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I. ON AN INCREASE IN THE NAIAD FAUNA OF SAGINAW BAY, MICHIGAN

II. THE NAIAD SPECIES OF THE GREAT LAKES

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I.

NINE species of Naiades were found by Dr. H. B. Baker to inhabit Saginaw Bay in the vicinity of Sand Point, Huron County, Michigan, when he made his study of the molluscan fauna of the region in 1908. The survey was a very thorough one and several weeks were devoted to the work.

Twenty-three years later, a much more perfunctory survey was made by the writers of this paper in the same locality, their visits to Sand Point being more in the nature of holidays than for collecting purposes. Yet their findings amounted to thirteen species in contrast to Baker's nine. Moreover, they are enabled to report that five of the nine species of the Baker list proved to be more abundant in 1931 than they were in 1908.

Such an increase in mollusca appears to be unusual in American species. The writers are unable to find in the literature of the subject any mention of anything quite like it. Instances have occurred where an introduced species, *Bythinia tentaculata* (Linnaeus), for example, has developed such a fecundity as to be a pest (F. C. Baker, 1902; Sterki, 1910). A

circumboreal land snail, *Vallonia pulchella* (Müller), is known to have developed exceedingly large colonies that probably were larger than those which existed before the transplantation of European agriculture on this continent (G. H. Clapp, 1897; Sterki, 1910). The increase of Naiades in Saginaw Bay has been entirely among species peculiar to the United States and common to the Great Lakes area. It has occurred in a period of widening industrialism in the drainage basin and of a multiplication of summer cottage residence along the shores—social alterations that might be expected to be inimical to such shallow water life as that of fresh-water clams. In the absence of detailed information upon limnological conditions in Saginaw Bay, either for 1908 or 1931, explanations for the increase must be speculative to a degree. So it is with some diffidence that the following hypothesis for it is advanced.

Saginaw Bay resembles in a number of ways the southwestern end of Lake Erie where Naiades are more abundant, both in species and individuals, than in any other place in the Great Lakes. Both localities have broad areas of shallows, many of which are exposed above water level during westerly winds. The bottom in each place is made up of sand and fine gravel. In the two regions are marshes that border the shores or occur immediately behind lake beaches, their surplus waters discharging through lagoons or slow-moving creeks. Corresponding to the Maumee River of Lake Erie is the Saginaw River of Saginaw Bay, each stream receiving pollution from domestic sources that necessarily increases the nitrogen content of the water.

At the Cleveland meeting of the American Association for the Advancement of Science in December, 1930, Dr. Stillman Wright, of the United States Bureau of Fisheries, read a paper entitled "A Limnological Study of Western Lake Erie." He showed that while such pollution-free water as that four miles east of Kelley's Island had a mean phytoplankton count of 94,000 per liter, June to October, 1929, the water two miles east of the Monroe Light had a count of 210,000. At

the outer end of the ship channel of Maumee Bay the count reached 508,000 per liter. It is this shallow area, Maumee Bay to Monroe, that constitutes the great breeding ground for clams. It is an area into which is poured the wastes of the Toledo section and, to a lesser amount, those of Monroe. Since phytoplankton is the food of Naiades we have at least one sound explanation for the numbers of these bivalves there. Remembering the likeness of the Saginaw Bay region to western Lake Erie, including the sources of domestic pollution, it seems plausible to account for the increase of Naiades in these waters as owing to betterments in their food conditions.

Species of the Baker List

Lampsilis ventricosa canadensis (Lea)

Baker found this mollusk to be "very abundant all along the unprotected north shore of Sand Point," and less so upon the protected south shore. The species still remains plentiful. A northeast storm in June, 1931, caused a great number of individuals to be thrown on the beaches. Some survived for a few days in pools that formed behind the sand barriers that had been made by the waves. They perished after the pools dried up even though they dug into the wet sand for a few inches. Baker gives measurements of 75 mm. length, 53 mm. height, and 39 mm. breadth for the largest male he found; 70 mm. length, 49 mm. height, and 42 mm. breadth for the largest female. Our own largest male specimen was 81.20 mm. by 48.70 mm. by 33.70 mm., and the largest female, 86 mm. by 48.10 mm. by 34.30 mm. These large examples were found at the extreme end of Sand Point where also the rarer species were in greatest number. For comparison, these measurements are given for the largest individual the Museum of Zoology has from Lake Erie: Length 86 mm., height 49 mm., and breadth 33 mm.

