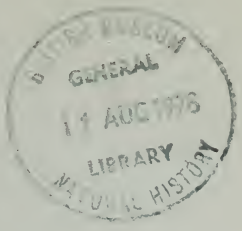

TRANSACTIONS OF THE NORFOLK & NORWICH NATURALISTS' SOCIETY

Vol. 22 PART 4

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CONTENTS

A SURVEY OF THE HISTORY OF THE NORFOLK AND NORWICH NATURALISTS' SOCIETY

By K. B. Clarke

One wonders why the Society came to be founded in the particular year of 1869. Why not, for instance, in 1859 or 1879? One thing which must have contributed greatly to the interest in Natural History about that time was the meeting of the British Association for the Advancement of Science which took place in Norwich in August and September of 1868 with that famous East Anglian Botanist, J. D. Hooker, as President. The meeting lasted from 19th August to 26th August in the presence of many of the greatest names of Victorian Science. After the meeting had finished came the excursions, to Holkham, to Breydon and Burgh Castle.

Another possible reason for the founding of the Society at this time may have been the death in November 1868 of Thomas Brightwell, Esq. at the age of 81. This may sound a strange reason but for the previous fifteen years Brightwell had been the leading figure in the Microscopical Society, whose limited membership included many of the best naturalists in the Norwich of that time. Brightwell was the very doyen of natural history in Norwich, magistrate, councillor, a Vice President of the British Association. For any Naturalists' Society to survive would have been impossible without his support – and his support was for microscopy. The first meeting of that Society was held in 1852 at the home of the Rev. J. Crompton, the same who was to become the first president of the Naturalists' Society. From the time of the founding of the Naturalists' Society the Miscroscopical Society slowly declined and in 1884 was wound up due to lack of interest.

The rise and fall of societies in Victorian Norfolk was mentioned by the Rev. J. Crompton in his first address to the Naturalists' Society. He said, "Some of us tried to stir up the Norwich people and one after another these societies arose and died away, each rotting and adding something to the soil. It may be the fate of this Society to die also and, if so, we shall leave a nice little debris for other people's benefit afterwards". This was happily not the fate of the Society and again one asks why. What was so different which prevented it joining the Science Gossip Club, the Meteorological Society and the Geological Society in the limbo of lost support?

A number of different factors must have contributed to the Society's success. Above all it embraced many scientific interests and disciplines and it therefore had a wider appeal than the other societies like the Geological or Meteorological Societies which were founded in the same decade. Above all the success of the Naturalists' Society must, however, be attributable to the magnitude of the support which it received. Besides including in its membership a number of "persons of quality" it also counted many of considerable influence, if of lesser rank. When the meeting of the Museum Committee discussed a request from the Society to be allowed to hold its meetings at The Museum, every member of the Committee present was also a member of the Society. The Society also had the very active support of Henry Stevenson, proprietor and editor of the *Norwich Mercury* and Secretary of the Museum Committee, whose "Birds of Norfolk" had been published only two years before. This latter must have also added to the growing interest in ornithology.

The Society was founded with a great heritage of East Anglian natural history already behind it. There are indeed traces of two earlier societies. In 1747 a Natural History Society was founded in Norwich and in 1867 a Norwich Naturalists' Society held a few meetings. It was only a new facet of this existing great tradition. It showed its consciousness of this tradition by publishing many letters and papers of early Norfolk naturalists during the first decade of its existence.

In the light of this heritage, therefore, it was most fitting that the Society should hold its first meeting at the Norwich Museum which, since 1824, had been the focus of natural history in Norfolk under the presidency of Sedgewick, Dawson Turner, Captain Glasspoole, among many notable naturalists (including, of course, Thomas Brightwell). The first meeting was held on 30th March 1869 with Dr. Beverley in the Chair. Twenty men were present and they passed a series of fifteen rules which, though they have been modified somewhat down the years, still form the basis of the Society's business. There were no ladies present. The Rev. J. Crompton, minister at the Octagon Chapel, was elected President and J. Hunt Junior, Secretary. Henry Stevenson and Fred Kitton were elected Vice-Presidents.

The first ordinary meeting of the Society on 27th April 1869 began by electing Professor Newton and John Henry Gurney as the Society's first Honorary Members. The Society had cause to be glad of their help for many years after. John Henry Gurney was three times President of the Society, once in the Jubilee year of 1919, and Professor Newton began the Society's happy and fruitful connections with the University of Cambridge.

The President made an opening speech which is recorded in the Transactions. A number of his remarks are apt even today, for he reminded members of the need not to go in a body to hunt for rare plants and each one claim a specimen. He reminded them also of a tendency prevalent then, as now, for bridle paths to become footpaths and for footpaths to become no paths at all.

Mr. Geldart then read the first Paper to the Society in which he suggested the division of the County into botanical districts.

Afterwards a number of specimens were displayed including Claytonia (now Montia) perfoliata from Rockland which had also been found at Workhouse Lane, Norwich. This alien was a precursor of the Society's interest in alien plants throughout the century. The Poa bulbosa, which was displayed from "the South Denes, Yarmouth", is still found there.

On 20th May 1869 the Society's first excursion took place. Members of the Naturalists' and Geological Societies went to Coltishall and Horstead. It poured with rain but during the afternoon the rain stopped. A strong wind blew all day. Later in the year the members visited Brooke, Scoulton, Stoke Holy Cross and Ranworth, and these visits are variously described as delightful, pleasant, etc. in the Minutes.

Since then the Society has held over a thousand meetings or excursions. At first there were twelve meetings a year in addition to excursions and only in 1910 were the summer ordinary monthly meetings dropped. For many years meetings were held on Tuesday evenings at 7.30 p.m. and until the end of the last war they were held on Tuesday at 5 p.m. with tea served to members before the meeting.

The early excursions were on a noble scale, starting early (8 a.m.) and travelling by four-horse omnibus to country houses where "kind hospitality" or "a substantial repast" awaited them. Much time was spent examining ornithological collections and Papers were often read in the course of the day. Return to Norwich appears to have been made about nine in the evening.

In March 1870 the first part of the Transactions was presented to members. 300 copies were printed by Fletcher & Son at a cost of £12 2s. 6d. These early Transactions made two important contributions beside the publishing of Papers which had been read at meetings. These were the lists of the Flora and Fauna of Norfolk and the publication of documents relating to older naturalists. The Flora and Fauna was in fourteen parts and covered Mammals, Reptiles, Mollusca, Fish, Birds, almost all plants including Fungi, Marine Algae and Diatoms, and the chief phyla of the insect world. Publication of the nineteen letters between Robert Marsham, of Stratton Strawless, and Gilbert White, of Selborn, took up 62 pages of the Transactions of 1876. They throw an interesting light on these two great naturalists and on the state of natural history interests in the last decade of the eighteenth century.

At an ordinary meeting in November 1909 the suggestion was made by W. G. Clarke that the Society should publish a "Flora of Norfolk" and a committee was set up to consider the proposal. The Secretary of the Society, W. A. Nicholson, had a great amount of material which proved very valuable for this purpose. Mr. W. T. F. Jarrold offered to publish a "Flora" for the Society but the Committee were not satisfied with the terms which he proposed. They therefore went ahead on their own. The editing of the work was left entirely in Nicholson's hands and the work finally appeared under his name in 1913, having been printed by Richard Clay, of Bungay.

The Society has always taken a leading part in the protection of wild life. It was not, however, until 1878 that this became an object of the Society when the original Laws were revised, but it had already used its influence (with that of J. J. Colman) to prevent the shooting of spring Woodcock. When Pallas's Sandgrouse visited Norfolk in 1863 all were destroyed, while their visit of 1888 caused the Society to move into action with propaganda on behalf of their protection. The passing of the Wild Birds Protection Act of 1880 was barely noticed by the Society while in 1893 the Society took a very active part indeed in the framing of the next Wild Birds Protection Act. The Bill was debated at an ordinary meeting of the Society and a great number of amendments were agreed after some discussion. These were forwarded by the President (Thomas Southwell) to one of the Society's Vice Presidents, the Earl of Kimberley, who was Lord President of the Council. Many of them were incorporated, with advantage, into the Act. Again the Society wrote to all the local members of Parliament to ask them to support a Bill which became the Wild Birds Protection Act of 1899.

In 1914 the Plumage Act was passed after similar action by the Society.

One of the most memorable periods in the Society's activities in the protection of wild birds occurred after the first World War. Its culminating point might be regarded as the 11th June 1923 when Scolt Head Island was given by the Society to the National Trust so that it might be preserved for ever as a nature reserve. The period began at a meeting of the Committee on 22nd February 1921, called especially to consider the co-ordination of wild bird protection within the County. It was resolved to submit a resolution to the

Annual General Meeting that a Wild Birds' Protection Committee of the Society be formed. This resolution was accepted and led to the Protection Committee's first meeting under the Chairmanship of J. H. Gurney in the Norfolk and Norwich Library on 17th May 1921.

The Committee considered the four areas which the County Council had designated under the Wild Birds Protection Acts. At Blakeney a whole-time watcher was employed by the National Trust and Mr. Quinton Gurney jointly. He received £2 6s. 0d. per week and all the rabbits he could catch. At Wolferton Colonel Cresswell employed a watcher during the breeding season with privately collected funds. His small Wolferton Wild Birds Protection Society enjoyed the patronage of His Majesty King George V. The large breeding area for terns at Wells was protected by the Earl of Leicester's keepers.

Breydon Water had enjoyed protection since 1888 when a society was formed with H. E. Buxton as President to enforce the Wild Birds Protection Act of 1880. It employed a watcher and maintained a punt and houseboat on a budget rarely exceeding £30 per annum. It never had a prosecution for the gunners very quickly learnt that Sam Chambers, the watcher, did not intend the law to be broken on Breydon. It was always the Breydon Society's hope that one day avocets would breed again in this country. The year before their foundation had seen five out of six visiting avocets shot there. It is pleasant to recall that recently this hope was fulfilled within thirty miles of Breydon.

Early in 1922 the Wild Birds Protection Committee assumed responsibility for three of these four areas; Breydon, Blakeney and Wolferton. In 1922 the island of Scolt Head came up for sale and was purchased by Lord Leicester. The Society's secretary discussed with him the desirability of retaining the island as a nature reserve and the Earl agreed to sell the island for £500. Dr. Long, the Secretary, then went to work with such a will that he had raised £200 before the Society opened the public appeal. The money was raised quickly and within a few months of the appeal being launched Lord Ullswater received the island on behalf of the National Trust and Miss E. L. Turner, a past president of the Society, moved into the Hut to be the first "watcher" there. She was watcher there for two years until a local man took over who could be there all through the year.

During 1926 Dr. Long got together sufficient funds to purchase 400 acres of Cley Marshes and these marshes were handed over at the end of the year to the newly-formed Norfolk Naturalists' Trust. The Naturalists' Trust also received from the Society the Dial House at Brancaster which had been bought for the Scolt Head watcher in June 1929 after an appeal by the Society. As the Norfolk Naturalists' Trust gained strength and experience it became increasingly apparent that it could deal with many of the matters with which the Wild Birds Protection Committee was concerning itself. At the Society's Annual General Meeting in 1933 it was resolved, therefore, that the duties of this Committee could be carried out by the Trust and that the funds held by the Society for payment of Watchers should be transferred to the Trust.

There has always been very close co-operation between the Society and the Norwich Museum. In a sense the Museum was an earlier form of the Society for already in the 1830s it held lectures and conversaziones at which appear most of the great names in early natural history in the county. It is more than just a happy coincidence that the Rev. J. Crompton frequently figured among the speakers.

All the Society's early meetings were held in the old Museum and when the Castle Museum opened in 1894 the Museum Committee agreed to the Society holding its meetings there. The establishment of a museum in the Castle, in place of a prison, was largely due to the energy of the Society's first Honorary Member, John Henry Gurney. Many of the exhibits, transferred from the old museum, were displayed according to the tastes of the Victorian era, as a collection of trophies rather than with any great intent to provide education, or to relate a species to its position in nature. However, in 1931, the Corporation of the city approved the re-arrangement of the Natural History exhibits to form a "Norfolk Room" and the Society voted a hundred guineas to meet part of the cost. A number of Society members served on the sub-committee which supervised the work and our president for the centenary year, E. A. Ellis, was one of the workers directly concerned with the carrying through of the scheme. The Norfolk Room also provided a home for many of the collections of Norfolk Fauna and Flora which had been made over the years. In 1935 the committee of the Society resolved to move the Society's library from the Norfolk and Norwich Library to the Norfolk Room and while many of the books were actually moved others became part of the Reference Library. A complete set of the Transactions of the Society was placed in the Norfolk Room.

From time to time the Society has formed sections to deal with special needs. Youth has a need to find out about nature for themselves rather than have experts take away the joys of discovery. With this in mind there was formed in January 1925 a juvenile section of the Society. This section waxed and waned through the ensuing decades according to the enthusiasm displayed by those in this very restricted age group.

Another special need was that of the outlying groups of naturalists. Norfolk is a large county and despite the railways attendance at meetings was not easy. Most vocal in the need for more local meetings were the members from Great Yarmouth and on 15th June 1893 a meeting was convened at Great Yarmouth by Mr. F. Danby Palmer and Mr. Arthur Patterson to form a "Yarmouth Branch" of the Society. Although the Branch was duly formed the Yarmouth members seem to have given it little support and it is not mentioned again. In 1927 it was revived by E. A. Ellis and others who were able to make use of a small balance which was still in an account with Barclay's Bank at Yarmouth.

Before recalling some of those who gave the Society a flavour of distinction by their membership it would be appropriate to mention the Royal Patronage which the Society has enjoyed since November 1921. His Majesty King George V had for many years been a patron of the Wolferton Wilds Birds Protection Society and when its functions were taken over by the Norfolk and Norwich Naturalists' Society His Majesty agreed to become Patron of our Society and H.R.H. the Prince of Wales agreed to be Vice Patron. Since that time the Society has enjoyed the patronage of succeeding monarchs.

When Dr. Michael Beverley died in 1930 the Society lost the last of its founder members. Indeed Dr. Beverley had claim to be *the* founder member, for it was in his room at the hospital that the discussions took place which were to lead up to the first meeting of the Society. He became President in 1872 and for the period of fifty-six years from 1874 to 1930 he was a Vice President of the Society. He was, nevertheless, not a very active naturalist. The flourishing practice which he had in the city took up most of his time and what little he had to spare had to be shared between natural history and his famous rose garden at Brundall. He contributed a Paper on Edible Fungi to the first issue of the Transactions.

Almost in direct contrast to Dr. Beverley was Arthur Patterson. For him nature came first. He had no employment so important as to distract his attention. His spare moments were all devoted to a study of nature and he recorded what he saw in voluminous note books and passed on his discoveries to the Society both at meetings and in the Transactions. From 1904 onwards he also brought our roughly one book a year. Over a period of almost forty years he reported in the Transactions on the birds and natural history of Great Yarmouth and he left most valuable fish records for he was well known to every Yarmouth fisherman.

Some members were living links with the past. Such a one was Alice Geldart, the Society's first woman President. Her father was a founder member of the Society, a member of the first Committee and a well-known botanist who presented a Paper at the first meeting of the Society. Alice Geldart grew up in the company of the great botanists of her day and she passed her whole life in botanical company for her home in Cotman Road, Thorpe, was a botanical rendezvous as long as she lived. Her father collected a valuable herbarium and she continued to add to it. At her death it passed to the Norwich Museum. Her father was three times President of the Society and she was twice President besides editing the Transactions for five years from 1930 to 1935. But botany was not her only interest, she was an Egyptologist, a water-colour painter and a violinist of very considerable merit.

Another botanist, editor of the Transactions, was the quiet, retiring William Nicholson. This frail bank employee was secretary and editor for twenty-one years and in 1914 the flora which he had written was published by the Society.

His period of office as secretary was exceeded by that of Dr. Sidney Long, who took over from Nicholson and occupied the post for a quarter of a century. Many will still remember him as he was in the years immediately before the war, a compact figure with a "Jimmy Edwards" moustache and a battered brown felt hat speeding along the lanes in an open car whenever his duties at the Jenny Lind or the Norfolk and Norwich Hospital permitted.

No review such as this would be complete without mentioning the contributions made to Norfolk natural history and to the life of the Society by the Gurney family. And yet the very magnitude of their contribution makes it difficult to deal with this adequately in the space available. There were seldom less than six members who belonged to the Gurney family and there was usually a Gurney on the committee. The present committee is no exception, Miss Catherine Gurney is the President-elect.

One cannot help looking back with a twinge of regret at the changes which have taken place in the Society. We seem to have become so much more colourless and conformist. Francis Dix, the meteorologist, always came to meetings in his Quaker dress and Mrs. Norgate refused to drink the Society's tea but brought a silver teapot with her and brewed her own.

The Society too has lost much of the serious (and often scathing) debate at its meetings. It has become much more a provider of entertainment than a provider of instruction or a forum for the exchange of observations of nature. And yet it is perhaps this ability to change which has allowed the Society to remain a vital living entity for a hundred years. It is perhaps the ability to adapt to a changing environment which, just as in nature, has been the key to the Society's survival. Survival is not really the correct description, however, for a society which has seen for the whole of its century a steadily growing membership until today this stands at the record figure of over 1,000.

PERIGLACIALLY MODIFIED CHALK AND CHALK RIDGE-DIAPIRS FROM NORWICH, NORFOLK

By Michael Leeder, B.Sc.
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Introduction

From 1965 to 1968 extensive excavations for the foundations of the University of East Anglia and other building projects have given opportunities for detailed study of the geology of the Yare valley between Colney and Cringleford on the western outskirts of Norwich.

Work on the site of the University (TG 194079) has revealed exposures in the Eaton Chalk division of the zone of *Belemnitella mucronata* (Peake and Hancock, 1961). Overlying the irregular chalk surface between 60′ O.D. and 80′ O.D. on the upper part of the valley side are complex deposits of discontinuous medium to coarse grained sands, poorly sorted gravels and occasional clay lenticles. Their thickness is variable, being absent in some parts but generally around 1 m. and up to 4 m. locally. Their age and lateral relations with the local Quaternary succession is unknown.

Periglacially modified chalk

The normal, soft, well-bedded chalk with parallel flint bands and abundant well-preserved fossils is overlain by a variable thickness (up to 5 m.) of reconstituted chalk, often called "putty" chalk by local engineers. This latter deposit consists of soft, thinly laminated or poorly bedded chalk containing occasional sub-rounded to sub-angular fragments of harder chalk in a soft, pasty matrix. The junction with the underlying normal chalk is broadly transitional. Mixing of reconstituted chalk with the overlying sands and gravels does not occur at this level on the valley side.

Whole, larger fossils, such as *Echinocorys*, *Belemnitella langei* Birkelund and *B. mucronata* Schlothiem, characteristic of the normal Eaton Chalk below, are rarely found. Belemnite fragments, however, are very common but adjacent fragments cannot be reassembled to form an individual. The fragments are often intensely pitted and etched. Separate echinoid plates are similarly common. In contrast, small fossils such as the rhynchonellid brachiopod *Cretirhynchia lentiformis* Woodward are often intact. Parallel flint bands do not occur. Instead, the flints occur in irregular and often highly undulose stringers or scattered randomly throughout the "putty" chalk.

All these features are taken as evidence for disruption of the fabric of the original chalk by some process of vertical and/or horizontal mixing.

Banham and Ranson (1965) describe chalk breccias from Weybourne, Norfolk, in which a gradation may be seen from finely jointed chalk, up through a zone with slightly rotated 2–3 in. blocks in a minimum of slurried chalk matrix, to an upper zone of fragments commonly less than 2 in. long set in a well developed matrix of reconstituted chalk. The fragments in the upper part of the breccia show a well-developed preferred orientation which Banham and Ranson ascribe to ice-movement. The origin of the breccia is thus tectonic.

The reconstituted chalk described above differs from this breccia in a number of ways:—

(i) The less common occurrence throughout of fragments of chalk.
(ii) The lack of angular fragments.
(iii) The absence of features such as folded or sheared tills and shear joints.

The formation of the reconstituted chalk may be best explained by the process of "freeze-thaw" in the water-saturated active layer (mollisol) which operates in areas of permanently frozen ground at the present day. Such a zone may be regarded as highly mobile and likely to have caused the postulated mixing of the normal chalk. A possible contribution due to solifluction, "the slow flowing from higher to lower ground of masses saturated with water" (Andersson, 1906), cannot be ruled out. Thus, in consideration of the Quaternary history of East Anglia, the modification of the chalk is probably due to periglacial processes.

Chalk ridge-diapirs

In one large exposure the surface of the modified chalk took the form of two adjacent parallel ridges 1 m. in height and several centimetres wide (Fig. 1, Plate 1). These were continuous with the reconstituted chalk at their base and broadened downwards from a slightly expanded top so that their cross section was that of elongate, tapering wedges projecting into the overlying poorly sorted sands. The ridges were continuous along the strike for at least 1 m. and in plan the crests were arcuate, being slightly asymmetrical towards the valley slope. They were surrounded by a thin zone of yellow/brown iron-stained sands. Adjacent elongate flints in the main body of sands were oriented with their long axes parallel to the sides of the ridges. Three other small projections of the reconstituted chalk into the overlying sands occurred adjacent to the chalk ridges. In contrast these were much smaller in amplitude and showed no great elongation.

Four processes may be considered which could form these features.

(i) Shear at the base of moving glacier ice.

(ii) Elevation of the chalk surface by frost heaving.

(iii) Differential solution of the chalk surface leaving ridges of chalk separating solution hollows.

(iv) Auto-injection of modified chalk into the overlying sands.

(i) Banham and Ranson (1965, p. 166, fig. 2F) have described chalk rafts at Weybourne, Norfolk and explain their origin by a process of thrusting from the surface of the in situ chalk. Such a tectonic process would account for some of the features of the chalk ridges but the hypothesis is rejected as a general explanation because of the following:—

(a) The Weybourne rafts are much larger than the chalk ridges and occur detached from the chalk surface and enclosed in sheared and folded till.

(b) The University sediments show no evidence of the glacier-induced stresses needed for this process to operate.

(ii) Frost mounds produced in areas of present-day permafrost have a much broader area and form domes rather than narrow elongate ridges (see West, 1968, pp. 74–76).

(iii) This process occurs at the present day in areas of chalk bedrock and is essentially static in relation to the position of the original chalk/sand interface. While solution could produce two-dimensional ridges bounding adjacent solution hollows, the persistence of the chalk ridges in the direction normal to Fig. 1 makes this explanation unlikely. In addition, the aligned marginal flints cannot be adequately explained by this process.

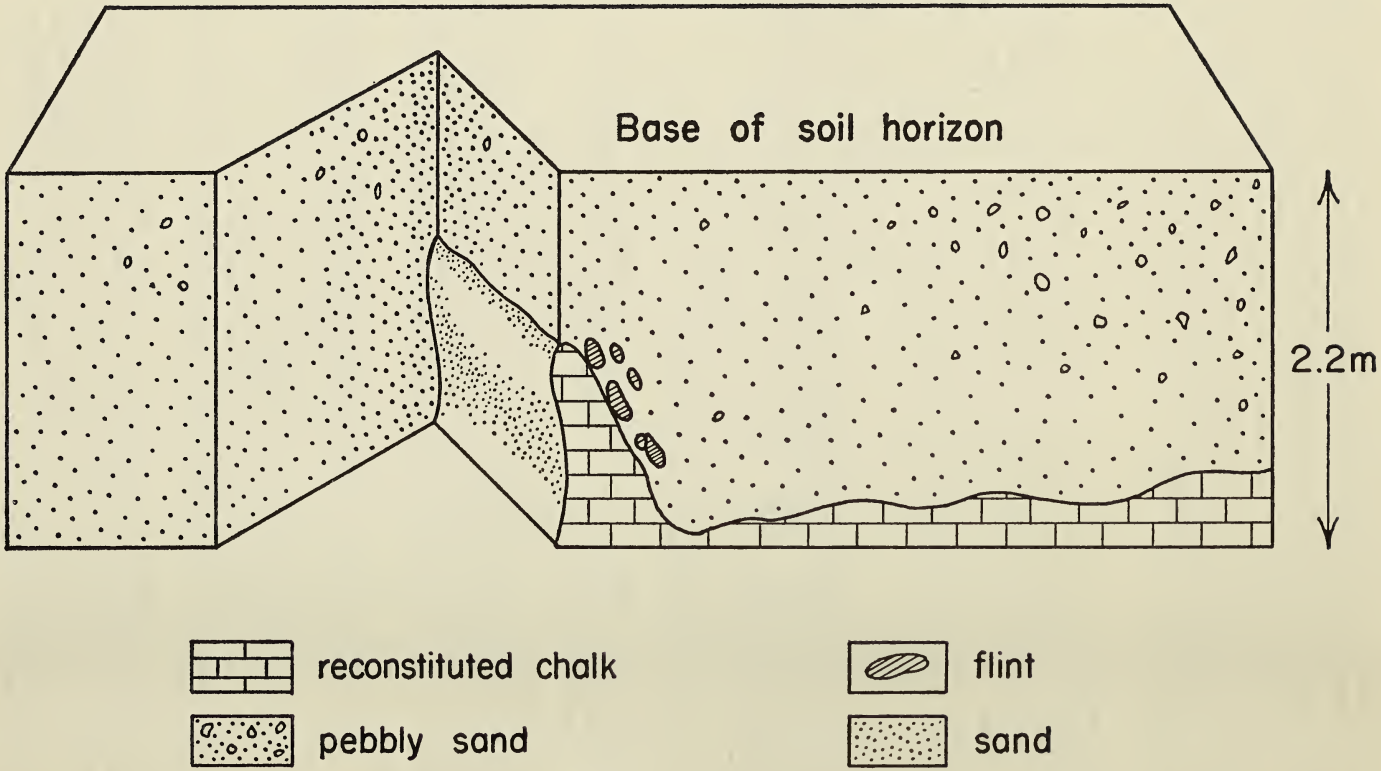

FIGURE 1. Schematic, three-dimensional diagram to show one of the chalk-ridge diapirs intruded into the overlying sands. Note the lateral persistence of the diapir and the aligned flint masses. (Drawn from field sketches and Plate 1.)

PLATE 1. Partly excavated chalk-ridge diapir. Talus conceals chalk surface (see Fig. 1).

(iv) Features produced by injection include certain types of load casts and flame structures which are common features in many deposits throughout the geological column. In experiments, Dzulynski and Walton (1963) and Butrym *et al* (1964) have demonstrated that sand resting on soft water-saturated clay is not a stable configuration. Small disturbances will "cause the growth of equidistant, round topped and columnar clay diapirs which may reach the top surface of the sand" (Butrym *et al.* op cit p. 2). This process is dependent upon the high thixotropy of many clays. Disturbances due to shock or unequal loading cause the clay to change reversibly to the sol state whereupon it is injected into the overlying sands. The clay subsequently consolidates by the rapid process of syneresis or dewatering (Boswell 1949).

Boswell states that the chalks he examined experimentally were moderately thixotropic but notes that their thixotropic properties were greatly increased if they contained clay (e.g. Chalk Marl) or if they were ground to reduce particle size. It may be that the vertical and/or horizontal mixing processes that operated upon the modified chalk have acted as a natural pestle and mortar, reducing the grain size by abrasion and causing an increase in thixotropy.

It is tempting to conclude that a water saturated, modified chalk/sand interface is similar to a clay/sand interface and that the products of boundary instability are also similar i.e. diapirs are produced. Evidence for the forceful movement of the chalk into the sands is provided by the flints elongated parallel to the margins of the chalk ridges.

The formation of the chalk ridges is thus thought to be the result of process iv). This hypothesis explains the majority of observations and correlates with previous theoretical and experimental results. The examples are thought to be the first recorded and discussed from the Quaternary of East Anglia.

Conclusions

While it is useful to heed the warnings of Butrym *et al.* (1964) that Quaternary involutions and solifluction phenomena should not be held diagnostic of periglacial conditions as a general rule, we feel that the evidence put forward above strongly indicates the formation of the chalk ridge-diapirs and modified chalk in a periglacial environment where the abundant ground water in the mollisol, held above a permanently frozen zone, provided ideal conditions for the causative mechanisms outlined above to operate.

As the age of the sands and gravels is unknown it is impossible to say at what time during the Quaternary the periglacial processes operated on the sediments to produce the structures described.

Acknowledgements

This work is an extension of a field work project undertaken with Mr. A. Fowler from 1965 to 1967 and to a large extent represents joint field observations. I thank Mr. C. E. Ranson for his encouragement and advice and Professor B. M. Funnell, Dr. P. H. Banham and Mr. N. B. Peake for helpful suggestions. Mr. Alan Fowler read and criticised the manuscript; for this, and for many long discussions, I thank him.

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RECORDS OF TICKS (*IXODOIDEA*) FROM NORFOLK

By Gordon B. Thompson and John G. Goldsmith

The purpose of this paper is to summarise the previous records and add a number of new records of this much neglected group of ectoparasitic arthropods. There are 22 species of ticks recorded from the British Isles of which only four have been previously recorded from Norfolk.

Ticks are blood sucking ectoparasites of mammals, birds and lizards in Britain. Because of their blood sucking habits they are of considerable medical importance as transmitters of disease. The life history of the tick is:—

Eggs → Larva → Nymph → Adult (male or female).

Only a very small part of their lives is spent on the host but blood meals are essential for the development of each of the stages. The abbreviations of L and N are used for Larva and Nymph in the records, and the ten kilometer squares are given in brackets. The new records are based on specimens in the Norwich Castle Museum Collection except for a few specimens in the collection of the senior author (G.B.T.).

1. *Ixodes ricinus* (L.)

The first record was by Laurie (1946), 1 N, *Myocastor coypus* (Molina) (Coypu), River Yare, Cringleford (TG 10), ii.1946 (*E. A. Ellis*). Newson (1968), Newson & Holmes (1968) added the following records from coypus: 1 ♀, Cantley (TG 30), ix.1964; 1 ♀, Crostwick (TG 21), xii.1964; 1 ♀, Ranworth Broad (TG 31), iii.1965; 31 other records (1 ♂, 6 ♀♀, 344 Ns, 2 Ls), Hickling Broad and Horsey Mere (TG 42), vi–vii.1965, vii–viii.1966.

New records: 1 ♀, ? host, Yarmouth (TG 50), v.1950; 1 ♀, "biting man's leg", Norwich (TG 20), viii.1958; 1 ♀, "from a house", Thetford (TL 88), v.1961; 2 Ns, "Golden Pheasant – ♂", Thetford (TL 88), 25.iv.1963; 1 ♀, "on dog", Wymondham (TG 10), 25.vi.1964; 6 ♂♂, 4 ♀♀, 4 Ns, *Cervus elaphus* L. (Red Deer – ♂), Melton Constable (TG 03), ix.1964; 26 Ns, *Sciurus vulgaris* L. (Red Squirrel – ♂), Santon Downham (TL 88), 20.iv.1971; 18 Ns, 2 Ls, *S. vulgaris* – ♀, Thetford Chase (TL 88), 11.vii.1970 (GBT Coll.); 2 Ns, *S. vulgaris* – ♂, Thetford Chase, 11.vii.1970 (GBT Coll.); 2 ♂♂♀♀ *in cop* 3 ♀♀, *C. elaphus* – ♀, near Gt. Hockham (TL 99), ix.1970 (GBT Coll.).

This tick, better known as the sheep tick, is the commonest British species. It is known to transmit louping ill and rickettsiae of tickborne fever to sheep and redwater to cattle. Newson & Holmes (1968) were referring to this species when they stated "the cattle on this land [an area within 1 km. of the north and east sides of Hickling Broad] were heavily infected with ticks".

2. *Ixodes hexagonus* Leach.

