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Observations on the Fauna of Wrack Beds

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CONTENTS

Wrack beds are accumulations of seaweeds of various kinds that have become detached from the rocks on which they have grown and have been cast up on the sea-shore. If such accumulations are formed beyond the high tide level, they may remain but little disturbed for several days or even for months. Here, as they gradually decompose, these wrack beds become the home and breeding place for many invertebrate animals. The most prominent of them are various species of flies, beetles and amphipods, and with them there occurs, less obviously, various mites, oligochaetes and nematodes. Over and above these regularly occurring animals there are numerous incidental visitors to the wrack beds.

Several lists of insects and mites found in wrack beds and in their vicinity have appeared in the literature. In Great Britain such lists, along with some ecological information, have been published by Yerbury (1919-22) (Diptera), Halbert (1920) (mites) and Keys (1918) (Coleoptera); and similar papers dealing entirely or partly with wrack animals have appeared in other countries (e.g. Madsen (1936) studied various groups in Greenland, and Lindroth (1931) studied wrack insects in Iceland).

No serious study of the fauna or consideration of its special attributes appeared until 1945, when Backlund published the results of his observations on the wrack fauna of Sweden and Finland. Backlund's paper is extensive, the work for it being carried out, on and off, over a period of eleven years, and it deals with nearly three hundred samples taken from various places covering almost the whole of the Finnish and Swedish coasts where wrack beds occurred.

In his paper Backlund divides the wrack beds he investigated into three types according to size and shape calling them wrack strings, wrack flakes and wrack banks. These terms are used in the present study although Backlund's definitions are altered slightly.

Wrack strings are long stretches of wrack usually less than 8 ins. deep and 12 ins. wide. They cannot retain water and at times may be hard and brittle. Wrack flakes are shallow, carpet-like accumulations of wrack. Wrack banks are larger masses of wrack, more than 8 ins. deep. They decompose rapidly becoming very soft and their deepest layers are always wet.

Most of the field work for this paper was carried out at Whitburn, Co. Durham, where the coastal features allow the formation of a variety of wrack beds of different sizes and shapes. A wrack bank was usually present on a rocky shore at the foot of low cliffs here. It measured between two to five yards long, one to three yards broad and up to three feet deep. Southwards of the rocky shore there is a gently-sloping sandy bay at, and above, the high-tide line of which, there was usually a wrack string. Between the areas where the wrack bank and the wrack string were found there is a flat stretch of shore on which wrack flakes, as well as wrack banks and wrack strings were formed.

Other observations on wrack fauna were made on the mainland opposite St. Mary's Island, Northumberland, about ten miles north of Whitburn. Here only large wrack banks, two or three feet deep, were formed.

The wrack beds at Whitburn and near St. Mary's Island were composed entirely, or almost entirely, of *Laminaria* and *Fucus*.

Further details of the wrack beds studied are given in Egglishaw (1960a).

All of the Durham coast and the Northumberland coast south of St. Mary's Island was examined at some time, but no other large area of wrack beds, similar to that occurring at Whitburn, was seen. Small stretches of wrack strings were sometimes found, and on the shore at Hart there once occurred a bank of debris among which was scattered a small amount of wrack.

Wrack banks of only short duration were sometimes seen in the harbour at Cullercoats.

In August, 1956, a wrack string at Llandudno, Wales, was examined. It was about 400 yards long and was composed of *Laminaria* and *Fucus*.

In August 1957 a wrack string on the Furness coast, Lancashire, was examined. It was made up entirely of a filamentous green seaweed, in clumps of about one foot long and four to six inches deep.

At Bamburgh, Northumberland, a wrack string of *Laminaria* and *Fucus* was examined on 3rd September 1957.

The field work was carried out from October 1955 to April 1958. The wrack beds at Whitburn were visited once or twice almost every week throughout this period, and those near St. Mary's Island were visited once or twice a week from September 1955 to March 1956 and thereafter on odd occasions. Between two and four hours were spent observing and collecting animals on each visit to the wrack beds.

Previous papers (Egglishaw, 1960a, 1960b, 1960c, 1961a, 1961b) have dealt with the young stages and the biology of the flies that bred in the wrack beds. These flies were *Coelopa frigida* (F.), *C. pilipes* Haliday, *Orygma luctuosa* Meigen and *Oedoparea buccata* (Fallén) (Coelopidae), *Helcomyza ustulata* Curtis (Dryomyzidae), *Fucellia maritima* Haliday (Muscidae), and *Thoracochaeta zosterae* (Haliday) (Sphaeroceridae). The present paper deals with the other insects more or less associated with wrack beds, with the predators and parasites present and with other more general aspects of the biology of wrack beds.

Some Species of Diptera Associated with Wrack Beds

The seven flies previously mentioned and on which papers have recently been published all bred in the wrack beds at Whitburn with a certain regularity and it is most probable that for this purpose at least they are confined to this type of habitat. It is also very likely that *Thoracochaeta brachystoma* is similar to *T. zosterae* in being confined to wrack beds. The young stages of *T. brachystoma* were not found although adults were common in the wrack string at Whitburn from late January until early March 1956.

Besides these eight species, there were other flies that were common at some time of the year, either as adults or larvae, and which were more or less closely associated with the wrack beds. They included species of the genus *Chersodromia, Sciara quinquelineta* Macquart., *Fannia canicularis* (L.), and *Scatophaga stercoraria* (L.).

Chersodromia *species found in wrack beds.*

Several species of *Chersodromia* (Empididae) have been found inhabiting the seashore by various students. Lundbeck (1910) mentions finding *C. difficilis* Lundbeck, *C. arenaria* (Halliday), *C. incana* Walker and *C. hirta* at seashore localities in Denmark. He found *C. cursitans* with them at times, but this species also occurred at the side of lakes and rivers. *C. arenaria* and *C. cursitans* were found on the shores of Sweden and Finland by

Backlund (1945). In England, Yerbury (1919-22) recorded *C. hirta* and *C. cursitans* found under seaweed at Torcross, Devon.

In the adult stage species of *Chersodromia* are predatory on other insects and this habit is discussed later.

C. hirta was fairly common at Whitburn from the beginning of June until the end of September. Most were found among the dry seaweed in the wrack string and on the sand down to about six yards below the high tide level, but some were found in the upper, drier layers of the wrack banks. At Llandudno, in August 1956, they were found in the wrack string and on the nearby sand.

The flies ran very quickly over the shore and made darting flights of one or two feet over the sand.

C. arenaria also occurred from June until September at Whitburn and was found in the same parts of the shore as *C. hirta*. *C. arenaria* was not quite as common as *C. hirta*.

Unlike *C. hirta, C. arenaria* has only very short wings and was never seen to fly. Lundbeck (1910) believed that the wings are not sufficiently developed for this purpose. The flies, however, ran very quickly among the wrack and shingle.

C. incana did not occur at Whitburn but was found on the Northumberland coast at Bamburgh in September 1957 and at Llandudno in August 1956. It is a small light-grey species and tones in well with the dry sand near the wrack strings where it was found in both of these localities. The flies ran very quickly over the sand and wrack and made short flights of a foot or so.

C. difficilis was found only in the wrack string at Llandudno in August 1956.

These four species of *Chersodromia* have not been recorded from habitats other than sea-shores and it is very probable that they breed in the wrack beds there. Some larvae which fit Lundbeck's description (1910) of the generalised Empididae larvae were frequently found in the wrack string at Whitburn in July and August. Although some larvae were often brought back to the laboratory along with the wrack in which they were found, the larvae soon died and none ever successfully pupated. Because of their size, 6 mms., however, they are more likely to be those of *C. hirta* (2-3 mms.) and not those of the much smaller *C. arenaria* (1 mm.).

Adults of *Chersodromia incana,* which were placed in jars containing pieces of wrack with which they had been found, mated frequently. The male first mounted the female and placed the tibiae and tarsi of his first pair of legs along the dorsal surface of the thorax of the female and his other legs round her abdomen. The first pair of legs of the male 'trembled' for a few seconds at a time and moved backwards and forwards jerkingly, the other legs remaining still. The male then moved backwards along the body of the female so that their genitalia could be opposed. The front legs of the male which continued to 'tremble' intermittently, were now over the wings of the female. Actual coition lasted about one minute after which the two flies immediately separated. The

whole procedure (throughout which the female remained motionless) from initial mounting of the male to this separation lasted about three minutes. Although several females mated, no eggs were ever laid.

