968, 1971) and Patnaik & Ray, (1967, 1968), on histopathology, ecology and geographical distribution and Seshaiya (1928) on breeding habits and fecundity.

Genus 29. **Lymnaea** Lamarck, 1799

Lymnaea Lamarck, 1799, *Prodr. Nouv. Clas. Coq.*, p. 75. Lamarck, 1801, *Syst. anim. Sans Vert.*, 91.

Type species: *Limnaea stagnalis* Linnaeus.

Shell generally thin, body whorl large, spire almost always exserted, columella spirally twisted.

Annandale and Rao (1925b) recognised 20 species and many varieties. Here only 17 species are treated as others being untenable. This arrangement is only provisional and further studies are needed to establish the status of each species and form.

The key is taken from Annandale and Rao (1925b).

Key to species

1. Shell very small, rather slender and delicate (less than 10 mm high), narrow with blunt apex 2

   Shell never so delicate and usually more than 10 mm. high 3

2. Spire with 2 whorls, columellar callus present ..... *L. mimetica*

   Spire with $2\frac{1}{2}$ whorls, columellar callus absent ..... *L. horae*

3. Spire scaleriform or at least canalised at the base, body whorl inflated 4

   Spire never scaleriform or canalised at the base, body whorl inflated 6

4. Spire very short (almost sunken), body whorl very much inflated, columellar fold narrowed abruptly below umbilicus, shell larger ..... *L. auricularia*

   Body whorl less inflated, columellar fold not narrowed immediately below the umbilicus, shell smaller 5

5. Spire moderately exserted, body whorl not greatly expanded ..... *L. lagotis*

   Spire extremely short, body whorl greatly inflated ..... *L. brevicauda*

6. Spire with 5 complete whorls, shell medium to large 7

   Spire usually with not more than 4 whorls 9

7. Shell less than 20 mm. high, body whorl not expanding outwards, spire less acuminate 8

   Shell large, body whorl expanding outwards, spire exceptionally elongated and acuminate, columellar callus well developed ..... *L. stagnalis*

8. Spire moderate, columellar callus exceptionally broad and coarse, aperture less than half of the shell length ..... *L. laticallosa*

   Columellar callus feebly developed, aperture large, nearly half of the shell length ..... *L. tungabhadraensis*

9. Shell with the columellar callus exceptionally well developed 10

   Columellar callus not exceptionally well developed 13

10. Whorls of spire increasing in size gradually, the basal whorl of the spire not twice as broad as the one above it 11

    Basal whorl of the spire more than twice as broad as the whorl above it 12

11. Body whorl much longer than spire in dorsal view ..... *L. andersoniana*

    Body whorl and spire subequal in dorsal view ..... *L. truncatula*

12. Suture impressed, umbilicus broadly rimate ..... *L. bowelli*

    Suture not impressed, umbilicus narrowly rimate ..... *L. hookeri*

13. Spire very short, at least 3 times as broad at the base as high 14

    Spire longer, much less than 3 times as broad at base as high 15

14. Spire passing evenly into the body whorl, shell almost bilaterally symmetrical in dorsal view ..... *L. ovalior*

    Spire very much narrower than upper margin of body whorl, shell very asymmetrical bilaterally, columellar fold poorly developed ..... *L. physcus*

15. Length of suture seen in dorsal view at base of spire considerably greater than height of spire 16

    Length of suture at base of spire not or hardly longer than height of spire 17

16. Height of aperture at least $\frac{3}{4}$ of the total height of the shell ..... *L. persica*

    Height of aperture less than half of the total height of the shell ..... *L. shanensis*

17. The outerlip very much expanded and convex in outline, spire acuminate ..... *L. acuminata*

    The outer lip not very much expanded and almost straight in outline, spire less acuminate ..... *L. luteola*

Subgenus **Pseudosuccinea**

125. **Lymnaea acuminata** Lamarck, 1822

(Figs. 254-265, 272)

Limnaea acuminata Lamarck, 1822, *Hist. nat. Anim. Sans Vert.*, **6** (2): 160. Type locality: "Bengale".

Limnaea acuminata: Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 177.

The nature of the spiral course of the shell, the form of outer lip and a number of negative characters are used in the specific diagnosis of the shell (Annandale and Rao, 1925).

It occurs in permanent water bodies with abundant vegetation.

Nine forms were recognised under this species:

form *typica* Lamarck, 1822. Distributed throughout India. (Figs. 258, 259)

form *patula* Troschel, 1837, *Arch. Naturgesch.*, **3**: 167. River Ganges, India. Distributed throughout India. Hubendick (1951) considers it as synonymous with race *rufescens* Gray. (Figs. 256, 257)

form *chlamys* Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 744. Moradabad, Uttar Pradesh. Throughout India = *rufescens* Hubendick (1951)

form *rufescens* Gray, 1820, in Sowerby: *Genera Rec. Foss. Shells*, **1**: pl. 178, fig. 2, India. Throughout India. (Figs. 254, 255)

form *gracilior* Martens, 1881, *Conch. Mittheil.*, **1**: 77. Bengal = *rufescens*. Throughout India and Burma. (Figs. 262, 265)

form *hians* Sowerby, 1837, in Reeve: *Conch. Icon.*, **18**: sp. 57. "Malabar." South and north-west India. (Figs. 264, 265)

form *malleata* Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 182, fig. III—8. Wazirabad. Peshawar, Punjab and Manipur. (Figs. 260, 261)

form *brevissima* Annandale & Rao, 1925, *Rec. Indian Mus.*, **27**: 182, fig. III—1. Nagpur. May be an abnormal form of *typica*.

form *pseudohorae* Rao, 1929, *Rec. Indian Mus.*, **31**: 295. Shwemyzu Pagoda, Indawgyi Lake, Burma. = *rufescens*. (Figs. 272) Synonym subsp. *tonapii* Ray and Raychowdhury.

Annandale and Rao (1925) made it clear that these forms intergrade into each other and generally it is difficult to assign shells definitely to any particular form. With some reasonable accuracy the species can be differentiated into two forms—*typica* and *rufescens* Gray. The former is characterised by ovate shell, short and broad spire, acuminate apex. In the latter the shell is narrow, the mouth is relatively shorter and less expanded.

Parasites—Larval forms of some important sheep, cattle and human parasites are recorded from this snail. It is recorded as the intermediate host of many flukes, viz. *Fasciola gigantica, Fasciola hepatica, Schistosoma*

indicum, S. nasalis, Schistosoma spindalis and Clinostomum giganticum, Echinostoma sp. etc. About 15 cercariae were recorded from this snail.

Echinostoma revolutum, E. malayanum, F. hepatica and *Orientobilharzia turkestanicum* develop in *L. acuminata* f. *rufescens.*

126. **Lymnaea biacuminata** Annandale and Rao, 1925.
(Figs. 277, 278)

Limnaea biacuminata Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 182, fig. III—2. Type locality: Hyderabad, Andhra Pradesh.

Types: ZSI Regd. No. M 12466/2.

Distribution: Secunderabad and Hyderabad, Kumaon, Nainital.

Remarks: This may be a phenotypic variant of *Lymnaea acuminata* f. *rufescens.*

127. **Lymnaea luteola** Lamarck, 1822
(Figs. 275-287)

Limnaea luteola Lamarck, 1822, *Hist. nat. Anim. Sans Vert.*, **6** (2): 160. Type locality: Bengal.

Limnaea luteola : Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 183.

Spire not very much pointed and the shell more ovate with a narrow ovate aperture.

The species is not very particular about its habitat. It is often found in temporary water bodies, which dry up in summer, and it tides over the unfavourable conditions by burying itself in the mud. The species is less variable than *L. acuminata.* It is considered as a pest of paddy and *Azola,* the latter being the producer of biofertiliser, in Chinsurah and Pandua areas of West Bengal.

The species has six forms as follows:

form *typica* Lamarck. (Figs. 275, 276) Throughout India and more common than *L. acuminata.*

form *ovalis* Gray, 1822, in Sowerby: *Genera Rec. Foss. Shells,* **1:** pl. 178, fig. 4. "The East Indies." Syn. *Limnaea physcus* Annandale and Rao, 1925, *Rec. Indian Mus.,* **27:** 104. Distributed throughout India, Andamans, Burma and Sri Lanka. (Figs. 266, 267, 283, 284)

form *australis* Annandale and Rao, 1925, *Rec. Indian Mus.,* **27:** 184, fig.V-3. India and Sri Lanka. (Figs. 279, 280)

form *impura* Troschel, 1837, *Arch. Naturgesch.* **3:** 172. River Ganges. India and Burma. (Figs. 281, 282)

form *succinea* Deshayes, 1834, *Voy. Belang. Zool.* p. 418. Malabar Coast. South and North India and Kashmir. (Figs. 286, 287)

form *siamensis* Sowerby, 1873, in Reeve: *Conch. Icon.,* **18:** 63, sp. no. 63, pl. x, fig. 63. Siam, Burma.

In our opinion only four forms stand out as distinct: f. *typica, impura, australis* and *ovalis* Gray.

Parasites: It is one of the important snail serving as the intermediate host of some parasites of cattle, pig, dog etc. viz. *Schistosoma indica, S. nasalis, S. spindalis, S. suis, S. incognitum, Fasciola gigantica, F. hepatica, Clinostomum giganticum, Echinostoma revolutum, Orientobilharzia dattae, Echinoparyphium bugulai.*

Besides the parasite *Fischoederius elongatus,* about 10 cercariae were recorded from the form *succinea.*

128. **Lymnaea ovalior** Annandale and Prashad, 1921.

(Fig. 285)

Limnaea ovalior Annandale and Prashad, 1921, *Rec. Indian Mus.,* **22:** 572, fig. 13 A, pl. VII, figs. 4-6. Type-locality: Loktak Lake.

Types: ZSI Regd. No. M 11717/2.

Distribution: Not known beyond Manipur.

Remarks: This may be a synonym of *L. luteola* f. *ovalis* Gray.

129. **Lymnaea horae** Annandale and Rao, 1925.
(Figs. 273, 274)

Limnaea horae Annandale and Rao, 1925, *Rec. Indian Mus.*, **22:** 176, fig. II-11. Type locality: Thumarkur nullah, near Railway bridge, Sorupeta, Assam.

Types: ZSI Regd. No. M 12481/2.

Distribution: Not known beyond type locality.

Remarks: Allied to *L. mimetica.* Spire better developed and broader, columellar callus absent, numerous close-set longitudinal striae.

Hubendick (1951) considered it as a transitional form between race *swinhoei* and race *rufescens* of *L. auricularia.* The form *latior* Annandale and Rao, 1925 must be a variant only.

130. **Lymnaea gedrosiana** Annandale and Prashad, 1919.
(Fig. 295)

Limnaea gedrosiana Annandale and Prashad, 1919, *Rec. Indian Mus.*, **18:** 48, pl. vii, figs. 2-4, text figs. 6 A & B. and var. *rectilabrum* p. 49, pl. vi, figs. 1-6; p. 40, figs. 5-B; p. 42, figs. 6c, 6d. Type locality : A pool near Nasratabad, Seistan.

Types: ZSI Regd. No. M 11534/2 (Syntypes).

Distribution: In desert pods in Baluchistan, and also in Salt Range, Punjab (Pakistan).

Remarks: According to Hubendick (1951) it is a "transitional form between the races *auricularia* and *rufescens* of *auricularia* L"

131. **Lymnaea mimetica** Annandale, 1918.
(Fig. 288)

Limnaea mimetica Annandale, 1918, *Rec. Indian Mus.*, **14:** 109, pl. x, figs. 9, 9a; pl. xi, fig. 4. Type locality: Inle Lake, Burma. Annandale and Rao, 1925, *Rec. Indian Mus.*, **27: 174.**

Types: ZSI Regd. No. M 11271/2.

Distribution: Inle Lake, Burma.

Remarks: It may be a local variant of *Lymnaea acuminata.*

132. **Lymnaea shanensis** Annandale, 1918
(Figs. 308, 309)

Limnaea shanensis Annandale, 1918, *Rec. Indian Mus.*, **14:** 107, pl. x, figs. 5-8, pl. xi, figs. 2, 3. Type locality: Shan States, Burma. Annandale and Rao, 1925, *Rec. Indian Mus.*, **27:** 173.

Types: ZSI Regd. No. M 12047/2.

Distribution: Burma.

Remarks: Shell small, never exceeding 10.5 mm. in height. Allied to *L. acuminata,* but less acuminate and narrower columellar callus.

The three forms *typica, superstes* Annandale and Rao, *hehoensis* Annandale and Rao may be phenotypic variations.

Subgenus **Galba** Schrank

133. **Lymnaea bowelli** Preston, 1909
(Figs. 298, 299)

Limnaea bowelli Preston, 1909, *Rec. Indian Mus.*, **3:** 115, Type locality: Te-Ring Gimpa, Tibet. Annandale and Rao, 1925, *Rec. Indian Mus.*, **27:** 169, fig. V-6.

Types: ZSI Regd. No. M 4232/1.

Distribution: Gyantse Valley, Tibet.

Remarks: Resembles *L. hookeri,* but differs from it in its impressed suture and much wider umbilicus and radula.

It occurs at high altitudes ranging from 13120 ft. to 16,000 ft. It often occurs in warm springs (Annandale & Rao, 1925).

134. **Lymnaea laticallosa** Annandale and Rao, 1925.

(Fig. 294)

Limnaea laticallosa Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 105, p. 160, **fig.** V-1 & 2. Type locality: Kalaw, He-Ho plain near Inle Lake, Burma.

Types: ZSI Regd. No. M 12055/2.

Distribution: Inle Lake, Burma.

Remarks: Resembles *L. andersoniana*, but differs in being larger, having more whorls, distinctly flattened, callus and columellar fold cover much of body whorl, columella almost vertical ventrally.

135. **Lymnaea hookeri** Reeve, 1850.

Limnaea hookeri Reeve, 1850, *Proc. zool. Soc. Lond.*, **18**: 49. Type locality: North side of Sikkim Himalaya, Tibet. Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 167, fig. V-7.

Types: BM (NH)

Distribution: Sikkim, Tibet, alt 13,000 ft. to 18,000 ft.

Remarks: Smaller form allied to *L. andersoniana,* upper margin of whorls broadly flattened, columellar callus thick, columellar fold not broad, aperture wider, outerlip more expanded.

136. **Lymnaea andersoniana** Nevill, 1881.

(Figs. 268, 269 & 310)

Limnaea andersoniana Nevill, 1881, *J. Asiat. Soc. Beng.*, **50** (2): 142, pl. v. fig. 9. Type locality: Nantin, Yunnan. Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 163.

Types: ZSI Regd. No. M 12426/2 & M 12427/2.

Distribution: Simla Hills, Kashgar, Kangra Valley, Ladak, Manipur; Nepal Valley; Southern Shan States; Yunnan.

Remarks: Size of the shell does not exceed 12 mm., generally umbilical pore rather conspicuous but rather occluded by columellar fold.

Annandale and Rao (1925) distinguished four forms of *L. andersoniana,* namely *typica, simulans* (Fig. 310) *intermedia* and *turbinicola.* The first one is common in the stagnant waters in the valleys of Himalayas; the form *simulans* is common in streams in Yunnan, and the form *intermedia* occurs in Western Himalayas and also in Assam near the base of Naga Hills. The form *turbinicola* is a torrent form and is known from the hills on the western side of the Manipur Valley.

137. **Lymnaea truncatula** (Mueller, 1774).
(Fig. 291)

Buccinum truncatula Mueller, 1774, *Verm Terr. Fluv. Hist.,* **2:** 130. Type locality: Denmark.

Limnaea truncatula: Annandale and Rao, 1925, *Rec. Indian Mus.,* **27:** 161, fig. V-3, 4, 5.

Lymnaea truncatula: Rajagopal and Subba Rao, 1968, *Proc. Symposium Mollusca,* pt. 1, p. 108.

Distribution: India: Kashmir, alt. 2730 M to 3,365 M., Leh, Chitral 9000 ft. It is mainly a palaearctic species having distribution in Europe, and extending to Ethiopian region, North-western Africa and Egypt, East Africa, and South Africa. Cameroun is a doubtful locality record. Brown (1980) gave a detailed distribution of the species.

Remarks: Closely allied to *L. andersoniana,* but umbilical pore more prominent and not occluded by columellar fold. Whorls slightly shouldered and spire longer in relation to body whorl. Mud-loving and amphibious.

Parasites: The snail serves as an intermediate host of *Fasciola hepatica.*

Subgenus **Radix** Montfort

138. **Lymnaea persica** Issel, 1865
(Figs. 304, 305)

Limnaea auricularia var. *persica* Issel, 1865, *Moll. Miss. Ital. Persia* (Torino), p. 47. Type locality: Iran.

Limnaea persica: Annandale and Rao, 1925, *Rec. Indian Mus.,* **27:** 151.

Distribution: India: Kashmir, Kumaon Lakes, Kangra Valley; North-west Frontier, Baluch desert near Nushki, Southern Persia.

Remarks: Rajagopal and Subba Rao (1968) did not record this species from Kashmir. It is probably a variant of *L. auricularia.*

139. **Lymnaea auricularia** (Linnaeus, 1758). (Figs. 300, 301)

Helix auricularia Linnaeus, 1758, *Syst. Nat.* ed. **10**: 774. Type locality: Sweden.

Lymnaea auricularia: Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 158, figs. I-2, 4.

Lymnaea auricularia: Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca,* pt. 1, p. 102.

Distribution: Europe as far south as Spain and Italy, Northern Asia, Afghanistan and Kashmir.

Remarks: Shell bigger, inflated, columella very much twisted, fold occludes umbilicus, spire sunken into body whorl. Hubendick (1951) considered this as a super species and recognised four races, namely *auricularia* s.str. *swinhoei* Adams, *rubiginosa* Michelin, and *rufescens* Gray. The last mentioned is treated here as a form of *L. acuminata.* Of the rest, races *auricularia* s.str. and *swinhoei* have some relevance in the Indian context. *L. mimetica* Annandale and *L. horae* Annandale and Rao were considered as transitional forms between *swinhoei* and *rufescens.*

Parasites: Only *Orientobilharzia turkestanicum* was known to develop in this snail in Srinagar area (Dutt and Srivastava, 1964). *Fasciola gigantica* was also recorded.

140. **Lymnaea brevicauda** Sowerby, 1873 (Figs. 302, 303)

Limnaea brevicauda Sowerby, 1873 in Reeve: *Conch. Icon.*, **18**: p. 105, sp. no. 105, pl. XV. Type locality: Kashmir (Hubendick, 1951, p. 182).

Limnaea brevicauda: Annandale and Rao, 1925, *Rec. Indian Mus.*, **25**: 157, fig. I-6.

Lymnaea brevicauda: Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca,* pt. 1, p. 103.

Types: BM (NH).

Distribution: Kashmir.

Remarks: Whorls 4, distinct, but narrow canal outside the suture at its base; body whorl inflated but the spire not sunk into it, columellar fold broad near umbilicus. May be synonymous with *L. auricularia.*

141. **Lymnaea peregra** (Mueller, 1774)
(Figs. 290, 306, 307)

Buccinum peregra Mueller, 1774, *Verm. Terr. Fluv. Hist.*, **2**: 130. Type locality; Frederiksberg, Copenhagen, Denmark.

Limnaea lagotis: Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 151.

Distribution: India: Kashmir; Tibet, Europe and U.S.S.R.

Remarks: Annandale and Rao (1925) included six forms in the species *L. lagotis.* They are f. *striata* Andreae, f. *costulata* Martens, f. *solidissima* Kobelt, f. *subdisjuncta* Nevill, f. *bactriana* Hutton and f. *defilippi* Issel. Excepting f. *bactriana* all the forms are restricted to lakes or ponds in the Himalayas.

Subgenus **Lymnaea** s. str.

142. **Lymnaea stagnalis** (Linnaeus, 1758)
(Figs. 292, 293)

Helix stagnalis Linnaeus, 1758, *Syst. Nat.* ed. **10**: 774. Type locality: Sweden.

Limnaea stagnalis: Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 147, figs. V-7 to 10.

Lymnaea stagnalis: Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca*, pt. 1, p. 100.

Distribution: India: Kashmir. Elsewhere its range extends over almost the whole of Europe, and the western parts of North Africa, Asia Minor, Syria, Iran and North America, New Zealand. Absent in Greenland and Iceland.

Remarks: A very distinctly elongated form with 6 whorls, pointed spire, outer lip sharp and not expanded or retroverted, umbilicus closed. Hubendick (1951) stated that many names applied to this species, only refer to phenotypes, ecophenotypes or microgeographical races i.e., single populations, and must be rejected. In the light of this, the two forms, namely *minor* Kobelt and *kashmirensis* Prashad described from Kashmir should be treated as variants only.

Subgenus **Stagnicola** Leach, 1830.

Confined to North America, Northern Europe and Northern Asia. Obviously it is a cold water subgenus. The occurrence of this subgenus in Andhra Pradesh, South India is rather intriguing.

143. **Lymnaea tungabhadraensis** Ray, 1967
(Figs. 296, 297)

Lymnaea tungabhadraensis Ray, 1967, *J. Conch.*, **104** (1): 4, fig. 1. Type locality: Main canal near Makdona village in the Tungabhadra project area, Kurnool district, Andhra Pradesh.

Types: ZSI Regd. No. M 17602/3 (Holotype).

Remarks: Shell elongate, conically turreted, post nuclear whorls 5, more inflated and rapidly increasing in size, slightly shouldered below sutures, aperture large, nearly half the shell length; outer lip thin and gently curved, inner lip greatly reflected over the columellar region forming a wide, smooth and triangular area occluding the umbilical pore.

It was not reported after its original discovery. Ray (1967) did not study the soft parts. The record of a cold water species in such a warm place like Kurnool is puzzling and a study of its anatomy may throw some light on the real identity of the species.

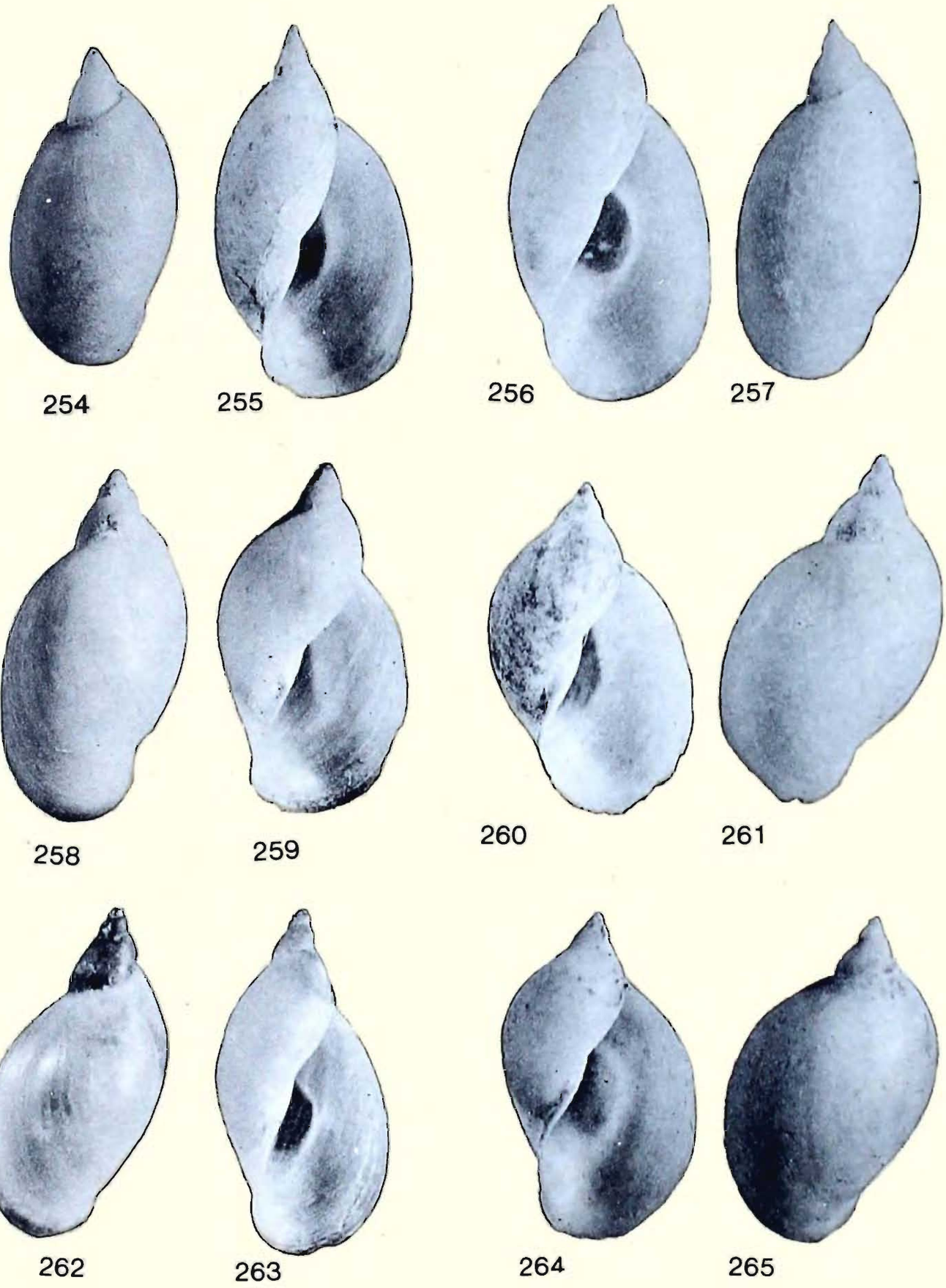
Family 11. ANCYLIDAE

"Freshwater limpets"

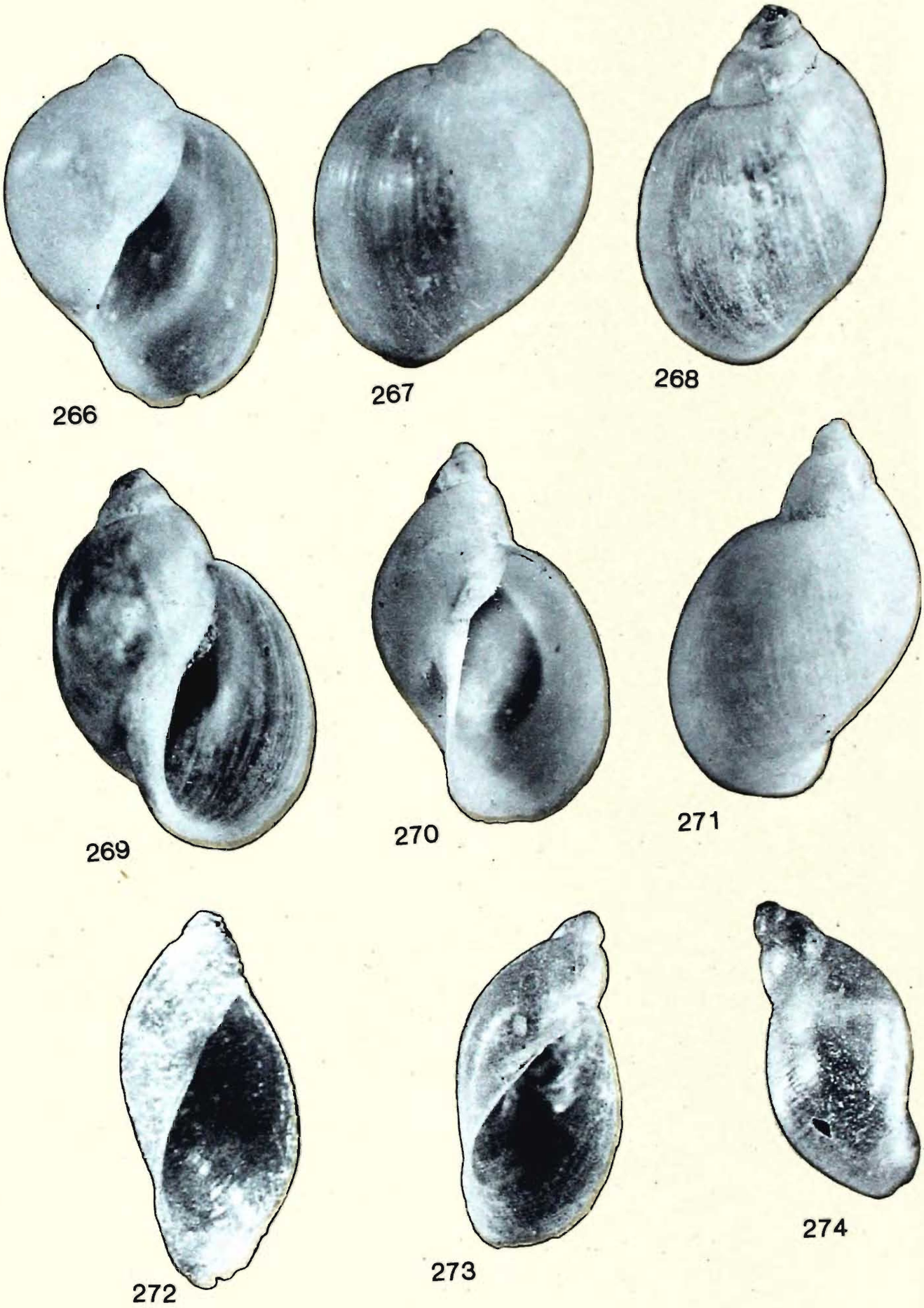
Shell small and cap-shaped or patelliform with a large aperture, animal completely covered by shell, foot broad and oval, tentacles short, blunt and cylindrical bearing eyes on their inner bases, pseudobranch on left and of numerous pieces, a penial stylet or flagellum opening into the vergic sac, genital and anal openings on left, hermaphrodite.

World-wide in distribution. In India a single genus *Ferrissia* Walker.

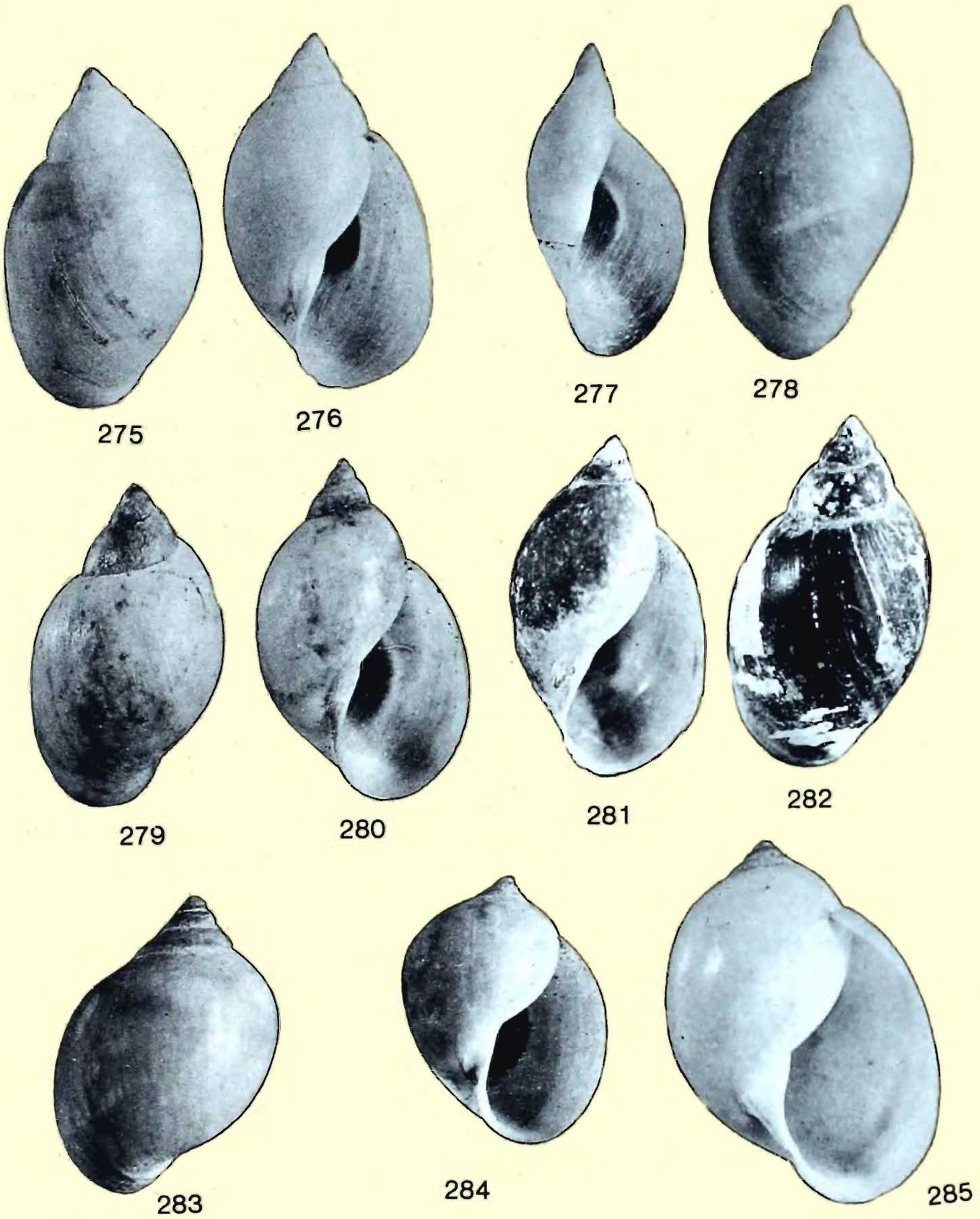
Found attached to vegetation in smaller ponds and ditches or on the stones or other debris in smaller rivers of moderate flow and streams. Not found in torrential streams.



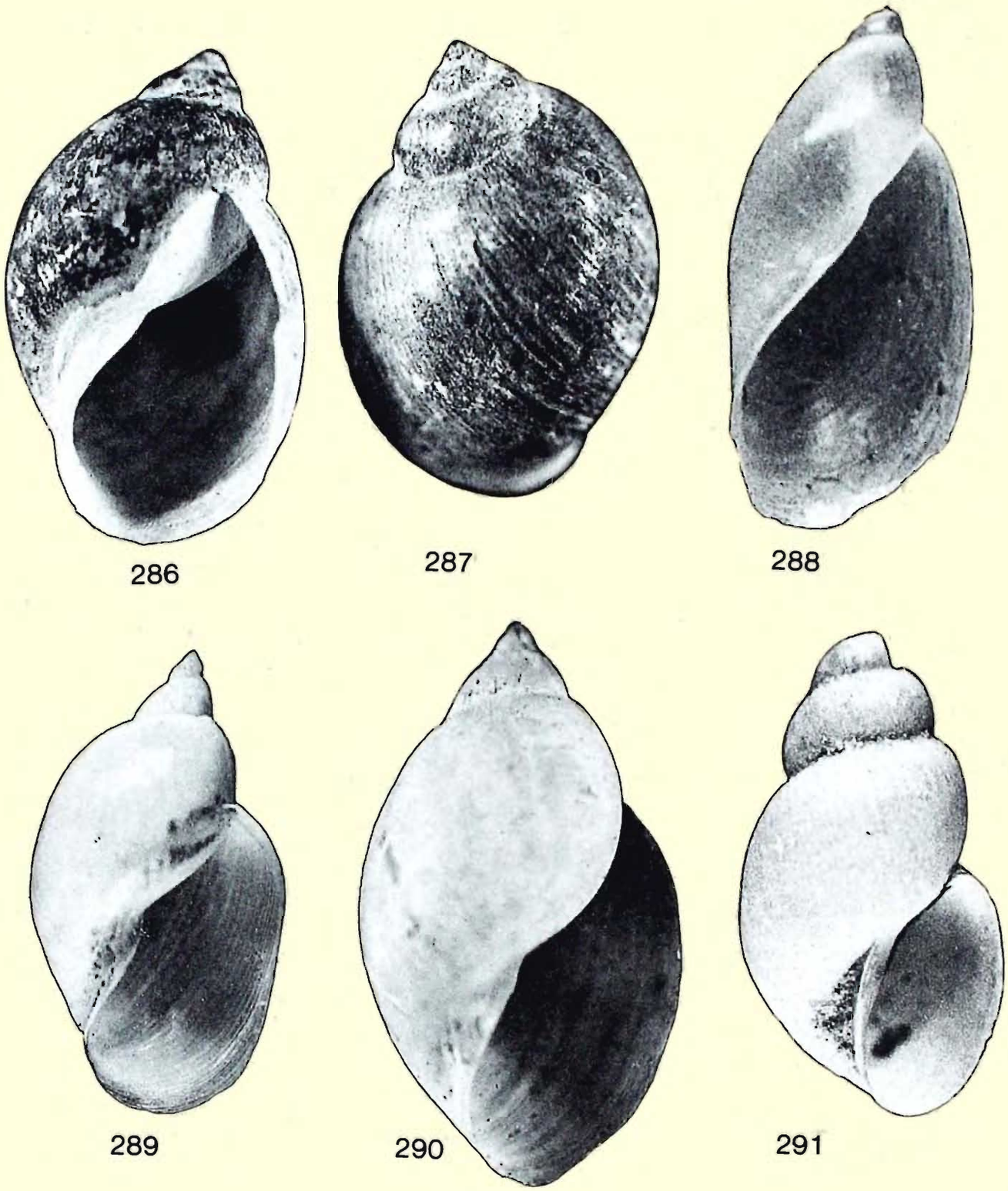
Figs. 254, 255. *Lymnaea acuminata rufescens*, 29.65 × 13.45 mm, Chotanagpur, Bihar. 256, 257. *L. acuminata* f. *patula*, 22.90 × 11.0 mm., Pune. 258, 259. *L. acuminata* f. *typica*, 20.10 × 11.20 mm., Gurudaspur, Punjab. 260, 261. *L. acuminata* f. *malleata*, 20.80 × 13.45 mm., Peshawar. 262, 263. *L. acuminata* f. *gracilior*, 22.95 × 9.90 mm., Barrackpore, near Calcutta. 264, 265. *L. acuminata* f. *hians*, *10.80* × 5.40 mm., Salt Range.



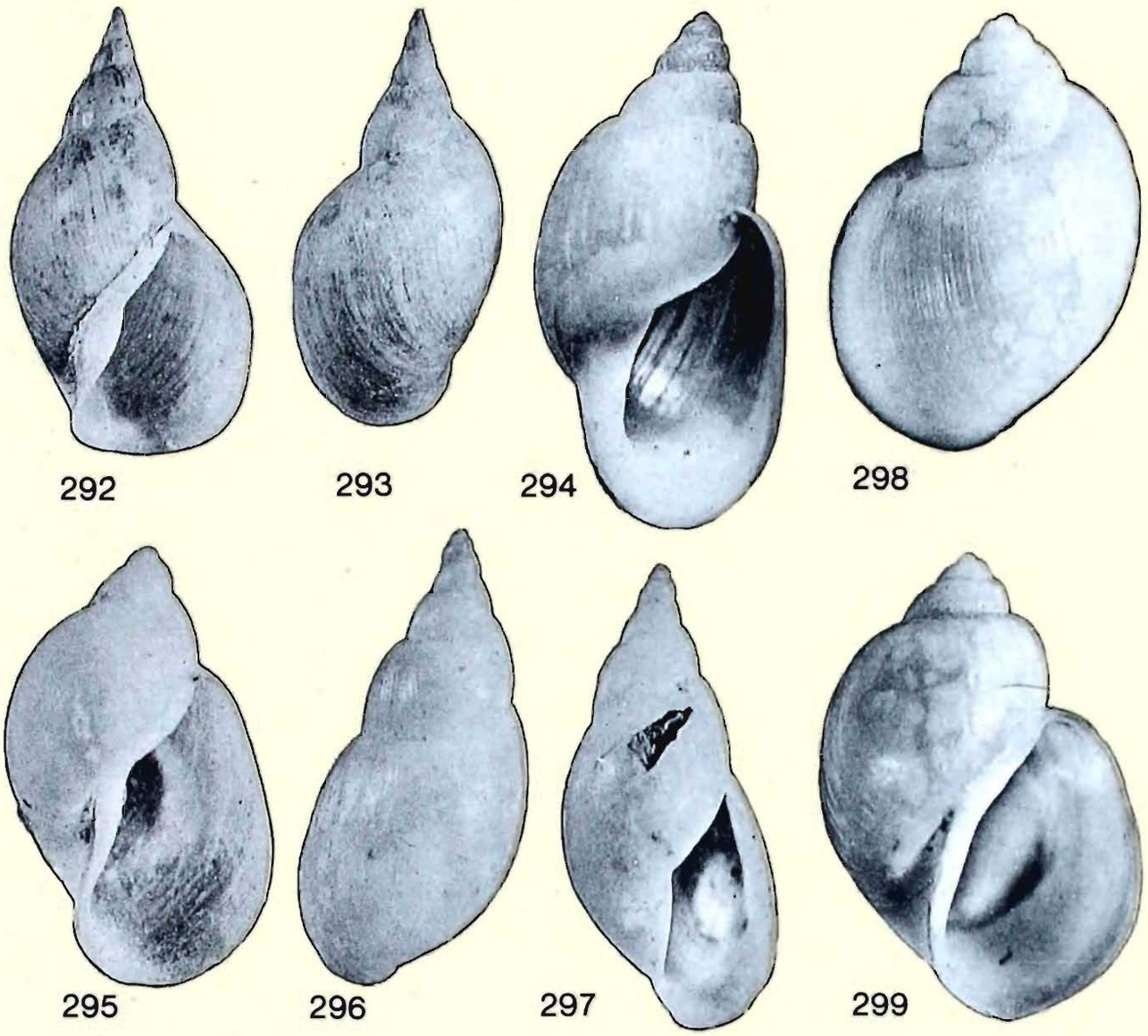
Figs. 266, 267. *Lymnaea physcus*, Holotype, 8.55 × 5.90 mm., Shan States, Burma. 268, 269. *L. andersoniana*, Holotype, 9.65 × 6.35 mm., Namtin. 270, 271. *L. nigricans* 272. *L. acuminata* f. *pseudohorae*, Holotype, 5.85 × 2.50 mm., 273, 274. *L. horae*, Syntypes, 5.45 × 3.0 mm.; 6.0 × 2.7 mm., Assam.



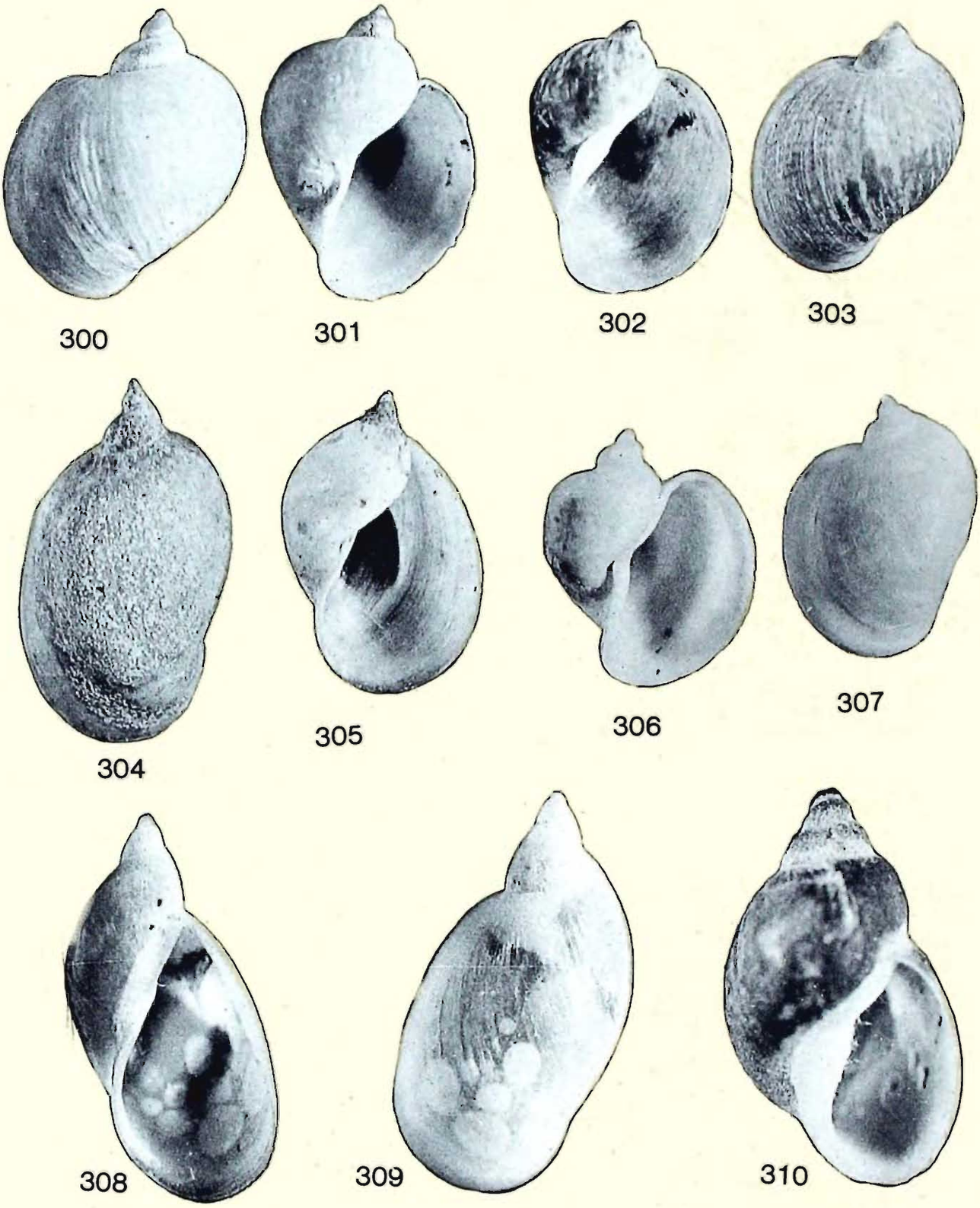
Figs. 275, 276. *Lymnaea luteola* f. *typica*, 24.65 × 14.10 mm., Madras. 277, 278. *L. biacuminata*, Syntypes, 17.85 × 9.90 mm., Secundrabad. 279, 280. *L. luteola* f. *australis*, 15.80 × 9.25 mm., Jumna tank. 281, 282. *L. luteola* f. *impura*, 16.20 × 9.40 mm., Barkuda, Orissa. 283, 284. *L. luteola* f. *ovalis*, 12.6 × 8.35 mm.; 12.4 × 8.15 mm., Calcutta, W. Bengal. 285. *L. luteola* f. *ovalior*, 14.45 × 9.25 mm., Manipur.



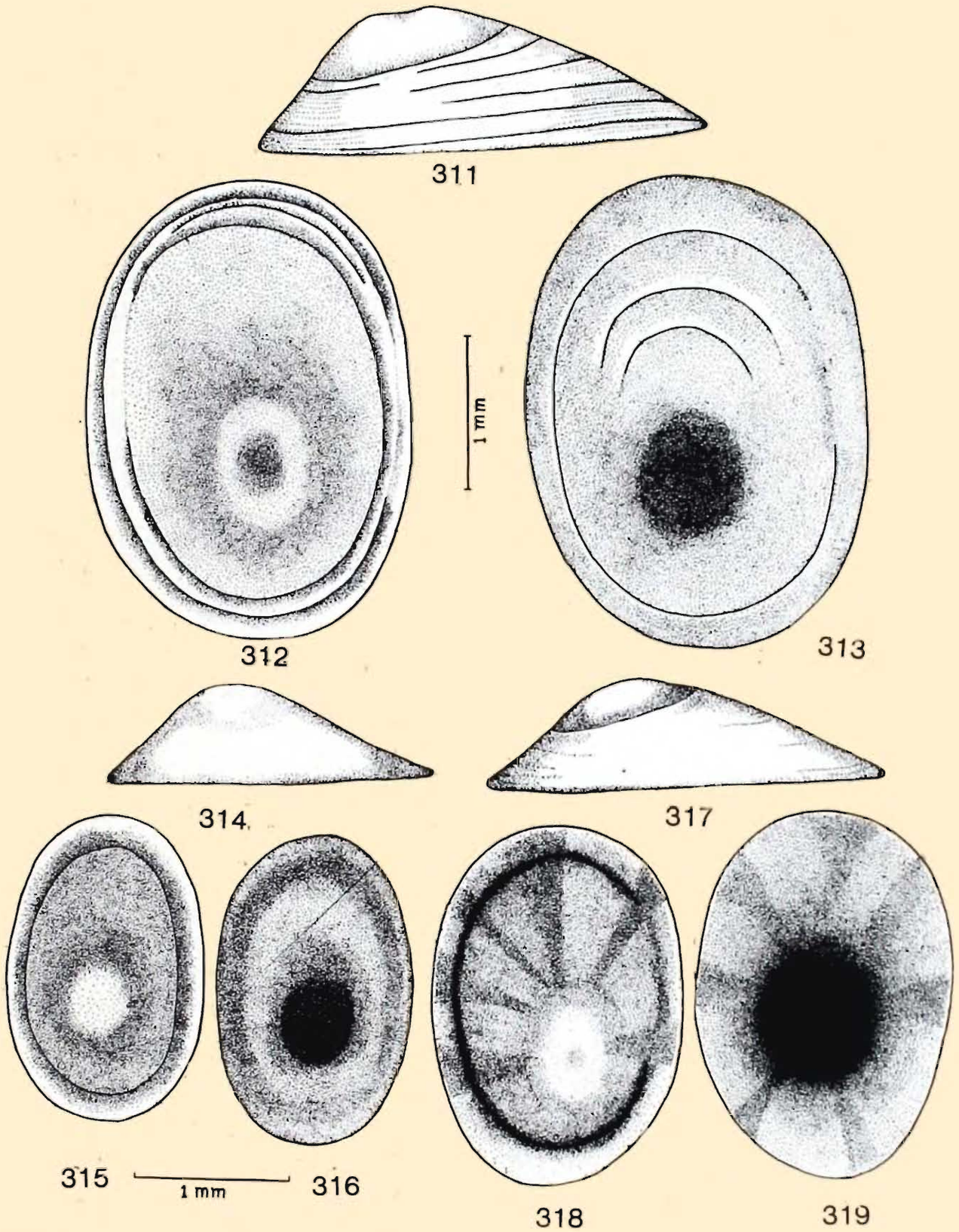
Figs. 286, 287. *Lymnaea luteola* f. *succinea* 18.42 × 8.45 mm., Bolaram tank, Secunderabad. 288. *L. mimetica*, Syntypes, 6.20 × 2.40 mm., Inle, Shan States, Burma. 289. *L. swinhoei*, 20.35 × 10.70 mm., Formosa. 290. *L. peregra*, 20.45 × 11.10 mm., Kashmir. 291. *L. truncatula*, 8.30 × 3.60 mm., Bombay.



