TRANSACTIONS OF THE NORFOLK & NORWICH NATURALISTS' SOCIETY

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TRANSACTIONS OF THE NORFOLK AND NORWICH NATURALISTS' SOCIETY

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Editor Dr E. A. Ellis

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SOME EFFECTS OF THE SEA FLOOD AT WELLS-NEXT-THE-SEA 11th JANUARY 1978 by P. R. Banham

Wells Field Centre, Wells-next-the-Sea

The damage caused by the exceptional high tide on the East Coast on the evening of the 11th January 1978, though less than that which was experienced in 1953, was still considerable, especially at Wells-next-the-Sea. Between noon on Tuesday the 10th January and 8 a.m. on Wednesday the barometric pressure in Wells dropped from 29.8" to 28.9", at which very low level it stayed until 2 p.m., rising steeply to 30.4" by 8 p.m. on Thursday. During Wednesday afternoon a N.N.E. gale sprang up, being of storm force by early evening. High tide was predicted for 29 minutes past eight at Wells Quay on Wednesday evening, with a height of 3.2 metres above Mean Sea Level. The tide normally starts to flow at the Quay some 3½ hours before high water, but by 5 p.m. there was already the appearance of a normal high tide there, with more than three hours to go; obviously something exceptional was on the way. In fact, the tide peaked about an hour early, just touching an incredible 5 metres. In practical terms, this meant that all the low-lying parts of the town East and West of the Quay were flooded, as well as the Quay itself.

Some sections of the main Sea Wall running North from the Quay to the Beach were only about 4.6 metres above Mean Sea Level (though most of it was 5m or more), so that parts of the wall were over-topped by the sea for nearly two hours; it must be remembered, too, that this takes no account of the height of the waves which, with a Northerly wind, have a considerable fetch available! Consequently we were not surprised, though dismayed, on Thursday morning to see that the wall had been breached in two places. So much is now, in August, ancient history; the wall has been rebuilt higher and much more substantial than before, the Beach Road is open again, the Caravan Site is getting back to normal and even the Wells Harbour Railway is re-established. The representatives of the media and their paraphernalia, so thick on the ground in January, have deserted us, but the really interesting time for naturalists and ecologists is now, the first growing season after the salt flood.

When the sea broke through the Sea Wall it flooded not only the Caravan Site and adjoining agricultural land (all former saltmarsh) but also the lower parts of the pinewoods, including much birch scrub, grassland and freshmarsh. Next to the northern breach in the wall a number of 20-year old mainly Corsican pines were swept away, first inland by the onrush of water and later (many of them) out with the tide, to be deposited up to two miles away on the outer bank of the beach between Wells and Holkham. Of the pines generally, those nearest this breach are mainly dead, while others which were



Fig. 1. The second breach in the Sea Wall, photographed on 15th January. This was the breach nearest the "Orchidetum", and also shows where a whole section of the 20 year old Pines was swept away.



Fig. 2. The ''Orchidetum'' a fortnight after flooding (photographed on 26th January). The water was unable to drain away through any of the established drainage dykes.

inundated for a shorter time and which looked dead earlier in the season are in many cases showing new growth at the tips of the twigs. The Monterey pines, however, all of which were planted as seed in 1956 principally in the area just west of Abraham's Bosom, suffered badly, with only a few surviving. They seem to have a lower salt-tolerance than Corsican or Scots pine, some of which are looking healthy next to Montereys standing stark and bare.

Other trees, notably birches and sallows, were less affected than the pines, though some died and others have dead branches amongst the living. This may be because most of the salt would have been leached away by the time their growing season began. Brambles, rather surprisingly, were quite badly affected; perhaps their roots go deeper than other species, into zones not reached in time by the leaching rainwater. Ground flora, be it grasses or broadleaved plants, seems quite unaffected in all places where there was nothing to stop the eventual run-off of seawater.

One area, however, will take a long time to recover. This is a large depressed stretch of marshy ground whose raised boundaries were just lower than the level reached by the flood, and from where the seawater was unable to escape except by slow percolation through the silty substrate. In fact, it is because of its retention of water even in drought conditions that this part of Wells was so interesting, supporting a good selection of marsh and wet meadow plants. We called it Wells "Orchidetum", and regularly found the following orchids there: early purple, common spotted, southern marsh, bee, pyramidal, twayblade and marsh helleborine. In 1977 we found adder's tongue fern, in a rather lanky etiolated form among fairly long grasses.

On the 26th January the water was still nearly a metre deep; assuming at least a full metre's depth of water at the time of the flooding, a rough calculation shows that the area had to cope with at least 500 tonnes of salt. For weeks the smell of salt-affected rotting vegetation was pervasive and, as winter turned to spring, we looked, without much hope, for signs of normal plant growth. Our lack of hope was reinforced by the knowledge that the salinity of standing water in the Orchidetum was still 17°/00 on the 4th March (standard North Sea salinity is about 35°/00) and 10°/00 on the 26th April. It was not until the 9th May that it had dropped to 3°/00; by then, 213.5mm (= 8.5′′) of rain or snow had fallen since the flood.

By the end of May it was apparent that the pines in the Orchidetum were all dead, while many birches and sallows were showing signs of die-back after producing leaves and flowers. Brambles and hawthorn were quite dead, though there was some life in privet and dog rose. Of the ground flora, silverweed was doing well, flowering even in the lowest parts of the marsh, and rosebay willowherb was growing strongly, as were rushes, grasses and sedges. Of orchids and adder's tongue, not a single plant could be found. In August the situation is still much the same, except that some sallows in this maximum salted area are looking surprisingly healthy, while a halophytic plant, sea milkwort, has appeared in some quantity on otherwise bare patches of mud. This, like the now common marsh arrow grass, we have not noticed in previous years, though of course we cannot guarantee that either of them was not there.

