STERKIANA

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ANNOUNCEMENT

Dr. David H. Stansbery, Ohio State University, Columbus, Ohio has accepted appointment to the Editorial Board of STERKIANA effective May 1, 1964

ANNOUNCEMENT

STERKIANA is named after Dr. Victor Sterki (1846-1933) of New Philadelphia, Ohio, famed for his work on the Sphaeriidae, Pupillidae, and Valloniidae. It is fitting that this serial should bear his name both because of his association with the Midwest and his lifelong interest in non-marine Mollusca.

The purpose of STERKIANA is to serve malacologists and paleontologists interested in the living and fossil non-marine Mollusca of North and South America by disseminating information in that special field. Since its resources are modest, STERKIANA is not printed by conventional means. Costs are kept at a minimum by utilizing various talents and services available to the Editor. Subscription and reprint prices are based on cost of paper and mailing charges.

STERKIANA accepts articles dealing with non-marine Mollusca of the Americas in English, French, or Spanish, the three official languages of North America. Contributors are requested to avoid descriptions of new species or higher taxa in this serial as the limited distribution of STERKIANA would probably prevent recognition of such taxa as validly published. Papers on distribution, ecology, and revised checklists for particular areas or formations are especially welcome but those on any aspect of non-marine Mollusca will be considered.

STERKIANA will appear twice a year or oftener, as material is available. All correspondence should be addressed to the Editor.

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STERKIANA es una coleccion de trabajos sobre los Moluscos extra-marinos viventes y fosiles de las dos Americas, editada por un grupo de malacólogos de los Estados Unidos centrales. Contenirá en el porvenir trabajos en inglés, francés, y español que serán acceptados por la mesa directiva. La correspondencia deberá ser dirigida al Editor.

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THE NATURAL SYSTEM OF THE NAIADES

HANS MODELL
Lindau/B Germany, 1942

Originally published in ARCHIV FÜR MOLLUSKENKUNDE 74(5/6): 161-191

Translated from the German with the consent of the author by

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Department of Zoology and Entomology, The Ohio State University, Columbus 10, Ohio, 1964

PREFACE TO THE TRANSLATION

This paper, kindly translated by Professors David Stansbery and Ulf Soehngen, must be read with the understanding that it was written in 1942 during World War II. All museum specimens and literature were then preserved underground and wholly inaccessible.

It has been 22 years since this paper was written, and I have tried to continue this work. Meanwhile we have come to know the recent Australian and South American Naiades through the efforts of MacMichael and Bonetto respectively. The fossil forms of Siberia have been studied by Rammelmayer and Martinson; those of East Asia by Suzuki and Hoffett; those of the Sahara by Mongin; and the North American material by Russell, Yen, and others.

Consequently it is not strange that my interpretations of 1942 are changed in many details. The basic outline, however, still stands.

Therefore I have no doubt that it is proper to reprint this old paper as a reference for all workers on Naiades who not only wish a system for use in classification, but for all questions confronting investigators in naiad phylogeny, their connections with climatology, paleogeography, and even geophysics.

I hope to publish a revised state of this system soon and also hope for the assistance of both authors of this translation.

Hans Modell
12 December 1963
Weiler am Allgäu
West Germany

THE NATURAL SYSTEM OF THE NAIADES

Since Simpson's great "Synopsis of the Naiades," of 1900 and its accompanying volumes, "The Descriptive Catalogue" of 1914, naiad research has not made very much progress. The main work of researchers has been directed towards the simplification of the species list which had become too lengthy, and toward the investigation of the anatomical relationships of individual species. In this regard in particular Ortmann's work "Notes Upon the Families and Genera of Naiades" of 1912 has been pioneering. Other works of Ortmann concerning the Naiades of Pennsylvania, the Tennessee and Cumberland systems, and those of South America have been additional contributions in anatomical as well as systematic fields.

The second part of the research, the arrangement of the species into natural groups, has also brought forth a series of important works. Several are: Frierson's "Checklist of the North American Naiades" of 1927; the revision of the Asiatic Naiades by F. Haas which was begun for the Conchyliencabinet in 1911, brought to a temporary halt in 1923, and was continued then in individual treatises. There are, in addition, the works on the inland Mollusca of Africa by the latter author in 1936 and a new revision of the Naiades of the Australian continent by T. Iredale in 1934.

Of the works listed, only those of Ortmann seemed to advance and support the system which Simpson had built to a great extent on inferences based upon analogies. Despite everything, our anatomical knowledge of the Naiades is not as general in all groups as might be desired. Furthermore, the anatomical structure varies in many cases so that we will not be able to clear up in this manner which are to be considered as species and generic characteristics and which are to be considered characteristics of the individual.

One thing, at any rate, is already certain today. The far-reaching conclusions made by Simpson, with regard to the use of the gills for incubation, were overextended and thereby his theory of the close relationship of the four-gill breeders or the outside-gill breeders are to be rejected. Simpson has, as Ortmann emphasized in 1912, paid too little attention to the shell and especially to the sculpture of the beaks. The sculpture of the beak has, in particular, proven itself to be a most important characteristic.

All too much has been described in the field of naiad systematics even if one disregards the thoughtless species-making of Bourguignat and his school and the mass describing of Lea which does not stand too far behind this school. In all diagnoses it becomes obvious that time and again most authors had no idea at all of what is important and unimportant in the shell of the Naiades. Thus, on the basis of the most insignificant forms (or types) which appeared, genera were set up such that the diagnosis, in many cases, does not show a single important characteristic clearly enough that it can be recognized again. The end result was that the much-plagued museum man looked on the Naiades as being a small phantom of fright and that our museums, in too many cases, are supplied abundantly with incorrect determinations. Generic names have been through a marked inflation since Simpson (1900) began, in a greater measure, the division into sub-genera. Haas, Frierson, and Iredale have subsequently added their fair share so that soon each good species could insist on its own generic name. However, on the other hand, there is something to be said for such groupings since each natural species is usually based on a long phylogenetic history containing many geologic mutations.

Simpson has already said much (which could still be said) in the introductions of both works named above, so that I can point to them. I am sorry to say that introductions are seldom read.

The work of most researchers has been limited during recent years to the reduction of the number of species. This has been based upon literature research.

The most critical examination of the original description, if possible of the type specimen, followed by the removal of superfluous names was the usual procedure. If there is sufficient participation, this process can bring us, in a hundred years, to a fairly usable and convenient system.

In order to arrive at a recognition of the species and higher categories which actually exist in nature, I have tried another approach. I have tried to view without bias the material which I have seen and worked over in our museums (i.e. Munich, Berlin, Stuttgart, and Frankfurt) together with that of my own collection and the material I have been able to obtain from the literature at my disposal. It is almost as if I had before me the material obtained on an expedition to an unexplored planet and I have used on it the experiences of a biological nature which I have obtained in better than 20 years of collecting.

I have come in this to surprising conclusions.

I emphasize emphatically that the present work is the first attempt to use equally and completely the possibilities of differentiation which have been given to us in the shell of the Naiades for the construction of a natural system. I am expecting the objection: What is a good species? and I have this answer: A good species is a community of individual animals of the naiad group which can be differentiated from every other community of equal standing by the form of the shell (the outline in the young specimens), the sculpture of the umbone (beak), and the structure of the hinge and - when it can be checked - of the soft body. This holds true only if the specimens are well preserved - and I believe the main importance should be placed on differentiability. With this concept I have arrived at a system of about 450 good species for the whole recent naiad fauna.

As important as the anatomy of the soft body has proven to be in many fields of molluscan research it may as easily be overestimated in its importance for the Naiades. If we disregard all "side work" there remain few points concerning the soft body which have value for systematics. These are mainly restricted to the true mutelids and their direct descendants, the North American elliptionids.

These are:

1. The position of the marsupium in the gills and the continuation of development up to the most complicated structure. In the latter case this can be known by the shell through difference of the sexes (Lampsilinae).

2. The growing together of the anal and supra-anal openings forming a distinct siphon can be seen at the shell through an indentation of the posterior margin of the mantle and occasionally also by the gaping of the shell. This development usually proceeds continuously to the enclosure of the body of the mussel through fusion of the lower mantle margins. Thus it is in part of the Mutelids.

3. The development of a long clinging foot with a sucking disc. This foot is especially strengthened with retractile muscles and the shell gapes at the rear end. So it is in the case of Mutelids and Elliptionids.

Most of the other anatomical characteristics go hand-in-hand with changes in shell form.

The shell itself gives us very few characteristics which are important for description and recognition except for following secondary anatomical characteristics:

1. The normal optimal form of the shell usually corresponding completely to the shell of the young.

2. The normal beak sculpture, varying biologically in swamp, stream, and lacustrine forms.

3. The normal structure of the hinge teeth of the species varying in the same manner.

The color of the mother of pearl can be used as an additional character in several North American, South American, and African species groups. However, it is assumed in this case that one is dealing with a character which has been acquired upon entering certain geologically homogeneous regions (orange and red coloration in tropical highlands, blue coloration in tropical lowlands, violet coloration in North America). Furthermore, in the hingeless African and South American mutelids the ligamental indentation, which very often has been lengthened into a hook, is a useful characteristic for differentiation.

For the fossil Naiades the conditions are more difficult since we usually have only incomplete remains. Thus most species in which one saw or suspected hinge teeth were placed in the Genus Unio and those lacking hinge teeth were placed into the Genus Anodonta. Henderson in 1935 still used both genera in this sense. He did this unjustly since today they correspond exactly to groups of species and are not a dumping ground for trash. As for the remainder, I have already tried, as far as is possible at this time, to build the fossil naiads into the system.

It is impossible to give exact descriptions of the individual parts of the naiad hinge and beak sculpture using current terms - which, in most cases, say almost nothing. I have redesignated these parts in a nonambiguous manner using several drawings. See table 6 and its explanation.

The hinge of the Naiades is very simple in its basic structure. It consists of two pairs of lamellae in the left shell and two single lamellae in the right shell. The attempt of Ihering, Stoliczka, and of others, to derive it from a taxodont hinge is mistaken and is based on an overestimation of a single observation of the hinge of the African mutelid group Iridina. Its hinge, however, is not originally taxodont but is an auxiliary hinge which has been newly formed following the loss of the true hinge through cross-grooving of the still-present hinge plate according to the hypothesis of the non-reversal of evolution.

If a taxodont hinge were really the original hinge of the Naiades, more vestiges would still be present today. However, they are missing completely. Only the hinge of the left shell is important since it is somewhat more complicated and therefore gives greater possibility for description. In table 6 I give a scheme of the original naiad hinge. The figures signify: I = anterior cardinal tooth, II = posterior cardinal tooth, III = ventral lamellar tooth, IV = dorsal lamellar tooth. Regardless of whether the cardinal teeth are formed as lamellae or as thick teeth the above terminology holds. Their being named pseudo-cardinal teeth in the naiad group is misleading and worthless.

The sculpture of the umbone of the Naiades has behind it a rich developmental history. In the mutelids we still find the simplest stage - small, seemingly insignificant, irregular dots. The rest of the mutelid group has developed a regular sculpture which consists of two arches which meet at the umbone in a rather obtuse angle (Plate 6, fig. E). The Elliptionidae, direct descendants of the Mutelidae, have the same sculpture. The true unionids, (Plate 6, fig. C) however, have both arches of the mutelids subdivided again at the posterior ridge and on the anterior slope of the umbone so that 4 arches are formed. I have named them as follows: 1. the primary arch, 2. the anterior arch, 3. the posterior arch, and 4. the areal folds (Plate 6, fig. C, D). From this all such seemingly complicated naiad beak sculptures are formed. I shall discuss details when I come to the individual groups. I refer the reader to the illustration on plate 6.

The possibilities of naiad shell development go in three directions:

1. Standing-water forms having the greatest possible decrease in hinge development up to total disappearance (Anodonta forms).
2. Normally moving water forms which have the anterior lamellar arches of the hinge shortened to true cardinal teeth (Unio forms), (Plate 6, fig. G).
3. Fast-moving water forms with a strengthening of the hinge and a reformation of the shell in the direction of a high three cornered to high four cornered "rollingstone" shell form, (Quadrula form) (Plate 6, fig. H).

After these somewhat roundabout but necessary explanations I still have to dwell somewhat longer on the evolutionary history of the naiads for an understanding of the systematics based on it.

The whole group of the naiads presents in itself a complete entity, a group of the Lamellibranchiata which is fitted, without exception, for life in fresh water. As far as it is possible for me to judge today the trigonids stand outside the naiad group and its progenitors. The Naiades are, however, more closely related to the Cardinids. This can be substantiated by a series of similar characteristics. It even seems probable that the Cardinids are a branch which has returned to the sea. This would not be surprising in view of the persistently fluctuating island-like nature of Mesozoic Europe.

Whether we can let the naiad stem begin with Fordilla troyensis Barrande from the middle Cambrian of New York or with the lower Devonian Amnigenia catskillensis Vanuxem is not yet clear. The first group we may definitely consider as Naiades is the Family Anthracosiidae which were worldwide in distribution from the Carboniferous to the Triassic. Probably during the Permian, and at the same time on all continents, the stems of the Naiades developed from these dwarf-like forms. Nothing remains from this oldest development. We may however assume with certainty that the naiad type of this early fauna was fairly uniform. It, to a large degree, corresponded in shell structure and in its absence of sculpture to forms which we may consider to be the last remains of that fauna: in South America the Genus Prisodon Schum., in Africa Pseudavicula Simps., and in Australia Velesunio Ired.

The separation of the north continents from the south continents started at this time. This was followed by the division of the south continent itself, and these events determined the further direction of evolution. In South America, still very similar to Africa with respect to its original mutelid fauna, these forms continued to develop into almost or completely hingeless forms. They have probably also undergone great changes in anatomy. These are the subfamilies Anodontitinae, Glabarinae, Mycetopodinae, Monocondylaeinae and, a group having an atypical origin, that subfamily of freshwater clams which have sprung from the Anodontitinae, the Bartlettiinae. Occasional later connections of shorter duration have also permitted the immigration of a species of the Spathopsinae and a species of the Iridininae from Africa. However, a connection with the North American continent, which probably had its origin before the Triassic, became more important. It brought to North America, in addition to the completely developed Mycetopodinae with its reduced hinge, the basic form of the unionids of that time. These small naiads of the type of Unio gallinensis Meek, and cristonensis Meek probably became the progenitors of the North American Unios. Van der Schalie has placed them in the Genus Trigonodus Alb. Development continued rapidly from these forms to the Pleurobeminae which Ortmann has considered to be the progenitors of his Elliptio. These finally gave rise to the true Elliptioninae accompanied by a better development of the umbone sculpture, and finally to the Quadruline forms which are the Ambleminae of today. Already in earlier times a subfamily had begun with the reduction of the hinge. It had started in an unusual manner with total loss of the upper lateral tooth and the reduction of the lower to a large degree (Alasmidontinae). One species has even gone so far as to develop an anodontid form. An additional subfamily (the Lampsilinae) has evolved in different directions from true elliptionids. They have the marsupium limited to the posterior end of the outer gill and, through a folding or rolling up of the marsupium, have developed better water circulation. Whether this extreme specialization can be considered to be the highest development appears questionable to me. At any rate, it is the highest level the naiads have reached in the care of the young. In other respects this group in particular has remained very primitive. This is demonstrated by its glochidium and umbone sculpture which are directly related to the African mutelids. In the lower Cretaceous this development has, for the most part, already been completed. This group has apparently never spread beyond its present range.

The African mutelids have developed, with the exception of the original relic Pseudavicula which differs in its hinge teeth, a series constituting the subfamilies Mutelinae, Aspathariinae, and Spathopsinae, which find a parallel in the South American forms. Of the Spathopsinae, one species later migrated to South America. As a special development the Iridininae changed the hinge plate, after the loss of the

(TEXT CONTINUED ON PAGE 7)

EXPLANATION OF PLATES

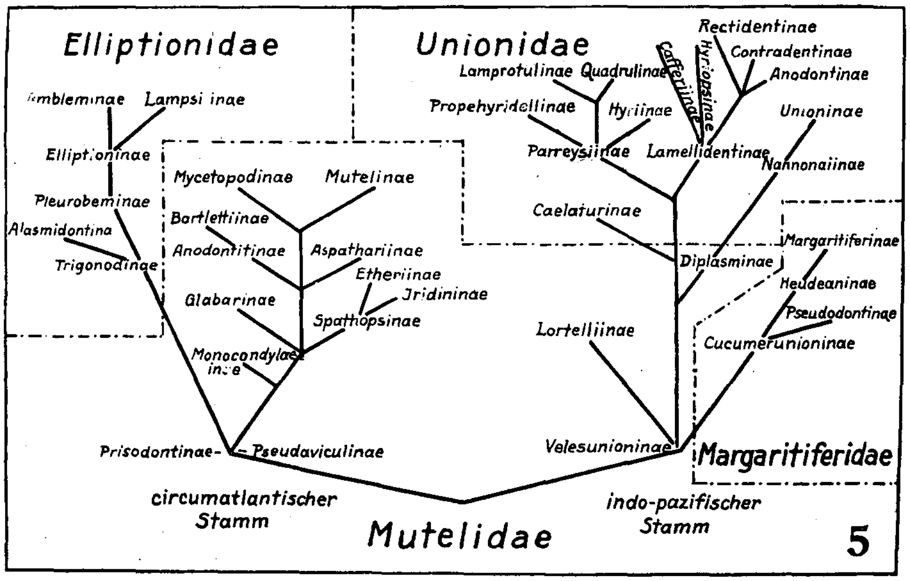
PLATE 5. Phylogenetic relationships of the Naiades.

PLATE 6. Fig. A, Outline of a Unio: I anterior margin, II umbone, III dorsal margin, IV ventral margin, V posterior margin (beak). Fig. B, View from above: I right valve, II left valve, III umbone. Fig. C, Unionid sculpture: I primary arch, II anterior arch, III posterior arch, IV areal fold. Fig. D, Parreysid or V-sculpture. Same terminology. Fig. E, Aspatharid sculpture. Same terminology. Fig. F, Lamellar hinge: I anterior cardinal tooth, II posterior cardinal tooth, III lower lamellar tooth, IV upper lamellar tooth. Fig. G, Unio-hinge. Fig. H, Quadrula-hinge.

Umbone sculptures: (slightly enlarged) Glabarinae: 1. Glabaris trigonus Spix, Spathopsinae: 2. Spathopsis wahlbergi Kr., Aspathariinae: 3. Asp. rugifera Dkr., 4. Asp. pfeifferiana Bern., 5. Asp. rubens Lam., Jridininae: 6. Jrid. ovata Sw., Pleurobeminae: 7. Pleurob. mytiloides Raf., Alasmidontinae: 8. Alasm. undulata Say, 9. Pressodonta calceola Lea, 10. Pegias fabula Lea, 11. Platynaias viridis Raf., 12. Simpsoniconcha ambigua Lea, 13.-15. Strophitus undulatus Say, 16. Anodontoides ferussacianus Lea, Elliptioninae: 18: Ell. buckleyi Lea, 19. Ell. dilatatus Raf., 20. Uniomerus tetralasmus Say, Ambleminae: 21. Amblema plicata Raf., Lampsilinae: 22. Lamps. fasciata Raf., 23. Lamps. teres Raf., 24. Lamps. recta Lam., 25. Ptychobr. fasciolare Raf., Cucumerunionae: 26. Cuc. beccarianus Tapp., Heudeaninae: 27. Heud. murinum Heude, Margaritiferinae: 28. Marg. margaritifera L., 29. Cumberl. monodonta Say, Pseudodontinae: 30. Pseud. inoscularis Gld., 31. Monodontina vondembuschiana Lea, 32. Obovalis loomisi Simps., 33. Microcond. compressa Mke., Hyriinae: 34. Dipl. chilensis Gray, 35. Dipl. rhuacoicus Orb., 36. Hyria rugosissima Sow., 37. Dipl. fluctiger Lea, 38. Castalia quadrilatera Orb., Propehyridellinae: 39. Pr. nepeanensis Conr., Parreysiinae: 40. Parr. corrugata Müll., 41. Acuticosta chinensis Lea.

PLATE 7. 42. Protunio messageri B. & Dautz., Lamprotulinae: 43. Lampr. leai Gray, 44. Inversidens japanensis Lea, Quadrulinae: 45. Quadr. quadrula Raf., 46. Megalonaias gigantea Barn., Lamellidentinae: 47. Lam. marginalis Lam., Hyriopsinae: 48. Hyr. schlegeli Marts., Cafferiinae: 49. Caff. caffra Kr., Rectidentinae: 50. Rect. orientalis Lea, 51-52. Physunio superbus Lea, 53. Pilsbr. exilis Lea, 54-55. Pyganodon grandis Say, 56-57. Lastena ohiensis Raf., 58. Last. suborbiculata Say, Contradentinae: 59. Contr. dimotus Lea, 60. Contr. (Sprickia) rusticus Lea, 61. Pressidens exanthematicus Kstr., 62. Caudiculatus caudiculatus Marts., Anodontinae: 63. PlethОlophus discoideus Lea, 65. An. japonica Cless., 66. An. marginata Say, Caelaturinae: 67. Cael. aegyptiaca Caill., 68. C. bakeri Ad., 69. C. hauttecoeuri Bourg., 70. Grandid. burtoni Woodw., 71. Cael. gabunensis Kstr., Nannonaiinae: 72. Nann. caerulea Lea, 73. Nann. crispata Gould, 74. Trapezoideus foliaceus Gould, 75. Nann. mossambicensis Marts., Unionae: 76. Unio schödei Haas, 77. Cuneopsis pisciculus Hde., 78. Cun. celtiformis Hde., 79. U. douglasiae osbecki Phil., 80. U. dougl. dougl. Gr. & Pldg., 81-87. U. mancus glaucinus Porro, Oberitalien, 88-92. U. terminalis Bourg., 93. U. tigridis Bourg.

