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SPECIES INHABITING THE

FLOTSAM LINE

OF SOME SANDY BEACHES,

AND THE GENERAL FEATURES OF

THEIR ENVIRONMENT

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University of Canterbury, 1966.

The Environment of the Flotsam line.

Macroenvironment.

This term is used to refer to the environment of the flotsam line as a whole.

One of the major factors affecting the environment is the tide, which brings about diurnal changes in conditions such as temperature. The $12\frac{1}{2}$ hour tidal pattern of change is superimposed upon daily, and seasonal variations.

Moore (p. 392) quotes figures from Buttle, 1932 to the effect that temperatures of mud-flat surface showed less minor fluctuations than air temperatures. Surface temperatures were $0 - 7^{\circ}$ C. higher than air temperatures, and the greatest difference between them occurred when the air temperature dropped, i.e. the heat was retained by the mudflat. Although the substrate being considered is not a mud-flat, the comparison is justified because the conditions are likely to be fairly similar. However, temperature variation may be expected to be less on a coarse substratum than on a fine substratum, and thus a difference of 7° C. may be higher than that found on any of the sandy beaches considered. Temperature within clumps of seaweed would probably tend to be higher than air temperatures, but may be subject to less variation than the sand surface.

Generally temperatures will be higher in the daytime, and in summer. A high tide during the daytime may effectively lower temperatures, and a high tide at night-time would prevent temperatures from dropping to freezing point, or below, if there was a local frost. Temperatures in the flotsam zone are determined by air temperatures at low tide; but at a high tide at least partly by the temperature of sea water which lies at a slightly lower level.

Local winds must affect the intertidal region, but even when conditions are generally calm, a beach is likely to have windy conditions - sea breezes during the day, and land breezes at night.

Apart from their abrading and eroding ability, these winds must tend to dry out seaweed stranded on the beach, by hastening evaporation of water. The topmost pieces of seaweed in a pile and single pieces of seaweed are often dried out by the combined action of heat and wind.

Diurinal wetting by waves must occur where the seaweed is stranded near current high tides. Any piece of seaweed which is stranded on the beach, must be eventually swept towards the highest level reaches by subsequent high tides, and left to rot. The few pieces of seaweed subject to submergence by the tide would be prevented from rotting, and would not constitute a part of the flotsam zone proper.

Discussion on the Nature of the Micro-environment.

Conditions in different parts of the flotsam line vary, and for any particular clump of seaweed, conditions vary also with time, in a somewhat predictable manner. This may be stated: the environment is heterogeneous in time and in space. Heterogeneity in space may be regarded in two ways: firstly seaweed is present at a particular position or it is not, and secondly the seaweed in this position may be fresh, or in any stage of decay.

These points may be obvious to a human observer standing on the beach, but the organisms which inhabit this zone, and are thus adapted to living in it, are not in such an omniscient position. Their behaviour must enable them both to find the environment which is suited to them, and to leave offspring before the environment changes, and becomes unsuitable for reproduction. Some offspring must be able to survive in the environment in which they hatch - i.e. where they have been placed by the female.

So far, it has been assumed that a particular micro-environment occurs, and it is then the 'job' of the species to find and live in the environment. This would seem to be necessary for all organisms whose habitat is decaying food matter. For these organisms, a particular piece of material exists only for a short time in a place suitable for their requirements. Since there is a low chance that a sexually mature adult will encounter a substrate suitable for oviposition, such forms usually have a

high fecundity, to allow for a large mortality. Winged insects, which have a great mobility, are particularly suited to this habitat.

Other types of decaying food matter that are inhabited by flies, for example, are rotting fruit, and the flesh of animals (usually dead). An insect restricted in one of its phases to living in the latter habitat is likely to miss out because of the comparative rarity of this occurrence. The conditions on the shore are rather different; it is likely that along any comparatively short stretch of beach there will be some freshly stranded pieces of seaweed, as well as decaying pieces. In this respect the flotsam zone may be one of the more favourable habitats of its type, because it occurs more regularly.

<u>Species Inhabiting the flotsam Zone.</u>
<u>Species Variety and habits.</u>

Species found in dry parts.

Slow-moving cryptically coloured Curculionids (weevils) were found associated with dry rubbish, or crawling over uncovered sand. A large spider of the family Dysderidae was also found under a log at Brighton beach, but was not common. Some Elateridae (click-beetles) and pericoptus larvae were found particularly at higher levels, towards the sand-dunes.

