PECTINATELLA MAGNIFICA LEIDY AN OCCASIONAL RIVER-PEST IN IOWA

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I

The common fresh-water Bryozoan, *Pectinatella magnifica* Leidy, with which this paper deals, is widely distributed in the United States, Northern Germany, and Czechoslovakia. First described from Pennsylvania in 1851, it has since been listed from New England, the Middle States, Ohio, Indiana, Illinois, Michigan, Wisconsin, southern Canada, and Florida. Competent students also report[1] its occurrence in abundance in northwestern Alabama, central and western Kentucky, southern Louisiana, northeastern Mississippi, Missouri, North and South Carolina, Tennessee, Texas, and West Virginia. It has also been found in quiet bayous of the Mississippi River from near its head in Minnesota to Cairo, Illinois; and beyond doubt continues to the mouth of the river. It is often found in considerable abundance; and doubtless is to be found generally distributed with other species of fresh-water Bryozoa in bodies of fresh water in North America, from the Gulf of Mexico into Canada; and from the Atlantic seaboard to the Great Plains. Because many teachers of zoology, even in college positions, are apparently not familiar with *Pectinatella,* or have never "fished" for it, its distribution is not known with exactness. The range given, wider than the published records and museum specimens would indicate, is based upon numerous reports received, sometimes accompanied by photographs, specimens, or statoblasts, from zoologists in all parts of the country.

In the present writer's experience, he first encountered *Pectinatella magnifica* in ox-bow lakes, former bayous of the Missouri River, northwest of St. Louis, Missouri, in the years 1922-24. Previously (1911-17) he had collected Bryo-

[1]Geiser, S. W. (1934), "The distribution of *Pectinatella magnifica* Leidy in the United States". *Field & Laboratory* 2:56-59.

zoa systematically in the Wapsipinicon River at Independence, in northeastern Iowa. There, *Pectinatella* was never encountered, although the genera *Plumatella, Fredericella,* and *Cristatella* were found abundantly on water plants (*Typha, Sparganium, Potamogeton, Castalia,* and *Nymphaea*)[2] as well as on the bottom of boats, submerged roots and branches, the shells of fresh-water mussels, and stones. The writer left Independence in 1917, and except for brief summer visits, made no further studies on the Bryozoa of that region until the summer of 1928.

II

In the year 1928, and without any known previous record in that locality,[3] *Pectinatella* appeared quite suddenly in the mill-pond of the Wapsipinicon River at Independence (a pond not far from 200 acres in extent). All during that summer, boatmen and fishermen noted the remarkable growth of jelly-colonies upon the bottoms of boats, in such masses as greatly to impede movement,[4] and the abundance of colonies on brush and water-plants, especially in an extensive shallow slough, "Morse's Slough", in Section 28, Washington Township, above Independence. In late July and early August, colonies of this bryozoan "from the size of an egg to the size of a dishpan" began to float down the river, particularly after the heavy rains of July 18-20, and August 3-4. Much newspaper publicity of the epidemic ensued, because of the clogging of the grates at the water-intake of the hydroelectric plant at the dam. During the first three weeks of August, large quantities of *Pectinatella,* loosened by the high water consequent upon heavy rains throughout the upper Wapsipinicon drainage basin, continued to float down the river. Many of the colonies were of large size. Several independent observers asserted at the time that colonies twenty-four inches in diameter were not

[2]Identification of that time as recorded in field-notes.

[3]My own notes dealing specifically with Bryozoa of Independence show no *Pectinatella* in the mill-pond from 1911 to 1917. Nearly all local fishermen deny that the species occurred there before 1928. The manager of the flourmill, Mr. Tom Potts, tells me that the species occurred very sparingly in the millpond in 1927.

[4]Reported by a former student, Paul G. Miller, and Henry Primus.

rare, although the average colony had a diameter of from six to eight inches.[5]

This unprecedented and wholly unexpected epidemic of Bryozoa was a source of grave concern to the city of Independence, the water-supply of which is taken from wells situated near the river. Correspondence was had with the State Hygienic Laboratory at Iowa City, and with the Iowa State Board of Health, which sent its assistant sanitary engineer to make an investigation. He found the "weeds and rushes along the river and in the sloughs" laden with the *Pectinatella* growth.