Scientific names of plants mentioned in text

Corsican pine Pinus nigra maritima (Ait.) Melville

Scots pine Pinus sylvestris L. Monterey pine Pinus radiata D.Don

Birches Betula pendula Roth & B. pubescens Ehrh.

Sallow Salix caprea L.
Bramble Rubus fruticosus agg.
Early purple orchid Orchis mascula L.

Common spotted orchid Dactylorhiza fuchsii (Druce) Soó
Southern marsh orchid Dactylorhiza praetermissa (Druce) Soó

Bee orchid Ophris apifera Huds.

Pyramidal orchid Anacamptis pyramidalis (L.) Rich.

Twayblade

Marsh helleborine
Adder's tongue fern
Hawthorn

Privet

Listera ovata (L.) R.Br.

Epipactis palustris (L.) Crantz

Ophioglossum vulgatum L.

Crataegus monogyna Jacq.

Ligustrum vulgare L.

Privet Ligustrum vulgare L.
Dog rose Rosa canina L.
Silverweed Potentilla anserina L.

Rosebay willowherb

Chamaenerion angustifolium (L.) Scop.

Glaux maritima L. (L.) Scop.

Marsh arrow grass Triglochin palustris L.

THE EFFECTS OF THE STORM OF 11 JANUARY 1978 ON BLAKENEY POINT

by D. J. B. WHITE

Department of Botany and Microbiology University College London

High water at Morston on Wednesday 11 January 1978 was due at 8.00 p.m. but water was up to the Quay by about 4.15 p.m. The height finally reached by the tide was lower than in the East Coast storm-surge of 1953 (some two feet lower judging by the height of the water reached in the Old Lifeboat House). But the gale blowing as it did from the North East generated much bigger waves and much of the damage to the Point resulted from wave action.

The sea wall or bank was breached at Cley (east of the Windmill) and the bank on the west side of the beach road was breached in two places.

The breaches were caused apparently by boats being driven against the bank by the waves. The bank between Morston and Blakeney held. The water just failed to reach the top of the bank as was shown by the position of the debris, seaweed, etc., left behind as the water level fell.

Morston Creek and Morston Marshes on the east side of the Creek were protected from the force of the waves by the Headland and although deeply covered by water, there was no violent action. The bridges over the Creeks were undamaged.

The main shingle bank felt the full force of the gale and the wave action. Enormous quantities of shingle were moved. Right along from the Cley beach to the bend at East Point, (''aeroplane gap''), large tongues of clean, fresh looking shingle project into the marsh. These shingle tongues are often 3 ft high. The bank appears to have moved landwards some 30—40 yards and in the region of East Point rather more. It is my impression that there was as much movement of shingle as there was in the 1953 East Coast Surge. In places, sand that was carried over by the water has been deposited on the marsh in front of the shingle tongues. In some places, a fair amount of sand was deposited between the tongues.

At the bend (aeroplane gap), much shingle and sand was moved into the low. The sand in this region extended as far as the last telegraph pole—forming a large wedge shaped mass 6 in. deep at the foot of the shingle, thinning out regularly until, just beyond the telegraph pole, there was only a thin dusting of sand.

The plants, mainly Armeria maritima, in this region of the Low were, of course, buried.

The landward movement of the main shingle bank has covered most of the plants of Suaeda fruticosa along what was its back edge and has completely obliterated the footpath which had become established there. Some idea of the amount of shingle which has been moved is seen by the exposure of the bases of several telegraph poles which used to stand on the crest of the ridge. These poles were removed shortly after the war. They were cut off near to ground level. The remains of about four of these poles now stand some three feet above the shingle.

When one stands on the main bank the Watchhouse seems very close. Watchhouse Bank is so much shorter because a further 30 or so yards of it have been buried by the landward movement of the main bank. The marsh on the west side of Watchhouse Bank is smaller for the same reason.

A creek in the marsh east of Watchhouse has been truncated by the advancing shingle. The channel towards Cley has received a lot of shingle; movement of any more shingle in the future would more or less block it. This channel was cut in 1921 (?) after the previous channel had become blocked in the same fashion.

As might be expected following such massive shingle movements, most of the vegetation on the main bank has disappeared, and the shingle looks bright and fresh.

In one or two places a few underground stems of Rumex crispus and some of the underground parts of Silene maritima remain, having been exposed by the moving shingle. There were no signs of the plants of Crambe maritima which were growing on the main bank east of the Hood. Crambe grows on the seaward face of the bank, just above high water level - a very vulnerable position at the best of times.

The dunes on the Hood do not seem to have suffered very much. Fresh shingle has moved right up to the foot of the dunes, so obliterating the vegetation which occurred there.

The Headland dunes have not been badly affected; nothing like they were in the 1953 floods. There has been some erosion of the dune face at East Point. This erosion only extends for a short distance along the dunes and is no greater than the amount of erosion which occurred in this position in the winter of 1976 when there were some high tides.

The dunes at the end of the Headland near the tea room have been cut back by the sea for a few yards, but, fortunately, the recent dune growth in the funnel-shaped area which we have been trying to repair was not completely destroyed. The dunes on both sides of the gap opposite the end of the tea room have been eroded and much of the dune on the marsh side (S.W. side) has been washed away. Some of the small dunes between the sea and the main dune ridge have suffered some erosion, as sand was washed away from around them as the water first advanced swirling around and then later retreating.

