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Observations on the biology of *Microsetella norvegica* *

By Charles J. Fish
Narragansett Marine Laboratory, University of Rhode Island

Summary—*Microsetella norvegica* is one of two microcopepod species which appear significant in the natural economy of certain western Atlantic boreal waters. During the winter months it extends its range southward at least as far as the latitude of Chesapeake Bay. North of Cape Cod in the Gulf of Maine region it is widespread with a tendency to form concentrations of limited area.

Propagation in 1932 began in March in the outer area between Georges Bank and Cape Cod and gradually expanded as the season progressed until it reached a peak in the Gulf along a band seaward of the 100 metre curve from Casco Bay to the Bay of Fundy.

There is evidence of three and possibly four generations between March and September. As in other endemic pelagic species there was a progressive delay to the eastward in the time of spawning, but unlike most of these *Microsetella* was found propagating successfully at low summer temperatures, averaging 11°–13·5° C, in the turbulent eastern (Frenchman's Bay) area.

INTRODUCTION

There has been increasing recognition of the importance of adult and larval microcopepods in the natural economy of both coastal and open ocean waters. Because of their small size and frequent preference for subsurface levels they cannot be representatively sampled with nets of the mesh most frequently used for zooplankton, and, consequently, are commonly much more important members of the pelagic population than published records indicate.

One member of this group, *Oithona similis* Claus, which Wilson (1941) has concluded to be the most widely distributed and numerous of all copepods, is also one of the most prolific in western Atlantic boreal coastal waters where its young provide an abundant source of food for larval plankton feeders in midsummer (Fish, 1936 c).

Relatively little attention has so far been accorded *Microsetella norvegica* Boeck, a second and even smaller (0·3–0·5 mm) microcopepod species, also endemic in boreal coastal waters. Although widespread, it has not been reported to be particularly abundant in north European coastal areas (Ruud, 1929; Störmer, 1929; Wiborg, 1954) or south of Cape Cod in the western Atlantic (Fish, 1925; Deevey, 1952).

Table I

Mean numbers of Microsetella norvegica *in Frenchman's Bay. Number per cubic metre. Upper 50 metres*

1930	*Adults-Copepodites*	*Nauplii*
July 10	208,360	404,720
July 18	293,467	195,567
August 1	248,850	169,523
August 7	152,820	92,850
August 14	295,460	93,600

* Narragansett Marine Laboratory Contribution No. 11.

However in certain localities north of Cape Cod it is at times very numerous. For example, in Frenchman's Bay it was found by the author to be the dominant species during two months of weekly observations in July and August 1930, when adults and young often comprised over 90% by number of the total zooplankton population. Again in 1931 in the same region 17,907 adults per cubic metre were taken in the upper 50 metres near Monhegan Island on August 21.

To determine its importance elsewhere in the Gulf of Maine and Bay of Fundy, an analysis has been made of collections obtained between July 28, 1931, and September 29, 1932. The area covered, location of stations and methods have been described in a previous report (Fish, 1936 A).