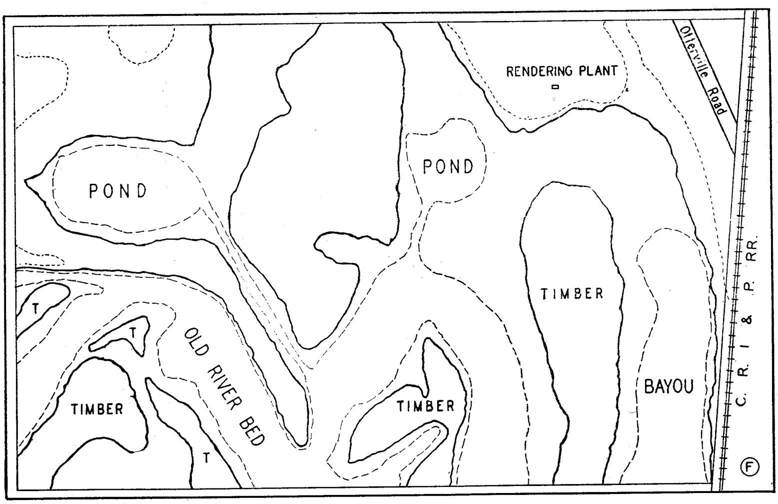

Fig. 1. Contour map of 40 acres of "Morse's Slough" in Section 26, Washington Township, Buchanan County, Iowa. The even line (datum) shows the water-level at the dam height; the broken line shows the —1-foot contour, and the dotted line the +3-foot contour. This slough was notably infested with *Pectinatella,* which may have been in part owing to the effluent from the rendering plant on the higher ground near the Otterville Road. Note also the large area of slough bottom exposed when the water-level in the mill-pond falls only one foot. (Map data courtesy of the Clerk of the District Court, Buchanan County, Iowa.)

On August 26-27, 1928, a record rainfall of 3.04 inches in twenty-four hours fell at Independence; and similar precipitation occurred in the upper drainage basin. This

[5]Newspaper accounts in the Independence *Conservative* (August 8 and 22, 1928), and the Independence *Bulletin-Journal* (August 9, 16, 23, 30, and October 11, 1928).

raised the Wapsipinicon to flood-height, with an elevation of the stage of the river of many feet. As a result, myriads of colonies of *Pectinatella,* still in the sloughs and bayous, were lifted and carried down stream.

The mill-pond of the river at Independence is closed by a concrete dam 223 feet in length, built about 1907. A hydroelectric plant with an iron-grated intake 42 feet long, and set ten inches below the crest of the flash-boards on the dam, stands at the east end of the dam. On August 24-25, following rains on August 18-19 (1.36 inches) and August 23 (1.10 inches), so much *Pectinatella* floated down the river that it was necessary to keep men constantly at the grates of the intake to clear them from floating masses of this Bryozoan.

The abundance of floating *Pectinatella* continued until the high-water which followed the deluge of August 26-27 had subsided. After this subsidence, the sloughs of the mill-pond were found to be cleared of most of the *Pectinatella,* at least as far as the larger colonies were concerned. In small overflow-pools below the dam, the writer shortly after the water-recession found numerous *Pectinatella* colonies, small flood-pools a few feet across having, in some cases, four or five six- to ten-inch disintegrating colonies.

It is hardly possible to calculate, except in a very broad way, the mass of *Pectinatella* originally present in the mill-pond from the mass that gathered on the hydro-electric plant intake. This latter mass must have been a very minute fraction of that which passed over the dam, for the intake was from forty to fifty feet upstream from the dam-crest, and, after the "going out" of the flashboards at the beginning of high-water, had a level only approximately equal to the dam-level. Consequently, the colonies would not be "skimmed into the intake-sluice." The great mass of the colonies must have passed over the dam, 223 feet long; and the total mass passed out of the mill-pond during the months of July and August, 1928 (the rainfall for the month of August was 294.4 percent. of normal) must have amounted to scores of thousands of tons. This from a mill-pond whose area is not far from two hundred acres.

