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IMPROVISUS DARWIN ON THE WEST
COAST OF SWEDEN

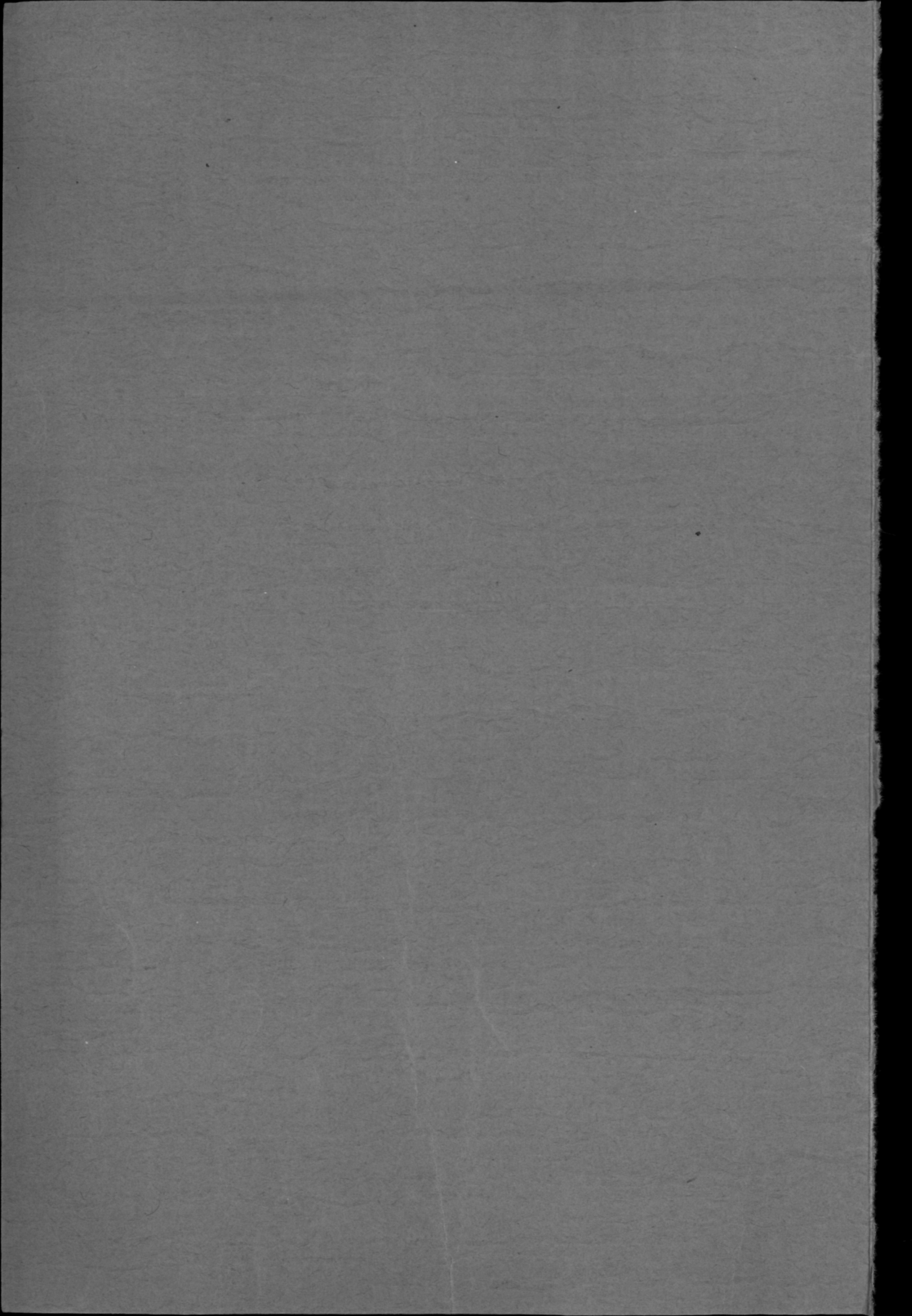
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Interest in and knowledge of the barnacles has greatly increased during the last few decades, mainly owing to the anti-fouling work, which has been carried out in many countries. In Great Britain, especially, many investigations concerning the ecology and biology of reproduction of barnacles have been made. Of great value are the descriptions of the larval forms of the most common barnacles, through which it has become possible to follow more continuously and accurately the occurrence in plankton of the different larval stages.