Large earwigs (<u>Anisolabis littorea</u>) were also present.

Some species were found within the sand, and these included the isopods <u>Actoecia</u> <u>euchroa</u>, and <u>Porcellio</u> <u>scaber</u>, the latter a woodlouse. Various instars of <u>Anabarynchus</u> <u>bilineatus</u> were found during a marine survey of Okains Bay beach. They occurred down to the high tide level and up to the base of the sand-dunes. The larva of this species is recorded by Hudson (1945) to be "almost certainly carnivorous, and probably a cannibal". The latter statement is supported by the fact that more than one larva never survived in a jar which originally contained more.

Other species were more common and less restricted in their place. Unidentified red mites were always numerous, particularly underneath seaweed. A small brown-grey beetle (not identifiable by P.M. Johns) was always found in a similar place, and was usually common. An ochreous-brown convex beetle, <u>Chaerodes</u> <u>trachyscelides</u>, was less numerous but not uncommon. It is a carnivore. <u>Cafius</u> <u>litoreus</u>, a staphylinid usually about 11mm long, was rarely found. More than the other species of this family, it tended to have a retreating habit, and was found rather on the surface of the sand than amongst the seaweed. Small Hemipterans, probably of the family Lygaeidae were extremely common on sand covered by seaweed. A shiny black Carabid beetle (9mm) and a small striped long-bodied beetle were each found only once, and they could not be further identified by the author.

Two species of Staphylinid were usually found closely associated with seaweed which was at least partly decayed. One species

was <u>Omalium</u> <u>litoreum</u>, and the other was unidentified. This specimen did not seem to fit a key compiled for Chatham Island species. Both types were very numerous and many were observed within the tissues of the spongy <u>Durvillea</u> species.

Larvae of <u>Chactocoelopa</u> <u>littoralis</u> and <u>C.huttoni</u> were always very abundant where seaweed decay was in process. Probably other diptesar larvae were also present, but as their taxonomy is not known, these could not be identified. One small white beetle larva (2mm) with black mouthparts could not be identified, and these were fairly common.

Adult flies formed the main population of seaweed piles, particularly at Taylor's Mistake. Species which were identified from this source were as follows:

Ephyridae

      Hecamede femoralis

Sphaeroceridae

      Leptocera aucklandica

Dolichopodidae

      (species not identified)

Coelopodidae

      Chaetocoelopa littoralis

      C. huttoni.

Therevidae

      Anabarynchus bilineatus

Muscidae

      (species not identified)

These species differed in their abundance on the different beaches, and also with substrate.

Both _Chaetocoelopa huttoni_, and _C. littoralis_ were taken as adults, over large piles of decaying _D'urvillea_, and _Macrocystis pyrifera_. They could also be seen crawling over this seaweed. However, at Okains Bay, although not many flies were present along the length of the beach at the visits made, _C. huttoni_ occurred only on the sandy part of the beach, while _C. littoralis_ occurred abundantly at one end of the beach, and never far from a rocky substrate. Rocky ledges were also present in Taylor's Mistake, and clusters of _C. littoralis_ occurred there.

Anabarynchus bilineatus adults were not found at Okains Bay, (although various larval instars were plentiful) and were less common than the two species discussed at Taylor's Mistake. Their habit seemed more roving than _Chaetocoelopa_ spp., and this would be correlated with their carnivorous habit.

The three smaller flies, _Hecamede femoralis_, _Leptocera aucklandica_ and Dolichopodidae were found by lifting back the covering of seaweed. They tended to crawl, rather than fly away from the disturbance and were thus easy to catch, apart from their abundance.

Muscoid flies were rarely found, and only at Taylor's Mistake.

This specimen would be likely to have come from nearby houses, and is probably not typical of this habitat.

Clustering of Chaetocoelopa littoralis.

Adults of this species were observed in large clusters, sometimes several flies deep, on rocks at Taylor's Mistake, under seaweed at Okains Bay, and in glass boxes in the laboratory. The clustering flies were not feeding.

Such clustering was observed for none of the other species of flies, but was so characteristic for this species that it could be expected to be of survival value.

Firstly, clustering must involve some sort of mutual recognition, and this is another way of saying that an order (a very low order) of social organisation exists. This is so far a rarely recorded event among Dipteran groups.