The tide swept over the dunes on the base of the old Far Point and over the embryo dunes on the new, now the true, Far Point, but did not completely destroy them. Providing there are no more heavy seas in the near future these dunes should start regenerating.

The Observation Hut on the seaward edge of the dunes suffered little damage.

All the Lows were flooded. Over a week later water was still standing in Glaux Low, Great Sandy Low and, to a lesser extent, in Long Row.

Water entered the Lows from three main points:

- 1) Via the shingle low (which is like a water course) which runs from the beach East of the observatory, through the dunes, into the Great Sandy and Glaux Lows.
- 2) From the landing area near Pinchen's Creek and thence towards the Lifeboat Houses.
- 3) Through the gap opposite the end of the tea room.

4) Over the main bank at the aeroplane gap.

The depth reached by the water in the lows and elsewhere, is shown by the tide marks left as the water level fell.

In Boathouse Low, the hummocks of sand around the bushes of Suaeda fruticosa are smaller and much sand has been distributed over the Low. The corner of the marsh enclosed by the Britannia bank has received much sand, largely washed over it by the water carrying sand from the dunes near the tea room.

As a result of all the water movement, the beach has been cleaned in a remarkable fashion. There are hardly any polythene bottles, light bulbs and other debris of this kind to be seen. Nor is there much driftwood on the foreshore. The larger pieces have been carried up the beach and left someway up the face of the main dunes. In one place, much driftwood was washed over small dunes and left more or less out of sight in one of the blowouts.

It will be interesting to see what happens to the vegetation in 1979. One might anticipate a paucity of strand line plants and that plants like *Cakile maritima* and *Salsola kali* may be found in unusual places where their seed may have been carried by the tides. There will probably be few plants on the main shingle ridge, although there should be a steady increase in vegetation as the crest and back of the ridge again become stabilised.

My thanks are due to the Warden, Mr W. E. Eales, for his help in compiling this report.

THREE RARE SPECIES ON THE NORTH NORFOLK COAST by J. P. Skipworth

Massey University, New Zealand

Introduction

Suaeda vera, Frankenia laevis and Limonium bellidifolium are three plant species often found growing together in the North Norfolk coastal area. Although locally quite common they are rare in the wider context of the British Isles each being rated A (''rare'') by Perring and Walters (1976) the last named among them in fact being A + . The three species have all been described as ''obligate halophytes'' by Chapman (1960a) and all belong to families whose members are strongly associated with saline environments. All could be described as Mediterranean species which are very near their northern limit in Norfolk and each could be said to be a strand plant. When they occur together, it is in a free draining situation where salt marsh abuts on the edge of sand dunes and here they could be said to comprise a community, albeit one which is very much part of a continuum.

Limonium bellidifolium (Matted sea lavender)

This, the rarest of the three, is one of some 200 species in a sub-cosmopolitan genus which is in fact the largest in the family *Plumbaginaceae*. It is recorded by Perring and Walters (1976) as occurring in the British Isles only on the north coast of Norfolk, South Lincolnshire and the Channel Islands. However, although Gibbons (1975) referred to it as being recorded on five occasions between 1789 and 1952 in South Lincolnshire, she believed that it had not been registered in the county since 1966. Bennett (1909) did not record the species outside Norfolk, but Perring and Walters note its occurrence to the east and the west of its present range prior to 1930 and this presents the possibility that the range has been contracting in the last 50 years. Both Butcher (1961) and Clapham, Tutin and Warburg (1962) have referred to the presence of this species on Suffolk coasts but Perring and Walters do not confirm this.

It is also recorded on north Mediterranean coasts from Gibraltar to the Black sea (Polunin 1964) and it is said there to be "rather like L. vulgare". This remark which is substantiated by a drawing, is of interest because it would be a most unlikely one to be responsibly offered with respect to the species in Norfolk. Moreover, Tutin, et al. (1972), after describing the species without referring to its markedly procumbent habit in Norfolk, state that "procumbent plants.....are recorded from the coast of west France and England as L. dubyi...; this may represent a distinct species". They go on to say, "L. danubiale.....from south west Ukraine is a larger variant of (L. bellidifolium)." There would seem to be a possibility therefore that the Limonium

bellidifolium of Norfolk might be a distinct species or subspecies, or that it might represent a clinal end point. A taxonomic investigation of the present species throughout its geographic range could be an interesting exercise.

Limonium bellidifolium is a rather attractive, perennial, herbaceous. rosetted hemicryptophyte with a tap root extending straight into the substratum for as far as 20cm. There are 10 - 20 leaves in each rosette and they die when the plant flowers. Flowering stems up to 25cm in length, 5 - 20 of which are associated with each rosette, radiate from the crown and are appressed to the ground for much of their total length but they do curve upwards distally. The stem bears numerous forked branches, the lower ones among which are peculiarly and characteristically quite sterile. The upper branches bear large numbers of flowers whose gross dimensions (3 - 4mm across) and lilac colour are imparted by petals. Flowering commences in early July and continues through to late August. Clapham, Tutin and Warberg (1962) record the species as dimorphic and self incompatible with a diploid chromosome number of 18. It is likely that pollination is effected by insects although no such vectors seem to have been recorded. Little seems known about seed dispersal and germination although some suspicions based on the careful study of L. vulgare and L. humile by Boorman (1968), may be entertained. These would be that dissemination by seawater and deposition on a high tide mark is a probability although dispersal by wind may also take place. Success of germination may depend on an intricate interplay of various impinging factors especially salt and fresh water. The species has been said to be a perennial but anatomical structure of the shoots suggests that a plant living more than 5 or 6 years may be unusual.