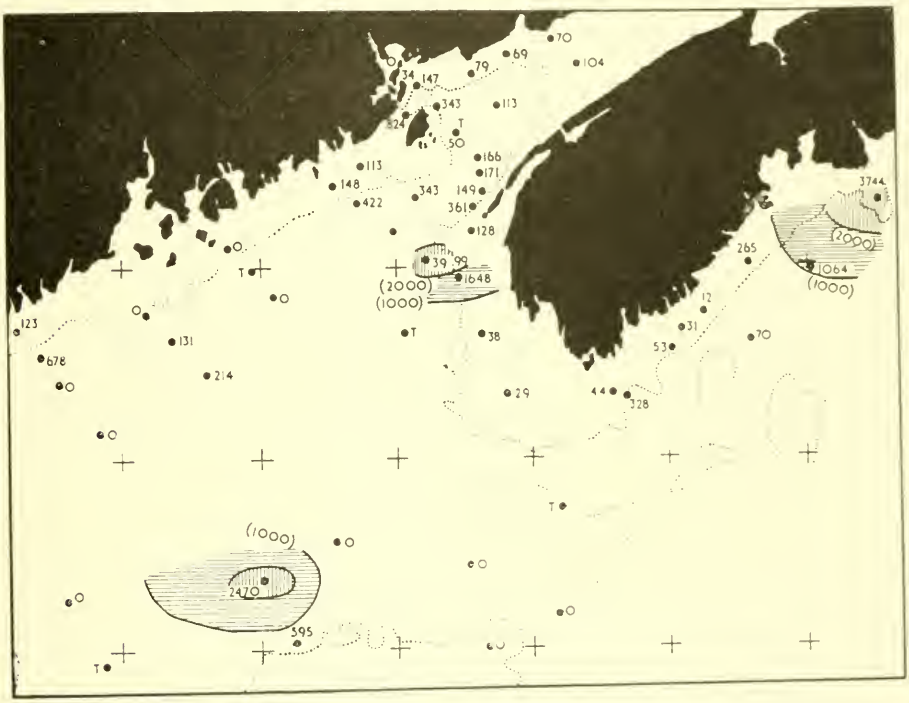

Fig. 1. Distribution of adult *Microsetella norvegica* in April 1932. Number per minute of towing

REGIONAL DISTRIBUTION OF THE ADULT STOCK*

In the western Atlantic *M. norvegica* ranges from Arctic waters (76° 02′ N, Jespersen, 1923) at least as far south as Chesapeake Bay where it was found by Wilson (1932) in December 1920 and January 1921. At Woods Hole it appeared in late March and early April 1923 (Fish, 1925), in Narragansett Bay in March 1906 (Sharpe, 1910) and in Block Island Sound in October and December 1949 (Deevey, 1952). These records indicate that, like most boreo-arctic plankton animals, *M. norvegica* extends its range southward along the coast during the winter months.

North of Cape Cod it is widespread in the Gulf of Maine and Bay of Fundy, with a tendency to form local concentrations of limited area (Fig. 1). When first observed

* Mature individuals and late copepodite stages have been combined in the counts.

in April 1932, the numbers were everywhere relatively sparse except in three widely separated localities where more than 1,000 per minute were taken in oblique hauls with half metre nets of number 10 mesh. Two of these were near the Nova Scotian coast, one approximately 25 miles east of Briar Island (3,999 per minute) and the other off Halifax (3,744 per minute). A third (2,470 per minute) was located off the inner margin of Georges Bank between the middle and western channels.

Varying numbers, usually small, were taken at all stations east of Mt. Desert in the Gulf, the Bay of Fundy, and along the west and south coasts of Nova Scotia. West of Mt. Desert, *Microsetella* appeared at but five of ten stations in the inner Gulf, and in the outer Gulf at but four of nine stations. The two eastern centres of abundance coincided with similar local concentrations of *O. similis* (FISH, 1936 c), the numbers of the two species off Halifax being approximately the same. The richest hauls of both species in the inner Gulf, at this time, were also obtained at the same location, St. 24A, seaward of the 100 metre contour off Casco Bay.

With observations restricted to the inner Gulf and Bay during the balance of the season, it was not possible to determine the duration of the three *Microsetella* concentrations observed in April. The distribution in succeeding months reveals a progressive shoreward movement of the eastern and western adult-copepodite stocks and gradual expansion to a seasonal peak everywhere in the inner Gulf seaward of the 100 metre contour (Fig. 2). Here the members ranged from 1,360 to 5,662 per cubic metre in August.

Contrasted with 1932, records for August 1931 show much smaller numbers at all comparable stations, although the local swarm near Monhegan Island (p. 243) yielded the highest counts of the two seasons. By September the numbers in the Bay of Fundy had declined greatly both in 1931 (188 per cubic metre) and in 1932 (179 per cubic metre).

PRODUCTION AND DISPERSAL

There are few available data on the biology of *Microsetella norvegica*, in fact the developmental stages, some of which are shown in Fig. 3, have not yet been described to the author's knowledge. The seasonal occurrence of adults south of Cape Cod would suggest that, like *Pseudocalanus*, spawning may begin at the southern portion of its range as early as November or December. It is not known, however, whether propagation continues offshore in deeper water after the species disappears from neritic areas south of the Cape with rising spring temperatures.

Distribution of eggs and larvae in 1932

By mid-April propagation in the Gulf was most advanced in the outer part of the western basin between Georges Bank and Cape Cod. Here late nauplius stages up to 1,544 per minute were found at two stations. Farther east in the outer Gulf spawning was still taking place and egg sacs up to 926 per minute were found coinciding with the local concentration of adults. Smaller numbers of early nauplii (309 per minute) appeared at one station in this region. Still farther east along the outer Nova Scotian coast neither eggs nor larvae were found. In the inner Gulf spawning had just begun in the eastern basin (up to 1,666 egg sacs per minute) and small numbers of eggs were found extending into the Bay of Fundy. Only one station (St. 29) west of Petit Manan yielded eggs at this time, and no larvae appeared anywhere in the inner Gulf or Bay.