Rearing experiments with *C. hirta* and *C. arenaria* were also unsuccessful although the adults mated frequently.

Sciara quinquelineta.

Another species that may breed in the wrack beds at Whitburn is *Sciara quinquelineta* (Mycetophilidae, subfamily Sciarinae) although no direct evidence that it did so was discovered.

The fly was fairly common at Whitburn in May and June and in September and October of each of the three years the wrack fauna was studied and it also occurred near St. Mary's Island, though it was rarer there. At Whitburn the flies were found in the wrack string and in the wrack flake, which sometimes formed, the deeper layers of both of which were damp, well-compressed and contained a certain amount of plant debris.

Although much of this wrack material was examined, only one larva that could possibly be ascribed to this species was found. It was 2 mm. long and had the head black, which is typical of larvae of this family. Unfortunately, the larva died in the conditions provided and no proof exists that *S. quinquelineta* breeds in the wrack beds.

The commonness of the flies and their regularity of occurrence, however, suggests that *S. quinquelineta* is more than just an accidental visitor to the wrack beds at Whitburn. Backlund (1945) frequently found both larvae and adults of Sciarinae in the wrack beds of Sweden and Finland.

Fannia canicularis.

Fannia canicularis (Muscidae) was the only species of fly found breeding in the wrack beds which is not confined to that habitat. The fly is well-known to breed in other kinds of decaying matter and in excrement.

No adults of *F. canicularis* were ever found in the wrack beds, but larvae were found on *Fucus* at two places four yards apart in the wrack string at Whitburn on 27th September 1956. There were between 60 and 80 larvae in various stages at each of the two places. With them were larvae of *Fucellia maritima* and *Helcomyza ustulata*. The larvae of *Fannia canicularis* which were collected continued feeding on *Fucus* in the laboratory, eventually pupated and later produced adults.

The wrack string was again visited on 10th October 1956, but in the meanwhile it had been covered with sand. No larvae were found and no further sign of *F. canicularis* was seen near the wrack beds.

Previous to the finding of these larvae in the field in September, eggs and larvae of *F. canicularis* were found on 10th May

1956 on some *Laminaria* stipes which had been kept in the laboratory for a few days. Adults were often attracted to the wrack material brought back to the laboratory for examination and, in this instance, a female had laid about one hundred eggs at the edge of the most decomposed part of the stipes. The larvae fed on a white slime that exuded through the outer surface of the *Laminaria* and they later pupated. Adults began to emerge on the 11th June 1956.

Larvae of *F. canicularis* are thus capable of living on either *Fucus* or *Laminaria* and the species probably crops up now and again in wrack beds when suitable conditions occur. Larvae of *F. canicularis* have previously been found by Backlund (1945) in wrack beds in Sweden and Finland.

Scatophaga stercoraria.

Scatophaga (*Scopeuma*) *stercoraria* (Cordyluridae) was another species of fly which was frequently found in the wrack beds. One or two adults were often found between March and August, while they were fairly common in September, October and November in the wrack string at Whitburn, where they preyed on other flies present there. This habit is discussed later.

On 17th September 1956 an unusually large aggregation of several hundred adults were attracted to a small area (2 ft. × 2 ft.) of an extensive wrack bank at Whitburn. Their abundance on this part of the wrack is shown by the fact that 50 males and 28 females were caught with one sweep of the kite net over the assemblage of flies. The area to which the flies were attracted was darker in colour than the rest of the wrack, was fetid and must have decomposed very rapidly. Its deeper layers were immersed in a putrid, brown semi-liquid.

The flies crawled over this part of the wrack bank and returned immediately to it if disturbed. Many pairs of flies were seen mating.

A jar of wrack material was collected from the area to which the flies were attracted and examined in the laboratory, but no eggs were found in it.

A similar aggregation of *S. stercoraria* adults was seen in the same place on 20th September 1956. By 24th September 1956 what had been a large wrack bank 2-3 feet deep was reduced to a wrack flake only about three inches deep and no *S. stercoraria* flies were seen on it.

Scatophaga stercoraria has not been recorded breeding in wrack beds, but Backlund (1945) found larvae of the closely related *Scopeuma litorea* Fall. and possibly also those of *Scopeuma villipes* Zett. in wrack beds in Sweden and Finland. At one locality (Petsamo) on the northern coast of Finland, he found that *S. villipes* and *Coelopa frigida* were the most typical wrack flies.

Structural Adaptations of the Young Stages of Flies for a Life in Wrack Beds

The eight species of Diptera which without doubt bred in the wrack beds at Whitburn may be arranged in three groups depending on the size and kind of wrack bed in which their larvae were usually found. The first group includes the flies which bred in the largest (and hence wettest and softest) wrack banks and contains *Coelopa frigida, C. pilipes* and *Thoracochaeta zosterae*. The second group contains only *Orygma luctuosa* which bred chiefly in small, drier wrack banks and is intermediate between groups one and three. Group three includes flies which bred in the smallest wrack banks and wrack strings and contains *Fucellia maritima, Helcomyza ustulata, Oedoparea buccata* (the most extreme of the group) and also *Fannia canicularis*.

The same grouping of the flies could be made based on certain adaptational features of the organs of feeding, movement and respiration in the larvae of these species. Some of these features along with adaptations in the egg and pupal stage will now be discussed.

Adaptations in the egg stage.

The most noticeable adaptation in this stage is the two long filaments found on the egg of *Orygma luctuosa*. These filaments remain in direct contact with the air throughout their length whilst the rest of the egg is buried in soft wrack, and they have already been shown (Egglishaw, 1960a) to have a respiratory function. Similar filaments are found on the eggs of a few other species of flies, e.g. *Drosophila melanogaster* Meigen and *D. funebrio* (Fab.). The eggs of these two species are laid in soft, or even semi-fluid, decomposing fruit and their filaments probably serve a similar function.

The filaments, when lying along the surface of the wrack, may prevent the egg from sinking into the soft wrack in laboratory conditions; however, many eggs were laid with the filaments projecting straight into the air when they could not function in this way. In *Fannia canicularis* longitudinal projections from the shell of the egg may help in preventing the egg from sinking into the soft materials on which they are laid.

Feeding adaptations.

The mouth hooks and sclerotised teeth of the larvae of the wrack-breeding flies are clearly adapted to the state of decomposition of the wrack on which the larvae feed.

The mouth hooks of *Coelopa frigida* and *C. pilipes* are bifurcate, each distally being composed of two downwardly curved finger-like processes with rounded edges (Egglishaw, 1960a). Larvae of both of these species feed on very soft wrack. The sclerotised teeth on the head lobes in *C. frigida* and *C. pilipes* are broad flattened plates which clearly project from the lobe surface. In

feeding, the head of the larva is raised from the wrack surface and extended forwards, it is then lowered on to the wrack surface and retracted, the mouth hooks and sclerotised teeth pulling back the soft wrack into the mouth.

In *Orygma luctuosa* larvae, which feed on harder wrack than the larvae of the *Coelopa* species, the mouth hooks are not bifurcate and are not as rounded as in those species. The mouth hooks of the larvae of *Oedoparea buccata* are pointed and their edges are sharper than those of the larvae of the other species of Coelopidae. Their sclerotised teeth are also narrower and firmer than in those species and they project only slightly from the head lobes. These features suit *Oe. buccata* larvae for feeding on the fairly hard *Laminaria* stipes in wrack strings on which they are found.

The mouth hooks of *Fucellia maritima* (Egglishaw, 1960c) and of *Helcomyza ustulata* (Egglishaw, 1960b), both of which feed on moderately hard wrack, resemble those of *Oe. buccata* in being pointed and having a sharp edge.

Adaptations for movement.

