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# EUPLOTES ALATUS, A HYPOTRICHOUS CILIATE NEW TO GREAT BRITAIN

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## Introduction

During the course of a study of the biology of the burrowing brackish-water sea anemone *Nematostella vectensis* Stephenson, 1935, it was noticed that almost every anemone had between one and five hypotrichous ciliates moving over the surface of its column. Examinations of large numbers of these Protozoa showed that they were all of the same species, *Euplotes alatus* Kahl, 1932. The identification was made on the basis of observations on living specimens using either lightfield or phase contrast microscopy and of examination of specimens fixed and stained by the nigrosin–$HgCl_2$–formalin method (Borror, 1968a).

## Observations

Specimens of *E. alatus* were obtained with *N. vectensis* in October, 1971, from two ponds in Norfolk, England; Abraham's Creek (Ordnance Survey Map Reference TF 909453) and Half Moon Pond (TG 049452). Water samples taken from just above the mud substrate in May and October, 1971, had total salinities from 9.3 to 25.1‰ w/w in Abraham's Creek, and from 29.3 to 33.0‰ w/w in Half Moon Pond. Total salinities were estimated by evaporating 100 g. water to dryness.

The body shape and distribution of the ciliary organelles in ventral view (Fig. 1) were almost identical to those of the form shown in Fig. 18.17 of Kahl's (1933) review of the Euplotidae. Furthermore, the optical cross-section and the five characteristic dorsal ribs described by Kahl (1933) in Fig. 18.18a and Fig. 18.18 respectively were typical of the presently described specimens. The size range observed (66–100 $\mu$) was slightly greater than that of Kahl's (1933) population (75–90 $\mu$). The only notable difference between the present *E. alatus* and that described by Kahl (1933), is in the positions of the four caudal cirri which were grouped rather more closely together here (Fig. 1) than in Kahl's specimens.

Specimens described by Borror (1968b) as *E. alatus* differed from the present population in body shape and in the relative positions of the fronto-ventral cirri (see Borror's Fig. 11), as well as in the size range (36–43 $\mu$), and in having four or five caudal cirri.

Mud samples from both Abraham's Creek and Half Moon Pond contained specimens of *E. alatus* identical in form to those seen on *Nematostella*.

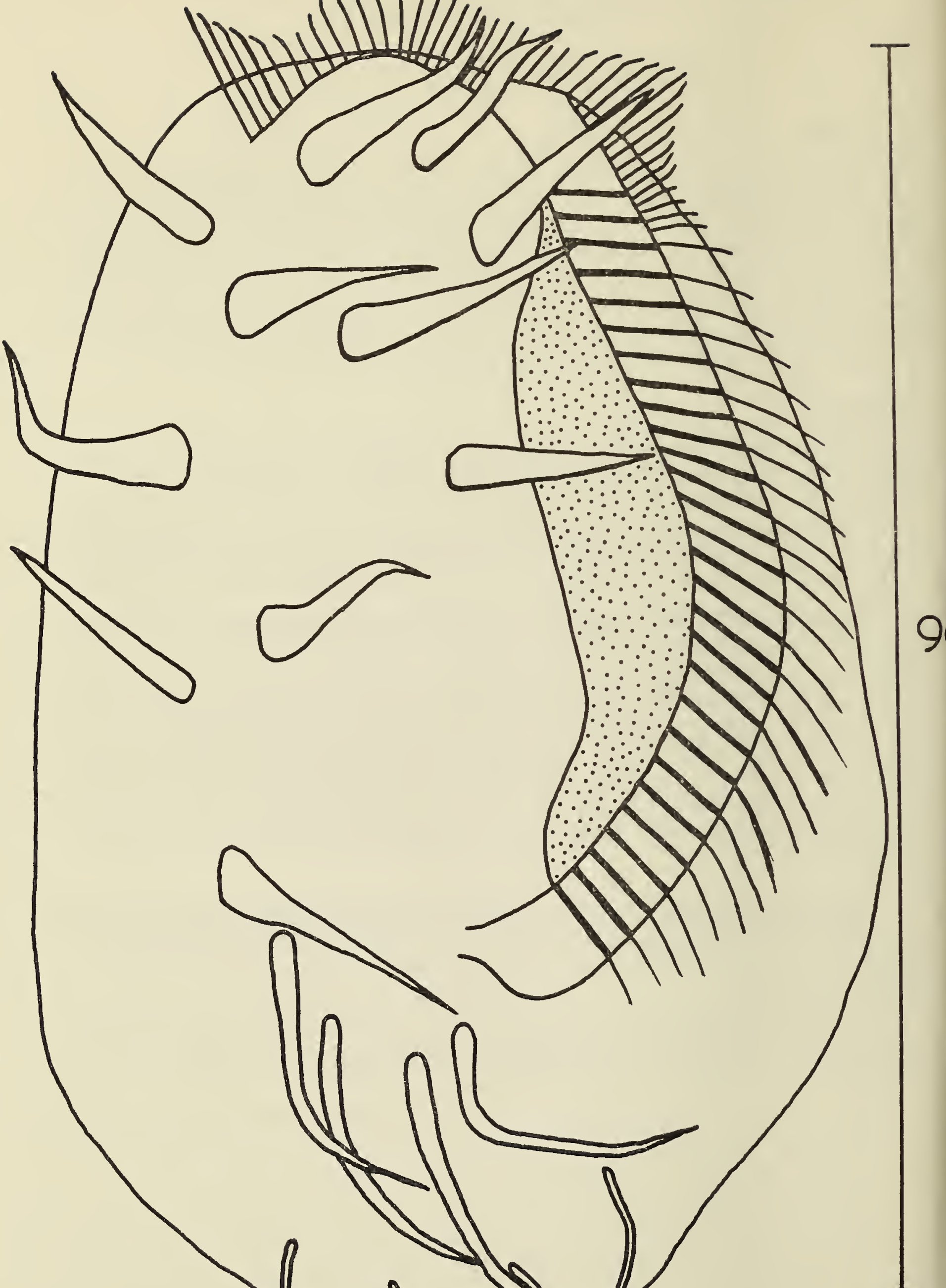

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Fig. 1. *Euplotes alatus*, a hypotrichous ciliate new to Great Britain.

### Discussion

Until now, *E. alatus* has been recorded only from Helgoland, Germany (Kahl, 1933) and from New Hampshire, U.S.A. (Borror, 1968b). Borror (1968b) considered that the species studied by Gelei (1938), and ascribed to *E. alatus*, was not, in fact, this species. The present report is therefore probably only the second since the original description of the species, and the first from Great Britain.

Of particular interest is the fact that *E. alatus* was so often observed on the column of the sea anemone *N. vectensis*. Such an association has not been reported previously, although André (1910) found *E. charon* in the gastrovascular cavity of the sea anemone *Sagartia parasitica* and on the surface of the sea urchin *Echinus esculentus*. Several species of *Euplotes* have also been found with marine sponges (Wenzel, 1961), but a strict relationship between Protozoa and sponges could not be established, and the observed association was interpreted as facultative commensalism.

Inquiline relationships have been demonstrated between *E. balteatus* and the echinoids *Allocentrotus fragilis* (Berger and Profant, 1961), *Strongylocentrotus droebachiensis* (Beers, 1948, 1954 and 1961, and Berger, 1960), *S. franciscanus* and *S. purpuratus* (Berger, 1961); and between *E. tuffraui* and *A. fragilis*, *S. echinoides* and *S. purpuratus* (Berger, 1965). *E. tuffraui* has been recorded only from the digestive tracts of sea urchins (Berger, 1965), but *E. balteatus* may be echinophilous or free-living and Berger (1965) considers that *E. tuffraui* and echinophilous populations of *E. balteatus* are undergoing a transition from a facultative to an obligatory entocommensal existence.

Since mud samples were found to contain specimens of *E. alatus* identical in form to those seen on *Nematostella*, it would be imprudent to term these present populations of *Euplotes* as true commensals, but they might be described, similarly to those found with marine sponges (Wenzel, 1961), as facultative commensals. It may be that the mucus secreted by *Nematostella* constitutes a particularly suitable environment for the multiplication of bacteria on which *E. alatus* might feed. If this is the case, the transition of *E. alatus* from a facultative to an obligatory ectocommensal might conceivably occur under suitable conditions.

### Acknowledgements

I am grateful to Dr. C. R. Curds of the British Museum (Natural History) who confirmed my identification of *E. alatus* and read this manuscript. Dr. R. Hamond originally drew my attention to the existence of *N. vectensis* in Norfolk, which led to the discovery of *E. alatus*.

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Fig. 1. Semi-diagrammatic ventral view of *Euplotes alatus* Kahl, 1932 from Half Moon Pond, Norfolk, England showing the positions of cirri and membranelles. The stippled area indicates the extent of the buccal cavity. Stained by the nigrosin–$HgCl_2$–formalin method and drawn to an accuracy of $\pm 1.7\ \mu$ using an eyepiece grid.

# THE SIGNIFICANCE OF SALINE LAGOONS AS REFUGES FOR RARE SPECIES

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## Introduction

Brackish water habitats can be divided into two groups; estuaries, and temporary or permanent lagoons more or less isolated from the sea. Whilst much work has been carried out on the biology of estuarine animals (see Green, 1968; Eltringham, 1971), relatively little has been published on lagoons. The few detailed studies include those of Howes (1939), Hunt (1971) and Williams (1972).

Despite some broad similarities between the two types of habitat, such as the generally lower salinity than that of the sea and their sheltered aspects, there are some essential differences. Firstly, changes in the water level of lagoons occur only gradually as the result of heavy rainfall or evaporation, whereas estuaries, being under tidal influence, are subject to a regular cycle of exposure and submersion. Secondly, lagoon salinities tend to be fairly constant for any one locality, although in periods of severe drought they may become more saline than sea water and are thus correctly termed poikilohaline rather than brackish (see Williams, 1972). Comparing different localities, however, lagoon salinities may cover a very wide range of concentrations. On the other hand, habitats within an estuary may be subjected to the complete range of salinity from fresh water to sea water in one tidal cycle. Although both types of habitat are relatively sheltered, fast tidal flow in estuaries can sometimes make some places uninhabitable by certain species due to the disturbing influences of the currents. Clearly then, the fundamental difference between a lagoon and an estuary is in the stability of the physical environment. It will be shown later that variations (either between localities or temporal) in the salinities of lagoons may be relatively unimportant to at least some species of organism, the significance of the lagunar habit lying probably in the extremely sheltered environment provided.

Boyden (1969) relates the occurrence of lagoons around the English coasts to the distribution of alluvial deposits, and points out that with the advent of sea walls in about the thirteenth century, the number of lagoons has gradually been reduced. The threat of losing such habitats to land reclamation schemes is increased by the problem of pollution. The accurate plotting of geographical distributions of lagunar flora and fauna has always been a difficult task, since so few people work on such habitats. Hence it is difficult to relate existing records with biological reality, and many gaps in our knowledge are due simply to nobody having examined the appropriate habitats. It is to be hoped, therefore, that more attention might be paid to lagoons by biologists and that such sites might become focuses of attention for conservationists. The purpose of this paper is to illustrate the importance of the preservation of lagoons with examples of their significance as refuges for some selected species, and to draw attention to the present state of some Norfolk lagoons threatened by pollution.

## The significance of lagoons to some selected species

Lagunar faunas may vary in different places, but some species at least appear to be practically ubiquitous in north Norfolk lagoons. In particular, the crustaceans *Corophium volutator* (Amphipoda) and *Idotea chelipes* (Isopoda) should be mentioned. However, other lagunar species will be discussed below which, as far as is known, present discontinuous distributions, and some possible reasons will be given for this.

(a) *Cerastoderma glaucum* (Lamellibranchia). The ecology of this cockle has been described by Boyden (1969), who suggests that since this species lives in the almost tideless Baltic and Mediterranean Seas, as well as in brackish lagoons in Britain, low salinity may not be essential; continual submersion in stagnant saline water may be the primary requirement of the animal. This hypothesis is consistent with the presence of *C. glaucum* in lagoons with such different salinities, e.g. Titchwell Lagoon (Williams, 1972), with a recorded salinity range of 30.1–57.8‰; Holkham Salts Hole (salinity 24.9–28.9‰) (Hunt, 1971); and Abraham's Bosom, Wells (Boyden and Russell, 1972), in which salinities as low as 13.3‰ have been recorded. (It is very probable that the record of *C. edule* as the "dominant benthonic animal" in Abraham's Bosom (Hamond, 1972) is based on a misidentification. A careful search on 7.1.73 failed to reveal any cockles other than *C. glaucum*).

Boyden (1969) considers that the present *C. glaucum* sites are remnants of a previously much wider distribution and that the drowning of marshland and replenishment of lagoons with saline water at the times of storm surges play some part in spreading the cockle from lagoon to lagoon. It is suggested by Boyden and Russell (1972), however, that the dispersal of *C. glaucum* is best accounted for by migrating wildfowl transporting the spat on aquatic vegetation. Further land reclamation will make this rare cockle even rarer. The few tidal populations (see Boyden and Russell, 1972, Appendix 2), may then become of relatively greater importance in potentiating the species in Britain.

(b) *Nematostella vectensis* (Anthozoa). This exceedingly rare sea anemone has so far been recorded in Britain only in brackish lagoons at Bembridge, Isle of Wight (Stephenson, 1935); Shinglestreet, Suffolk (Robson, 1957); and in Norfolk by Dr. R. Hamond in Abraham's Bosom, Wells and in Half-Moon Pond, Cley and by myself in Abraham's Creek, which is connected to Abraham's Bosom by a ditch. The only other published records of this species are from California, U.S.A. (Hand, 1957) and the Atlantic coast of North America (Crowell, 1946; Bailey and Bleakney, 1966), all from brackish lagoons.

*N. vectensis* is a small (usually $< 2$ cm. long) anemone which usually lives buried in mud with only the tentacle crown exposed, but it is sometimes found attached to vegetation by its physa. A lagunar habitat is possibly essential to *Nematostella* since it may be the only environment where suitably undisturbed mud may be found. Salinity may be of only secondary importance, since this anemone appears to be tolerant of a very wide range (see Table 1). It seems possible that the method of colonisation is similar to that of *C. glaucum*, i.e. directly from lagoon to lagoon (either on weed carried by wildfowl or carried by storm surges), especially as the anemone has never been recorded from the shore; and that the present distribution represents fragments of a previously wider distribution.

TABLE 1

Recorded salinity ranges of *Nematostella vectensis* habitats in Britain

| Lagoon | O.S. Map reference | Salinity range (‰) | Authority |
|---|---|---|---|
| Bembridge, Isle of Wight | SZ 637882 | 11.1–49.1* | Stephenson, 1935 |
| Shinglestreet, Suffolk | TM 359409 | 20.3–25.8* | Robson, 1957 |

| | | | |
|---|---|---|---|
| Abraham's Bosom, Norfolk | TF 912453 | 13.3–30.4 | Present author and Boyden & Russell, 1972 |
| Abraham's Creek, Norfolk | TF 909453 | 9.3–25.1 | Williams, 1973 |
| Half-Moon Pond, Norfolk | TG 049452 | 29.1–33.0 | Present author |

*Converted from % NaCl.

(c) *Haliplanella luciae* (Anthozoa). The geographical distribution of this sea anemone is circumboreal and it occurs on both sides of the Pacific and Atlantic, and in the North Sea, the Mediterranean and the Adriatic. In Britain the species is rather rare and is found frequently, though not always in brackish water, often attached to vegetation, such as *Zostera* or *Ruppia*. In California, Hand (1955) found it always in sheltered bays or estuaries. Crowell (1946) found it with *N. vectensis* in a brackish lagoon at Woods Hole, U.S.A., and it is also present with this species at Shinglestreet, Suffolk (personal communication from Dr. E. A. Robson). The records of *Haliplanella* from British lagoons are listed in Table 2. All other British records are also from sheltered positions, such as estuaries, bays or docks.

TABLE 2

Lagunar habitats recorded for *Haliplanella luciae* in Britain

| Lagoon | O.S. Map Reference | Authority | Whether still present |
|---|---|---|---|
| Pagham, Sussex | Not known* | G. C. Robson (Specimens in Natural History Museum. Reg. No. BM(NH)1920.3.27. 1–10) | Not known |
| New England Creek, Essex | Between TQ 967904 and TQ 983894 | Howes, 1939 | Not known |
| Shinglestreet, Suffolk | (1) TM 363421<br>(2) TM 373437<br>(3) TM 359409 | G. B. T. Abbott (Personal communication, 18.3.71)<br>Dr. E. A. Robson | No-lagoon dried up. Yes<br>Not known |
| Salthouse, Norfolk | (1) TG 062447**<br>(2) TG 067446** | Gurney, 1923 | Probably not |
| Titchwell, Norfolk | TF 765448 | Williams, 1972 | Yes |

*May be SZ 884970 in which Boyden and Russell (1972) recorded *Cerastoderma glaucum*.

**Lagoons in the proximities of these locations were searched in June, 1971 (see p. 389), but it is not possible to be absolutely certain that they are the same lagoons as Gurney's (1923).

Since, in Japan and America, *H. luciae* is typically an intertidal rocky shore form, and in Britain it is also to be found on the shore, it is clear that the lagunar habitat is not as critical for the survival of this species as it is for *C. glaucum* or *N. vectensis*. However, since the species is so uncommon in Britain, the loss of any habitat constitutes a serious threat to the continued existence of this anemone on our coasts. In an attempt to discover whether *H. luciae* lives in any further lagoons on the north Norfolk coast, a number of likely habitats were searched during June, 1971, but without success.