Lampsilis siliquoidea (Barnes)

Baker reports this to be the "most abundant, widely distributed and variable unione in the region studied." The

statement holds true for the observations of 1931. The numbers of shells of the species that are to be seen on the beaches after storms, in heaps where they have been left by muskrats and minks and in windrows that were probably caused by the "ice-push" are, indeed, astonishing. The wide distribution of the species in the United States from western New York to the Rocky Mountains seems to be correlated with the abundance of members that nearly every colony contains.

Ligumia recta (Lamarck)

One specimen was taken by Baker in shallow water off Sand Point. It measured 87 mm. length, 37 mm. height, and 20 mm. breadth. Twenty-six were brought away in 1931, nearly all being "dead" specimens from the tip of the Point. The largest was 118 mm. by 41.50 mm. by 25.20 mm. This was a female. The largest male had measurements of 104.50 mm. by 34.60 mm. by 20 mm. Shells of this species from the Great Lakes were long known as variety *sageri* Conrad, but Ortmann (1913) called attention to the fact that Lamarck's specimens came from Lake Erie and that for stream forms the varietal name *latissima* Rafinesque was available. It is usually assumed that the lake form is invariably smaller than stream forms and always has a bluish white nacre. The Sand Point shells are not smaller than the average river shell. Of the twenty-six specimens taken in 1931, fourteen had the purple nacre associated with the stream subspecies. It is clear that the demarcation between *recta* and subspecies *latissima* is not so sharply defined as has been supposed. The largest Lake Erie specimen that is available for measurement has 97 mm. length, 36.5 mm. height, and 20 mm. breadth.

Ligumia nasuta (Say)

Found "abundantly" by Baker. Few living specimens were collected in 1931, but "dead" shells were common on Sand Point beaches, particularly along the line of what is probably the limit of the "ice-push." A few were in the muskrat heaps. Baker gives measurements of 66 mm. length,

31 mm. height, and 18 mm. breadth for a "large specimen," presumably the largest taken. The largest of the 1931 catch was 67.60 mm. by 21.50 mm. by 11.70 mm.

Strophitus rugosus (Swainson)

Baker reports that "a single shell of this species was found in about four feet of water off the south, protected shore of Sand Point." Eleven were collected in 1931 from the north and south sides of the Point, about half of them living. Baker's specimen, having a length of 83.5 mm., was more than twice as large as any taken in 1931, though all of the latter appear to be adults. Ortmann (1919) spoke of the dwarfed forms of this species that occur in the Great Lakes, but he did not think it advisable to give them a varietal name. Considering the large size of Baker's specimen, taken in much the same kind of habitat as the small ones of 1931, dwarfing does not appear to have become a fixed or racial characteristic. The species shows a great variation in the matter of size in inland waters of Michigan.

Anodonta grandis footiana (Lea)

The 1908 findings of this species amounted to only three specimens. Those seen in 1931 were not counted, but the numbers of individuals ranked next to those of *Lampsilis ventricosa canadensis*. They were common on both shores of the Point and southwestwardly along the Bay as far as Sebewaing. The largest of the 1931 collection was 97 mm. length, 46.60 mm. height, and 27.40 breadth, comparing with Baker's largest example of 85 mm. by 44 mm. by 33 mm. Several of the oldest specimens were straight along the basal margin and a few were even arcuate. To judge by material in the Museum of Zoology, this variation is rare.