(THE THREE PLATES OF THE ORIGINAL ARE HERE GROUPED INTO ONE)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Lamprotulinae
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Cafferiinae
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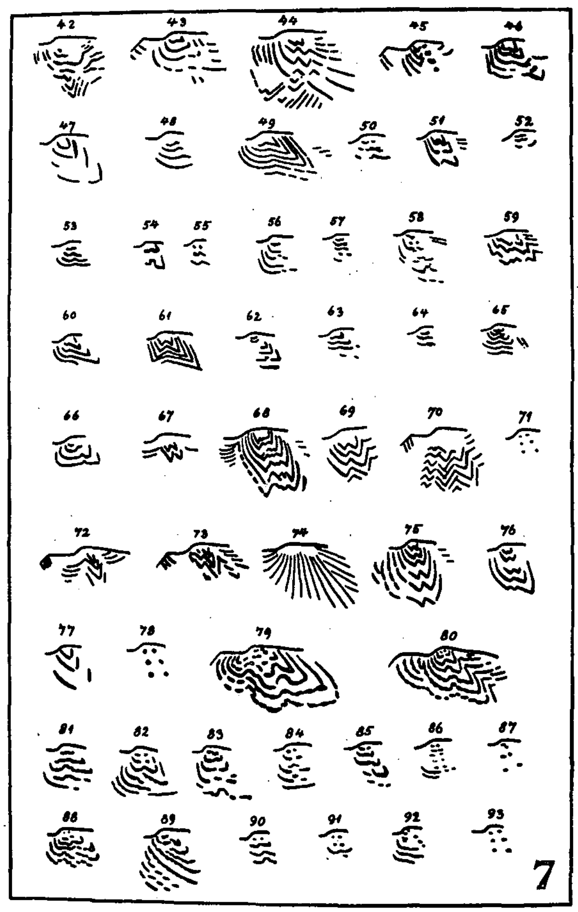
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original hinge (as in their ancestral group the Spathopsinae) into a new cross ribbed hinge.

The Etheriinae, coming from the Aspathariinae, reached the typical form of an oyster as did the South American Bartlettiinae. The Indian fresh water oyster P s e u d o m u l e r i a Anth. probably also belongs to this group. For the rest, Africa has seemingly added nothing directly to the further development.

The third large southern continent, Australia, compared to the Africa and South America of today, appears to be more ancient in its mutelid fauna in so far as all still have hinge teeth i. e. have not progressed very far in the reduction of these structures. The Subfamily Lortiellinae Ir. forms a parallel with the Mycetopodinae and the Mutelinae of the other southern continents and has, in the case of one genus, spread as far as southeast Asia. The other Subfamily, the Velesunioninae Ir., still shows the steps of transition from the true lamellar hinge to the unionid hinge. They remain, however, without sculpture. It is probable that one must trace the development of the Family Margaritanidae back to Australia. Their original sculpture consists only of the two middle arches which have small upswept lines on both sides. At any rate, Australia still has the most primitive subfamily of this family, the Cucumerunioninae Ir. The remaining subfamilies, the Heudeaninae, the Pseudontinae with the reduced hinge, and the true Margaritiferinae are still found in nearby southeast Asia. The later expansion of the whole family occurred in the upper Cretaceous and Eocene. A further main migration of the Pseudodontinae to Europe and North America took place in late Miocene to Pliocene and the last circumpolar migration of M a r g a r i t a n a m a r g a r i t i f e r a L. in late Pliocene.

The most difficult problem is the nature of the connection of the true unionids to the mutelids. Following an intermediate stage, the Unionids appear to be connected with the Velesunionids of Australia. This stage corresponds to the American Trigonids and is represented by T r i g o n o d u s in the Raibler strata of the Triassic in Europe and by the living sculptureless Diplasmids in India. This transition may have occurred at the time when Australia, according to Wegener's theory, was still located farther west. The fauna of the Indian continental block already represents a further developed stage. The structure of the hinge has developed slowly into the Unionid hinge and the sculpture is more primitive in-so-far as the rising arch and the areal folds are fully developed and separated. However, both middle arches, in complete contrast to the mutelid sculpture, form an acute angle pointing downward. Since a large number of the groups which have this sculpture soon develop the true Unionid sculpture, we can say, in the case of this Parreysien sculpture, that its appearance as a time-bound type-characteristic is to be understood in the sense of Dacqué's theory of types. Probably in the Indian area where all basic forms are still living, there appeared in quick succession the three branches: the Parreysiinae, Lamellidentinae, and Nannonaiinae.

The Parreysiinae, which have a definite "radial sculpture," continue to live in the main part of India and have continued to develop in eastern Asia and Europe into the Lamprotulinae which have the Unionid sculpture. In the Triassic of North America the subfamily Parreysiinae appears with the Hyriinae. The Parreysiinae of North America, however, change gradually in the Jurassic and Cretaceous into the Quadrulinae. The Hyriinae have today covered all of South America and have, in the Pliocene, advanced again toward North America together with the giant South American sloth. A last branch of the Parreysiinae, the Propehyridellinae Ir., still live in Australia.

The Lamellidentinae, which were also originally provided with V-sculpture, had also a complete lamellar hinge. They became, through scarcely noticeable, though not yet obliterated transitional characters, the progenitors of a series of subfamilies all of which, however, have Unionid sculpture. The first of the series is the subfamily Cafferiinae which is limited to South Africa today. Secondly, the Hyriopsinae in the Tertiary exhibited a strong development of the shell and, today includes the largest living naiades, Hyriopsis and Dipsas. On the other hand, this subfamily has the teeth and, in particular, the cardinal teeth reduced in part. They have also been represented in Europe from the Miocene to the end of the Pliocene. A further branch of the Lamellidentinae is split into the Contradentinae, Rectidentinae, and the Anodontinae. The former remain limited to southeast Asia, the Rectidentinae migrate, after the loss of their hinge, to Europe and North America. The Anodontinae also lose their hinge and spread over all of the north continents. A further subfamily, the Caelaturinae of Africa, forms the transition to the Nannonaiinae of East India. Also in this case the original sculpture is V-shaped. However, already within the stem group, the sculpture has changed to the Unionid type. This has a later throwback into an apparent V-sculpture in a single genus (Cuneopsis). For the rest, the development continues almost without deviation to the true Unioninae. These have occupied Europe and Asia since the Upper Cretaceous but have never reached North America.

Thus we see that the faunal pattern of today's Naiades has terminated, for the most part, at a geologically early time, i.e. the Upper Cretaceous. Only a few groups, which belong mostly to the higher developmental steps of the Unionids, made still further progress in the Tertiary. The last attempt to form new Quadruline forms in the European Pliocene was by these young groups and this was disrupted by the onset of the ice age.

The over-all picture of the developmental history of the Naiades given here is probably as interesting as the development of the mammals. With "Altmeister" (old master) Boelsche one could write a volume titled "Wanderings of Naiades in Ancient Times."

I hope to be able to publish, within a short time, the bases for this paper. I am adding a compilation of the most important types of beak sculpture. They will give the reader a concept of the probability of what has been presented. The "family tree," which has also been added, is not, of course, meant to be a family tree in the sense of Haeckel's school but only a presentation of those transition lines which represent the connection of relationships between the naiad groups. Despite its limited size, one may recognize in it several important points, which until now could not be discussed. One is the division of the originally uniform development into two lines. A circumatlantic branch, which has, in the southern portion of its range, already completed development to the Anodontid form and in its northern range, has reached its highest development in the Elliptionidae with the hinge retained. An Indopacific branch, whose mutelids have, for the most part, continued to develop into modern forms and brought forth the modern Unionids after having split off the older Margaritiferidae. I consider these and not the one-sided highly-specialized Lampsilinae to be the only Naiades capable of further development.

In the following compilation I have assigned a series of Central American forms to the subfamilies Elliptioninae, Lampsilinae, and Quadrulinae, although this assignment is open to question. Frierson's compilation and assignments also have to be checked over critically. This was impossible for me to do because of the incompleteness and confusion of the literature and the sparse material present in German museums. I have also reserved a large part of the fossils for a later presentation.

I. Family Mutelidae (Gray) Ihering, 1893.

The lasidium of Ihering as the glochidial stage of the Mutelidae has not been found again since its discovery. Thus it remains questionable. If it should really exist, it would mean that this early stage of the mutelids has already gone through a far-reaching special development and reduction. It could possibly be identical with the original larval stage of the Naiades. Rather we are dealing with a form which presupposes the closing of the animal in a cylindrical shell which is approached in many cases in the mutelids today. In the concept of the family, I agree with v. Ihering and set aside the Hyriinae of Ortmann as being totally heterogeneous. On the other hand, I include the primitive sculptureless forms of Australia.

The greater number of today's mutelids have become hingeless. There still remain, however, several groups in Australia and India which retain the lamellar hinge that was originally characteristic of all mutelids. Individual special developments, such as the apparently taxodont hinge of the Iridininae and the development of the Bartlettiinae and Etheriinae (which is similar to that of the oyster), can be explained by special adaptations during the infinitely long span of time of their existence. The definition of the family, therefore, has to be very broad:

Naiades, originally with no sculpture but later developing a punctiform sculpture, or double archs reaching from the anterior to the posterior margin with the tip at the umbone. Originally there was a lamellar hinge (left shell with two cardinal teeth and two lateral teeth; right shell with one cardinal and one lateral tooth), which later became completely reduced. It is often closed off by a triangular to hook formed ligamental indentation at the posterior margin. Anatomically there is a trend toward siphon formation of the anal and supra-anal openings, toward the fusion of the lower mantle margins, and toward the formation of a mushroom-shaped clinging foot.

Distribution today: South America to southern Middle America, Africa south of the Sahara, India, Australia, New Guinea, and New Zealand.

A. South American Developmental Series

1. Subfamily Prisodontinae n. subfam.

Type species: Prisodon syrmatophorus van Meuschen, 1781. Last remnant of originally fully-toothed mutelids of South America. Hinge consisting of teeth, umbone sculpture missing. Distribution: High land of Guiana (Archiguiana v. Ihering) to the Amazon River. Single genus: Prisodon Schumacher, 1807.

2. Subfamily Monocondylaeinae n. subfam.

Type species: Monocondylaea paraguayana Orbigny, 1835. Umbone sculpture missing, hinge largely reduced in two phases. The first with a hinge plate still present and with teeth on top. The second is without a hinge plate, with the teeth seemingly coming from the shell margin. Lateral teeth have completely disappeared; on the left a cardinal tooth is still present.

This group includes the genera: 1. Phase: Iheringella Pilsbry, 1893; Marshalliella Haas, 1931; Diplodontites Marshall, 1922; Tamsiella Haas, 1931. 2. Phase: Monocondylaea Orb., 1835; Fossula Lea, 1870. Distribution: Tropical South America east of the Andes.

3. Subfamily Glabarinae n. subfam.

Type species: Glabarus exoticus Lamarck, 1819 (=Gl. trapesialis Lam., 1819). Anodontine development without hinge teeth, however with hinge plate still retained and triangular to hook-formed, ligamental indentation. Mother-of-pearl white, bluish to red. The development is parallel to the African Aspathariinae.

This group includes the genera: Glabaris Gray, 1847, with the species groups mortonianus Lea, 1834, patagonicus Lam., 1819, trigonus Spix, 1827, trapesialis Lam., 1819, and Leila Gray, 1840.

I find myself forced to use the generic name Glabaris Gray which has been re-introduced by Simpson (1900) for the species groups which I have mentioned since the name Anodontites refers to another species group which is considerably further advanced in their anodontine change, thus probably having begun to change much earlier.

Distribution: Tropical South America and southern Central America.

4. Subfamily Anodontitinae n. subfam.

Type species: Anodontites crispatus Bruguière, 1792. Umbone sculpture missing. The shell is elongate to knife-formed. Hingeplate almost disappeared, ligamental indentation hook-formed. Mother-of-pearl blue-gray to blue-green. The shell sculpture appearing in tropical forms, and called "festoons" is not even useful as a species characteristic.

This group includes the genus: Anodontites Brug., 1792, with the species groups crispatus Brug., 1792, and tenebricosus Lea, 1843.

Distribution: Tropical South America.

5. Subfamily Bartlettiinae n. subfam.

Type species: Bartlettia stefaninii Moricand. Oyster-shaped transformations of the Anodontitinae having pointed ligamental indentation hooks. They have a broad hinge plate and blue-green mother-of-pearl. Found living in the limestone debris below falls (Bartlettia) or attached to the sand bottom of rivers (Acostaea).

This group includes the genera: Acostaea Orbigny, 1835; Bartlettia H. Adams, 1870.

6. Subfamily Mycetopodinae n. subfam.

Type species: Mycetopoda siliquosa Spix, 1827. Umbone sculpture missing. Hingeplate completely disappeared. Ligamental indentation long and flat. Mother-of-pearl bluish. Shell at the posterior margin gaping. "Sucking foot" well formed.

Into this group: Lamproscapha Swainson, 1840; Mycetopoda Orbigny, 1835; Mycetopodella Marshall, 1927.

Distribution: Tropics South to Central America. Known as a fossil since the Triassic from North America.

B. African Developmental Series

7. Subfamily Pseudaviculinae n. subfam.

Type species: Pseudavicula johnstoni Smith, 1893. Hinge with complete lamellae, umbone sculpture missing. A parallel to Prisodon. Into this group: Pseudavicula Simpson, 1900, Lake Mweru.

8. Subfamily Spathopsinae n. subfam.

Type species: Spathopsis wahlbergi Krauss, 1848. Elongate oval to rectangular species with hinge plate lacking teeth. Umbone sculpture single points. Mother-of-pearl reddish-orange. Ligamental indentation hook formed.

Into this group: Spathopsis Simpson, 1900 in Africa and with one species in the Guiana region of South America.

9. Subfamily Iridininae n. subfam.

Type species: Iridina exotica Lamarck, 1819. Continuation of development of the Spathopsinae by the re-introduction of an apparently taxodont hinge; originated in the great African lakes by grooving of the hinge plate. Point sculpture barely indicated.

Into this group: Iridina Lam., 1819; Pleiodon Conrad, 1834; Cameronia Bourg., 1879; a fossil species (upper Cretaceous or lower Eocene) in the state of São Paulo, Brazil; otherwise in Tropical Africa in the Tanganyika, Tschad, and West African rivers.

10. Subfamily Aspathariinae n. subfam.

Type species: Aspatharia rugata Dunker, 1848, (=Asp. camerunensis Ortm. & Walker). Short oval to elongate species with triangular ligamental indentation, hinge plate present, but without teeth. Mother-of-pearl white to bluish and red. Umbone sculpture double arches which meet below the umbone in an obtuse angle. Represents the South American Glabarinae and, in part, the Anodontitinae.

Into this group: Aspatharia Bourg., 1885, with pfeifferiana Bernardin; rubens Lam.; Leptospatha Roch. and Germain, 1904; Arthropteron Rochebrune, 1904, in which the Asp. petersi Martens forms a closer analog to the Anodontinae.

Distribution: Tropical Africa.

11. Subfamily Etheriinae n. subfam.

Type species: Etheria elliptica Lamarck, 1807. Development similar to that of oysters with a hinge plate and ligamental indentation; probably evolved from the Aspathariinae of the rubens Lam. group.

Into this group: Etheria Lam., 1807, in Tropical Africa and North Madagascar; Pseudomulleria Anthony, 1907, in South India.

12. Subfamily Mutelinae Ortmann, 1911.

Type species: Mutela dubia Gmelin, 1791. In contrast to Ortmann, I am limiting the subfamily to the African relatives of Mutela dubia Gm.

Elongate thin-shelled forms; analogous to the Mycetopodinae; shell gaping at both ends. Mother-of-pearl bluish. No umbone sculpture; siphon development and probably clinging foot.

Into this group: Mutela Scopoli, 1777; Chelidonopsis Ancey, 1887; Pseudospatha Simpson, 1900; Brazzaea Bourg.; Moncetia Bourg., 1885.

Distribution: Tropical Africa.

C. INDIAN Developmental Series

13. Subfamily Diplasminae n. subfam.

Type species: Diplasma vitrea Raf. (=Nodularia olivaria Lea and author).

Small forms with a glossy shell structure, without sculpture, and with weak Unionid teeth. A remnant of a very old developmental step, which is represented in North America by Trigonodinae. Probably they are very close to the forerunner of the Unionidae.

Into this group: Diplasma Raf., 1831, in Assam, East India.

D. Australian Developmental Series

14. Subfamily Velesunioninae Iredale, 1934.

Type Species: Velesunio balonnensis Conrad, 1850. Umbone and shell smooth. Hinge completely lamellident, in part in the process of changing to the Unionid hinge. Umbone seldom "seemingly angled" (in Hydrunio).

Into this group: Velesunio Iredale, 1934; Westralunio Iredale, 1934; Centralhyria Iredale, 1934; Hyridunio Iredale, 1934; Alathyria Iredale, 1934.

Distribution: Australia, New Guinea, New Zealand.

This subfamily, or rather its geologic forerunners, has become the origin of all developmental series in the Indo-Pacific region. Also its forms today have not gone along with the Atlantic series in their development to the anodontine form possibly as a result of the increasingly dryer condition of Australia.

15. Subfamily Lortiellinae Iredale, 1934.

Type species: Lortiella rugata Sowerby, 1868. Elongate species, a younger parallel series to the Mycetopodinae and Mutelinae. In the oldest stages there is still a lamellar hinge, which later becomes rudimentary. Partially developed digging foot. Sculpture (in Solenaia) "weak concentric double arches."

Into this group: Lortiella Iredale, 1934; Solenaia Conrad, 1869.

II. Family Elliptionidae n. fam.

Starting with the South American forerunners of today's mutelids the elliptionids developed in North America at the latest since the Triassic. They have always remained limited to North America. The oldest known forms have an oval outline and no sculpture. They were followed by oval forms with a unionid hinge, the unionid-like forms immediately followed by quadruline forms, as a sideline a group with partially or totally reduced hinge, and, finally, as the highest developmental stage, the Lampsilinae with specialized marsupium. The primitiveness of the whole group is demonstrated by the umbonal sculpture which goes directly back to the aspatharid sculpture, as well as by the hookless glochidium which makes impossible a parasitic juvenile stage on the fishes. As a timewise and biological analog can be considered the family Margaritiferidae from the Indopacific developmental series. The definition of the family is as follows:

Naiades of North America with a complete to missing hinge, the umbone sculpture, as a rule, limited to the two inside arches whose posterior arch meets the anterior arch in an obtuse angle. The posterior arch can have, through a strong upward sweep, the character of a hook (Alasmidontinae) or may, through a downward curve and an increase in thickness, form shell sculpture (Ambleminae). In the Lampsilinae, which are characterized by a special brood chamber in the posterior part of the outer gills, the sculpture is the most primitive, being similar to that of the African Aspatharia. The shell surface often has radial green stripes (also inherited from the Mutelidae). Glochidium without hooks.

16. Subfamily Trigonodinae n. subfam.

Type species: Trigonodus sandbergeri v. Alberti, 1864. Shell short oval to short triangular, umbone without sculpture. Hinge unionid.

Into this group: Trigonodus v. Alberti, 1864; a series of so-called "Unio" species from the Triassic of southwest U.S.A. (cristonensis Meek; gallinensis Meek) which, for the first time, van der Schalie has placed in an equal footing with Trigonodus of the east-alpine Triassic.

17. Subfamily Pleurobeminae n. subfam.

Type species: Pleurobema mytiloides Rafinesque (=Unio clavus auct.)

Primitive forms with shortened oval to quadrate shell, umbone sculpture hardly noticeable (I only saw anterior end hooks in P. mytiloides) and a unionid hinge often of the thickened type. The type species itself is a special development with the umbone in a forward position. At times the shell sculpture occurs in a central row of knobs (Plethobasis).

Into this group: Pleurobema Raf., 1820; Lexingtonia Ortmann, 1914; Plethobasis Simpson, 1900; Pleuronaia Frierson, 1927; Fusconaia Simpson, 1900; Obliquata Frierson, 1927.

Distribution: North America, west of the Rocky Mountains, south probably to Central America.

18. Subfamily Alasmidontinae Frierson, 1927.

Type species: Alasmidonta undulata Say, 1817. Following Trigonodinae and Pleurobeminae, this group has begun very early with the reduction of the hinge teeth. At first the lower lamella disappeared (III) and in its place there occurred a thickening of the posterior cardinal tooth through the interdental tooth, which for its part is connected to the remains of the lamella III. The upper lamella disappeared completely. The further development led to the complete loss of the hinge or the remaining of only a weakened posterior cardinal tooth (Strophitus). The sculpture is very uniform, short, flat, double arches, often protruding and, as often, with a strong upward arch at the end which can almost appear to be a radial sculpture.

Into this group: Alasmidonta Say, 1818; Prolasmidonta Ortmann, 1914; Bullella Simpson, 1900; Pressodonta Simpson, 1900; Sulcularia Raf., 1831; Lasmigona Raf., 1831; Pterosyna Raf., 1831; Platynaias Walker, 1918; Decurambis Raf., 1831; Arcidens Simpson, 1900; Arkansia Ortmann and Walker, 1912; Pegias Simpson, 1900; Strophitus Raf., 1820; Pseudodontoideus Frierson, 1927; Jugosus Simpson, 1914; Simpsoniconcha Frierson, 1927; Hemistena Raf., 1820; Anodontoides Simpson, 1898.

19. Subfamily Elliptioninae n. subfam.

Type species: Elliptio niger Raf., 1820 (= U. crassidens auct.). Unionid-like form which developed in North America. Umbone sculpture consisting of very flat double arches which scarcely arch up in the middle. Clinging muscles present at the posterior cardinal tooth. Found in North America at least since lower Cretaceous. There are several special developments in the southern states and in Central America.