The habitats were: (1) Pools on the beach and in marshes in the region of Holme-next-the-Sea (TF 702444). (2) Small lagoon at Titchwell (TF 763449). (3) Large lagoon at Overy Staithe (TF 854450). (4) Abraham's Bosom and Abraham's Creek at Wells-next-the-Sea. (5) Half-Moon Pond and another marsh pond (TG 048449) at Cley-next-the-Sea. (6) Salthouse Broads (cf. Gurney, 1923) – TG 062447 and TG 067446. (7) Three ponds surrounding Gramborough Hill (TG 087443). Clearly, such "negative records" are never unequivocal, but the probable rarity of *Haliplanella* on this coast was confirmed.

*H. luciae* is a recent addition to the British fauna, having arrived (probably on the bottom of a ship) in Millbay Docks, Plymouth in 1896 (Walton, 1908). Gurney (1923) speculated that it arrived in the Salthouse Broads in 1897, probably from an independent source. The widely scattered British records of this anemone probably represent several separate introductions rather than remnants of a well established continuous distribution. It is likely that the dispersal of *H. luciae* over the Northern Hemisphere has been greatly assisted by Man, possible modes of transport being with oysters (Verrill, 1898) or on the bottoms of ships (Stephenson, 1935). Subsequent to these types of dispersal, the initial colonisation of lagoons has probably been from the sea or from estuaries, but further colonisation of lagoons may have been brought about by storm surges (see Gurney, 1923) or by transport on weed by wildfowl similarly to *N. vectensis* and *C. glaucum.*

(d) *Zostera marina* (Phanerogam). This plant appears to require more or less continual immersion. It is a euryhaline species and is found usually in sheltered habitats in bays and estuaries.

In Norfolk, it has become established in Titchwell Lagoon (Williams, 1972) and also in Abraham's Bosom, Wells, which is completely isolated from the sea. Hamond (1972) reported a *Ruppia* species in the latter habitat, but I have never found any *Ruppia* here and it is possible that a misidentification is involved (personal communication from Dr. R. Hamond, 12.8.72). *Z. marina* is not uncommon but its presence in lagoons is notable considering that it is really a marine form.

(e) *Ruppia cirrhosa* (Phanerogam). Though said to be rather rare, this plant is widespread in salt-marsh pools and brackish ditches, and occurs in Holkham Salts Hole (Hunt, 1971), in Titchwell Lagoon (Williams, 1972) and in Half-Moon Pond, Cley. Whilst the tolerated salinity range of *Z. marina* is from marine to brackish water, that of *R. cirrhosa* is from brackish to fresh water. The occurrence of both species together, as in Titchwell Lagoon, is therefore considered to be peculiar to brackish habitats (den Hartog, 1970).

It is concluded from the preceding observations that *C. glaucum*, *N. vectensis*, and *H. luciae*, despite their diverse modes of life, have one requirement in common, i.e. a sheltered habitat. Based on the known habitats of these species, dependence on lagoons for their survival is probably as follows:—*N. vectensis* > *C. glaucum* >*H. luciae.* It appears that *N. vectensis* may be an obligate lagunar species whilst *H. luciae* is a facultative lagunar species, as is the plant *Z. marina.* All four species are markedly euryhaline. *R. cirrhosa* is never marine.

**The importance of preserving brackish lagoons**

Conservationists are continually expressing concern with preventing the extinction of rare species of mammals and birds. To the marine biologist, however, rare invertebrates are of equal importance. Often, in the case of an uncommon species, little is known of its biology, simply because of the difficulty of obtaining experimental animals. If a particular species is dependent on a specific type of habitat for survival, it is clearly of importance to preserve the few known habitats, otherwise further information on the species may never be available to Science. Work is in progress at present on the biology of *N. vectensis* in Half-Moon Pond, Cley, but unless a careful watch is kept over this habitat, it might soon be polluted by the recently increasing amounts of building and agricultural refuse being dumped in and around it.

A survey of Abraham's Bosom on 7.1.73 revealed that this habitat is already becoming badly polluted. Large areas of the bottom were covered by a grey gelatinous mass, and in certain parts a foul smell was evident even without the bottom-mud being disturbed. *N. vestensis* was not found where Dr. R. Hamond first discovered it, in the north-east corner of the lagoon; nor where I subsequently found it, where Abraham's Creek joins the lagoon. At both these places, hundreds of empty *C. glaucum* shells littered the bottom: I found only one live specimen. Abraham's Creek and the southern end of Abraham's Bosom appear to be relatively unpolluted as yet. Thus, at least two, and possibly three, of the only five known habitats of *N. vectensis* in Britain are threatened by pollution.

A further reason for the preservation of lagoons is that unless records are made of their fauna, the distribution of many lesser known species might never be fully worked out before they become extinct in certain areas due to pollution or land reclamation. Species of animals new to Britain are still being discovered in brackish habitats in Norfolk (Hamond, 1972; Williams, 1973).

There are occasions, however, when changes, natural or otherwise, in the environment of a lagoon might provide interesting research opportunities. Hamond (1972) has already pointed out the desirability of monitoring the continued growth of pollution in Abraham's Bosom. After Titchwell Lagoon was drained early in 1971 and the breaches in the sea wall were repaired, it was thought that all the indigenous flora and fauna had perished (Williams, 1972). Several small pools were left after mud was removed from the lagoon bed to shore up the sea wall. Searches of these pools during 1971 and in early 1972 failed to reveal any living macrofauna. On 15.10.72 I again visited the lagoon to find that the sea had once more gained entry to the old lagoon site via the small lagoon to the north west (see Williams, 1972, Fig. 1). Even more remarkable was the fact that *C. glaucum* was once again common here and two specimens of *H. luciae* were also found. (A single water sample taken at this time had a temperature of 11° C. and a salinity of 37‰). It is assumed that these animals were descended from survivors in the deeper parts of the pools left after the lagoon was drained, since they are not known to live in any nearby habitats. Beds of *Z. marina* and *R. cirrhosa* were re-established, amongst which were living *Idotea chelipes*, *Arenicola marina*, *Praunus flexuosus*, *Hydrobia ulvae* and many unidentified copepods and amphipods. It is not known whether the last four named species were descended from survivors of the original lagoon population or whether they were swept in by the sea from the north-west lagoon. These circumstances present an interesting opportunity to study the recolonisation of the lagoon.

**In conclusion**

It is appreciated that the sacrifice of lagoons in land reclamation schemes is often necessary to prevent further coastal erosion. However, it is hoped that those lagoons as yet unclaimed by such necessities will be preserved from pollution and be carefully studied by biologists. I should be particularly pleased to hear of any records of brackish water sea anemones.

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# ADDITIONS TO THE NORFOLK FLORA

*By* R. P. Libbey and E. L. Swann

"The day that a *Flora* is published is the day it is out of date." The truth of this oft-repeated statement is amply borne out by the many new records, indeed, new plants that have been found since the publication of the *Flora of Norfolk* in 1968. Many of the finds have resulted from our intensive field-work in the years 1971–1972 and for these our names are not given but, to those who have very kindly given us the benefit of their work, we have added their names.

For distribution purposes we have continued the use of the 10-kilometre grid squares and the vice-comital division of East and West Norfolk. To bring our work into line with the latest nomenclature we have used the *List of British Vascular Plants* (Dandy, 1968) which is revised from time to time; where it departs from the familiar second edition of *The Flora of the British Isles* (Clapham, Tutin & Warburg, 1958) we have added the names given in the latter work as synonyms; for the grasses we have used Dr. C. E. Hubbard's *Grasses* (2nd ed., 1968).

The list is divided into three sections: Natives; Hybrids; and Casuals.

NATIVE is a term which admits of various meanings. The extreme view, which we do not hold, is that any plant which arrives and establishes itself by natural means in natural or semi-natural habitats without allowance for the time factor is a native; thus the American Willow-herb (*Epilobium adenocaulon*) would be called native by some and this is absurd. Our estimate of native status is based on distribution, both inside and outside our area; nature of the habitat; and historical evidence.

HYBRID. One of us (ELS) has already described how these may be determined (1). Far from being a curiosity and, therefore, to be passed over, a hybrid challenges one's powers of observation and also one's knowledge of the individual characters of the putative parents. Here an attempt is made to focus upon the tangible features of some newly-discovered hybrids; in fact, just those features which first struck the observer and made him suspect a hybrid showing a combination of characters appearing together in one plant.

CASUALS are plants of alien origin such as garden escapes or throw-outs; plants found on rubbish tips mainly from bird-seed; some weeds of arable land and gardens; in other words, plants intentionally or unintentionally introduced by man. Although "alien hunts" are castigated by some as so much "dung-hill botanising" he would be a rash man who would deny that some of these casuals would never become integrated into the flora and, in time, merit a higher rank than a mere casual. Many are doomed to failure by reason of the climatic factor but some, e.g., *Veronica filiformis* and *Galinsoga parviflora* appear to be well on the way to becoming established. It is essential to give the date of their first appearance to guide future workers, e.g., *Veronica persica* was first recorded for Norfolk in 1860 and has now become one of the commonest weeds of cultivated fields.

**Natives**

*Lycopodium clavatum L.* Stag's-Horn Moss.
This species, relegated to the list of extinctions in the *Flora*, may now be restored. East: 01, Lenwade, marshy hollow in pine plantation, 1969, M. J. Wigginton; 23, N. Walsham, 1969, Mrs. M. W. Andrews, det E. A. Ellis; 41, Winterton, small

patch in dunes, 1963, F. W. Simpson *in lit.*

*Dryopteris pseudomas* (Wollaston) Holmb. & Pouz.

(*D. borreri Newm.*) Golden-scaled Male Fern.

West: 73, near Waterden House, M. Rickard; 88, Croxton, H. W. Wiard; 90, Scoulton Mere and Watton railway station, M. Rickard; 93, Thursford; East: 03, Hempstead.

*Polypodium interjectum* Shivas Polypody.

A widespread and abundant species, particularly in East Norfolk, so much so that many of the earlier records for *P. vulgare* should probably be referred to this species.

East: 01, Swanton Morley; 03, Edgefield Heath; Stody; 22, Bryant's Heath, Felmingham.

*Crambe maritima* L. Seakale.

Following bulldozing of the shingle ridge at Snettisham this rare species has now appeared for the first time in West Norfolk. The additional records from East Norfolk suggest we may confidently look for an increase along our coast.

West: 63, Snettisham, five plants in 1970.

East: 04, Blakeney Point, 1968, D. J. B. White, *in lit.*; Salthouse, E. T. Daniels.

*Cochlearia officinalis* L. Common Scurvy-grass.

Does this species still occur in Norfolk? Although stated to be common in both the 1914 and 1968 *Floras*, we have so far failed to find it in any of the salt-marshes visited. There are undoubted specimens in the Castle Museum Herbarium from "Roadside, Knapton, 1908, F. Long" and "Dilham, 1858, S. T. Taylor". We find *C. anglica* to be both widespread and abundant; when in fruit the ovoid-oblong, flattened siliculae, each with a strong median furrow are unmistakable. We would welcome observations from readers.

*Rorippa islandica* (Oeder) Borbas Marsh Yellow-cress.

In the 1968 *Flora* this species is given as native, "Rather common. Ponds and ditches". We have been puzzled by the differing habitats in which we have seen it, e.g., concrete and gravel paths, platforms of railway stations, as a garden weed, in the so-called "Black fen" arable fields, rubbish tips, besides the margins of the Breckland meres and river banks. This suggests to us that we have either a plant tolerating a wide variety of habitats or more than one taxon is involved. Our work has led us to Jonsell's treatment (2) in which he distinguishes two species, *R. islandica* (Oeder ex Morray) Borbás with an Atlantic coastal distribution and *R. palustris* (L.) Besser widespread all over Europe on river banks and waste places. His key (translated) reads:

Siliqua 2–3 times as long as its pedical. Sepals not reaching 1.6 mm. Seeds very finely papillose ............................ *R. islandica.*

Siliqua never more than twice as long as its pedicel. Sepals exceeding 1.6 mm. Seeds more coarsely papillose ............................ *R. palustris*

The plate given in Jonsell's work matches Norfolk plants. None of the material examined, both pre-1968 and after, has siliqua length greater than twice the pedicel and we have to conclude that all our plants should be referred to *R. palustris* and that *R. islandica*, as its name implies, is more correctly applied to the northern plant.

*Veronica hederifolia* L. Ivy-leaved Speedwell.
The widespread distribution of this taxon, both in arable land and as a garden weed, has given us the opportunity to study its variation. It has been divided by Fischer (3) into three species and we have found two in Norfolk. *V. hederifolia* L., in its restricted sense is a robust plant with leaves having more acute lobes; corolla blue, 3 mm. long; anthers blue, 1 mm. long; pollen grains averaging 40 $\mu$. We find this in arable fields and our first record comes from Croxton, W88. *V. sublobata* M. Fischer is greyish-green in colour; leaves with more obtuse lobes; corolla pale lilac or whitish, not exceeding 2 mm. in length; anthers whitish, 0.5 mm. long; pollen grains about 32 $\mu$. This new species appears to be the more widespread of the two segregates and is an abundant garden weed.

*Utricularia neglecta* Lehm. Bladderwort.
West: 61, flowering in abundance in a drain at Shouldham Warren, 1972. This very rare species has only been recorded three times before in Norfolk; Stow Bedon, 1917, F. Robinson; Martham Dyke, A. Bennett; and at Wheatfen Broad, E. A. Ellis, 1937. In accepting a voucher specimen we were informed by Kew that this species is on the increase. It is not given for Norfolk in the *Critical Supplement* to the *Atlas of the British Flora*.

*Senecio vulgaris* L., var. *hibernicus* Syme Rayed Groundsel.
We have followed Allen (4) in referring the inland rayed form to this variety which appears to be increasing; var. *denticulatus* (O. F. Muell) Hylander applies to similar forms in maritime habitats which so far have only been seen along the south and south-west coasts of Britain.
West: 62, waste ground, King's Lynn; 71, Gayton, 91, Beetley gravel pit.

*Tripleurospermum maritimum* (L.) Koch Sea Mayweed.
subsp. *maritimum* var. *maritimum*
West: 63, Snettisham beach, 1972; 84, Scolt Head, Q. O. N. Kay, 1963.
East: Blakeney Point, E. T. Daniels.
For some time we have been puzzled by the differences between our inland and maritime populations of this species but Kay's paper (5) has cleared up the problem. The Snettisham and Blakeney plants show the characteristic elongated oil glands on the achenes which have narrow slits between the ribs whereas the inland plants have isodiametric oil glands and the ribs are divided by wider spaces.

*Potamogeton praelongus* Wulf. Long-stalked Pondweed.
East: 32, Honing.
In view of the disappearance of many of the less common Pondweeds due to pollution of the Broads we were pleased to find this species flourishing in a backwater of the River Ant. Viewed in the water it might be mistaken for *P. lucens* but closer examination reveals its distinctly hooded apex to the leaf.

*Festuca tenuifolia* Sibth., Fine-leaved Sheep's Fescue.
var. *hirtula* (Hack. ex Travis) Howarth
In company with Dr. Hubbard we have paid close attention to the coastal fescues and it would appear that this species is a newcomer to the Wolferton dunes. It may have been introduced as a result of the 1953 sea-flood. It differs from the normal plant in being somewhat larger and usually has hairy lemmas.

*F. rubra* L., subsp. *litoralis* Red Fescue of salt-marshes.
(G. F. W. Meyer) Auquier
West: 62, Wolferton and N. Wootton.
This new name is applied by one of our correspondents, M: Paul Auquier, a

Belgian botanist, to the frequent species of Red Fescue occurring typically amongst *Puccinellia maritima* on salt-marshes and, occasionally, on stable dunes.

*Holcus mollis* L., var. *parviflorus* Parn. Small-flowered Creeping Soft-grass.
West: 78, Snake Wood, Weeting.
This variant, probably common in Breckland, was pointed out to us by Dr. Hubbard. It differs by having smaller lemmas, 2.0 mm. instead of 2.5–3.0 mm., and smaller anthers, 1.2 mm. instead of 2.0 mm.

*Molinia caerulea* (L.) Moench, agg. Purple Moor-grass.
At the suggestion made by Dr. Hubbard we have been carrying out an investigation of this widespread and very variable species. Our researches are by no means finished but we have found the following taxa and have used Conert's work (6) to determine our gatherings.

*Molinia litoralis* Host
West: 60, Shouldham Warren; Shouldham Fen; 62, Wootton Woods; 70, Marham Fen; 79, Stoke Ferry Fen.
It differs from *M. caerulea* in being a much taller plant (1.2–1.6 m.); larger panicles (30–50 cm.); longer spikelets (6–9 mm.) and lemmas to 6 mm. It is usually to be found in fens and, occasionally, in damp woodland. A gathering from Marham Fen (ELS, 1944) is cited by Conert in his work.
*M. caerulea* in its restricted sense is widespread in a variety of habitats.
Var. *obtusa* (Peterm.) Aschers. & Graeb.
Var. *trichocolea* Roemer
Var. *arundinacea* (Schrank) Aschers.
Var. *depauperata* (Lindl.) Aschers. & Graeb.
Var. *capillaris* Rostrup
Var. *subspicata* Figert
Var. *robusta* Prahl

These varieties have been recorded during 1972 and it is hoped to publish the results of our investigations later.