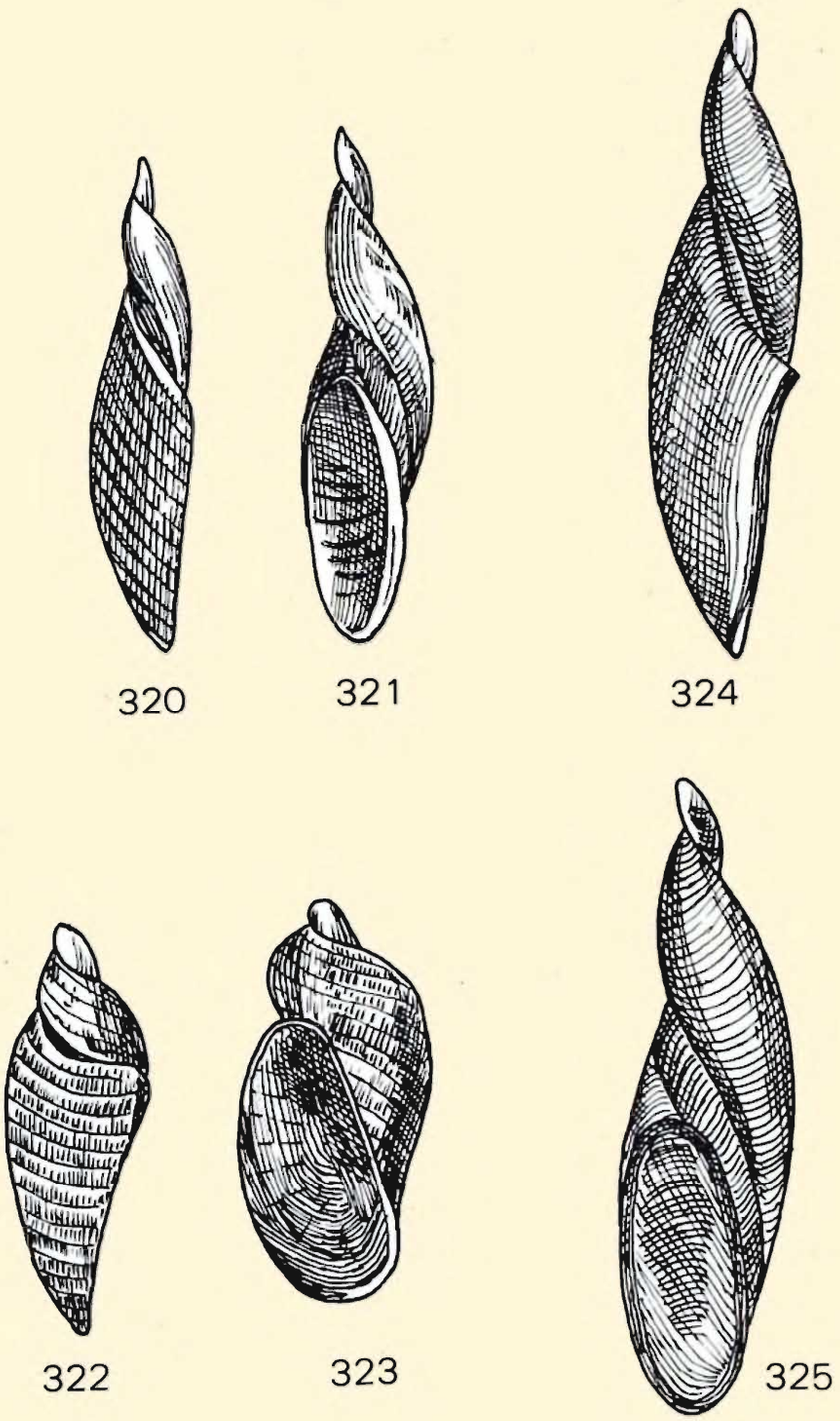
Figs. 292, 293. *Lymnaea stagnalis*, 42.60 × 20.80 mm., 40.25 × 19.45 mm., Srinagar, Kashmir. 294. *L. laticallosa*, 15.10 × 8.05 mm., Shan States, 295. *L. gedrosiana rectilabrum*, 10.20 × 15.4 mm., Nasratabad. 296, 297. *L. (Stagnicola) tungabhadraensis* Holotype, 18.85 × 8.25 mm., Kurnool. 298, 299. *L. bowelli*, Holotype, 8.75 × 5.40 mm., Gyang-tse.



Figs. 300, 301. *Lymnaea auricularia*, 15.65 × 13.0 mm.; 14.90 × 11.35mm., Tangitar. 302, 303. *Lymnaea brevicula*, 13.0 × 8.45 mm.; 12.55 × 8.30 mm., 304 305. *L. persica*, 25.70 × 15.10 mm., New Delhi. 306, 307. *L. solidissima*, 21.20 × 15.50 mm.; 20.70 × 15.50 mm., Kashmir. 308, 309. *L. shanensis*, Holotype, 10.3 × 4.85 mm., 310. *L. andersoniana* f. *simulans* 8.10 × 4.42 mm., Nepal.



Figs. 311-313. *Ferrissia verruca*, 3.75 × 2.25 × 1.10 mm., Manipur. 314-316. *F. tenuis*, 2.80 × 1.5 × .90 mm., Nilgiris. 317-319. *F. viola*, Holotype, 3.05 × 1.50 × 1.35 mm., Manipur.



Figs. 320, 321. *Camptoceras terebra*, 5.5 × 1.30 mm., Mogra, Hooghly Dist., W. Bengal. 322, 323. *C. lineatum* 3.90 mm × 1.95 mm., Dacca, Bangladesh. 324, 325. *C. austeni*, 6.40 × 1.70 mm., Dhaka, Bangladesh.

Genus 30. **Ferrissia** Walker, 1903

Ferrissia Walker, 1903, *Nautilus*, **17**: 15.

Type species: *Ancylus rivularis* Say.

Shell with radial striae on apex, a flat pseudobranch and a penial stylet on the vergic sac, eggs laid on water plants or stones.

Australia, New Zealand, South-east Asia and South-east Africa—World-wide (Brown, 1980).

Annandale and Prashad (1921) who revised the Indian species preferred to treat it as a subgenus of *Ancylus*, but the recent anatomical studies have shown its position as a genus (Hubendick, 1964; Burch, 1965).

The genus includes five species that are given below. No anatomical data is available on the Indian species and as such grouping them into subgenera is not attempted.

Key to the species

1. Apex of shell sharply pointed, very little reflected; shell over 5 mm. long ..... *F. ceylanicus*

   Apex blunt, reflected to the right, shell less than 5 mm. long 2

2. Greatest breadth of shell near the middle; outline of shell distinctly bilaterally asymmetrical ..... *F. verruca*

   Greatest breadth of shell in posterior third; outline of shell almost bilaterally symmetrical 3

3. Sides of shell not parallel; height much less than 1/3 of length ..... *F. baconi*

   Sides parallel; height more than 1/3 of length 4

4. Shell deep violet internally, with minute radiating striae ..... *F. viola*

   Shell dull yellowish internally, without distinct microscopic sculpture ..... *F.tenuis*

All the species are known by shell characters only. There is a general convergence of these characters and it becomes difficult to distinguish the species. Anatomical and biological studies are needed to distinguish the

species on a more rational basis. Hubendick (1958) made a thorough study of the anatomy of *Ferrissia tenuis* in particular and of the family Ancylidae in general.

144. **Ferrissia baconi** (Bourguignat, 1853).

Ancylus baconi Bourguignat, 1853, *J. Conchyl. Paris,* **4:** 181. Type locality: "Cetle espece habitele Bengale".

Ancylus (*Ferrissia*) *baconi*: Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22:** 592.

Types: MNNH

Distribution: India: Orissa, West Bengal; Burma: He-Ho Gorge; the Philippines.

145. **Ferrissia ceylanica** (Benson, 1864).

Ancylus ceylanicus Benson, 1864, *Ann. Mag. Nat. Hist.*, (3) **13:** 139. Type locality: Ceylon, Hanley and Theobald, 1874, *Conch. Indica,* pl. 81, figs. 1, 4.

Ancylus (*Ferrissia*) *ceylanicus:* Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22:** 591.

Types: ?

Distribution: Manipur: Imphal; Sri Lanka.

Remarks: It may be a variety of *F. verruca* Benson (see Annandale and Prashad, 1921 p. 592). Starmuehlner (1974) did not include any freshwater limpet in his account on freshwater molluscs of Sri Lanka.

146. **Ferrissia tenuis** (Bourguignat, 1862).
(Figs. 314, 316)

Ancylus tenuis Bourguignat, 1862, *Spicil. Malac.*, 1862: 208. Type-locality: Nilgiris.

Ancylus (*Ferrissia*) *tenuis:* Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22:** 592.

Types: MNNH

Distribution: South India, Maharashtra.

Remarks: Snails are found in large numbers on the dried decaying leaves completely submerged in water.

In Gimvi village it was observed that the snail starts breeding from January onwards. Eggs are laid singly on decaying leaves in a gelatinous mass secreted by the snail.

Parasites: This snail was considered as an intermediate host of human blood fluke, *Schistosoma haematobium*, in the endemic focus situated in Gimvi village in the Ratnagiri district of Maharashtra. Gadgil and Shah (1955) reported that they were successful in infecting *F. tenuis* in the laboratory and observed cercarial emission in large numbers though they did not find any natural infection. But it is still unconvincing whether this snail could serve as an intermediate host of a human schistosome.

Brown (1980) did not find any evidence to implicate this species in the transmission of schistosomiasis in Africa.

147. **Ferrissia verruca** (Benson, 1855).
(Figs. 311, 313)

Ancylus verruca Benson, 1855, *Ann. Mag. nat. Hist.*, (2) **15**: 12. Type locality: "Bhimtal Kemaonsem in palude prope, Moradabad, nivo Rajhera." Hanley and Theobald, 1876, *Conch. Indica*, pl. 81, figs. 2, 3.

Ancylus (*Ferrissia*) *verruca:* Annandale and Prashad, 1921, *Rec. Indian. Mus.*, **22**: 589, fig. 18B.

Distribution: Throughout India and Sri Lanka, but sporadic (Annandale & Prashad, 1921).

148. **Ferrissia viola** Annandale and Prashad, 1921
(Figs. 317, 319)

Ancylus (*Ferrissia*) *viola* Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 589, figs. 18 A, 19. Type locality: Loktak Lake, Manipur.

Types: ZSI Regd. No. M 11718/2.

Distribution: Manipur, Nagaland (Dimapur). Found on the lower side of floating grass stems in a small sluggish muddy stream.

Remarks: Sides of the shell compressed, anterior slope slightly convex and posterior slightly concave. Apex blunt, not elevated and situated in posterior third part.

Family 12. PLANORBIDAE

Shell flattened, discoidal or planispiral, with small aperture, apex do not project above the plane, foot simple, elongate and tapers to a point posteriorly. A broad and short fleshy portion, called velum, situated above the foot in its anterior region, velum bears the head, tentacles and eyes, tentacles filiform and flattened at their bases bearing eyes on the inner bases. The radula with a bicuspid central tooth, large bi—or tricuspid lateral teeth and long, narrow and multicuspid marginal teeth.

The genitalia, the excretory and respiratory organs on the left side. The animal mainly breathes by means of a lung, supplemented by an extra pulmonary appendage or pseudobranch or false gill situated on the left side close to the pallial aperture.

Hermaphrodite; the penial complex variable, but always with a preputium and a verge. The genital and pulmonary apertures situated on the left side. Eggs deposited in gelatinous mass attached to water weeds.

Very widely distributed; essentially found in shallow waters and littoral regions. A few species may thrive well in large lakes or tanks, but majority confined to small ponds or ditches that get dried up during summer.

In spite of some important contributions by Germain (1921—23), Annandale (1922) and Rao (1923), the taxonomy of Indian planorbids is still in confused state. Earlier descriptions of Indian forms were based on shell characters alone. The classification of Planorbidae is based on the genitalia and other anatomical characters (Baker, 1945). A study of these characters in Indian planorbids may necessitate rearrangement of species and some may lose their specific status. The anatomical investigations of Hubendick (1955), and Meier Brook (1979) are significant in this respect.

In general the Indian planorbids have not received much attention. Annandale and Prashad (1921) attempted a generic revision of the Indian species. Most of the earlier studies were however, concentrated on the common and widely distributed Indian planorbid, *Indoplanorbis exustus.*

The family is divided into five subfamilies but the Indian species fall under three subfamilies, namely Bulininae, Planorbinae and Segmentininae. The classification is based mostly on the internal anatomy. But the Indian genera can be directly identified by their shell characters as given in the following key.

Key to genera

1. Shell ovoid or elongate, acuminate ..... **Camptoceras**

   Shell discoidal, apex and whorls in one plane 2

2. Shell large, whorls rounded at periphery ..... **Indoplanorbis**

   Shell small, usually not more than 5 mm. in diameter, whorls rounded or carinate at periphery 3

3. Whorls narrowly coiled, last whorl large embracing a greater part of the preceding whorl, viewed ventrally only last whorl seen, aperture heart shaped 4

   Whorls widely coiled, regularly increasing, last whorl proportionately large, embraces only a little part of the preceding whorl, viewed ventrally all whorls seen, aperture oblique or oval shaped 5

4. Shell with internal lamellae or septa ..... **Segmentina**

   Shell without internal septa ..... **Hippeutis**

5. Shell greatly depressed, carinate or subcarinate at the periphery, three or four rapidly increasing whorls ..... **Gyraulus**

   Shell comparatively less depressed, usually round at the periphery, whorls more than four ..... **Planorbis**

Subfamily BULININAE

Shell ovoid or elongate and acuminate as in *Camptoceras* or disc-shaped as in *Indoplanorbis,* sinistral, when disc-shaped distinguished from shells of other subfamilies by the shape of the last whorl, large and dilated forward to the aperture.

Branchial process lobed, prostate gland compact and fan-shaped, verge introverted and coiled inside the verge sac (Malek & Cheng, 1974).

Africa, Middle, Eastern and Southern Europe, India, Malay Peninsula, Sumatra and Japan.

Includes two genera, *Camptoceras* and *Indoplanorbis.*

Genus 31. **Indoplanorbis** Annandale and Prashad, 1921

Indoplanorbis Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22** (4): 578.

Type species: *Planorbis exustus* Deshayes.

Shell large and thick, sutures deeply impressed, aperture ear-shaped.

Animal sinistral, foot relatively broad and short, leaf-shaped, broadly rounded anteriorly and pointed posteriorly, branchial process lobed.

Genital aperture slit-like and relatively large, penis long, a simple cylindrical tube, no penial stylet.

The genus is monotypic.

149. **Indoplanorbis exustus** (Deshayes, 1834). (Figs. 326, 327)

Planorbis exustus Deshayes, 1834, in Belanger, *Voy. Indes-Orientales*, p. 417, pl. 1, figs. 11-13. Type locality: Malabar Coast.

Indoplanorbis exustus: Benthem Jutting, 1956, *Treubia*, **23** (2): 471. Rajagopal and Subba Rao, 1968. *Proc. Symposium on Mollusca*, pt. 1, p. 110.

Distribution: Throughout the plains of India, Jammu & Kashmir; Pakistan, Persia, Sri Lanka, Burma, Malaya, Indo China, Thailand, Sumatra, Java, Celebes.

Remarks: Characters same as given for the genus. Annandale and Prashad (1921) discussed the impact of ecological changes on this species. There were several studies on this species—Biswas & Subramanian (1978a, b) on laboratory rearing and breeding and host-parasite relationship; Durani and Chaudhury (1967), Dutt and Bali (1977) on life-history; Kathuria *et al* (1956) on bionomics; Matta and Rai (1971) on metacercaria; Mulherkar and Rao (1963, 1964) on physiology; Nagabhushanam and Chintawar (1977a, b) on temperature tolerance and ecology; Ong and Khan (1974) on reproductive system and effect of parasitism; Rao, H. S. (1925) on anatomy; Rao, M.B. (1944) and Islam (1977) on life-cycle; Sherbert and Lakshmi (1964a, b, c, d) on development and metabolism; and Michael (1966) on development.

Parasites: A number of trematodes of horse, goat, sheep, camel, dog, buffalo and other cattle develop to cercarial stage in this mollusc. Largest number of cercariae are recorded from this snail. The following are some

important parasites who use the snail as intermediate host:—*Artyfechinostomum sufrartyfex, Schistosoma indicum, Schistosoma nasalis, Schistosoma spindalis, Fasciola gigantica, Paramphistomum mehrai, Paramphistomum explanatum, Gastrodiscus secundus, Petagifer srivastavi, Plasmiorchis orientalis, Pseudodiscus collinsi, Gastrothylax crumenifer, Enterohaemotrema paleorticum, Cotylophoron cotylphorum, Cotylophoron indica, Cotylophoron bhaleraoi, Cotylophoron mathurapurensis, Echinostoma* sp. Besides these parasites, about 57 types of cercariae were recorded from this snail.

Genus 32. **Camptoceras** Benson, 1843

Camptoceras Benson, 1843, *Calcutta J. Nat. Hist.*, **3**: 465.

Type species: *Camptoceras terebra* Benson, 1843. Annandale and Prashad, 1920, *J. & Proc. Asiat. Soc. Beng.*, (N.S.), **16**: 31.

Shell sinistral, ovoid or elongate, apex rather acute, whorls 3-4, whorls angular or subangular and extremely oblique, suture very broad and deep, aperture elongate, not as large as the spire.

Externally the animal very much resembles that of *Gyraulus*, but distinguished from it by a large anal siphon, and absence of penial stylet or flagellum. Foot short, not projecting beyond the aperture.

The ecology of the genus is not well known. It was found crawling slowly on weeds in a deep pool in the bed of river Ramgunga at Moradabad (Benson, 1855). It secretes an epiphragam to tide over unfavourable conditions (Annandale & Prashad, 1918). It is extremely local and hard to discover.

The anatomy of Indian species is poorly known. Hubendick's (1955) studies however have shown that the genus belongs to the family Planorbidae. There has been no recent collection of *Camptoceras subspinosum* and *C. lineatum* and hence it is not possible either to corraborate or to disagree with the statement of Hubendick (1955) that these species "cannot be definitely classified until their anatomy is known"

Distribution: Discontinuous and localised, in India, Burma, Thailand, Siberia and Japan. Includes four species from India. Annandale and Prashad (1918, 1920) discussed in detail the habits and taxonomic position of this genus.

Key to the species (after Annandale and Prashad, 1920)

1. Shell extremely elongate, at least three times as long as broad, without strong spiral sculpture 2

Shell irregularly ovate, less than three times as long as broad, sculptured with strong, some times subspinose spiral lines 3

2. Shell less than 4 mm. long, with two whorls, aperture with narrow attenuate peristome, aperture less than half the length of the shell ..... *C. austeni*

Shell at least 8 mm. long, with four whorls, aperture with an incomplete narrow attenuate peristome, aperture equal to more than half the length of the shell ..... *C. terebra*

3. Shell not more than 4.5 mm. long, with 2½ whorls, suture well-defined and angulate at its margin ..... *C. lineatum*

Shell more than 5 mm. long, with four whorls, suture much less well-defined and not so angular at the margins ..... *C. subspinosum*

Subgenus **Camptoceras** s.str.

Type species: *Camptoceras terebra* Benson

150. **Camptoceras austeni** Blanford, 1871
(Figs. 324, 325)

Camptoceras austeni Blanford, 1871, *J. Asiat. Soc. Beng.*, **40**: 40, pl. 2. Type locality: Nazirpur, Shushong, Mymensingh Dist., Bangladesh. Annandale and Prashad, 1918, *J. & Proc. Asiat. Soc. Beng.*, (N.S.) **14**: 457, pl. ii, figs. 3, 3a.

Types: Not known.

Distribution: Bangladesh.

Remarks: A rare species. Shell small with only 2 whorls, aperture irregularly ovate, inner upper margin comparatively less flattened than in *C. terebra.*

The paratype figured by Annandale and Prashad (1918) is probably lost.

151. **Camptoceras terebra** Benson, 1843.
(Figs. 320, 321)

Camptoceras terebra Benson, 1843, *Calcutta J. Nat. Hist.*, **3**: 465. Type-locality: Ram Gunga, at Moradabad, U.P. Benson, 1855, *Ann. Mag. Nat. Hist.* (2) **15**: 10, Annandale and Prashad, 1918, *J. & Proc. Asiat. Soc. Beng.*, (N.S.). **14**: 457, pl. xii, figs. 1, la (Paratype).

Distribution: Uttar Pradesh, West Bengal: Mogra (Hooghly Dist.)

Remarks: Annandale and Prashad (1918) figured the paratype which should have been deposited in the Zoological Survey of India, but no such collection is available at present.

A rare species, characterised by elongate elliptical shell and vertical aperture with flattened inner upper margin.

Subgenus **Culmenella** Clench, 1927

Type species: *Culmenella hirasei* Clench (Prashad, 1931)

152. **Camptoceras lineatum** Blanford, 1871
(Figs. 322, 323)

Camptoceras lineatum Blanford, 1871, *J. Asiat. Soc. Beng.*, **40**: 40, pl. 11, fig. 3. Type locality: Nazirpur, Shushong, Mymensingh Dist., Bangladesh. Gude, 1941, *Fauna Brit. India, Moll.* **2**: 464, fig. 144. Annandale and Prashad, 1921, *Rec. Indian Mus.*, **22**: 586.

Types: BM (NH).

Distribution: Manipur: Loktak Lake; Bangladesh: Mymensingh.

Remarks: Whorls contiguous except behind the peristome, aperture oval and suboblique.

153. **Camptoceras subspinosum** Annandale and Prashad, 1920

Camptoceras subspinosum Annandale and Prashad, 1920, *J. & Proc. Asiat. Soc. Beng.*, (N.S.) **16**: 28, fig. 1, Type locality: "Between Khanabal and Islamabad, Kashmir" (alt. 4000 to 5000 ft.)

Types: ZSI Regd. No. M 11671/2. (Not available)

Distribution: Kashmir.

Remarks: According to Annandale and Prashad (1920) the types were deposited in the Zoological Survey of India and the Register also bears testimony to that effect. But the specimens are not available for study.

Shell sculptured with subspinose spiral lines.

Subfamily SEGMENTININAE

Shell small, low, bright, smooth, glossy and discoidal, the last whorl embraces the shell, aperture heart-shaped, preputium may bear an appen-

dage, one or two external flagella on the vergic sac near its junction with the vas deferens.

There are differences of opinion regarding the generic grouping within the subfamily. Baker (1945), and van Benthem Jutting (1956) recognised four genera namely, *Segmentina, Polypylis, Hippeutis* and *Helicorbis.* Annandale (1922) proposed a new genus, namely *Intha* to include a burmese species. Pace (1973) recognised two genera namely, *Segmentina* and *Hippeutis,* including *Polypylis* as a subgenus of the former and *Helicorbis* as a sub-genus of the latter and *Intha* was synonymised with *Helicorbis.*

Following Pace (1973) only two genera are dealt here.

Key to genera

Shell with internal lamellae ..... **Segmentina**

Shell without internal lamellae ..... **Hippeutis**

Genus 33. **Hippeutis** Charpentier, 1837

Type species: *Helix fontana* Lightfoot, 1767. = *Helix complanata* Linnaeus, 1758.

Shell similar to that of *Segmentina,* but flattened, without internal lamellae. Hermaphrodite, with preputial appendage.

Europe, India, South east Asia, China, Taiwan, the Philippine Islands and Japan.

Two subgenera-European *Hippeutis* and Oriental *Helicorbis.* The former is represented by one species in Kashmir.

Subgenus **Hippeutis** s.str.

Shell lenticular, vergic sac or penial sac with two short flagella, with accessory preputial appendage.

154. **Hippeutis (Hippeutis) fontanus** (Lightfoot, 1786). (Figs. 336-338)

Helix fontana Lightfoot, 1786, *Phil. Trans.*, **26** (1): 165, pl. ii, fig. 1. Type locality: Europe.

Hippeutis fontanus: Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca,* pt. 1, p. 112, pl. 1, figs. 5—7.

Distribution: India: Kashmir; Transcaucasia, West Siberia, Yarkand and Europe.

Remarks: Shell flat, transparent with prominent transverse striae, deeply open umbilicus.

Inhabits still and undisturbed waters.

Subgenus **Helicorbis** Benson, 1850

Type species: *Planorbis umbilicalis* Benson, 1836.

Shell similar to that of *Hippeutis* but differs from that in having less carinate periphery of the shell, angularity close to or at the base but not in the middle as in *Hippeutis*.

Penis without a stylet (van Benthem Jutting, 1956), vergic sac with a long flagella and duct connecting the proximal part of the preputium with the accessory preputial appendage (Pace, 1973).

India, Burma, Eastern and Central China, the Philippines, Java and Sumatra.

Two species.

155. **Hippeutis (Helicorbis) capitis** (Annandale, 1922)
(Figs. 330-332)

Intha capitis Annandale, 1922, *Rec. Indian Mus.*, **24:** 360. Annandale, 1925, *Rec. Indian Mus.*, **27:** 111, fig. 3, Type locality: Inle Lake, Burma.

Types: ZSI Regd. No. M 11997/2. (Holotype).

(Annandale, 1922, p. 362 cited wrongly the Regd. No. M 11998/2).

Distribution: Burma: Inle Lake, He-Ho Gorge, S. Shan states.

Remarks: Shell minute, highly polished, whorls 3, a minute pinhole on the upper surface at the base of outerlip, a minute lobe at the origin of outer lip, aperture very large, inner lip with a broad callus extending on to the shell, lower surface quite flat, umbilicus narrow, externally with fine curved vertical striae.

Pace (1973) considered the genus *Intha* Annandale as synonymous with *Helicorbis*. As there is not much generic distinction between the two *Helicorbis* is only taken as valid.

156. **Hippeutis (Helicorbis) umbilicalis umbilicalis** (Benson, 1836). (Figs. 333-335)

Planorbis umbilicalis Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 741. Type locality: Sylhet, Bangladesh.

Planorbis caenosus Benson, 1850, *Ann. Mag. Nat. Hist.*, (2) **5**: 349. Type locality : Moradabad, Uttar Pradesh.

Segmentina umbilicalis: Germain, 1923, *Rec. Indian Mus.*, **21**: 176, pl. 11, figs. 19—21.

Helicorbis caenosus: Benthem Jutting, 1956, *Treubia*, **23** (2): 479, fig. 134.

Distribution: India: Uttar Pradesh-Kumaon Lakes; West Bengal, Assam; Burma; Indonesia. In the Manipur valley it is the most abundant occurring in the Loktak Lake and in ponds and swamps amidst dense vegetation (Annandale, 1922).

South east Asia, Southern China, Taiwan and the Philippines (Pace, 1973).

Remarks: Shell periphery bluntly angular, whorls roundly convex above.

Pace (1973) discussed about this subspecies and another one, *H. umbilicalis cantori* (Benson), which according to him occurs in India also.

Parasites. This species is incriminated as an intermediate host of *Fasciolopsis buski*, the definite host of which is pig and man. Pace (1973) has not recorded any parasite developing in this species, but mentions about other reports suggesting it as a possible intermediate host of *Paragonimus westermani.* But in Taiwan *Fasciolopsis buski* was found to develop in *Segmentina* (*Polypylis*) *hemisphaerula* Benson.

Dutt & Srivastava (1972) were successful in experimentally infecting this snail (*H. caenosus*) with *Gastrodiscoides homines,* an intestinal parasite of man and several species of mammals, including the domestic pig. Human infections of this parasite were reported from Assam, Bengal, Bihar and

Orissa. Tripathi *et al.* (1973) reported experimental infection of this snail with *Fasciolopsis buski.* However, natural infection of this snail was not reported. *Cercaria helicorbis* was also recorded from this snail (Kumar & Jain, 1968).

Genus 34. **Segmentina** Fleming, 1817.

Segmentina Fleming, 1817, *Edinburgh Encyclopaedia, Conchology,* ed. VII. Vol. XII.

Type species: by monotypy *Nautilus lacustris* Lightfoot = *Planorbis nitidus* O.F. Mueller. Baker, 1945, *The Molluscan Family Planorbidae,* p. 96.

Shell small and glossy, thin, whorls convex above and flattened below, deeply embracing the previous one, body whorl very large and carinate or angular, internal cavity divided by opaque, white, transverse laminae of enamel-like substance, aperture lunate or subtriangular, with three transverse parietal basal and upper labial lamellae.

Mantle edge thickened. Radula with narrower teeth, smaller cusps and multicuspid laterals. Penial sheath without a horny stylet.

North Africa, Europe, and Asia.

The oriental forms are included in the subgenus *Polypylis* Pilsbry, 1906.

Subgenus **Polypylis** Pilsbry, 1906

Polypylis Pilsbry. 1906. *Proc. Acad. Nat. Sci. Philad.,* **58:** 166.

Type species: Segmentina largillierti Dunker. OD (=*S. hemisphaerula* Benson.)

Shell less compressed than in *Segmentina* s.str. and not carinate, parietal laminae obliquely transverse, the others transverse, basal long, a shorter one in the outer wall, wide space between the lamellae. Preputium without a penial gland.

Eastern China, India, Burma and the islands off their coasts.

Represented by three species, namely *Segmentina* (*Polypylis*) *calathus, S.* (*P.*) *taia* and *S.* (*P.*) *trochoidea.* Benson's *Planorbis caenosus* was also assigned to this genus by Annandale (1922), but Prashad (1922) showed its affinity with *Hippeutis fontanus.*

157. **Segmentina (Polypylis) calatha** (Benson, 1850) (Figs. 339-341)

Planorbis calathus Benson, 1850, *Ann. Mag. nat. Hist.*, (2) **5**: 348. Type locality: Moradabad, Uttar Pradesh.

Segmentina calatha: Germain, 1923, *Rec. Indian Mus.*, **21**: 168.

Segmentina calathus: Prashad, 1922, *Rec. Indian Mus.*, **24**: 16.

Distribution: Widely distributed in northern India; Uttar Pradesh, Bihar, West Bengal, Assam, Imphal and Mingyang Pukri in the Manipur Valley; Burma and Sri Lanka.

Remarks: Shell with four whorls, impressed sutures, Vergic sac long with two short flagella

158. **Segmentina (Polypylis) taia** (Annandale and Rao, 1925) (Figs. 349, 350)

Segmentina taia Annandale and Rao, 1925, *Rec. Indian Mus.*, **27**: 110, fig. 2. Type locality: Inle Lake, Burma.

Type: ZSI Regd. No. M 12461/2 (Holotype).

Distribution: Andamans; Burma: Inle Lake, Yawnghwe, South Shan States.

Remarks: Shell yellowish-brown, conoidal, flattened below and concave above, $4\frac{1}{2}$ whorls, body whorl with abrupt slope towards the ventral surface, umbilicus minute and as a shallow pit, internal ridges visible from below in adult shell, aperture quadrate when viewed ventrally, ventral margin of peristome almost straight meeting the strongly arched and convex dorsal margin.

Distinguished from *S. calathus* by its more pronounced conoidal form, whorls gradually increasing in size, sides of the keel forming a small angle, straight lower or ventral margin, and greatly arched upper or dorsal margin.

159. **Segmentina (Polypylis) trochoidea** (Benson, 1836) (Figs. 347, 348)

Planorbis trochoideus Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 742. Type locality: Barrackpore, near Calcutta.

Segmentina trochoidea: Germain, 1923, *Rec. Indian. Mus.*, **21**: 175.

Trochorbis trochoideus: Baker, 1945, *The Molluscan Family Planorbidae*, p. 108.

Distribution: India: West Bengal-Calcutta, Barrackpore, Port Canning, Tamilnadu—Madras, Karnataka-Belgaum; Sri Lanka: Balapiti; Burma: Inle Lake.

Remarks: Shell trochoid, much smaller than in *S. calatha*, whorls $3\frac{1}{2}$, periphery more acute, umbilicus small or totally absent, apertural lamellae weak.

Baker (1945) assigned it to a separate genus *Trochorbis* Benson, 1855, while showing its resemblance to *Polypylis*. Kennard and Woodward (1926) considered *Trochorbis* Benson a synonym of *Segmentina*. Like many other planorbid species its anatomy is also not known and because of its resemblance to other species in shell characters, it is also grouped along with them in the genus *Segmentina*.

Rensch (1934, p. 215) synonymised *S. trochoidea* with *Polypylis kennardi* (Bullen) and it was supported by Benthem Jutting (1956).

Parasites: *Fasciolopsis buski* was found to develop in this snail in Assam (Mehra, 1980).

Subfamily PLANORBINAE

Shell discoidal, whorls distinct from each other, regularly increasing in size, upper and lower sides flattened.

Prostate duct long and separated from the sperm duct, prostate diverticula simple and placed all along the duct. Verge may be with or without stylet.

Genus 35. **Planorbis** Geoffroy, 1767

Planorbis Geoffroy, 1767, *Traite Coq., Paris*, p. 12.

Type species: *Helix planorbis* Linnaeus, by tautonomy (Baker, 1945).

Planorbis: Baker, 1945, *The Molluscan Family Planorbidae*, The University of Illinois Press, Urbana. p. 51.

Shell discoidal with few whorls, coiled in a plane, body whorl with a carina on the upper side, aperture small, rounded or oval; right margin of aperture projecting beyond the left.

Animal with a simple branchial process, radula long and narrow, cusps of teeth thin, penis short and swollen when retracted, asymmetrical, penis sheath with a thick walled preputium, with two retractor muscles. Verge without stylet.

Throughout Europe, on east up to Western Russia, also northern Asia, Asia Minor and northern Africa.

160. **Planorbis planorbis tangitarensis** Germain, 1918.
(Figs. 353-355)

Planorbis (*Tropidiscus*) *planorbis* var. *tangitarensis* Germain, 1918, *Bull. Mus. Hist. nat. Paris,* **24** (4): 267, Type locality: North Tangitar.

Planorbis planorbis var. *tangitarensis:* Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca,* pt. 1. p. 109.

Types: MNNH.

Distribution: Kashmir; Central Asia: Tangitar.

Remarks: Shell compressed and flattened, angulation not very distinct, spire showing distinctly all five whorls, aperture more contracted than in the typical form, and the under side less deeply sunk.

161. **Planorbis rotundatus** Poiret, 1801
(Figs. 356-358)

Planorbis rotundatus Poiret, 1801, *Coq. Ausne environs de Paris,* Prodrome, p. 93. (non *Planorbis rotundatus* Brongniart). Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca,* pt. 1, p. 109, pl. 1, figs. 2-4.

Types: MNNH.

Distribution: India: Kashmir; Siberia; Europe.

Remarks: Shell thick, rounded, whorls 5, gradually increasing, rounded without any angulation, aperture oval.

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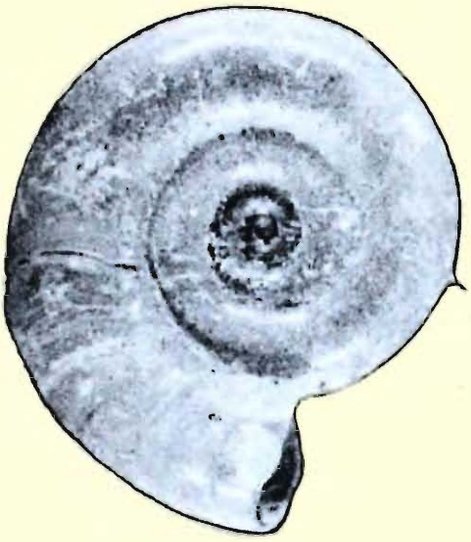

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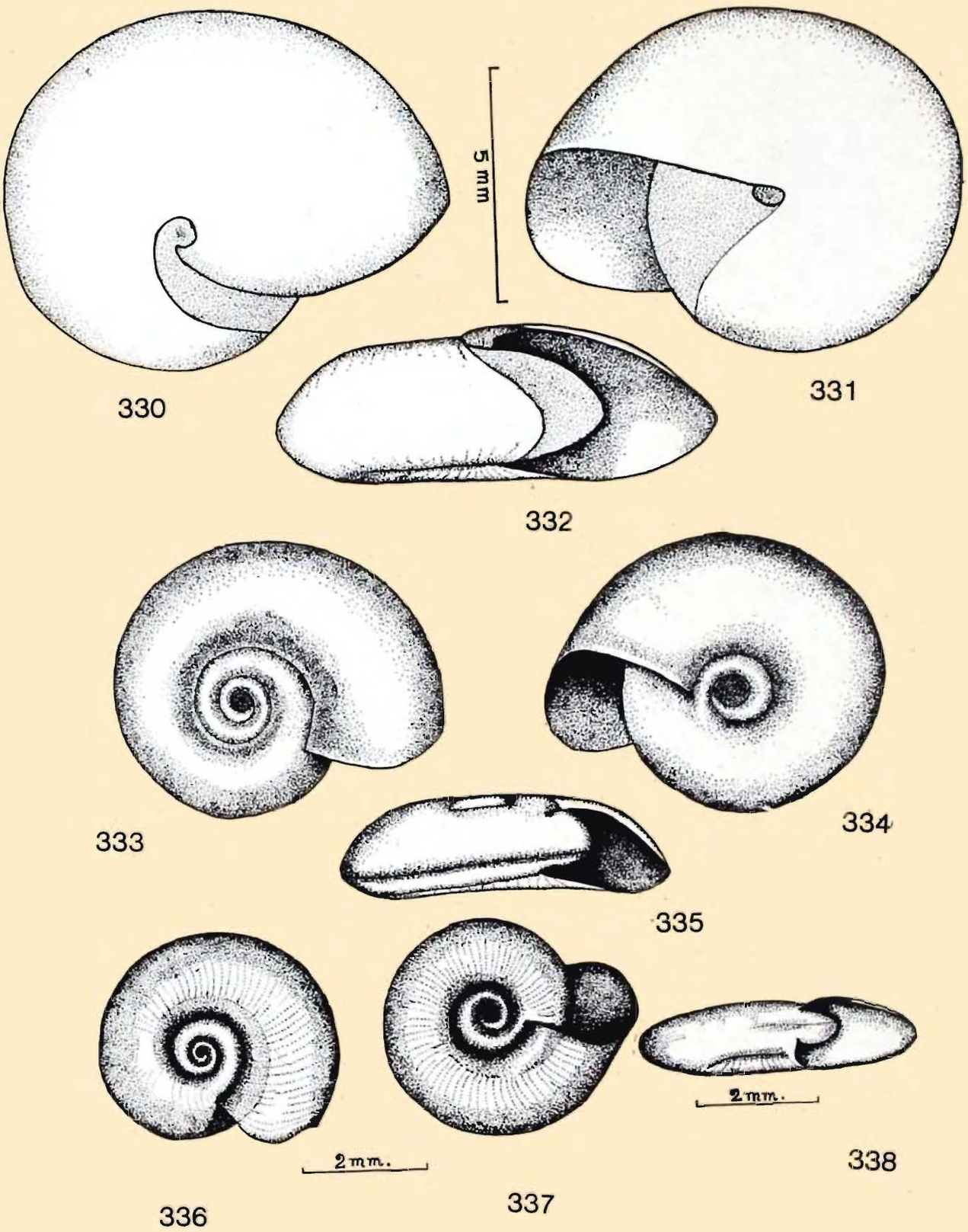
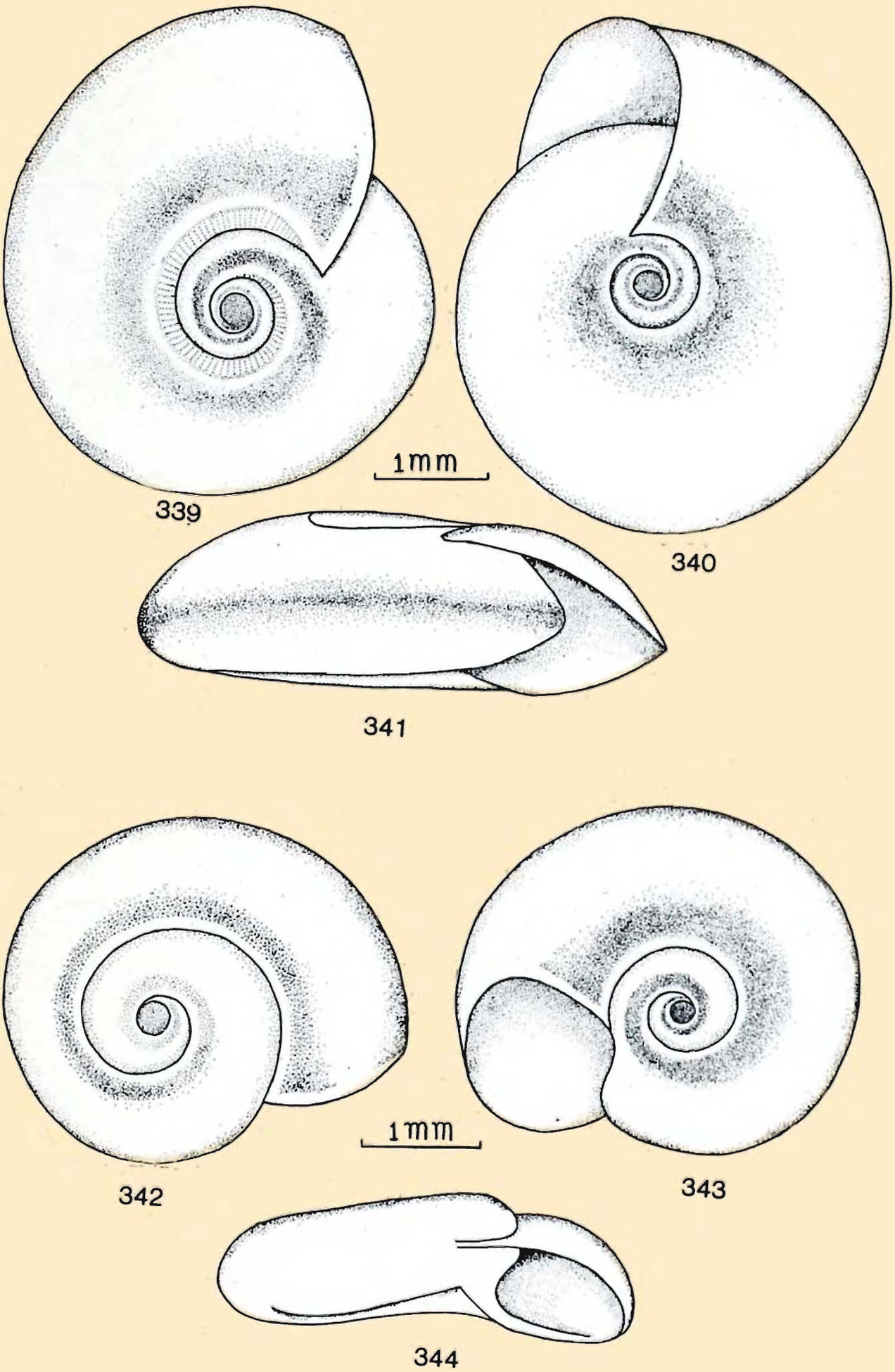
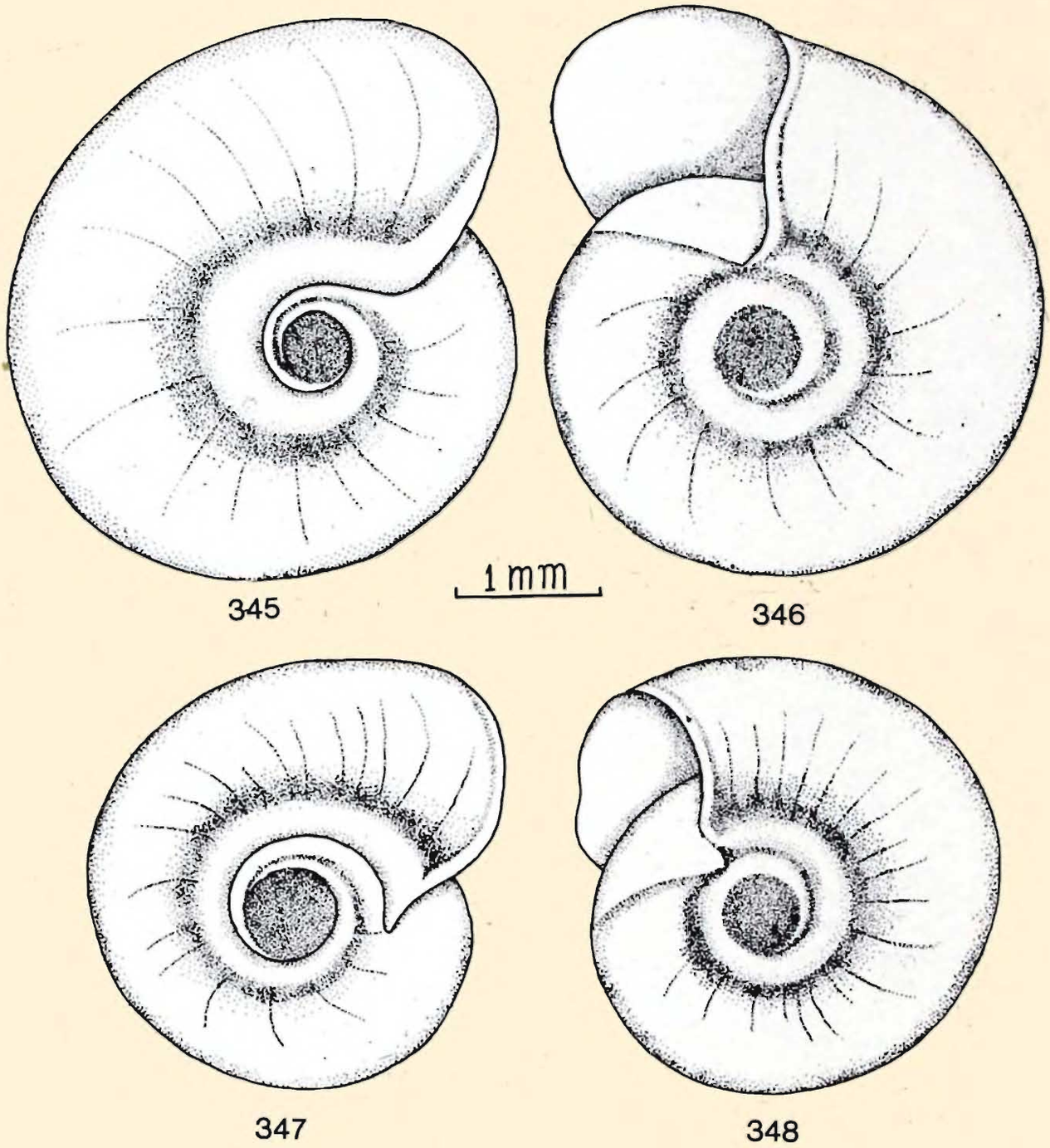
Figs. 326, 327. *Indoplanorbis exustus*, 15.70 × 5.95 mm., Pune. 328. *Gyraulus rotula*, 3.0 × 8.0 mm., Indawgy L., Burma. 329. *G. velifer*, Syntype 2.70 × .55 mm., Shan States.