Larvae that have to move through or over soft materials need to have larger gripping surfaces (spines and plates, etc.) than larvae which move through or over harder material. The larvae of the flies that breed in the various types of wrack beds at Whitburn illustrate this need.

The larvae of *Coelopa frigida* and *C. pilipes* and *Thoracochaeta zosterae,* all of which live in the softest wrack, have numerous black sclerotised spines in transverse rows on the ventral surface. The spines vary in size but those in the same row are usually alike. The larva of *Orygma luctuosa* has similar transverse rows of spines but the largest of them are smaller than the largest of those of the two *Coelopa* species; the larvae of the three flies being about the same size.

The larvae of the species that live among harder and drier wrack bear no large spines other than those few normally present in the anal region. *Fucellia maritima* and *Oedoparea buccata* larvae each bear numerous rows of very small, white spines. The larva of *Helcomyza ustulata* has no spines other than the anal ones but it is covered in small backwardly-directed, almost transparent plates.

Adaptations for respiration.

Observations carried out in the laboratory and in the field showed that several species of larvae live buried in the wrack material with only their posterior spiracles remaining in direct contact with the air. Larvae often found in this position were those of *Coelopa frigida* and *C. pilipes* and *Thoracochaeta zosterea* and the first and second instar larvae of *Orygma luctuosa.* Each of these larvae is supplied with groups of 'hairs' on their posterior

respiratory spiracles which are spread over the surface of the wrack.

These groups of 'hairs' have the following functions. Firstly, when the larvae of these four species enter soft wrack, the 'hairs' are forced backwards to form a cone over the spiracular plates thus preventing the spiracular openings from becoming blocked. The 'hairs' of *Coelopa frigida* and *C. pilipes* are particularly well adapted to forming this cone for this purpose, being broad at the base and tapering distally.

Secondly, this bending backwards of the 'hairs' causes air to be entrapped within the cone formed (it is visible as a bubble in larvae submerged in water) and so allowing the larvae to remain entirely immersed in the wrack for some time.

Thirdly, the splayed 'hairs', presumably, act normally as a check against the movement of the larvae into soft wrack, thus preventing them from losing contact with the air.

In addition to these functions the 'hairs' of *Orygma luctuosa* were found to be very sensitive to touch and this may be true for the other three species. If, when the young larvae of *O. luctuosa* were buried in the wrack with only their posterior spiracles visible, a few of the 'hairs' were gently touched with a fine needle, the larvae immediately disappeared into the wrack, the soft tissue closing over behind them. The larvae remained entirely buried in the weed for ten to fifty seconds before pushing their posterior spiracles backwards into the air again. If, however, water was dropped onto their posterior spiracles, the larvae, instead of disappearing into the wrack, jerked themselves backwards until the 'hairs' broke the surface and the larvae once more gained contact with the air. If the water covering the posterior spiracles was too deep and after some backward movements the larvae could not reach the surface they moved quickly through the wrack and pushed their posterior spiracles into the air elsewhere.

The larvae of *Oedoparea buccata* which live among comparatively hard and dry wrack bear only a small number of 'hairs' on their posterior spiracles. These 'hairs' are too small and too few to perform the functions of the 'hairs' found in the four species mentioned above. It is possible that these small 'hairs' are only the vestiges of a former functional state that was present in larvae that lived in larger and softer wrack beds. Large wrack beds provide a more constant environment than wrack strings and are possibly the simpler habitat in which to live. Hence the ancestors of *Oedoparea buccata* may quite well have bred in large wrack banks.

The larvae of both *Helcomyza ustulata* and *Fucellia maritima* which live in fairly hard, well-drained wrack, bear no 'hairs' on their posterior spiracles.

Pupal adaptation.

The larvae of species that live in the wrack banks (*Coelopa frigida, C. pilipes, Thoracochaeta zosterae*) pupate in its upper

layers or among shingle on its landward side. Larvae that live in the well-drained wrack string (*Oedoparea buccata, Fucellia maritima* and *Helcomyza ustulata*) pupate among the lower layers of the wrack and in the sand and shingle beneath it.

Orygma luctuosa is the only species that always pupates in the wrack itself and it secretes a white calcareous covering to the puparium.

Nematodes, Oligochaetes, Amphipods and a Lepidopteran

In addition to the larvae of the fly species mentioned, there were usually species of nematodes, oligochaetes and amphipods which fed on the wrack at Whitburn, and on one occasion larvae of a lepidopteran were found feeding on wrack there.

The nematodes (which probably all belonged to the same small unidentified species) were always present in the wrack beds and were the first animals found in beds that were freshly formed. They were also present in accumulations of wrack found all down the shore to the edge of the sea and were easily the most widespread members of the wrack fauna. The wrack at the high-tide level always contained very large numbers of the nematode, but the pieces of wrack nearer the sea usually contained only a few specimens and these difficult to find. If these pieces of wrack, however, were kept in the laboratory, the few nematodes reproduced very rapidly and within two or three days there were vast numbers of them.

These nematodes are undoubtedly the most important animals in causing the initial breakdown of the wrack tissues. Their quick reproductive rate and their activity release the water and other liquids bound up in the wrack tissue, causing the hard, fresh *Laminaria* stipes to be reduced rapidly to the soft material on which the young larvae of the wrack flies can feed. The softening of the wrack allows the nematodes to move about more quickly and this in turn increases the rate of decomposition of the wrack tissue. The nematodes also prevent the growth of moulds on the wrack. *Laminaria* stipes in which the nematodes have been killed by immersing the stipes in boiling water for several minutes, instead of decomposing and becoming softer, wither and dry up. Moulds often form on these stipes and an opaque slime exudes through the outer surface. Wrack in this state is unsuitable as food for other wrack animals, particularly the various fly larvae.

Most species of fly larvae found it very difficult (and *Fucellia maritima* found it impossible) to survive on wrack that had not previously been partially decomposed by these nematodes.

The oligochaetes have a decomposing action on the wrack tissues similar to the nematodes, but they are not so widespread in the wrack beds. The oligochaetes are found only in the wettest regions of the wrack beds and do not enter solid wrack tissue as do the nematodes, they merely move over its surface. Backlund (1945) found the two Enchytraeid species, *Pachydrilus* Müll. and *Enchytraeus albidus* Henle, in large numbers in the wrack beds of

Sweden and Finland and it is likely that these are the species that occur at Whitburn.

The amphipods were usually present in the wrack beds throughout the year. *Orchestia gammarella* was the chief species, although at times large numbers of *Gammarus marinus* occurred in the wrack beds near St. Mary's Island. All, of course, fed on the wrack itself. They were nearly always common, and at certain times occurred in very large numbers, usually to the exclusion of the larvae of *Coelopa frigida* and *C. pilipes*. When the latter species were present in large numbers there were fewer amphipods.

Tinea pallescentella Stainton (Lepidoptera).

Larvae of *Tinea pallescentella* were found in material brought back to the laboratory from the wrack string at Whitburn on 27th September 1956. The wrack string at this time was composed of a very dry and brittle surface layer of *Laminaria* and *Fucus* covering a moist layer about two inches deep, and it had not been disturbed by high water for several weeks. Also among the wrack material collected there were larvae of the three fly species, *Fannia canicularis, Fucellia maritima* and *Helcomyza ustulata*. This was the only occasion larvae of *T. pallescentella* were found and no adults of this species were ever seen in the field. It is interesting to find that larvae of two species of insects (*T. pallescentella* and *Fannia canicularis*) which occurred only once in the wrack beds were found in the same wrack at the same time.

The larvae matured and eventually spun silken cocoons of fine interlacing threads, which in places formed a close mesh. On the outside of this was added a covering mainly of sand grains but also of small pieces of wrack, empty fly puparia and pieces of cardboard from the lid of the rearing jar. Each cocoon was attached to either dry wrack or to the lid of the jar by fine threads. The cocoons were about 7 mm. long and 2 mm. wide.

The adults (fourteen) of *T. pallescentella* emerged in the second week of January 1957. They were very active when disturbed and ran quickly through the dry wrack in the rearing jar. The empty pupal skins were found almost entirely sticking out from the top of their respective cocoons.