**Hybrids**

*Hypericum* x *desetangsii* Lamotte
(*H. maculatum* x *perforatum*)
West: 62, Dersingham.
Plants agreeing with the description of this hybrid were found growing amongst scrub on the margins of Dersingham Common, a first record for the county. Although it was pointed out by Swann (l.c.) that the examination of pollen grains helped to confirm doubtful cases the present hybrid is an exception for, although 45% of the grains were found to be abortive, cases are known where the pollen in this hybrid has been proved to be "good".

*Geranium* x *magnificum* Hyl.
In the 1968 *Flora* there are two records for *G. platypetalum* which, at that time, appeared to be the correct name for such garden-escapes. In the light of McClintock & Yeo's note (7) we now consider these plants should now be referred to this hybrid.

West: 79, roadside, Whittington, 1956; 80, Lit. Cressingham; 89, Tottington; 91, Gressenhall, 1956.

East: 02, Foxley; 33, large patch on cliffs, Mundesley, M. Heath, det. RPL & ELS.

We realise that indumentum of critical taxa should be accepted with caution but we now interpret the situation as follows:

*Indumentum of sepals and pedicels*

1. Mixture of short and very long eglandular hairs ...... *G. ibericum* Cav.
2. All glandular hairs ................ *G. platypetalum* Fisch. & Meyer
3. Mixture of short glandular and long eglandular hairs; sterile *G. x magnificum* Hyl.
4. As No. 3 but fertile ...................... *G. jubatum* Handel-Maz.

*Potentilla anglica* x *erecta*
(*P. suberecta* Zimmet.)
East: 29, Brooke Wood; 33, Witton Park.
*P. anglica* possesses the larger flowers (14–18 mm.) and is predominantly 5-petalled whilst *P. erecta* has normally smaller flowers (7–11 mm.) and is almost 100% 4-petalled. The hybrid is conveniently compromising by having flowers 12–14 mm. diameter, 4- and 5-petalled mixed, the larger 4-petalled flowers being quite unmistakable. Little or no seed is produced and the pollen is misshapen. New to the county.

*Epilobium adenocaulon* x *obscurum*
West: 98, Ringmere.
Four species of Willow-herb occur in some abundance around the margin of Ringmere but this was the only hybrid seen. Readily distinguished in the field by considerable branching in the upper half of the otherwise single stem and the abortive, shrivelled seed.

*Veronica catenata* x *anagallis-aquatica*
West: 84, Burnham Overy, margins of feeder stream of River Burn.
At first sight this hybrid, new to the county, is easily overlooked for one of the parents. Closer examination shows that no capsules are formed, and that the racemes are much longer and spreading, with up to 70 flowers per raceme compared with a maximum of about 40 in either of the parents.

*Senecio squalidus* x *vulgaris*
West: 62, King's Lynn.
East: 50, Gt. Yarmouth, P. W. Lambley conf. ELS.
Usually noticed as a "*squalidus*-like plant with smaller ligulate florets", the rays being half the size of the normal plant. Care, however, is needed to avoid confusion with the rayed forms of the Common Groundsel though in the latter plant the rays soon become revolute. A further distinguishing character is to be found in the fruit which is often fertile in the hybrid: *S. vulgaris* possesses lines of hairs on the *ridges* of the fruit whilst in *squalidus* these are to be found in the *grooves* between the ridges, and this character seems to remain in the hybrid.

*Glyceria* x *pedicellata* Towns.
(*G. fluitans* x *plicata*)
West: 62, South Wootton.
East: 32, East Ruston.
It may be suggested that the three species of Sweet-grass are difficult enough to separate without looking for hybrids! They are certainly not easy and, like all aquatic species, vary according to the water-level of the habitat. Recourse to anther characters, which are quite diagnostic, will confirm doubts about the identity of both species and hybrid.

X *Agrohordeum langei* (K. Richt.) Camus
This very rare intergeneric hybrid between *Agropyron repens* and *Hordeum secalinum* was found by Dr Hubbard near Tuck's Farm, Beeston, W81, in September 1972, on a roadside bank. New to Norfolk it has only been found once before in the British Isles.

*Poa chaixii* x *nemoralis*
The locality of this exceedingly rare hybrid is withheld until further work has been carried out by Dr Hubbard who informs us that it is not only new to Britain but, so far, he has been unable to trace any record for it in foreign works.

**Casuals**

*Potentilla intermedia* L. No English name.
West: 89, Snake Wood, Weeting, 1971. Its first Norfolk record. It is puzzling to account for this new species in a forest ride; maybe it is on a par with the *Scutellaria hastifolia* in Emily's Wood nearby, for which we suggest introduction by pheasant food.

*Prunus serotina* Ehrh. Rum Cherry.
West: 98, Kilverstone Heath, a single tree growing in a clearing with bracken dominant, just west of Ringmere. Resembles *P. padus*, the Bird Cherry, but the flower colour is cream rather than white; the racemes are rigid and shorter; petals only 4 mm., and the receptacle glabrous within. Its first record which is surprising in view of a locality much frequented by botanists.

*Verbascum speciosum* Schrad. Mullein.
West: 79, in waste ground formerly occupied by the military at Didlington. An introduction from the old gardens of the hall. Although known for many years it was not until recently that its name was confirmed by Kew.

*V. phlomoides* L. Mullein.
West: 81, on site of former garden, Litcham, 1972.

*Veronica filiformis* Sm. Slender Speedwell.
West: 80, Saham Toney churchyard; S. Pickenham churchyard. In spite of rarely setting seed there is ample evidence that this species is rapidly spreading.

*Parentucellia viscosa* (L.) Caruel Viscid Bartsia.
West: 99, Stow Bedon.
Messrs P. G. Lawson and A. Copping found this growing along the disused railway near Stow Bedon. Further search has revealed it to occur in some abundance in adjacent meadows, an impurity of the reseeding grass mixture used here.

*Alisma gramineum* Lejeune subsp. *gramineum* Grass-leaved Water Plantain.
West: 98, Langmere, 1972.
We consider this to be our most important find as it is but the third British record, the first coming from a pool near Droitwich nearly thirty years ago and the second from Lincolnshire seven years later. It occurs in Denmark and the Baltic States and we think it owes its occurrence here to migrating wildfowl, our claim being supported by Mr. Bagnall-Oakeley. We hope to publish a longer paper on this species later.

*Poa nemoralis* L., var. *glaucantha* (Gaud.) Reichb.
(*P. glaucantha* Gaud.)
East: 20, Harford tip, 1972.

For its last year as a rubbish tip Harford has produced a few new finds and this grass, confirmed by Dr. Hubbard, is one. It differs from *P. nemoralis* by its larger, more flowered spikelets and stiffer erect type of growth.

*Agrostis castellana* Boiss. & Reut. Highland Bent.
East: 20, Harford tip, 1972, P. G. Lawson & A. Copping, det. Dr. Hubbard. It resembles *A. tenuis* but has lemmas awned from the base. There are two kinds of spikelet: the terminal ones being awned and 5-nerved, and those below 3-nerved and awnless. It is now being introduced into lawn grass seed so that more records are likely to be found.

*Beckmannia syzigachne* (Steud.) Fernald American Sloughgrass.
East: 20, Harford tip, Messrs P. G. Lawson & A. Copping, det. Hubbard. This new record is a native of N. America and N. E. Asia. It has a nearly simple panicle of laterally compressed spikelets and its specific epithet refers to its scissors-like glumes.

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# VERBASCUM PULVERULENTUM IN THE NORWICH AREA

*By* E. T. Daniels

As a British plant the Hoary Mullein is confined to Norfolk and Suffolk, and ever since Ray recorded it here in 1670 it has had special associations with Norwich. In order to see how it has fared over the span of 300 years a survey was made in 1972 covering the stations I was able to find within a radius of about 12 miles of Norwich. The total count came to 940, to which must be added many hundreds of non-flowering rosettes in its Halvergate locality. Norwich contains 13 sites, from which 525 plants were counted, and the largest site (204 plants) is by the river in the industrial area where the plants are under constant threat of disturbance – in fact 54 were in a heavily sprayed zone and drooping badly. The other parishes where populations were noted were Arminghall, Cawston, Colney, Halvergate, Hellesdon, Hempnall, Keswick, Rackheath and Stoke Holy Cross. In two of these stations plant numbers topped the one hundred mark.

Interesting instances of persistence occurred, namely at Rackheath and Cawston, both mentioned in Arthur Bennett's 1908 paper "East Anglian Plants" (Trans. Norfolk Norw. Nat. Soc. 8, 691–92). Perhaps even more remarkable, S. Alcorne in Blackstone's "Specimen Botanicum" of 1746 reported it as "Bishopsgate-ferryhouse plentifully". A single plant was seen on this stretch of the river bank during my survey.

The habitats all consisted of road verges or rough grassland in waste places, and in all stations seen the plant is very vulnerable.

# ALBINISM, DOUBLING, PELORY AND CLEISTOGAMY IN SOME NORFOLK PLANTS

*By* E. A. Ellis and E. L. Swann

White colour-variants occur commonly in the populations of some kinds of wild flowers, but rarely in others. Occasional mention of them has been made in the Norfolk county *Floras*, but so far, no comprehensive list of such variants found in this area has been published. This also applies to instances of "doubling", where there is partial or complete substitution of stamens and carpels by petals or petaloid sepals. A few species show an occasional tendency to produce radially symmetrical (peloric) flowers in place of the normal zygomorphic ones. Cleistogamic flowers, which are self-pollinated without opening, are produced regularly by violets and wood sorrel as a secondary method of ensuring seed-production; they also occur abnormally in other plants from time to time.

The writers have compiled the following catalogue with the help of other members of the Norfolk and Norwich Naturalists' Society in the hope that by reviewing the present state of our knowledge in this field, more intensive recording may follow.

**White-flowered variants**

*Ranunculus ficaria.* Lesser Celandine. The flowers often appear bleached with age, but no examples of true albinism have been noted here.

*Papaver rhoeas.* Corn Poppy. In spite of the widespread presence of variously coloured "Shirley" poppies in cultivation, white wild corn poppies are found only rarely.

*Raphanus raphanistrum.* Wild Radish White Charlock. The white form (f. alba F.Gér.) is common as an arable weed in sandy, acid soil; the petals are streaked with lilac veins.

*Cardamine pratensis.* Lady's Smock. Although plants with almost white flowers occur quite commonly, we have yet to meet with pure albinism in this species.

*Viola odorata.* Sweet Violet.. The var. *dumetorum* with white petals suffused with some violet coloration occurs frequently.

*Viola riviniana.* Common Wood Violet. A pure white form seen in some abundance at Kettlestone.

*Polygala serpyllifolia.* Heath Milkwort. Often white-flowered.

*Helianthemum chamaecistus.* Common Rock-rose. The cream-coloured form is very uncommon here.

*Silene dioica.* Red Campion. Albino examples occur occasionally in pure woodland populations and are not to be confused with the much commoner pale specimens resulting from hybridisation with *S. alba.*

*Silene maritima.* Sea Campion. Plants lacking anthocyanin pigment occur in most of the larger stands of this species on our shingle beaches.

*Lychnis flos-cuculi.* Ragged Robin. Only very occasionally white.

*Dianthus deltoides.* Maiden Pink. A plant with almost white flowers showing red veins seen by Alec Bull at Ickburgh in 1972.

*Malva moschata.* Musk Mallow. Occasional, also in cultivation.

*Geranium pratense.* Meadow Cranesbill. Often occurs with the normal from asa garden escape.

*Geranium dissectum.* Cut-leaved Cranesbill. Great Yarmouth.

*Geranium molle.* Dove's-foot Cranesbill. Great Yarmouth.

*Geranium robertianum.* Herb Robert. Little Melton and Ingham, 1972.

*Erodium cicutarium.* Common Storksbill. Not uncommon; most frequent in Breckland.

*Impatiens glandulifera.* Policeman's Helmet. An isolated colony with pure white flowers seen at Stratton Strawless. Pale forms occasional in other feral populations.

*Ilex aquifolium.* Holly. Yellow-berried forms infrequent but widespread.

*Ononis repens.* Common Restharrow. Great Yarmouth.

*Ononis spinosa.* Spiny Restharrow. Rare.

*Trifolium pratense.* Red Clover. Occasional.

*Astragalus danicus.* Purple Milk Vetch. Uncommon.

*Vicia sepium.* Bush Vetch. The var. *ochroleuca* with creamy-white flowers has been seen at Wymondham and Foxley Wood.

*Vicia sativa.* Common Vetch. Occasional.

*Vicia angustifolia.* Narrow-leaved Vetch. Occasional; sometimes locally common.

*Rubus idaeus.* Raspberry. Yellow-berried stocks are not uncommon in wild populations.

*Rubus ulmifolius.* Blackberry. Yellow-berried, but with pink flowers, in a field hedge at Runhall (E.Q.Bitton).

*Crataegus monogyna.* Hawthorn. Rarely with yellow berries.

*Daphne mezereum.* Mezereon. The white-flowered form has been found outside cultivation.

*Epilobium hirsutum.* Great Hairy Willowherb. Rather infrequent, but may be locally plentiful.

*Epilobium montanum.* Broad-leaved Willowherb. Rare.

*Epilobium angustifolium.* Rose-bay Willowherb. Waste ground, Lakenham (Norwich).

*Anthriscus sylvestris.* Cow Parsley. Plants lacking anthocyanin may be found occasionally.

*Angelica sylvestris.* Wild Angelica. Albino specimens occur annually in very small numbers at Wheatfen Broad (E.A.E.).

*Calluna vulgaris.* Ling. Sporadic, but occurs in a number of localities in small quantities.

*Erica tetralix.* Cross-leaved Heath. Not uncommon and sometimes locally plentiful, as at Winterton Dunes.

*Erica cinerea.* Bell Heather. Very occasional.

*Limonium vulgare.* Sea Lavender. Rare, North Norfolk.

*Armeria maritima.* Thrift. Occasional.

*Centaurea erythraea.* Common Centaury. Not infrequent; sometimes locally plentiful in Breckland.

*Gentiana pneumonanthe.* Marsh Gentian. Rarely white or rose pink.

*Gentianella amarella.* Felwort. Occasionally white in Breckland.

*Myosotis scorpioides.* Water Forget-me-not. Colony with primrose-yellow flowers in sallow carr at Wheatfen Broad.

*Echium vulgare.* Viper's Bugloss. Very occasionally white.

*Solanum dulcamara.* Woody Nightshade. Only at Wheatfen Broad.

*Solanum nigrum.* Black Nightshade. Plants with yellow fruits have appeared at Harford Tip near Norwich annually for several years. Also seen on waste ground at Gt. Yarmouth.

*Verbascum nigrum.* Dark Mullein. A single plant with cream-coloured flowers seen at Beetley pit, 1972.

*Cymbalaria muralis.* Ivy-leaved Toadflax. Wall at Hillington Hall.

*Digitalis purpurea.* Foxglove. Often white-flowered.

*Veronica serpyllifolia.* Thyme-leaved Speedwell. Frequently pure white.

*Veronica agrestis.* Green Field Speedwell. Rarely.

*Odontites verna.* Red Bartsia. Occasionally.

*Origanum vulgare.* Marjoram. Rarely.

*Thymus pulegioides.* Wild Thyme. Broome Common and near the Warden's house at East Wretham Nature Reserve.

*Acinos arvensis.* Basil Thyme. Frequent, especially in Breckland.

*Prunella vulgaris.* Self-heal. White and pink forms occur occasionally.

*Ballota nigra.* Black Horehound. Rarely.

*Lamium hybridum.* Cut-leaved Deadnettle. Occasionally.

*Lamium purpureum.* Red Deadnettle. Rather frequently.

*Galeopsis tetrahit.* Common Hemp-nettle. Commonly.

*Ajuga reptans.* Bugle. Rarely white or pink.

*Campanula rotundifolia.* Hare-bell. Occasionally.

*Sherardia arvensis.* Field Madder. Occasionally.

*Sambucus nigra.* Elder. A form with translucent yellow berries, lacking anthocyanin, occurs in a few localities near Norwich.

*Viburnum opulus.* Guelder-rose. A few bushes with yellow berries are present at Wheatfen Broad, also some with fruits orange-coloured, intermediate between these and the normal red ones.

*Centranthus ruber.* Red Valerian. White and pink forms occur commonly.

*Knautia arvensis.* Field Scabious. Occasionally.

*Succisa pratensis.* Rather rarely.

*Eupatorium cannabinum.* Hemp Agrimony. Colonies with white flowers seen at Catfield Common and Wheatfen Broad.

*Artemisia vulgaris.* Mugwort. A plant lacking anthocyanin seen at Surlingham.

*Carduus nutans.* Nodding Thistle. Rarely.

*Cirsium vulgare.* Spear Thistle. Rarely.

*Cirsium arvense.* Creeping Thistle. Clones with white flowers are not uncommon and sometimes extensive.

*Cirsium palustre.* Marsh Thistle. White and pinkish forms common.

*Cirsium acaulon.* Stemless Thistle. Rarely.

*Cirsium dissectum.* Meadow Thistle. White and pink forms occasional.

*Centaurea scabiosa.* Greater Knapweed. Occasionally.

*Centaurea nemoralis.* Knapweed. Rarely.

*Endymion non-scriptus.* Bluebell. A few plants with white and mauve flowers can usually be found in large colonies.