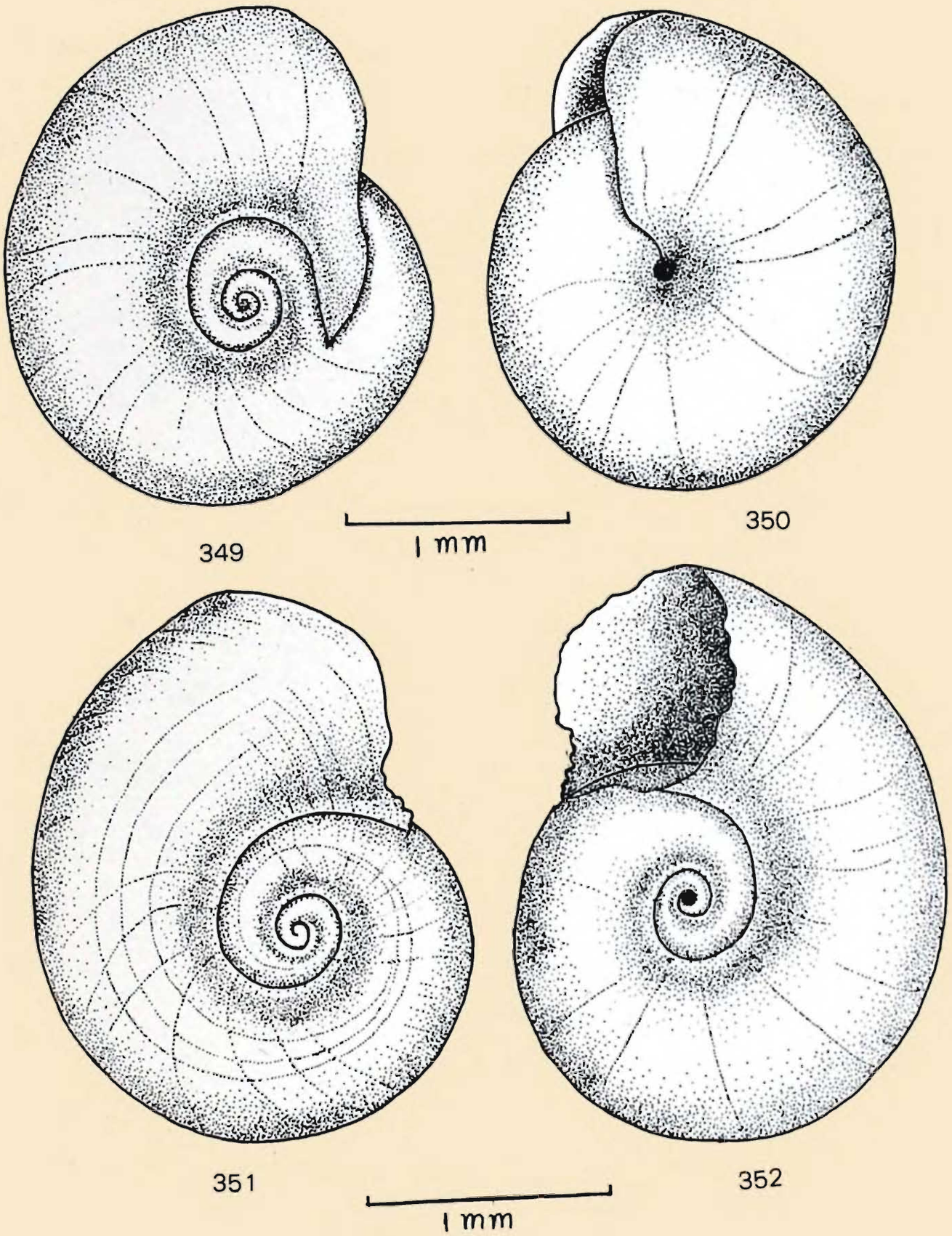
Figs. 330-332. *Intha capitis*, Holotype, 2.55 × 1.0 mm., Shan States. 333-335. *Segmentina umbilicalis*, 6.85 × 2.15 mm., Manipur. 336-338. *Hippeutis fontanus*, 4.50 × .80 mm., Kashmir.



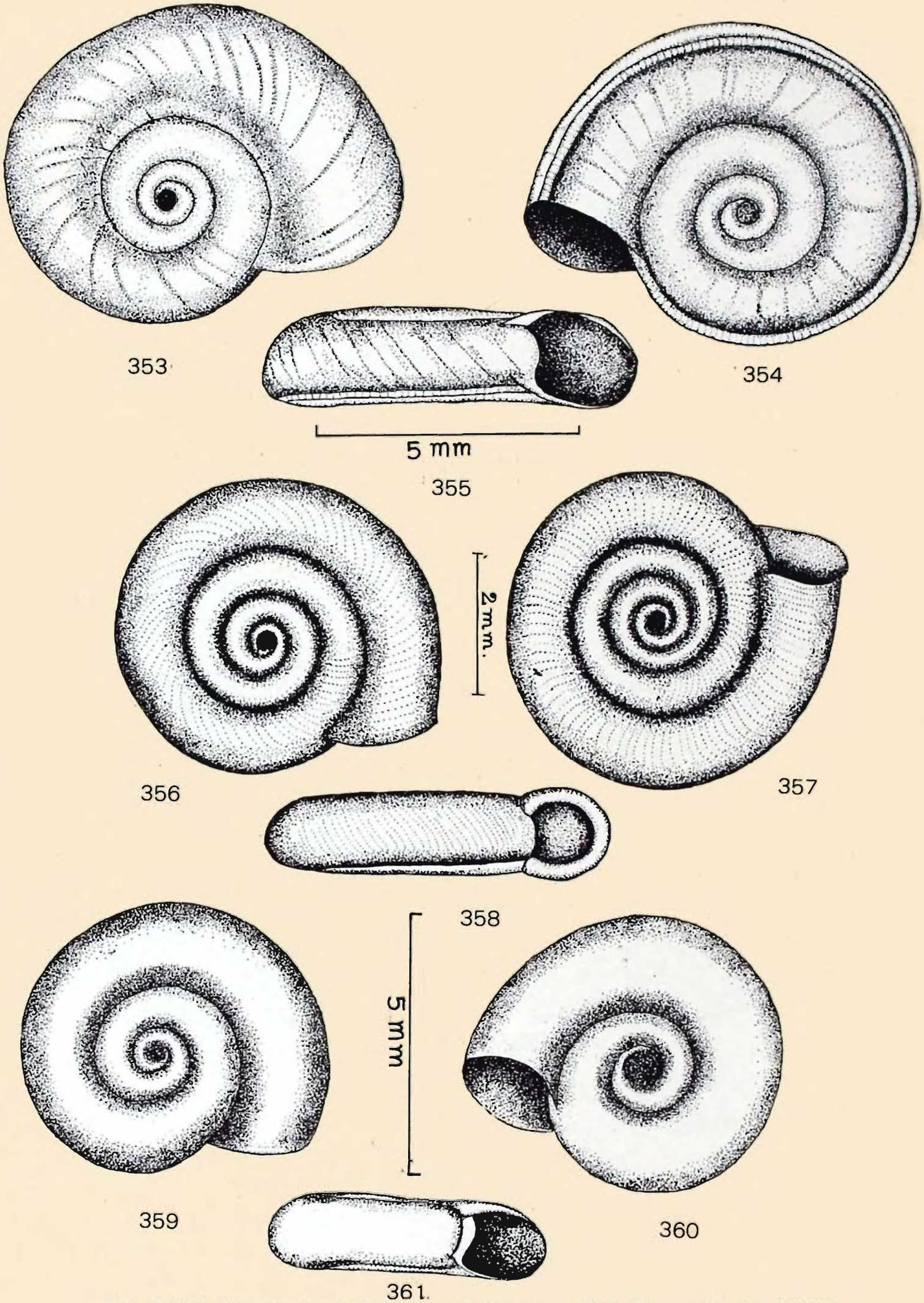
Figs. 339-341. *Segmentina calatha*, 4.5 × 1.85 mm., Chandernagar, West Bengal. 342-344. *Gyraulus labiatus*, 3.75 × .95 mm., Calcutta.



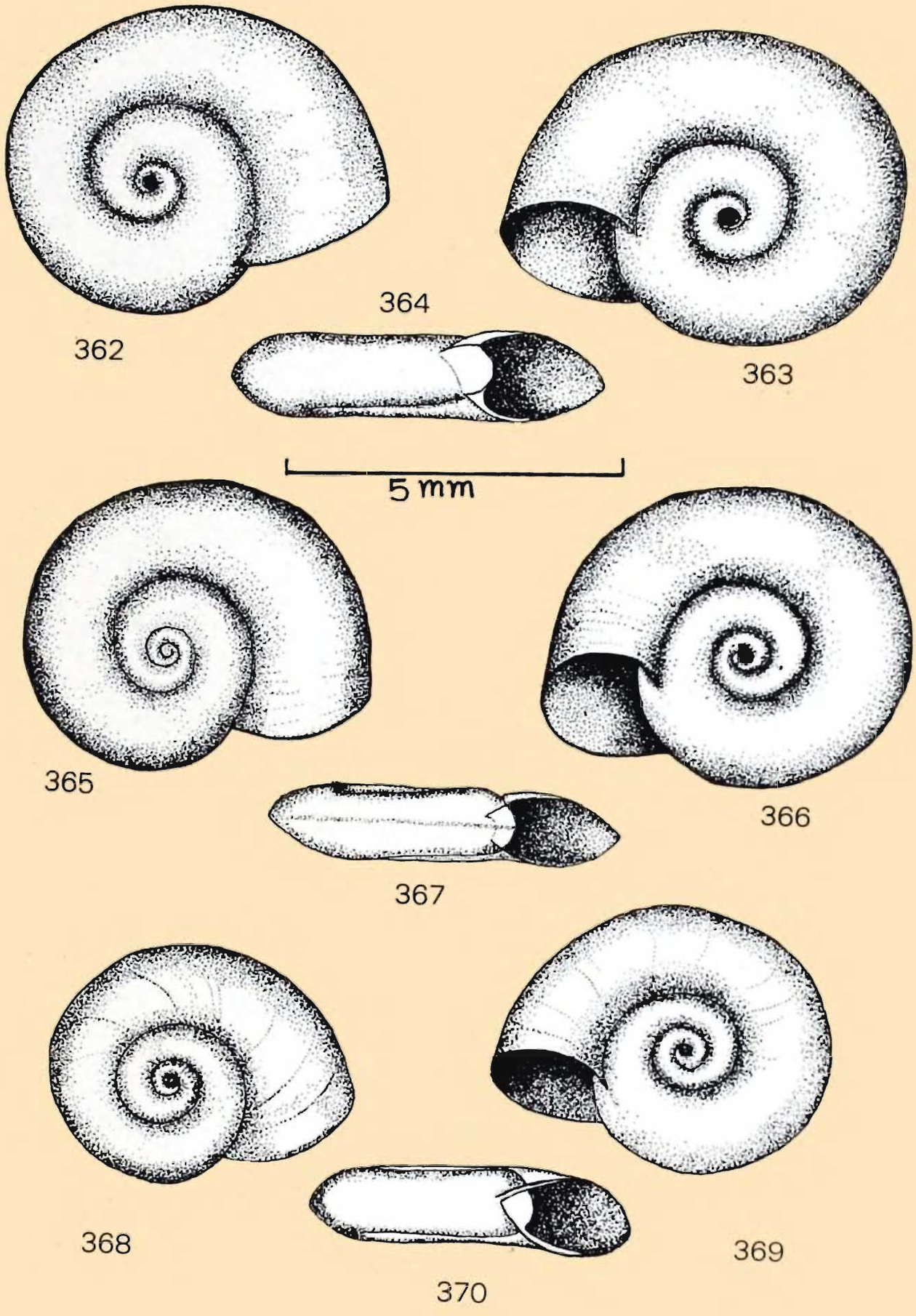
Figs. 345, 346. *Segmentina caenosa*, 5.20 × 1.75 mm.; Shan States. 347, 348. *Segmentina trochoidea*, 3.65 × 1.30 mm., Kashmir.



Figs. 349, 350. *Segmentina taia*, Syntype, 2.25 × .80 mm., Shan States. 351, 352. *Planorbis velifer*.



Figs. 353-355. *Planorbis planorbis tangitarensis*, Holotype, 6.78 × 1.80 mm., Tangitar. 356-358. *Planorbis rotundatus*, 4.10 × 1.0 mm., Kashmir. 359-361. *Gyraulus ladacensis*, Syntype, 5.90 × 1.60 mm., Leh in Ladak.



Figs. 362-364. *Gyraulus convexiusculus*, 6.86 × 1.60 mm., Calcutta. 365-367. *G. euphraticus*, 5.75 × 1.15 mm., Salt Range. 368-370. *G. pankongensis*, 5.30 × 1.30 mm.; 5.20 × 1.25 mm., Srinagar, Kashmir.

Genus 36. **Gyraulus** Charpentier, 1837.

Gyraulus (Agassiz MS) Charpentier., 1837, *Neue Denkschr. Allg. Schweiz. Gesell,* **1,** no. 2: 21.

Type species: *Planorbis albus* Mueller = *Planorbis hispidus* Draparnaud SD Dall, 1870. Annandale and Prashad, 1909, *Rec. Indian Mus.*, **18:** 52. Baker, 1945, *The Molluscan Family Planorbidae,* p. 65.

Shell small, always less than 1 cm. in diameter, thin, greatly depressed, pale translucent or transparent, with three to five rapidly increasing whorls, without strong transverse ribs, with or without short, hair-like projections of the periostracum, with or without peripheral keel, body whorl at aperture slightly deflected, aperture oblique, simple lip.

Radula with a bicuspid central tooth, bi-or tricuspid laterals and several sharp cusps on marginals.

Mantle edge not thickened, the vas deferens continues into a narrow penis, verge with a well developed stylet.

World wide, particularly in North America, parts of the West Indies and northern South America, Europe, Asia, Africa, Australia, Malaysia, Fiji, New Caledonia, the Philippines and other islands of the Pacific Ocean.

Baker (1945) listed 33 species from India and Asia. Preston (1915) included 18 species from Oriental India. Excepting a few common species all the other species are very imperfectly known and hence a key could not be provided to the species of *Gyraulus.*

A provisional arrangement includes nine species as given below. Details are provided only for the well-known species, giving only a list of other too little known species. A revision of the group could bring out the important characters and validity of each species described from India.

162. **Gyraulus barrackporensis** (Clessin, 1886)

Planorbis barrackporensis Clessin, 1886, *Limnaeiden:* in Martini und Chemnitz's *Syst. Conch. Cab.,* p. 125, pl. xviii, fig. 2. Type locality: Barrackpore.

Planorbis huttoni Clessin, 1886, *Limnaeiden:* in Martini und Chemnitz's *Syst. Conch. Cab.,* p. 139, pl. xviii, fig. 4.

Gyraulus barrackporensis: Prashad, 1922, *Rec. Indian Mus.,* **24:** 15.

Types: Mus. Berlin.

Distribution: West Bengal: Barrackpore, Calcutta; Uttar Pradesh: Benaras; Tibet.

Remarks: Whorls rapidly increasing, body whorl more rounded and more dilated at its extremity, aperture very oblique, shell thin, shining yellowish brown, fragile, subtransparent, sculptured with fine longitudinal striae.

163. **Gyraulus convexiusculus** (Hutton, 1849)

(Figs. 362-364)

Planorbis convexiusculus Hutton, 1849, *J. Asiat. Soc. Beng.*, **18** (2): 657. Type locality: Afghanisthan.

Planorbis saigonensis Crosse et Fischer, 1864, *J. Conchyl.* **11**: 362, pl. xiii, fig. 7. Type locality: Saigon.

Planorbis compressus von Martens, 1867: in Weber *Zool. Ergebn. Niederl. Ost. Ind.*, **4**: 13, pl. 1, figs. 17-22, pl. xii, figs. 7, 10. Type locality: Java.

Planorbis demissus Westerlund, 1885, *Ur. Vega Expeditionens Vetenskapliga Jakattagelser*, **4**: 204, pl. 4, fig. 16. Type-locality: Point de Galle, Ceylon.

Gyraulus convexiusculus: Benthem Jutting, 1956, *Treubia*, **23** (2): 463.

Types: ?

Distribution: A very common species occurring in lakes, ditches, ponds and rice fields. Its range extends from Iran to Philippines.

Remarks: Maximum diameter rarely exceeds 5 mm, whorls 4 or 5, rounded, suture well defined, periphery subangulate, closely and obliquely striate, umbilicus wide, all the whorls distinctly seen from above, aperture ovate-lunate.

Radula with a well developed central, bearing sharply pointed cusps, inner laterals with two stout, sharply pointed cusps, outers with three cusps, marginals with four to six similar and slender cusps.

Meir-Brook (1979) considers this as a subspecies of *G. chinensis* (Dunker). Bali and Dutt (1980) studied the life cycle.

Parasites. Larval forms of *Gastrothylase crumenifer, Paramphistomum explanatum, Fasciola elongatus* and other cercariae viz. *C. chugathi, C. gyraulusi, C. rithorensis, C. furgolensis* were recorded.

164. **Gyraulus euphraticus** (Mousson, 1874)
(Figs. 365-367)

Planorbis euphraticus Mousson, 1874, *J. Conchyl,* **22**: 44. Type-locality: "La-Basse—Mesopotomie"

Planorbis compressus Hutton (nec. Michaud), 1834, *J. Asiat. Soc. Beng.* (2) **3**: 93.

Gyraulus euphraticus: Annandale and Prashad, 1919, *Rec. Indian Mus.*, **18**: 54, fig. 7A, 8A.

Types: Zoologischer Museum, Zurich.

Distribution: Salt Range; Essentially Palaearctic; Baluchistan, Afghanistan.

Remarks: Superficially it resembles *G. convexiusculus* but differs from it in being more compressed and more strongly carinte, shell larger, more opaque and more coarsely and irregularly sculptured, body whorl deviates from the spiral of the upper whorls.

Annandale and Prashad (1919) discussed the affiinities of this species.

Parasites. Larval forms of *Echinostoma ilocanum,* a parasite of rats and human beings and *Diplodisus amphicrus* were recorded from this snail.

Sewell (1922) recorded a few cercariae.

165. **Gyraulus labiatus** (Benson, 1850)
(Figs. 342-344)

Planorbis labiatus Benson, 1850, *Ann. Mag. nat. Hist.*, (2) **5**: 350. Type locality: "In stagne prope urbem, Moradabad."

Planorbis (Gyraulus) labiatus: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda & Pelecypoda), p. 119, fig. 5.

Gyraulus labiatus: Annandale, 1925, *Rec. Indian Mus.*, **27**: 109.

Distribution: Tamilnadu: Mettupalayam; Maharashtra: Khandala; Madhya Pradesh; West Bengal: Calcutta; Burma: He Ho Gorge, Shan States,

Remarks: Shell obliquely striated, whorls $3\frac{1}{2}$, sutures impressed, aperture oblique, heart shaped, body whorl with remarkable departure from the axis of previous whorls, whitish rib within the aperture.

This was found along with *Planorbis compressus* Hutton and Benson's description of the *G. labiatus* also shows the similarity of the latter with the former. It is quite possible that both may be referred to one and the same species.

166. **Gyraulus ladacensis** Nevill, 1878.
(Figs. 359-361)

Planorbis (*Gyraulus*) *laevis* var. *ladacensis* Nevill, 1878, *Scientific Results Second Yarkand Mission,* p. 10. Type locality: Ladakh.

Gyraulus ladacensis: Prashad, 1937, *Rec. Indian Mus.,* **39**: 273.

Types: ZSI Regd. No. M 17822/3 (Syntypes).

Distribution: India: Ladakh; Tibet.

Remarks: Shell quite solid, depressed, almost flat above and below with oblique longitudinal striae, $4\frac{1}{2}$ convex whorls, with a slope, separated by deep sutures, body whorl rounded, not angular, but slightly compressed in the middle towards the extremity, and a little dilated, quite widely and less deeply umbilicate, aperture less oblique, ovate, transverse, upper margin reaching a little beyond the columellar margin.

167. **Gyraulus pankongensis** (von Martens, 1882)
(Figs. 368-370)

Planorbis pankongensis von Martens, 1882, *Mem. Acad. Imp. Sci. St. Petersbourg,* (7) **30** (11): 45, pl. iv, figs. 14 a-c. Type locality: Lake Pankong, Tibet.

Gyraulus pankongensis: Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca,* pt. 1, p. 111, pl. 1, fig. 1.

Distribution: India: Kashmir; Tibet.

Remarks: Shell solid, white or yellowish, with oblique longitudinal striae, subconvex above, with a quite narrow central margin, whorls 3—$3\frac{1}{2}$, very rarely 4, convex, rapidly increasing, sutures deep, body whorl very large, convex above and below, neither carinate nor angular, well dilated,

some times more or less descending at the extremity, deeply umbilicate, aperture oblique, round with convergent and approaching margins united by a wide callosity, peristome interiorly bordered with a very clearly marked white thickening.

168. **Gyraulus rotula** (Benson, 1850)
(Fig. 328)

Planorbis rotula Benson, 1850, *Ann. Mag. nat. Hist.*, **5**: 351. Type locality: Moradabad, Uttar Pradesh.

Planorbis (*Gyraulus*) *liratus* Westerlund, 1885, in *Ur. Vega Expeditionens Vetenskapliga Jakatagelser*, **4**: 206, pl. iv, fig. 18. Type locality: Point de Galle, Ceylon.

Planorbis (*Gyraulus*) *rotula:* Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 122.

Distribution: India: Uttar Pradesh, Maharashtra; Sri Lanka; Thailand.

Remarks: Whorls $3\frac{1}{2}$, obsolete spiral striations, sutures impressed, periostracum thin, brightly, sometimes lightly tinted greenish, sculptured with longitudinal striae, sometimes strong enough to be called subcostae.

Resembles very closely *G. convexiusculus* but can be distinguished from it in having less number of whorls and a neatly rounded body whorl.

169. **Gyraulus saltensis** Germain, 1922

Planorbis (*Gyraulus*) *saltensis* Germain, 1922, *Rec. Indian Mus.*, **21**: 127. Type locality: Salt Range, Punjab (Subfossil).

Types: MNNH.

Distribution: Not known beyond Type locality.

Remarks: Shell well depressed, convex above and subconvex below, whorls $3\frac{1}{2}$, rapidly increasing, first ones very small and deeply sunk, body whorl very large and well dilated at the extremity, aperture very oblique.

Germain (1922), while describing this new species, expressed a doubt regarding its validity and the need for the collection of more material for study.

170. **Gyraulus velifer** (Annandale, 1918).
(Fig. 329)

Planorbis velifer Annandale, 1918, *Rec. Indian Mus.*, **14**: 112, pl. xi, figs. 7—11. Type locality: Inle Lake, Burma.

Gyraulus velifer: Annandale, 1925, *Rec. Indian Mus.*, **27**: 108.

Types: ZSI Regd. No. M 11288/2

Distribution: Inle Lake, Burma.

Remarks: Shell transparent, with very fine close-set regular transverse striae, whorls $3\frac{1}{2}$, upper surface very slightly convex and the suture impressed, periphery faintly carinate, aperture large, broad, moderately oblique, edge of the lip sharply defined without thickening.

Annandale (1918) himself pointed out that it may be a variety or phase of *Gyraulus saigonensis* which has been synonymised with *G. convexiusculus.*

Preston (1915) included 18 species in the subgenus *Gyraulus* without any critical assessment. A list of species included by Preston (1915) and Germain (1921-24) which are of doubtful identity is given below. Further study and collections are needed to prove the validity of these species.

1. *Gyraulus sivalensis* (Hutton MS) Clessin, 1884, *Conch. Cab.*, p. 194, pl. 28, fig. 9.
2. *Gyraulus hohenackri* Clessin, 1884, *Conch. Cab.*, p. 205, pl. 31, fig. 7.
3. *Gyraulus himalayanus* (Hutton MS) Clessin, 1884, *Conch. Cab.*, p. 141, pl. 20, fig. 8.
4. *Gyraulus elegantulus* Dohrn, 1858, *Proc. zool. Soc. Lond.*, 1858: 134, Sri Lanka.
5. *Gyraulus stelzneri* Dohrn, 1858, *Proc. zool. Soc. Lond.*, 1858: 134. Sri Lanka.
6. *Gyraulus hyptiocyclos* Benson, 1863, *Ann. Mag. nat. Hist.*, (3) **9**: 89.
7. *Gyraulus cherraequris* Godwin-Austen, Germain, 1921-24. *Rec. Indian Mus.*, **21**: 129.
8. *Gyraulus nanus* Benson, 1856, Germain, 1921-24. *Rec. Indian Mus.*, **21**: 131, pl. ii, figs. 10—12.

class BIVALVIA

order ARCOIDA

Family 13. ARCIDAE Lamarck, 1809

Subfamily ANADARINAE Reinhart, 1935

The members of the family are primarily marine inhabitants. A few however, have successfully invaded brackish-and fresh-waters. Only genus *Scaphula* need to be considered here as a freshwater representative.

Genus 37. **Scaphula** Benson, 1834

Scaphula Benson, 1834, *Proc. zool. Soc. Lond.*, p. 91.

Type species: *Scaphula celox* Benson, 1836. SD.

Shell small, equivalve, inquilateral, subtrapezoidal, elongate, smooth, lacking ornamentation over most of the shell surface excepting at the angle, posterior umbonal carina high and narrow, ligament external, hinge linear with numerous subequal teeth, separated into two by the middle edentate portion of cardinal lamina, the laminar posterior teeth sometimes ramose, turning obsoletely and obliquely into the interior of the shell, muscular impressions distinctive, the lower one on the posterior side squarish.

Ghosh (1922) described the anatomy of this genus.

India: Gangetic delta, Mahanadi River; Burma: Irrawaddy estuary Tenasserim River; Thailand.

Three species are distinguished by their shell shapes. Recently another species viz. *Scaphula nagarjuni* had been described (Radha Krishna and Janakiram, 1984). As I could not examine any specimens of this species (reported from Nagarjuna Sagar Lake, Guntur Dist. Andhra Pradesh) I have not included it in the present account.

171. **Scaphula celox** Benson, 1836
(Figs. 371-373 & 380, 381)

Scaphula celox Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 750, pl. 7, figs. 2, 3. Type locality: Calcutta. Blanford, 1867, *J. Asiat. Soc. Beng.*, **36** (2): 71, pl. iii, figs. 14, 15. Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 129.

Types: BM (NH).

Distribution: Madhya Pradesh: River Cane, near Banda (Bundelkhand); West Bengal: Calcutta (Rabindra Sarovar, Kidderpore Docks).

Remarks: Shell elongate, tumid, with parallel margins, hinge teeth 15—20.

172. **Scaphula deltae** Blanford, 1867
(Figs. 374-376)

Scaphula deltae Blanford, 1867, *J. Asiat. Soc. Beng.*, **36** (2): 71, pl. iii, figs. 7—10. Type locality: Irrawaddy delta.

Types: BM (NH).

Distribution: India: Gangetic Delta, Rabindra Sarovar (Calcutta), Mahanadi River; Burma.

Remarks: Distinguished from the other two species by its strong ribs parallel to the posterior keel and by the far greater tumidity of the valves, nearly twice as thick as the height. Unlike the other two species it is found occurring in brackish water, generally away from the sea.

Under stones in creeks adhering by a byssus (Blanford, 1867).

173. **Scaphula pinna** Benson, 1856
(Figs. 377-379 & 382, 383)

Scaphula pinna Benson, 1856, *Ann. Mag. Nat. Hist.*, (2) **17**: 129. Type locality: Tenasserim River, Burma.

Types: BM (NH).

Distribution: Burma: Tenasserim River; Thailand.

Remarks: Shell elongately triangular, divided into two parts by a strong posterior carina running from the umbones to the podium, sculpture of fine radial sulci, dorsal margin curved, posterior end broader than the anterior one.

order UNIONIDA

Superfamily UNIONACEA Fleming, 1828

Shell generally equivalve and isomyarian except in Etheriidae, chiefly nacreous, ornamented, porcelain-white to bluish nacre, hinge normally with two cardinals and two posterior lamellar teeth on the left valve.

Freshwater mussels of India are mostly known by their shell characters. Although Ghosh (1921) and Prashad (1918, 1919) studied the anatomy of various Indian genera there had been no serious attempt to apply these anatomical characteristics in the classification. Hitherto, the emphasis was given more to shell characters. Ortman (1910, 1911) proposed the classification based on anatomical characters. He however, observed that shell characters are useful in defining genera and species, but the higher taxa can be differentiated by using anatomical characters like structure of marsupium, larvae, etc. Haas (1969) suggested a recent classification based on conchological characters. But Heard and Guckert (1970) and Heard (1974) stressed the importance of soft-part anatomy, reproductive morphology and habits in classification of freshwater mussels and describing their phylogenies. Recently Brandt (1974) provided a classification for the Thailand freshwater mussels. Drawing conclusions from the anatomical studies made by Prashad (1918, 1919a, b), Bloomer (1931) and Ghosh (1921) the Indian and Burmese freshwater mussels are classified into four families viz. Unionidae, Amblemidae, Margaritiferidae and Etheriidae.

Family 14. UNIONIDAE Fleming, 1828

Shell equivalve, covered with a thick periostracum, umbones generally corrugatedly sculptured and with remnants of larval shell, umbonal cavity deep, ligament elongated and projecting, hinge with strong teeth, two cardinals and two posterior lateral lamellar teeth in left valve and a single cardinal and lateral in right valve, gills with water tubes, marsupium occupying outer pair only or all the four gills.

Although Haas (1969) recognised six subfamilies all the Indian forms fall under one subfamily Unioninae.

Subfamily UNIONINAE s.str.

Shell equivalve, umbonal sculpture mostly concentric.

Shell very variable and cannot be always taken as a reliable structure in classification above species level. Subfamilies, genera and subgenera are mainly distinguished using the gills and their relation to marsupium. Mantle margin around inhalent siphons and the larval form, glochidium are also useful in the classification of freshwater mussels. In this connection studies by Prashad (1918, 1919) on the anatomy of *Balwantia (=Solenaia), Parreysia, Lamellidens, Physunio* and *Pseudodon* are worth noting.

Although a few studies were made on the biochemistry, physiology and life cycles of a few freshwater mussels, especially *Lamellidens* and *Parreysia* so far no attempt was made to make a revision of the group and study its zoogeography.

Blanford (1866) made an attempt towards the revision of Indian unionids. He had pointed out the amount of variation exhibited by these molluscs and the difficulty in classifying them. But unfortunately, Preston (1912, 1915) did not refer to his work, wherein remarks were made on the possible validity of many Indian, Ceylonese and Burmese species.

Prashad (1922) reviewed all the earlier works on Indo-Burmese Unionidae and made a revision of the Burmese Unionidae. He recognised 26 species endemic to Burma. No attempt was however, made to revise the Indian species. In spite of several gaps in our knowledge of this family an attempt is made here to present the taxonomic arrangement of the group as it is understood to-day and to introduce stability in the system of classification.

Preston (1915) included nine genera viz. *Solenaia* Conrad, *Unio* Retzius, *Nodularia* Conrad, *Physunio* Simpson, *Pseudodon* Gould, *Parreysia* Conrad, *Lamellidens* Simpson, *Trapezoideus* Simpson and *Arcidopsis* Simpson, But later studies by Prashad revealed that the species treated under *Nodularia* are to be included in the genus *Indonaia,* which is now synonymous with *Radiatula* Simpson.

The following eight genera viz: *Solenaia, Arcidopsis, Oxynaia, Lamellidens, Physunio, Pseudodon, Parreysia* and *Trapezoideus* are formerly grouped in the family Unionidae, According to Heard and Guckert (1970) these genera fall under two distinct families viz: Unioidae and Amblemidae Brandt (1974) also adopted the same system, However, the key given below includes all the eight genera irrespective of their family position. The genus *Scabies* has been included at a later stage and hence does not find a place in the key.

Key to genera

1. Shell soleniform, hinge toothless (edentulous) ..... **Solenaia**

   Shell not soleniform, hinge with cardinal and lateral teeth 2

2. Shell elongate 3

   Shell not elongate, but ovate or rounded or irregularly obovate or trapezoidal 5

3. Dorsal and ventral margins almost straight and parallel, cardinals short and supported by long fulcrum ..... **Arcidopsis**

   Dorsal and ventral margins not parallel, cardinals without any support 4

4. Shell comparatively narrower, posterior end pointed, cardinals stout ..... **Oxynaia**

   Shell comparatively broader, posterior end broad, cardinals compressed and elongated ..... **Lamellidens**

5. Shell ovate to elliptical, narrow anteriorly, posterior slope high and winged 6

   Shell subrhomboidal trapezoidal, posteriorly not winged 7

6. Umbones prominent with deep umbonal cavities, auxiliary tooth in each valve, a distinct supra anal aperture ..... **Physunio**

   Umbones low with shallow umbonal cavity, single blunt cardinal without auxiliary tooth, no supra anal aperture ..... **Pseudodon**

7. Shell rounded to subrhomboidal, tumid, umbones high with radially zigzag ribs, cardinals vertically striate, compressed ..... **Parreysia**

   Shell trapezoidal, umbones less prominent, cardinals elongate, without any striations ..... **Trapezoideus**

Genus 38. **Lamellidens** Simpson, 1900

Lamellidens Simpson, 1900, *Proc. U. S. natn. Mus.*, (Washington) **22**: 854.

Type species: *Unio marginalis* Lamarck, 1819, OD. Annandale and Prashad, 1919, *Rec. Indian Mus.*, **18**: 59.

Shell elongate-elliptical, anterior end narrow and curving regularly, posteriorly broad, with a slight post dorsal wing, a low, often biangulate posterior ridge, and generally with two sharp, radiating lirae above it. Umbones with curved radiating ridges which may be slightly zigzag or almost concentric, fade out as they approach each other, periostracum smooth, shining, brownish or dark, often with concentric bands of lighter colour, nacre bluish-white to straw, left valve with two elongated cardinals and two laterals, right valve with two parallel, lamellar cardinals and one lateral.

Exhalent aperture with a row of minute tubercles in its extreme lateral margins, inhalent aperture with a single row of short and stout tentacles.

India, Bangladesh and Burma (six species, Prashad, 1922). Ghosh (1918) dealt in detail on the comparative anatomy of *Lamellidens, Solenaia* and *Physunio,* Prashad (1918, 1919) described the marsupium, glochidium and anatomy of *Physunio, Lamellidens, Parreysia* and *Radiatula* (=*Indonaia*)

174. **Lamellidens consobrinus** (Lea, 1859)
(Figs. 384, 385)

Unio consobrinus Lea, 1859, *Proc. Acad. Nat. Sci. Philad,* **3**: 331. Type-locality: China.

Lamellidens consobrinus: Prashad, 1921, *Rec. Indian, Mus.,* **22**: 608.

Types: ANSP (Paratype), USNM (Holotype).

Distribution: India and Sri Lanka.

Remarks: Shell rhomboidal, thick, umbones more inflated than in *L. marginalis,* dorsal margin curved and obliquely truncate, posterior side obtusely angled, anterior side rounded, left valve with two ragged cardinals, anterior large and more developed.

175. **Lamellidens corrianus** (Lea, 1834)
(Figs. 386, 387)

Unio corrianus Lea, 1834, *Trans. Amer. Philos. Soc.*, 6 (2): 65, pl. 9, fig. 25. Type locality: India.

Lamellidens corrianus: Simpson, 1900, *Proc. U. S. natn. Mus.*, **22**: 857. Prashad, 1921, *Rec. Indian Mus.*, **22**: 609, fig. 29c.

Types: USNM

Distribution: Common throughout India, Bangladesh and Burma.

Remarks: Shell narrow and elongate elliptical, umbones slightly inflated, periostracum smooth and dark brown, dorsal margin almost straight and long, two cardinals in each valve.

Closely resembles *L. marginalis* but differs from it in being more transverse, umbones more turned up and the absence of light border on the ventral margin.

Narain (1975) made observations on shell. Nagabhushanam and Lohgaonkar (1978) studied its biology.

Lamellidens narainporensis Preston, 1912 (Figs. 402, 403) and *Lamellidens nongyangensis* Preston, 1912 (Figs. 400, 401) and *L. mainwaringi* Preston, 1912 may be treated as synonyms of this species.

"Lea's original type is a young form of one of the varieties of *marginalis* approaching *U. anodontina* of Lamarck" (Blanford, 1866, p. 140).

176. **Lamellidens generosus** (Gould, 1847)
(Figs. 388, 389)

Unio generosus Gould, 1847, *Proc. Boston Soc. nat. Hist.*, **2**: 220, Type locality: Tavoy, Burma.

Lamellidens generosus: Prashad, 1922, *Rec. Indian Mus.*, **24**: 107, pl. ii, figs. 12—17.

Types: USNM

Distribution: Burma.

Remarks: Shell solid, oblong-ovate, anteriorly rounded, posteriorly oblique, subrostrate, dorsal margin straight, ventral margin arcuate, posterior wing narrow in adults.

Prashad (1922) gave a complete synonymy.

177. **Lamellidens indawgyiensis** Prashad, 1930
(Figs. 408, 409)

Lamellidens indawgyiensis Prashad, 1930, *Rec. Indian Mus.*, **32**: 253, pl. viii, figs. 9, 10. Type locality: Indawgyi Lake, Burma.

Types: ZSI Regd. No. M 13024/2 (Holotype), M 13025/2 (Paratype).

Distribution: Burma.

Remarks: Shell large (more than 100 mm), elongate-ovate, rather thick, moderately inflated, surface with low, concentric ridges, umbones anterior, not prominent, dorsal margin almost straight, ventral margin somewhat arched, anterior end short and broad, posterior end rostrate, with well-marked post-dorsal wing.

178. **Lamellidens jenkinsianus** (Benson, 1862).
(Figs. 390, 391)

Unio jenkinsianus Benson, 1862, *Ann. Mag. Nat. Hist.*, (3) **10**: 185. Type locality: "Berhampooter river, Assam."

Lamellidens jenkinsianus: Prashad, 1920, *Rec. Indian Mus.*, **19**: 172. Pl. IX, figs. 3, 4.

Types: BMNH?

Distribution: Upper Brahmaputra (Tezpur), Assam; Bangladesh, Dacca,

Remarks: Shell transversely elongated, thick, tumid, anterior end short and rounded, posterior side sloping, right valve with two cardinals, lower long, thick and heavily built and very ragged, upper one usually thin, a single blade like lateral, left valve with a small pad-like tooth from the inner margin of the umbo, two lamellar teeth.

Prashad (1920) gave synonymy and added to the earlier description.

179. **Lamellidens jenkinsianus** sub. sp. **daccaensis** (Preston, 1912). (Figs. 394-397)

Parreysia daccaensis Preston, 1912, *Rec. Indian Mus.*, **7**: 300. Type locality: Dacca.

Lamellidens jenkinsianus sub. sp. *daccaensis:* Prashad, 1920, *Rec. Indian Mus.*, **19**: 173, pl. IX, figs. 5—8.

Types: ZSI Regd. No. M 6105/1

Distribution: India: Bhagalpur (Bihar); Assam; Bangladesh: Dacca, Mirpur, Nababgang (Jessore Dist.) and Sylhet.

Remarks: Shell much shorter, broader, more convex, much more swollen, umbones more distinct and convex, dorsal margin more arched than in the typical form.

180. **Lamellidens jenkinsianus** sub. sp. **obesa** (Hanley & Theobald, 1877) (Figs. 392, 393)

Unio marginalis var. *obesa* Hanley and Theobald, 1877, *Conch. Indica.* p. 20, pl. XIII fig. 3. Type locality: Irrawaddy river, Burma.

Lamellidens jenkinsianus sub. sp. *obesa:* Prashad, 1920, *Rec. Indian Mus.*, **19**: 170, pl. IX, figs. 1. 2.

Distribution: Assam; Bangladesh; Burma.

Remarks: Shell elongate, thick, convex, greatly inflated, posteriorly spatulate, anterior margin broad, regularly curved, posterior margin narrow, round, posterior ridge straight or slightly curved with a narrow post dorsal wing.

181. **Lamellidens lamellatus** (Lea, 1838) (Figs. 398, 399 & 410, 411)

Unio lamellatus Lea, 1838, *Trans. Amer. Phil. Soc.*, **6**: 19, pl. vi, fig. 16. Type locality: Bengal.

Lamellidens lamellatus: Prashad, 1922, *Rec. Indian Mus.*, **24**: 108.

Types: ANSP

Distribution: Burma.

Remarks: Shell in general as in *L. scutum* but differs from it in being less elongate and in having low umbones and more prominent "wing"

182. **Lamellidens marginalis** (Lamarck, 1819)
(Figs. 404, 405)

Unio marginalis Lamarck, 1819, *Hist. Nat. Anim. Sans. vert.*, **4**: 79. Type locality: Bengal.

Lamellidens marginalis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 854. Prashad, 1921, *Rec. Indian Mus.*, **22**: 606, fig. 29A.

Distribution: Widely distributed in India; Bangladesh; Burma; Sri Lanka.

Remarks: Shell oblong-ovate, thin, very smooth, periostracum blackish-brown and shining, light brown border along the ventral margin, posterior side broad, roundedly angular, produced, wing very narrow, dorsal margin a little curved, anterior side short and narrow, ventral margin slightly contracted in the middle, hinge with two cardinals in the right valve, lower better developed, a single lateral and trace of a second one, left valve with one feebly developed cardinal, two curved lateral teeth.

Preston (1915) dealt about 12 varieties of this species; two of them are now treated as distinct species and the rest of them may be simple variations and are not worth of any recognition.

183. **Lamellidens phenchooganjensis** Preston, 1912.
(Figs. 406, 407)

Lamellidens phenchooganjensis Preston, 1912, *Rec. Indian Mus.*, **7**: 306. Type locality: Phenchooganj, Central Sylhet (Bangladesh)

Type: ZSI Regd. No. M 4368/1 (Holotype)

Distribution: Bangladesh.

Remarks: Shell elongately ovate, dark blackish-brown, umbones flat, anterior side angled above, gently rounded below, posterior margin obtusely rounded, antero-dorsal margin gently sloping, postero-dorsal margin more rapidly sloping in a slight curve.

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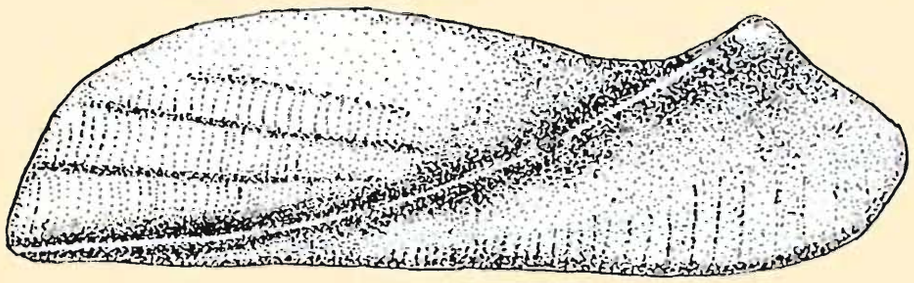

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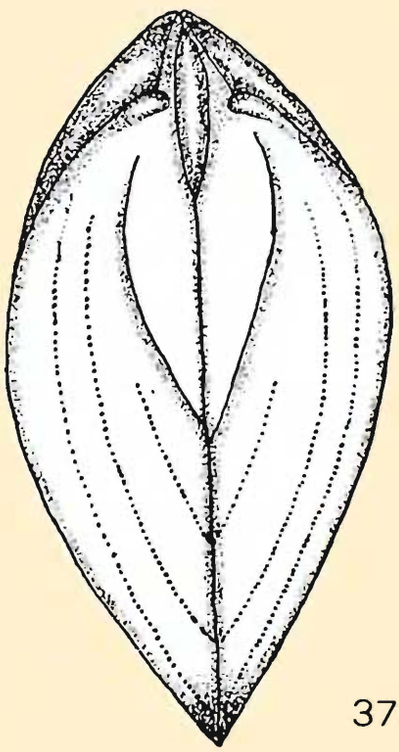

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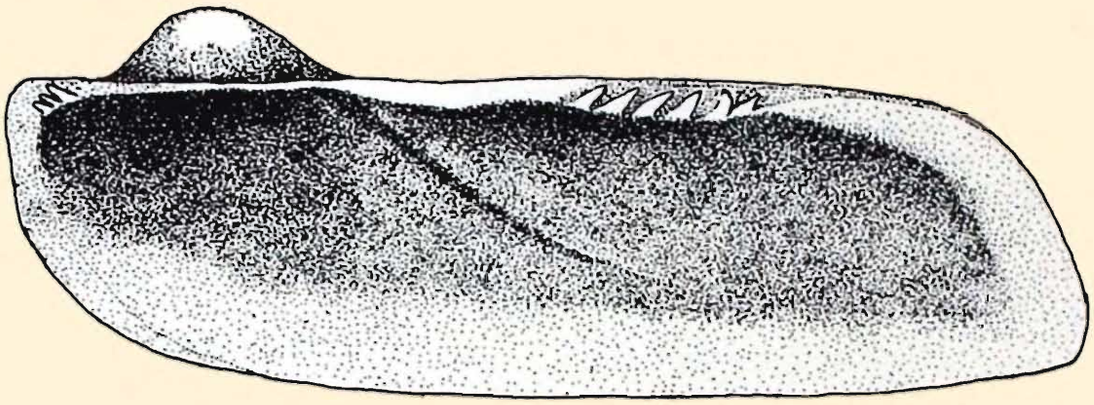
Figs. 371-373. *Scaphula celox*, 9.83 × 5.18 mm., Orissa.



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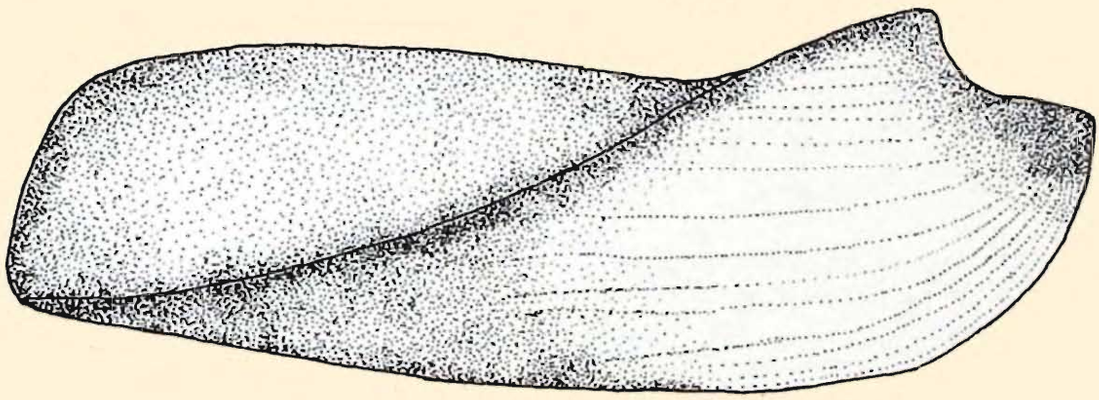

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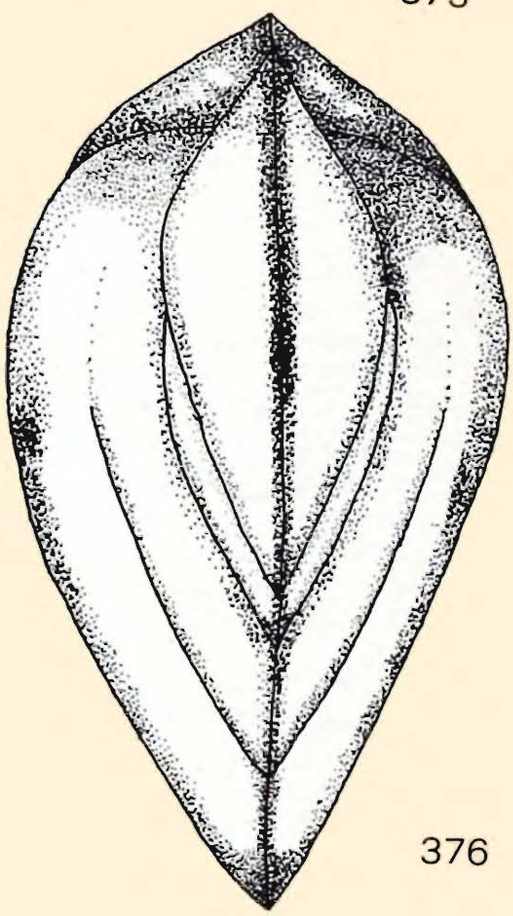

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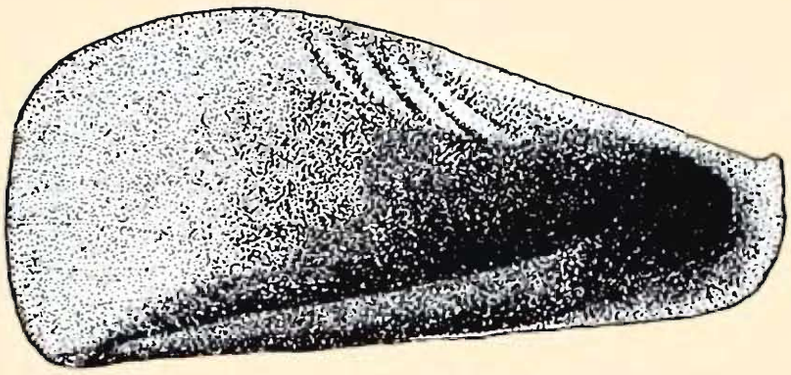
374-376. *S. deltae*, 8.30 × 3.11 mm., Ballygunge, Calcutta.