The adults laid eggs from which larvae appeared. Some of these, which were transferred when very young to jars containing *Laminaria* stipes that had been sterilised by boiling, continued feeding and quickly grew in size. They eventually spun up on the cardboard lid of the jar, pieces of which were used in building the cocoon, and adults emerged later.

The occurrence of the larvae of *T. pallescentella* in the wrack string at Whitburn appears to be the first record of a lepidopteran from wrack beds. Meyrick (1895) gives grain and dry refuse as its usual food. There is no doubt, however, that this moth can live on wrack only and it probably occurs in wrack beds now and again when the right conditions occur.

The Parasites Found in the Wrack Beds

Collections of larvae and pupae of the four species of Coelopidae and of *Helcomyza ustulata, Thoracochaeta zosterae* and *Fucellia maritima* were frequently brought back to the laboratory from the wrack beds at Whitburn so that information could be gained concerning their parasites. The pupae collected and those resulting from the larvae collected were placed in jars containing damp sand. Here they were kept until all flies and parasites had emerged: any puparia still intact were then dissected to examine their contents.

Only two of these seven species of flies were ever found to be parasitised—the Coelopid *Orygma luctuosa* by the hymenopterans *Platymischus dilatatus* (Diapriidae) and *Nedinoptera subaptera* (Cynipoidea), and *Thoracochaeta zosterae* by *Nedinoptera subaptera.*

Platymischus dilatatus Westwood.

Platymischus dilatatus occurred, normally only one or two at a time, in the wrack beds at Whitburn from July to October. However, on 1st July 1957 a large number were found together with *Nedinoptera subaptera* (Walker) crawling over the dry wrack and stones on top of the wrack bank at Whitburn. In fifteen minutes a collection of the two species was made which contained forty females and three males of *P. dilatatus.* A similar large number were again found here on the 8th July 1957 and in fifteen minutes sixty-three females and three males were collected. By 16th July 1957 the numbers had been greatly reduced, only seven females being collected in one hour on that date. On 1st October 1956 thirty *P. dilatatus* were found walking over some sand under which a wrack string had previously been buried. These were the only occasions on which more than four specimens of this parasite were found at one time in the wild.

In the three years in which the wrack fauna was studied between three hundred and four hundred puparia of *Orygma luctuosa* were brought back to the laboratory from the field. From only eight of these did *P. dilatatus* emerge. The particulars are as follows, the date given being that on which the puparia were collected

(1)	18.x.55. 25f. 9m.	(5)	1.xi.56. 4f. 6m.
(2)	18.x.55. 5f. 10m.	(6)	1.xi.56. 16f. 9m.
(3)	15.x.56. 16f. 10m.	(7)	1.vii.57. 4f. 7m.
(4)	15.x.56. 11f. 7m.	(8)	16.vii.57. 6f. 11m.

giving 19·5 as an average number of parasites per parasitised pupa. The parasites emerged through three or four small holes they had made in each of the puparia.

In his study of the wrack fauna of Finland and Sweden, Backlund (1945) bred ninety-two *P. dilatatus* from seven pupae of *Orygma luctuosa,* an average of 13·1 parasites per pupa.

Backlund (*op. cit.*) pointed out that the Hymenoptera emerging from a parasitised pupa did so at a date later than the fly would have done, and that this prolonged stay in the pupal stage helped to keep the balance between host and parasite, since the pupa is the weakest stage with regard to drowning through storms and high water. Seventeen pupae of *O. luctuosa* which were collected from the wrack beds at Whitburn at various times and which produced neither adults nor parasites within a few weeks were dissected. Five contained withered young pupae, eight contained dead adults and the other four each contained dead *P. dilatatus* adults and pupae. The exact number of parasites in each puparium could not be counted as many of them were immature and all were brittle and badly damaged. These figures, few as they are, show that there is a higher proportion of parasitism (4 of 17) among pupae that die through drowning than in those that successfully produce adults of some kind (8 of 300-400), which gives support to Backlund's view. In fact about one third of the *P. dilatatus* die before emerging from the puparia of *O. luctuosa*.

Nedinoptera subaptera (Walker).

Nedinoptera subaptera occurred usually in only small numbers throughout the year, two or three often being found in the wrack string and the wrack banks at Whitburn. On 1st July 1957, however, large numbers of this species were found with *Platymischus dilatatus* (see above) walking over dry wrack and stones and the mixed collection of these two species made in fifteen minutes contained 155 *N. subaptera*. On 8th July 1957, large numbers were still present and 16 were caught in fifteen minutes (along with the 66 *P. dilatatus*) but on 16th July 1957 only two were seen.

N. subaptera was parasitic on *Thoracochaeta zosterae* chiefly. One or two usually emerged from groups of puparia of this fly collected at all times of the year. The degree of parasitism was always less than 10%. Only one *N. subaptera* emerged from each parasitised pupa. On four occasions a single *N. subaptera* emerged from a pupa of *Orygma luctuosa*.

Backlund (1945) does not mention *N. subaptera* and no records of its parasitising these species appear to have been published.

Other hymenopterous parasites that have been bred by other students from wrack-breeding flies are Braconidae sp., and *Isocyrtus* sp. from *Orygma luctuosa*; Ichneumonidae sp., *Gelis* sp. and Braconidae sp. from *Scopeuma litorea; Trichophria laticeps* Kff. from *Thoracochaeta zosterae;* Braconidae sp. from *Fucellia* sp. (all Backlund) and *Aphaereta cephalotes* Mal. from *Orygma luctuosa* (Scott 1920).

Parasitic Staphylinidae

Several species of the genus *Aleochara* are parasites of various invertebrates. *A. algarum* is a well-known parasite of some species of Coelopidae, having been bred from puparia of *Coelopa frigida*

and *C. pilipes* by Scott (1920) and from puparia of *Orygma luctuosa* by Backlund (1945).

Only four specimens of *A. algarum* were found in the wrack beds at Whitburn; two in the wrack string on 8th July 1957 and two on 28th July 1957. On 24th June 1957 ten specimens were collected from a wrack bank near St. Mary's Island. Although many hundreds of puparia of its hosts were brought back to the laboratory from Whitburn, no *A. algarum* ever emerged from them. The species is obviously a rare one there. Scott (1920), however, bred about one hundred from a large number of puparia of *Coelopa frigida* and *C. pilipes* collected at Swanage, Dorset. Only three of the hundred parasites emerged from puparia of *C. frigida,* all the others were from *C. pilipes.*

Both of the two species *Aleochara grisea* and *A. obscurella,* which very closely resemble *A. algarum* structurally, were present in the wrack beds at Whitburn. *A. grisea* was found throughout the year, but *A. obscurella* occurred only from April to November. Both occurred chiefly in the wrack string but in only small numbers. On 8th July, 1957, however, a fairly large number of both species were found on the sand under the wrack string. Altogether 121 specimens of *A. grisea* and 120 of *A. obscurella* were collected at Whitburn from October 1955 to October 1957. Nothing is known of the life-history of these two species, but it is possible that they, too, are parasites of species of Diptera.

All told, at Whitburn only a small number of fly larvae and pupae were parasitised by either species of Hymenoptera or of Staphylinidae. Backlund (1945), however, found that in Sweden and Finland there were often large swarms of hymenopterous insects on the wrack beds and that most dipterous larvae were heavily infected by hymenopterous parasites. It is possible that the wrack beds Backlund studied were more stable than those at Whitburn, allowing the parasites to flourish there. At Whitburn, the wrack beds were constantly being disturbed by storms and high water and the two main hymenopterans (*Platymischus dilatatus* and *Nedinoptera subaptera*), both of which are small and easily wetted and have only minute (presumably functionless) wings, are ill-adapted to living in such wet and unstable conditions.

Predators Found in the Wrack Beds

The chief predators of the animals living in the wrack beds at Whitburn were sparrows, starlings and rooks. Flocks of at least one of these species were usually present when the wrack beds were not being disturbed. The food of these birds is known to contain a large percentage of invertebrates of various kinds and, presumably, when feeding in the wrack beds they accept whatever they happen to turn up. Pied wagtails, jackdaws, thrushes and various sea birds were also seen now and again on the wrack beds at both Whitburn and near St. Mary's Island. Backlund (1945) lists fifteen species of birds that he has seen on the wrack beds of Finland and Sweden; most, however, being only occasional visitors.