*Epipactis palustris.* Marsh Helleborine. Rarely with yellowish-white flowers.

*Gymnadenia conopsea.* Fragrant Orchid. Not uncommonly.

*Ophrys apifera.* Bee Orchid. Plants with greenish-white sepals occur occasionally.

*Orchis morio.* Green-winged Orchid. Occasionally.

*Orchis mascula.* Early Purple Orchid. Occasionally.

*Dactylorhiza incarnata.* Early Marsh Orchid. Occasionally.

*Dactylorhiza praetermissa.* Common Marsh Orchid. Occasionally.

*Dactylorhiza fuchsii.* Common Spotted Orchid. Occasionally.

*Briza media.* Common Quaking Grass. Plants with yellowish spikelets are not uncommon.

*Arrhenatherum elatius.* False Oat. Occasionally yellowish.

*Holcus lanatus.* Yorkshire Fog. Albinos not uncommon.

*Phalaris arundinacea.* Reed Canary Grass. Occasionally.

*Calamagrostis canescens.* Purple Small-reed. Distinctive albino clones have been seen in several Broadland localities and on Stoke Ferry Fen.

*Agrostis gigantea.* Black Bent. A plant conspicuous by its pale colour seen on a fallow field at Hockwold.

**Plants with "double" flowers**

*Caltha palustris.* Marsh Marigold. Chiefly in cultivation.

*Anemone nemorosa.* Wood Anemone. Occasionally.

*Ranunculus acris.* Meadow Buttercup. Occasionally.

*Ranunculus ficaria.* Lesser Celandine. A colony at South Runcton has persisted for more than fifty years.

*Chelidonium majus.* Greater Celandine. Not uncommon.

*Cardamine pratensis.* Cuckoo Flower. Locally frequent.

*Silene maritima.* Sea Campion. Rarely.

*Lychnis flos-cuculi.* Ragged Robin. Rarely.

*Saponaria officinalis.* Soapwort. Commonly.

*Cerastium holosteoides.* Common Mouse-ear Chickweed. In a forest ride at Methwold a few plants occur with the normal petals replaced by an additional set of sepals, the inner ring being much smaller.

*Minuartia hybrida*. Fine-leaved Sandwort. Once found with double flowers resembling a miniature *Gypsophila*, in Breckland.

*Filipendula ulmaria*. Meadowsweet. Marsh at Surlingham.

*Rubus ulmifolius*. Common Hedge Bramble. Mousehold Heath and Brundall.

*Saxifraga granulata*. Meadow Saxifrage. The double form is found in cultivation and its status as a wild plant must be in some doubt, although it may be present with the normal form, e.g. in churchyards.

*Calluna vulgaris*. Ling. Found once at Winterton, by J. W. Dyce.

*Vinca minor*. Lesser Periwinkle. Double and semi-double forms have long been in cultivation and occur as denizons.

*Tripleurospermum inodorum*. Scentless Mayweed. Double at Rockland St. Mary, 1972. Rayless form seen by E.L.S.

**Peloric flowers**

*Linaria vulgaris*. Yellow Toadflax. Apparently rare. Colonies have been found at Ludham and Martham and, from 1930 to 1948, alongside the railway at North Wootton.

*Digitalis purpurea*. Foxglove. Plants with large terminal symmetrical flowers are common in cultivation and appear occasionally in wild colonies.

*Galeobdolon luteum*. Yellow Archangel. Seen on several occasions at Framingham Pigot and Wayland Wood.

*Lamium album*. White Deadnettle. Surlingham.

*Lamium amplexicaule*. Henbit. Great Yarmouth.

**Cleistogamic flowers**

(in addition to those produced commonly by *Viola* spp. and *Oxalis*)

*Silene maritima*. Sea Campion. Rarely.

*Impatiens capensis*. Orange Balsam. Occasionally (Broads).

*Lamium hybridum*. Cut-leaved Deadnettle. Occasionally.

*Spartina anglica*. Common Cord-grass. Whilst studying *Spartina* on the salt marsh north of King's Lynn with Dr. Hubbard, E.L.S. was shown a cleistogamous spike enclosed in a leaf sheath. Although *S.* x *townsendii*, the male-sterile plant, can only spread vegetatively, *S. anglica* is fully fertile, spreading both by seeds and offshoots, so that the provision of cleistogamy seems anomalous.

# THE MARINE AND BRACKISH-WATER BRYOZOA OF NORFOLK

*By* R. Hamond

*    *    *    *    *    *

**Summary**

Including all previous records, five species of entoproct and 73 of gymnolaematous ectoproct are now known from Norfolk marine or brackish waters; the Phylactolaemata are excluded, as they are found only in fresh water. The main reasons for the poverty of the fauna appear to be: (1) the action of strong waves and currents upon relatively unstable substrates in shallow water causes a scarcity of entoprocts in spite of the presence of numerous suitable hosts; (2) the ever-present danger of being smothered by silt restricts the ectoprocts; and (3) the variable salinity (particularly close inshore) and the wide annual and diurnal range of temperature acts adversely on both these groups as well as on many other kinds of marine invertebrates. Many species are shown to be able to exist here for a short while only; as they are all much commoner further north, their presence here is linked with invasions of northern water. By analogy with the "Tiefe Rinne" near Helgoland, it is suggested that Lynn Well may act as a basin in which such water might persist, and that a survey might show the presence in Lynn Well of many otherwise rare species; conversely, if the water-type in Lynn Well was constantly the same as that elsewhere in our area, any faunistic differences between a given substrate in Lynn Well and the same substrate in a shallower part of the Norfolk area would offer a means of distinguishing depth-dependent factors from other factors, when considering the distributions of marine invertebrates.

**Introduction**

Although traditionally considered together, the exact relationship between ectoprocts and entoprocts has always been a matter of dispute; the most recent view (Nielsen, 1971) is that they are classes of the Phylum Bryozoa (=Polyzoa). Of the ectoprocts, the fresh-water Phylactolaemata are not considered here; the Gymnolaemata (all the ectoprocts in this paper) are further divided into Cyclostomata (spp. 1 to 8), Cheilostomata (9 to 54), and Ctenostomata (the rest). The entoprocts were identified from the literature cited in Table 1, and the ectoprocts from Hincks (1880) except for the following genera: *Crisia* from Harmer (1891) and Ryland (1967); *Scruparia* from Hastings (1941); *Bugula* from Ryland (1960); and *Hypophorella* from Ehlers (1876). The nomenclature is that of Ryland (1969); other useful taxonomic works, unfortunately not available for the present survey, are Prenant & Bobin (1965, 1966) and Ryland (1965b). For anatomy and biology see Hyman (1951, 1959) and Ryland (1970).

Altogether 44 ectoprocts and two entoprocts have been found in the Norfolk area (Hamond, 1969) by various authors (Kirchenpauer, 1875; Möbius, 1875; Hincks, 1880; Vine, 1892; Garstang, 1901; Redeke & van Breemen, 1904; Serventy, 1934; and Gilson, Hollick, & Pantin, 1944); of these, I have not seen the entoproct *Loxosomella phascolosomata* (q.v.) and eleven of the ectoprocts, but on the other hand have added 3 entoprocts and 29 ectoprocts (collecting-grounds and station lists, Hamond, 1963, 1969; methods, Hamond, 1966a, 1967b) to give a total for the Norfolk marine area of five species of entoproct and 73 species of ectoproct.

TABLE 1

Entoproct hosts found without entoprocts in Norfolk waters, with the entoprocts which have been found associated with them elsewhere in Western Europe. The references are arranged from north to south, as follows:—A. Bergen, Norway (Nielsen, 1964b); B. Gullmarfjord, western Sweden (Franzén, 1962); C. Kattegat (Nielsen, 1964a); D. Northumberland (Eggleston & Bull, 1966); E. Isle of Man (Eggleston, 1965); F. South Wales (Ryland, 1961); G. Plymouth (Plymouth Marine Fauna, including Atkins, 1932, with revised names); H. St. Vaast-la-Hougue, Normandy (Bobin & Prenant, 1953a); I. Roscoff, Brittany (Bobin & Prenant, 1953b); J. Roscoff (Bobin & Prenant, 1953d); K. Roscoff (Bobin & Prenant, 1953e); L. Monaco (Bobin & Prenant, 1953c).

| Host animal | Entoproct | Reference |
|---|---|---|
| PORIFERA | | |
| *Dysidea fragilis* (Montagu) | *Loxosomella teissieri* (Bobin & Prenant) | J |
| BRYOZOA | | |
| *Crisia eburnea* (L.) | *Loxosomella nordgaardi* Ryland | C |
| *Schizomavella linearis* (Hassall) | *L. nordgaardi* Ryland | D |
| *Cryptosula pallasiana* (Moll) | *Barentsia mutabilis* (Toriumi) | F |
| MOLLUSCA | | |
| *Mysella bidentata* (Montagu) | *Loxosomella phascolosomata* (Vogt) | G |
| SIPUNCULOIDEA | | |
| *Golfingia elongata* (Keferstein) | *L. phascolosomata* (Vogt) (q.v., in present paper, above) | G |
| POLYCHAETA (Hamond, 1966) | | |
| *Aphrodite aculeata* (L.) | *Loxosomella obesa* (Atkins) | A, E, G |
| | *Loxosomella fauveli* Bobin & Prenant | C, D, E, G |
| | *Loxosomella claviformis* (Hincks) | E, G |
| *Hermione hystrix* (Savigny) | *Loxosomella fagei* Bobin & Prenant | I |
| | *Loxosomella claviformis* (Hincks) | E, G, I, L |
| | *Loxosomella fauveli* Bobin & Prenant | E, I |
| | *Loxosomella globosa* Bobin & Prenant | L |
| | *Loxosoma loricatum* Harmer | I |
| *Gattyana cirrosa* (Pallas) | *Loxosomella compressa* Nielsen & Ryland | C, D |
| | *Loxosomella harmeri* (Schultz) | C, D |
| *Lagisca extenuata* (Grube) | *Loxosomella compressa* Nielsen & Ryland | A, C, D, E |
| *Sthenelais boa* (Johnston) | *Loxomespilon perezi* Bobin & Prenant | G, K |
| *Nephthys caeca* (O. F. Müller) | *Loxosomella varians* Nielsen | C |
| *Nephthys hombergi* Lamarck | *L. varians* Nielsen | C |
| *Chaetopterus variopedatus* (Renier) | *Loxosomella marsypos* Nielsen & Ryland | E |
| *Notomastus latericeus* Sars | *Loxosoma singulare* Keferstein | H |
| | *Loxosoma claparedei* Bobin & Prenant | K |
| *Clymene praetermissa* (Malmgren) | *Loxosomella elegans* Nielsen | A, C |
| *Pectinaria belgica* (Pallas) | *Loxosoma pectinaricola* Franzen | A, B, C, D |
| *Pectinaria auricoma* (O. F. (Müller) | *Loxosomella murmanica* (Nilus) | C |
| *Sabella pavonina* Savigny | *Loxosomella crassicauda* (Salensky) | G |

**Entoprocta**

Systematic List

*Barentsia gracilis* (Sars).

The species *B. benedeni*, which is probably a synonym of *B. gracilis*, has been recorded from within our area at Hull (cf. Ryland, 1969, p. 245). *B. gracilis* is moderately common on hydroids and on large bryozoans, either offshore or under rocks at low water at West Runton (where it also occurred on the tunicate *Polyclinum* on 7.10.1960); also, on 4.10.1951 it was found living on *Sertularia argentea* which was growing in an unusual situation for this species, in the Threshold of Blakeney Harbour (Hamond, 1963, p. 11). In general *B. gracilis* prefers the same sort of situations as *P. cernua*, and often grows intermingled with it, but is far less tolerant of low salinities and has never been found here on algae. The intermingled colonies were definitely not *B. mutabilis* (Toriumi) (see Ryland, 1961, as *Pseudopedicellina*; 1965a, as *Barentsia*).

*Pedicellina cernua* (Pallas). Garstang (1901).
Very widespread offshore on hydroids (cf. Eggleston, 1968) and bryozoans, especially *Vesicularia spinosa* (on which Harmer also found it; Garstang, 1901), and less often on the tests of tunicates (*Microcosmus claudicans*) and the carapaces and legs of crabs (*Hyas araneus*, *H. coarctatus*, *Macropipus holsatus*). Intertidally it prefers to grow on the alga *Ceramium* (Strong Pool, Freshes Lays, "Hjördis") and on the hydroid *Dynamena pumila* (under rocks at West Runton; more rarely at East Runton, *fide* J. Fisher); I have also found it once on *Anguinella palmata* under Wells Rocks and once on *Walkeria uva* on Hunstanton Scaup.

*Loxosoma singulare* Keferstein.
Sometimes common on the polychaete *Notomastus latericeaus* (the typical host) in Blakeney Harbour (see Hamond, 1966b); clearly all this species and not *L. claparedei* which is also found on *N. latericeus* (Table 1).
"*Loxosoma phascolosomatum*, Vogt". Garstang (1901).
Under this name Garstang quotes the entoprocts found by Möbius (1875) at P.108, on a host (alleged to be *Phascolosoma vulgare*) of which Möbius distinguished two varieties:—

(1) Smaller specimens, in which the lower part of the proboscis and the rear end of the body had warts which were only feebly developed, and with these parts of the same colour (light brown) as the rest of the body; these specimens bore no entoprocts.

(2) Larger specimens, in which the above-named parts were of a darker brown than the rest of the body, and were covered with well-developed warts; these specimens were covered with entoprocts ("Büscheln von Pedicellineen", Möbius) which were not included in the "Pommerania" bryozoans described by Kirchenpauer (1875).

As Möbius's material cannot now be traced, the identities of both host and entoproct remain questionable. The former is now known as *Golfingia vulgaris*, which I have never found here although the smaller *G. elongata* (invariably without entoprocts, and determined by the late A. C. Stephen) is fairly common in dredgings in the Blakeney-Wells area. It is impossible to say whether Möbius's two varieties were due to differences in age or sex, or genuinely represented two distinct species; if the larger ones were indeed *G. vulgaris*, then the entoproct could well have been its usual associate *Loxosomella phascolosomata* (Vogt) (as it should now be called; see Nielsen, 1964a, pp. 37–39). This entoproct also occurs on the bivalve *Mysella bidentata* (Montagu), but only if the *Mysella* is itself living in the burrow of *G. elongata* (see Atkins, 1932), whose entoprocts in that case simply overflow onto the *Mysella* (Nielsen, 1964a, p. 39). In Norfolk waters *Mysella* has been found in the tube of *Pectinaria koreni* (cf. Hamond, 1966b) and elsewhere, but never with *Golfingia* nor with any entoproct.

It is possible that "Büscheln von Pedicellineen" should be translated, not as "closely packed groups of entoprocts" (assumed above to be loxosomatids) but as "bunches of pedicellinids" (in these waters, *B. gracilis* or *P. cernua*), although the skin of a *Golfingia* is a most unlikely place for either of the latter; it is a great pity that neither Möbius nor Kirchenpauer gave any further details by which to recognise these entoprocts.

*Loxosomella ornata* Nielsen.
Hitherto known only from the original find in Danish waters, on the inside wall of the tube of the polychaete *Thelepus cincinnatus* (cf. Nielsen, 1964a). This polychaete is quite common in certain dredgings off the North Norfolk coast but from 1964 to 1967 not one of the specimens caught by me had *L. ornata*; however, of the six *Thelepus* at D. 55 (on muddy ground, about 12 metres deep, on 21.8.1967), one had numerous *L. ornata*, the first for the British Isles. They agreed well with Nielsen's very clear description; nearly all had gonads which appeared to be mature, and some carried buds as well.

**Ecology of the Entoprocta**

From Table 1 it will be seen that Norfolk waters harbour numerous potential but few actual hosts for entoprocts (see also lists of hosts and associated entoprocts given by Nielsen, 1964a, table 1 on p. 63; Soule & Soule, 1965; and Ryland, 1969, pp. 245–248). I have not been able to examine Norfolk material of some hosts (*Hermione, Chaetopterus, Pectinaria belgica, P. auricoma*), and my two Norfolk specimens of *Clymene praetermissa* were both very small, although the much bigger (up to 10 cm. long, *fide* Möbius) specimens taken by the "Pommerania" were not noted as carrying any entoprocts. *Sabella* is probably an accidental host; it is included only because *Loxosomella crassicauda* multiplied freely in an aquarium tank in the Plymouth Laboratory, and settled on all the sessile animals in the tank of which *Sabella* happened to be one (Atkins, 1932). I have examined all my preserved Norfolk material (in some cases abundant) of each host in Table 1 (all the polychaetes being examined alive in the first instance, and several *Aphrodite* being individually dissected alive in seawater) without finding a single entoproct.

When the dredging-grounds here are compared with those (off the Isle of Man, Northumberland, and Denmark) on which the same species of polychaetes carry numerous entoprocts, it immediately appears that in those places the infested worms are taken in mud, muddy sand, or muddy gravel, in depths of between 20 and 100 metres, whereas the offshore gravels and sands in the Blakeney-Wells area are relatively free from mud and in a maximum depth of 24 metres (usually between 10 and 20 metres). However, D.55, where *Loxosomella ornata* was taken, was in the "Muddy Hole" about half a mile south-west of the South-East Docking Buoy, and in which the substratum is probably the nearest imitation in North Norfolk waters to the entoproct-rich grounds elsewhere which have just been mentioned; even so, at D.57 (also in the "Muddy Hole", slightly north of D.55, and on 7.9.1967) there were only two *Thelepus* and neither of them had any *L. ornata*, nor were there any other animals in these two hauls that could not be found on other kinds of ground. Furthermore, the same kinds of polychaete off the Isle of Man, Northumberland, and Denmark, when taken on rough grounds with little mud in less than 20 metres (i.e. more like the Norfolk grounds), have far fewer entoprocts than their brethren in deeper waters.