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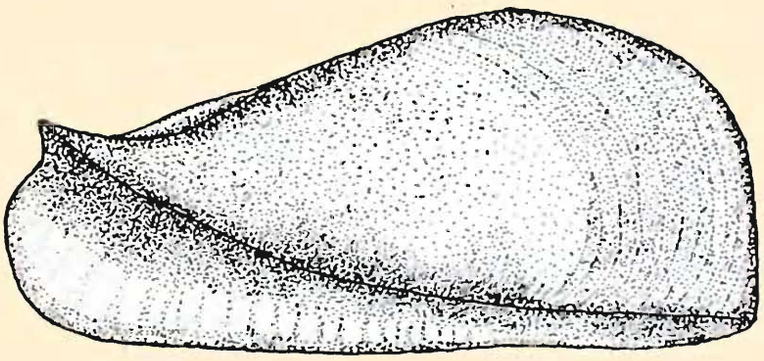

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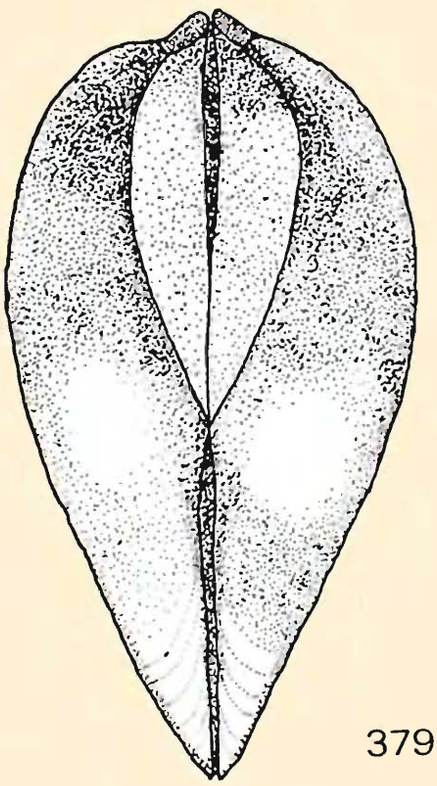

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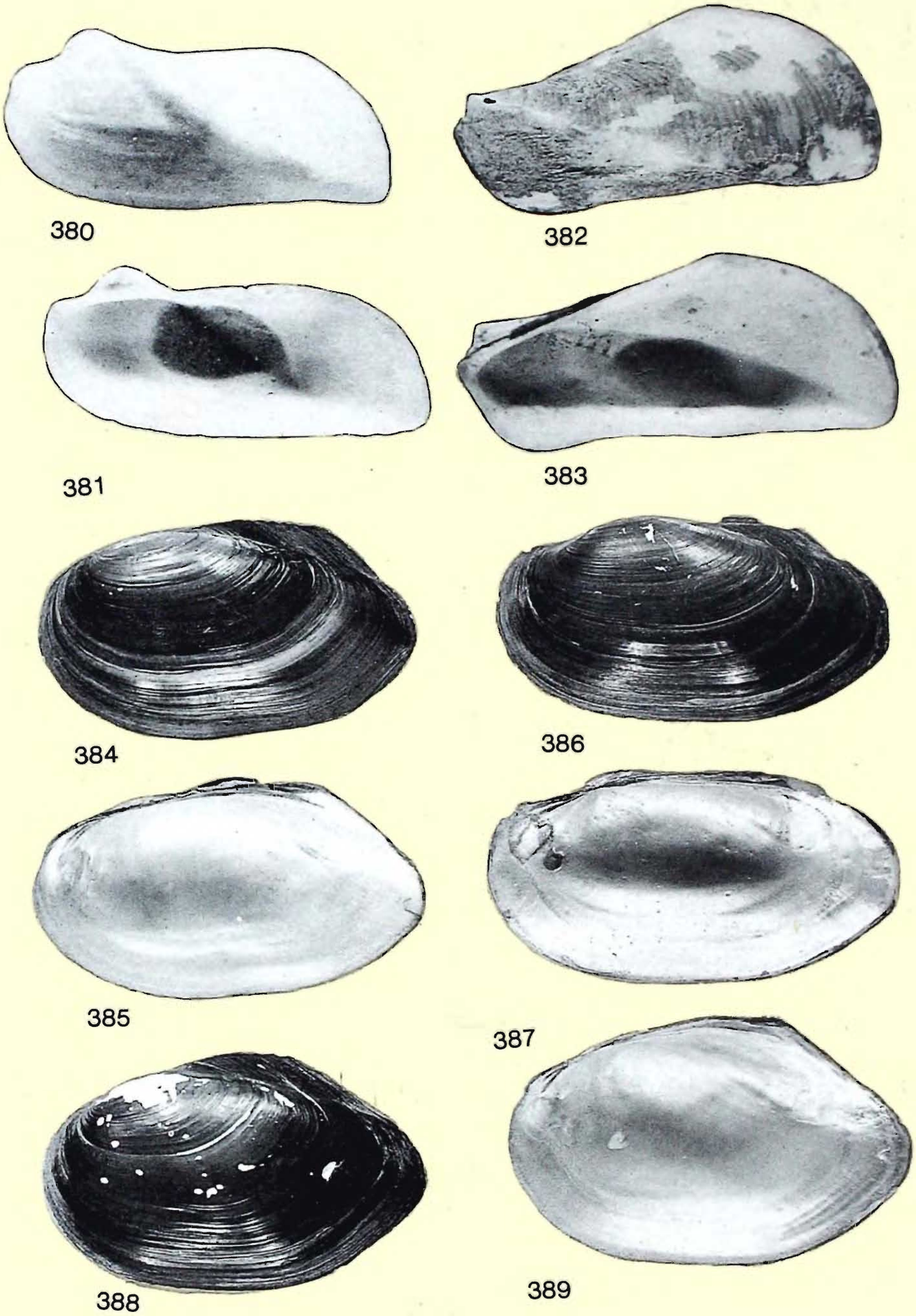
377-379. *S. pinna*, 9.60 × 4.20 mm., Burma.



Figs. 380, 381. *S. celox* 382, 383. *S. pinna* 384, 385. *Lamellidens consobrinus*, 96.65 × 53 mm., Pune, Maharashtra. 386, 387. *L. corrianus*, 95.70 × 48.35 mm., Bihar. 388, 389. *L. generosus*, 101.90 × 61.70 mm., Burma.

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Figs. 390, 391. *Lamellidens jenkinsianus*, 115.65 × 55.45 mm., Tezpur, Assam. 392, 393. *L. jenkinsianus obesus*, 117.70 × 67.75 mm., Burma. 394, 395. *L. daccaensis*, Type 396, 397. *L. jenkinsianus daccaensis*, Holotype, 76.60 × 47.35 mm., Dacca, Bangladesh. 398, 399. *L. lamellatus*, 87.50 × 58.95 mm., Burma.

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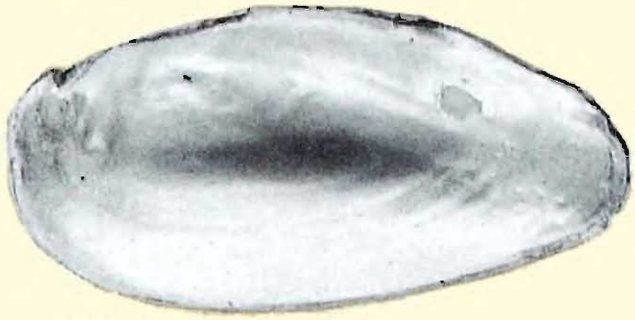

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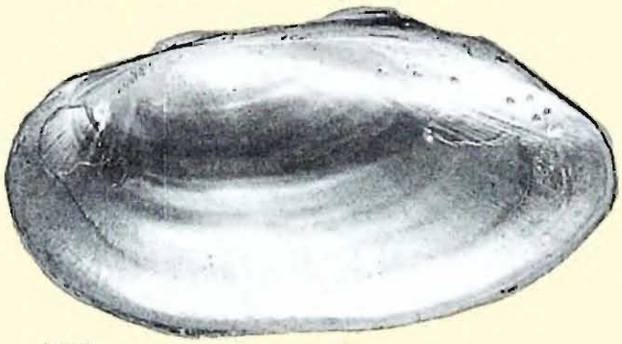

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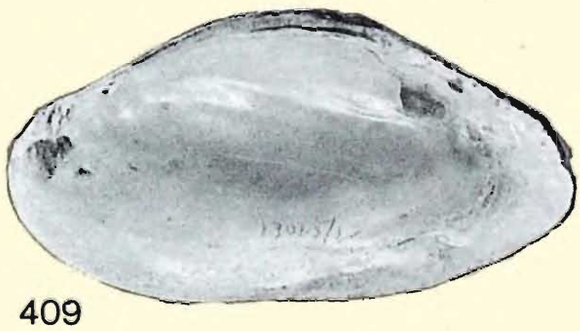

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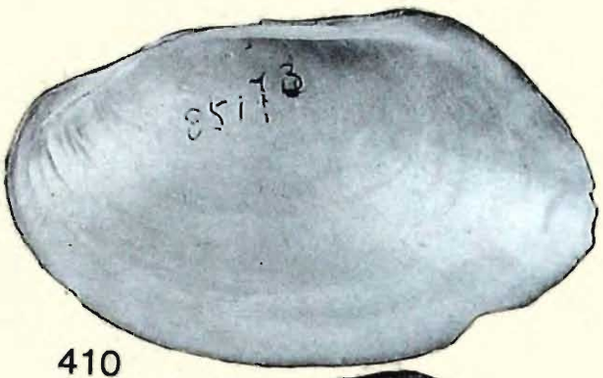
Figs. 400, 401. *Lamellidens narainporensis*, Holotype, 79.20 × 34.70 mm., Narainpur, Murshidabad. 402, 403. *L.nongyengensis*,Holotype, 93.25 × 46.70 mm., Nongyang L., S. of Patkai. 404, 405. *L. marginalis*, 67.70 × 36.85 mm., Andhra Pradesh. 406, 407. *L. phenchooganjensis*, Holotype, 88.20 × 43.35 mm., Phenchuganje, Sylhet. 408, 409. *L. indawgyensis*, Holotype, 107.25 × 57.30 mm., Indawgy L., Burma.



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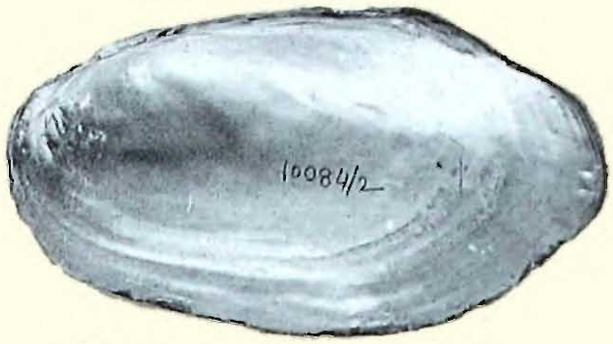

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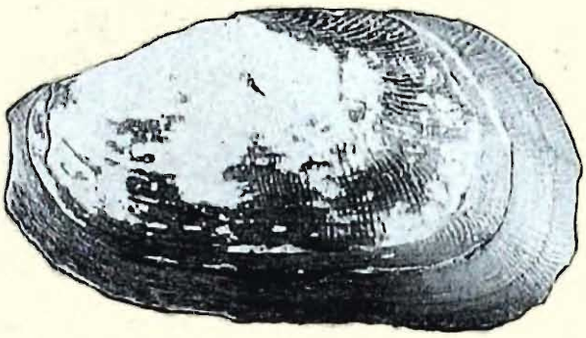

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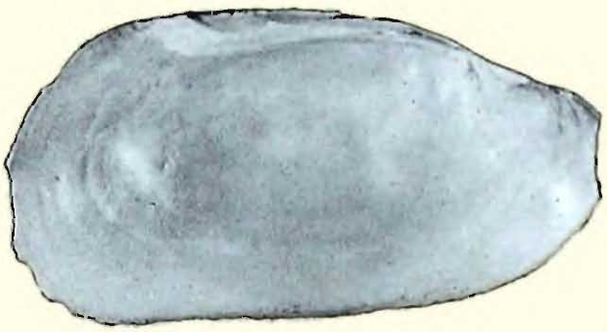

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410, 411. *Lamellidens lamellatus.* Type, Ganges R., India. 65.5 × 38 mm. 412, 413. *Lamellidens scutum.*, 88.4 × 49.1 mm., Rangoon. 414, 415. *Arcidopsis footei*, Neotype, 43.80 × 23.40 mm., Satara, Maharashtra. 416, 417. *Physunio velaris*, 33.65 × 29.35 mm., Assam.

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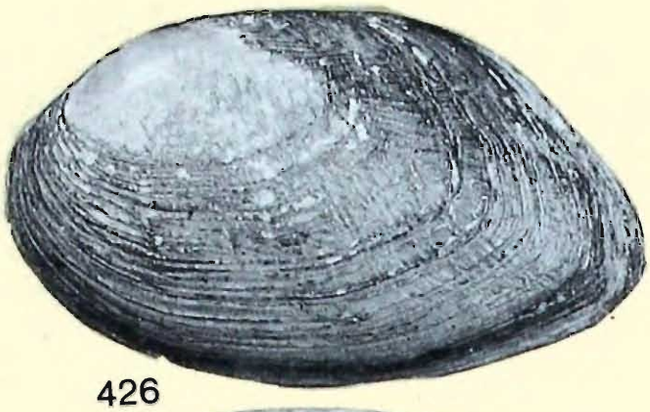
Figs. 418, 419. *Pseudodon (Trigonodon) crebristriatus*,68.15 × 42.10 mm., Burma. 420, 421. *Physunio micropteroides*, 62.23 × 39.90 mm., Cambodia. 422, 423. *Pseudodon (Trigonodon) peguensis* 55.5 × 39.05 mm., Burma. 424, 425. *Pseudodon (Pseudodon) inoscularis*, 43.28 × 28.90 mm., Burma.



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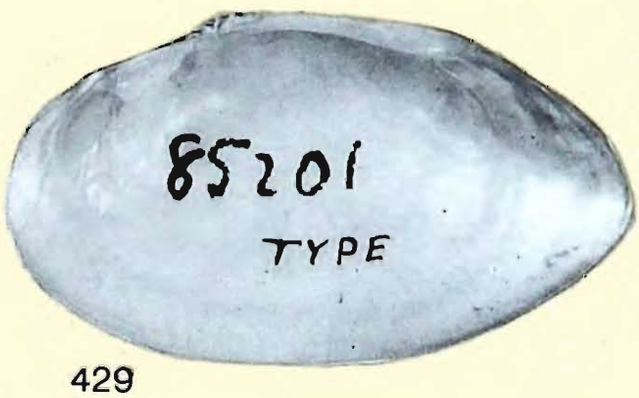

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Figs. 426, 427. *U. occata*, Type, 35 × 21 mm., Bengal, India. 428, 429. *U. nuttaliana* Type, 34.6 × 20 mm., India. 430, 431. *Monocondylea inoscularis*, Type, 64.2 × 41.3 mm., River Salween, Tavoy. 432, 433. *Unio foliaceus* Type, 42.7 × 24.0 mm., Tavoy, Burma.

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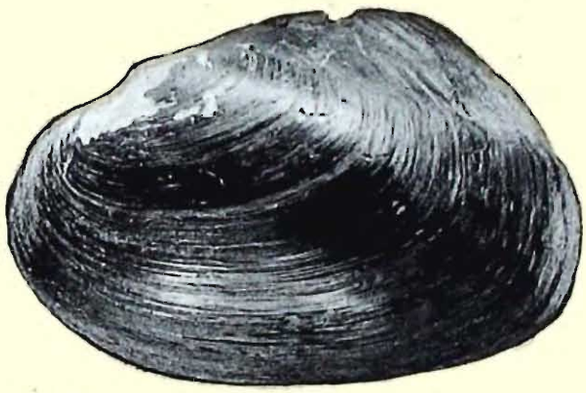

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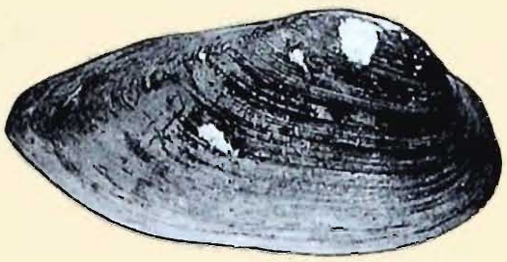
Figs. 434, 435. *Pseudodon salwenianus*, 67.95 × 46.50 mm., Burma. 436, 437. *Pseudodon ava* 87.80 × 54.15 mm., Burma. 438, 439. *Acostaea dalyi*, 45.90 × 43.40 mm., Koyna Valley, Satara. 440, 441. *Pseudodon vondembuchsiana*,70.10 × 43.15 mm., Philippines.



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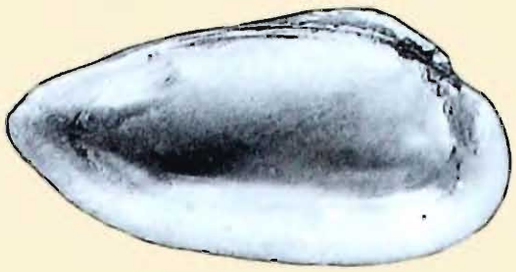

441b

Figs. 441a, 441B. *Oxynaia pugio*, 23.79 × 14.25 mm., Assam.

184. **Lamellidens scutum** (Sowerby, 1868)
(Figs. 412, 413)

Unio scutum Sowerby, 1868, in Reeve's *Conch. Icon.*, **16**: Unio pl. xciv. fig. 510. Type locality: Tenasserim.

Lamellidens marginalis vars. *zonata* (p. 177), *sublamellata* (p. 181), subsp. *scutum*, var. *humilior* (p. 181) Preston, 1915, *Fauna Brit. India.* Mollusca (Freshwater Gastropoda and Pelecypoda) pp. 177, 181, figs. 1-3.

Lamellidens scutum: Prashad, 1922, *Rec. Indian Mus.*, **24**: 108.

Types: Unio scutum in BM (NH). *Lamellidens marginalis* var. *sublamellata* Preston is in ZSI Regd. No. M 4711.

Distribution: Burma.

Remarks: Shell elongate, oblong, thick, rather indented in the middle, very inequilateral, uniformaly pitch colour, smooth, umbones slightly projecting, anterior end narrow, posterior end broadly rostrate, two carinae on each valve extending from the umbones in a posterodorsal direction, dorsal margin curved, ventral margin scarcely rounded anteriorly but more curved posteriorly.

Genus 39. **Arcidopsis** Simpson, 1900

Arcidopsis Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 861

Type species: *Unio foatei* Theobald, 1976, OD

Shell elongate with almost straight dorsal and ventral margins, posterior slope ill defined; periostracum black, surface with fine concentric and radial ridges; cardinals strong, short, supported by riblike fulcrum; lamellar teeth short, muscle scar well impressed, pallial line distinct.

India. Monotypic

185. **Arcidopsis footei** (Theobald, 1876)
(Figs. 414, 415)

Unio footei Theobald, 1876, *J. Asiat. Soc. Beng.*, **45**: 187, pl. 14, figs. 9, 9a. Type locality: Gutparba falls, Krishna river.

Arcidopsis footei: Preston, 1915, *Fauna of British India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 196.

Types: Prashad (1920) raised doubts as to the existence of types and hence created neotypes (Reg. Nos. M 7673/1, M 7675/1) which are present in Zoological Survey of India. The specimen bearing No. M 7676/1 is however, not traceable now.

The neotypes were collected by Dr. F. H. Gravely in April, 1912 at Taloshi in the Koyna Valley, Satara district, Maharashtra at an altitude of about 2.000 ft.

Distribution: River system of Western Ghats.

Remarks: Shell elongate, a strong ridge running back and down from the beaks, ventrally strongly compressed in the anterior region.

Prashad (1920) commented on the relationships and type-locality of the species and added to the previous descriptions. However, no soft parts were studied as the collection included shells only.

Genus 40. **Oxynaia** Haas, 1913

Type species: *Unio jourdyi* Morelet, 1886 OD

Shell elongate, rounded anteriorly and pointed posteriorly, posterior slope low, umbones prominent, with zigzag ridges on oldest part, cardinals stout, laterals slender.

South-east Asia.

186. **Oxynaia pugio** (Benson, 1862)
(Figs. 441A, 441B)

Unio pugio Benson, 1862, *Ann. Mag. Nat. Hist.,* (3) **10:** 193. Type locality: "in region Ava."

Oxynaia pugio: Prashad, 1922, *Rec. Indian Mus.,* **24:** 96.

Types: ?

Distribution: Burma: Tenasserim, Pegu, Sawaddy River, Maydong.

Remarks: Very short anterior and posterior margins, strongly marked and angled posterior ridge running to the cuneate posterior margin, right valve with two cardinals, a thin, lamellar anterior one and a thickened, triangulate and more or less canine shaped posterior one, left valve also with two cardinals, a small anterior separated by a deep cavity from the elongate posterior one.

Family 15. AMBLEMIDAE Rafinesque, 1820

Shell of medium size, generally thick, tooth shaped or lamelliform pseudocardinals, posterior laterals, muscle scars as seen in Unionidae.

Differs from Unionidae mainly in the soft part anatomy, all four demibranchs marsupial, gills with continuous interlamellar septa and water tubes. Glochidia hookless, relatively long parasitic life.

Cosmopolitan distribution

The Indian species fall under three subfamilies viz. Ambleminae, Parreysiinae, and Rectidentinae. Hitherto all these were grouped in the family Unionidae.

Subfamily AMBLEMINAE s.str.

Shell broadly oval, with a short wing, gills with well developed and continuous septa and water tubes. Short term breeders retaining glochidia for a short while i.e. tachytictic.

Two genera viz. *Pseudodon* and *Solenaia* are known from India and adjacent countries. The two genera can be easily distinguished from each other by the shell shape. In *Pseudodon* the shell is elliptical with a wing but in *Solenaia* it is soleniform and elongate.

Genus 41. **Pseudodon** Gould, 1844

Pseudodon, Gould, 1844, *Proc. Boston. Soc. Nat. Hist.*, 1: 161.

Type species: *Anodon inoscularis* Gould, 1844 OD.

Ovate to elliptical, moderately inflated, very inequilateral, ornamented with W-shaped wrinkles, posterior slope high, well defined, with a compressed "wing" ornamented in some, periostracum dark brown or black;

single, blunt, mostly blade-shaped cardinal in each valve, umbones little projecting and little inflated, umbonal cavities shallow.

East Asia and South-east Asia.

Three subgenera viz. *Pseudodon, Indopseudodon* and *Trigonodon* from India and adjacent countries.

Subgenus **Pseudodon** s. str.

Elliptical, thick, ventricose, with distinct posterior slope, which may be alate and crossed with wrinkles, cardinals heavy and rounded above.

China and South east Asia.

187. **Pseudodon (Pseudodon) inoscularis** (Gould, 1844)
(Figs. 424, 425 & 430, 431)

Anodon inoscularis Gould, 1844, *Proc. Bost. Soc. nat. Hist.*, **1**: 160. Type locality: Salween river, Burma. Hanley and Theobald, 1876, *Conch. Indica*, p. 5, pl. 9, fig. 2.

Pseudodon (Pseudodon) inoscularis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 837. Preston, 1915, *Fauna Brit. India.* Mollusca (Freshwater Gastropoda and Pelecypoda) p. 152.

Types: USNM

Distribution: Burma: Salween river, Tenasserim

Remarks: Shell transversely oblong, thick, anterior side short and round, posterior side truncate, ventral margin arcuate.

Prashad (1922) made a few remarks on the status of this species and treated it as a variety of *P. vondembuschiana.* (Figs. 440, 441).

Subgenus **Trigonodon** Conrad, 1865

Type species: *Monocondylaea crebristriata* Anthony, 1863 OD.

Shell rhomboid, solid, compressed, surface irregularly and concentrically wrinkled, cardinals heavy, triangular, auxiliary tooth in each valve.

Burma, Inodnesia.

Two species, differentiated mainly by the shape. Both the species may be varieties of one and the same species. In such a case *P.* (*T.*) *peguensis* should have the priority (Prashad, 1922).

188. **Pseudodon (Trigonodon) crebristriatus** (Anthony, 1865) (Figs. 418, 419)

Monocondylaea crebristriata Anthony, 1865, *Amer. J. Conch.*, **1**: 205, pl. 18. fig. 1. Type locality: Pegu.

Pseudodon (*Trigonodon*) *peguensis* var. *crebristriatus:* Preston, 1915. *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 150.

Trigonodon peguensis var. *crebristriatus:* Prashad, 1922, *Rec. Indian Mus.*, **24**: 98.

Types: MCZ (Holotype), ANSP (Paratype).

Distribution: Burma: Pegu.

Remarks: Shell elongately rhomboid, more compressed with more strongly marked sculpture, umbones a little more inflated than in *P. peguensis.*

189. **Pseudodon (Trigonodon) peguensis** (Anthony, 1865) (Figs. 422, 423)

Monocondylaea peguensis Anthony, 1865, *Amer. J. Conch.* **1**: 205, pl.18, fig. 2. Type locality: Pegu.

Pseudodon (*Trigonodon*) *peguensis* and var. *curvata:* Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 150.

Trigonodon peguensis: Prashad, 1922, *Rec. Indian Mus.*, **24**: 98.

Types: MCZ (Holotype), ANSP (Paratype).

Distribution: Burma: Pegu.

Remarks: Shell thick, less elongated, smooth, posterior side subtruncate and corrugated.

Subgenus **Indopseudodon** Prashad, 1922

Type species: *Anodon salwenianus* Gould, 1844

Shell elongate-rhomboid, comparatively high, thick, inflated, anterior end short and low, posterior long and high with distinct posterior slope, left valve with one cardinal, right with two.

Burma.

190. **Pseudodon (Indopseudodon) ava** (Thoebald, 1873)
(Figs. 436, 437)

Monocondylaea avae Theobald, 1873, *J. Asiat. Soc. Beng.*, **42** (2): 209, pl. xvii, fig. 15. Type-locality: Ava, Burma.

Pseudodon (Bineureus) ava: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 153.

Indopseudodon ava: Prashad, 1922, *Rec. Indian Mus.*, **24**: 99.

Type: BM (NH).

Distribution: Burma: Mandalay.

Remarks: Shell more elongate, surface smooth, posterior end more pointed and without any plications.

191. **Pseudodon (Indopseudodon) salwenianus** (Gould, 1844)
(Figs. 434, 435)

Anodon salwenianus Gould, 1844, *Proc. Boston, Soc. nat. Hist.*, **1**: 160. Type locality: Salween River.

Pseudodon salwenianus: Preston, 1915, *Fauna Brit. India,* Mollusca, (Freshwater Gastropoda & Pelecypoda), p. 152.

Indopseudodon salwenianus: Prashad, 1922, *Rec. Indian Mus.*, **24**: 99.

Types: USNM.

Distribution: Burma: Tenasserim river.

Remarks: Shell of considerable length, posterior wing with strong plicate sculpture, posterior end broad.

Genus 42. **Solenaia** Conrad, 1868

Solenaia Conrad, 1868, *Am. J. Conch.* **4**: 246. Type species: *Mycetopus emarginatus* by O.D.

Balwantia Prashad, 1919, *Rec. Indian Mus.*, **16**: 290, text fig. 1. Type species: *Anodon soleniformis* Benson, O.D. Monotypy.

Shell elongate and soleniform, thin, anterior end narrow and gaping, posterior margin broad with low slope, umbones not prominent, hinge line narrow, teethless, only vestigial laterals, foot large, anterior end swollen in the form of a bowl.

The genus includes three species viz: *Solenaia soleniformis* (Benson) from India, *Solenaia emarginata* (Lea) from Thailand and *Solenaia irideneus* (Heude) from China. Because of their shell similarities all the three species are included together in the same genus (Heard, 1976). Only the Indian species is known by its anatomy and larval forms.

192. **Solenaia soleniformis** (Benson, 1836)
(Figs. 442, 443)

Anodon soleniformis Benson, 1836, *J. Asiat. Soc. Beng.*, **5**: 750. Type locality: Assam.

Solenaia soleniformis Simpson, 1900, *Proc. U. S. natn. Mus.*, **22**: 656. Preston, 1915. *Fauna Brit. India* Mollusca (Freshwater Gastropoda and Pelecypoda) p. 132.

Balwantia soleniformis: Prashad, 1919, *Rec. Indian Mus.*, **16**: 290, text fig. 1.

Distribution: Eastern India (Assam), Daleswari, in Barak river, Cachar.

Remarks: Shell valves strongly compressed, margins very sharp.

Ghosh (1918) studied the anatomy, Godwin-Austen (1919) and Annandale (1919) added notes on the burrows and habits of animals. Prashad (1919) added more information on its anatomy and Hora (1916) made interesting observations on its distribution and burrowing habits.

Subfamily PARREYSIINAE

Shell oval or rhomboidal, medium or small sized; umbones sculptured with 'U' or W shaped lines giving a corrugated appearance, marsupia in all four gills.

South, East and South-east Asia.

The Indian and burmese species may be grouped under two genera viz. *Parreysia* and *Scabies*.

Genus 43. **Parreysia** Conrad, 1853.

Parreysia Conrad, 1853, *Proc. Acad. nat. Sci. Philad.*, **6**: 267.

Type species: *Unio multidentatus* Philippi, 1847 OD.

Shell heavy and inflated, rounded to subrhomboidal, with distinct radial zigag ribs on beaks, periostracum smooth; cardinals heavy, ragged or vertically striate, lamellar teeth short, cavity of beaks somewhat deep. All four gills marsupial, supra anal opening rather widely separated from the anal, the inner lamina of the inner gill entirely connected with the abdominal sac.

Ortmann (1910) distinguishes this genus from others and opines that it is somewhat similar to North American genus *Quadrula*. Preston (1915) lists 20 species and varieties of *Parreysia*. So far no attempt has been made to make a systematic revision of the genus. However, biochemical, and biological studies are conducted on a few common species.

India, Burma and other South-east Asian Countries and Africa.

Two distinct subgenera viz *Parreysia* and *Radiatula*

Key to subgenera

Shell with centre of ventral margin swollen, thick, strong beak sculpture ..... **Parreysia**

Shell with almost straight ventral margin, comparatively thin, beak sculpture not strong, surface covered with radiating or zigzag shaped or divaricate ridges ..... **Radiatula**

Subgenus **Parreysia** s. str.

193. **Parreysia (Parreysia) annandalei** Preston, 1912. (Figs. 444, 445)

Parreysia annandalei Preston, 1912, *Rec. Indian Mus.*, **7**: 302, Type locality: Gowhatty;

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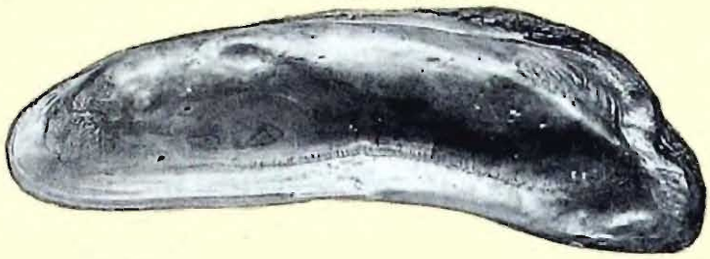

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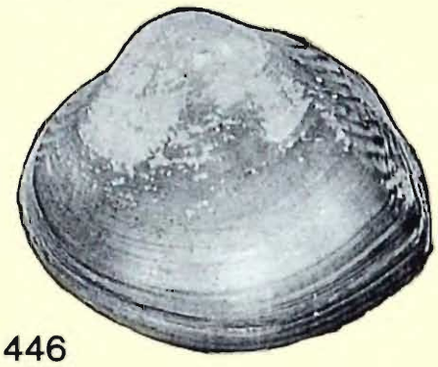

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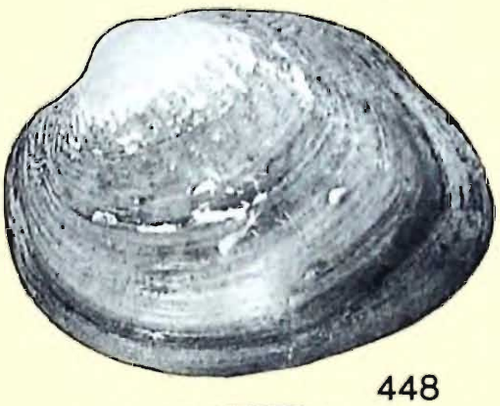

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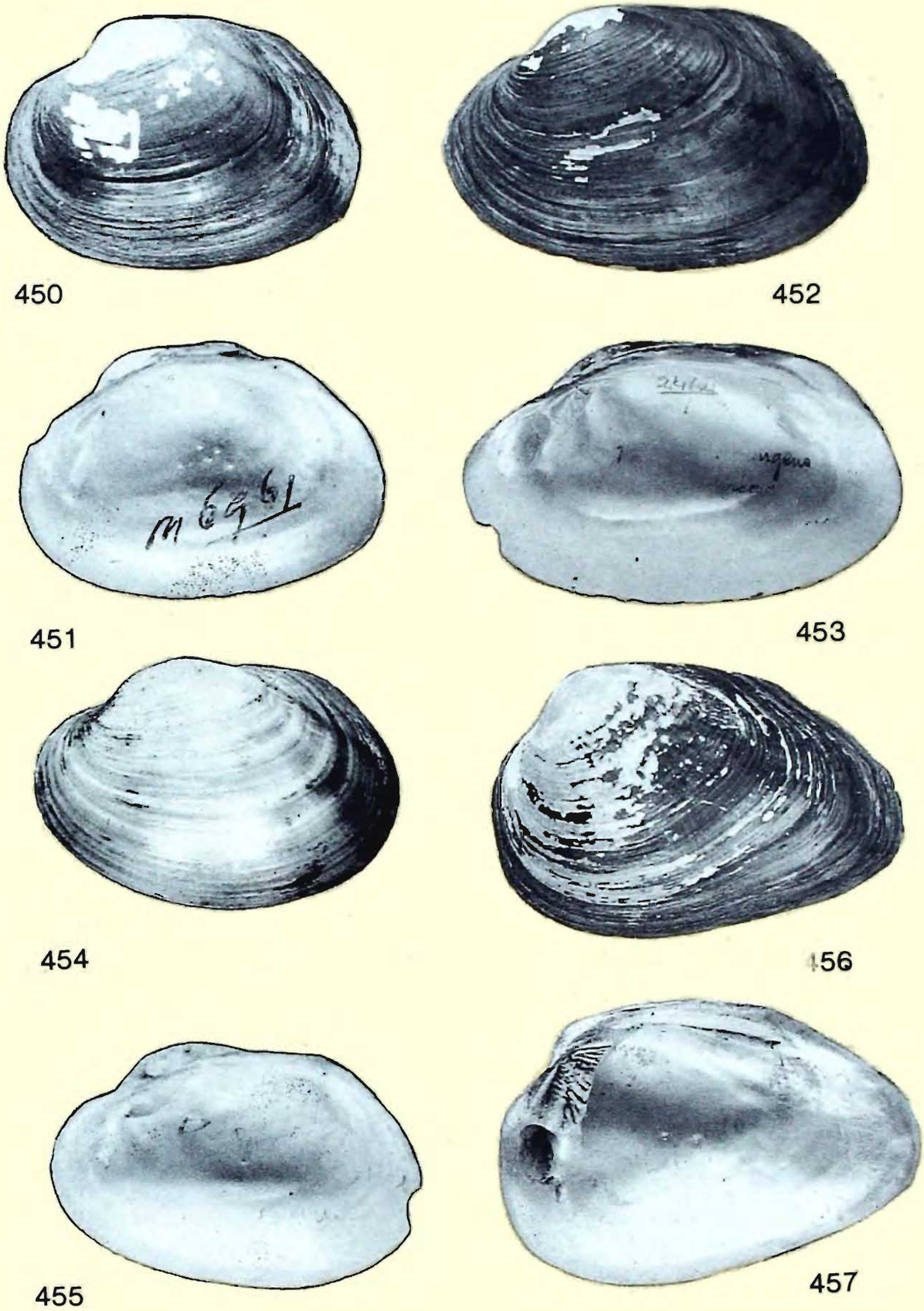
Figs. 442, 443. *Solenaia soleniformes*, 143.70 × 46.0 mm. Assam. 444, 445. *Parreysia annandalei*, Holotype, 41.0 × 29.0 mm., Gauhati, Assam. 446, 447. *P. bhamoensis*, 36.20 × 29.95 mm., Pegu, Burma. 448, 449. *P. corrugata*, 35.55 × 21.10 mm., Orissa.



Figs. 450, 451. *Parreysia corrugata nagpoorensis*, 29.30 × 21.50 mm., Orissa. 452, 453. *P. corrugata laevirostris*, 70.65 × 43.80 mm., Chittagong, Bangladesh. 454, 455. *P. corbis*, 23.35 × 15.45 mm., Assam. 456, 457. *P. favidens pinax*, 46.80 × 28.60 mm., Bihar.

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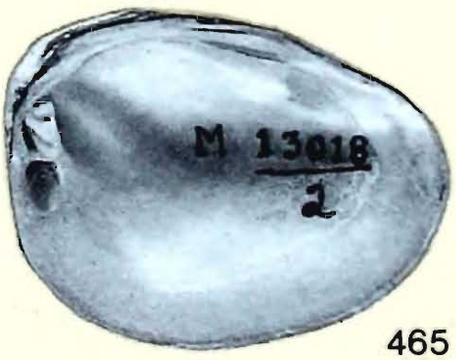

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Figs. 458, 459. *Parreysia burmanus myitkyina*, Paratype, 33.80 × 23.30 mm., U. Burma. 460, 461. *P. cylindrica*, Paratype, 43.65 × 25.25 mm., Maharashtra. 462, 463. *P. burmanus*, 45.65 × 31.0 mm., Bhamo. 464, 465. *P. choprae*, Holotype, 39.65 × 30.55 mm., U. Burma.

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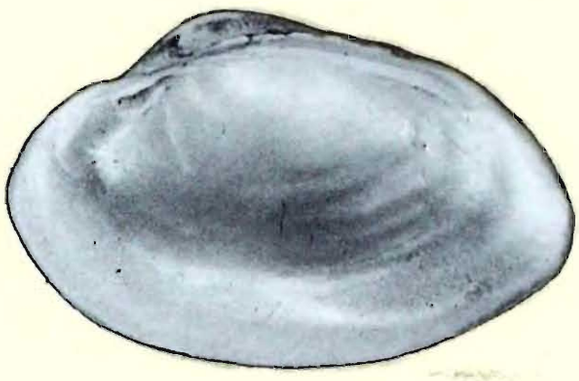

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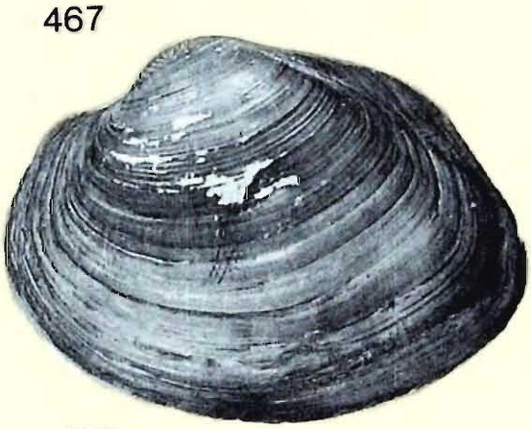

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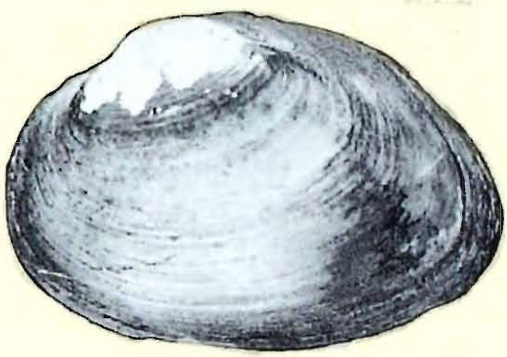

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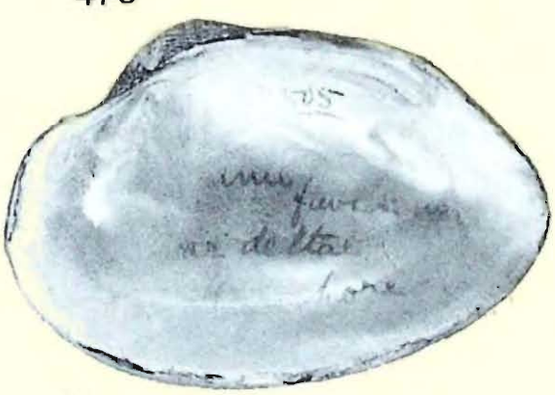

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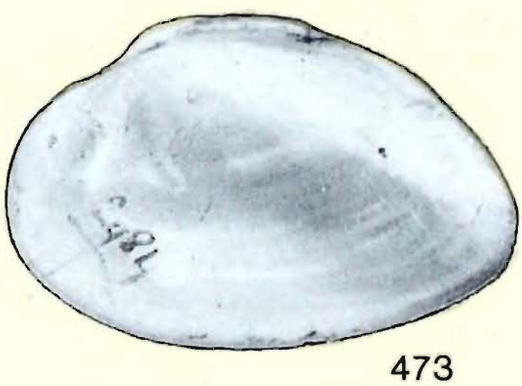

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Figs. 466, 467. *Parreysia favidens*, 47.70 × 34.30 mm., Assam. 468, 469. *P. favidens assamensis*, Paratype, 56.55 × 38.50 mm., Assam. 470, 471. *P. favidens deltae*, 61.40 × 43.55 mm., Uttar Pradesh. 472, 473. *P. favidens plagiosoma*, 38.15 × 26.60 mm., W. Bengal.

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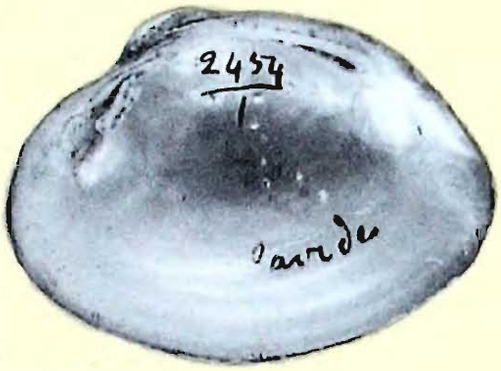

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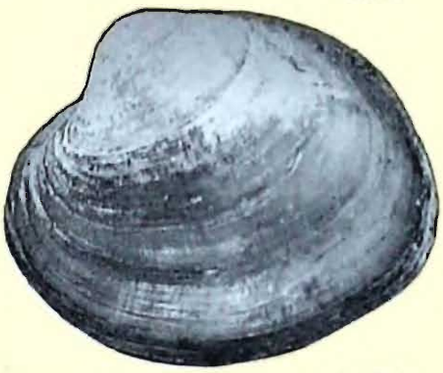

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Figs. 474, 475. *Parreysia favidens viridula*, 39.90 × 28.65 mm., Bihar. 476, 477. *P. feddeni*, 32.40 × 24.50 mm., Bhamo, Burma. 478, 479. *P. houngdaranicus*, 45.90 × 34.60 mm., Tenasserim, Burma. 480, 481. *P. feae*, Cotype, 42.90 × 34.90 mm. Tenasserim, Burma.

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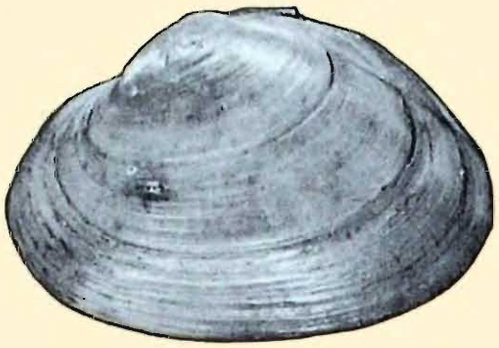
Figs. 482, 483. *Parreysia wynegungaensis*, Type, USNM No. 85328, Wynegunga R., Deccan. 484, 485. *P. favidens*, 40.15 × 34.30 mm., Assam. 486, 487. *P. rugosa*, 50.35 × 32.50 mm., Karnataka. 488, 489. *P. sikkimensis*, 31.15 × 22.80 mm., Assam.



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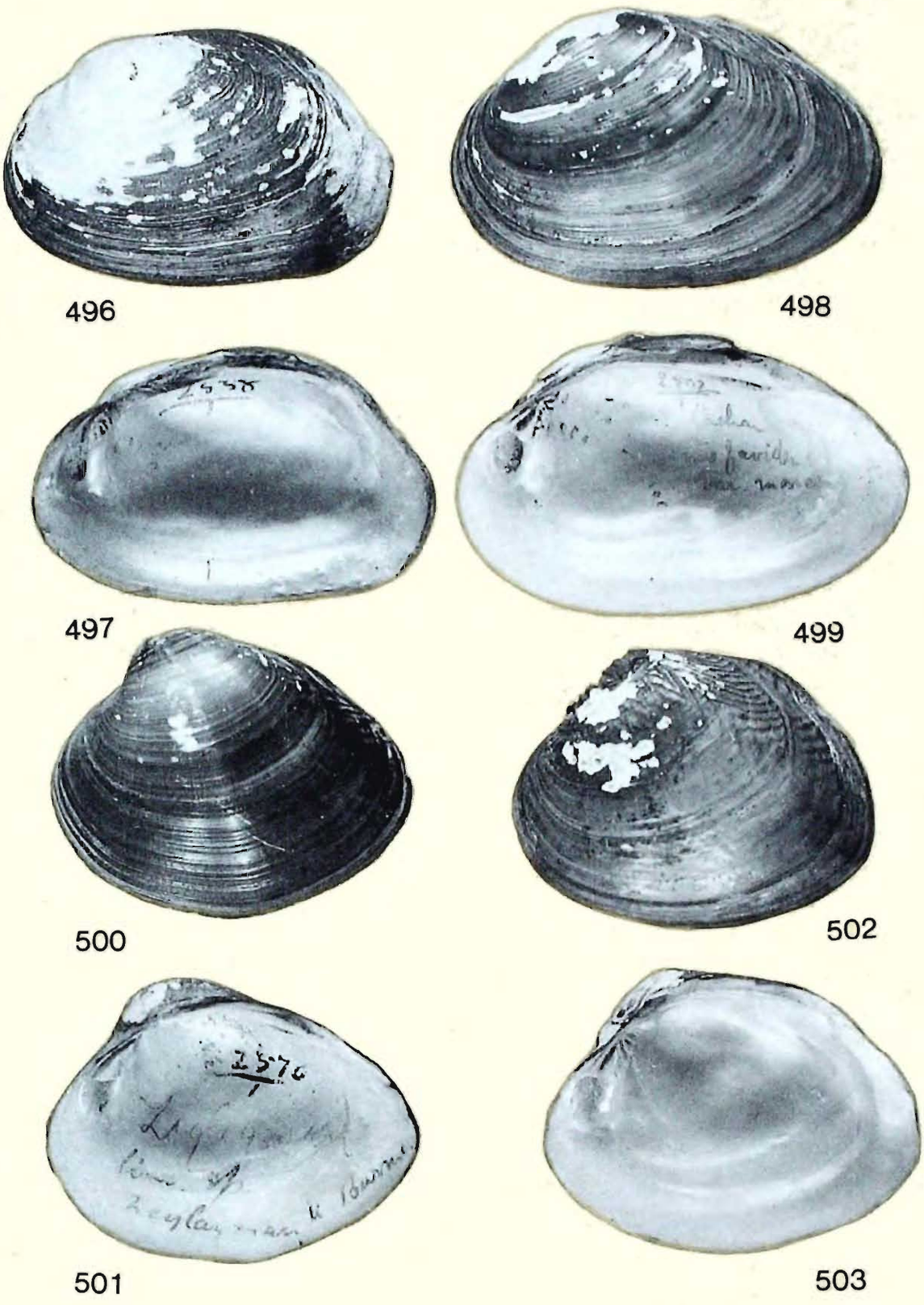
Figs. 490, 491. *Parreysia olivacea*, Holotype, 38.45 × 23.05 mm., Burma. 492, 493. *P. rajahensis*, Type, USNM No. 84638, 35.7 × 28.3 mm., Rajah's tank, India. 494, 495. *P. perconvexa*, Type, 56.15 × 36.85 mm., Nangyong Lake.



