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WILDLIFE 2000

During its 125th anniversary celebrations, the Norfolk and Norwich Naturalists' Society announced its intention to document the wildlife of Norfolk for the start of the new millenium in a project called **Wildlife 2000.** In practical terms the project was launched in May 1995 when representatives of the Society, English Nature, Norfolk Wildlife Trust and the Castle Museum met and agreed to share this common vision.

Sir Thomas Browne has given us a fascinating glimpse of seventeenth century wildlife in the County of Norfolk. He writes of bustards, storks, ravens and kites; salmon and otters; and the mole cricket which he describes as common in "*fenny places.... and dunghills and churchyards in this citty*."

Nineteenth century records of the mole cricket from Castle Acre and Stoke Holy Cross suggest a lingering presence for this species in river flood plains across the county, but we are left tantalisingly ignorant of its historic distribution. How widespread was it, how abundant where it did exist, and until how recently did it survive?

Wildlife 2000 is a project designed to ensure that twenty first century naturalists will have the answers to the equivalent questions they might ask about our flora and fauna, as they approach the end of their own century.

Wildlife 2000 seeks to create a "time capsule" which will preserve our knowledge of the countryside, and what could be found in it at the start of the third millenium. The project is not just concerned with nature reserves and rare species, but seeks to give an accurate account of the wider countryside and the commoner species which abound within it.

Just as the mole cricket was common in Thomas Browne's day but is now lost, so any other creature or plant which we take for granted could become rare or extinct over the next century. By documenting the wildlife heritage which we pass into the care of the twenty first century, those who come after us may be in a better position to preserve and protect that legacy.

In this issue of the *Transactions of the Norfolk and Norwich Naturalists' Society* two papers reflect the aims of the **Wildlife 2000** project. Derek Howlett and Roy Baker in their paper *Freshwater Bivalve Mollusca of Norfolk* look back over the 20th C. at the status of Norfolk mussels and examine the current distributions and the factors affecting them at the turn of the century. Keith Clarke follows a similar format in reviewing *Norfolk Centric Diatoms*. His paper is illustrated with scanning electron microscope photographs which reflect the changing technologies of the late 20th C.

WILDLIFE 2000

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DEATH IN THE WILD - ALL GLOOM AND DOOM?

THE PRESIDENTIAL ADDRESS DELIVERED TO THE SOCIETY ON 13th JANUARY 1998

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When I was eight years old my ambition was to be a naturalist, but my father pointed out that this would not enable me to earn a decent living. "Why not become a vet. instead?" he suggested. With the honour that the Society has bestowed upon me by electing me as President for 1997/98 I now feel that at last I have fulfilled my original ambition.

It appears to be traditional for the Presidential Address to contain some autobiographical details:- I spent most of the first 18 years of my life at Foxley, (except when I was boarding at a preparatory school in Bacton). Until I was called up during the war my habitat was the Street Meadows and Foxley Wood. At the age of 13 I went to Norwich High School for Boys (now Langley School). When studying Botany and Zoology for my Higher School Certificate I came under the influence of the late Mr Henry Howard, one of Norfolk's leading naturalists. He gave me much encouragement when I chose an area of Foxley Wood for an ecological project. After leaving the army, I was accepted by the Royal Veterinary College of London University, from where I graduated in 1952. Although I was proud to become a veterinary surgeon, I was still a biologist at heart and disappointed that the course did not include more information about non-domesticated animals. Together with a like-minded friend who graduated with me, we vowed to make the study of diseases of these species our main career. We planned a mobile field laboratory in which we could tour the country treating and saving sick and injured wild animals and investigating unusual mortality. At the time, this was seen by most veterinarians with whom we had contact, as crazy and impractical! Oil

slicks and chemical pollutants were unforeseen future problems and even road casualties went unnoticed in those days when all kinds of wildlife were plentiful and combustion engines relatively few in number. However, we were not easily discouraged, and decided to appeal for help to Dr W. R. Wooldridge, a famous veterinarian, who founded the Animal Health Trust at Newmarket. He gave us a sympathetic interview at his offices in London, but to our dismay made us realise that we needed more experience before we could hope to embark on such a project. However, he took us seriously (unlike everybody else!) and we left him determined that eventually we would make wildlife disease our career. Thanks to persistence and an element of luck, I eventually succeeded with that ambition.

I spent my first year as a vet. in practice doing *locum tenens* work in various parts of the country including Yorkshire, near where "James Herriot" was working. I had similar experiences! To my surprise, I soon realised that, in spite of my country upbringing, farm animal work was not for me. After two years in small animal practice in London, I decided that suburbia and town life were also not my scene! In 1956 I left veterinary practice and joined the Ministry of Agriculture, Fisheries & Food (M.A.F.F.), Central Veterinary Laboratory in Surrey, to become a Research Officer, where I was trained in avian pathology. Fortunately the Deputy Director, Dr E.L. Taylor, was a keen naturalist and he encouraged me to write my first two scientific papers on diseases of wild birds (Keymer, 1958a, 1958b). After six years there, I joined the London School of Hygiene & Tropical Medicine and led three expeditions to Central Africa (one with the British Museum [Natural History]) to study infections of wild mammals communicable to humans. It was at this postgraduate medical school that I obtained my Ph.D. In 1966 I was appointed Pathologist to the Zoological Society of London where I necropsied all mammals, birds, reptiles and amphibians and many of the fish which died in the Society's collections. In 1976 Norfolk called me home and I rejoined the M.A.F.F. by becoming a Veterinary Investigation Officer at the Norwich Veterinary Investigation Centre. Since early retirement in 1986 I have continued to pursue my paid hobby, by doing consultancy veterinary work. This has included investigating penguin mortality in the Falklands and working in

Saudi Arabia, New Zealand, Australia and the United Arab Emirates.

As wildlife disease is such a vast topic I am limiting this contribution to aspects of most relevance to naturalists. I shall concentrate on diseases in Norfolk's wildlife (except fish) which pose a possible threat to the species concerned. I shall also deal briefly with those diseases which are communicable to humans (zoonoses) and are also a possible threat to domestic animals and other species. "Disease" can be defined as the "Discernible response of any body tissue to any form of damage caused by infectious or toxic agents, hormonal or other internal or external disorders (including genetic abnormalities), radiation and physical injuries".

Non-infectious causes of wildlife mortality

I am sure that by now many people realise that in Norfolk (and many other places) habitat destruction, such as excessive water abstraction, removal of hedgerows, the autumn ploughing of stubble, winter sowing of some crops and agricultural monocultures, are indirectly, all serious causes of wildlife mortality. These activities lead to starvation and/or dispersal of many species.

The effects of hunting, shooting and fishing are less clear and indeed can be beneficial, because they depend on habitat conservation which is essential for species diversity of plant and animal life. However unpleasant and cruel these blood sports may appear to some people, their prohibition could have disastrous effects on wildlife, because many farmers, would no longer consider it financially justifiable to maintain hedges, spinneys, streams etc for the benefit of game and other species.

There is a multitude of other man-made activities detrimental to wildlife, none of which is peculiar to Norfolk. Some of these are selective for certain species. Rabbits (*Oryctolagus cuniculus*), hares (*Lepus europaeus*), otters (*Lutra lutra*), badgers (*Meles meles*), hedgehogs (*Erinaceus europaeus*) and toads (*Bufo bufo*) appear to be especially vulnerable to death and injuries on the road. Between 1976 and 1986 I counted the numbers of dead hedgehogs and hares on a 18 mile stretch of the B1149 between Edgefield and Norwich Airport. The total was 370 hedgehogs

(Keymer, *et al.*, 1991) and 78 hares. I undoubtedly missed some. These were high figures for a country road, but probably much lower than for similar roads in other more populated areas of the United Kingdom. Since then, there has been a considerable increase in traffic, which may have had a significantly adverse effect on the population of some species. However, although some may have been adversely affected in this way, there is evidence that the carcases may have benefited carrion feeders especially magpies (*Pica pica*) and carrion crows (*Corvus corone*). Discarded fishing lines with hooks attached and collision with overhead power lines often cause injury and death to swans (*Cygnus* spp.). Otters perish in fyke nets (Jefferies, *et al.*, 1993) used for catching eels (*Anguilla anguilla*). Cetaceans such as dolphins (*Delphinus delphis*) likewise drown in fishing nets around our coasts (Kuiken, *et al.*, 1994a).

The list of anthropogenic hazards (Sainsbury, *et al.*, 1995a, Kirkwood *et al.*, 1994) is almost endless and unfortunately increases as human beings multiply. Oiling of marine life progresses unabated and toxic chemicals (eg. heavy metals and polychlorinated biphenyls [PCBs]) in the environment continue to be a problem in some situations. Fortunately, accidental poisoning by agricultural pesticides appears to be less of a hazard than previously, at least in the UK. However, the effects of horticultural pesticides used in gardens needs monitoring. They may be causing more wildlife mortality than is realised. Metaldehyde, a molluscicide commonly used in gardens, can certainly poison hedgehogs (Keymer, *et al.*, 1991). Unfortunately, deliberate, illegal poisoning of some predators still occurs. Legally available substances such as alphachloralose, organochlorine pesticides, carbamates, metaldehyde and strychnine are used and even mevinphos (an organophosphorus compound) which was withdrawn from the market over three years ago. Surprisingly, a permit can still be obtained to use strychnine (an unpleasant substance causing convulsions) in order to kill moles (*Talpa europaea*), without any noticeable protestations from members of the public. Rats (*Rattus norvegicus*) and other rodents are still killed legally using anti-coagulant poisons which also cause severe pain. Many people, however, object most strongly to killing foxes (*Vulpes vulpes*) and hares by a much quicker and more humane method using hounds! Thousands of people injure fish (the skin of which is plentifully

supplied with pain receptors) with a hook on the end of a fishing line, haul them out of the water and often let them suffocate to death, but virtually nobody seems to bother, even when live baits are used. However, in their defence, it must be said that people who fish are the guardians of water quality in rivers, lakes and the sea.

We have long since reached the stage where not only habitats have to be managed by such methods as tree felling to preserve heathland, but some species of wild animals have to be controlled as well. These are facts which country people accept and understand. Unfortunately millions of people now live in an urban society where they are not exposed to the natural cycles of life and death, so that hypocrisy, ignorance and anthropomorphism thrive.

Even when modern man attempts to benefit wildlife instead of killing it, he may unwittingly cause problems (Kirkwood & Sainsbury, 1996). An example is feeding wildlife in the garden. The concentration of birds in one place for extended periods assists predators such as domestic cats and sparrowhawks (*Accipiter nisus*). Areas around bird tables become contaminated with excreta and this can lead to outbreaks of infectious disease (Kirkwood & Macgregor, 1997) especially salmonellosis (see later). If suspended peanut containers are not kept clean and periodically sterilised, there is a risk that damp nuts in the bottom of the feeders will go mouldy. If birds eat these contaminated nuts they are at risk from fungal diseases such as aspergillosis (*Aspergillus fumigatus* infection) and mycotoxicosis caused by toxin producing fungi. Keymer & Hime (1977) suspected that excessive feeding of nuts (which have high phosphorus and low calcium contents) may have caused a metabolic bone disease similar to rickets, in a free-living red squirrel (*Sciurus vulgaris*).

Some of the activities of well meaning people running captive breeding centres or treating sick and injured wild animals can prove harmful to wildlife (Sainsbury, *et al*.,1995a; Kirkwood & Sainsbury, 1996), in addition to the commonly recognised problems of releasing species back into the wild, such as finding a suitable habitat and overcoming territorial disputes with animals already in possession of a territory, the possible introduction

of infectious agents to the wild population has also to be considered (Kirkwood 1993). Duff (1993) drew attention to the risk of salmonellosis being spread by captive barn owls (*Tyto alba*) destined for release into the wild, as the result of feeding them day-old domestic chicks. I isolated *Salmonella binza* a poultry pathogen, from a free-living otter in Norfolk which had probably been exposed to day-old chicks that had been fed to nearby captive otters (Keymer, 1993).

Infectious causes of wildlife mortality

It used to be thought that infectious disease did not pose a significant threat to the survival of wild populations. However, now that some species have declined to dangerously low levels or have become isolated due to restriction of suitable habitat, this view has to be questioned, and the role of infectious disease seriously investigated. Important, predisposing causes of infections are starvation and over population, both of which can lead to stress and increase the susceptibility of animals to disease. These and other factors are discussed below.

All vertebrates normally harbour an immense variety of protozoan and metazoan (mainly arthropods and helminths) parasites, most of which under ordinary circumstances cause little or no adverse effect on their host. Most parasites only become seriously pathogenic when their hosts' resistance has been lowered by some other pathogen or by starvation. Corbet & Harris, (1991) have provided a good source of information on parasites of British and other European wild mammals.

Strictly speaking, some fungi, bacteria and viruses are also parasites, although some are normal inhabitants of the body. However, many of these organisms, especially bacteria and viruses, are pathogens or potential pathogens. Their pathogenicity depends on a variety of factors including the susceptibility of the species of animal which they infect.

The threat of disease, especially infections, to populations of wild animals.

Under some circumstances infectious disease appears to play a role in adversely affecting populations of free-living animals. It is seldom the sole cause and its importance is difficult to assess.

Mammals.

Lagomorpha. When first introduced into this country in 1953, the virus causing myxomatosis had a devastating effect on the rabbit population and also affected the populations of other species. At first, buzzards (*Buteo buteo*) corvids, stoats (*Mustela erminea*) and foxes benefited from the plentiful supply of sick and dead rabbits, but wheatears (*Oenanthe oenanthe*) and stock doves (*Columba oenas*) lost the burrows as nesting sites. The lack of close grazing by rabbits especially in the Brecks had a marked effect on the vegetation and deprived lizards (*Lacerta vivipara*) of basking areas. Some plants thrived and others declined and this affected insect life such as butterflies. As rabbits developed immunity to the infection, their populations have slowly recovered, although we are not yet back to the pre 1950s situation.

Rabbit viral haemorrhagic disease (RVHD) caused by a calicivirus is a recent infection. It was first recorded in the U.K. in domestic rabbits in 1992 and in Norfolk in 1994 at Great Yarmouth. It was in 1994, in Kent and Devon, that it was first diagnosed in wild rabbits. It has not yet been confirmed (February, 1998) in wild rabbits in Norfolk, but in 1996 was diagnosed at Six Mile Bottom near Newmarket in Suffolk (R. Trout, pers. comm.,1998). Unfortunately the MAFF withdrew notifiable status of the disease in October 1996 making it more difficult to trace its spread. I have already speculated (Keymer, 1995a) on the possible effects of this infection on our wild rabbit population in the 1994 *Norfolk Bird & Mammal Report*. Hopefully, as far as conservationists are concerned, the disease will have less environmental impacts than myxomatosis, because recent research has shown that a proportion of healthy wild rabbits had antibodies to a non-pathogenic strain of the virus prior to the disease being confirmed in the UK (Chasey, *et al.*, 1997). These workers have shown that such seropositive rabbits are protected from the pathogenic form of the disease.

The calicivirus which causes the European Brown Hare Syndrome (EBHS) is very closely related to, but distinct from, the calicivirus which causes RVHD. It poses a similar threat to our hare population as RVHD does to rabbits. This is because a non-pathogenic strain of EBHS has been shown to have been present in hares prior to confirmation of the first outbreaks of

the disease in 1989 (Duff *et al.*, 1994; Duff *et al.*, 1997). I also briefly mentioned this infection in the 1994 *Norfolk Bird and Mammal Report* (Keymer, 1995a). In addition to this disease, hares often succumb to so-called grass sickness (dysautonomia), which is well known in horses and may be due to a naturally produced neurotoxic agent in pastureland (Griffiths & Whitwell, 1993). Hares are also susceptible to viral fibromatosis. I suspected this infection in Norfolk on several occasions between 1978 and 1984 and was able to confirm it for the first time in the UK in a hare from Shropshire in 1985 (Keymer, 1995b). *Yersinia pseudotuberculosis*, a bacterial infection, and especially coccidiosis caused by *Eimeria* sp. protozoa are also not uncommon. As stated previously, stress can predispose susceptibility to infections and this is probably especially true when high densities of hares occur in the autumn.

Hares have declined in many parts of England due to loss of suitable habitat and possibly disease. If hare hunting and coursing become illegal, it is likely that some farmers will not tolerate this species on arable land as they have done previously. Populations will then become isolated, making them more vulnerable to the effects of disease. In addition to road accidents, the species is also highly susceptible to paraquat (a herbicide) poisoning. The future of hares in this country is therefore uncertain.

Rodentia. Without doubt the infection of most importance to the survival of a rodent species is parapox infection of red squirrels. I have discussed the history of this disease in some detail in the 1994 *Norfolk Bird and Report* (Keymer, 1995c). Since then, it has been shown that grey squirrels (*Sciurus carolinensis*) can succumb to the disease (Duff, *et al.*, 1996). An antibody serological test has recently been produced (Sainsbury, *et al.*, 1995b) so that it will soon be possible to bleed and test both species in the wild and detect where there are likely to be individuals most susceptible to the infection or where populations are already infected. Red squirrels appear to be more susceptible to infectious diseases than greys (Keymer, 1983) and, in addition to parapox, are sometimes affected by coccidiosis caused by *Eimeria sciurorum* and toxoplasmosis caused by *Toxoplasma gondii* (both protozoa). It has been noted that, in the presence of grey squirrels, the reds are very vulnerable not only to disease, but also appear

to be unable to compete with the more aggresive greys for food. The future for the red in many areas of the UK and especially for the remnant population in Thetford forest on the Norfolk/Suffolk border looks bleak.

Camivora. Although otters in Norfolk and some other areas have been more common during the last few years, following their reintroduction by the Otter Trust at Earsham, there has been a worry whether otter populations can be maintained indefinitely (Mason & Macdonald, 1993). This is because of the possible adverse effects of organochlorine (OC) pesticides and PCBs in the environment. It is believed by some researchers that these chemical contaminants previously played an important role in the decline of otters. However, recent research by Mason (1998) has provided evidence for optimism, because as the result of analysing livers and muscle from 32 otters found dead between 1983 and 1992, he has found a decline in total PCB concentrations in these tissues. He believes that PCBs are now unlikely to pose a threat to otter populations. Nevertheless, the pathogenic role of PCBs remains controversial (Mason, 1997 and Kruuk, 1997). Kruuk has pointed out that provided the "habitat is sufficiently rich in resources, an otter population can sustain heavy mortality from whatever source" (including possible PCB toxicity) "as long as the animals can reproduce fast enough". Kruuk (1997) believes that there is no convincing evidence that PCBs "are adversely affecting otter populations". We might now have a clearer picture of the toxicity of PCBs and OC pesticides, if instead of relying entirely on the chemical analyses of otter tissues, the recommendations of Keymer, *et al.*, (1988) had been carried out, namely that detailed systematic, pathological examinations should be done on otter carcases, in conjunction with chemical analyses. It is clear that more research needs to be done on this complex problem.

Pinnipedia. In 1988 heavy mortality occurred in common seals (*Phoca vitulina*) in the North Sea due to phocine distemper (a morbillivirus infection). A survey suggested that the mortality in the Wash and Blakeney Point areas alone probably amounted to 60% (McConnell, 1989). Relatively few grey seals (*Halichoerus grypus*) were affected and they appear to be less susceptible. The precise cause of the outbreak remains unknown. It may not be related to pollution as originally thought (Kuiken, *et al.*,

1994b). The seal population was very high at the time and this may have been a contributory factor. Fortunately the disease has not reoccurred, but it remains to be seen what happens if the seal population continues to increase.

Birds.

During the period of the 1950s-1960s especially, poisoning due to agricultural pesticide OCs was an important cause of morbidity and mortality in a wide range of seed-eating species. Numerous game birds, pigeons and passerines were affected. However, some predatory animals especially birds which fed on these species, also became indirectly affected. The decline of the sparrowhawk during this period is well known. Not only did individuals become poisoned, but those that survived, laid thin shelled eggs, leading to egg breakage, also many incubated eggs failed to hatch (Ratcliffe, 1970; Newton, 1974).

Botulism caused by a potent toxin produced by the ubiquitous *Clostridium botulinum* bacteria was first recognised in the UK in 1969 in the Midlands by Blandford, *et al.*, (1969) and in London by Keymer, *et al.*, (1972). It has been a common cause of death in waterfowl during long hot summers ever since. They are mainly affected when they ingest the toxin in mud and water whilst feeding. Insectivorous species can also become poisoned by eating maggots (which are unaffected by the toxin) that have fed on the carcases of poisoned waterfowl and other birds. The bacteria can only produce toxin under anaerobic conditions and when the temperature of the water rises to at least 37 degrees centigrade. Similar conditions encourage the growth of poisonous cyanobacteria (so-called blue green algae). By carrying out a retrospective study Roberts, *et al.*, (1972) demonstrated that botulism probably also first occurred in the Broads in the hot summer of 1969. This coincided with the start of the deterioration of water quality in the Broads caused by eutrophication. If prolonged hot summers occur frequently, it remains to be seen how much longer aquatic birds in affected habitats can tolerate this type of heavy mortality. The disease sometimes occurs in gulls (Laridae) as the result of feeding on rubbish dumps which can provide suitable conditions for toxin production. Many outbreaks of mortality in aquatic birds are not now investigated on the assumption they

are due to botulism. This is unfortunate, because sometimes other causes may well be involved and overlooked.

Lead poisoning especially in mute swans (*Cygnus olor*) caused by the ingestion of discarded lead fishing weights was a frequent cause of swan mortality, until the use of lead weights weighing between 0.07g and 28.35g was banned in July 1987 (Environment Agency, 1997). However, it still occurs because the lead weights remain in many aquatic environments and are eaten by birds which mistake them for grit. The lead then becomes ground up in the gizzard and absorbed.

Lead poisoning can also occur in game birds due to the ingestion of lead gunshot pellets (Keymer & Stebbings, 1987) and is easily overlooked. Poisoning of this type has been a serious problem in North America for many years. The situation in this country needs to be watched closely especially where clay pigeon shooting takes place frequently in strictly confined areas.

Reptiles and Amphibians.

There is little information available concerning the diseases of free-living species. However, Cunningham, *et al.*, (1993) have described heavy mortality in frogs (*Rana temporaria*) associated with poxvirus-like particles in several parts of south east England, two unconfirmed cases of which occurred in Norfolk. However, more recently Cunningham *et al.*, (1996) have shown that iridovirus-like particles are also involved. The syndrome is manifested by either skin ulceration or systemic haemorrhages, and sometimes by a combination of both.

Threat of disease in wildlife to man, domestic and other animals

Many infectious diseases of wildlife are capable of infecting humans, domestic and other animals. It is important, therefore, for bird ringers, mammal trappers, fishermen, shooters and all persons handling or eating game and other free-living species to be made aware of the possible risks (however slight) and take suitable precautions (Kirkwood & Macgregor, (1997).

Viral diseases. In the UK relatively few animal borne viruses pose a threat to humans. Avian influenza viruses have been isolated from some species of wild birds and are a potential threat to humans and some domestic animals. This is because they can mutate and produce very pathogenic strains, as the recent experience with a poultry strain of the virus has illustrated in Hong Kong.

Strains of parapoxvirus which cause pustular dermatitis (orf) in sheep and also infect seals (Nettleton, *et al.*, 1995; Simpson *et al.*, 1994) are infectious to humans. These viruses are closely related to parapoxvirus of squirrels, so care should be taken when handling infected squirrels in case this infection is also a zoonosis.

Bacterial and related diseases. These diseases are the most common ones to "jump the species barrier" and they are legion. Salmonellosis caused by a variety of *Salmonella* spp. is the most prevalent and widespread bacterial infection. *S. typhimurium* which often causes food poisoning in humans can infect almost any species of mammal, bird or reptile. Gulls and other birds feeding at sewage outlets, and rats which come in contact with sewage sometimes become infected. Several strains of the bacteria occur in small passerine birds and can be spread at feeding areas in gardens as already mentioned. Strains (phage types Nos. 40 and 160) found in greenfinches (*Cardnelis chloris*) have also been isolated from pheasants (*Phasianus colchicus*) and calves (Keymer, Unpublished). A strain of *S. enteritidis* (phage type 11) which occurs in hedgehogs (Keymer, *et al.*, 1991) can infect children and dogs. They are probably most at risk from contaminated faeces, because hedgehogs frequently inhabit gardens.

The avian strain of tuberculosis (*Mycobacterium avium*) is widespread in birds including game, and also occurs in deer, the meat of which is frequently used for human consumption. Although this strain of TB seldom infects humans, when it does, it is particularly serious. Carcases to be used for human consumption therefore need to be carefully inspected. *M. bovis* the bovine strain, is a well known human pathogen. In wildlife it is mainly restricted to the south west of England where it is locally common in badgers, in areas where the infection is also a problem in cattle. It has been

less commonly isolated from other species including moles, rats and foxes in that area. There is much controversy concerning the control of tuberculosis in badgers and cattle. A recent scientific Review Group chaired by Professor J. Krebs recommended even more research, but nevertheless states that "while most of it is indirect, the sum of evidence strongly supports the view that, in Britain, badgers are a significant cause of TB in cattle and that, in total, this evidence is compelling " (Anon. 1998). I think it is likely that badgers were originally infected by cattle. So far as is known badgers in Norfolk are not infected.

Pseudotuberculosis (usually caused by *Yersinia pseudotuberculosis* or *Y. enterocolitica* spp.) is common and widespread in a wide range of free-living birds (including game) and mammals, especially hares and several species of rodents. *Yersinia* infections also occur in hedgehogs, shrews (*Sorex* and *Neomys* spp.) and deer. Yersiniosis is a serious disease of humans and *Y. pseudotuberculosis* can cause symptoms resembling appendicitis leading to death if not treated correctly.

Leptospires of several species, some of which are human pathogens are widespread in wild mammals, including hedgehogs, moles, voles and other rodents, and foxes. Rats are a particularly dangerous source of *Leptospira icterohaemorrhagiae* which causes the potentially fatal Weil's disease, in humans.

A similar organism to that which causes leptospirosis, is *Borrelia burgdorferi* the cause of Lyme disease in humans and occasionally in some domestic animals. The organism is transmitted by sheep ticks (*Ixodes ricinus*) and is prevalent in Breckland, where it has been found to be carried by wood mice (*Apodemus sylvaticus*) and field voles (*Microtus agrestis*) (Keymer, 1995b) in addition to its usual host i.e. the roe deer (*Capreolus capreolus*). Although this is an unpleasant infection in humans (but fortunately can be easily treated, if diagnosed sufficiently early), it seems to have no adverse effects on the wild animals in which it has been found.

Fungal diseases. Ringworm is caused mainly by *Trichophyton* and

Microsporum spp.. These are widespread fungi inhabiting the hair and skin of a wide range of mammals and less frequently birds, without necessarily causing lesions. *Trichophyton mentagrophytes* var. *erinacei*, however, sometimes cause skin lesions in hedgehogs and can infect humans (Keymer, *et al*., 1991). Ringworm also occurs in squirrels.

This list of zoonotic infections is by no means complete and I have only dealt with those which are most likely to be encountered. If sensible precautions are taken when handling wild animals, the risk of contracting an infectious disease is small.

Conclusions

The future of wildlife is entirely in the hands of *Homo sapiens*. Much more research and more education of the general public, and the realisation of the importance of habitat protection are urgently needed, because the future of all life on this planet, including that of humans, is seriously threatened. Time is running out.

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ERNEST DANIELS - 70 YEARS A SOCIETY MEMBER

Alec Bull

During his early years, Ernest Daniels lived in Portland Street and, from the age of eleven, over the gas offices in Market Place. From his earliest days he was fascinated by wildlife and he spent long periods watching the perambulations of ants crossing and recrossing paths. There was no garden at the gas offices but before moving there he struck up a friendship with a boy of his own age whose father, James Sallow, a handgraver by trade, was one of the last of the old time collectors. James Sallow gave young Ernest every encouragement in his thirst for knowledge of the natural world, lending him books on various subjects. At a time when two boys could wander off and find out things for themselves without anyone worrying when they would be back, many a trip was made from the Market Place to the open countryside a mere twenty minutes away at than time. Caterpillars were brought home to rear and jars of pondlife, including tadpoles and many water creatures, were used for study. With no garden all rearing and studying had to be done in the bedroom. These studies were quite often curtailed by the death of the subjects, not by neglect but from the toxic fumes from the gas offices. The roadside verges were teeming with replacements. Drinker moth and garden tiger moth caterpillars were in abundance as replacements, though even when reared to maturity many proved to be parasitised so making the outcome of the study different to that anticipated. Nevertheless the countryside was a land of plenty. The balance of nature had always provided an abundance of wildlife and no one thought it could ever change, a theme that Ernest returns to frequently.

A further early source of inspiration was H.J.Howard of Norwich Castle Museum who instructed primary children in natural history once a week. Howard was an authority on Mycetozoa but he was also a wonderful all-round naturalist. He was a very good teacher of the young, an unpatronising speaker when addressing adults, and a Society President.

In spite of his first instructor having been a collector, Ernest has always been more a recorder and observer. He did have a few specimens of butterflies and other insects, but none of these have survived.

In the mid-1920's Ernest's horizons were widened with the possession of a bicycle. With friends he would set out for Breydon, for Salthouse and for Cley to go birdwatching. The chief drawback, Ernest recalls, particularly at Cley, was that the 'gentry', able to get there early by car, had blasted everything off the marshes and out to sea by the time the bicycling fraternity had arrived. This was particularly frustrating on cold, damp winter's days when they had cycled for two hours in macs and gumboots, to be rewarded with a few dots on the horizon. Even small birds were considered 'fair game' by the 'gentry' at this time, a time which provided limited protection for a restricted list of birds and their eggs in the breeding season. To remedy the lack of books, the 'gentry' carried small bore shot guns to obtain specimens to be turned into skins to aid identification of further victims in ensuing years. There was great rivalry to bag a bluethroat on autumn migration amongst those who ought to have known better.

Amongst those 'locals' Ernest met with at Breydon, was Arthur Patterson, 'John Knowlittle', who introduced Ernest to Ted Ellis. This led to many trips by bicycle and train to places of mutual interest. This was from 1925 when he was 14 years old.

At this time membership of the Sociey was open to those over 16, but such was his keeness and knowledge that he was admitted to meetings before reaching that age. Immediately after his 16th birthday, he was proposed for membership with several seconders at a general meeting of the Society and his election was confirmed in March 1928. This would have been recorded in the Eastern Daily Press which reported the Society's meetings.