Arthur (1953) published the first records of this species from the county. 1 N, 1 N 2 Ls, 1 ♀ 4 Ns 7 Ls, 1 N, all from *Erinaceus europaeus* L. (Hedgehog), Garvestone (TG 00), 20.x. 1950, 1.xi.1950, 7.viii.1951 and 20.vi.1952 respectively. In later publications Arthur (1953, 1963) refers to a single record and five records respectively from Norfolk but the fifth one seems untraceable.

New records: 4 ♀♀, *E. europaeus* – ♂, New Costessey (TG 11), 19.vii.1961; 62 ♀♀Ns, *E. europaeus* – ♀, Eaton (TG 21), vii.1966; 1 ♀ "from a house", Norwich (TG 20), 7.x.1967; 1 ♂, 1 ♀, 1 N, *Meles meles* (L.) (Badger), Hedenham (TM 39), 14.v.1968.

This tick is usually referred to as the Hedgehog tick. The males are rarely found on the hosts but can be found in the nests. Foxes, badgers, weasels, stoats, etc. are also hosts to this tick.

3. *Ixodes lividus* (C. L. Koch).
New records: 1 ♀, *Riparia riparia* L. (Sand Martin – juvenile), King's Lynn, Shouldham Warren (TF 61), 19.vii.1964 (GBT Coll.); 5 ♀♀, 1 N, *R. riparia* – adult, same locality, 19.vii.1964 (GBT Coll.); 1 ♀, *R. riparia* – adult, Swaffham, Newton by Castle Acre (TF 81), 20.vii.1964 (GBT Coll.); 2 ♀♀, *R. riparia* – juvenile, Alderby (TM 49), 21.vi.1971; 1 ♀, *R. riparia* – ♀, Caistor St. Edmunds (TG 20), 14.vii.1971.

The sand martin is the specific host of this tick. Its whole life history is passed in the nest except for brief periods for feeding on the hosts.

4. *Ixodes arboricola* Schulze & Schlottke.
New records: 1 ♀, *Parus caeruleus* L. (Blue tit – adult), Poringland (TG 20), 27.iii.1970; 3 Ns, *P. caeruleus* – adult, Poringland (TG 20), 14.iv.1970; 1 N, *P. caeruleus* – adult, Hardley Floods (TM 39), 19.iv.1970; 3 ♀♀, *P. major* L. (Great tit – ♀), Framingham Earl (TG 20), 19.ix.1971.

This species is a bird tick parasitising those birds which build their nests in holes. The males are only to be found in the nests.

5. *Ixodes arvicolae* Warburton (=*I. apronophorus* Schulze).
Arthur (1963) recorded this tick for the first time from *M. coypus*, Strumpshaw, v.1962. (TG 30) Newson (1968), Newson & Holmes (1968) added many more records of ♀♀, Ns, Ls, *M. coypus*, Brundall, Surlingham Broad (TG 30), Crome's Broad, Wroxham Broad and Woodbastwick Marshes (TG 31), Martham and Hickling Broads (TG 42), xii.1960 – i.1966 and ii.1966 – iv.1967.

New record: 1 ♀, *Clethrionomys glareolus* (Schreber) (Bank vole – ♂), Wheatfen (TG 30), 10.iv.1971; 1 ♀, same host species – ♀, Wheatfen (TG 30), 10.iv.1971.

Warburton's description of this species was based on females from *Arvicola terrestris* (L.), Cambs, Quy, v.1925. It seems almost certain that Schulze's *apronophorus* is the same species.

The Norfolk specimens constitute new host records for the tick.

6. *Ixodes pari* Leach.
New records: 1 ♀, *Turdus ericetorum philomelus*, Brehm (Song thrush – "continental type"), Caistor St. Edmunds (TG 20), 6.x.1968.

A rare species in Britain. The male has not yet been found.

7. *Ixodes trianguliceps* Birula.
First recorded from Norfolk by Arthur (1963) (see Thompson, 1967), 1 ♀, "field mouse", Gooderstone (TF 70). Newson & Holmes (1968) stated "One adult female and one nymph found on a coypu from Surlingham Broad in November 1962 are mentioned by Arthur (1963)". There seems some doubt over this record because Arthur does not list the coypu in his hosts and the record "Norfolk (Arthur, unpublished)" is the record quoted above and sent to GBT by Prof. Arthur. One other nymph was recorded by Newson & Holmes (1968) from Hickling Broad (TG 42) in July 1966.

New records: 1 L, *Sorex araneus* L. (Common Shrew), Ludham, How Hill (TG 31), 9.viii.1970; 1 L, same host species, Hickling (TG 42), 17.ix.1970; 1 L, same host species and locality, 24.ix.1970; 4 L, *C. glareolus* (Bank vole – ♂), How Hill, 12.viii.1970.

This is a very common tick on small mammals. The males are rarely found on the host.

8. *Hyalomma* (*Hyalommasta*) *aegyptium* (L.).
New record: 1 ♀, "Tortoise", Norwich (TG 20), 28.vi.1950.

All stages of this imported tick are common on land tortoises (*Testudo* spp.) in the Mediterranean area and the Middle East. It does not appear to have become established in Britain.

9. *Argas* (*Carios*) *vespertilionis* (Latreille).
New records: The following records are all from *Pipistrellus pipistrellus* (Schreber) (Pipistrelle bat), 1 N, West Walton (TF 41), 17.viii.1970; 1 L, 5 Ls and 5 Ls from different host specimens, Colney (TG 10), 12.vii.1971.

This is a bat tick common on Pipistrelles. Only the larvae and nymphs are normally found on the bats. The adults should be looked for in the roosts.

It is hoped the publication of these records, in which the number of species of ticks recorded from Norfolk is increased from four to nine, will stimulate interest.

Anyone with an interest in birds and mammals who handles live or dead specimens must have observed ticks, lice, fleas, flat-flies, mites, etc. on them. Fortunately a few people have collected and preserved the specimens which form the basis for the records in this paper. Dead hosts can be placed in linen bags or plastic bags containing absorbent paper, and examined carefully at leisure, but parasites can be collected from living hosts. In the case of birds, ticks are invariably found around the eyes, at the base of the beak and in the ears and may be eased off carefully with the aid of fine pointed forceps, preferably after lifting the abdomen of the tick to expose the ventral aspect. It is essential not to pull ticks off carelessly leaving the mouthparts in the skin of the host. Unfortunately there is no easy method for collecting ticks. All ectoparasites from a single host should be placed in a tube of 70 per cent alcohol together with a label, written in pencil. The data required are name of host, sex or stage of host, location of parasite on host, locality and date of collection and collector's name.

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SOME MARINE AND BRACKISH-WATER COPEPODS FROM WELLS-NEXT-THE-SEA, NORFOLK, ENGLAND

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* * * * * *

Summary

Six collections from two localities near Wells-next-the-Sea have yielded a total of one species of cyclopoid, *Cyclopina gracilis* (Claus), and 43 species of harpacticoids, of which none are new to science; however, *Eurycletodes irelandica*, *Laophonte baltica*, and *Heterolaophonte longisetigera* are all new to Britain, and *Amonardia phyllopus*, *Amphiascoides nanus*, *Ameira scotti*, and *Mesochra heldti* are all new to the North Sea. *Paramphiascopsis giesbrechti* is new to the east coast of England. The specimens of *Paralaophonte brevirostris* from Wells Quay are in some ways intermediate between the respective descriptions of this species and of *P. congenera*.

The purpose of this paper is to provide the background for detailed taxonomic studies, which will be published elsewhere, and to show that the area involved, being restricted and easily accessible, is extremely vulnerable to pollution but at the same time is very suitable for experimental work on this and kindred subjects of an ecological nature.

Introduction

Of harpacticoids recorded from Norfolk before 1938 (Lang, 1948, under each species), the freshwater and semiterrestrial species have received the most attention, the brackish-water species somewhat less, and the marine species hardly any; almost all these records were by the late Dr. Robert Gurney, whose work was largely confined to the East Norfolk river system including the Norfolk Broads.

On the other hand my own samples, complementary to those of Gurney, are mainly from marine habitats, although quite a number are from more or less brackish waters (Hamond, 1968b, 1969a, 1970, 1971, and unpublished); the present paper deals with a brackish habitat and a fully marine habitat, about a kilometre apart, and with the numerous harpacticoids found in them.

Habitats sampled

Of the two habitats in question, Wells Rocks (Hamond, 1963, bottom para. on p. 8) is well sheltered by Wells Quay, by the seawall, and by the marshes on the opposite side of the channel, and is exposed to tides of fully marine salinity. The level of immersion at low water of spring tides depends largely on the configuration of the sandbanks in the channel, seaward of the Rocks; but in most years it is possible to sample the upper part of the lowest zone, which is dominated by *Laminaria saccharina* and *Halichondria panicea*.

Abraham's Bosom is a brackish boating lake on the landward side of the seawall, about a kilometre north of Wells Quay and Rocks; it is exceedingly well sheltered for such a saline habitat, on the north by large conifers, on the west by reeds, and all round by a margin of earth and stones from which it slopes rapidly to a maximum depth of less than two metres. The total area of the lake

is about half an acre. The bottom is firm enough to wade upon, but is covered with a variable thickness of soft mud, intertwined by the roots of flourishing seagrass (*Ruppia* sp.). The dominant benthonic animal is the cockle *Cerastoderma edule*. The fauna as a whole is far more distinctively marine than that of the Salts Hole (see Hunt, 1971), which lies about 2 km. further west. From the east side of the lake a small outflow (in whose upstream end sample E was taken) drains by a somewhat circuitous route to a culvert in the seawall, though which it emerges by a sluicegate into the main channel at a point about 100 metres north of the northern extremity of Wells Rocks. Faunistically, Abraham's Bosom is virtually a landlocked portion of the sea, and as such would make an excellent subject for ecological work; indeed, according to Mr. Banham (in litt.) the name "Bosom" may be a corruption of the Dutch "boesen", meaning a relict saline lake behind dunes, to which the name Abraham (cf. St. Luke 16, vv. 22, 23) was later attached to convey the idea of a desirable and peaceful spot for recreation and relaxation.

The six sampling localities (Table 1) all have a continuous flow of water over them (except for F, at which the water level is substantially constant), and are all accessible by road to within a few metres' distance, either at low tide (the Rocks) or at any state of the tide (Abraham's Bosom).

TABLE 1

Sample	*Description*
A	Under Wells Rocks, 20.12.1956, among small red and brown algae.
B	Under Wells Rocks, 3.8.1959, among the polyzoan *Bowerbankia imbricata*.
C	Under Wells Rocks, 20.10.1960, among the polyzoan *Anguinella palmata*.
D	Besides, and downstream of, Wells Rocks, 16.9.1962, among the hydroid *Laomedea flexuosa* growing on the bladder-wrack *Fucus vesiculosus*.
E	Abraham's Bosom, 15.9.1966, among matted green algae in the upstream end of the outflow from the lake.
F	Abraham's Bosom, 20.9.1966, among dead *Ruppia* sp. floating close to the bank at the northern end of the lake.

Material and Methods

In each of the six samples, about four-fifths of a litre of the plants of animals indicated in Table 2 were collected by hand, transported to the laboratory at Morston in a sealed jar, and left to soak in a dish of seawater until most of the small invertebrates had emerged, the remaining species being collected by rinsing the contents of the dish three or four times through plankton gauze of pore size about 0.3 mm., and sorting the filtrate under a binocular microscope. All copepods were studied by my usual methods (Hamond, 1969b, 1971); the present paper is intended to serve as background for detailed taxonomic studies which will be published elsewhere.

Notes on certain species

Ectinosoma normani T. & A. Scott.

The two females from sample B agreed with this species except for the presence of a tubercle (or pore, see Lang 1965, p. 15) on P5.

Amonardia phyllopus (Sars).

This is the first North Sea record; the specimens agreed closely with the account given by Yeatman (1962).

TABLE 2

Numbers of copepods in the Wells-next-the-Sea samples. An expression such as 12,2,3,0, denotes 12 females of which 2 bore eggs, 3 males, and no juveniles; the hundreds of *Tisbe* and *Diosaccus* also included females with eggs. "A pair" denotes a pair in precopula.

	A	B	C	D	E	F
CYCLOPOIDA:—						
Cyclopina gracilis					1,1,0,0,	8 5 0,0
HARPACTICOIDA:—						
Longipedia weberi	14,0,0,0	1,0,0,0,				
Ectinosoma dentatum	5,1,0,0	1,1,0,0	9,0,0,0			6,0,0,0
E. melaniceps	12,0,0,0	2,0,0,0	6,0,0,0		2,2,0,0	55,3,0,0
E. normani		2,0,0,2				
Halectinosoma gothiceps		4,0,0,0				
Harpacticus gracilis	ca.100					
H. littoralis			54,1,0,0	8,4,0,0		
H. uniremis			1,0,0,0			
Zaus goodsiri	1,0,0,0		1,0,0,0			
Z. spinatus	1,0,0,0					
Tisbe furcata		0,0,1,0			8,0,3,0	ca. 100
Alteutha interrupta		12,2,3,0 & 1 pair	1,0,0,0	2,0,0,0		
Parategastes sphaericus	1,0,0,0		26,0,0,0			
Parathalestris clausi				4,3,3,0		
Phyllothalestris mysis	3,0,0,0		2,0,0,0			
Rhynchothalestris rufocincta	15,0,8,0		4,0,0,0			
Diarthrodes pygmaeus	2,0,0,0	9,0,0,0	9,0,0,0	3,0,0,0		
Dactylopodia vulgaris	1,0,0,0					
Paradactylopodia latipes	0,1,0,0			3,3,1,1		
P. brevicornis			57,0,18,8			
Dactylopodella flava	1,0,0,0					
Diosaccus tenuicornis			3,0,0,0		Hundreds	ca. 100
Amphiascus minutus	8,0,1,0	5,2,0,0	3,3,1,1	6,4,1,0		
Amonardia phyllopus			1,0,1,0			
Paramphiascopsis giesbrechti					2,0,2,1	
Bulbamphiascus imus					1,0,1,0	
Amphiascoides nanus	21,3,0,0	9,4,0,0	4,4,0,0	4,2,0,0		10,7,3,0
Ameira scotti	10,7,2,0	2,0,2,0	13,1,6,0			
Nitocra spinipes					1,0,0,0	1,0,0,0
Psyllocamptus propinquus	1,0,1,0					
Mesochra heldti	1,0,0,0					
M. lilljeborgi						2,0,0,0
M. pygmaea	3,1,0,8	16,0,0,0	4,2,1,0	17,12,0,0		
Eurycletodes irelandica	1,0,0,0					
Laophonte baltica	6,1,5,0	7,3,2,0	2,2,0,0	4,4,0,0		
L. elongata	18,0,0,0	2,0,1,0	4,0,0,0			
L. inopinata		0,0,1,0		0,0,1,0		
Pseudonychocamptus koreni	10,0,0,0	8,5,1,12	5,4,1,0	4,2,0,1		
Heterolaophonte stromi					1,0,1,0	
H. minuta	ca. 80					
H. longisetigera	ca. 80		1,0,0,0	6,1,0,0 & 1 pair		
Paronychocamptus curticaudatus	23,6,3,0	3,0,0,0				
Paralaophonte brevirostria	2,0,0,0	1,0,0,0	ca. 200	5,0,0,0	2,0,0,0	1,0,0,0

Paramphiascopsis giesbrechti (Sars).

The separation of this species from *P. longirostris* (Claus) is not always easy. The respective males are readily separable by the shape of the exopod of P5 (in which the present males agree closely with Lang, 1948, fig. 277, 2aP5♂), but Lang's key character (1948, p. 687, couplet 2) for separating these two species regardless of sex is not readily applicable to the present material, in which the first endopod segment of P1 is about as long as the entire exopod of P1, within small limits either way. However, in certain other characters as figured by Lang (1948), the present females agree entirely with *giesbrechti* as against *longirostris*:—

(1) The nature of the basal swelling on the largest furcal seta (used as a key character by Lang, 1965, p. 272, but liable to be lost through this seta being broken off);

(2) The length–breadth ratio of segment 4 of the antennule;

(3) The length–breadth ratio of the second exopod segment of P1; and

(4) The form of P5.

This is only the second British record of *P. giesbrechti*, the first being by Brough, Delhanty, and Thompson (1964).

Amphiascoides nanus (Sars).

First North Sea record; as implied by its name (*nanus* = dwarfed), it is a small species which is readily overlooked.

Ameira scotti (Sars).

First North Sea record; in two of the otherwise entirely normal females from sample C, the exopod of P5 lacked the small seta and carried only the four large setae.

Nitocra spinipes (Boeck).

The otherwise normal female from sample F had only three terminal setae on the distal endopod segment of P2, as in *N. lacustris* (Schmankewitsch).

Mesochra pygmaea (Claus).

In sample A it was noticed that the juveniles had well-developed girdles of small spinules on each of the abdominal somites, whereas the adult females had only short combs of spinules in the same positions (as in Hamond, 1971, figs. 50–52).

Mesochra heldti (Monard).

The first North Sea record of this mainly Mediterranean species; the only other British record is from near Exeter (Wells, 1963).

Eurycletodes irelandica (Roe).

Agrees perfectly with the comprehensive description and figures of Roe (1959) from near Cork; previously found near Dublin (Roe, 1958, as *Eurycletodes* sp. near to *E. verisimilis* Willey). The present record is the first for England and for the North Sea; it has not yet been recorded from outside the British Isles.

Laophonte baltica (Klie).

A very small species, here recorded for the first time from England, although known from the Continent (Lang, 1948) and from near Cork (Roe, 1959).

Heterolaophonte longisetigera (Klie).

First British record; originally described as *H. littoralis* var. *longisetigera* by Klie (1950) from Heligoland, and raised to specific rank by Boer (1971), who found it in Brittany. Both these accounts are very incomplete; a thorough description will be given elsewhere.

Paralaophonte brevirostris (Claus).

The present specimens appear to be intermediate between this and the closely related *P. congenera* (Sars) in the following respects:—

Female antennule with seven segments (as in *congenera*), but with an incipient thorn on the rear edge of the second segment (as in *brevirostris*, though less marked). Shape of prosome in dorsal view, shape of rostrum, form of maxillipede, and length–breadth ratio of furcal ramus, all definitely as in *brevirostris;* P5 shaped as in *brevirostris* but covered with transverse rows of setules, very much as in *P. gurneyi* (Lang) and far more thickly than in *congenera*. In some males from the present material, which otherwise agree with *brevirostris*, the endopod of P3 appears to be more like that of *congenera*, and comparison of the present specimens of both sexes with the descriptions of Sars (1908), Lang (1948), and Yeatman (1962) by no means precludes the possibility that these two species intergrade with one another in Norfolk waters; similar intergradation is known for certain other copepods (Hamond, 1968a) and syllid polychaetes (Hamond, 1969c). On the other hand, the *congenera* found at West Runton (Hamond, 1969a) appeared to be fairly typical.

I have not yet been able to follow up Dr. Yeatman's suggestion (*in litt.*) that the Wells-next-the-Sea population of *P. brevirostris* would be suitable for rearing experiments, in which the range of variation within and between broods (a brood being all the larvae hatched from the egg mass carried by a single female) could be determined.

Discussion

The only non-harpacticoid copepods in these samples were some *Cyclopina gracilis* (see Table 2) and an indeterminable (damaged) immature *Acartia* sp. in sample F. The 43 species of harpacticoid in Table 2 are all characteristic of shallow waters in Northern Europe, often with reduced salinities; the most markedly brackish-loving of them is *Mesochra lilljeborgi*, with *Nitocra spinipes* a close second, although *Mesochra pygmaea* can also tolerate low or variable salinities to some extent (Lang, 1948; Hamond, 1971 and unpublished). An interesting find is that of two supposedly entirely marine species, *Bulbamphiascus imus* and *Paramphiascopsis giesbrechti* (see records in Lang, 1948), in the brackish waters of Abraham's Bosom, although the record by Brough & al. (1964) of the latter was from a salt-marsh in South Wales. The harpacticoid fauna of Abraham's Bosom is unusually rich for a brackish locality, with no less than 11 species (cf. the Salts Hole, in which Hunt (1971) found only *M. lilljeborgi*, and in which I have not yet found any harpacticoids). Why the two above-mentioned marine species, *B. imus* and P. *giesbrechti*, are not among the 37 found under Wells Rocks, is not at present clear; both they and the other species found only in Abraham's Bosom (namely *Heterolaophonte stromi*, *M. lilljeborgi*, and *N. spinipes*) are all found elsewhere in Norfolk waters, between tidemarks or (*B. imus* only) offshore.

With the continual increase, both of the permanent population of Wells itself and of the holiday population in caravans next to Abraham's Bosom during the summer, it would be most desirable to monitor the continued growth of pollution in both these habitats, which are small and very susceptible to substances discharged into them. During most of the tidal cycle there is a strong flood or ebb past Wells Quay and the Rocks, but at low tide there is a considerable "dead volume" of water that never drains away but forms a temporary lake in which the concentration of sewage and other pollutants steadily rises until the flood tide returns, due to all the drains pouring into it. The surface of the dead volume forms the permanent low-water mark for the Quay and the Rocks, so that any organisms living at or below it will be subjected to the full effect of a twice-daily dose of effluent; this is possibly why the magnificent growths of the sponge *Halichondria panicea*, and the large numbers of the sea-anemone *Metridium senile*, both of which were formerly present below this false low-water mark, have in recent years dwindled appreciably. Although the evidence is by no means conclusive that pollution is the only or even the dominant factor in this most unwelcome decline, nevertheless the habitats dealt with in this paper would seem to be made to order, not only for long-term or short-term monitoring of natural effects, but for pilot-scale experimental work.

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HYBRIDS AND HABITATS

By E. L. Swann

Following up the interest shown and the discussion aroused when the writer gave his talk to the Society on "Our Changing Flora" in September 1971, it has been suggested that a paper on the incidence of hybrids occurring in disturbed ground might be of some interest. So far 95 plants of hybrid origin have been detected in Norfolk representing about 6 per cent of the total of 1479 species.

Forms of hybrids

A hybrid may arise by one of three ways in the wild; it may be the result of crossing between two or more different species; the resultant product may then be back-crossed by one of its parents, a process known as introgression. Provided the conditions be favourable these introgressants may, by natural selection, make use of a recombination of genes so that a hybrid swarm is formed. Whilst the majority of hybrids are interspecific, crosses between genera are not unknown. In all cases it is the genes that control and exert their influence; they produce new combinations and bring about a gradual infiltration of the germ plasm.

Habitats

It has become almost axiomatic that disturbance of the habitat favours hybridisation. There are so few areas of natural habitats left that "disturbed ground" may well apply to the greater part of our land. Human activities are the greatest factor. Fields are rarely allowed to lie fallow and farmers now plough up land considered at one time to be intractable; arable fields replace much of our woodland and scrub; hedges have been uprooted and dykes filled in; whilst the construction of new roads and building operations have all added their toll. There is certainly no lack of disturbed ground where hybrids may occur and it is mainly in intermediate habitats that they persist and spread.

Detection of hybrids

Where hybrids take on characters intermediate between the putative parents their detection in the field may be made with some confidence particularly in the cases of closely related parents. They may differ in exhibiting more vigorous vegetative organs; they may flower earlier, longer and more profusely; the flowers may be larger or smaller or the colour may be intermediate, and they may occur in intermediate habitats.

In doubtful cases, the examination of pollen is useful. It is necessary to find out the relative abundance of well-filled grains, a procedure facilitated by using a suitable chemical stain. If more than half are abortive and mis-shapen it is reasonable to assume that something has gone wrong with the meiotic process to inhibit pollen-formation.

Clues afforded by seed must always be suspect as there is such a long chain of events from bud stage to seed-setting involving pollination, fertilisation, development of the embryo and final seed-formation. Some hybrids, such as those in the willows, are fertile although they only retain their viability for about a week; others, like the willow-herbs, are usually completely sterile.

Sometimes the absence of one of its parents may give rise to doubts concerning a presumed hybrid. The so-called Leopard orchid is an example but it has been so long-established by workers that this is a hybrid between the Common Spotted and Common Marsh orchids (*Dactylorhiza fuchsii* x *D. praetermissa*) that we accept this.

There are, however, examples of a species that its hybrid origin may be hidden. Such a species would show considerable variation, a bewildering array of forms, and a range of chromosomes. The American botanist, Edgar Anderson, has shown that "It is possible, working within a single variable population of a species formerly unknown to the investigator, to draw up a precise description of the other species which is introgressing into that population"[1]; Moreover, "It is even possible to work with a hybrid swarm and draw up detailed descriptions of BOTH parents when neither of them is known to the observer" (l.c.).

By constructing a series of graphs in the form of pictorialised scatter diagrams, it is possible to find the answers to two questions: What characters stay together? What pattern do they take on? Care must be taken to choose characters that are not dependent on each other, for example, leaf length and indumentum, but length of petal and leaf vary together. Such, briefly, is Anderson's method of "Extrapolated Correlates".

Dispersal

If fertile, dispersal and spread may be either by seed or vegetative divisions, the so-called ramets; if sterile, then by vegetative means only. The hybrids will possess a new combination of genes, those bearers of heredity, preadapting it either for a new environment, intermediate to that of its parents, or becoming adapted gradually within the new environment. In such ways a physiological "strain" will become adapted, natural selection will play its part, and in time – a very long time – a new "species" may arise.

Man himself has used the properties of genes and by plant-breeding, coupled with careful selection, has brought into existence for his domestic use all manner of farm and garden crops but he has been compelled to nurse and protect by hoeing, fertilising, mulching, watering, spraying and draining so as to ensure successful crops. Left to their own, all his plants would deteriorate and perish. With our wild hybrids, natural selection is one of the chief factors and Man, unwittingly, has played an important part in providing disturbed ground.

Mutants

It should be borne in mind that hybridity is not alone in bringing about new plants. Mutation is another factor. It applies to a species that undergoes a sudden, spontaneous alteration, the causal agent being frequently unknown but probably due to physical or chemical agents. There may be a loss of a single gene, or structural changes in either a single chromosome or a complete set. We know that the drug colchicine or X-rays may be used to bring out a mutation but, in the wild, it is thought to be a random choice and not always to the advantage of the species. Examples of mutants are the peloric forms of the Toadflax (*Linaria vulgaris*) and Foxglove (*Digitalis purpurea*); the Cut-leaved Elder (*Sambucus nigra* var. *laciniata*) and the Copper Beech (*Fagus sylvatica* var. *purpurea*).

Examples

From our 95 hybrids we shall find many that fulfil our requirements and one of the best is the cross between the Red and White Campions. The hybrid usually has pink flowers; "they are fertile and may back-cross with either parent giving types more closely resembling that parent. Further crossing may give rise to

[1]Anderson, Edgar. *Introgressive Hybridisation*, 1949.

intermediates of all kinds".[2] The Red Campion is a true native of well-drained woodland on the better soils whilst the White Campion, although stated to be a native in the 1968 *Flora of Norfolk*, is more strictly a naturalised alien of arable land and waste places. The hybrid frequently occurs in ground between wood and arable such as road verges and hedgerows. At Horstead in 1969, Miss Gillian Tuck found a small colony, "some pale pink, a few bizarre forms completely bicoloured, the sharp dividing line between the red and white running down the centre of the corolla"; such a bizarre form is a mosaic hybrid.

Geum x *intermedium*, the cross between Water Avens (*Geum rivale*) and Herb Bennet (*G. urbanum*) is well known, the former species occurring in wet meadows, fens and damp woods whilst Herb Bennet is a woodland and hedgerow plant. The hybrid tends to favour *G. rivale* and grows where the two species meet. The forms it takes are numerous and Turrill has pointed out that it is not only self-fertile but also "back crosses with the parent give different results according to the parent supplying the double dose. Thus, *intermedium* x *urbanum* gives offspring more like *G. urbanum*. . . . On the other hand, *intermedium* x *rivale* gives offspring very like *G. rivale*".[3] Miss Maxey's photograph No. 33 in our *Flora* is *G. intermedium* x *urbanum*.

Of the two Hawthorns in Norfolk, the May (*Crataegus monogyna*) is ubiquitous but the other, the Midland Hawthorn (*C. oxyacanthoides*) is very rare whilst the hybrid is somewhat more frequent. The writer suggests that the rare species was probably introduced at the time when considerable planting of woodlands was carried out in the nineteenth century and persisted until woods were felled on a large scale thus providing more open communities when the two species met and favoured hybridisation. Most of the present-day records of the hybrid are from woodland margins and field borders.

Hybrids in the Willow-herbs occur occasionally and several species are involved. This is not surprising as all have the same complement of chromosomes, $2n=36$. Many of them grow in disturbed ground and the American species, *Epilobium adenocaulon*, has proved to be a powerful parent.

Willows provide much interesting, and sometimes puzzling, material for the study of hybrids. Following the extraction of gravel most pits become filled with water and such habitats have ideal conditions for willows, chiefly Sallow (*Salix cinerea*), Osier (*S. viminalis*), White Willow (*S. alba*), and Goat Willow (*S. caprea*). The hybrids are fertile but quickly lose their viability. One of our more uncommon hybrids, the Fine Basket Willow (*S.* x *forbiana*), commemorates one of Sir J. E. Smith's contemporaries, the Rev. F. Forby, who held a living at Fincham near King's Lynn. It was formerly grown in osier holts and is noteworthy by reason of its being a ternary hybrid, *S. cinerea* x *purpurea* x *viminalis*. Smith, Norfolk's most famous botanist, did not believe in hybrids and expressed his denial in no uncertain terms. It must be one of life's ironies that his name is commemorated by our commonest hybrid, *S.* x *smithiana* (*S. cinerea* x *viminalis*).

Our three most frequent Mulleins hybridise occasionally. There appears to be little difference in their habitats, Aaron's Rod (*Verbascum thapsus*) and our speciality, the Hoary Mullein (*V. pulverulentum*) occurring in sunny places on dry soils but the Black Mullein (*V. nigrum*) tends to favour more calcareous soils. A large colony of *V. nigrum* and *V. pulverulentum* was found at Fring in

[2]Clapham, Tutin & Warburg. *Flora of the British Isles*, ed. ii, 1962.
[3]Turrill, W. B. *British Plant Life*, New. Nat. Series.

1970 with many intermediates. Examination of the seed capsules showed them to be only partly fertile and confirmation of their hybridity was obtained from the pollen grains; some were found to be abortive, without plasma. Variation in colour sometimes indicates hybridity and this is very apparent in the plant we call the Blue Comfrey, *Symphytum* x *uplandicum*, reputed to be the cross between the Rough Comfrey (*S. asperum*) and the cream-coloured plant of dyke- and river-sides (*S. officinale*). Authorities do not agree on the limits of this fertile plant. So far as the writer is aware, *S. asperum* does not occur in Norfolk and it is very rare elsewhere in the British Isles. However, a walk along the banks of the river Wissey near Wretten Fen is instructive so far as colour range is concerned; both on the wash-plain and by the several dykes, there are many thousands of plants in every shade of red and blue.

If a genus be sought for that is remarkable for the number of hybrids then the mints must be very high on the list. Considerable attention was given to the county's mints, particularly by the Rev. Kirby Trimmer who published his work in the first *Flora of Norfolk* (1866) and *Supplement* (1885). Grown extensively in gardens they all too frequently become invasive and are thrown out to continue growing along roadsides and in waste places. The Glabrous Red Mint or Black Peppermint, first described by Smith under *Mentha rubra*, has been found to be a ternary hybrid, *M. aquatica* x *arvensis* x *spicata*. The commonest escape is Lamb Mint, a cross between the Long-leaved and the Round-leaved mints (*M. longifolia* x *rotundifolia*); either *M. rotundifolia* was formerly more frequent than it is today for it is only known from the side of the lake at Didlington or all our plants have come from a clone of its first occurrence. It is so uniform that its hybrid origin is difficult to believe although the functionally male flowers support this view. It flourishes in many areas of waste ground.