Thus, BASSINDALE (1936) has described the larvae of *Balanus balanoides*, *Chthamalus stellatus*, and *Verruca stroemia*. HERZ (1933) and PYEFINCH (1948c) have described the larvae of *Balanus crenatus*. PYEFINCH (1948a) has also shown how to identify and distinguish the larvae of *Balanus balanoides*, *B. crenatus*, and *Verruca stroemia*. The larvae of *Balanus improvisus* have been described by BUCHHOLZ (1951) and JONES & CRISP (1953).

Of special interest for Swedish purposes are the descriptions of the larvae of *Balanus balanoides*, *B. crenatus*, *B. improvisus*, and *Verruca stroemia*. Of these the three *Balanus* species are most common as fouling on small boats and are regularly found attached to suspended panels.

A good deal of information is found in the literature about the occurrence of the larvae in plankton and the settling times of different species.

Balanus balanoides

Along European coasts the settling of this species occurs mainly in April.

In Norway RUNNSTRÖM (1925) found at Herdla north-west of Bergen that settling occurred during the second half of April.

In England RUNNSTRÖM (1925) found in Liverpool Bay the first cyprid

larvae in plankton on April 6 and the cyprid maximum from April 15–20. MOORE (1935) found at Port Erin (Isle of Man) very small variations in the time of settling: he observed the first attached cyprid larvae on April 26 in 1932 and on April 25 in 1933 and 1934.

In Scotland PYEFINCH (1948*b*) found at Millport the strongest settling in the beginning of April (based on four years of observation). Within the same area (Clyde Sea Area) BARNES (1950) found strong settling during the first half of April.

In France HATTON & FISCHER-PIETTE (1932) found at Saint Malo in Brittany large variations in the dates for the first cyprid settling and in the length of the settling periods. Thus, in the year 1930 settling began March 29–April 2 and lasted six weeks, while in the year 1931 settling began as early as February 15–21 and lasted three months.

In the U.S.A. FISH (1925) found cyprid larvae in February–March at Woods Hole, which agrees well with GRAVE's (1933) observations of settling during the period February 15–March 15.

On the Atlantic coast of Canada BOUSFIELD (1954) found settling from the middle of April to the beginning of June with the maximum approximately on May 1 (at St. Andrews) and the first settling about April 10 (in Halifax Harbour).

Balanus crenatus

There is not as much information on *Balanus crenatus* as on *B. balanoides*. *B. crenatus* spawns, in contrast to *B. balanoides*, more than once a year.

PYEFINCH (1948*b*) found at Millport in Scotland, that nauplius larvae of *B. crenatus* appear in the plankton somewhat earlier than nauplius larvae of *B. balanoides*. The first settling occurs at the same time for both species at the end of March. Larvae of *B. crenatus*, however, are to be found at intervals during the whole summer, and settling occurs now and then during the period March–October. Within the same area (Clyde Sea Area) BARNES (1950) confirmed that the larvae of *B. balanoides* and *B. crenatus* occur at the same time in the plankton, and that the settling is strongest during the first half of April.

On the Atlantic coast of Canada BOUSFIELD (1954) found in the Miramichi Estuary that spawning of *B. crenatus* begins approximately two weeks earlier than the spawning of *B. balanoides*. *B. crenatus* spawns there both spring and autumn, April–June and September–October.

Balanus improvisus

Balanus improvisus can tolerate appreciably lower salinity than either of the above-mentioned species and is the only barnacle occurring far into the Baltic Sea.

At the mouth of the Göta Älv in Gothenburg TENGSTRAND (1931) found larvae in the plankton from the end of May to the end of September. The settling began in the end of June and lasted to the middle of July, varying slightly from year to year depending on the water temperature.

In the Oslo Fiord BROCH (1924) observed the first settled cyprids at the end of May and the settling continued during the first half of June, occurring thus a whole month earlier than TENGSTRAND (1931) observed at Gothenburg.

In Danzig LUCKS (1940) found larvae in the plankton during July and October.