The advantage which clustering affords may be protection. A group of flies heaped upon one another has proportionately less area exposed directly to the environment than the total for each fly separately. Thus a fly in the 'in group' is less likely to encounter dangers than as a single specimen outside the group. This may be stated as follows: social co-operation for the advantage of the group, results from the sacrifice of the specimens on the outside of the cluster.

Also as a result of clustering, low temperatures may be avoided by those in the centre of the group, because a certain amount of movement will tend to raise the temperature of the surrounding air. On this account it would be interesting to conduct an experiment with these flies in a box heated at one end.

Whether the flies tend to clump when temperatures are cold for example, could be verified or falsified by this experiment.

3.   Experiments with Chaetocoelopa littoralis.

3.1

The above species was chosen to experiment with, firstly because adults were plentiful, and secondly because the larvae were found in very large numbers in the field throughout the piles of decaying seaweed. Differences in sizes of adults had been noticed. It was therefore intended to raise larvae to adulthood from eggs laid on uncontaminated seaweed. They were to be raised at different temperatures, and the lengths of the various larval instars noted. Also, differences in weights of adults were to be looked at, and perhaps correlated with amount of food, and for temperature.

Only one such experiment was successful for this species. The procedure for this experiment was as follows:

Half-pint Agee jars with gauze lids, and containing about an inch of moist sand, with four large fronds of uncontaminated

Macrocystis pyrifera were supplied with six adult females, and
two adult males. The flies were obtained from field collection
at Taylor's Mistake. Three jars were kept in an environment
where the temperature remained about 82°F., and one jar kept at
room temperature. The adults were removed after three days.

Results:

Temp.°F.	Series	First adult hatching	Last adult hatching	Speed of hatching	Oviposition period	No. hatching
82	1	13th day	–	not taken	3 days	12
82	2	13th day	–	not taken	3 days	12
82	4	13th day	–	not taken	3 days	50
Room temp.	3	27th day	after 29 days & before 32 days	2 days	3 days	36 51

Conclusions:

Larvae raised at room temperature took no less than 27 days
to hatch, as compared to at least 13 days at 82°F. The spread of
hatching time at room temperature could not be regarded as in-
dicative of a very narrow variability, but it can be stated that
the maximum variation was no more than 5 days. There was a large
variation in numbers of adults hatching, and although the figures
indicate that fewer hatched at high temperatures, replications
would have to be made to verify this.

Discussion

The length of larval life appears to be adjusted to the
length of time taken by the seaweed to decay. As decay takes

place more quickly at higher temperatures, so does larval develop-
ment. Thus the food available is used as efficiently as possible,
in the time available.

<u>Note</u>: Larvae were collected from the experimental jars, and
preserved in alcohol. The sets are incomplete, (early instars
were not collected to prevent disturbing the experiment) but the
later instars, and pupae were all collected. This material will
be suitable for description when the earlier instars are available.

Further experiments were attempted but none were successful.
The chronological order of different types of attempts is as
follows:

1. The same procedure as for the above experiment, except that
   the flies were obtained from ones which had hatched in the
   laboratory and the seaweed was several days old, and beginning
   to decay.
2. Flies obtained from laboratory stock were incubated with fresh
   seaweed collected from Taylor's Mistake.
3. Flies obtained from Taylor's Mistake were incubated with fronds
   of <u>Macrocystis pyrifera</u>. This was not fresh in that it had
   been pulled from below low-water level, but newly-stranded
   pieces of seaweed, which looked fresh were chosen and washed
   in seawater to ensure that no contamination could take place.

No oviposition took place in the first two cases. In the third experiment, the substrate was not disturbed for three days, when first instar larvae should have been present if there had been any eggs, and the eggs had hatched. No larvae were observed.

Reasons_suggested_for_the_failure_of_these_experiments.

Discussion_of_the_field_environment_of_Chaetocoelopa_littoralis

Flies are notoriously easy to breed: the failure to do so successfully in this experiment therefore seems rather surprising. However, conditions which the flies encountered in this experiment were not the conditions which induced them to oviposit, or the young larvae to grow. Therefore it is worth considering what conditions in the field might be which bring about the behaviour of oviposition. This is the reason for the following discussion.

The flies which were used in the successful experiment were obtained from Taylor's Mistake on 31/3/66. On this date, large amounts of seaweed were present on the beach, where they had been cast up after a storm. In the other cases where flies were collected in the field, no such large amounts of material were present on the beach, and the laboratory populations could not have encountered these conditions. It would seem that oviposition may be triggered by some condition present when fresh seaweed is present on the beach.