The years that followed were spent in a virtual wonderland of wildlife as Ernest looks back now and compares the countryside with the deserts of today, whether they be deserts of wall to wall barley or the urban sprawl which has swallowed up so much of Norfolk's natural world.

By the start of war service, Ernest had set up home with Bessie in Dereham Road. This was badly biltzed by a large bomb but remained still just inhabitable enougth to house Bessie, their small baby, Bessie's unwell mother and two dogs. During 1942, Ernest was sent on active service overseas as part

of a reconnaissance regiment which meant that he spent much of the time infront of the front line. Those years saw Ernest and his companions make their way across Tunisia, up the length of Italy and into Austria. Even in the heat of war there were natural history moments that come to mind. The hundreds of alpine swifts speeding out of the darkening sky to roost among the old houses of Bone in Tunisia. The marvellous North African raptors, particularly the griffon vultures, which sometimes got shot at by mistake as they drifted low overhead in the misty half light of dawn, mistaken for some sort of enemy aircraft as they glided on motionless wings. The 'sea monster' he saw in an Italian river coming sinuously through the water towards him, its large head and neck swaying well above the water's surface. As it drew level, he realised that it was a large grass snake carrying a carp aloft in its mouth.

When the war ended the fortunes of the Society were at a low ebb. All meetings and excursions had been in abeyance for six years and the only contact between members had been through the *Transactions*, kept alive by Ted Ellis at the Castle, but much curtailed by paper shortages and many members on active service. The recovery was slow for many years after 1950 when the late F.J.Taylor-Page was elected secretary. With Jim Taylor-Page at the helm, the secretary's job being the key one at that stage, a dynamic leader was in place. It was due to his resourcefulness and hard work that the Society became what it is today. In 1953 he invited Ernest to stand for the post of treasurer, a post which he held for fourteen years until 1967.

It was the secretary's job to arrange the programme of events for all ages and all walks of life. Many young people became active in the Society and in a number of cases within spheres of national life. Amongst those who joined the Society and received their first practical training in wildlife skills on excursions were Oliver Rackham, Clive Jermy, Richard Pankhurst and Brian Funnel. A photograph at that time depicted the oldest and youngest members on an excursion: H.J.Howard, Richard Pankhurst and Ernest's son Michael. An example of one such excursion illustrates the amount of thought and work that went into them. A walk was arranged along the length of the Mermaid from Cawston to Aylsham. 70-80 members attended and everybody did their own thing with the experts helping those less experienced. The results were collated and published in a report to the participants. Included in the winter programme

at that time was the Christmas Public Lecture which was usually given by nationally known figure. One such speaker was Peter Scott who filled S Andrew's Hall. The Soeiety made a nice profit which pleased the treasurer!

It was during this time that Michael Seago and Jim Taylor-Page eollaborate in producing the first *Norfolk Bird and Mammal Report.* This publishin venture put a eertain amount of strain on the finances but by judiciou handling of the Soeiety's affairs, increases in subsciptions were kept as smal as was felt to be prudent. Even so, over the fourteen years that Ernest wa treasurer, subscriptions rose by 50% from 10/- per annum to 15/-. By this tim the annual costs of *Transactions* and *Bird and Mammal Report* rose to £450

Even after the war there was still plenty of wildlife to be found within th eity. The garden on Dereham Road had 14 species of breeding birds, whils overhead lights on the corner of what is now a roundabout, attraeted larg numbers of moths from nearby Sweet Briar marshes.

His first car enabled Ernest to spread his wings across the county. It was Ford Popular bought in 1954 after having his name for six months on waiting list. A few years later, whilst still primarily an entomologist, h attended an excursion to Alderford Common where he met Eric Swann. H also spoke to Geoff Smith of Attlebridge Pet Farm who asked him if he woul be interested in seeing broad leaved helleborine which had flowered b Felthorpe erossroads for the previous eleven years. Ernest wrote to Eric Swan about it and so started a correspondenee and friendship which lasted unti Eric's death in 1989. This included reading through the transcript of the 196 *Flora of Norfolk*. After Ernest's retirement the pair engaged in botanica rambles in many parts of the eounty.

Following in the footsteps of Petch and Swann is the forthcoming Beckett an Bull *Flora* based on tetrad recording. Ernest has provided many of the record for the four tetrads covering the City of Norwich as far as Earlham and Swee Briar Marshes, Cringleford and of course, Lakenham. These were done i 1990-91 with additions sent in every year since. Two of the tetrads have total of over 500 species and it is doubtful if even Ernest can get them muel higher.

IT HAPPENED LIKE THIS

Ernest Daniels
Vice-President Norfolk and Norwich Naturalists' Society

For more than twenty years to 1992 I have chronicled various botanical matters, mainly in Norfolk, with which I was concerned, and friends have suggested that excerpts from my Diaries may be of interest to Society members. The plant names are those used in Flora of the British Isles Second Edition 1958 by Clapham, Tutin and Warburg. Nearly all the people whose names appear were Society members at the time.

Mundesley: 14th July 1973. A quite extraordinary day. We went hoping to see *Orobanche purpurea* and after much unsuccessful searching on the cliff top in quite unsuitable territory (rank with tall grasses) we finally looked in the churchyard where, in the short grass areas, we found three spikes attached in no uncertain fashion to *Achillea millefolium*. The broomrape is a splendid plant - far superior to any coloured plate I have seen - and its flowers are of quite a startling beauty in their delicate yet somehow glowing blue flushing into pale purple. The cliff top produced a colony, very vigorous and thriving despite their garden origin, of a large pink *Centaurea* (? *dealbata*) and much *Myrrhis odorata*, the latter thriving quite nicely in what was a garden abandoned many years ago.

Dickleburgh: 7th April 1974. Bess and I visited the famous site of *Primula elatior* which is preserved as a Reserve by Norfolk Naturalists' Trust. The plants had an abundance of blossom, although the drought is causing them to wilt. Some of the clumps are 18" in diameter and it is not possible, without unwarranted disturbance, to be sure whether more than one plant is present. However, taking some doubtfuls as comprising only one plant, I counted altogether thirty plants. These included one non-flowering and three flowering seedlings. I thought three of the plants seemed to be the hybrid *elatior* x *vulgaris*, basing my view on large corolla size and very pale colouration. The throat markings, too, seemed intermediate. Growing in the general area was a fair quantity of each of *Primula vulgaris* and *Primula veris*, several of the latter in full flower. The nearest plants were,

however, some way from the oxlips exactly as described by Woodell in his paper in 1969 "*Watsonia*".

Sprowston: 22nd April 1975. In a small enclosure next to Sprowston Grange (now the Eiger Hotel) we examined a population of *Primula veris* which contained, among many normal forms, 14 spikes of coloured flowers. I can only describe the colour as orange-brown with a touch of wine. The colony varied from pale to quite a deep tone and the extent to which corollas were tinted varied from 30% to 100% of the surface area. Both sides of the flowers were tinted. The area was quite wet, and the large field behind contained a great abundance of, so far as we could see from the fence, normal yellow cowslips. Peter Lambley told me of the station. He heard about it from a lady who has known of the coloured cowslips for about 7 years. Other things in the same enclosure were a few *Symphytum orientale* and a large colony of *Doronicium pardalianches* with quite a number of fully expanded flowers. Our assessment of the site was that at one time it formed part of a carriage drive leading to the Grange.

Beachamwell: 22nd May 1977. In the afternoon the party of 60 members and friends of the Society went to Swaffham Forest where on the track mentioned in Swann's "Flora" were three plants of *Herniaria glabra*. In previous years there were many scores. Along a track about 300 yards further (GR 772081) Alec Bull, Peter Lambley and I found more than 100 plants of this species. At the end of the ride was a fine flowering tree of *Prunus padus*. An unexpected freak find in the forest was one plant of *Lunaria annua*.

Warham: 12th June 1977. We went with a party of Norfolk & Norwich Naturalists' Society to the Celtic fort to inspect the superb chalk grassland flora which carpets the embankments. The fort itself is circular with a diameter of about 200m for the inner circle, then there is a dry depression followed at a distance of about 20m by the outer bank. The flora was very fine consisting of an abundance of each of - *Primula veris*, *Cirsium acaulon*, *Hieracium pilosella*, *Helianthemum chamaecistus*, *Arenaria serpyllifolia*, *Briza media*, *Carex flacca*, *Hippocrepis comosa* and *Poterium sanguisorba*. Everybody, including the real experts such as Eric Swann,

Charles Petch and Paul Banham, was very surprised when *Arabis hirsuta*, scattered but in some quantity, was found. They had never seen it before. We also saw *Linum catharticum*, *Polygala vulgaris* (with flowers bright pink or mauve-purple, none blue) and two Dactylorchids - not yet flowering but Petch said that they were *D.fuchsii*.

Kilverstone: 17th June 1977. The colony of *Salvia pratensis* was flowering beautifully - wonderful sight. However some grazing animal(s) had done great damage treading down the central foliage and nipping off many of the flower spikes. A wanton type of damage, apparently as nothing appeared to have been eaten. I am inclined to blame red deer, the tracks of which were abundant in the sandy soil of the nearby track. In a field of *Brassica nigra* the crop was understoried with a vast carpet of *Anthemis arvensis* flowering abundantly.

Norwich: 12th September 1977. I took Peter Lambley to Donkey Lane where we examined the *Rosa* population. He took specimens of *Rosa agrestis* and *Rosa agrestis* x *canina* for the Museum herbarium. There are now vouching specimens in the following herbaria - Kew, Castle Museum, R.P.Libbey and E.L.Swann. I made gatherings for the latter and took them over to him in the afternoon.

Holt: 23rd September 1977. On an old wall I saw a few plants of *Polypodium vulgare* v. *vulgare* and in the little lane leading from the car park to Spout Common were naturalised *Oxalis articulata* (few scattered plants) *and Oxalis corniculata* (one plant) and one quite large patch of *Geranium pratense* full of flowers. Some orchid fanatic had written to Peter Lambley claiming to have found *Dactylorhiza majalis* at Spout Common, although E.A.Ellis who examined the populations recently failed to see it. The letter writer's credentials seemed all right, so today Bessie and I went over this lovely place where we found marsh orchids in countless thousands, a really wonderful sight. We also noted *Dactylorhiza fuchsii*, *D. praetermissa*, *D. praetermissa* x *fuchsii*. The vast majority were *D. fuchsii*. *Anagallis tenella* - common and widespread, *Carex flacca* - very abundant, *Carex echinata* - common, *Menyanthes trifoliata* - locally common, *Sagina nodosa* - occasional, *Lotus uliginosus* - common,

Hypericum tetrapterum - rare and *Epilobium hirsutum* - locally dominant.

Hargham: 12th August 1977. Eric Swann wrote to me that he had at last found undoubted *Symphytum asperum* and this afternoon Bessie and I, accompanied by William and Robert, went over to the churchyard of the about to be abandoned church at Hargham where we found this delectable plant exactly as described by Swann, "both widespread and abundant". There were many hundreds, including great numbers of seedlings up to a foot high in the mown grass, although the mature plants were all in the overgrown and neglected portions. Swann says the plant is characterised by:-

"Leaves petiolate, scarcely decurrent; flowers intense blue, calyces of flowering plants not longer than 3mm, but as much as 13mm in fruit. These are the best characters as the calyces of *S.* x *uplandicum*, both when flowering and in fruit, remain more or less constant at < 10mm".

He might have added that the buds were of a striking deep rose-red colour and the fruits almost ovoid and thickly covered with stoutbristles reminiscent, in minature, of the curved prickles of some roses and brambles. The whole plant was quite different from any *Symphytum* I have hitherto seen.

Warham: 23rd September 1977. In the early evening we walked along the chalk banks of the Camp. It was unbelievably lovely with literally millions of blue flowers of *Scabiosa columbaria*, *Knautia arvensis* and, especially, *Succisa pratensis*; also *Campanula rotundifolia*, of which I found two white flowered plants. *Centaurea nigra / nemoralis* was impressively abundant, rather dwarf, with dark purplish mauve flowers. The whole display was remininiscent of an alpine meadow. We found a dozen or two *Gentianella amarella*, mostly long past flowering, but three or four were still in bud. None were flowering, however. In the pasture adjoining the bank was one rosette of *Onopordum acanthium*.

Holt: 21st October 1977. A Wonderful day! Earlier in the week Mr A.F.Twist of Warren Farm, High Kelling, had written to Peter Lambley

reporting the presence of *Spiranthes spiralis* in (a) a remote corner of the playing field at Gresham School where it was seen by his son, a pupil there, and (b) in the chalky ride on the Old Racecourse. The letter was supported by vouching material in the shape of a pressed spike. Peter asked me to go over there with him to investigate and today three of us, Peter, Bess and I, met in the pull-in space at the top of Edgefield Hill. Peter first took us into the wood on the south-west side of the Norwich-Holt road, where about 150 yards south of Heath House we found *Goodyera repens* very commonly in the bracken litter. The tiny rosettes showed up vividly against the brown background. The actual spot was only a few yards from where I abandoned my search earlier in the year. We then cast around in an easterly direction, finding rosettes in hundreds in 5 different but nearby adjoining zones. It was very nice indeed to see this great rarity here where it has been known for nearly ninety years. We then went into the conifer plantation on the opposite side of the road about halfway between where the ride leading to Heath House debouches onto the road and the junction of the Hunworth road and Norwich-Holt road. A few yards into the the wood is a wide chalky drive leading south to an area of higher land, very acid, covered with *Erica cinerea* and other calcifuges. In the ride just before the acid zone is reached we found *Spiranthes spiralis*. After much searching we found 10 fruiting spikes and almost miraculously, one spike with two-thirds of the flowers still showing. Peter photographed this. Apparently this station is what is meant by the Old Racecourse. As we did not wish to be bothered with obtaining permission, we did not investigate Gresham's School.

Blickling: 4th June 1978. We went over to the National Trust property and found *Poa chaixii* flowering well and quite freqent in semi-shade positions in some of the rides. In one area *Cardamine pratense* was common, including a few double-flowered forms, and I noticed one plant of *Silene alba* x *dioica*. The *Poa chaixii* was a very striking thing, some of the examples being nearly 4 feet tall.

Denton: 29th June 1978. Eric Swann, Richard Libbey and I went on to Denton from Blo Norton. We had written directions from Miss C.Forrest, and with these, plus Eric's recollections of 22 years ago, and some detective

work on the O.S.map, we drove to the lane just in front of Denton House. At first sight the prospect was not alluring, with the woodland apparently solid with *Urtica*, as was the roadside ditch. We prowled along the lane for some time without result when suddenly Richard's sharp eyes descried in the dark wood a clump of *Lilium martagon* in tight bud. It was a great moment for all of us. We went into the wood and found another colony, about 50/60 plants, some of which were flowering nicely. Richard, who like me, had never seen the plant before executed a little war dance. It was really wonderful to see this species which has been in the locality since at least the 1870's. The plants we could examine at close quarters were growing in a fairly open, heavily shaded situation where the ground was closely carpeted with *Vinca minor*.

Burnham Overy: 4th August 1978. Yesterday Peter Lambley rang me with some terrific news. Martin George had just found a colony of *Gnaphalium luteo-album* and this evening Bessie and I trudged along the sea wall from Overy Staithe and into the dunes where we found the plants. We counted altogether 74 separate plants, some of which were quite tiny seedlings, although several had elongated main stems and well developed flower heads. The colony was occupying a circle roughly 15 feet in diameter in a grey dune area.

Trowse, Westleton and Bungay: 21st September 1978. Today Eric Swann and Richard Libbey came over and I showed them *Hordeum jubatum* at Trowse, *Filago apiculata* at Westleton and *Potamogeton praelongus* at Bungay. Neither had seen the *Hordeum* before except on rubbish tips, and Richard had never seen *Filago apiculata* alive, although Eric had supplied him with a herbarium sheet from which he entertained some doubts as to the validity of the taxon. Now that he has seen it growing he is quite converted and admits the clear difference between the two *Filagos* as they grow side by side.

Ovington: 16th April 1979. We went over this afternoon to look at the churchyard, the spinney adjoining and the meadow near the house. The lady of the house (who knew Swann and Libbey quite well) took us to a large clump of widely spaced trees in the meadow. At the edge of these

were growing *Anemone ranunculoides*, *Corydalis solida* and *Narcissus pseudonarcissus*. We were very thrilled to see the *Anemone* flowering beautifully in hundreds and still seeding itself, although sparingly.

West Harling: 17th June 1979. We met the joint Kent/Norfolk members at Harling Forest and were able to show them some nice Breck things, viz- *Ornithogalum umbellatum* flowering in great quantity along rides and by the road verge near Ride 78 (Grid ref. TL 976843). Along the edge of West Harling Hill Plantation we found *Astragalus danicus*, *Silene otites* (abundant), *Silene conica* (abundant) and *Phleum phleoides*. *Nardurus maritimus* was occasional in the old chalk pit at Grid ref. TL 982829.

Burgh Castle: 21st June 1979. Today Eric Swann and Richard Libbey came over and I took them to Burgh Castle to a location provided by John Trist at grid ref. 493058. The site was old saline grassland between the estuary wall and the Delph dyke. Here among halophytes such as *Glaux maritima*, *Ranunculus sardous*, *Juncus gerardii* and *Plantago maritima* were growing abundantly plants of *Alopecurus geniculatus*. In one rather restricted area we found *Alopecurus bubosus* to be quite frequent. My friends were delighted particularly Eric who had never seen it as a live plant before in his life. They spent a long time on their stomachs peering through lenses, and agreed that it is indeed distinct from *Alopecurus geniculatus* in floral characters, and not a mere form of that species, as some have misguidedly held. When the two grow together the much slenderer and more tapering spikes of *bulbosus* are very apparent.

Horsey: 1st July 1979. Today we joined a party of Norfolk and Norwich Naturalists' Society on an excursion to Mr John Buxton's estate. The party was split in two and in the morning I was deputed to lead one group to Horsey Warren. We found *Dactylorhiza praetermissa* in abundance and flowering beautifully. The hybrid *D. praetermissa* x *fuchsii* was occasionally seen and some showed extreme hybrid vigour. In the dunes was much *Corynephorus canescens* and we also noted *Festuca juncifolia* but we merely glanced at a small area near the path to the beach. In the afternoon John Buxton kindly took us over his marsh to the Mere. On the

raised path *Sonchus palustris* was abundant and very vigorous. *Atropa bella donna* was very common, huge plants, full of flower. A surprise was to see *Corydalis claviculata* in great profusion scrambling over pathside shrubs. In one place there was a great quantity of *Digitalis purpurea*, with a few white flowered forms. In the spinney near the Hall was a quantity of each of *Daphne laureola* and *Geranium pratense*. A very small area by the boathouse cut was rich in halophytes - *Juncus gerardii*, *Glaux maritima*, *Scirpus tabernaemontani* and *Apium graveolens*. Mr Buxton said the explanation was that the autumn gales funnelling into the spot brought salt spray to give this very local effect.

Felmingham: 4th July 1979. This evening I went with a party of Norfolk and Norwich Naturalists' Society members to survey the disused rail track westwards from the old Felmingham station. Dr Bob Leaney, our titular head, was unable to come because of a medical emergency. Those present were Alec Bull, Roy Baker, Mr and Mrs F.E.B. Johnson, Alan Scowen and an unknown (to me!) lady. The soils were mostly sands and gravels in places very acid, and the outstanding plants were:- *Lupinus arboreus*, very abundant near the old station. The rare purple tinged form occurred in some numbers, but yellows and whites formed the rest of the population. *Lotus tenuis*, a great surprise this. In the utmost profusion by the trackside for 0.75km from the station. *Dactylorhiza fuchsii* hybrid, two plants on the south side. Alec and I disagreed as to the putative parents - I think it was *D.fuchsii* x *ericetorum*. *Carex muricata* in one small clump. *Trifolium medium* in one patch and a single bush of *Rosa rubiginosa*. *Malus sylvestris* as one tree. *Silene gallica* var. *quinquivulnerata* as one tiny plant with flowers with two flowers in the track. Another plant on the north embankment with fruits but no leaves left was *S.gallica* but it was impossible to assign a subspecies or varietal name. *Juncus tenuis* as a sizable colony in the track midway along the first cutting. The plants were often quite robust. *Trifolium subterraneum* as one tiny plant near the station, *Erica cinerea* and *Calluna vulgaris* common in small areas, and one plant of *Hieracium anglorum* on the track.

Norwich: 27th July 1979. This evening I had a look round Carrow Abbey and was intensely pleased and surprised to see how abundant was

Aristolochia clematitis. It was flowering profusely in great stands and drifts behind the old ruins in fairly dense shade. I was shown the plant here in August 1963 by a Norwich worthy Mr Grimsdick, an offieial of the Red Cross who then had the tenaney of the Abbey. Grimsdick showed it to me on the north side of the ruins, whieh I could not approaeh tonight. The plants I saw tonight were on the south side.

Holt: 20th August 1979. Yesterday Erie Swann gave me some details about *Equisetum sylvaticum* and today I went to Holt Lowes and found this horsetail to be very abundant in the very wet carr near the junction of the stream with the River Glaven. It is a most delieate plant and the textbooks give no real idea of the appearance of the plant in the field. In particular the branches are extremely fine, almost threadlike and this coupled with the ramifying of the seeondary branehes and the drooping of the ends, gives the speeies a very distinctive, not to say, distinguished, appearanee.

Snettisham: 30th August 1979. I went over to Eric Swann's at King's Lynn, left my ear in his drive and he, Riehard Libbey and I went for a sort of grand tour of West Norfolk. We first went to the beaeh at Snettisham, wonderful spot, paeked with luxuriant halophytes and with *Glaucium flavum* absolutely dominant over wide areas. Very noteworthy plants ineluded *Arenaria serpyllifolia* var. *macrocarpa* - a eommon very distinct taxon - very prostate, densely eompaeted, very large elumps some as big as dinner plates with large fruits. The dwarf growth habit gives a general appearance of unusual leafiness. *Senecio* x *londinensis* (*S.squalidus* x *S. viscosis*). These plants with both parents, oecurred on the ridge, about 1km north of the ear park. It is a striking plant in the field, very twiggy, with non-revolute ray florets, flowers otherwise resembling *S.viscosus*, and with sterile aehenes, and beeause of this sterility the fruiting heads do not "balloon out" as in other eomposites - notably *S.viscosus*. This non-opening-out is most notieeable and forms a striking and reliable spotting feature. There were about a dozen plants in all. They were found by Erie a few weeks ago. The plant is new to Norfolk.

Cringleford: 14th March 1980. This morning John Bishop of Birmingham University eame over and I took him to the wet wood to see *Leucojum*

vernum. There were huge drifts of the plant, a splendid sight. Heavy rain on Thursday had caused the river to rise and flood the wood, most of which was impassable, even with gum boots.

Corpusty-Saxthorpe. 27th April 1980. We attended a field meeting of Norfolk and Norwich Naturalists' Society led by Mrs Anne Brewster. About 60 attended. She conducted us over various riverside pastures, some of then relatively undisturbed. We first visited the site of *Myosurus minimus* at Little London. There was a large solid sward of the plants many thousands strong and mostly in flower. They were only two to three inches high and will presumably elongate as the seeds develop. They were nearly all on the flat portion of the pasture just above the cattle scramble and only a few could be seen near the water. We were all delighted to see that the colony had spread, as a few plants were found some hundreds of yards away in an open part of the ground near a drainage ditch. On the pastures downstream of the Mill in a wet carr much *Chrysosplenium oppositifolium* was flowering and further along right against the parish boundary with Oulton, again in two wet shady spots, was a fair quantity of *Chrysosplenium alternifolium*. Three splendid things to see in Norfolk.

Lound: 28th September 1980. We went with a party of Norfolk and Norwich Naturalists' Society to the grounds of Lound Waterworks by invitation of Keith Clarke. The land area for some distance around the reservoirs is strictly controlled so that agricultural poisoners are very firmly made to behave. A very nice result of this was a colony of *Datura stramonium* growing in a bare area of rabbit scrapes in a pasture. There were also two plants in an outlying situation. E.A.Ellis, who was with us, said that many years ago the plant was cultivated in this area for use as a sedative for horses. One of the main objects of the excursion was to try and refind *Pilularia globulifera* and with this in mind we devoted a great deal of time to exploring the north side of the large body of water where it was last seen. We were unsuccessful and we spent very much time examining a most extraordinary situation. The water level had dropped some feet in the last few months and on the steep gravelly bank was a multitude of pale green tufts of some plant with narrow twisted leaves. This puzzled us all. The leaves were flattened and channelled, but no sporocarps could be

found. For a time Ellis and I were inclined, reluctantly, to assign them to *Pilularia*. The truth was little short of astounding. Ellis found a plant of *Zannichella palustris* in the water and by tracing the stems back he arrived at one of these clumps, which could very easily have been mistaken for a young plant of *Juncus*. But the real excitement came later when E.A.Ellis found *Pilularia* on the opposite shore. There was a huge stretch of it in a particularly pure sward. Everyone (except me!) found sporocarps among them.

Bramerton: 9th May 1982. Colin Dack and George Hart called this afternoon to tell me about a plant noticed by one of the members of the Geological Society. It was growing by the river edge. They offered to take me over and we found two fine plants of *Tellima grandiflora* **BUT** they had been deliberately planted as we were told by the lady who planted them. Maybe they will spread by natural means. We continued to explore the area and found *Allium paradoxum* in fantastic abundance on roadside verges, in hedgebanks, in spinneys and carpeting the woodland floor.

Great Witchingham: 7th July 1983. Peter Lambley gave me a "fix" and this evening Bessie and I went over and saw the wonderful spectacle of *Rosa multiflora* absolutely covered with flowers along the hedge in Blackwater Lane at grid ref. 088200. The species was very nearly dominant and I paced it over a stretch of 145 paces (say 85 yards). Another breath taker in a field on the opposite side of the road and a little to the west was the sight of solid mass of flowering *Papaver rhoeas* growing over 12 acres or so among ripening capsules of rape. I have seen nothing like it since the spring outburst in the plains of Tunisia forty years ago. The final touch of this extraordinary evening was the finding of a flowering *Lonicera caprifolium* in a hedge at grid ref. 082192.

Strumpshaw: 28th July 1983. Mike Blackburn (Reserve Warden) invited me over this evening and we went botanising over part of the marshes and woods. He first took me to the conifer planting at the back of his house where a quite extraordinary situation has developed. The area which is now wooded was ploughed by the previous owners and as recently as 1966 a kale crop was grown. They then planted spruce for Xmas trees and the area

was progressively thinned, a policy which the RSPB have continued since they became owners so that they are now six to eight feet apart and much more light gets through. Despite the punishing regime imposed since 1966 *Primula veris* has appeared (or presumably re-appeared) and flowers well. This year 4, possibly 5, species of orchids have come along and Mike showed me *Dactylorhiza praetermissa* (flowering), *Dactylorhiza fuchsii* and more than 30 plants, some still with flowers, of *Ophrys apifera*. Each of these latter was protected by an upright wire netting cylinder to frustrate their Dutch rabbit Kim, an amazing character who wanders freely through the woods and fields like a dog, returning to the house at night and for extra feed when he feels like it. Until the wire cylinders went up he was seen to have a great partiality for *Ophrys*. Mike told me that earlier on they had *Listera ovata* in the planting and he showed me a non-flowering orchid which is anyone's guess. I thought that it might be *Dactylorhiza* but it might equally have been *Epipactis*. Mike told me that there was some clay in the soil where the trees were planted. We then went onto an open marsh where was his pride and joy, two colonies of *Epipactis palustris*, one with 24 flowering stems and the other with 80+.

Felbrigg: 22nd September 1985. Last week Edwina Beaumont made two very fine discoveries, subsequently confirmed by others. They told me about it and today Bessie and I went to Felbrigg Hall. On the north side was *Mimulus moschatus* flowering beautifully and naturalising itself abundantly in paving crevices and at the foot of walls. The next was a real gem, *Selaginella kraussiana* forming an almost solid sward about 20ft x 8ft in grassland immediately north of the Orangery. This is new to Norfolk and God only knows how this sub-tropical thing can exist and thrive in our Norfolk weather. I wish I could!. Most were prostrate and creeping, but outliers under bushes were erect. It is new to Norfolk.

Swanton Novers: 17th May 1986. I was invited to join a party led by Peter Lawson, George Maybury, Charles Petch, Edwina and Alan Beaumont, Charles and Bessie Barsted and David Cramer (an ornithologist from Bedfordshire). We went into the Great Wood and found the superb colony of *Maianthemum bifolium*. I last saw it on 5th June 1972 and since then the two patches have coalesced and spread on the perimeters so that there

is now a great circular area about 50 feet in diameter, solid with thousands upon thousands of the "plants", forming a dense packed and totally dominant cover.

Norwich: 14th July 1987. I botanised along the disused railway line, from which the sleepers and clinker have now been removed, from Barrett Road to Sandy Lane. I found *Hypericum montanum*. A great thrill this! Quite common and in full flower by the track side towards Sandy Lane. Dr Frewen Moore recorded it from "near Norwich" (Petch and Swann) while in Nicholson's *Flora* it was recorded from Lakenham by Robert Wigham (1785-1855) and R.J.Mann (1817-1886). It is possible, but very unlikely, that my plants were Dr Frewen Moore's, as the rail was very much used in his time and not easily approached. Both Wigham and Mann could well have found it before the track was laid and "Lakenham" would certainly encompass the area where my plants grow.

Beeston Common: 10th August 1988. Having heard through Alec Bull of the refinding of a *Lycopodium* species in this station I decided to look for it myself. Today Bess and I went over and were met by Ken Durrant who escorted us round. We saw *Lycopdium clavatum* with numerous radiating stems, prostrate and hugging the ground. One was about 30cms long with numerous side shoots. There were no cones. It was growing on the fairly open, sandy side of an old war-time trench near a blown up pill-box. Up until two years ago the whole was over-shaded by a gorse thicket. This was removed and the plant appeared and was found by David Mower and his wife. According to published information the species was last seen on the Common in 1903 by W.H.Burrell.