Various authors have described the habitat of Limonium bellidifolium as "marsh", "normally sandy marsh", "sandy places in salt marshes", "drier parts of sandy salt marshes", "sandy margins of salt marsh" etc. It is a little strange that the word shingle does not appear in any known description yet it seems there is almost always a component of shingle in the substratum where the species is growing and that it is not in fact common to find it on pure sand. The plant indeed seems to thrive best in a free draining situation where there is a thin layer (0.5 - 1.0cm) of sand overlying a mixture of sand and shingle, especially where this is 5 - 10 cm thick and in turn overlies pure sand. It is in this underlying sand, which is almost always damp, that most of the feeding roots are to be found. An approximate evaluation of particle size in the surface sand, (this presumably being of special significance as the layer in which seedlings must first become established) has been made. Based on this it is suggested that the species seems confined to a zone where 1.5 - 7.5% (by weight) of the particles are less than 0.1mm in diameter and 50 - 65% are more than 0.25mm in diameter.

The zone occupied by the species has been delineated by Chapman 1960b) as 2.24 - 3.36 ft above I.Z.L., that is a little more than a vertical foot rather high in the intertidal region. Little reason is seen to dispute these figures although consideration of exceptional plants would probably produce wider limits. Boorman (1971) recorded transplanting L. bellidifolium to lower than normal regions. Death followed and was attributed "probably" to the effect of frequent submersion in sea water. Boorman concluded that the

"lower limit may be determined by the height above mean tide level and thus by the number and duration of tidal submergences". Chapman (1960b) has shown that at its lowest limit, the species is submerged some 170 times per year by tides and at its upper limit 85 times. It could also be noted that the spring tides of June/July and of December/January do not reach the upper part of the zone. Some evidence has been collected which would support the implications inherent in these evaluations. These are that the plant will tolerate considerable variations in salinity ranging from hypersalinity (as evaporation concentrates salts when tides recede) to 'full' salinity during tidal immersion to very low salinity following leaching of salts by rain at times when plants are not being reached by tides. It is suggested therefore that salinity itself (and by inference other chemical factors which would be subjected to similar erratic concentration and flushing) does not strongly influence mature plants. This is not to say that an appropriate and perhaps precise juxtaposition of chemical factors might not influence germination and seedling survival.

The physical and chemical parameters of the soil which might delimit the species seems in fact to be largely unknown and could only be determined by a detailed investigation. Drainage, aeration, compaction, and percentages and decay rates of organic matter, could all be important and careful consideration would need to be given to particle size and nutrient regimes both on the surface and at the depth where feeding roots are found.

In the zone in which Limonium bellidifolium exists, the community is often rather open and the dominant species in normally Suaeda vera, although there is no suggestion of interdependence between the two. Limonium bellidifolium in fact seems to thrive best where Suaeda is growing less robustly and where its cover value is less than 50%. In such a situation the density of Limonium may be 60 plants/square metre with virtually no other species present. However, usually, Puccinellia maritima, Frankenia laevis, Suaeda maritima and less frequently Halimoine portulacoides, occurring together with Suaeda vera are to be found with, or very near to L. bellidifolium.

Suaeda vera (Shrubby sea blite)

Suaeda vera appears to be the more correct name (Tutin, et. al. 1964) for this member of the Chenopodiaceae also, and perhaps better known as S. fruticosa. It is a shrub which may be 3 - 4 feet in height and is near its northern limit on the Norfolk coast. It occurs also on south eastern coasts in the British Isles and finds its western limit in Dorset. Plants were known at Gibraltar point in 1977 but Gibbons (1975) refers to the species as having come and gone several times to and from the south Lincolnshire coast and Chapman (1947) associates its northern limit with the 61°F August isotherm which runs virtually along the north Norfolk coast. It may have also formerly occurred in Glamorgan, the Channel Islands, and possibly Yorkshire and Ayrshire (Chapman 1947). Tansley (1968) has fairly said that it tends "to be found abundantly where it occurs". Outside England it is reported from Brittany, the Atlantic coasts of France, Portugal and Spain (where it also occurs inland), and through the Mediterranean. It probably does not reach India, Afghanistan and central Asia as claimed (for S. fruticosa) by some authors

e.g. Chapman (1947), Clapham, Tutin and Warberg (1962).

It is a virtual evergreen, but Ranwell (1972) has recounted that after the cold winter of 1962-63, plants at Blakeney Point lost all their leaves, and it is densely branched shrub with smallish cross-sectionally oval, dull green leaves. Flowers are inconspicuous axillary, greenish in colour and are present from July to September. Seeds are almost certainly water-borne and deposited on a strandline where in appropriate conditions they germinate. Usually the plants lowest in the zone occupied by *S. vera* are smaller which suggests that they do not live as long as those higher up. Anatomical examination of wood increment supports this. Where the plant is most dense it forms definite thickets in which no other plant grows.