In 1943 Dr. Ellis and the late H. J. Howard found a plant growing amongst a mixed colony of the Common Groundsel (*Senecio vulgaris*) and Oxford Ragwort (*S. squalidus*) on the Norwich Castle mound which appeared to be the hybrid between these two species. Subsequent cytological examination showed this determination to be correct. The following year further hybrids were found on bombed sites in Norwich, decidedly disturbed ground. In 1968 a plant from Great Yarmouth was submitted to the writer and proved to be a further record of this hybrid. The rayed form of the Groundsel has so increased of late that care must be taken to distinguish it from the hybrid; the latter has shrivelled achenes and a further character lies in the "papilliform hairs at the end of the stigmatic arms which in the Groundsel are all few and short, or almost absent; in *S. squalidus* they are much longer and more numerous, making a well-marked conical tuft".[4] This character was used for the Yarmouth plant which was in flower only.

The Common Marsh and Spotted orchids are notorious for their misalliances. Wherever there are colonies, large or small, it is easy to believe that we have evolution going on before our eyes. Those members who have been on our excursions need hardly be reminded of the various conflicting opinions expressed in the field. To the difficult opinion of what constitutes a "species" in orchids, particularly the genus *Dactylorhiza*, Prof. J. Heslop Harrison has the best answer; he defines it as "assemblages of breeding populations marked off by discontinuities in the variation range and possessing definable distributional areas".[5]

[4]Brenan, J. P. M. In *Bot. Soc. & Exc. Club*, XIII, pt. 4, 1953.
[5]Harrison, J. Heslop. *Bot. Soc. Brit. Is. Abstracts*, 1971.

Thanks to the help and encouragement given by Dr. Hubbard, the writer feels on much safer ground when dealing with grass hybrids. Along our sandy beaches and "nearer the sea than any other British dune grasses"[6] we have the Sand Couch (*Agropyron junceiforme*); the Sea Couch (*A. pungens*) occurs in salt-marshes and on the shingle banks and dunes. The hybrid between these two (*A.* x *obtusiusculum*) occurs frequently in an intermediate zone.

In the Hybrid Fescue (x *Festulolium loliaceum*) we have a sterile intergeneric cross between the Meadow Fescue (*Festuca pratensis*) and Perennial Rye-grass (*Lolium perenne*). The *Lolium* is both widespread and abundant in varying habitats but the *Festuca*, when present, for it is often absent, favours damp meadows; the hybrid usually occurs in meadows.

In the well-known sterile intergeneric Hybrid Marram (x *Ammocalamagrostis baltica*), a cross between Marram Grass (*Ammophila arenaria*) and the Wood Small-reed (*Calamagrostis epigejos*), the latter parent very rarely occurs with Marram Grass. The hybrid is frequent on the East Norfolk coast and, by reason of its sand-binding properties, has been introduced at Holme-next-the-Sea and elsewhere following the 1953 sea flood. It is sterile throughout its range and Dr. Ellis has suggested that all the plants must be clones probably originating in the Winterton–Horsey area where it is most abundant. It is remarkable that the *Calamagrostis* parent occurs mainly in damp woods, fens and many of the Breckland conifer plantations and is not found as a seaside species.

The classic example of a hybrid grass is the cross between our native Cord-grass (*Spartina maritima*) and a North American species (*S. alterniflora*). It has spread naturally and, due to its ability to bind soft mobile mud, has been introduced on a large scale. It has become so widespread and abundant that it is recorded from every Norfolk salt-marsh. Of the four taxa occurring in the British Isles, three occur in Norfolk, namely, the native *S. maritima* favouring the higher zones particularly around depression pans; the male-sterile *S.* x *townsendii* and the fertile *S. anglica* occur in the tidal mud-flats and salt-marshes. All the taxa have been re-investigated and J. C. Marchant of Kew has corrected the chromosome counts. Material of the native plant including some from Wolferton has $2n = 60$, never 56.

Dr. Hubbard has shown that the name "*S. townsendii*" has been used indiscriminately to cover both fertile and sterile plants. These have now been separated; the most abundant is the fertile *S. anglica*, $2n = 122$, whilst the male-sterile plant, recorded from Wolferton in 1962, retains the original name, thus, *S.* x *townsendii*, $2n = 62$.

In the 1968 *Flora of Norfolk* the writer drew attention to the extremely variable forms of the Purple Moor-grass (*Molina caerulea*) with its inflorescences ranging from "more or less spicate to very loose panicles". These, coupled with its range of chromosomes, $2n = 18, 36, 90$, suggest hybridisation and introgression. Preliminary work has shown that there is much greater variation than at first realised; height of the culm may be as much as 120 cm., or as low as 30 cm.; width of panicle, 12–2 cm.; spikelets, 9–4 mm.; lemmas, 6–3.5 mm.

In his *Monograph*[7] Conert describes no fewer than twelve varieties and cites four from Norfolk, namely, vars. *caerulea*, *obtusa*, and *arundinacea* gathered by Dr. Hubbard from Dersingham Common and one, var. *robusta*, from the

[6]Hubbard, C. E. *Grasses*, Pelican Books, A295, ed. ii, 1968.
[7]Conert, H. J. *Die Systematik und Anatomie der Arundineae*, 1961.

writer's collection. Conert also cites one of my gatherings from Marham Fen under specific rank, *M. litoralis* Host; it may be that it is cytologically distinct; if so, then *M. caerulea* itself may, in the distant past, have hybridised with this species and their product, perhaps by chromosome doubling, has converged to form one very variable taxon. It is hoped to carry out more intensive work on this genus, recording the different varieties, describing the different habitats for although it favours acid soils where there is an adequate supply of soil water there are a few stations in Norfolk where these conditions are not always apparent; ultimately, it may be possible, using Anderson's methods, to discover the parentage of this taxon.

The examples given are only a very small but representative number of hybrids occurring in disturbed ground; there is little doubt that further field-work will bring many more to light, the disturbance wrought by Man providing just those conditions for their growth, persistence and spread.

SOME OBSERVATIONS ON THE RARE SAND BURROWING CRUSTACEAN AXIUS STIRYNCHUS (LEACH)

By E. A. Ellis and R. E. Baker

Specimens of the rare, lobster-like crustacean *Axius stirynchus* Leach have, until this year, been recorded only three times off the Norfolk coast. Hamond (1971) reviewed the previous records in which A. H. Patterson discovered one in a shrimper's haul at Yarmouth in July 1903 and another in April 1907; a further specimen was collected in October 1962 by Frank Moore from the Barber Sands off Yarmouth. This summer has been remarkable in that three more specimens have been trawled by Messrs. Moore and Fred Symonds. Two males were taken in shrimp trawls from the Cockle Gap off Yarmouth on 8th August 1971 and a further male specimen about three miles north of Yarmouth on 14th September. This means that as many of these small crustaceans have been recorded in six weeks as had been recorded in the previous sixty-eight years. The two specimens collected in August were kept alive in aerated sea water and this allowed observations to be made on their feeding habits, locomotion and behaviour. One specimen lived until mid-September whilst the second one survived until 10th November, three months after trawling.

Elsewhere in Britain *Axius stirynchus* was first noticed off the coast of Devon about 150 years ago and since then it has turned up only very occasionally in British waters, mainly in the neighbourhood of Plymouth. (Marine Biological Association, 1957.)

The three specimens were tinged shrimp-pink in colour, with orange patches on their claws and paddles. They were readily distinguished as males by the feathery hairs swathing the basal halves of their long antennae. Figure 1. Of the two specimens collected in August one had the right hand claw larger than the other, while in the second specimen these proportions were reversed. When extended the animals were 4 cm. in length from the tip of the cephalothorax to the end of the abdomen. For a full description of *Axius* see Bell (1853).

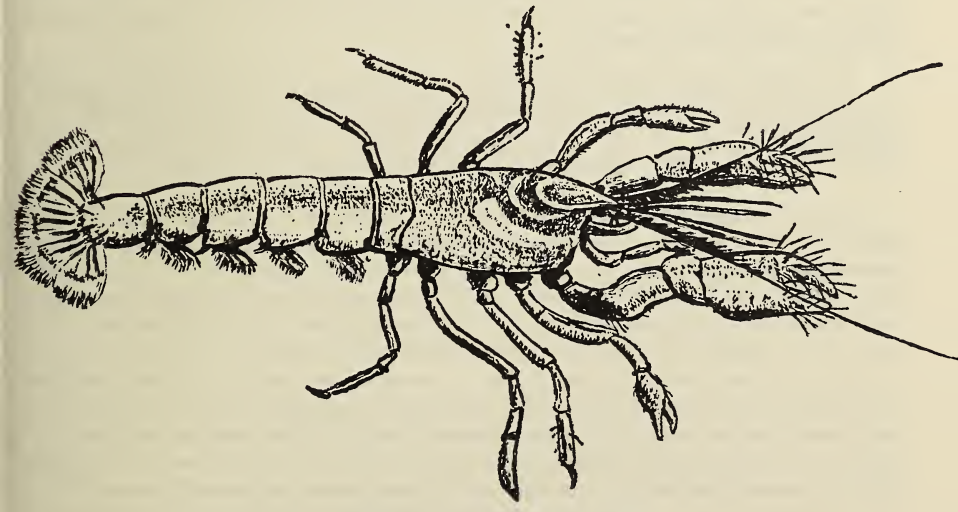

Fig. 1. *Axius stirynchus* (Leach)

When placed in seawater in a glass tank with sand, seaweeds and an irregularly shaped flint stone, *Axius* selected a cavity under one side of the stone as a shelter. The sand in the bottom of the tank was scooped towards the mouth and rapidly balled with mucous secretions. These soft brick pellets were built into the walls of the cavity as the animal enlarged its burrow. The pellets were finally pushed home with the tip of one of the claws. The setae of the claws were clearly of some assistance in sand gathering. Green and brown algae were on occasion pulled off the stone and embodied into the wall of the cell. In this manner an irregularly shaped tunnel about 10 cm. long and 3 cm. wide was constructed under the overhang of the stone. The animal rearranged the tunnel boundaries from time to time, but mostly it kept a front and back entrance clear. Within the chamber *Axius* led a restless life, frequently reversing its position by turning a neat somersault so as to face either end of the tube alternatively. Occasionally the creature walked round the stone, but always returned fairly soon to the lair. At intervals *Axius* paddled vigorously to draw water currents through the tunnel.

Virtually nothing has been recorded about the feeding habits of this species, but several rather similar types of crustacea are known to subsist on microscopic matter drawn into their burrows with currents of water set up by the paddling action of their swimmerets. When presented with little masses of freshwater algae and associated material in the laboratory tank, *Axius* collected them together in a mucilaginous secretion from the mouth. This coagulated mass was then slowly eaten. K. B. Clarke examined the freshwater material and reported finding species of *Mougeotia* sp., filaments of *Spirogyra* sp. and numerous colonies of *Anabaena* sp. It also contained nematodes, small annelids and algae, including *Chroococcus* sp. and the desmid *Cosmarium* sp. Living seaweeds, in this case *Fucus vesiculosus* L. and *Enteromorpha* sp., were also pulled off the stone and mixed with mucus before being eaten. *Axius* was also fed on a mixed diet of small earthworms, slugs and fragments of meat and fish. The larger pieces of meat were seized by the chelated appendages and broken into smaller portions before consumption. Bait too large to cope with at one sitting was buried in the sand and eaten later when it had become softened through partial disintegration.

A curious feature was the bristliness of the pincers which had a number of reddish setae projecting from them, arranged rather like the boughs of a Christmas tree, but without subsidiary branchlets. These bristles appeared to assist in gathering soft, weedy material to form into wads for feeding.

When moving from rest *Axius* first lifted itself off the ground with its four pairs of spidery walking legs. The anterior chelated pair were not used directly in walking but probably acted in balancing the creature. As the abdomen lost full contact with the ground the four pairs of abdominal appendages or swimmerets began to beat rhythmically at a rate of between 150 and 180 beats per minute. Initially the tail fan was bent forward under the abdomen with the five lobes in the closed position; in this manner the fan acted as a barrier to the backward flow of water created by the beating swimmerets. The water flow was thus directed downwards and so greatly assisted the creature in lifting the abdomen off the sandy substrate. The whole abdomen hinged at the junction with the cephalothorax at an angle of articulation of between 20° and 25° to the horizontal plane. This dorso-ventral flexing and extension of the abdomen

in relation to the cephalothorax aided *Axius* by giving the beating swimmerets space in which to paddle fully. The segments were incapable of lateral movements.

Having raised the abdomen the backward flow of water created by the swimmerets was less sharply angled both by the positioning of the tail fan and angle in which the abdomen itself was held. The lobes of the fan were no longer held in the closed position and some water escaped through the gaps between them. The acute flexing of the tail fan was also reduced so that it was held more obtusely in relation to the ground. Movement in *Axius* was largely dependent upon the forces produced by the swimmerets whilst the walking legs acted more as lifting and balancing organs than propulsive ones. In the laboratory tank *Axius* walked over the sand substrate at a speed approaching 2 metres per minute.

Analysis of cine film of walking in *Axius* showed that the swimmerets beat not in unison but out of phase with one another. At rest the swimmerets were held vertically and movement began with the anterior pair flexing and moving forward. Simultaneously the third and fourth pairs moved in the opposite direction. As the first pair of swimmerets gathered momentum the second pair began to swing forward, although they failed to complete a full arc before the first pair had commenced the return stroke. As both pairs of anterior swimmerets made their effective stroke so the posterior pairs moved forward in the recovery phase, such that all four pairs met centrally beneath the abdomen. The recovery strokes of the anterior appendages began before the completion of the comparable strokes from the hind pairs so that for a brief moment all four pairs of swimmerets moved forward in unison. This was soon followed by the effective strokes of the posterior swimmerets. The appendages of *Axius* thus beat in such a way that two pairs were in the effective phase and two pairs in the recovery phase of the stroke cycle, except for the brief moment described when all four moved in unison. At no stage were all four appendage pairs completely in phase with one another.

On occasion *Axius* was observed walking backwards for short distances. The walking legs only were used and no assistance was given by the swimmerets.

Swimming necessitated the rapid beating of the swimmerets with the tail fan held closed beneath the abdomen. The walking legs thrashed weakly in the water. Normally *Axius* swam on its side and only rarely was it noted in a dorsoventral plane. When descending gently the animal nose dived with the aid of the weakly beating swimmerets. Rapid descent, in contrast, was tail first with the abdominal appendages idle.

When prodded with a stick *Axius* either grasped it tightly in its chelae or reversed away rapidly. The defensive movements resulted from sudden sharp flexings of the abdomen with the tail fan closed. The animal literally scooped itself backwards. In moderate retreat the jerking action carried *Axius* backwards about 4 cm., but when fully alarmed a single flexing could result in over 10 cm. being covered in an instant. The jerking movements could be repeated several times in quick succession.

The two males caught in August were placed briefly in the same tank where they fought furiously, although rather ineffectively since their weak spidery legs prevented powerful attacks. The males faced one another in attack and their main strength seemed to lie in their broad tail fans which were doubled underneath and "sat on" whilst battle was in progress.

The longest-kept specimen cast its carapace successfully during the night of 3–4th November, the new shell being of a milky colour at first, but hardening and becoming pale pink by 5th November. The animal was fairly active at first, but took no interest in any food and became gradually more feeble until it died on 10th November. After moulting it was actually smaller than before.

Acknowledgements
The authors are grateful to Messrs. Frank Moore, Fred Symonds and Percy Trett for the specimens of *Axius*, and to Mr. Jack Philips for the cine film taken of the animal.

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THE UNUSUAL CLARITY OF THE ORMESBY BROADS DURING 1971

By K. B. Clarke

The Ormesby group of Broads are not famous for the clarity of their waters. Indeed the water is usually so turbid with planktonic algae that the bottom is rarely visible although large areas are less than one metre deep. At the end of April 1971 the water cleared very quickly and the Broads contained crystal clear water throughout the summer and autumn. The water finally became turbid again in February 1972 with a monoalgal plankton of *Stephanodiscus hantzschii*.

The group consists of five lakes varying in depth up to 3.5 metres. These are, from north to south, Ormesby Broad, Rollesby Broad, Lily Broad, Little Ormesby Broad and Filby Broad. The two extreme Broads connect to the others by culverts navigable by rowing boat while the central Broads are connected by openings 10 m. and 40 m. wide. The Broads are a source of public water supply for the East Anglian Water Company.

On three occasions during the year samples were taken over the whole series of Broads and showed that while there were minor local differences the general picture was the same throughout the group.

These notes examine the history and possible causes of the clearance of the water which has considerable economic significance for the waterworks and record some matters noted in consequence of this clarity.

2. The sequence of planktonic algae in the Ormesby Broads does not follow the classical pattern. Fundamentally one might say that the Broad had a plankton of *Asterionella formosa* which is joined by *Synedra acus* in the spring and *Melosira granulata* at various times of the year. (Fig. 1 shows the appearance of the algae mentioned.) Over the winter of 1970–71, however, there was a heavy bloom of *Aphanizomenon flos-aquae*, the blue green algae which produced a green paint-like scum on the surface from December to March.

In the spring of 1969 there was a heavy diatom plankton of *Synedra*, *Asterionella* and *Melosira*. The *Synedra* disappeared at the end of April and the *Asterionella* at the end of June. The summer plankton was of *Melosira* with the blue-green alga *Anabaena* and the delicate green wheels of *Pediastrum*. *Microcystis* and *Ceratium* were also present. The winter of 1969–70 had a steady diatom plankton as in the spring. This plankton fell away in the late spring 1970 to leave a fairly clear water dominated by *Pediastrum*. This was joined by *Melosira* and *Microcystis* during the summer for a while. The zooplankton was dominated by the water flea *Bosmina longirostris*. The winter plankton really began in October 1970 when masses of *Asterionella* began to dominate the lakes and this persisted until February 1971. With the *Asterionella* we had from November 1970 the heavy bloom of *Aphanizomenon* mentioned above. *Synedra acus* joined the plankton in January 1971 and increased until in March it dominated the samples.

On 15th April 1971 the plankton was made up mostly of *Asterionella* and *Aphanizomenon* with the latter looking sick, yellowish and appearing on the lake as mustard coloured flakes. There was a significant quantity of *Dinobryon* which is otherwise rare in Ormesby Broad. A few *Bosmina longirostris* were present.

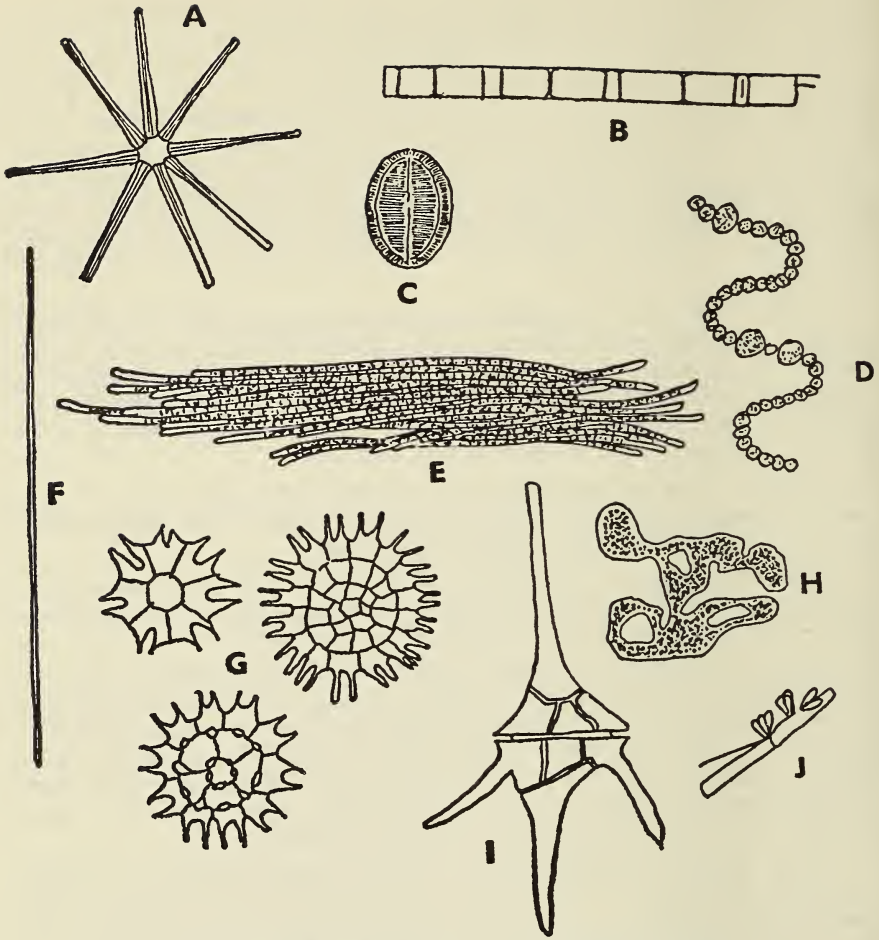


Fig. 1 Plankton Algae from Ormesby Broad. X 500

A. *Asterionella formosa.*
B. *Melosira granulata.*
C. *Cocconeis placentula.*
D. *Anabaena sp.*
E. *Aphanizomenon flos-aquae.*
F. *Synedra acus.*
G. *Pediastrum sp.*
H. *Microcystis aeruginosa.*
I. *Ceratium hirundella.*
J. *Characium sp.*

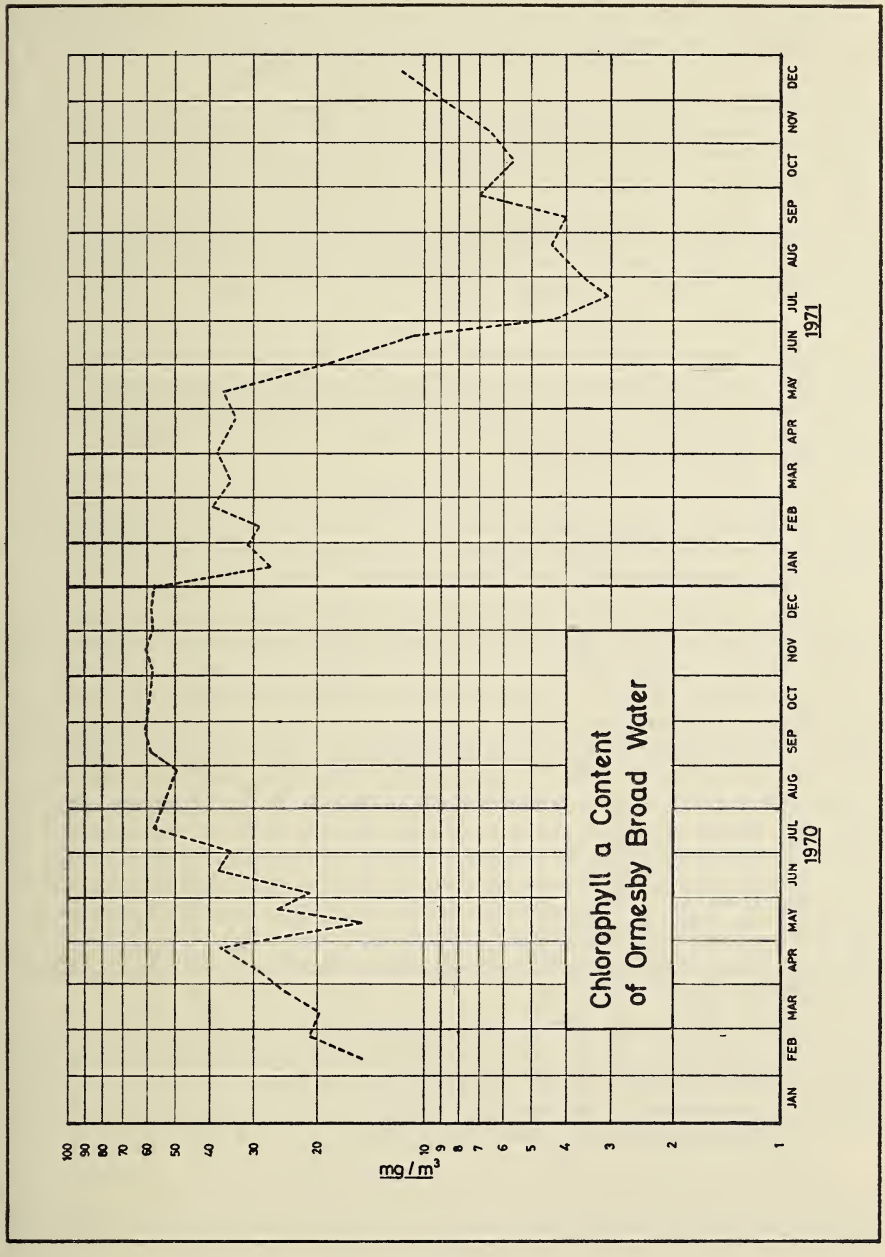

Chlorophyll a Content
of Ormesby Broad Water
mg/m³
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1970
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1971

Fig. 2

In both 1969 and 1970 the late spring and early summer were typified by a decline in algal numbers. In 1971, however, nothing grew following this decline. Our task now will be to examine possible reasons.

The Chlorophyll *a* content (Fig. 2) shows how poor the open water was in microscopic plant life during the summer of 1971. An interesting fact, however, is that while observers were commenting on the clarity of the water in late April there was no significant fall in the Chlorophyll *a* values for a month afterward. This was due to the presence of the flakes of *Aphanizomenon*. This organism consists of cells arranged in straight filaments but the filaments aggregate together lying side by side to form a macroscopic colony. It is thus possible to have considerable clarity while the water still contains large numbers of algal cells.

3. The first concern must be to establish whether the water had, in fact, become toxic to algal forms. This fear could be readily dispelled by examining the reeds which still carried, as in other years, a thick growth of epiphyic diatoms. Also the planktonic water fleas had cells of *Characium* and the diatom *Cocconeis placentula* attached to their shells.

4. The clarity of the water focussed attention on the water fleas as a possible cause of absence of the plankton algae. It is known that *Daphnia magna* is very effective in reducing populations of small unicellular algae[1] but the evidence for smaller water fleas and larger algae is scarce and conflicting.

It was certainly a good spring for water fleas and at the time the algae disappeared in late April clouds of *Daphnia hyalina* were noticed on one of the slow sand filters giving the water a brown and turbid appearance. In the two previous summers there has been very few *D. hyalina* in the Broad but they continued to be abundant in 1971 from April onwards. In previous years the smaller *Bosmina longirostris* had been dominant. However, in April 1963 there had been clouds of *D. hyalina* in the Broad of sufficient magnitude to cause a special note of the fact to be mentioned in my diary. Comparison with the Paper by Robert Gurney[2] shows, however, that in 1927–28 the zooplankton had had a different species of *Daphnia*, namely *D. cucculata*. Did the *Daphnia* "eat the lake clean"? More work needs to be done on their food before a certain answer could be given. An important factor could have been the appearance in the Broad of *Daphnia magna* from July onward. However, *D. magna* was still present in some numbers in February when the bloom of *Stephanodiscus* brought the period of clarity to an end.

5. It was thought possible that there might have been a change in the Broad water due to changes in the water entering. The Broad comes in for greater use as a source of public supply nowadays than had been the case in the past. However, examination of the quantities abstracted from the Broad give no clue as to why 1971 should have been specially different.

During the winter of 1970–71 the internal drainage board carried out the dredging of the Ormesby St. Margaret dyke leading from that village into Ormesby Broad. This resulted not only in a considerable amount of backed up ground-water entering the Broad but the dredging exposed gravel beds which

[1] van Heusden. G.P.H. (1944) Ervaringen bij de bestrijding van "groene" filters. Water 28 No. 5 pp 34-41

[2] Gurney R. *The plankton of Ormesby Broad.* Trans. Norfolk & Nor. Nat. Soc. 1972 vol. 22 p. 261-265

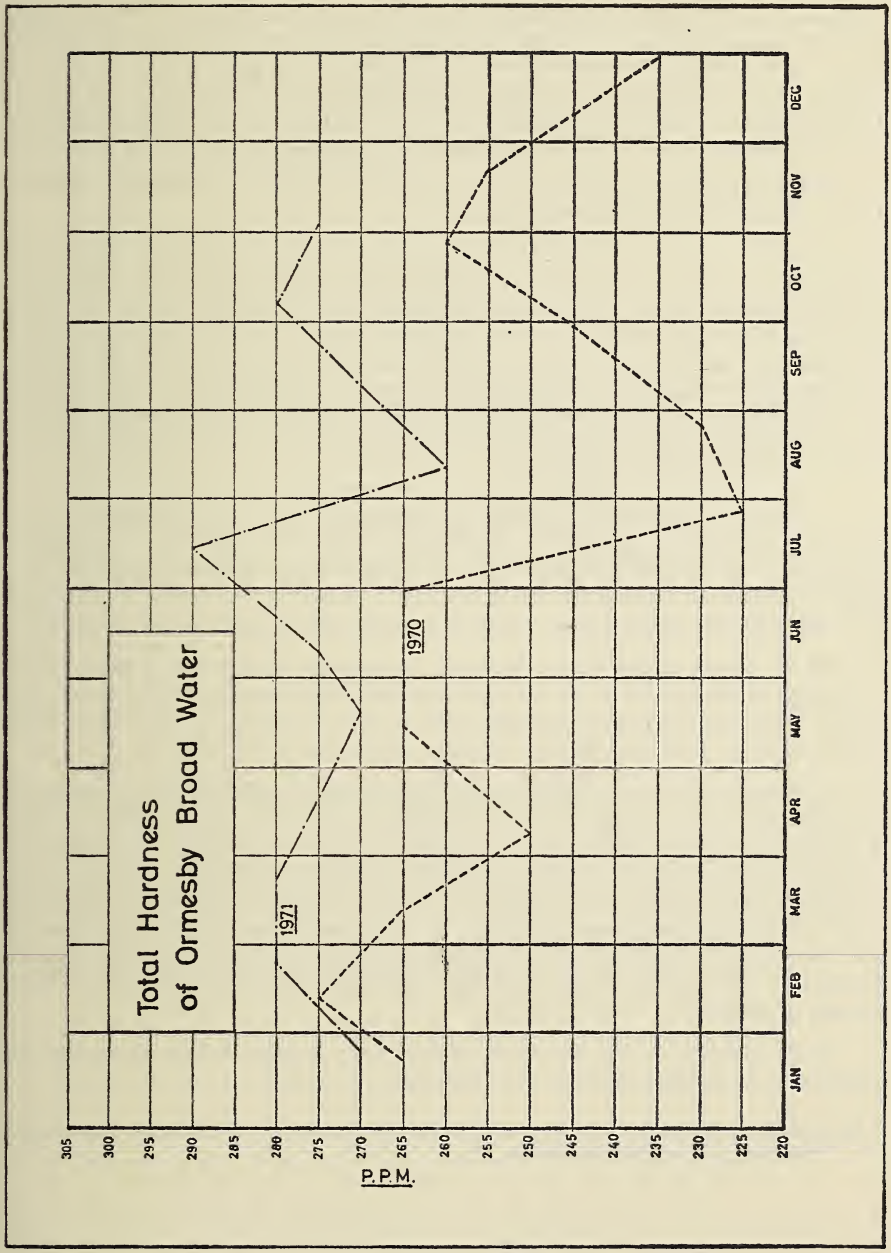

Total Hardness
of Ormesby Broad Water
1971
1970
P.P.M.
305
300
295
290
285
280
275
270
265
260
255
250
245
240
235
230
225
220
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Fig. 3

must have contributed considerably to the Broad in the spring of 1971. Comparison of the hardness of the Broad water in 1970 and 1971 (Fig. 3) shows a rise of some 20 mg. per litre due to an increase in the non-carbonate hardness values. The availability of nitrogen compounds in the water gives no clue as to the absence of planktonic algae (Fig. 4). It may, however, be significant that nitrates were absent during the five months following the clearing of the water.

pH values were a little lower than usual (7.2–7.8) but this is the result of lack of algae rather than the cause.