There is a logical case for flies ovipositing only on fresh seaweed. It was noted in the laboratory that fresh seaweed soon became sticky, particularly at high temperatures, and it is likely that a fly would become entangled in the exuded mucus if it attempted to move on this surface.

This process must also occur to some extent in the field, and it is therefore probable that the flies have evolved a delicate physiological adjustment, by selection against those genotypes tending to oviposit at a less favourable time.

Possibilities of adjustments which could be made are mainly from a theoretical point of view.

If seaweed tended to be thrown up at regular intervals, for instance according to a lunar periodicity, then selection would favour those genotypes which produced sexually mature adults at the 'correct' interval of time. The species could 'predict' when the seaweed would be thrown up, and sexual maturity and oviposition could be regulated by a biological clock mechanism. If it had happened that at the time the flies were present in the prepared jars, the biological clock did not indicate that oviposition should take place, then this would explain the failure for oviposition to take place. However, in this species, it has been shown that length of larvae life is greatly dependent on temperature. It is difficult to imagine that temperature could be related to the interval at which seaweed is thrown up, and

so a biological clock <u>independent of temperature</u> would have to
be employed. Such a separation of mechanisms is difficult to
imagine, but could not be categorically stated to be impossible.
However, it is unlikely that seaweed does tend to be stranded at
certain equal intervals.

Thus the solution of the problem of morphogenesis sets the
pattern of availability of adults according to temperature, i.e.
the temperature at which larval growth takes place. If the rate
of maturation of the adults is also a function of temperature,
then it will be a matter of chance whether such an adult encounters
a suitable substrate for oviposition before its death, unless some
environmental factor attracts the flies to the suitable substrate.

No selective advantage would be possessed by a fly with a
genotype resulting in an attraction to a substrate favourable for
oviposition, if flies with no such genotype were equally success-
ful in finding a substrate. Such a situation might arise where
there was always a large supply of suitable substrate on hand.
In fact it is probable that on at least some occasions, suitable
substrata are in short supply. Therefore if a favoured genotype
did exist, it would tend to become established in the population.

A different way for a species to solve the same problem
would be by the possession of random searching habits by each
member of the population. A large number of flies would fail to
find a suitable habitat, but the chances would be that some fly

would find every suitable substrate. A high fecundity would then ensure that the population was continued.

These different types of searching could be designated respectively,'individually efficient' and 'individually in-efficient', although both would be efficient with reference to the population as a whole. In both cases, the final trigger might be a result of trial and error. If the substratum 'tastes' right, then oviposition takes place, and if it 'tastes' sticky, then no oviposition occurs, and further searching is initiated.

In one of the experiments, seaweed which was fresh was used in conjunction with flies from laboratory stocks, and oviposition did not occur. It was tentatively suggested (Dr. R.S. Bigelow) that sexual maturity may have been prevented because of the restricted laboratory invironment of the flies. Some species of <u>Drosophia</u> are known to require a space in which to fly before sexual maturity will take place. In the field it would not be expected that a fly could find a suitable substrate for oviposition without some searching by flying. This constant conjunction would tend to become obligatory in the history of the species.

The last experiment therefore utilised flies which were obtained from the field. Failure to oviposit cannot be explained on the basis of any of the preceding factors, except perhaps that the flies detected that the substrate was not 'really' fresh.

This extreme sensitivity is not too far-fetched, since flies have extremely sensitive feet, and it was observed that this seaweed did seem to exude an excessive amount of mucus. This may have been as a result of the washing in sea-water (to decontaminate the surface).

Summary

Flies which oviposited were collected, from Taylor's Mistake, on a day when fresh seaweed was present. Other flies either were collected on a day when there was little fresh seaweed, or were from laboratory populations which would not have encountered such conditions. Therefore oviposition may be triggered by the presence of fresh seaweed.

The advantage to the population of this habit is noted.

It is suggested that this behaviour could be the result of timing by an internal clock, but as temperature has a large effect on rate of larval development, it is difficult to imagine the clock operating independently of temperature.

Therefore the trigger may be the 'taste' of the substrate as encountered by a fly walking over the seaweed. Flies may be attracted to the seaweed from a distance by some mechanism, such as smell, or they may each search randomly.

As well as this final trigger, other conditions may have to be present for sexual maturity to take place. A certain amount of flying may be necessary. The conditions required for oviposition to take place are probably many, and the flies are probably very sensitive to slight changes in chemical composition of the substrate.

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