Reymerston: 23rd September 1989. In May 1973 Miss Dorothy Maxey wrote to me to say she had found the leaves of a *Cyclamen* sp. at Reymerston but at that time of the year no flowers were present, so identification was impossible. I do not know if she followed it up but I have diaried it annually with the intention of one day going over to see it! Today the spirit moved me and Bessie and I went over and found *Cyclamen hederifolium* in great drifts. There must have been many scores of thousands. Some were in short grass in deepest shade in the path leading

to the church. Here were many individual young plants well away from the main aggregation. On the opposite side of the road in the entrance to what was once a drive to the vicarage the ground was carpeted solid with them over a wide area, with many isolated plants and clumps. Further down the road is what is now the main drive to the house (the one time vicarage) and here there were nearly as many, with drifts under trees further into the grounds. At this site the species is spreading well with numerous small groups and individuals growing on a ditch side. The notable thing about all these sites was that white flowered plants were nearly as numerous as the pink forms. A further thrill was finding a plant of *Crocus nudiflorus* growing in flower among the *Cyclamens*. Altogether a day to remember and a truly wonderful spot.

Ditchingham: 24th September 1989. For many years I had known of the presence of naturalised *Cyclamens* in the grounds of the Convent of All Hallows and this afternoon Bessie and I went over to see what could be found. We searched without success along the roadside and we were about to give up when we met two of the nuns out for a walk. When we raised the topic of *Cyclamens* they conducted us through the wood at the back of the Convent where *Cyclamen hederifolium* was in really enormous abundance. Almost certainly there were far more than at Reymerston, although they were not so massed. However, they were everywhere in light shade with a very high proportion of white flowered plants. The corms as measured by the numbers of flowers produced spanned a wide age range and we found a very young plant with only one flower. One of the nuns, Sister Florence, had been with the Convent for 40 years and had known the *Cyclamens* for 50 years. There are far more now than in those days. The tradition at All Hallows, which was founded and built in 1875, is that the original corms were planted by the first Mother Superior so it is even money they have been there at least a century.

Attlebridge: 17 October 1990. *Vaccinium myrtillus* is still by the old rail track and occupies a larger area spreading into the track bed and near woodland. The severe competition from dense tree cover has meant that the plants are sprawling and drawn up as much as 1½ feet. A few berries were present.

Miscellaneous observations

Wells Quay. Naturalists have long known the delight, and even value, of keeping an eye on a regular "beat". Mine, since retirement in 1989, has been a cycle ride from Wells Quay along the sea wall to the beach, more mornings than not, at around eight-thirty. This gives me the full range of tides every fortnight, and an 0830 tide in Wells is a spring tide - even more so in summer, when 0830 really is 0730!

For the last few years, up to a dozen turnstones have taken up on-and-off winter residence on the Quay. Why no other waders? There are no stones for them to turn, but I imagine they find the occasional sea slater *Ligia oceanica*. In certain weather conditions these giant woodlice crawl out of the cracks in large numbers. Also in recent winters, large flocks of lapwings have joined the brents in the harbour at low tide. Are numbers increasing, or are they favouring Wells more than before?

Trying to count little grebe, often present near the Quay, is frustrating, while counting mergansers, which are generally further down the Run or off the beach, is dead easy. Why? Because dabchicks take it in turn to dive, so you cannot tell how many may be under water, while mergansers practise synchronised diving, and come up within a few seconds of each other! This is just one fact new to me which my "beat" has revealed. I confidently expect others.

Paul Banham

Insects speared by marram grass. When as a small lad I used to search for insects amongst the marram grass *Ammophila arenaria* on the west cliff tops at Cromer (now putting and bowling greens) I was made aware of their sharp rolled leaf blades by the many pricks on my unprotected legs, little did I realize that I was witnessing nature's own rapiers in action.

Over the years when on the dunes of our Norfolk coast between Wells and Great Yarmouth, even with trousers protecting my legs, I have still felt the occasional stab when moving amongst the marrams. I have collected various insects which have been impaled on the leaves of the grass when

the wind has caused the leaves to swish about.

The most common species are flies *Philonicus albiceps* Mg., *Sarcophaga carnaria* L., *Calliphora vomitoria* L., *Pollenia rudis* Fab. and *Helina protuberons* Zett. I have also noticed a number of much smaller flies where the wind has deposited them and suspected that they have fallen victims of attack by the predatory Assassin flies *Philonicus albiceps* Mg. or *Dismachus trigonus* Mg. who hunt the dunes. Later, however, I was to find out that they too were victims of the wind blown marram grass, but not by being speared.

On Horsey dunes I disturbed a small grey fly *Delia albula* Fln. which took flight as I approached, but it was hit by marram leaves swinging in a gust of wind and dropped back onto the sand. It was dead when I picked it up so no doubt other flies meet the same fate.

The largest insect that I have found speared on marram grass is a worker small earth bumble bee *Bombus lucorum* L. which I took at Wells and retained in my collection as found. The grass blade had penetrated the thorax under the head between the front legs. (Figure 1).

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Ken Durrant

WILDLIFE 2000

FRESHWATER BIVALVE MOLLUSCA OF NORFOLK

Derek Howlett & Roy Baker
The Ted Ellis Trust: Wheatfen Broad, NR14 7AL

Introduction

Norfolk is a county rich in freshwater habitats for molluscs. It possesses slow flowing calcareous rivers many with tidal reaches, chalk streams, chalk springs, man-made channels, drains, dykes and ditches, the extensive broads, lakes, meres, gravel pits, ponds and the glacial pingos. Bivalve molluscs abound in this wealth of watery habitats. The ravages of pollution of the last four decades are now being tackled. Sites are being restored and water quality is high on the agenda both at governmental and local levels.

Traditional fenland management has largely been replaced by modern machinery. Dykes are cleared less sympathically than in the past but increasingly we are seeing an awareness of the need to think of the flora and fauna when restoring the waterways.

At the turn of the last century naturalists such as J.B.Bridgman (1872) and Arthur Mayfield (1909) recorded the distribution of Norfolk bivalves in the *Transactions*. In the 1930's and 1940's Arthur Ellis and Ted Ellis (no relation to each other) studied the molluscs of the Yare valley and Broadland. A.E.Ellis published his studies in his classic paper on "The Mollusca of a Norfolk Broad" based on Wheatfen and in the the Collins book "The Broads" edited by Ted Ellis (1965). In the 1970's Rob. Driscoll and Michael Jackson surveyed many broadland sites by focusing on the grazing marshes and associated broads. As the 20th C. comes to its end this paper re-examines the status of bivalve molluscs in Norfolk as part of the county Wildlife 2000 project.

Rivers

The chalk ridge which runs from near Thetford in the south to Hunstanton

in the north is the watershed for the major rivers of Norfolk. Those flowing westward discharge into the Wash, whilst the eastern rivers Waveney, Yare, and Bure with their major tributaries enter the North Sea at Yarmouth. The River Yare and its principal tributaries, the Wensum, Waveney and Bure, drain some 3500km^2 of land in Suffolk and Norfolk. The lower reaches of these rivers are tidal to points 40 to 50km from the mouth at Great Yarmouth. In the case of the River Waveney the tidal reaches are 58% of the total river length. All the broads area lies below the highest river levels and thus is susceptible to flooding. The most damaging events occur as a result of storm surges in the North Sea (Clarke 1990). The salt waters flowing into the rivers increase and penetrate far upstream. These saline incursions cause serious damage to the ecology of the normally freshwater reaches and have been shown to restrict the distribution of mussels.

On the northern coast a number of small streams - Rivers Mun, Glaven, Stiffkey and Burn - flow directly into the North Sea. These streams support a lower diversity of mollusc species than the larger slow flowing rivers.

The major waterways of west Norfolk, including the Rivers Little Ouse and Wissey, flow into the River Great Ouse and its linked man-made drains and dykes. These all discharge into the Wash through a series of sluices built to drain and protect the fens from flooding. The Great Ouse and its tributaries drain the Chalk and Chalky Boulder Clay and are clear calcareous waterways.

The Broads

The flooded derelict peat diggings of the 12th to 14th C form a complex of shallow open lakes fringed with reed and willow carr. Many of these are linked directly to the rivers Yare, Bure, Ant and Thurne and to varying degrees form tidal freshwater lakes. Some are brackish. The salinity is caused either directly from the brackish waters of the tidal rivers (River Thurne) or from seepage through coastal sand dunes and dykes. Other broads are landlocked freshwater lakes. The waters are calcareous with a pH usually in excess of 8.0.

Dykes and ditches

The low lying marshes and fens of Norfolk are drained by a mosaic of dykes and ditches. Many of these dykes are fed from land springs which maintain water levels, although in many cases water seepage through river banks is an important factor. In the Yare and Bure valleys many of these dykes are directly linked to rivers and this results in twice daily tidal freshwater cycles. These dykes provide habitats for many bivalve molluscs. Their successful conservation depends on management techniques in dredging and clearing the dykes. Traditionally the dykes were dredged by hand using dydles, maegs and cromes but in recent times they are being cleared by machines which, whilst efficient, are less sensitive to the ecological needs of mussels.

Lakes, Meres, Ponds and Pingos

There is a wide range of ponds, meres and lakes across the county. Many of these are man-made water filled pits for marl and gravel extraction. Other lakes have been dug for their landscape and amenity values. The Norfolk Meres are water-table lakes on the Chalk outcrop. There is still no good account of the origin of these crater-shaped lakes. The problem facing many of these lakes is one of siltation and the prohibitive costs of dredging and mud-pumping. The hundreds of small ponds scattered across the farmland of Norfolk show signs of eutrophication and pollution. Many support little wildlife, although conservation work is underway across the county to re-instate some of these sites. Pingos were formed when dead ice melted at the end of the last glaciation. In many cases they are rich in molluscs but planting by the Forestry Commission and encroachment by scrub has been detrimental to many of the sites. The major factor threatening many of these Norfolk wetland habitats arises from water extraction, expecially in times of drought (Lambley 1994).

Family Unionidae

There are five unionid species present in Norfolk. In Broadland the pollution and poor water quality of the 1950's-1990's dramatically affected the mussel populations. The marked improvements in curtailing pollution and improving water quality in Broadland has seen a pattern of recolonization and growth in mussels such that as the 21st C. approaches

an optimistic picture emerges for all freshwater plants and animals. (Clarke & Ives 1996).

Unio pictorum (L.)

In 1872 Bridgman observed that the painter's mussel *Unio pictorum* was abundant in almost every stream in Norfolk and that the variety *compressa* Jeffrey was to be found at the sharp angle of rivers at Surlingham Ferry and Bramerton. In 1909 Mayfield recorded the mussel at Postwick, Whitlingham, Trowse, Surlingham and Brundall in the River Yare: at Wroxham in the River Bure and in the Thurne Stream. The Rev.S.S.Pearce found it in Heigham Sound at the junction between the Thurne and Hickling Broad. On the River Wensum above Norwich Mayfield collected mussels at Heigham and Hellesdon. At Wheatfen Broad E.A.Ellis (1934) and Captain M.J.Cockle (1940) recorded the mussel in the tidal channels and dykes.

E.A.Ellis writing in 1961 said, "It is a common mussel of the rivers of eastern Norfolk and in some lakes of their side valleys where becks supply slow currents of water. Oddly enough there seem to be no records from west Norfolk. The shells were used by old Dutch painters as palettes. In the 19th C. they were still used in England as receptacles for powdered gold and silver by illuminators". Today in Russia shells are used in the manufacture of mother of pearl and the meat as feed for swine and poultry (Zhadin 1965).

A.E.Ellis (1978) noted that as with other freshwater mussels, considerable variation occurs in different habitats. Zhadin (1965) observed that in Russia it is a highly variable species. Environmental changes are reflected in growth rate and shape of shell - closely connected with nutritional and physiochemical factors. In Russia the largest shells are found in small rivers with appreciable amounts of hydroyzable organic matter on the bottom and water with a fairly low mineral content. In studies in Sweden Agrell (1949) showed that shell weight increases as trophic conditions and dissolved calcium increase.

In the 1970's *Unio pictorum* was recorded at the following sites:- Hoveton

Great Broad (P.Cobb), Rockland Broad (R.J.Driscoll), (M.Jackson), Langley in the River Yare (E.A.Ellis), Decoy Broad, Hoveton Little Broad, Belaugh Broad, (M.Jackson), River Great Ouse Hilgay (R.C.Preece & R.D.Wilmot).

The current Norfolk status of painter's mussels shows records from the Rivers Yare, Bure, Ant, Waveney, Great Ouse, Little Ouse and the Cut-off Channel of the Fen Relief Scheme. Also at Wheatfen, Rockland, Buckenham, Hassingham, Ormesby and Lound Broads. It is absent from the River Thurne and Hickling-Horsey Broads where Cl^- levels exceed 1000mg/l. The preferred habitat is between 2-3m depth. Below 3m the density falls away rapidly. An interesting discovery is of *Unio pictorum* in a steep sided flooded gravel pit at Ringland where the mussels bore into the near vertical sides and live like marine piddocks. It was very common in this pit. (surveys by Howlett, Baker, Clarke 1995-1998).

Negus (1966) has shown that *Unio pictorum* can live for upwards of 15 years. After fertilisation the embryos develop as glochidia in the outer gill chambers. The parasitic phase of larval life takes place on the gills of fish before the glochidia metamorphose into juvenile mussels. Growth is most rapid between June and August and is extremely limited in the winter season. After one year juveniles attain a length of about 18mm and by the second year this will have doubled. Collections of young shells from the River Yare and The Fleet leading into Rockland Broad in the autumn of 1997 show distinctive nodules, giving the shells a deformed appearance, radiating from the umbones. The shells at this stage are a translucent white. However, both J.G.Jeffreys (1862) and L.Reeve (1863) note that in adults the umbones are only slightly wrinkled and less so than in *Unio tumidus*.

At Wheatfen Broad in 1996 the parasitic water mite *Unio bonzi* (Clap.) was recorded from *Unio pictorum* by Dr R.K.Jones.

***Unio tumidus* Philipsson**

The swollen river mussel inhabits slow rivers and canals in England. It needs fresher, cleaner water than the commoner *Unio pictorum*, and is essentially a river mussel. Negus (1966) showed that in the River Thames

it has a life span of about 11 years. It has a short breeding season between mid-April and mid-August. Gloehidia are released as soon as they are mature and they pass through a parasitic phase attached to the gills of fish. They metamporphose into juvenile mussels and fall off into the river muds. Growth is rapid in the first year and they attain lengths of about 20mm which inereases to 40mm in the seeond year. The growing season is from mid-April until mid-October and this is followed by six months of little or no growth. The preferred habitat for adults is at depths between 2-3 metres and few mussels live in depths greater than 3m.

Agrell (1949) observed that shell weight decreases as trophic conditions and dissolved calcium inerease. Agrell argued that trophic conditions and dissolved ealeium are both important for shell seeretion. In Sweden both *Unio* species are most abundant in habitats where they are capable of seereting the heaviest shells.

The first Norfolk record for *Unio tumidus* is from the survey of R.C.Preeee and R.D.Wilmot (1978) in the River Great Ouse at Hilgay. In 1988 E.B.Rands found a second site in the River Little Ouse at Hockwold eum Wilton.

The current survey shows the species at a number of sites linked to the River Great Ouse and the artificial channels of the fen flood relief schemes. In the River Great Ouse at Willow Farm and Horse Fen Farm it is rare, whilst it is occasional in the River Little Ouse at Brandon Creek and the Cut-off Channel of the Fen Flood Relief Scheme at Fordham, West Dereham and Feltwell. Between Denver and King's Lynn sluices in the Flood Relief Channel the speeies is rare. In October 1997 the lack of water flow, tepid water temperatures, reduced oxygen levels and evidence of saline incursions through King's Lynn sluice gates indicated that the low densities may be related to adverse eonditions arising from the hot weather and drought. (surveys by Howlett, Baker, Clarke 1996-97).

***Anodonta cygnea* (L.)**

The swan mussel is an inhabitant of rivers, canals, lakes and broads. It prefers a muddy bottom. Its gloehidia are parasitic on fins and gills of fish.

It is a non-specific fish parasite having been recorded on chub, dace, bream, roach, perch, carp, eels, tench and both 3 and 9-spined sticklebacks. Guisti *et al* (1975) suggest that the lurking predatory strategy of pike presents the fish with more opportunities of glochidial attack than other fish species. Dartnall *et al* (1979) noted that swan mussels release glochidia *en masse* mainly from December until mid-May and that infection amongst 3-spined sticklebacks can be as high as 86%. Swan mussels produce prodigious numbers of glochidia that drift passively in the water and encounter fish in a density-dependent fashion.

J.G.Jeffreys (1862) noted that in France shells were used as milk skimmers. The mussels are procured by means of a long pointed stick, which is inserted between the gaping valves when the animal is feeding. These valves close on the stick and allow the mussel to be drawn out of the water.

There are numerous 19th C. records for the species in Norfolk:- River Yare at Postwick, Bramerton (Pearce 1893), at Acle (Pearce 1897), River Wensum at Heigham and Hellesdon (Mayfield 1909), at Weeting (Mayfield 1909), and at North Wootton in a drain (Petch 1895). There are two very large specimens in the 19th C. collections at the Castle Museum which are 174mm long and 80mm wide from Wretham Mere (W.J.O.Holmes) and 195mm x 108mm from Framingham (W.Jecks). Bridgman (1872) observed that the mussel was common in Norfolk.

In the 20th C. the records include:- Patterson (1905) at Lound Run, Fritton and Filby Broad; R.Gurney (1920) at Stalham (Sutton Broad); A.E.Ellis (1940) at Alderfen Broad, South Walsham Broad, Upton Broad; E.A.Ellis (1943) at Wheatfen Broad and River Yare at Whitlingham; E.A.Ellis Hickling Broad (1961); Cobb (1969) Narborough gravel pits; How Hill Cobb (1968) where it was described as being " common". A.E.Ellis (1941) noted the species as the only unionid at Wheatfen; Baker (1972/73) at Seamere, River Yare at Barnham Broome Fen, River Glaven at Glandford, Bayfield Park, Sandy Hill Mill, Holt Lowes (1979); Hoveton Great Broad (Cobb 1972); Stanford Water (Watson 1974); Preece & Wilmot River Great Ouse (1978); Jackson (1977) Hoveton Broad, Alderfen Broad, Burnt Fen

Broad, Surlingham Broad, Belaugh Broad, Malthouse Broad, Little Ormesby Broad, Snape's Water, Ranworth Broad, Ormesby Broad; Kerney at Cley (1979); River Nar at Blackborough (Baker 1980), Pentney (1982); Sennowe (Durrant 1990); abundant in Oxburgh Hall moat (Howlett 1988).

The current status of swan mussels includes the River Yare at Brundall, Coldham, Whitlingham, Postwick, Rockland Broad Short Dyke, Fleet Dyke, Rockland, Wheatfen, Buckenham Broads; Bluestone Wood Lake Heydon; River Bure at Salhouse Broad, Larkbush, Wroxham Broad, Bridge Broad, Belaugh Broad, Pump House, Home Farm, Suffolk Water Co. intake, Rising Sun Inn, Crabbetts Marsh, Decoy Broad; Ormesby; Lound; Cut-off Channel Fen Relief Scheme Methwold and Feltwell; Seamere (Howlett, Baker, Clarke surveys 1996-1998). The specimens at Feltwell are very large and at their maximum size for the species. They can be no more than 30-33 years old because of the construction of this channel in 1964. In the Flood Relief Channel above the King's Lynn sluices the numbers are small and the populations appear to be threatened by the minimal water flow through the system after three drought years, the tepid summer waters and the build up of chloride on the silt surfaces probably from back-leakage through the sluices. In the River Waveney Killeen (1992) reported the swan mussel as being common but no living specimens were found by the authors from Beccles to Somerleyton, only dead shells in a once prolific site for the mussel (1996). The species is in decline in Rockland Broad.

An unusual habitat for Norfolk of the swan mussel is the shallow, moderately fast flowing waters with sandy-flint beds of the River Mun near Gimingham. Mussels up to 50-60mm in length are common in the river below the mill pond outfall. The stream was recently mechanically dredged yet the numbers of mussels remains high. Sticklebacks are common and since these are often the major host for glochidia then the continued presence of healthy mussels communities may be part explained.

Rands (1986) notes that in the River Great Ouse at Bedford the mussel used to be very common in the early 1970's but is now in decline. She suggests that the 8-10 year dredging cycle is too short for the mussel to survive.

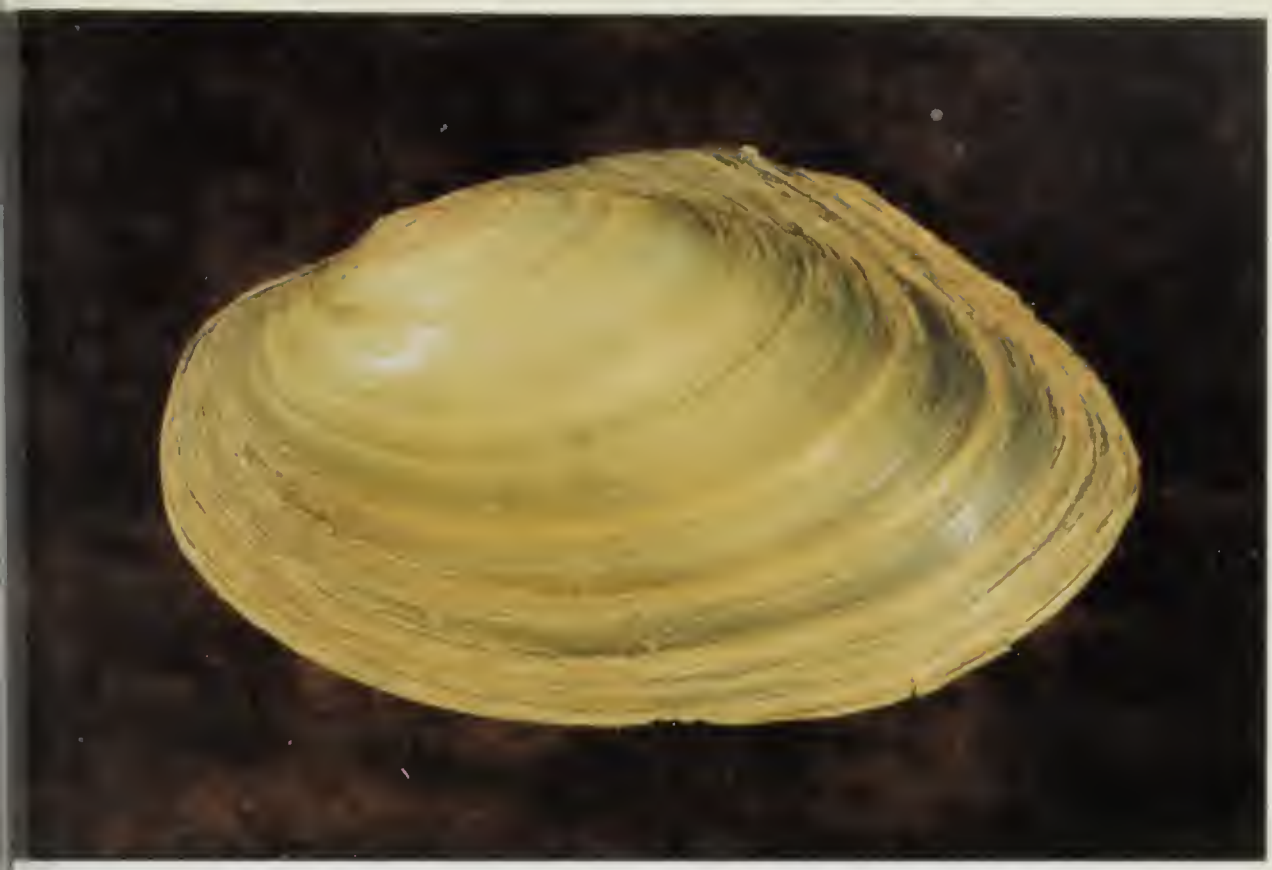
Anodonta anatina (L.)

The life span of the duck mussel is from 9-10 years (Crowley 1957; Negus 1966). The embryos develop into glochidia larvae in the outer gill chambers of the female. They are released from late February to early April when they pass through a parasitic stage on the fins of fish. This phase lasts three weeks. As young mussels they fall off the fish. The juveniles are most numerous along the edges of reed beds and beneath stages where fish are known to congregate to breed. By the end of their first year of growth they show shell lengths of about 30mm which increase to 50mm in the second year. As with other unionids there is no growth in the winter. The greatest densities in the River Thames are at depths of 2-3m when levels of $12.5m^{-2}$ were noted. (Negus 1966). In Norfolk rivers *Anodonta anatina* is the commonest unionid species and is an important member of the bottom fauna where it feeds on organic detritus. Since the mussels are relatively long lived they represent a large amount of energy stored within their trophic level which is only released on death. There are few predators of mature mussels.

At Wheatfen Broad the parasitic watermite *Unio bonzi* (Clap.) was noted and at Rockland Broad both nymphs and adults of *Unionicola intermedia* (Koen) were found in the mantle and gills. (det. Dr R.K. Jones 1996-97). In specimens collected from the River Great Ouse in 1997 the watermite *Uniocola crassipes* was found in the encrusting freshwater sponge (det. Dr R.Hamond).

In the early 20th C. Mayfield (1909) records duck mussels from the Rivers Yare, Bure and Wensum at Heigham and Hellesdon. The only other record is from Blo Norton.

A.E.Ellis (1941) notes the species in the dykes opening into the River Yare at Wheatfen. He observes that, "*Anodonat anatina* is definitely a river mussel and is absent from the broads, where *Anodonta cygnea* is often abundant". However, there are later records from broads and lakes in Norfolk. Upton Broad (A.E.Ellis 1962), (Wortley 1971), Seamere (Baker 1972), Little Ormesby Broad (Jackson 1977), Ranworth Broad (Jackson 1977), Ormesby Broad (Jackson 1977).



Depressed river mussel *Pseudanodonta complanata* (Derek Howlett)

Painter's mussel *Unio pictorum* (Derek Howlett)

Swan mussel *Anodonta cygnea* (Derek Howlett)

Duck mussel *A nodonta anatina* (Derek Howlett)

Currently the species is abundant in most Norfolk rivers. In the River Yare it is present from Whitlingham to Langley Marshes. The numbers decline rapidly downstream of the Beauchamp Arms as saline waters intrude up the river. Previously E.A.Ellis (1963) found specimens at Hardley Cross which may indicate lower saline levels at that time. Above Norwich it has been sampled at Marlingford. It is present in Rockland, Wheatfen and Buckenham Broads. In the River Bure the mussel can be collected from Coltishall to the Thurne Mouth. In the Bure broads it has been recorded from Belaugh, Wroxham and Bridge Broads. It is occasional in the River Mun. It is a common species in the River Ant but only two specimens have been collected recently from the River Thurne near Womack Water. In the River Waveney the mussel occurs below Beccles to the Oulton Broad Dyke confluence and in Lound Ponds. The earliest Norfolk record from the River Great Ouse was at Hilgay (Preece & Wilmot 1978) and recent surveys have confirmed its presence in the river throughout the Norfolk reaches. It has been found in the rivers Little Ouse and Wissey as well as in the Cut-off Channel, Flood Relief Channel between Denver and King's Lynn sluices and the drain at Stowbridge. In inland waters it has been noted at Little Melton Reservoir where there is a small stream which maintains the reservoir water levels. This stream is 1m wide and 50cm deep. During the hot summer of 1996 the stream dried up and in the baked mud bottom up to 1km downstream of the reservoir there were many recently dead specimens of duck mussels. The shells were small, but were not juveniles as they were quite inflated (Howlett, Baker, Clarke 1996-98).

Rands 1986 in her studies of the River Great Ouse at Bedford concludes that the duck mussel does not appear to have been badly affected by dredging operations.

Pseudanodonta complanata **Rossmassler**

The compressed or depressed river mussel inhabits slow flowing rivers. It is a western European species and is known from the Ipswichian Interglacial. Since unionids have comparatively long life spans and their parasitic larval stages make them particularly vulnerable to environmental changes such as pollution and alterations to waterways, their current status and the factors affecting them is of importance in the conservation of the

species. The vulnerability is closely linked to that of their fish hosts in the larval phase of their life cycle.

The mussel is known to be threatened throughout its range in western Europe. In the UK since 1950 it has been recorded from only 63 ten kilometre sites from Somerset through the Welsh borders to south Yorkshire. The UK has probably the healthiest populations of the mussel in Europe, with the possible exception of Finland. The conservation importance of the mussel has been endorsed by the Government's placing it as a priority species in the UK's Biodiversity Action programmes.

Pseudanondonta complanata was first recorded in Norfolk by Mayfield in 1909 in the River Yare from Norwich to Surlingham. A.E.Ellis in 1940 found it in the River Yare below the city. He recorded one shell having a length of 87mm, which is towards the upper size range for the species, i.e. 88-90mm. A.E.Ellis (1965) wrote in E.A.Ellis *The Broads*, "The River Yare provides an outlying station for this species". A.E.Ellis (1941) did not record the species from either Wheatfen Broad or from the main dykes linking the Wheatfen marshes to the River Yare. E.A.Ellis in his lifetime studies of both Wheatfen and Rockland Broads also failed to record its presence. The inferenrence from the lack of records for these two major sites suggest that these southern broads had not, at that time, been colonized by the mussel.

In 1994 Derek Howlett found a small colony in the Short Dyke leading from the River Yare to Rockland Broad. In both 1994 and 1995 the species was recorded by the authors from Wheatfen Broad. The Conchological Society of Great Britain and Ireland on a field visit to Wheatfen and Rockland Broads on 27th July 1996 dredged living specimens from both sites. The evidence points to the mussel having recently colonized both these linked broadland systems.

In terms of conservation it seems to have survived in the mid-Yare river valley the damaging pollution levels between the early 1950 and 1990's. It appears to have always been rare but when present it can be dredged, albeit

in small numbers. In August 1996 a total of 389 unionid specimens of *Anodonta cygnea* (L.), *Anodonta anatina* (L.), *Unio pictorum* (L.) and *Pseudanodonta complanata* were dredged from the River Yare. 54 specimens of the depressed mussel were found in this initial series of trawls. These represented 14% of the catch. The size ranged from 21mm to 87mm. Later specimens of 90mm were noted. Whilst the numbers collected between Whitlingham Marshes and Cantley represented 14% of the total unionids dredged, the numbers within the area where *Pseudanodonta complanata* are to be found gave a value of 15% of the total unionid catch. In the Fleet Dyke the numbers were of the order of 11% of the total catch. Both dredging and hand searching by subaqua-diving gave similar values. On 8th November 1996 a dramatic drop in the water levels of Rockland Broad resulted in most of the Short Dyke being exposed. *Pseudanodonta complanata* made up 10% of the unionids present in the dyke, although in Rockland Broad itself it was absent. In the current study no accurate estimates of the density of the mussel were obtained, but Negus (1966) gave estimated densities of $0.4m^2$ in the River Thames at Reading.