In Holland van BREEMEN (1934) noted settling in Amsterdam in the end of June but also during the period August–September.

In Canada *B. improvisus* spawns during the period June–July and probably also again in September–October according to BOUSFIELD (1954).

Material and Methods

In order to obtain information concerning reproduction and settling times of barnacles of the West Coast of Sweden panel experiments and plankton studies have been carried out for a number of years at Kristineberg's Zoological Station, Fiskebäckskil, Bohuslän. Panels of polyethylene (15 × 15 cm) were suspended from a raft every week and taken in again after a week for examination and counting. Plankton samples were taken weekly and through these could be followed the occurrence of the different larval types.

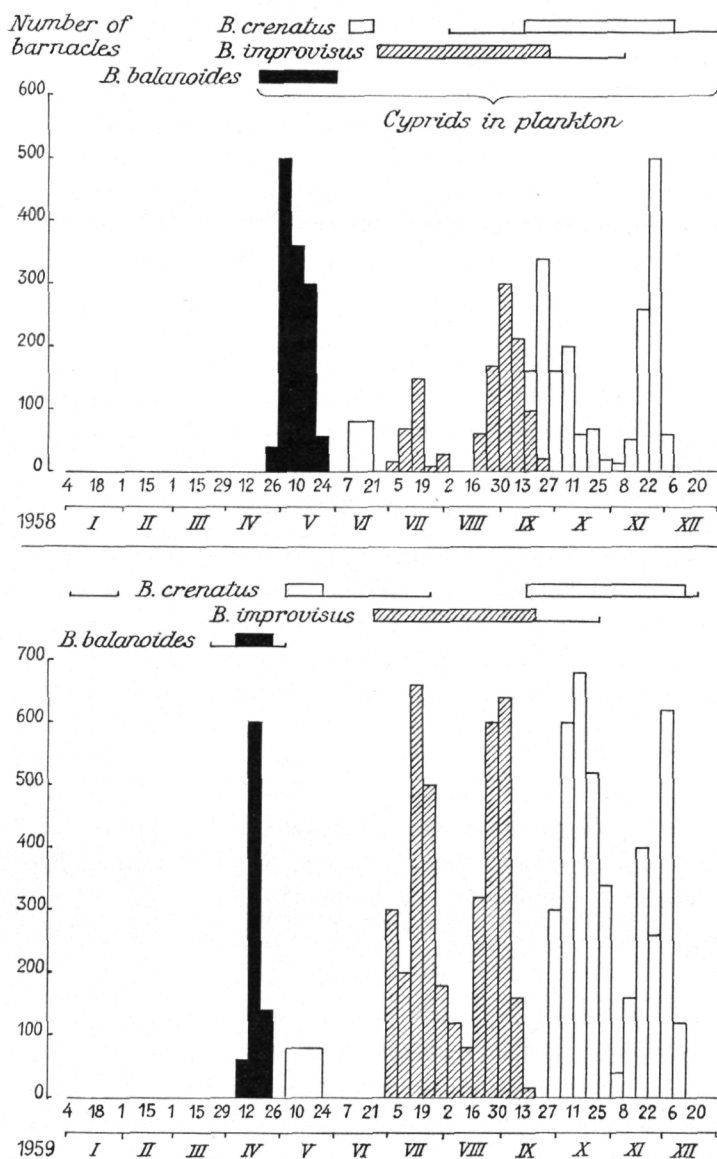
The material shown in the diagram is from the years 1958–59. The test panels from which *Balanus balanoides* were obtained were placed at the surface; the others at a depth of two meters.

Results

Only three of the six species of barnacles of the West Coast of Sweden were obtained from the panels, namely, *Balanus balanoides*, *B. crenatus* and *B. improvisus*. At the same time, larvae of a fourth, *Verruca stroemia*, were found in the plankton, but no indication of its settling on panels could be determined. The diagram shows the time and intensity of settling of the different species and in addition the time of occurrence of the cyprid larvae in the plankton. Below follow some short comments about the diagram.

Balanus balanoides

In the spring of 1958 the settling of *B. balanoides* began in the last week of April, continued with a distinct maximum during the first half of May and then diminished towards the end of the month.



DIAGRAM

Time and intensity of settling of barnacle cyprids on suspended panels during two successive years on the West Coast of Sweden.