III

No evidences are at hand to show in what manner these Bryozoa came into the region. Whether the reproductive bodies, or statoblasts, starting the epidemic arrived on the feet of birds[6], or were carried undigested in the gut of fishes or aquatic birds,[7] or were distributed in a desiccated condition, in dust-storms, are questions still unanswered. It is highly probable that *Pectinatella* was present (although inconspicuous) in the Wapsipinicon River during the years preceding the remarkably exaggerated infection of 1928. From what we know of the biology of *Pectinatella,* this maximal infection may have been owing to one or more of the following factors:

(1) Low water stages in the summer of 1927 might effect a higher degree of germination of statoblasts and hence a greatly increased population of *Pectinatella* in the subsequent year, by permitting a high degree of lodgement of the statoblasts.

(2) Deficient rainfall and low water stages in the fall might prevent a washing away of the statoblasts, thereby increasing the number of individuals forming colonies next year.

(3) An excessively warm autumn in 1927 might facilitate germination of the statoblasts that very fall, and ensure a heavy infestation of the mill-pond the following year. Or a warm, very early spring might cause early germination and fixation of the Bryozoa, with a consequent minimal loss of statoblasts from the pond during April "rises".

(4) Freezing and desiccation of the statoblasts might increase the percentage of germination of the statoblasts.

(5) An excess of food suitable to nutrition of Bryozoa would greatly increase the abundance of Pectinatella in the locality.

Some of these suggested causes of the epidemic appear valid in the face of actual situations met with. Thus, in regard to the part that low water may have played in conserving the statoblasts, the records of the U. S. Weather Bureau observer at Independence show pertinent facts. The Wapsipinicon River showed low stages from August, 1927 to February, 1928, in spite of the more than normal rainfall in September and October, 1927 (v. Table, p. 70). This was due to the excessive dryness of the summer months. Although for the past ten years water for power is not used when the river is at low stage, and an attempt is made to keep the mill-pond level constant; nevertheless, the stage of the river tends to fluctuate a foot or more in times of severe

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[6]Darwin, Charles (1872), *The Origin of Species,* 6th edition, chap. xiii.

[7]Zacharias, O. (1888), "Ueber die Verbreitung niederer Wassertiere durch Schwimmvoegel", *Biol. Centrbl.* 8:368.

WEATHER AT INDEPENDENCE, IOWA
January, 1927-August, 1928

Year and Month	Monthly Temperature Departure	Mean Temperatures Maximum	Mean Temperatures Minimum	(Percentage of Rainfall Normal)
1927, January	+ 2.7°	28.2°	11.1°	29. %
February	+10.1°	40.5°	22.1°	20. %
March	+ 5.9°	50.4°	29.7°	69. %
April	— 0.1°	58.6°	38.8°	122.8%
May	— 2.0°	68.5°	46.6°	212.4%
June	— 2.3°	76.3°	55.8°	31.1%
July	— 1.0°	84.2°	59.7°	101.9%
August	— 5.1°	78.3°	54.0°	76.3%
September	+ 2.7°	77.9°	55.3°	134.9%
October	+ 3.7°	68.2°	43.5°	147.2%
November	+ 0.6°	46.0°	28.2°	109.0%
December	— 4.2°	29.7°	9.2°	42.0%
1928, January	+ 7.2°	33.3°	14.9°	31.6%
February	+ 6.8°	36.7°	19.4°	220.0%
March	+ 3.5°	48.1°	27.0°	94.1%
April	— 5.1°	56.0°	31.3°	56.5%
May	+ 2.5°	75.9°	48.3°	54.1%
June	— 4.7°	75.2°	52.4°	94.3%
July	— 0.4°	83.2°	62.1°	93.4%
August	— 0.2°	82.1°	60.1°	294.4%

drought. During some summers, when the river is a foot or more below dam level, an extensive portion of bottom, perhaps as much as sixty acres, is exposed to sun and wind, so shallow is a considerable portion of the mill-pond. Much of this exposed bottom is area in which *Pectinatella* grows most abundantly. Colonies thus exposed desiccate, and the statoblasts lodge in the mud or upon the stems of bottom plants. The extensive experimental observations of Brown[8] would make it appear doubtful whether such desiccated statoblasts could later germinate; although Brooks[9] earlier, and somewhat less extensive experiments tended to show only progressive retardation of hatching with increasing desiccation.