In an impressive piece of work for its time, Oliver and Salisbury (1913) accurately described the plant's morphology and its response to accreting sand. This particular article with its several lucid illustrations has clearly provided a baseline for subsequent appraisal of the species for example by Chapman (1947) and Tansley (1965) and while it is unnecessary to recount the work again, it is appropriate to re-emphasize the role that the plant can play as a sand binder. Shoots will stand burial in sand and shingle and in fact this action stimulates the production of new branches which soon emerge above the surface. Adventitious roots will form on the buried branches and the whole composit structure serves to restrict further movement of sand. Tansley (1968) referred to it as "a very remarkable plant" and was clearly impressed by its ability to "climb" beaches. That is, as inorganic material continues to accumulate on a beach, S. veta continues to grow through it until it may reach the crest of the dune.

There are some special points which could be made with respect to the species in Norfolk. First, it has frequently been described as being associated with shingle. Shingle though is by no means a prerequisite. It grows well for example on the banks of marshy creeks near Wells, on compacted artificial stop banks at Burnham Overy and on semi-protected sandy beach at Holkham. Moreover there is a distinct impression that if there is a strong shingle component on the marsh/dune interface where the species is generally common, it grows less robustly (and Limonium bellidifolium and Frankenia laevis rather better), than when there is a higher proportion of sand and mud. Reference could also be made to the occasional tendency for it to be "banded" in its distribution. That is plants of several different sizes (and by inference ages) form that number of more or less distinct bands along the shore. This could be attributed to the occurrence of occasional years when seeds are deposited on a strandline in particularly favourable circumstances or are of exceptional quality.

At the top of the marsh and probably where it occurs on the sea facing dunes as well, Suaeda vera grows over a rather wider zone than does Limonium bellidifolium (0.0 - 4.0 ft above I.Z.L.). This means that at its lower limit roots would be submerged by tides on at least half the days of the year and at its upper limit by few more than equinoctial tides. Some mature plants therefore grow in a situation virtually devoid of the influences of sea-water and others in situations ranging from full to hypersalinity. Just as Suaeda vera

seems capable of existing through a wider range of salinity than *Limonium bellidifolium* so also it seems to be associated with a wider range of soil particle size and presumably other soil characters as well. Perhaps this in part explains the wider distribution of *Suaeda vera* in the north Norfolk area.

Frankenia laevis (Sea Heath)

A member of the small family Frankeniaceae, this species has a distribution in the British Isles very similar to Suaeda vera, that is, somewhat irregularly on south and east coasts from Northern Norfolk to Hampshire. It is, in addition found on the Channel Islands (Perring and Walters 1976). Like the previous two species its existence on the Lincolnshire coast is somewhat tenuous but it is said by Gibbons (1975) to have appeared there in 1975. Like the others also, it occurs on Mediterranean (eastwards to Italy) and southern Atlantic coasts of Europe and in addition on certain islands to the west of North Africa.

The plant could fairly be classified as a Chamaephyte - a mat plant - and the small dark green, reddish tinged leaves and pink flowers do suggest the heath family although systematically Frankeniaceae and Ericaceae are not at all closely related. It could also fairly be described as a perennial with an extensive though essentially shallow root system. Usually, solitary, sterile, axillary flowers are produced in July and August and according to Salisbury (1952) production of fertile seed is poor in Britain. How seed is dispersed is uncertain.

It typically occurs with Limonium bellidifolium and Suaeda vera but seems to occupy a narrower zone than the other two: roughly the upper half of the Limonium zone and perhaps extending above it. It occurs especially in small depressions and where the proportion of shingle is high. At certain particularly shingly sites it seems to be pioneer species with Suaeda vera secondarily becoming established in its mats. As a mat plant with its own rather humid microenvironment immediately beneath, it is well suited to pioneer situations. Free drainage seems to be a particular requirement and as with the other two species, it must be able to tolerate at least briefly, high salinity.

Conservation

It should be to the great advantage of the three species that they exist in some abundance in the almost continuous strip of coastline reserves between Holme and Weybourne. Limonium bellidifolium in Britain is almost certainly confined to these reserves although fortunately it is in no real danger of becoming extinct. Even if it were so it may be argued that it is no Whooping Crane or Jarvan rhinoceros. Yet it is probably the only plant species confined to the north Norfolk reserves and if ever a regional symbol were sought, this attractive, somewhat dainty rather unusual little species would be worthy of consideration. Nevertheless without being an alarmist it would have to be said that the continued existence of this species in Norfolk is something which cannot be unequivocally guaranteed. Various events in the past 25 years emphasize that changes, which are so much a part of this particular coast, could sooner or later prove to be a threat to the species. Chapman (1960 b) for

example has asserted that "Puccinellia and Halimoine have increased in dominance and L. bellidifolium is being suppressed since the rabbits have gone" (a consequence of the advent of myxomatosis). It may well be that this statement is not now as poignant as it was 18 years ago nor was it necessarily applicable to the region as a whole but it emphasizes that any change in an ecosystem can have unexpected consequences. Here it seems that the removal of the herbivores was causing reduction in numbers of a particular herb. And because in this case the herb was rare and confined to the region it would be possible to argue that removal of this herbivore (which in the event has been only partial) would not be an altogether desirable thing. A further thought might exercise the minds of Norfolk naturalists with respect to the plant that they might with some justification regard as their own. Where it occurs, it occupies as has been mentioned, a rather narrow band and people tend to walk not in the soft sand above nor in the squelchy mud below but precisely in this band. A subjective but conservative estimate near Gun Hill would be that 10% of the area potentially available to Limonium bellidifolium is hardpacked, bare, man-made track. What if and when human usage of this area doubles? trebles? increases tenfold? Other changes over the last 25 years included the 1953 storm surge which apparently removed two species from Scolt Head Island (Chapman 1960 b) and as well resulted in the "loss of peculiar flora associated with the pit" at Norton Hills. The appearance of Spartina anglica has also induced a change modifying, again according to Chapman "the whole pattern of the early stages of marsh formation". To reiterate, Limonium bellidifolium is not a threatened species but its future performance on a coast which throughout recorded history has been subject to marked changes (Steers 1960) might be watched with interest.