6. The clarity of the water allowed things to be seen which had not been noticed previously. It was surprising how much of the bottom appeared to be clean sand. In places it had small craters like those produced by springs. In places there were beds of *Enteromorpha intestinalis* lying on the bottom with *Lemna trisulcata*. In other places there were thin green clouds of the filamentous green alga *Spirogyra* lying on the bottom a foot or more across (300 mm.). The *Daphnia* were either dispersed through the whole body of water or in tight clouds 6 inches to 2 feet across (150 mm.–600 mm.). The clouds appeared to be more common where the bottom was sandy.

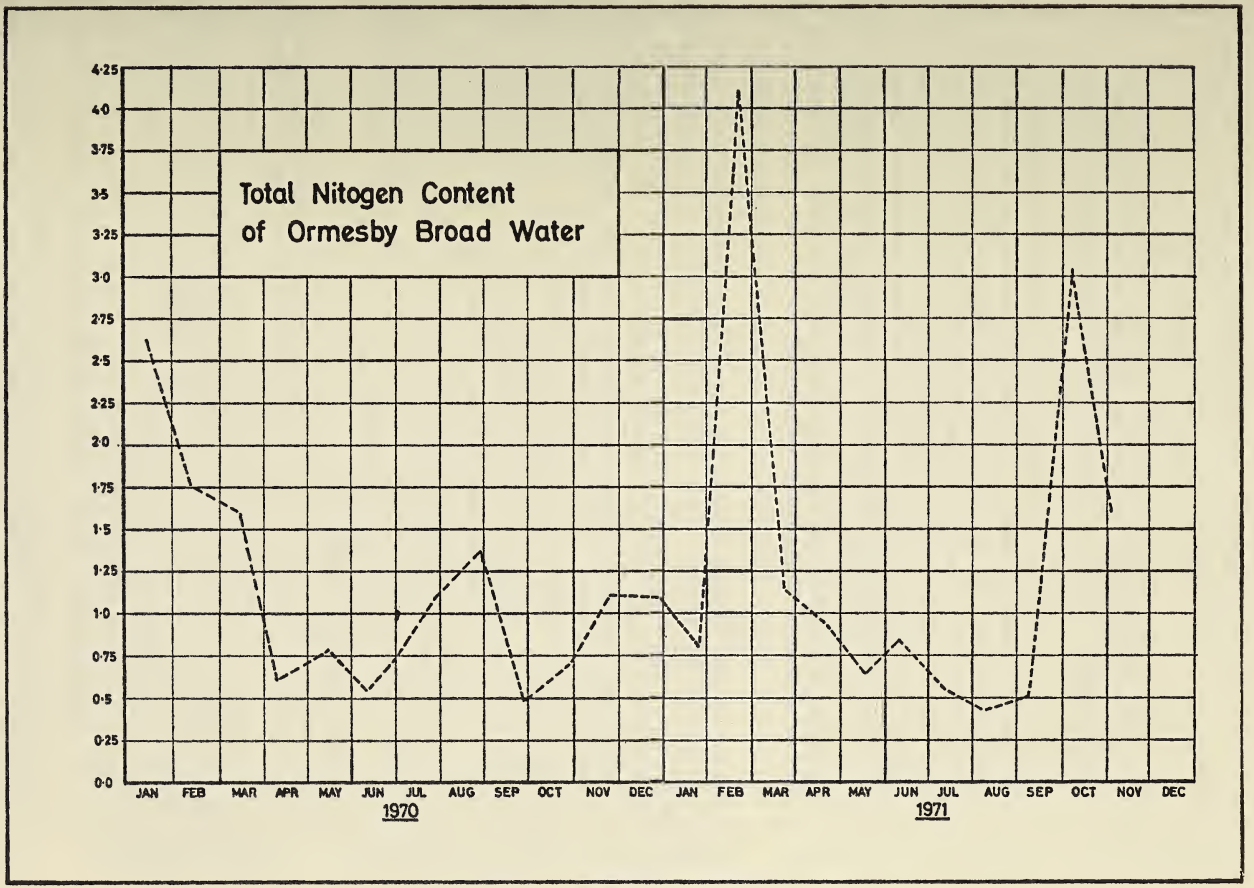
It was noted in October that the *Daphnia* in the swarms were larger than those in the plankton generally. No identifications were made but the majority of those in the swarms may have been *D. magna* as the mean size was 2.41 mm. which is almost the maximum size given for *D. halina* by Scourfield & Harding.[3] In June 1972 the swarms were found to contain almost exclusively *D. hyalina*.

Mr. C. Evins of the Water Research Association staff kindly looked at the Crustacea in the plankton for me and reported *Diaptomus gracilis* present both in the June and December samples sent to him. *Cyclops vernalis americanus* was present in June and *Cyclops strenuus abyssorum* in December.

7. The clarity of the water also revealed the presence of shell deposits especially in Rollesby Broad similar to the well-known ones of Rockland Broad. They seemed to correspond to areas of *scirpus* along the shore line. The deposits consist mostly of dead *Valvata piscinalis*, *Dreissena polymorpha* and young *Anodonta cygnea* with a few nerites. Live and dead specimens of *Hydrobia jenkinsii* and *Bythinia tentacula* occur. Both *Limnaea auricularia* and *L. pereger* are found. The deposits are the home of *Asellus aquaticus*, *A. meridianus*, *Gammarus pulex* and a leech which Dr. Ellis kindly identified for me as *Glossiphonia complanata*.

I am grateful to the Directors of the East Anglian Water Company for permission to publish much of this material.

[3] Scourfield & Harding. "A Key to the British Species of Freshwater Cladocera". *Freshwater Biological Association*.


Total Nitogen Content
of Ormesby Broad Water
4·25
4·0
3·75
3·5
3·25
3·0
2·75
2·5
2·25
2·0
1·75
1·5
1·25
1·0
0·75
0·5
0·25
0·0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1970
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1971

Fig, 4

THE PLANKTON OF ORMESBY BROAD

By The Late Robert Gurney, 1931

This Paper is a valuable record of the plankton of Ormesby Broad in 1927–28 and stands halfway between Gurney's classic Paper of 1904, "The Fresh and Brackish Water Crustacea of East Norfolk", Trans. Norfolk & Norwich Nat. Soc., Vol. VII, p. 637–60 and the present day. The changes in the Cladocera since 1904 are instructive. At that time *D. cucullata*, *D. lacustris* (=*D. hyalina var lacustris*) and *D. longispina* were present in Ormesby Broad. *D. cucullata* was recorded as abundant in all the open Broads. In this Paper it is the only *Daphnia* recorded. During the 1960s and up to the present day I have not seen a specimen from Ormesby Broad which I could ascribe to this species. *D. hyalina var lacustris* had replaced it until the late summer of 1971 when *D. magna* joined it. The latter species is absent from this Paper and in 1904 was "common in farm ponds".

K. B. Clarke, 1972

The plankton of the Norfolk Broads has never been systemmatically studied, though its general features are fairly well known. Whether any comprehensive quantitative investigation would repay the labour involved is very doubtful, since such quantitative studies are more designed to reveal the biology of the species themselves than the ecological conditions. It is the latter which are of most interest in connection with the Norfolk Broads, and the information needed can probably be got by simpler means. Qualitative comparison of the different Broads on the one hand, and of the Broads as a whole with other areas, could profitably be undertaken. The zooplankton presents little difficulty, but the phytoplankton requires an accuracy of determination which can only be achieved by a specialist. The observations on the plankton of Ormesby, of which an account is given here, were undertaken for the purpose of obtaining knowledge as to the reproductive cycle of *Diaptomus gracilis* and *Cyclops vicinus*. No attempt was made to deal with the phytoplankton, except in a very general way, the dominant genera alone being noted.

Seven samples only were taken, between 14th November 1927 and 27th September 1928. The method adopted was quite rough; a townet of rather coarse mesh was towed right across the Broad at a point a little south of the waterworks intake, over a course of about 300 yards. No attempt was made to treat the catches quantitatively, in the usual sense, but samples from each were counted in order to obtain the relative abundance of each species of Crustacea. This method is, I think, adequate for the purpose. The general conclusions to be drawn seem to be these:

(1) The phytoplankton always forms a large proportion of the plankton.

(2) Phytoplankton decreases very rapidly from September, and is at its minimum from November to March. *Melosira* does not completely disappear, and there are always many unicellular algae.

(3) There is a rapid increase of Phytoplankton towards the end of March, reaching its maximum in June, when there is striking water-bloom, mainly due to *Anabaena*. *Melosira* is, however, the generally dominant form. *Asterionella* reaches its maximum in August or September.

(4) The dominant Crustacea vary with the season. In November 1927 *Daphnia cucullata* was dominant, in enormous numbers, *Bosmina* coming next. Together they made up 96 per cent of the zooplankton. Both decreased to insignificance in March, when the Copepods increased, and became dominant. *Cyclops vicinus* was dominant in March, and reproducing freely, the young (older than nauplii) accounting for 56 per cent of the plankton.

In April Copepods were still dominant; but there was a marked increase in *Daphnia* and *Bosmina*. A month later *C. vicinus* had almost disappeared, and the Cladocera had risen to 83 per cent. In June the proportions were much the same, but a number of *Cyclops leuckarti* had appeared, and took the place of *C. vicinus*. *Diaptomus* were still very few. Unfortunately I was not able to collect in July and August, two critical months. In September *Daphnia* had almost disappeared; but *Bosmina* and *Ceriodaphnia pulchella* were dominant. The latter had been noted before as occasional individuals, not always present in the samples counted, but in September it springs up to 53 per cent of the whole. *Diaptomus* had increased a little, but adult *C. vicinus* were very rare. A considerable number of young, however, indicated a start to recovery.

	1927		1928				
	14.XI	9.II	16.III	23.IV	25.V	12.VI	27.IX
Daphnia cucullata	79·3	18·5	3·4	9·1	22·9	46·8	1·02
Ceriodaphnia pulchella	—	—	p	p	p	·27	52·78
Bosmina longirostris	16·5	12·2	3·73	16·2	60	31·8	28·3
Chydorus sphaericus	—	—	—	·42	—	2·1	1·17
Diaptomus gracilis							
D. gracilis adults	·83	14·48	9·0	8·4	1·85	1·1	4·24
D. gracilis males	—	3·4	5·3	5·5	1·16	·27	1·9
D. gracilis females	·83	11·08	3·7	2·9	·69	·83	3·34
D. gracilis young	2·08	26·3	1·24	22·4	14·0	·66	7·9
Cyclops vicinus							
C. vicinus adults	·62	15·87	26·8	13·8	·92	·55	1·17
C. vicinus males	·62	13·6	16·8	10·0	·46	·55	·88
C. vicinus females	—	2·27	10·0	3·8	·46	—	·29
C. vicinus young	·41	12·5	55·7	17·2	—	5·8*	3·22
Cyclops leuckarti	—	—	—	10·5	—	4·1	·14

ZOOPLANKTON OF ORMESBY BROAD

The figures given are percentages of the total number of individuals counted.
*A number of young *C. leuckarti* are probably included here, as it was not practicable to separate the early stages of the two species.

A point of some importance is the establishment of a very definite seasonal variation in size in *Diaptomus gracilis*. The accompanying diagram shows a striking difference in average size between the adults in April and those measured in September, but it is not easy to understand exactly how this variation can be explained in terms of generations. While breeding takes place all the year round, there appear to be two main generations, in spring and late summer, the summer generation being much smaller than those of the spring.

An interesting point with regard to the zooplankton is this. At present the Broad itself is not drawn from for the supply to Yarmouth, but water is taken from the river Bure at Horning and conveyed to filter beds at Ormesby. These filter beds are sometimes flushed out into the Broad, so that the plankton of the river can be conveyed to the Broad. The fauna of the filter beds is very dominance of the species. For instance *Asplanchna priodonta* may attain here rich, and contains the plankton usual in the river, but generally differing in the

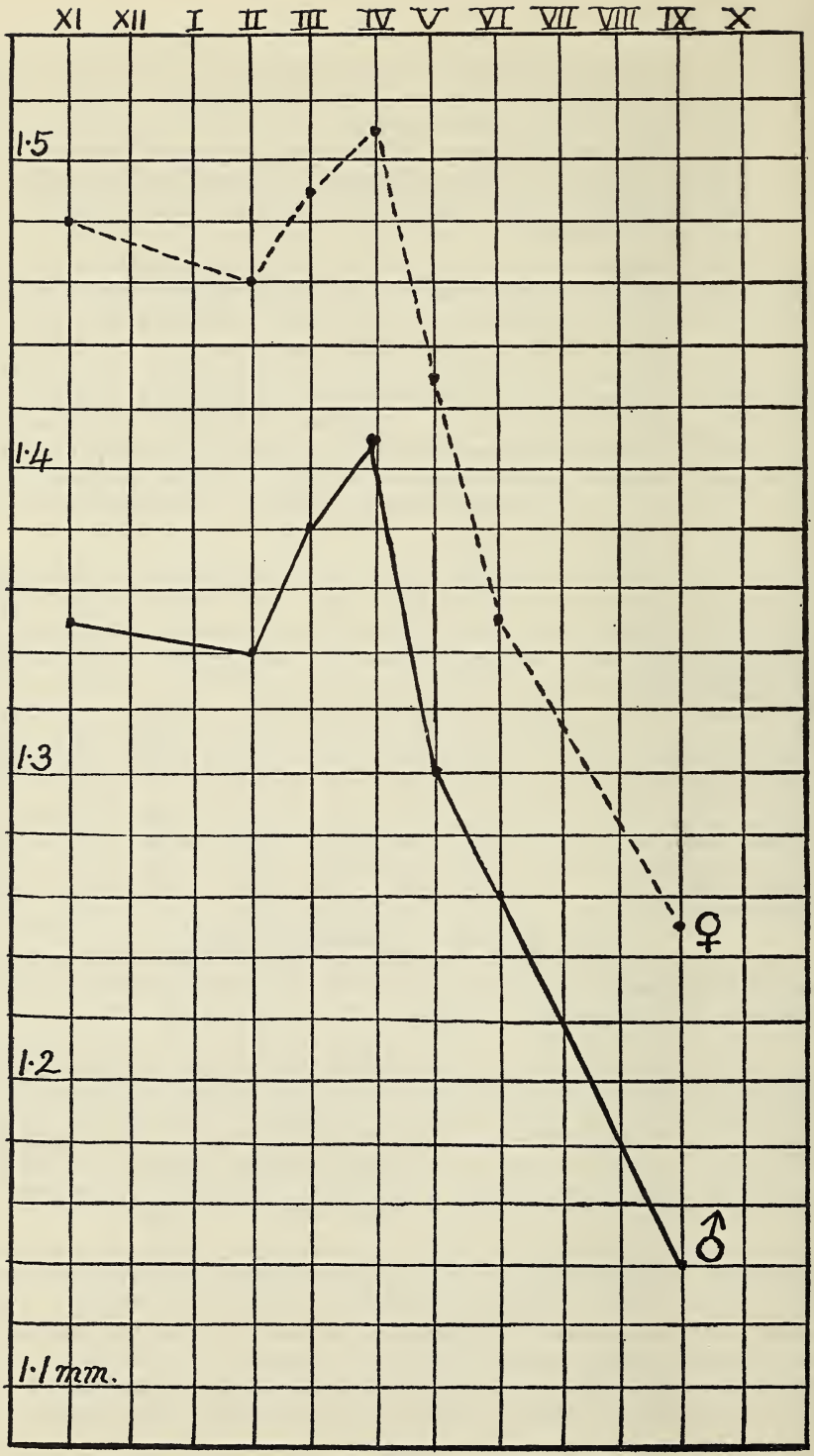


Diagram showing average length of *Diaptomus Gracilis* in Ormesby Broad Nov. 1927—Sept. 1928

quite unusual numbers. It contains also two species, *Eurytemora velox* and *Cyclops hyalinus*, which are not found in the plankton of the Broad. Apparently these species are unable to establish themselves there. In the case of *E. velox* it is certainly not a case of competition between it and *D. gracilis*, since both species occur in the filter beds.

Phytoplankton

The phytoplankton is, as one would expect, very rich in summer, and gives rise to a water-bloom which is sometimes very conspicuous. Mr. Millard Griffiths[1] has given an account of it as found in August 1924, at which time there was a marked bloom. The species taken are shown in the following list, and, for comparison, is given a list of species identified by Mr. R. W. Butcher from a sample sent to him by me in April 1928. This sample was not, however, taken in the open Broad, but was dipped from close to shore, to which a mass of water-bloom had drifted. It may not, therefore, be a fair sample of the plankton, and some of the differences between the two lists may be due to the inclusion by Mr. Butcher of some littoral and bottom forms. The differences cannot be wholly accounted for in this way, and are largely due to season.

PHYTOPLANKTON OF ORMESBY BROAD

(1) Millard Griffiths, 1924 (August).
(2) R. W. Butcher, 1926 (April 28th).

	(1)	(2)
DINOFLAGELLATAE		
Ceratium hirundinella	rr	
Diplopsalis acuta	rr	
CHLOROPHYCEAE		
Ulothrix subtilissima		dom.
Staurastrum dejectum	r	
S. tetracerum	rr	
S. paradoxum	rrr	
Pandorina morum	c	
Gonium perctorale		rr
Pediastrum boryanum	c	c
P. var longicorne	r	
P. duplex	c	c
P. duplex var. clathratum	rr	
P. duplex var. rugulosum	rrr	
P. tetras	rrr	
P. biradiatum	c	
P. kawraiskii	rr	
Coelastrum sphaericum	rrr	
Scenedesmus acuminatus	r	
S. opoliensis	rrr	
S. opoliensis var carinatus	rrr	
S. raciborskii	rrr	
S. quadricauda		rr
S. obliquus		r
Selenastrum bibraianum	rrr	
Tetraedron limneticum	rr	
Richteriella botryoides	rrr	
Dictyosphaerium pulchellum	c	
BACILLARIAE		
Melosira granulata	cc	c
M. distans	c	
Cyclotella operculata		ccc
C. cornuta		c
Fragilaria virescens		rr
F. crotonensis		rrr
F. construens		rrr
Asterionella formosa	c	ccc
Gyrosigma acuminata		cc
G. kutzingii		cc
C. spenceri		r
Bacillaria paradoxa		c
Nitzchia sigmoides		cc
N. sigma		c
N. palea		r
Surirella anceps		cc
S. ovalis		rrr
Cymatopleura solea		rrr
Navicula sculpta		r
Amphora minuta		rr
Epithemia turgida		rrr
Tryblionella punctata		rrr
Synedra ulna		c
S. acus		cc
MYXOPHYCEAE		
Anabaena spiroides	c	
A. affinis	c	cc
A. lemmermani	rrr	
A. circinalis	rrr	
Aphanizomenon flos aquae	c	
Gomphosphaeria naegeliana	rr	
G. lacustris	c	
Microcystis aeruginosa	c	
M. flosaquae	r	
M. holsatica	r	
Chroococcus limneticus	r	

Key

r = rare
rr = very rare
rrr = extremely rare
c = common
cc = very common
ccc = abundant
dom = dominant

[1] *Journ. Linn. Soc. Botany*, XLVII, 1927, pp. 595–612.

Particular attention should be directed to the presence of *Ceratium hirundinella*, though it is at no time common. I have never seen it in any other broad, though it is common in the west Norfolk meres. It is an abundant species in the plankton of the lakes of Denmark, with which that of the Norfolk Broads has, according to Mr. Millard Griffiths, some resemblance. He points out that the plankton of the Norfolk Broads differs markedly from that of any other area in Britain, but continues: "In Denmark, perhaps, one finds the closest parallel to the conditions prevalent in the Norfolk area, and the plankton of the Danish lakes correspondingly resembles that found here". This conclusion I find it difficult to accept. If a Danish lake such as Furesö[2] is taken, and the species of the plankton tabulated, the only agreement seems to be the relative abundance of Diatoms, particularly of *Melosira* (but of different species). The specific differences in the list may partly be due to changes in nomenclature, which I am unable to check, but they cannot all be so explained. In the presence of *Ceratium* Ormesby approaches nearer than other Norfolk Broads, but it is so rare here that it is quite insignificant. *Dinobryum* is very abundant in Furesö, but in the Norfolk Broads it is very rare. I have found it once in Ormesby. Millard Griffiths records it as common in Rockland Broad and Wroxham, but not elsewhere.

The Crustacean plankton differs fundamentally in the presence of *Cyclops oithonoides*, *Diaptomus graciloides*, *Bosmina coregoni*, *Bythotrephes longimanus* and *Leptodora kindti* in Denmark and their absence from any of the Norfolk Broads. The selection of Furesö for comparison is perhaps not the best possible, since it contains "relict" Crustacea and is rather exceptional; but *C. oithonoides* and *L. kindti* are present in all the lakes described by Wesenberg Lund, and *D. graciloides* and *B. coregoni* in nearly all, so that the differences remain, whatever example is chosen.

[2]Wesenberg Lund, 1904. "Plankton Investigations of the Danish Lakes", Special Part. *Copenhagen.*

NOTES ON STICKLEBACKS FROM THE NORFOLK BROADS

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The three-spined stickleback *Gasterosteus aculeatus* is one of a small group of fishes capable of withstanding extreme changes in salinity. The fresh, brackish and salt waters that constitute the complex of rivers, broads and dykes of the Norfolk Broads provide a suitable habitat for the stickleback or "stannickle".

During the first three weeks of May, 1969, we investigated the distribution and host-parasite relationship between this species of fish and *Thersitina gasterostei* (Pagenstecher, 1861), a copepod parasite. (For the results of this parasite survey see Walkey, Lewis and Dartnall, 1970.)

Nearly 1,000 three-spined sticklebacks were examined, 70 per cent of which were infected with *T. gasterostei*. The majority of the specimens were found on the operculum (74 per cent), though the gills (11 per cent) and the skin round the gills and operculum (15 per cent) were also infested. In very heavy infections (204 specimens were recorded from one fish) the dorsal and pelvic spines and the pectoral fins were also infested. This parasite showed no preference for any individual gill though the faces of the anterior hemibranch were infested with nearly 3 times as many parasites as the faces of the posterior hemibranch.

Thersitina is parasitic on estuarine fishes and although no relationship was found between intensity of infection and increasing salinity the parasite was found in all waters of salinity more than 0.5 per cent NaCl. In the freshwater regions, headwaters of the Rivers Bure, Yare, Waveney and along the whole length of the River Ant this parasite was not found [see also Gurney, 1907 and 1913].

Samples of sticklebacks were examined for other parasites and the following 8 species were found in fresh and brackish waters:

Trichodina domerguei, *T. tenuidens*, *Glugea anomala*, *Dermocystidium gasterostei*, *Gyrodactylus* sp., *Diplostomum spathaceum*, *Argulus foliaceus* and glochidia larvae. *Trichodina domerguei*, *T. tenuidens*, *Glugea anomala* and *Dermocystidium gasterostei* are protozoan parasites. *Trichodina domerguei* was found on the skin and fins and *T. tenuidens* on the gills. *Glugea anomala* and *Dermocystidium gasterostei* were found encysted in the tissues and on the body surface respectively. *Gyrodactylus* sp. is a monogenetic trematode occurring on the fins, gills and skin. The digenetic trematode *Diplostomum spathaceum* was found in the outer layer of the lens capsule. Glochidia are larval stages of freshwater mussels of the genus *Anodonta* and *Unio* and they were found encysted on the body surface, fins and gills of fishes. Single specimens of *Argulus foliaceus* were present on the body surface of some sticklebacks. *Dermocystidium gasterostei* has previously been recorded only from Newdigate Ponds (Elkan, 1962). No correlations were observed between any of these parasites and the salinity of the capture site.

Several other species of fish were also caught – the nine-spined stickleback, roach, bream, eel, perch, ruffe, pike, flounder and the lesser goby *Gobio minutus*.

Both the goby and nine-spined stickleback *Pungitius pungitius* were found to be infected with *Thersitina gasterostei*. The other species of fish were not examined for this parasite.

Prior to this investigation we had expected to find both species of stickleback from mouth to source of all rivers. Nine-spined sticklebacks were not so common as the three-spined and the distributions of the two species were different. The dykes and rivers of the Broads provide numerous stickleback habitats; however, at some of these seemingly suitable sites only nine-spined fish were found. The water at these sites generally proved stagnant. At some sites both three- and nine-spined fish were caught and if these fish were kept in containers prior to dissection deaths often occurred. The three-spined stickleback invariably died first so that after a period of several hours only the nine-spined were observed swimming around despite the reduction in oxygen and build-up of carbon dioxide that presumably asphyxiated the three-spined fish (see Lewis, Walkey and Dartnall, 1972).

The distribution of the three-spined stickleback was not uniform in the Broads and these fish only occurred along the whole length of the River Thurne. This river is always under a saline influence. At the limit of navigation where the river runs parallel to the coast, seepage occurs and a high salinity, equivalent to 15 per cent seawater, was recorded. Sticklebacks were also captured in the saline or lower reaches of the Rivers Bure, Yare, Waveney, and again in the freshwater headwaters of these rivers and also the River Ant.

In the middle reaches of the Rivers Bure, Yare and Waveney and the lower reaches of the River Ant, the three-spined stickleback was very scarce and in these areas it was impossible to collect adequate samples.

The absence of sticklebacks from the middle regions of these rivers might be explained by the isolating breeding mechanisms of the various "races" of the three-spined stickleback. Hagen (1967) in a study of the Little Campbell River in British Columbia, found that the leiurus (freshwater) "form" breed in the upper reaches of the stream while the anadromous trachurus (marine) "form" enters the lower freshwater reaches to breed. The two breeding grounds are basically isolated, though in the middle region some hybridisation occurs.

This could well be the case on the Norfolk Broads and this problem, as well as the relationship between the three- and nine-spined fish, warrants further examination.

We thank Mr. Vincent Ellis and the East Suffolk and Norfolk River Authority for permission to collect samples in the Broads.

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BAWDESWELL HEATH

By Alec Bull

A survey of the flora and fauna was attempted during 1971, though this was not quite complete as no time was available to net Lepidoptera. An attempt to remedy this may be made during 1972. A comparison is possible with the heath as it was in 1958, thanks to a paper made available to the author by Dr. Hornby and written by B. F. T. Ducker and R. G. Pawsey of the Nature Conservancy.

Description (B. F. T. D. and R. G. P.)
The Fuels Allotment Charity known as Bawdeswell Heath, lays on the north side of the B.1147, East Dereham/Reepham road. Of 37 acres, it consists of a steep-sided plateau which continues into fields on the north-eastern boundary, but slopes down to a fen on the north. The drainage ditch from the fen forms the western boundary. A small stream bounded by marsh bisects the narrow valley running alongside the road. The top of the plateau is moderately flat, though here and there, depressions mark places where gravel has been extracted for one purpose and another. (This is still occasionally taken, even in 1971 though in no great quantity.)

The contrast between the flora of the valley and the dry upland portion is very marked, and some changes can be noted by comparing the situation in 1958 with that in 1971.

The Flora (A. L. B.)
The area can be conveniently divided into four:

1) the southern stream valley. 2) the fen. 3) the steep sides of the plateau. 4) the dry heath. 1) The stream enters the heath at the eastern end. This area is much wetter than in 1958 due to improved drainage on the adjacent land. Since 1969 a very large dairy unit housing nearly 400 cows has been in operation about half a mile upstream. The much increased flow of water resulting from this is held back on reaching the confines of the heath by luxuriant growth of *Urtica dioica*, *Epilobium hirsutum*, *Filipendula ulmaria*, and in the stream itself by *Apium nodiflorum*. This has resulted in an extension of the fenny area into several large, shallow pools and a much more vigorous growth of two species of Bog Moss; *Sphagnum palustre* and *S. recurvum*. In future, it would seem probable that an area of Alder Carr will form here and a start in this direction has already been made. The growth of much Birch here was seen as a threat to the plant community, but has not materialised to any extent. Some has been cut in the traditional manner for firewood and peasticks; probably because this corner of the heath is nearest the village!

Among the more interesting species found in the valley as a whole, many of them not mentioned in the earlier survey, are *Succisa pratensis; Myosotis palustris; Ranunculus flammula; Cardamine pratensis; Lychnis flos-cuculi;* a small quantity of *Achillea ptarmica*, and an area of *Molinia caerulea*, though this would appear to be much less extensive than formerly.

The Bryophyte Flora is very good, more especially on the slightly drier ground near the road where may be found *Hylocomium splendens; Bartramia pomiformis; Thuidium tamariscinum; Mnium longirostrum*, and many other common species.

2) The Fen on the north side has quite a rich flora. At the eastern end *Carex disticha* is dominant, while further west its place is taken by *Molinia caerulea*. In association with the latter, *Achillea ptarmica* is frequent – much more so than in the roadside valley. Several other sedges also appear here including *Carex elata; C. nigra* and *C. hirta. Oenanthe fistulosa; Lotus uliginosus; Potentilla erecta; Pulicaria dysenterica; Stellaria graminea* and *Ranunculus flammula* are all frequent, as is *Hydrocotyle vulgaris, Hypericum tetrapterum,* and *Epilobium palustre*. One surprising plant in such a wet habitat is *Myosotis discolor* growing on the side of a *Molinia* tussock.

Bryophytes included *Sphagnum plumulosum; Aulocomnium palustre* and *Dicranum bonjeani.*

3) The plateau sides were formerly dominated by Bracken but now Birch has taken over and is dominant in large areas with the result that Bryophytes form the larger part of the ground flora in several places. In such conditions *Campylopus piriformis* is often dominant. On one section of the western slope there is quite a good stand of the Liverwort *Lophozia ventricosa,* which has possibly spread in from a colony just across the road in Bylaugh Park.

4) The plateau is rather more definitely segmented than at the time of the former survey with an area of maturing trees – Birch and Pine at the western end. That changes are still taking place here is borne out by the fact that in 1969, a thriving colony of the moss *Rhacomitrium canescens* was found between the trees, which any amount of diligent searching failed to reveal in 1971.

From the trees eastwards lies an area of Grass Heath-Festuca/*Agrostis* with a few scattered Oaks and Elders and many Bryophytes, including *Polytrichum piliferum; Dicranum scoparium; Hypnum cupressiforme* var, *ericetorum,* and the Liverwort, *Cephaloziella hampeana.*

Further east still, the grass heath gradually gives way to *Calluna/Erica cinerea,* which has apparently extended its range since 1958, at which time it was considered to be in danger of being smothered by the grass.

The final belt before the eastern fringe of Oaks is reached, is of *Ulex europaeus* and *U. gallii,* which has also apparently extended its range somewhat in the intervening period.

One final word is perhaps necessary on the flora of the disused gravel workings. Here may be found the only colony of *Ornithopus perpusillus.* Apart from this quite a number of garden throwouts occur, these included *Hesperis matronalis,* which has been here for a number of years. (*Flora of Norfolk,* Petch and Swann.) Other species found include *Ornithogalum umbellatum; Papaver somniferum;* and, oddest of all, *Polemonium caeruleum.* This latter species is well established, some of the plants being two or three years old. This is the first Norfolk record of the species, which is of casual occurrence away from a few areas of Limestone in the Pennines.