In the Yare system the largest numbers of mussels were collected near the edges of the reed beds and adjacent to the older boat mooring stages. The number declined in areas of dense tree cover, usually sallows, and where steel sheet or timber piling form the river banks. At Postwick the banks formed from flints also show reduced densities. This irregular distribution is probably linked to the nature of the river beds, current velocities, and to the fact that it is in reed beds that some fish species congregate to breed and thus provide maximum opportunities for glochidia to attach themselves. Where there are ronds colonized in front of the piling by reeds then the mussels are unaffected but where piling is directly onto the river then the ecological balance is adversely affected (Baker, Clarke, Howlett 1998).

A study of the distribution across the River Yare between the Surlingham and Strumpshaw banks showed that *Pseudanodonta complanata* occurs in depths to 2.7m. The largest numbers are found from the Surlingham bends where current velocities are lower and where silt is deposited. Consequently the river bed shelves less dramatically on this bank. In contrast fewer mussels are present on the Strumpshaw bank where the profile falls sharply

and where little silt is deposited. The river bed on this side shows clay lump, presumably from banking work. No unionids occur in mid-river where the depths approaches 4.5 metres.

Down river of the Beauchamp Arms the limit of mussel distribution is probably related to the degree of saline incursions into the river. Cantley represents the normal limit of saline incursion on the surface but no data are available for the saline wedge on the mud surface beneath the freshwater.

In unionids embryos are developed on the gill filaments and these hatch into minute free swimming glochidia. These clamp onto fish where they develop as tiny blisters in the skin, usually the fins, where they live as minor parasites for several weeks before undergoing histolysis and leaving as tiny mussels. The presence of healthy fish populations are essential for the survival of the mussel. European mussel species all favour cyprinid fish as hosts.

The recent colonization of Rockland and Wheatfen Broads and the discovery of *Pseudanodonta complanata* in the River Waveney at Beccles is probably linked to the glochidial stage of the life cycle on fish. Glochidia represent the major free moving phase of the life cycle on unionid mussels and the spread of the species beyond its immediate habitat sites. In the River Yare the increasingly salinity of the water below Cantley probably acts to prevent fish vectors carrying larvae into the Rivers Chet, Bure, Ant and Waveney systems. It is possible, however, that at low tides with minimal water movement that saline levels are low enough for fish and attached larvae to enter the River Chet. Breydon Water with its essentially saline water acts as an effective barrier to the major broadland rivers in facilitating the spread of the mussel. Some fish species move from saline to freshwater sites, e.g. the saltwater flounder is now found in large numbers in the surface silts of Wheatfen Broad (Ellis 1955; Baker, pers. observation 1995) and is thus able, in theory, to carry glochidia throughout the Broadland system. Knowledge of fish migratory patterns in Broadland and the influence of chloride in the water on glochidia would be beneficial to an understanding of the distribution of the mussel in Norfolk.

On the Norfolk-Suffolk border Killeen (1992) records *Pseudanodonta complanata* from the River Waveney below Beccles where it has been collected on only four occasions. It was unknown before 1973 when three dead specimens were dredged at North Cove. In 1985 live specimens were collected at Beccles and in 1990 at Share Mill. The numbers remained very small in the River Waveney.

The evidence from a 1996 survey confirms the observation of Killeen that the species occurs in the River Waveney below Beccles but only in small numbers. The river is far less productive of unionids than the River Yare. A total of only 74 live unionids, *Pseudanodonata complanata* representing 6% of the total catch, were collected in this survey. Two shells collected near the Gillingham Marshes were at the maximum size for the species (84mm & 90mm) and at first glance appeared to be *Anodonta anatina* except the they were slender when viewed end-on. They were confirmed as *Pseudanodonta complanata* from their hinge and muscle characteristics (Howlett, Baker, Clarke 1998).

In west Norfolk *Pseudanodonta complanata* has only been found once previously in the River Great Ouse at Hilgay (Preece and Wilmot 1979). The river at this point has depths of between 3-4 metres with a bottom composed of very fluid silty-clay material. It is slow flowing with an estimated water velocity of the order of 15cmsec^{-1}, although occasionally this may rise to 1msec^{-1}. The River Great Ouse and its tributaries drain the Chalk and Chalky Boulder Clay and this is reflected in the mean calcium concentration of the water (153mg/l Ca) and mean alkalinity (224mg/l $CaCO_3$). Preece and Wilmot note that during very low flow conditions some saline intrusion occurs at Denver Sluice, although the molluscan assemblage shows no evidence of this reaching as far upstream as Hilgay. Measurements in May 1997 during the current survey showed that the river was all freshwater with chloride levels of 72 mg/l Cl^-. There was no evidence of seawater penetration.

The River Great Ouse is an artificially banked river with steep vertical sides held in place with asbestos piling sheets. The water depths near the margins are of the order of 1m and this allows marginal aquatics to form

stable plant communities. Common species include reed, reed sweet-grass, reedmace, bulrush and yellow water lilies. In the current survey *Pseudanodonta complanata* was recorded along the length of the River Great Ouse in Norfolk. The numbers are small but this may reflect the problems associated with using a dredge armed with metal probes through beds of reed and water lilies where it rapidly becomes snagged in the rhizomes. Successful dredging in the waters immediately beyond the marginal vegetation at depths of 1m succeeded in significant catches being taken.

At Horse Fen Farm a total of 44 unionids were collected in a single trawl: *Pseudanodonta complanata* (5 specimens), *Anodonta anatina* (36) and *Unio pictorum* (3). The depresssed river mussel represented 8% of the total catch. Elsewhere occasional specimens of *Unio tumidus* were collected in the trawls.

The Cut-off Channel is a man made waterway completed in the early 1960's as part of an integrated fen flood relief scheme for Norfolk and Cambridgeshire. Near Methwold and Feltwell the channel cuts through chalky substrata and the bed is made up of fine silts with little aquatic vegetation. On the county border at Hockwold cum Wilton the channel is dominated by *Potamogeton lucens*, *Elodea canadensis* and other aquatics. There is little water flow through the system. *Pseudanodonta complanata* was collected in the fine chalky silts at Brookville near Methwold. At Blackdyke Farm, Feltwell, the channel has been cut through chalk. It is 4m deep with aquatics and blanket weed near the sides and a chalk silt bottom. Examination of dredged spoil in September 1997 showed that the depressed river mussel is irregularly distributed along the channel. It appears that favoured habitats may be between 100 and 150m apart. It can be described as being rare and unevenly distributed along the dyke.

Below Denver Sluice a flood relief channel was built in the early 1960's to King's Lynn. It carries water at times of high run-off from Denver to the tidal Great Ouse at King's Lynn. Flow is controlled by inlet sluices at Denver and a tail sluice at King's Lynn The channel is 10km long and 80m wide. The depth is normally between 2-3m, although in October 1997

the depths had fallen to between 1m and 1.5m. The margins are either reed fringed or have piling, often constructed from tyres. The channel bottom is mainly of fine silt with reed debris. *Pseudanodonta complanata* occurs in small numbers in the channel. In October 1997 major mortalities amongst unionid mussels were noted. The water was tepid since there had been no flushing movement because of the extreme summer drought. Measurement of chloride levels by the Environment Agency show summer concentrations of 150mg/l Cl^- whilst those taken during the October survey gave levels of 300mg/l Cl^- near Magdalen road bridge, about midway along the channel. These levels indicate that there is some contamination by brackish water from the estuary, presumably through the tail sluice. Oxygen levels for August were between 150-200% and for September between 70-80%. Chlorophyll *a* readings for August gave values of 8 microgrammes/l and for September 15 microgrammes/l. These were at the surface.

The trawling evidence from early October 1997 indicated that the mortality amongst the unionid mussels, *Pseudanodonta complanata*, *Anodonta cygnea*, *Unio Pictorum* and *Unio tumidus*, is a recent event. A possible explanation may be found from a similar situation at the lock at Oulton Broad in Suffolk. There may be some leaking back through the sluices at certain times from pressure by the tidal waters of the Ouse. The lack of flow and flushing in the channel would then result in a saline layer lying beneath the freshwater on the bottom silts. Organic material in the silts decompose using up the oxygen from the saline layer. The mussels then die-off. Evidence to support this hypothesis comes from the low phytoplankton counts in the surface waters. The planktonic diatoms fall into the saline layer where they are effectively retained. There is no lifting into the upper layers and they are effectively trapped. This would explain the low Chlorophyll *a* counts noted for August and September.

The 32km long New Bedford River connects directly with the tidal River Great Ouse near Denver Sluice. The drain often has high levels of suspended sediments which normally settle on the outside of bends in the system. Dredging until ten years ago was on a regular 8-10 yearly basis but is now carried out on a "needs" basis as and when silts accumulate in the drains. This flexible strategy is probably beneficial for the depressed river

mussel. Dr John Reynolds University of East Anglia (pers. comm.) has found healthy *Pseudanodonta complanata* populations near Mepal at the Earith end of the New Bedford River. Chloride levels are normally low in this section. The mussels are on a clay bed with some gravel. Silt levels are low. Depths range between 2-3m. Water level range about 1.5m. The density noted is of the order of $2m^2$. This represents about 10% of the unionid population in the site. The maximum size noted was 70mm, which shows a smaller shelled mussel than the 90mm specimens from both the Waveney and Yare rivers.

Examination of 7km of dredged spoil from the Counter Drain (Welney Marshes) in August 1997 confirmed the irregular distribution of the depressed river mussel along what is a uniform man-made waterway. Weeds are cut annually and in some sections a weed rake is used from the banks; in effect a shallow dredge which can scrape the silt/mud bottom. Essentially the Counter Drain is a freshwater drain which picks up water from the higher lands around Earith. At the pumping station for Block Fen the marine clays provide sulphide and sulphate ions which, following the irregular pumping, reduce the pH to between 5-6. This can seriously affect the acidity levels in the Counter Drain and Old Bedford River. Pumping is irregular and dependent upon rainfall conditions etc prevailing at the time.

The Old Bedford River and Delph River have slow flowing freshwater which pick up lots of silts. The sluice gates at Earith control flooding. The water depths range from 1-1.2m. Aquatic weeds are cut annually. Weed raking from bank can remove silts - carried out about 2-3 years. *Pseudanodonta complanata* is present along these reaches, although evidence from dredged spoil banks shows that the distribution is irregular and sparse.

During the current surveys Dr R.K.Jones identified a number of watermite species in the collections. *Unionicola intermedia* (Koen) in mussels from the Fleet Dyke Rockland in September 1997. The only other record from *Pseudanodonata complanata* for this mite is by Hever (1975) from Kiel in Germany where it was attached to the gills (Jones 1998). *Unionicola ypsilophora* (Bonz) from the same site is the first record for this mite other

than in *Anodonata cygnea*. Jeffreys (1862) observed that this mite is so tenacious of life that it can survive boiling water sufficient to kill the swan mussel.

Family Sphaeriidae

***Sphaerium corneum* (L.)**

The horney orb mussel is found throughout Norfolk in both running and standing waters. Boycott (1936) considered it to be a very good indicator of good conditions for molluscs. In Broadland it is a very common species of rivers, broads, ditches and dykes in both fen and grazing marshes.

Sphaerium corneum has an annual life cycle with some adults living for two years. The young are held within each mature individual and can number between 2 and 20 depending on the size and maturity of the adult. Five specimens dredged in 1996 from the Fleet Dyke at Rockland Broad exceeded the published UK maximum size of 14mm by 2mm

***Sphaerium lacustre* (Müller)**

The lake orb mussel is a species which prefers living more in still rather than running water. It is more tolerant to poor conditions than *Sphaerium corneum* and in Norfolk is a species more associated with broads, ditches, dykes and ponds. A.H.Clarke (1992) notes that in Canada it is ordinarily found in mud, but sometimes in sand. Driscoll (1976) recorded the species as being generally distributed in broadland dykes. In a a detailed survey of the grazing marshes of Ludham SSSI in 1996-97 the authors found the lake orb mussel to be generally distributed and common, although it was absent from a number of dykes where conditions appeared to favour its presence. Large specimens were also collected in 1997 from cattle grazed freshwater dykes fed from an active spring at Brancaster. The mussel has also been recorded from Upton Broad, Alderfen Broad (A.E.Ellis 1940), Wheatfen Broad (E.A.Ellis 1933, A.E.Ellis 1941, Howlett 1994), Lound (Ellis 1985), Devil's Punch Bowl in Thetford Forest (Howlett 1987), Strumpshaw Fen (Howlett 1996) and a single specimen from the River Bure near Crabbett's Marsh (Howlett, Baker, Clarke 1996). Jackson notes specimens from Belaugh Broad, Crome's Broad, Hoveton Broad and Rockland Broad (1995). The mussel is common in the shallow waters with

sandy-flint and silt beds of the River Mun (Howlett & Baker 1998).

Family Pisidiidae

***Pisidium amnicum* (Müller)**

The river pea mussel inhabits rivers, canals and lowland lakes, nearly always in moderately hard water. In Norfolk it has been recorded by Mayfield (1909) in the Rivers Tas, Yare and at Wormegay (R.Nar?) and Weeting (R.Wissey?). Patterson (1905) collected it at Yarmouth; Ted Ellis (1935) at Bungay in a stream on the northern side of the River Waveney; A.E.Ellis and E.A.Ellis at Wheatfen Broad (1935-1940).

The species is currently found throughout the county. The distribution appears to be patchy but this may reflect the activity patterns of the recorders. River Great Ouse at Hilgay (Preece & Wilmot 1978), River Wensum at Norwich (Baker 1979); (Kerney 1979) at Cley and Holt; and at Wheatfen Broad; in Rockland Broad where it is occasional, River Wissey at Hilgay, Sugar factory, Stoke Ferry; River Bure at Belaugh rare, Rockland Boat Dyke rare. During 1995 a large fish pond was excavated adjacent to the River Yare at Marlingford Hall. The spoil heap revealed thousands of sub-fossil shells all of which were a very large size (10-14mm) for this species (surveys Howlett & Baker 1996-1997).

In a Dorset chalk stream *Pisidium amnicum* has been shown (Bass 1979) to have one annual brood in May. A small proportion of the largest adults survived to initiate a second brood during August. Mean brood sizes of 13 individuals per mussel with a maximum of 37 were recorded from adults of 8.0-8.5mm. The young are nurtured in brood sacs in the branchial chamber and are released as immature adults.

***Pisidium casertanum* (Poli)**

Arthur Ellis (1941) noted caserta pea mussels from Wheatfen Broad (var. *ponderosa*), Upton Broad and the River Yare. It was recorded in the River Yare at Whitlingham in 1950. At Wheatfen it is present in tidal dykes linked to the River Yare but is absent from the dykes subject to the ebb and flow of the tide, but having no through current such as scour channels.

Wortley collected specimens from Upton and Alderfen Broads in 1971. Preece & Wilmot found the mussel in the Great Ouse at Hilgay in 1978, Kerney during the Conchological Society survey studies at Cley and Holt in 1979.

During their current surveys the authors have recorded the species at Wheatfen, Rockland and Buckenham Broads, Cantley Marshes, Lound, River Bure at Crabbett's Marsh, The Mermaid, Searrow Beck, River Mun, River Wissey at the sugar factory, River Stiffkey at Great Snoring and Houghton St Giles, Marlingford in the River Yare in a *Glyceria* dyke. The variety at Marlingford is var. *ponderosa*. In standing waters the molluscs has been recorded at Gunton Great Water. Further records are at East Walton Common (Killeen 1991), Heron's Marsh Surlingham (Killeen 1996), Belaugh Broad (Jackson 1995) The species is widely distributed in Norfolk.

This species has the widest ecological tolerance and can be found in a whole range of habitats. For example it has been found in oligotrophic bog waters or in association with many other species in calcareous rivers. (Bishop & Hewitt 1974). Arthur Ellis (1978) considers this species to be the most successful of the freshwater bivalves, living in all types of habitat, good and bad, in hard and soft waters indifferently.

***Pisidium subtruncatum* Malm.**

Mayfield in 1909 noted short-ended pea mussels in the River Tas at Stoke Holy Cross and Swainsthorpe, at Horning Ferry in the River Bure, at Old Lakenham, Thorpe and Surlingham Ferry in the River Yare, at Costessey in the River Wensum, at Holt, Babingley, North Wootton and Weeting (River Wissey). Cockle recorded it at Wheatfen Broad in 1939 and Arthur Ellis (1941) at the same site - especially in the pools and channels.

In his survey of Broadland dykes Driscoll found the species in TG41 in 1972, Kerney at Cley and Holt (1979), Preece & Wilmot (1978) in the River Great Ouse at Hilgay, Wortley in Upton Broad in (1971), at Barton Bendish in the River Wissey by Kerney (1984).

The mussel continues to survive at Wheatfen Broad (1995), Rockland

Broad (1994) and Buckenham Fen (1997). Killeen (1996) recorded it in dykes at Surlingham and Claxton. It is found in the River Yare at Marlingford (1994), River Tud at Honingham (1998), River Tas (1998), River Wissey at Hilgay (1997). In dykes and ditches it has been found at Acle Marshes (Killeen 1996) where it is occasional. In the Bure valley it has been collected by Jackson at Hoveton Great Broad (1995) and by the authors in Searrow Beck and the River Mun (1998). In an intensive study of Ludham grazing marshes the authors discovered the mussel in only one dyke (1997) and in north Norfolk at Brancaster grazing marshes in a freshwater dyke (1997). Jackson (1997) discovered specimens in dykes at Gelderston in the Waveney valley. In central Norfolk it has been collected by Killeen at East Walton Common (1991) and Thompson Common (1996). The mussel is widely distributed in Norfolk.

Arthur Ellis (1978) considered it to be one of the commonest of *Pisidium*, especially in habitats with flowing water.

The species has an annual life cycle with two broods a year which are released in either June or October.

***Pisidium pulchellum* Jenyns**

The iridescent pea mussel has always been rare and/or under-recorded in Norfolk. Mayfield (1909) noted it at Flordon Common and Stoke Holy Cross in the River Tas valley. It was also collected at Colney on The River Wensum and at Gaywood in the west of the county. A.E.Ellis (1941) described it at Wheatfen, Thorpe and Surlingham in the Yare river valley. In 1978 the mussel was collected from the River Great Ouse at Hilgay and in 1979 at Holt. Kerney (1976) records it from 7 sites post-1950.

At Wheatfen in the 1940's *Pisidium pulchellum* was found in tidal dykes where reed and *Glyceria* encroached and in dykes shaded by trees which were devoid of vegetation and whose bottoms were thickly covered with dead leaves. It was also collected from non-tidal dykes. In 1996 Howlett collected large numbers from a RSPB reserve fen at Surlingham bordering on the Wheatfen reserve. The bivalve was found in two very shallow dykes on two sides of a grazed marsh with canopies of sallow and hawthorn. The

emergent vegetation is dominated by *Carices* and *Callitriche* spp.

***Pisidium supinum* Schmidt**

There are a few early Norfolk records for the hump-backed pea mussel. Wilton Bridge Hockwold Little Ouse, Lloyd-Evans (1967). Kerney (1976) from a few fens and fenland rivers.

There are a small number of recent records. Erskine (1986) from River Yare at Bramerton; Howlett (1995) from Rockland Broad; a single specimen from the centre of the Broad at a depth of 1m in bare mud near water lily pads. Other species noted from the site included *Pisidium nitidum* and *P. casertanum*. Jenny Kitchen (1994) collected a single specimen from a shallow water margin in Salhouse Broad

Rands (1986) studying the River Great Ouse in Bedfordshire noted that the species prefers a muddy but clean bottom with fairly fast river flow.

***Pisidium obtusale* (Lamarck)**

There are early records for porous pea mussels from Colney, Swainsthorpe, Roydon Fen, St Germains by A.Mayfield (1909), Whitlingham by H.Lindley-Jones (1938), Upton Broad, Wheatfen Broad and River Yare by A.E.Ellis (1941).

Kerney (1976) shows the species to be widely distributed in Norfolk. Recent records are from Wheatfen Broad in tidal channels in *Glyceria*; Surlingham in Church Marsh, Strumpshaw Fen, Rockland Dykes, Rockland Broad in *Glyceria* litter, Rockland Island, Surlingham in *Glyceria*; Cantley and Buckenham marshes; Ludham grazing marshes; Honingham in ditches. In the Waveney valley specimens were collected from the grazing marshes at Gillingham from overgrown dykes dominated by *Carex riparia* and *Sparganium erectum*. A number of these mussels lacked the diagnostic pseudocallus on the posterior lateral teeth (confirmed by M.P.Kerney), (Howlett, Baker, Clarke 1996-98); Upton Marshes, Muckfleet Marshes, Sutton Broad, Claxton and Rockland Dykes (Killeen 1996), Flordon Common (Erskine det. Kerney 1984); Peter St Burgh (Jackson 1997).

The porous-shelled pea mussel shows a preference for polluted places where few other molluscs are found.

***Pisidium personatum* Malm.**

Historically there are few records for red-crusted pea mussels although in the Conchological Society Survey of 1976 it is shown as being widely distributed. Early records are from A.E.Ellis (1941) at Alderfen Broad, Upton Broad and Wheatfen Broad where it was described as being very common in reed swamp but rather less frequent in some of the shallow drains. It did not occur in deep waters. Lloyd Evans (1967) at Didlington Park.

Recent records include East Walton Common (Killeen 1991), Flordon Common (Erskine 1982), Cley (Kerney 1997), Wheatfen Broad, Rockland Broad, Marlingford where it is common in a stream, Ludham Marshes, Roydon Fen and Gillingham dykes bordering River Waveney, Saxlingham Thorpe Common bordering River Tas, River Stiffkey at Thursford Hall, the Mermaid in outflow waters from Cawston Tower Lake, Honingham fen ditches (Howlett & Baker surveys 1995-98).

Rands (1986) showed a preference for polluted spots along River Great Ouse where few other molluscs are found. Dirty outfalls and cattle drinking areas being favoured.

***Pisidium milium* Held.**

Kerney (1976) observed that most records of the quadrangular pea mussel are from Broadland and south of county. Few are from the Wash and Fen regions. This view is supported by the surveys of Jackson who found the species in Crome Broad, Hoveton Great Broad, Hoveton Little Broad, Belaugh Broad, Cockshoot Broad and Rockland Broad in 1995-1996. Further sites discovered by the authors (1998) are at Honingham in the Tud valley, at Buckenham and Cantley marshes in the Yare valley, River Tas (1998) and at Gillingham in the Waveney valley. In the latter site the mussels were often found attached to thread algae in the freshwater dykes. At Wheatfen Broad A.E. Ellis (1941) recorded quadrangular pea mussels in tidal dykes shaded by trees along the edge of Surlingham Wood and in

non-tidal dykes and tidal dykes invaded by reed swamp.

Ladle & Baron (1969) noted no clear picture of the annual cycle - although they consider it to be an annual species in the River Tarrant in Dorset.

***Pisidium henslowanum* (Sheppard)**
Early records are from Mayfield (1909) at King's Lynn; Lindley-Jones (1938) at Kirby Bedon; A.E.Ellis (1941) at Wheatfen Broad and at Whitlingham (1950); River Wissey at Stoke Ferry Kerney (1964); River Great Ouse at Hilgay Preece & Wilmot (1978); Holt Kerney (1979). Kerney (1976) noted that it is common in Broadland, and in fens and fenland rivers but is absent from King's Lynn - Wash area.

Recent records are from Wheatfen Broad, Rockland Broad, Marlingford in River Yare, River Wissey at Stoke Ferry and Hilgay, River Bure at Crabbett's Marsh, Cawston Tower Lake, River Mun, Cut-off Channel in Fen Relief Scheme at Feltwell and at Lound (Howlett & Baker 1994-1998). Jackson collected specimens from Rockland Broad, Burnt Fen Broad, Barton Broad, Belaugh Broad and Rollesby Broad (1995).

Rands (1986) observes that it likes swift flowing water. Usually a deep water species. At Wheatfen it is only occasionally found in dykes, is frequent in the tidal channels and is abundant in the large drains near the river where it is associated with a fluviatile group of snails.

***Pisidium hibernicum* Westerlund**
This is a rare species in Norfolk, although it is known to tolerate most habitats. The early records for globular pea mussels reflect the collecting sites of Arthur Ellis who holidayed at Thorpe. Wheatfen Broad in non-tidal dykes A.E.Ellis (1941), Thorpe St Andrews (1940), Whitlingham (1950). Kerney (1976) records only five sites in Norfolk - all in Broadland except one in central Norfolk at Gressenhall.

***Pisidium moitessierianum* Paladilhe**
Kerney records only four sites in Norfolk for 1976. Gressenhall (1972); Goodchild (1964) in River Yare at Whitlingham; Baker (1977) at

Billingford in River Wensum; Preece & Wilmot (1978) in River Great Ouse at Hilgay.

***Pisidium pseudosphaerium* Schlesch.**
All the records for false orb pea mussels are recent. It was first discovered in Norfolk during a field study visit by Conchological Society of Great Britain and Ireland by Ian Killeen in 1996 in a number of sites at Wheatfen Broad in a dyke dominated by hornwort; Rockland Broad dykes, Muckfleet Marshes, Upton Marshes, Claxton Dyke, Thompson Common.

The false orb pea mussel was discovered by D.Howlett (December 1997) at Gillingham Marshes near the River Waveney. These are grazed marshes with many overgrown dykes. The mussels were found attached to thread algae and to a lesser extent in silts. Subsequent survey examinations have shown the mussel to be present in numerous dykes in the Norfolk grazed marshes of the Waveney (Jackson 1997).

***Pisidium nitidum* Jenyns**
The shining pea mussel is generally distributed in ponds, lakes, broads, dykes, streams and rivers throughout Norfolk, although there are no records from the Fens other than in the River Great Ouse. In Broadland it can be commonly found in most freshwater broads. In other localities it is most common in the smaller rivers such as the Tud, Tas, Nar, Glaven, Mun and Stiffkey where there is a fast flow and in the upper reaches of the large Broadland rivers where the waters flow quickly over shallow stretches of sandy-gravels.

***Dreissena polymorpha* (Pallas)**
Before the 19th C. the zebra mussel was restricted to the Black and Caspian Seas. In the British Isles it was first noted in the London docks in 1824 and by the 1850's it had spread via canals and rivers through central England. Its early presence in the Broads rests on the finding of a single shell in Breydon (Bridgman 1872). In 1927 the next discovery was made by A.J.Rudd who found living mussels in Oulton Broad.. In Norfolk it turned up in the River Bure shortly after the Horsey sea flood of 1938 and quickly became abundant from above Wroxham Bridge to the Ant mouth.

A.E.Ellis recorded it in South Walsham Broad in 1940 and E.A.Ellis & A.J.Rudd at Woodbastwick Little Decoy Broad and Salhouse Broad in 1942. Three years later it was found in Ormesby Broad by S.A.S.Walton and subsequently it became a major problem in the waterworks (Clarke 1952). Its presence in the River Waveney was noted by Clarke in 1973 and in the Norfolk reaches of the River Great Ouse by Preece and Wilmot (1978). Morton reported it from the River Wissey at Hilgay in 1964.

The zebra mussel has been recorded from the Rivers Bure, Waveney and Great Ouse and in Ormesby Broad 1996-97 (Howlett, Baker, Clarke). The colonization of the River Yare appears to be of recent origin. Specimens were collected by the authors in the river adjacent to the Beauchamp Arms and Langley Green in 1996 and in Rockland and Wheatfen Broads between 1994-1997. In the latter two sites *Dreissena polymorpha* was found in stretches of the Short Dyke and Fen Channel with sandy-stoney bottoms. The mussel has colonized similar coarse, pebbly, quartz sands of the Sandringham Sands/ Kimmeridge Clay at Fordham in the Cut-off Channel of the Fen Flood Relief Scheme completed in the early 1960's. Jackson notes specimens from Filby Broad, Wroxham Broad (1985), Ranworth Broad (1989), Ormesby Broad (1992, Hoveton Little Broad (1993).

In the Flood Relief Channel between Denver to King's Lynn Sluices occasional live but numerous dead shells were noted by the authors. No fully grown mussels were collected (October 3rd 1997). Stanczykowska (1964) noted then greatest abundances of the zebra mussel at depths of 4 metres and at greater depths of 11-12 metres it was absent. These observations are in accord with those noted in Norfolk.

Dreissena polymorpha is not confined to rivers and is frequently found in reservoirs and lakes. The possession of a free-living veliger larva is considered to be a primitive feature which is unique amongst British freshwater bivalves. In open waters the larvae swim near the surface, but retract the velum and sink at the slightest disturbance. The free-swimming phase is about 7 days before the larvae sink and live on the bottom. The larvae normally settle in waters at depths between 4-7 metres between late July and early August. The retention of the active byssal apparatus in adult

life enables the mussel to colonize stones and shells of *Anodonta* and *Unio*. On these substrates it builds up colonies which in time allows the mussels to form secondary colonies on shells of its ancestors. In the Norfolk broads and rivers the tourist influx has produced an additional habitat on beer and lager tins discarded by holiday makers. The silty-peaty beds of the broads and Broadland rivers offer poor attachment sites for the mussels, although E.A.Ellis noted them attached to reeds, water-lily rhizomes and alder roots in Woodbastwick Little Decoy Broad in 1942. Metal and asbestos sheet piling on many river banks provides additional attachment sites if there are deep waters immediately adjacent. The zebra mussel is reported to live for 4-5 years but the average lifespan is 3-4 years. The major predators of the mussels are roach (*Rutilus rutilus*) and eels (*Anguilla anguilla*) (De Nie,1982). Diving ducks eat both adult and juvenile mussels whilst the leech *Glossiphonia complanata* is reported to feed on young specimens (Smit *et al*., 1993).

Untreated water is pumped from the River Bure through 15km of 60cm diameter main into an open sedimentation reservoir. From this reservoir water is drawn by pumps into rapid gravity filters. In 1944 Zebra Mussels 13cm thick were found in pipe leading to the filters. In water pipes the larvae do not move in the current but remain in the sheltered waters among grown mussels. Intermittent chlorination of the water supplies has greatly reduced the blockages of water pipes, ducts and channels. Chlorine doses up to 50mg/l Cl_2 for upwards of 2 weeks are used to destroy the mussels (Clarke 1952).