Figs. 496, 497. *P. gowhattensis*,40.35 × 26.95 mm., Gowhatty. 498, 499. *Parreysia f. marcens*, 61.5 × 41.20 mm., Cachar. 500, 501. *P. mandelayensis*, 41.0 × 31.40 mm., Burma. 502, 503. *P. tavoyensis*,46.40 × 36.0 mm., Tavoy.

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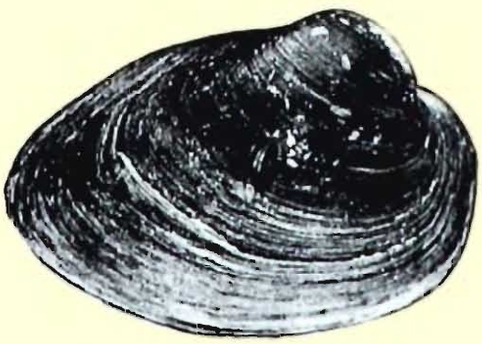

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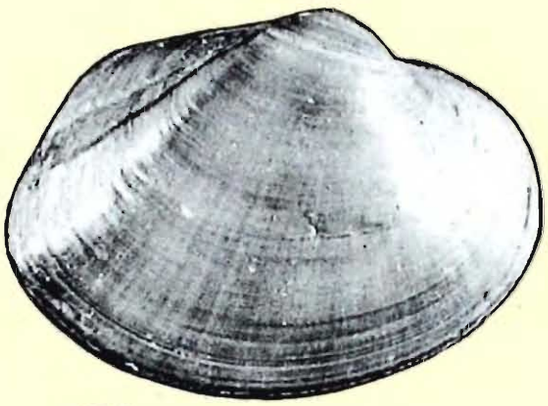

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Figs. 504, 505. *Parreysia smaragdites*, 24.70 × 16.65 Burma. 506, 507. *P. triembolus*, 47.60 × 41.0 mm., West Bengal.

Types: ZSI Regd. No. M 2490/1.

Distribution: Assam.

Remarks: Shell oval, convex, coarsely and concentrically ribbed, periostracum brownish olivaceous, umbones not prominent, dorsal margin arched, ventral margin considerably rounded, anterior side sharply rounded, posterior side bluntly subrostrate.

194. **Parreysia (Parreysia) bhamoensis** (Theobald, 1873) (Figs. 446, 447)

Unio bhamoensis Theobald, 1873, *J. Asiat. Soc. Beng.*, **42** (2): 207, pl. xvii, fig. 1. Type locality: Near Bhamo, Pegu, Western Prome.

Parreysia bhamoensis: Simpson, 1900, *Proc. U. S. natn. Mus.*, **22**: 843. Prashad, 1922, *Rec. Indian Mus.*, **24**: 100.

Distribution: Burma: Sagaing, Zayleyman and Tavoy.

Remarks: Shell subtriangular, beaks high but not placed well forwards, not very thick, lamellar pseudocardinals.

Prashad (1922) distinguished it from *P. mandelayensis* and established the clear identity of the two species.

195. **Parreysia (Parreysia) burmanus** (Blanford, 1869) (Figs. 458, 459, 462, 463)

Unio burmanus Blanford, 1869, *Proc. zool. Soc. Lond.*, p. 449. Type locality: Irawaddy river, near Bhamo.

Parreysia burmanus: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 845. Preston, 1912, *Rec. Indian Mus.*, **7**: 301.

Parreysia pernodulosa Preston, 1912, *Rec. Indian Mus.*, **7**: 300. Type locality: Zayleyman, Upper Burma.

Parreysia burmanus myitkyinae Prashad, 1930, *Rec. Indian Mus.*, **32**: 250, pl. viii, figs. 5—7, Type locality: Kamaing, in Myitkyina Dist.

Types: ZSI Regd. No. M 5232/1. M 13020/2 (Holotype); 13021/2 (Paratype) of *M. burmanus myitkyinae.*

Distribution: Burma: Bhamo, Zayleyman, Teinzo in the Mule stream, north east of Bhamo.

Remarks: Shell ovate to subovate, solid, brown or dark brown or brownish olivaceous, sculptured with coarse, corrugated ridges in the anterior region, nodulose and irregular in the median and posterior regions, umbones rather large, dorsal margin rapidly sloping anteriorly, slightly sloping posteriorly, ventral margin somewhat rounded, anterior side sharply rounded, posterior side broad and gradually sloping.

196. **Parreysia (Parreysia) choprae** Prashad, 1930
(Figs. 464, 465)

Parreysia choprae Prashad, 1930, *Rec. Indian Mus.*, **32:** 248, pl. viii, figs. 1—4. Type locality: Bank of a hill stream about 5 miles from Hopin towards Namna, Myitkyina District, Burma.

Types: ZSI Regd. No. M 13018/2 (Holotype); M 13019 (Paratype).

Distribution: Burma.

Remarks: Shell small (not more than 40 mm. length), slightly inflated, umbones prominent, very forwardly placed, umbonal cavity moderately deep, young shells with radial zig-zag sculpture all over the surface, adults with slightly thick, irregular and somewhat arched bars over the dorsal slope, anterior margin very short, posterior margin subtruncate, periostracum dark brown in adults, greenish brown to yellow in young ones.

197. **Parreysia (Parreysia) corbis** (Benson, 1856).
(Figs. 454, 455)

Unio corbis Benson, 1856, in Hanley's *Recent Bivalve shells,* 1856, pl. xxiii, fig. 43. Type locality: Assam.

Parreysia corbis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22:** 845.

Type: BM (NH)

Distribution: Assam.

Remarks: Shell oval, rather thin, concentric zones of bluish green and ochraceous yellow, glossy, smooth, umbones corrugated, anterodorsal margin concave, ventral margin convex, anterior side straight.

198. **Parreysia (Parreysia) corrugata** (Mueller, 1774)

(Figs. 448, 449)

Mya corrugata Mueller, 1774, *Verm. Terr. et. Fluv.*, pt. 2, p. 214, no. 398. Type locality: Rivers of Coromandel.

Parreysia corrugata: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22:** 841. Preston, 1912, *Rec. Indian Mus.*, **7:** 297.

Types: MNNH

Distribution: A common species with a wide range of distribution. Andhra Pradesh: Gudur; Bihar: Manbhoom, Arrah; Karnataka: Mysore; Maharashtra: Chanda; Punjab: Ambala; Phenchoogunj, Sylhet Dist. (Bangladesh).

Remarks: Shell green, elliptic to oval, scarcely inequilateral, smooth, umbones prominent, sculptured with somewhat radiating, oblique, linear ridges, ventral margin convex, lunule well marked, cardinal teeth strong, not lamellar.

Lomte (1971, 1972a, b & 1979), Nagabhushanam and Lomte (1971a, c, 1972 a, c) studied anatomy, histology, biochemistry and reproductive cycle.

199. **Parreysia (Parreysia) corrugata** (Mueller) subsp. **laevirostris** (Benson, 1862).

(Figs. 452, 453)

Unio laevirostris Benson, 1862, *Ann. Mag. nat. Hist.*, (3) **10:** 191.

Parreysia corrugata (Mueller) var. *laevirostris:* Simpson, 1900, *Proc. U.S. natn. Mus.*, **22:** 842. Preston, 1912, *Rec. Indian Mus.*, **7:** 297.

Types: BM (NH.)

Distribution: Assam; Bihar: Arrah; Andhra Pradesh: Hyderabad; Bangladesh: Chittagong hills.

Remarks: Specimens compared with Benson's type (Regd. No. M 16945/2) are available in ZSI. They were obtained from streams near Chunar above Benares (=Varanasi).

200. **Parreysia (Parreysia) corrugata** (Mueller) subsp. **nagpoorensis** (Lea, 1860).
(Figs. 450, 451, 482, 483)

Unio nagpoorensis Lea, 1859, *Proc. Acad. nat. Sci., Philad.*, **3**: 331. Type locality: Ambajori Tank, Nagpoor (=Nagpur), Maharashtra.

Unio wynegungaensis Lea, 1859, *Proc. Acad. nat. Sci. Philad.*, **3**: 331. Type locality: Wynegunga River, 30 miles east of Nagpur.

Parreysia corrugata (Mueller) sub var. *nagpoorensis:* Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 842.

Types: ANSP (Holotype); USNM (Holotype of *U. wynegungaensis*)

Distribution : Andhra Pradesh: Gudur, Godavari River; Maharashtra; Gujarat; Orissa; Assam.

201. **Parreysia (Parreysia) cylindrica** Annandale and Prashad, 1919.
(Figs. 460, 461)

Parreysia cylindrica Annandale and Prashad, 1919, *Rec. Indian Mus.*, **16**: 150, pl. iv. figs. 6, 7. Type locality: Yenna River, Upper Krishna Watershed, at Medha. Maharashtra.

Types : ZSI Regd. No. M 11398/2 (Syntypes).

Distribution : Maharashtra

Remarks : Shell thick, dorsal margin straight and anterior margin broadly rounded, umbonal region sculptured with corrugated ridges.

It closely resembles *P. favidens* in all characters except in the shell, which is more elongated.

202. **Parreysia favidens** (Benson, 1862)
(Figs. 466, 467, 484, 485)

Unio favidens Benson, 1862, *Ann. Mag. nat. Hist.*, (3) **10**: 188. Type locality: "Bhitoura on the Ganges between Cawnpore and Allahabad".

Parreysia favidens: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 842. Preston, 1912, *Rec. Indian Mus.*, **7**: 299.

Distribution: Assam; Andhra Pradesh: Kurnool; Madras; Maharashtra; Orissa; Uttar Pradesh; Bangladesh: Dacca, Sylhet.

Remarks: Shell more inequilateral than in *P. corrugata,* thick, angulate both posteriorly and anteriorly, cardinal teeth strong and broad.

Patil and Bal (1967) studied seasonal, chemical and gonadal changes.

It is a very variable species and the following four subspecies are distinguished.

203. **Parreysia (Parreysia) favidens** subsp. **assamensis** Preston, 1912. (Figs. 468, 469)

Parreysia favidens var. *assamensis* Preston, 1912, *Rec. Indian Mus.*, 7: 299. Type locality: Digong, Assam.

Type: ZSI Regd. No. M 2479/1 (Holotype), M 9996/2 (Cotypes—4)

Distribution: Assam: Digong; Bihar: Arrah.

Remarks: Shell convex, anterior side more rounded and posterior slightly natuate, dorsal margin rather less posteriorly angled.

204. **Parreysia (Parreysia) favidens** subsp. **chrysis** (Benson, 1862)

Parreysia favidens (Benson) var. *chrysis* Benson, 1862. *Ann. Mag. nat. Hist.*, (3) **10:** 189. Type locality: Dojora river, Kareily Ghat near Bareily. Hanley & Theobald, 1876, *Conch. Indica,* p. 19, pl. 41. fig. 3.

Types: ZSI Regd. No. M 2459/1.

Distribution: Bihar: Patna; Uttar Pradesh: Bareilly.

Remarks: Shell longer and less broad in proportion, umbonal rugae very strong and extended, periostracum green with yellow bands, cardinal narrow.

205. **Parreysia (Parreysia) favidens,** subsp. **deltae** (Benson, 1862) (Figs. 470, 471)

Parreysia favidens var. *deltae* Benson, 1862, *Ann. Mag. Nat. Hist.*, (3) **10:** 189. Hanley & Theobald, 1876, *Conch. Indica,* p. 19, pl. 62, fig. 2, Type locality: Jellinghy river, Bengal.

Types: ZSI Regd. No. M 16944/2.

Distribution: West Bengal: Calcutta, Hazrapur.

Remarks: Periostracum olive green and yellow, umbones with distinct rugae, lunule broad.

206. **Parreysia favidens** subsp. **viridula** (Benson, 1862)
(Figs. 474, 475)

Parreysia favidens var. *viridula* Benson, 1862, *Ann. Mag. nat. Hist.*, (3) **10**: 189. Type locality: "Jheel between Hameerpore and Someerpore, Bundel Khand".

Distribution: Bihar: Damuda, Gandak, Manbhoom, Patna; West Bengal : Ranigange.

Remarks: Shell compressed, cardinals broad.

207. **Parreysia (Parreysia) feae** (Tapparone-Canefri, 1889)
(Figs. 480, 481)

Unio feae Tapparone-Canefri, 1889, *Ann. Mus. Civ. Stor. Nat. Genova,* **27**: 340. Type locality: Meetan, Houngdaran river, Burma.

Parreysia feae: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 844.

Types: ZSI Regd. No. M 16944/2. ("Type" and Co-types).

Distribution: Burma: Meetan, Houngdaran.

Remarks: Shell subrhomboidal when young but more elongate in adults, zigzag radial sculpture conspicuous in young and obsolete in adult shells; umbones prominent, recurved forwards and inwards but not meeting each other, dirty yellow to yellowish brown sculpture.

208. **Parreysia (Parreysia) feddeni** (Theobald, 1873)
(Figs. 476, 477)

Unio feddeni Theobald, 1873, *J. Asiat. Soc. Beng.*, **42** (2): 208, pl. xvii, fig. 3. Type locality: Burma.

Parreysia feddeni: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 845. Preston, 1912, *Rec. Indian Mus.*, **7**: 300.

Type: BM (NH).

Distribution: Burma: Rice fields at Pegu and Yaylaymaw.

Remarks: Shell quadrate, with concentric sulcations, anterior end round, posterior end subtruncate.

The species does not occur in India, but the type locality was inadvertently given as "Peengunga river, Central India" (Prashad, 1922).

209. **Parreysia (Parreysia) gowhattensis** (Theobald, 1873). (Figs. 498, 499)

Unio gowhattensis Theobald, 1873, *J. Asiat. Soc. Beng.*, **42(2)**: 208, pl. xvii, fig. 4. Type locality: Gauhati.

Parreysia gowhattensis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 845. Preston, 1912, *Rec. Indian Mus.*, **7**: 301.

Distribution: Assam.

Remarks: Shell quadrately ovate, thick, inequilateral, periostracum brownish-yellow, concentrically striated and rugose, anterior side short, and curved, posterior side long and truncate, postero-dorsal margin rather straight between the umbones and suddenly sloping on the posterior margin, ventral margin curved and indented on the posterior side; umbones prominent but eroded.

210. **Parreysia (Parreysia) houngdaranicus** (Tapparone-Canefri, 1889) (Figs. 478, 479)

Unio houngdaranicus Tapparone-Canefri, 1889, *Ann, Mus. Civ. Stor. Nat. Genova*, **27**: 341. Type locality: Houngdaran river, Meetan, Tenasserim, Lower Burma.

Parreysia houngdaranicus: Prashad, 1922, *Rec. Indian Mus.*, **24**: 101, pl. ii, fig. 6.

Types: Museo Civico Distoria Naturale, Genoa.

Distribution: Lower Burma.

Remarks: Prashad (1922) studied the types and showed its affinities to P. *bhamoensis* and *P. mandelayensis.*

Shell subrhomboidal to subovate, moderately inflated, beaks high, placed very anteriorly and recurved outwards and downwards, posterior margin longer than the anterior.

211. **Parreysia (Parreysia) mandelayensis** (Theobald, 1873) (Figs. 500, 501)

Unio mandelayensis Theobald, 1873, *J. Asiat. Soc. Beng.*, **42** (2): 208, pl. xvii, fig. 2. Type locality: Mandalay.

Parreysia mandelayensis: Prashad, 1922, *Rec. Indian Mus.*, **24**: 101.

Types: BM (NH).

Distribution: Burma: Bhamo, Sheinmagah, Myadong, Pegu.

Remarks: Shell triangular, beaks very high and forwardly placed, the beak and umbonal region very strongly sculptured, often with distinct tubercles or even spines, hinge very strong, with compact, thick and distinctly tooth-like pseudo-cardinals.

212. **Parreysia (Parreysia) olivacea** Prashad, 1930 (Figs. 490, 491)

Parreysia olivacea Prashad, 1930, *Rec. Indian Mus.*, **32**: 251, pl. viii, fig. 8. Type locality: Kamaing, Myitkyina Dist. Burma.

Types: ZSI Regd. No. M 13022/2 (Holotype), M 13023/2 (Paratype).

Distribution: Burma.

Remarks: Shell small (less than 36 mm.), subtriangular, umbones high, somewhat inflated, forwardly curved, without radial sculpture, anterior end rounded, dorsal margin almost regularly curved, posterior end rounded to subtruncate, periostracum olive green, with a trace of yellow below the umbones. It is a small, smooth shelled form and apparently forms a connecting link between the genera *Parreysia* and *Indonaia* (Prashad, 1930).

213. **Parreysia (Parreysia) perconvexa** Preston, 1912 (Figs. 494, 495)

Parreysia perconvexa Preston, 1912, *Rec. Indian Mus.*, **7**: 302. Type locality: Nangyong Lake, Burma.

Types: ZSI Regd. No. M 5069/1 (1 ex.).

Distribution: Not known beyond type locality.

214. **Parreysia (Parreysia) rajahensis** (Lea, 1841) (Figs. 492, 493)

Unio rajahensis Lea, 1841, *Proc. Am. Phil. Soc.*, **2**: 30. Type locality: Rajah's tank, Calcutta.

Parreysia rajahensis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 844. Preston, 1912, *Rec. Indian Mus.*, **7**: 301.

Distribution: Narmada River, Rann of Kutch, Sepree, Sahib ganje.

Remarks: Shell triangular, inflated, posteriorly angulated.

215. **Parreysia (Parreysia) sikkimensis** (Lea, 1859) (Figs. 488, 489)

Unio sikkimensis Lea, 1859, *Proc. Acad. nat. Sci. Philad.*, **3**: 151. Type locality: Sikkim.

Parreysia sikkimensis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 845. Preston, 1912, *Rec. Indian Mus.*, **7**: 301.

Types: BM (NH).

Distribution: Assam: Cachar, Dihing, Sibsagar; Sikkim: Namtsik; West Bengal: Siliguri.

Remarks: Blanford (1866) expressed doubt regarding the type locality. Shell considerably convex in porportion to its size, short, broad and generally ovate.

216. **Parreysia (Parreysia) smaragdites** (Benson, 1862) (Figs. 504, 505)

Unio smaragdites Benson, 1862, *Ann. Mag. nat. Hist.*, (3) **10**: 190. Type locality: "Berhampooter" (= Brahmaputra river), Assam.

Parreysia smaragdites: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 843. Prashad, 1922, *Rec. Indian Mus.*, **24**: 102.

Types: Specimens collected from Brahmaputra river, Assam and

compared with Benson's type (No. M 16946/2) are available in ZSI.

Distribution: Assam, Upper Burma.

Remarks: Shell beautiful green interspersed with lemon yellow in the middle, beaks submedian and greatly deflected forwards with deep cavities and a well marked lunule.

217. **Parreysia (Parreysia) tavoyensis** (Gould, 1843) (Figs. 502, 503)

Unio tavoyensis Gould, 1843, *Proc. Bost. Soc. nat. Hist.*, p. 140. Type locality: Tavoy, Burma.

Parreysia tavoyensis: Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 843. Preston, 1912, *Rec. Indian Mus.*, **7**: 300. Prashad, 1930, *Rec. Indian Mus.*, **32**: 247.

Types: Holotype MCZ.

Distribution: Burma: Arakan, Mandalay, Pegu and Tavoy.

Remarks: Shell subtriangular to subovate, umbones and a considerable part of the shell sculptured with zigzag corrugations in young shells, but obsolete in full grown individuals.

218. **Parreysia (Parreysia) triembolus** (Benson, 1855) (Figs. 506, 507)

Unio triembolus Benson, 1855, *J. Asiat. Soc. Beng.*, **35**: 44. Type locality: Nerbudda (= Narmada). Hanley & Theobald, 1876, *Conch. Indica*, p. 43, pl. 107, fig. 2.

Parreysia tavoyensis var. *triembolus:* Preston, 1915, *Fauna Brit India*, Mollusca (Freshwater Gastropoda & Pelecypoda), p. 167.

Types: BM (NH).

Distribution: Uttar Pradesh: Ramganga near Moradabad; Assam : Cachar, Barack river, Silchar; West Bengal: Calcutta.

Remarks: Prashad (1922) examined Benson's type series of specimens and showed that it is a distinct species.

Subgenus **Radiatula** Simpson, 1900

Type species: *Unio crispisulcatus* Benson, 1962.

Prashad (1918) proposed the genus *Indonaia* to include all the Indian species which were formerly grouped along with the Japanese and African species in the genus *Nodularia* (Preston, 1915, pp. 135—146).

Haas (1969) has rightly included *Radiatula* as a subgenus of *Parreysia* synonymizing *Indonaia* with it.

The members of this genus carry the glochidea in all the four gills, a character of the subfamily. It agrees with the genus *Parreysia* in its anatomical character but differs from it in the beak sculpture and structure of glochidia.

It includes 20 species as given below:

219. **Parreysia (Radiatula) andersoniana** (Nevill, 1877) (Figs. 508, 509)

Unio andersonianus Nevill, 1877, *J. Asiat. Soc. Beng.*, **46**: 40. Type locality: Myadong, Upper Burma.

Nodularia (*N*) *andersoniana:* Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda) p. 143.

Types: ZSI Regd. No. M 5192/2.

Distribution: Assam: Silchar; West Bengal: Siliguri; Myadong. (Burma).

Remarks: Smaller in size, thin, umbo indistinct, not at all raised. strong sculpture on umbonal region, pallial line prominent.

In general shape it resembles *P. caerulea* but sculpture on umbonal region stronger, shells greenish, also less tumid than in *P. caerulea.*

220. **Parreysia (Radiatula) bonneaudi** (Eydoux, 1838) (Figs. 510, 511)

Unio bonneaudi Eydoux, 1838, *Mag. de Zool. cl.*, **5**: 101, pl. 119, figs. 1, 1a.

Nodularia (N) bonneaudi: Simpson, 1900, *Proc. U. S. natn. Mus.*, **22:** 813.

Indonaia bonneaudi : Prashad , 1921 , *Rec Indian Mus.*, **22:** 603.

Distribution: Manipur, Assam and Burma.

Remarks: Exhibits variation in shape and colour. Shell thick, tumid, finer sculpture on umbonal region, also vertically sculptured with faint zigzag lines accross the valves, posterior side broader than anterior, umbo almost at the centre of the dorsal margin.

221. **Parreysia (Radiatula) caerulea** (Lea, 1831) (Figs. 516, 517)

Unio caeruleus Lea, 1831, *Trans. Amer. Phil. Soc.*, **4:** 95, pl. 13, fig. 25. Type locality: "Hooghly river, 100 miles above Calcutta."

Nodularia (N) caeruleus: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda) p. 136.

Types: USNM (Holotype), ANSP (Paratype).

Distribution: Assam, Bihar, Orissa, Punjab, Sind, Uttar Pradesh, West Bengal (represents more or less all districts), Burma.

Remarks: Variable, in grown up valves sculpture restricted to umbonal region, in case of young the whole surface sculptured, posterior umbonal carina very distinct.

222. **Parreysia (Radiatula) caerulea** subsp. **gaudichaudi** (Eydoux, 1838). (Figs. 518, 519)

Unio gaudichaudi Eydoux, 1838, *Mag. de Zool.*, **5:** 10, pl. 118, fig. 3.

Nodularia (N) caeruleus var. *gaudichaudi:* Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 137.

Distribution: Rivers of Bengal; Dacca, Bangladesh.

Remarks: More tumid, strongly built, posterior end pointed.

There is another variety *P. (R) caerulea keraudreni* (Eydoux) which is found abundantly in the vicinity of Chandannagar, West Bengal.

It is characterised by short obtuse anterior side and gently sloping posterior side with a blunt extremity (Figs. 520, 521).

223. **Parreysia (Radiatula) chaudhurii** (Preston, 1912) (Figs. 522, 523)

Nodularia (N) chaudhurii Preston, 1912, *Rec. Indian Mus.*, **7**: 290. Type locality: Burma.

Types: ZSI Regd. No. M 2545/1

Distribution: Upper Burma.

Remarks: Prashad (1922) studied the type series of Preston and remarked that it may turn to be a form of *P. bonneaudi* (Eydoux). However, it differs from it in the following: shell shorter, more ovate, less inflated with more pronounced sculpture.

224. **Parreysia (Radiatula) crispisulcata** (Benson, 1862) (Figs. 524, 525)

Unio crispisulcatus Benson, 1862, *Ann. Mag. nat. Hist.*, (3) **10**: 193. Type locality: Burma.

Nodularia (Radiatula) crispisulcata: Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 146.

Distribution: Pengong River, Burma.

Remarks: General shape in this species very distinct from all others, rather trigonal and more like as in the subgenus *Parreysia*. Shell yellowish brown, very distinctly sculptured throughout. In the posterior region the sculpture consists of strong vertical ridges and rather distant spiral grooves. On the rest of the shell the vertical ridges much finer and the spiral grooves close giving a beaded appearance.

225. **Parreysia (Radiatula) involuta** (Benson, 1856)

Unio involutus Benson, 1856, in Hanley's *Recent Bivalve Shells*, p. 385, pl. 23, fig. 19. Type locality: Assam.

Nodularia (N) involuta: Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 146.

Distribution: Assam; Bangladesh.

226. **Parreysia (Radiatula) khadakvaslaensis** (Ray, 1966) (Figs. 514, 515)

Indonaia khadakvaslaensis Ray, 1966, *J. Conch. Paris,* **105** (4) : 226. Type locality : Khadakvasla dam, Pune.

Distribution: Maharashtra: Pune.

Types: ZSI Regd. No. M 17531/3 (Holotype), Regd. No. M 17532/3 (Paratype).

Remarks: Very close to *P. pachysoma,* similar inflated shells, posterior end pointed, sculpture appears to be a little more pronounced.

227. **Parreysia (Radiatula) lima** (Simpson, 1900) (Figs. 528-531)

Nodularia (*Radiatula*) *lima,* Simpson, 1900, *Proc. U.S. natn. Mus.,* **22:** 820. Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 147.

Indonaia lima: Prashad, 1921, *Rec. Indian Mus.,* **22:** 604.

Distribution: Assam, Sikkim, West Bengal.

Remarks: Shell small, greenish, broader posterior end, umbo much anteriorly placed, scarcely raised, conspicously sculptured, sculpture more pronounced on umbonal region, typical zigzag lines—transverse lines prominent on posterior side, sculpture on anterior side finer.

It is a highly variable species. Corrugation in the umbonal region is prominent in some specimens but in a few it is almost absent. Preston (1908) described a species, namely *Unio siliguriensis,* which he later (1915) treated as a variety of *Nodularia (Radiatula) lima.* On examination of the holotype of *Unio siliguriensis* (ZSI Regd. No. M 6099/1; figs. 542, 543) it is found to be only a variety and hence treated under species *P. lima.*

228. **Parreysia (Radiatula) nuttalliana** (Lea, 1856) (Figs. 428, 429, 532, 533)

Unio nuttallianus Lea, 1856, *Proc. Acad. nat. Sci. Philad.* **8:** 103; Type locality: India.

Nodularia (*N*) *nuttalliana:* Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 145.

Types: USNM

Distribution: Assam: Cachar.

Remarks: Smaller, smoother, devoid of any sculpture, olive green, umbo more prominent, placed at the middle.

229. **Parreysia (Radiatula) occata** (Lea, 1860) (Figs. 426, 427, 526, 527)

Unio occatus Lea, 1860, *Proc. Acad. nat. Sci. Philad.*, **4**: 307. Type locality: Bengal,

Nodularia (N) occata: Preston, 1915, *Fauna Brit. India* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 138.

Indonaia occata: Prashad, 1921, *Rec. Indian Mus.*, **22**: 603.

Types: USNM

Distribution: Assam, Madhya Pradesh, U.P., West Bengal, Bangladesh.

Remarks: Close to *P. lima,* narrower, dorsal side less convex, umbo little more central in position, sculptured throughout.

230. **Parreysia (Radiatula) olivaria** (Lea, 1831). (Figs. 534, 535)

Unio olivarius Lea, 1831, *Trans. Amer. Phil. Soc.*, **4**: 108, pl. 16. fig. 38. Type locality: Burrail river, north of Cachar, Assam (see Benson, 1866, p. 140).

Nodularia (N) olivaria: Preston, 1915, *Fauna Brit. India* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 144.

Types: ANSP (Syntypes)

Distribution: Assam; U.P.: Agra, Moradabad; West Bengal: Raniganj.

Remarks: Very close to *P. nuttalliana,* thinner.

231. **Parreysia (Radiatula) pachysoma** (Benson, 1862) (Figs. 540, 541)

Unio pachysoma Benson, 1862, *Ann. Mag. nat. Hist.*, (3) **10**: 186. Type locality: "Barhamapooter river, Assam."

Nodularia (N) pachysoma: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 139.

Distribution: India: Assam, West Bengal; Bangladesh, Burma.

Remarks: Related to *P. bonneaudi* and *P. caerulea.* Distinguished from the former by its more elongate, more inflated, but less deep shells, more pronounced umbones and much stronger hinge; from the latter by its much brighter and more inflated shells and in lacking radial sculpture on the sides.

232. **Parreysia (Radiatula) shurtleffiana** (Lea, 1856) (Figs. 512, 513)

Unio shurtleffianus Lea, 1856, *Proc. Acad. nat. Sci. Philad.*, **8**: 94.

Nodularia (N.) shurtleffiana: Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 138.

Distribution: Maharashtra: Ahmednagar.

Remarks: Very similar to *P. olivaria* and *P. nuttalliana,* but differs in possessing some typical sculpture on umbonal regions and also on anterior slope.

It may prove to be a variety of common *P.* (*R.*) *caerulea* (Lea).

233. **Parreysia (Radiatula) theobaldi** (Preston, 1912) (Figs. 536-539)

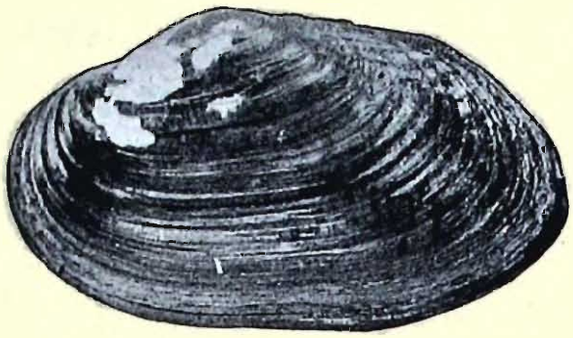
Nodularia (*N.*) *theobaldi* Preston, 1912, *Rec. Indian Mus.*, **7**: 292. Type locality: Manipur.

Indonaia theobaldi: Prashad, 1921, *Rec. Indian Mus.*, **22**: 604.

Types: ZSI Regd. No. 4710 (Holotype); M 2478/1 (Cotype).

Distribution: Manipur, Assam.

Remarks: Shell larger, broader and more elongated than in typical *Radiatula,* no sculpture on dorsal surface of valves.



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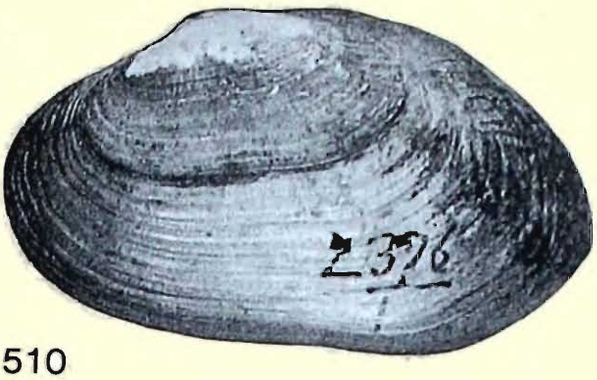

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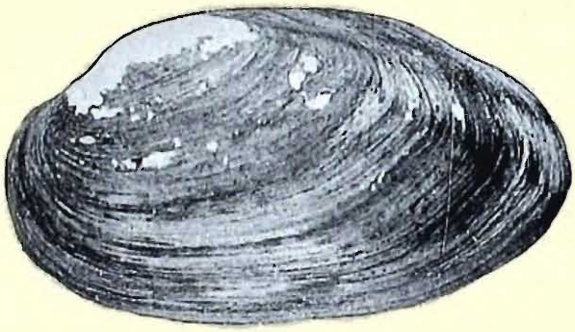

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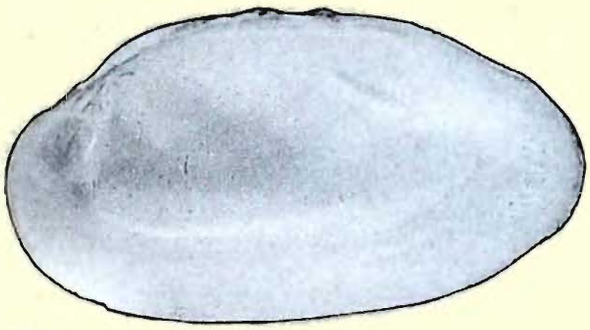

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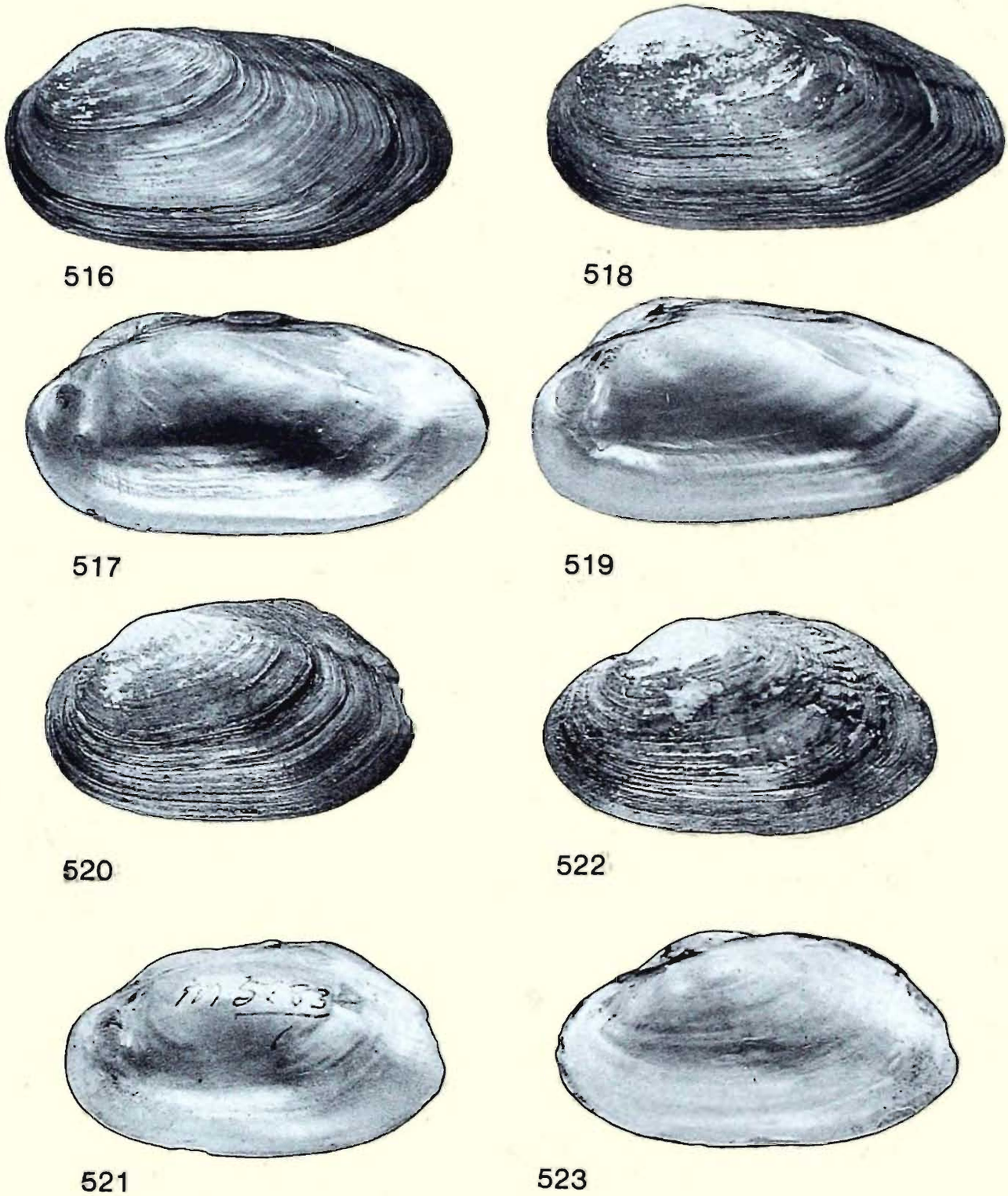
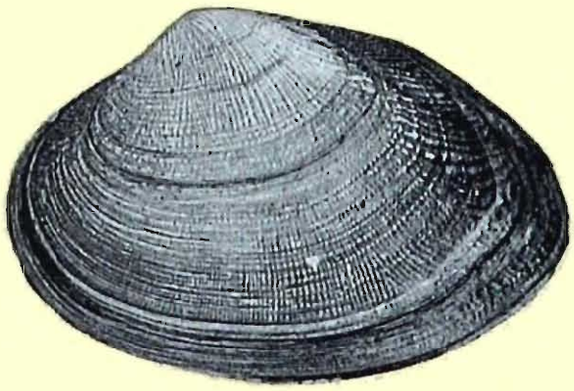
Figs. 508, 509. *Parreysia (Radiatula) andersoniana*, 31.55 × 18.05 mm, Burma. 510, 511. *P. (R.) bonneaudi*, 36.70 × 20.80 mm, Burma. 512, 513. *P. (R.) shurtleffiana*, 40.45 × 25.0 mm; U.P. 514, 515. *P. (R.) khadakvaslaensis*, Holotype 47.65 × 23.75 mm., Maharashtra.



Figs. 516, 517. *Parreysia (Radiatula) caerulea*, 45.40 × 22.85 mm., Calcutta. 518, 519. *P. (R.) caerulea gaudithaudi*, 46.50 × 22.30 mm., W. Bengal. 520, 521. *P. (R.) caerulea keraudreni*, 34.65 × 20.80 mm., W. Bengal. 522, 523. *P. (R.) chaudhuri*, Paratype, 24.30 × 18.85 mm., Burma.



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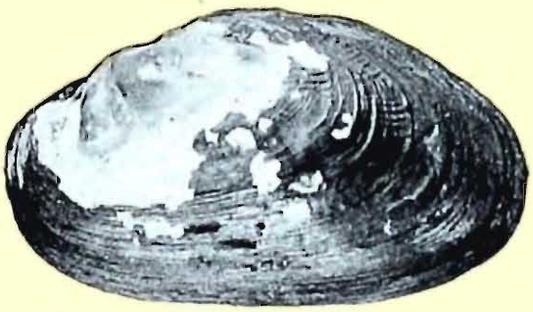

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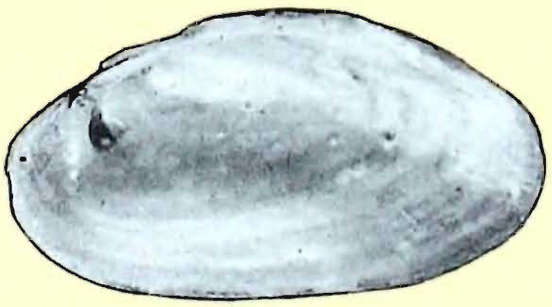

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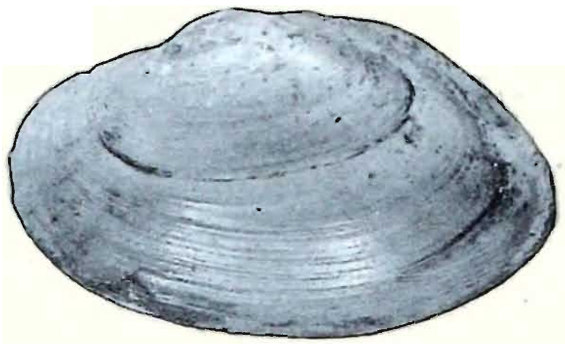
Figs. 524, 525. *Parreysia (Radiatula) crispisulcata*, 47.80 × 31.50 mm., Burma. 526, 527. *P. (R.) occata*, 29.45 × 17.30 mm., Burma. 528, 529. *P. (R.) lima* — juvenile shell, 25.25 × 15.30 mm., W. Bengal. 530, 531. *P. (R.) lima* — grown-up shell, 31.30 × 18.0 mm., W. Bengal.



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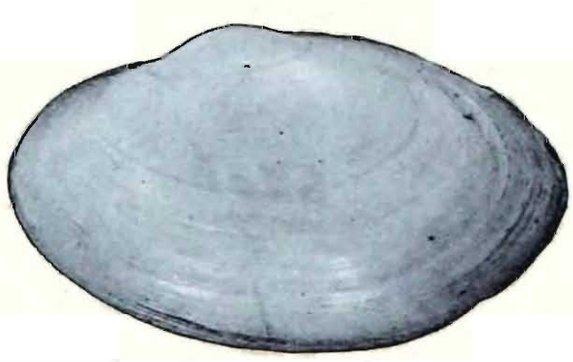

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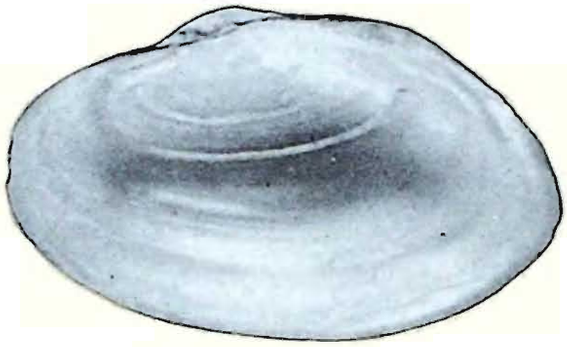

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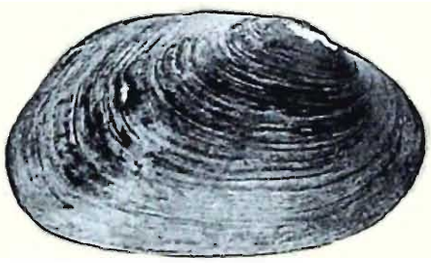

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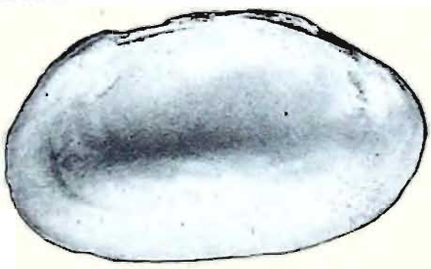

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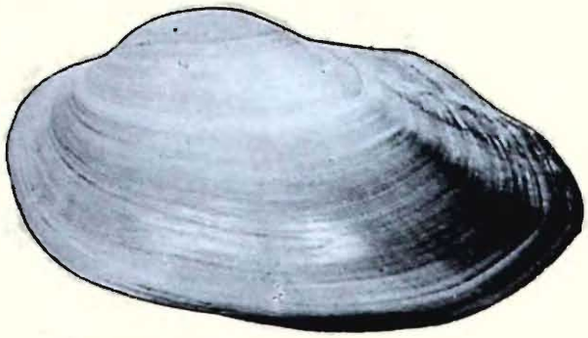
Figs. 532, 533. *Parreysia (Radiatula) nuttaliana*, 25.20 × 15.30 mm., Assam. 534, 535. *P. (R.) olivaria*, 34.45 × 20.30 mm., Assam. 536, 537. *P. (R.) theobaldi*, juvenile shell, 40.50 × 24.25 mm, Manipur, 538, 539. *P. (R.) theobaldi*, a grown-up shell, 59.95 × 34.15 mm., Holotype, Manipur.



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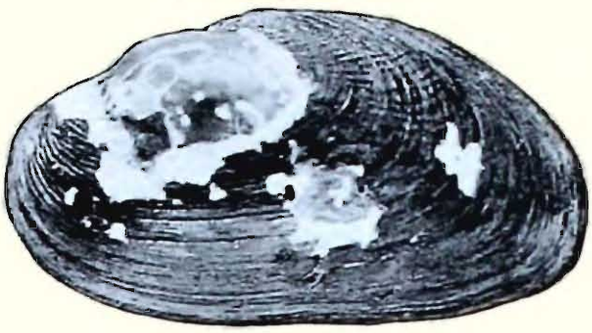

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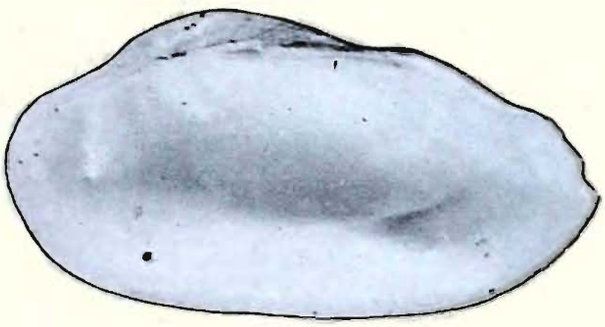

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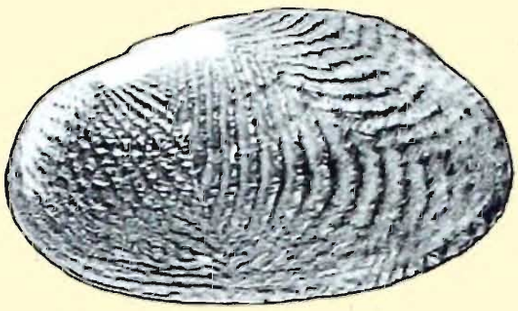
Figs. 540, 541. *P. (R.) pachysoma*, 44.70 × 23.30 mm., Assam. 542, 543. *P. (R.) siliguriensis*, Holotype, Fully grown-up shell, 37.65 × 20.85 mm., Siliguri.



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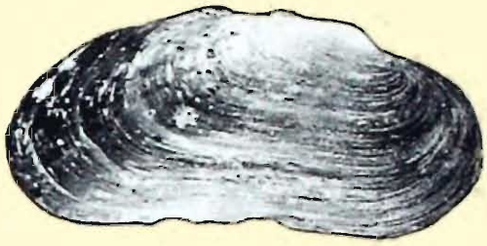

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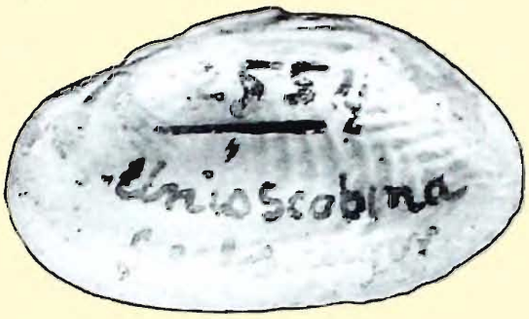

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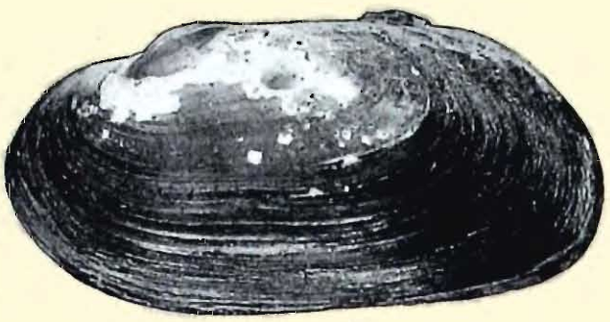
Figs. 544, 545. *Scabies crispata*, 34.60 × 18.15 mm., 546, 547. *Margaritifera laosensis*, 60.30 × 27.10 mm., Burma. 548, 549. *Trapezoideus dhanùshori*, 35.65 × 18.85 mm., Assam.