During this period of low water (July, 1927 to February, 1928) such colonies of *Pectinatella* as were present undoubtedly underwent desiccation in considerable numbers; and, during the winter, a degree of freezing. Braem's[10] investigations of freshwater Bryozoa convinced him that

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[8]Brown, C. J. D. (1933), "A limnological study of certain fresh-water Polyzoa, with special reference to their statoblasts", *Trans. Amer. Micr. Soc.*, 52:271-316.

[9]Brooks, C. M. (1929), "Notes on the statoblasts and polypids of *Pectinatella magnifica*", *Proc. Acad. Nat. Sci. Phila.*, 81:427-41.

[10]Braem, F. (1890), "Untersuchungen ueber die Bryozoen des suessen Wassers. Die Bryozoen-Fauna der Province Preussen", *Bibliotheca Zoologica* 2^6:66ff.

freezing increased the germination-percentage of statoblasts; but Brown's experimental results showed no change in this respect. The author's field data offer no evidence of decisive value in regard to Braem's contention. It is of interest to note, however, that the month of December, 1927, was the most severe for many years in the state of Iowa. In fact, the years 1927 and 1928 were marked by anomalous weather in many respects, and drought, rainfall, heat and cold, and unseasonable weather followed upon each other in extremes.

If prolonged warm weather in the fall causes statoblasts to germinate and fixate (as has been suggested by one or two writers) this may help to explain the epidemic. The fall of 1927 at Independence established a record for warm weather and ample sunshine. The last half of October, 1927, was "one of the most remarkable periods of so-called 'Indian Summer' that ever prevailed over the state. . . the sunshine was 100 per cent of the possible amount for two weeks from the 14th to the 27th, inclusive".[11] The first twenty days of November were slightly below normal in temperature, but the remaining days of the month were unseasonably warm. Our field conditions, both as concerns the warm fall weather, and the epidemic the following summer, might be interpreted as tending to establish a positive relation between prolonged warm weather in the fall and maximum statoblast-germination.

After a severe December, the year 1928 opened with mild weather. From the sixth to the fifteenth of January, the weather was unusually warm: the mean monthly temperature of January was 7.2 degrees above normal. February also was mild, with a mean temperature 6.8 degrees above normal. March was mild, with almost unprecedentedly warm weather from the twentieth to the twenty-sixth of the month. If germination of the statoblasts is facilitated by warm spring weather, before the spring floods drive them out of the river channel, then it would appear that this factor might help explain the remarkable abundance of this Bryozoan in the summer of 1928.

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[11]U. S. Department of Agriculture, *Climatological Data* (Iowa Section) 83:73, (October, 1927).

Food appears of primary importance, however, in explaining the rapid extension and growth of *Pectinatella* at Independence. During 1928, the writer observed in the sloughs infested with *Pectinatella* an unusually abundant growth of *Chlorophyceae* and diatoms, the natural food of the Bryozoa. This growth was especially abundant in "Morse's Slough"—a body of shallow water quickly heated in the summer. The water of this slough was contaminated to a very considerable degree by the effluent of an offal-rendering plant erected at the north end of the slough in the spring and summer of 1927 (see Fig. 1, p. 67). The water of this slough was a light pea-green, through abundance of *Chlorophyceae*. When a sample was held to the light, the minute organisms (chiefly *Pediastrum, Scenedesmus, Stephanodiscus,* and *Amphora* in great abundance),[12] were readily apparent. Kofoid's[13] finding, in his study of the Illinois River, that prolonged low water and higher temperatures in the later autumn increase the *Chlorophyceae* plankton—*Pediastrum, Scenedesmus, Coelastrum,* and *Botryococcus*—agrees with our own experience. And Whipple[14] has noted the importance of nitrogen in the development of diatoms in reservoir waters. Our observation that shallowness of water and ample nitrogen produce excessive food suitable for the excessive multiplication of *Pectinatella* thus appears to have confirmation in the results of other workers.

Looking at the matter as a problem in ecological dynamics, the writer is forced to the conclusion, in the present state of our knowledge, that the chief factors involved in this epidemic were low-water stages of the river during the preceding fall, winter, and early spring, which held a maximal number of statoblasts in the mill-pond until they could germinate; and the production of an adequate food supply for the developing Bryozoa.