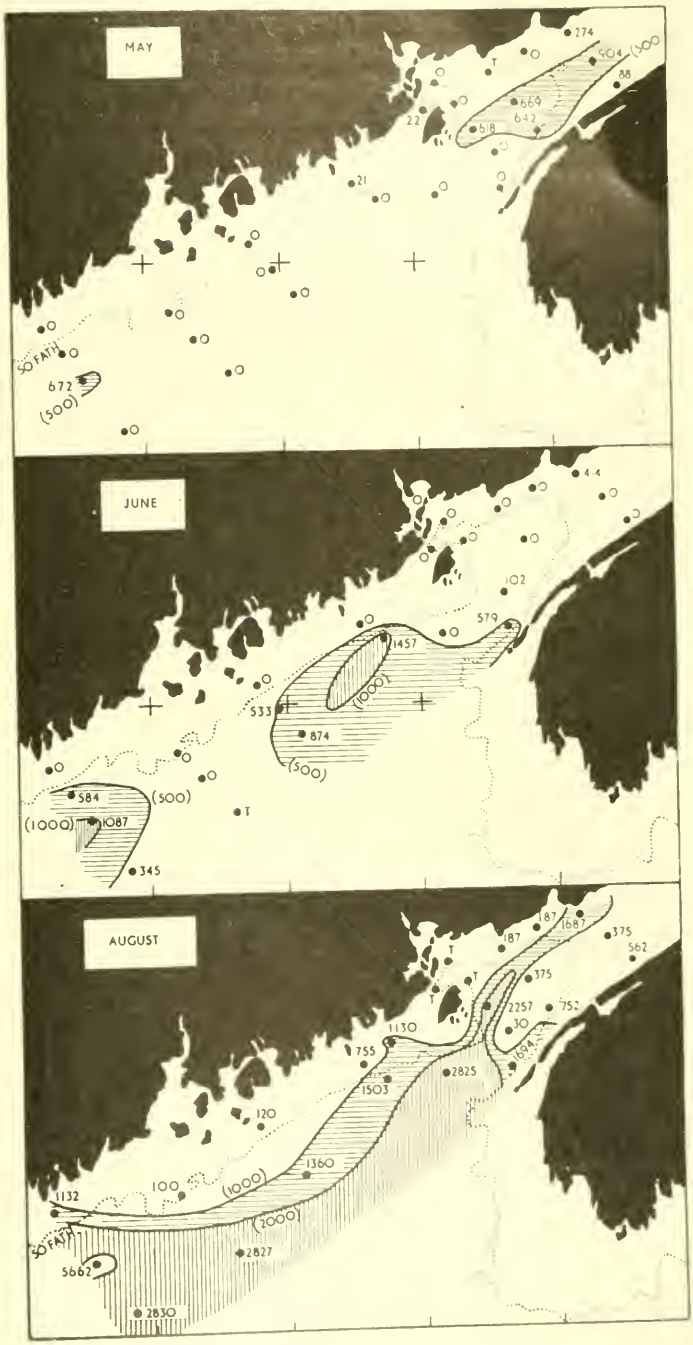

Fig. 2. Distribution of adult *Microsetella norvegica* in 1932. May–June: number per minute of towing. August: number per cubic metre

In late May propagation extended to the western part of the inner Gulf where local patches were found off Casco Bay and Mt. Desert. East of Mt. Desert, egg sacs were taken only along the Nova Scotian side of the Bay of Fundy.

The June distribution would suggest offshore production in the eastern and western basins of the Gulf. Eggs were restricted largely to the two outer stations of the most western section and along the course of the drift into the Bay.