A number of North American researchers have found that heavy fouling (infestation) by zebra mussels on unionids can lead to sharp declines in their host densities. Schloesser *et al* (1996) noted high mortalities in unionids with between 100-220 zebra mussels attached to their shells, whilst Ricciardi *et al* (1996) found that death occurred with infestations as low as 10 zebra mussels per shell. In Norfolk the infestations noted on living unionids have been less than 5 zebra mussels per shell. Strayer *et al* (1996) found low infestations on unionids from the Hudson River despite dense populations of zebra mussels in nearby habitats. These authors observed that competition for food was a major causal factor in the decline

of unionid populations. The biomass of phytoplankton in the Hudson River dropped sharply following the invasion of zebra mussels in the early 1990's.

Bivalve Records

The detailed records for bivalve molluscs are maintained in the Data Bank at the Castle Museum, Norwich.

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WILDLIFE 2000

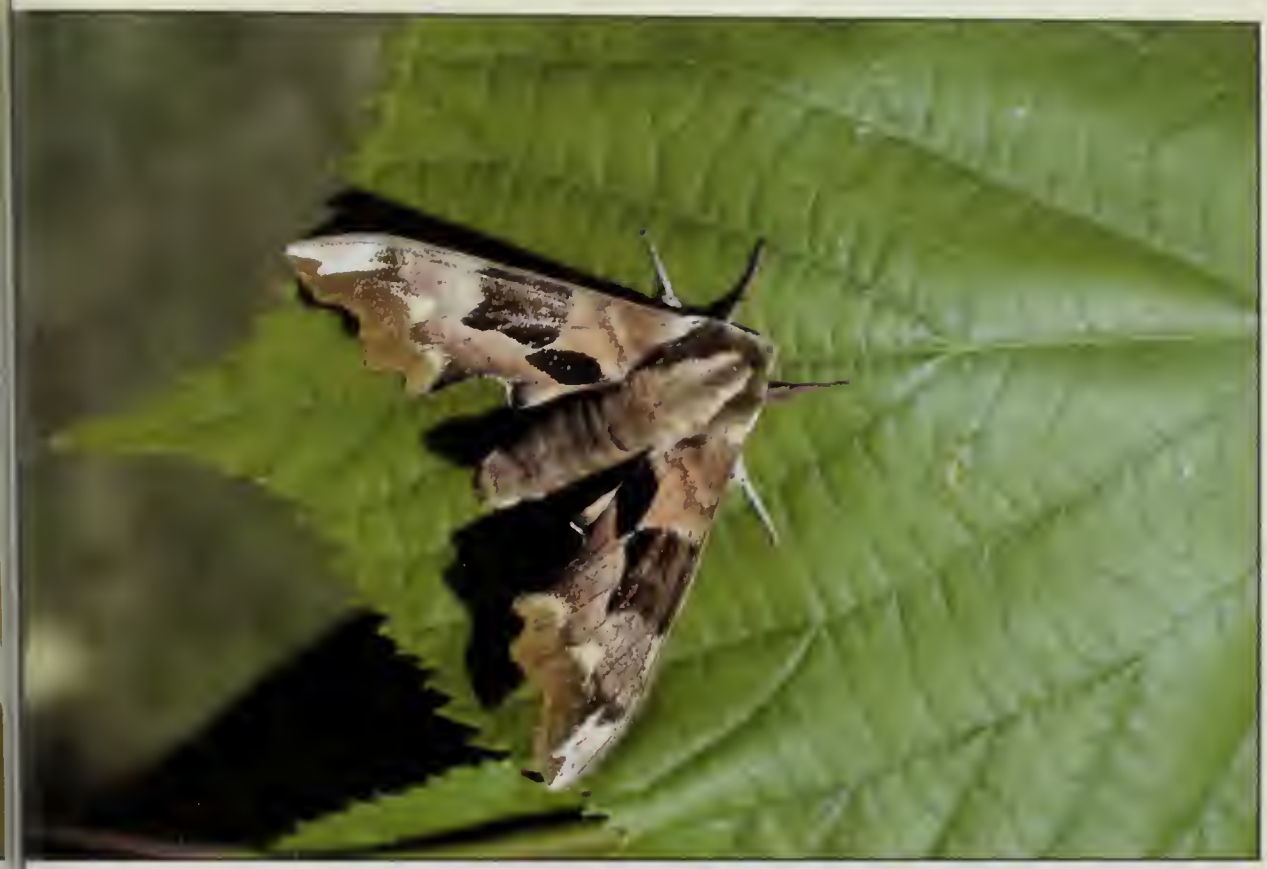
One of the aims of the **Wildlife 2000 Project** is to record a miscellany of observations of the natural history of Norfolk. In these four pages of the *Transactions* a selection of photographs by members of the Society's Photographic Group illustrate some of the diversity in the flora and fauna of the County.

Common spotted orchid *Dactylorhiza fuchsii* (Reg Jones)

Green-winged orchid *Orchis morio* (Reg Jones)

Banded demoiselle *Calopteryx spendens*. River Yare. (Tony Howes)

Migrant hawker *A eshna mixta* Upton Fen (Tony Howes)



Lime hawk moth *Mimas tiliae* (Reg Jones)

Horntail (woodwasp) *Urocerus gigas* (Tony Howes)

Hunting Spider *Pisaura mirabilis* with egg cocoon. Upton Fen. (Tony Howes)

7-spotted ladybird *Coccinella 7-punctata*. Burnham Overy (Norman Carmichael)

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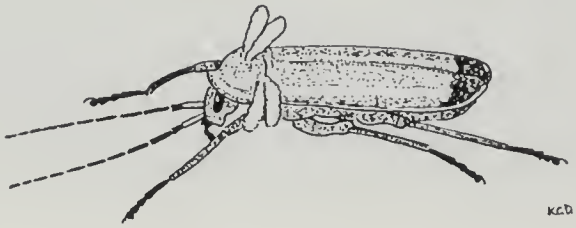
Miscellaneous observations

Insect pollinators of orchids. During the summer months when various orchids are in flower on Beeston Regis Common I always look out for the insects that help to cross pollinate them. Self pollination (autogamy) does occur in areas where insects are scarce, however over the years I have collected and noted the various insects found transporting the pollinia (pollen sacs) from one plant to another to perform cross pollination (allogamy). Unfortunately when more than one species of orchid is in flower at the same time it is possible to get hybrids by this means, resulting in much confusion by visiting botanists.

Silver Y moths are frequently seen visiting lesser butterfly (*Plantanthera bifolia*) and pyramidal (*Anacamptis pyramidalis*), while the 5 and 6 spot burnet moths visit the marsh helleborine (*Epipactis palustris*). Nearly every year I find some of them flying about resembling aircraft with a radar probe, their proboscis held straight out in front unable to be recoiled because of the many pollinia adhering to it.



Other insects found with pollinia attached on their heads are the Hymenoptera *Apis melifera* L. (honey bee), *Cryptopimpla errabunda* Grav. (Ichneumon), *Banchus volutalorius* L. (Ichneumon), the Diptera *Scatophaga stercoraria* L., *Phaonia incana* Wied, *Helophilus pendulus* L., *Tropidea scita* Har., *Syritta pipiens* L., *Trichopsomyia flavitaris* Mg., *Neoasia dispar* Mg., and the Coleoptera *Strangalia maculata* Pod. (alder beetle), *Rhagonycha lignosa* Mu. and *Rhagonycha fulva* Scop. (the common soldier beetle shown with two pairs of pollinia attached to its thorax).

References

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NILISSON, S., 1979. *Orchids of N.Europe*. Penguin Nature Guides.

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BUTTLER, K.P., 1991. *Field Guide to Orchids*. Crowood Press.

Ken Durrant

A North Norfolk Damselfy. Having searched a small North Norfolk pond for a couple of seasons after hearing that a colony of the red-eyed damselfly *Erythromma najas* (Hansemann) was present, Alec Humphrey and I were in luck in 1997. Following a thunderstorm on the afternoon of June 8th the skies cleared and as the sun came out the lily pads glistened. Using binoculars we scanned the leaves in vain, seeing blue-tailed *Ischnura elegans* (van der Linden), azure blue *Coenagrion puella* (L.) and common blue *Enallagma cyanthigerum* (Charpentier) damselflies everywhere, until the "red-eye" was spotted. Once seen it was comparatively easy to pick them out from the others, as apart from the distinctive red eyes, it is generally larger. The original source of the colony is believed to have been eggs or nymphs transported with water plants from Broadland that were used to stock the pond. According to the dragonfly survey (Milford & Irwin 1990) they are fairly widespread from the broads, through central Norfolk and into the southwest of the county. This North Norfolk colony appears to be an accidential introduction that has persisted.

Reference

MILFORD, P.J. & IRWIN, A.G., 1990. The Dragonflies of Norfolk. *Trans. Norfolk Norwich Nat. Soc.* **28** (5), 357-380

Francis Farrow

***Tetrix subulata* at garden pond**. The groundhoppers are diminutive relatives of the grasshoppers distinguished by backward extensions of the thorax to cover the whole of the abdomen. Unlike grasshoppers they overwinter as dormant adults or late instar nymphs becoming active again in April and May. Common groundhoppers *Tetrix undulata* are flightless, but the slender groundhopper *Tetrix subulata* will fly short distances after the manner of

grasshoppers. Both species can be found in damp meadows being most readily noticed in areas of bare mud such as cow wallows or tractor ruts.

Although usually thought of as sedentary, there is evidence of dispersal over large distances. Twice over the last five years, *T. subulata* has occurred at the writer's garden pond (3x2m with narrow mud margin and marsh flora) being present in 1992 and 1997. On both occasions adults were first noted in late May with first instar nymphs observed about a month to six weeks later. The implication is flight dispersal by gravid females as the nearest known colonies are 800m to the west and to the south east, separated from the author's garden by roads and housing.

1992 was the best season with a distinctive nymph with a missing left femur surviving until 10th September. Successful colonisation is unlikely because of the small size of the pond and the limited area of adjacent natural vegetation, the garden being mainly lawn and vegetable plot.

D I Richmond
42 Richmond Rise, Reepham, NR10 4LS

Water Measurer. The water measurer *Hydrometra stagnorum* is an extremely thin insect. It is generally greyish brown in colour and usually lives in vegetation at the edges of freshwater streams and ponds. They are predatory bugs that, like the pond skater *Gerris*, hunt other prey over the water, although they usually spear such as water fleas, mosquito larvae etc., with the rostrum through the surface film. Up to September 1997 I had not noticed these insects before, however, while cutting back dead vegetation around my garden pond in Sheringham I disturbed about thirty individuals. They were last seen in November.

Francis Farrow

Roesel's Bush Cricket *Metrioptera roeselii* (Hagenbach): A new record for Norfolk. During the summer of 1997 I was working at Holkham NNR for English Nature. Part of my summer tasks was to locate and map out any intertidal areas between Wells-next-the-Sea and Cley-next-the-Sea containing either of the two species of *Zostera*, the eelgrasses, found in

North Norfolk. On the 14th August I had completed the last section between Stiffkey and Warham then returned across the saltmarsh. The afternoon was warm and sunny and the subtle marsh colours looked so attractive in the softening light that I decided to take the long route back to my car via Warham Greens. Coming onto the Greens I followed the line of goosefoot growing from the tangle deposited by the highest marsh tides.

Suddenly I was aware of a continuous 'buzzing' sound coming from a thick patch of goosefoot. The sound was quite similar to hearing a distant Savi's warbler, sometimes described as sounding like an electric shaver. This noise was new to me but I had a suspicion who the culprit was. After a careful search I eventually found it: a bush-cricket unfamiliar to me. I quickly made some sketches and notes then watched it for some time. This individual was a male, quite worn with his right hind femur missing. The most striking features were the dark pronotum with a yellow border, and the first three abdominal segments which were blackish with a neat yellow spot in the centre of each. These, combined with the distinctive song were all clear pointers to my first, and as I later found out the county's first, Roesel's bush-cricket. This male was of the long-winged form *f. diluta* (Charpentier). The tips of the wings were very worn and ragged suggesting a seasoned traveller.

I searched similar areas nearby for any further individuals but found none. During the four day period I observed him, instantly recognisable by his missing limb, he moved westwards a couple of metres each day. This period of the summer of 1997 was particularly good for immigrant insects in my local area. Breathtaking numbers of small tortoiseshell butterflies *Aglais urticae* had been moving west on several days. Nearby in the dunes and Corsican pines of Lodge Marsh on the 16th August, I noted two to three hundred migrant hawker dragonflies *Aeshna mixta*, forty five common darters *Sympetrum striolatum*, a yellow-winged darter *Sympetrum flaveolum*, and a worn four-spot chaser *Libellula quadrimaculata* basking in the sunshine. These sightings helped to strengthen my thoughts that my bush-cricket was a lone vagrant rather than a wanderer from a recently established colony.

Roesel's bush cricket has been spreading rapidly in the south-east of England and the national orthoptera recorder has found it as near as Ely. In hot summers an extra long-winged form is produced which disperses readily. The Norfolk specimen was a male so for the moment the species can only be recorded as a vagrant in the county, but its ability to reach the North Norfolk coast demonstrates that colonisation of the county is a realistic possibility and recorders should listen out for this species on waste ground and salt marsh edges. Its continuous stridulation, likened to an electric shaver above, has also been described as like the discharge from electricity lines on damp days.

James R McCallum.
9 Chapel Yard, Holkham Village, Wells-next-the-Sea, NR23 1RQ

Butterfly notes. The white-lettered hairstreak has been an elusive butterfly for Alec Humphrey and myself for many years. In 1995 we were shown a small colony on some mature elms near Thetford. In late July 1997, however, while "working a tetrad" for the *Flora* near Baconsthorpe we found a small colony on wych elm suckers in a field hedge. There were about six flying at any one time. The presence of these butterflies on such small trees indicates that further colonies may exist in similar circumstances and should be looked for.

Another scarce butterfly in North Norfolk is the Essex skipper, and although looked for annually on Beeston Common it was only in 1997 that it was proved to be present. David Mower caught what he suspected was an Essex skipper and Ken Durrant confirmed it to be a female. Later David discovered another colony of the skipper near Beeston Bump. The *Atlas* (Hall 1991) shows Kelling, some 6 km to the west as the nearest recorded sighting.

Reference

HALL, M.R., 1991. An Atlas of Norfolk Butterflies, 1984-1988. *British Butterfly Conservation Society, Norfolk Branch.*

Francis Farrow

Additional dragonfly record. In the review of dragonflies for Sheringham and Beeston Commons (Farrow 1997) I should have included a 14th species, the keeled skimmer *Orthetrum coerulescens* (Fabricius). From 1989-91 keeled skimmers were observed by Ken Durrant and David Mower and indeed were known to have attemped to breed in one of the small bog pools that was created by damming a small calcareous stream. Unfortunately the persistent dry weather of latter years, that has produced drought conditions throughout Norfolk, has meant that the stream is prone to drying in any extended period without rain, consequently the pond also dries. Although the dragonflies have not been seen in recent years, it is hoped that if weather patterns return to a more usual seasonal rhythm then we can expect a return of this delightful insect. It presently occurs at a site within 7 miles of the Commons in reasonable numbers so its re-establishment may not be too far away.

References

FARROW, F.J.L., 1997. Dragonflies of Sheringham and Beeston Commons. *Trans. Norfolk Norwich Nat.Soc.*, **31** (1), 83-86.

Francis Farrow

Plant notes for 1997. As it is hoped to have our new *Flora of Norfolk* on the bookshelves by Easter 1999, in other words before the next edition of *Transactions*, we thought it would be a good idea to put members in the picture as to what has been achieved so far and what to expect when the *Flora* is published.

For the last few months, Gillian has been writing the basic text to make sure that we have a consistent style throughout the plant entries. We are then both amending it in the light of our knowledge of our respective halves of the county. Once this has been done and the text made as complete and perfect as possible, it will be sent to Paul Westley, a designer of book layouts by trade. He will prepare our text by putting it into the computer format which the publishers will be using while keeping the style as we want it. Paul Westley is doing a good job and already has saved us a few basic errors. We will be sending the text to him in batches through

the spring and summer for him to prepare and for now it is being left in continuous text. This means that slotting in the maps and photographs and then dividing the whole thing into pages, can wait as late as possible next summer to accommodate all those plants we hope will be found this year (1998).

Perhaps the most important decision made in late autumn was to go ahead with a *Flora* printed throughout in colour. This means we can use the excellent coloured soil maps which have been devised especially for the *Flora* by Robert Ellis on his computer. These, with the dots added for the particular species, will illustrate exactly what soil types the plant prefers far more graphically than any text could do. To use a bit of modern jargon, they will also be far more user friendly than a series of overlays, especially as we hope also to add river systems for plants of wet ground and water and maps showing which roads are salted to illustrate the spread of maritime plants along our main roads. Another bonus of using colour in this way is that we can insert illustrations wherever we want them instead of having just a sheaf or two of colour sewn in wherever it is convenient to the binders. We shall also be able to slot in photographs to fill any awkward gaps caused by the arrangement of the maps. This means that quite a number of coloured slides will be needed. The subjects have not yet been finally chosen, but fairly obviously will include mostly plants which are Norfolk specialities. The plan is to ask recorders who are also photographers to submit their pictures later in the year and we shall hope to chose all we need from these. Only if we are unable to get a particular subject, or one taken to a high enough standard will we go outside our Flora Groups for help.

How is this all being financed? Once our treasurer (John Snape) got over the initial shock of seeing the costs of the *Flora* increase by some 50% because of the use of colour, he has nobly got on with money raising and has produced a chart which shows that with donations so far received, about £10,000, and loans, about £12,000, together with projected pre-publication sales, we are short of somewhere between £3 and £5,000 to make us feel secure. This is working on a final selling price of hopefully not more than £35 and a pre-publication offer nearer £28. This compares

very favourably with the first full colour Flora, that of Cumbria which retails at £42, though that runs to well over 600 pages and is the result of 25 years recording.

At one time we thought of asking for sponsors for our colour plates, but now the whole book will be in colour, this no longer applies. Instead if you have a favourite plant, would anyone like to sponsor the page on which it appears? This would be in the region of £100 per page and could take the form of a gift or loan. Of course anyone offering a larger gift or loan will not be turned away! Donations will be acknowledged in the book. Anyone who feels disposed to help us should write directly to our treasurer, Mr J.Snape FCA, 8 The Old Church, St Matthew's Road, Norwich, NR1 1SP, making out cheques to *'The Norfolk Flora'*.

All records and information should be sent to us as soon possible and by June 30th at the latest, so please check back on anything of interest you may have seen but not sent in to us. A record sent in by twenty different people is far better than one not sent at all! Pre-publication offers will be out in late summer. Keep watching for them and don't miss a bargain - and what about all the Christmas presents too?

Alec Bull & Gillian Beckett

A new habitat for the water-mite *Unionicola ypsilophera* Bonz. 1783.
Adults of the mite *Unionicola ypsilophera* have previously been found only in the mussel *Anodonta cygnea*. Three mussels of the rare species *Pseudanodonta complanata* from the Fleet Dyke, R.Yare area were examined and were found to contain mites as follows. First specimen: one *U.ypsilophera* male; the other two each contained one *U. ypsilophera* male and two females; while one mussel also held one *Unionicola intermedia* female. The latter mite has previously been found in this mussel by Hevers (1975).

Reference

HEVERS, J., 1975. *Ph.D.Thesis, University of Kiel.*

R.K.H.Jones

WILDLIFE 2000

NORFOLK DIATOMS
Part 1: Centric Diatoms

K. B. Clarke
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Introduction

In 1877 Fred Kitton published a list of Norfolk Diatoms as part of the ambitious Flora and Fauna of Norfolk which the Society was publishing in the *Transactions*. In 1884 he revised and extended this list (Kitton 1884), adding 81 species to the earlier list making a total of 345 recorded taxa. Norfolk was almost alone among British counties in having a county list of diatoms. In addition Fred Kitton issued a number of sets of 100 prepared slides of Norfolk Diatomaceae. One of these sets is in the Natural History Museum. Thomas Brightwell formed a collection of diatom slides which he presented to the Norwich Microscopical Society in 1862. This collection was recovered by the Society and is kept in the Castle Museum Norwich (Clarke 1986) He also exchanged specimens with many other diatomists and Norfolk diatoms found their way into other collections. A search of the Catalogue of Diatoms in the Farlow Herbarium of Cryptogamic Botany (Edgar 1987) revealed prepared slides of centric diatoms from Norfolk in the collections of Eulenstein, H.L.Smith and Van Heurck.

The North Norfolk coast attracted workers in the middle of this century including Salah (1953,1955) and Ross and Abdin (1949). More recently Moss & Balls (1989) studied the River Bure Broads and Waterford & Driscoll (1992) and Driscoll & Waterford (1994) examined the abundant epiphytic diatom flora in marsh dykes and broads.

The current state of the Norfolk Diatom List is that about 700 taxa have been recorded, which is double the size of Kitton's list. Of the 700 taxa, 122 taxa are centric diatoms.

Method.

The survey covers the administrative county of Norfolk and the surrounding sea area. Much of the southern boundary of Norfolk is the two rivers Waveney and Little Ouse. Records include both banks of these rivers.

A quarter of Norfolk's diatom taxa are found on the beach having come from the open sea. Besides sand washings, Kitton listed the stomachs of *Noctiluca* as a source of many species. For the purposes of this survey the county is taken to include the southern half of British Marine Census area number 12 omitting the coast of Lincolnshire and the western half of the Wash. Marine planktonic diatoms have been collected by the Environment Agency and by Dr Richard Hamond.

The survey is based on about 2000 prepared slides, mounted in Naphrax from about 200 locations within the county. Bernard Hartley collected extensively within the county and has kindly made diatom species lists available from a number of his slides.

A large part of the interest of the survey has been due to developments in taxonomy in the last two decades resulting partly from work with the scanning electon microscope. Where recent papers have been used in the identification of diatom taxa in this survey they are referred to in the text.

Actinocyclus octonarius = Actinocyclus ehrenbergii

Valves circular, concentrically waved, 50 - 300µm diameter, radial rows of areolae arranged in sectors. A submarginal zone with much smaller areolae and with a single conspicuous ocellus. Records from N. Sea, plankton 53° 05'N, 00°51'E from Hamond (Noted by B. Hartley on Kitton's slide 75 from Cromer).

Actinocyclus octonarius var crassus (Wm Smith) Hendey 1954

The marginal zone is more strongly developed. Kitton lists this from "Sand Washings - Hunstanton, Breydon. Rare" Not seen in recent collections.

Actinocyclus octonarius var ralfsii (Wm Smith) Hendey 1954

Most radial rows of areolae stop far short of centre. Kitton lists this from "Sand Washings - Hunstanton, Breydon. Rare" Not seen in recent collections.

Actinocyclus roperi (Breb) Grunow in van Heurck 1881
A distinctive *Actinocyclus* because of its oval shape. Marine. Only found on the northwest coast but often there in considerable numbers. Kitton's slide No 63 from Hunstanton sands. Scolt Head Island (Adams Series) sand washings at TF 844 462. Also in pool on Great Aster Marsh TF 840 460. Sand washings from Brancaster.

Actinocyclus subtilis (Greg) Ralfs in Pritch 1861
The submarginal zone with its network of areolae covers about 90% of valve. There is a hyaline ring within which are random somewhat larger areolae. Kitton's slide 69. - "*Actinoptychus subtilis* from Cromer" is not an *Actinoptychus* but *Actinocyclus subtilis*.

Actinoptychus senarius (Ehrenberg) Ehrenberg = ***Actinoptychus undulatus***
A smaller species than *A. splendens* (20-150µm dia.) and fewer segments usually six, hence the name). Characteristic of brackish water and seawater. Frustules found occasionally in tidal freshwater. Recorded by Hartley from Gorleston, from Brancaster Beach also from Titchwell. Found in the Nene and on the saltmarshes of the north coast, among seaweed at W Runton. Kitton's list from Yarmouth (*Noctiluca)* as *A undulatus*, abundant Breydon, Hunstanton. Kitton's slide No 35 as *A. undulatus* from *Noctiluca* at Yarmouth Present on Kitton's "Stomachs of cockles Brancaster"- teste Hartley.

Actinoptychus splendens (Shadbolt) Ralfs in Pritchard
It is much bigger (75-200µm dia.) than *A. senarius* and has more segments usually 18-20. This species is used in Holland for dating sediments. Its presence there is taken to date deposits to the last 2000 years. Here it is occasional along the north coast in salt marshes and sand washings. Also found in N. Sea material from 53°05'N, 00°51'E from Hamond. Kitton's slide No 19 from Yarmouth Harbour. Kitton's List has Yarmouth Harbour mud, rare.

Actinoptychus vulgaris Schum
There is some doubt about the identity of this taxon. Hustedt (1930) sets out the problem p.482. Recorded by Hartley from Brancaster Beach and from Titchwell.

Attheya armata (West) Crawford 1994 = ***Chaetoceros armatus*** West
Forms chains of cells with oval valves each bearing two horns. The colonies have much mucilage attached to them. In the H.L.Smith collection 628 from Yarmouth Norfolk and Eulenstein has a slide (No 17) from Hornsea (sic) Norfolk. Kitton's slide No 59 is "*Chaetoceros armatum* from Yarmouth Sands". In his list he says "This doubtful diatom is frequently found at low water, forming a greenish-brown pellicle on the wet sand." In September 1997 the sand on Gorleston beach was a dirty brown colour in places, due entirely to this diatom. Hustedt (1930) lists this species among those incompletely known and gives its locality as "Littoral im Nordseeschlick". This incomplete knowledge was remedied by Crawford *et al.* (1994) who placed it in the genus *Attheya.*

Aulacodiscus argus (Ehrenberg) A.Schmidt 1886
A large (100-260µm dia.) dark valve with a complex double net structure. 3 to 5 long pear shaped processes. North Sea 55^0 05'N 00^0 51E. Kitton reported from mud from Yarmouth Harbour (Rare) Kittons slide No 17 is *Eupodiscus argus* - see Hendey (1964) - from Yarmouth Harbour.

Aulacoseira ambigua (Grunow) Simonsen
Long thin filaments which are distinguished from *A.granulata* by having a deep and wide sulcus instead of the V shaped sulcus of *A.granulata.* Also the terminal cells do not have the long thorns of *A.granulata. A.italica* has spines and a ring of silica rather than the deep sulcus. Not listed by Kitton. It is difficult to distinguish between this species and *Aulacoseira granulata* which he listed as *Melosira punctata* Sm (See below) Occurs in river plankton of Bure around Horning. Also in Barton Broad and Ormesby Broad.. (I have a slide KBC48 from Ormesby Broad from May 1957 with *A.ambigua* present). Figured by Lund (1954) from Malthouse Broad. Kindly checked by Elizabeth Howarth and compared to Lake district specimens and Berrington Pool.

Aulacoseira crenulata (Ehrenberg) Thwaites
The Check List (Hartley 1986) has this as synonymous with *A. italica* (Ehr) Simonsen. Further research is needed on the ecology of both species (Hakansson 1991). The main difference is in the large connecting spines of *A.italica* which might be affected by electrolytes but Norfolk localities do not bear this out. Found in the River Nar at Castle Acre Common and in ditches at Heigham, Norwich. On plants at Buckenham (Joanna Clitheroe).

Aulacoseira epidendron (Ehrenberg) Crawford 1981 = ***Melosira roeseana*** Rabenhorst
Drum shaped cells, the valve having three large pores the valve mantle distinctly punctate with puncta lying parallel to the apical axis. Small teeth at the valve-mantle junction. The structure and taxonomy of *Aulacoseiras* has been investigated by Crawford (1981). Found on moss growing on the stumps of trees at Wheatfen. This was a new record for Norfolk (Clarke 1996).

Aulacoseira granulata (Ehrenberg) Simonsen 1979
Kitton listed this species as *Melosira punctata* Sm "Ormesby Broad, rare". A slide made from Glasspool's herbarium specimen of *Potomogeton* (19th C.) is devoid of *Aulacoseira* species. *A.granulata* is now far from rare in that locality and can be found in many other places. Moss & Balls (1989) reported it as *Melosira granulata* from Bure broads. Belcher found it at Wheatfen although *A.granulata* is uncommon in the Yare. It is essentially planktonic, depending on turbulence from wind or boats to suspend it in the water. It used to form the winter plankton of Fritton Lake and is even present there in summer. It is present in Cockshoot Broad, a small, sheltered broad without boat traffic and in College Basin (Parish of Belton). Its ability to adapt to adverse conditions is shown by its presence in Martham Broad (1820mg/l chlorides). Consists of filaments of cylindrical cells. The length of the filaments is kept to about a dozen cells (See Crawford 1979) by the formation of separation valves. These valves have long spines and the spines serve to identify the species even in live material. The frustules are coarsely punctate in the typical variety. There are two other distinct forms in the Broads. (See below).

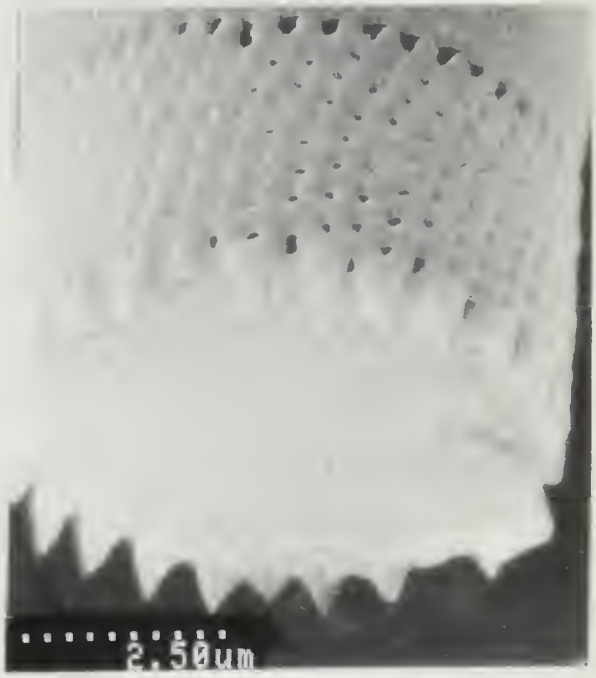
Aulacoseira granulata var angustissima (O.Müller) Simonsen
Cells narrow and long with very fine markings. It can still be recognised as *A.granulata* by the spines of the separation valves. Not mentioned by Kitton. It is commonly found with the type. Moss & Balls (1989) from the Bure.

Morphotype *curvata*
The threads are curved which forms sometimes circles or spirals. Especially found in Barton, Bure Broads and Ormesby Broad. Moss & Balls (1989) report this from Bure and Bure Broads.