In this group: Elliptio Raf., 1819; Elliptoideus Frierson, 1927; Uniomerus Conrad, 1853; Nephronaias Crosse and Fischer, 1893; ?Sphenonaias Cr. & Fisch., 1893; ?Pachynaias Cr. & Fisch., 1893; ?Reticulatus Frierson, 1927; Popenaias Frierson, 1927; ? Martensnaias Frierson, 1927; Micronaias Simpson, 1900; ?Canthyria Swainson, 1840; Plesielliptio Russell, 1934; Protelliptio Russell, 1934; Barynaias Cr. and F. 1893; Psoronaias Cr. and Fisch., 1893.

20. Subfamily Ambleminae n. subfam.

Type species: Amblema plicata (Say, 1817). A further development of the Elliptionids in the lower Cretaceous to strongly sculptured quadruline forms with an elongation and enlargement of the posterior arch of the normal Elliptionid sculpture across the whole shell.

In this group: Amblema Raf., 1819; Loxopleurus Meek, 1870; Plectomerus Conrad, 1831.

Distribution: North America between the Alleghany and Rocky Mountains, south to Central America.

21. Subfamily Lampsilinae Ortmann, 1912.

Type species: Lampsilis ovatus Say, 1816. Similar in development of the shell to different groups of the Elliptionids. As the forms point out, they have in common the unique limitation of the marsupium to the posterior part of the outermost gill and the differentiation of the shell in both sexes. The rounded interdentum is considered to be a further characteristic. Concerning the sculpture see above. Known in North America since the Cretaceous, common since the upper Cretaceous.

Into this group: Ptychobranchus Simpson, 1900; Subtentus Frierson, 1927; Obliquaria Raf., 1820; Cyprogenia Agassiz, 1852; Dromus Simpson, 1900; Friersonia Ortm., 1912; Lampsilis Raf., 1820; Ligumia Swainson, 1840; Ortmanniana Frierson, 1927; Villosa Frierson, 1927; Venustaconcha Friers., 1927; Leptodea Raf., 1820; Disconaias Cr. & Fisch., 1893; Proptera Raf., 1819; Carunculina Simps., 1898; Truncilla Raf., 1819; Plagiola Raf., 1819; Obovaria Raf., 1819; Pseudoon Simps., 1900; Glebula Conr., 1853; Arotonaias Martens, 1900 ?; Medionidus Simps., 1900; Lemiox Raf., 1831; Dysnomia Agassiz, 1852 with Penita Friers., 1927; Torulosa Friers., 1927; Capsaeformis Friers., 1927; Pilea Simps., 1900; Epioblasma Raf., 1831; Actinonaias, Delphinonaias, Cyrtonaias Cr. & Fisch., 1893; Friersonia Ortm.

III. Fam. Margaritiferidae Ortmann 1911.

The family of the Margaritanidae is (as I see it here, in contrast to Ortmann's view) very enlarged. Ortmann's view concerned only the closer group of the Margaritanidae. The apparently old and primitive structure of the body and especially of the gills caused him to separate them. However, more groups exist for which the same holds true. Perhaps we may see in its body structure really an older stage of the original Mutelid group, even if Margaritifera has brought forth here several special developments. In any case, the Margaritanidae are very old. Nevertheless, today's distribution is of fairly recent origin. Perhaps we may conclude from this that until their time of spread they had been limited to the isolated Australian continent where its most primitive group (to which Iredale has given the name Cucumerunioninae) is still found today. At least since the upper Cretaceous, and possibly earlier, active spread started. The subfamily of the Heudeaninae seems to have come up to Europe in the Upper Cretaceous. Today, however, it is limited to southeast Asia. The Margaritiferinae had also come as far as North America by the beginning of the Tertiary and have, at least since Oligocene, become an important part of the European Fauna. As a result of its last Pliocene migration, Marg. margaritifera L. has become circumpolar. The Margaritiferinae already showed a tendency toward a reduction of the lamellar teeth. This was the case to a great degree in the Pseudodontinae which are mainly found today in Southeast Asia but which have come in the course of their migrations in the Pliocene and Miocene up to Europe and western North America where they still occur today. Their teeth, with the exception of one cardinal tooth in each shell, have disappeared.

The diagnosis of the Family is as follows: Primitive Naiades with crude gill structure; shell with complete unionid hinge having a continuation of reduction of the lamellae toward their total disappearance; cardinal teeth in a single group (Pseudodontinae) also in the process of reduction; umbone sculpture consisting of two small curved nodules which are not connected in the center and with a tendency toward the formation of an extensive folding sculpture which extends from the dorsal margin out over the shell.

Distribution: All north continents and Australia.

22. Subfam. Cucumerunioninae Iredale, 1934.

Type species: Cucumerunio novaehollandiae Gray, 1934. Elongate species with complete hinge which demonstrates the initial stage of lamellar reduction. A distinct shell sculpture with partially regular - partially irregular systems of folds which extend from the dorsal margin over the disc of the shell.

Distribution: Australia, New Guinea, and New Zealand.

Into this group: Cucumerunio Iredale, 1934; Virgus Simpson, 1900.

23. Subfam. Heudeaninae n. subfam.

Type species: Heudeana murinum Heude, 1883. Shell elongated rectangularly; hinge complete, unionid; sculpture consisting of an anterior arch and a posterior nodule; the dorsal fold sculpture of the other Margaritanidae also occurs in this group.

Distribution: Borneo, South China. In the upper Cretaceous as far as Europe.

Into this group: Heudeana Frierson, 1922; Schepmannia Haas, 1910; Ctenodesma Simpson, 1900.

24. Subfam. Margaritiferinae n. subfam.

Type species: Margaritifera margaritifera L. Shell large, strong, with complete unionid hinge. In several species the hinge becomes reduced with increasing age through the shell material tending to grow over the lamellar teeth. In others the lamellar teeth disappear completely. Sculpture: 2 small hooked nodules set very close together (touching). In addition, at times numerous dorsal folds accompanied by shell sculpture.

Distribution: Europe, East Asia, North America.

Into this group: Margaritifera Schumacher, 1816; Margaritanopsis Haas, 1912; Cumberlandia Ortmann, 1912; Ptychorhynchus Simpson, 1900. This group definitely contains those which occur in calcium-poor water and those in calcium-rich waters. I have already mentioned above their distribution and wanderings in the European Tertiary.

25. Subfam. Pseudodontinae Frierson, 1927.

Type species: Pseudodon inoscularis Gould, 1844. Shell long to short oval, hinge reduced to cardinal teeth and these definitely very much worn off, button-form, and has a tendency toward a decrease to one in each shell. Sculpture has weak double arches, neither of which have an up or a down arch.

Distribution: Adriatic region, Syria, Mesopotamia, East Asia from Japan to Java, Pacific coast of U.S.A., center in back India.

Into this group: Pseudodon Gould, 1844; Monodontina Conrad, 1853; Nasus Simpson, 1900; Cosmopseudodon Haas, 1920; Obovalis Simpson, 1900 in Asia; Pseudodontopsis Kobelt 1912; Leguminaia Conrad, 1865; Microcondylaea v. Vest, 1866 in Europe; Leptanodonta Wenz, 1927 in the Pliocene of Rumania; Gonidea Conr., 1857 in California.

The group is especially interesting because of its Tertiary migrations.

IV. Family Unionidae (Adams) Ihering, 1893.

Contrary to the opinion of Ihering I have taken the genera Margaritana and Pseudodon out of this group and put them in the Margaritiferidae.

Most of the Naiades living today belong to the Family Unionidae.

Their independent development must have begun very early. I have already mentioned above the difficulty of determining their direct derivation. It is based largely on the fact that even today more and more variable connecting lines to forerunners can be established for the Unionidae than for any other family.

A. Parreysia

The umbone sculpture necessitates the subdivision of the family into two separate series which, however, are very close to each other in their origin. So it is not surprising that the individual characteristics of one series occur individually or as generic characteristics in other series.

The older developmental series (I shall call them the Parreysiads in the following) has, as a special characteristic, an unusual sculpture consisting of an upward arch and dorsal folds. Both arches in the middle go down in toward the center and meet in an acute angle. In this way the arches transect each other and form a complicated zig-zag sculpture (V-sculpture). We must consider the Indian Parreysiinae as the oldest form which is left to us. As early as the Triassic they occur in North America, while in east Asia, the Parreysiinae continued to develop into quadruline forms and thereby lose the old V sculpture in favor of the more modern double arch of the unionids. At the same time the American Parreysiinae continued their development in the old land locked lakes of the Rocky Mountains of today in the same direction and developed the true Quadrulinae which, in many cases, have the whole sculpture on the shell. An additional series comes from the oldest North American Parreysiinae and reaches an extensive distribution in South America as the Hyriinae, keeping the original sculpture. The last group, the Propehyridellinae, have remained in Australia as several relic populations.

Diagnosis of the Parreysia in the broad sense: Shell mostly shortened high quadratically to high triangularly, Quadruline, hinge strengthened often with heavy cardinal teeth. The sculpture consists of an upward curving arch, and two middle arches which have united into a V, and dorsal folds. In the higher developmental stages there is a double V in place of the single V, or double arches of the Unioninae.

26. Hyriinae Ortmann, 1911.

Type species: Hyria corrugata Lamarck, 1819. Naiades of America with definite V-sculpture, unionid hinge structure with a tendency toward splitting into partial teeth; variable outline.

Into this group: Diplodon Spix, 1827; Cyclomya Simpson, 1900; Bulloideus Simpson, 1900; Castalia Lamarck, 1819; Callonaia Simpson, 1900; Castalina Ihering, 1891; Castaliella Simpson, 1900; Hyria Lamarck, 1819; fossil genera: Antediplodon Marshall, 1929; Prodiplodon Marshall, 1928; Eodiplodon Marshall, 1928; Equadoria Marshall and Bowles, 1932; Castalioides Marshall, 1934.

In North America it is known in the Triassic and again in the Pliocene; in South America it is known as a fossil since Pliocene, and is recently limited to South America.

27. Subfam. Propehyridellinae Iredale, 1934.

Type species: Propehyridella nepeanensis Conrad, 1850. The shell is unionid, hinge complete, having a V-sculpture from which develop the shell folds.

Into this group: Propehyridella Cotton and Gabriel, 1932; Protohyridella Cotton and Gabriel, 1932.

Isolated at least since Upper Cretaceous in Australia. It seems to me that in the case of Naiades that Ihering's hypothesis of the connection of his Archiplata with Australia cannot be proven.

28. Subfam. Parreysiinae n. subfam.

Type species: Parreysia corrugata Mueller, 1774. Shell short oval to high triangular; V-sculpture with upward growing arch, at times areal folds. In several cases the sculpture covers the whole shell. In the continuing development there is a change to unionid sculpture.

Into this group: Parreysia Conrad, 1853; Radiatula Simpson, 1900; Unionella Haas, 1912; Acuticosta Simpson, 1900; Pseudobaphia Simpson, 1900; Protunio Haas, 1912; Chrysopseudodon Haas, 1920; Schistodesmus Simpson, 1900.

Distribution from southern India to northern China, in the Pliocene to Siberia.

Chrysopseudodon Haas I have placed into this group because of the characteristics of its sculpture and in spite of the reduced hinge.

29. Subfam. Lamprotulinae n. subfam.

Type species: Lamprotula nodulosa Wood 1875. Shell unionid to quadruline. Sculpture double V to angular double arches with an upward and a downward bow. The beginning arch and the radial folds often pass over the whole shell and disintegrate into rows of nodules. Hinge completely unionid to thick.

Into this group: Lamprotula Simpson, 1900, (syn. Gibbosula Simpson, 1900), Inversidens Haas, 1911; Psilunio Sabba Stefanescu, 1896; Discomya Simpson, 1900.

Distribution: Southeastern and Southwestern Europe, Southern Asia, Morocco to Tunis, East Asia from Japan to Tonkin, Borneo. Known as a fossil since the Eocene in Europe and as a Tertiary developmental series in the Pliocene of Southeast Europe, Siberia, and China.

30. Subfam. Quadrulinae Haas, 1929.

Shell highly quadratic to high triangular, originally had V-sculpture, which later was transferred to the shell, and, in many cases, today leaves the umbone free of sculpture. The beginning arch and dorsal folds are still found in youthful specimens of richly sculptured species. The hinge is enlarged (strong) to thick, and quadruline.

Type species: Quadrula quadrula Rafinesque, 1820.

Into this group: Quadrula Raf., 1820; Tritogonia Agassiz 1852; Pustulosa Frierson, 1927; Quincuncina Ortmann, 1922; Luteacarnea Frierson, 1927; Orthonymus Agassiz, 1852; Cyclonaias Pilsbry, 1922; Pachynaias Crosse and Fischer, 1893; Rotundaria Raf., 1820; Megalonaias Utterback, 1918; Psorula Haas, 1929.

Fossil genus: Proparreysia Pilsbry, Upper Cretaceous.

Represented since the Triassic in North America by the Proparreysia which are related and directly connected to the Parreysia. The change in the course of the Jurassic and Cretaceous is to the present forms, each of which goes back to a certain old lake region of the Rocky Mountain zone. Today's distribution: North America east of the Rockies south to Middle America.

B. Unionen

This second modern main group of the Unionidae also begins with a V-shaped sculpture with an upward arch and dorsal areal folds present in its first representatives. This sculpture, however, is soon replaced by a double V, that is, a double arched sculpture which is formed by a crossing of the V-arches. Thus the sculpture of the older forms is somewhat angular and the rounded sculptures of the younger forms are formed only later by the wearing off of the former. The shell is long oval to short oval, seldom changed to a quadruline form. The hinge is always complete with shortened cardinal teeth. The distribution today reaches over all of Africa, Europe, and Asia.

31. Subfam. Lamellidentinae n. subfam.

Type species: Lamellidens marginalis Lamarck, 1819. Shell elongated, unionid hinge, lamelliform laterals with a tendency toward the shortening of the cardinal teeth. Umbone sculpture very weak, V-formed.

Into this group: Lamellidens Simpson, 1900.

Distribution: India and Burma.

32. Subfam. Hyriopsinae n. subfam.

Type species: Hyriopsis delphinus Gruner, 1841. The development starts from the thin-shelled forms with lamellar teeth, which are closely related to the original Rectidentines and Contradentines. The sculpture is hardly noticeable. The first ones, which have a simple double arched sculpture, are the large and, in many cases, thick-shelled forms which developed from the former two groups. A special development has resulted in the loss of the cardinal teeth totally.

Into this group: Hyriopsis Conrad, 1853; Lamproscapha Lindholm, 1932; Arconaia Conrad, 1865; Lepidodesma Simpson, 1896; Chamberlainia Simpson, 1900; Cristaria Schumacher, 1817.

Distribution: East Asia from the Amur to Malakka, Borneo, and Sumatra. Fossil in the Miocene and Pliocene of middle and east Europe and in Siberia.

33. Subfam. Cafferiinae n. subfam.

Type species: Cafferia caffra Kraus, 1848. Mussel of the unionid type. Hinge teeth unionid, and powerful, umbone sculpture consisting of an anterior arch and a posterior sharply pointed triangle.

Into this group: Cafferia Simpson, 1900.

Distribution: South Africa.

This group, standing somewhat isolated, has its nearest relatives in the Contradentinae of Southeast Asia.

34. Subfam. Rectidentinae n. subfam.

Type species: Rectidens orientalis Lea, 1840. Shell long-ligulate to long-elliptical. Originally with lamellar hinge which, in most groups, disappeared very early. Umbone sculpture flat double arches without an upward or a downward arch, at times a double V with a long up and down arch.

Into this group: Rectidens Simpson, 1900; Pilsbryoconcha Simpson, 1900; Pseudodonta Bourg., 1876; Lastena Raf., 1820; Physunio Simpson, 1900; Ensidens Frierson, 1911; Pyganodon Crosse and Fischer, 1893.

Distribution: North Europe, Southeast Asia, North America east of the Rockies. This subfamily makes up a large part of the Anodontine Naiades of the North Continents.

35. Subfam. Contradentinae n. subfam.

Type species: Contradens contradens Lea, 1848. Shell short to long oval, umbone sculpture consisting of double hooks, often largely dissolved and reaching far into the shell. Teeth regularly lamellar form, the cardinal teeth are seldom shortened as in the unionids.

Into this group: Contradens Haas, 1913; Sprickia n. subgen.; Pressidens Haas, 1911; Simpsonella Cockerell, 1903; ?Gaudiculatus Simpson, 1900.

Distribution: Philippines, Java, Sumatra, Borneo, back part of India, possibly reaching into Middle China.

Caudiculatus Simpson is still doubtful to me even after a close study of the Berlin types. The preservation of the sculpture is not good enough for a sure grouping into the classification. I am assuming at present that I am dealing with a reduced Contradens sculpture.

Subgen. Sprickia n. subgen. I am proposing as a new name for the definite lake species, which are characterized as are Sprickia verbeeki von Martens and Sprickia rusticus Lea by the possession of an expanded shell sculpture with crosswise ridged folds.

Type species: Contradens (Sprickia) verbeeki von Martens.

Distribution: Singkarak Lake, Sumatra; Lake Tonle-Sap, Cambodia.

The new subgen. is dedicated to Mr. J. Sprick-Stralsund previously Oels, in grateful recognition for his many years of assistance in the field of the Naiades.

36. Subfam. Anodontinae Ortmann, 1910.

Contrary to the opinion of Ortmann the group is limited to a few species which belong together (as seen) on the basis of their sculpture. The original lamellar hinge has disappeared completely in most cases. The sculpture consists of double arches which may contain an upward arch and a downward arch.

Type species: Anodonta cygnea L., 1758.

Distribution: All of Europe, western part of North Africa, North and East Asia, is missing in India and the largest part of the back part of India, North America south to Mexico. Known as a fossil since the Eocene.

Into this group: Anodonta Lamarck, 1799; Pletholophus Simpson, 1900; Haasiella Lindholm, 1925; Pteranodon Fischer, 1893.

37. Subfam. Caelaturinae n. subfam.

Type species: Caelatura aegyptiaca Caillaud, 1827. Shell usually small, short to long oval, teeth lamellident with many changes to the unionid hinge. Umbone sculpture a double V with upward arches and dorsal folds.

Distribution: Tropical Africa between Sahara and Kalahari, Nile.

This subfamily has a long independent development behind it, which places it somewhat aside of the related groups such as Cafferiinae and Nannonaiinae.

Into this group: Caelatura Conrad, 1853; Mweruella, Kistinaia, Rhytidonaia, Kalliphenga, all Haas, 1936; Grandidieria Bourg., 1855; Zairia Rochebrune, 1886; Laevirostris Simpson, 1900; Mesafra, Afroparreysia, Nyassunio Haas, 1936.

38. Subfam. Nannonaiinae n. subfam.

Type species: Nannonaia caerulea Lea, 1831. Mostly small species with long to tongue-shaped outline. Sculpture consisting originally of an upward arch, a V-angle and dorsal folds which is later changed to a double V-sculpture, which is further ground down into a flat double arched structure. Hinge unionid and, in individual cases, reduced.

Into this group: Indonaia Prashad, 1918; Nitia Pallary, 1924; Trapezoideus Simpson, 1900; Nannonaia Haas, 1912.

Distribution: East Africa, Madagascar, Réunion, all of India, South China, Borneo.

This subfamily which perhaps follows directly the Diplasminae is connected through continuous transitions with the following Unionae.

39. Subfam. Unioninae Ortmann, 1910.

Contrary to the opinion of Ortmann, who unites in this place all species groups with a unionid hinge, my understanding of this subfamily is that it is very limited.

Type species: Unio tumidus Retz., 1788. Shell long-oval to long-lingulate form. Hinge with shortened cardinal teeth; umbone sculpture with upward arch and dorsal folds, two V V angles or double arches in the middle.

Into this group: Scabies Haas, 1911; Unio Retz., 1788; Rhombuniopsis Haas, 1920; Oxynaia Haas, 1912; Cuneopsis Simpson, 1900; Lanceolaria Conrad, 1853.

Distribution: All of Europe, western part of North Africa, East Asia to back part of India. Fossil in Europe known from the Eocene, perhaps going as far as the Jurassic.

I know that it was impossible to have hit the right thing on the first attempt in all cases and would appreciate technical corrections. It is different in the case of questions concerning nomenclature, especially in the North American Naiades where, after Simpson's divisions were not sufficient for these purposes, I had to go along completely with the uniform system of Frierson in order to give a better picture. With this however I also had to use Frierson's concepts of Rafinesque's names completely, although I know that these concepts are not shared by many North American researchers and are partially in contrast to the data of Ortmann, Pilsbry, and Walker.

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LATE CENOZOIC NON-MARINE MOLLUSCAN ASSOCIATIONS IN EASTERN NORTH AMERICA

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(Continued from STERKIANA 13: 53)

INCIDENCE OF SPECIES IN ASSOCIATIONS

The numerous species recorded in previous parts of this paper present a bewildering abundance and an extremely varied stratigraphic and geographic distribution. In order to facilitate interpretation of these data, the species recorded are listed here in order, followed by the numbers of the associations, living or fossil, in which they have been recorded. It would be hazardous, to say the least, to draw firm conclusions from these lists concerning the value of species as index fossils for parts of the Pleistocene. Our knowledge is as yet too fragmentary for this and experience has shown in the past that whenever a species was designated as the guide fossil for a particular part of the Pleistocene, further collecting almost infallibly recorded it for higher or lower divisions. What these data can yield, I think, is to show which species occur most frequently or most rarely in a given part of the Pleistocene and what species commonly or rarely occur with it. Since living assemblages are included, these lists can provide useful ecologic data for interpreting fossil assemblages.