Even an ardent preservationist would find fewer reasons for focussing attention on *Suaeda vera* and *Frankenia laevis*. Unlike *Limonium bellidifolium* there is no suggestion that they might be genetically special in Norfolk and they are in any case found elsewhere in Britain. Moreover in the unlikely event of the peculiar marsh/dune ecotone ceasing to exist, *Suaeda vera* and less certainly *Frankenia laevis* would continue to exist in the region.

As a plant community, the one characterised by the three species is almost certainly found nowhere else in Britain and to this extent it is presumably something a little special. The degree of similarity to any plant assemblage which involves these same three species in for example the Mediterranean is an interesting though so far as is known, currently unanswered question.

As a final thought, it has been mentioned that the northern limit of Suaeda vera has been related to a particular August isotherm. It would be logical to apply the same constraint to the other two species. What would happen to the community if temperatures became colder? Where indeed was the community in the "mini ice age" of the early 17th century when there was ice in the north sea and the Thames Estuary was frozen in winter?

The performance of these three species and the community in which they occur, should as much as any plants, provide naturalists with food for thought, for interest and for mental stimulation, and that is probably what being a naturalist is all about.

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BIRDS OF THE CROMER FOREST BED SERIES OF THE EAST ANGLIAN PLEISTOCENE by C. J. O. Harrison

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Summary

Specimens from the Cromer Forest Bed Series identified in the last century have been re-examined and additional material identified. The Shoveler Spatula clypeata and Capercaillie Tetrao urogallus are removed from the existing list. The list of species now includes the Cormorant Phalacrocorax carbo and fourteen species of waterfowl including the Mandarin Duck Aix galericulata, now found only in eastern Asia. There is a new species of eider duck Somateria gravipes. A buzzard, possibly the Common Buzzard B. buteo, is present, and an extinct species of junglefowl Gallus europaeus. Additional water birds are the Moorhen Gallinula chloropus and Green Sandpiper Tringa ochropus, and the Guillemot Uria aalge and Razorbill Alca torda; while land birds include the Eagle Owl B. bubo (apparently resembling the smaller southern form B. b. ascalaphus and the Blackbird Turdus merula. Starling Sturnus vulgaris and Jay Garrulus glandarius or the ancestral forms of these. The strata from which some specimens originate is uncertain, but most are referable to the Pastonian and Cromerian warm stages, when the area had a temperate mixed oak forest as the dominant vegetation. Problems in assigning some birds to recent species arise from the existence of apparent Late Pleistocene speciation in these taxa.

Introduction

In describing the vertebrate fauna of the Cromer Forest Bed Series of the Pleistocene deposits of East Anglia, Newton (1882) listed and figured three avian carpometacarpi which he referred to — Anser sp., Anas?, and Genus?. In addition, with the second specimen he also referred to a distal end of a coracoid which resembled that of the Mallard Anas platyrhynchos (the earlier name A. boschas being used). Later (Newton 1891) he added to these the Cormorant Phalacrocorax carbo, the Shoveler Anas clypeata (using the generic name Spatula), the Guillemot Uria aalge (earlier U. troile) and the Eagle Owl Bubo bubo (earlier B. maximus and B. ignavus). To this Lydekker (1891) added the Pochard Aythya ferina (earlier Fuligula ferina) and the Capercaillie Tetrao urogallus.

Most of this material, together with other unidentified specimens from these deposits, is in the collection of the Department of Palaeontology of the British Museum (Natural History). The Cormorant and Shoveler were in the collection of W. Barker of Birmingham and their present whereabouts is unknown; but they were figured by Newton and their identities can be

checked. The Guillemot specimen has not been traced, but additional material from the same deposits confirms the presence of the specimen. The specimen and figures, together with additional material, have been studied and the earlier list of species has been revised. The additional material is mainly from collections formed in the last century by A. C. Savin and the Rev. C. Green.

Old List	New List
	PHALACROCORACIDAE
Phalacrocorax carbo	Phalacrocorax carbo
	ANATIDAE
Anser sp.	Cygnus bewickii
•	Anser anser
Anas boschas	Anas platyrhynchos
_	Anas penelope
Anas sp. ?	Anas crecca
_	Netta rufina
Fuligula ferina	Aythya ferina
_	Aythya fuligula
_	Aix ? galericulata
	Somateria gravipes sp. nov.
_	Melanitta nigra
_	Bucephala clangula
-	Mergus albellus
-	Mergus serrator
Spatula clypeata	Anatidae? species
	ACCIPITRIDAE
_	Buteo? buteo or B.buteo/lagopus/
	rufinus superspecies.
	PHASIANIDAE
Tetrao urogallus	Gallus europaeus
	RALLIDAE
_	Gallinula chloropus
	SCOLOPACIDAE
Genus?	Tringa ochropus
	ALCIDAE
Uria troile	Uria aalge
	Alca torda
	STRIGIDAE
Bubo ignavus	Bubo bubo
	TURDIDAE
_	Turdus? merula or T. merula/boulboul
	superspecies
	STURNIDAE
-	Sturnus? vulgaris or S. vulgaris/unicolor
	superspecies CORVIDAE
	Garrulus? glandarius or Garrulus
_	superspecies
	- Superspecies

In the systematic list which follows the specimens have been discussed where necessary; and in the final section they have been considered in relation to the stages of the Forest Bed Series, and the ecological implications briefly examined.