Fungi

The fungi of the heath are quite diverse, with a preponderance of species favouring Birch heath, including *Amanita muscaria; A. fulva; Lactarius turpis; Paxillus involutus,* and, on wood, *Piptoporous betulinus; Pleurotus ostreatus* and *Crepidotus variabilis,* which is especially abundant on Nettle stalks at the eastern end of the Fen.

Butterflies
Only four species were noted, with Orange Tip especially abundant along the valley stream. However, mention must be made of the Green Hairstreak which was found sunning itself on Gorse blossom on 13th May.

Birds
Ornithologically, the Heath has much to offer, with the stream a favourite drinking place attracting such species as Siskin and Redpoll. The latter breeds freely in the area. The former species is a winter visitor, at which time it is frequently joined by Brambling attracted by a line of Beech trees along the roadside bank. The pools in the valley have even proved attractive enough, in winter, to lure a Water Rail to tarry for a while. Due no doubt to the close proximity of Bylaugh Park, which still has quite a few old trees, though no longer a big estate, all three species of Woodpecker are frequent. They all probably breed here, as holes of varying sizes have been noted in the trunks of dead and semi-dead trees. Nuthatches are frequent visitors foraging after Beech mast, as are all members of the Tit family. In summer, most of the Warblers have been encountered at one time or another, with occasional records of Nightingale and Tree Pipit.

As can be seen from this brief account, Bawdeswell Heath is a thriving place from the naturalist's viewpoint, but it is worthwhile remembering that this is also an area much loved by the general public; in summer for picnics and ball games, all year round for dog walks, and in winter when the slopes of the disused gravel workings attract sledgers from miles around. So far the demands of Nature and those of Man are in no way opposed to each other and should not be if the present balance is maintained. In fact, the use by the public does mean that the Birches are thinned to some extent, the paths are kept open, and the grass kept short by trampling.

At the time of the previous survey myxomatosis had wiped out the rabbit population and it was feared that the Birches would soon over-run the whole Heath. Though this has to some extent taken place, chiefly on the steep sides of the plateau, the cutting mentioned has helped to hold the Birch population within certain bounds. With a thriving rabbit population now re-established, it is to be hoped that the number of new saplings will not again threaten the main open areas.

Conclusion (B. F. T. D. and R. G. P.)
To the plant ecologist, Bawdeswell Heath is an interesting area, because a number of distinct situations exist where growing conditions differ, thus allowing the growth of particular plant groups having distinct preferences. In these groups particular species of moss and flowering plant occur which, though they may not be called rarities, are characteristic of situations which have been left undisturbed by the hand of man for long periods. Examples of this type of natural vegetation are becoming increasingly scarce and it is essential that the management of such pleasing places as Bawdeswell Heath should not change the natural features with which they are endowed as, once lost, the character of such places will be changed forever.

References
All Bryophyte records verified by E. L. Swann. Flora: "Clapham, Tutin and Warburg, 2nd Edition". Fungi: "Collins Field Guide to Mushrooms and Toadstools". *Lange and Hora.*

THE MARINE MOLLUSCA OF NORFOLK

By R. Hamond

Introduction

The Norfolk marine area (Hamond, 1969a) extends from the east coast of England to 03°00′ E., and from 54°00′ N. to 52°30′ N., so that it corresponds exactly to the marine molluscan Census Area 12 of Heppell (1964) with the addition of half a degree of longitude along its eastern edge. The Norfolk marine area falls entirely within Area IX of Thorson (1965), which comprises the southern and central North Sea.

The object of the present paper is to bring together all published and unpublished records of marine and brackish-water molluscs in the Norfolk area; except where otherwise stated the scope of the paper, the shore and offshore grounds worked by me (Hamond, 1961, 1963a, 1969a), and my own methods of collection (Hamond, 1965, 1966a), are as in papers on other groups of marine invertebrates (Hamond, 1957, 1966b, 1967, 1971). Of these groups the molluscs are by far the most extensively documented by previous workers, whose very numerous records have necessitated a system of abbreviations (Table 1); records without any such abbreviation are my own, and are usually placed last in the account of each species.

Records by the *Pommerania* (My, Mz) and the *Huxley* (Wa) are in Tables 2 and 3 respectively; my own offshore records (station list in Hamond, 1969a) are too numerous for convenient tabulation, but where necessary individual offshore station are quoted under the species concerned. The entire record of any species not seen here by me is placed in square brackets; where more than one record refers to the same material (e.g. *Loripes lucinalis*) the abbreviation of the original finder is placed first, and is followed in parentheses by the abbreviations of the workers who quoted the original find without making fresh finds of their own. An abbreviation without a synonym (e.g. Sy and Gi in the case of *Lepidochiton cinereus*) means that the worker in question used the name adopted in the present paper.

Some authors state when or where they made their collections. Norman (J1, J2), Munford (Mu), and Greene & Babington (GB), all collected near Hunstanton; Patterson collected molluscs sporadically from April 1899 onwards, and Beckett and Harmer for some years before that, all at or near Great Yarmouth (AHP, P1–P6, BP, and HP; however, Hr refers to records made along the Norfolk coast at unspecified points). Mayfield (M1) states that his records were "made in the spring of 1893, when I was residing at Great Yarmouth, and in July 1890 while making a holiday-tour along the coast from Yarmouth to Hunstanton"; for many years after this he and C. G. Doughty (a Suffolk naturalist who died in 1939, see Mo) continued to collect from Yarmouth to Felixstowe (unpublished undated material, now in the Ipswich Museum). At Scolt Head, collections were made during a few days in December 1931 and January 1932 and during a fortnight in June and July 1932 (Sy), during 1932 and 1933 (E2), on 1.6.1938 (Gi; later discarded, *fide* Dr. F. S. J. Hollick), and in August 1959 (Pa). An isolated habitat of great interest is the Salts Hole at Holkham (Hunt, 1971). Except where otherwise stated, my own records are intertidally from Cromer to Hunstanton and offshore within the Blakeney–Wells area (Hamond, 1969a, fig. 1); apart from the nudibranchs I cannot claim to have

searched for molluscs on purpose, but I have recorded all specimens of all species seen by me between 1949 and 1967, and have preserved examples of all my species (except *Philine punctata*, q.v.) in my own collection.

Of collections made by previous authors, I have been able to examine the single *Callochiton achatinus*, a selection of the shells collected by Mayfield and Doughty (see above), and various species from Scolt Head (Pa; now in the Department of Zoology, Downing Street, Cambridge; for Gi see above). The specimens dredged by the *Porcupine* in Lynn Well, the deepest part of the Wash (J8), are now with the rest of the Jeffreys collection in the United States National Museum (*fide* Dr. J. Rosewater), and all Patterson's specimens were destroyed when the Tollhouse Museum in Yarmouth was bombed in 1940 (see Hamond, 1971). The collections made by other workers cannot be traced at present, and probably no longer exist.

Synonyms present no serious difficulty, but have been freely quoted in order to avoid confusion. The names used by Munford were considered obsolete even by Harmer, who (as did Greene & Babington, Beckett, Mayfield, and Patterson) followed the nomenclature of Jeffreys (1863–69). Ellis and Serventy followed a mixture of Winckworth (1932) and the *Plymouth Marine Fauna* (1931), whereas Gilson and his colleagues followed the latter exclusively; Pantin and his group followed the *Plymouth Marine Fauna* (1957) as far as possible, while Morley (1938) used a mixed nomenclature not consistently derived from any one source. For the present paper the nomenclatural sources are:

Bivalvia:	
Nucula to *Palliolum* inclusive	Bowden & Heppell (1966)
Other species	Tebble (1966)
Gastropoda:	
Prosobranchiata	Fretter & Graham (1962)
Nudibranchiata	Miller (1961)
Other groups	Winckworth (1932, 1951)
Solenogastres and Polyplacophora	Winckworth (1932, 1951)
Cephalopoda	Jaeckel (1958)

My own identifications were made from the following:

Nudibranchiata (always alive or freshly dead)	Alder & Hancock (1845–1855)
Cephalopoda (always alive or freshly dead)	Jaeckel (1958)
Bivalvia	Tebble (1966), Jensen & Sparck (1934), Ziegelmeier (1957)
Other groups, and some of the above	Forbes & Hanley (1848–53)

The species are listed in the order of the Plymouth Marine Fauna (1957), except for the Prosobranchiata (as in appendix 1 of Fretter & Graham, 1962). For the placing of the pyramidellids with the opisthobranchs, see p. 12.

SOLENGASTRES

1. [*Chaetoderma nitidulum* (Loven). Table 2 (Mb, as *Chrystallophrisson nitens*, n.g., n.sp.). This is the only solenogastre to be found in shallow water around the British Isles (cf. Hyman, 1967, p. 66), the other North-European species all being confined to deeper water (von Salvini-Plawen, 1970, p. 14). Strictly speaking, this species was caught just outside our area, but so many of the other molluscs taken with it are found nearer the Norfolk coast that its inclusion seems justifiable.]

2. *Lepidopleurus asellus* (Gmelin). Wells, Sheringham, and Cromer (M1); Yarmouth, "scarce near harbour mouth" (BP); possibly this species, offshore (Table 2); all as *Chiton cinereus*. Occasionally RL, WR, and D.

3. *Lepidochiton cinereus* (L.). Hunstanton (Mu); Sheringham and Cromer (M1); both as *Chiton marginatus*. Scolt Head (Sy, Gi). Very common RL, moderately so on the Strond of Blakeney Harbour and the Freshes Lays there; occasional D.

4. *Callochiton achatinus* (Brown). One specimen, RL, now in NCM (R, as *Chiton laevis*). *Acanthochiton crinitus* (Pennant). One at W.23.

GASTROPODA

Prosobranchiata

6. *Patella vulgata* (L.). Hunstanton (Mu); not common (Hr); Scolt Head (E2); Gorleston (Gr2, M2; on the breakwater there, BP). Regularly in small numbers, RL and higher up the shore at West Runton; a few near the Strond Pool.

7. [*Patina pellucida* (L.). At high-water mark, X (Wells, M1; Yarmouth, BP; both as *Helcion*).]

8. *Acmaea virginea* (O. F. Müller). Not common (Hr); rare at Yarmouth, X (BP); both as *Tectura*. Three living and three dead, singly at various times, all RL; two live ones at Q.2. This species thus appears to be restricted to the rocky strip along the coast of north-east Norfolk, mainly below low-water mark.

9. [*Monodonta lineata* (L.). In the British Isles this species is confined to the south-west; the unconfirmed record from Norfolk (J5, as *Trochus*) is almost certainly erroneous.]

10. [*Margarites helicinus* (Fabricius). Norfolk (BH).]

11. *Gibbula cineraria* (L.). The only really common Norfolk trochid, being frequent both intertidally (Hr, Mu, both as *Trochus;* E2) and offshore (Table 2, RV, and P4, all as *Trochus;* H3). RL, common from early July to late October, rare there at other times; a few now and then in the Strond Pool and in the Dam.

12. *Gibbula magus* (L.). Hunstanton (Mu); Wells and Heacham, X (M1, M12); all as *Trochus*. The single specimen of the var. *conica* Marshall, sent from Heacham by Mayfield to Marshall's own collection at Torquay, was the only east coast record of this species known to Marshall, although *G. magus* is common in the west of England. One large dead shell, X, near Wells Lifeboat House on 29.3.1956, of the normal form of this species.

13. [*Gibbula tumida* (Montagu). Both local records (Table 2, J8, both as *Trochus*) are from offshore.]

14. [*Gibbula umbilicalis* (da Costa). Yarmouth, Cromer, Wells, and Hunstanton (M1); dredged on stony gravel, a mile out to sea off Hut Hills on Scolt Head (Pa); both this and *G. cineraria* common on the Suffolk coast (Mayfield, see Mo). However, Mayfield's material in the Ipswich Museum did not contain any East Anglian examples of this species, and I have not been able to see those from off Scolt Head; I suspect that these records in fact refer to a form of *G. cineraria* which is not uncommon here, which has rather coarser markings than in the usual form but which intergrades completely with it, and which might be mistaken for *G. umbilicalis* by anyone who had not seen (as I have) genuine *G. umbilicalis* from the west coasts of the British Isles, and had merely referred to the published descriptions and figures.]

15. [*Cantharidus striatus* (L.). Wells, X (M1, as *Trochus*).]

16. *Calliostoma zizyphinum* (Lamarck). Common (Hr, Mu); in Yarmouth shrimp-trawls (P3, P4) and further offshore (Table 2, RV); all as *Trochus*. Scolt Head (E2). Intertidally, I have seen from 90 to 100 specimens all told on ten different occasions at RL (about 20 at once on 29.8.1961, on 24.9.1961, and on 14.10.1962, and a dozen on 10.9.1961, but otherwise not more than four or five specimens on any one day; the *Calliostoma* occurred singly or in twos and threes under large rocks), as well as one from East Runton (11 or 12.7.1959, JF), and six very tiny ones (all about 2 mm. high) on the colonies of *Cryptosula pallasiana* which covered the inner surface of about one per cent of the dead *Modiolus*-shells at ELWST on Hunstanton Scaup, 31.7.1961. Offshore, *Calliostoma* is sometimes common in D and W, on grounds supporting a varied invertebrate fauna.

17. *Lacuna crassior* (Montagu). Hunstanton (Norman in J1 and J2); common (Hr). My only record is of three living specimens at S.4.

18. [*Lacuna pallidula* (da Costa). Yarmouth, X, few (M1, BP).]

19. *Lacuna parva* (da Costa). Five dead shells and one small live one at D.23.

20. *Lacuna vincta* (Montagu). Not common (Hr); at Yarmouth, X, few (BP, M1 [P3, P4]); Gorleston, X (M2); all as *L. divaricata*. One of Mayfield's Yarmouth specimens was of the "var. *gracilior* Metc." (M1). Rare in D (the var. *gracilior* not distinguished).

21. [*Lacuna vestita* (Duncker & Metzger) (in Mz, as n.sp.; the only mollusc at P.109, see Table 2). A doubtful species, possibly a synonym of *L. crassior;* not mentioned by Ankel (1936), nor by Fretter & Graham (1962).]

22. *Littorina littoralis* (L.). Not common (Hr); near the harbour mouth at Yarmouth (BP, HP); all as *L. obtusata*. Scolt Head (Sy, Gi, Pa). Fairly common high up the shore at East Runton (JF) and more so at West Runton, both under rocks and on the *Fucus* covering them; in small numbers on the Strond, and one specimen was taken at the Sheepbridge (the eastern end of Morston Quay) on 7.10.1964 among *Chondrus*.

23. *Littorina littorea* (L.). Very common along the entire Norfolk coast on all sorts of substrates apart from wave-beaten clean sand (most authors); especially plentiful in Breydon (P3, P4), at West Runton, and all over the western half of Blakeney Harbour, in which the eggs and larvae are abundant in plankton from March to September.

24. [*Littorina neritoides* (L.). On Breydon seawalls, either rare (M1, M2, Gr2) or "common under the bladderwrack" i.e. *Fucus* sp. (BP). Until further specimens are found on the Norfolk coast these records must be viewed with caution, since *L. neritoides* is supposed to be virtually absent on British shores between Yorkshire and the Isle of Wight (Crisp & Southward, 1958; Newell & Newell, 1966), although on the French side of the Channel it occurs as far east as Calais, and a small population has become established in Holland (Stock, 1950).]

25. *Littorina saxatilis* (Olivi). Not common (Hr); rare on Breydon (P3, P4, who also found a few offshore, perhaps carried there by pagurids); Gr2, Gi; all as *L. rudis*. Scolt Head (EO, Sy, Pa). I have found it in numbers only at or above HWNT on the rocky shore from Sheringham to Cromer (including both East and West Runton), apart from the variably coloured population in the Salts Hole at Holkham (Hunt, 1971; own observations); careful search might reveal a wider distribution. No attempt has been made to distinguish locally the varieties or subspecies described by James (1968).

26. *Hydrobia ulvae* (Pennant). Common (Hr, GB, both as *Rissoa*); enormously abundant on *Zostera*-covered mudflats and in saltmarshes (P3, P4, Sy, Gi, Pa, H3), and very often taken in the plankton (see Newell, 1962) in the Pit of Blakeney Harbour and in Morston Creek. All over the flat middle part of the shore at Holkham, a fairly dense population was seen on sandy mud on 16.9.1962; it is also common in the Salts Hole (Hunt, 1971; own observation).

The Blakeney Harvour "*ulvae*" do not quite fit into any of the species as defined by Muus (1963), since they have an almost completely black head and muzzle on which the pattern has become quite obscure, a small penis set very far back and having a noticeably elongate and acuminate tip (basically as in Muus's *ulvae* but approaching that of his *ventrosa*), and tentacular markings and shell characters as in his *ulvae*. There is also a very pale-coloured population in the culvert by the gate at the northern end of Lady Anne's Road, Holkham, which is still more difficult to reconcile with any one of Muus's species.

27. *Hydrobia ventrosa* (Montagu). Gr2, as *Paludestrina;* M1, BP, Pa; found at Scolt Head (Pa), and common on Breydon (all authors who have collected there). My own record of this species is somewhat unusual, consisting of 24 full-grown, and 22 smaller, dead shells at D.23.

28. *Hydrobia jenkinsi* (Smith). Scolt Head area (Pa, as *Potamopyrgus*). 36, mostly adult, among *Cordylophora* on waterlogged wood from Haddiscoe Cut, 18.5.1966.

29. [*Pseudamnicola confusa* (Frauenfeld). Lower Yare and Waveney (EAE); for description and habitat, see Macan (1960).]

30. *Cingula proxima* (Forbes & Hanley). In stomachs of grey mullet from the Norfolk coast, now in NCM (M13, as *Rissoa*); dead shells occasionally in D.

31. *Cingula semicostata* (Montagu). Lynn Well (J8, as *Rissoa striata*); one dead shell at D.22 and another at D.23.

32. *Cingula semistriata* (Montagu). Lynn Well (JB, as *Rissoa*); one dead shell at D.22.

33. *Cingula vitrea* (Montagu). With *C. proxima*, q.v. (M13, as *Rissoa*); one dead shell at D.23.

34. *Rissoa inconspicua* (Alder). Near Yarmouth, "rare on seaweed" (BP); 22 living specimens of the var. *parva* at D.23.

35. *Rissoa membranacea* (J. Adams), var. *grossa* (Michaud). Lynn Well (J8, as *R. membranacea*); rare in D, and then only as dead shells.

36. *Rissoa parva* (da Costa):

var. *parva;* Yarmouth, X, few (M1, BP); off North Norfolk, D, living or dead, but never numerous.

var. *interrupta;* not common (Hr), but plentiful at Yarmouth (BP); in large numbers among *Corallina* at West Runton, and (less numerous) among *Laurencia* in the Strond Pool, among *Plumaria* at Q.2, among hydroids at ELWST on Hunstanton Scaup, and at a few stations offshore.

37. *Rissoa sarsi* (Loven). Twenty-one of the normal variety, and two with widely spaced ribs confined to the body-whorl, living among the hydroids *Sarsia eximia* and *Eudendrium rameum* inside the *Hjordis* on 1.8.1962; otherwise only offshore, where it may sometimes be abundant, living or dead.

38. *Assiminea grayana* (Fleming). King's Lynn, Scolt Head, Stiffkey Freshes, Yarmouth, and St. Olaves (all E1); for ecology see E2. Dr. Ellis also verified my own determination of a single dead shell from Stiffkey Freshes in August 1959.

39. *Skeneopsis planorbis* (Fabricius). The finding in reduced salinities (Breydon; M1, as *Skenea*) of this otherwise purely marine species is somewhat unexpected; Mayfield does not say from what part of Breydon his specimens came (at the seaward end the salinity may at times be fully marine), nor whether they were alive when found. Occasional, D (dead shells only); about twelve, probably of this species, were found among *Corallina* at West Runton on 6.4.1959.

40. *Turritella communis* (Risso). One adult shell at W.12; this may have contained a hermit-crab, but was empty when found.

41. [*Bittium reticulatum* (da Costa). Wells, X (M1, M2); Yarmouth, rare near the harbour mouth (BP [M2]); both as *Cerithium.*]

42. [*Aporrhais pes-pelecani* (L.). Hunstanton (Mu, as *Strombus*); one water-worn shell at Wells, X (M1). In spite of its distinctive appearance, there are no other records from within the Norfolk area. The larvae ascribed by me (Hamond, 1961) to this species are now known to belong to *Lamellaria perspicua* (q.v.).]

43. *Velutina velutina* (O. F. Müller). Lynn Well (J8); Table 2; both as *V. laevigata.* A single living adult was taken at D.44, but the larvae have not been found here. Diehl (1956) finds that it eats tunicates, usually *Styela coriacea* but possibly also *Dendrodoa grossularia* and *Phallusia virginea;* the first two both occur here, but at D.44 the only tunicate was *Ciona intestinalis,* of which numerous rather small ones were found inside old shells of *Modiolus.*

44. *Lamellaria perspicua* (L.). In 7 fathoms near the Dudgeon (i.e. about 20 miles north of Wells) (FH); one at D.18. Intertidally, RL with sponges and tunicates (three on 28.9.1951, six on 10.4.1952, two on 4.9.1952, and three on 4.10.1952), and inside the *Hjordis* (one on *Didemnum candidum,* on which it may have been feeding, 13.10.1961). In the echinospira-larvae (Pit plankton, July to September, 1957, 1958, and 1959) the six-lobed shape of the velum was so like that of *Aporrhais* (see Thorson, 1946, figs. 128A and B) that the resulting misidentification (Hamond, 1961) was corrected only on examining the larval shells (Fretter & Graham, 1962, fig. 246A and p. 468). The Pit larvae had, on the tip of each velar lobe, an almost circular patch of pigment, bluish-black by transmitted light but bright lemon yellow by reflected light on a dark ground; in this respect they once again resembled the published descriptions of *Aporrhais* rather than of *Lamellaria.*

45. *Trivia arctica* (Montagu). Common (Hr, GB); Table 2; all as *Cypraea europaea;* Scolt Head (E2, as *T. monacha*). Soon after Ellis's specimens had been collected and named, Lebour (1933) found that the presence (*T. monacha*) or absence (*T. arctica*) of dark spots on the shell was correlated with differences in the genitalia, apparently at the level of species, whereas previously they had been considered merely as varieties of *T. monacha.* As far as I know, all the Norfolk material is of *T. arctica,* which is frequent in small numbers, D and W, mainly during the spring and summer (cf. H3).

46. [*Crepidula fornicata* (L.). Gorleston, X, occasionally (EAE); an important pest of oysters on the coasts of Suffolk and Essex.]

47. *Natica alderi* (Forbes). Scolt Head, X (E2, as *N. poliana alderi*); common (Hr, P2, P4, Table 2); either living or with a pagurid it is not infrequent offshore, where two small living specimens were found in bottom plankton near the Blakeney Overfalls Buoy during 1965 (one on 12.7. and the other on 15.8). A complete coil of *Natica*-spawn and fragments of another coil were taken at D.39;

from their relatively small size (outer diameter of coil 22 mm., inner diameter 8 mm.), and from the fact that this is the only species of the genus found living in North Norfolk waters, it seems justifiable to refer these coils to *N. alderi*.

48. *Natica catena* (da Costa). Common (Hr); Scolt Head, X (E2); offshore in small numbers, D or S (Table 2, P3, P4, H1); two with pagurids, one on the Freshes Lays on 28.3.1959 and the other in a whelkpot at 53°03′30″ N. 00°59′ E. on 13.3.1961. I have not found it often, and never alive.

49. [*Natica fusca* (Blainville). Gorleston, X (Mo; in Ipswich Museum).]

50. *Clathrus clathrus* (L.). Hunstanton (Mu, as *Turbo*); not common (Hr); one at Yarmouth, S, 4.7.1904 (P4); both as *Scalaria communis;* Table 2, as *S. clathrus*. Other records:

(1) An empty shell, X, Burnham Overy Staithe, June or July 1961 (SMH).

(2) An empty shell (probably deserted by a pagurid), S, 52°54′ N. 00°23′30″ E., first week of January 1962 (MC); now in my own collection.

(3) Two shells with pagurids, W, about 1 mile south or south-west of the South-east Docking Buoy, no date, sent by Mr. F. Long to the Norfolk and Norwich Naturalists' Society, at whose next meeting they were exhibited (*Eastern Daily Press*, 26.9.1907); present whereabouts unknown; caught by Mr. Cox (father of WC).

(4) A living specimen, W, from almost exactly the same place as No. 3, late January 1953 (WC), later accidentally destroyed.

(5) A shell with a pagurid, W, place as for Nos. 3 and 4, February or March 1953 (WC), now in my own collection.

Records (3), (4), and (5) are all apparently in what the Wells fishermen call the "Muddy Hole", in which I have dredged (D.55 and D.57; Hamond, 1969) without finding this species, or any other that could be considered to prefer this kind of substrate. Since (4) was alive, perhaps a small isolated population of *C. clathrus* lives in this hole (actually a shallow depression of about one square kilometre or less), from which dead shells are carried around in all directions by pagurids.

51. [*Eulima trifasciata* (J. Adams). Lynn Well (J8, as *E. bilineata*).]

52. *Trophon truncatus* (Strom). J8 and Table 2, but no records from the Yarmouth area or further south; uncommon offshore in North Norfolk, mainly W. Also, Mistakidis (1957) specifically notes it (as *Trochus* [*sic*]) from the Wash but not from the coasts of Suffolk or Essex; the North Norfolk coast is therefore probably its southern limit on the east coast.

53. *Nucella lapillus* (Röding). Common (Hr, P3, P4, Gr2, GB; all as *Purpura*). At West Runton this species is common throughout the year; large numbers (from 30 to 100 at a time) have been seen there under rocks with freshly laid spawn from January to May, and in close proximity to apparently dead capsules in September and October. On 9.3.1961 it was noticed that the *Nucella* apparently fell into two groups, one comprising the larger specimens (with smooth shells, usually dull green but sometimes wholly or partly orange) which were thickly congregated under rocks with the spawn, and the other group consisting of half-sized specimens (mostly pure white and with more or less pronounced shell-sculpture) which occurred singly under rocks and only very seldom together with members of the first group; it was as if the small white specimens kept away from the others, which may have been the spawning females.

Apart from West Runton a few, all rather large, have been found alive on Hunstanton Scaup and one or two at East Runton (JF, 11 and 12.7.1959), while dead shells are sometimes found offshore. It is frequent in Breydon, and occasional in the Yarmouth shrimptrawls (P3, P4, including unpublished records by S. F. Harmer of the var. *imbricata* from near Yarmouth; I have not attempted to distinguish this variety).

54. *Ocenebra erinacea* (L.). From the Wold and the Dudgeon, but not further north (FH); common (Hr); Hunstanton (GB); frequent off Yarmouth, S (P3, P4; cf. J6); Table 2; all as *Murex*. Scolt Head (E2), and in whelkpots offshore (H3), in which (and in dredgings) living examples are sometimes common from May to August.

55. *Colus gracilis* (da Costa). Common (Hr, Gr1, GB, all as *Fusus*); forms less than one per cent of the catch in the whelkpots (H3; see *Buccinum*, below), and rare in D; most of the ones I have seen were alive, but I have never heard of a sinistral (left-handed) specimen here.

56. [*Colus howsei* (Marshall). Gr1 (as *Fusus propinquus*). Along with numerous *Neptunea* and a few *Buccinum*, cast out of the nets which fishermen were cleaning on the beach at Sheringham in the summer of 1898, Greene noticed a few *Colus gracilis* and also some of a small species which he thought was probably this. I have never been able to identify any species of *Colus* here, other than *gracilis*, but the members of this genus are not easy to identify except by an expert; this record needs confirmation.]

57. *Buccinum undatum* (L.). Common (almost all authors). This is so abundant off North Norfolk as to support a small fishery based on Wells-next-the-Sea, the whelks being caught in pots baited with stale salted fish (see also Hamond, 1961, 1963a, and 1969a); a similar fishery formerly carried on from Sheringham (P4) has now been almost entirely supplanted by the celebrated fishery for crabs and lobsters (see Hamond, 1971). The whelk fishery is carried on throughout the year except from later December to early April (or sometimes March), during which period the whelks are supposed by the fishermen to be numbed by the cold and to burrow just under the surface of the sea-floor in order to undergo a sort of hibernation; the catch (totalling between one and two thousand million whelks every year) is sent by road to the markets from Wells, either raw or (most often) after being boiled in whelkhouses close to the quayside.

Abnormal whelks are fairly rare; about 20 or 30 sinistral *Buccinum* are landed at Wells in an average year (some years as many as 50, or as few as 5 or 10), but I have never heard of abnormal opercula there, and of only three specimens of the var. *acuminatum* (locally called "Queen Whelk") in at least ten years previous to 1967. Of these only one was caught alive, the other two having hermit-crabs. Full breeding season here unknown, but young hatched from capsules in June.

58. *Neptunea antiqua* (L.). Rare off Yarmouth, S (P3, P4); common (Hr, Gr1, GB); all as *Fusus*. Scolt Head, X (E2); spawn, S, early in July 1961 off Yarmouth (RR). More numerous in whelkpots than *Colus*, but less so than *Buccinum*, comprising from 0.1 to 10 per cent of the total whelks brought ashore at Wells; rare in D. At Wells, *Buccinum* is called the "Whelk", *Neptunea* the "Almond Whelk" (because its smooth brown outer shell-surface reminds one of almond paste), and *Colus* is the "Bullet" (because of its long and pointed shell). The

only sinistral *Neptunea* that I ever heard of locally was taken in the middle of Blakeney Deeps, W, about the middle of November 1967 (EJ). For the biology, including some excellent photographs, see Pearce & Thorson (1967).

59. *Nassarius incrassatus* (Strom). Not common (Hr); off Yarmouth, D (HP); both as *Nassa*. In my experience it is more common than *N. reticulatus*, being found occasionally offshore, D, and usually alive.

60. *Nassarius reticulatus* (L.). Common (Hr); Hunstanton (GB); rare near Yarmouth (BP); all as *Nassa*. Scolt Head, X (E2); fairly scarce in my experience, and then only as dead shells. It is doubtful whether "*Nassa nitida*" is a genuinely distinct species (see Collyer, 1961). Some Norfolk workers distinguished it (Hr, BP), but the Suffolk list (Mo) treats it as a variety of *reticulatus*, and I have not been able to separate it.

61. *Lora rufa* (Montagu). Common (Hr); off Yarmouth, D (HP); Table 2; all as *Pleurotoma*. Dredged in 40 fathoms (?) in Lynn Well by the *Porcupine* (M11, as *P. rufa* var. *ecostata* (Marshall), but unaccountably omitted by J8). My only record is of a single shell with a pagurid in the entrance to the Wash (not far from Lynn Well), 53°00′ N. 00°28′ E., S, 17.7.1962 (MC).

62. *Lora turricula* (Montagu). Common (Hr); Yarmouth, S (and ? X), rare (BP, P3, P4); Table 2; all as *Pleurotoma*. Dead shells (usually with pagurids) may be dredged anywhere in the BW area (Hamond, 1969a), but the few living specimens have almost all been found just to the north and east (within a kilometre or two) of the Blakeney Overfalls Buoy, on grounds with plenty of other invertebrates.

63. *Philbertia linearis* (Montagu). One dead shell at D.23.

Opisthobranchiata

Fretter & Graham (1949) revived and strengthened the concept that the Pyramidellidae, if not actually opisthobranchs, are very closely related to them; their monograph (1962) includes the Aclididae in the Aglossa (=Pyramidellacea) among the Prosobranchiata, but curiously enough the pyramidellids themselves are excluded from this arrangement, and hence implicitly from the Pyramidellacea! In the following section the Pyramidellacea and Bullomorpha are treated as separate, purely for convenience.