Anodontoides ferussacianus buchanensis (Lea)

This is the name that is employed by Ortmann for a small, thin, light green shell of the Great Lakes. It is, no doubt, the form that Baker termed *subcylindraceous*. He found one shell only on the north side of Sand Point, but many "in the

lower portion of Pigeon River and in an oxbow pond off of it." "Dead" shells were very common at the east end of Sand Point in 1931 where, apparently a few years back, a shallow pond had existed, draining off through the sand as the lake levels fell. It seems probable that this habitat had approximated that of the oxbow pond observed by Baker, and had permitted the existence of a large colony.

Alasmidonta calceolus (Lea)

Baker collected one specimen in a beach pool on Little Oak Point, to the east of Sand Point. One was found alive on the north side of Sand Point in 1931. The species is common mostly to small streams and to rivers at the stage of creeks. Its occurrence in Saginaw Bay and in Lake Erie, in both instances rare, possibly indicates that the fish which serves as the host of *calceolus,* glochidia enters the Great Lakes only in few numbers and at great intervals.

Elliptio dilatatus sterkii Grier

About twenty specimens were taken in 1931 as against the two of Baker's 1908 catch. It is the short, thick, swollen form for which Grier provided a subspecific designation in 1918. It appears to be confined to the Great Lakes with the exception of Lake Winnebago, Wisconsin, where it was collected by Frank Collins Baker.

Species Taken in Saginaw Bay in 1931, But Not There in 1908

Fusconaia flava parvula Grier

Baker reports the finding of a single specimen of *Quadrula rubiginosa* (Lea), recognized now as *Fusconaia flava* (Rafinesque), in the lower part of Pigeon River. No example of the lake form, *parvula,* was seen by him. Judging offhand by the material collected and seen at Sand Point in 1931, this Naiad has become nearly as common to Saginaw Bay as it is to Lake Erie, where it is abundant. Forty-five examples were

brought away and a great many more than these were observed that were not taken.

Proptera alata (Say)

Three "dead" specimens were found in 1931 at the extreme east end of Sand Point. The two largest measure:

Length	Height	Breadth
97.0 mm.	46.0 mm.	34.0 mm.
84.0	48.0	22.5

The Great Lakes forms are usually more swollen than the forms of the rivers; the Saginaw Bay shells are proportionally more swollen than Lake Erie specimens. All three of them are probably females.

Lasmigona complanata katherinae (Lea)

Twelve specimens were found in 1931, two of which contained the soft parts. The typical *complanata* occurs in Cass River, one of the two main rivers which make up the Saginaw River. The subspecies *katherinae* is common at the mouth of Saginaw River. It has been thought that colonies in the bay were confined to a fairly small area near this mouth. The findings of 1931 show plainly that migration is occurring and that the subspecies, though in small numbers, is established sixty to eighty miles east of its former limits. One of the living specimens was taken at the base of Sand Point on the north side, thus removing any suspicion or thought that the shells may have been washed northward and eastward by the general movement of the bay waters. *Katherinae* was described as from Lake Superior, but it seems likely that the specimens that reached Lea's hands were from waters tributary to Lake Superior rather than from the lake itself. The largest Sand Point specimen measures: 84 mm. length, 51 mm. height, and 20 mm. breadth.

Dysnomia triquetra (Rafinesque)

A single valve was found on the mud flats at Sebewaing and might possibly have come from Sebewaing River, a half

mile east. Yet the species is not uncommon in the west end of Lake Erie, and there is probably no good reason why it should not prosper in Saginaw Bay.

II.

Naiad Species of the Great Lakes

In preparing this paper, the writers found it convenient to compile a list of the Naiades that are known to occur in the Great Lakes. So far as they are aware, there is no other such list, and they have added it to the account of the Saginaw Bay fauna in the hope that it will be useful to others as it has been to themselves.