In addition, these lists are the primary data on which studies in dispersal can be based. Several of these, for individual species as well as genera, have been completed and others are under way. They have yielded interesting results which will be published individually. As an example of one of these studies, a detailed analysis of the Newell Lake (Nos. W-45-47) and Jewell Hill (Nos. W-48-51) deposits shows the diversity of species that reached two very similar Pleistocene lakes which were practically contemporaneous and of the same order of size. The factors which are responsible for the observed diversity appear to be extremely complex but may be revealed, in part, by detailed analysis.

Incidence by Species

1. NAIADES

Naiad fragments:
W-26 27 35

Actinonaias carinata
MICH 52 54 56 57 58 59 60 63 64 65
NY 35

[1] The page number in parentheses is that of the complete paper; the one to the right of it is that of this number of STERKIANA

Actinonaias carinata (cont.)
OHIO 43
WIS 6 7 27 76 79 80 83 108 114 120 121 127
130 131 132 133
Actinonaias ellipsiformis
MICH 56 57 58 59 60 61 62 63 65
Alasmidonta calceolus
MICH 47 48 49 50 53 56 57
OHIO 43
Alasmidonta marginata
MICH 48 49 50 51 52 56 57 59 61 63 65
OHIO 43
ONT 5
WIS 108
Alasmidonta marginata variabilis
WIS 58 76 121 132
Alasmidonta undulata
NY 24
ONT 1
QUE 1 4
Amblema costata
MAN 38
OHIO 43
WIS 58 81 83 115 131 132
Amblema plicata
WIS 6
Anodonta sp.
W-29 (fragments)
Anodonta cataracta
NY 5b, 5c, 7 14 23 24 25 26 30 35 38
ONT 1 9
Anodonta fluviatilis
ONT 7 9
Anodonta fragilis
QUE 2
Anodonta grandis
N-1 (?)
S-6 (?)
MICH 41 42 43 44 45 48 49 50 51 52 53 54
55 61 68
OHIO 43
QUE 5
Anodonta grandis benedictensis
ONT 1
Anodonta grandis footiana
MAN 36 38
MINN 15
NY 3a 5c 14 17 20 23 24 29 40b

Anodonta grandis footiana (cont.
WIS 1 2 7 16 22 25 42 53 56 79 82 85 89
119 123
Anodonta grandis plana
WIS 14 17 27 49 54 58 60 77 81 83 86 93 96
100 105 106 117 120 122 127 130 131 132
Anodonta imbecillis
MICH 49 51 52 53 54
OHIO 43
WIS 58 83 87
Anodonta implicata
NY 3a 17 22 23 24 26 30 35 40b
WIS 7
Anodonta kennicotti
MAN 16 23
MINN 13a 18
WIS 14 16
Anodonta lacustris
QUE 2
Anodonta marginata
W-45 46 47
MINN 15 18
NY 14 24 31 35 40b
QUE 1 3 4 7
WIS 1 2 7 8 9 12 14 16 19 20 22 23 27 28
33 34 41 42 44 47 49 51 53 54 55 56 58
59 60 62 68 75 78 79 80 81 82 83 87 89
93 95 96 105 106 116 117 120 121 123 124
127 128 130
Anodontoides birgei
WIS 17
Anodontoides ferussacianus
MICH 46 47 48 49 53 57 65 67
OHIO 43
ONT 1
WIS 54
Anodontoides ferussacianus subcylindraceus
ONT 10
WIS 14 42 47 49 58 59 75 81 83 85 87 89 93
108 117 123 130 131
Anodontoides modesta
MINN 13a 18
Carunculina parva
MICH 52 53 54
OHIO 43
Cyclonaias tuberculata
MICH 51 52 54 63 65
OHIO 43

Cyprogenia irrorata
OHIO 43
Dysnomia torulosa rangiana
OHIO 43
Dysnomia triquetra
MICH 45 49 50 51 54 59
Elliptio complanatus
NY 2a 2b 3a 4c 5b 5c 6 7 10 13 14 15a 15b 16 17 18c 19 21 22 23 24 26 27 28 29 30 32 33 34 35 40b 41 42 45
OHIO 43
ONT 1 7 10
QUE 1 2 3 4 5 7 8
Elliptio dilatatus
MICH 45 48 49 50 51 52 54 55 56 57 58 59 61 62 63 64 65 66 67
OHIO 43
ONT 1
WIS 58 131
Elliptio dilatatus delicatus
WIS 27 58 76 83 108
Elliptio dilatatus sterkii
WIS 82
Fusconaia flava
MICH 52 54 55 56 57 61 63 64 65
OHIO 43
WIS 27 58 76 82 83 87 108 115 127 130 131
Fusconaia subrotunda
OHIO 43
Fusconaia subrotunda kirtlandiana
OHIO 43
Lampsilis fasciola
MICH 49 50 51 52 54
OHIO 43
Lampsilis radiata
NY 2a 3a 5b 5c 6 15a 15b 23 29 30 32 35 38 40b 41 45
ONT 1 9 10
Lampsilis radiata borealis
NY 15b 32 35 40b 42 43b 45
Lampsilis radiata siliquoidea
W-45 46 47
MICH 42 43 44 45 48 49 50 51 52 60
Lampsilis radiata siliquoidea+rosacea
MINN 13a 18 22a
NY 15a 23 29 33 35
OHIO 43
ONT 5 7 9

Lampsilis radiata siliquoidea + rosacea (cont.)
QUE 2 5 7 8
WIS 1 6 7 17 27 54 58 76 78 80 81 83 105 114 117 120 121 127 130 131 132 133
Lampsilis radiata siliquoidea rosacea
MAN 23 36 38
WIS 9 12 16 23 25 29 42 47 59 79 82 85 86 89 93 106 122 123
Lampsilis ventricosa
MAN 23 38
MICH 43 44 45 49 50 51 52 53 54 56 57 59 60 62 64 65
OHIO 43
ONT 1
WIS 6 7
Lampsilis ventricosa lurida
WIS 25 26 42 47 79 80
Lampsilis ventricosa occidens
MINN 22a
WIS 27 58 76 81 83 108 114 120 121 127 130 131 132 133
Lasmigona complanata
MICH 52 53 67
OHIO 43
WIS 121 127 130 131 132
Lasmigona complanata katherinae
MAN 36 38
Lasmigona compressa
MICH 46 47 48 49 50 55 66
OHIO 43
ONT 4
WIS 7 14 17 27 58 76 81 82 83 87 108 120 123 130 131
Lasmigona costata
MICH 50 51 52 54 55 56 57 65
OHIO 43
ONT 5 10
WIS 7 27 58 76 80 81 83 87 108 120 121 122 127 131 132
Lastena lata
OHIO 43
Leptodea fragilis
ONT 1
Ligumia nasuta
MICH 54
Ligumia recta
WIS 6 82

Ligumia recta latissima
MAN 38
MICH 50 51 52 53 54
OHIO 43
ONT 1 5
WIS 58 76 83 108 121 132
Ligumia subrostrata
PLI-3?
Margaritana margaritifera
NY 13 15a 15b 17 21 41 43b
Obovaria olivaria
ONT 1
Obovaria subrotunda
MICH 54
OHIO 43
Plethobasus cyphyus
OHIO 43
Pleurobema clava
OHIO 43
Pleurobema cordatum coccineum
MICH 59 65
OHIO 43
WIS 58 83 108 131
Pleurobema cordatum pyramidatum
OHIO 43
Proptera alata megaptera
MAN 38
ONT 1
Ptychobranchus fasciolare
MICH 49 50 51 52 54
OHIO 43
Quadrula cylindrica
OHIO 43
Quadrula metanevra wardii
OHIO 43
Quadrula pustulosa
MICH 54
OHIO 43
Quadrula quadrula
S-6
Simpsoniconcha ambigua
OHIO 43
Strophitus rugosus
MAN 36 38
MICH 43 44 45 47 48 49 50 51 55 56 57 59
60 61 63 65
NY 19 22
OHIO 43
Strophitus rugosus (cont.)
ONT 1 5 10
QUE 1
WIS 7
Strophitus rugosus pavonius
WIS 27 58 76 79 80 81 83 87 108 120 121
122 127 130
Tritogonia tuberculata
OHIO 43
Truncilla triquetra
OHIO 43
Villosa fabalis
MICH 52 54
OHIO 43
Villosa iris
MICH 45 47 48 49 50 51 52 54 56 57 58 59
62 63 64 65 66 67
NY 15b 22
OHIO 43
Villosa iris novi-eboraci
OHIO 43

2. SPHAERIIDAE

Pisidium sp.
K-5 --- W-35 71 72
MICH 10 11
MINN 10 11a 12 13a 15 16 20
NY 4b 11 21
OHIO 29 30 31 37
Pisidium adamsi
W-27 36 37 38 39 42
MAN 20
OHIO 43
WIS 15 27 42 49 55 58 63 79 81 85 95 116
121 123 128 130 133
Pisidium adamsi affine
W-27
Pisidium aequilaterale
NY 21
Pisidium casertanum
PLI-1 2 3 --- N-1 2 --- S-1 2 4 5 6 --- W-
27 28 29 36 37 38 45 48 49 50 51 52 53 54
56 57 58 59
MAN 25
NY 1
OHIO 43

Pisidium casertanum (cont.)
ONT 3 7 9
WIS 4 5 21 43 68 89 95 102 106 107 109 118 133
Pisidium compressum
N-1 --- K-1 2 --- Y-1 2 4 7 8 11 12 13 14 15 16 17 18 19 20 --- S-1 6 --- W-26 27 28 29 30 31 32 33 34 36 37 38 39 40 41 42 45 46 47 53 54 55
OHIO 43
ONT 9
QUE 3
WIS 15 16 17 27 28 29 49 54 55 56 60 79 80 84 85 86 89 93 97 121 123 128 130 133
Pisidium compressum laevigatum
NY 4b 4c 11 21
W-27
Pisidium cruciatum
OHIO 43
Pisidium dubium
ONT 1
WIS 6 123 133
Pisidium fallax
W-26 27
OHIO 43
Pisidium fallax septentrionale
WIS 80 87
Pisidium ferrugineum
W-27 28 29 33 34 37 38 39 42 45 46 47 52 53 54 55
WIS 51 79 98 116 121 128
Pisidium henslowanum
NY 21
Pisidium idahoense
WIS 110
Pisidium levissimum
WIS 79
Pisidium lilljeborgi
W-27
WIS 13 27 29 55 79 85 98 116 123 128
Pisidium lilljeborgi cristata
WIS 15 79
Pisidium nitidum
N-1 2 --- S-6 --- W-27 28 29 31 32 33 34 36 37 38 39 41 42 45 46 47 48 49 50 51 52 53 54 55
OHIO 43
WIS 55 79 129
Pisidium nitidum contortum
S-1 --- W-53 54 55
Pisidium nitidum pauperculum
W-30 31 32 33 34 37 38 39 40 41 42 45 46 47 53 54 55
WIS 15 16 28 29 51 54 79 93 116 123 128 133
Pisidium obtusale
S-1 --- W-27 28 31
Pisidium obtusale rotundatum
W-45 48 49 50 51 52 53 54 55
WIS 13 43 79
Pisidium obtusale ventricosum
W-33 34 37 38 39 41 42 52 53 54 55
ONT 3
Pisidium ohioense
W-27 28
Pisidium punctatum
OHIO 43
WIS 133
Pisidium pusillum
WIS 61
Pisidium variabile
W-27 29 31 33 34 36 37 38 39 41 42 52 53 54 55
NY 4b 21
OHIO 43
WIS 15 16 28 29 32 37 42 54 59 60 68 71 78 79 84 85 86 89 93 97 109 116 123 124 128 133
Pisidium walkeri
W-27 36 38 39 42 53 54
OHIO 43
Pisidium walkeri mainense
W-38 54 55
Sphaerium sp.
PLI-1 --- Y-8 9 11 16 19 20 --- W-35
OHIO 29 32 33 34 35 36 37 38 39 40 41 42
Sphaerium fabale
OHIO 43
Sphaerium jayense
WIS 51 78
Sphaerium lacustre
N-2 --- W-29 33 34 36 37 38 39 41 42 45 46 47 50 51 53 54
MAN 25
Sphaerium lacustre ryckholti
WIS 107

Sphaerium nitidum
MAN 24
Sphaerium occidentale
S-1
MAN 30
MINN 19
NY 1
OHIO 43
ONT 7
WIS 4 21 43 136
Sphaerium partumeium
N-1 2 --- S-2 --- W-27
MAN 25
MICH 10 14
MINN 15 17
OHIO 43
WIS 30 42 45 51 60 63 99
4 136
Sphaerium rhomboideum
W-27 33 34 36 38 42 53 54 55
OHIO 43
ONT 1 3 9
QUE 1
WIS 42 68
Sphaerium rosaceum
NY 35
QUE 1
WIS 5 28 54 68 79 102
Sphaerium securis
W-27
MAN 21
MINN 15 16 17
NY 1 35 37
OHIO 43
ONT 3
WIS 4 10 23 43 45 53 60 61 63 102 106
107 133
Sphaerium simile
ONT 9
WIS 1
Sphaerium steinii
WIS 87
Sphaerium striatinum
PLI-1
N-1 --- S-6 --- W-27 31
NY 14 25
OHIO 43
ONT 1 4

Sphaerium striatinum (cont.)
WIS 6 83 134
Sphaerium striatinum f. bakeri
WIS 122
Sphaerium striatinum f. emarginatum
ONT 4
WIS 58 76 80 83 87
Sphaerium striatinum f. modestum
ONT 6
Sphaerium striatinum f. solidulum
OHIO 43
WIS 122
Sphaerium striatinum f. stamineum
W-27
MINN 22a
OHIO 43
WIS 17 27 58 60 79 80 81 108 117 131 132 133
Sphaerium striatinum f. vermontanum
NY 3a 4b 4c 10 11 15b 21 23 24 26 30 32 37
Sphaerium sulcatum
N-1 --- S-1 --- W-27 29 31 33 34 45 46 47
53 54 55
MINN 10 11a 13a 15
OHIO 43
ONT 5 7
QUE 2
WIS 25 28 42 49 54 60 68 80 106 117 123 125
Sphaerium sulcatum f. crassum
MAN 16
WIS 83 132
Sphaerium sulcatum f. fallax
WIS 15 16 47 50 60 62 78 83 89 130
Sphaerium transversum
N-1 2 --- S-6
MAN 23
OHIO 43
ONT 1 6

3. FRESHWATER GILL-BREATHING GASTROPODS

Amnicola sp.
MAN 33
QUE 3
Amnicola integra
WIS 3
Amnicola leightoni
W-29 30 31 32 33 34 38 39 40 41 42 45 46
47 48 49 50 51

Amnicola limosa
W-27
MAN 19 23
MINN 9 10 11b 13a 13b 14a 14b 15 16 17
18 22a
NY 21 36
OHIO 18 19 29 43
ONT 3 9
QUE 2
WIS 11 14 15 16 17 27 28 29 32 37 38 39 42
45 46 47 48 51 52 55 56 59 60 65 68 69
70 79 80 85 86 87 88 89 90 92 93 94 95
97 98 106 113 116 123 133
Amnicola limosa parva
K-2 --- Y-1 16
Amnicola lustrica (see also Marstonia lustrica)
W-27 28 33 33* 34 34* 36 37 38 39 40 41 42
45 46 47 48 49 50 51
* "aff. precursor"
MINN 9 10 11b 15 16
NY 2b 4b 4c 11 12 21 23 25 32 37 40a
ONT 9
WIS 15 16 28 29 47 51 52 55 59 79 84 85 86
88 89 90 98 116 123 128
Amnicola precursor
W-33 34
Amnicola walkeri
W-29 53 54 55
MAN 23
MICH 10
MINN 17
OHIO 43
WIS 28 42 81 98 124
Bulimus tentaculatus
NY 3b 10 14 15b 21 22 31 32 36 37 38 40a
42 43
ONT 1 3
Campeloma decisum
MAN 26 35
MICH 40 (drift)
NY 19 20
ONT 1 5 7 9
QUE 1 2 3 4
WIS 1 6 7 17 19 25 38 39 42 46 47 52 57 60
62 73 75 79 80 81 83 87 100 117 118 120
123 129 132 133
Campeloma integrum
NY 4b 4c 5a 10 11 15b 22 24 32 40a 42
OHIO 43
Campeloma milesii
WIS 28 29 33 35 48 49 55 56 57 62 79 83 85
86 87 93 96 103 106 108 111 116 123 124
128 129 131
Campeloma rufum
W-31 (cf.) 32 (cf.)
MINN 22a
Campeloma subsolidum
U-10
OHIO 18
Gillia altilis
NY 3b 4b 4c 15b 32
Goniobasis depygis
W-25
Goniobasis livescens
W-28
NY 3a 5b 6 7 15a 15b 16 21 22 23 26 27 29
30 32 35
OHIO 8 9 10 11 12 13 14 16 17 18 19 21 43
ONT 4 6 7
Goniobasis livescens gracilior
OHIO 43
Lithasia obovata
OHIO 43
Lyogyrus pupoideus
W-27 (?)
Marstonia crybetes
PLI-1 3 --- N-2
Marstonia decepta (see also Amnicola lustrica)
PLI-1
Marstonia lustrica (see also Amnicola l.)
OHIO 43
Pleurocera acutum
OHIO 17 18 21
Pleurocera labiatum
OHIO 43
Pomatiopsis cincinnatiensis
Y-7 10 16
Pomatiopsis lapidaria
W-25 26 28 56 58 59 --- U-10
Probythinella lacustris
S-6 --- W-27 ---
OHIO 43
Somatogyrus subglobosus
NY 3b 14 15b 32
ONT 1
Somatogyrus subglobosus isogonus
OHIO 43

Somatogyrus tryoni
WIS 132 133
Valvata bicarinata normalis
NY 4b 32 37 38 43
Valvata lewisi
N-1 --- K-1 --- Y-8 --- W-35 53 54 55
MAN 25
NY 1
ONT 3 5
WIS 15 69 84 85 86 93 123
Valvata sincera
W-27 29 33 34 72
Valvata sincera nylanderi
WIS 98
Valvata tricarinata
N-1 2 --- K-1 2 4 7 --- Y-1 7 8 11 16 ---
S-1 6 --- W-27 29 30 31 32 33 34 36 37 38
39 40 41 42 45 46 47 48 49 50 51 54 55 72
MAN 12 23 32 33
MINN 9 10 11b 13b 14a 15 16 17 18
NY 3b 21
OHIO 20 29 43
ONT 9
QUE 8
WIS 15 51 59 75 79 86 89 97 98 123 124 128
Viviparus contectoides
NY 3b 42
Viviparidae, indet. --- N-2

4. FRESHWATER LUNG-BREATHING GASTROPODS

Acella haldemani
W-27 33 34 37 38 39 45 47 54
MINN 9 15
NY 2b 4a 12 36
WIS 11 31 42 47
Acroloxus coloradensis
N-1 2
Anisus pattersoni
N-1 2 --- K-1 2 --- Y-2 3 9 11 12 13 14
19 20 --- S-6 7 --- W-60
Aplexa hypnorum
N-1 --- A-1 --- K-4 --- Y-7 11 12 13 14
--- S-1 6 --- W-28 --- U-4
MAN 1 2 3 4 7 11 25 35
MICH 11 12 13 37
MINN 20
NY 1
Aplexa hypnorum (cont.)
OHIO 32 33 43
WIS 4 136
Armiger crista
K-4 --- S-4 --- W-27 28 35 48 49 50 51 53
54 57 58 59
MICH 10
MINN 15 17
ONT 3
Bulimnea megasoma
N-1 2
MAN 20 21 35
MINN 9 14d 15
QUE 1 7 8
WIS 4 18 31 40 42 47 54 60 72 79 83 86 106
123 137
Ferrissia?
MICH 10
OHIO 29
Ferrissia meekiana
N-1 2 --- S-2 6 --- W-27 28
OHIO 43
Ferrissia parallela
Y-2 4 7 14 18 19 20 --- S-1 --- W-27 29 34
35 36 37 38 39 41 42 45 54 56 57 58 59 28
MAN 21
MINN 9 17 18
NY 12 40a 43
OHIO 18 19
ONT 5 7
WIS 3 4 5 15 29 42 47 60 63 64 83 104 106
107 117 123 124
Ferrissia rivularis
PLI-1 2 3 --- N-1 2 --- S-1
MAN 36
MINN 22a
OHIO 43
Ferrissia shimeki
OHIO 43
Ferrissia tarda
W-31 32
MINN 22a
NY 18a
OHIO 43
WIS 108
Fossaria sp.
W-73

Fossaria dalli
PLI-1 3 4 --- N-1 2 --- A-1 --- S-2 3 6
--- W-28
MAN 25
MICH 11 13
Fossaria dalli grandis
W-60
Fossaria galbana
Y-21 --- I-5 --- S-1 (cf.) --- W-35
Fossaria humilis
OHIO 8 9 10 11 13 15 19 20 43
Fossaria humilis modicella
S-1 --- W-27 28 56 57 58 59
MAN 6
WIS 134
Fossaria humilis rustica
W-28
Fossaria obrussa
N-1 --- S-6 --- W-38 39 45 46 47 48 49
50 51
OHIO 29 31 32 33 34 35 37 38 40 41 42
WIS 4 48 54 59 61 79 106 119 128
Fossaria obrussa decampi
W-27 29 30 31 32 33 34 45 46 48 49 50 51
52 53 54 55 56 57 58 59 72
MAN 12
MINN 13a 13b 16 17
WIS 55 79 84 85 123
Fossaria obrussa exigua
MAN 6 15 30 31 33
WIS 14 59
Fossaria parva
K-5 6 7 --- Y-6 7 8 11 13 15 --- I-7 ---
W-9 10 28 43 64 67 69 71
MICH 37
OHIO 31
Fossaria parva sterkii
MAN 37
Fossaria parva var.
MAN 11
Fossaria umbilicata
MAN 37
ONT 4
Gyraulus sp.
QUE 3
Gyraulus altissimus
W-29 30 31 32 33 34 35 36 37 38 39 40 41 42
45 46 47 48 49 50 51 52 56 57 58 59 72