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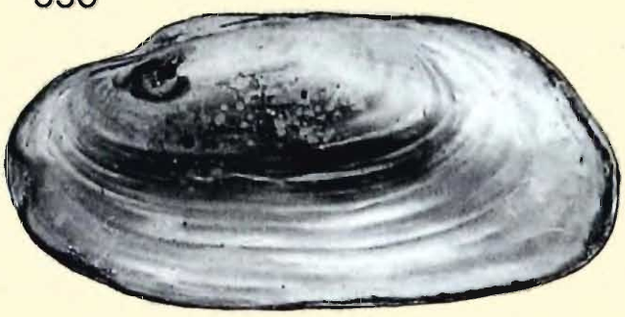

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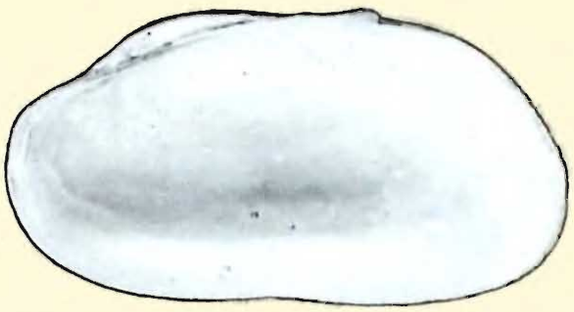

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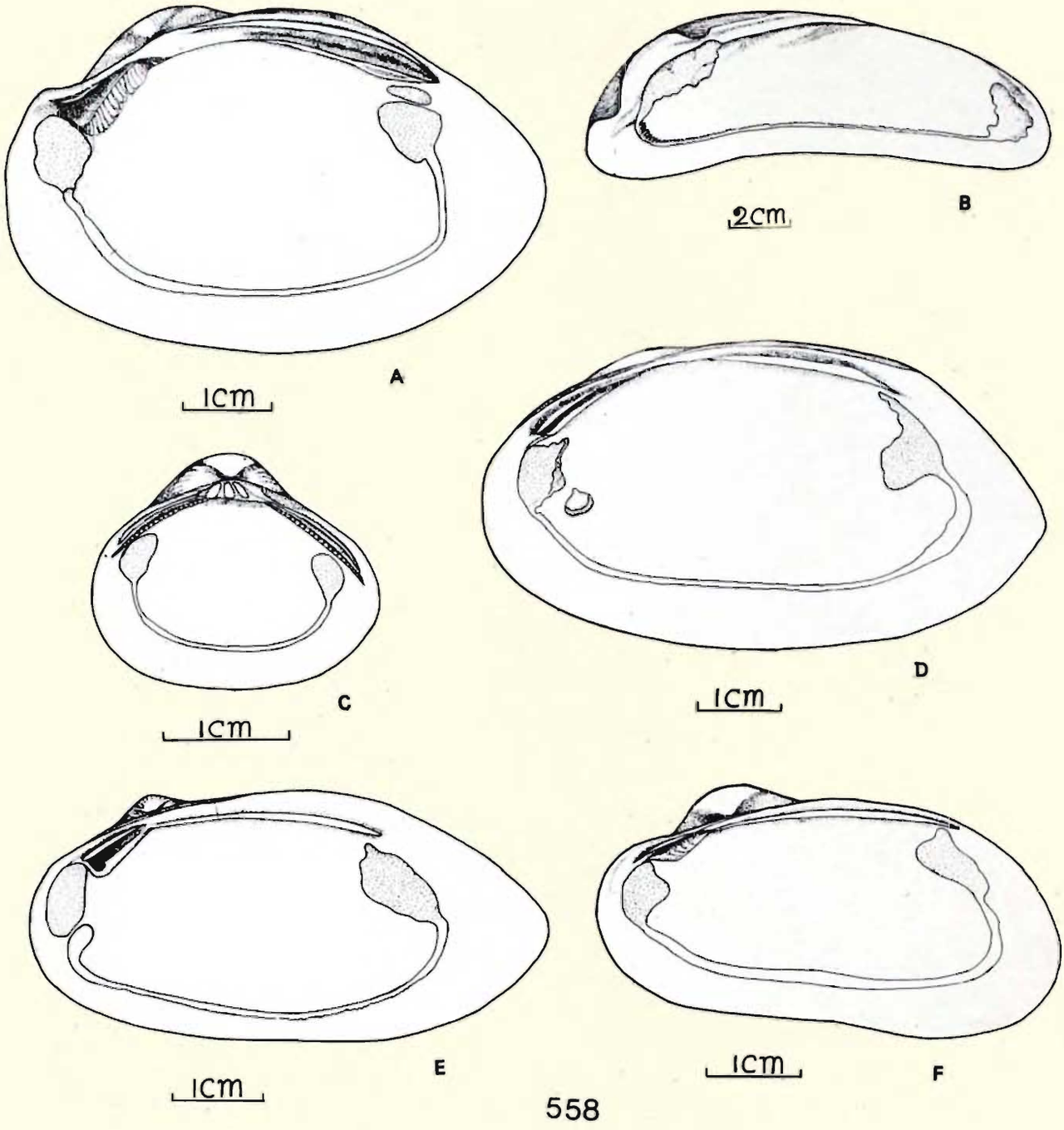
Figs. 550, 551. *Trapezoideus exolescens*, 39.70 × 20.0 mm., Burma. 552, 553. *T. foliacea*, 46.15 × 26.0 mm., Burma. 554, 555. *T. misellus*, var. *subclathra* 31.80 × 17.70 mm., Burma. 556, 557. *T. misellus*, 31.50 × 17.15 mm., Manipur.



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Figs. 558 A to F. Inner view of a few bivalve shells.

Genus.44. **Scabies** Haas, 1911

Type species : *Unio scobinatus* Lea.

Shell not as thick as in *Parreysia*, elongately oval, shell surface sculptured with zig-zag pattern or ridges.

Thailand, Laos, Cambodia, S. Vietnam, Burma and India.

One species from India and Burma.

234. **Scabies crispata** (Gould, 1843)
(Figs. 544, 545)

Unio crispata Gould, 1843, *Proc. Boston Soc. nat. Hist.*, **1**: 141. Type locality: Tavoy, Burma.

Unio scobinatus Lea, 1856, *Proc. Acad. nat. Sci. Philad.*, **8**: 93. Type-locality: Siam.

Unio scobina: Hanley, 1856, *Recent Bivalve shells*, p. 382, pl. 23, fig. 40.

Nodularia (*Nodularia*) *scobina:* Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 142.

Nodularia (*Nodularia*) *crispata:* Preston, 1915, *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda), p. 142.

Indonaia scobina: Prashad, 1921, *Rec. Indian Mus.*, **22**: 603.

Scabies crispata: Brandt, 1974, *Arch Moll.*, **105**: 281, pl. 20, fig. 33.

Distribution: India: Assam: Sibsagar; Burma: Tavoy, Bhamo; Siam, Cambodia and Thailand.

Remarks: Shell strongly and deeply sculptured, zig-zag radial lines, interspersed here and there with thicker nodules on yellowish to brownish background, ridges transverse in the anterior region and vertical in the posterior region of the shell.

Brandt (1974) dealt in detail and remarked on the possibility of three geographic races within its area of distribution.

Subfamily RECTIDENTINAE Modell, 1942

Shell rhomboidal or ovate, or trapezoid, generally with a high posterior wing. Umbones in the anterior third of the shell, sculptured with concentric zigzag lines, hinge plate very narrow, pseudocardinals lamelliform or very weak, all four demibranchs marsupial.

South, East and South-east Asia; Indonesian and Philippine Islands.

The subfamily is represented by two genera viz. *Physunio* and *Trapezoideus* from the Indian and Burmese region.

The two can be distinguished by the shell structure; in the *Physunio* it is more or less thin and inflated while in the *Trapezoideus* it is thick and compressed.

The two species of *Physunio* described by Annandale from Inle Lake were synonymised by Haas (1969: 87) with *Physunio micropterus* (Morelet), but it was contradicted by Brandt (1974: 296).

Genus 45. **Trapezoideus** Simpson, 1900

Trapezoideus Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 858.

Type species: *Unio foliacea* Gould, 1843.

Shell trapezoidal, compressed with low posterior slope, umbones not prominent, ornamented by zigzag ridges, surface concentrically sulcate, hinge with elongate cardinals. Outer and inner gills of nearly the same width posteriorly, outer shorter in length than the inner, palpi large, branchial aperture large, with many rows of elongate papillae on the margins, anal aperture with a single row of minute papillae on its margins.

India: Assam, Manipur. South and South-east Asia.

235. **Trapezoideus exolescens exolescens** (Gould, 1843) (Figs. 432, 433, 548-557)

Unio exolescens Gould, 1843, *Proc. Boston Soc. nat. Hist.*, **1**: 141. Type locality: Tavoy, Burma.

Unio foliaceus Gould, 1843, *Proc. Boston Soc. nat. Hist.*, **1**: 141. Type locality : Tavoy, Burma.

Unio misellus Morelet, 1865, *J. Conch. Paris*, **13** : 21. Type locality : Siam.

Unio siamensis Lea, 1866, *Proc. Acad. nat. Sci. Philad.*, **10** : 133. Type locality : Siam.

Unio misellus var. *subclathratus* Martens, 1899, *Arch. Naturqesch.*, **65** : 44, pl. 6, fig. 3. Type locality : Chindwin river near Kalewa, Burma.

Trapezoideus foliaceus var. *zayleymanensis* Preston, 1912, *Rec. Indian Mus.*, **7**: 307. Type locality: Bhamo, Burma.

Trapezoideus dhanushori Prashad, 1921, *Rec. Indian Mus.*, **22**: 611, fig. 31. Type locality: Dhanushori stream, about a mile from Dimapur, Assam.

Trapezoideus exolescens exolescens: Brandt. 1974, *Arch, Moll.*, **105** : 299, pl. 26, fig. 63.

Types: USNM. ZSI Regd. No. M 11962/2 (*T. dhanushori*).

Distribution: India: Manipur, Assam; Burma: Mandalay, Bhamo, Tenasserim, Zayleymann.

Remarks: Shell very thin and compressed or inflated, umbones depressed, occasionally prominent, anterior end narrow or obliquely truncated, posterior side dilated, posterior wing not very distinct or narrow, periostracum greenish brown, or brownish yellow.

Genus 46. **Physunio** Simpson, 1900

Physunio Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: *828*

Type species ; *Unio gravidus* Lea, 1856 OD

Shell irregularly obovate, thin, anteriorly narrow, posteriorly broad and produced at base, posterior slope high, winged, excavated with distinct posterior ridge, umbones prominent with zigzag folds, with deep cavities, surface smooth, periostracum yellowish or brownish-green, hinge with elongate cardinals, short and somewhat curved laterals, old shells with auxiliary tooth in each valve.

Exhalent aperture smooth, inhalent aperture with elongate tentacles arranged in three rows. Marsupium formed by 11-17 simple water tubes in the middle region of outer gills, leaving a larger posterior and a much smaller anterior unmodified portion for respiration. Glochidium hookless.

Characteristic of Indo-Chinese region. One species penetrated as far west as Assam, and another to Sumatra, but mainly found in Cambodia, Cochin China and Siam. Two species from the Inle Lake.

Marsupium and glochidium were described by Prashad (1918) and its anatomy was worked out by E. N. Ghosh (1919).

Subgenus **Physunio**

236. **Physunio ferrugineus** Annandale, 1918

Physunio ferrugineus Annandale, 1918, *Rec. Indian Mus.*, **14:** 139, pl. xix, figs.4-9. Type locality: Semi-liquid mud at the bottom of the central region of the Inle Lake.

Type: ZSI Regd. No. M 11296/2

Distribution: Inle Lake, Burma. (In about 7 to 12 feet deep water).

Remarks: Shell larger, thinner, wing better developed, a pair of strong ridges, surface covered with finer and more regular striae.

237. **Physunio (Physunio) micropteroides** Annandale, 1918 (Figs. 420, 421)

Physunio micropteroides Annandale, 1918, *Rec. Indian Mus.*, **14:** 139, pl. xix, figs. 1-3. Type locality: Sluggish streams on the Yawnghwe plane, in dense mud in about 3 feet of water.

Type: ZSI Regd. No. M 11084/2

Distribution: Streams of Yawnghwe (In 3 feet deep water).

Remarks: Shell suboval, elongate, a broad and low blunt wing, a pair of low diverging ridges, coarse and irregular transverse striae.

Subgenus **Velunio** Haas, 1914

Type species : *Unio velaris* Sowerby

Shell compressed, well developed wing, umbones incurved forwards.

238. **Physunio (Velunio) velaris** (Sowerby, 1868)
(Figs. 416, 417)

Unio velaris Sowerby, 1868, in Reeve's *Conch. Icon.*, **16**: *Unio* pl. 72, fig. 368. Type locality: Assam.

Physunio (*Lens*) *velaris:* Simpson, 1900, *Proc. U.S. natn. Mus.*, **22**: 831. Preston, 1915, *Fauna Brit. India,* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 149.

Types: BM (NH).

Distribution: Assam.

Remarks: Shell thin, compressed, pale green, neither radiated nor sculptured, anterior extremity very narrow, ventral margin arcuated, rising abruptly anteriorwards; umbones prominent.

Family 16. AETHERIIDAE Swainson, 1840

Shell nacreous and irregular. In adult condition fixed to the substratum, either by right or left valve, inequivalve. Shell substance foliaceous or lamellar and covered by thick, olive coloured, deciduous periostracum, hinge endentulous, anterior adductor muscle impression lacking in some. Foot generally absent and labial palps large.

South America, tropical Africa, Madagascar and India.

Of the three genera viz. *Aetheria* Lamarck, 1807, *Barlettia* A. Adams, 1866 and *Acostaea* d'Orbigny, 1851, the first one is restricted to Africa and Madagascar, the second one to South America and the third one is distributed in South America and India.

Genus 47. **Acostaea** d' Orbigny, 1851.

Type species : *Mulleria lobata* Ferussac, 1823

Shell attached by right valve, inequivalve and covered by thick periostracum, umbones very much elongate, anterior adductor muscle lacking in adult attached state, but present in young free state.

Divided into two subgenera viz. *Acostaea* s. str. and *Pseudomulleria* Anthony, 1907 restricted to South America and India respectively.

Subgenus **Pseudomulleria** Anthony, 1907

Type species : *Mulleria dalyi* E. A. Smith, 1898.

Shell irregularly quadrate and without any distinct anterior projection, the anterior adductor muscle absent. Not known in fossil state.

239. **Acostaea (Pseudomulleria) dalyi** E. A. Smith, 1898. (Figs. 438, 439)

Mulleria dalyi Smith, 1898, *Proc. malac. Soc. Lond.*, **3**: 14. Text fig. Type locality: "Probably near Mudgiri, Kadur Dist." Karnataka. Woodward, 1898, *Proc. malac. Soc. Lond.*, **3**: 87, text figs. (Anatomy). Preston, 1915, *Fauna Brit. India*, Mollusca. (Freshwater Gastropoda and Pelecypoda), p. 197.

Types: BM (NH).

Distribution: Western Ghats. Preston (1915), probably based on the original reference, gave Kadur in Karnataka State as its locality, but the collection in Zoological Survey of India are from Taloshi, Koyna Valley, Satara district, Maharashtra.

Remarks: Shell irregularly quadrate, periostracum rich deep brown or blackish-brown, nacre mixture of white, bluish, greenish, olive and pinkish tints, margin olive brown.

Woodward (1898) gave an account of its anatomy.

Family 17. MARGARITIFERIDAE Haas, 1940

Shell equivalve and generally compressed, umbonal cavities shallow, posterior lamellar teeth tending to be reduced. Gills without water tubes, partly free posteriorly, marsupium occupying all four gills.

Europe, North America and Asia.

Genus 48. **Margaritifera** Schumacher, 1816

Type species ; *Mya margaritifera* Linnaeus, 1758

Europe, N. America and Asia.

Subgenus **Margaritanopsis** Haas, 1910

Type species : *Unio laosensis* Lea, 1863

Shell elongate, compressed, kidney shaped, cardinals and posterior lamellar teeth with long interdental area.

South east Asia.

240. **Margaritifera (Margaritanopsis) laosensis** (Lea, 1863) (Figs. 546, 547)

Unio laosensis Lea, 1863, *Proc. Acad. nat. Sci. Philad.*, **7**: 190. Type locality: Laos mountains, Cambodia.

Margaritanopsis woodthorpi Godwin-Austen, 1919, *Rec. Indian Mus.*, **16**: 204, pl. 15, figs. 1—4. Type locality: Port Stedman, Shan States.

Margaritanopsis laosensis: Prashad, 1922, *Rec. Indian Mus.*, **24**: 93, pl. ii, figs. 1-4.

Margaritanopsis laosensis: Brandt, 1974, *Arch. Moll.*, **105**: 261.

Types: ANSP (Paratype), USNM (Holotype)

Distribution: Burma, Siam and Cambodia.

Remarks: Shell rhomboidal, thick, ventral margin arcuate, right valve with two cardinals, anterior thick and knob-like, the posterior elongated and anteriorly raised into a trigonal tooth-like structure, one lateral, left valve with a single cardinal divided into two parts, two laterals.

Family 18. CORBICULIDAE

Shell rounded-triangular to oval, thick, concentrically striated or ribbed, strong fibrous periostracum, yellow, green or brown, hinge with three cardinal teeth in each valve, and one or two laterals, ligament strong, external, pallial sinus absent or when present shallow.

Foot large, siphonal openings prolonged into small tubes, orifices with or without papillae, two pairs of gills, outer pair smaller than the inner one, the latter serving as brood pouch.

South America, Africa, Asia and Australia.

Four genera, namely *Geloina, Villorita, Batissa* and *Corbicula* are included. The last mentioned is a primary freshwater genus, the rest being primarily estuarine, often extending into coastal freshwaters.

Key to the genera

1. Shell less than 5 cm. in length, strongly and evenly ribbed, hinge with serrated lateral teeth ..... **Corbicula**
   Shell large, adult shell more than 5 cm., ribs not even, lateral teeth not serrated 2

2. Lateral teeth transversely grooved, umbonal region little inflated ..... **Batissa**
   Lateral teeth smooth, umbonal region much inflated 3

3. Shell deeply trigonal, higher than long ..... **Villorita**
   Shell longer than high ..... **Geloina**

Genus 49. **Corbicula** Megerle von Muehlfeld, 1811

Corbicula Megerle von Muehlfeld, 1811, *Mag. Gesell. Naturf. Berlin*, **5**: 56.

Type species: *Tellina fluminalis* Mueller, 1774 (designated, ICZN, 1955).

Shell subtrigonal, thick, with strong, concentric ribs, umbones prominent and central, ligament prominent and external, hinge with three cardinal teeth in each valve, lateral teeth elongated, compressed, lamelliform, finely serrated, right valve with two laterals on each side, left with one on each side, pallial line mostly without sinus.

Mantle margin with papillae, siphons very short and close, orifices without papillae.

Asia, Africa and Australia.

Prashad (1928) revised the Asiatic species including those from India. The same author (1920) described the anatomy of *Corbicula fluminalis* (Mueller).

241. **Corbicula annandalei** Prashad, 1928
(Figs. 558 G. H.)

Corbicula annandalei Prashad, 1928, *Mem. Indian Mus.*, **9**: 22, pl. iv, figs. 11, 12. Type locality: Varkalay, Kerala.

Types: ZSI Regd. No. M 5253/1 (Holotype).

Distribution: Not known beyond Type-locality.

Remarks: Shell rather thin, small (14 mm), somewhat trigonal, dorsal margin with a steep slope on the anterior side, ventral margin slightly arched, umbones prominent, greatly inflated and curved forwards, periostracum shining light yellow, regular and concentric striae, hinge very feeble.

242. **Corbicula arata** (Sowerby, 1878)
(Figs. 563, 564)

Cyrena arata Sowerby, 1878, in Reeve's *Conch. Icon.*, **20**: *Cyrena*, pl. 17, fig. 93. Type locality: Tenasserim, Lower Burma.

Corbicula arata: Prashad, 1928, *Mem. Indian Mus.*, **9**: 26, pl. iv. figs. 17-20.

Types: BM (NH)

Distribution: Lower Burma, Thailand.

Remarks: Shell thin, trigonal, greatly inflated, obliquely and narrowly truncate, dorsal margin greatly arched, ventral margin evenly rounded in the anterior half and then suddenly curving, umbones prominent, inflated, anteriorly situated, periostracum deep shining yellow, concentric ridges fewer, widely separated, distinctly raised, nacre creamy white or purple in adults.

243. **Corbicula assamensis** Prashad, 1928
(Figs. 561, 562)

Corbicula assamensis Prashad, 1928, *Mem. Indian Mus.*, **9**: 22, pl. iii, fig. 12. Type locality: Phenchooganj, Sylhet, Bangladesh.

Types: ZSI Regd. No. M 3986/1 (Holotype).

Distribution: Assam, Bangladesh.

Remarks: Shell thin, small (12.2 mm.), ovate or triangularly ovate, dorsal margin regularly arched, convex, anterior side short and rounded, posterior broad and truncate, ventral margin regularly arched ending in a truncated beak posteriorly, umbones slightly marked, inconspicuous, striae regular, concentric, distinct but not deep, shining light yellow colour.

It is allied to *C. striatella* but distinguished from it in its thin shell, weak sculpture, hinge and general form of shell.

244. **Corbicula bensoni** Deshayes, 1854
(Figs. 565, 566)

Corbicula bensoni Deshayes, 1854, *Proc. zool. Soc. Lond.*, p. 345. Type locality: Bengal. Prashad, 1928, *Mem. Indian Mus.*, **9**: 23, pl. iv, figs. 1-4.

Corbicula tribeniensis Preston, 1911, *Rec. Indian Mus.*, **6**: 40, fig. 3. Type locality: Tribeni near Calcutta.

Distribution: West Bengal: Calcutta; Bihar: Bhagalpur; Bangladesh: Chittagong.

Remarks: Shell subtringonal, thin, striae fine and microscopic.

245. **Corbicula cashmiriensis** Deshayes, 1854.
(Figs. 567, 568)

Corbicula cashmiriensis Deshayes, 1854, *Proc. zool. Soc. Lond.*, p. 344. Type locality: Kashmir. Prashad, 1928, *Mem, Indian Mus.*, **9**: 20, pl. iii, figs. 14—18.

Types: BM (NH).

Distribution: Restricted to Kashmir.

Remarks: Shell rather trigonal, dorsal margin sloping and almost straight on either side of the umbones, ventral margin evenly arched, ending posteriorly in a distinct truncated beak in full grown specimens, sculptured with prominent and raised ribs, hinge broad and strongly developed.

246. **Corbicula iravadica** Blanford, 1880
(Figs. 571, 572)

Corbicula iravadica Blanford, 1880, *J. Asiat. Soc. Beng.*, **49**: 221. Type locality: "Ad Mandelay, Urban capitalem regni Avae." Prashad, 1928, *Mem. Indian Mus.*, **9**: 25, pl. iv, figs. 7-10.

Distribution: Upper Burma; North Thailand.

Remarks: Shell rather thin, dorsal slope slightly arched anteriorly, ventral margin distinctly arcuate anteriorly, posteriorly short and evenly arched, umbones prominent, the lunule and the escutcheon regions distinctly marked off by a darker colour, two valves raised as narrow wing in the middle of the escutcheon, striae may be absent or develop into distinct ribs.

247. **Corbicula krishnaea** Ray, 1967
(Figs. 569, 570)

Corbicula krishnaea Ray, 1967, *Arch. Moll.*, **96**: 191, figs. 1, 2. Type locality: Krishna River, near Sangli, Pune, Maharashtra.

Type: ZSI Regd. No. M 17807/3 (Holotype).

Distribution: No subsequent report.

Remarks: Shell thin, small, triangularly ovate, inequilateral, anterior side narrow and more produced, posterior side broader and shorter, umbones prominent, slightly tumid, striae regular and distinct, escutcheon bearing distinct ribs, hinge plate well developed.

248. **Corbicula noetlingi** von Martens, 1899
(Figs. 559, 560)

Corbicula noetlingi von Martens, 1899, *Arch. Naturgesch.*, p. 47, pl. iv, figs. 7-9. Type locality: Small pool near H. Paung in the Northern Shan States. Annandale, 1918, *Rec. Indian Mus.*, **14**: 141, pl. xix, fig. 12. Prashad, 1928, *Mem. Indian Mus.*, **9**: 24, pl. iv. figs. 21-25.

Distribution: Widely distributed in the Northern and Southern Shan States, Burma; Thailand.

Remarks: Shell elongate ovate to subtrigonal, slightly inflated, broadly rounded anteriorly, narrowly truncate posteriorly, dorsal margin greatly arched anteriorly, nearly straight posteriorly, ventral margin slightly arched, umbones prominent, not inflated, anteriorly situated, periostracum olive yellow to brown or even black, sculptured with numerous distinctly raised concentric ridges, with broad interspaces.

249. **Corbicula peninsularis** Prashad, 1928
(Figs. 583, 584)

Corbicula peninsularis Prashad, 1928, *Mem. Indian Mus.*, **9**: 21, pl. iv. figs. 13-16. Type locality: Bombay.

Type: ZSI Regd. No. M 12833/2 (Holotype).

Distribution: Not known beyond type locality.

Remarks: Shell thick, large (30 mm.), ovately triangular, dorsal margin, very convex, posteriorly drawn out into a regular beak-like structure, umbones prominent, tumid, periostracum glossy, chocolate brown colour, concentric, regular, broad and shallow ribs, pallial line distinctly notched, hinge strongly developed, anterior laterals shorter than the posterior ones.

250. **Corbicula solida** Clessin, 1887
(Figs. 577, 578)

Corbicula solida Clessin, 1887, *Mal. Blatt.*, (n.f.) **9**: 76, pl. iii, fig. 1. Type locality: Sri Lanka. Prashad, 1928, *Mem. Indian Mus.*, **9**: 27.

Type: BM (NH).

Distribution: Sri Lanka.

Remarks: Shell small, thick, triangular, anteriorly rounded, posteriorly subtruncate, dorsal margin angulate, ventral very arched, striations regular and fine, periostracum light olive green.

251. **Corbicula striatella** Deshayes, 1854.
(Figs. 575, 576)

Corbicula striatella Deshayes, 1854, *Proc. zool. Soc. Lond.*, **22**: 344. Type locality: Pondicherry. Prashad, 1928, *Mem. Indian Mus.*, **9**: 18, pl. iii, figs. 9—11.

Corbicula subradiata Prime, 1861, *Proc. Acad. Nat. Sci. Philad.*, p. 128. Prashad, 1921, *Rec. Indian Mus.*, **22**: 613.

Types: BM (NH).

Distribution: Commonest Indian species and occurs throughout India, Pakistan, Peshawar, Sindh and Burma.

Remarks: Shell thick, large (22.7 to 42.3 mm), tumid, triangular ovate to ovate, dorsal margin arched, more on the anterior side than on the posterior, umbones prominent, periostracum shining lemon yellow in young, darker and often brownish in full grown specimens, striae regular, concentric and raised into ridges, pallial line with a trace of sinus, muscle scars fairly deeply developed.

252. **Corbicula subnitens** Clessin, 1887

Corbicula subnitens Clessin, 1887, *Mal. Blatt.* (n.f.) **9**: 77, pl. iii, fig. 5. Type locality: Sri Lanka. Prashad, 1928, *Mem. Indian Mus.*, **9**: 27, pl. iii, fig. 13.

Type: Not found (Prashad, 1928).

Distribution: Sri Lanka.

Remarks: Shell moderately thick, rather triangular, dorsal margin arched, umbones central, periostracum dark olive-yellow, thick, distinct, concentric and regular ribs.

253. **Corbicula sylhetica** Preston, 1908
(Figs. 573, 574, 579, 580)

Corbicula sylhetica Preston, 1908, *Rec. Indian Mus.* **2**: 47. Type locality: Phenchooganj, Sylhet, Bangladesh. Prashad, 1928, *Mem. Indian Mus.*, **9**: 24, pl. iv, figs. 5, 6.

Types: ZSI Regd. No. M 16950/2 (Syntypes).

Distribution: Not known beyond type locality.

Remarks: Shell tumid, subtrigonal, dorsal margin sloping, ventral margin rounded, umbones slightly prominent, striae fine and irregular. It is allied to *C. bensoni* Deshayes and *C. iravadica* Blanford.

254. **Corbicula tibetensis** Prashad, 1929
(Figs. 581, 582)

Corbicula tibetensis Prashad, 1929, *Mem. Indian Mus.*, **9**: 61, pl. viii, figs. 3-5. Type locality: Tibet.

Type: ZSI Regd. No. M 12837/2 (Holotype)

Distribution: Tibet.

Remarks: Shell thick, triangulately oval, olive brown colour, surface with concentric regular ribs, anterior side some what shorter than posterior. Umbones prominent, tumid, strong hinge, laterals compressed. According to Prashad (1929) the species is allied to *C. fluminea* on one hand and to *C. cashmiriensis* on the other.

Genus 50. **Villorita** Griffith and Pidgeon, 1934

Villorita Griffith and Pidgeon, 1934, *Animal Kingdom*, **12**: pl. xxxi, fig. 5.

Type species: *Cyrena cyprinoides* Gray, 1825.

Shell trigonal, thick, dorsal margin thick, umbones prominent, very distinct lunule, hinge with three oblique cardinal teeth in each valve, middle one well developed, anterior cardinal in the right and posterior cardinal in the left obsolete, two laterals, finely striate, anterior short and thick with a groove, posterior compressed, elongated and diverging, pallial line with a distinct but poorly developed sinus near the posterior adductor impression.

Mantle margin with a regular row of finger shaped papillae, anal siphon very much short, siphonal orifices papillose, foot triangular and rather large, inner pair of gills broader. Backwaters of South India.

Prashad (1921) discussed regarding the name and validity of the genus. He described the soft parts of *V. cyprinoides* (Gray).

Prashad (1921) recognised only three distinct species viz. *Villorita cyprinoides* (Gray), *V. corbiculoides* Prashad and *V. cornucopia* Prashad.

Key to species

1. Shell higher than long 2

   Shell longer than high ..... *V. corbiculoides*

2. Lunule very short and even absent ..... *V. cornucopia*

   Lunule narrow but always present ..... *V. cyprinoides*

255. **Villorita corbiculoides** Prashad, 1927.
(Figs. 585, 586)

Villorita corbiculoides Prashad, 1927, *Rec. Indian Mus.*, **29**: 284, text fig. 1 a-d. Type locality: Bombay.

Types: ZSI Regd. No. M 12703/2 (Holotype). Paratypes in MNHN

Distribution: Bombay.

Remarks: Shell trigonal, moderately thick, more elongate, periostracum shining yellow to light brown, anterior margin short, regularly curved, ventral margin greatly arched, posteriorly developing into an acuminate beak, concentric ridges on the surface, umbones slightly anterior, recurved forwards and inwards almost touching the hinge line, ridges prominent in the umbonal region, hinge weakly developed, laterals elongate and relatively thinner, pallial line slightly arched with a distinctly marked sinus.

256. **Villorita cornucopia** Prashad, 1921.
(Figs. 589, 590)

Villorita cornucopia Prashad, 1921, *Rec. Indian Mus.*, **22**: 118, pl. xv, figs. 11-14. Type locality: Komarakam, Vembanad Backwaters, Kerala.

Types: ZSI Regd. No. M 11896/2.

Distribution: Kerala backwaters, occasionally found in freshwaters.

Remarks: Shell very high and comparatively narrow, dorsal margin broadly arched, anterior margin long and regularly curved, posterior margin much longer than the anterior, ventral margin almost straight, umbones comparatively broad and high and recurved umbonal region with coarse concentric ridges, ligament very long and thick.

257. **Villorita cyprinoides** (Gray, 1825)
(Figs. 587, 588, 591, 592)

Cyrena cyprinoides Gray, 1825, *Annals of Philosophy*, ns. **9**: 136. Type locality: Backwaters of Kerala.

Villorita cyprinoides: Prashad, 1921, *Rec. Indian Mus.*, **22**: 114, pl. xv, figs. 1-4.

Types: BM (NH).

Distribution: Backwaters of Kerala.

Remarks: Shell fairly large, thick, anterior margin short, regularly curved above, almost straight in the middle, then with a rapid curve and meeting the ventral border, the latter curving upwards and meeting the posterior margin, the posterior margin nearly straight, much larger than the anterior, with thick concentric ridges, umbones prominent, near the anterior side, recurved, a large, thick external ligament posteriorly.

Prashad (1921) distinguished two varieties, viz. *V. cyprinoides* var. *cochinensis* (Hanley) and *V. cyprinoides* var. *delicatula* Preston. The distribution of the varieties is same as that of typical form. The two varieties differ from each other and the typical form only in the general shape of the shell and in hinge teeth.

Genus 51. **Batissa** Gray, 1853.

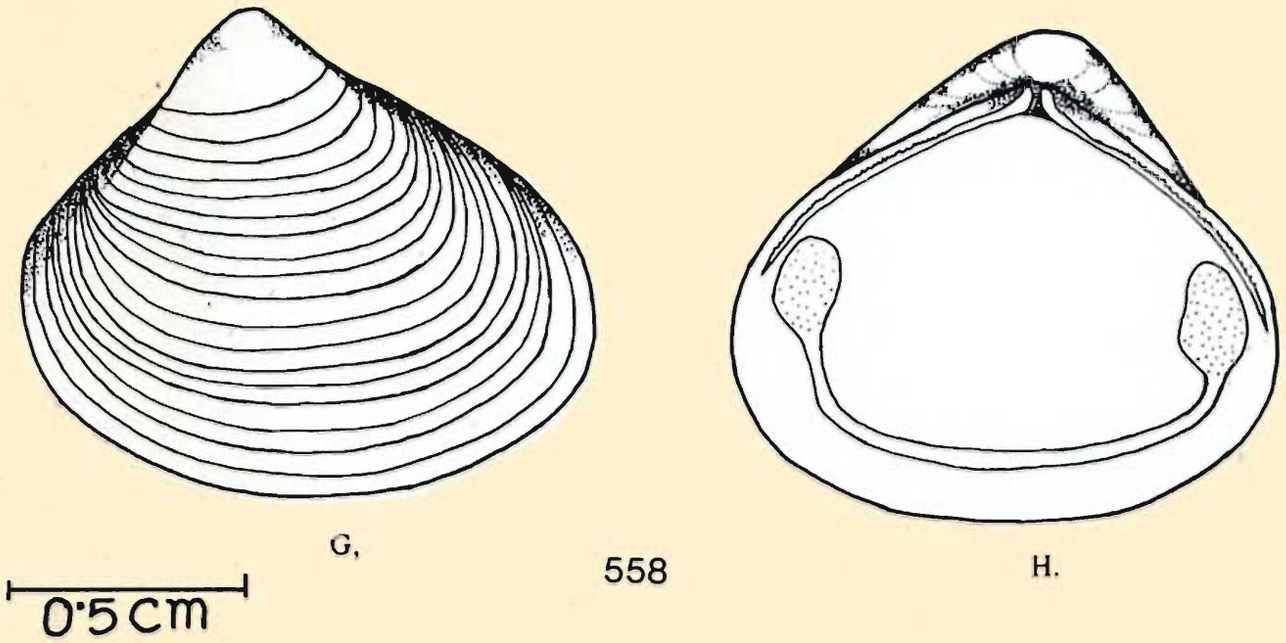
Batissa Gray, 1853, *Ann. Mag. nat. Hist.*, **11**: 38.

Type species: *Cyrena tenebrosa* Hinds 1842, SD Stoliczka, 1871.

Shell roundedly ovate or subtrigonal, solid, thick, inequilateral, surface rough but without regular ridges, generally black in colour, anterior region short, regularly curved, posterior region much longer, umbones prominent, anteriorly placed, recurved forwards and inwards, but never touching each other in the middle, strong external ligament, hinge with three divergent cardinal teeth in each valve and two curved lateral teeth, the latter unequal, and serrated.

Pallial impression simple or subsinuous, mantle lobes simple or fringed, two short siphons, united at their bases.

Andaman and Nicobar Islands and Indonesia. Backwaters, may extend into freshwaters.



Figs. 558 G, H. *Corbicula annandalei,* Paratype, 12.20 × 10.65 mm., Kerala.

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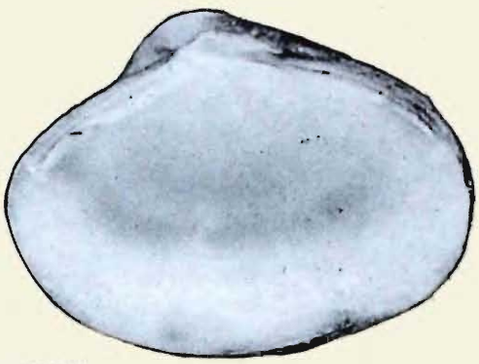

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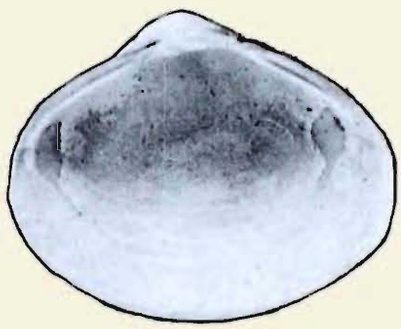

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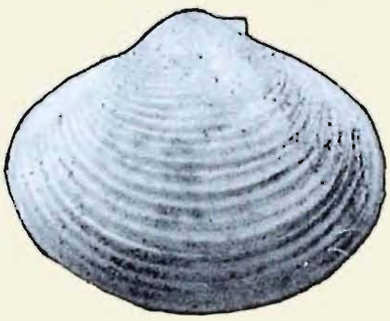

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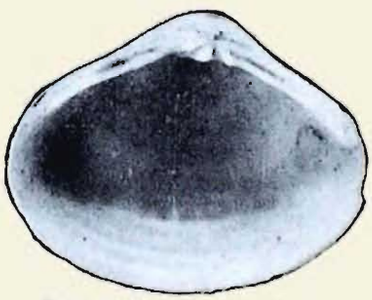

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Figs. 559, 560. *Corbicula noetlingi*, 32.10 × 25.0 mm, Burma. 561, 562. *C. assamensis*, Holotype, 12.10 × 9.25 mm, Sylhet. 563, 564. *C. arata*, 19.10 × 15.05 mm, Burma. 565, 566. *C. bensoni*, 8.65 × 6.80 mm, West Bengal.

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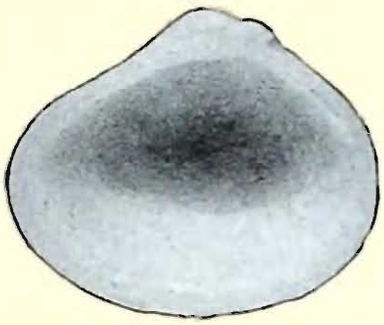

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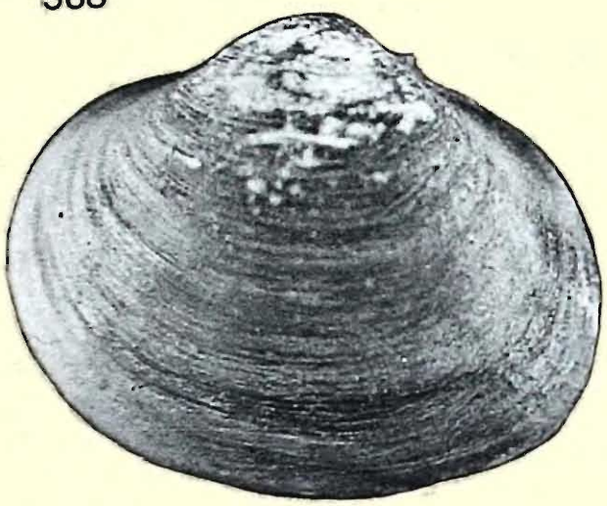

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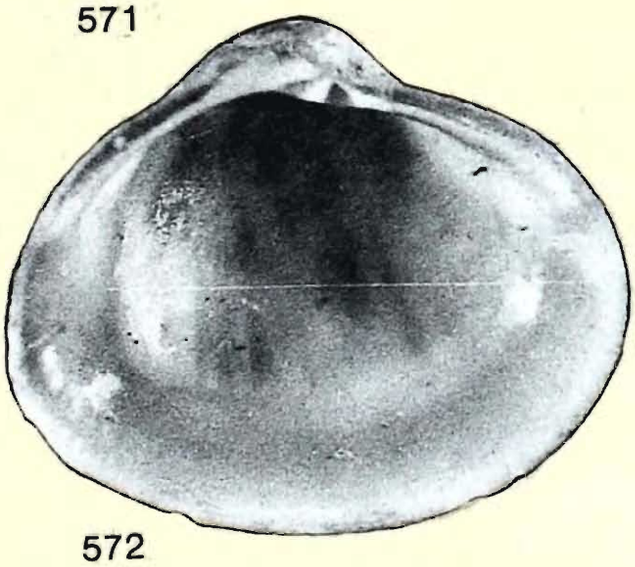

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Figs. 567, 568. *Corbicula cashmiriensis*, 48.10 × 40.0 mm., Wular Lake, Kashmir. 569, 570. *C. krishnaea*, Holotype, 11.60 × 5.55 mm., Maharashtra. 571, 572. *C. iravadica*, 10.05 × 7.75 mm., Burma. 573. 574. *C. sylhetica*. Cotype, 11.15 × 9.65 mm., Sylhet.

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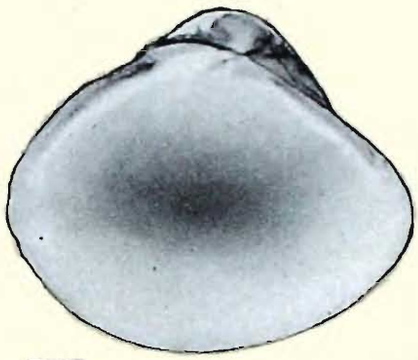

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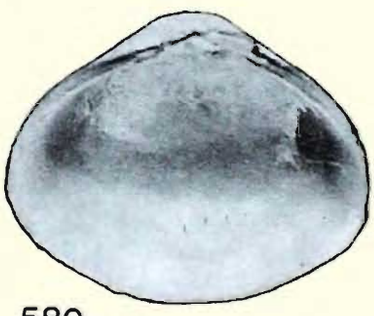

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Figs. 575, 576. *Corbicula striatella*, 22.15 × 18.60 mm., Uttar Pradesh. 577, 578. *C. solida*, 29.50 × 26.55 mm. 579, 580. *C. sylhetica*, Holotype, 12.10 × 11.70 mm., Sylhet. 581, 582. *C. tibetensis*, Holotype, 22.85 × 21.25 mm., Tibet.

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Figs. 583, 584. *Corbicula peninsularis*, Holotype, 28.10 × 24.70 mm., Maharashtra.

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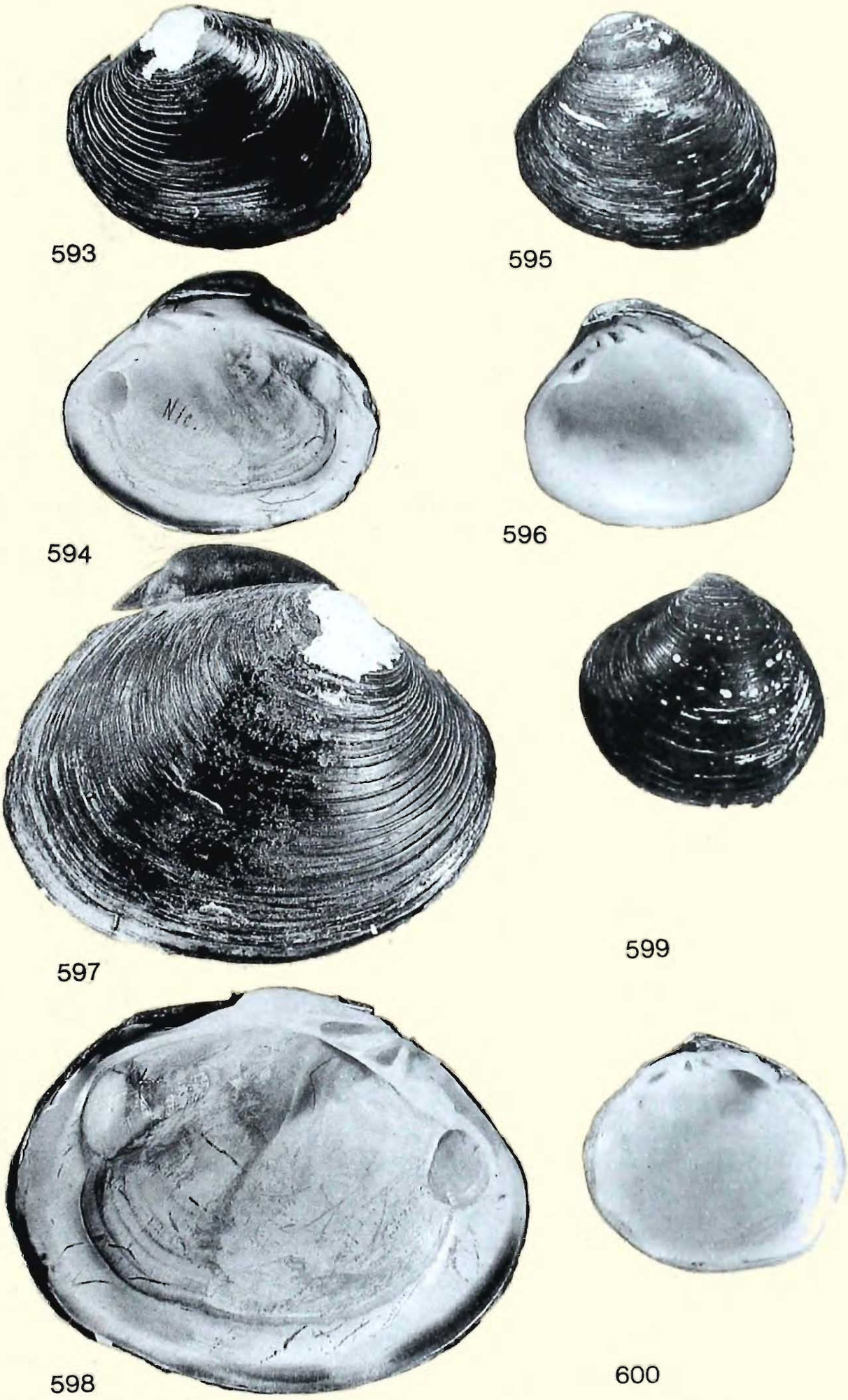
Figs. 585, 586. *Villorita corbiculoides*. Holotype, 29.80 × 25.30 mm., Bombay. 587, 588. *V. cochinensis*. Type, 4.65 × 4.40 mm., Cohin. 589, 590. *V. cornucopia*, 31.40 × 41.95 mm., Travancore. 591, 592. *V. cyprinoides*, 36.95 × 36.50 mm., Malabar.



Figs. 593, 594. *Geloina bengalensis*, 60.0 × 53.50 mm., West Bengal. 595, 596. *G. erosa*, 54.80 × 48.85 mm., Nicobars. 597, 598. *Batissa similis*, 111.5 × 91.40 mm., Nicobars. 599, 600. *G. galathea*, 75.35 × 69.15 mm; Nicobars.

Prashad (1921) studied the soft parts and discussed the Indian species of the genus. He recognised two species viz. *Batissa similis* Prime and *Batissa inflata* Prime.

258. **Batissa inflata** Prime, 1860

Batissa inflata Prime, 1860, *Proc. zool. Soc. Lond.*, p. 320. Type locality: Nicobars. Prashad, 1921, *Rec. Indian Mus.*, **22**: 149, fig. 2b.

Distribution: Andaman and Nicobar Islands.

Remarks: Differs from *B. similis* in the following: Shell more oblique, inflated, anterior margin shorter and more slanting, posterior margin more curved and not biangulate, hinge much more arched, teeth comparatively smaller, broader and coarser, laterals more serrate, cardinals sharper.

259. **Batissa similis** Prime, 1859
(Figs. 597, 598)

Batissa similis Prime, 1859, *Ann. Lyceum Nat. Hist. Soc.*, New York, **7**: 112. Type locality: Nicobars. Prashad, 1921, *Rec. Indian Mus.*, **22**: 147, fig. 2a.