Lake Superior

Elliptio complanatus (Dillwyn)
Anodonta grandis footiana (Lea)
Anodonta kennicottii Lea
Lasmigona complanata katherinae (Lea)
Lampsilis siliquoidea (Barnes)
Lampsilis superiorensis (Marsh)

While the Museum of Zoology has many specimens of *E. complanatus* that were taken in streams or lakes in the drainage of Lake Superior, it has none that are credited to the lake itself. F. C. Baker (1928) says that it has "recently been found in the western part of Lake Superior" and names Duluth as a locality on the authority of Walker. We are unable to find the Walker reference. The *Unio radiata* Gmelin that is mentioned in Agassiz's "Lake Superior" is probably an error for *L. siliquoidea*. *L. superiorensis* was described as from Michipicoton River, Ontario, but a specimen in the Museum of Zoology is labeled Lake Superior. It seems likely that "Lake Superior region" is meant. This seems also to be the case with *Lasmigona complanata katherinae*.

Lake Huron

Amblema costata plicata (Say)
Fusconaia flava parvula Grier

Elliptio complanatus (Dillwyn)
Elliptio dilatatus sterkii Grier
Strophitus rugosus (Swainson)
Anodonta grandis Say
Anodonta grandis footiana (Lea)
Anodontoides ferussacianus (Lea)
Anodontoides ferussacianus buchanensis (Lea)
Lasmigona complanata katherinae (Lea)
Alasmidonta calceolus (Lea)
Proptera alata (Say)
Ligumia nasuta (Say)
Ligumia recta (Lamarck)
Lampsilis siliquoidea (Barnes)
Lampsilis ventricosa canadensis (Lea)
Dysnomia triquetra (Rafinesque)

The *Amblema* was taken at Harbor Beach, Huron County, Michigan. *E. complanatus* in Lake Huron is confined to Georgian Bay. Robertson (1915) speaks of finding typical *A. grandis* in these same waters. His figure of *A. ferussacianus* corresponds with the subspecies *buchanensis* of Saginaw Bay, but the specific name is included here because of a typical specimen that was taken in Saginaw Bay at Sebewaing.

LAKE MICHIGAN

Alasmidonta calceolus magnalacustris F. C. Baker
Anodonta grandis footiana (Lea)
Anodonta marginata Say
Anodontoides birgei F. C. Baker
Anodontoides ferussacianus buchanensis (Lea)
Lampsilis siliquoidea (Barnes)
Lampsilis ventricosa canadensis (Lea)
Ligumia fasciola (Rafinesque)
Truncilla truncata (Rafinesque)
Utterbackia imbecillis fusca F. C. Baker

The records for F. C. Baker's species and subspecies are taken from his "Fresh Water Mollusca of Wisconsin" (1928); those for *L. fasciola* and *T. truncata* from his "Mollusca of the

Chicago Area'' (1898). Specimens of *A. ferussacianus buchanensis* that are in the Museum of Zoology from Escanaba agree with Ortmann's identification of the subspecies and may be identical with Baker's *A. birgei.*

LAKE ST. CLAIR

Alasmidonta calceolus (Lea)
Amblema costata plicata (Say)
Anodonta grandis footiana (Lea)
Anodontoides ferussacianus buchanensis (Lea)
Dysnomia triquetra (Rafinesque)
Elliptio dilatatus sterkii Grier
Fusconaia flava parvula Grier
Lampsilis siliquoidea (Barnes)
Lampsilis ventricosa canadensis (Lea)
Lasmigona costata eriganensis Grier
Leptodea fragilis (Rafinesque)
Ligumia nasuta (Say)
Ligumia recta (Lamarck)
Micromya iris (Lea)
Obovaria leibii (Lea)
Obovaria olivaria (Rafinesque)
Pleurobema cordatum pauperculum (Conrad)
Proptera alata (Say)
Ptychobranchus fasciolare (Rafinesque)
Truncilla truncata (Rafinesque)

This list is made up in part from material in the Museum of Zoology, partly from a catalogue in Reighard (1894), and to some extent from collections by one of the writers of this paper. A specimen of *A. costata plicata* that was taken in 1931 at New Baltimore measured 109 mm. length, 65 mm. height, and 45 mm. breadth. Save that it is longer in proportion to height than specimens of *A. peruviana* (Lamarck) from the mouth of Grand River, Michigan, the two forms appear to be identical. For comparison, measurements of *plicata,* the largest at hand, are given:

	Length	Height	Breadth
Detroit River, Stony Island	96.0 mm.	63.0 mm.	46.0 mm.
Lake Erie, Monroe Co., Mich.	74.5	46.0	32.0

The record for *O. olivaria* is based upon a single living specimen that was taken in Anchor Bay in 1893. The species could not be found there in 1931. *Strophitus rugosus* (Swainson) is doubtless in Lake St. Clair though, so far, it has not been observed there.