Pyramidellacea

64. [*Graphis albida* (Adams) (M14, as *Cioniscus unicus*).]

65. *Aclis ascaris* (Turton) (M14).

66. *Aclis minor* (Brown) (M14, as *A. supranitida*).

The above three species were all found together at Skegness by Marshall, whose identifications appear to have been very reliable on the whole; they are the only Aclididae as yet found in the Norfolk area, in which none of them has been found since then. They were most likely cast ashore as dead shells, but Marshall gives no details whatever.]

Family Pyramidellidae (Norfolk genera *Chrysallida*, *Odostomia* and *Menestho*). Fretter & Graham (1949) found that each species of pyramidellid was more or less closely associated with a "traditional" host, but this has been upset by Ankel & Christensen (1963) (see below). There are no data from the Norfolk area on the relationships of any pyramidellid to its host(s), which is surprising considering how abundant some of the latter are.

67. *Chrysallida obtusa* (Brown). Lynn Well (J8, as *Odostomia interstincta*). D only, rare; living specimens so far only at D.22. Traditional host unknown.

68. [*Chrysallida spiralis* (Montagu). Lynn Well (J8, as *Odostomia*). Traditional host at Plymouth is probably *Sabellaria alveolata* (*Plymouth Marine Fauna*, 1957, pp. 139, 302) which is unknown from Norfolk, although the closely related *S. spinulosa* is common there (see Hamond, 1966b).]

69. [*Menestho dolioliformis* (Jeffreys). Yarmouth, X, rare (BP); Sutton-on-Sea and Skegness, presumably X (M16); both as *Odostomia*. Traditional host unknown.]

70. [*Odostomia scalaris* (Macgillivray). Lynn Well (J8, as *O. rissoides*). The traditional host (the mussel, *Mytilus edulis;* see Pelseneer, 1914; Thorson, 1946) and two gastropod hosts (*Littorina saxatilis* and *Hydrobia ulvae;* see Ankel & Christensen, 1963) are all common here; two further hosts (*Lacuna vincta* and *Rissoa membranacea;* see Ankel & Christensen) are rare here. *O. scalaris* has not yet been noticed attacking these or any other hosts in Norfolk waters, for the following reasons:

(1) The early Norfolk workers were simply shell-collectors, who rarely bothered to make other than casual observations on living molluscs;

(2) *O. scalaris* appears to be rare here (this is the only record in our area); and

(3) according to Marshall (M15), it is most capricious as to whether it affects mussels in any given habitat; he found that they preferred mussels no larger than about half adult size, generally about mid-tide level, and living if possible matted together. Once such a mat of mussels is torn open "the *O. rissoides* may be seen absolutely swarming underneath in a thin stratum of mud, very often themselves anchored or entangled in the byssi". (M15).

There is also the possibility that, when the mussels which have grown in the wild state (out on the "Scaups" or "Scalps" on the sandbanks in the middle of the Wash) are collected, washed, transported for a day or two by boat without the chance to open their shells, and are finally relaid in a somewhat lower average salinity on the Freshes Lays, any *Odostomia* initially present may drop off at some stage (cf. *Pinnotheres pisum*, in Hamond, 1971). I have not yet had a chance to take samples on the Scaups themselves.]

71. *Odostomia unidentata* (Montagu). Wells, X (M1); Yarmouth, X, rare (BP); offshore, rare but usually alive when found. The only intertidal Norfolk record is of a broken shell in a holdfast of *Laminaria saccharina* in the Run (next to the Freshes Lays) on 9.5.1963. The traditional host is *Pomatoceros triqueter* at Plymouth, but there is no relationship between their sumiltaneous distributions in Norfolk waters (Table 4), let alone the abundant Norfolk records (Hamond, 1966b) of *P. triqueter* without *O. unidentata.*

Bullomorpha

72. [*Diaphana minuta* (Brown). Lynn Well (J8, as *Utriculus hyalinus*).]

73. *Retusa alba* (Kanmacher). Not common (Hr); Yarmouth, not common, X (BP); in "muddy estuaries (such as those of the . . . Wash, Humber . . .) and in brackish water on many other parts of our coast" (J7); all as *Utriculus obtusus*. Off North Norfolk, D, occasional.

74. *Retusa retusa* (Maton & Rackett). Rare off North Norfolk, D; the only live specimens have been one at D.23, and one in a plankton net that accidentally touched gritty sand at 53°01′ N. 00°58′30″ E. on 13.9.1962. The latter specimen

was seen to progress in jerks, the foot being extended forward to its full length and then anchored while the shell was pulled up to it; each "step" was about 2 mm. (or about a third the length of the foot), and the animal ploughed its way at between 20 and 30 steps a minute through a sprinkling of sand on the floor of a glass dish.

75. *Retusa obtusa* (Montagu). In the Cockle Bight at Scolt Head (Gi, as *Cyclichna*), between HWST and HWNT on a wide area of thin mud, overlying firm sandy mud and covered with *Zostera nana* (Roth.), very much as in North Germany, where it is stated (Hagmeier & Kandler, 1927, p. 16, as *R. truncatula;* Linke, 1939, p. 211, as *Utriculus truncatulus*) to prey on *Hydrobia ulvae*. However, on similar grounds in various parts of Blakeney Harbour (Morston Strond, and north of Blakeney Cut), among myriads of *H. ulvae*, I have never seen any *Retusa* at all; I have found *R. obtusa* only in Abraham's Bosom (the brackish boating lake at Wells) in September 1966 (one on the 15th among matted filamentous green algae on the floor of the outlet stream, and two more on the 20th among dead *Ruppia* leaves floating loose at the north end of the lake).

76. *Philine punctata* (Adams)? A very small gastropod from D.52 (about 2 mm. long) was accidentally lost soon after being first seen, but was so like fig. 2 of Horikoshi (1967) that I feel sure it was this species; I cannot remember whether the rear end was smooth or frilled, but the trapezoidal head-shield and its relation to the lateral lobes agreed perfectly. The soft parts were yellowish-pink, but so thickly covered with dark epidermal spots that the animal appeared almost black; the shell, which was completely covered by flesh, showed through as pale brown, but nothing was noticed about its form or sculpturing.

Pteropoda

77. *Clione limacina* (Phipps). Morston Creek plankton at HW, April 1954; two on the 7th and two more on the 19th (see also H2). In the Norfolk area this species is an indicator of a vigorous influx of north-western North Sea water (Newell & Newell, 1966, p. 133; Hamond, 1969a).

Aplysiomorpha

78. *Aplysia punctata* (Cuvier). Of the two Norfolk specimens the first, "a red gasteropod the size of a small walnut" (AHP), collected at Cromer on 11.10.1904 by the Revd. H. C. Fitch, was submitted via Patterson to Mr. (later Professor) W. Garstang for identification; its fate is unknown, except that (AHP) Mr. Fitch did not want it back. The second specimen, about 10 cm. long, found dead on West Runton beach (KW & PP) on 13.2.1963, is now in my own collection.

These two finds, about three kilometres apart, are right in the middle of a substantial gap in the known British distribution as shown by Grigg (1949, fig. 1).

Sacoglossa

79. *Alderia modesta* (Loven). In the little creek, opening on the north side of the Pit east of Pinchen's Creek, and draining the muddy area in the south-west corner of the North Side to the east of the Long Hills (see Bird & Wain, 1963, fig. 1), creeping in numbers among *Cladophora* which bore many diatoms (E1; own obs.). Occasionally among green algae, both in other parts of the Harbour (mostly round the Pit) and in Harbour plankton.

80. *Limapontia depressa* (Alder & Hancock). Common at Scolt Head (Pa, as *L. capitata*), and in the little creek with *Alderia* but much more abundant (E1);

sometimes numerous in the *Salicornia*-marsh on Blakeney Point and in Pit plankton (among algae, mostly from December to May, and especially in April); the two latest I have seen (3.7.1965) were among stones with *Pomatoceros* in the Strond Pool. A specimen from Plover Marsh on Scolt Head (Pa) is clearly this species and not *capitata;* this agrees with Gascoigne (1952) and Miller (1961), both of whom find that *L. depressa* and *Alderia modesta* live in salt-marshes whereas *L. capitata* and *Actaeonia senestra* prefer rocky shores. The latter pair have not been found in Norfolk waters, even when specially looked for in the only locality (West Runton and nearby) where they would be most likely to occur.

Nudibranchiata

Most of the species found by Walton (1908) are clearly synonymous with those recorded in the Norfolk area by me, but some of the species present nomenclatural difficulties, as follows:

Species	Walton	Swennen (1961)	Present paper
Coryphella verrucosa (=*C. rufibranchialis* s.str.)	(1)		x
C. lineata	(1)		x
C. pedata (=*C. landsburghi*)	(1)		x
C. pellucida	remainder		x
C. gracilis		x	x
Aeolidiella glauca	*A. glauca* (+*A. alderi*)	x	x
Lomanotus (spp. ?)	(*L. genei*) ..		*L. marmoratus*

The exact number of species in each of the above genera, even in British waters, has always been a subject for discussion. According to Tardy's excellent revision (1969) there are three British species of *Aeolidiella*, of which *glauca* is the only one we may expect in the southern North Sea; Walton's *alderi* was found outside our area, and is therefore in brackets in the above table, but I think that it was probably a colour form of *glauca*. The taxonomy of *Lomanotus* is so insecure that it is impossible to be certain whether *Walton* had the same species as that which has been found off east Norfolk (see below).

Finally, everyone who has seen *Coryphella* in North-European waters appears to have different opinions as to how many species there are. My own experience has been that any given individual corresponds pretty exactly to one or other of the coloured plates in Alder & Hancock; I agree with Walton that *C. pedata* is probably only a colour variety of *C. pellucida*, and that *C. lineata* is indistinguishable from them apart from the white line down the middle of the back, which may in any case be broken, partly missing, or generally indistinct. Walton had one *verrucosa* in our area (Table 3), one each of *lineata* and of *pedata* outside it, and all the rest of his material was of *pellucida*, both inside and outside our area; his records of *C. salmonacea* (Couthouy) were from outside Norfolk waters (where I have never found it), and neither he nor I have noticed the small species recently described from Danish waters, *C. parva* Hadfield (1963; I was unaware of this paper until after I had left England in April 1968).

Assuming for the purposes of this paper that there are only these six species of *Coryphella* (cf. Winckworth, 1932, 1951; *Plymouth Marine Fauna*, 1957; Miller, 1961), one species of *Aeolidiella*, and one of *Lomanotus*, in the North Sea, then Walton's list contains 29 species collected over the whole western North

Sea "from Cromer to St. Abb's Head more or less parallel to the coastline, and also a series [of stations] further to the north and extending around the eastern borders of the Dogger Bank" (Wa). Of the 29 species, only three (named by Walton as *Archidoris testudinaria*, *Coryphella salmonacea*, and *Idaliella aspersa*) have not been found in the BW area by me, nor in the entire Norfolk area by anyone else, and were taken by Walton only to the north of latitude 55°N.; "*Aeolidiella glauca*" and "*A. alderi*" were taken by him only between 55 and 54°N., and are probably both identical with *A. glauca* which is rare in the BW area; while of the 16 species, either taken by him in the Norfolk area (Table 3) or described by him as "generally distributed" (*Tritonia hombergi*, *T. plebeia*, *Dendronotus frondosus*, and *Acanthodoris pilosa*), all have been found here by me except for *Goniodoris castanea*, which may well turn up here in future as it has also been found in Suffolk. This clearly shows that the nudibranchs follow the same trend as other groups of marine organisms; the greatest number of species in the group is found north of the Tyne, and this number falls progressively as one goes southward, the minimum being most probably on the coasts of Essex or northern Kent. A large number of northern species appear to fade out at about 54°N., and any species capable of living south of this line will probably be able to endure the conditions in the BW area (see Hamond, 1969).

Assuming that, if a nudibranch is sitting on a living organism such as a hydroid or polyzoan it is probably feeding on it, my findings on the foods of various species in our area agree in general very closely with those of Walton, of Miller (1961), and of Swennen (1961); for Norfolk hydroids, see Hamond (1957, 1963b).

81. *Archidoris pseudoargus* (Rapp). Rare offshore (Table 2, as *Doris tuberculata*); occasionally at Scolt Head (Gi, as *A. britannica;* Pa). Offshore I have found only one, at D.5; otherwise twice inside the *Hjordis*, occasionally on Hunstanton Scaup and on the Freshes Lays, and most of all RL, although not common even there.

82. [*Thecacera pennigera* (Montagu). Of this rare species the present record (Me in Table 2, quoted by Swennen as "off Lowestoft") is probably the only one for the southern North Sea.]

83. [*Polycera quadrilineata* (O. F. Müller). Gorleston Breakwater, not common among the hydroid *Tubularia indivisa* (EAE, in Mo; however, Miller (1961) has shown that this species feeds on polyzoans).]

84. *Polycera dubia* (M. Sars). Two in a large tuft of the polyzoan *Eucratea loricata* at W.10, and one amongst hydroids (*Sertularia argentea*, *Tubularia indivisa*) at D.32.

85. *Polycera nothus* (Johnston). One among mixed hydroids inside the *Hjordis*, 17.9.1951; one on *S. argentea* with *E. loricata* at West Runton, X, 1.8.1954; one at D.18; two at D.20, on *Hyas coarctatus;* and 13 large specimens (which may have come together preparatory to spawning), WR, 22.3.1961.

86. *Acanthodoris pilosa* (Abildgaard). Table 2 (as *Doris*); fairly widespread offshore (Wa), but not common in my own dredgings. Rare, RL and Hunstanton Scaup, but fairly common in Blakeney Harbour from December to May; as late as August (1959 and 1963) specimens have been found there with spawn. Adults also occur with spawn in December, March, and April. The most usual colours of this species are deep inky mauve, blackish violet, pale brown, and pure

white; the last may be confused with *Onchidoris muricata*, from which it may at once be distinguished by the tubercles being long and conical, with their bases nearly in contact on all sides with one another.

87. *Acanthodoris subquadrata* (Alder & Hancock). Two specimens at D.23; one about 5 mm. long on a colony of *Alcyonidium* (either *A. gelatinosum* or *A. proliferans*), X, LW on south side of Pit, 26.1.1955.

88. *Adalaria proxima* (Alder & Hancock). D only, apparently rare but small and inconspicuous; very much like small *Onchidoris muricata*, but deep yellow instead of white and with an entirely different radula (Alder & Hancock, 1845–1855; Thompson, 1958).

89. *Onchidoris fusca* (O. F. Muller). At a few offshore stations, sometimes numerous (Wa, as *Lamellidoris bilamellata;* Table 3), but never in my own dredgings; hundreds with spawn on Gorleston Breakwater, January to February 1924 (EAE in Mo); common with spawn (April, May, June, and August) on the Freshes Lays; less often on Hunstanton Scaup, WR, RL, and on wreckage near the *Hjordis*. The biology is described by Potts (1970).

90. *Onchidoris muricata* (O. F. Müller). H3, as *O. aspera*. Rare in the Strond Pool, in the *Hjordis*, in bottom plankton near the Blakeney Overfalls Buoy, and at D.44; several records from ELWST on Hunstanton Scaup, and at RL. Animals found from August to December (one at RL in April); spawn (probably this species) RL in September.

Allegedly widespread in the North Sea (Swennen, 1961), but not in Jaeckel's list (1952). In November 1963 numerous small dorids were seen at ELWST, both on Hunstanton Scaup and at West Runton, of a deep yellow colour (as *A. proxima*) but with the tubercles distinctly flattened on top (as *O. muricata*); the results of examining several radulae were inconclusive.

91. *Goniodoris nodosa* (Montagu). Widely distributed both intertidally and offshore, never more than four together and most often singly. On three occasions small ones have been taken in plankton, once in the Pit but otherwise near the Blakeney Overfalls Buoy, always in August or September (although admittedly most of the plankton samples near the Buoy were taken during these two months, when the weather was most favourable). Most shore finds are from Blakeney Harbour and RL, but a few are from Hunstanton Scaup; it has habitat preferences similar to those of *Ancula*, but is much less common.

92. [*Goniodoris castanea* (Alder & Hancock). Once in the Norfolk area (Table 3), and once on the coast of Suffolk (Gr2); these records were apparently overlooked by Jaeckel (1952).]

93. *Ancula cristata* (Alder). One near Sheringham Shoal (Table 3); very small ones on river pilings near Gorleston lower ferry at LWST on 13.5.1933, feeding on *Laomedea geniculata* (EAE in Mo); widespread but not numerous intertidally, rare offshore, at any time of year but mostly from February to April; spawn in July, September, and December. It seems to prefer small feathery brown algae in a continuous flow of water (WR, RL, among *Corallina* at West Runton, and in the bed of Morston Creek).

94. *Tritonia hombergi* (Cuvier). Widespread offshore, especially with *Alcyonium* (Wa); always with *Alcyonium* off North Norfolk (offshore, inside the *Hjordis*, and just below ELWST on Hunstanton Scaup).

95. *Duvaucelia plebeia* (Johnston). Scolt Head (Pa); offshore with *T. hombergi* (Wa, as *Tritonia*); just north of the Norfolk area, at a station where *Alcyonium* was fairly common (Anon. 1909, pp. 152–3, as *Tritonia*). More numerous than *T. hombergi* inside the *Hjordis* and below the Scaup, although only taken thrice offshore (one at D.20 and one at D.52, both on *Alcyonium;* one loose at D.55, which had probably fallen off *Alcynoium*, which was also taken in this haul).

96. *Duvaucelia alba* (Alder & Hancock). Six in the *Hjordis*, 17.9.1951, on *Alcyonium* with *D. plebeia;* the single egg ribbon, found on the same colony of *Alcyonium* as some of each of these small tritoniids, might have belonged to either species.

97. [*Lomanotus marmoratus* (Alder & Hancock). Table 2 (Me).]

98. *Dendronotus frondosus* (Ascanius). Throughout the western North Sea (presumably including the Norfolk area) on *Tubularia* (Wa); Lynn Well (Anon. 1909, pp. 134–5, bottom); both as *D. arborescens*. Entirely offshore in places with abundant hydroids, not uncommon in some seasons; one, X, near the *Hjordis* among hydroids, 24.3.1955.

99. *Doto coronata* (Gmelin). Scolt Head (Gi, as *Idulia*); offshore, rare (Wa) or common (H1), frequently X, not uncommon in Blakeney Harbour. Strongly prefers hydroids (*S. argentea* (H1), *Sarsia tubulosa*, *Tubularia larynx*, *Eudendrium ramosum*, *Laomedea* spp., *Halecium* spp., *Diphasia rosacea* and *Dynamena pumila*); less common among branching polyzoa and tufts of small algae. Spawn in June, July, September, and October.

100. *Doto fragilis* (Forbes). Occasionally offshore among hydroids (Tables 2 & 3); one adult with three coils of spawn on a large *Nemertesia antennina* at W.26, and 3 adults without spawn on a colony of the same hydroid at D.54.

101. *Coryphella verrucosa* (M. Sars). Table 3 (Wa, as *C. rufibranchialis* in part): few, often, among *Tubularia indivisa* on Gorleston Breakwater (EAE, in Mo). One inside an old boiler near the *Hjordis*, ELWST, on *Eudendrium arbusculum*, 6.8.1956; one, possibly this species but very young, at W.19; one at W.3, and a small one at D.47.

102. *Coryphella gracilis* (Alder & Hancock). Occasionally offshore (Wa, as *C. rufibranchialis* in part). Inside the *Hjordis* on *E. arbusculum*, two on 28.7.1953 and several on 21.6.1955. Those seen on the latter date were all about 1 cm. long, and (it being ELWST on a perfectly calm day) some hung foot uppermost from the surface film while others crawled over the hydroids.

103. *Coryphella pellucida* (Alder & Hancock). Common from Northumberland to Norfolk, offshore (Wa, as *C. rufibranchialis* in part; Table 3); altogether 45 specimens in D near the Blakeney Overfalls Buoy, August to October 1965, of which the ten largest were each about 4 cm. long, exactly like Alder & Hancock's figures.

104. *Coryphella lineata* (Loven). "One specimen (12 mm.) found 20th December 1954 near Den Helder on a stranded buoy originating from North Hammonds Knoll; its normal place is 12 miles off the Norfolk coast at about 52°54′ N. and 1°54′ E". (Swennen, 1961, p. 210); Walton also found this species, but not inside the Norfolk area. Both my specimens were only about 1 cm. long; one, from D.6, had the *lineata*-stripe very clearly defined, while the other, from D.44, had a fragmented *lineata*-stripe apart from which it exactly resembled *C. pellucida*.

105. *Coryphella pedata* (Montagu). Scolt Head (Pa). Two little ones with a larger *C. pellucida* (of which they may only be the young, so close was the resemblance apart from the violet tint on the *pedata*) on *Alcyonium*, just below ELWST on Hunstanton Scaup, 1.11.1963; one on *Alcyonium* and three others on *Halecium halecinum*, same place, 9.9.1964; one, RL, 13.5.1964.

106. *Eubranchus tricolor* (Forbes). Offshore (Wa, as *Galvina*). Never above low-water mark here, but apparently common offshore in the BW area. Of my 48 specimens 25 were dredged (several times clinging to *N. antennina*), the other 23 (i.e. 48 per cent) being found in bottom plankton (some in Blakeney Deeps, but most near the Overfalls Buoy). The planktonic percentage is far in excess of that found by me for any other nudibranch; this may perhaps be because, whereas most species have a predation rate within the replacement rate of their food supply at that place, *E. tricolor* has an exceptionally heavy appetite (it is one of our largest nudibranchs) and, having eaten all the available food at a particular place for the time being, has no alternative but to seek fresh pastures by releasing its hold and drifting on the tidal current with the minimum expenditure of energy. This kind of wandering I propose to call *nomadism;* similar riding on the tide, for unknown reasons, has been recorded in Norfolk waters (Hamond, 1971) for *Cancer pagurus* and *Pandalus montagui*, and may be an alternative explanation for the finds by Miller (1961) of Manx nudibranchs (including *E. tricolor*) away from their usual food-organisms, which he ascribed to falling off the harbour buoy, or being dumped amid trawl-refuse, or being washed off their food by currents.

Only two other benthonic molluscs are also commonly found as adults in the Norfolk plankton; *Limapontia depressa* may perhaps be nomadic, but is most often carried up from the bottom on torn-off algae on which it had been feeding; *Hydrobia* feeds by a mucus net at the surface (Newell, 1962), and is therefore unlikely to be nomadic.

107. *Eubranchus pallidus* (Alder & Hancock). (H3). Easily confused with young *E. tricolor;* however, most Norfolk specimens are clearly one or the other. Typical *E. pallidus* are often found among algae and hydroids in Blakeney Harbour, less often at Hunstanton and West Runton, and seldom offshore. *E. pallidus* is also found in offshore plankton, but much less often than *E. tricolor.*

The colour is usually as in Alder & Hancock's plate, but with the brown speckles more separated so that the whole animal appears paler. Small specimens among *Laomedea* spp. are sometimes milky yellow, with green instead of brown markings, or with markings in both these colours. One, in bottom plankton near the Blakeney Overfalls Buoy on 18.7.1965, was pale greenish with chestnut spots, while a few from the same area at different times had both brown spots and pale yellow spots intermingled but widely separated, so that they closely resembled *E. tricolor.*

108. *Eubranchus exiguus* (Alder & Hancock). (H1, H3). Constantly on luxuriant growths of *Laomedea* spp., mostly offshore, from May to October; several specimens among *Fucus* in the lowest reach of Morston Creek, 9.12.1956. It seems to avoid *Laomedea flexuosa*, whose nematocysts appear to be much more powerful than those of other Norfolk species of *Laomedea* (cf. Hamond, 1969b, p. 443).

109. *Eubranchus cingulatus* (Alder & Hancock). (H1). One specimen in the Silver Pit, north of our area (Wa, as *Galvina*). Numerous adults with spawn among *Kirchenpaueria pinnata* on *Chorda filum* on the Reef, 30.9.1950; one on *Halecium beani*, X near the *Hjordis*, 25.9.1953.

110. *Eubranchus vittatus* (Alder & Hancock). Between 6 and 10 of this species among at least 20 *E. cingulatus*, 30.9.1950. Edmunds & Kress (1969) doubt whether these two species are in fact distinct, but prefer to keep them apart for the time being, and are followed here.

111. *Cuthona concinna* (Alder & Hancock). One very small one (colour and radula definitely this species), X, near the *Hjordis* among hydroids, 15.4.1957; one at D.23; and 30 tiny ones among *T. indivisa* and *S. argentea* at D.32.

112. *Cuthona nana* (Alder & Hancock). A few, always on *Hydractinia echinata* (Wa, who did not find it in our area). Three on *Tubularia larynx* on the channel marker buoy nearest the *Hjordis* on 10.9.1959; a small one inside the *Hjordis* among the tunicate *Sidnyum elegans*, 27.8.1961, and two there among *Sarsia eximia* on 15.10.1962; and one among *T. larynx* on a crabpot buoy, floating loose near the Blakeney Overfalls Buoy on 13.9.1965.

113. *Cuthona amoena* (Alder & Hancock). Scarce, on *S. argentea* (Table 3; Wa, as *Cratena*); one on *Diphasia rosacea*, X, Stiffkey Sands, 5.10.1961; thirteen specimens all told on *Halecium halecinum*, once offshore (D.44) and twice below ELWST on Hunstanton Scaup.

114. *Cuthona pustulata* (Alder & Hancock). One at W.5 among hydroids; one among *H. echinata* (on *Buccinum*, with *Pagurus bernhardus*) at W.18; four tiny ones in dredgings, two at D.55 and two at D.57. The only intertidal record is of one among sponges, tunicates, and polyzoa, inside the *Hjordis* on 27.8.1961.

115. *Trinchesia viridis* (Forbes). One on *H. halecinum* with *Sertularella polyzonias*, X, near the *Hjordis* on 6.3.1954; one on *H. halecinum* below ELWST on Hunstanton Scaup, 31.7.1961.

116. *Trinchesia aurantia* (Alder & Hancock). Lives entirely on gymnoblast hydroids (*Tubularia* spp., *Eudendrium* spp.; Table 3 (Wa, as *Amphorina*); H1, as *Cuthona*). Five or six among *T. indivisa* at D.48; six inside the *Hjordis* on 17.9. 1962, one inside *Guenowle* on 16.9.1951, and one there with spawn on 3.10.1952, all on *T. larynx*. On 28.3.1951 five were found among a large tuft of *Eudendrium arbusculum*, and spawn (? this species) was found on *T. indivisa*, cast up at Sheringham.

117. *Trinchesia foliata* (Forbes & Goodsir). Two among *Haliclona oculata*, growing below decks inside the *Hjordis*, 1.7.1965.

118. *Trinchesia glottensis* (Alder & Hancock). One among hydroids (mostly *S. argentea* and *Hydrallmania falcata*) between Weybourne and Salthouse, X, 11.2.1950.

119. *Embletonia pallida* (Alder & Hancock). In Morston Creek, near the mouth among *Laomedea* spp. (mostly *L. gelatinosa*, but some *L. loveni*) on which it probably feeds; two specimens in March, two in April, and one in June. With the latter specimen there was plentiful spawn which hatched ten days after collection. When growing luxuriantly, these hydroids support, besides *E. pallida*, a few pycnogonids and numerous syllid polychaetes (see Hamond, 1969b) without any visible signs of over-predation.

120. *Embletonia* sp. The single specimen, found creeping over a *Modiolus*-shell at D.44, was unfortunately later lost. Length ca.6 mm. (or about thrice that of *E. pallida*); very active, with a long narrow head in which the eyes were set far back; rhinophores small, erect and peg-like, cerata bluntly rounded. Close to

E. pulchra (Alder & Hancock), but body-colour pale greenish yellow, with sage-green cerata; it would be unsafe to name this specimen until more is known about the limits of variation in species of this genus.

121. *Tergipes despectus* (Johnston). (H1). Very common among *Laomedea* spp., especially in summer; nearly always found with *Eubranchus* spp., either *E. pallidus* intertidally or *E. exiguus* offshore. Spawn plentiful in June and July, less so until October, and (rarely) as early as April.

122. *Facelina auriculata* (O. F. Muller). A few times on *T. larynx* (Table 3; Wa, as *F. drummondi*). Common, RL, from 1947 onwards (H1, as *F. longicornis*) but not seen there since 1952; Scolt Head (Pa); uncommon, usually among hydroids (mainly *T. larynx*), most often near low-water mark but sometimes offshore. The largest yet seen here was 3 cm. long (from MC, with *Lora rufa*, q.v.) but was so badly damaged as to be unidentifiable except from the radula; the usual length is about half this.

123. *Aeolidiella glauca* (Alder & Hancock). One in plankton net with *Retusa retusa* (q.v.). Tardy (1969) finds that this (including *A. angulata* as a synonym) is the only species of the genus in Danish waters (where it is common), and it is thus most likely the only species in our area also (as in Dutch waters: Swennen, 1961).

124. *Aeolidia papillosa* (L.). One adult on Gorleston Breakwater, May 1933 (EAE in Mo); Scolt Head (Pa). In pools, mostly on the Freshes Lays, less often on Hunstanton Scaup and RL; frequent from February to May, rare in June, September, November, and December; offshore only in July and August (a small one at D.23, 3 large and 1 small from MC with *Lora rufa*, and 4 medium-sized from him taken at 53°02′ N. 00°30′ E. on 18.7.1962). The most usual colour in nearly white, fairly often brownish-mauve or blackish-mauve (cf. *Acanthodoris pilosa*). In springtime on the Freshes Lays, this and *Onchidoris fusca* can be found spawning together; the latter lays its egg ribbons in full view on the upper of mussels (or, less often, of stones), whereas *A. papillosa* lays its egg ribbons underneath these.

Pulmonata

125. [*Leucophytia bidentata* (Montagu). Not common (Hr, as *Melampus*).]

126. *Ovatella myosotis* (Draparnaud). Not common (Hr, as *Melampus*); Scolt Head (EO, as *Phytia*). Abundant in the *Spartina*-fragments all along the high-water mark on Morston Marshes.

SCAPHOPODA

127. *Dentalium entale* (L.). Hunstanton (Mu); Wells, X (M1). One dead shell at D.45 and one at D.47.

BIVALVIA

128. *Nucula nucleus* (L.). Common (Hr, P3, P4, M1, GB); Table 2; scarce at Gorleston (Mo). Dead shells abundant in some dredgings, but the living one I have seen was at D.47.

129. *Nucula nitidosa* (Winckworth). Off Yarmouth, and common off Lowestoft (P3, P4); rare at Gorleston (Mo) and off east Norfolk (Dv); all as *N. nitida*. One living, 17.7.1962, with *Lora rufa* (q.v.).

130. *Nuculana minuta* (O. F. Müller). Not common (Hr, GB, Table 2; all as *Leda*); 26 valves at D.23, about half of which had been bored by *Natica* (probably *N. alderi*).

131. [*Arcopsis lactea* (L.). Off the Norfolk coast (FH; Table 2; both as *Arca*).]

132. *Modiolus modiolus* (L.). Very common (Hr, Mu, both as *Mytilus;* Table 2, P3, P4, all as *Modiola;* E2); living just below ELWST on Hunstanton Scaup (H3, p.6). Often living, D or X (the latter especially around Hunstanton and Yarmouth).

133. [*Musculus discors* (L.). Common in seaweed; Yarmouth, Cromer, Palling (M1); Table 2; both as *Modiolaria*. Cockle Bight at Scolt Head (Pa, Sy). Whether any of these were living is not stated.]

134. [*Musculus marmoratus* (Forbes). Lynn Well (J8); Table 2; rare at Gorleston (M1); all as *Modiolaria*. Not stated if living.]