It thus seems that Norfolk waters are too much exposed to wave and current action, as well as to rapid changes of temperature and salinity and to a wide annual range of temperature (Hamond, 1967a), to favour loxosomatids even if their hosts are present; of course, such conditions may also exclude the hosts themselves, and therefore any entoprocts that are confined to those hosts (for instance, from the literature quoted in Table 1, *Phascolion strombi* (Montagu) is the host of several species of loxosomatids, of which *L. murmanica* was often confused with the related *L. nitschei*, which occurs on various non-Norfolk ectoprocts; see Nielsen, 1964a, p. 36; 1967; Eggleston & Bull, 1966, p. 7).

**Ectoprocta**

Systematic List

For the numbering of the species, see the succeeding section on Ecology.

1. *Crisidia cornuta* (L.). *Crisia cornuta* Vine (1892).

A few colonies on other sessile organisms (mostly out to sea, but sometimes cast ashore) from 1950 to 1956 inclusive.

2. *Crisia eburnea* (L.). Vine (1892).

Very common offshore on hydroids (mostly *Hydrallmania falcata* and *Abietinaria abietina*, less often on *Amphisbetia operculata*), other ectoprocts (mostly *Flustra foliacea*, less often *Vesicularia spinosa*), and dead shells of the horse-mussel *Modiolus modiolus*.

3. *Crisia aculeata* Hassall. Garstang (1901).

With *C. eburnea* but even more abundant; mainly on *H. falcata* and *F. foliacea*, less often on the other supports recorded above for *eburnea*. The paper by Jebram (1970) appeared only after I had left Norfolk (May 1968) for Australia; I have not, therefore, been able to find whether my supposed *aculeata* contains more than one species.

4. *Crisia denticulata* Lamarck. Vine (1892).

Cleethorpes (Lincs.) on algae, "not frequent, so far as I am aware" (Vine). This species is rare in the North Sea, and Vine may perhaps have had *aculeata* (which he does not mention) before him; however, Vine's other identifications show him as a reasonably competent identifier, and he used the excellent descriptions and figures of Harmer (1891) for *Crisia* spp., so this record may be allowed to stand.

5. *Tubulipora liliacea* (Pallas). *Idmonea serpens* Vine (1891).

Not common, and entirely offshore; rarely on hydroids (*H. falcata*, *A. abietina*) but more often inside dead bivalve-shells (*M. modiolus*, *Chlamys varia*) and in whelk-shells (*Buccinum undatum*) tenanted by hermit-crabs (*Pagurus bernhardus*).

6. *Berenicea patina* (Lamarck). *Diastopora patina* Garstang (1901).

Also uncommon and entirely offshore; inside the same dead bivalve-shells as for *T. liliacea*, on tubes of "ross" (the polychaete *Sabellaria spinulosa*) (Harmer, in Garstang; my own observations), and on *Flustra*.

7. *Disporella hispida* (Fleming).

A few colonies on flints at Q.2 (brought up by scuba divers from about a quarter of a mile northwest of Sheringham Lifeboat House on 5.8.1962); the flints were as large as a human head, and were covered with a *Plumaria*-like red alga on top and with sponges, serpulids, and bryozoa underneath.

8. *Lichenopora verrucaria* (Fabricius). Vine (1892).

Four small colonies on *A. abietina* cast ashore on Hunstanton Scaup, 23.3.1952.

9. *Aetea anguina* (L.). "?*Aetea truncata* Landsborough" Vine (1892).

Only from 1950 to 1954 inclusive; apart from those profusely covering a red alga cast up at West Runton (15.9.1950) and those on the hydroid *Campanularia verticillata* cast up near the "Hjördis" (19.3.1954), the Norfolk colonies were all found offshore in whelkpot rubbish on other ectoprocts, on hydroids, and on *Hyas coarctatus*. Vine found only a "small fragment", and assigned it with some doubt to "the stoloniferous portion of the dwarf variety of this species" (i.e. his supposed *A. truncata*); since *Aetea* is so rare in our area, it seems unlikely that more than one species is in fact involved, particularly as Vine's fragment had no zooids.

10. *Scruparia ambigua* (D'Orbigny). *Eucratea chelata* Vine (1892); Garstang (1901).

Common among hydroids and bryozoa in whelkpot rubbish during 1950 and 1951, but absent since then except for fertile colonies growing on small green algae in the Pit (Blakeney Harbour) on 25.9.1953. The colonies from Cleethorpes (on an unstated substratum; Vine) and Yarmouth (on the bryozoans *Amathia* and *Vesicularia*; Harmer, in Garstang) were both probably this species, which occurs all round the British Isles and as far north as Scandinavia, whereas the closely similar *S. chelata* (L.) has its northern limit in southwest England (Hastings, 1941; Ryland, 1963).

11. *Eucratea loricata* (L.). *Gemellaria loricata* Vine (1892).

Abundant in the trawl in Blakeney Deeps, especially on its northern slope (the landward slope of Blakeney Overfalls); very common in whelkpot rubbish and often cast ashore.

12. *Membranipora membranacea* L. Vine (1892). Serventy (1934).

"Common on *Laminaria digitata*" (Vine); this association is well established on other British coasts, but neither *L. digitata* nor *M. membranacea* have ever been found in Norfolk waters.

13. *Electra pilosa* (L.). *Membranipora pilosa* Kirchenpauer (1875); Vine (1892); Garstang (1901).

Probably the most widespread marine bryozoan in Norfolk waters; absolutely ubiquitous on other bryozoans and on hydroids out to sea, and very common on the lower part of the shore at West Runton where it forms a lace-like layer round the thallus of a hispid brown alga. These latter colonies are clearly of *E. pilosa*, although they superficially resemble *E. verticillata* as shown by Bobin & Prenant (1960).

14. *Electra crustulenta* (Pallas). *Membranipora monostachys* var. *fossaria* Garstang (1901).

Of Garstang's two records (both from near Yarmouth) that from "ditches of brackish water a mile from the sea" (Wigham) is probably correct, whereas the other ("abundant on mussel-shells, etc." – Harmer) is more likely to have been *Conopeum reticulum* (q.v.). I have found it twice in the northern sluicegate of

Cley East Bank (a strongly brackish locality), but so far nowhere else; the specimens were kindly identified by Miss P. L. Cook.

15. *Electra monostachys* (Busk).

A small colony inside an old shell of *Macoma balthica*, cast up at Hunstanton on 23.3.1952, was identified by Miss Cook.

16. *Conopeum reticulum* (L.). *Membranipora lacroixii* Garstang (1901); *M. reticulum* Vine (1892).

Very common intertidally, less so offshore, on shells and stones; along the North Norfolk coast it is extremely abundant on mussels (*Mytilus edulis*) living on the lower part of the shore.

17. *Conopeum seurati* (Canu).

Some old and worn colonies at Cley, with *E. crustulenta* (q.v.) and likewise determined by Miss Cook; often confused with related species (Jebram, 1968; 1970, pp. 346–347).

18. *Callopora lineata* (L.).

Small colonies are sometimes found under rocks at extreme low water at West Runton, but this species is apparently much more plentiful sublittorally because large and abundant colonies were taken at Q.2. It seems to be confined in our area to the rocky grounds off Sheringham and Cromer (of which the shore at West Runton is merely the intertidal fraction), the very grounds on which crabs (*Cancer pagurus*) and lobsters (*Homarus vulgaris*) are fished commercially, although I know of nothing to suggest that *C. lineata* is directly associated with either of these species.

19. *Callopora dumerili* (Audouin).

Entirely offshore, seldom in less than 10 metres' depth; very common inside the mouths of whelkshells tenanted by *P. bernhardus*, but less so on stones or dead shells of *Modiolus* or *Ostrea*.

20. *Callopora aurita* (Hincks).

In exactly the same situations as the preceding species, and if anything even more abundant.

21. *Tegella unicornis* (Fleming).

One colony inside the mouth of a *Buccinum*-shell tenanted by *P. bernhardus* at W.33.

22. *Flustra foliacea* (L.). Kirchenpauer (1875); Vine (1892); Garstang (1901); Redeke & van Breemen (1904).

Extremely abundant on the more pebbly grounds, though perhaps not on larger rocks, and widespread in smaller quantities, always offshore; one of the chief constituents of the rubbish in whelkpots and crabpots, and of the debris cast ashore at high-water mark.

23. *Securiflustra securifrons* (Pallas). *Flustra truncata* Kirchenpauer (1875); *F. securifrons* Vine (1892).

Several colonies were cast ashore between Blakeney and Holkham from 1947 to 1950 inclusive, since when the only record is of a colony cast up at Holme in the first week of July 1967 (collected by Group-Captain D. D. Christie).

24. *Tricellaria ternata* (Ellis & Solander). *Menipea ternata* Kirchenpauer (1875); Garstang (1901).

Not seen here since the "Pommerania" took it at P.108 (Kirchenpauer, as usual quoted by Garstang).

25. *Scrupocellaria scruposa* (L.). Kirchenpauer (1875); Garstang (1901); Vine (1892).

Very common on *Modiolus*-shells, other bryozoans, and hydroids; less so on stones, sponges, ascidians, tubes of *Sabellaria spinulosa*, and carapaces of *Hyas* spp.; always offshore except for single living colonies, one in "Guenowle" (before 1954, when this wreck was covered by advancing sand) and the other under waterlogged wood on the Freshes Lays on 13.5.1950, and for numerous living colonies on the inner wall of the "Hjördis".

26. *Scrupocellaria scrupea* Busk. Kirchenpauer (1875); Garstang (1901); Gilson & al. (1944).

At P.108 (Kirchenpauer; Garstang) and at Scolt Head (Gilson & al.); I am rather surprised that I have never seen this species in spite of careful examination of a large number of Norfolk colonies of this genus, all of which were either *S. scruposa* or *S. reptans*. A key to West European *Scrupocellaria* spp. is given by Ryland (1963, p. 11).

27. *Scrupocellaria reptans* (L.). Vine (1892); Garstang (1901).

Invariably present on large colonies of *Flustra*; much less frequent on other supports (e.g. the basal mat of the hydroid *Nemertesia antennina*, old shells of *Buccinum* and *Modiolus*, or the inside wall of the "Hjördis"), on all of which it is usually outnumbered by *S. scruposa*.

28. *Scrupocellaria ?elliptica* Reuss. Vine (1892).

Vine stated that a small fragment, found by him on algae, did not agree exactly with the figures either of Hincks (1880) or of Reuss, but was closest to Hincks's plate VI, fig. 5.

29. *Epistomia bursaria* (L.). *Notamia bursaria* Hincks (1880).

Cromer (Wigham, in Hincks); no other Norfolk records.

30. *Bicellariella ciliata* (L.). *Bicellaria ciliata* Vine (1892); Garstang (1901).

Under rocks near low water at West Runton, 1.8.1954; inside "Guenowle" with *S. scruposa* (q.v.); otherwise exclusively offshore, where it is very widespread and sometimes exceedingly abundant on other bryozoans and on hydroids, though less so on ascidians, polychaete-tubes, and dead bivalve shells.

31. *Bugula avicularia* (L.).

Common in whelkpots on stones, shells, *Flustra*, *Hyas* spp., tubes of *Sabellaria* and large solitary ascidians, during 1951, 1952, 1955, and 1956, but not seen at all here since then.

32. *Bugula plumosa* (Pallas). Kirchenpauer (1875); Garstang (1901).

Under rocks near low water at West Runton, and inside the "Hjördis", from early June to late September (sometimes abundant); otherwise entirely offshore, where it is often plentiful in trawls and whelkpots.

33. *Bugula flabellata* (Thompson).

In dredgings and whelkpot rubbish, not common; always on *Flustra*, except for some colonies inside dead *Modiolus*-shells at D.22.

34. *Bugula turbinata* Alder.

On shells and *Hyas coarctatus* in whelkpot rubbish; one record each year in 1951, 1952, and 1954.

35. *Cellaria fistulosa* L. Vine (1892).

"A small but very perfect zoarium . . . in my 1879 gathering . . . nestling in the bulky roots of *Flustra foliacea* in company with *Scrupocellaria scruposa*. Hincks does not record Scarborough as a locality for this species, yet I have had sent to me a few forms from that neighbourhood as *Salicornaria farciminoides* Johnston" (Vine).

36. *Membraniporella nitida* (Johnston).

A few fertile colonies during July and August 1951, inside the mouths of whelk-shells tenanted by *P. bernhardus*, in whelkpots; definitely this and not the extremely similar *Callopora rylandi* Bobin & Prenant (1965; see also Ryland & Stebbing, 1971).

37. *Cribrilina annulata* (Fabricius). Garstang (1901); *Lepralia annulata* Kirchenpauer (1875).

Not seen here since its capture at P.115 on the inside of an un-named dead bivalve shell.

38. *Celleporella hyalina* (L.). *Schizoporella hyalina* var. *tuberculata* Vine (1892).

Occasionally (out to sea or cast ashore) on *Amphisbetia operculata*, *Scrupocellaria reptans*, or *Flustra*; rarely in red algae at West Runton (cast ashore). The colonies are always very small, but often have ovicells.

39. *Chorizopora brongniarti* (Audouin).

Several fertile colonies inside old *Modiolus*-shells at D.22.

40. *Escharella immersa* (Fleming). *Lepralia peachii* Kirchenpauer (1875); *Mucronella peachii* Garstang (1901).

Extremely common on stones and old *Modiolus*-shells, in whelkpot rubbish and dredgings; often inside the mouths of whelk-shells tenanted by hermitcrabs.

41. *Escharella ventricosa* (Hassall). *Mucronella ventricosa* Hincks (1880).

Burnham (Hassall, in Hincks); I have found it on stones and shells, once in dredgings and once in whelkpot-rubbish.

42. *Escharella variolosa* (Johnston). *Lepralia trispinosa* Kirchenpauer (1875).

In whelkpots and dredgings with *E. immersa*, but about half as common; also on flints at Q.2.

43. *Escharina vulgaris* (Moll). "?*Schizoporella* sp.", Redeke & van Breemen (1904).

Close by the Spurn Head Lightship on 4.8.1901, not uncommon on small stones in 18 metres of water on a sandy bottom (Redeke & van Breemen); they state that their specimens agreed in every way with Smitt's figure (1868, pl. 25, fig. 78) of *Mollia vulgaris* forma *spinifera*, which Dr. Ryland informs me is a synonym of *E. vulgaris*.

44. *Schizomavella auriculata* (Hassall).

Common offshore on and in whelkshells with hermitcrabs, on *Modiolus*-shells, and on stones; also found under rocks near low water at West Runton, and at Q.2.

45. *Schizomavella linearis* (Hassall). *Schizoporella linearis* Garstang (1901).

Distribution as for the preceding species; if anything more abundant, especially at West Runton, although it was not taken at Q.2 which is only a mile or two away.

46. *Hippoporina pertusa* (Esper). *Lepralia pertusa* Kirchenpauer (1875); Garstang (1901).

At P.108 (Kirchenpauer); not seen here since then.

47. *Cryptosula pallasiana* (Moll).

Fairly common at times on Hunstanton Scaup, and under rocks near low water at West Runton; common on the Freshes Lays in 1950 and 1951, but not seen there since.

48. "*Umbonula verrucosa* Esper." Vine (1892).

"A small but very distinct fragment" (Vine); this may have been:—

(a) *Umbonula littoralis* Hastings (1944), one of the species formerly confounded under the name *verrucosa* until recognised as distinct by Hastings, who also records it from Scarborough among other places;

(b) *C. pallasiana*, which I often mistook for *Umbonula* in the early stages of this survey, and it is not impossible that Vine also made this mistake;

(c) much less likely than either (a) or (b), *Umbonula arctica*, which Hastings (1944) also records from Scarborough; however, if Vine had seen *arctica*, he would almost certainly have used the name given in Hincks (1880), namely *Mucronella pavonella*.

49. *Microporella ciliata* (Pallas). Vine (1892).

Entirely sublittoral; a few at Q.2 on large flints, otherwise several large colonies in whelkpots and dredgings, living in whelkshells with hermitcrabs or on dead *Modiolus*-shells.

50. *Fenestrulina malusi* (Audouin). *Microporella malusii* [sic] Vine (1892).

Distribution as for *Escharella immersa*, but much less common; not found at all from the beginning of 1953 to the end of 1964.

51. *Omalosecosa ramulosa* (L.).

Two colonies in whelkpot rubbish (one in 1950, the other in 1951), and a third cast up dead among hydroids at Hunstanton in 1953.

52. *Turbicellepora avicularis* (Hincks).

Very common among hydroids and other bryozoans in whelkpot-rubbish during 1950 and 1951, but not seen here since then.

53. *Celleporaria pumicosa* (Pallas). *Cellepora pumicosa* Vine (1892).

Twice during 1951 (June and July) in whelkpot-rubbish.

54. *Celleporina hassalli* (Johnston). *Cellepora Hassalli* [sic] Kirchenpauer (1875); *Cellepora costazi* Garstang (1901).

Rare on hydroids (*H. falcata*, *A. abietina*), and always offshore, rarely cast up.