Distribution: Andaman and Nicobar Islands.

Remarks: Shell very thick, anterior side shorter, posterior side much longer, biangulated distally, umbones anterior, hinge with two laterals, both serrated along upper inner margin, three cardinals, areas between the teeth deeply canaliculate.

Prashad (1921) synonymised *B. capillata* Preston with this species.

Genus 52. **Geloina** Gray, 1842

Geloina Gray, 1842, *Synopsis Brit. Mus.*, p. 75.

Type species: *Cyrena zeylanica* Lamarck, 1818. (= *Venus coaxans* Gmelin, 1791, SD Gray, 1847).

Shell medium to large, comparatively thinner than in *Batissa* and *Villorita*, oval to subtrigonal, rather convex, periostracum generally brownish-green or yellow, without conspicuous ribs, umbones prominent, almost central and incurved, cardinal teeth three in each valve, lateral teeth smooth and short, two in left valve and four in right valve, pallial line entire.

Gills unequal in size, triangular labial palps.

India, Sri Lanka, Malay Archipelago, Phillippines and Australia. Estuarine or backwater, may extend into freshwater.

Prashad (1921) studied and revised the Indian species of the genus *Cyrena* (*Geloina*). Prashad (1932) reported three species from the Siboga collections. The species are very variable and "specimens even from the same locality differ in form, sculpture and thickness of shells" (Prashad, 1932). The examination of collection in ZSI, has also proved the veracity of above statement. He included *Geloina* and *Batissa* under a separate family Geloinidae. Pending a final revision of this genus, the following two species have been provisionally recognised.

G. erosa (Solander) and *G. bengalensis* (Lamarck)

260. **Geloina bengalensis** (Lamarck, 1818)
(Figs. 593, 594)

Cyrena bengalensis Lamarck, 1818, *Hist. Nat. Anim. Sans, Vert.*, **5**: 554. Type locality: "Au Bengale, dans les rivieres."

Geloina bengalensis: Prashad, 1932, *Siboga Expedition, Pelecypoda,* 53 C: 175.

Distribution: Wide range in the Indo-Pacific region.

Remarks: Shell solid, subtrigonal, tumid, thick, inequilateral, periostracum blackish-brown, coarsely striated, posterior side produced, dorsal margin very small with a long slope, truncated at the end, anterior margin very short, posterior margin very long, high, markedly convex, umbones anterior.

Prashad (1932) opined that the *Cyrena sinuosa* Deshayes and *Cyrena impressa* Deshayes should be referred to *Geloina bengalensis.*

261. **Geloina erosa** (Solander, 1786)
(Figs. 595, 596, 599, 600)

Venus erosa Solander, 1786, *Portland Catalogue,* pp. 71, 186.

Geloina erosa: Prashad, 1932, *Siboga Expedition, Pelecypoda,* 53c: 174.

Distribution: Indo-Pacific, backwaters and estuaries.

Remarks: Shell large, solid, subtrigonal, inequilateral, periostracum thin and yellow or thick and a little brown, striae indistinct and in smaller specimens fringed, posterior side obtusely two angled, flattened, anterior side rather short.

Prashad (1932) gave an extensive synonym. *Cyrena ceylonica* (Chemnitz) and *C. galatheae* (Moerch) mentioned by Preston may be synonyms of this species.

Family 19. PISIDIIDAE Gray, 1857

[ICZN, 1955, name corrected ex. Pisidiadae — Cycladidae Forbes & Hanley, 1853; Sphaeriidae Jeffreys, 1862]

Shell small to minute, oval or quadrate, concentrically striated or ribbed, ligament partially to completely internal, hinge plate narrow, in each valve one or two small cardinals, those of right valve straight, right valve with two lateral teeth on either side, left with one anterior and one posterior.

Mantle flaps separate, posteriorly one or two short siphons, one or two gills on either side, inner pair of gills serve as marsupium, hermaphrodites.

The family includes three cosmopolitan genera, namely *Sphaerium* Scopoli, 1777, *Musculium* Link, 1807 known as fingernail clams and *Pisidium* C. Pfeiffer, 1821, known as pill clams. The genus *Musculium* is not recorded from India.

Key to the genera

1. Posterior end of the shell longer than anterior end, beaks anterior, or if subcentral on the anterior side of the centre ..... **Sphaerium**

   Anterior end of the shell longer than posterior end, beaks posterior or if subcentral on the posterior side of the centre ..... **Pisidium**

Genus 53. **Sphaerium** Scopoli, 1777

Sphaerium Scopoli, 1777, *Introductie ad Historiam Naturalem*, p. 397.

Type species: *Tellina cornea* Linnaeus, (ICZN opinion 94).

Shell oval or bluntly triangular, rather solid and concentrically striate, with nearly median beaks, without projecting caps.

Branchial and anal siphons short and fused at their bases, embryos develop in each anterior gill in several thin walled longitudinal sacs, byssal gland absent.

Subgenus *Sphaerium* s. str.

Beaks rounded, not set off by projecting caps.

Holarctic, Africa,

Represented by five species in India and Burma. All in stagnant waters.

Key to the species

1. Umbones prominent, capped with the embryonic shell, cardinal teeth weakly developed 2

   Umbones less prominent and not capped, hinge stronger ..... *S. indicum*

2. Shell large, 9.5 mm in length, very much tumid, with strong concentric striations ..... *S. avanum*

   Shell smaller and not very tumid, less strong concentric striae 3

3. Shell elongate ovate, rather thick and opaque, umbones more prominent projecting upwards and inwards ..... *S. austeni*

   Shell subquadrate, umbones less prominent 4

4. Shell with nearly straight and short anterior half of dorsal margin, posterior part somewhat longer, markedly sloping and truncate ..... *S. kashmirensis*

   Shell with almost equal anterior and posterior halves ..... *S. montana*

262. **Sphaerium (Sphaerium) austeni** Prashad, 1921
(Figs. 602-605)

Sphaerium austeni Prashad, 1921, *Rec. Indian Mus.*, **22**: 617, fig. 35. Type locality: Naga Hills.

Types: ZSI Regd. No. M 7141-8/2 (Syntypes).

Distribution: Nagaland, Manipur.

Remarks: Shell elongate ovate, swollen, anterior margin small and broadly rounded, posterior margin truncated and almost straight, umbones prominent and somewhat touching each other in the middle, shell smooth in young ones but with close-set concentric striae in the adult, dark horny to yellowish brown, nacre whitish to light blue. Right valve with two lamellar teeth, lower well developed, two cardinals, anterior large and triangular, posterior small and rounded, left with a single lateral on each side, two cardinals, anterior rounded and pad-like, posterior small, thin and lamellar.

263. **Sphaerium (Sphaerium) avanum** Theobald, 1873
(Figs. 606, 607)

Sphaerium avanum Theobald, 1873, *J. Asiat. Soc. Beng.*, **42** (2): 200, pl. 17, fig. 6. Type locality: Near Ava.

Distribution: Burma: Ava, Pegu.

Remarks: Shell quadrately round, anteriorly round and posteriorly truncate, equilateral, colour brownish yellow.

264. **Sphaerium (Sphaerium) indicum** Deshayes, 1854
(Figs. 600, 601, 611, 612)

Sphaerium indicum Deshayes, 1854, *Proc. zool. Soc. Lond.*, **22**: 342. Type locality: Rivers of India. Prashad, 1921, *Rec. Ind. Mus.*, **22**: 615, fig. 34.

Distribution: India: Plains and Himalayas.

Remarks: Shell inequilateral, right valve with a single well-developed cardinal, the second one when present very much reduced, laterals much better developed and less curved than in *S. austeni.* Mantle very thin and without any papillae on the edge.

Prashad (1921) gave an account of its soft parts.

265. **Sphaerium (Sphaerium) kashmirensis** Prashad, 1937.
(Figs. 608-610)

Sphaerium kashmirensis Prashad, 1937, *Rec. Indian Mus.*, **39** (3): 276, text. fig. 1. Type locality: Wular Lake, Kashmir. Rajagopal and Subba Rao, 1968, *Proc. Symposium on Mollusca*, Part. 1, p. 150.

Type: ZSI Regd. No. M 16951/2

Distribution: Kashmir.

Remarks: Shell moderately swollen and moderately thick, anterior half of dorsal margin short, nearly straight, posterior part somewhat longer, markedly sloping, slightly arched in the upper region, then sharply truncate, umbones very prominent, very tumid, incurved almost touching in the middle line. Shell shining and light olive-coloured, well marked and close-set striae.

266. **Sphaerium (Sphaerium) montanum** Tapparone Canefri, 1889 (Fig. 613)

Sphaerium montanum Tapparone-Canefri, 1889, *Ann. Mus. Civ. Stor. Nat. Genova,* **7** (2): 356. Type locality: Burma, Tenasserim. Prashad, 1921, *Rec. Indian Mus.*, **22:** 630, text fig. 36.

Types: Genova Museum.

Distribution: Burma.

Remarks: The species seems to be not very common. There is only one example in the National Zoological collections studied by Prashad (1921).

Genus 54. **Pisidium** Pfeiffer, 1821

Pisidium C. Pfeiffer, 1821, *Naturgeschichet Deutscher Land und Wasser-Schnecken,* Molluske *i,* pp. 17, 123, pl. 1. fig. 19; *ii,* 1825, p. 33; *iii,* 1828, p. 68.

Type species: *Tellina amnica* Mueller, 1774 Subsequent designation Gray, 1847, & ICZN opinion 335.

Preston, 1915, *Fauna Brit. India* Mollusca (Freshwater Gastropoda and Pelecypoda), p. 224. Prashad, *Rec. Ind. Mus.*, **22:** 618.

Shell small, ovoid to orbicular, equivalve, inequilateral, posterior side shorter and broader than the anterior side, more or less concentrically striate, thin, with olive horny periostracum, umbones prominent or tumidly obtuse, beaks posterior, ligament subexternal, lateral teeth double in right valve, single in left valve, cardinals two in left valve, one in right valve.

Mantle flaps with single siphonal canal, branchial siphon absent or represented by a mantle slit, embryos develop in each anterior gill in a thick-walled sac containing individual chambers for the embryos, byssal gland absent. Self fertilisation appears to be common.

Mud-dwelling clams, with certain grain size preferences (Meir-Brook, 1969).

Cosmopolitan, often occurring at considerable altitudes.

Prashad, (1925, 1933) dealt in detail on the species of *Pisidium* from India, Tibet, Yarkand, Persia and Syria. Kuiper (1962) dealt with the systematics of the genus. Dance (1967) reported on the species collected by the Mount Everest Expedition.

Subgenus **Pisidium** s.str.

267. **Pisidium (Pisidium) casertanum** (Poli, 1791)
(Figs. 617, 618)

Cardium casertanum Poli, 1791, *Test. Utr. Sicil.*, **1**: 65, pl. 16, fig. 1. Type locality: Sicily.

Pisidium hydaspicola Theobald, 1878, *J. Asiat. Soc. Beng.*, **47**: 147. Type locality: Stream near Shupion, Kashmir. Prashad, 1925, *Rec. Ind. Mus.*, **27**: 414, pl. VII & VIII.

Pisidium (*Pisidium*) *casertanum:* Brandt, 1974. *Arch. Moll.*, **105**: 329, pl. 30, fig. 4.

Distribution: India: Kashmir. Cosmopolitan

Remarks: Shell strong, subcordate, ovate, somewhat tumid, feeble but distinct concentric striae, more distinct in young shells than in the old, dorsal margin sloping regularly more along the anterior than on the posterior side, ventral margin nearly straight, juveniles yellowish, full grown shells deep yellow, darker olive bands, ligament pit long and deep extending to about the middle of the hinge plate.

Subgenus **Odhneripisidium**

268. **Pisidium (Odhneripisidium) annandalei** Prashad, 1925
(Figs. 621, 622)

Pisidium annandalei Prashad, 1925, *Rec. Ind. Mus.*, **27**: 420, pl. VII & VIII. Type locality: Pareshnath hill, Bihar (at an altitude of 1200 m.)

Types: ZSI Regd. No. M 7033—7034.

Distribution: Sicily, Greece, Israel, S. E. Asia and Indonesia.

Remarks: Shell small (2.6 mm), subtrigonal, thin, porcellaneous, slightly tumid, concentrically striated, close-set on the surface but less marked on the umbonal region, umbones not prominent, only slightly projecting, dorsal margin short, slightly arched with well marked shoulders on both anterior and posterior slopes, shining horny, ligament pit placed very far back starting from near the posterior end of the umbo.

269. **Pisidium (Odhneripisidium) appressum** Prashad, 1933

Pisidium appressum Prashad, 1933, *Rec. Indian Mus.*, **35**: 44, pl. 1, fig. 56. Type locality: Yarkand, W. Tibet.

Type: ZSI Regd. No. M 14258/2 (Holotype).

Distribution: Not known beyond type locality.

Remarks: Shell small (2.8 mm), subtrigonal ovate, thin, fragile, close set and thick striae all over the surface, umbones prominent, placed posteriorly, dorsal slope regularly arched on either sides, ligament pit less than half the length of the umbo.

Allied to *P. yarkandense* but differs from it in having more elongate shell, more prominent umbones, and markedly different hinge.

270. **Pisidium (Odhneripisidium) atkinsonianum** Theobald, 1876 (Figs. 625, 626)

Pisidium atkinsonianum Theobald, 1876, *J. Asiat. Soc. Beng.*, **45** (2): 189. Type locality: Jongla, Sikkim, at an altitude of 10,000 ft. Prashad, 1925, *Rec. Indian Mus.*, **27**: 417. pl. VII & VIII.

Distribution: Darjeeling, Sikkim.

Remarks: Shell medium-sized, orbiculately ovate, not much swollen, feebly striate in young, more distinct and irregular in adults, umbones slightly tumid, not prominent, dorsal margin sloping slightly with a well-marked shoulder on the posterior slope, anterior margin subtruncate, broadly arched, posterior margin short, rounded, juveniles yellowish, adults dirty-

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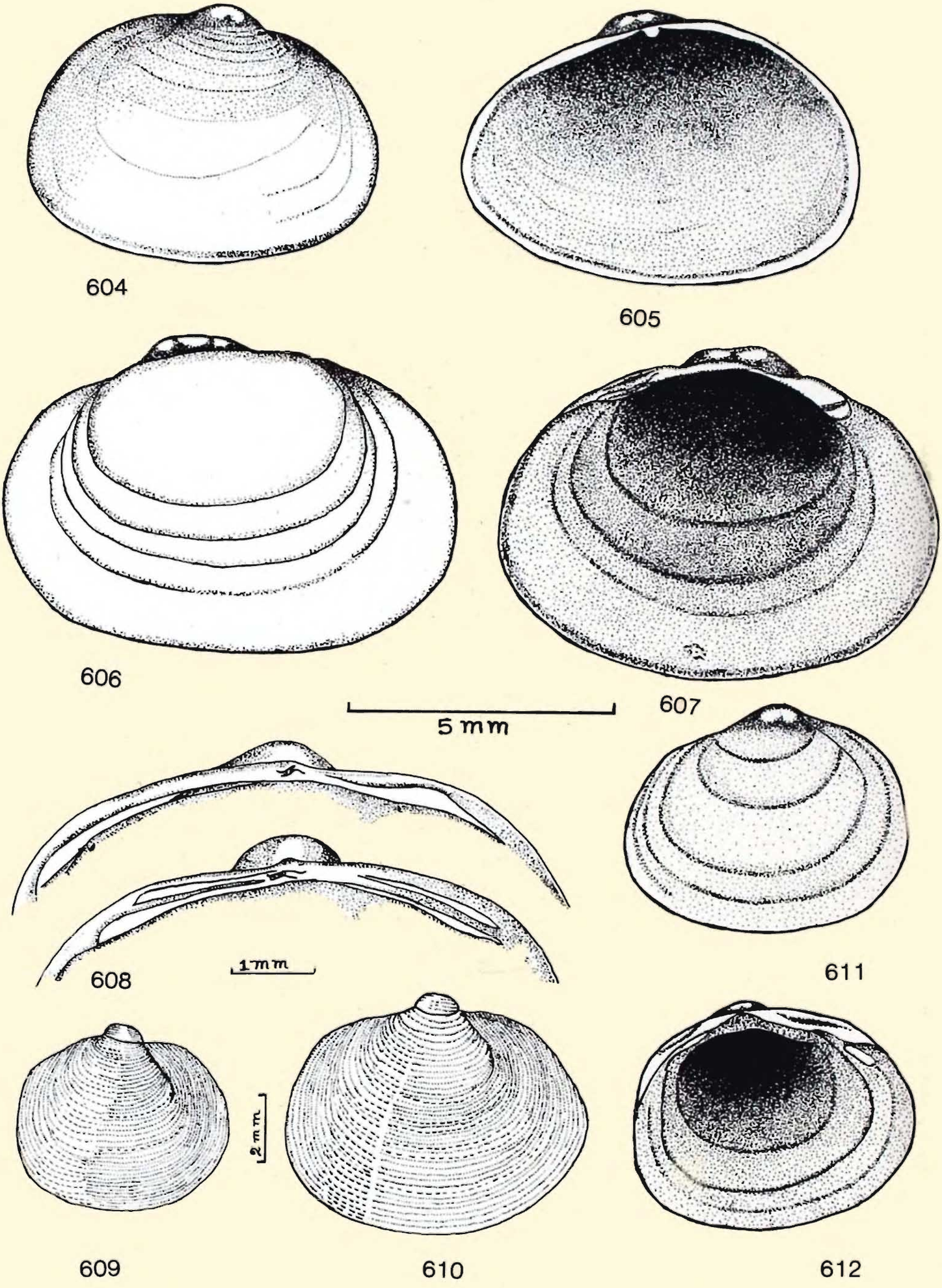
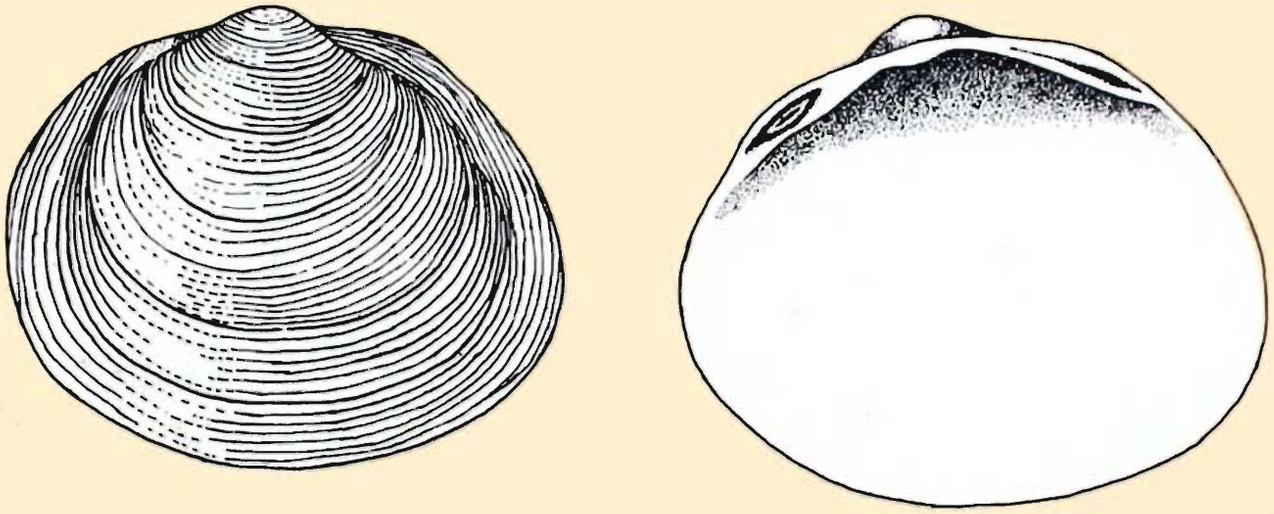
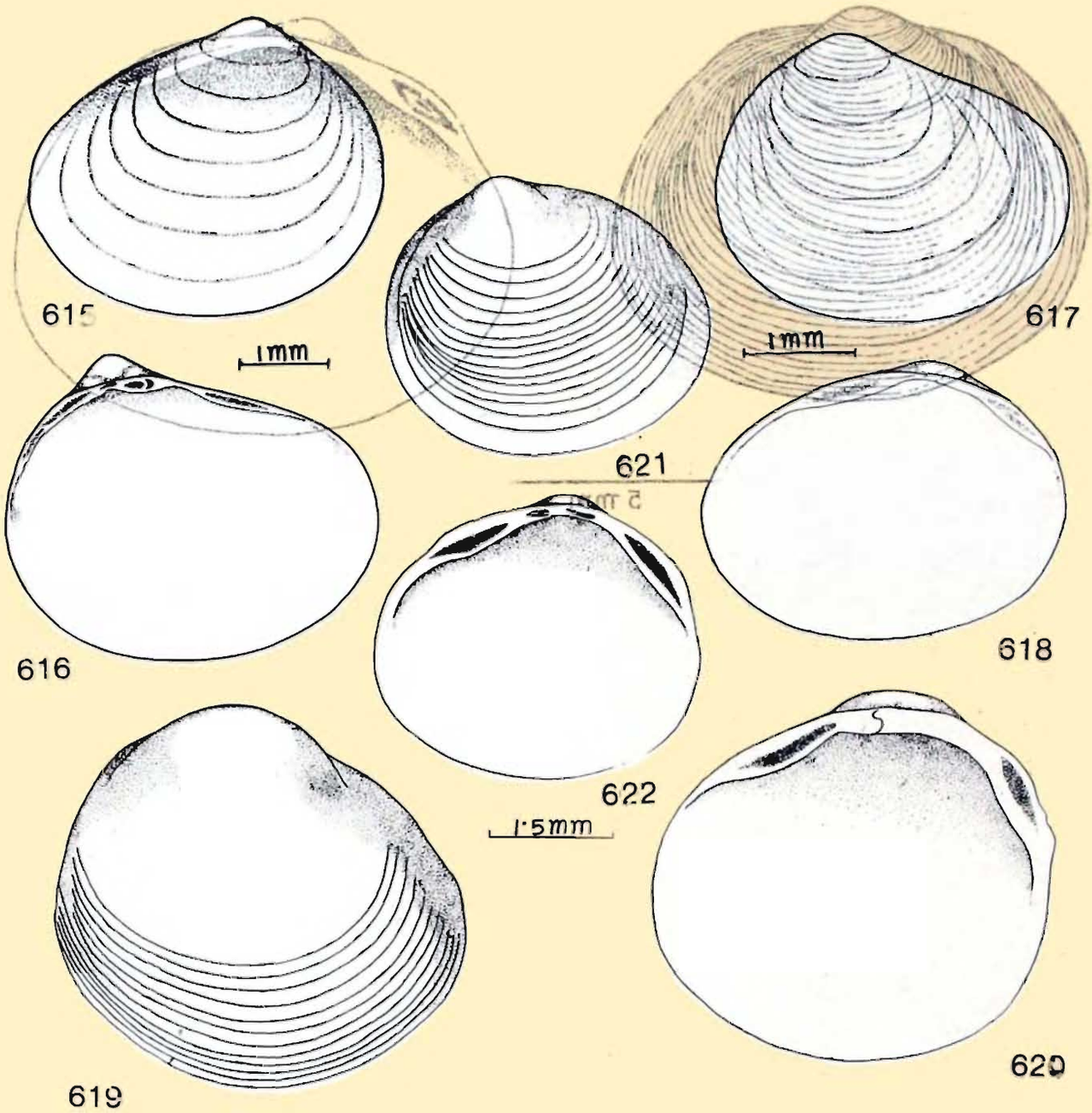
Figs. 600A. *On P. 213 under sp. no. 264 Figs. 600 to be read as 600A.*, 601. *Sphaerium indicum.* 7.10 × 5.55 mm., Bhimtal. 602, 603. *S. austeni,* Syntype, 6.25 × 4.55., Meghalaya.



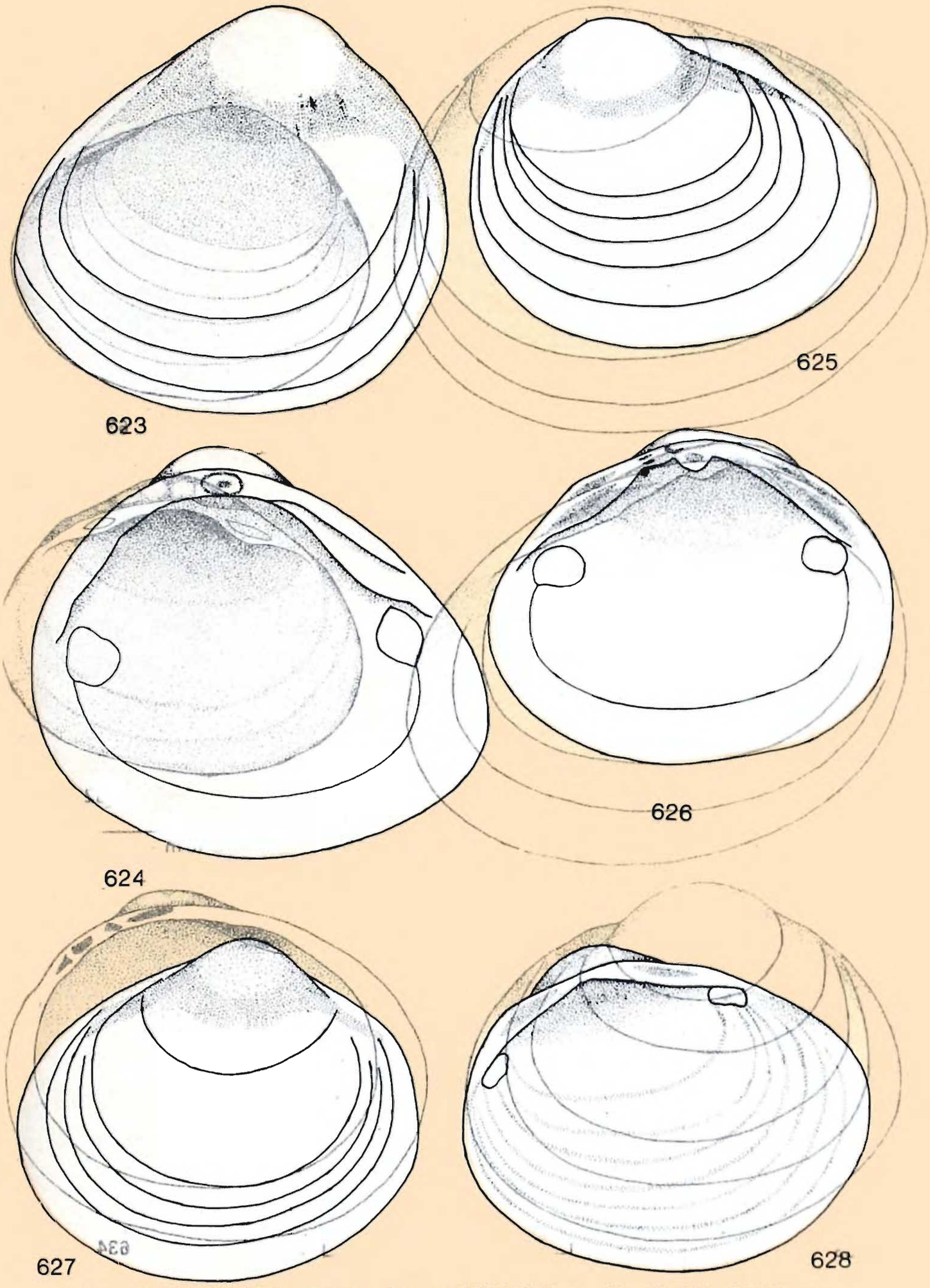
Figs. 604, 605. *Sphaerium austeni*, Syntype, 5.90 × 4.50 mm., Assam. 606, 607. *S. avanum*, 5.25 × 4.85 mm., Pegu. 608-610. *S. kashmirensis*, Holotype, 5.70 × 4.75 mm., Kashmir. 611, 612. *S. indicum*, 6.65 × 5.75 mm., Manipur.



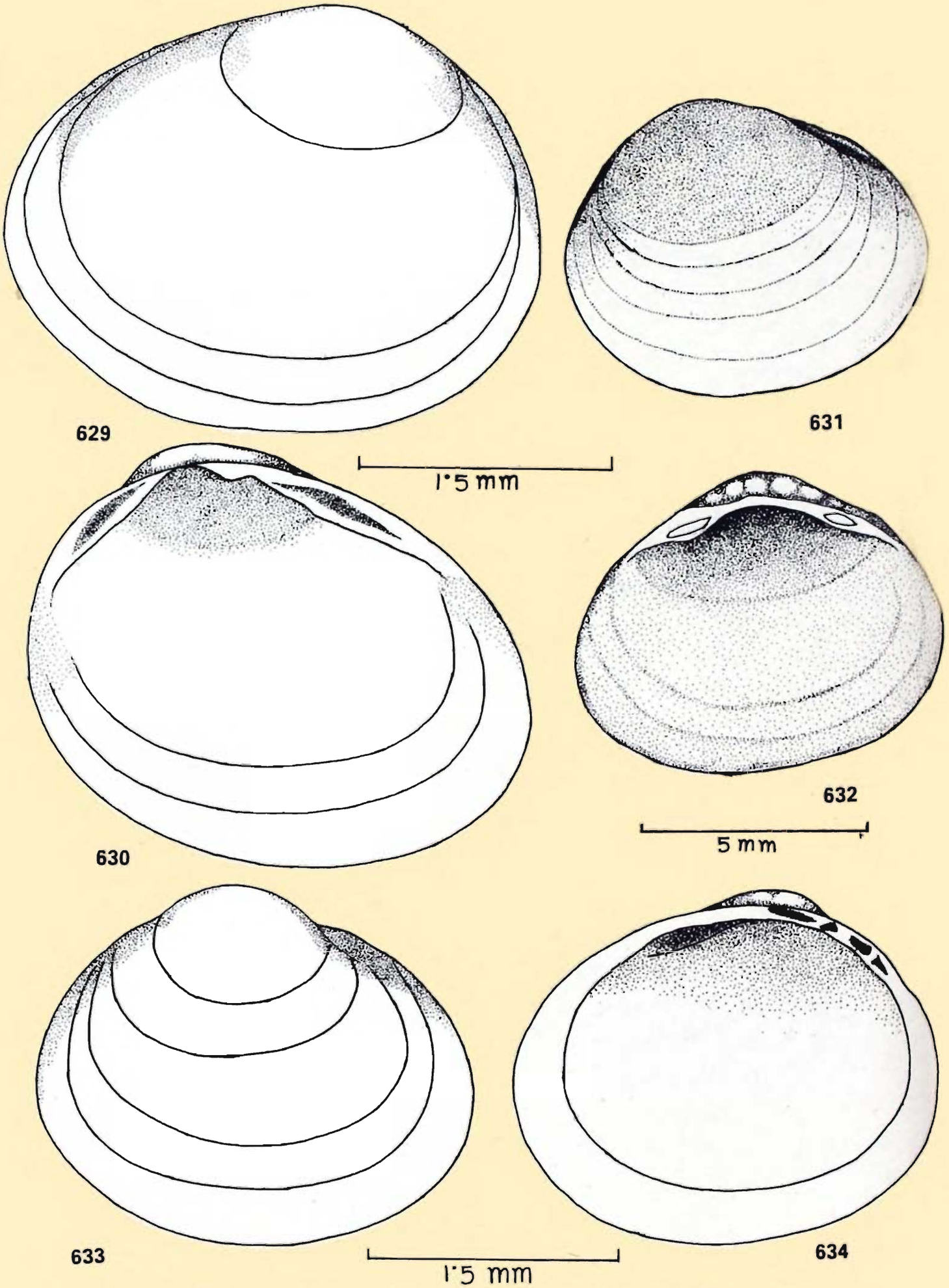
613,614. *Sphaerium montanum*, 7.95 × 7.60 mm., Burma.



Figs. 615, 616. *Pisidium clarkeanum*, 5.45 × 4.20 mm., West Bengal. 617, 618. *P. casertanum*, 5.20 × 4.50 mm., Ajaccio. 619, 620. *P. zugmayeri*, Cotype, 3.05 × 3.10 mm., Tibet. 621, 622. *P. annandalei*, Holotype 2.60 × 2.55 mm., Bihar



Figs. 623, 624. *Pisidium nevillianum*. Holotype, 3.70 × 3.80 mm., Uttar Pradesh. 625, 626. *P. atkinsonianum*. 3.85 × 3.60 mm., Sikkim. 627, 628. *P. mitchelli*. Holotype, 3.60 × 3.35 mm., Kashmir.



Figs. 629, 630. *Pisidium stewarti*, Holotype, 3.5 × 3.0 mm., Tibet. 631, 632. *P. stoliczkanum*, Holotype, 2.30 × 2.25 mm., Yarkand. 633, 634. *P. yarkandense*, Holotype, 2.65 × 2.40 mm., Yarkand.

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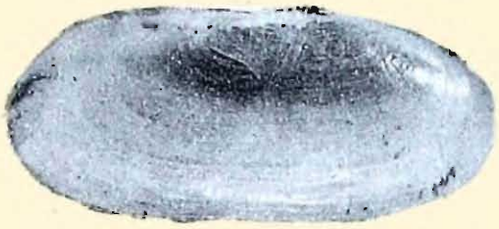

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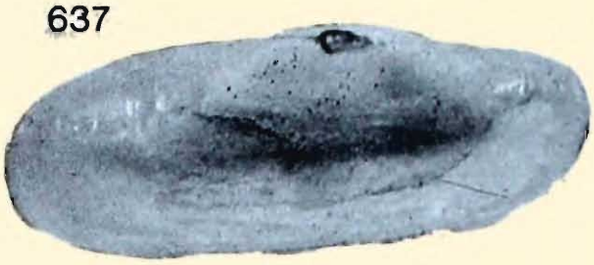

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Figs. 635, 636. *Novaculina andamanense,* Holotype, 17.50 × 7.85., Andamans. 637, 638. *Novaculina gangetica,* 32.20 × 11.15 mm., Patna, Bihar. 639, 640. *Tanysiphon rivalis,* 19.65 × 11.30 mm., Sagar Island. 641, 642. *Neosolen aquaedulcioris,* 18.70 × 5.15 mm., Chilka Lake, Orissa.

olive, ligament pit about 2/3 the length of the umbo, deep, nearly reaching below the middle of the hingeplate.

Allied to *P. hydaspicola,* but distinguished from it in the form of the shell, less prominent umbones and in hinge teeth.

On examining the illustrations given by Prashad (1925) for this species, Dance (1967) opined that it may actually belong to *P. kuiperi* Dance.

271. **Pisidium (Odhneripisidium) kuiperi** Dance, 1967

Pisidium (*Odhneripisidium*) *kuiperi* Dance, 1967, *J. Conch., Lond,* **26** (3): 176, figs. 1-5. Type locality: Yatung, Himalaya Mountains, Sikkim, 3000 m.

Types: BM (NH).

Distribution: Sikkim.

Remarks: Shell thin, semitransparent, dorsal margin with a steeper slope posteriorly, ventral margin almost straight, umbones broad, central, not prominent, striae fine, irregularly spaced and concentric, periostracum pale yellowish-brown, hinge plate not conspicuously narrowed beneath the umbones, ligament pit long, about 1/5 length of the shell.

According to Dance (1967) the shell illustrated by Prashad (1925) as *P. atkinsonianum* Theobald from Gangtok, Sikkim, may belong to this species.

272. **Pisidium (Odhneripisidium) stewarti** Preston, 1909
(Figs. 629, 630)

Pisidium stewarti Preston, 1909, *Rec. Indian Mus.,* **3:** 116. Type locality: Tering Gompa, Gyantse Valley, Tibet, 4350 m.

Pisidium (*Neopisidium*) *prashadi* Odhner, 1937, *Arch. Moll.,* **69:** 117, text. figs.

Types: ZSI Regd. No. M 4231/1 (Holotype).

Distribution: Tibet: Gyantse Valley, Kampa Dzong.

Remarks: Shell small (2.3 mm.), subtrigonal, rather inflated, fine, concentric striae, umbones prominent.

The altitude at which this species was recorded constitutes the highest for a living bivalve mollusc (Dance, 1967).

273. **Pisidium (Odhneripisidium) yarkandense** Prashad, 1933 (Figs. 633, 634)

Pisidium yarkandense Prashad, 1933, *Rec. Indian Mus.*, **35**: 3, pl. 1, figs. 3, 4. Type locality: Yarkand.

Type: ZSI Regd. No. M 14257/2 (Holotype).

Distribution: Yarkand.

Remarks: Shell small (2.5 mm.), rather thin, almost transparent, orbicular-ovate, regular concentric striae, umbones less prominent, slightly tumid, placed posteriorly, with minute striae, ligament pit deep, about half the length of the umbo.

274. **Pisidium (Odhneripisidium) zugmayeri** Weber, 1910 (Figs. 619, 620)

Pisidium (*Fossarina*) *zugmayeri* Weber, 1910, *Zool. Jahrb.*, **29**: 10. Type locality: Pangong Lake, Tibet. Prashad, 1933, *Rec. Indian Mus.*, **35**: 2, pl. 1, figs. 1.2.

Type. ZM

Distribution: Tibet.

Remarks: Shell thick, with well-developed concentric ridges, hinge teeth very strongly developed.

Subgenus **Afropisidium**

275. **Pisidium (Afropisidium) clarkeanum** G. & H. Nevill, 1871. (Figs. 615, 616)

Pisidium clarkeanum G. & H. *Nevill*, 1871, *J. Asiat. Soc. Beng.*, **40**: 9, pl. 1, figs. 4, 4a-d. Type locality: Moisrakha, on the banks of the Damodar river in Bengal. Prashad. 1925, *Rec. Indian Mus.*, **27**: 408, pl. 7, figs. 1-2, pl. 8. figs. 1-3.

Type: ZSI Regd. No. M 12531/2.

Distribution: Bihar: Harrapur, Bhagalpur; Uttar Pradesh: Roorkee; Maharashtra: Bombay; West Bengal: common in Calcutta tanks; Tamilnadu: Nilgiris (alt. 7400 ft); Manipur; Burma, Thailand, Laos.

Remarks: Shell moderately thick, greatly inflated, dorsal anterior slope distinct, somewhat curved, ventral margin only slightly curved, umbo projecting greatly over the hinge, surface pale yellow with close-set striae, much closer on the body than on the umbonal region, ligament prominent, thick, of a brownish colour, ligament pit narrow, about 1/3 the width of the hinge plate.

276. **Pisidium (Afropisidium) ellisi** Dance, 1967

Pisidium (Afropisidium) ellisi Dance, 1967, *J. Conch., Lond.*, **26** (3): 178, figs. 6-10. Type locality: Yatung, Himalaya Mountains, Sikkim, 3000 m.

Types: BM (NH).

Distribution: Sikkim.

Remarks: Shell thin, semitransparent, dorsal margin sloping steeply on the posterior side, ventral margin gently curved, periostracum yellowish brown, striae fine and irregularly concentric, ligament pit long, about 1/3 length of shell.

277. **Pisidium (Afropisidium) nevillianum** Theobald, 1876
(Figs. 623, 624)

Pisidium nevillianum Theobald, 1876, *J. Asiat. Soc. Beng.*, **45**: 288. Type locality: Rurki (Roorkee), Uttar Pradesh. Prashad, 1925, *Rec. Indian Mus.*, **27**: 412, pl. VII & VIII.

Type: ZSI Regd. No. M 12532/2.

Distribution: India: Roorkee, Narmada River; Bangladesh: Bolaganj.

Remarks: Shell large, trigonal, thin and porcellaneous, striae all over, very distinctly marked, very regular, umbonal region with much stronger and closely placed striae, umbones prominent, round, without appendiculae, dorsal margin sloping regularly and equally on both sides of the umbo, ligament pit comparatively long and deep, nearly straight below, about half the width of the hinge-plate in the middle, narrowing gradually on either ends.

Apparently allied to *P. clarkeanum* but differs from it in the shape and hinge, which is strongly developed in *P nevillianum.*

278. **Pisidium (Afropisidium) stoliczkanum** Prashad, 1933
(Figs. 631, 632)

Pisidium stoliczkanum Prashad, 1937, *Rec. Indian Mus.*, **35:** 5, pl. 1, figs. 7, 8. Type locality: Yarkand.

Type: ZSI Regd. No. M 13825/2.

Distribution: Yarkand, Western Tibet (14,000 ft.).

Remarks: Shell small (not more than 2.5 mm.), suborbicular to ovate, somewhat tumid, thin, strong, fine, concentric striae, dorsal margin sloping almost equally, rounded anteriorly and posteriorly, ligament pit deep, with ventral margin sloping.

Allied to *P. yarkandense,* but in *P. stoliczkanum* the shell is more equilateral and more tumid, umbones more prominent and centrally situated, and the hinge more strongly developed.

Subgenus **Eupisidium**

279. **Pisidium (Eupisidium) mitchelli** Prashad, 1925.
(Figs. 627, 628)

Pisidium mitchelli Prashad, 1925, *Rec. Indian Mus.*, **27:** 419, pl. VII & VIII. Type locality: Srinagar, Kashmir (out of the stomach of a trout caught in the Mansabal lake at an altitude of 1500 m).

Type: ZSI Regd. No. M 12533/2.

Distribution: Kashmir.

Remarks: Shell large, subtrigonal, very tumid, thin and fragile, distinct close-set striae all over, deep horn colour, shining.

Family 20. CULTELLIDAE Davies, 1935

Genus 55. **Tanysiphon** Benson, 1858

Type species: *Tanysiphon rivalis* Benson, 1858 by monotypy.

Shell small, thin and transversely elongated, periostracum greenish, beaks situated anteriorly; ligament external and short, hinge bearing three cardinal teeth in each valve, anterior two smaller and posterior tooth large and flattened, pallial sinus large.

Inhabits estuarine waters, some times extending into freshwaters.

Because of its superficial resemblance to *Glauconome*, it was grouped in the family Glauconomidae (formerly Glaucomyidae).

280. **Tanysiphon rivalis** Benson, 1858
(Figs. 639, 640)

Tanysiphon rivalis Benson, 1858, *Ann. Mag. nat. Hist.* (3) **10:** 408, pl. 12B, figs. 1-3. Type locality: Calcutta. Hanley and Theobald, *Conch. Indica*, p. 47, pl. 116, figs. 1 &4.

Types: BM (NH).

Distribution: Gangetic delta.

Remarks: Foot hatchet-shaped, thick and posterior side notched, siphons united almost equallying the length of the shell, free extremity surrounded by distantly placed, inequal tentacles, branchial siphon larger, and orifice with tentacles, anal siphon smaller and orifice naked.

Genus 56. **Neosolen** Ghosh, 1920

Type species: *Neosolen aquaedulcioris* Ghosh, OD

Shell small and thin with truncate anterior and rounded posterior ends, one small long tooth in right valve, anterior adductor impression long and triangular, posterior one small and rounded.

Chilka Lake, Sunderbans.

281. **Neosolen aquaedulcioris** Ghosh, 1920.
(Figs. 641, 642)

Neosolen aquaedulcioris Ghosh, 1920, *Rec. Indian Mus.*, **19:** 57, pl. ii, fig. 12, pl. iii, figs. 13, 14. Type locality: Off Samal Island, Chilka Lake.

Types: ZSI Regd. No. M 9981/2 (Syntypes).

Distribution: Off samal Island, Chilka Lake and Sunderbans.

Remarks: Body flattened laterally with a narrow ventral surface, no cruciform muscle, siphons fused, long and segmented, with tentacular fringe around its aperture, gills plicate, short and deep.

The species was first thought to be a dwarfed form of *Solen fonesi* Dunker (Annandale & Kemp 1916; Ghosh, 1916).

Family 21. SOLECURTIDAE d'Orbigny, 1846

Shell quardrately elongated with wide gapes at both ends. Hinge plate narrow and weak; the pallial sinus either deep or shallow.

Geologically the family dates back to Lower Eocene. It is divided into two sub-families, viz. Solecurtinae s.str. and Novaculininae E. N. Ghosh, 1920; the latter one is represented in the Oriental region.

Subfamily NOVACULININAE E. N. Ghosh, 1920

Originally the author erected this subfamily for the reception of the genus *Novaculina* Benson, but later *Sinonovacula* Prashad was also grouped in the same subfamily. Formerly the subfamily was included in the family Solenidae. But later researches have shown that in soft parts the members of this subfamily show more resemblance to that of Solecurtinae than to that of Solenidae.

Shell inequivalve, long and cylindrical resembling that of Solenidae, beaks placed anteriorly; hinge with two or three cardinal teeth.

Foot short and stout with a disc-like anterior end projecting forwards and downwards.

Genus 57. **Novaculina** Benson, 1830

Type species: *Novaculina gangetica* Benson, 1830 by Monotypy.

Shell subinequivalve, transversely elongated, with uniform width throughout, umbones prominent and hinge line almost straight, hinge with three cardinals in left valve and two in right valve.

Siphons separate and as long as the shell in fully extended state, siphonal apertures constricted but not ciliated, no cruciform muscle.

Not known in fossil state. Generally in freshwater.

In the Fauna volume two species were reported by Preston (1915).

282. **Novaculina andamanensis** Preston, 1910.
(Figs. 635, 636)

Novaculina andamanensis Preston, 1918, *Rec. Indian Mus.*, **2**: 209, pl. 16, fig. 40. Type locality: Andamans.

Type: ZSI Regd. No. M 20765/4 Holotype.

Distribution: Andamans.

Remarks: Shell oblong-elongate, periostracum yellowish-brown, umbones small, dorsal margin slightly sloped anteriorly, ventral margin constructed in the middle, anterior side rounded, posterior side produced in the middle, ventral margin somewhat angled below (Preston, 1915).

The animal or the definite type-locality is not known. Until more material is collected the validity of this species is doubtful.

283. **Novaculina gangetica** Benson, 1830
(Figs. 637, 638)

Novaculina gangetica Benson, 1830, *Gleanings in Science*, Calcutta, **2**: 63; 1858, *Ann. Mag. Nat. Hist. Lond.*, (3) **10**: 408, pl. 12B, fig. 4. Hanley and Thoebald, 1876. *Conch. Indica*, p. 41, pl. 116, fig. 7. Preston, 1915. *Fauna Brit. India*, Mollusca (Freshwater Gastropoda and Pelecypoda) p. 229.

Types: BM (NH)

Distribution: Ganges and the rivers connected with it. Specimens were collected from as far interior as Benaras (Varanasi), Bangladesh.

Remarks: Shell oblong, with truncated extremities, periostracum olivaceous.

Animal flattened in dorsoventral direction, foot stumpy with a disc-like flattened surface.

Branchial siphons longer and stouter than the anal, surface of siphons finely ribbed but not segmented, apertures constricted and without tentacular fringe.

E. N. Ghosh (1920) made a detailed study of the anatomy of the species and remarked that it is more primitive than the members of Solecurtinae.

FRESHWATER MOLLUSCS IN AQUACULTURE

N. V. Subba Rao and A. Dey

Aquaculture has developed into an effective tool in providing additional food resources for the increasing human population in our country. It has been laying more stress on farming of fish, fin-fish and shell-fish in coastal waters, through several techniques involved in mariculture. Inland aquaculture is primarily limited to raising of fish and to some extent fin-fish i.e. crustaceans. Although shell-fish are slowly gaining importance in coastal aquaculture, these are never viewed as commercially exploitable products in inland aquaculture.

During the course of our faunistic surveys in Eastern and North-eastern States we have observed that there is a regular sale of shell-fish in several of the vegetable markets. It is particularly so in Bihar, West Bengal, Mizoram and Arunachal Pradesh. Shell-fish are harvested in nature and brought to the market. The following data has been collected from different states.

Bihar:

Although there are several species of molluscs occurring in Bihar, only four species, namely *Pila globosa* (Swainson), *Bellamya bengalensis* (Lamarck), *Lamellidens marginalis* (Lamarck) and *Lamellidens corrianus* (Lea) are favoured as food. These shell-fish are mainly consumed by people in the South Bihar. There is a regular sale of shell-fish in the markets - in the districts of Singbhum, Ranchi, Palamau and Hazaribagh. The shell-fish are occasionally sold in the weekly markets in the towns of Tatanagar, Ghatsila, Haludpukur, Chaibasa, Chakradarpur, Manoharpur etc. The rate varies from Rs. 1/- to Rs.3/- per kg.

Bellamya bengalensis is favoured as a food by all sections of the people, while the other three species are eaten by tribal people.

West Bengal:

Freshwater shell-fish are sold in the markets in the districts of Purulia, Bankura (part), Midnapur (part), Darjeeling and Jalpaiguri.