Aulacoseira italica (Ehrenberg) Simonsen
A.italica appears to be quite rare in Norfolk. Possibly seen by me at Horning 17 April 1969. This species identified by Ross (*pers. comm.*) on a slide made by Kitton which is in BM(NH) from the rudder of the wherry Britannia. Moss & Balls (1989) record this from the Bure and its broads as *Melosira italica*. Hartley (*pers. comm.*) reported this species from filter beds at Ormesby. I have very typical material of *Aulacoseira italica* from a pond to the west of Thompson Common (TL930955). See also *Melosira orichalcea* which name Kitton used for *A. italica* in a ditch at Ormesby.

Aulacoseira subarctica (O.Müller) E.Y.Haworth. = ***A. italica* subsp. *subarctica*** (O.Müller) Simonsen.

The connecting spines are sharp and there is a strong silica ring near the end of the mantle. It was collected by Z. Waterford from the lake at East Bilney (TF945198). It also occurs in the Shotford gravel pits, just on the Suffolk side of the River Waveney.



Aulacoseira islandica (O.Müller) Simonsen.
A delicate taxon with the pervalvar striae on the mantle running parallel to the axis. More structural details in Genkal & Popovskaya (1991). Recorded from R. Bure and its broads by Moss & Balls (1989).

Auliscus sculptus (Wm. Sm) Ralfs in Pritchard
Cells solitary. Valves circular or elliptical. There are 2 conspicuous ocelli on elevations. The valve surface is ridged. Normally found on the strand line where it lives attached to sand grains. Snettisham strand line.

Biddulphia alternans (J.W.Bailey) van Heurck 1883 = ***Triceratium alternans***
Kitton's List: " Stomachs of *Noctiluca*, Hunstanton sands, rare" Haven Bridge Stracey Arms, West Runton. Recorded by Hartley from Titchwell.

Biddulphia antediluvianum (Ehrenberg) Grunow
Kitton has this as *Amphitetras antediluvianum*. He said "I have only found a few specimens on seaweed from Cromer".

Cerataulus radiatus (Roper) Ross = ***C. smithii*** Ralfs
A small form with thin tapered processes. In plankton off Yarmouth at S.W. Scroby buoy. Found by Hartley at Gorleston in Sand Washing. Kitton's list of Norfolk Diatoms Breydon.

Cerataulus turgidus (Ehrenberg) Ehrenberg
A robust form with short fat processes. In sand washings from Stiffkey Sands. Kitton's list of Norfolk Diatoms Breydon.

Chaetoceros diadema (Ehrenberg) Gran = ***Chaetoceros curvisetus*** Cleve
Bent filaments without special end cells. Setae all bent to the same side of filament. Part of the North Sea neritic plankton. By S.W. Scroby Buoy in Yarmouth Roads.

Chaetoceros muelleri Lemmermann
Cells not usually forming chains. Long thin bristles. Spores with a smooth membrane. Johansen & Rushforth (1985) looked at the taxonomy of *C. muelleri* in relation to similar taxa. The typical *Chaetoceros* of Hickling

Broad (chlorides around 2000mg/l) and Oulton Broad. Leah *et al* (1978) give counts of *Chaetoceros* in Hickling Broad over a year (1976-77) reaching a peak of 2500 cells/ml in the middle of winter.

Chaetoceros simplex Ostenfeld
Thin delicate bristles at right angles to axis. Spores with spiny membrane Occasionally in the Bure Broads. Very small and appearing sometimes to be living communally in a mucilage envelope.

Chaetoceros socialis. Lauder 1864
Cells forming short chains in a gelatinous mass. All bristles point to one side except a single long bristle pointing in the opposite direction. Found on the North Norfolk coast and in Yarmouth Harbour.

Chaetoceros subtilis Cleve 1896
Chains of a few cells with elliptic valves. Our valves were domed or recessed but Hustedt (1930) has them completely flat. The chaetae (40-100µ long) are all pointing in the same direction. The chromatophores are single or double plates on the girdle side. In August 1992 the middle part of the Yare-Waveney had considerable numbers of *C.subtilis*. It was found at Reedham, Haddiscoe, Burgh St Peter and Oulton Broad.

Chaetoceros wighamii Brightwell
Very variable. Forms short chains with simple windows. End bristles tend to be slightly S shaped. Kitton lists this as " In a ditch near the Berney Arms Breydon". This is the type locality for this species. The collection

was made by Mr Wigham, a tobaeeonist (and Kitton's employer) of the Haymarket in Norwich at the end of a day's exeursion while they were returning to the station. Kitton's slide 58 claims to be the original material for *C.wighamii.* I have examined all the ditehes around Berney Arms without finding it. However, a colleetion made on a Naturalist Soeiety visit to Martham Broad in August 1992 contained (KBC1534) *C.wighamii* amounting to about 50% of the centric diatoms present. Sinee Brightwell established this species in 1856 it has often been in doubt. However a reeent paper (Sanchez-Castillo *et al* 1992) elarified the taxonomy and left *C.wighamii* as the "inland water" *Chaetoceros* with *C.bottnicus* as the species occuring in marine environment. In the colleetion of H.L.Smith No 58 is *Chaetoceros whighamii* Brightwell from Breydon.

Coscinodiscus apiculatus Ehrenberg
Coarsely areolate with round areolae. Hartley reports from Blakeney. Not seen in Norfolk by the author but abundant in Deben estuary in Suffolk.

Coscinodiscus asteromphalos Ehrenberg
Has a rosette of larger areolae in the eentre. Strong polygonal areolation with characteristic secondary and tertiary structure N.Sea. 53°05'N, 00°51'E from Hamond.

Coscinodiscus centralis Ehrenberg
Large (200µm dia.). Margin has spines and two asymmetrical processes. S.W. Scroby Buoy off Yarmouth.

Coscinodiscus concinnus W. Smith
Areolae delieate, a hyaline area in eentre. Marginal spines with clear lines running towards the centre N. Sea. 53° 05'N, 00° 51'E.

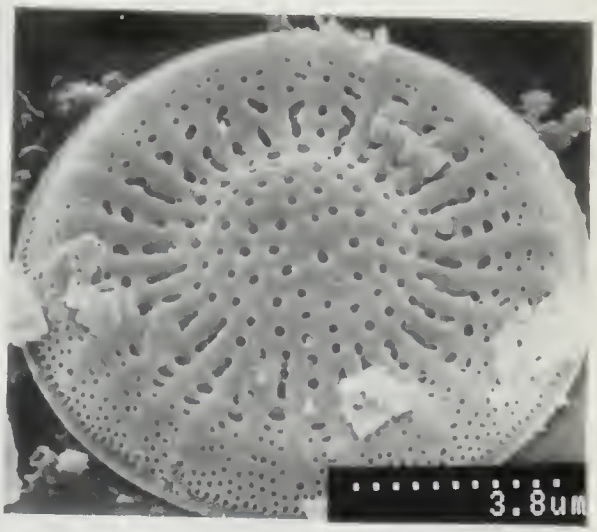
Coscinodiscus granii Gough
Cells with eccentrically domed valves and wedge-shaped girdle bands Reported by Prof. Dodge from Hunstanton beaeh sample June 1996.

Coscinodiscus radiatus Ehrenberg
Coarse areolations, the same size over the whole valve surface, arranged in

radial rows. Kitton's slide of Norfolk Diatoms No 55 from Brancaster (stomachs of cockles).

Coscinodiscus wailesii Gran et Angst
Large (290-370µm dia.) with a clear centre into which some of the rows of areolae protrude. Hasle & Lange (1992) reviewed the structure and the culture work of Schmid (1990) and Schmid & Volcani (1983). Reedham on R Yare.

Cyclostephanos dubius (Fricke in A Schmidt) Round
Valve face tangentially plicate. Alveolae under the rows of areolae give an impression of its being both a *Cyclotella* and a *Stephanodiscus*, hence the name. Hickel & Håkansson (1987) showed that there exist two morphotypes of this diatom Both morphotypes are present in Ormesby Broad. The distribution of *Cyclostephanos dubius* in Norfolk was reviewed by Clarke (1989) who showed that it was generally confined to larger bodies of water in the east of the county.



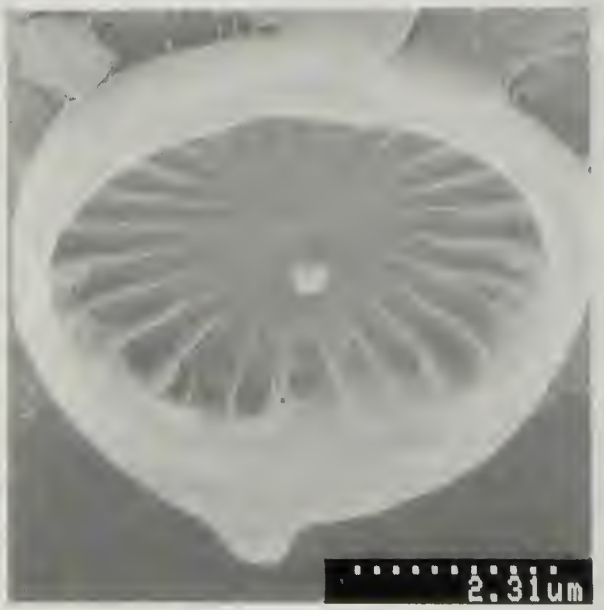
Recent samples from the Flood Relief Channel between Denver and Kings Lynn show it to be present there but under rather strange water quality conditions. It appears to be a recent invader of the Broads. Bennion (1996) found it only in the upper 15cm of her Barton Broad cores.

Cyclostephanos invisitatus (Hohn & Hellermann) Ther. Stoerm & Hak
= ***Stephanodiscus invisitatus*** Hohn & Hellermann.
Fine rows of areolae on the valve face. A single strutted process near the centre of the valve face. Valves 6.4 to 14 µm in diameter. There is a spine at the end of each interstria.

Fairly common in the Rivers Bure, Ant and yare. Always in relatively small numbers Bennion (1996) found it only in the upper 20cm of her Barton Broad cores and the top 40cm of her Wroxham Broad cores. These correspond roughly to the period betwen 1935 and the present day.

Cyclotella atomus Hustedt
A small diatom with distinct marginal strutted processes on some ribs which gives the impression of a clock face. A very clear central strutted process. For morphology and taxonomy see Hakansson & Clarke (1997). Seems to prefer slightly brackish conditions. In Barton Broad core (upper 15cm only) Bennion (1996).

Cyclotella cryptica Reiman, Lewin and Guillard.
Probably = ***C. meneghiniana***
Resembles *C. meneghiniana* but the marginal alveolae do not have a sharp inner end. The ribs continue towards the centre of the valve Reiman *et al* (1963). This appears to be a brackish water form of *C. meneghiniana* (Shultz 1971). It occurs often in Hickling Broad but has been found at Wheatfen.



Cyclotella distinguenda Hustedt 1927 = *C. operculata* auct nonul (for the confusion with *C. operculata* see Häkansson (1989))
Resembles *Cyclotella meneghiniana* in general appearance but has longer and closer radial striae in the outer zone. Kitton recognised this diatom as *Cyclotella operculata* Kutz. and found it in Ormesby Broad, Costessey and St Faiths. Unlike many similar diatoms this one is found here and there right across Norfolk. I have found it in the Fens (Well Creek), in a stream running into the Titchwell bird reserve, at Gooderston and in Ormesby Broad.

var mesoleia (Grunow) Hakansson 1989
This is a doubtful variety but is recorded by Kitton as *C. operculata* var *mesoleia* from Flordon.

Cyclotella sp 1
This diatom is very similar to *Cyclotella meneghiniana*. It occurs especially in the Well Creek, a Fenland canal which receives saltwater at times from the Great Ouse estuary. It occurs also in the Broads at Horning and Wheatfen. The areolated striae are much longer than the alveolae, giving the illusion of a ring across the striae and in certain focus levels making the striae appear bottle-shaped with the neck inwards.

In both the Well Creek material and the Horning material partial striae occur or the striae too appear branched. There is a resemblance in the structure to *Cyclotella gamma* Sovereign. A full description of this taxon is in course of preparation.

Cyclotella glomerata Bachmann
Table 3 in Waterford & Driscoll (1992).

Cyclotella kuetzingiana Thwaites
Hakansson showed (1990) that this species is conspecific with *C. meneghiniana*. Kitton's slide 88 from Ormesby Norfolk 1874 with "*C. compta*" Van Heurek 7 has "*Cyclotella kuetzingiana*" from Breydon Water.

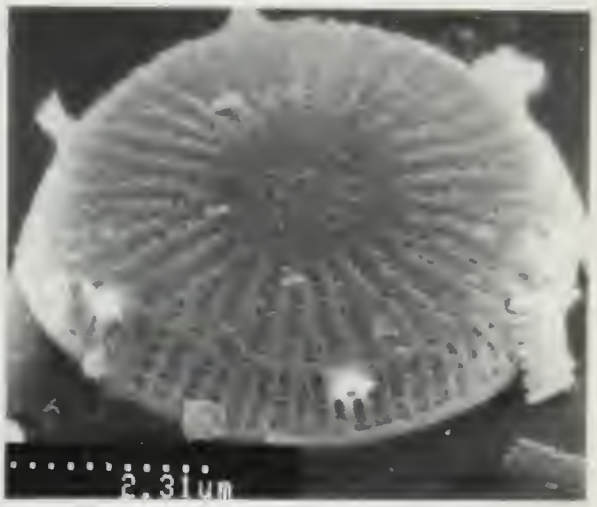
Cyclotella meduanae Germain
Resembles *C. meneghiniana*. of which it may be a form (Håkansson 1991 p.45). Spines and central fultoportulae absent with marginal strutted processes only on every second or third radial rib. Stracey Arms. Haddiscoe, frequent in R. Thurne at Potter Heigham.

Cyclotella meneghiniana Kützing 1844 = *C. Kuetzingiana* Thwaites
The valve surface is tangentially waved. The outer zone has large, slightly tapered alveolae while the central zone is usually clear except for one or more strutted processes. Kitton must have recognised this species as *C. Kuetzingiana* Thwaites. Investigation of the type material by Håkansson (1990) showed that *C. meneghinana* and *C. kuetzingiana* are conspecific. Indeed the only mention of *C. meneghiniana* by Kitton is the doubtful variety var. *rectangula* Grun. This differs from *C. meneghiniana* in the absence of any markings from the central zone except possibly 1 to 3 bright points. He listed it from Ormesby, Horning, Costessey and Whissonsett. But this is a very variable species (Schoeman & Archibald 1976) and the variety is not a true one. Kitton's slide No 88 contains "*C. Kuetzingiana* Ormesby 1874" Examination of this slide BM 54626 shows *Cyclotella meneghinana* present in small numbers. *C. meneghiniana* is a littoral form, occuring in the plankton. It is said to prefer slightly saline water but this preference is not reflected in its Norfolk distribution. Indeed it is often the only centric diatom present in the headwaters of Norfolk rivers. It is characteristic of the metaphyton of plants in marsh dykes. Also found on the salt marshes of the north coast e.g. Scolt Head Great Aster Marsh on plant stems.

Cyclotella ocellata Pantocsek = *C. kuetzingiana* var *planetophora.*
About three large hollows or papillae on the valve face and a single strutted process Although the lower sediments of Barton Broad contained small populations of *C. ocellata* it has only been found in the present survey in the Hopton Ponds.

Cyclotella praetermissa Lund 1951
This diatom resembles *Cyclotella radiosa* and *Cyclotella quadrijuncta.* It is, however, enclosed in a mucilage envelope which can be confirmed in live material by introducing a little indian ink under the cover slip. It was present in Rollesby Broad in early March 1994 (700 cells/ml) and has been recorded for the Lound Basins and Fritton Lake .

Cyclotella pseudostelligera Hustedt = *C.stelligera* var *pseudostelligera* (Hustedt) Haworth & Hurley
Although it was shown by Haworth & Hurley (1986) that there is a gradual transition of characters to *C. stelligera* I have followed Häkansson (1991) in retaining this taxon for the feebly marked centric with strong marginal processes. It is a common member of the phytoplankton of the broads.



Cyclotella radiosa (Grunow) Lemmermann = *Cyclotella comta* Kg
Central zone punctate, outer zone striate. Every third or fourth stria thickened to form a "shadow-line" The taxonomy of diatoms in this group is under review but it seems that the Norfolk populations are true C. *radiosa* in the sense of the revisions by Hakansson (1986, 1991) Kitton's spelling as *Cyclotella compta* seems to be idiosyncratic. Only one, word is given for the distribution of this diatom by Kitton: "Ormesby". Moss & Balls (1989) reported a population reaching 5,800 at Swan Bend Horning in the river Bure and one of 2400 in Wroxham Broad with similar levels in Cockshoot and S. Walsham Inner Broad. This is in contrast to Bennion

(1996) who found that *C. radiosa* disappeared from the upper part of her Wroxham Broad core (loc.cit. p.32). They recorded only very small populations or absence in other parts of the Bure Broads system e.g. Malthouse Broad. Kitton's slide No 88 has *Cyclotella compta* from Ormesby 1874. I have no record of *C. radiosa* in the other two major Broadland rivers, the Yare and the Waveney. It occurs regularly in Oulton Broad, which drains into the Waveney and it probably occurs in the Waveney at the point where the Oulton Dyke enters. I have no records of it in the centre or east of the County. This sporadic distribution would be worth further investigation.

Cyclotella stelligera Cleve & Grunow
Haworth & Hurley (1986) showed that there is a gradual transition of characters to other stelligeroid diatoms. *C. stelligera* has been regarded as the centric diatom with a distinctive central marking in the form of a star as described and figured by Chang (1991). Compared to *C. pseudostelligera* this taxon is far rarer in Norfolk. Some records may refer to *C. pseudostelligera* but authenticated records with sketches and SEM photographs are from the Bure at Belaugh and from Mill Water at Lound and Hopton No 3 basin.

Cyclotella striata (Kützing) Grunow 1880
Valves strongly tangentially undulate especially in central zone which is colliculate. Marginal zone striated with close clear striae. See Hakansson (1996) Records are all from brackish water, Stracey Arms, Reedham and Martham Broad. Kitton listed *C. striata* from Breydon.

Ditylum brightwellii (T West) Grunow in van Heurck
Shaped like a triangular prism. Valves triangular with a long central spine. Very feebly siliceous. Kitton lists this as *D. trigonum* Bail from the stomachs of *Noctiluca*. It has been recorded by me from the River Bure at Stokesby and in the plankton at Yarmouth (Britannia Pier). Found in washings from Stiffkey Sands.

Ellerbeckia arenaria (Moore) Crawford

Ellerbeckia has large cylindical cells, about as broad as long. Dia 60-100 µm with very fine cross hatching on the girdle face (Crawford 1988). Kitton's slide No 5 from Hellesdon. Kitton has "*Melosira arenaria* (Moore) Plentiful in a ditch at Hellesdon. Rare in other localities." I have found it in sandy areas on the shore of Rollesby Broad and the Carr along the river at Heigham, Norwich. This latter area was close to the point where Kitton did most of his collecting but without finding this diatom. (TG207096). Perhaps this was the family of ditches alongside the Wensum at "Hellesdon" where Kitton found his diatom. It also occurs on stones at E. Lexham in the Nar and on piling at Belaugh Broad.

Eucampia zodiacus Ehrenberg
Cells form flattened chains, usually curved. Valve surface depressed in centre, forming two end processes. This leaves an oval intercellular apperture. Yarmouth Haven Bridge 1993. Kitton's list of Norfolk Diatoms from stomachs of *Noctiluca* "very rare" as *E. Brittanicus*.

Guinardia delicatula (Cleve) Hasle = ***Rhizosolenia delicatula*** Cleve
Cylindrical cells united to form short straight chains. Feebly silicified. Valves have a small marginal spine which fits into a recess on the next cell. Very occasional in North Sea plankton. Great Yarmouth Haven Bridge 1993

Guinardia striata (Stolterfoth) Hasle = ***Rhizosolenia stolterfothii*** H. Peragallo 1888.
Curved cylindrical cells united to form small chains. Valves have a short sharp marginal spine. Feebly silicified. Contains many elongate chromatophores. Nucleus visible on one wall. Forms an occasional feature of North Sea plankton in late summer. Recorded at Cromer and Yarmouth piers. Kitton's List of Norfolk Diatoms from stomachs of *Noctiluca miliaris*. Reported by Kitton as *Eucampia striatus* (Stolterfoth) on the authority of a drawing prepared by Tuffen West for Thomas Brightwell.

Hyalodiscus scoticus (Kützing) Grunow
Cells lens-shaped usually united in pairs by girdle bands. Attached by mucillage pads formed from the central area of the valve. The valve face

has a delicately areaolate outer zone and a clear central area (the umbilicus). Marine and brackish. Epiphyte. Usually not at all common. Common in sample from behind the shingle bank at Salthouse Nbk 14.112 Slide 352. N43/0 at first thought to be air bubbles. Kitton's List as *Cyclotella scotica* from R. Bure near Yarmouth.

Isthmaea nervosa Kützing
(Kitton's slide No 8 from Cromer). Not recorded in this survey.

Isthmaea obliquata (J.E.Smith) Agardh
Kitton's slide No 77, *Isthmaea enervis* from Cromer. Not recorded in this survey.

Leptocylindricus danicus Cleve
Weakly siliceous tubular cells, forming a straight chain 5µm - 16µm diameter. Reported by Professor Dodge to Environment Agency from Hunstanton beach sample in May 1996.

Melosira lineata (Dillwyn) Agardh = ***Melosira juergensii*** C.A. Agardh .
Differs from *Melosira varians* in the inner face of the mantle is curved. The structure is described by Crawford (1978) It occurs in two morphotypes, one, Morphotype *orichalcea sensu* Crawford is not unlike *Melosira varians* at first glance. The other morphotype, Morphotype *juergensii sensu* Crawford has strongly domed valves which go over without feature to the mantle. This latter is somewhat constricted toward the mantle edges. Kitton's slide No 13 "*Melosira juergensii* from Breydon". When found, it is often in considerable numbers. Occurs in the ditch on the west side of the National Trust car park at Horsey Mill where it constitiuted 87% of diatoms present.

Melosira moniliformis (O.F.Müller) Agardh (= ***Melosira borreri*** Greville)
This brackish water diatom is in long filaments, the domed valves are held together by mucilage pads and girdle bands with distictive markings. Kitton's slide No 56 as *M. Borreri* from Breydon. Kitton recorded it from "Ditches, Breydon, and near Vauxhall Station". The latter site has been built over but the altered drainage has so far not yielded this species. The

soke dike on Breydon near Stone Point contains large numbers. Found in a ditch behind the staithe at St Olaves and behind the shingle bank at Salthouse before it was rebuilt. In all these cases the water has percolated through a bank.

Melosira nummuloides (Dillwyn) Agardh = ***Melosira salina*** Kg
Kitton found this species in a ditch near Vauxhall Station. It is still there in the altered drainage system. Chlorides 7,000mg/l (slide KBC1778) Kitton's slide No 100 containing *M. nummuloides* is only marked "Yarmouth". It was found epiphytic on seaweed at the top of Breydon near Berney Arms by me in 1960. (slide KBC 142). *M. nummuloides* forms chains of cells. The valves have a keel at about half valve diameter which renders the species easily recognisable (Crawford 1973). Frequent in some samples from the drainage dykes in the Bure Loop at Yarmouth.

"***Melosira orichalcea*** Kützing"
This is a doubtful species. Kützing's figure (Tafel 2 XIV 1-3) appears to be the brackish water diatom *M. lineata*. But the protologue says "In fresh water through the whole of Europe". Kitton has "Common in freshwater ditches". This is certainly not the case today. What taxon was he referring to? His slide No 4 in Diatoms of Norfolk is marked "*Melosira orichalcea*. Kg Ormesby" I have looked at this slide in the Natural History Museum (BM 27116.) It contains a form of *Aulacoseira italica* with large curved teeth but extremely fine areolation of the mantle. As it is associated on the slide only with *Meridion circulare*, *Surirella minuta*, *Pinnularia brevistriata*, *Fragilaria capucina* and *Achnathes minutissima* it could be assumed that the material came from a ditch and not from Ormesby Broad. All likely ditches in the parishes of Ormesby St Michael and Ormesby St Margaret were examined and one was found with the same diatom present as on Kitton's slide No 4. So Kitton's reference was really to *Aulacoseira italica*.

Melosira varians Agardh
Simple cylindrical cells, almost devoid of markings. For details of structure see Crawford (1971,1978). Kitton has "Common in freshwater localities" which just about sums up its distribution in Norfolk. The large, undecorated cells turn up in many samples. It is not, however, a planktonic species.

growing on the mud surface or as a loose epiphyte (metaphyton). I once found an almost pure population of *M. varians* in the water flowing out of Little Switzerland (old chalk workings) into the River Bure near Belaugh. It often produces brown, trailing fronds on plants in the late winter.

Odontella aurita (Lyngbye) Agardh = ***Biddulphia aurita.***
This taxon has two horns and two fine setae on each valve. The horns bear mucillage pads and the setae are the external opening of rimoportulae. It is distinguished from similar *Biddulphias* by the horns having a thick base and being directed outwards. Not uncommon in North Sea plankton but usually attached in long chains to weed or stones. Kitton's slide No 35 as *Biddulphia aurita* from *Noctiluca*, Yarmouth. Recorded by Hartley from Titchwell. Reported from "R.Nene near Wisbech" by Wm. Smith. Found in most marine samples and as far up river as Reedham, Haddiscoe and Stracey Arms in the Broads estuary.

Odontella granulata (Roper) R.Ross
A coarse granular form with distinctive arrangement of setae on the valve. Closely resembles *O. rhombus*. Normally marine litoral. Fairly rare. Found at Horning pumping station, 20 miles from the sea, after storm surge on 19.2.89.

Odontella mobiliensis (J.W.Bail) Grun
Each valve has two horns and two slender hollow spines. The horns do not have the broad base and angle of those of *O. aurita.* Although its normal habitat is attached in chains to firm objects it frequently gets into the plankton of the North Sea. Kitton's slides of Norfolk Diatoms No 35 from *Noctiluca*, Yarmouth. Kitton's list of Norfolk Diatoms from Yarmouth as

Biddulphia baileyi N.Sea. 53°05'N, 00°51'E from Hamond. S.W. Scroby Buoy Recorded by Hartley from sand washings from Gorleston beach.

Odontella regia (Schultze) Simonsen
Resembles *O. mobiliensis* but larger (>100µm on apical axis) Spines are coarser than in *O. mobiliensis*. S.W. Scroby Buoy off Yarmouth. There is an excellent study of *O. regia* by Mayer and Schmid (1995).

Odontella rhombus (Ehrenb) Kütz
Coarsely granulate. Several setae on valve. Brancaster Kitton's list of Norfolk Diatoms from Breydon, Wells, mud from Yarmouth Harbour. N. Sea. 53°05'N, 00°51'E from Hamond. Off Cromer. Recorded by Hartley from Brancaster Beach and Titchwell.

Odontella rhombus fo trigona (Cleve ex Van Heurck) R.Ross
A three cornered form of *O. rhombus*. Recorded by Hartley from Titchwell.

Odontella sinensis (Grev) Grunow
A feebly silicified form, often in considerable numbers in the plankton. Small horns with setae close to them. N. Sea. 53°05'N, 00°51'E from Hamond S.W. Scroby Buoy off Yarmouth.

Paralia sulcata (Ehrenb) Cleve
Large cylindrical cells with heavily ornamented walls Hartley found it in Sand Washings from Titchwell (BH2132). Found almost everywhere in tidal waters. Not found in brackish waters of Bure Loop (isolated from tidal waters) W.Runton, Sand washings Gorleston. Stiffkey Salt Marsh Brancaster Reported by Hartley from Blakeney. Found occasionally in the

brackish parts of the Broads estuary. Yarmouth Harbour Haven Bridge 1993 Stracey Arms on R. Bure. Reedham and Wheatfen on R. Yare. Haddiscoe on R.Waveney. In Kitton's list of Norfolk Diatoms as *Melosira marina* from stomachs of *Noctiluca miliaris* Yarmouth N.Sea. 53°05'N. 00° 51'E from Hamond.

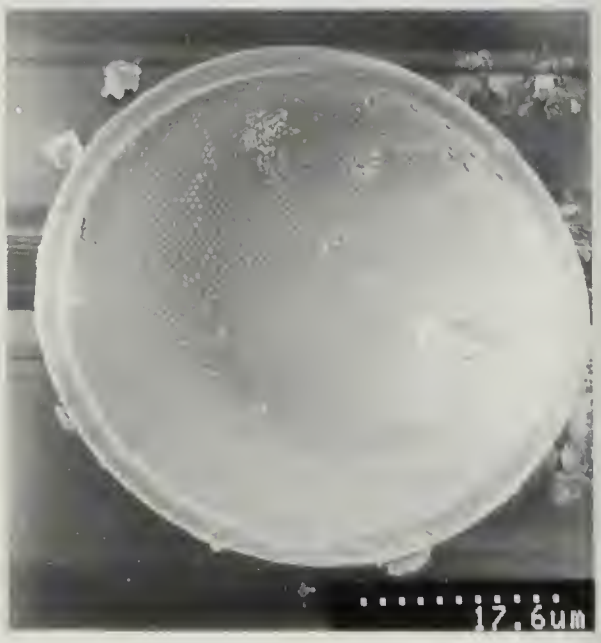
Pelagodictyon fritzii Clarke
Type locality Wheatfen Broad. R.Yare Rockland, R. Waveney Ellingham (Clarke 1994).

Pelegodictyon tenue Clarke
Type Locality Wheatfen Broad, River Bure Belaugh (Clarke 1994).

Pelagodictyon spinosum Clarke
Type Locality Mill Water, Lound. Only found in type locality. Clarke (1994).

Pleurosira levis (Ehrenb) Compere
The cicular valves have two hyaline "eyes". The valve mantle is very deep and together with the girdle gives the frustule a long pervalvar axis. Piling at Share Mill on River Waveney (The river here forms the county boundary and Share Mill is on the Suffolk side of the river).

Podosira stelliger (Bailey) Mann
Lens-shaped cells with a central umbilicus, irregularly edged. The marginal part of the valve has clear sectors, covered with radial areolae. Found in the North Sea (53°05'N, 00°51'E), West Runton beach and also at Stracey Arms and the Haven Bridge in the Broads estuary. Recorded by Hartley from Gorleston, from Brancaster Beach and from Titchwell.



Psammodiscus nitidus (Greg) Round & Mann = *Coscinodiscus nitidus.*
Circular valves have widely speced areolae becoming smaller at the margin. (Round & Mann 1980). Attached to sand grains on beach Brancaster. Recorded by Hartley from Titchwell.