Propagation in the inner Gulf reached its peak in July and early August. By mid-August the greater part of the stock was in late nauplius (Fig. 4) and copepodite

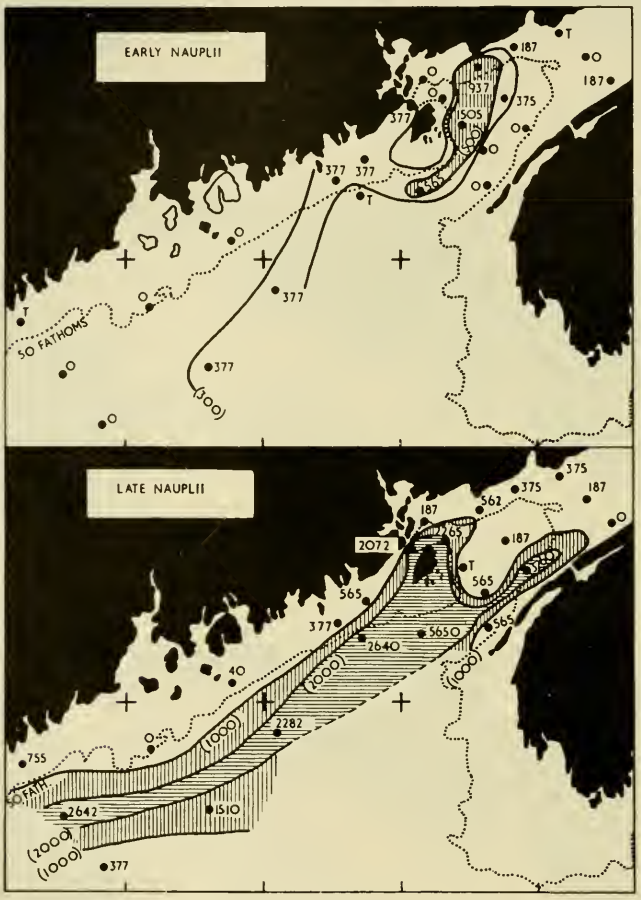

Fig. 4. Late nauplii of *Microsetella norvegica*, presumably the western stock, and early nauplii of the eastern stock in August 1932. Number per cubic metre

stages, the largest hauls (plus 2,000 per cubic metre) occurring along a band seaward of the 100 metre curve and extending from Casco Bay to the Bay of Fundy. Early nauplii, presumably the product of the eastern area, appeared in small numbers, restricted almost entirely to the eastern part of the Gulf (Fig. 4). Eggs were widely scattered in small numbers in the Bay of Fundy, particularly in the entering drift and at a few stations farther west in the Gulf.

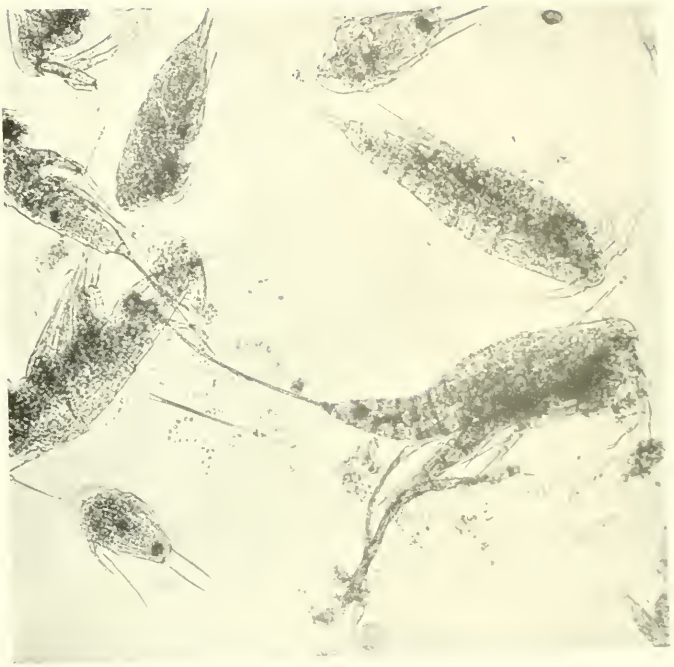

Fig. 3. Developmental stages of *Microsetella norvegica* taken in Frenchman's Bay on August 1, 1930

By September few eggs and young remained in the Bay, the largest number of nauplii, 374 per cubic metre, being taken in New Brunswick waters off Point Lipreau.

Table II

Mean numbers of adults and egg sacs of Microsetella norvegica *in successive months. April–June: number. per minute. August–September: number per cubic metre. - - - : no observations*

Year	Month	Gulf of Maine		Bay of Fundy	
		Adult	Egg sac	Adult	Egg sac
1932	April	150	9	104	38
	May	45	243	328	177
	June	425	109	103	321
	August	1264	170	776	250
	September	—	—	179	37
1931	August	423	189	—	—
	September	—	18	188	T

DISCUSSION AND CONCLUSIONS

Annual cycle

Possibly because of its very unequal distribution during the early season, developmental stages of *Microsetella* were not taken in sufficient numbers to permit tracing with certainty successive generations in different areas until August.