Systematic List

CORMORANT *Phalacrocorax carbo*. Distal end of a coracoid from West Runton, Norfolk, collected by W. Barker; shaft of a right humerus from Overstrand, Norfolk, Savin no. 715, BMNH A651. The distal end of a coracoid was not traced but is figured by Newton (1887, 1891). It is a typical cormorant coracoid of a size referable to this species. The humerus shaft is also similar in size to that of *P. carbo*. The nutrient foramen is very proximally sited on it. There is some variation in the site of the foramen in specimens examined but none is as proximal, and if this is significant it may indicate that the humerus was proportionally shorter than that of the Recent bird.

Bewick Swan Cygnus bewickii. Distal end of a left carpometacarpus, from East Runton, Norfolk, Savin no. 336, BMNH A645. A cervical vertebra, Savin no. 1986, BMNH A3422, and two thoracic vertebrae, Savin no. 1706, BMNH A3415, all from the Upper Freshwater Bed, West Runton, Norfolk. The distal end of carpometacarpus was referred by Newton (1882) to "Anser sp." but is too large for known species of that genus and more similar to those of Cygnus species. In size it very closely approximates to that of some specimens of C. olor but is closer to C. bewickii which it also resembles in the relative shortness of the zone of fusion of the metacarpals at the distal end. The three fragments of vertebrae are difficult to assign certainly but closely resemble those of this species.

GREY-LAG GOOSE Anser anser. Distal half of a right radius, and incomplete distal end of a left coracoid, both from the Upper Freshwater Bed, West Runton, Norfolk, Savin nos. 1611, 1987, BMNH A3406, A3402.

MALLARD Anas platyrhynchos. Incomplete distal end of a left coracoid, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 332, BMNH A649. Fragmentary left humerus, from East Runton, Norfolk, Savin Collection, BMNH A656. Also, from the Upper Freshwater Bed, West Runton, Norfolk, from the Savin Collection, part of five humeri, two carpometacarpi, two radii, seven caracoids, one ulna and one tibiotarsus, BMNH nos. A648, A652 (part), A3382-3, A3388-9, A3392, A3395, A3398-9, A3410, A3417, A3426, 46902.

Wigeon Anas penelope. Distal end of left humerus, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 1693, BMNH A3407. Distal end of left tibiotarsus, from the same locality, Savin no. 971 (part), BMNH A3432 (part).

TEAL Anas crecca. Left carpometacarpus lacking the unfused part of metacarpal IV, from West Runton, Norfolk, Savin BMNH A647. This is the specimen referred to by Newton (1884) as "Anas?".

RED-CRESTED POCHARD *Netta rufina*. Proximal end of left ulna, from the Forest bed, Ostend, Norfolk, Green BMNH 17686 (part). Two distal ends of left coracoids, from the Upper Freshwater Bed, West Runton, Norfolk, Savin Collection nos. 386 and 1760 (part), BMNH A3411 and A3390 (part).

POCHARD Aythya ferina. Distal end of a right tibiotarsus, from Ostend, Norfolk, Green Collection, BMNH 17686. Proximal end of a right carpometacarpus, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 971 (part). BMNH A3432 (part). The first specimen, together with a number of other

elements, was referred by Lydekker (1891) to this species but the other bones are either from different species or indeterminate.

TUFTED DUCK Aythya fuligula. Distal end of right humerus, Savin no. 1430, BMNH A3408; distal end of left tibiotarsus Savin no. 1988, BMNH A3418; and of right tibiotarsus Savin no. 739 (part), BMNH A3433; proximal end of right carpometacarpus, Savin BMNH A3432 (part); and another, Savin no. 461, BMNH A652 (part); distal end of tarsometatarsus, lacking trochleae, Savin no. 114, BMNH A5021. All from Upper Freshwater Bed, West Runton, Norfolk.

MANDARIN DUCK Aix galericulata. Distal end of a left coracoid, Savin no. 1660, BMNH A652 (part), and another less complete specimen, Savin no. 1760 (part), BMNH A3390 (part). Both from the UpperFreshwater Bed, West Runton, Norfolk. Osteologically this species and the related Wood Duck Aix sponsa are very similar. From the comparative material available (three specimens of each) the coracoids appeared more likely to be those of the former, with a more slender termination of the distal head.

THICK-LEGGED EIDER Somateria gravipes sp. nov.

Etymology. The specific name is formed from the Latin *gravis* (= heavy) and *pes* (= a foot) in reference to the stoutness of the tarsometatarsus.

Diagnosis. Tarsometatarus similar in length to that of the Common Eider *Somateria mollissima* but the shaft in all its aspects much thicker, with well defined grooves for muscles and ligaments.

Material. Holotype a left tarsometatarsus lacking the trochlea for digit IV, A.C. Savin no. 1956, BMNH A3396. A left coracoid, A.C. Savin no. 2020, BMNH A3397, lacking the distal head and the external part of the sternal end, is tentatively referred to this species. It is similar to that of S. mollissima but it seems preferable not to assume the presence of two species from the present scanty material.

Occurrence. Upper Freshwater Bed, Cromerian, Middle Pleistocene; West Runton, Norfolk, England.