Pseudopodosira westii (Wm Smith) Sheshukova-Poretzkaya = *Melosira westii* Wm Smith
Kitton has "Hunstanton, very rare". Cells globular with a ridged outline. About half way between the flattened central area of the valve and the valve margin, on the sloping portion of the valve is a siliceous ring which gives the valve a stepped appearance in girdle view. (Hendey 1964). Recorded by Hartley from Brancaster Beach.

Rhizosolenia.
Kitton lists 5 species from the stomachs of *Noctiluca.* Thomas Brightwell (1858) showed that the supposed fossil genus of Ehrenberg was common in the North Sea off Norfolk.

Rhizosolenia hebetata fo semispina (Hensen) Gran= *Rhizosolenia semispina*
Valves produced into a long terminal spine. Although Lebour (1930) states that this is a Boreal-Arctic form it is occasionally common in the North Sea in summer. Found at the Haven Bridge in Yarmouth Harbour 1994 and in the R Bure at Stracey Arms.

Rhizosolenia setigera Brightwell
Terminal spines thickened over a considerable length at the base. Seta very long. Only seen once in sand washing from Stiffkey beach. Kittons List from *Noctiluca* at Yarmouth. H.L.Smith's slide N° 450 from Yarmouth.

Rhizosolenia shrubsolei Cleve = *R. imbricata var Shrobsolei*
Clear and delicately decorated girdle bands. Smaller and more delicate than *R. imbricata.* Stiffkey sand washings. Kitton's List of Norfolk Diatoms from stomachs of *Noctiluca miliaris.*

Rhizosolenia styliformis Brightwell
Has a short terminal spine with two ears at the base. N.Sea Cromer. SW

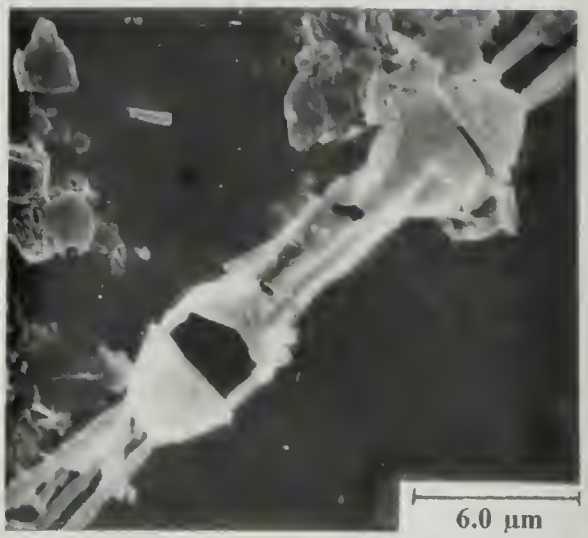
Scroby Buoy Kitton's list from *Noctiluca* Gorleston.

Skeletonema costatum (Greville) Cleve

Discoid or spherical cells united into short filaments by a marginal ring of long hollow spines. Although this is a marine diatom it has been found several times in the Bure at Stracey Arms and once at Horning Waterworks following a surge tide. It differs from *S. potamos* in the form of its spines Hasle & Evensen (1976). The genus *Skeletonema* was not mentioned by Kitton.

Skeletonema potamos (Weber) Hasle

Domed valves separated by long spines which interlock at their distal ends The chloroplasts are unlike *Aulacoseira* so that it can easily be distinguished even in unprepared material. It has its maximum development in the River Thurne around Potter Heigham. (chlorides 1000mg/l). In all Great Ouse samples as far down as Stow Bridge in May 1994 (Hilary Belcher). Found at King's Lynn in July 1994.



Skeletonema subsalsum (Cleve-Euler) Bethge
Valves almost flat, fixed together by modified spines which interlock. In material prepared with acid the cells separate at their midpoints and form little H shapes. Its structure and distribution in the Broads has been described by Clarke (1995). When counting under low power it would be possible to regard this as a species of *Aulacoseira* or *Melosira* and possibly it was recorded in this form by Moss & Balls (1989) from the Bure. It has been present in the Bure since at least 1969. Found also in the lower Broads estuary at the Haven Bridge in Yarmouth and at Stracey Arms. Found at Wheatfen. At times it has been the dominant organism in the R.Yare.

Stephanodiscus alpinus Hustedt
Strong radial waves. Spine on every interfascicle. Only two localities, Lily Broad and the new broad at the University of East Anglia which was excavated in the early 1960's.

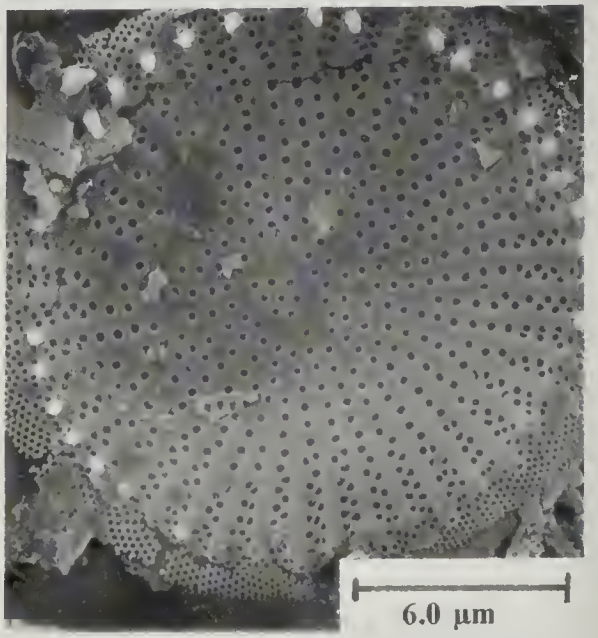
Stephanodiscus binderanus (Kützing) Krieger
Filaments of barrel shaped cells. The strutted processes are clearly visible on the margin of the valve. Abundant in the plankton of Selbrigg Lake but not found otherwise.

Stephanodiscus hantzschii Grunow
Drum-like cells with circular valves with radial fascicles of areolae. The interfascicles are clear and each one ends in a small spine. No central strutted process. Much rarer in the Norfolk than the forma *tenuis*. Finds especially from the broadland rivers and the broads. Kitton's List, Breydon as *S. Hantzschiana* Kitton's Slide No 95 from Breydon. The location of these reports is strange.

Today you would find this taxon in most of the broads and very rarely in Breydon. In Barton Broad, Bennion (1996) found *S. hantzschii* in the upper 30cm of her core corresponding to the period since 1938 while in Wroxham Broad it increased from 4% of the diatom flora in 1935 to 40% at the present time.

Stephanodiscus hantzschii forma ***tenuis*** (Hustedt) Hakansson & Stoermer = ***Stephanodiscus tenuis*** Hustedt.

More delicate than *S. hantzschii* often with an annular ring near the centre of the valve. Hakansson & Stoermer (1984) observed that *S. hantzschii* is polymorphic and regarded this as a form. Polymorphism was subsequently proved conclusively in culture experiments by Kling (1992). *Stephanodiscus hantzschii forma tenuis* frequently dominates the phytoplankton of the Broadland rivers, especially the R. Bure and its broads. It is usually infected by a chytrid fungus (Clarke 1989).



Stephanodiscus minutulus (Kützing) Cleve & Möller

Circular valve face raised or lowered in the centre. A distinct strutted process near the centre Very difficult to distinguish from *S. parvus*. To be sure of the identification Kützing's original material was examined in the SEM at the University of East Anglia. The material (Natural History Museum Packet No 906) was on a mica slip "Diatomeenmehl der Lünerburger Heide" Found in most of the broads, often dominating the phytoplankton. Numbers in excess of 10,000 cells per ml (Clarke 1992). See Spamer and Theriot (1997).

Stephanodiscus neoastraea Hakansson & Hickel
A larger *Stephanodiscus* (18-52µm dia.). Circular valve with submarginal spines at the end of every second to fourth interfascicle. No strutted processes on the valve face. This taxon is fairly rare in Norfolk. Ellingham, River Waveney. The protologue to Kitton's slide No 86 "Ormesby 1874" has "*Stephanodiscus astraea* ??" I have examined this slide (BM 54626) and could not find anything which might be "*S. astraea*". See Hakansson & Hickel (1986).

Stephanodiscus oregonicus ? (Ehrenberg) Hakansson
Spines on all the interfascicles which are thickened and distinct. Could be confused with coarse forms of *S. parvus* but 6-20.5µm diameter (*S. parvus* 3-11µm dia.) University Broad, Norwich. R. Waveney at Ellingham. Found in Diss Mere by Fritz (1989).

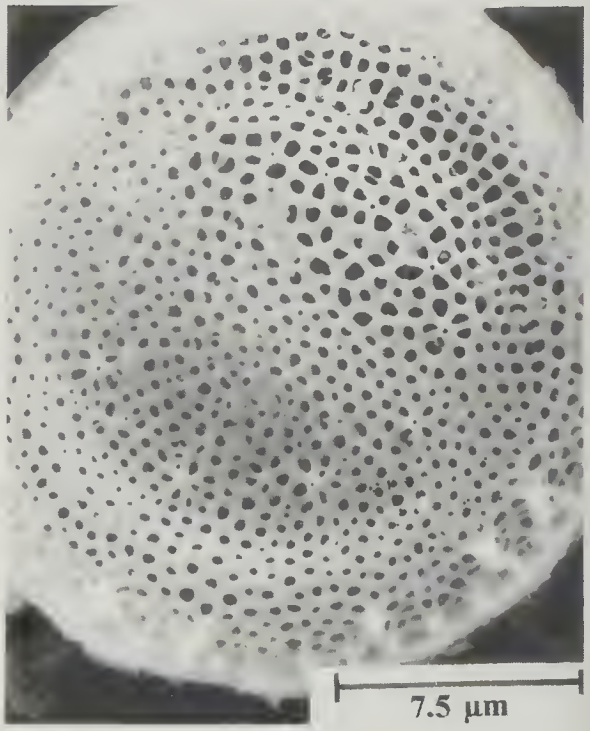
Stephanodiscus parvus Stoermer & Hakansson
Circular valves almost flat 5-11µm dia. Barely resolvable puncta in biseriate fascicles 13-15 in 10µm. A spine on each interfascicle. Strutted process below every 3rd to 6th spine. One eccentric strutted process on the valve face. See Stoermer & Håkansson (1984). Found in lower part of Broadland rivers (Reedham, Haddiscoe) and in some broads (Mill Water, Fritton Lake).

Stephanodiscus rotula (Kützing) Hendey
Resembles *S. neoastraea* but differs in posessing a central strutted process on the valves. As "*Cyclotella (Stephanodiscus) rotula*" in Kitton's List, from Ormesby & Horning. The taxon as described by Hendey has not been seen recently in Norfolk. According to him it is a brackish and marine species found especially in estuaries.

Thalassiosira baltica (Grunow) Ostenfeld
This truly brackish species became common in South Walsham Broad in January 1992. It has marginal rings of processes and usually two central processes close together.

Thalassiosira bramaputrae (Ehrenberg) Hakansson et Locker

The possibly earliest Norfolk record is by William Smith (1853) from the River Nene near Wisbech. It is a feature of the brackish part of the Broadland rivers and has been found in the R. Bure at Stracey Arms, the R. Yare at Reedham and the R. Waveney at Haddiscoe. It occurs both in Oulton Broad and at Wheatfen on the R. Yare. In the 1950s it occasionally dominated the phytoplankton of the River Yare in the "Zone of Maximum Turbidity" between Brundall and Reedham. Kitton's Slides of Norfolk Diatoms No 3 & 21 from Breydon as *Cyclotella punctata* and in Kitton's List from Breydon and Titchwell (Clarke 1992 p 699 and fig 4).



Thalassiosira decipiens (Grunow ex van Heurck) Joergensen

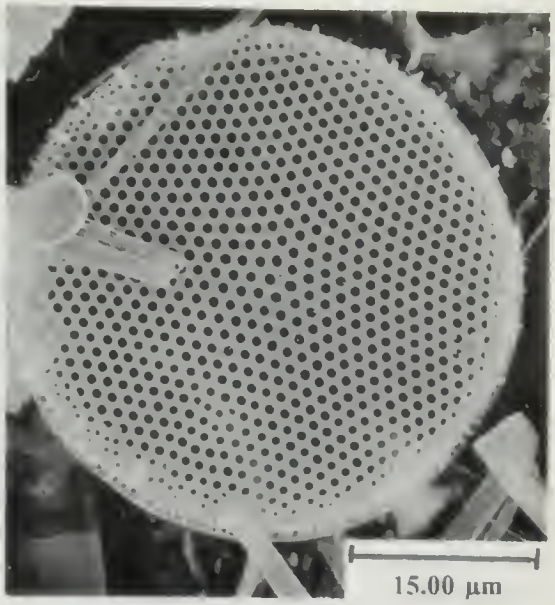
Similar to *Thalassiosira eccentrica*. It has conspicuous polygonal areolae and curved marginal spines. A single central strutted process on the valve. Radial rows of areolae occur besides the eccentric curved rows. Found at Downham Market in June 1994 in one of a series of samples from the River Ouse supplied by John Sanders of UEA. Bernard Hartley recorded it from Blakeney.

Thalassiosira gravida Cleve

Circular valves have faint radial markings and scattered points on the face. In the centre is an array of a dozen or so fultoportulae. There is a distinct labiate process near the edge. North Sea plankton. Found at 53^0 05'N, 00^0 51'E from Hamond. At Haven Bridge in Great Yarmouth by the author.

Thalassiosira eccentrica (Ehrenberg) Cleve

The name refers to the curved pattern of areolae on the valve. In life the cells are often surrounded by dirty mucilage. A widely distributed marine and brackish diatom from R. Nene (Sutton Bridge), North Norfolk beaches (Stiffkey Sands), R. Yare (Reedham) and even collected by Hamond out in the North Sea at 53°05'N, 00°51'E. At a time of storm surge it was found in the R. Bure 20 miles from the sea at Horning. In Kitton's List from the stomachs of *Noctiluca* from Yarmouth.



Thalassiosira guillardii Hasle

The circular valve has a marginal ring of strutted processes, a single labiate process among them. 0 - 3 strutted processes on the valve face This marine and brackish water *Thalassiosira* also occurs in fresh water (Hasle 1978). It has been found in Oulton Broad (slightly brackish, connected to the River Waveney) and at Wheatfen. Found in the Well Creek at Salters Lode. Belcher & Swale (1986) from Great Ouse at King's Lynn.

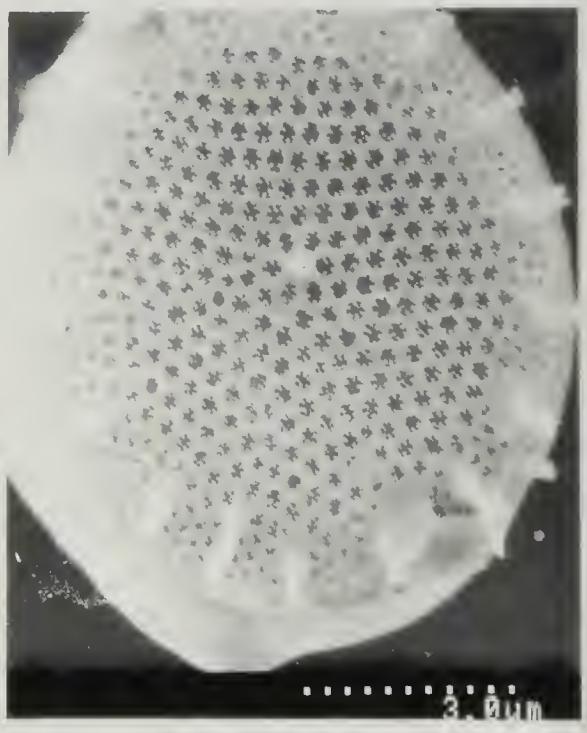
Thalassiosira incerta Makarova

There is a neat grouping of half a dozen strutted processes close together in the centre of the valve face. The areaolae in the centre of the valve face are larger and arranged in rows. Near the margin they are smaller and there are two marginal rings, one of spines and one of strutted processes. Belcher and Swale reported this taxon from the Great Ouse at King's Lynn (1986) and a series of samples on the tidal portion of that river between Denver and King's Lynn showed it to be present in June 1994 as 1-6% of the diatoms at all stations. Occasional in the plankton of the Rivers Yare and Waveney.

Thalassiosira leptopus (Grun in van Heurck) Fryxell et Hasle
= *Coscinodiscus lineatus*
Distinct areaolae are arranged in straight parallel lines across the valve face. Gorleston sand washings. Reported by Hartley from Blakeney.

Thalassiosira minima Gaarder emend Hasle = *Coscinosira floridana* Cooper
Valves areolate, 3 to 13µm diameter with two adjacent strutted processes in the centre of the valve and 5 to 11 marginal ones. See Hasle (1980). Common in the Thames estuary and found in the Great Ouse at Kings Lynn (Belcher & Swale 1986) but only seen at the Haven Bridge Great Yarmouth on one occasion.

Thalassiosira minuscula Krasske = *T. monoporocyclus* Hasle
A single ring of marginal strutted processes with a single labiate process located some distance away from the valve margin with one strutted process close to its base. Valves domed. See Hasle (1976). Haven Bridge Great Yarmouth 1994.



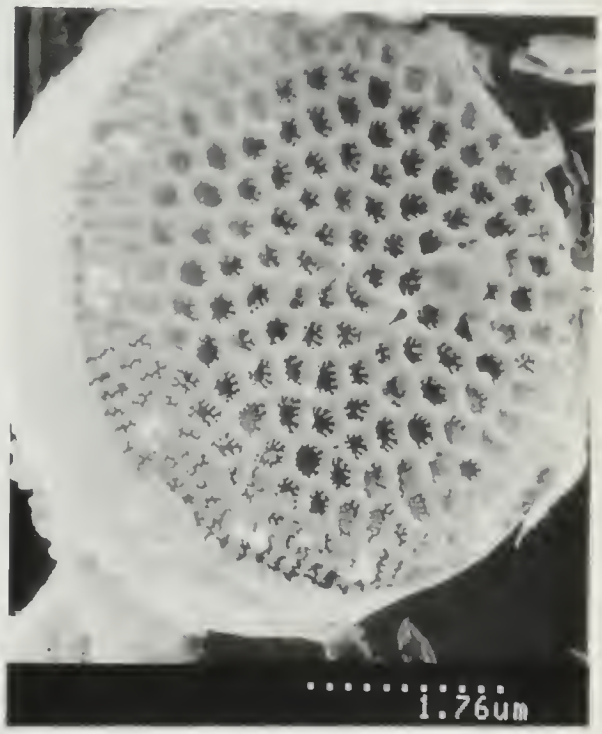
Thalassiosira nordenskioldii Cleve
A single central strutted process on the valve. A sub-marginal circlet of long, thin spines (strutted processes). Hasle (1978b) Haven Bridge Great Yarmouth 1994. N. Sea. 53° 05'N, 00° 51'E from Hamond .

Thalassiosira profunda (Hendey) Hasle
Very small 1.8 to 5µm diameter with a central strutted process adjacent to an enlarged areola. Great Yarmouth Haven Bridge 1994. Belcher & Swale

(1986) from Great Ouse at King's Lynn.

Thalassiosira proschkinae Makarova
Similar to *T profunda* but with a labiate process adjacent to the central strutted process. The external opening of the labiate process is triangular. Areolae on the valve face are large and distinct in the centre but radial slits at the margin.

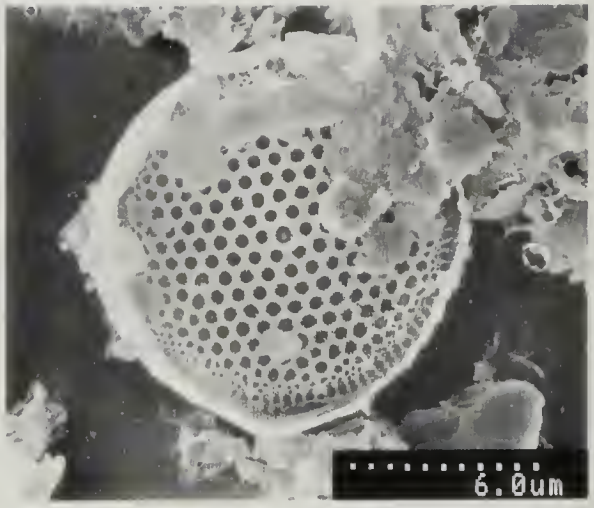
The areolae are partly occluded by volae. Occasionally present in South Walsham Broad and at Potter Heigham on the River Thurne. Their presence follows incursions of saline water following storm surge in the North Sea. Found on the ronds at St Olaves. These ronds are only flooded by high tides and their presence there is probably also connected with storm surge. Found in the River Waveney at Haddiscoe and the Bure at Reedham. Seen at Wheatfen by Hilary Belcher. Belcher & Swale (1986) from Great Ouse at King's Lynn.



Thalassiosira pseudonana Hasle & Heimdal = ***Cyclotella nana*** Hustedt
A very small *Thalassiosira*, 4-5µm diam. with a marginal ring of strutted processes. Found in many freshwater localities. R. Waveney at Homersfield, R. Thet at Thetford and R. Yare at Surlingham Ferry (Belcher & Swale 1977), Wheatfen (R.Yare) and Waveney at Burgh St Peter. Belcher & Swale (1986) from Great Ouse at King's Lynn.

Thalassiosira tenera Proshkina-Lavrenko

Areolae in straight rows, the central areola being larger than the rest and containing a strutted process. See Hasle & Fryxell (1977). Haven Bridge at Great Yarmouth 1994, Stracey Arms on R. Bure, Reedham on R. Yare. Belcher & Swale (1986) from Great Ouse at King's Lynn.

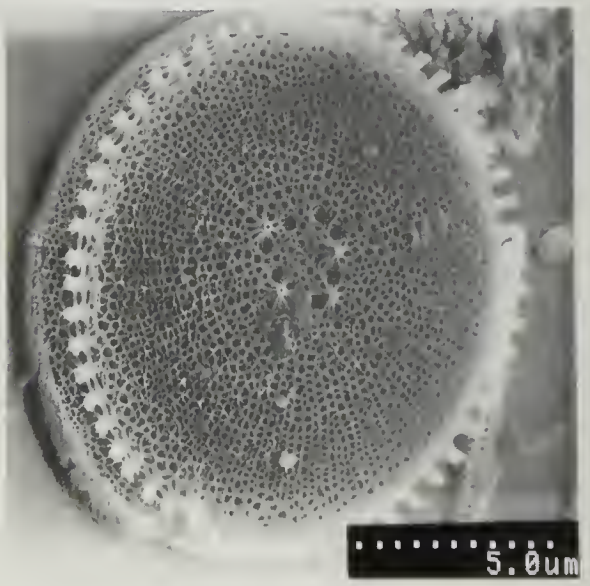


Thalassiosira visurgis Hustedt

Resembles *T. baltica* but it has a single central strutted process and one marginal ring of strutted processes. Reported by Belcher from Wheatfen. Belcher & Swale (1986) from Great Ouse at King's Lynn North Sea 53^0 05'N, 00^0 51'E from Hamond.

Thalassiosira weissflogii (Grunow) Fryxell & Hasle

This centric diatom has a distinctive ring of fultoportulae, plainly visible with the light microscope at about the middle of the radius. Equally distinctive is a single short line near the margin of the valve which is the rimoportula. Marking on the valve is very fine. Found in many freshwater localities. R. Waveney at Homersfield, R. Thet at Thetford and R. Yare at Surlingham Ferry



(Belcher & Swale 1977). Belcher & Swale (1986) from Great Ouse at King's Lynn.

On coastal saltmarshes (Wash, Stiffkey) and in Bure Loop dykes at chloride values between 5000 and 10000mg/l. Found occasionally in the River Waveney at Ellingham also at Wheatfen (HB). A large population was found in scum on a small pond at Tilney where the chlorides were 500mg/l. Kitton had "Breydon. Rare".

Triceratium alternans.
See *Biddulphia alternans*

Triceratium antediluvianum (Ehrenberg) Grunow
See *Biddulphia antediluvianum*

Triceratium favus Ehrenberg
Triangular in valve view with regular hexagonal cellulation parallel to sides. Reported by Kitton from Breydon and Yarmouth mud. Kitton's slide No 18 from Yarmouth Harbour. Brightwell (1853) gives "at the junction of the Yare and Waveney near Yarmouth." Hartley recorded this species from Blakeney. Found in the plankton off Yarmouth (S.W. Scroby Buoy).

Acknowledgements.
Bernard Hartley undertook the fearsome task of bringing Kitton's names up to date. He also listed Kitton's slides of Norfolk Diatoms with notes on the slide contents. Many of the records are his. His check list (Hartley 1986) has been invaluable. Hilary Belcher kindly made her studies of Norfolk diatoms available to me in manuscript as well as giving guidance on the genus *Thalassiosira*. I must thank the staff of the Natural History Museum for the kindness shown to me on visits to the museum and for loan of slides and material. Many people have collected diatoms for me, especially Zandra Waterford and Erica Swale and I am especially indebted for two collections of samples, Chris Adam's work at Scolt Head and Sarah Caswell's collection from the Bure Loop. Dick Hamond provided material and help from North Norfolk. I am grateful to my colleagues in the Wheatfen Partnership for their patience on collecting expeditions and to English Nature who supported these expeditions and facilitated access to sites.

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WEATHER REPORT 1997

J.G. Hilton
Morley Research Centre, Morley, Wymondham NR18 9DB

1997 was the warmest (10.2°C) and wettest (637.0mm) for three years and the sunniest since 1995 (1660.3 hours).

January was the driest since 1964 and the coldest for ten years. It was the sunniest for three years. It was cold and dry until the 11th. Rain on the 19th (5.4mm) produced more than 50% of the month's total.

February was 2.9°C above normal, but was cooler than February 1995. Strong westerly winds prevailed and the second half of the month was particularly mild.

March was the driest since 1976 and the mildest for seven years. 10°C was exceeded on all but seven days and 16.6°C was recorded on the 27th and 31st. Rainfall was evenly spread and the highest daily recording was 2.8mm (18th).

April was the wettest for three years despite having only 57% of the long-term average. Most of the rain fell in the second half of the month. The number of ground frosts was the highest since 1984 and -7.9°C was recorded on the 21st.

May was the wettest since 1983 and the sunniest for five years. Heavy rain (11.0mm) fell on the 5th and 20th (17.0mm) but it became dry after the 23rd.

June was the wettest since 1985 and the second wettest in our records which began in Sprowston in 1925. Sunshine was the lowest for six years. heavy showers fell from the 5th to the 7th and further spells of rain were recorded from the 8th to the 13th. Rain was recorded on every day but one after the 13th and exceptional falls of 37.6mm (27th) and 25.0mm (30th) were recorded together with substantial falls on other days.

July was the driest for six years and the dullest for five. Dry, sunny conditions prevailed until the 13th (5.0mm of rain) but the second half of the month was more unsettled.

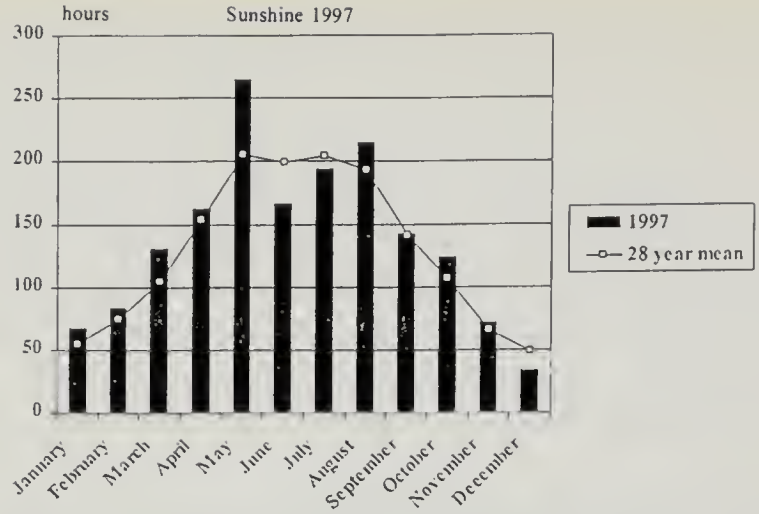
August was the warmest in our records: 20°C was exceeded on every day except the 27th (19.9°C) and 30°C was reached on six days. Showers fell on the 13th (6.0mm) and 22nd (4.0mm), but significant proportions of the month's rain fell in the period the 25th to the 30th.

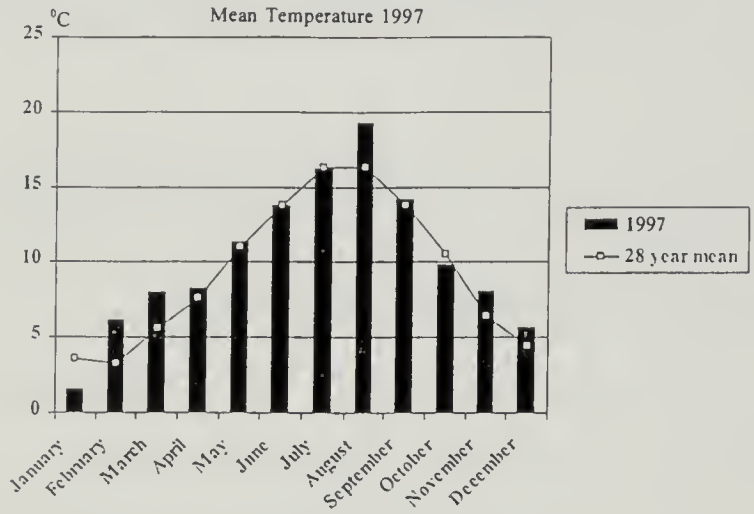
September was the driest for eight years and the warmest for six. Most of the month's rain (16.0mm) fell in the first twelve days.