Gyraulus altissimus (cont.)
MINN 17
Gyraulus "albus" (Müller)
W-27 (?)
Gyraulus "arcticus"
MAN 7 10 16 21 25 31 32 33 34
NY 1
WIS 59
Gyraulus circumstriatus
S-2 3 4 5 6
MINN 12 19
OHIO 43
WIS 43 79 85 95 123
Gyraulus circumstriatus walkeri
NY 1
Gyraulus deflectus
W-29 33 34 53 54 55
MAN 12
MICH 10
OHIO 43
ONT 3 9
QUE 2
WIS 9 23 37 42 47 60 61 79 80 85 89 95 99
112 113
Gyraulus deflectus obliquus
MINN 13b 16 17
NY 1
QUE 4
WIS 14 15 16 42 59 69 80 85 86 90 93 94 96
98 102 116 123 124 135
Gyraulus hirsutus
W-29
MAN 12 16 21 25 34 35
MICH 10
NY 2b 4b 5b 16 18b 21 23 29 37 40a
OHIO 43
ONT 9
WIS 3 4 29 55 66 70 79 89 98 106 119 123 128
Gyraulus labiatus
K-4 5 --- Y-1 3 4 6 8 9 10 11 14 15 16 17
18 19 20
Gyraulus parvus
PLI-1 2 --- N-1 2 --- A-1 --- S-6 7 ---
W-27 28 60
MICH 10 11
MINN 9 10 13b 14b 15 16
NY 1 38 43
OHIO 10 19 20 29 31 32 33 34 35 36 37 38
40 41 42 43

Gyraulus parvus (cont.)
ONT 7 9
WIS 3 5 14 16 18 27 28 29 51 54 55 68 74 79 84 85 86 89 94 104 106 107 123 124
Gyraulus similaris
K-1 2 4 5 --- Y-3 5 9 12 14 15 16 18 19 --- I-3(?) --- S-1
Helisoma anceps
PLI-1 --- N-1 2 --- Y-16 20 --- I-3 --- S-1 6 --- W-60
MAN 36
MICH 10
NY 2a 6 14 15b 21 22 30 32 37 40a
OHIO 43
ONT 7 9
QUE 3 8
WIS 14 15 16 19 25 27 28 29 44 46 47 56 58 73 79 81 85 89 93 100 103 104 112 116 117 123 127 128 133
Helisoma anceps cahni
WIS 8 9 16
Helisoma anceps latchfordi
QUE 1
Helisoma anceps sayi
MAN 16 17 21
ONT 5
WIS 28 42 59 60 67 86 98 106 119 123
Helisoma anceps striatum
W-29 30 31 32 33 34 36 37 38 39 41 42 45 46 47 48 49 50 51 53 54 55
MINN 10 11b 11c 13b 14b 14c 15 16
WIS 1 2
Helisoma anceps unicarinatum
WIS 4 20 28 31 42 63 68 87 99 102 106 111 124 128
Helisoma "binneyi"
NY 5a 14 16 22 35 40a 41
WIS 1 2 4
Helisoma campanulatum
W-27 29 33 34 38 45 46 47 48 49 50 53 54 55
MINN 10 11b 11c 13a 13b 14a 14b 14c 15 16 17
NY 2a 2b 3b 4a 4b 5b 6 7 9 10 11 14 15b 16 21 22 23 25 27 29 30 32 34 36 37 40a 41 42 43 44
OHIO 29 43
ONT 9

Helisoma campanulatum (cont.)
WIS 1 2 3 15 19 20 23 28 29 30 42 47 68 69 79 85 87 89 90 93 94 96 97 100 112 116 123 124 128
Helisoma campanulatum davisi
MAN 8
Helisoma campanulatum ferrissii
WIS 50
Helisoma cf. H. campanulatum wisconsinense
Y-1 3 4 9
Helisoma campanulatum wisconsinense
MAN 16 17
ONT 5
QUE 1 2 3 4 8
WIS 9 16 23 28 47 56 59 67 83 86 91 98 101 106 119 123 126
Helisoma infracarinatum
ONT 5
QUE 2
Helisoma pseudotrivolvis
WIS 51
Helisoma trivolvis
N-2 --- K-2 4 --- Y-7 8 10 11 14 15 16 --- S-1 2 6 --- W-25 27 28 32 35 50 51 56 57 58 --- U-2 4
MAN 8 25
NY 1 2b 7 15b 18b 31 34 35 36 37 38 39 42
OHIO 18 19 20 30 37 42 43
ONT 1 3 7 9 10
QUE 3 8
WIS 4 10 15 23 40 42 47 49 54 59 60 68 72 79 80 81 83 86 87 89 106 112 116 117 123 125
Helisoma trivolvis macrostomum
MINN 10 11c 14d 15 16 21
Helisoma trivolvis pilsbryi
MAN 16
QUE 1
WIS 29 42 47 59 93 106
Helisoma trivolvis winslowi
WIS 58 91 98
Laevapex diaphanus
OHIO 43
Laevapex fuscus
MINN 11c
NY 36 38
OHIO 18 19
WIS 86

Laevapex kirklandi
S-6 --- W-27 28
OHIO 43
WIS 98
"Limnaea fragilis"
U-4 5
Lymnaea indet.
Y-8 11 12 17 --- U-4
Lymnaea stagnalis
MAN 25
Lymnaea stagnalis jugularis
S-6 --- W-27 33 34 45
MAN 8 10 16 32 33 34 35
MINN 10 11c 14c 14d 15
ONT 1 5 9
QUE 3 5 8
WIS 4 16 27 80 93 94 96 106
Lymnaea stagnalis lillianae
MAN 14
NY 5a 7 16 22 29 30 34 35 36 38 39 41
QUE 1 4
WIS 1 2 25 42 47 79 81 89 106 128
Lymnaea stagnalis sanctaemariae
MAN 17
WIS 19 98 102 105
"Lymnaea stagnalis wisconsinensis"
WIS 1
Menetus sp.
W-60
Menetus dilatatus
W-27
Menetus opercularis multilineatus
W-32
Menetus pearlettei
K-1 2 4 --- Y-1 3 4 9 10 14 15 16 19 20
Physa sp.
Y-3 4 10 --- W-26
QUE 4 8
Physa anatina
PLI- 1 2 3 4 --- N-1 2 --- A-1 --- K-2 4 5 --- Y-15 18 --- S-1 (cf.) --- S-2 3 4 6 --- W-29
Physa "ancillaria"
MAN 13
Physa ancillaria (including "magnalacustris")
OHIO 8 9 10 11 13 14 15 19 20 43
ONT 3 5
WIS 1 2 3
Physa ancillaria warreniana
NY 2b 3b 4a 4c 5a 5b 6 7 8 9 14 15b 16 21 22 23 26 29 30 32 34 35 36 37 40a 41 42 43 44
Physa aplectoides
W-28
Physa "billingsi"
ONT 6 7
Physa elliptica
Y-9 14 16 17 --- S-1 (cf.) --- W-28
MICH 10 12
NY 1
WIS 79
Physa gyrina
N-1 2 --- S-2 6 --- W-27 28 30 31 32 35 36 37 38 39 42 48 49 50 51 56 57 58 59 --- U-4
MAN 7 8 9 10 17 21 25 31
MINN 9 10 11b 11c 13b 14b 14c 16
NY 9 18b
OHIO 30 31 32 35 36 40 42 43
WIS 4 59 66 104 125 135
Physa "gyrina hildrethiana"
MAN 29
Physa heterostropha
W-27 33 34 --- U-1 4
OHIO 29 43
ONT 7 9
Physa "integra"
W-27 28
MAN 32 36
NY 3b 15a 31 32
ONT 5
WIS 17
Physa laphami
WIS 9 11 14 16 25 47 56 88 95 100 102 116 133
Physa latchfordi
QUE 1 3
Physa michiganensis
WIS 27
Physa obrussoides
WIS 74 81
Physa "sayi"
W-27 45 46 47
WIS 15 23 24 28 30 36 37 38 39 42 44 50 54 58 62 67 74 93 96 98 106 117 123 124 128
Physa skinneri
N-1 2 --- A-1 --- S-6
"Planorbis sp."
U-4

Planorbula armigera
N-1 2 --- W-28 35 51 56 57 58 59 --- U-4
MAN 10
MICH 10 12 14
MINN 15
OHIO 43
WIS 4 106 107 112 136
Planorbula campestris
MAN 3 4
Planorbula crassilabris
MAN 4 16 20 25 31
Planorbula nebraskensis
Y-1 3 4
Planorbula vulcanata
Y-4 5 9 10
Planorbula vulcanata occidentalis
Y-12 14 16
Promenetus dilatatus
OHIO 43
Promenetus exacuous
S-1 --- W-27 29 30 32 33 34 35 36 37 38 39 41 42 45 46 47 48 49 50 51
MAN 8 10 12 16 18 21 35
MICH 10 14
MINN 13b 15 16 17
NY 1 33
OHIO 20 29 39 41 43
ONT 3 9
QUE 1
WIS 15 42 54 58 61 79 98 116
Promenetus exacuous megas
MINN 13b 15 16 17
WIS 28 59 68 79 97
Promenetus kansasensis
PLI-1 2 3 --- N-1 2 --- A-1 --- S-2 4 6
Promenetus rubellus
NY 1
OHIO 43
Promenetus umbilicatellus
PLI-1 2 3 4 --- N-1 2 --- A-1 --- K-1 4 --- Y-2 3 10 12 14 17 18 19 20 --- S- 2 6 --- W-28
MAN 1a 4 28
MINN 20
OHIO 43
Pseudosuccinea columella
W-27 45 46
NY 2b 4a 9
Pseudosuccinea columella (cont.)
OHIO 33 35 36 38 40 43
QUE 1 3
WIS 3 4 8 31 95 106
Pseudosuccinea columella "casta"
MAN 18
Stagnicola sp.
PLI - 1 4 --- A-1
Stagnicola cf. S. arctica
MAN 39
Stagnicola bulimoides
K-4 5 --- Y-11 15 --- S-1
Stagnicola bulimoides techella
PLI-1 2 3 4 --- A-1
Stagnicola caperata
PLI-4 --- N-1 2 --- A-1 --- K-1 4 5 --- Y-7 14 19 20 --- I-3 --- S-1 2 3 4 5 6 --- W-28
MAN 3 4 11
ONT 7 10
Stagnicola catascopium
MAN 22
NY 3a 4c 5a 5b 6 7 10 14 15a 15b 21 22 23 25 26 27 29 30 32 34 35 36 37 40a 41 42
ONT 10
WIS 79
Stagnicola desidiosa
OHIO 43
ONT 9
QUE 2
Stagnicola emarginata
MAN 12 (var.) 22
NY 7 13 14 23
ONT 4 6
WIS 16 73 97 123
Stagnicola emarginata canadensis
QUE 3
Stagnicola emarginata vilasensis
WIS 28
Stagnicola emarginata wisconsinensis
WIS 98 106
Stagnicola exilis
PLI-3
MINN 15
WIS 42 47 83 100
Stagnicola lanceata
W-35
MAN 5 21 35

Stagnicola lanceata (cont.)
WIS 2 4 9 47 99 106 123
Stagnicola nashotahensis
W-28
Stagnicola palustris
K-2 4 5 --- Y-1 2 3 4 7 9 10 11 14 --- Y-16 17 --- S-1 (cf.) --- W-29
MAN 2 4 7 8 9 10 24 25 29 30 31 32 34 37
MICH 12 13 14 37
OHIO 29 31 32 34 37 41 42 43
ONT 3 7
Stagnicola palustris elodes
W-35
NY 1
WIS 18
Stagnicola cf. S. reflexa
N-1
Stagnicola reflexa
N-2 --- Y-9 12 14 --- S-6 --- W-28
Stagnicola umbrosa
W-50 51 --- U-2
Stagnicola woodruffi
OHIO 20

5. LAND GASTROPODA

Allogona profunda
W-24 25 26 27 28 --- U-1 5 8 9 12 13
MICH 40
OHIO 3 5 7 22 23 43
ONT 11 14
Allogona profunda strontiana
OHIO 1 2
ONT 12 13
Anguispira alternata
W-24 25 26 28 62 73 --- U-3 5 6 --- U-9 10 12 13
MICH 1 2 3 4 6 7 8 23 25 26 27 28 29 31 32 33 36 39 40
MINN 4
OHIO 3 6 7 26 27 28 29 43
ONT 7 8 11 14
Anguispira alternata eriensis
OHIO 1 2
ONT 12 13
Anguispira kochi
W-24 25 26 28 --- U-8 9 10 12 13

Anguispira kochi (cont.)
OHIO 1 5 7 43
ONT 11
Anguispira kochi mynesites
OHIO 3
Anguispira kochi roseoapicata
ONT 11 13 14
Anguispira kochi strontiana
OHIO 2
ONT 12
Bulimulus dealbatus
U-12 (var.) 13
Carychium sp.
N-1
Carychium exiguum
PLI-3 --- N-2 --- S-1 (cf.) 2 3 4 6 --- W-6 16 27 28 56 57 58 59
MICH 2 20 22 25
OHIO 1 6 43
ONT 7
Carychium exile
W-28 51 73 --- U-10
OHIO 43
ONT 3
Carychium exile canadense
K-6 --- &-21 --- I-5 6 --- W-43 44 56 57 58 59 60 64
MINN 3 4 5
Carychium perexiguum
K-1 2 --- Y-3 4 5 6 7 10 12 13 17 18 19 20
Catinella gelida var.
K-6 7 --- I -5
Catinella gelida
I-7 --- W-61 62 63 64 65 66 67 68 69 70 71
Cionella lubrica
K-6 --- Y-2 6 7 11 12 13 21 --- I-5 --- S-7 --- W-5 6 9 24 43 44 60 61 62 64 65
MICH 1 30 31 40
MINN 1 3 4 5 8
OHIO 43
ONT 3 7 8
Columella sp.
I-2
Columella alticola
W-5 6 9 12 15 17 44 61 62 63 64 66 67 69 73
MAN 39
Columella edentula
K-6 --- Y-21 --- I-5 --- W-28

Columella edentula (cont.)
MICH 1 40
OHIO 43
ONT 2 3
Deroceras sp.
Y-21 --- I-6 --- W-44
OHIO 29
Deroceras aenigma
PLI-1 2 3 4 --- N-1 2 --- A-1 --- K-1 2 --- Y-2 3 5 6 7 11 12 13 16 17 18 19 20 --- S-1 (cf.) 2 3 4 5 --- W-28 (cf.)
Deroceras laeve
K-7 --- I-5 --- W-2 3 4 12 28 (cf.) 62 64 65 67 69 71
MAN 39
MICH 1 22 28 31 32 33 34 35 36 40
OHIO 4 34 39 43
ONT 7 14
Deroceras reticulatum
MICH 30 31
OHIO 32 34 37 38 39 42
Discus cronkhitei
K-1 2 5 6 --- Y-2 4 5 6 7 8 12 13 14 16 17 21 --- I-3 5 --- S-6 --- W-2 3 4 5 6 7 8 11 12 13 17 18 22 24 26 27 28 44 64 65 66 69 73 --- U-2 4 7 14
MICH 30
OHIO 1 6 43
ONT 7 8 10
QUE 6
Discus cronkhitei anthonyi
MINN 1 2 3 4 5 7 8
Discus cronkhitei catskillensis
MICH 1 4 7 8 9 40
Discus mcclintocki
W-60
Discus patulus
W- 24 28 61 --- U-9
OHIO 29 43
Discus shimeki
W-2 3 4 5 6 7 9 11 12 13 15 17 18 19 20 21 22
Euconulus sp.
W-43 (?)
Euconulus chersinus
W-28
MICH 1 9 17 18 20 21 22 23 25 26 28 31 32 33 34 38 39
Euconulus chersinus polygyratus
MICH 40
Euconulus fulvus
K-6 --- Y-2 5 6 7 8 10 12 13 14 17 --- Y-21 --- I-5 --- S-1 2 3 4 7 --- W-2 4 5 6 9 10 12 15 16 17 19 20 21 22 28 56 57 58 60 61 62 64 65 66 67 69 73
MAN 39
MICH 1 9
MINN 1 2 4 5 7
OHIO 43
ONT 7 8 10
Gastrocopta sp.
S-1 --- W-28
Gastrocopta armifera
N-2 --- K-3 6 7 --- Y-3 10 14 19 20 --- I-3(?) 4 5 --- S-1 2 3 4 5 6 --- W-1 8 9 24 28 62 63 64 65 70 73 --- U-3 4 10 12 13 14
MICH 32 33 35
OHIO 1 4 7 43
ONT 11
Gastrocopta chauliodonta
N-1 2 --- A-1
Gastrocopta contracta
K-2 --- Y-8 10 18 --- S-1 2 3 4 5 6 --- W-24 26 28 56 57 58 59 --- U-10 13
MICH 5 21 22 23 25 26 32 33 40
OHIO 1 4 7 43
ONT 2 3 10 11 12 14
Gastrocopta corticaria
W-28
MICH 25
OHIO 43
ONT 3 11
Gastrocopta cristata
PLI-4 --- N-1 2 --- A-1 --- Y-2 13 15 17 18 19 20 --- S-1 2 3 4 5 6
Gastrocopta cf. G. falcis
K-3
Gastrocopta falcis
Y-11 13
Gastrocopta franzenae
PLI-1 2 3 4
Gastrocopta holzingeri
PLI-1 3 --- Y-6 17 --- S-1 2 3 4 6 --- W-6
OHIO 1 4 7
Gastrocopta mcclungi
K-3 --- I-4

Gastrocopta paracristata
PLI-1 2 3 4 --- A-1
Gastrocopta pellucida hordeacella
PLI-2 3 --- N-2 --- S-2 3 4
Gastrocopta pentodon
S-1 --- W-28 48 49 50 51 67
MICH 18 25 26 32 33 34 36
OHIO 1 4 43
ONT 2
Gastrocopta proarmifera
K-1 3 5 --- Y-2 6 7 8 11 12 13 14 15 16 17 19 20 21
Gastrocopta procera
N-2 --- K-3 --- Y-8 16 17 18 --- I-4 --- S-1 6 --- W-73 --- U-10(?)
Gastrocopta rexroadensis
PLI-1 2
Gastrocopta riograndensis
I-3(?)
Gastrocopta scaevoscala
PLI-4 --- N-2
Gastrocopta tappaniana
PLI-1 3 4 --- N-1 2 --- A-1 --- Y-2 3 4 5 6 8 10 11 12 14 15 17 18 19 20 --- I-3 7 --- S-1 (cf.) 2 3 4 5 6 --- W-28 54 56 57 58 59 70
MINN 3 4
OHIO 1
Gastrocopta tridentata
Y-7
Guppya sterkii
W-28
OHIO 43
Haplotrema concavum
W-24 25 26 28 --- U-8 9 12 13 14
MICH 1 2
OHIO 22 23 24 25 26 43
ONT 7 8 11 12 13
QUE 6
Hawaiia minuscula
PLI-1 2 3 4 -- N-1 2 --- A-1 --- K-1 4 --- Y-2 3 4 6 7 10 11 12 13 14 15 16 17 18 19 20 --- I-3 --- S-1 2 3 4 5 6 --- W-2 3 4 5 8 9 15 17 20 21 22 23 28 35 44 47 56 57 58 59 60 63 --- U-10
MICH 22 25 28 32 33 34 39
OHIO 1 4 29 43

Hawaiia minuscula (cont.)
MINN 3
ONT 11
Helicodiscus sp.
W-43
Helicodiscus parallelus
N-2 --- K-2 3 --- Y-7 8 10 11 16 17 18 --- I-3 --- S-1 2 3 4 5 --- W-8 9 14 15 21 22 24 28 56 57 58 59 --- U-2 4 10 12 13
MICH 1 7 8 25 26 32 33 34 39 40
MINN 2 4 5 7 22b
OHIO 1 6 7 25 43
ONT 3 8 12
QUE 6
Helicodiscus singleyanus
PLI-1 3 4 --- N-1 2 --- A-1 --- K-3 --- S-2 4 5 6 --- W-3 9 17 21 26
OHIO 43
Helicoid, undet. fragments
W-43
Hendersonia occulta
K-2 4 6 --- Y-2 7 21 --- I-5 --- S-7 --- W-4 5 60 61 62 64 65 73 --- U-7 10 12 13 14
MICH 40
Mesodon appressus
W-24 --- U-8 9 10 12 13
Mesodon clausus
W-26 35 --- U-9
OHIO 24
Mesodon dentiferus
ONT 7
Mesodon elevatus
W-24 25 26 --- U-8 9 10 12 13
OHIO 1
Mesodon inflectus
W-24 26 --- U-9 13
OHIO 1 2 3 5 7 27 28 43
ONT 11 12 13 14
Mesodon mitchellianus
W-24 26
OHIO 43
Mesodon pennsylvanicus
W-24 28 --- U-9
OHIO 43
Mesodon sayanus
MICH 1 2 7
ONT 7 8

Mesodon thyroidus
W-24 25 26 28 --- U-8 9 10
MICH 1
OHIO 5 7 23 24 29 43
ONT 7 12
Mesodon zaletus
W-24 26 --- U-10
OHIO 1 2 5 7
ONT 11 12 13 14
Mesomphix cupreus
OHIO 43
Mesomphix inornatus
OHIO 22
ONT 8
Mesomphix perlaevis
OHIO 22
Nesovitrea? sp.
PLI-1
Nesovitrea binneyana
W-24(cf.) 56 57 58 59
MICH 1 40
MINN 1 2 3 4 5 7
ONT 7
Nesovitrea electrina
PLI-3 --- N-2 --- K-2 6 --- Y-2 6 7 8 11 12 13 14 16 17 19 20 21 --- I-3 5 --- S-1 2 3 4 --- W-2 4 5 6 12 28 63 64 65 67 73 --- U-7 14
MICH 20 25 26 27 33 34
OHIO 4 26 43
ONT 7 8 10 14
Oxyloma sp. (?)
K-5
Oxyloma decampi gouldi
K-6 --- Y-21 --- I-5 --- W-64
Oxyloma navarrei
Y-9 10 11
Oxyloma retusa
N-2 --- S-6 --- W-26(?) 27 28 35 56 57 58 59 73 --- U-12 13
MICH 5 15 16 17 19 24 25 36 40
MINN 6 13b 16
NY 34
OHIO 7 29 31 39 43
ONT 7 8 10
Oxyloma retusa higginsi
OHIO 4 19