55. *Alcyonidium gelatinosum* (L.). Kirchenpauer (1875); Garstang (1901).

Not uncommon in the trawl; frequent in whelkpot-rubbish, particularly on the carapaces and legs of *Hyas araneus* and *H. coarctatus*; Redeke & van Breemen also took it, but only at stations outside our area. I have seen colonies cast ashore (on 26.1.1955, and 17.8.1962) which may have been the closely allied *A. proliferans* Lacourt (1949), but on neither occasion was I able to make a reliable identification.

56. *Alcyonidium polyoum* (Hassall).

Very common in whelkpots; on the legs of *Hyas araneus*, and inside the mouths of whelkshells with hermitcrabs, but less often on living whelks, on living or dead *Modiolus*, or on stones. Intertidally it has been found several times in Blakeney Harbour (on *Fucus* in the Pit; on the Strong; in the lowest reach of Morston Creek; on dead shells of *Ostrea* and *Mytilus* in the Freshes Lays; on old iron and shells in the Threshold; and under a brick on the Reef), as well as under rocks at low water at West Runton.

57. *Alcyonidium mytili* Dalyell.

In the Threshold, with *A. polyoum*; rarely in whelkpots. Harmer's statement that *A. mytili* is "common on shells, etc." in the Yarmouth area (quoted by Garstang) is probably due to confusion between these two species (see le Brozec, 1956).

58. *Alcyonidium hirsutum* (Fleming).

Four times on algae at West Runton; two of these were on *Fucus*, one on a red alga resembling *Rhodymenia*, and one on an unidentified alga.

59. *Alcyonidium parasiticum* (Fleming).

Always on hydroids offshore; occasional on *H. falcata*, and rare on *Bougainvillia ramosa*, *Tubularia indivisa*, and *Laomedea bicuspidata*.

60. *Alcyonidium mammillatum* Alder.

In small amounts, always offshore and mostly in whelkpot-rubbish, on a variety of hydroids, crabs, ascidians, and dead shells.

61. *Flustrellidra hispida* (Fabricius).
Confined to *Fucus* at West Runton, where it is scarce.

62. *Vesicularia spinosa* (L.). Garstang (1901); *Valkeria* [sic] *spinosa* Kirchenpauer (1875).

Distribution as for *Eucratea* (no. 11), but even more abundant; it usually carries a heavy population of epizoic "lodgers" (other bryozoans, hydroids, sessile ciliates, etc.).

63. *Bowerbankia pustulosa* (Ellis & Solander).
Occasionally in dredgings, and often cast ashore.

64. *Bowerbankia imbricata* (Adams). Garstang (1901).

Common offshore on *Hydrallmania* and *Flustra*, less often on other supports; intertidally it is sometimes taken on algae in Blakeney Harbour, in Abraham's Bosom, in caverns in the submerged forest at Brancaster, inside the "Hjördis", in Titchwell Main Lagoon on a submerged treestump (only on 18.11.1967), and commonly under Wells Rocks on *Anguinella* and algae.

65. *Bowerbankia gracilis* Leidy.

Until recently better known as *B. caudata* (Hincks) (but see Bobin & Prenant, 1954). A few times under rocks at West Runton, once under stones in the lowest reach of Morston Creek, and once in whelkpot-rubbish; in brackish waters (a)

Titchwell North Lagoon (only on 20.10.1971, *fide* R. B. Williams), and (b) the Salts Hole at Holkham (Hunt, 1971, but not found there by me).

66. *Bowerbankia citrina* (Hincks).

In large mossy clumps all over the under side of an isolated boulder lying on hard clayey sand just below low-water mark on Hunstanton Scaup, 5.9.1952.

67. *Bowerbankia*, sp. indet.

Miss Cook (in litt.) thinks that this may be undescribed; the zooids are much smaller than in other Norfolk species of this genus. It has been found on the mast-stump of the "Hjördis" on 3.9.1962, among *B. imbricata* under Wells Rocks on 6.4.1951, cast ashore at Hunstanton, and (with *Aetea*) on *Amathia* in whelkpot-rubbish.

68. *Farrella repens* (Farre). *Triticella flava* Garstang (1901).

On stones with the hydroid *Laomedea* in Morston Quay; in the lowest reach of Morston Creek and in the Pit of Blakeney Harbour; under Wells Rocks; and several times among hydroids and bryozoans cast ashore. Two unusual records were:—

(1) All over a dead female swimming-crab (*Macropipus holsatus*), cast ashore on the Freshes Lays on 25.6.1951, soon after hatching her spawn.

(2) All over an ovigerous female of the parasitic copepod *Lernaeocera lusci*, on the gills of a *Gadus luscus* taken by Mr. J. Fisher off Yarmouth beach on a handline on 23.9.1961.

Harmer's supposed *Triticella* (quoted by Garstang) was taken on the carapaces of *M. holsatus* at Yarmouth, thus in the same situation as (1) and the same geographical area as (2). All other records of British *Triticella* indicate a preference for deeper and cooler waters, rather as for the entoprocts (see above); if it is present in our area at all (which I very much doubt), I would expect to find it on *Upogebia* or *Axius* (Norfolk records, Hamond, 1971, pp. 99–100), the only Norfolk relations of the burrowing thalassinid *Calocaris macandreae* which is constantly infested with *Triticella* off the coast of Northumberland.

69. *Amathia lendigera* (L.). Vine (1892); Garstang (1901).

Moderately common in whelkpot-rubbish; usually on *Hydrallmania* and *Modiolus*, but also on other hydroids, *Flustra*, ascidians, wormtubes, and *Hyas araneus*.

70. *Walkeria uva* (L.).

Occasionally plentiful in the lowest reach of Morston Creek, the Pit, the Reef and the Threshold (all in Blakeney Harbour); prefers small red and green algae, but sometimes occurs on stones. Under Wells Rocks it has occurred several times with *B. imbricata*.

71. *Hypophorella expansa* Ehlers.

On the only occasion when I looked for this species, in the walls of *Lanice*-tubes buried in the sand at extreme low-water mark north of Brancaster Golf Club on 16.9.1966, it was present in small numbers; it may in fact be quite widespread in Norfolk waters, where *Lanice* is common (Hamond, 1966b).

72. *Nolella pusilla* (Hincks).

Rare on *B. imbricata* (twice under Wells Rocks and once cast ashore), and once on the hydroid *Laomedea loveni* in the lowest reach of Morston Creek. Of these four records, two were in August and two in September.

73. *Anguinella palmata* van Beneden.

Abundant at times under Wells Rocks; occasionally on Hunstanton Scaup, in the lowest reach of Morston Creek, and under rocks near low water at West Runton.

**Ecology of the Ectoprocta**

For the sake of brevity each species will be referred to by its number; poorly known species are excluded.

The Norfolk ectoprocts can be grouped according to habitat preferences and the methods of capture most likely to secure them; as shown above, a given species may occur in more than one group, so the following is based on the most frequent occurrences only.

(1) Cast ashore, or passively drifted into whelkpots lying on the seafloor:—

(a) Large branching species; common, 11, 22, 32, 55, and 62; less common, 23 and 63.

(b) Small species often epizoic on those in group (a); common, 2, 3, 13, 25, 27, 30, 64, and 69; uncommon, 1, 8, 9, 10, 33, 38, 51, 52, 54, 59, 60, and 68.

(2) Mainly encrusting species, living offshore inside the mouth of whelkshells tenanted by hermitcrabs, on dead bivalve-shells, and on stones, taken in whelkpots or by dredging:—

common, 13, 19, 20, 40, 42, 44, 45, and 56; uncommon, 2, 3, 5, 6, 9, 21, 31, 33, 34, 39, 41, 49, 50, 51, 52, 53, 54, 57, and 69.

| (3) Among boulders subtidally (e.g., Q.2) | | common | uncommon |
|---|---|---|---|
| Occurrence subtidally) | common | 13, 16, 44 | 6, 40, 42, 49 |
| elsewhere in Norfolk ) | so far unknown | 18 | 7 |

(4) Intertidally among rocks:—

(a) At West Runton; common, 32, 44, 45, 47; uncommon, 13, 18, 30, 56, 65, 73.

(b) Under Wells Rocks; common, 64, 73; uncommon, 13, 67, 68, and 72.

(5) In brackish water; 14, 17, and to some extent 65.

(6) Intertidally, confined to algae; 58, 61.

(7) Walls of *Lanice*-tubes; 71.

**Discussion**

Even after some 20 years of collecting at frequent intervals by methods which catch far more epifaunal animals (such as bryozoans) than infaunal or interstitial animals, and including all previous records, I have not been able to list for the entire Norfolk area more than a relatively low percentage of the total number of any given major group of marine invertebrates. For all such groups which I have studied here, the combined percentage is about 40; however, for the ectoprocts it is only about 20 and for the entoprocts about 10 (assuming that all Nielsen's Danish entoprocts will sooner or later be found in British waters, as indeed several have since they were first described). Although the Blakeney–Wells area (my offshore collecting area; Hamond, 1969, fig. 1 and pp. 209–213) is only a small part of the Norfolk area, it appears to be typical of it and in many ways one of the richest parts of it; the above low percentages therefore reflect a genuine paucity of bryozoans in our waters, some possible reasons for which will now be discussed.

A hydrological and biological exploration of Lynn Well might help to throw light on this problem. Lynn Well is the deep central basin of the Wash, with maximum depths of 35 to 50 metres, surrounded on all sides for many miles by depths of less than 20 metres; not until Yorkshire, or far to the east of northeast Norfolk, are depths of 50 metres met with again. As far as I could learn from the King's Lynn shrimpers, the dominant substrata in Lynn Well are composed of stones and shells, and it is continually scoured by quite strong tidal currents, though direct wave action at such a depth is likely to be slight since Lynn Well has land on three sides of it at a radius of about ten miles, and within that radius many large sandbanks which are more or less exposed at low tide, thus reducing considerably the "fetch" of wind-induced waves except from the north. No readings of temperature or salinity from the depths of Lynn Well are available to me, but at any given time there are two main alternative possibilities:—

(1) It constantly has the same kind of water in it as in the shallower sea all around it; if so, it presents a combination of the depths found off Yorkshire or (closer inshore) off Northumberland, with the usual kind of water found off Norfolk. Any faunal differences between similar substrata in Lynn Well and in the shallower Norfolk waters would thus offer a means of disentangling depth-dependent factors from other factors influencing the distribution of marine invertebrates here.

(2) Lynn Well resembles the "Tiefe Rinne" (the "deep ditch") a few miles south of Helgoland, in being a submarine basin in which a residual puddle from an invasive water-mass may remain for long after the latter has retreated, and is dissipated (by mixing or displacement) relatively slowly. This difference in water-type is reflected in the plankton; the invasive water in the "Tiefe Rinne" can contain plankton dominated by the chaetognath *Sagitta elegans* for weeks or months at a time, even though local plankton dominated by *S. setosa* extends not only all around it but over the top of it as well, and the *elegans*-plankton may be reinforced at any time by fresh invasions from the north or northwest.

Off Norfolk, *S. elegans* is the dominant chaetognath in local water anyway, and there are very few species in the rather poor permanent plankton which could be considered at all reliable as indicators (cf. Hamond, 1969, p. 213); however, an invasion of northern water would almost certainly bring with it the larvae of non-native invertebrates, which would settle on the floor of Lynn Well if given a suitable substratum; the history of their subsequent development would represent a compromise between their powers of survival, their rates of growth, and the duration of the invasive water until it was dissipated. Even if all these invasive animals then died, those which left resistant remains (e.g. calcified skeletal structures), firmly attached to rock or other objects which could be assumed not to have drifted very far (if at all), would provide a history of the habitat from which the pattern of previous invasions of non-local water could possibly be reconstructed. Suitable animals in Norfolk waters are the barnacles and the encrusting cheilostomatous ectoprocts; in this paper, species 8, 21, 36, 37, 39, 43, and 46 would be best as they are unable to flourish in our area for very long, whereas the structurally similar species 5, 6, 7, 18, 19, 20, 40, 41, 42, 44, 45, 49, and 50 would make poor indicators as they are all well able to live locally. The calcareous shells of molluscs and ostracods are also less suitable as indicator-because, although very resistant to physical destruction, they are highly susceps tible to drifting into a submarine basin in which they could not possibly have existed when living.

An approach to this is already implied in the notes under each species-name; many species were definitely present in some years and absent in others, both from my own records and from those of earlier observers. Since nearly all Norfolk water comes from further north, these species are probably at the southern limit of their range along the east coast of Britain, and are capable of periodic invasions here but not of survival on any long-term basis. The early nineteen-fifties appear to have been exceptionally favourable for many species, but the value of continuous monitoring in Norfolk waters cannot be too strongly emphasised, as it seems that any of these irregularly-occurring species may be found again from time to time.

The family Calloporidae (nos. 18 to 21) and the genus *Bugula* (nos. 31 to 34) offer an interesting comparison, each being a group of allied species having different ecological tolerances and preferences. *Callopora aurita* and *C. dumerili* are both obviously well able to live and breed in our offshore waters, where they are common in dead whelkshells and bivalve-shells; *C. lineata* is restricted to large boulders, and yet is the only calloporid to extend above low-water mark here; while *Tegella unicornis*, although having the same general habitat-preferences as the first two, seems to be near or at its southern limit. *Bugula avicularia* and *B. turbinata* were found only in the early nineteen-fifties, and *B. flabellata* from 1951 to 1959; on the other hand, *B. plumosa* has always been common, and is also the only one of these four species to have been found living naturally in the intertidal zone.

Encrusting ectoprocts, whether calcified or not, also furnish another clue to the possible reason why so few species of bryozoan are found here. The intertidal species often grow under rocks or shells, which in this region protect them from direct sunlight and air; however, out to sea where the light near the bottom is very dim at best and where dessication could not possibly occur, we nevertheless find that many species prefer overhanging surfaces just as if they were on the shore. The insides of dead whelk-shells a short way in from the mouth (i.e. the "ceiling" of the hermit-crab's house as the hermit-crab site looking out of it), and the concave inner surfaces of dead bivalve shells, yield not only the most numerous but also the best-developed bryozoan colonies, whereas the *outer* surface of a whelk-shell (whether it contains a hermit-crab or the living whelk) seldom has large or numerous colonies of encrusting bryozoans. This position ("hanging head downwards from the ceiling") appears to be an adaptation against smothering with silt; colonies in dead whelk-shells have the additional advantage of being bathed in the hermit-crab's respiratory current, which brings food to the colonies and washes them clean. Norfolk waters carry a heavy load of fine silt, which I believe to be the main reason why the percentage of ectoprocts is so much lower than that of so many other groups; this offers an interesting comparison with the reasons suggested previously for the paucity of entoprocts.

Apart from the effects of silting, however, it should be remembered that Norfolk sea-temperatures (Hamond, 1967a) seem to be too high in summer for many northern species (compare the present list with those of Roper (1913) and of Eggleston & Bull (1966), both for Northumberland) and too cold in winter for both these and many Channel species (Buge & Lessertisseur, 1968, and refs.) which are able to penetrate as far east as Belgium (Prenant, 1931; Loppens, 1948) or even to Holland (Lacourt, 1949); these limits apply both to bryozoans and to many other groups of marine invertebrates.

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# THE CHELICERATE MARINE ARTHROPODS (ACARINA AND PYCNOGONIDEA) OF NORFOLK

*By* R. Hamond

**Summary**

Eleven pycnogonids and eighteen mites (of which only three pycnogonids and one or perhaps two mites had previously been recorded in Norfolk waters) are now known from the Norfolk marine area; the mite *Copidognathus loricifer* André is new to the British Isles, and the pycnogonid *Callipallene emaciata tiberi* (Dohrn) is new to the North Sea. The mites *Bryobia* sp. and *Hyadesia* sp. could not be identified with certainty.

**Introduction**

Whereas in the Norfolk marine area (Hamond, 1963, 1969, for station-lists and all place-names) the mandibulate arthropods are represented by a rich variety of crustaceans, the chelicerate arthropods are small and few although quite widespread; all are dealt with in the present paper. Of the Acarina (the mites), the terrestrial and maritime species of Blakeney Point have been listed by Luxton (1966); of the truly marine family Halacaridae the present paper records 14 species, all for the first time in Norfolk waters. Three of the pycnogonids (sea-spiders) were recorded in the Yarmouth shrimptrawls by the late Arthur Henry Patterson (cited as A.H.P.; see Hamond, 1971); all other records are from my own collections, intertidally around Cromer and Sheringham (West Runton in particular) as well as from Blakeney to Hunstanton, and offshore by dredging in the Blakeney–Wells area.

**Class Pycnogonidea**

(identified from Sars, 1891, and Bouvier, 1923; the very useful paper by King & Crapp, 1971, did not appear until after I had left Norfolk for Australia).

*Nymphon rubrum* Hodge. *N. gracialis* [sic] A.H.P.

Very widely distributed in small numbers among hydroids offshore. Ovigerous males (Table 1) are found from October to April in sheltered intertidal situations permanently covered by water (e.g. the lowest reach of Morston Creek, the Strond Pool, or inside the "Hjördis") among tufts of hydroids (*Laomedea* spp., *Opercularella lacerata*).

*Nymphon brevirostre* Hodge.

Easily confused with *N. rubrum* (see Norman, 1908), but much less common here; found among hydroids in the summer of 1955, twice offshore and once in the "Hjördis".

*Nymphon hirtum* Fabricius.