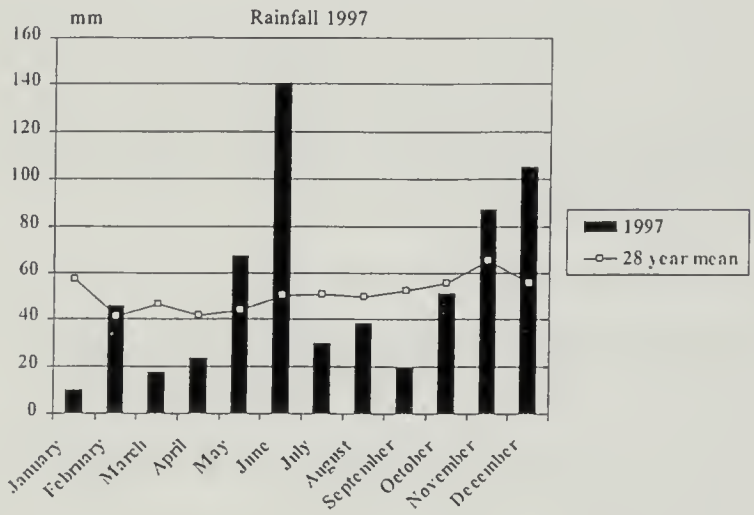
October was the sunniest for seven years and 0.6°C below normal. Rainfall was 4.0mm below average. The first ten days were warmer than normal, but the last week was much colder. The recording of -4.6°C in the air on the 31st and the grass minimum of -8.2°C on the 30th were the lowest recordings in October since 1931.

November was the mildest for three years and the sunniest for four. Rainfall was well above normal, but it was not as wet as November 1996. Prolonged rain fell on the 6th (17.8mm) and 7th (18.0mm).

December was the wettest since 1989 and the dullest since 1985. The number of ground frosts was the lowest since 1934, and the mean temperature was 1.3°C above normal.


hours
Sunshine 1997
300
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December
1997
28 year mean


°C
Mean Temperature 1997
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
1997
28 year mean


mm
Rainfall 1997
160
140
120
100
80
60
40
20
0
January
February
March
April
May
June
July
August
September
October
November
December
1997
28 year mean

CHECK LIST OF NORFOLK WATER-MITES. UPDATE OF 1991 LIST

R.K.H. Jones
"Broadlands", Station Road, Potter Heigham, Norfolk

In my previous check list I compared the list published by Soar and Williamson 1925-27 with my own recent records. There were 86 species in the S. & W. list and in 1991 I was able to confirm the continued presence of 48 of these. I also recorded 32 species not found by S. & W. bringing the total number of water-mites recorded from the county to 118.

As a result of collections made recently by myself in the Ted Ellis Reserve at Wheatfen and widespread collections made by Michael Jackson in more than 20 broads, I am now able to add another four mites to the Norfolk list and to confirm the continued presence of a further eight listed by Soar and Williamson.

The new additions are as follows:-

Hydrachna (Diplohyrachna) globosa	Norfolk Broads	
Eylais discreta	Norfolk Broads	
E. rimosa Piersig	Wheatfen	**New Norfolk record**
E. wilsoni Soar	Norfolk Broads	**New Norfolk record**
Unionicola (Pentatax) bonzi	Norfolk Broads-Wheatfen	
U. (P.) intermedia	Norfolk Broads	
Neumania spinipes	Wheatfen	
N. deltoides Piersig	Norfolk Broads	**New Norfolk record**
Piona variabilis	Wheatfen	
Hydrochreutes krameri Piersig	Norfolk Broads	**New Norfolk record**
Mideopsis orbicularis	Norfolk Broads	
Arrenurus forpicatus	Norfolk Broads	

Reference

JONES R.K.H., 1991. A check list of Norfolk water mites (*Hydracarina*). *Trans Norfolk Norwich Nats. Soc.* **29** (1).

THE NORFOLK HEDGE AND BOUNDARY SURVEY
An Interim Report.

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The importance of hedges

Hedges and other boundary features are very important elements of the Norfolk landscape, contributing much to the particular character of the county's various regions. Norfolk hedges are of very varied ages and origins, but display broad regional patterns, related in large measure to the history of enclosure. Some hedges were created by the enclosure of open fields and commons in the eighteenth and nineteenth centuries, often as a result of Parliamentary acts. Such hedges are a particularly prominent feature of the 'Goodsands' region of the north-west. Here the landscape is dominated by large, rectilinear fields defined by flimsy, well-trimmed hedges which are, for the most part, composed entirely of hawthorn. Many hedges have much earlier origins, however, especially in the south and east of the county, where some boundaries appear to have prehistoric or Roman origins (Williamson 1987). Where hedges still survive in this intensively arable region, they tend to be of mixed species which define a distinctive pattern of small, approximately rectangular fields. Between these two extremes there is a wide variety of hedge types and patterns, and even within relatively homogeneous areas there is often much variation in detail, reflecting the complex, intricate history of the enclosure of farmland.

Hedgerows are particularly important to indigenous wildlife. In an intensively arable county where a large proportion of woodland has been lost, hedgerows often represent the only available woody habitat away from habitation.

Hedgerow loss and replacement

Hedge removal was occurring on some scale, especially in clayland areas, in the nineteenth century but the rate of loss was reduced with the onset of agricultural depression in the 1870s. Removal accelerated markedly after

the Second World War, and was worsened by the offer of agricultural grants designed to increase field sizes, improve farming operations and boost production. The devastation this loss of boundary features wrought on the Norfolk landscape was recognised by the County Council in 1977 following its 'Farmland Tree Survey' of 1975. That survey drew in turn upon the findings of Baird and Tarrant's study of *Hedgerow Destruction in Norfolk 1946-1970* (Baird and Tarrant 1973).

The practical result of the County Council's survey was the pioneering landscape improvement programme, based upon the incentive of grants for amenity tree planting, carried out in association with the Countryside Commission. As that programme has developed, more and more landowners became interested in planting both hedges and trees: the current rate of hedge planting under the County Council's scheme is around 20km each year. The Norfolk Hedge and Boundary Survey was initiated in 1994 by Norfolk County Council and the Centre of East Anglian Studies at the University of East Anglia partly to assist in this work of reconstruction, and partly as a programme of academic research into historical ecology and landscape history. The survey work was carried out by parish-based volunteers. The aims of the project were:

- to provide a statistical base for comparison with previous surveys;
- to further identify local variations in hedgerow pattern and type;
- to investigate the historical development of hedges in Norfolk;
- to enable grants and advice to be better targeted.

Survey methods

Hedges have been recorded from 46 different civil parishes in the county. In some cases only a handful of hedges were examined, in others almost all surviving examples in a parish. The survey methodology was as follows:

- Homogeneous hedge-lengths were identified on the basis of uniformity of species composition and condition, and recorded in standard lengths of 30 metres.
- Presence or absence of woody species, climbers, and in some cases, herbaceous hedge-bottom species were noted for each 30 metre section.

Standard trees growing within hedgerows were also recorded.

- Hedge condition was recorded using an eight point scale ranging from well-maintained to gappy;
- The height of the hedge was recorded, together with the presence and character of associated banks, and of such adjacent features as watercourses, roads and tracks.

The aims of this interim report are more limited: it seeks to briefly describe and explain some aspects of the character and pattern of regional variation in the species composition and species diversity of Norfolk hedgerows, and to establish patterns of regional variation for certain key hedgerow species. It represents a preliminary statement (for further on-going survey work is currently on-going with the Norfolk Society).

Classifying hedges

Once the data had been collected, we needed to find a way in which the many different hedges could be categorised. In the 1970s the botanists Hooper and Pollard first proposed - on the basis of a study of more than 220 hedges dated with varying degrees of confidence by documentary means - that the age of any hedge was, within fairly broad limits, related to the number of different shrub species which it contained within a standard length of c.30 metres. Put simply, they suggested that the number of species is approximately equal to the age of the hedge in centuries (Pollard, Hooper and Moore 1974). Hooper's theorem has been widely employed to date hedges in England, but there has been a certain amount of disagreement concerning its reliability and accuracy (Johnson 1980).

As well as considering the number of species present in a hedge we also looked at the *kinds* of species present, classifying hedges in terms of co-varying associations of shrub types they contain. In doing this we employed a system of national classification developed by Cummins *et al* (1992), partly in order to allow our results to be compared with other surveys elsewhere in the country. We did, however, adapt this system slightly to the local situation, and in order to fulfil the particular research aims of the project. The system developed by Cummins *et al* used data collected for a survey based on 10 metre, rather than 30 metre hedge

Mixed hedge (Colin Blake: NPS Graphic Design)

Single species hedge (hawthorn). Typical of north-west Norfolk (Colin Blake: NPS Graphic Design)

Guelder rose fruits *Viburnum opulus* (Reg Jones)

Spindle *Euonymus europaeus* (Norman Carmichael)

lengths, but the classification appears to be reliable for 30 metre hedge lengths if constancy values are used to classify the hedges.

The following categories of hedge were used.

Class 1: hedges dominated by non-native species

Class 2: hedges dominated by wild privet (*Ligustrum vulgare*).

Class 3: hedges dominated by beech (*Fagus sylvatica*).

Class 4a: hedges dominated by hawthorn (*Crataegus* spp.).

Class 4b: mixed hawthorn hedges: hedges dominated by hawthorn but including a range of other species maple (*Acer campestre*), elder (*Sambucus nigra*), ash (*Fraxinus excelsior*) are usually well represented and often with more than four species in a 30m length.

Class 4c: elder-hawthorn hedges: hedges dominated by hawthorn but with elder present in almost every sample length, although few other species.

Class 5a sallow/rose hedges: hedges which have *Salix* spp. as a constant species, present in almost every length, and usually with *Rosa* spp. well-represented.

Class 5b: mixed hazel hedges: species-rich hedges with no overwhelmingly dominant species, but with *Corylus avellana* and *Crataegus* as constant species.This category was, for the purposes of the Norfolk survey, broken down into two sub-categories: 5bi hedges are moderately species-rich hedges, containing 4-6 species per 30m length; 5bii are those containing more than 6.

Class 6: hedges dominated by blackthorn (*Prunus spinosa*). For the purposes of the Norfolk survey, this category was subdivided: 6i hedges are species-poor, with fewer than 4 species present in a 30m length; 6ii are species-rich hedges, with 4 or more species present (in these the % cover and constancy of *Prunus* is reduced and species such as *Acer campestre*, *Coryllus avelana*, and *Cornus sanguinea* are often well represented).

Class 7: elm hedges: generally species-poor, due to the invasive tendency of *Ulmus*

Class 8a: gorse hedges.

Class 8b: Scots pine hedges.

Regional variations in hedge type

One of the main purposes of the survey was to ascertain the extent to which hedgerows in Norfolk display clear patterns of regional variation. The following analysis considers hedgerow variation in terms of a number of distinct sub-regions. These are ultimately based on aspects of geology and soil type. Such factors had a complex effect upon the history of the landscape, determining the pace at which land was cleared and woodland eradicated, the types of farming practised in the medieval and post-medieval periods, and the extent to which land lay open and unhedged - in arable open-fields and commons - or enclosed, in hedged closes, in any period. In some parts of Norfolk hedges were already widely established by the end of the Middle Ages; elsewhere, as already noted, the majority of land lay open until the eighteenth or even nineteenth centuries. The analysis divides the county into six main regions. Other landscape regions exist in the county, but these are not described either because none of the parishes so far surveyed fall within them (the Flegg area of north-east Norfolk) or because they are areas of low-lying drained marsh and fen within which field boundaries take the form of water filled ditches (Norfolk Broads, Halvergate Marshes, and the Fens).

The heavy boulder clays

The southern and central areas of Norfolk consist of a plateau of poorly-draining clays forming two quite distinct regions. In the south, and in a narrow strip of land extending on to the high watershed between Hingham and Dereham. The plateau is level, relatively undissected by river valleys, with heavy soils and poor drainage. Unlike many other parts of Norfolk, this area seems to have been relatively uncleared in early prehistoric times, although by the Roman period clearance and settlement were taking place on a substantial scale. Nevertheless, much woodland survived here throughout the Middle Ages, and it is here that most of Norfolk's ancient woods can be found today.

This was the area of the county which was enclosed earliest. In the Middle Ages there were some areas of open-field here, and some tracts of common grazing, but even then many enclosed fields existed. In the period between c.1400 and c.1750 the proportion of enclosed ground increased as the open

fields were gradually enclosed. This usually happened 'piecemeal', as individual landowners acquired groups of contiguous strips which they then surrounded with a hedge. The main motive for this development was a change in the agrarian economy. The region came increasingly to specialise in dairying and bullock fattening. In the late eighteenth and early nineteenth centuries there were further changes; arable agriculture increased once more in importance, aided by the widespread adoption of under drainage. The pastures were gradually ploughed up. Most of the remaining greens and commons were enclosed, and put to the plough. All parishes in the region include both areas of very heavy clay, lying on the higher, more level areas - the so-called Beccles Association soils - and areas of more sandy, loamy, freely-draining Burlingham or Hanslope Association soils on the valley sides (Hodge et al 1984). Most of the medieval enclosed fields, and also the larger commons, were located on the heavier soils: the bulk of the open fields occupied the lighter land.

The survey reveals that the heavier plateau soils have the highest concentration of species-rich hedges in Norfolk (figure 1). Most of the hedges here fall into the 4b or 5bi categories; that is, they are moderately species-rich hedges, with between 4 and 6 species present in a 30 metre length. In the former, hawthorn is noticeably dominant, in the latter there is no dominant species. In addition, most parishes studied have a good scatter of hedges in the 5bii category - that is, very mixed hedges with more than six species, in some cases more than ten, in a 30 metre length (figure 2). Some hedges in the 6ii category (relatively species-rich, but dominated by sloe) also occur. The former are often, and the latter are usually, found beside roads or tracks. Some parishes (such as Denton) contain noticeable clusters of elm hedges (category 7), but these are not a typical feature of these heavy soils. Occasionally, concentrations of species-poor hawthorn hedges are found (categories 4a and 4c), often marking where commons were enclosed in the early nineteenth century but sometimes associated with pockets of rectilinear boundaries, probably resulting from the rationalisation of the earlier, irregular field pattern in the late eighteenth or nineteenth centuries (Wade Martins and Williamson 1995).

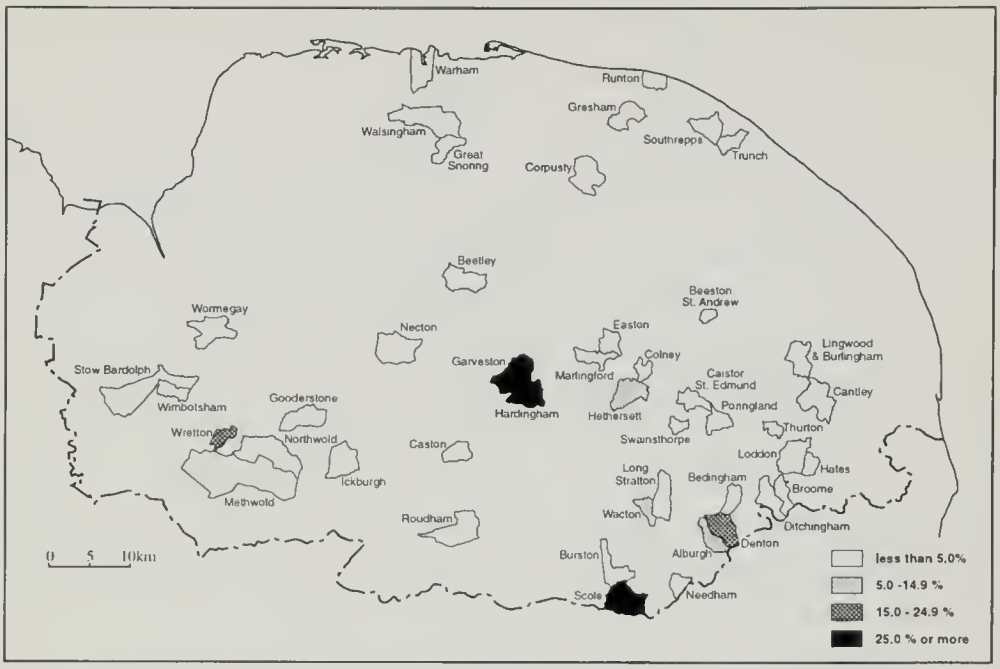

Figure 1. Map of Norfolk showing the proportion of hedgerows in each parish which contain between 7.0 and 7.9 woody species

Figure 2. Map of Norfolk showing the percentage of the total recorded number of class 5bii hedgerows occurring in each parish

On the better-drained valley soils of the *Burlingham Association* the hedges are noticeably less species-rich. The proportion of 4b and 5bi hedges is greater, those in the 5bii category noticeably fewer, although these are still fairly frequent on roadsides. There is also a higher proportion of species-poor hawthorn hedges (4a and 4c), and species-poor sloe hedges (6i) occasionally occur.

The light clay regions

Towards its edges - especially in the centre of the county - the clay plateau becomes more dissected, and the soils generally lighter. Small patches of heavy *Beccles Association* soils also occur, but most parishes are dominated by the well-drained loams of the *Burlingham Association*. In places, patches of glacial sands or gravels can be found, most of which carried areas of common grazing until enclosed by parliamentary acts in the early nineteenth century. Some areas of open field were also removed at this time, but most had, as in the region just discussed, already been enclosed piecemeal during the previous three centuries.

The light clay loams of the *Burlingham Association* which predominate in these areas are characterised by a fairly high proportion of species-poor hawthorn hedges (categories 4a and 4c), but these are often outnumbered by hedges in the 4b and, to a lesser extent, 5bi categories; as already noted, moderately species-rich hedges, with between 4 and 6 species present in a 30 metre length. In marked contrast to the region of heavier clay soils to the south, there are here a fair number of sloe hedges - mainly species-poor (6i), but with some in the 6ii category, mainly on roadsides. This is where the relatively few 5bii hedges found in this region also occur. There are also localised concentrations of elm hedges (category 7), as in Loddon.

The areas of late-enclosed commons on the sands and gravels, and on pockets of particularly poorly-draining clay, often show up noticeably as clusters of 4a and 4c hedges, as in Caistor St Edmunds, or Limpenhoe.

Breckland

In complete contrast are the hedges of Breckland, an area of acid sands and

gravels which now carries extensive areas of modern conifer plantation. This region was completely cleared of woodland in prehistoric times. It was largely occupied by open fields and vast tracts of treeless heathland before the period of parliamentary enclosures in the late eighteenth and early nineteenth centuries. The vast majority of hedges recorded in the region are species-poor. Most are dominated by hawthorn (4a, 4c). Sloe hedges of any kind are rare in Breckland. There were also, originally, a large number of Scots pine hedges in the area - locally known as 'deal rows' - but few of these are now managed as hedges, having grown into lines of twisted, gnarled trees.

There are a few hedges with more mixed composition - a scatter of moderately species-rich 4b and 5bi hedges. It is noticeable that the majority of these occur beside roads or tracks.

North-west Norfolk (the 'Good Sands' region)

This, too, was an area which was cleared of woodland at an early date, and which had few hedges in the Middle Ages. Early maps show that some hedges had been planted before the seventeenth century, usually around piecemeal enclosures in the open fields. In addition, some parishes were enclosed following their complete acquisition by large landed estates like Holkham or Houghton in the course of the seventeenth and early eighteenth centuries. Many, however, remained largely open until enclosed by Parliamentary Acts in the later eighteenth or early nineteenth centuries. In other words, like Breckland (although to a lesser extent) this was an area in which both woods and hedges were relatively rare before the end of the eighteenth century.

As in Breckland, species-poor hedges predominate. These are mainly hawthorn-dominated, although, in contrast to the former region, a number of sloe hedges (6i) also occur, mainly on roadsides or parish boundaries. A few elm hedges were recorded: and, very occasionally, example of a 5bi (mixed, 4-6 species) hedge. There are no recorded examples of hedges in the more species-rich 4b or 5bii categories, and only two examples of a 6ii.

North Norfolk heathlands

This is a useful term for the area of generally acid soils which extends northwards from Norwich to the sea. In many ways it is like a milder version of Breckland. In medieval times it was an open landscape of heaths and common fields, but the soils being better here the heaths were less extensive than in Breckland. More woodland existed here in medieval times than in either of the two areas (Breckland, North-west Norfolk) just discussed. In some parishes open fields were enclosed gradually in the course of the seventeenth, eighteenth and nineteenth centuries, but large areas survived until the Parliamentary Enclosure Acts, which also swept away extensive tracts of heathland.

In terms of its enclosure history, this region falls somewhere between the Good Sands and Breckland on the one hand, and the two clayland regions on the other. It is interesting to note that while species-poor hedges again predominate, they do so to a lesser degree than in either Breckland or the north-west. Both species-poor hawthorn (4a and 4c) and species-poor sloe (6i) hedges are thus numerous, but rather more mixed, hawthorn-dominated hedges (4b) can often be found, especially around closes near to villages; and other mixed or species-rich hedges - 5bi, 5bii, 6ii - also occur, infrequently as field boundaries, but fairly often on roadsides.

The Fen edge

One of the most interesting results of the Norfolk Hedgerow Survey was the way it has helped to highlight a small but distinct landscape region within the county, the identity of which is generally overlooked. Between Breckland and the Fens in the west of Norfolk, in the area around Downham Market, lies a small area of mixed soils - mainly clay, but with some sandy loams. Although the details of the landscape history of this region remain unclear, the survival of several areas of 'ridge and furrow' - the earthwork corrugations made by medieval ploughing, otherwise rare in Norfolk - suggests that it may have been enclosed, and put down to pasture, at an early date (Silvester 1989). This explains perhaps the peculiar character of the hedges here, which have much in common with those of the main clayland areas in the centre and south of the county, little in common with those in the areas of Breckland immediately to the east.

Three parishes in this region were examined in the survey. All included areas of peat fen and areas of higher fen-edge ground. There are few hedges in the former areas, field boundaries instead being marked by water-filled dykes. Those which do occur are species-poor hawthorn (4a or 4c) or species-poor elm (7), but some examples of sallow hedges (5a) also occur (a regional speciality. The only other example recorded was in the east of the county, at Cantley on the Norfolk Broads).

On the higher ground, species-poor hawthorn hedges again predominate (4a, 4c) but scattered amongst them are examples of the more mixed 4b type, and on roadsides and parish boundaries mixed and species-rich hedges (5bi, 5bii, 6ii) frequently occur. There are, therefore, very real differences in the kinds of hedges found in different parts of Norfolk, a pattern of variation which appears to be broadly related to the landscape history of the regions concerned.

Regional variation in hedges : other aspects

The same pattern of variation emerges, albeit less distinctly, when hedges are considered simply in terms of the number of shrub species which they contain in a standard 30 metre length. As the accompanying map shows, hedges with seven or more species in a standard 30 metre length (hedges which, according to the dating formula, ought to be 700 years or more in age) are strikingly concentrated on the clays, especially the heavier clays, and to a lesser extent on the Fen edge.

This pattern of regional variation is also mirrored in the distribution of particular species found in hedgerows. Certain shrub species are characteristic only of species-rich hedges and are thus markedly clustered on the heavier clays, and to a lesser extent on the light clays and on the Fen edge: these include dogwood (*Cornus sanguinea*), hornbeam (*Carpinus betulus*), guelder rose (*Viburnum opulus*) and spindle (*Euonymus europaeus*). A number of herb species sporadically found in hedges, which are otherwise usually associated with ancient woods, have a similar distribution: these include primrose (*Primula vulgaris*), cowslip (*Primula veris*), wood avens (*Geum urbanum*), and dogs' mercury (*Mercurialis perennis*) (figure 3).

Figure 3. Map of Norfolk showing the percentage of hedges in each parish which contain *Mercurialis perennis*

Explaining patterns of variation

It is a moot point how far these regional variations in the character of Norfolk's hedges are a function of enclosure chronology, and how far they are a consequence of other factors. It is clearly true that older hedges are, in general, more species-rich than younger ones; and, as Hooper and Pollard suggested, this is probably largely because they have had more time in which to be colonised by other plants. In general in Norfolk, areas of late enclosure are characterised by species-poor hedges, areas of early enclosure by mixed and species-rich hedges: in general, too, pockets of recent enclosure within early-enclosed areas - as where commons have been enclosed in the early nineteenth century - are identifiable as restricted areas of species-poor hedges. But this is not always the case. As one surveyor, Philip Lazaretti, commented in his detailed report on the hedges of Denton, a hedge established after a common was enclosed in 1804 was found to have, over a length of 135 metres, an average of 7.9 species per 30 metres! Clearly, species content is not in itself an infallible guide to the age of an

individual hedge. Hedges, or at least, the boundaries which they define, might also have *fewer* species than Hooper's theorem might predict, for there is abundant documentary evidence from the eighteenth and nineteenth centuries for landowners replanting, with pure hawthorn, hedges which had become gappy or neglected (Wade Martins and Williamson 1997, 29).

Anomalies of the Denton variety hint that variations in the chronology of enclosure may not in themselves be sufficient to explain the observed patterns. These might, in fact, be the consequence of several inter-related factors. Older hedges may often have been planted with more than one species originally, for the simple reason that it was difficult to obtain large amounts of pure hawthorn or sloe in the remote past. Large-scale commercial nurseries only developed in the course of the eighteenth century. But it is also likely that multi-species planting continued after this, although more commonly in some areas than in others. As already noted, some parts of Norfolk, such as the Breckland and the north-west, were largely deforested in prehistoric times. On the claylands, in contrast, some areas of woodland always existed. In Breckland and the Good Sands, hedges too had largely disappeared by the middle ages, the landscape comprising vast areas of open arable and heath. On the clays, hedges were a more common feature of the medieval landscape. This abundance of woods and hedges would have provided a ready supply of hedging plants. In addition, multi-species planting may have been encouraged on the clays because these areas were, traditionally, characterised by smaller landowners, men with less capital available than the large estates which had, by the seventeenth century, come to dominate the areas of lighter soils in the north and west of the county. An abundance of old woods and hedges would, in addition, have provided a steady stream of seeds to the hedge once it had been planted.

In areas like Breckland, in contrast, very early deforestation meant that ready sources of shrubs were lacking. Landowners wishing to enclose land, in whatever period, would have had to look further afield for hedging plants. In doing so they would naturally have chosen the species best suited to the task - hawthorn, or sloe. After the hedge had been planted the paucity of local woodland (and of other hedges) would have meant that

relatively few seeds of other species would be available for colonisation. In other words, in areas of Norfolk now characterised by species-poor hedges not only would farmers have been more likely to plant single-species hedges, but in addition such hedges would have been less susceptible to subsequent colonisation by additional species.

The fact that woodland was entirely cleared at an early date from some parts of the county, but survived as managed pockets in others, may thus be a significant factor in the observed pattern of variation. Certainly, a number of interesting features revealed by the survey indicate that age along is insufficient to account for variations in species content. In particular, it is striking how, in all areas, hedges bordering roads and tracks are consistently more species-rich than those merely dividing the neighbouring fields. Thus on the claylands 5bii and 6ii hedges are noticeable clustered on roadsides; in more species-poor Breckland the richest hedges, of 4b and 5bi type, likewise occur beside roads and tracks. It is possible, of course, that roadside hedges are, in general, older than others in any area: but the available map evidence does not entirely bear this out. In the pre-enclosure landscapes of Breckland or the north-west tracks, like arable strips and furlongs, were often unhedged. Another factor might be the ease with which colonising plants could gain a foothold in such hedges. Roadsides were more disturbed environments: hedges here would constantly be damaged by traffic, and by the movement of stock, so that colonising plants might more easily become established. At the same time, it is likely that the seeds of certain plants might be transported by animals and traffic along roads: modern railway lines often have a high number of plant species growing beside them, for similar reasons.

Many features of the mapped distributions are thus probably a function both of straightforward environmental factors *and* of landscape history. Some distributions, like that of sloe hedges, remain problematic. Sloe hedges, especially species-poor ones, are an uncommon feature on the heaviest clays, and are rare in Breckland (figure 4). They occur sporadically in other regions but are most noticeably a feature of the northern heathlands. How far this reflects human choice, chronology, or the dictates of the environment, remains unclear.

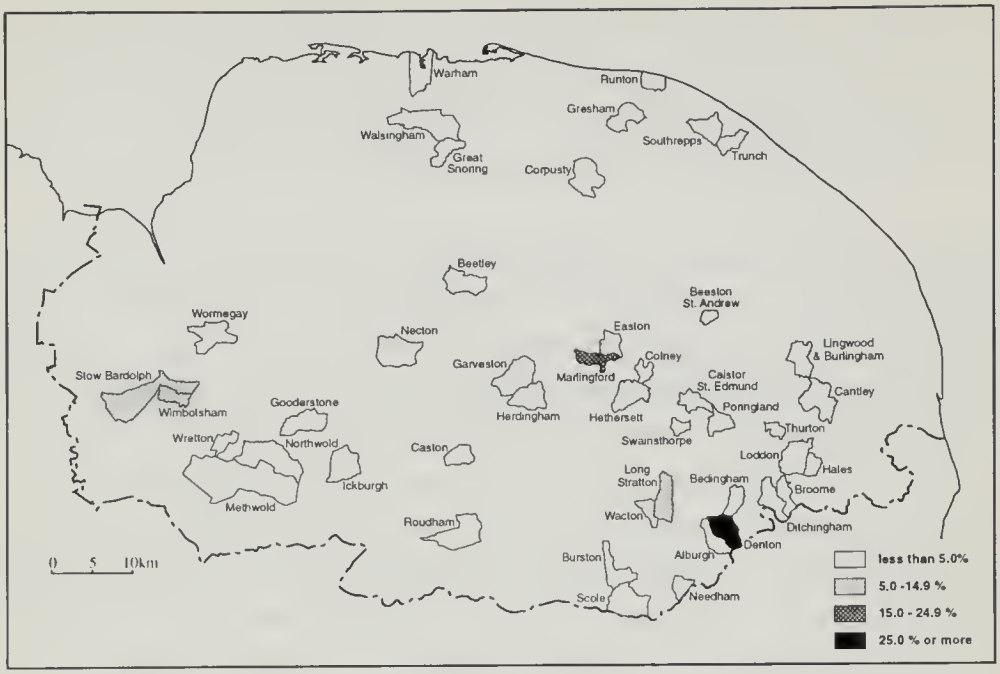

Figure 4. Map of Norfolk showing the percentage of the total recorded number of class 6ii hedgerows in each parish.

Survey work and analysis are still continuing, and it is hoped that both will throw further light on the development of this most vital feature of the Norfolk landscape.

Acknowledgements
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Miscellaneous observations

A rust fungus found on annual seablite *Sueda maritima* during a Society workshop on Wells Saltmarsh (TF 925-438), was subsequently identified by Reg. and Lil. Evans as *Uromyces chenopodii* (Duby) Schröter. Mr and Mrs Evans noted, "We have no previous record on our list, although it no doubt occurs in old recordings. The name is very misleading as it does not occur on the genus Chenopodium."

David Paull

NOTES FOR AUTHORS

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