135. *Musculus niger* (Gray). Off Norfolk (FH, as *Crenella*); not common (Hr, Table 2, both as *Modiolaria*). One recently dead at D.5, and 8 living ones at D.22.

136. *Mytilus edulis* (L.). Common intertidally (many authors), but not found offshore except by accident; common on the *Hjordis*, all over the shore at West Runton, and under the quays at Wells and Yarmouth. Young mussels are brought from the natural beds ("Scaups"; see above, *Odostomia scalaris*) for re-laying on the cultivated beds ("lays") during the summer, and are harvested during the winter months when of marketable size. The Strond Pool Dam on Morston Strond (H3) was constructed in 1956 by the late Mr. L. Green of Stiffkey in order to form the Strond Pool for the long-term storage of live mussels at an unnaturally high tidal level, where they would be far more accessible than on the Freshes Lays about half a mile further west; faunistically the Dam has become an extremely rich (although spatially very restricted) habitat, owing to the continual draining away through it of water from the Pool.

The spawning season is confined to a few days in April and May, its onset and duration depending on the rate at which the sea-temperature rises (Chipperfield, 1953); tiny seed mussels have been noticed in enormous numbers on *Sertularia argentea*, on algae, or on suitable hard surfaces, in April, May, July, and August. At W.37 a mussel about 2 cm. long was found under the abdomen of a female *Hyas araneus*, in the position normally occupied by the crab's own eggs.

137. *Ostrea edulis* (L.). Common (Mu, Hr, P3, P4, E2, H3) but nowadays only as dead shells; a flourishing fishery ceased off North Norfolk for unexplained reasons in 1908, and off Yarmouth in 1905 due to overfishing (P4). The North Norfolk oysters lived in submarine depressions on only a few yards each way, to locate which the most precise navigation was required (by means of shore-marks whose locations and nature were jealously guarded secrets); using such of these marks as are still remembered locally I have failed to find a single living oyster in Blakeney Deeps, but one was taken about a mile off the beach at Blakeney in 1934, and another about 1½ miles south-east of the Blakeney Overfalls Buoy on 9.6.1966 (RB, who reported that it tasted good, if a bit coarse, but that he felt rather unwell for the next day or two).

138. *Anomina ephippium* (L.). Not common (Hr); common at Hunstanton (GB). RL, at ELWST in the Threshold, and under stones in the Strond Pool Dam; D and W offshore (inside the mouths of old *Buccinum*-shells, on old valves of *Modiolus*, and on *Hyas*-carapaces). Nearly always living, but nowhere common.

139. *Monia patelliformis* (L.). One living one at D.47.

140. *Heteranomia squamula* (L.). Lynn Well (J8, as *A. ephippium* var. *aculeata*). One live one, RL, 10.9.1961; three live ones at D.22. I have preferred to retain the more familiar generic names rather than *Pododesmus* (see Bowden & Heppell, 1966).

141. *Aequipecten opercularis* (L.). Not common (Hr, Mu), but common near Lowestoft (BP); offshore (RV, Table 2); all as *Pecten*. Dead shells X or D, occasionally; a small live one wedged in the meshes of a whelkpot just north-west of the Blakeney Overfalls Buoy on 12.10.1961 (JY), a live one and about 20 dead valves at D.52, and two live ones at D.53.

142. *Chlamys varia* (L.). Small (? living) specimens, S, off Yarmouth (P3, P4); valves common, X (Mu, Hr) and offshore (Table 2, Mu, RV, Hr, P3, and P4); all as *Pecten*. Scolt Head (E2). Valves plentiful around the Freshes Lays and less so on other shores, but I have not seen any live ones here.

143. *Palliolum tigerinum* (O. F. Müller). Table 2 (as *Pecten*); a valve at D.48, and a smaller valve at D.53 (both det. JB).

144. [*Astarte sulcata* (da Costa). Five in 26 fathoms, 53°56′30″ N. 00°24′ E. (Dv).]

145. *Astarte montagui* (Dillwyn). Live ones regularly found within a kilometre (most often south and south-west) of the Blakeney Overfalls Buoy; dead shells in small numbers everywhere offshore.

146. *Astarte triangularis* (Montagu). Not common (Hr); dead shells sometimes numerous offshore.

147. [*Loripes lucinalis* (Lamarck). One specimen at Gorleston (BP, Gr2, M2); all as *L. lacteus*).]

148. [*Cyprina islandica* (L.). X, not common (Hr, E2) and at Hunstanton only in winter (GB); Table 2; the only one I have seen was just outside our area (H1, p. 320).]

149. *Phacoides borealis* (L.). X, not common (Hr); off Hunstanton, D (GB); both as *Lucina;* three specimens at 53°37′ N. 02°28′ E., 15 fathoms (Dv). Two single valves and a pair at D.23.

150. *Turtonia minuta* (Fabricius). One in holdfast of *Laminaria saccharina* in the Threshold, 9.5.1963; one on *Plumularia setacea*, RL, 2.11.1963. Easily overlooked and probably more common than these records suggest.

151. *Kellia suborbicularis* (Montagu). Lynn Well (J8). Two valves at D.20, a live one at D.23, and a second live one (pure white) at D.53.

152. *Mysella bidentata* (Montagu). Not common (Hr); X, "Norfolk coast" (Hr), at Hunstanton (GB, Norman in J1), and at Yarmouth (BP); all as *Montacuta*. One living in the tube of *Pectinaria koreni* at S.5 (Hamond, 1966b, p. 432); not yet seen intertidally on the Norfolk coast, either in the burrows of *Barnea candida* (cf. Pelseneer, 1925) or elsewhere.

153. [*Montacuta substriata* (Montagu). Norfolk area (J3); fairly common in a trawl-haul from 52°43′ N. 02°25′ E. to 52°36′ N. 02°39′ E. (approximately) on 23.6.1905 (exact position in Anon. 1909, pp. 154–155). Otherwise the nearest record is on the Dogger Bank (Jaeckel 1951b, p. 223). Usually associated with the sea-urchins *Spatangus purpureus* and *Echinocardium cordatum* (J3; experimental analysis by Gage, 1966).]

154. *Laevicardium crassum* (Gmelin). Not common (Hr, as *Cardium Norvegicum* [*sic*]). D only, and then only as isolated valves; most common near the Blakeney Overfalls Buoy, but less confined to that area than *Astarte montagui*.

155. *Parvicardium ovale* (Sowerby). Not common (Hr); Table 2; both as *Cardium fasciatum*. One live one at D.22; a live juvenile and an adult valve at D.23.

156. *Parvicardium exiguum* (Gmelin). Not common (Hr); off Yarmouth (HP); both as *Cardium*. A few dead shells, D.

157. *Cerastoderma edule* (L.). Common all along the North Norfolk coast (many authors, all as *Cardium*) in clean or muddy sand, in bound shingle (as on Morston Strond), and sometimes in mud with contained shingle as in the bottoms of certain creeks; also in Abraham's Bosom at Wells. Dead shells sometimes numerous offshore. Post-larvae continue to float in the plankton for some time after metamorphosis; in Blakeney Harbour they are most abundant in July, but can be found from May to September.

158. *Cerastoderma glaucum* (Poiret) (=*C. lamarcki* (Reeve); see Rygg, 1970). The only bivalve in the Salt Hole at Holkham, where it is large and abundant (Hunt, 1971; own observations).

159. *Dosinia exoleta* (L.). Not common (Hr, as *Venus*); offshore (RV, as *Artemis*). One valve at Brancaster, X, 9.11.1961, and a valve at D.52.

160. *Venus ovata* (Pennant). Not common (Hr); Table 2. A live one at D.22 and two valves at D.23.

161. *Venus striatula* (da Costa). Not common (Hr); offshore (RV; Table 2); one specimen at 53°30′ N. 02°53′ E. in 18 fathoms (Dv); all as *V. gallina*. One perfect pair of valves, X, west side of Holkham Bay, June 1961 (SMH).

162. *Venerupis rhomboides* (Pennant). Not common (Hr, as *Tapes virgineus*). One valve at D.48, and a pair of valves at D.51. For key to British *Venerupis*, see Holme (1961).

163. *Venerupis pullastra* (Montagu). Common all along the North Norfolk coast (many authors, as *Tapes*, *Paphia*, or *Venerupis;* GB, as *Tapes virgineus*). Fairly common living among mussels in the Freshes Lays, buried in the stony flat at ELWST on Hunstanton Scaup, or in crevices, old *Zirfaea*-burrows, and other holes in the hard chalk at West Runton; less common in the Threshold, and in the peat at Brancaster. Four small specimens were found hanging on the polyzoan *Scrupocellaria scruposa*, growing on the inner wall of the *Hjordis* on 14.9.1962. In D offshore, live specimens are very rare. The ecology of this species is much the same in Norfolk as in Scotland (Quayle, 1952) and in Denmark (Rasmussen, 1958).

164. [*Veverupis decussata* (L.). Hunstanton (GB).]

165. *Petricola pholadiformis* (Lamarck). Occasionally in the hard chalk at West Runton and Sheringham, but much more plentiful in the peat (submerged forest) at Brancaster (H3); dead shells at Scolt Head, X (E2, Pa), and all along the coast.

166. [*Spisula subtruncata* (da Costa). Off Norfolk in 24 fathoms (FH, as *Mactra*); this is most likely off East Norfolk, but might alternatively be in Lynn Well (the deep central part of the Wash).]

167. *Spisula solida* (L.). Dead shells abundant, both X (Hr, Mu, both as *Mactra;* Sy, E2, Mo, H3) and offshore (Table 2 (dead or alive?); RV (dead); both as *Mactra*). One living in clean sand at D.25.

168. *Spisula elliptica* (Brown). Not common (Hr, as *Mactra solida* var. *elliptica;* FH, as *Mactra*); valves occasionally, S (HP, as for Hr) or D; one living at S.4. Glémarec (1968) has resurrected *S. ovalis*, which is very much like *S. elliptica;* I have not been able to check the S.4 specimen against this paper, which appeared after I had left for Australia.

169. *Mactra corallina* (L.). Common (Hr); off Yarmouth, 2 (P3) and abundant on hard ground (P5), whence X in large numbers after easterly or north-easterly gales (P1, P2, P4, Gr2); all as *M. stultorum*. Scolt Head, X (E2). Large live ones numerous in clean sand at ELWST north of Brancaster Golf Club (24.4.1966, TP; 16.9.1966, self); three live juveniles at D.36.

170. *Gari depressa* (Pennant). Not common (Hr, GB, both as *Psammobia vespertina*); one in 19 fathoms at 53°55′ N. 01°36′ E. (Dv, as *Psammoacla* [*sic*]). One valve, X, at Brancaster on 27.3.1964.

171. [*Gari tellinella* (Lamarck). Lynn Well (J8, as *Psammobia*).]

172. *Abra prismatica* (Montagu). Table 2 (as *Syndosmya*); common all over the southern North Sea (various authors, *fide* JB). Dead shells occasionally in D.

173. [*Abra nitida* (O. F. Müller). Table 2 (as *Syndosmya*); fairly common near the Harbour mouth at Yarmouth (P3, P4, both as *Scrobicularia*); no North Norfolk records.]

174. [*Abra tenuis* (Montagu). Scolt Head (Sy).]

175. *Abra alba* (W. Wood). Table 2; Hunstanton (GB); not uncommon at Gorleston (M2); all as *Syndosmya*. Common (Hr), a few from Yarmouth Harbour mouth (BP); forming the great majority of the food of the dragonet (*Callionymus lyra*) on the Yarmouth shrimping grounds (AHP); all as *Scrobicularia*. Dead shells sometimes abundant in D; a live juvenile at D.36, and about 140 newly settled spat on 13.9.1962 with *Retusa retusa* (q.v.).

176. *Scrobicularia plana* (da Costa). Norfolk, reaching its northern limit in the North Sea near the Dudgeon (FH); Hunstanton (GB; Norman in J1); common (Hr); plentiful in Breydon, living (P3, P4); numerous shells of all sizes in the River Ant at Ludham Bridge in the summer of 1906, the valves unbroken and still joined in pairs, indicating that they had lived and died *in situ* when the Ant was more saline than nowadays, and not that they had been discarded from the kitchens of St. Benet's Abbey close by (Gu); all as *S. piperata*. Scolt Head (Sy, Gi, Pa). Living specimens are abundant in muddy sand on the north side of Blakeney Harbour (just west of Pinchen's Creek), and in the mud of suitable creeks all along the North Norfolk coast; several were also found about 50 yards south-west of Wells Lifeboat House, at the foot of the seawall, on 23.5.1959 (JF). Offshore only at D.26, as dead shells. Very small specimens (just post-larval) seen floating in Blakeney Harbour plankton in February, March, and May.

177. *Macoma balthica* (L.). Common (Hr, GB, P3, P4); under Ludham Bridge in the same condition as *S. plana* (Gu); all as *Tellina*. Scolt Head (Sy, Gi, Pa); near Yarmouth (Gr2). It prefers cleaner sand than *S. plana*, and the dead shells are more often found offshore; in Blakeney Harbour live ones are numerous in the sandbank south of the Watch House and in the floor of Pinchen's Creek, and are found in small numbers in the Freshes Lays.

178. [*Tellina pygmaea* (Loven). Lynn Well (J8, as *T. pusilla*).]

179. [*Tellina donacina* (L.). Off Norfolk (FH).]

180. *Tellina fabula* (Gmelin). Not common (Hr); Scolt Head (E2); around Yarmouth (HP, Mo); Table 2. A few live ones on the outside of Blakeney Point, between the Bar and the *Hjordis*, 7.7.1962 (RN); valves at Holkham, X, about a quarter as numerous as *T. tenuis*, 11.5.1963; one valve at 52°59′ N. 00°25′ E., 16.7.1962, and a pair of valves three days later at 53°02′ N. 00°30′ E. (all S, from MC).

181. *Tellina tenuis* (da Costa). Common (Hr, Mu, Pa, AHP); forming with other invertebrates the food of a sturgeon (*Acipenser* sp., date and place of capture unknown) landed at Yarmouth on 20.6.1927 (AHP). Large living specimens common in clean sand at ELWST at Holkham and north of Brancaster Golf Club; smaller ones being found in Blakeney Harbour.

182. *Donax vittatus* (da Costa). Not common (Hr); Hunstanton (GB); Table 2; a few in the Yarmouth shrimp-trawls (P3, P4). One fresh pair of valves at EHWST on north side of Blakeney Point, 7.7.1962 (RN); single valves, X, Yarmouth (8.4.1902, AHP), near Brancaster Golf Club (12.4.1962, SMH), and on the east side of Wells Bar (12.10.1961).

183. [*Phaxas pellucidus* (Pennant). Table 2; one in 26 fathoms at 52°52′ N. 02°16′ E., and one in 19 fathoms at 53°04′ N. 02°43′ E. (Dv); both as *Cultellus*.]

184. [*Solen marginatus* (Pulteney. Not common (Hr, Mu); a single valve on Yarmouth North Beach, X, 20.4.1906 (AHP); all as *S. vagina*.]

185. *Ensis ensis* (L.). Formerly common (Hr, Mu, both as *Solen*), but rare nowadays (see below); Scolt Head (E2). Two pairs and three single valves, X, west side of Holkham Bay, 2.6.1962, among about 100 pairs of valves of *E. siliqua;* one pair of valves at D.23.

186. *Ensis siliqua* (L.). Common (Hr, Mu), and especially so at Yarmouth, X, where avidly fed upon by gulls (P3, P4); offshore (RV); all as *Solen;* Scolt Head (E2, Gi, Pa). Dead shells common from Blakeney to the Wash; living specimens at ELWST in clean sand on the most exposed shores (Wells Bar, Holkham, Brancaster). In Norfolk waters neither species of *Ensis* much exceeds 13 cm. in length, and it is unknown whether either of them becomes sexually mature here.

187. *Hiatella arctica* (L.). Common (Hr); common at Yarmouth (P3, BP, M2); a very fine one in hard chalk between tidemarks at Sheringham, summer 1898 (Gr1); all as *Saxicava rugosa*. Lynn Well (J8), and Yarmouth (HP), both as *S. rugosa* var. *arctica*. Table 2, as *S. rugosa* and *S. arctica*. In my experience confined to dredgings where it is usually alive; it is often found among the matted hydrorhizae of the hydroid *Nemertesia antennina*, and at D.18 and at D.53 large numbers were found boring holes in moorlog.

188. *Corbula gibba* (Olivi). Norfolk (FH, as *C. nucleus*); not common (Hr); occasionally at Yarmouth (HP). Dead shells only, D.

189. *Mya arenaria* (L.). Common along the North Norfolk coast and in the Wash (various authors) as well as on Breydon (P3, P4), where it was neither eaten nor used for bait although employed for both these purposes round King's Lynn (AHP). About fifty yards west of Pinchen's Creek on Blakeney Point, and about the same distance south of the shingle bank running westwards from the creek, there is a small population of well-grown *M. arenaria*, living in muddy sand, which has altered hardly at all within living memory, as regards the number and sizes of individuals taken in an hour's digging. Recently settled young ones are

sometimes found offshore, D; those at P.108 (see Table 2) were supposed by Metzger to have been transported there (a possibly unfavourable habitat) by currents tending away from the shore.

190. *Mya truncata* (L.). Common (Mu, Hr, P4, E2, H3) as dead shells intretidally; also offshore (Table 2). Dead shells widespread and abundant, X or D; small living specimens are also fairly common, X near Yarmouth (BP) and D off North Norfolk, while 10 very small living ones were taken in bottom plankton near the Blakeney Overfalls Buoy on 12.7.1965. The larger individuals burrow too deeply to be taken by the dredge, which merely cuts off their siphon-tips; the latter are very common in hauls on the north and east sides of the Blakeney Overfalls Buoy.

191. [*Sphenia binghami* (Turton). Lynn Well (J8, as *Mya*).]

192. *Barnea candida* (L.). Common (Hr); Hunstanton (Mu; Norman in J1); a few near Gorleston, X (BP, HP); a few, X, at Scolt Head (Gi); all as *Pholas*. Gorleston (Gr2) and Scolt Head (Pa). Common living in the submerged forest at Brancaster with *Petricola* (see H3, p. 7), and less so in the hard chalk which extends from Sheringham to Cromer).

193. *Zirfaea crispata* (L.). Common (Hr); Hunstanton (GB, Norman in J1); Scolt Head (Gi); all as *Pholas*. More recent records (E2, Pa, H1, H3) confirm this littoral range and extend it as far east as Cromer, making it roughly the same as that of *Barnea;* but *Zirfaea* is abundant in the hard chalk and comparatively scarce in the submerged forest, although just to the west of the forest (ELWST at Gore Point, halfway between Brancaster Golf Club and Hunstanton Scaup) it is common in thick dark clay. Offshore, I found 3 valves at D.23, about 100 cut off siphon-tips at D.42, a tiny live one at D.52, and 12 small ones in moorlog at D.53, while Anon. (1909, bottom of pp. 142–3) found it near the Dogger Bank at a station (outside the Norfolk area) at which moorlog was also taken.

194. [*Pholas dactylus* (L.). "I have occasionally found this species in lumps of chalk that in all probability were originally used as ballast in vessels that have been wrecked" (P3, P4); there are no records to suggest that this species in fact lives in Norfolk waters.]

195. *Teredo navalis* (L.). Not common (Hr); apparently confined to pier pilings at Yarmouth (Gr2, J4, P3, P4) and Gorleston (Gr2), where it was exceedingly destructive before the introduction of creosote treatment for the piles (P3, P4). The only ones I have seen (per PT) were in a block of waterlogged wood (S, off Caister) which was so hard that we were unable to split it with an axe in order to extract the *Tersedo*, which I have assumed was *navalis* merely because all previous local records are under this name.

CEPHALOPODA

196. *Sepia officinalis* (L.). Near Yarmouth, X, mostly bones but a few entire; animals more often taken in large trawls or S (P3, P4, Mo); five entire specimens at Gorleston, X, untouched by the numerous gulls (Mo); Patterson's unpublished notes record only three adults in trawls near Yarmouth, on 29.5.1900, 12.6.1906, and 17.6.1935. I have seen plenty of cuttle-bones washed up, but no animals from any source; there is nothing to show that *Sepia* spawns in the Norfolk area.

197. *Sepiola atlantica* (d'Orbigny). Common, S, off Yarmouth (P3, P4, as *S. rondeletii* [*sic*]; Mo), in the Wash (MC), and on the sandy inshore grounds from Blakeney Point to Hunstanton; constantly present in Brancaster Harbour every

year from early July to late September (JP). Intertidally I have seen two adults at ELWST in sandy pools, one at West Runton on 24.9.1961 and one near Wells Bar on 12.10.1961; recently hatched specimens (probably this species) have been taken in plankton, one in the Pit on 11.9.1962, and another close to the bottom near the Blakeney Overfalls Buoy on 15.8.1965.

198. [*Sepiola pfeffen* (Grimpe). Hull, without details (Jaeckel, 1958); no evidence that it was in fact living in our area, or even cast ashore there, particularly as Hull is a trawling port.]

199. *Loligo forbesi* (Steenstrup. Norfolk (BH); Yarmouth, X, occasionally (P3, P4), and sometimes S (AHP); all as *L. vulgaris*. Some fifty years ago (AHP, Mo) it may well have been more common off Yarmouth than it is now. The only one I have seen was cast up on the sand near Blakeney Bar, about 1952, but the spawn is often found attached to whelkpots (H3, p. 16) like bunches of slimy white bananas, in May and June, less often in September.

200. *Alloteuthis subulata* (Lamarck). Common all round the Norfolk coast, S (AHP, as *Loligo media;* RR, WW, MC) and sometimes X (E2, as *A. media*); seen together with *Sepiola* in Brancaster Harbour in August and September (JP), but it appears that these two species are mutually exclusive in the Wash (MC and others), one or the other being exclusively present on any given sandy ground offshore. Spawn in July and September; of immense quantities of spawn trawled in Blakeney Deeps on 12.7.1965, most was newly laid, but some was old enough to release myriads of young, between 29.7. and 2.8, which unfortunately did not survive for more than three days. For rate of growth ,see Adam (1933, pp. 18–20).

201. *Ommatostrephes sagittatus* (Lamarck). Common, X only (e.g. E4, as *Todarodes*), and then only from December to early May (based on all records since 1923). Apparently a mass death of this species must have occurred in the Wold (the stretch of deep water between the north-east coast of Norfolk and the Haisborough Sand) during the night of 14–15.4.1963, because over the next few days the corpses began to float ashore; hundreds were stranded around Hemsby, Eccles, and Walcot, from which the numbers thinned out in either direction to one at Scolt Head (now preserved at Bradfield College, Berkshire: TP) and to one or two just south of Lowestoft. From a later specimen (Cley Beach, 5.3.1966, SW; now in Hunterian Museum, Royal College of Surgeons of England), as from any cephalopod that I was able to obtain fresh, a portion of the excretory organ was removed and preserved as a possible source of dicyemids (Phylum Mesozoa).

In spite of Hardy's comment (1958), I am inclined to think that *O. sagittatus* is a normal inhabitant of Norfolk coastal waters, for the following reasons:

(1) The stranded specimens are always absolutely fresh, almost always entirely uninjured, and sometimes (as in the Cley specimen, *fide* SW) with the skin blushing and fading as the chromatophores continue their activities. Cephalopods, dead or dying, are a most acceptable food for many marine animals and birds (but see *Sepia*, above), so that death must precede stranding by at most a few hours or even minutes.

(2) At about 7 a.m. on 15.5.1966 Mr. F. J. Symons and a colleague, both of Yarmouth, were working a driftnet about four or five hundred yards offshore from the cliffs at Corton church, where in five fathoms the bottom is covered with boulders (about the size of a human head) over which a thick deposit of mud had at that time recently formed. As they hauled in the net a squid, about

18 inches (45 cm.) long, was seen hanging onto, and biting into the middle of, a herring caught in the meshes; as that part of the net approached the surface, the squid let go and darted away tail first without releasing any ink. The water was very cloudy, and the fishermen got a good view of the squid only just before it released its hold; the injured fish was photographed by Mr. Trett, thanks to whom I was able to hear the above account from Mr. Symons in person. In our waters a length of 18 inches would be average for *O. sagittatus*, quite exceptionally large for *L. forbesi*, and out of the question for *A. subulata;* the formidable armament of the suckers in *O. sagittatus* (see Jaeckel, 1958, fig. 3) also agrees well with the aggressive behaviour of Mr. Symons's specimen, and with the wounds that it caused.

202. *Eledone cirrhosa* (Lamarck). One, tentacles and body together ca. 60 cm. long, X, on Hunstanton South Beach (about 2 km. south of the Scaup) on 25.11.1957 (*Eastern Daily Press*, 28.11.1957, with photograph); another almost as large, W, 52°58′30″ N. 00°23′ E., 27.2.1961 (AL & VP) (now in NCM); and a third, body length ca. 7 cm., S, 52°58′ N. 00°22′ E., 4.6.1962 (MC) (now in my own collection). All three were thus very close together in the north-east corner of the Wash.

203. *Octopus vulgaris* (Lamarck). One, body nearly 30 cm. long, W, 53°05′ N. 00°52′30″ E., on 12.12.1960 (DC), definitely of this species; however, it is not known whether an octopod of similar size, taken in almost exactly the same place, W, in about 1920 (*fide* EJ) had one (*Eledone*) or two (*Octopus*) rows of suckers on the distal parts of the arms. None of the other whelkers questioned (LG, WC, WEC, or JY) had ever heard of an octopod in the BW area; it should be noted that the two larger *Eledone* (q.v.) were also of about this size, and that one of them also occurred in a whelkpot.

For the same reason the identities of six specimens from off Yarmouth (P2, P3, P4), in trawls (not S), remain obscure; in Patterson's words, one had a body "the size of a coconut" (i.e. comparable with the Wells specimens), four were "the size of a lemon" (=body ca. 10 cm. long), and one was "the size of a pheasant's egg" (=body ca. 4 cm. long).

Discussion

203 species of mollusc have been dealt with above by name; of these, five (*Gibbula umbilicalis*, *Monodonta lineata*, *Lacuna vestita*, *Pholas dactylus*, and *Sepiola pfefferi*) must be excluded from our fauna for various reasons. Of the remaining 198 species which are reasonably authenticated for the Norfolk marine area (and all of them also for Census Area 12, see Introduction), I have not seen 43 in our area, within which the intertidal molluscs, and the larger species regardless of habitat, both appear to be fairly well known. Additions to this list will consist almost entirely of species which are small and inconspicuous, or seasonal, or confined to a specialised habitat, or which burrow deeply; many living records may be expected of species so far found here only as dead shells. The methods of Hulings & Gray (1971) should be especially useful for extracting the smaller species living in sandy or muddy substrates.

When it comes to attempting to forecast the names, rather than the overall characteristics, of the species awaiting discovery in our area, it is natural to compare the Norfolk list with similar lists by other workers nearby. In the following section 25 (18) denotes 25 species of which 18 have not yet been found

in our area. All records have been included, whether doubtful or certain, living or dead; all synonyms and varieties have been sunk in their respective nominate species, and all pyramidellids transferred to opisthobranchs.

(A) All molluscs in the entire southern North Sea (Thorson, 1962, Table 1, Area IX); 397 (199). I have not quoted Thorson's totals for the separate groups, as he does not give the names of the species concerned.

(B) Prosobranchs:

(1) English east coast from Dover to Hull (Ankel, 1936); 73 (35).

(2) Southern North Sea and Dogger Bank (Jaeckel, 1951a, table 1); 17 (4).

(3) Central North Sea (Jaeckel, 1951a, table 1); 35 (18).

(4) Holland, sublittoral (Eisma, 1966, appendix 1); 15 (4).

(C) Opisthobranchs (1 to 4 in Jaeckel, 1952, table at end):

(1) English east coast from Dover to Hull; 51 (24), composed of
(a) pyramidellids (Ankel, 1936); 6 (4), and
(b) others (Jaeckel); 45 (20).

(2) Southern North Sea; 8 (2).

(3) Dogger Bank; 22 (12).

(4) Central North Sea; 35 (18), composed of
(a) pyramidellids (Jaeckel, 1951a, table 1); 9 (8), and
(b) others (Jaeckel, 1952); 26 (10).

(5) Holland; 35 (10), composed of
(a) nudibranchs (Swennen, 1961); 30 (5), and
(b) other kinds, sublittoral (Eisma, 1966, appendix 1); 6 (6).

(D) Bivalves (1 to 3 in Jaeckel, 1951b, table 1):

(1) Southern North Sea; 28 (5).

(2) Dogger Bank; 43 (8).

(3) Central North Sea; 65 (19).

(4) Holland, sublittoral (Eisma, 1966, appendix 1); 61 (14).

The Solenogastres, Polyplacophora, and Cephalopoda contain too few species to make this sort of computation worth while.

It is by no means safe to assume that those non-Norfolk species, which occur most often in the above lists, will be the first to be found here when further search is made. In about 1955 I drew up an unpublished list of all my own finds of marine invertebrates (the forerunner of this and other papers) for comparison with lists from elsewhere in the North Sea, as a basis for guessing which species were most likely to be added to the Norfolk fauna. Over the next decade it became clear that these guesses had been "wrong" at least as often as "right"; quite a few unexpected species were found, while several expected species were found only seldom or not at all. The most probable reasons for these uncertainties are:

(1) The above sub-areas of the southern North Sea are not precisely defined, particularly as regards possible overlapping;

(2) They have not been sampled with equal intensity (i.e. number of samples per unit area of similar substrate), nor with the same type of gear (which in some cases is not even mentioned); and

(3) A small minority of the identifications are suspect for one or other of a variety of reasons, even though accepted here at face value.

The most one can say is, that records from elsewhere in the southern North Sea afford a very rough indication of what is likely to be found here (irrespective of whether any species has in fact been found here or not), and that the probability of such a find increases as one approaches the Norfolk area, being highest for the shores of adjacent counties and near the offshore edges of our area. There is no list of the marine molluscs of Lincolnshire (whose coast in any case lies entirely within the Norfolk area), but the Suffolk list (Mo) includes 114 species, of which 11 are non-Norfolk. Many of the Suffolk records are from the Yarmouth area and the "Pommerania", and have been treated above as Norfolk records, producing a definite degree of overlap; the Suffolk list also includes an interesting Essex record (the rare *Circulus striatus* from Walton-on-the-Naze) but does not mention the American whelk-tingle *Urosalpinx cinerea* (Say), an important pest of the Essex oyster-beds which (*fide* Dr. D. A. Hancock) has spread as far north as Felixstowe.

Just outside the north-east corner of our area, two stations worked by the "Wodan" (Redeke, 1907) yielded molluscs which are rare or unknown in Norfolk waters, as follows:

Station 59. 53°44′ N. 03°28′ E., 42 metres, end of July 1906.

1. *Acanthocardia echinata* (Redeke, as *Cardium;* I have also seen large specimens from the Dogger Bank, per EJ), 1 *Ensis ensis* (as *Solen*), 1 *Gari fervensis* (as *Psammobia ferroensis*), and several *Turritella communis*.

Station 4. 54°05′ N. 02°57′ E., 40 metres, 7.2.1907.

Numbers not given; species present were *Arcopagia crassa* (as *Tellina*), *Venus striatula* (as *V. gallina*), *Dosinia exoleta* (as *Artemis*), *D. lupinus* (as *Artemis lincta*), *Laevicardium crassum* (as *Cardium norvegicum*), and *Thracia papyracea*.

Within the Norfolk area itself, and at some other stations just outside it, Redeke found only the most ordinary species.