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[12]My own field-determinations; which agreed with laboratory determinations made by Jack J. Hinman, of the Iowa Health Laboratory. (*See* Independence *Bulletin-Journal,* August 9, 1928).

[13]Kofoid, C. A. (1908), "The plankton of the Illinois River . . . Part II . . . ", *Bull. Ill. State Lab. Nat. Hist.* 8:22.

[14]Whipple, G. C. (1894), "Some observations on the growth of diatoms in surface waters", *Tec! ·· Quar*t*erly* 7:214-31.

IV

Of the phenomena encountered by the field zoologist, perhaps the most arresting and difficult to explain is the sudden appearance in great numbers of species of animals apparently new to a region; or its converse, the sudden disappearance from a fauna of species that long have characterized it. Allied to these cases, and no less involved, is the sporadic appearance of a species at localities widely remote from its previously-reported range. A case in point, both as to sudden, sporadic appearance, and as to remarkable local abundance, is that of the fresh-water medusa, *Craspedacusta,* in recent years in America. Discovered first in London, in 1880, it appeared next in Lyons, France, in 1901; and in Munich in 1905. In 1907 Professor C. W. Hargitt found it in abundance for several weeks in a conservatory-aquarium in the District of Columbia. Nothing further was heard of it in its former localities until, in 1916, Garman discovered it in immense numbers in Benson Creek, near Frankfort, Kentucky. There, its occurrence was entirely unexpected, since Garman for years had fished the stream systematically, with no observation of the species. The next year, Garman found it in undiminished numbers. It then disappeared from the vicinity of Frankfort until 1924, seven years later. The source of the infection (for the species assumed epidemic proportions) was carefully sought by Garman, but with no results. Since then, the *Craspedacusta* has been found widely, and somewhat erratically, distributed.

The literature of zoology offers a number of other striking examples of sudden faunal changes. Among these are the sudden, and so far unexplained, appearance "by thousands" in New Caledonia of the West-Indian mollusk, *Stenogyra octomo*[15]; of the appearance "in immense numbers" of another mollusk, *Physa* (*Aplecta*) *hypnorum,* and its equally sudden eventual disappearance within a few days from a given locality [16]; and the reappearance in Scotland, in 1907, of a Phyllopod crustacean, *Apus cancriformis*

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[15]Layard, E. L. (1888) *Proc. Zool. Soc. London,* 1888, p. 358.

[16]Jenyns, L. (1846), *Observations in Natural History,* p. 319.

Schaeffer, that had disappeared from the British fauna about 1850[17].

Field zoologists are also familiar with outbreaks or epidemics of species indigenous to a given region which, due to normal balance of environmental factors, ordinarily maintain a subordinate role in the fauna of that region. Examples of such outbreaks in aquatic organisms are to be found in the epidemic of *Cyclops*, a Phyllopod, in the water-reservoir at Monroe, N. C. (April to October, 1930), reported by Johnson[18]; in Kemna's[19] experience with *Cladocera* in the Antwerp reservoirs (1896) in which multiplication of the organisms was increased at an alarming rate; and in the great epidemic of *Limnaea peregra* at Burnley, Lancashire, reported by Hickson[20]. Students of entomology are familiar with the fluctuations in numbers shown by insects in various years, varying from marked scarcity in some years to outbreak-abundance in others[21]. After epidemics, the species often becomes markedly reduced in numbers, and may even approach extinction in the locality where once extremely abundant, as was noted for the mollusk *Limnaea glutinosa* by Jenyns[22], many years ago.

An extensive correspondence with field zoologists shows that *Pectinatella* is wont to appear in fluctuating numbers in a given locality, over a period of years. Professor E. Hentschel, Director of the Zoological Museum of Hamburg, in a personal communication, says:

> As to how Pectinatella magnifica got to Hamburg, we do not know; but in any case the statoblasts must have been brought over by ship-commerce. The locality in which they were first observed, the Bille, is a small tributary of the Elbe, which through the tide-sluices [since built] has been obliterated. Then, apparently, it further extended itself in the territory of the Elbe and the Oder; and especially was observed in Brandenburg, Mecklenburg, and Schleswig. Later it seems to have become

[17]Gurney, R. (1907).