In the spring of 1959 settling was concentrated in a few weeks. It began in the second week of April, had a strongly marked maximum during the period April 12-17 and then diminished rapidly so that by April 25 it was quite insignificant. The settling maximum occurred 2-3 weeks earlier than the year before.

Cyprid larvae of *B. balanoides* occur in the plankton for about 1½ months but mass occurrence is limited to 1-2 weeks.

Balanus crenatus

B. crenatus has two distinct optimal spawning periods, one in the spring and the other in the autumn. During the years 1958 and 1959 the spring maximum was insignificant compared with the very intensive autumn spawning.

Settling in the spring occurs mainly during 1-2 weeks, some time between the beginning of May and the middle of June. After this period a few cyprid larvae may be encountered occasionally but not until September do they occur in numbers and they are then strongly represented on the panels.

Two clear settling maxima can be observed during the autumn with 1½-2 months between them. As late as the beginning of December the cyprid larvae occur in great numbers but then they diminish quickly and disappear completely during the winter.

Balanus improvisus

Cyprid larvae of *B. improvisus* begin to appear in the plankton at the end of June and settling begins at the change of the months June-July. In both 1958 and 1959 two distinct settling maxima were obtained, one in the middle of July and the other near the end of August and the beginning of September. A few cyprid larvae are found in the plankton during the whole of October and part of November.

The number of cyprid larvae appearing in the plankton during the year 1959 was significantly greater than the year before and resulted in a more intensive settling.

Discussion

Settling maxima of *B. balanoides* for the last four years have occurred in the last week of April 1957, the first half of May 1958, the middle of April 1959 and April 18-25, 1960. Of these, the year 1958 had an extremely cold spring and the ice did not break up in the investigation area until April 8. The second half of April may be considered to be the normal settling time of *B. balanoides* on the West Coast of Sweden. This agrees with what

RUNNSTRÖM (1925) found in West Norway, MOORE (1935) at Port Erin and BOUSFIELD (1954) in Canada, where, however, the settling period is somewhat longer. In Scotland, on the contrary, the most intensive settling of *B. balanoides* occurs a couple of weeks earlier (PYEFINCH 1948b).

The duration of the settling period of *B. balanoides* is 3–5 weeks, but most of the larvae attach themselves within a few days (the years 1957, 1959, 1960). The long settling period of 6–12 weeks found by Hatton & Fischer-Piette (1932) in Brittany was not confirmed here.

The spring spawning of *B. crenatus* occurs somewhat later than that of *B. balanoides*. When the cyprid larvae of *B. balanoides* have almost completely disappeared, then the cyprid larvae of *B. crenatus* begin to appear. The cyprid maximum in the plankton and the settling of *B. crenatus* follow 1–3 weeks after the settling maximum of *B. balanoides*. This does not agree with the condition in Scotland, where PYEFINCH (1948b) and BARNES (1950) found that the spawning and settling of the two species occurred at the same time, or with the condition in Canada, where, according to BOUSFIELD (1954), *B. crenatus* spawns a couple of weeks earlier than *B. balanoides*.

According to PYEFINCH (1948b), *B. crenatus* settles in Scotland up to and including October but not later. In Sweden, on the contrary, settling also occurs during November and part of December.

The conditions in Canada where there is a marked spring and autumn spawning are more like the Swedish, but the autumn spawning does not last longer there than into October either (BOUSFIELD 1954).

The settling periods of *B. improvisus* agree rather well with what TENGSTRAND (1931) found in Gothenburg, van BREEMEN (1934) in Holland and BOUSFIELD (1954) in Canada. On the contrary, BROCH (1924) found settling in the Oslo Fiord as early as the second half of May, a whole month earlier than the authors found at Kristineberg.

Two settling maxima have also been observed by van BREEMEN (1934) and BOUSFIELD (1954).

Summary

Data are presented concerning the time of occurrence and settling of the cyprid larvae of three common species of barnacles on the West Coast of Sweden.

Balanus balanoides: settling normally mainly during the second half of April.

Balanus crenatus: settling during May–June and September–December with two distinct maxima in the autumn.

Balanus improvisus: settling from the end of June to September with two distinct maxima.

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