Oxyloma verrilli
MAN 39
Pallifera sp.
OHIO 29
Pallifera dorsalis
MICH 9
OHIO 43
Philomycus caroliniensis
MICH 3 4 25
OHIO 5 43
ONT 7 10
Philomycus rushi
MICH 25 26 28 29 32 33
Paravitrea multidentata
OHIO 43
Planogyra asteriscus
MICH 2
MINN 7
ONT 3
Polygyra rexroadensis
PLI-3 4
Polygyra texasiana
Y-17
Punctum minutissimum
K-6 7 --- Y-21 --- I-5 7 --- S-1 --- W-28 56 57 58 62 63 64 65 70
MICH 18 25 26 32 33
OHIO 1 43
ONT 3
QUE 6
Pupilla blandi
Y-17 --- I-3 --- S-1 4 6 --- W-1 2 4 5 9 11 12 15 16 17 19 20 21 22 23 73(?)
Pupilla muscorum
K-2 4 6 7 --- Y-2 5 6 7 8 12 13 --- Y-14 16 17 19 20 --- S-6 7 --- W-1 3 4 5 6 7 8 9 11 12 13 14 15 16 17 18 19 20 21 22 23 60 61 62 64 65 66 67 68 69 73
MAN 39
Pupilla muscorum sinistra
Y-6 7 11 12 --- S-6
Pupillid?
PLI-2 --- A-1 (n. gen.?)
Pupoides albilabris
PLI-1 3 4 --- N-1 2 --- A-1 --- K-3 5 --- Y-3 4 6 11 15 17 18 19 20 --- I-3 4 --- S-1 2 3 4 5 6 --- W-24 28 73 --- U-13

Pupoides albilabris (cont.)
MICH 32 33
OHIO 43
Pupoides inornatus
PLI-2 3 --- N-1 --- S-6
Retinella sp.
W-52 53 54
QUE 6
Retinella indentata
W-26 27 28 56 57 58 59 73 --- U-4 12
MICH 1 3 4 9 21 25 26 27 28 29 32 33
OHIO 1 4 43
ONT 10
Retinella indentata paucilirata
OHIO 22
Retinella rhoadsi
S-1 (cf.) --- W-28
MICH 1
Retinella wheatleyi
W-28
OHIO 23 26 43
Stenotrema sp.
I-6 --- W-43 44
Stenotrema fraternum
U-10 13
MICH 1 2 3 4 7 8 9 21 23 25 26 27 28 29 31 32 33 34 39 40
OHIO 1 23 24 25 26 28
ONT 11
Stenotrema hirsutum
Y-21 --- I-5 --- W-25 26 28 --- U-3 9 10 13 14
MICH 21 25 28 29 36
OHIO 23 24 25 26 27 29 43
Stenotrema leaii
K-1 3 6 --- Y-5 7 8 11 12 13 16 21 --- I-4 5 7 --- S-1 2 3 4 5 6 --- W-24 25 28 35 61 64 65 67 73 --- U-3 9 10 14
MICH 6 30
OHIO 4 7 43
ONT 7 8
QUE 6
Stenotrema stenotrema
W-24
Striatura exigua
MICH 18
OHIO 43

Striatura exigua (cont.)
ONT 2 3
QUE 6
Striatura ferrea
OHIO 43
QUE 6
Striatura milium
W-5 6 9 12 16 17 19
MICH 17 18 23 25
MINN 3 7
OHIO 43
ONT 2 3
QUE 6
Strobilops sp.
QUE 6
Strobilops aenea
OHIO 29
Strobilops affinis
W-28
MICH 20 21
Strobilops labyrinthica
PLI-1 --- K-6 --- Y-21 --- I-5 --- W-28 56 57 58 59 60 --- U-12 13 14
MICH 1 4 9
MINN 1 2 3 4 5 6 7 8
OHIO 43
ONT 10
Strobilops labyrinthica virgo
MICH 40
OHIO 43
Strobilops sparsicosta
PLI-2 3 --- N-1 2 --- Y-2 5 6 12 17 18 19 20
Strobilops texasiana
S-1
cf. Succinea
PLI-1 2 3 4 --- N-1 2 --- A-1
Succinea sp.
W-25
Succinea avara
Y-12 15 --- S-1(cf.) --- W-1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 26 27 28 43 44 51 52 53 54 55 56 58 59 73 --- U-6
MAN 39
MICH 1 5 22 32 33 34 36 40
NY 42
OHIO 7 43
ONT 11 12 14

Succinea avara var.
Y-21
Succinea grosvenori
K-2 4 --- Y-2 3 4 5 6 7 8 11 12 13 14 15 16 17 18 19 20 --- I-1 2 3(?) 4 --- S-1 7 --- W-2 4 5 6 7 9 12 13 15 16 17 18 19 20 21 43 44 60 61 64 --- U-3
Succinea "obliqua"
U-4
Succinea ovalis
Y-11 16 --- I-6 --- S-1 --- W-2 24(?) 27 28 35 48 49 50 51 62 63 --- U-4 (?) 6 12 13
MICH 1 7 8 17 20 25 28 29 32
MINN 3 7
OHIO 5? 43
ONT 7 8 10
Triodopsis albolabris
W-24 26 28 --- U-2 8 9 10 13
MICH 1 2 4 7 8 9 21 22 25 26 27 28 29 32 33 34 36 40
OHIO 1 3 4 5 22 25 26 43
ONT 7 8 10
Triodopsis albolabris alleni
U-8 9
Triodopsis albolabris goodrichi
ONT 12 13
Triodopsis denotata
W-24 28
OHIO 23 43
ONT 7 11
Triodopsis divesta
U-3
Triodopsis fraudulenta
ONT 11 12 13
Triodopsis fraudulenta vulgata
W-26 28
OHIO 5 7 27 28 43
Triodopsis multilineata
W-24 26 28 --- U-1 2 4 6 10 12 13
OHIO 4 7 43
Triodopsis tridentata
W-24 25 28 --- U-12
OHIO 22 23 24 25 26 29 43
Vallonia sp.
U-10
Vallonia albula
I-7 --- W-64 65 66 67 69

Vallonia costata
W-73
MICH 32 35
OHIO 43
Vallonia cyclophorella
S-6
Vallonia excentrica
OHIO 4 43
Vallonia cf. V. excentrica
K-6 --- I-7
Vallonia gracilicosta
PLI-3 --- K-1 3 4 7 --- Y-2 5 6 7 8 10 11 12 13 14 15 16 17 18 19 20 --- I-3 --- S-1 2 4 6 --- W-1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 43 44 63
MINN 2 5
Vallonia parvula
PLI-4 --- S-1 2 3 4 5 6
OHIO 1 4
ONT 11 14
Vallonia perspectiva
PLI-1 3 --- N-2 --- A-1
Vallonia pulchella
N-1 --- K-3 --- Y-2 8 10 11 12 15 19 20 --- W-24 28 73 --- U-4 7 10
MICH 31 32 33 34 35 38
OHIO 1 4 7 43
ONT 7
Ventridens demissus
OHIO 25 26
Ventridens intertextus
OHIO 22 23 24 43
Ventridens ligerus
W-24 26 28 --- U-9 10
OHIO 22 23 24 27 43
Ventridens suppressus
MICH 25 27 28 32 33
OHIO 43
Vertigo sp.
QUE 6 (3 species)
Vertigo alpestris oughtoni
K-6 --- S-7 --- W-43 44 60 61 64 66 67 68 69
MAN 39
Vertigo binneyana
MAN 39

Vertigo bollesiana
ONT 2
Vertigo coloradensis
W-2
Vertigo elatior
K-6 7 --- Y-21 --- I-5 7 --- W-28 63 64 65 66 69 70
MICH 40
OHIO 43
Vertigo gouldi
Y-6 8 12 14 --- S-6 --- W-73
OHIO 43
ONT 2
Vertigo gouldi hannai
K-7 --- W-70
Vertigo gouldi hubrichti
K-6 --- W-62 65
Vertigo gouldi paradoxa
W-4 5 6 7 9 12 15 17 19
Vertigo hibbardi
PLI- 1 3
Vertigo milium
PLI- 1 2 3 4 --- N-1 2 --- A-1 --- K- 1 5 --- Y-2 4 6 8 10 12 14 17 18 --- S- 1 2 3 4 6 --- W-3 13 28 56 57 58 59
OHIO 1 43
Vertigo modesta
K-4 6 --- Y-2 7 21 (cf.) --- I-5 7 --- W-4 5 6 9 12 13 15 16 17 18 19 20 21 22 --- W-62 64 65 66 69
Vertigo modesta corpulenta
W-73
Vertigo morsei
W-28 52 53 54 55 56 57 58 59
Vertigo nylanderi
I-7
Vertigo ovata
N-1 2 --- A-1 --- K-1 4 5 --- Y-2 3 5 10 11 12 13 14 15 17 18 19 20 --- S-1 2 3 4 5 6 --- W-28 35 48 49 50 51 67
MICH 17 22
OHIO 43
ONT 2 3 7
Vertigo pygmaea
S-7 --- W-60 61
Vertigo tridentata
Y-10 --- W-2 28
OHIO 43
Vertigo ventricosa
MICH 8 18
MINN 3 4
OHIO 43
Vitrina limpida
MICH 1
MINN 3 7
ONT 7
Zonitoides sp. ---- QUE 6
Zonitoides arboreus
N-2 --- K-2 --- Y-7 8 10 11 12 16 --- S-1 2 3 4 5 6 --- W-6 7 9 17 26 27 28 56 57 58 59 73 --- U-10 14
MICH 1 3 4 7 8 9 17 20 23 25 26 27 28 31 32 33 34 36 38 39 40
MINN 1 2 3 4 5 6 7 8 22b
OHIO 1 3 4 7 26 43
ONT 7 8 10 11 14
Zonitoides nitidus
MICH 24 30
OHIO 43
ONT 3 7
Zoögenetes harpa
MICH 1 5

Discussion

NAIADES. The scarcity of Naiades in Pleistocene deposits is worth noting. Sparks (1964:20) has noted a similar scarcity in the Pleistocene of England and attributes it to the fact that "thick-shelled genera, *Unio* and *Potamida*, usually shale off into flakes, while the thin-shelled *Anodonta* is easily crushed in the sediment." He notes also that in open sections, where the shells can be extracted with care, more Naiades turn up. There is no doubt that snails, in general, are more numerous than Naiades in absolute numbers of individuals: the size of the adult is a factor here and accounts for the relatively greater frequency of Sphaeriidae as well as snails.

Nevertheless it is a striking fact that in deposits that have been collected by methods which should turn up Naiades in abundance (e.g. W-28-42 and 45-59) they are scarce or lacking and represented by few species, as compared with their abundance and variety in northern lakes at present. This scarcity may be due to the hazards of distribution as parasites of fish but it would seem that some other factor enters into play here to yield such a low incidence of Naiades. Perhaps the fact that many Pleistocene collections are from lakes that did not form part of a river system may have something to do with the observed scarcity of Naiades. On the other hand, there is the possibility that the chaotic drainage - or lack of drainage - in lakes formed on a moraine surface may have prevented fish from reaching the isolated ponds and lakes studied. If this is true, we can only wonder at the much more efficient methods of dispersal available to Sphaeriidae and snails in general, although there are notable exceptions to their generally wide distribution which will be discussed later in this paper. Finally, it should be pointed out that Naiades were much more abundant in some beds of the Paleocene and Eocene (e.g. the Flagstaff, Colton, and Green River formations of Utah) than in the Pleistocene associations studied here. In addition, although some of the Naiades in these Tertiary beds have suffered severe crushing and distortion, they do not flake off until exposed to weathering; freshly exposed specimens preserve the shell intact and the details of the umbonal sculpture are as clear as they were in life. To sum up, judging by frequency of occurrence alone, Naiades are the scarcest of the five ecological groups of Mollusca recorded in Pleistocene assemblages in North America. Whether this was due to inferior means of dispersal or unsuitability of environment for most species remains to be ascertained.

SPHAERIIDAE. Discussion of this group can be undertaken much more satisfactorily since Herrington (1962) has given us a rational arrangement of the species. His classification has been followed in the lists presented in the first part of this paper and many specific names proposed by Sterki have been reduced to synonymy as advocated by Herrington.

A striking fact which immediately stands out is the number of circumpolar species that are found in the Pleistocene deposits of North America along with a small number of purely North American species. These records should lay to rest once and for all the possibility that some of these European species, first known as living species, were introduced here. They may have been reintroduced by Man but we can be certain that most of them had already come to our continent by other means than human introduction during the Pleistocene. In fact, some of them may have originated here and have spread to Asia and Europe where they happened to attract first notice by scientists; the fact that a genus or species was first described from Europe by Müller, Poli, or Pfeiffer does not mean that it originated there. This point needs to be emphasized as it has been taken for granted by many writers in the past, in the Mollusca and in other groups of invertebrates and vertebrates.

As compared with the Naiades, the Sphaeriidae have excellent means of dispersal and a high reproduction rate - in spite of a smaller number of young - as exemplified by their incidence both in Pleistocene and present nonmarine environments. On the other hand, the species are distributed in a seemingly - perhaps truly - haphazard way. To exemplify this, we need only examine the lists of sphaeriids for deposits in northern Ohio (W-27, 28, 29, 45-51). Within a restricted area, in penecontemporaneous deposits, the records for individual species vary not only from deposit to deposit as a whole but in the various stratigraphic levels within a single deposit. (See Table 1).

TO BE CONTINUED IN A FUTURE NUMBER OF STERKIANA

A CHECKLIST OF PLEISTOCENE AND RECENT FRESHWATER OSTRACODS IN CANADA

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From La Rocque's short note on non-marine ostracods, in STERKIANA, 1963, No. 12, p. 7, it appears that a comprehensive checklist of freshwater ostracods of Pleistocene and Recent age would be helpful to malacologists.

The present checklist is restricted to freshwater ostracods found in Canada only. Several lists of United States ostracods have been prepared, the most up-to-date to be found in Tressler (1959). Ostracods of the Great Lakes are included.

The data for the checklist were compiled from literature known to the author, and also from information obtained by a canvass of twenty-two geology and zoology departments in Canadian universities. The help of Dr. R. Green, Research Council of Alberta, who submitted a list of Alberta species, is acknowledged.

The name, author, and date of each species, together with the author, date, and page reference of each subsequent record of the species, are given. Abbreviations used for unpublished records are as follows: Alta. - specimen identified from Alberta by Dr. Green; Man. - Manitoba (University of Manitoba thesis by I. G. Arnason); GMUS - specimen, identified by the author, from Saskatchewan deposited in the Geological Museum, University of Saskatchewan; GMUS (Man.) - specimen from Manitoba, identified by the author, deposited in the Geological Museum, University of Saskatchewan.

SUBFAMILY CYPRIDINAE

CYPRIS PUBERA Mueller, 1776. Sars, 1926, p. 4; Alta.; GMUS.

CYPRICERCUS AFFINIS (Fischer), 1851. Sars, 1926, p. 6.

CYPRICERCUS FUSCATUS (Jurine), 1820. Klugh, 1927, p. 55.

CYPRICERCUS HORRIDUS Sars, 1926. Sars, 1926, p. 6; GMUS.

CYPRICERCUS RETICULATUS (Zaddach), 1844. Klugh, 1921, p. 73; Klugh, 1923, p. 337.

CYPRICERCUS TUBERCULATUS (Sharpe), 1909. Bigelow, 1923, p. 60; GMUS

CYPRICONCHA BARBATA (Forbes), 1893. Sars, 1926, p. 5; Tressler, 1957, p. 421.

CYPRICONCHA MACRA Blake, 1931. Alta.; GMUS

CYPRINOTUS GLAUCUS Furtos, 1933. Furtos, 1933, p. 445; Staplin, 1963a, p. 792; GMUS

CYPRINOTUS INCONGRUENS (Ramdohr), 1808. Sars, 1926, p. 7; Klugh, 1927, p. 24; Furtos, 1933, p. 448; Alta.; Man.; GMUS

CYPRINOTUS SALINUS (Brady), 1868. GMUS

EUCYPRIS CRASSA (Mueller), 1785. GMUS

EUCYPRIS VIRENS (Jurine), 1820. Man.

STENOCYPRIA LONGICOMOSA Furtos, 1933. Furtos, 1933, p. 442.

CYPRIDOPSIS ACULEATA (Liljeborg), 1853. Sars, 1926, p. 8; GMUS

CYPRIDOPSIS CANADENSIS Ferguson, 1959. Ferguson, 1959, p. 64.

CYPRIDOPSIS DENTATOMARGINATA (Daday), 1902. Kupsch, 1960, p. 291.

CYPRIDOPSIS HARTWIGI (?) Mueller, 1900. Kupsch, 1960, p. 291.

CYPRIDOPSIS HELVITICA Kaufmann, 1893. Sars, 1926, p. 8.

CYPRIDOPSIS VIDUA (Mueller), 1776. Klugh, 1921, p. 73; Klugh, 1923, p. 337; Reed et al., 1924, p. 273; Klugh, 1927, p. 20-24; Karrow et al., 1961, p. 662; Staplin, 1963b, p. 1184; Benson & MacDonald, 1963, p. 21; Alta.; Man.; GMUS.

POTAMOCYPRIS COMOSA Furtos, 1933. Furtos, 1933, p. 435.

POTAMOCYPRIS SMARAGDINA (Vavra), 1891. Reed et al., 1924, p. 274; Klugh, 1927, p. 25; Furtos, 1933, p. 436; Staplin, 1963b, p. 1185; Man.; GMUS.

POTAMOCYPRIS VARIEGATA (Brady & Norman), 1889. Staplin, 1963b, p. 1186.

SUBFAMILY HERPETOCYPRIDINAE

HERPETOCYPRIS TESTUDINARIA Cushman, 1908. Cushman, 1908, p. 706.

ILYODROMUS PECTINATUS Sharpe, 1909. Bigelow, 1923, p. 60.

PRIONOCYPRIS CANADENSIS Sars, 1926. Sars, 1926, p. 7; Alta.

FAMILY CYCLOCYPRIDIDAE

CYCLOCYPRIS CASTANEA Klugh, 1923 [non Brady, 1913]. Klugh, 1923, p. 337; Klugh, 1927, p. 55.

CYCLOCYPRIS FORBESI Sharpe, 1897. Klugh, 1927, p. 20; Kupsch, 1960, p. 291; Karrow et al., 1961, p. 662; Alta.; GMUS.

CYCLOCYPRIS GLOBOSA (Sars), 1863. Sars, 1926, p. 8.

CYCLOCYPRIS LAEVIS (Mueller), 1776. Klugh, 1921, p. 73; Alta.

CYCLOCYPRIS LUTEA Klugh, 1923. Klugh, 1923, p. 340; Klugh, 1927, p. 60.

CYCLOCYPRIS OVUM (Jurine), 1820. Staplin, 1963b, p. 1181. Man.

CYCLOCYPRIS SERENA (Koch), 1838. Sars, 1915, p. 222.

CYCLOCYPRIS SHARPEI Furtos, 1933. Staplin, 1963b, p. 1182.

CYPRIA EXSCULPTA (Fischer), 1855. Alm, 1914, p. 7; Kluch, 1927, p. 22.

CYPRIA LACUSTRIS Sars, 1890. Sars, 1926, p. 8.

CYPRIA OBESA Sharpe, 1897. GMUS.

CYPRIA TURNERI Hoff, 1942. Staplin, 1963b, p. 1175.

PHYSOCYPRIA INFLATA Furtos, 1933. Furtos, 1933, p. 471.

PHYSOCYPRIA PUSTULOSA (Sharpe), 1897. Furtos, 1933, p. 470; Benson & MacDonald, 1963, p. 20.

FAMILY CANDONIDAE

CANDONA ACUTA Hoff, 1942. GMUS (Man.).

CANDONA ALBICANS Brady, 1864 [= C. parallela auct.]. Klugh, 1923, p. 337; Staplin, 1963a, p. 763; Alta.; GMUS.

CANDONA BRETZI Staplin, 1963. Staplin, 1963a, p. 765.

CANDONA CANDIDA (Mueller), 1776. Man.; Alta.; GMUS.

CANDONA CAUDATA Kaufmann, 1900. Benson & MacDonald, 1963, p. 13; Alta.; GMUS.

CANDONA CROGMANIANA Turner, 1894. Tressler, 1957, p. 420; Kupsch, 1960, p. 291; Benson & MacDonald, 1963, p. 14; Staplin, 1963a, p. 769; Alta.; GMUS.

CANDONA DECORA Furtos, 1933. Tressler, 1957, p. 418; Alta.; GMUS.

CANDONA DISTINCTA Furtos, 1933. Kupsch, 1960, p. 291; Alta.; GMUS.

CANDONA ELLIPTICA Furtos, 1933. Furtos, 1933, p. 482.

CANDONA ERIENSIS Furtos, 1933. Furtos, 1933, p. 484.

CANDONA FABA Benson & MacDonald, 1963. Benson & MacDonald, 1963, p. 15.

CANDONA INDIGENA Hoff, 1942. Alta.

CANDONA LACTEA Baird, 1850. Karrow et al., 1961. p. 662; Staplin, 1963a, p. 776.