LAKE ERIE

Alasmidonta calceolus (Lea)
Alasmidonta marginata (Say)
Amblema costata plicata (Say)
Anodonta grandis benedictensis (Lea)
Anodonta grandis footiana (Lea)
Anodonta imbecillis Say
Anodonta marginata Say
Anodontoides ferussacianus buchanensis (Lea)
Carunculina parva (Barnes)
Cyclonaias tuberculata (Rafinesque)
Dysnomia rangiana (Lea)
Dysnomia sulcata delicata (Simpson)
Dysnomia triquetra (Rafinesque)
Elliptio dilatatus sterkii Grier
Fusconaia flava parvula Grier
Fusconaia subrotunda (Lea)
Fusconaia undata (Barnes) ?
Lampsilis siliquoidea (Barnes)
Lampsilis ventricosa canadensis (Lea)
Lasmigona compressa (Lea)
Lasmigona costata eriganensis Grier
Leptodea fragilis (Rafinesque)
Ligumia fasciola (Rafinesque)
Ligumia nasuta (Say)
Ligumia recta (Lamarck)

Micromya fabalis (Lea)
Micromya iris (Lea)
Obliquaria reflexa (Rafinesque)
Obovaria leibii (Lea)
Obovaria olivaria (Rafinesque)
Pleurobema cordatum pauperculum (Conrad)
Proptera alata (Say)
Proptera leptodon (Rafinesque)
Ptychobranchus fasciolare (Rafinesque)
Quadrula pustulosa prasina (Conrad)
Quadrula quadrula (Rafinesque)
Simpsoniconcha ambigua (Say)
Strophitus rugosus (Swainson)
Truncilla donaciformis (Lea)
Truncilla truncata (Rafinesque)

These forty species and subspecies are those given by Walker (1913) as belonging to Lake Erie, including the Detroit River. The following are of the river rather than of the lake:

Alasmidonta marginata
Anodonta grandis benedictensis
Dysnomia rangiana
Dysnomia sulcata delicata
Fusconaia subrotunda
Fusconaia undata
Lasmigona compressa
Micromya fabalis
Obovaria olivaria
Proptera leptodon

The Jay *Catalogue of Recent Shells,* edition of 1852, mentions *Margaritana margaritifera* (Linnaeus) as from Lake Erie. This is an error. Letson (1909) gives *Lampsilis ligamentinus* (now *Actinonaias carinata* Barnes), *L. anodontoides* (Lea), and *Symphynota viridis* Conrad (*Lasmigona subviridus* Conrad) as occurring in Niagara River, and (1905) *Quadrula solida* (*Pleurobema catillus* Conrad) as a fossil of Post-Pliocene deposits of Goat Island. *A. carinata* is common in Lake Erie tributaries, but has not been seen in lake waters proper. The citation of *L. anodontoides* is doubtless a mistake, as the species does not inhabit the St. Lawrence drainage basin.

LAKE ONTARIO

Anodonta cataracta Say
Anodonta grandis footiana (Lea)
Anodonta marginata Say
Elliptio complanatus (Dillwyn)
Lampsilis radiata (Gmelin)
Lampsilis siliquoidea (Barnes)

DeKay (1843) ascribes *Anodonta plana* Lea to this lake. The form is now known as *A. grandis gigantea* (Lea), for which *A. grandis footiana* was probably mistaken by DeKay. *A. cataracta* is mentioned as a Lake Ontario shell by Ortmann (1919). *L. radiata* is in Miss Letson's list of 1909.

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