In order to pinpoint localised populations of molluscs and other animals, and to elucidate their relationships to any given features of the substratum, it would be well worth while to survey Blakeney Deeps according to the methods of Eisma (1966). The floor of Blakeney Deeps is liable to vary suddenly over a short distance (sometimes of no more than a few yards), showing almost every imaginable combination of sand, silt, large and small shells (complete or fragmented), and flint pebbles from the size of a fist downwards; (Hamond, 1963a, pp. 18–21); the only major components of other North Sea substrates which are lacking here are rocks (though the rocks, found intertidally around Sheringham and Cromer, are said to extend as far west as Salthouse at a distance of about half a kilometre offshore) and thick soft mud (such as, in deep water off Northumberland, carries abundant *Nephrops norvegicus, Calocaris macandreae*, and *Pandalus borealis;* cf. Hamond, 1963a, pp. 20–21; 1969a, p. 211; 1971, p. 93). Lacking Decca navigation (used by Eisma), I have always found it very difficult to locate a previously selected offshore ground with any precision unless close to a buoy (Hamond, 1963a, fig. 1); since the nearest to home of these, the

Blakeney Overfalls Buoy, also happens to be on the south-west corner of a faunistically rich ground, it is not surprising that a great many of my dredge-hauls were clustered round it within a radius of about a kilometre (Hamond, 1969a, fig. 2). These clustered hauls have revealed an interesting pattern with regard to a few species; just south and south-west of the Buoy, the coarse and uncompacted sand with abundant shell-fragments, forming the upper slope of the Blakeney Overfalls itself, contains living *Astarte montagui*, dead valves of *Laevicardium crassum*, and rather few other living animals, whereas *Lora turricula* is found only north-east of the Buoy on firmer but siltier grounds with larger shells and pebbles, and a rich macrobenthos including large, deeply burrowing, *Zirfaea* and *Mya truncata*. In the same area as *Lora*, and further east, the dredge is likely to take moorlog, which is riddled with smaller *Zirfaea* and with *Hiatella*, and which has a very rich and varied fauna of small invertebrates. As far as my records show, *Lora* and *Astarte* never occur on each other's territory.

In the same way, the placing of the South-East Docking Buoy so close to the "Muddy Hole" (see *Clathrus clathrus*) is exceedingly convenient. Unfortunately, a similar muddy hole off Stiffkey ("six-fathom depression", Hamond, 1963a, p. 18) has no buoy near it since the "Wimbledon" Buoy was removed (Hamond, 1969a, p. 216–7) and is not at all easy to locate from shore-marks; in the single dredge-haul taken in it (D.14), the only mollusc was a living *Natica alderi*.

Navigational difficulties, and the fact that the dredge has to be pulled for some distance, over which it bites into the ground very unevenly, make it clear that dredging, as a sampling technique, does not have the resolving power to trace small changes in the substratum over distances of a few yards or less; even when I have taken two hauls as nearly as possible over the same track (using a dan-buoy; the hauls were probably about five yards apart) the difference in the two catches was quite noticeable. Nevertheless, the fact that an empirical classification of bottom deposits (Hamond, 1963a, p. 22) has required only slight emendation after almost twice as many dredge-hauls had been taken (Hamond, 1969a, pp. 218–9), suggests an underlying pattern of substrate structure whose components can be analysed only by an Eisma-type survey.

Even without the methods of Eisma, or of Hulings & Gray, the Norfolk area is now known to contain twice as many species as were known here a century ago (Harmer, 1872, 96 spp.), although only half as many as are recorded from the entire southern and central North Sea (Thorson, 1962, Area IX). Modern sampling techniques might well raise the number of species found here to between 200 and 250, and will certainly produce an immense number of records, from other places within the Norfolk area, of species which have hitherto been recorded only at one or two Norfolk localities. However, primitive and anecdotal as they were, the early records *in toto* gave a surprisingly good idea of the distributions of the great majority of Norfolk marine molluscs; the centenary of Harmer's list seems as good a time as any to collate these records, in order to provide the fullest possible regional and ecological basis for further work, which it is hoped will place far more emphasis on living material.

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TABLE 1: ABBREVIATIONS IN THE TEXT

AHP	Arthur Henry Patterson, unpublished natural history diary, 1878–1934, now in County Library, Norwich.
AL	A. Large (unpublished).
BP	J. B. Beckett, in Patterson (1905).
BH	J. Bridgman, in Harmer (1872).
D	Dredging stations (list in Hamond, 1969a).
DC	D. Cox (unpublished).
Dv	Davis (1925).
E1	Ellis (1934a).
E2	Ellis (1934b).
E3	Ellis (1944).
E4	Ellis (1951).
EAE	E. A. Ellis (unpublished).
EJ	E. C. Jarvis (unpublished).
EB	E. J. Bean (unpublished).
EHW, ELW	Extreme high or low water (of NT or ST, q.v.).
EO	Ellis & Oldham (1934).
FH	Forbes & Hanley (1848–1853).
GB	Greene & Babington's revision of Munford's list, in Wilson (1888); put against only those species not quoted in the first place by Mu (q.v.).
Gi	Gilson, Hollick & Pantin (1944).
Gr1	Greene (1899).
Gr2	Greene (1903).
Gu	Gurney (1909)
H1	Hamond (1957).
H2	Hamond (1961).
H3	Hamond (1963a).
Hr	Harmer (1872; reprinted; comments deleted, in Harmer, 1884).
HP	Harmer, in Patterson (1905).
J1	Jeffreys (1859a).
J2	Jeffreys (1859b).

J3	Jeffreys (1864–1869) *2*, p. 206.
J4	Ibid. *3*, p. 172.
J5	Ibid. *3*, p. 319.
J6	Ibid. *4*, p. 308.
J7	Ibid. *4*, p. 424.
J8	Jeffreys, in Harmer (1872.)
JB	J. Bowden (unpublished).
JF	J. Fisher (unpublished).
JM	J. Machin (unpublished).
JP	J. Peake (unpublished).
JY	J. Youngman (unpublished).
KJ	K. A. Joysey (unpublished).
KW	Miss K. Wiltshire (unpublished).
LG	L. Green (unpublished).
M1	Mayfield (1896).
M2	Mayfield (1908).
Mb	Möbius (1875)
MC	M. Castleton (unpublished).
Ml 1–6	J. T. Marshall, records in J. Conch., as follows:
Ml 1	*7* (8), p. 263 (1893).
Ml 2	*9* (3), pp. 69–70 (1898).
Ml 3	*9* (5), pp. 133–134 (1899).
Ml 4	*9* (6), p. 168 (1899).
Ml 5	*9* (8), p. 227 (1899).
Ml 6	*9* (10), p. 289 (1900).
Mo	Morley (1938).
Mu	Munford, in Wilson (1867).
My	Meyer (1875).
Mz	Metzger (1875).
NCM	Norwich Castle Museum
NT	Neap tides.
P1	Patterson (1900).
P2	Patterson (1902).
P3	Patterson (1903).
P4	Patterson (1905).
P5	Patterson (1906).
P6	Patterson (1909).
PT	P. G. W. Trett (unpublished).
PP	Miss P. Pantry (unpublished).
Pa	Pantin, Hollick, Joysey & Bidder (1960).
Q1, Q2	Sampes brought up by divers (station list, Hamond, 1969a).
R	Reid (1884).
RB	R. Bishop (unpublished).
RL	Under rocks at West Runton, at or near LWST.
RN	R. C. Newell (unpublished).
RR	Mrs. Race (Miss R. M. Barnes).
RV	Redeke & van Breemen (1904).
S	Shrimptrawls (for S1 to S6, see station list, Hamond, 1969a; otherwise, hauls by professional shrimpers from Yarmouth or King's Lynn).
ST	Spring tides.
Sy	Serventy (1934).
SW	S. A. Whitcher (unpublished).
SMH	S. & M. Hornsey (unpublished).
TP	T. Potts (unpublished).
VP	V. Pells (unpublished).
W	Whelkpots (station list, Hamond, 1969a).
Wa	Walton (1908)
WC	W. Cox (unpublished).
WEC	W. E. Cooper (unpublished).
WR	Under Wells Rocks.
WW	W. J. Woolston (unpublished).
X	Cast ashore, washed up.

TABLE 2

Mollusca taken in the Norfolk area by the "Pommerania" (*Chaetoderma*, Mb; nudibranchs, Me; others, Mz; modern nomenclature). At P.109 the only mollusc was *Lacuna vestita*.

	P.105	P.107	P.108	P.111	P.112	P.113	P.114	P.115
Chaetoderma nitidulum	x							
Lepidopleurus asellus		x						
Gibbula cineraria		x	x					
Gibbula tumida		x				x		
Calliostoma zizyphinum			x		x	x		
Velutina velutina		x	x					
Trivia arctica				x		x		
Natica alderi				x		x		
Natica catena						x		
Clathrus clathrus						x		
Trophon truncatus			x			x		
Ocenebra erinacea			x	x				
Lora rufa			x	x				
Lora turricula		x				x		
Archidoris pseudoargus				x				
Thecacera pennigera				x				
Acanthodoris pilosa				x				
Lomanotus marmoratus					x			
Doto fragilis			x	x				
Nucula nucleus			x					
Nuculana minuta			x					
Arcopsis lactea							x	x
Modiolus modiolus			x	x		x		
Musculus discors			x					
Musculus marmoratus			x					
Musculus niger	x							
Aequipecten opercularis	x		x			x		x
Chlamys varia			x	x		x		x
Pallioum tigerinum			x					
Cyprina islandica	x							
Parvicardium ovale			x					
Venus ovata						x		
Venus straitula	x							x
Spisula solida			x		x	x		
Abra prismatica								x
Abra nitida	x							
Abra alba						x		
Tellina fabula								x
Donax vittatus						x		x
Phaxas pellucidus	x							
Hiatella arctica	x		x					
Mya arenaria			x					
Mya truncata	x							

TABLE 3

Nudibranchs taken in the Norfolk area by the *Huxley* (Wa; modern nomenclature). For stations HX_2 to HX_6, see Hamond, 1969a, Table 1 and Fig. 1; there were no nudibranchs at HX_1 or HX_5.

Voyage XCIV.

Stn. 2	Northeast of "Sheringham Bank" (i.e. Sheringham Shoal), exact position not stated; 14 fathoms.
	1 *Ancula cristata*.
Stn. 38	North of Haisborough Lightship (i.e. ca. 53°00′ N. 01°35′ E.); 14 fathoms.
(=HX_2)	1 *Doto fragilis*.
Stn. 45	53°22′ N. 00°34′45″ E.; 15 fathoms.
	5 *Coryphella pellucida;* many *Doto coronata* with spawn.
Stn. 47	53°28′45″ N. 01°39′ E.; 14½ fathoms.
(=HX_3)	1 *Trinchesia aurantia*, 1 *Coryphella pellucida*, 1 *Facelina auricylata*, and 1 *Onchidoris fusca*.
Stn. 52	53°30′ N. 01°30′30″ E.; 10 fathoms.
	3 *Onchidoris fusca*.
Stn. 54	53°40′ N. 01°28′ E.; 47 fathoms.
(=HX_4)	1 *Goniodoris castanea*.

Voyage XCV.

Stn. 23	53°24′ N. 01°42′ E.; 24 fathoms.
	2 *Cuthona amoena*, 1 *Doto coronata*.
Stn. 24	As Stn. 23, but in 13 fathoms.
(=HX_6)	Fairly common *Onchidoris fusca*, 1 *Coryphella verrucosa*, 1 *Aeolidiella glauca*, and 1 *Eubranchus tricolor*.

TABLE 4

Simultaneous occurrences of *Odostomia unidentata* and *Pomatoceros triqueter* in North Norfolk waters.

	D.22	D.23	QX.2	D.26
O. unidentata, living	7	0	1	2
dead	2	3	0	0
P. triqueter (assumed to be living)	absent	4	some	Numerous, on old *Modiolus*-shells.

ADDITIONS TO THE FLORA OF BLAKENEY POINT, NORFOLK—2

By D. J. B. White

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Introduction

The second edition of the annotated list of the flowering plants and ferns occurring on the Point (White, 1967a) included those additions to the flora made since the first edition was published (White, 1960, 1967b). Since then a few more species have been observed. These, along with five species which have either reappeared after a lapse of some years or which have spread to another part of the Reserve, are listed below.

DICOTYLEDONES

Cruciferae

Crambe maritima L. Seakale

There are now three plants on the main shingle bank between Cley beach and the Hood. The largest plant, which I first saw in 1968, is on the seaward edge of the shingle bank, east of the Hood and about one-third of the way along towards the Watch House. There is a smaller plant near the Cley beach and the third plant which is the smallest is about midway between the other two.

Have these plants come from long-buried seed derived from the original plant which was destroyed in the storm-surge of 1953? The largest plant, at least, flowers annually (I do not know about the other two). I believe seed production to be very low. Possibly *Crambe* shows a high degree of self-incompatibility as do many members of the Cruciferae.

Papilionaceae

Lathyrus japonicus Willd. Sea Pea

Several plants were found in 1970 on the main shingle bank east of Watch House. Introduced to the Point; see White, 1967.

Rosaceae

Rosa pimpinellifolia L. Burnet Rose

A plant has been known for some years on the main dunes.

Onagraceae

Epilobium adenocaulon Hausskn. American Willow-herb

A plant was found by Mr. A. J. Davy on the Yankee Bank in July 1967. Another plant was found on the main dunes in 1970.

An alien, first recorded in Britain in 1891, it is now common in south-east England and is spreading northwards. Common in Norfolk (Petch and Swann, 1968).

Umbelliferae

Anthriscus caucalis Bieb. Bur Chervil

In June 1968 several plants were found flowering and fruiting on the Watch House Bank. Hitherto it had been found only in disturbed ground near the Lifeboat Houses where it still occurs.

Scrophulariaceae

Scrophularia sp.

A plant was found in June 1970 growing on the shingle of the main bank near the bend, by Messrs. J. Holmes and I. Howes.

Digitalis purpurea L. Foxglove

One plant was found in flower on the Watch House Bank in 1967. More plants were seen there in 1968. In 1969 there were two patches growing on the shingle by the Laboratory. One patch had white flowers and the other pinkish. By 1971 they had spread farther into Long Low.

Veronica arvensis L. Wall Speedwell

In 1969 I found several plants in flower on the dunes near Glaux Low. This appears to be the only recent record for the Wall Speedwell and the first for this region. Oliver and Salisbury (1913) reported it as occurring on the Long Hills but rather rare.

Rubiaceae

Galium aparine L. Goosegrass, Cleavers

In 1970 I found several plants which were in flower growing in the detritus which had accumulated among the *Suaeda* bushes on the shingle in the western angle between the Watch House Bank and the main ridge.

In June 1971 there were several plants in flower among the Lupins surrounding the well.

Previously to 1970 this annual plant had not been recorded on the Point.

Compositae

Senecio sylvaticus L. Wood Groundsel

Found in September 1968 on the relict dune forming the "outlier" to the Long Hills. Not common on the Point but occurs on the Hood (White, 1967).

Filago arvensis L.

Professor G. E. Fogg found at least 30 plants of this casual growing on the grey dunes near the well in July 1969. *F. arvensis* is an introduced species in the British Isles.

Carduus nutans L. Musk Thistle

One plant found in August 1971 on the ridge south-east of the Lifeboat House by E. A. Ellis.

MONOCOTYLEDONES

Liliaceae

Endymion non-scriptus (L.) Garcke. Bluebell

In May 1968 I found five small patches of bluebells growing on the relict dune near Long Hills. I dug up the smallest patch and subsequently replanted it. This patch contained bulbs of various sizes including some which were probably one year old. The leaves in all the patches were nibbled by rabbits. There were two inflorescences at this time, one of which had been nibbled through recently. The plants must have been present for several years.

This dune was accidently burnt over in the autumn of 1969. It was noticeable afterwards that paths which were well-trodden but covered with short vegetation

did not burn. The patches of bluebells by the edge of a path were coming through nicely in the April following the burning.

I was unable to locate any bluebells in 1971 by which time the surrounding vegetation had become very dense.

Orchidaceae

Anacamptis pyramidalis (L.) L. C. Rich. Pyramidal Orchid

In June 1969 I found a single plant of this orchid growing on the slope of the dunes on the west side of Glaux Low, and nearly opposite the "neck" of this Low. The plant was about 9 inches high. The nature of the surrounding vegetation in which this orchid was growing is indicated by the list below.

Ammophila arenaria. Very passé
Festuca rubra + + +
Agropyron pungens +
Cerastium spp.
Senecio jacobaea
Cladonia foliacea [=*Cl. alcicornis*]
Cladonia pyxidata
Hypnum cupressiforme

This orchid has not been seen since. It is only the second orchid ever recorded on Blakeney Point. In 1914 the late Sir Frederick Hooper found a solitary flowering specimen of the Marsh Helleborine *Epipactis palustris* (L.) Crantz on the Headland dunes (see Blakeney Point Report for 1914, page 14).

FERNS

FILICALES

Polypodiaceae

Asplenium adiantum-nigrum L. Black Spleenwort

In June 1970 Dr. F. B. Goldsmith found an *Asplenium* growing on the Headland dunes, which at the time was thought to be *A. marinum*. Later in the year, by which time the sporangia were better developed, doubts arose about the specific identity of this plant. A frond was submitted to Mr. A. C. Jermy who determined the plant as *A. adiantum-nigrum*.

The plant was growing mingled with a patch of *Polypodium vulgare*. It had three fertile, current year's fronds. There were also several dead fronds from the previous year so that the plant was certainly two years old. From its size this plant may well have been several years old.

Although this plant has not been recorded from Blakeney Point before it occurs on Scolt Head Island (Chapman, in Steers, 1960).

Dryopteris dilatata (Hoffm.) A. Gray. Broad Buckler-fern

Hitherto only recorded from the Hood, where it is spreading. In 1970 it was found growing in a small depression on the dune forming the "outlier" of the Long Hills"

Ophioglossaceae

Ophioglossum vulgatum L. Adder's Tongue

In June 1970 Mr. R. W. Laycock found a patch of this fern on the Hood. There were some 40–50 plants, somewhat yellow-green in colour and a bit attenuated,

possibly as a result of the height of the surrounding vegetation. The patch was not far from the big patch of ferns (which is mainly *Dryopteris dilatata* with a little *D. filix-mas*). The vegetation in which the *Ophioglossum* occurred is indicated by the following list.

Carex arenaria	a
Ammophila arenaria	f, in poor condition
Luzula pilosa	
Hypochaeris radicata	
Festuca rubra	
Agrostis stolonifera	
Dicranum scoparium	
Hypnum cupressiforme	
Dryopteris dilatata	

Ophioglossum has not been recorded on the Point before. It is not listed for Scolt Head Island (Chapman, in Steers, 1960).

In 1971 I did not find so many plants, but those present were sporing.

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1971 WEATHER SUMMARY IN NORFOLK

By T. B. Norgate

JANUARY. Though a dull month, most of the county was rather warmer than usual – about 1°C., with a mean of 4°C. The maximum was nearly 12°C. inland and 10½°C. on the coast. Ground frost was recorded 13 times and air frost 9. Sunshine amounted to 34–35 hours compared to an average of just over 50, fog on 7 or more days being partly responsible. Rainfall was largely confined to the last 10 days and was 25 per cent on the high side on the coast and up to 50 per cent inland. Snow fell on 2 or 3 days.

FEBRUARY. This was a much drier month and the driest since 1963, nowhere in the county recording 30 mm. and it included snow on three days. Temperatures were slightly above normal inland though ground frosts were measured on 17 nights. Sunshine was just double that for January, 70–75 hours and about 10 per cent above the usual. The mean temperature was 4½° to 5°C. (inland *versus* the coast) and almost exactly our average. Fog occurred on 3 to 4 days.

MARCH. In conformity with the apparent recent trend, this month was colder than normal, 5½°C. instead of 6½° with frosts on 16 or 17 nights culminating in more than 9° below (on the ground) on the night of 5/6th. Sunshine was a little over 100 hours against an expected 125. Rainfall was about average in the south of the county, i.e. 40 mm. but rather less in the north. Snow fell on 5 or 6 days in the first week, up to 75 mm. (3″) deep in central Norfolk whereas the last week was dry and much warmer.

APRIL. The month was notable for a dearth of sunshine, 120–125 hours compared with 150–160, though 12 hours was recorded on the 21st. In consequence the mean temperature was only 7°C. instead of the usual 8° and ground frosts were experienced as many as 12 times, inland. On the 22nd a maximum of 21°C. was just exceeded after an overnight temperature of —2°. It was the third successive dry month and the driest April in central Norfolk since 1948 with only 16 mm. in some places and almost 50 per cent of expectations. A drought was experienced in many parts – broken by a thunderstorm. In addition to the shortage of rainfall, against the average, a further 25 mm. nett deficiency must be allowed for due to transpiration losses.

MAY. Another rather dry month especially south of Norwich, the Waveney valley having under 18 mm., or half the usual amount, whereas the extreme west of the county had over 50 mm. A mean temperature of 11°C. was only ½° below average and it was notable that a ground frost was measured 9 times and even an occasional air frost. Sunshine hours amounted to 235, about 10 per cent above normal. Two thunderstorms occurred during the month.

JUNE. The mean temperature was a little over 12°C. and almost 2° below normal and it was the coldest June for 40 years in some parts of the country. Though there were no frosts, the grass minimum fell to a little over 2° short at the very end of the month and the maximum only touched 21° once. Hail fell on 2 or 3 days and thunder was reported on 7 days. Rainfall varied from 40 mm. on the coast to 90 mm. towards Breckland and 45 mm. in the Norwich area, or

about average. Sunshine hours were under 150 inland, 50 hours less than the normal and though the coast fared a little better it was a cold, dull, miserable month. An upper air jet-stream from the north-west was noted at the end of the month – travelling at an estimated 140–150 k.p.m. (90 m.p.h.) – bringing in Arctic air.

JULY. This month made some amends by logging over 250 hours sunshine, as much above average as June was below, though the coastline was not quite so favoured as inland on account of 4 or 5 foggy days. The mean temperature of 16½°C. inland was slightly above normal and the 11th had the highest maximum for 10 years, exceeding 28°C. A week later the minimum was but 2°C. on the ground. Thanks to several thunderstorms rainfall was very uneven and mostly fell on 4 days during the last week and nearly three weeks drought started the month in some places. A parhelion was observed on the 21st.

AUGUST. Again thundery activity on 6 days caused an uneven distribution of rainfall and most parts of the county exceeded their average. The writer recorded some rainfall on every day for the first fortnight. Previous Augusts in recent years have been on the cool side but this year the mean was 16½°C., just about the normal while the maximum exceeded 24° four times. Despite this it was a dull month with only 145 hours sunshine inland (40 hours short) but the coast reached 160 hours which is about 15 per cent low.

SEPTEMBER. This was a much more cheerful month with up to 180 hours sunshine inland and even 190 on the coast, both nearly 25 per cent above average. Though the maximum temperature exceeded 22°C. on 5 days, in the middle of the month the first frost of the autumn occurred (only ½°) on the ground, and within 3° of freezing in the air. The mean was nearly 14° or about normal. Rainfall was only ⅓ to ½ of the usual for September with three weeks drought to begin with. The last week experienced thunderstorms, especially East Carleton where 38 mm. of rain fell on the 27th in 2 hours and some hailstones up to 50 mm. diameter (2″) while a few miles away it was dry. A sun-pillar was seen at sunset on the 15th and a parhelion on the 22nd.

OCTOBER. Another pleasant month with nearly 140 hours sun inland (25 per cent high) and the best for 12 years, but slightly less on the coast. Coupled with the sunshine, the mean (screen) temperature was just over 11°C., 1° above normal – despite 4 air frosts and 6 ground. Rainfall was again on the low side, especially on the northern fringe of the county and was confined to 7 or 8 days in the middle of the month, finishing with a hailstorm on the 20th. Central Norfolk had under 50 mm. or 75 per cent of expectations and there was a faint lunar halo at the end of the month but the rain that approached petered out before reaching East Anglia.

NOVEMBER. After a start of 4 days each with maxima of 15°C. or above, the month finished with a mean of only 5½° (1° below average) and ground frosts were recorded 13 times in the centre of the county, 16 times in the Waveney valley area and only 6 times on the coast. Inland a maximum of but 1°C. was measured on the 19th when winter can be said to have started. Thunder, lightning, hail and snow all were experienced on 2 or 3 days, the latter 63 mm. (2½″) deep on the 19th. Rainfall, including of course the snow, was double the usual in some places, Shotesham, Dereham, Fakenham and Hingham all having over

130 mm. Few had under 75 mm. including Bacton and the Fens. Though fogs were less frequent than usual, only 80 hours sunshine was reported representing 80 per cent inland and only 50 per cent of normal on the coast.

DECEMBER. Strangely this month was slightly warmer than the last with a mean of nearly 6°C. and more than 1° above average, with fewer frosts (5 or 6 air and 10 ground). Snow and hail fell just before the New Year but did not last. The first 18 days of the month had no rain to speak of – a claim that few Decembers can boast – the total was thus only a little over 50 per cent in mid-Norfolk with still less in the south-west of the county, 40–25 mm. respectively. Sunshine was about 75 per cent of the average, about 35 hours, half of it in the last week along with the colder weather.

THE YEAR. Apart from January, August and November the other months had less than their usual amounts of rainfall in large parts of the county, though June was only fractionally so. Mid-Norfolk with 570 mm. (a little over 22″) was about 13 per cent down, but the shortage is really worse than this when due allowance is made for "potential transpiration" losses. According to figures prepared for Morley St. Peter by the end of the summer there was a net deficiency of 190 mm. (7½″). We were not the only "sufferers", as by the end of October it was reported that the Rhine was within 1″ of its ever-known lowest level. So far as Norfolk is concerned it was the driest year at Taverham since 1962.

The overall mean temperature was almost exactly the average, i.e. 10°C., and it is interesting to note that there was virtually no difference between the seaside and inland temperature. The former was a degree or two warmer in the winter months but in the summer it was reversed. It was a late spring, and it was not until the middle of the first week of April that the mean daily temperature reached a figure of 5.6°C. (with a few lapses a little later). Plant growth then begins and spring can be said to have started, in this case about a fortnight late. Though the arrival of winter was also late, most of December recording "growing days", the damage was done by two cold spells in November.

The warm and extended autumn caused oaks and other trees to retain their leaves later than usual and it was almost bizarre to see them still in leaf during an appreciable snowfall. The late leaf fall even interfered with sportsmen's chances to get pheasants to take flight.

The sunshine total for the year, just over 1,500 hours, was only 1 per cent below normal, but this is an over-simplification. November was nearly 40 per cent brighter than usual, July, October and September, too, in descending order. And with the reduced rainfall during the two latter months, farmers were able to get on well with their after-harvest work – cleaning stubble and drilling winter corn. Sugar beet responded well to the clement autumn. Snow fell on 31 days in the year in central Norfolk (counting sleet as half a "snow-day") which is just about the average for the last 22 years and much better than 1970 which claimed a figure of 41 such days. Thunder was heard on 20 days in the year compared to a 20-year average of about 12 days. But they were seldom severe (except that in September), and did not therefore help to make good an overall slight shortage of rainfall.

Parasites of Mussels

A recent survey of the common mussel *Mytilus edulis* collected from Stiffkey Marsh (55 and 19 individuals) and West Runton (25 individuals) suggested the absence of the copepod parasite *Myticola intestinalis* from both populations. Comparative material (35 individuals) of *M. edulis*, provided by the Marine Biological Association laboratory at Plymouth was found to contain some 63 individuals of *M. intestinalis*, both male (23 individuals) and female (32). Nine of the females carried paired egg sacs.

Peculiar to the Stiffkey population of *M. edulis* was an echinostome digerean parasite found encysted in the foot. This was present in all 19 individuals of *M. edulis* examined. Successful artificial excystment of two echinostomes was achieved following the method of Howell, M. J. (*Parasitology*, 58, 573–82), the specimens obtained possessing a single anterior ring of 27 spines, linearly arranged about one large central spine. No formal identification of the parasite was achieved.

Roger Mann,
University of East Anglia.

Eggs of the Silky Snail

The Silky Snail, *Monacha granulata* Alder, normally pairs in the late autumn when two or three eggs are laid by each individual. At Wheatfen Broad the snails appear to carefully select their sites for oviposition and most eggs are laid in the basal parts of the broad leaves of the Yellow Flag Iris. The eggs measure over 1 mm. in diameter and are very conspicuous as crystalline white spheres against the blackened peaty ground litter. The Silky Snail overwinters mainly in the egg stage and the numbers of eggs failing to hatch is remarkably small, usually under 6 per cent of the total numbers laid. The snails hatch from the eggs in the April–May period and live for about eight months.

R. E. Baker

Woodlice of an Urban Refuse Tip

In the first week of January 1969, when there was snow on the ground, disturbance of steaming compost on the Harford refuse tip at Norwich revealed numerous colonies of the warmth-loving woodlouse *Metopornothus pruinosus* (Brandt) associated with house crickets. Three adults were placed with moist earth in a transparent plastic box and kept under observation. They were supplied from time to time with living and dead leaves, soil algae and mouldy cheese and newspaper. They were seen to eat only microscopic algae and fungi while living under these conditions during the next three months. Each woodlouse excavated a separate "lair" in the soil, with a narrow passage leading to the surface, and although all took meandering walks, especially at night, each concentrated its browsing in a particular area. By April, numerous young had been produced and these were white and slightly over one millimetre long on 2nd April. The adults were found to retain their pinkish-grey "bloom" however much they came in contact with wet, sludgy material.

A Bush Cricket eating its own eggs

On 11th October 1969 a female bush cricket, *Pholidoptera griseoaptera* (Degeer) was seen straddling a hazel leaf alongside a path at Wheatfen Broad, Surlingham,

late in the afternoon. It was observed to raise itself on tip-toe, with the body quivering. The abdomen was then flexed downwards, bringing the ovipositor into use and a viscous white body which appeared to be an egg was extruded on to the leaf surface. During this operation the insect's head was bent underneath as though it was watching the egg-laying procedure. The insect then moved backwards a little and devoured the egg. Two further eggs were laid and eaten as before during the next fifteen minutes.

Threat display of a pale Tussock Caterpillar

On 1st October 1969, at Rockland St. Mary, a full-grown larva of the Pale Tussock Moth (*Dasychira pudibunda* (L.), when faced at close range by a camera lens, reared up, gnashing its jaws, while the posterior section of the body lunged forward with the red tail plume projecting like a scorpion's sting. Immediately after this initial threat display the insect underwent a series of violent contortions in which head and tail almost touched like the tips of calipers seven times in rapid succession.

Spider's web anchored by pebbles

On 5th October 1970, I inspected a web occupied by a large female garden spider, *Araneus diadematus* (Clerck) beneath the eaves of a bungalow at Thorpe-next-Norwich. The web was ballasted by a flint pebble suspended three inches above the ground on a strong thread approximately six feet long. A fairly strong wind was blowing at the time and this caused the stone to swing like a pendulum. When the thread was severed above the anchor the whole web collapsed. The pebble was later found to weigh 1.333 grammes. The occupant of the bungalow had reported that several such pebbles had been used in the same way by this spider each time the web was destroyed. On one occasion the flint stone was left hanging three feet above the ground, where it dangled and was dashed against a window by a gust of wind, slightly cracking a pane. I was shown the damaged window.

E. A. Ellis

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NOTES TO CONTRIBUTORS

1. All manuscripts submitted for publication should be sent to Dr. E. A. Ellis, Wheatfen Broad, Surlingham, Norwich.

2. Manuscripts should be typed double spaced on one side of the paper. Latin names of genera and species should be underlined. Dates should be in the form 1 January 1972. Text figures should be referred to as Fig. 1, etc.

3. All Latin names should be followed by the authority when the name is first mentioned in the text or table.

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