CANDONA NOVACAUDATA Benson & MacDonald, 1963. Benson & MacDonald, 1963, p. 16.

CANDONA OHIOENSIS Furtos, 1933. Alta.; GMUS.

CANDONA PARVULA Sars, 1926. Sars, 1926, p. 9.

CANDONA RAWSONI Tressler, 1957 [= C. nyensis auct., C. swaini Staplin, 1963a]. Tressler, 1957, p. 421; Karrow et al., p. 660, 662; Benson & MacDonald, 1963, p. 17; Alta.; GMUS.

CANDONA RENOENSIS Gutentag & Benson, 1962. Alta.; GMUS.

CANDONA SCOPULOSA Furtos, 1933. Furtos, 1933, p. 480; Kupsch, 1960, p. 291; Staplin, 1963a, p. 783.

CANDONA SIMPSONI Sharpe, 1897. Staplin, 1963a, p. 785.

CANDONA SUBTRIANGULATA Benson & MacDonald, 1863 [= C. houghi Staplin, 1963a]. Benson & MacDonald, 1963, p. 18; Staplin, 1963a, p. 775.

CANDONA TRUNCATA Furtos, 1933. Kupsch, 1960, p. 291; Karrow et al., 1961, p. 662; Staplin, 1963a, p. 788.

CANDONA WANLESSI Staplin, 1963. Staplin, 1963a, p. 790.

PARACANDONA EUPLECTELLA (Brady & Norman), 1889. Man.; GMUS.

SUBFAMILY ILYOCYPRIDINAE

ILYOCYPRIS BRADYI Sars, 1890. Klugh, 1927, p. 25; Alta.; GMUS.

ILYOCYPRIS GIBBA (Ramdohr), 1808 (sensu lato). Alta.; GMUS.

FAMILY NOTODROMADIDAE

NOTODROMAS MONACHA (Mueller), 1776. Alta.; GMUS.

CYPROIS MARGINATA (Straus), 1821. Alta.; GMUS.

CYPROIS OCCIDENTALIS Sars, 1926. Sars, 1926, p. 3.

FAMILY DARWINULIDAE

DARWINULA AUREA (Brady & Robertson), 1870. Karrow et al., 1961, p. 662; Staplin, 1963b, p. 1192.

DARWINULA STEVENSONI (Brady & Robertson), 1870. Furtos, 1933, p. 425.

SUBFAMILY NEOCYTHERIDEIDINAE

CYTHERISSA LACUSTRIS (Sars), 1863. Karrow et al., 1961, p. 662; Staplin, 1963b, p. 1203; Benson & MacDonald, 1963, p. 22; Alta.; GMUS.

FAMILY ENTOCYTHERIDAE

ENTOCYTHERE INSIGNIPES (Sars), 1926. Sars, 1926, p. 10.

FAMILY LIMNOCYTHEREIDAE

LIMNOCYTHERE FRIABILIS Benson & MacDonald, 1963 [= L. chippewaensis Staplin, 1963b]. Benson & MacDonald, 1963, p. 24; Staplin, 1963b, p. 1193.

LIMNOCYTHERE HERRICKI Staplin, 1963. Staplin, 1963b, p. 1194.

LIMNOCYTHERE ILLINOISENSIS Sharpe, 1897. GMUS.

LIMNOCYTHERE INOPINATA (Baird), 1843. GMUS.

LIMNOCYTHERE ORNATA Furtos, 1933. Furtos, 1933, p. 423; Staplin, 1963b, p. 1195.

LIMNOCYTHERE OUGHTONI Tressler, 1957. Tressler, 1957, p. 422.

LIMNOCYTHERE RETICULATA Sharpe, 1897. Huntsman, 1922, p. 132; Bigelow, 1923, p. 60; Moore, 1953, p. 423; Karrow et al., 1961, p. 660.

LIMNOCYTHERE STAPLINI Gutentag & Benson, 1962. Alta.; GMUS.

LIMNOCYTHERE TRAPEZIFORMIS Staplin, 1963. Staplin, 1963b, p. 1200; Alta.; GMUS.

LIMNOCYTHERE VERRUCOSA Hoff, 1942. Karrow et al., 1961, p. 660; Benson & MacDonald, 1963, p. 23; Staplin, 1963b, p. 1202; Alta.; GMUS.

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NEW PUBLICATIONS

SPARKS, B.W. (1964) The Distribution of non-marine Mollusca in the last Interglacial in South-East England. -- Proc. Malac. Soc. London, v. 36, pp. 7-25.

A study which has a great deal of interest for workers on Pleistocene Mollusca in North America, both from the standpoint of methods used and conclusions reached. The distribution of Mollusca is summarized in terms of vegetation zones which the author states "provide the only reasonable approach to a climatic and chronological framework for the period." It is worthy of note that the author found "a somewhat greater continental influence than at present" and that "the apparent slowness of arrival of Mollusca in the early part of the Interglacial is contrasted with their apparent survival into intemperate climates in the latter part of the Interglacial."

A. L.

LIKHAREV, I.M. and RAMMEL'MEIER, E.S. (1962) Terrestrial Mollusks of the Fauna of the U.S.S.R. -- Izdatel'stvo Akademii Nauk SSSR, Moscow and Leningrad, 1952. Translated by Dr. Y. Lengy and Z. Krauthamer, published for the National Science Foundation, Washington, D.C., and the Smithsonian Institution, by the Israel Program for Science Translations, Jerusalem, 1962, 574 pp., 420 figs.

Leafing through this long-awaited volume (ordered in January 1963 and received May 9, 1964) one has the impression that it is a solid piece of work well done, based on a great deal of collecting in a very large and important area of the world. Table V (pp. 61-63) is particularly useful to the paleontologist since it summarizes the geologic range of contemporary genera in Europe. The figures leave something to be desired, but perhaps they have lost some of their original sharpness in reprinting; I have not seen the original, but having some familiarity with offset reproduction, I am inclined to blame the process rather than the originals for lack of sharpness. Outline maps showing ranges would be a distinct addition to this work.

A. L.

REPRINTS OF RARE PAPERS ON MOLLUSCA

THREE PAPERS BY JOSEPH FREDERICK WHITEAVES

1. "Trans-Atlantic Sketches. -- No. 1. On the Little Miami River, Waynesville, Warren County, Ohio." (From the "Zoologist," for February, 1863, pages 8119-8124)

(page 8119)

It is a sultry afternoon in the latter end of July, as we leisurely stroll from our little village hotel in the "buck-eye" State, the thermometer at from 90° to 95° in the shade. We have been watching the ruby-throated humming bird hovering over the flowers of the trumpet-creeper at the end of the verandah. Into the village street, shaded by "trees of heaven," locust trees and the beautiful Indian bean, with its pods fully a foot long. Along a dusty turnpike road, running parallel or nearly so, with the little Miami river, our main object being to collect the Unionidae of that stream. On one side of the road, fields of Indian corn stretch down to the river; opposite to these are hills, partly cultivated, partly woodland, crowned with large peach orchards. The commonest road-side weeds here are Mentha viridis, the cosmopolite Anthemis cotula, Scrophularia nodosa, Vernonia noveboracensis, Datura stramonium, Phytolacca decandra, Verbena hastata, V. urticifolia, Ambrosia artemisiæfolia, and Cynoglossum Morisoni. When just outside the town, we strike a short distance up the hill into a friend's garden to examine a nest of the American goldfinch (Chrysomitris tristis). It is built in a fork of a peach tree, and in its construction closely resembles that of the European species, the lining of the nest in each

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case being of thistle-down, but the eggs of the American species are white, with a very faint bluish tinge, and generally unspotted; the birds themselves are very distinct. Peach trees in Ohio, it should perhaps be observed, are not trained against a wall, as in England, but grow free, like apple trees. Speaking of birds' nests, not far from here I found a nest of the Virginian colin (Ortyx virginianus): it was placed in a field of Indian corn, between the rows, where two small decayed logs were lying at right angles, surrounded by a patch of weeds, principally Rumex and Chenopodium, with a little grass. The nest itself was a shallow hole scratched in the ground, in the angle formed by the aforesaid logs, and possessed hardly any lining, a very little dirty straw and a feather or two. The scantiness of lining and its want of cleanliness may account for the stains so often seen on these eggs, the original colour being probably pure white. The old bird was sitting as we approached, partly concealed by the logs and grass. The eggs in this particular case were six, the full complement being from about fifteen to twenty.

But to return to our stroll. On the hill-side, in grass fields, we observe Silene stellata and Tradescantia pilosa. A little further on we come to some woods with little or no undergrowth. Here the black walnut is frequent, also the fœtid or Ohio "buck-eye" (Æsculus glabra), the abundance of which in this part of the world has suggested the popular name of the State. Under their shade are flocks of the American goldfinch, occasionally a robin (Turdus migratorius), also blue birds (Sialia sialis), "chipping sparrows" (Spizella socialis), and now and then a purple grackle (Quiscalus versicolor). We get into the road again, and, clambering over the fences, cross through the tall Indian corn to the river. In among the corn grow the beautiful wild potato vine (Ipomæa pandurata), the ground cherry (Physalis viscosa), Sicyos angulatus, Phaseolus diversifolius and Portulaca oleracea. Shells of snails of three species (Helix clausa, H. profunda and H. elevata) occur in myriads strewn over the fields, in a kind of semi-fossil state. Cultivation has had the effect of making these, especially the last-named, comparatively rare, at least in the immediate neighbourhood. Between us and the river a dense weedy thicket intervenes, conspicuous among which, both in size and relative number, is the tall coarse Ambrosia trifida, reaching here to the height of from twelve to fifteen feet. Other plants composing it are the tall nettle (Urtica gracilis), the horse mint (Monarda punctata), Actinomeris helianthoides, Teucrium canadense, with occasionally bushes of the American elder (Sambucus canadensis) and other trees.

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We push through this tangled thicket towards the river, and hearing a heavy splash are just in time to see a large snapping turtle take the water. The leather-backed and the musk turtle (Trionyx ferox and Sternothærus odoratus) are abundant in this river, also many of the more critical forms, but having no books with us we are compelled, rather unwillingly, to ignore their existence. A little further on a narrow creek runs into the river, and here we propose to commence active operations. Where the small stream and river meet is a shady grove. The trees are principally planes (Platanus occidentalis), often festooned with the graceful winter grape (Vitis cordifolia), sugar maples, red and white oaks, and, rather more rarely, the red mulberry (Morus rubra) and the hackberry (Celtis occidentalis).

We pause here and botanize for a short time. The plants of most general interest are Mimulus ringens, Impatiens fulva, Scutellaria lateriflora, Lobelia syphilitica, the Indian plantain (Cacalia suaveolens), the American blue bell (Campanula americana), the bunch berry (Cephalanthus occidentalis) and the cup plant (Silphium perfoliatum). At the point where the two streams meet is a small island covered exclusively with Dianthera americana. The bottom is gravelly and somewhat pebbly. The shore is strewn with dead valves of Unio, principally U. costatus, indications of the mania for hunting pearls which has existed, and yet does exist, in this village. Having examined many Unionidæ, I am led to infer --- first, that although pearls are most abundant in the animals of the genus Alasmodon, they are not peculiar to that group of shells; I have found them in the Unio phaseolus, U. gibbosus, U. costatus and U. multiradiatus: secondly, that they may be found in almost any part of the animal except the foot; I have found a tolerably large pearl thoroughly enveloped in the cardinal muscle of an Alasmodon.

We proceed to wade into the water, but cautiously, lest we should get our feet badly cut by dead shells. As soon as we are fairly out in the stream, we lift up and examine these defunct mollusks. In them we find Cyclas solidula, Melania depygis, Paludina integra and an Ancylus -- alive, also dead shells of Pisidium virginicum and Amnicola Sayana. The Amnicola Sayana is a terrestrial species, living in damp places with Helix, Succinea and Pupa, and occurs alive near the banks of the river, about a mile above the spot we are exploring. Occasionally with these we get the American crayfish (Astacus Bartoni?) and the curious larva of a Phryganea (?), whose case looks so much like the turbinated shell of a mollusk that Mr. Lea described it as a new species, under the name of Valvata arenifera. The living

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Unionidæ are abundant further out, where the current is most rapid, and the water about knee-deep, two-thirds of the shell being buried in the gravel. We wade slowly for some time, feeling with our hands along the bottom for the points of the shells.

During a month's stay at Waynesville, in the most favourable part of the year, we found the following fresh-water shells in the Little Miami River, within a mile or two of the town: --

Anodonta plana, Lea
" edentula, Say
" imbecilis, Say
Margaritana (Alasmodon) rugosa, Barnes
*" " truncata, Say
*" " calceola, Lea
*Unio costatus, Rafinesque
(U. undulatus, Barnes)
*U. flavus, Raf.
(U. rubiginosus, Lea)
" cardium, Raf.
(U. ventricosus, Barnes
U. subovatus, Lea
U. occidens, Lea, female var.?)
*" triqueter, Raf.
(U. triangularis, Say)
*" clavus, Lamarck
" rectus, Lamarck
*" lapillus, Say
" dilatatus, Raf.
(U. gibbosus, Barnes)
Unio siliquoidens, Barnes
" alasmodontinus, Barnes
(U. pressus, Lea)
*" fasciolus, Raf.
(U. multiradiatus, Lea)
" fasciolaris, Raf.
(U. phaseolus, Hildreth)
*" parvus, Barnes
*" subrotundatus, Raf.
(U. circulus, Lea)
*" tuberculatus, Raf.
(U. verrucosus, Barnes)
Sphaerium (Cyclas) solidulum, Prime
Pisidium virginicum, Bgt.
(Cyclas dubia, Say)
Paludina integra, Say (and reversed variety)
*Melania depygis, Say
Planorbis trivolvis, Say
Physa heterostropha, Say
Ancylus (undetermined)

Of these twenty-seven shells about half are purely western species, and do not extend far north (say not so far as the 43rd or 44th degree of N. latitude) or east of the Alleghany Mountains; to these an asterisk is prefixed. All the rest (save Anodonta imbecilis and Paludina integra) occur as far north as Lower Canada, for example, and, the two species excepted, have been found so far north in the state of New York, that it is not unlikely they may exist in the "Eastern townships" of Lower Canada.

But we are again digressing. During the wading we have been silently watching the proceedings of two musk rats, as they leisurely swim across the stream. Three red-headed woodpeckers (Melanerpes erythrocephalus), two males and one female, are investigating some rotten plane trees on the opposite side of the river. A belted kingfisher (Ceryle Alcyon) perches on a dead tree: suddenly we hear a

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splash, and looking towards the spot whence the sound proceeded, we observe the kingfisher jubilantly return to the tree crunching one of the river crayfish with evident satisfaction. "From the woods came voices of the well-contented doves,"* the dove in this case being the American turtle (Zenaidura caroliniensis). A little lower down several green herons (Butorides virescens) and some "kill deer" plovers (AEgialites vociferus) are wading about seeking what they may devour.

But, tired of wading, we cross the river to the railway, and walk some distance along the line.

* Tennyson's 'Gardener's Daughter.'

Passing by the station we observe some shady woods, towards which we turn. The trees are mostly the American beech (F a g u s f e r r u - g i n e a), with little undergrowth save papaw bushes (A s i m i n a). The May apples (P o d o - p h y l l u m p e l t a t u m) are beginning to ripen, and about the roots of the trees we notice the delicate green fronds of Adiantum pedatum. Some rotten logs are lying about, which we turn over and hunt for land shells. After about half an hour's search, we have obtained living specimens of Helix albilabris, H. thyroidus, H. clausa, H. palliata, H. tridentata, H. inflecta, H. alternata, H. striatella and H. perspectiva. After a short rest we turn towards the river again. Just below a dam, on one bank a section exposes alternations of the shales and clays of the Hudson river group, which are Lower Silurian. Its most abundant fossils here are † Strophomena alternata and S. planumbona of Hall, Orthis Lynx, O. subquadrata, O. testudinaria and O. occidentalis, Rhynchonella capax and R. modesta, Ambonychia radiata, Ciclonema bilix, Orthoceras crebriseptum; the delicate bryozoon Stenophora fibrosa, and the trilobite so common in Ohio, the Calymene senaria of Conrad, -- probably identical with the well-known British species Calymene Blumenbachii. Living under small pieces of timber lying about on the damp grass, &c., we find Helix ligera, Bulimus marginatus, Pupa armifera, P. contracta, P. ovata, and Carychium exiguum, one of the smallest of the American land shells.

But it has taken some time to collect these, it is getting dusk, and the fireflies, called "lightning bugs" in the elegant phraseology of the district, are beginning to appear; so we stroll gently homewards. Many interesting Coleoptera, Lepidoptera, &c., were observed, but these I have not enumerated, fearing lest I should overburden this sketch with mere lists of species.

† These fossils were kindly determined for me by my friend Mr. Billings, the palæontologist of the Canadian Geological Survey.

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It has been urged in favour of Natural History studies that they are eminently conducive to health. This appears to me to be a great fallacy. Three years practical out-of-doors work in Oolitic Geology has helped considerably, in my case, to induce severe asthma. On leaving England I found similar results awaited me. Not more than two months spent in collecting the fresh-water mollusks of the interior of the state of Ohio resulted in an attack of fever and ague; and I was told that collecting Unios in this very river cost Mr. Lea, the brother of the well-known author of so many papers on American Unionidæ, his life. The botanist and the ornithologist have to investigate swamps, &c., at the risk not only of malaria, but of bronchial complaints, &c., to which so many of our fellow-countrymen are already predisposed. That these evils may, to some extent, be guarded against is true, but the cause of Natural History can never have anything to gain either by the suppression of facts or the distortion of truth.

J. F. Whiteaves.

2. "NOTES ON RECENT CANADIAN UNIONIDAE."
(From the Canadian Record of Science, vol. 6, No. 5, pp. 250-263, 1895).

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The present paper is intended as a contribution to our knowledge of the geographical distribution of the Unionidæ in North America. It consists of a list of all the species from Canadian localities that are now represented in the museum of the Geological Survey at Ottawa, and is based almost exclusively upon specimens that were either collected by members of the Survey staff or presented by friends interested in its museum. So far as the writer is aware, however, the U n i o t e n u i s s i m u s of Lea, which was collected by Dr. G. M. Dawson in 1873, in the

Souris River, Manitoba, is the only species of Unionidæ known to occur in Canada that is not represented in the Survey museum. Specimens of most of the nominal species of Anodonta and of a few of the more difficult species of Unio enumerated in this list have been kindly compared by Mr. Charles T. Simpson, of the United States National Museum, with Dr. Lea's types of North American Unionidæ now preserved in that institution, and identified as correctly as the small number of shells sent from each locality and the incompleteness of his studies of the family would permit. The nomenclature employed throughout this list is that which is now in general use among students of this group in North America, as it is still quite uncertain which of the earlier names of Rafinesque,

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Lamarck and others, will ultimately have to be retained for some of these shells.

ANODONTA, Lamarck, 1879.

ANODONTA BENEDICTII, Lea.

Specimens which appear to have been identified with this species by Dr. Lea have already been recorded by Dr. R. Bell[1] as having been collected by himself, in 1860, at Batch-ah-wah-nah Bay, Lake Superior; in the St. Mary River, near Sugar Island, and on the north shore of Lake Huron, at Lacloche Island. Professor Macoun has recently (1894) collected it at Rondeau, near Point aux Pins, on the Ontario side of Lake Erie, and a few specimens, which Mr. Simpson thinks are probably referable to A. Benedictii, were collected by Dr. R. Bell, in 1883, at Lake Winnipeg, between Fort Alexander and Elk Island. Mr. Simpson is inclined to believe that A. Benedictii may be only a variety of A. ovata, Lea.

ANODONTA DECORA, Lea.

Eight full grown specimens and one immature shell of a very large Anodonta, which Mr. Simpson refers to A. decora, were collected by Mr. Law, of Chatham, at Rondeau, Ontario, and presented by him to the Museum of the Survey, through Professor Macoun, in 1884. One of the adult shells from this locality, a fairly average specimen, measures 6.6 inches in length, 4 inches in height and 3.1 inches in breadth or thickness. The umbones of each are remarkably ventricose and prominent. The test is rather thick, the hinge line short, and the cardinal angles are rounded in front and obtusely angular behind. The writer has long been under the impression that these shells could be identified with the typical form of A. grandis, Say, as they do not correspond at all well with Lea's figures or measurements of A. decora,

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the "breadth" or, as it would now be called, the length of which is stated to be 3.9 inches. The recent receipt from Mr. Simpson of outline drawings of specimens from Dr. Lea's collections, labelled "A. decora, from the canal at Cincinnati, Ohio," has, however, convinced the writer of the correctness of Mr. Simpson's determination, though it is very generally believed that A. decora is not more than a mere variety of A. grandis.

ANODONTA EDENTULA, Say. (A. undulata, Lea, et auct., but possibly not of Say; A. Pennsylvanica, Lamark, and A. areolata, Swainson.)

Dr. R. Ellsworth Call has expressed the opinion that A. edentula, Say, is peculiar to the Mississippi drainage system, and A. undulata, Say., to those waters that drain into the Atlantic, but the writer has never been able to see any tangible difference between these two shells. In a recent letter to the writer, Mr. Simpson says, "Anodonta undulata is no doubt the small form which we have here in the Potomac. Though Say gives no locality, he speaks of it as 'thin and fragile, length near half an inch; breadth seven-tenths.' The figure fairly

[1] In Canad. Nat. and Geol., Vol. VI., p. 269.

well represents our shell. This may run into A. edentula, but I have never yet been able to connect it with that. The material in Lea's collection, under the name of A. undulata, Say, is merely a form or forms of A. edentula."