All of the other known predators in the wrack beds at Whitburn were invertebrates and all but one of them (*Scatophaga stercoraria*) were, more or less, fairly closely bound to the wrack.

Although the wrack beds were visited numerous times and many hours were spent observing their fauna, only on a few occasions were predators actually found with their prey. The species that hunted for their prey on the sand and surface of the wrack beds, e.g. *Scatophaga stercoraria, Chersodromia hirta, C. arenaria* and *Erigone arctica* were, of course, the easiest to observe in the field. The species that hid among the wrack (e.g. the Staphylinid beetles and the mites) were difficult to observe and most of the information concerning their prey has come from laboratory observations.

It will be most convenient to treat each of the predatory invertebrates in turn giving some indication of their abundance at Whitburn and what was discovered concerning their prey.

Scatophaga stercoraria.

The frequency of occurrence of this species at Whitburn has already been mentioned (p. 194). *S. stercoraria* was the most easily observed predator encountered, being frequently seen preying on *Fucellia maritima* adults in the wrack string at Whitburn. *F. maritima* appeared to be its only prey at Whitburn, but on 19th October 1956, on the shore at Hart, Co. Durham, where *F. maritima* was absent, *S. stercoraria* preyed on the Bibionid *Dilophis febrilis.*

Although it often attempted to catch adults of *Oedoparea buccata* at Whitburn and at Hart, no successful attempt was seen. Even when the two species were confined together in small jars *Oe. buccata* always managed to avoid being preyed on by *S. stercoraria.*

Chersodromia hirta and *C. arenaria.*

The presence of these two species in the wrack beds at Whitburn has already been mentioned (p. 192). Both species run very quickly over the sand and dry wrack and each is provided with a very strong proboscis. On only one occasion was *C. hirta* caught with its prey, which proved to be an adult of *Thoracochaeta zosterae. C. arenaria* was never found with its prey. *Thoracochaeta zosterae* seems to be the most likely prey for both of these species as it is the only fly about equal to their size. All of the other flies present in the wrack beds are several times larger than the *Chersodromia* species.

Some idea of the voracity of *C. hirta* can be gathered from the fact that eight flies of this species killed 64 *Thoracochaeta zosterae* with which they had been placed within twenty hours. The *T. zosterae* were reduced to empty shells, the contents of the head and thorax having been removed in most cases, and in some the contents of the abdomen had been removed. In the laboratory *C. hirta* attacked dead flies of various kinds probing them with

their proboscis. They frequently attacked each other but they were never seen to actually kill and prey on their own species. Usually there was a scuffle between the two flies after which they quickly separated.

Erigone arctica and other spiders and a harvestman.

In the laboratory, *Erigone arctica* fed on oligochaetes brought back from the wrack beds, on various fly larvae and on adults of *Thoracochaeta zosterae* and *Fucellia maritima*. No other kinds of food were offered. When feeding on the oligochaetes, the abdomen of the spiders became dark green, which was similar in colour to that of spiders found on the wrack banks at Whitburn. This suggests that the natural prey of these spiders is oligochaetes. Spiders that lived and fed in the wrack string, where there are far fewer oligochaetes since it is dry, had black abdomens and presumably preyed on some other animals.

In the laboratory, *E. arctica* spun cocoons on the damp sand and weed and made rough 'webs' in which they occasionally caught an adult of *Thoracochaeta zosterae* or *Fucellia maritima*. The 'webs' were not strong enough to hold any of the Coelopidae.

E. arctica was the only spider that occurred frequently and regularly in the wrack beds at Whitburn. Several other species of spiders were found, once or twice, and presumably they were only accidental visitors.

On 30th April 1957, eight immature specimens of *Opilio parietinus* were found in the wrack string at Whitburn and two in the wrack bank there. One or two were found on other occasions in May and June of the same year. Their prey in the wrack beds is unknown.

Cafius xantholoma (Gravenhorst) and other Staphylinid beetles.

Cafius xantholoma is the commonest beetle occurring in the wrack beds at Whitburn and the largest species of Staphylinidae regularly found there.

On only one occasion was *C. xantholoma* actually found feeding. This was on 1st July 1957, when one was found in the wrack string with a third instar larva of a *Coelopa* sp. between its mandibles. The beetle and prey were lifted into a glass tube where the beetle continued feeding. Within twenty-five minutes the prey had been entirely devoured.

Individuals and small groups of *C. xantholoma* were often found partly buried in the sand under stones with only their mandibles projecting. They were found in similar positions in the laboratory when they were placed in jars containing sand. On a few occasions fairly large numbers (40-100) of *C. xantholoma* adults were found together under stones. On 31st January 1957 a large stone at the edge of the wrack string at Whitburn was moved to reveal twenty beetles. Most were on the surface of the sand but some were in burrows in it. Near the entrance to the burrows there were several small piles of dead flies and their

remains. All of these piles were collected with a small trowel and examined in the laboratory. The material collected consisted of portions of the hard parts of at least 11 *Coelopa frigida* adults (2m. 5f. 4 sex indet.) and six *C. pilipes* adults (3m. 1f. 2 sex indet.) along with thirty complete or almost complete legs of these two species, twenty-one wings, either separated or attached to small pieces of thoracic exoskeleton, odd tarsi, claws, tibiae, etc. The flies had almost certainly been killed and partially eaten by *C. xantholoma*. Nearly all of the bare edges of the various parts were jagged and marked in a way similar to the exoskeleton of *Coelopa* sp. when these flies were preyed on by *C. xantholoma* in the laboratory. The combination of the parts remaining, e.g., a wing or leg attached to a small piece of thorax (i.e., hard parts being held together by softer parts) were not the normal ones expected if the flies were merely decomposing after a natural death. Some adults of *C. xantholoma* were fed in the laboratory on *Coelopa* sp. adults. All parts of the flies were eaten except for the wings and legs, as seemed to be true for these remains found in the field.

Backlund (1945) found that *Cafius xantholoma* kept in the laboratory ate a great variety of invertebrates both living and dead and it is likely that in the wild it eats any prey it can catch. Possibly the full-grown larva of this species eats similar food to the adult.

No observations were made in the field on the food of *Omalium rivulare* (Paykull) nor of the species of *Aleochara*. In the laboratory *O. rivulare* fed on small oligochaetes brought back from the wrack beds. *Aleochara obscurella* Gravenhorst and *A. grisea* Kraatz attacked similar small oligochaetes but neither were seen actually to feed on them.

Nine other species of Staphylinidae were found in the wrack beds at Whitburn. Not more than half-a-dozen of each were seen in three years and, if any were predators, they presumably affected the wrack fauna only slightly.

Broscus cephalotes (L.).

Broscus cephalotes is well known to be a voracious shore-frequenting species of Carabidae. At Whitburn both the larvae and adults of this species were found under wrack and stones in the wrack string. Sometimes the larvae were found in burrows in the sand with only their mandibles projecting and at other times they were seen walking over damp sand under wrack with their mandibles apart.

In the laboratory, adults and larvae fed on all kinds of food offered—adult flies of various species, larvae of *Coelopa* sp. and of *Oe. buccata*. All parts of the flies were eaten except the wings and legs. Both the larvae and adults of *B. cephalotes* were very active and they snapped their jaws at anything that moved, even at flies that were flying just above them.

Nothing is known of the feeding habits of the other six species of Carabidae, none of which occurred, however, more than twice in the wrack beds.

Cercyon litoralis (Gyllenhal).

Larvae of *Cercyon litoralis* bear well-formed jaws but no larvae were ever found with their prey and they proved difficult to keep in the laboratory. Backlund (1945) states that in the laboratory they feed on more or less soft-skinned animals such as *Pachydrilus* sp., *Enchytraeus albidus* and fly larvae.

Mites.