Scarce in dredgings, usually on the rich grounds east and northeast of the Blakeney Overfalls Buoy; this has by far the greatest leg-span of any Norfolk pycnogonid (about 4 cm.), although the body is less bulky than that of *Pycnogonum littorale* (q.v.). A northerly species, extending along the east coast as far south as Margate (Norman, 1908) but on the west coast no further south than the Isle of Man (King & Crapp, 1971); sometimes placed in the genus or sub-genus *Chaetonymphon* which is probably not worth keeping apart from *Nymphon* s.str. (J. H. Stock, in litt.; King & Crapp, 1971).

TABLE 1

Months in which more (X) or fewer (x) ovigerous male pycnogonids have been observed; there are no breeding records in Norfolk waters for *N. brevirostre* or *N. hirtum*, nor for any of the acarines listed in this paper.

| | | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Nymphon rubrum* | | X | x | x | x | | | | | | x | X | X |
| *Callipallene b. brevirostris* | | | | | | | | | x | x | | | |
| *C. e. tiberi* | | | | | | | | | | x | | | |
| *Phoxichilidium femoratum* | | | | | | | | | | | | | x |
| *Anoplodactylus petiolatus* | | | | | | | x | x | | X | | | |
| *A. pygmaeus* | | | | | | | | | | X | | | |
| *Achelia echinata* | | | x | | x | x | x | x | X | | | | |
| *A. longipes* | | | | | x | | | | | | | | |
| *Pycnogonum littorale* | | | | x | | x | | | | | | | |
| 9 spp. | spp/month | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 4 | 1 | 1 | 2 |

*Callipallene brevirostris brevirostris* (Johnston).

Widely distributed among hydroids and bryozoans offshore, but in very small numbers (less common than *N. rubrum*); twice (both times in August) under rocks at low-water mark at West Runton, but otherwise found intertidally only among floating material in the plankton or among hydroids and bryozoans cast ashore. On one occasion a female (not quite fully grown) was seen to feed on the polyps of the hydroid *Kirchenpaueria pinnata*.

*Callipallene emaciata tiberi* (Dohrn).

Rare in dredgings, and one under rocks at extreme low-water mark at West Runton on 6.9.1959 (confirmed by Professor Stock). For the use of trinomial names, and of *Callipallene* in place of *Pallene*, see Stock (1952). This is the first time in the North Sea, and the furthest north anywhere, that *C. e. tiberi* has yet been found.

*Phoxichilidium femoratum* (Rathke). *P. coccineum* A.H.P.

Occasionally among the alga *Corallina* (whose crimson colour it matches almost exactly) at West Runton; in winter many of the specimens found here are ovigerous males. Less common offshore, and found there always among hydroids, though never among *Tubularia* spp. (*T. indivisa*, *T. larynx*), which have been searched repeatedly without success for this and for the closely allied *P. tubulariae* Lebour (1947).

*Anoplodactylus petiolatus* (Krøyer).

Common among hydroids offshore; sometimes found under Wells Rocks, in the Pit of Blakeney Harbour, and under rocks at West Runton.

*Anoplodactylus pygmaeus* (Hodge).

Scarce among hydroids offshore; relatively common under Wells Rocks, and less so in the Pit and at West Runton, though more abundant intertidally than is *A. petiolatus*.

*Achelia echinata* (Hodge).

In the same habitats as *Anoplodactylus* spp., but about equally common intertidally (especially among *Corallina* at West Runton) and offshore (among branching bryozoans, mostly *Eucratea loricata* and *Vesicularia spinosa*).

*Achelia longipes* (Hodge).

In the same situations as *A. echinata*, but if anything even more numerous.

*Pycnogonum littorale* (Strøm). A.H.P.

Occasionally in dredgings, in shrimp-trawls, and in rubbish cast ashore.

**Class Acarina**

Of the four British orders of mites (Evans, 1957), the Metastigmata (the ticks) are not represented in the Norfolk marine area (Thompson & Goldsmith, 1972).

Order Prostigmata.

Family Tetranychidae.

*Bryobia* sp.

Three specimens, still alive and very active, in clean sand just north-east of the mouth of Morston Creek (i.e. almost right in the middle of Blakeney Harbour) during low tide on 9.5.1967; Dr. Sheals, who kindly identified this species, writes that it is "a terrestrial plant-feeding species, probably blown onto the sand". This may or may not be the same as *B. cristata* (Dugès) from Blakeney Point (Luxton, 1966); in any case, none of the British Tetranychidae are truly marine.

Family Halacaridae.

Named as in the British list by Green (1960), but identified from André (1946) and Fountain (1953).

*Halacarus actenos* Trouessart.

Three at D.5.

*Copidognathus granulatus* (Hodge).

Moderately common among small algae and hydroids, in the Pit and under Wells Rocks; once each under Hunstanton Pier, and cast up near the "Hjördis", in both cases among hydroids.

*Copidognathus rhodostigma* (Gosse).

In the same habitats as *C. granulatus*, as well as in the *Pelvetia*-marsh near Pinchen's Creek on Blakeney Point.

*Copidognathus loricifer* André.

The first record for the British Isles; common at times under Wells Rocks but rare elsewhere (among the bryozoan *Bowerbankia pustulosa* cast up at West Runton, and among *Opercularella lacerata* under stones in the lowest reach of Morston Creek).

*Copidognathus fabricii* (Lohmann).

Probably the most generally common intertidal species of the genus in North Norfolk, and certainly by far the most often collected in Blakeney Harbour; also common under Wells Rocks, and taken a few times at Hunstanton (especially under the Scaup, but also under the Pier). Offshore, however, the only record is of a deutonymph at W.32.

*Copidognathus oculatus* (Hodge).

Distribution as for *C. fabricii* (though rather less numerous), but also found among *Corallina* at West Runton. This and the next species are sometimes (André, 1946, but not Green, 1960) put into the sub-genus *Copidognathopsis*.

*Copidognathus gracilipes* (Trouessart).

Whereas the other Norfolk species of this genus are markedly intertidal, this species is found entirely offshore, except for one among *Corallina* at West Runton on 21.12.1956. All my specimens were of the typical form, and not of the varieties described by André (1946, p. 104).

*Rhombognathus notops* (Gosse).

Among algae and *Bowerbankia imbricata* under Wells Rocks (four on 18.9.1954 and three on 20.12.1956), and two among feathery red algae (which had been soaked for a few minutes in very dilute formalin-seawater) growing in Backwater Creek (a tributary of Morston Creek) on 19.12.1962.

*Rhombognathus magnirostris* Trouessart.

About thirty among a sample of *Fucus vesiculosus* (covered with *Laomedea flexuosa*) from the mouth of Morston Creek on 19.12.1962, and one from Backwater Creek on the same day (with *R. notops*, q.v.).

*Rhombognathides pascens* (Lohmann).

So far only at West Runton; about 35 in a sample (0.8 litres) of *Corallina* on 21.12.1956, one on a colony of the polychaete *Sabellaria spinulosa* on 8.2.1955, and one among thick red and brown algae near extreme low-water mark on 11.7.1956.

*Rhombognathides seahami* (Hodge).

One from Morston Creek with *R. magnirostris* (q.v.), and one under Wells Rocks with *R. notops* on 20.12.1956.

*Metarhombognathus armatus* (Lohmann).

Very common among green algae and tide-line rubbish in Morston Creek, February 1955; about 20 there in *Fucus* with *R. magnirostris* (q.v.).

*Simognathus minutus* (Hodge).

One among holdfasts of *Laminaria saccharina* in the Threshold on 18.12.1956, and one in *Corallina* with *R. pascens* (q.v.) at West Runton three days later; otherwise confined to dredgings offshore on gravelly ground (type $C_2$ or $H_2/C_2$, see Hamond, 1963, 1969) with a rich fauna of hydroids and other organisms, where it is never numerous.

*Lohmanella falcata* (Hodge).

One adult on 18.9.1954 and two more on 20.12.1956, all of them under Wells Rocks.

Order Mesostigmata.

*Halolaelaps marinus* (Brady). Luxton (1966).

Rare in Blakeney Harbour (twice in the Pit, and once in the Threshold among *Laminaria saccharina*). These three specimens were all determined by Dr. Evans; for the British species of this genus, see Hyatt (1956). Luxton found it in the loose clumps of *Pelvetia* in the marsh near Pinchen's Creek (where I found *C. rhodostigma*, q.v.).

*Phaulodynichus minor* (Halbert).

One deutonymph (det. Dr. Evans) hanging onto a gill of the amphipod *Talorchestia deshayesi*, collected in sand above high-water mark on the outside of the Point, facing the "Hjördis", on 15.4.1957.

Order Cryptostigmata.

*Hyadesia* sp.

One found creeping on a colony of the ascidian *Botrylloides leachi*, cast up at high-water mark near Hunstanton Scaup on 23.5.1955. As it is a deutonymph the species cannot be determined with certainty, but Bénard's key (1961) brings it to *H. furcillipes* Bénard. Dr. Luxton (in litt.) says that his *Hyadesia* sp. from Blakeney Point (Luxton, 1966) may possibly have been *H. fusca* Michael; further collections are necessary to determine how many (and which) species really occur here.

## Discussion

The taxonomy of most of the above species is fairly straightforward; for the pycnogonids, King & Crapp (1971) give a very useful discussion of *Nymphon* spp., but appear to have overlooked Stock's (1952) paper on *Callipallene*. Adults of *Achelia* spp. other than *longipes* or *echinata* were carefully looked for, but without success; in the present state of our knowledge the numerous sub-adult *Achelia* collected were best left unidentified. The identification of adult halacarids gave no difficulty; other kinds of mites were identified when found although not specially looked for, but appear to be genuinely rare in our marine environment.

Norfolk offshore waters being shallow and turbulent, with easily disturbed substrata, it is not surprising that both mites and pycnogonids are rare there, almost as if most species preferred to withstand the wider intertidal range of salinity and temperature for the sake of more reliable microshelter. At the moment I cannot satisfactorily explain why so many of our pycnogonids have been found at West Runton; some occur entirely offshore (*N. hirtum*, *P. littorale*) or mainly so (*Callipallene* spp., *A. petiolatus*); however, *A. pygmaeus* seems to be the only species which is more frequent intertidally here than offshore. Two species (*N. rubrum* and *P. femoratum*) make clearly defined migrations inshore in winter to breed, remaining offshore at other times of year. Of the halacarid mites, only *H. actenos* and *C. gracilipes* occur entirely offshore (except for the latter being found once at West Runton), and *S. minutus* mainly so; all the other species have a strong preference for life either above low-water mark or at any rate only just below it (as for instance in the Pit of Blakeney Harbour which, although it never dries out, is nowhere more than two or three metres deep and is three-quarters enclosed by land). The Rhombognathinae (*R. notops* to *M. armatus*) all feed solely on algae, and thus have a good "excuse" for being obliged to live on the shore; this will not do for the other halacarids, which are supposed to be microcarnivores. Wells Rocks is still the only Norfolk locality for *L. falcata*, and for the great majority of *C. loricifer*, possibly because these species demand exceedingly stable microshelter; why West Runton should be the only locality for *R. pascens* is, however, quite unknown (and may even be accidental).

This kind of brief survey inevitably raises more questions than it could possibly answer; the most it can reasonably be expected to achieve is to indicate the most suitable sources of living material for experimental work on these fascinating but far too little-known creatures.

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# SOIL TEMPERATURES

*By* T. B. Norgate

Thanks to co-operation from the staff at the Norfolk School of Horticulture at Burlingham, the writer was given access to soil temperatures recorded there. It was hoped that some worth-while information would be available for inclusion in the 1972 weather summary on another page.

Temperatures at such "agro-met" stations are measured at 9.0 a.m. daily, at both 4″ and 8″ depths. [It is hoped the editor can accept the British rather than metric units.] Though last year had a cold summer, especially in June, this was not apparently reflected in the soil temperatures, at either depth. In fact the mean temperatures since 1967 were 9.5° and 9.6°C at 4″ and 8″ respectively, whereas for 1972 they were 9.4° and 9.3°C.

These soil temperatures do not, naturally, fluctuate as much as air temperatures but are nevertheless influenced by sunshine and have their own diurnal fluctuations. The daily cycle of thermal diffusivity (i.e. penetration of air temperature changes) is delayed by about two hours (and the amplitude halved) for each 4″ of depth. Thus, at a depth of 2 feet the diurnal amplitude is less than 2% of that on the surface and therefore quite small. In general daily fluctuations do not reach as far as 4 feet down.

An average temperature for central Norfolk at a depth of one foot in February is 4°C, and at four feet it is about 5°. In August the corresponding figures are 17° and 16°. There is a small rise ($\frac{1}{4}$°–$\frac{1}{2}$°) towards the Suffolk border in all four positions. At increasing depths, observations show that seasonal surface changes of temperature are delayed by 6 days for every foot of depth – thus at 30 feet the maximum summer temperature would not be realized until the following winter, a delay of 6 months.

Soil temperatures appear simple enough to record, but in fact conductivity of thermometer tubes and their casings, protruding through the surface, cause inaccurate readings. This has resulted in the use of thermo-electric equipment to reduce the errors. Measuring at 9.0 a.m. means that at a depth of one foot the figures represent a *minimum* one, thanks to about three hours' delay compared with air temperatures.

At still greater depths, influence of the heat from the centre core of the earth becomes noticeable. Temperature of the crust increases by about 1°C for each 100 feet depth. If maintained this rate of increase would mean a temperature at the centre of 200,000°C! But the heat gradient drops to perhaps one fiftieth of the rate quoted above, and at a depth of 50 miles the temperature is thought to be something over 1,000°C. At the centre it is believed to exceed 2,200°C and the increase of temperature quoted above maintains a steady rate only through the outer crust. Its thickness is relatively no more than is the shell of an egg or the skin of an apple. Though interesting enough this is beyond the subject under discussion. Soil, strictly, is confined to the top few feet of the crust and which has been altered by three agencies thus:—

(1) Plant life, bacteria and insects.

(2) Surface moisture dissolving and removing chemicals.

(3) Erosion of hard material by weathering – frost action in particular.

Moisture in the soil, whether natural or from irrigation, affects temperatures by raising its specific heat. As a result there is still more delay before diurnal changes take their full effect and consequent levelling out of peaks. Experiments were carried out some years ago at the Research Station at Wellesbourne near Warwick – and in Russia – to find out the effect of irrigation on soil temperatures. There is a rapid drop of 7°C at 1″ depths and about 3° at 6″ and this reduction persists for at least 3 days at reducing amounts. However the gain in plant growth following watering is thought more than to compensate for the lower temperature which might inhibit it. Surprisingly these temperature reductions do not appear to be influenced by the initial temperatures at the spray lines. Experiments included heating the water and applying ¾″ (75 mm.) equivalent rainfall.

Micro-climate is a specialized subject, and insects and plants (especially seedlings) are subjected to sudden and extreme climatic changes and they have to be very resilient. It is not unusual for a hard bitumen road to reach a temperature of 54–55°C on a summer's day whereas on a sandy soil the surface would not exceed perhaps 44°C and 6° less on grass. In the latter case higher temperatures are prevented by the insulation provided by air trapped within the blades of grass. In addition, trapped moisture further retards any temperature rise on a hot day, with the reverse effect during the night. It is for this reason that artificial covering of ground will add to the risk of any frost damage to growth immediately above. Straw, therefore, should not be put on the ground between rows of strawberry plants too soon in the season, and so add to the risk of frost damage to blossom.

Minimum ground temperatures are usually a few degrees below that at 4 feet, the accepted height of a "screen" for measuring air temperatures. In 1972 the maximum difference amounted to 6½°C and occurred during the third week of October. There were 33 nights with over 4° difference of which 7 exceeded 5°C. On the other hand there are some occasions when the ground temperature exceeds that in the air and occurred only half a dozen times last year and then only by less than 2°. Snow cover can cause such conditions but this did not arise in 1972.

# WEATHER SUMMARY FOR 1972

*By* T. B. Norgate

JANUARY. The month began with up to 100 mm. (4″) of snow and a mean temperature of just under 3°C, a degree below normal and was the coldest January for 6 years. Air frosts were recorded 14 times with bitter east winds at the end and an air temperature down to −12°C. It was dull with less than 40 hours sunshine, only 75% of what might be expected and less still on the coast. Rainfall was uneven in the county and was largely influenced by several hours of sleet, snow and rain during the night of the 26th/27th in some parts, with a N.W. gale. Total amounts were generally on the high side, varying from 90 mm. at Lower Bodham to under 40 mm. at Burlingham. Norfolk escaped the worst of the weather, Dublin and Heath Row Airport were hampered by snow and Guernsey had over 150 mm. (6″).

FEBRUARY. This was a drier month, especially near the coast, most places recording only 30–35 mm., i.e. 30% below average. Sunshine was about 20% down with only 50 hours. Though there were only 6 air frosts, the mean temperature for the month was nearly 4°C compared with an average of 4½°.

MARCH. It was a much more cheerful month with over 150 hours sunshins (40 hours on the high side) and again dry throughout the county except towarde The Fens. An official drought (15 or more consecutive days without rain) was experienced until the end of the month when rain was followed by sleet. Temperatures exceeded 19°C, to give a mean of 6½°, slightly above normal. The "growing period" (with mean temperatures above 5½°C) began mid-March which is about a week late. Parhelions were then observed and a pronounced solar halo on the 25th followed by a lunar one after dark. The day had been very blustery with a 52–53 knot N.W. wind and fierce towering clouds and a little rain the next day or two.