Under one or the other of these names this shell has previously been recorded as having been collected in Lake Matapedia, P.Q., by Dr. R. Bell in 1857; in a small lake in the valley of the Riviere Rouge, P.Q., by W.S.M. D'Urban, in 1858; in the St. Charles River, near Quebec city, by the writer, in 1861, and at Brome Lake, P.Q., by Mr. R. J. Fowler, in 1862.

More recently, it has been collected by Dr. R. Bell in 1883, at Lake Winnipeg, between Forts Alexander and Simpson, and by Professor Macoun, in 1894, in Ontario,

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at Rondeau, on Lake Erie, and in the east and west branches of the Grand River at Galt and Ayr.

In another letter to the writer, Mr. Simpson makes the following remarks upon this species, "The so-called Anodontas of which this is the type, have more or less perfect cardinals and occasional vestiges of laterals. They group with Margaritana Elliotti, M. Spillmani, M. Raveneliana, etc. The genus Margaritana is a medley of forms, which, for the most part, are more nearly related to various groups of Unio than to each other. I believe that Margaritana should be merged into Unio, and with it the Anodontas of the edentula group."

ANODONTA FERUSSACIANA, Lea.

L'Orignal Creek, Ottawa River, Dr. R. Bell, 1855 (as A. pavonia, Lea). Ponds at the Mile End, Montreal, Dr. R. Bell, 1858, and J. F. Whiteaves, 1862.

ANODONTA FLUVIATILIS, Dillwyn. Sp. (A. cataracta, Say.)

Several specimens of this common eastern species, which has previously been recorded as occurring at many localities in the Province of Quebec and neighbourhood of Ottawa, were collected by Dr. R. Bell, in 1883, at Flying Post Route, 100 miles north-east of Michipicoten, and, in 1889, from a small lake near Proudfoot's north and south line, in the Sudbury district of Ontario. A single specimen, which may be referable to this species, was collected by Professor Macoun, in 1884, at White Fish River, north of Lake Superior.

ANODONTA FOOTIANA, Lea.

Specimens which are said to have been identified with this species by Dr. Lea were collected by Mr. W. M. S. D'Urban, in 1858, from three small lakes tributary to the Riviere Rouge, P.Q. Since then, specimens, which Mr. Simpson refers to A. Footiana, have been collected in

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Ontario, by Professor Macoun, in 1884, at White Fish River, north of Lake Superior, and at Lake Hannah, on the Nepigon River; by Dr. A. C. Lawson, in 1886, at Rainy Lake; by Mr. W. Spreadborough, in 1894, from the Muskoka River, near Georgian Bay; and in Manitoba, by Dr. R. Bell, in 1883, at Shoal Lake, Red River. Mr. Simpson also is of opinion that specimens collected by Mr. R. J. Fowler in the Lachine Canal at Montreal, in 1863, and referred by the writer to A. Lewisii, Lea, are young shells of A. Footiana.

ANODONTA FRAGILIS, Lamark (A. lacustris, Lea.)

This shell was apparently first collected in Canada by Mr. D'Urban in 1858, associated with A. Footiana, in three small lakes in the valley of the Riviere Rouge, and identified shortly afterwards by the late Dr. Isaac Lea with the A. fragilis of Lamarck. Specimens collected by Professor Macoun in 1885, from a lake six miles up the Becscie River, Anticosti, were identified with A. fragilis by Mr. F. R. Latchford, of Ottawa, and similar shells have long been known to occur at Meach's Lake, near Ottawa. Some of these Anticosti specimens were sent to Mr. Simpson, who thinks that they are essentially similar to shells labelled A. fragilis in Dr. Lea's collection, but cannot see how these latter are to be distinguished from A. lacustris, Lea, and does not pretend to be always able to separate A. fragilis from A. fluviatilis.

ANODONTA IMPLICATA, Say.

Lake Winnipeg, between Fort Alexander and Elk Island, Dr. R. Bell, 1883; and Souris River, near Roche Percée, Dr. A.R.C. Selwyn, 1890; a few specimens from each of these localities, which have been identified with this species by Mr. Simpson. It had previously been recorded as occurring in the St. Charles River, near Quebec, where it was collected by the writer in 1861.

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ANODONTA MARRYATTANA, Lea.

Lake Hannah, Nipigon River, and east side of Lake Nipigon, Ontario, Professor Macoun, 1884; and Fairford River, Manitoba, J. F. Whiteaves, 1888; as identified by Mr. Simpson.

ANODONTA NUTTALLIANA, Lea (A. Oregonensis, Lea.)

Okanagan Lake, B.C., A.J. Hill, 1882; two specimens of the variety Oregonensis. Near Victoria, V. I., James Fletcher, 1885, and Rev. G. W. Taylor, 1889. Nicola Lake, B.C., Dr. G. M. Dawson, 1889; three specimens of the typical form and one of the variety Oregonensis. Salmon Arm, Shuswap Lake, B.C., Dr. Dawson, 1894; several examples of both forms of the species. Stream entering Clayoquot Sound, V.I., at Stubbs Island, W. Spreadborough, 1894.

ANODONTA OVATA, Lea.

Coulée No. 5, Vermilion River, Alberta, J. B. Tyrrell, 1886.

ANODONTA PEPINIANA, Lea.

Specimens which Mr. Simpson refers to this species were collected by Dr. R. Bell, in 1883, from the Winnipeg River, Manitoba, and in 1886, from the Attawapishkat River, in the Severn district, which now forms the eastern part of Keewatin. Two left valves of a shell which may be referable to this species were collected by Mr. J. B. Tyrrell, in 1884, at the Lake of the Woods. Mr. Simpson is of the opinion that A. Pepiniana may be merely a variety of A. Simpsoniana, Lea.

ANODONTA SIMPSONIANA, Lea.

In Ontario this species was collected by Dr. A. R. C. Selwyn in 1883, at Black Bay, Lake Superior; by Prof. Macoun, in 1884, at the north end of Lake Nipigon, in

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1885, at Port Dover, Lake Erie, and in 1890, at Port Colborne, on the same lake.

In Manitoba, it was collected by Dr. R. Bell in 1878, at the outlet of Lake Winnipeg and from Lake Winnipeg between Fort Alexander and Elk Island. It occurs, associated with A. Marryattana, Lea, in the Fairford River, and is the only species of Anodonta that the writer was able to find in Lake Manitoba (in 1888).

In the district of Saskatchewan one perfect specimen was collected by Dr. R. Bell, in 1882, at Buffalo Lake, near Methy Portage.

Mr. Simpson, to whom the writer is indebted for the identification of specimens from most of these localities, is convinced that A. Dallasiana and A. Kennicotti, of Lea, are both synonyms of A. Simpsoniana.

ANODONTA SUBCYLINDRACEA, Lea.

Widely distributed in the provinces of Quebec and Ontario, from Lakes Metapedia and St. John to the eastward, to creeks, rivers and bays at the east end of Lake Superior and north side of Lake Erie to the westward. Mr. Simpson, however, regards A. subcylindracea as a mere synonym of A. Ferussaciana, Lea.

MARGARITANA, Schumacher, 1819.

MARGARITANA CALCEOLA, Lea. (M. deltoidea, Lea.)

Lake Erie at Fort Dover, Professor Macoun, 1890. Grand River, at Belwood, Ontario, J. Townsend, 1892. East and west branches of the Grand River at Galt and Ayr, Professor Macoun, 1894.

MARGARITANA COMPLANATA, Barnes.

Manitoba. Upper Assiniboine River, Dr. R. Bell, 1874; Souris River, Dr. A. R. C. Selwyn, 1882 and 1884; Shoal River and near Elk Island, Lake Winnipeg, Dr. R. Bell,

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1883; Swan River, J. B. Tyrrell, 1887, and Assiniboine River, J. B. Tyrrell, 1884.

Keewatin. Nelson River, Dr. R. Bell, 1878.

Saskatchewan. Shell River (township 50, range 2 and 3, west of third Initial Meridian) north of the north Saskatchewan, O. J. Klotz, 1890.

MARGARITANA MARGARITIFERA, L.

From the Province of Quebec this species has already been recorded as having been collected by Dr. R. Bell (in 1857) in the Green and Rimouski rivers, at Lake St. John and both the Metapedia Lakes, and by the writer, (in 1861) in the River St. Charles, near Quebec City. More recently it has been collected in that province by Dr. H. M. Ami, in 1883, in the Assumption River, near Rawdon; by N. J. Giroux, in 1892, at the Lac de la Ferme, Riviere du Loup, en haut, and in that river; also by A. P. Low, in 1894, in the Romaine River.

In British Columbia, small and thin but characteristic specimens were found by Dr. G. M. Dawson, in 1885, in small streams entering Malaspina Strait, on the mainland side; also, in 1890, in Kakwous Lake, the source of the Bonaparte River, at an altitude of about 4,000 feet.

MARGARITANA MARGINATA, Say.

The small and typical eastern from of this shell is common in the province of Quebec and in eastern Ontario. A few specimens of the large western variety known to students of the Unionidae as M. truncata, Say (M. S.) were collected by Professor Macoun, in 1894, at Galt and Ayr, from the east and west branches of the Grand River.

MARGARITANA RUGOSA, Barnes. (?=M. costata, Rafinesque, sp.)

This species is widely distributed in the provinces of

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Quebec and Ontario. In the latter province unusually large and thick specimens, measuring five inches and a half in length by three inches in height, were collected by Prof. Macoun, in 1894, in the east and west branches of the Grand River, at Galt and Ayr. The species has been recorded by Dr. G. M. Dawson as occurring, though rarely, in the Roseau River, Manitoba.

MARGARITANA UNDULATA, Say.

St. Lawrence River, at Montreal and Quebec, J. F. Whiteaves, 1861. Near Ottawa City, G. C. Heron, 1879.

UNIO, Philipsson, 1788.

UNIO ALATUS, Say.

Widely distributed throughout Ontario. The most easterly locality at which it has been collected is the Ottawa River at L'Orignal, as recorded by Dr. R. Bell, in the Canadian Naturalist and Geologist for June, 1859 (Vol. IV., p. 219). In Manitoba it has been collected in the Red River by Dr. G. M. Dawson, in 1873, and by T. C. Weston, in 1884.

UNIO BOREALIS, A. F. Gray.

A pair of specimens of this species, from the Ottawa River, at Duck Island, the typical locality, was presented to the museum of the Survey by Mr. F. R. Latchford, of Ottawa, in 1886.

UNIO CANADENSIS, Lea.

Two specimens, from the Ottawa River, near Ottawa, which are believed by the donor to be referable to this enigmatical species, were presented to the Museum of the Survey by Mr. Latchford, in 1893.

UNIO CIRCULUS, Lea. (?=U. subrotundus, Rafinesque.)

Lake Erie, at Kingsville, Ontario, J. Mc Queen, 1880,

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two specimens. Thames River, at Chatham (several specimens) and Detroit River, below Sandwich, Ontario (one specimen), Professor Macoun, 1894.

UNIO COCCINEUS, Lea.

Grand River, Cayuga, Ontario, Professor Macoun; one "fairly typical specimen," (C. T. Simpson).

UNIO COMPLANATUS (Solander?) Lea. (U. purpureus, Say.)

Abundant in Nova Scotia, New Brunswick, Quebec and Eastern Ontario. Collected by Dr. R. Bell, in 1859, in creeks, rivers and bays on the north shore at the east end of Lake Superior, along the entire north shore of Lake Huron, also in the St. Mary River. Lake Nipissing, Dr. A. R. C. Selwyn, 1884 (whence it had previously been recorded by Dr. Bell, in 1859). Montreal River, Lake Temiscaming, Ontario, Dr. R. Bell, 1887.

UNIO CORNUTUS, Barnes. (?=U. reflexus, Rafinesque.)

Grand River, Cayuga, Ontario, Professor Macoun, 1890; a perfect and fresh left valve.

UNIO ELEGANS, Lea. (U. truncatus as of Rafinesque.)

Thames River, at Chatham, (Ontario), Professor Macoun, 1894; one dead but perfect specimen.

UNIO ELLIPSIS, Lea. (?=U. olivarius, Rafinesque.)

Ottawa River, opposite L'Orignal, R. Bell, 1854, and near Ottawa, G. C. Heron, 1879 (as U. olivarius, Rafinesque). St. Lawrence River, at Montreal, R. Bell, 1858, and near Quebec, J. F. Whiteaves, 1861. Missisaugi River, on the north shore of Lake Huron, Dr. R. Bell, 1860. Lake Erie, at Port Colborne, and Detroit River, near Windsor, Professor Macoun, 1885.

UNIO GIBBOSUS, Barnes. (?=U. dilatatus, Rafinesque.)

This species, which has long been known to be abundant

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in the St. Lawrence and Ottawa rivers, has recently been collected by Professor Macoun in Lake Erie, at Port Colborne, in the Grand River at Cayuga, and its two branches at Galt and Ayr, also in the Detroit River, at Windsor.

UNIO GRACILIS, Barnes. (?=U. fragilis, Rafinesque.)

Collected by Professor Macoun, in 1885, from Lake Erie, at Port Colborne, and the Grand River, at Cayuga; in 1890, at Port Dover, Ontario, and in 1894, in the River Thames, at Chatham.

UNIO LACHRYMOSUS, Lea. (Probably = U. quadrulus, Rafinesque.)

In Ontario, Professor Macoun collected specimens of this species in the Grand River at Cayuga, in 1885, and in the Thames River, at Chatham, in 1894.

In Manitoba it was found to be abundant in the Red River, by Dr. G. M. Dawson, in 1873, and Professor J. Fowler has presented to the museum of the Survey a specimen, which he collected at Emerson in 1887.

UNIO LIGAMENTINUS, Lamarck.

Grand River, at Caledonia, Ontario, J. Townsend, 1885, and at Cayuga, Professor Macoun, 1890. Thames River, at Chatham, Professor Macoun, 1894. Roseau River, Manitoba, Dr. G. M. Dawson, 1873, and Assiniboine River, at Millwood, J. B. Tyrrell, 1888.

UNIO LUTEOLUS, Lamarck.

Common almost everywhere in Canada east of the Rocky Mountains, though its exact range east of Ontario is a little uncertain, owing to its close resemblance to U. radiatus. Dr. Lea, in 1862, records it as occurring in Great Slave Lake, Lake Athabasca, and near the mouth of Moose River, Hudson's Bay. In Manitoba it was collected by Mr. J. B. Tyrrell, in 1887, from the Swan River;

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in 1888, from the Assiniboine, and in 1889, from the Red Deer River. It appears to be the only Unio in Lake Manitoba, where it was collected by the writer in 1888, and from the Fairford River. In Alberta, Mr. Tyrrell collected it, in 1885, in the Blind Man, Battle and Medicine Rivers.

UNIO NASUTUS, Say.

Two fine specimens of this species, from Toronto Bay, were presented to the museum of the Survey, by Mr. Latchford, in 1886, and since then numerous specimens of it were obtained by Professor Macoun (in 1894) at Rondeau, on Lake Erie.

UNIO NOVI-EBORACI, Lea. (Perhaps = U. iris, Lea.)

Grand River, at Cayuga, Professor Macoun, 1890; one perfect specimen. Thames River, at Chatham (two specimens) and Detroit River, below Sandwich (one specimen), Professor Macoun, 1894.

UNIO PHASEOLUS, Hildreth. (?= U. fascio-laris, Rafinesque.)

Detroit River, at Windsor (one specimen) and Lake Erie, at Port Colborne (two specimens), Professor Macoun, 1885. Lake Erie, at Kingsville, Ontario (one specimen), J. T. McQueen, 1890, and Thames River, at Chatham (one specimen), Professor Macoun, 1894.

UNIO PRESSUS, Lea.

Boulder River, one of the upper branches of the Attawapishkat River, west of James Bay (in lat. 52° 30' and long. 87° 30'), Dr. R. Bell, 1886; a perfect and fresh right valve. West branch of the Grand River, at Ayr, Ontario, Professor Macoun, 1894, a slightly distorted but living shell. This species has long been known to be common in the Rideau Canal and river, near Ottawa, where it was first noticed by the late E. Billings, about the year 1856 or 1857.

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UNIO PUSTULOSUS, Lea. (?= U. bullatus, Rafinesque.)

Grand River, Caledonia, Ontario, J. Townsend, 1885; one specimen. Thames River, at Chatham, Professor Macoun, 1894; two specimens.

UNIO RADIATUS (Gmelin), Lamarck.

No new localities are to be recorded for this common eastern species, which has long been known to range from Nova Scotia to at least as far to the westward as Ottawa.

UNIO RANGIANUS, Lea. (Perhaps a var. of U. perplexus, Lea.)

Lake Erie, at Kingsville, Ontario, J. T. McQueen, 1890; one perfect specimen of the shell of the female.

UNIO RECTUS, Lamarck.

Common in the St. Lawrence and Ottawa rivers, and in western Ontario. In Manitoba, it was collected by Dr. G. M. Dawson, in 1873, from the Roseau River, and by Mr. J. B. Tyrrell, in 1888, in the Assiniboine River at Millwood.

UNIO RUBIGINOSUS, Lea. (?= U. flavus, Rafinesque.)

In Ontario this shell has been collected by

Professor Macoun, in 1890, in the Grand River at Cayuga, and in 1894, in the Thames River, at Chatham. In Manitoba, it was found by Dr. G. M. Dawson, in 1873, in the Red and Roseau Rivers, and by Dr. R. Bell, in 1883, in Lake Winnipeg, between Fort Alexander and Elk Island.

UNIO SUBROTUNDUS, Lea.

Grand River, Caledonia, J. Townsend, 1885, one specimen, which "approaches U. ebenus" (C. T. Simpson). Port Dover, Lake Erie, a specimen "which approaches U. solidus, Lea," (C. T. Simpson), and Rondeau, Lake Erie, one specimen, Professor Macoun, 1894.

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UNIO TRIANGULARIS, Barnes. (? =U. triqueter, Rafinesque.)

Collected by Professor Macoun, in 1885, at Port Colborne, Ontario, and in 1894, at Rondeau and in the Thames River at Chatham.

UNIO TRIGONUS, Lea. (? =U. undatus, Barnes.)

Port Dover, Lake Erie, Professor Macoun, 1890, two perfect but worn specimens, which were identified with this species by Mr. Simpson.

UNIO UNDULATUS, Barnes. (? =U. costatus, Rafinesque.)

Ontario. Sable River, at Thedford, Mr. Bissell, 1883, per Dr. H. Ami. Grand River, Caledonia, J. Townsend, 1885. Lake Erie, at Port Colborne, and Detroit River, at Windsor, Professor Macoun, 1885. Grand River, at Cayuga, Professor Macoun, 1890, and Thames River, at Chatham, Professor Macoun, 1894.

Manitoba. Black River, Lake Winnipeg, Dr. R. Bell, 1883, two specimens, with the umbonal regions much eroded. Emerson, Professor J. Fowler, one specimen of a small form which approaches U. plicatus (Le Sueur, MS.S.) Say.

UNIO VENTRICOSUS, Barnes. (U. occidens, Lea, female, and U. subovatus, Lea, male: ?=U. cardium, Rafinesque.)

Common in the St. Lawrence and Ottawa rivers and throughout Ontario. In Manitoba it has been collected in the Red and Roseau Rivers by Dr. G. M. Dawson, in 1873, and at Lake Winnipeg, between Fort Alexander and Elk Island, by Dr. R. Bell, in 1883.

OTTAWA, November 30th, 1894.

"ADDITIONAL NOTES ON RECENT CANADIAN UNIONIDAE."
(From the Canadian Record of Science, vol. 6, No. 6, pp. 365-366, 1895).

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UNIO CANADENSIS, Lea.

In a letter to the writer, dated June 18th, 1895, Mr. Simpson says, "I think there can be little doubt, from examining the type of U. Canadensis, that it is a somewhat injured specimen of the male of U. ventricosus, Barnes.

Mr. Bryant Walker, of Detroit, informs the writer that he has, in his cabinet, specimens of each of the following species, from the Detroit River:

MARGARITANA HILDRETHIANA, Lea.

Main channel of the Detroit River off Belle Isle, collected by the Michigan Fish Commission in 1895.

UNIO LEIBII, Lea.

Detroit River, at the upper end of Fighting Island, collected by Mr. Walker in 1873 or 1874, and identified by the late Dr. James Lewis.

UNIO MULTIRADIATUS, Lea.

Same locality, collector and date as for the preceding species; also, Thames River, Ontario, from the collection of the late Dr. George A. Lathrop.

UNIO SULCATUS, Lea. (=U. perplexus, var. perobliquus, Conrad. Types from the Detroit River, and Wabash R., Indiana.)

Collected by Mr. Walker in the Detroit River at the upper end of Fighting Island, in 1873 or 1874; at the

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upper end of Belle Isle in 1894; and in the same river, at the locality first mentioned, by the Michigan Fish Commission, in 1895.

UNIO VERRUCOSUS, Barnes.

Main channel of the Detroit River off Belle Isle, collected by the Michigan Fish Commission in 1895, and Detroit River opposite Grassy Island, collected by Mr. Walker in 1895.

Mr. Walker also states that he has, in his collection, twenty-six species of Unionidae from the Detroit River and Lake St. Clair, viz., Anodonta Benedictii, A Footiana, A. fragilis and A. subcylindracea; Margaritana deltoidea, M. Hildrethiana, M. marginata, and M rugosa; Unio alatus, U. circulus, U. coccineus, U. ellipsis, U. gibbosus, U. gracilis, U. Leibii, U. luteolus U. multiradiatus, U. nasutus, N. Uovi-Eboraci, U. phaseolus, U. pressus, U. Rangianus, U. rectus, U. triangularis, U. ventricosus and U. verrucosus.

OTTAWA, July 9th, 1895.

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NAUTILUS

VOLUMES 3-75 AND ITS PREDECESSOR THE

CONCHOLOGISTS' EXCHANGE

VOLUMES 1 AND 2

COMPILED BY

AURÈLE LA ROCQUE

COLUMBUS, OHIO
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