Five species of mites occurred in the wrack beds at Whitburn. Two of these, *Thinoseius fucicola* and *Parasitus kempersi,* were nearly always found in fairly large numbers in both the wrack strings and banks there. *Macrocheles superbus* was sometimes found in large groups of between thirty and fifty individuals, but more often only one or two occurred together. The other two species, *Molgus litoralis* and a species of Anoetidae, were very rare, only three of the former being found and about ten nymphs of the latter. These Anoetidae nymphs were found on four *Thinoseius fucicola* which were attached to the bodies of *Coelopa* sp. flies.

Thinoseius fucicola was kept in culture in 6″ × 1″ glass tubes containing only *Laminaria* and nematodes on which the mites were frequently observed to be feeding. After lifting a nematode from the wrack each mite appeared to arrange it between its mandibles so that it could be taken (possibly sucked) into the mouth longways. The mites were often seen mating in the glass tubes. The females laid ovoid eggs, usually in groups of between ten and thirty, in small cavities in the moist *Laminaria* stipes, but odd ones laid on the surface of the wrack and on moist parts of the glass tube. The eggs hatched in three to five days. The nymphs fed, like the adults, on the nematodes present in the wrack.

Parasitus kempersi is a very quick-running mite and in the laboratory has been seen preying on the nymphs of either *Thinoseius fucicola* or its own species.

Macrocheles superbus, on the other hand, is a fairly slow moving and large mite and most likely feeds on oligochaetes and nematodes. It never fed in laboratory conditions and always died within a day or two.

No observations were made on three specimens of *Molgus litoralis* found. King (1914) saw it feeding on *Thoracochaeta zosterae* and quotes the occurence of it feeding on Collembola.

Differences between Wrack Faunas due to Location and Season

The differences found in the faunas of wrack beds are due to various causes, chief of which are the geographical location of the wrack beds, their size and shape, and the position of the wrack beds on the shore. In addition to faunal differences that can be attributed to these factors, there are seasonal changes in each of the wrack beds.

Some differences due to geographical location.

Madsen (1936) investigated the shore fauna of East Greenland and compared it with the shore fauna of West Greenland and other arctic regions. Since he dealt with the whole shore fauna, animals occurring in the wrack beds are included. The number of species found in the wrack beds in these arctic regions is much less than the number occurring in the wrack beds of Sweden and Finland, and even in the much smaller locality of Whitburn. In his study of the Swedish and Finnish wrack beds, Backlund collected about 500 different species of invertebrates (excluding mites) in eleven years. The present writer collected 85 different species at Whitburn in three years. Madsen (*op. cit.*), however, mentions less than twenty wrack species from Greenland. That only a few species occur on these arctic shores must be due to the harder climatic conditions there.

The predominant wrack animals in the arctic are several species of mites and oligochaetes. In addition to these, there are some Collembola, flies of the genus *Fucellia,* and a few spiders.

Some of the more interesting differences between the wrack fauna of these three areas are now considered.

Collembola.

Collembola are very common in the wrack beds on the arctic shores and in Sweden and Finland. Madsen found six species and Backlund 35, 15 of which occurred fairly regularly. Only a few Collembola were seen in the wrack beds at Whitburn and they were all probably of the same species. This paucity in the Collembola fauna at Whitburn need not necessarily be due to geographical latitude but to some peculiarity of the Whitburn wrack beds.

Diptera.

No species of the family Coelopidae are recorded from the Greenland shores by Madsen, but *Coelopa frigida* is known to occur, however, 800 miles within the Arctic Circle at Spitsbergen (Summerhayes and Elton). The four species that occurred at Whitburn also occur in Sweden and Finland (although *C. pilipes* is not included in the list of species Backlund collected).

Several species of *Fucellia* (Muscidae) are found in the arctic shores. *F. ariciiformis* (Holmgren), *F. pictipennis* (Becker), *F. fucorum* (Fallén) and *F. intermedia* (Lund) being recorded from Greenland. *Fucellia maritima,* the only species of the genus that occurred in the wrack beds at Whitburn, is apparently not found in Greenland. No species of *Fucellia* are mentioned by Summerhayes and Elton (1923) as occurring in Spitsbergen or Bear Island.

Coleoptera.

The beetle fauna of wrack beds on arctic shores appears to be very small compared with the beetle fauna found in more

southerly wrack beds. Backlund lists 212 species from Sweden and Finland, thirty of which occurred fairly regularly. At Whitburn 27 species of beetles were found, six occurring regularly.

The only beetle Madsen mentions as occurring in seaweed on Greenland's shores is *Micralymma brevilingue*. Species of the genus *Micralymma* are well-known shore-frequenting beetles; none, however, occurred at Whitburn.

Spiders.

The spider *Erigone arctica* is recorded from the arctic shores, and from Sweden and Finland; it was found at Whitburn, too. Only one other spider (*Microphantes nigriceps*) was found by Madsen in Greenland. At Whitburn, besides *E. arctica*, there occurred five other species, but they were fairly rare. Backlund lists almost fifty species from the Swedish and Finnish wrack beds, but only three or four of them occurred regularly.

Mites.

The large red mite *Molgus littoralis* was found in great abundance in Greenland by Madsen and it is common on other arctic shores. Only three specimens were found at Whitburn. Backlund, unfortunately, does not deal with mites in his work.

Differences in the fauna of wrack strings and wrack banks.

There were several obvious differences between the fauna occurring in the extreme types of wrack beds investigated—the large wrack bank on the rocks at Whitburn and the wrack string some 150 yards south of it. The larvae of *Coelopa frigida* and *C. pilipes* were almost confined to the wrack bank, whilst those of *Oedoparea buccata* and *Helcomyza ustulata* were found only in the wrack string. The adaptations of these species to life in these different habitats have already been discussed.

Of the species of insects that were found only occasionally in the wrack beds at Whitburn, far more were found in the wrack string than in the wrack bank. Of these occasional visitors, 11 species of Diptera and 16 species of Coleoptera were found in the wrack string and only two species of Diptera and one species of Coleoptera in the wrack bank. This paucity of the non-breeding fauna in the wrack bank is presumably due to the extreme conditions prevailing in this habitat. The wrack string, on the other hand, has a wider variation in its physical properties and is, therefore suitable to a larger number of species. Many of the occasional visitors to the wrack string were actually found on the sand underneath the wrack and probably it is the protective value of the covering of wrack that is important here.

Differences due to the position of the wrack beds on the shore.

On several occasions two or three wrack beds were found on the shore at different levels seawards of the main wrack bank on the rocks at Whitburn.

The most seaward of these wrack banks existed for only a few hours between successive tides. The only animals found in them were nematodes and these only in very small numbers. The wrack banks farther up the shore contained amphipods and oligochaetes as well as the nematodes, but only the most landward of the wrack banks contained the various insect species and their larvae.

Seasonal variation in the fly fauna of the Whitburn wrack beds.

Although there were many changes in the fauna of the wrack beds during the year, only the changes in the fly species will be mentioned.

The change from one dominant species of fly to another always occurred fairly quickly, within about ten days, the decline in the number of one species being accompanied by the sudden emergence of large numbers of the other. As has been shown (Egglishaw, 1960a) *Coelopa frigida* was present chiefly from October to early January and *C. pilipes* from early January to March. Adults of *Orygma luctuosa* were present for about one month (in September) before the large winter *Coelopa* spp. population and for a month after (in May). The other Coelopid, *Oedoparca buccata,* was present as adults from October to January but was found only in the wrack string. Only on one or two days in October were adults of all four Coelopids found together. At this time *O. luctuosa* was in its decline and *Oe. buccata* adults had just emerged.