[18]Johnson, E. M. (1931), "An attempt to control Cyclops in a water plant", *Jour. Amer. Waterworks Assn.* 23:582-85.

[19]Kemna, A. (1899), "La biologie du filtrage au sable", *Bull. Soc. Belg. Geol.* 13:34*ff.*, especially pp. 47-8. So numerous were the Cladocera that screens were necessary before the filters, and these had to be changed constantly. Kemna estimates that ten tons of Cladocera were excluded from the water filters by the use of the screens.

[20]Hickson, S. J. (1903) [Presidential Address of Zoological Section, B.A.A.S], *Rept. British Assn. Adv. Science, Southport Meeting*, 1903, p. 675.

[21]This periodicity of abundance of harmful insects is being investigated, since 1921, by an insect-pest commission in America.

[22]Jenyns, L. (1846), *Observations in Natural History*, p. 318.

very much restricted (*wieder sehr zurueckgegangen zu sein.*) Near Hamburg, I have never seen it myself in the local waters, in spite of many years of investigation; and also in other localities it appears not to have been recently observed. Only in the year 1927, or perhaps a couple of years before, it again emerged (*see* Honigmann, *Zool. Anz. 74*:164-66). It appears, therefore, that since the first discovery by Kraepelin, in the year 1883, it has always been present, but generally has been rare. In the places from which recently it has been reported, it occurs apparently abundantly, but, after all, not so abundantly that one could designate its occurrence as an epidemic one.

Professor W. R. Coe[23], of Yale University, reports his impression that in places observed by him large or conspicuous colonies appear at three to five years intervals, and irregularly; Professor H. J. Van Cleave[23] says, in part, "I have a very definite remembrance of irregularity of its appearance in the same locality . . . In [Illinois] *Pectinatella* is by no means a constant element in our streams and lakes. There are pronounced seasonal variations in abundance and a stream that has it in abundance one summer may seem to be entirely free from it another." Professor J. G. Needham[23] says of his own experience, "I have made no regular observations, but have casually noticed great abundance several seasons and have had difficulty locating any specimens at times . . . Conditions favoring a new anchorage for statoblasts each season are not to be expected." Professor George Wagner[23], of the University of Wisconsin, reports: "It is at times very abundant in Lake Pepin, a part of the Mississippi [river] on our western Boundary. On one or two occasions when I was out there, I could have easily collected a wheel-barrow load in half an hour . . . . I can state in general from my observations that Coe, Van Cleave, and Gray are correct [regarding periodic abundance]. In only one year was the form so abundant in Lake Pepin. And I have found it so elsewhere. This is probably the reason why laymen running across it are so intrigued, and send specimens in here, usually to the botanists."

Professor I. E. Gray[23] reports that in 1928, when the *Pectinatella* were so abundant in Iowa, they also were abundant in Louisiana. On a Sunday in October, 1928, when on the Tchefuncta River, Tammany Parish, between Covington, Louisiana, and Lake Pontchartrain, he took several

[23]Personal communication.

large colonies, the largest of which weighed approximately fifty pounds. In a later letter clearing up some points, he further states, "The cases I have mentioned are the only ones where I actually saw specimens. When I said that *Pectinatella* was abundant, I am assuming it to be from the few colonies I had encountered when not looking for it . . . 1928 was the only year [from 1926 to 1930] that Pectinatella came to my attention. I can remember on at least two occasions people asking what the 'jelly masses' were that were in the rivers and streams. This also was in 1928." It will be seen that the year 1928 may have been a year most suited to great multiplication of *Pectinatella;* and a comparison of the weather encountered in Louisiana with that of Iowa, from January, 1927 to August, 1928, shows considerable correspondence. In 1933, *Pectinatella* was again abundant at Independence, Iowa; and Van Cleave[23] also reports it abundant in the back-water lakes of the Illinois River. It is probable that climatic factors, such as sunshine, temperature, and rainfall, are largely the determiners, primarily and secondarily, of abundance of *Pectinatella;* and that coupled with this may be involved low water stages in rivers and lakes during the preceding season, which will facilitate statoblast fixation. It is highly desirable that extensive observations be made over a wider area, to ascertain to what extent such cycles of abundance generally exist in this species, and what are the major factors involved.