All the four species of shell-fish that are favoured as food in Bihar are consumed by people in Lower Bengal. In the districts of Jalpaiguri and Darjeeling, a thiarid, *Brotia costula* is eaten by workers of teagardens.

There is a regular sale of pond-snail, *Bellamya bengalensis* and freshwater mussels, *Lamellidens marginalis* and *Lamellidens corrianus* in the market of Jhargram. *Bellamya* sp. is sold at the rate of Rs. 3/- to 4/- per kg. whereas 8 to 10 nos. of *Lamellidens* cost Rs. 2/-. These shell-fish are normally sold with their shells intact. But sometimes soft fleshy part removed from the shell is also sold. *Brotia* is sold in the fair or *hat* in teagarden areas. One lot of *Brotia* consisting of 20 to 25 nos. are packed in a banana leaf and is sold at Rs. 1/-.

Mizoram:

Molluscs form a staple food for people of Mizoram (Subba Rao and Dey, 1986). Local Mizo and Riang tribal people are very much fond of shell-fish. The following are the important edible shell-fish.

Brotia costula (Rafinesque)
Paludomus conica Gray
Paludomus blanfordiana Nevill
Solenaia soleniformis (Benson)
Trapezoideus exolescens (Gould)
Parreysia sikkimensis (Lea)
Parreysia caerulea (Lea)

The above species of shell-fish are collected regularly from the local streams and sold in Aizawl market. There is a continuous market for the freshwater shell-fish. The two common edible shell-fish are *Brotia* and *Paludomus*. The former is sold at Rs. 1/- per tin, weighing 250 gms. which includes 15 to 20 average-sized specimens. The latter is sold at Rs. 2/- per 250 gms. which include about 40 to 50 average-sized specimens.

The shell-fish are also sold in packets made of fresh banana leaves. Each packet consisting of 20 to 25 specimens of *Paludomus* or 10 to 12 specimens of *Brotia* is priced at Rs. 1/-.

The shell-fish are eaten throughout the year, except during monsoon months of June and July, but maximum during summer months (March to May). The level of consumers is variable from state to state. Shell-fish is generally a favoured item of low income groups. *Pila, Lamellidens* and

Brotia are eaten by low income group in Bihar and Bengal. The shell-fish are eaten by people in the rural areas.

Process of preparation

The fleshy part is removed by breaking open the shell with a piece of stone or hammer. The flesh is cleaned with water. In case of mussels (bivalves) the flesh is removed after boiling the shell in water. When the flesh is cooked with oil, spices and vegetables especially, potato and brinjal, it is ready for consumption.

It is the opinion of the people who eat shell-fish that there is no difference between it and the meat, except for a slight difference in taste. The rural consumers also believe that shell-fish food has some medicinal value. It helps in the improvement of eye sight and in controlling diarrhoea and gastric disorders.

Collection

Shell-fish are collected from their natural habitat by hand-picking and sometimes with the help of fishing nets. In some parts of Bihar (Singhbhum) *Bellamya* is collected by leaf-trap method. In this process palm leaves are placed in the littoral region of a pond or ditch in the evening. A number of pond-snails get attached to the palm-leaves. Next morning these are removed and the snails are hand picked.

Compared to fish-farming, the aquaculture of molluscs is still in its infancy in our country. Nevertheless, this represents an underdeveloped area of aquaculture that deserves increased attention in view of its potential.

There are two constraints in the development of shell fish resources in our country, sociological and unscientific exploitation. The first one is not a problem at least in some parts of eastern and north-eastern India. The local people are aware of the nutritive value of these molluscs. At present shell-fish are harvested in nature. Introduction of cultural practices will ensure a steady and improved supply of proteinous recipe to the reciprocative local population.

As in agriculture, the health of shell-fish must be taken into consideration in aquaculture. Molluscs are intermediate hosts for a number of pathogenic zooparasites. The public health aspects of farming shell-fish have also to be taken into consideration.

A LIST OF EDIBLE FRESHWATER MOLLUSCS

Sl. No.	*Name of the species*	*Local Name*	*State in which used as food*	*Rate*
1.	*Pila globosa* (Swainson)	Genri – Bihar Samuk – W. Bengal	Bihar, West Bengal	Re 1/= for 20 to 25 nos.
2.	*Bellamya bengalensis* (Lamarck)	Samuk/Gugli – Bihar, W. Bengal	Bihar, West Bengal	Rs. 2/- to 4/- per kg.
3.	*Brotia costula* (Rafinesque)	Chenkal – Mizo Chikangbook – Riang	North Bengal, (W. Bengal) Arunachal Pradesh, Mizoram	Re. 1/- per tin which include 15 to 20 average size specimens.
4.	*Paludomus conica* Gray	-do-	Arunachal Pradesh, Mizoram	Rs. 2/- per tin which include 40 to 50 average size specimens.
5.	*Paludomus blanfordiana* Nevill	-do-	-do-	-do-

*6.	*Lamellidens marginalis* (Lamarck)	Jhinuk – Bihar Katli – W. Bengal	Bihar, West Bengal	Rs. 2/- for 20 nos. in a lot.
*7.	*Lamellidens corrianus* (Lea)	-do-	-do-	-do-
8.	*Solenaia soleniformis* (Benson)	Tuikep – Mizo Clampy - (Beta) - Riang	Mizoram	Not observed in market
9.	*Trapezoideus exolescens exolescens* (Gould)	Tuikep – Mizo Clampy - (Betia) - Riang	-do-	-do-
10.	*Parreysia sikkimensis* (Lea)	-do-	Arunachal Pradesh	-do-
11.	*Parreysia caerulea* (Lea)	-do-	-do-	-do-

* Species producing pearls.

FRESHWATER PEARLS

In addition to their importance as a supplementary food item of man, freshwater snails are also a valuable source of food for ducks. A few species of freshwater mussels produce pearls under natural conditions. Although pearls of marine origin are popular now, it is in fact in the freshwater that the first pearls have been cultured. Ancient Chinese had the knowledge of freshwater pearls. In the 13th century they had cultivated pearls in freshwater mussels. Pearl production had its origin in the idea that the introduction of a foreign body into the mantle of a mussel induces the animal to secrete a pearl. In the old chinese method the shell of the mussel, *Cristaria plicata,* is opened and a small piece of metal or a pellet of mud is introduced into the mussel between its mantle and the shell. The mussel is then returned to its bed. Due to the irritation caused by the foreign body the mussel secrets the shelly nacre around the foreign body, which becomes the nucleus. Pearls are generally recovered after three years. The cultured pearls of chinese were exclusively blister pearls, which were of hemispherical shape. But the production of whole cultured pearl was perfected by Japanese by using the marine pearl oyster.

A molluscan shell generally consists of three layers. The outermost layer is the conchin, which is also known as periostracum. It is followed by two calcareous layers, the middle prismatic and the innermost nacreous layer or the mother-of-pearl layer. A pearl is made up of nacre surrounding a central nucleus. From this it can be inferred that every mollusc which has a shell can produce a pearl. But valuable pearls are produced by species which have an inner nacreous layer.

In India, pearls are produced by two species of freshwater mussels viz., *Lamellidens marginalis* and *Lamellidens corrianus.* Both the species are common and widely distributed in India. Pearls have been recorded in the former in freshwater bodies near Calcutta. The size of the pearls ranged in weight from 0.8 mg to 10 mg (Raut & Biswas, in press). The size and colour of pearls varied from pond to pond and even within the same pond. These findings, however, indicate the possibility of freshwater pearl culture in India. Basic data on the natural history of pearls in Indian freshwater mussels has to be collected to make freshwater pearl culture a commercially viable project. Attempts are already in progress in Bangladesh to cultivate freshwater pearls.

Irregular nacreous secretions are occasionally encountered inside the shell of the common freshwater bivalve, *Lamellidens.* But the authentic

reports on the occurrence of freshwater pearls are from West Bengal. In addition to the previous records from Burdwan, Bongaon, Dum Dum and other places around Calcutta, the most significant occurrence of freshwater pearls is from a pond in Vidya Sagar Colony, Ramgarh, Jadavpur, Calcutta. Pink coloured pearls, whose colour correspond to the colour of the mother-of-pearl layer, were found in *Lamellidens marginalis*. As per the information given to us the mussels were around two years old. Pearls were found in the mussels having shell measurements of 82×40 mm. and above. But it does not mean that all the shells with higher measurements will yield pearls. Normally each mussel would yield only one natural pearl. According to some jewellers of Calcutta the pond pearls can fetch Rs. 15 to Rs. 50 per each depending on the size and quality. From these observations it can be inferred that the aquatic bodies of West Bengal offer ideal conditions for the culture of freshwater pearls.

Some of the important aspects of pearl culture that deserve special attention are as follows:

1. Production of seed. In order to achieve perfection in this, detailed studies are to be undertaken on the life history of *Lamellidens marginalis* and *L. corrianus*.

2. Selection of a suitable nucleus. Marine pearl culture is already a success. The same nucleus which is used in the marine pearl cultivation, can be used in the freshwater mussel also. Some of the species of *Parreysia* have thick shells, which may be tried as a source of calcareous nucleus.

3. Insertion of nucleus into the body of a mussel. The timing and technique of the insertion of nucleus into freshwater mussel have to be developed.

SHELL-FISHERIES OF NORTH BIHAR

Freshwater shell-fish play an important role in the cottage industries, in Mehsi town of East Champaran district, Bihar. Shells of freshwater mussels are used in the manufacture of shell-buttons, ornaments and also in the preparation of slaked lime. Shell grit, dust and residual pieces are used in the preparation of poultry feed and mosaic tiles respectively (Banerje and Satish, 1988; Datta Munshi and Chowdhary, 1988). *Parreysia (Radiatula) caerulea* (Lea), *Parreysia (Parreysia) favidens* (Benson) and

Lamellidens corrianus (Lea) are the important shell-fishes on which the century-old shell industry of Mehsi town has been thriving.

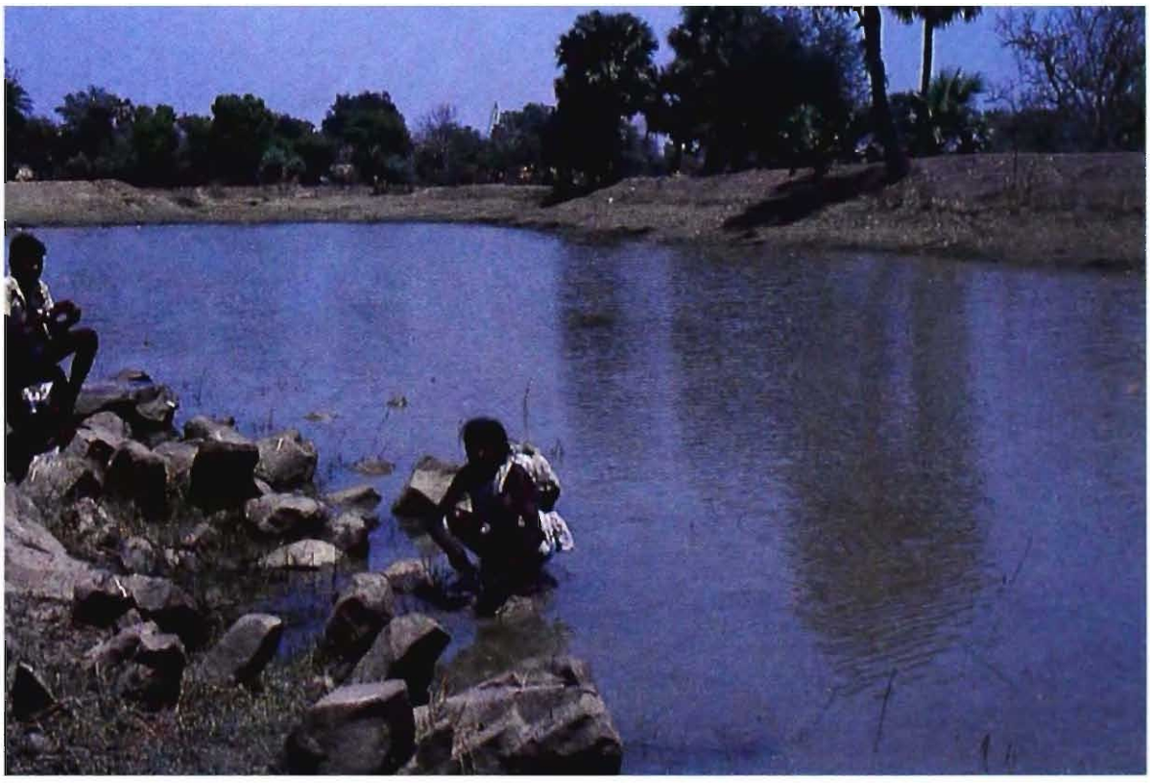
According to one report (Banerji and Satish, 1988) Shell Button Industries, Mehsi are marketing finished shell products worth Rs. 20 lakhs annually. The annual requirement of raw material is around 700 tonnes. If the requirements of other manufacturers and also of the lime industry are taken into account the raw material demand will be definitely on the higher side. Such a huge demand for raw material had resulted in the over-exploitation of local resources leading ultimately to their depletion. In the begining shell-fish were collected from the tributaries of Ganga in North Bihar, such as Bagmati, Burhi Gandak and its tributaries. Depletion of local stocks has led to search of new areas. Collection centres have been shifted to the basins of River Bapti, Gomati of Eastern Uttar Pradesh and from Kamla. Balan and Kosi river system in north-east Bihar (Banerji and Satish, 1988; Datta Munshi and Choudhary, 1988). Nonavailability of raw material had its impact on the industrial units of the Mehsi town. The number of industrial units engaged in the Shell button and other shell products had decreased from the original 350 to 84 as at present (Datta Munshi and Choudhary, 1988).

From the foregoing account it is clear that freshwater shell-fishes are important as food, as producers of pearls and as raw material to shell industry. It also points out the need for sustained utilisation of the species involved and for the revival of shell-fish resources by aquaculture.

Collection of shell-fish by a cast net, Noagram, Singbhum Dist. Releasing the catch from the net. Photo : A. Dey.

Hand picking of shell-fish, Noagram, Singbhum Dist.

Washing shell-fish after collection. Photo : A. Dey.



Sale of shell-fish in Jhargram market, West Bengal. A basket containing *Bellamya bengalensis*. A seller weighing shell-fish for the prospective customer. Photo : A.Dey.

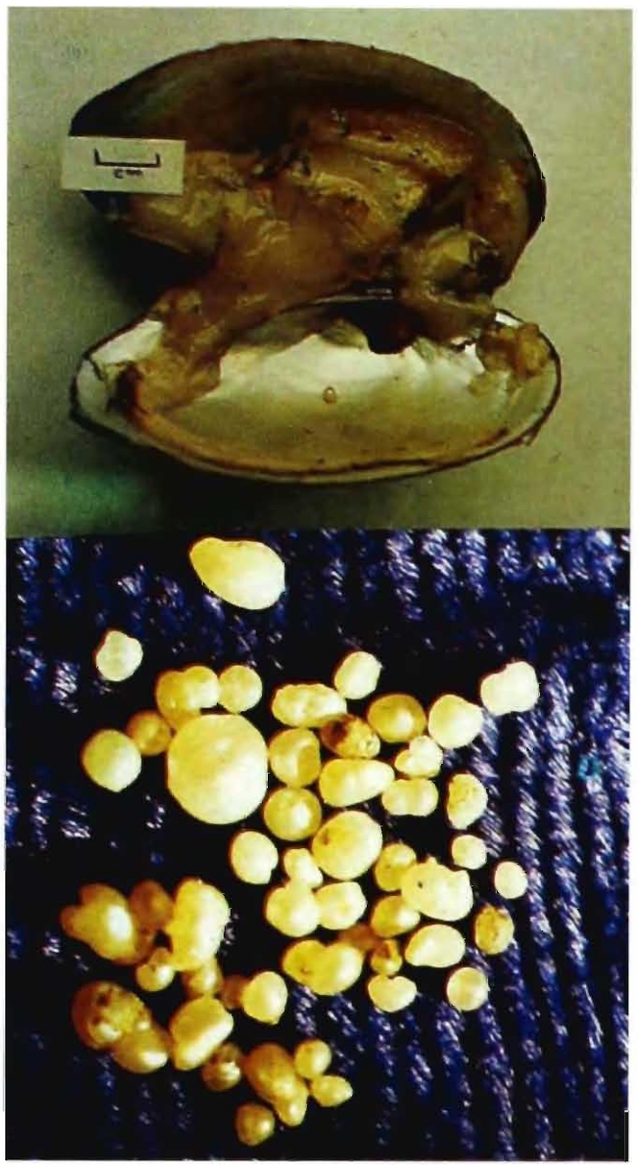
A seller with *Brotia costula*, waiting for a customer, Atiabari *hatt*, near Jalpaiguri. Photo : A. Dey.

A view of the shell-fish market in Aizawl, Mizoram. Photo : A. Dey.

A close-up view of the baskets containing shell-fish; on the left *Brotia costula* and on the right *Paludomus conica* . Photo : A. Dey.

An old woman removing the fleshy part of *Pila virens* to be fed to ducks in a village of Colair Lake. Heaps of empty shells of *pila* can be seen in some parts of Colair Lake, Andhra Pradesh. Photo : E.V. Muley.

Flesh is removed by breaking the shell, Noagram . Photo : A. Dev.



Lamellidens marginalis, a common freshwater mussel of India is known to produce pearls. So far all the records of natural freshwater pearls are from ponds in West Bengal. A mussel collected from the Vidyasagar pond, Jadavpur, Calcutta is shown on the top with valves open. A pink coloured pearl removed from below the ligament is kept in the valve.

(Below) Pearls collected over years by Mr. A.C. Pal from a pond in Biratti, near Calcutta. Photo : S. Chatterjee.

Two views of *Camptoceras terebra* Benson. The two specimens, measuring 4.65 × 1.45 mm and 5.50 × 1.50 mm in length and diameter respectively were collected by Mrs. K. Mitra (in December, 1987) from the exposed bed of River Hooghly at Mogra, 50 kms. north of Calcutta. This is the only recent collection of the species after its original discovery by Benson in 1843. Photo : S. Chatterjee

(For text please see species No.151 on page 144)

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*Not seen in original

Subject Index

The numbers below correspond to the serial numbers given in parentheses at the end of each reference under Bibliography.

References on a particular family/genus/ species are cited under each of the concerned taxon in the text.

General

26, 44, 49, 76, 134, 147, 149, 164, 166, 198, 205, 207. 209, 226, 230, 235, 250, 259, 266, 281, 293, 301, 312, 313, 352, 356, 369, 375, 385, 390, 396, 438, 450, 456, 475, 499, 526, 527.

Geographical

Andhra Pradesh	78, 224, 448,459.
Bangladesh	179.
Bihar	85, 86, 142, 452, 457, 545.
Burma	28,72,94,95,96,99,109,110, 111, 114, 376, 393, 394, 441, 443, 531, 533.
China	67,91.

Himachal Pradesh	6,9.
Indonesia	101,102,155.
Kashmir	212,389,419,534,552.
Madhya Pradesh	8,13.
Maharashtra	30,59,108,205,207,388,420,442,458,460,525,540,541.
Malay Peninsula	40.
Manipur	42,55.
Meghalaya	54.
Mesopotamia	29,62,374.
Mizoram	523.
Nagaland	407.
Orissa	27,37,47,50,56,57,76,359,360,362,408,409.
Pakistan	14,240,475.
Punjab	70,71,160,208,546.
Seistan	38,61,69.
Sri Lanka (Ceylon)	109,383,510,518,520.
Tibet	405.
Uttar Pradesh	375.
West Bengal	23,24,44,49,60,136,209,410,499,526.
Yunnan	53,379.

Faunistic

3,6,8,9,13,14,23 to 25,28 to 30,32,36 to 38,40,42,46,47,50,53 to 57,59 to 62,67 to 72,78,86,98,111,114,137,160,181 to 188,192,204,212,217,240,242,248, 270, 336 to 340, 345, 363, 373, 374, 379,383,389,393,394,402,405,408 to 412, 441 to 443,452,453,455,476,512,516 to 519,525,531 to 534,540,541,546,552.

Systematics

17,33,34,43,45,48,58,63,64 to 66, 73,77,81,82,88 to 97, 99 to 102, 108 to 110,112,113,117,127,129, (Cytotaxonomy), 130,138, 143, 144, 146, 150 to 152, 155, 156, 167, 172, 173, 176,191,192,195,196,199,200,202,203,213,214,216,225, 227 to 229,237,243,247,268,269,286 to 289, 343,347,367,370 to 372,378,380, 382, 386 to 388,392,395,397 to 401,403,404,406,407, 444, 454, 457 to 467,469, 471,481,511,513,514,520,522,535,536,537,543,544,549,554.

Ecology & Behaviour

31,193,206,208,236,238,245,298,303,311,323,362,473,480.

Anatomy & Morphology

19 to 21,41,43,51,87,104,115,116,154,174,175,177,178,180,201,256,260 to 262,274,325,330,344,353,354,364 to 366,368,381,391,422,423,439,440,451,472, 473,482,484 to 490,497,505,521,538,539,551,553.

Physiology & Biochemistry

10,105,125,132,135,165,170,231 to 234,239,241, 246, 251 to 254, 257, 258, 272,273,275 to 280,282 to 284,291,294,296 to 298,304 to 307,311,314,315, 317 to 322,324,327,329,332,335,346,348,351,355,384,413 to 417,421 to 424, 433 to 436,445 to 447,462 to 464,466 to 468,474,477 to 479,491,501,506 to 509, 528, 548, 555.

Reproduction & Development

5,15,16,18,79,80,103,106,118 to 124,131,157 to 159,171,194,218,299,300, 308,349,418,422,423,425,426,429 to 432,437, 448, 449, 483, 492 to 496, 502 to 504, 539.

Growth

4,7,11,12,301,326,328,331.

Cytology

129,133,219 to 222,316,333,334,427,428.

Parasitology & Control

1,2,22,35,52,74,83,84,107,128, 139 to 141, 145, 146, 148, 153, 160 to 163, 168, 169, 179, 197, 210, 211, 215, 223, 241, 244, 249, 263, 264, 265, 267, 271, 292,295,302,309,310,342,350,357 to 362,465,498, 500, 510, 515, 529, 530, 542, 545, 547, 550.

Fisheries

85,142,524.

Palaeozoology

39,190,341,377,387,389,390.

ADDENDUM

The following two species are inadevertently left out in the main text. The number preceding each species indicates its position in the text.

75*a* **Stenothyra monilifera** Benson, 1856

Stenothyra monilifera Benson, 1856, *Ann. Mag. nat. Hist.*, (2) 17: 477.

Type locality: Mergui, Tenasserim, Burma. Annandale & Prashad, 1921, *Rec. Indian Mus.*, **22**: 127.

Distribution: Burma: Akyab, Amherst; Malaysia: Penang.

Remarks: In the collections examined distinct punctations are not seen and the specimens agree with *Stenothyra minima* (Figs, 163, 164).

130*a* **Lymnaea physcus** Annandale & Rao, 1925
(Figs. 266, 267)

Limnaea physcus Annandale & Rao, 1925, *Rec. Indian Mus.*, **27**: 104.

Type locality: He-Ho Plain, Southern Shan States

Type: ZSI Regd. No. M 12045/2 (Holotype)

Distribution: Burma: He-Ho Plain, Southern Shan States.

Remarks: Known from types only. The body whorl relatively large, aperture also large but not expanded.

Although Annandale & Rao (1925) mentioned that it is allied to *Lymnaea peregra* it seems to be a juvenile form of either *Lymnaea luteola* f. *ovalis* or *L. luteola* f. *succinea.*

APPENDIX

LIST OF COMMON FRESHWATER MOLLUSCS OF INDIA

As many as 285 species of gastropods and bivalves are included in this 'Handbook on Freshwater Molluscs of India and adjacent countries' But of the total number listed in the book only 200 species are reported from India. Among these only a small number of species are common. From our experience in the field and on the basis of the collections that we have been receiving in the Zoological Survey of India for identification from various individuals and institutions it has been seen that there are hardly 47 species (13 families) which are generally come across by any one engaged in the collection of molluscs. When one makes a collection of molluscs it is advised that at first one should sort out the collection into families and then take the help of the list given below supported by the illustrations and the remarks given under each species. A serious student of molluscs however, should follow the text given in the book.

In order to facilitate an easy identification and to act as a ready reference a list of common molluscs of India is given below; where a particular species is common in a specific geographical area the name of such an area is mentioned. All the other species generally occur throughout India.

Name of the species	Occurrence	Reference to page	& figure
Class Gastropoda			
Subclass Prosobranchia			
Order Archaeogastropoda			
Family Neritidae			
Neritina (Dostia) violacea (Gmelin, 1791)	In river mouths and estuarine regions.	37	30, 31
Order Mesogastropoda			
Family Viviparidae			
Bellamya bengalensis (Lamarck, 1822)		45	55–59
Bellamya dissimilis (Müller, 1774)		48	64–67
Angulyagra oxytropis (Benson, 1836)	Manipur	51	70
Family Pilidae			
Pila globosa (Swainson, 1822)	North India	58	80
Pila virens (Lamarck, 1822)	South India	60	87
Family Bithyniidae			
Gabbia orcula producta (Nevill, 1884)		77	142
Gabbia travancorica (Benson, 1860)	South India	78	145, 146
Digoniostoma cerameopoma (Benson, 1830)		79	121
Digoniostoma pulchella (Benson, 1836)		80	113, 114 119 & 120
Family Stenothyridae			
Stenothyra deltae (Benson, 1836)	Estuarine regions	87	166a
Gangetia miliacea (Nevill, 1880)	Estuarine regions	91	175–178
Family Thiaridae			
Thiara (Thiara) scabra (Müller, 1774)		96	185, 186
Thiara (Stenomelania) torulosa (Bruguiere, 1789)	South India	100	202
Thiara (Tarebia) granifera (Lamarck, 1822)		101	212, 213
Thiara (T.) lineata (Gray, 1828)		101	191
Thiara (Melanoides) tuberculata (Müller, 1774)		103	183, 184
Paludomus (P.) blanfordiana Nevill, 1877	Streams of North-east India	112	222

Name of the species	Occurrence	Reference to page	& figure
Paludomus (P.) conica (Gray, 1834)	Streams of North-east India	113	227
Paludomus (P.) regulata Benson, 1856	East India	118	236
Paludomus (P.) tanschauricus (Gmelin, 1771)	South India	118	221, 252 253
Subclass Pulmonata			
Order Basommatophora			
Family Lymnaeidae			
Lymnaea (Pseudosuccinea) acuminata Lamarck, 1822		126	254–259
Lymnaea (P.) luteola Lamarck, 1822		128	275, 276 & 279–289
Lymnaea (P.) truncatula (Müller, 1774)	Kashmir	133	291
Family Planorbidae			
Indoplanorbis exustus (Deshayes, 1834)		142	326–327
Hippeutis (Helicorbis) umbilicalis (Benson, 1836)		148	333–335
Segmentina (Polypylis) calatha (Benson, 1850)	North India	150	339–341
Gyraulus barrackporensis (Clessin, 1886)	North India	153	
G. convexiusculus (Hutton, 1849)		154	362–364
G. labiatus (Benson, 1850)		155	342–344
Class Bivalvia			
Order Unionoida			
Family Unionidae			
Lamellidens corrianus (Lea, 1834)		165	386, 387
Lamellidens marginalis (Lamarck, 1819)		168	404, 405
Family Amblemidae			
Parreysia (Parreysia) corrugata (Müller, 1774)		179	448, 449
Parreysia (Parreysia) favidens (Benson, 1862)		180	466, 467 484, 485
Parreysia (Radiatula) andersoniana (Nevill, 1877)	North-east & East India	187	508, 509

Name of the species	Occurrence	Reference of page & figure	
Parreysia (R.) caerulea (Lea, 1831)		188	516, 517
Parreysia (R.) occata (Lea, 1860)	North & East India	191	526, 529
Parreysia (R.) olivaria (Lea, 1831)	North & East India	192	534, 535
Parreysia (R.) pachysoma (Benson, 1862)	North & East India	192	540, 541
Order Veneroida			
Family Corbiculidae			
Corbicula bensoni Deshayes, 1854	North & East India	202	565, 566
Corbicula striatella Deshayes, 1854		204	575, 576
Villorita cyprinoides (Gray, 1825)	South India (Kerala backwaters)	208	591, 592
Geloina bengalensis (Lamarck, 1818)	Estuarine	210	593, 594
Family Pisidiidae			
Sphaerium indicum Deshayes, 1854		213	600, 601
Pisidium clarkeanum G. & H. Nevill, 1871		218	615, 616
Family Cultellidae			
Tanysiphon rivalis Benson, 1858	Gangetic Delta	221	639, 640
Family Solecurtidae			
Novaculina gangetica Benson, 1830	Gangetic delta	223	637, 638

INDEX

acanthica, Melania 96
Acostaea 197
Acrostoma 107
aculeata, *Nerita* 120
acuminata, Lymnaea 124,126
acutus, Paludomus 118
Aetheria 197
AETHERIIDAE 197
Afropisidium 218
albus, Planorbis 153
Alocinma 75
alticola, Gabbia 76,78
amarula, Thiara 97
AMBLEMIDAE 171
AMBLEMINAE 171
amnica, *Tellina* 214
Amnicola 75,76,78
Ampullaria 58,60
ampullacea, Helix 57
ANADARINAE 159
Anculotus 63
ANCYLIDAE 5,23,25,136
Ancylus 137
andamanensis, Novaculina 223
andersoniana, Lymnaea 125,132,133
andersoniana, Paludomus 111,118
Angulyagra 43,50
annandalei, Bellamya 46
annandalei, Iravadia 70
annandalei, Paludomus 112
annandalei, Parreysia 176
annandalei, Pisidium 215
anodontina, *Unio* 165
Antimelania 108
aperta, Turbinicola 61
appressum, Pisidium 216
aquaedulcioris, Neosolen 221
arata, Corbicula 201
ARCIDAE 159
Arcidopsis 163,169
aspirans, Thiara 98.99
assamensis, Corbicula 201
assamensis, Parreysia 181
ASSIMINEIDAE 2
Astenothyra 91
ater, Faunus 109
atkinsonianum, Pisidium 216
auricularia, Lymnaea 125,134
auriculata, Neritina 37
austeni, Camptoceras 144
austeni, Pisidium 212,213
australis, Gabbia 75
australis, Lymnaea 129
ava, Pseudodon 174
avarix, Hydrobioides 81
avanum, Sphaerium 212,213
baconi, Ferrissia 137,138
bactriana, Lymnaea 135
balteata, Bellamya 46
Balwantia 162,175
Barlettia 197
barrackporensis, Gyraulus 153
Batissa 2,200,208
Belgrandia 91
Bellamya 11,12,43,44
bellamya, Paludina 44
BELLAMYINAE 43
bengalensis, Bellamya 45,225,226,228
bengalensis, Geloina 210
bensoni, Corbicula 202,205
bhamoensis, Parreysia 177
biacuminata, Lymnaea 128
bicinctus, Paludomus 119
bicolor, Clithon 39
Biomphalaria 29
Bithynia 72,73,80,83
BITHYNIIDAE 72
BITHYNIINAE 72,73
blanfordiana, Paludomus 112,226,228
blanfordiana, Stenothyra 86,87
blisteri, Melanoides 107
bonnaeaudi, Parreysia 187
borbonica *Patella* 41
bowelli, Lymnaea 126,131
Brotia 11,12,107
brevicauda, Lymnaea 125,134
brevissima, Lymnaea 127
Buccinum 133
Buliminae 73
Bulimus 74
BULININAE 141
burmanica, Paludomus 112
burmanus, Parreysia 177
caenosus, Planorbis 148,149
caerulea, Parreysia 188,226,229,231
calatha, Segmentina 149,150

Camptoceras 3,141,143
canaliculatus, Cremnoconchus 64
capillata, Batissa 209
capitis, Hippeutis 147
carinatus, Cremnoconchus 63
cashmiriensis, Corbicula 202
celox, Scaphula 159,160
cerameopoma, Digoniostoma 79
ceylanica, Ferrissia 137,138
ceylonica, Cyrena 211
charon, Melania 100
chaudhurii, Parreysia 189
cherraequris, Gyraulus 158
chilinoides, Paludomus 113
chilkaensis, Stenothyra 87
chinensis, Gyraulus 154
chlamys, Lymnaea 127
choprae, Parreysia 178
chrysis, Parreysia 181
Cipangopaludina 43,44,49
clarkeanum, Pisidium 218
clavus, Tiara 98
Clithon 2,33,38
coaxans, Venus 209
cochinensis, Villorita 208
colairensis, Bellamya 46
compacta, Pila 60
complanata, Helix 146
compressus, Planorbis 154,155
conica, Paludomus 113,226,228
conicus, Cremnoconchus 64
consobrinus, Lamellidens 164
convexiusculus, Gyraulus 154,158
Corbicula 49,200
CORBICULIDAE 199
corbiculoides, Villorita 206,207
corbis, Parreysia 178
cornucopia, Villorita 206,207
corrianus, Lamellidens 23,165,225,226, 229,230-232
cornea, Nerita 40
cornea, *Tellina* 211
corona, Clithon 39
corrugata, Parreysia 23,179
costigera, Mysorella 84
costula, Brotia 108,226,228
costulata, Lymnaea 135
crassa, Bellamya 48
crassicallosa, Taia 53
crassispiralis, Bellamya 47
crebra, Thiara 105
crebristriatus, Pseudodon 173
Cremnobates 62
Cremnoconchus 24,62
crenulata, Tiara 25,100
crispata, Scabies 193
crispisulcata, Parreysia 189
Cristaria 230
cristata, Valvata 55
Culmenella 145
CULTELLIDAE 220
curta, Bithynia 83
CYCLADIDAE 211
curvata, Pseudodon 173
cylindrica, Parreysia 180
Cyrena 208,210,211
cyprinoides, Villorita 206,207,208
daccaensis, Lamellidens 167
Dactylochlamys 50
dalyi, Acostaea 198
defilippi, Lymnaea 135
delicatula, Villorita 208
deltae, Parreysia 181
deltae, Scaphula 160
deltae, Stenothyra 87
demissus, Planorbis 154
dhuma, Paludomus 114
dhanushori, Trapezoideus 195
Digoniostoma 72,79
dissimilis, Bellamya 48
distoma, Hydrobioides 82
doliaris, Bellamya 47
Dostia 34,37
dravadica, Septaria 42
eburnea, Bellamya 46
echinata, Stenothyra 87,88
elegans, Thiara 96
elegantulus, Gyraulus 158
elitoralis, Taia 53
ellisi, Pisidium 219
emarginata, Solenaia 175
ennurensis, Iravadia 70,71
episcopalis, Brotia 109
erosa, Geloina 210
euphraticus, Gyraulus 155
Eupisidium 220
evezardi, Sataria 74,75
exolescens, Trapezoideus 195,226,228
exustus, Indoplanorbis 140,142
fasciolata, Melanoides 103

Faunus 109
favidens, Parreysia 180,231
feae, Parreysia 182
feddeni, Parreysia 182
Ferrissia 136,137
ferrugineus, Physunio 196
foliaceus, *Unio* 194,195
fonesi, Solen 222
fontanus, Hippeutis 146,149
footei, Arcidopsis 169
Fossarina 218
foveolata, Stenothyra 88
funerea, Iravadia 70,71

Gabbia 72,73,75
Gabbiella 76
galatheae, Cyrena 211
Galba 131
Gangetia 85,91
gangetica, Novaculina 223
gaudichaudi, Parreysia 188
Geloina 2,200,209
generosus, Lamellidens 165
gibbosula, Gangetia 92
Glauconome 221
globosa, Pila 57,58,225,228
globulosa, *Melania* 110
gowhattensis, Parreysia 183
gracilior, Lymnaea 127
gracilis, Pila 60
granifera, Thiara 101
gravelyi, Tricula 66,67
gravidus, *Unio* 175
gregoriana, Tricula 67,68
Gyraulus 141,143,153

hehoensis, Lymnaea 131
Helix 57,73,134,135,146,151
Helicorbis 146,147,148
hemisphaerula, Segmentina 148,149
hians, Lymnaea 127
himalayanus, Gyraulus 158
hirasei, Culmenella 145
hispidus, Planorbis 153
Hippeutis 141,146
hohenackeri, Gyraulus 158
horae, Lymnaea 124,130,131
horae, Tricula 67,68
hookeri, Lymnaea 126,132
houngdaranicus, Parreysia 183
hügeli, Sulcospira 107
humilior, Lamellidens 167
hungerfordiana, Stenothyra 86,88
huttoni, Planorbis 153
hydaspicola, Pisidium 215
Hydrobia 91
HYDROBIIDAE 64
HYDROBIINAE 65
Hydrobioides 78,80
hyptiocyclos, Gyraulus 158

impressa, Cyrena 210
impura, Lymnaea 129
incrassatula, Pila 58
indawgyiensis, Lamellidens 166
indicum, Sphaerium 212,213
Indonaia 212,213
Indoplanorbis 140-142
Indopseudodon 172,173
Indopyrgus 65
Inflata, Batissa 209
inflatus, Paludomus 114
inoscularis, Pseudodon 172
intermedia, Lymnaea 133
Intha 146,147,148
intha, Taia 53
involuta, Parreysia 189
Iravadia 70
IRAVADIINAE 2,64,69
iravadica, Corbicula 203,205
iridineus, Solenaia 175

jenkinsianus, Lamellidens 166
jourdyi, *Unio* 170

kashmirensis, Bithynia 74
kashmirensis, Lymnaea 135
kashmirensis, Sphaerium 212,213
kennardi, Polypylis 151
keraudreni, Polypylis 188
khadakvaslaensis, Parreysia 190
kuiperi, Pisidium 217
krishnaea, Corbicula 203

labiatus, Gyraulus 155
lacustris, Nautilus 149
lacustris, Taia 54
ladacensis, Gyraulus 156
laevirostris, Parreysia 179
laevis, Planorbis 156

lagotis, Lymnaea 125,135
lamellatus, Lamellidens 167
Lamellidens 23,162-164
laosensis, Margaritifera 199
largillierti, Segmentina 149
laticallosa, Lymnaea 125,132
latior, Lymnaea 130
layardi, Neripteron 37
layardi, Pila 57
lecythis, Cipangopaludina 50
Lecythoconcha 49
Lens 197
lima, Parreysia 190
Limnaea 124
lineata, Thiara 24,101
lineatum, Camptoceras 143-145
liratus, Planorbis 157
Lissoconchus 63
LITTORINIDAE 23,62
lobata, Mülleria 197
loricatus, Paludomus 117,121
luteola, Lymnaea 124,126,128
Lymnaea 124
LYMNAEIDAE 23,25,128

Mainwaringia 95,106
mainwaringi, Lamellidens 165
major, Tricula 68
malleata, Lymnaea 127
mandiensis, Bellamya 46
mandelayensis, Parreysia 177,184
Margaritanopsis 199
Margaritifera 198
MARGARITIFERIDAE 198
marginalis, Lamellidens 23,25,168,225, 226,230,231
martini, Tricula 68
maura, Ampullaria 60
MELANATRIINAE 93,106
Melanoides 95,103
MELANOPSINAE 93,109
micron, Bellamya 44,49
microchaetophora, Angulyagra 51
micropteroides, Physunio 196
miliacea, Gangetia 91
mimetica, Lymnaea 124,130,134
minor, Lymnaea 135
minor, Pila 58
minima, Stenothyra 86,89
misellus, Unio 195
mitchelli, Pisidium 220
monilifera, Stenothyra 86
Monocondylaea 172,174
montana, Tricula 66,68
montanum, Sphaerium 212,214
Mulleria 197,198
multidentatus, *Unio* 176
Musculium 211
Mya 179,198
Mycetopus 175
myitkyinae, Parreysia 177
Mysorella 72,83
MYSORELLINAE 72,73
Mysoria 83

nagarjuni, Scaphula 159
nagpoorensis, Parreysia 180
nana, Hydrobioides 81,82
nana, Paludomus 114
nana, Stenothyra 86,89
nanus, Gyraulus 158
narainporensis, Lamellidens 165
nassa, Hydrobioides 81,82
naticoides, Taia 52,54
Nautilus 149
Navicella 85
Nematura 85
Neopisidium 217
Neosolen 221
nepalensis, Bellamya 47
Neripteron 34,37
NERITIDAE 13,23,32
Nerita 120
Neritina 2,33,34
Neritodryas 33.40
neritoides, Paludomus 121
nevilli, Potamopyrgus 65
nevilliana, Pila 59
nevillianum, Pisidium 219
nigricans, Paludomus 119
nitidus, Planorbis 149
Nodularia 162
noetlingi, Corbicula 203
noetlingi, Taia 54
nongyangensis, Lamellidens 165
Novaculina 2,222
NOVACULININAE 222
nuttalliana, Parreysia 190
nux, Ampullaria 61

obesa, Lamellidens 167

obesus, Paludomus 115
obesula, Stenothyra 87
occata, Parreysia 191
Odhneripisidium 215
olea, Pila 59
olivacea, Parreysia 184
olivaria, Parreysia 191
orcula, Gabbia 76
orissaensis, Stenothyra 89
ornata, Stenothyra 86,90
ornatus, Paludomus 115
ovalis, Lymnaea 129
ovalior, Lymnaea 126,129
Oxynaia 163,170
oxytropis, Angulyagra 51

pachysoma, Parreysia 192
pagodula, Melania 107
Paludina 44,74,79,80
Paludomus 110
PALUDOMINAE 93,110
paludomoidea, Thiara 306
palustris, Paludomus 115
pankongensis, Gyraulus 156
Parreysia 23,162,163,176
PARREYSIINAE 175
parvula, Paludomus 116
Patella 41
patula, Lymnaea 127
peddamunigalensis, Melanoides 104
peguensis, Pseudodon 173
peninsularis, Corbicula 204
perconvexa, Parreysia 184
peregra, Lymnaea 135
pernodulosa, Parreysia 177
perottetiana, Neritina 35,36
persica, Lymnaea 126,133
phenchooganjensis, Lamellidens 168
Philopotamis 111,118
physcus, Gabbia 76,78
physcus, Lymnaea 126
Physunio 162,163,195
Pila 25,27,61
PILIDAE 23,56
pinna, Scaphula 160
piscinalis, Valvata 56
PISIDIIDAE 211
Pisidium 211,214
PLANORBIDAE 23,25,140
PLANORBINAE 151
Planorbis 141,142,149,150,151
planorbis, *Helix* 151
planorbis, *Planorbis* 151
platyconcha, Neritina 38
plicaria, Thiara 94,98,99
plicata, Cristaria 230
Polypylis 146,149
porcellana, Septaria 42
Potamopyrgus 65
prashadi, Pisidium 217
prashadi, Thiara 103
princeps, Iravadia 70,71
producta, Gabbia 77
Pseudodon 162,163,171,172
pseudohorae, Lymnaea 127
Pseudomulleria 198
Pseudosuccinea 126
pugio, Oxynaia 170
pulchella, Digoniostoma 79,80
pulligera, Neritina 34
punctata, Thiara 98
pustulosa, Paludomus 116
pyramis, Melania 103

Quadrula 176

Radiatula 162,176,187
Radix 133
rajahensis, Parreysia 185
raoi, Melanoides 105
regalis, Paludomus 119
regulata, Paludomus 116,118
reticularis, Clithon 39,40
retifera, Neritina 40
reticulata, Paludomus 117
riqueti, Thiara 102
rivalis, Tanysiphon 221
rivularis, Ancylus 137
robsoni, Pila 57
rotula, Gyraulus 157
rotunda, Paludomus 117
rotundatus, Planorbis 152
rotungensis, Paludomus 112
rubiginosa, Lymnaea 134
rudis, Thiara 97
rufescens, Lymnaea 127,134

saigonensis, Planorbis 154,158
saltensis, Gyraulus 157
salwenianus, Pseudodon 174

Sataria 72,74
saxea, Turbinicola 61
Scabies 193
scabra, Thiara 24,94,96
Scaphula 2,159
SEGMENTININAE 145
Segmentina 141,146,149,151
scobina, Unio 193
scobinatus, Unio 193
scutata, Pila 57,58,59
scutum, Lamellidens 168,169
semigranosa, Tarebia 101
semilaevigata, Brotia 108
Septaria 2,5,33,41
Sermyla 95,102
shanensis, Lymnaea 126,131
shanensis, Taia 52,54
shurtleffiana, Parreysia 192
siamensis, Lymnaea 129
siamensis, Unio 195
sikkimensis, Parreysia 185,226,229
siliguriensis, Unio 190
similis, Batissa 209
simulans, Lymnaea 133
Sinonovacula 222
sinuosa, Cyrena 210
sistanica, Amnicola 75
sivalensis, Gyraulus 158
smaragdites, Parreysia 185
smithi, Neritina 35,36
SOLECURTIDAE 222
Solen 222
Solenaia 163,171,175
soleniformis, Solenaia 175,226,229
solida, Corbicula 204
solidus, Paludomus 121
soluta, Stenothyra 86,90
SPHAERIIDAE 23,211
Sphaerium 211
stagnalis, Lymnaea 124,125,135
Stagnicola 136
stelzneri, Gyraulus 158
Stenomelania 95,98
Stenothyra 85
STENOTHYRIDAE 2,84
stenothyroides, Gabbia 76,77
stephanus, Paludomus 117
stewarti, Pisidium 217
stoliczkana, Valvata 56
stoliczkanum, Pisidium 220
Stomatodon 111,122
stomatodon, Paludomus 122
striatella, Corbiculla 204
Strombus 109
subangulata, Gangetia 91,92
subclathratus, Unio 195
sublamellata, Lamellidens 169
subnitens, Corbicula 205
subradiata, Corbicula 205
subspinata, Brotia 108
subspinosa, Brotia 108
subspinosum, Camptoceras 143,144,145
subsulcata, Neritodryas 40
subtuberculata, Brotia 108
succinea, Lymnaea 129
sulcatus, Paludomus 118,120
Sulcospira 107
superstes, Lymnaea 131
swinhoei, Lymnaea 134
syhadrensis, Cremnoconchus 53
sylhetica, Corbicula 205

Taia 43,52
taia, Segmentina 149,150
Tanalia 111,120
tangitarensis, Planorbis 152
tanjoriensis, Paludomus 118
tanschauricus, Paludomus 118
Tanysiphon 2,220
tavoyensis, Parreysia 186
taylori, Tricula 67,69
Tellina 200,211,214
tenebrosa, Cyrena 208
tentaculata, Bithynia 74
tenuis, Ferrissia 137,138
terebra, Camptoceras 143,144
textum, Digoniostoma 79,80
theobaldi, Parreysia 192
theobaldi, Pila 57,60
theobaldi, Taia 52,55
Theodoxis 36
Theodoxus 40
Thiara 2,94
THIARIDAE 5,23,92
THIARINAE 93
tibetensis, Corbicula 206
tigrina, Melanoides 104,105
tonapii, Lymnaea 127
tornatella, Melania 102
torulosa, Thiara 92,94,98,100

Trapezoideus 163,194
travancorica, Gabbia 76,78
triembolus, Parreysia 186
tribeniensis, Corbicula 202
Tricula 66
TRICULINAE 64,65
Trigonodon 172
trochoidea, Segmentina 149,150,151
Trochorbis 151
troscheli, Bithynia 74
Tropidiscus 152
truncatula, Lymnaea 125,133
tuberculata, Thiara 24,94,103
tungabhadraensis, Stagnicola 125,136
Turbinicola 57,61
turbinicola, Lymnaea 133
turrita, Hydrobioides 80,81,83
turrita, Neritina 35,36

umbilicalis, Hippeutis 148
UNIONIDAE 23,161
UNIONINAE 162
Unio 162,164,169,174

Valvata 24,55
VALVATIDAE 55
variabilis, Melania 103
variegata, Neritina 35
variata, Paludina 48
velaris, Physunio 197
velifer, Gyraulus 158
Velunio 196
Venus 210
verruca, Ferrissia 137,138,139
viola, Ferrissia 137,139
violacea, Neritina 37
Villorita 2,200,206
virens, Pila 57,59,60
viridula, Parreysia 182
Vittina 34,35
Vivipara 49,51,52
VIVIPARIDAE 13,23,42
VIVIPARINAE 43
Viviparus 44
vondembuschiana, Pseudodon 172

woodmasoniana, Stenothyra 86,90
wynegungaensis, Parreysia 180
woodthorpi, Margaritanopsis 199

yarkandense, Pisidium 218,220

zayleymanensis, Trapezoideus 195
zeylanica, Cyrena 207
zonata, Lamellidens 169
zugmayeri, Pisidium 218