The chief summer species of fly was *Fucellia maritima* which was found as adults from the end of March to September, the period in which the *Coelopa* spp. were comparatively scarce. *Helcomyza ustulata* was also a summer species, being found as adults in June and September, but it occurred in much smaller numbers than *F. maritima.*

Some Effects of the Weather

The wrack animals suffered great losses at times when excessive high water either invaded or destroyed the wrack beds. These high tides had their most disastrous effects on the large winter populations of larvae of *Coelopa frigida* and *C. pilipes* in the wrack banks at the foot of cliffs near St. Mary's Island. On several occasions, all or large parts of these wrack banks were carried out to sea and the fly larvae and most of the animals they contained were presumably drowned. The species involved, however, quickly re-established themselves in new wrack beds that were formed. On 28th October 1955 vast numbers of *C. frigida* larvae were seen in the wrack banks near St. Mary's Island. The sea was very stormy the following day and most of the wrack banks were carried out to sea. The wrack that remained and the nearby shingle was flooded with water. No *Coelopa frigida* larvae and

only five adults were found in two hours collecting. By 18th November 1955, however, the population was re-established, thousands of larvae and adults of *C. frigida* being found in the newly-formed wrack beds. Similar destruction of the wrack beds and the subsequent restoration of the fauna in newly-formed beds occurred on several other occasions near St. Mary's Island.

At Whitburn excessively high tides were not so immediately disastrous as those near St. Mary's Island. At Whitburn the wrack beds were usually pulled down the shore by the ebbing tide. Some fly larvae usually managed to remain attached to the wrack which was cast up beyond the high-tide level at the following high tide. Many larvae, however, were washed out of the wrack and left stranded on the sand. In this exposed position they were soon eaten by the various birds present on the beach.

On 15th December 1955, some *C. frigida* larvae which had been washed out of the wrack banks at Whitburn were found in very wet wrack near the low-tide line and some were found submerged in seawater in a nearby depression in the sand. Although in the laboratory larvae of *C. frigida* and of *Thoracochaeta zosterae* can survive being entirely immersed in seawater for at least twenty-four hours, it is difficult to see how larvae washed out of the wrack beds and separated from them by several yards can regain them safely. This ability to survive periods of immersion in seawater would, however, be of great value in cases where the high water floods the wrack beds without destroying them.

During periods of strong wind the sand in the bay at Whitburn was blown along the shore and accumulated round the wrack string. At times the wrack string became buried in sand with only small pieces of wrack showing above the surface. This covering of their habitat with sand did not seem to affect the wrack fauna deleteriously, however, as living adults and larvae of *Fucellia maritima, Oedoparea buccata* and *Orygma luctuosa* were at some time found under the sand. The wrack bank on the rocks at Whitburn was occasionally covered with large amounts of shingle that had been washed there by high water, but this did not appear to affect the animals in the wrack bed.

The wrack beds being warmer than the surrounding air (Egglishaw, 1960a) allows certain flies to continue breeding during the winter months. Larvae of *Coelopa frigida, C. pilipes* and *Thoracochaeta zosterae* have been found active in the wrack beds when the air temperature was 0°C. At this temperature, however, the adults of *C. frigida* and *C. pilipes* are lethargic; and although they vibrate their wings they are unable to fly, while *T. zosterae* makes only very short flights of 3-6 inches. *Oedoparea buccata,* although rare during the cold weather, has been seen flying when the air temperature was 1°C. The larvae of this species in the wrack string hardly move at all when the weather is so cold. The only species of wrack animal found hibernating in groups at Whitburn was the beetle *Cercyon litoralis.*

List of Species found in the Wrack Beds

Most of the animals found in the wrack beds were identified. Only the nematodes and oligochaetes and about ten other species of very rare occurrence are not included in this list. The number in the bracket refers to the number caught on each occasion.

wb = wrack bank; ws = wrack string; wf = wrack flake

Isopoda

Ligia oceanica B. and W. Whitburn, ws, 7.xi.55 (1); 3.ix.56 (1).

Amphipoda

Orchestia gammarella Pallas, Whitburn, wb chiefly, common throughout the year. St. Mary's Island, wb, common. Llandudno, ws, 10.viii.56, common. Furness, ws, 8.viii.57.
Gammarus marinus B. and W. St. Mary's Island, wb.

Chilopoda

Several specimens found in wrack string at Whitburn in spring.

Dermaptera

Forficula auricularia L. Whitburn, ws, 3.ix.56 (3f); 8.vii.57 (1f); 16.vii.57 (1f).

Lepidoptera

Tinea pallescentella Stn. Whitburn, ws, 27.ix.56, larvae.

Coleoptera

Carabidae

Broscus cephalotes L. Whitburn, ws, 30.iv.57 (1); 15.v.57 (3); 21.v.57 (1); 11.vi.57 (2); 20.vii.57 (1). Larvae, on sand under wrack at Whitburn, October to May.
Bembidion ustulatum L. Whitburn, ws, 1.vi.56 (1).
B. obtusum Serville. Whitburn, ws, 21.i.57 (1).
Amara spreta Dejean. Whitburn, ws, 15.x.56 (1).
A. familiaris Duftsch. Llandudno, ws, 10.viii.56 (1).
A. apricaria Payk. Whitburn, ws, 17.ix.56 (1); 1.vii.57 (1).
A. convexiuscula Mrsh. Bamburgh, ws, 3.ix.57 (1).
Agonum dorsalis Pont. Whitburn, ws, 14.vi.56 (1).
Loricera pilicornis Fab. Whitburn, ws, 24.ix.57 (2).

Dytiscidae

Agabus unguicularis Thomson. Whitburn, ws, 20.ix.56 (1).

Hydrophilidae

Cercyon litoralis Gyll. Whitburn, ws and wb, common throughout the year. St. Mary's Island, wb. Larvae from July to October.

Ptilidae

Ptenidium punctatum Gyll. Whitburn, in a small clump of densely packed wrack from wrack string, 8.vii.57 (14).

Staphylinidae

Omalium rivulare Payk. Whitburn, common throughout the year in all types of wrack accumulations.
Philonthus cephalotes Grav. Whitburn, ws, 4.x.56 (2); 30.iv.57 (1).
P. tenuicornis M. and R. Whitburn, ws, 20.ix.56 (1).
Creophilus maxillosus L. Whitburn, ws, 15.v.57 (1).
Cafius xantholoma Grav. Whitburn, ws and wb, common throughout the year, sometimes up to 100 being found together. Larvae found all the year. St. Mary's Island, common in wb.
Quedius cinctus Payk. Whitburn, ws, 3.ix.56 (1). St. Mary's Island, wb. 4.x.55 (1).
Q. tristis Grav. Whitburn, ws, 3.ix.56 (1).
Tachyporus hypnorum Fab. Whitburn, wf, 1.vi.56 (1); ws, 17.ix.56 (2), 15.v.57 (1).
Aleochara obscurella Grav. Whitburn, ws chiefly, April to November. Bamburgh, ws, 3.ix.57 (3).
A. grisea Kr. Whitburn, ws chiefly, throughout the year. St. Mary's Island, 24.vi.57 (5).
A. algarum Fauv. Whitburn, ws 8.vii.57 (2), 28.vii.57 (2). St. Mary's Island, wb, 24.vi.57 (10).
Gauropterus linearis Oliv. Whitburn, ws, 17.ix.56 (1), 26.xi.56 (1).
Carpelimus corticinus Grav. Whitburn, wb, 21.vi.56 (1).

Coccinellidae

Coccinella 7-punctata L. Whitburn, ws, 18.x.55 (2), 14.vi.56 (2).
Adalia 10-punctata (L.). St. Mary's Island, 13.x.55 (1).

HYMENOPTERA

Cynipidae

Nedinoptera subaptera Walk. Whitburn, a few found in all types of wrack beds throughout the year, was very common in July 1957. Bamburgh, ws, 3.ix.57. (1).

Diapriidae

Platymischus dilatatus Wast. Whitburn, ws and wb, often found from July to October; was very common in July 1957.

Ichneumonidae

Alomya debellator F. Whitburn, ws, 3.ix.56 (1f).
Thersilochus sp. St. Mary's Island, 4.x.55 (1f).

DIPTERA

Tipulidae

Tipula czizeki de Jong. Whitburn, ws, 8.x.56 (1).

Bibionidae

Dilophus febrilis L. Whitburn, wb, 1.vi.56 (2). St. Mary's Island, wb, 13.x.55 (3).

Scatopsidae

Scatopse notata L. Whitburn, ws, 1.vi.56 (1).

Mycetophilidae

Sciara quinquelineta Macquart. Whitburn, ws, May-June and September-October, fairly common. St. Mary's Island, rarer.