APRIL. For the first time since 1937 the April temperature did not exceed 16°C. Despite this, the mean of 8° was very little below average and there was only one air frost. Sunshine hours were 10 less than in March and almost normal for April. Rainfall varied from a little over 25 mm. at Bacton (usually dry) to 65 mm. at Hardingham and generally speaking was about 10% on the high side. Hail and thunder were recorded on the 10th.

MAY. It was mainly a wet month with thundery showers which the west of the county seemed to escape, and a total precipitation of 65 mm. in central Norfolk was about 20 mm. on the high side. Sunshine topped 200 hours at Gorleston with 15–30 hours less inland. Though a maximum temperature of 21°C was reached once, the mean was under 11°C and again ½° below normal with 6 ground frosts inland.

JUNE. The month was notable for producing a mean temperature of only 12°C, a full 2° on the low side (and just a touch of ground frost quite early in the month inland), never reaching 22°. It was the coldest June this century. On mid-"summer" day the temperature did not even reach 17°C. Sunshine hours were under 160 inland, 20% light, so on no count could it be called a "flaming" June. There were 14 raindays in mid-Norfolk, but thunderstorms caused very variable amounts. Generally speaking there was a deficiency again.

JULY. History was made this month at Costessey where, during a thunderstorm as much as 135 mm. (5.42″) of rain fell in under 3 hours. Actually it occurred during the early hours of the 1st August and is credited to July 31st since our "rainday" begins at 9.00 a.m. G.M.T. when rainfall is officially measured. According to the Met. Office such a rapid downpour has a "return period" (i.e. likelihood of a repetition there) of over 1000 years, yet within a few miles quite trivial amounts were recorded. Sunshine hours were nearly 20% down, varying from 155–165 (inland and on the coast respectively). Equally disappointing for a summer month was the temperature with a mean of only 15½°C, almost 1° below normal and dropping to within 2° of frost (on the ground) on the 12th.

AUGUST. Though sunshine hours were almost up to 200, 8% above average, the mean temperature was again down, 15°C instead of 16½° for the time of year though the maximum did manage to reach 24°C in Blakeney twice in the first week. Rainfall was very low on the coast from Bacton southwards with but 3 mm. at Hopton, falling on only 3 or 4 days in one or two places. Other parts had the remains of "Costessey's deluge" *after* 9.00 a.m. G.M.T. on the 1st and therefore entered as for August. Scotland even had some snow.

SEPTEMBER. Another dry cold month, drought conditions starting on the 19th in Norwich and northwards, lasting into October. Hingham measured 33 mm. (1-1/3″) during a thunderstorm the day before and so "topped the list" with a total of 60 mm. compared with but 22 mm. at Stratton Strawless, the lowest figure. The mean temperature for the month was yet again below normal (11.7° against 13.3°), the maximum just exceeding 21°C on the 1st. Sunshine too was deficient, 117 hours on the coast and rather less inland, only about 80%.

OCTOBER. What is usually our wettest month, in 1972 it was the driest October for over 100 years in some parts of both the county and country. The highest rainfall in Norfolk was but 12½ mm. at Felmingham while Clenchwarton had under 3 mm. against averages of over 60 mm. As a result of several dryish months, the year's total rainfall was 75% down by the end of October, not allowing for additional transpiration losses during the "warmer" weather. The mean temperature was just over 10°C inland (about normal), the maximum almost touching 22° twice and therefore better than September in this respect. But there were a few slight air frosts, with 10 or 12 on the ground in lowlying places. Sunshine amounted to only 90–95 hours, nearly 20 hours below average.

NOVEMBER. The mean temperature was 6°C which is about what can be expected this month, with a maximum of 15° on the 1st. But by the 14th the first of 8 air frosts was recorded this winter but none more than −1.6°C on the 15th. By then the daily mean had dropped well below the critical 5½° and so ended the "growing period" abruptly. Sunshine was about 40% above normal, reaching 78 hours but not enough to keep the temperature any higher. Rainfall was unevenly distributed, well above average in the north of the county on the Cromer Ridge but 25 mm. less in the south. There were only two really wet days.

DECEMBER. Yet another dry month with little over 25 mm. in the centre of the county, the driest December there since 1963 and only half the average. The rainfall was more than double this in the N., and N.W. especially. It was yet another cool month with a mean just over 5°C, only ¾° lower than November's and more than 1° above the average for December. Sunshine hours were nearly 53, 20% on the high side.

SUMMARY FOR THE YEAR. 1972 was an unusually dry year, the driest since 1963 in the centre of the county but since 1921 at Aylsham. Here the total was only 47.8 cms. (just over 18″), being almost 23 cms. (9″) below normal. The dry conditions were of course aggravated by transpiration losses amounting to 15 cms. or so. Farmers on heavy land had difficulty lifting sugar beet, and with autumn cultivations, on account of hard ground. The meres in Breckland and several ponds in the county were exceptionally dry by the end of the year.

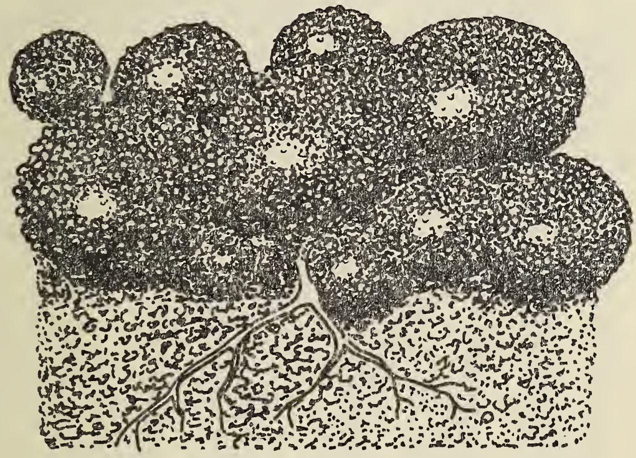
Sunshine amounted to about 1400 hours in the centre of the county, with a bit more on the coast, which is 6% lower than usual. Only March, November and December showed any appreciably high figures, while June and July were both 20% down. As a result the year seemed more sunless than it was, since a 40% excess in November was literally cold comfort for what was lacking in the summer.

The maximum temperature for the year was 24½°C (76°F) in mid-July, while August only reached within 1° of this, once. The dull chilly summer was more comparable with summers expected in the Shetlands. However, this year northern Scandinavia had temperatures in excess of 31°C early in July. A very mild March in the Arctic caused early melting of ice and the resulting icebergs travelled much further south than usual. This cooled the North Atlantic and caused depressions to be routed over Gt. Britain instead of clearing North Scotland. The mean temperature for the year, 9°C, was only ½° below normal however; but, as in the case of sunshine, the lack of warm weather was mostly in the summer months. There were 40 air frosts against an average of about 60 but ground frosts were recorded 101 times.

Despite this lack of any hot weather, thunder or lightning was recorded on 11 days, only one less than a long-term average in central Norfolk. Probably the instability was the result of the unusual Atlantic chill. Some snow or sleet fell on 9 days in the year (counting sleet as half a day), against an average of 17 days. This fact highlights that 1972 was notable for its cold summer.

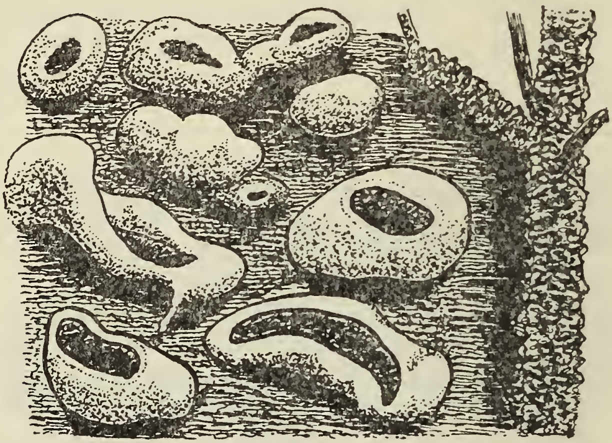
*Botrydium granulatum* (L.) Grev. This alga has appeared regularly on garden soil in late spring and summer for many years at Wheatfen Broad, Surlingham. The spherical coenocytes occur as clusters of small green bubbles arising from colourless rhizoids embedded in the soil. The largest specimens seldom exceed 2 mm. in diameter, but groups of them may cover much ground, being then as conspicuous as patches of moss. At maturity the bubbles collapse in the centre and then have the appearance of shallow cups. In dry weather their green colour becomes bleached so as to appear ice-blue with the formation of numerous white lime crystals on the surface. In wet weather the vesicles release motile zoospores asexually and these develop directly into new plants. This alga, though widespread in the British Isles, is not often noticed. It is most likely to be seen in the mud of newly dried out ponds or on dredgings in summer, especially in lime-rich areas.

E. A. Ellis



*Peridermium pini* [Pers.] Lev. This rust-fungus producing "resin top" disease in Scots pine (*Pinus sylvestris* L.) has spread extensively in the Breckland forest in recent years. The large orange-coloured aecidia are conspicuous on the upper parts of the main stem and branches during the summer and the perennating mycelium eventually kills the tree. This is a non-alternating race of *Cronartium flaccidum* (Alb. & Schw.) Wint. which has other forms infecting both pines and herbaceous hosts such as *Tropaeolum, Impatiens* and *Paeonia.* In this instance the pines are directly infected by aecidiospores. The rust has long been indigenous in Scotland and is thought to have been brought to East Anglia with pines introduced from the Spey valley.

E. A. Ellis

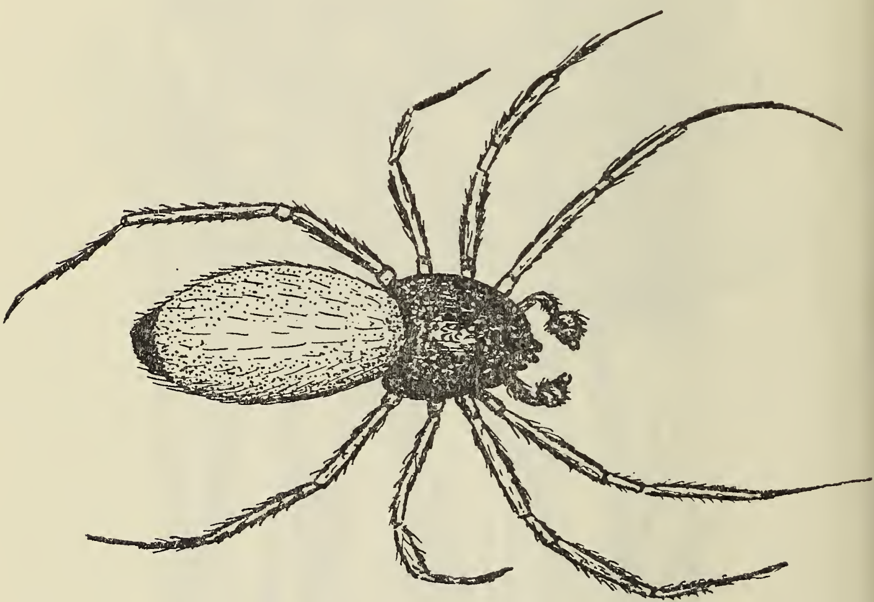


*Narcissus pseudonarcissus* L. Wild daffodils are by no means common in Norfolk and persist mainly in the untilled swards of country churchyards. In the east of the county they still occur at Hethel, Braconash, Swardeston, Stoke Holy Cross, Saxlingham Nethergate, Claxton, Sprowston and Rackheath, including some woodland sites. In west Norfolk colonies were found at several sites, including the churchyard, in the parish of Ingoldisthorpe by Dr. John Weston Wells, April, 1973. They are usually the first daffodils to open in spring. In the main, these dwarf "Yellow Crowbells" stand only about six inches tall, with nodding blooms whose butter-yellow, crinkly-edged trumpets are scarcely longer than the pale yellow perianths. The leaves and compressed stalks are of a glaucous green colour.

E. A. Ellis

*Ostearius melanopygius* (O.P.-Camb.), a much-travelled spider. In the autumn of 1960 a number of manure heaps on farms in various parts of Norfolk attracted attention owing to their being covered with silvery sheet-webs. The spiders responsible proved to be *O. melanopygius*, previously unrecorded from East Anglia, but reported from similar habitats elsewhere in Britain, mainly in the south, following a gradual spread across the world from, it is thought, New Zealand. The warmth generated by the manure is favourable to these spiders, which also are able to feed on the abundant midges and mites present in the decaying material. Periodically, swarms of the younger spiders rise into the air on parachute threads and are dispersed widely in this way, helped initially by thermals produced by the rotting manure. Following the severe winter of 1963 it appeared that the species had been eliminated from local habitats, but a colony was discovered at Bramerton in September, 1972.

E. A. Ellis



## Lichens on Weeting Heath

During a visit to the rabbit enclosure part of Weeting Heath in February 1972 a number of lichens characteristic of grassland, developing on chalk rubble were found. These included 2 plants of *Buellia epigaea* (Hoffm) Tuck. otherwise only known in Britain from Lakenheath Warren, Deadmans Grave Icklingham and formerly Thetford Warren. Other lichens in this community included *Toninia coeruleonigricans* (Lightf) Th.Fr., *Squamarina lentigera* (Web) Poelt (another rare species), *Diploschistes scruposus* var. *bryophilus* (Ach) Mull Arg., and *Petractis clausa* (Hoffm) Kremp. new to East Anglia, on a chalk pebble. It is apparent that the present management policy of keeping a high population of rabbits on this site is proving very suitable for these exacting species.

P. W. LAMBLEY

*Castle Museum*

## Lichens on Marsham Heath

This is one of the better east Norfolk heaths having suffered less from heathfires and scrub invasion than some of the others. I visited it in December 1972 and discovered a small colony of *Cladonia gonecha* (Ach) Asah. among *Calluna*. This was subsequently confirmed by Peter James at the British Museum Natural History. This is a rare species in lowland Britain, but becomes common on moors in the north. Other lichens recorded on this and a subsequent visit with Brian Coppins included the following species.

Cladonia coccifera (L) Willd.
Cladonia floerkeana (Fr.) Sommerf.
Cladonia macilenta (L) Hoffm.
Cladonia crispata (Ach) Flot.
Cladonia impexa Harm.
Cladonia glauca Florke.
Cornicularia aculeata (Sch) Ach.
Hypogymnia physodes (L) Nyl.
Lecanora conizaeoides Nyl ex Cromb.
Lecidea erratica Korb.
Lecidea uliginosa (Sch) Ach.
Lecidea granulosa (Hoffm) Ach.
Bacidia nitschkeana (Lahm ex Rabenh) Zahlbr. on *Calluna* litter and a flint pebble.
Bacidia melaena (Nyl) Zahlbr.
Rhizocarpon obscuratum var. reductum (Th.Fr.) Eitner

P. W. LAMBLEY

## Hull Wood

This is a small wood on the west side of the Glaven valley situated on hilly terraine. It has a large number of very old oaks (*Quercus robur* L.) including one about 7 metres in circumference 1 metre from the ground a number of others also approach this size. The ground flora includes *Corydalis claviculata* (L) DC. in abundance. However it is the lichen flora which is of considerable interest with 76 species so far recorded including several characteristic of ancient woodland such as *Opegrapha lyncea* (Sm) Borr. ex Hook. and *Lecanactis premnea* (Ach) Arnold. *Parmelia reticulata* T. Tayl. was found by Dr. Francis Rose and myself in 1972 and is new to Norfolk. *Thelotrema lepadinum* (Ach) Ach. is another forest species which occurs in a small wood called Bush Wood about 500 m. south of Hull Wood. This is known to occur in East Anglia only at Staverton in Suffolk, Blickling and Swanton Novers Great Wood in Norfolk.

P. W. Lambley

**Fossil holly seeds**

Seeds of holly (*Ilex*) were found in material collected by John Goldsmith from the shelly part of the Upper Freshwater Bed at West Runton. It was subsequently identified as this species by Mrs. Gay Wilson of the sub-department of Quaternary Studies at Cambridge. It is the first record for this species from the Upper Freshwater Bed.

P. W. Lambley

**Acaena** Pirri-pirri bur

Material of this alien plant collected from Kelling Heath by Ruth Barnes (now Mrs. Race) and placed in Norwich Museums herbarium has been revised to *Acaena novae-zelandiae* Kirk not *Acaena anserinifolia* (Foster) Druce following the publication of keys to the genus by Peter Yeo. These keys also give other records from Kelling Heath.

P. W. Lambley

*Cladocera.* Two species of Cladocera were collected from the upper reaches of the River Yare during the late spring and summer. *Simocephalus vetulus* (Müller) was abundant amongst the plants growing in the quieter regions of the river at Keswick Mill, Colton and Coston. Both males and females were collected. Eggs at varying stages of cleavage were noted in specimens during early April and June 1973. The numbers of eggs varied from 7 to 9 per female. *Eurycercus lamellatus* (Müller) was collected in equal abundance at all three sites. Females examined in early June contained up to ten eggs, often in advanced stages of cleavage.

Gurney (1907, Trans. Norf. Norw. Nat. Soc.) collected both species from the lower reaches of the River Yare, where *Simocephalus vetulus* was found in more saline waters than *Eurycercus lamellatus*.

R. E. Baker

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LIST OF CONTRIBUTORS

## LIST OF ILLUSTRATIONS

(Plates are to be found opposite the pages indicated.)