

Darkness was also necessary before swarming took place, the limiting light intensity being somewhere between dusk light and bright starlight. Consequently the appearance of the heteronereids grew later as the day length increased. The first heteronereids was seen at 8.35 p.m. on 14 September, but not until 9.53 p.m. on 10 January. The effect of full moon light is not known as a hill to the east shaded the area at high tide. The response to tide was modified slightly by the light intensity as on one occasion heteronereids did not appear until 30 minutes after high tide, when the last trace of daylight had faded. On the other hand, the first heteronereid never appeared more than 30 minutes before high tide even on nights when darkness fell two or three hours before.

Variations in the other environmental factors studied did not affect swarming. The salinity at high tide varied from 20.0‰ at neap tides to 29.1‰ at springs, while the highest and lowest water temperatures in which swarming occurred were 21.5° C. in January and 9° C. in September. Heavy rain inhibits swarming (Korringa, 1957: 927) but during this study heavy rain did not fall on any of the nights when swarming was expected. Consequently the effect of rain on the swarming of *N. aestuariensis* was not observed.

Korringa (1957: 921) in a review of lunar periodicity distinguished three components in breeding systems of this sort: "an *annual rhythm*, a breeding season of longer or shorter duration, which may be controlled by water temperature, a *lunar periodicity*, perhaps better called a tidal periodicity, which brings about maxima in spawning twice a month during the entire breeding season, and next a *daily rhythm* which limits spawning activities to certain hours of the day or tidal cycle". *N. aestuariensis* fits this pattern with its breeding season in spring extending at a lower intensity into autumn, swarming restricted to a few nights in each fortnight, and to an hour just after high tide on those nights.

Generalising on fortnightly periodicities, Korringa further stated (1957: 922), "In all cases it is a question of rhythmical ripening of eggs and sperm synchronised with the cycle of neaps and springs. The maxima are therefore not necessarily observed at new or full moon". But the swarming of *N. aestuariensis* maintained a close relationship to the new and full moon rather than following the shifting cycle of neaps and springs (Text-fig. 3). However, another characteristic of the tides, their timing, does have a constant relationship to the phases of the moon. The afternoon tide at Lyttelton on the day of new and full moon is always high between 4 p.m. and 6 p.m. and at the collecting area in the Heathcote Estuary it is about 50 minutes later. Consequently a few days after new and full moon high tide in the Estuary occurs just after dark, and this conjunction of the two factors which were necessary for swarming recurs once each fortnight. Furthermore swarming did not occur on all high tides at night but only on the first few in each fortnight, so that successive periods of swarming were completely separated.

The observed periodicity of swarming can be explained by assuming that swarming is initiated by the combination "high tide shortly after nightfall". The correctness of this conclusion, and the exact stimuli to which the worms respond, could be established only by experiments with metamorphosing worms kept under controlled conditions of light and tide.

A collection of heteronereids from Bluff Harbour in the teaching collection of the Zoology Department, University of Canterbury, was examined. The heteronereids were *Nicon aestuariensis* agreeing in all respects with specimens from the Heathcote Estuary. They were netted from a wharf on 13 January 1951, at 11.15 p.m. This was five days after full moon and two and three-quarter hours after sunset, but four and three-quarter hours after high tide. There appears to be the same relation as at Heathcote between swarming and the moon and sunset, but a less marked relation to the tide.