Empidae

Tachista arrogans L. Whitburn, ws, 7.vi.57 (1).
Chersodromia hirta Walk. Whitburn, all types of wrack beds, June to September, common. Llandudno, ws, 10.viii.56 (14).
C. difficilis Lund. Llandudno, ws, 10.viii.56, fairly common.
C. arenaria Hal. Whitburn, all types of wrack beds, June to September, common.
C. incana Walk. Llandudno, ws, 10.viii.56, fairly common. Bamburgh, ws, 3.ix.57, fairly common.

Lonchopteridae

Lonchoptera lutea Panzer. Whitburn, ws, 23.xi.55 (2f), 29.x.55 (2f), 15.xii.55 (1f), 8.x.56 (1f), 12.xi.56 (1m), 19.xii.57 (1m).

Syrphidae

Eristalis tenax L. St. Mary's Island, wb, 13.x.55 (1f).

Piophilidae

Piophila vulgaris Fallen. Whitburn, ws, 20.ix.56 (1m).

Dryomyzidae

Helcomyza ustulata Curt. Whitburn, ws and wf, June and September, fairly common. Bamburgh, on sand seawards of a wrack string, 3.ix.57 (16). Llandudno, ws, 10.viii.56, fairly common. Larvae. Whitburn, ws, July to October; Llandudno, ws, 8.viii.56.

Coelopidae

Coelopa frigida (Fab.). Whitburn, large numbers from October to January, fewer from then till March, small

number March to September. Larvae, Whitburn, chiefly in large wrack banks from September to December. Large numbers of larvae and adults were also found near St. Mary's Island.

C. pilipes Haliday. Whitburn, large numbers from mid-January to March. Larvae, Whitburn, chiefly in large wrack banks from December to February. Adults and larvae also present near St. Mary's Island.

Orygma luctuosa Meigen. Whitburn, common in wrack string and small wrack banks, April-May and in September, a few about in June and October-January. Larvae, Whitburn, in small wrack banks chiefly in May, September and October.

Oedoparea buccata (Fallen). Whitburn, ws, chiefly from October-December Larvae, October-March.

Borboridae

Thoracochaeta zosterae Haliday. Whitburn, wrack beds, commonest fly throughout the year. St. Mary's Island, very common all the year round.

T. brachystoma Stenh. Whitburn, ws, late January-early March 1956, fairly common.

Copromyza nigra (Meigen). Whitburn, ws, 21.v.57 (3).

Copromyza similis Collin. Whitburn, ws, 26.ii.56 (2); 26.xi.56 (1); 8.v.57 (1); 21.v.57 (fairly common); 6.vi.57 (2).

C. nitida Meigen. Whitburn, ws, 16.ii.56 (1); 23.ii.56 (1).

Borborus ater Meigen. Whitburn, ws, 29.xi.55 (1).

Sphaerocera subsultans L. Whitburn, ws, 23.ii.55 (7); 12.i.56 (1); 16.ii.56 (1); 21.v.57 (5); 6.vi.57 (1); wb, 17.ix.56 (1).

Calliphoridae

Calliphora erythrocephala R.-D. Whitburn, wb, 7.ix.57 (2). St. Mary's Island, wb, 13.x.55 (1); Hart, 19.x.56 (1).

Lucilia sericata Meigen. Llandudno, ws, 10.viii.56 (4f).

Muscidae

Fucellia maritima Haliday. Whitburn, all types of wrack beds, March to September (common), October and November (few). St. Mary's Island, March to September (common). Cullercoats, fresh wrack bank, 12.vi.56. Horden shore devoid of wrack, 24.iv.56. Hart, 19.x.56. Llandudno, ws, 10.viii.56. Larvae, Whitburn, ws and small wb, from April to October. Furness coast, in ws of filamentous green seaweed, 8.viii.57.

Fannia canicularis L. Larvae, Whitburn, ws, 27.ix.56 (c. 140); 4.x.56 (1).

Cordyluridae

Scatophaga stercoraria L. Whitburn, ws and small wb, September to November (often fairly common); March to April (fewer). A large number attracted to rapidly decomposing wrack, 17.ix.56 and 20.ix.56. Hart, 19.x.56 (11).

Araneida

Erigone arctica (White). Whitburn, ws and wb, March to October, two or three often present, sometimes fairly common.

E. dentipalpis (Wider). Whitburn, ws, 30.vii.57 (3m, 1f).

Lephyphantes tenuis (Blackwell). Whitburn, ws, 31.x.57 (6f, 1m).

Ostearius melanopygius (O.P.-C.). Whitburn, ws, 8.vii.57 (1f); 24.ix.57 (1m).

Centromerita sp. Whitburn, 31.x.57 (2f).

Opiliones

Opilio parietinus (De Geer). Whitburn, ws, 30.iv.57 (8), odd ones in May and June 1957.

Acarina

Thinoseius fucicola (Halbert). Whitburn, in all kinds of wrack beds and phoretically on various fly species, chiefly Coelopidae (Egglishaw, in press). Always common.

Parasitus kempersi Oudemans. Whitburn, in all kinds of wrack beds, common all the year.

Macrocheles superbus Hull. Whitburn, ws and wb, May-September, a few could usually be found. On occasions 30-50 occurred close together in the wrack.

Molgus littoralis (L.). Whitburn, wb, 27.vi.56 (1); 1.vii.57 (1); 8.vii.57 (1). Some Anoetidae deutonymphs were found on occasions attached to the mite *T. fucicola* when this species was found on various flies.

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References

Backlund, H. O. 1945. Wrack fauna of Sweden and Finland, Ecology and Chorology. *Opusc. ent., Suppl.*, **5**: 1-236.

Egglishaw, H. J. 1960a, Studies on the family Coelopidae (Diptera). *Trans. R. ent. Soc. Lond.*, **112**: 109-140.

———. 1960b. The life-history of *Helcomyza ustulata* Curt. (Dipt., Dryomyzidae). *Ent. mon. Mag.*, **96**: 39-42.

———. 1960c. The life-history of *Fucellia maritima* (Haliday) (Diptera, Muscidae). *Entomologist*, **93**: 225-231.

———. 1961a. Mass Migrational Flights of *Coelopa frigida* (Fabricius) and *C. pilipes* Haliday (Diptera, Coelopidae) and *Thoracochaeta zosterae* Hal. (Diptera, Sphaeroceridae). *Entomologist*, **94**: 11-18.

———. 1961b. The life-history of *Thoracochaeta zosterae* (Hal.) (Dipt., Sphaeroceridae). *Ent. mon. Mag.*, **96**: 124-128.

———. (In press.) The phoretic habit of the mite *Thinoseius fucicola* (Halbert). *Ent. mon. Mag.*

Halbert. 1920. The Acarina of the seashore. *Proc. roy. Irish Acad.*, **31**.

Keys, J. H. 1918. A list of the Maritime, Sub-Maritime and Coast-frequenting Coleoptera of South Devon and South Cornwall. *Journ. Marine Biol. Ass. U.K.*, **11** (N.S.).

King, L. A. L. 1914. Notes on the habits and characteristics of some littoral mites of Millport. *Proc. R. Phys. Soc. Edinburgh*, **19**: 6.

Lindroth, C. H. 1931. Die Insektfauna Island und ihre Probleme. *Zool. Bidr. Upsala.*, **13**.

Lundbeck, W. 1910. *Diptera Danica. Vol.* **3**. London.

Madsen, H. 1936. Investigations on the shore fauna of east Greenland with a survey of the shores of other arctic regions. *Medd. om. Gronland*, **100**: 8.

Meyrick, E. 1895. *A Handbook of the British Lepidoptera.*

Scott, H. 1920. Notes on (1) the parasitic staphylinid *Aleochara algarum* Fauvel. and its hosts, the Phycodromid flies. *Ent. mon. Mag.*, **56**: 148-156.

Summerhayes, V. S. and Elton, C. S. 1923. Contributions to the ecology of Spitsbergen and Bear Island. *J. Ecol.*, **11**: 214-86.

Yerbury, J. W. 1919-22. Seashore Diptera. *Journ. Marine Biol. Ass. U.K.*, **12** (N.S.).