Considering the region as a whole, it appears probable that, like *Oithona*, there are at least three and possibly four generations of the stock spawning in late March and reaching late nauplius stages in mid-April. A second breeding period is indicated by an increase in egg sacs in the Gulf in late May (Table II) followed by an increase of copepodite-adults in June. The abundance of late nauplius-copepodite stages combined with relatively few egg sacs in August (Table III) suggests a maturing of the second generation and the appearance of a third crop of eggs in July. Egg sacs in the Bay of Fundy on September 15–16 may represent a fourth relatively unimportant generation. There would thus appear to be propagation periods in March, May, July and possibly September, with a cycle of approximately two months.

Table III

Mean numbers (per cubic metre) of Microsetella norvegica *in different areas in* 1931 *and* 1932

	Total Gulf		Western Area		Central Area		Bay of Fundy	
	1931	1932	1931	1932	1931	1932	1931	1932
	Aug. 21–26	Aug. 8–15	Aug. 21–25	Aug. 11–14	Aug. 26	Aug. 8–15	Sept. 4–5	Sept. 15–16
Egg sac	376	103	489	126	93	94	T	37
Early nauplius	162	188	227	94	—	188	112	61
Late nauplius	698	1531	920	1006	141	958	225	51
Copepodite-Adult	2922	1840	3998	2336	234	1001	150	211

Regarding regional production, *Microsetella norvegica* appears first as an offshore species which later penetrates and propagates in the inner Gulf some time after augmentation has taken place in the region of the outer banks. The brood in the

vicinity of the south channel had attained late nauplius stages by mid-April in 1932, when eggs but no larvae were found in the eastern basin. No evidence of propagation was found farther east off Halifax at this time, or in the inner Gulf west of Mt. Desert where the first evidence of local production was found in late May and June. As in the outer region, and corresponding to *Calanus finmarchicus* (FISH, 1936 A), *Pseudocalanus minutus* (FISH, 1936 B) and *Oithona similis* (FISH, 1936 C), a progressive delay to the eastward in the time of spawning was evident in the inner coastal area after the species had become established there in 1932. This is indicated in Fig. 4 showing early nauplii limited to the eastern Gulf at a time when late nauplii, presumably the western crop, dominated everywhere. By September, propagation had largely ceased in the Gulf, both in 1931 and 1932 (Table II).

Although the progressive delay to the eastward in the time of spawning, and the relatively small numbers of adults and larvae in the New Brunswick region of the Bay of Fundy (Figs. 2 and 4) indicate that *Microsetella* responds in a general way to the limiting factor of low temperature, in a manner characteristic of the boreal zooplankton population, there is evidence that it can reproduce at somewhat lower temperatures than *Calanus* and *Pseudocalanus*. In Frenchman's Bay in 1930 (Table I) *M. norvegica* propagated successfully in large numbers during July and August at surface temperatures averaging from 11°–13·5° C. and was the only pelagic copepod (with the exception of *Temora longicornis*) found developing in those waters. An abundant population of offshore species dominated by *Calanus* and *Pseudocalanus* (adults and late copepodite stages) was present in the lower levels of Frenchman's Bay throughout the summer of 1930, but their eggs and larvae rarely appeared in the collections.

Table IV

Relative abundance of adults of Oithona similis *and* Microsetella norvegica *in the Gulf of Maine and Bay of Fundy in* 1931 *and* 1932. *April–June: mean numbers per minute. August–September: mean numbers per cubic metre. - - -: no observations*

1932	*Gulf of Maine*		*Bay of Fundy*	
	O. similis	*M. norvegica*	*O. similis*	*M. norvegica*
April	1380	150	212	78
May	3672	45	983	246
June	4534	425	1858	77
August	3735	1635	3120	770
September	—	—	332	179
1931				
August	3550	423	—	—
September	—	—	94	188

It would appear, therefore, that although *Microsetella* and its nauplii ordinarily provide a less abundant supply of food for summer larval plankton feeders in the Gulf of Maine and Bay of Fundy than *Oithona* they do appreciably supplement the latter stock in those waters and seem to be of particular significance in areas like Frenchman's Bay and the adjacent turbulent coastal region eastward from Mt. Desert where low surface temperatures prevent successful summer propagation of the more dominant Gulf zooplankton species.

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