Description and discussion. The specimen is very similar in size to that of *S. mollissima*, and the leg bones of other eider species are similar in proportions to the latter. In proximal view the tarsometatarsus of the new species is a little stouter on the external side. In distal view it is similar to *S. mollissima* but the trochlea for digit III is a little deeper anteroposteriorly and a little narrower. The main difference is in the shaft which, from trochleae to hypotarsus, is considerably stouter, with well-defined edges to the surfaces, and noticeable grooves for muscles and ligaments. It is about one-third as wide again as that of *S. mollissima* and the flat proximal half of the external surface is about half as wide again. In general appearance it is more similar to the tarsometatarsus of the Australian Musk Duck *Biziura lobata* than to that of any eider. This may indicate that the species had an even greater ability to swim and feed underwater than do the Recent eiders.

Measurements. The measurements of a tarsometatersus of a similar-sized S. mollissima are given in parentheses. Length 48.7 (50.3); anteroposterior thickness of trochlea for digit two 7.2 (7.2), for digit three 8.0 (7.5); width

of trochlea for digit two 3.6 (3.8), for digit three 5.0 (5.3); width and thickness of shaft 30 mm from distal end 6.1×4.6 (4.5 × 3.6); at 15 mm from proximal end 6.8×6.1 (5.5 × 4.5); projection of anterior external edge beyond anterior proximal fossa 3.6 (2.8) mm.

COMMON SCOTER Melanitta nigra. Left coracoid, from the Forest Bed, Mundesley, Norfolk, Savin BMNH A650. Proximal end of a right femur, from the Forest Bed, Ostend, Norfolk, Green BMNH 17686 (part). The second specimen was a part of the material originally referred by Lydekker (1891) to Aythya ferina.

Goldeneye Bucephala clangula. Distal right tarsometatarsus lacking the trochlea for digit two, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 614 (part), BMNH 3382 (part). Distal end of left humerus, from the same locality, Savin no. 720, BMNH A3403.

SMEW Mergus albellus. Proximal end of a left ulna and distal end of a right radius, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 568, BMNH A3386.

RED-Breasted Merganser Mergus serrator. Distal end of left humerus with shaft, from the Upper Freshwater Bed, Runton, Norfolk, Savin no. 1087, BMNH A3391. Right carpometacarpus lacking the unfused portion of matacarpal IV, from the same locality, Savin no. 771, BMNH A3393.

ANATIDAE? The left coracoid of a duck, from the Forest Bed, West Runton, Norfolk, originally in the collection of W. Barker, was identified by Newton and figured by him (1887, 1891) as that of the Shoveler *Spatula* (= Anas) clypeata. The original specimen has not been traced, but from the figure it appears to be the coracoid of a diving duck. In the absence of the specimen it cannot be satisfactorily identified.

COMMON BUZZARD Buteo? buteo (or B. buteo/lagopus/rufinus superspecies). Hind claw (terminal ungeal of digit one), from Bacton, C. Green (no. 6?), BMNH 17654. The specimen can be identified by the size and shape of the ventral prominence and the paired lateral foramina. Three Recent species of this genus occur in the Western Palaearctic, ecologically specialised and with minor osteological differences. The present species is the most similar and ecologically the most likely, but the period of speciation producing the Recent forms is unknown and the present bird might be ancestral to more than one Recent species.

EUROPEAN JUNGLEFOWL Gallus europaeus. C.J.O. Harrison 1978. A left coracoid from Ostend, Norfolk, C. Green BMNH A489. This specimen was described by Lydekker (1891) as a bone of the Capercaillie *Tetrao urogallus* and he explained away the small size by describing it as a young bird, although there is no osteological evidence of immaturity. It appears to be evidence of an extinct species of junglefowl, similar in size to the wild form of Gallus gallus.

MOORHEN Gallinula chloropus. A proximal end of a right carpometacarpus, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 114 (part), BMNH A5022.

Green Sandpiper Tringa ochropus. Left carpometacarpal, lacking the unfused portion of metacarpal IV, from West Runton, Savin BMNH A646. This

specimen was figured by Newton (1882) merely to show the range of avian material found in the earlier studies of the Forest Bed Series, and no attempt was made to identify it. In size and shape it agrees with that of the above species.

GUILLEMOT *Uria aalge*. A shaft of a left humerus, lacking ends, from Chillesford Crag deposits, Aldeby, Norfolk, collected by Crowfoot and Dowson. Proximal end of a right radius, from Chillesford Crag deposits, Chillesford, Suffolk, presented by Dr Macfadyan, BMNH A1940. The original humerus has not been traced. It was figured by Newton (1882) and, in spite of minor discrepancies in the two views shown, appears to be of this species.

RAZORBILL Alca torda. Distal end of a left humerus, from Bacton, Norfolk, Savin no. 2363, BMNH A655. In Newton's interleaved copy of his "Vertebrates of the Forest Bed Series" in the Library of the Department of Palaeontology, British Museum (Natural History) there is a sketch of this bone and a note of its identification; but he did not include it in his later work.

EAGLE OWL (small race) Bubo bubo (ascalaphus/desertorum). A right tarsometatarsus lacking the proximal end, from East Runton, Norfolk, Savin no. 508, BMNH A644. The trochlea for the fourth digit has been broken off and replaced again, the break being partly filled with plaster or wax, coloured to resemble the original. As a result the trochlea projects further laterally and creates a large intertrochlear notch and a more distally-projecting posterior edge. This appears to have occurred when the specimen was originally collected, since it is present in early casts without the break being indicated.

The specimen is small and the shaft is slender, resembling that of the smaller North Africa — Middle East forms. From the distal end of the tubercle for the tibialis anticus to the base of the trochlea for the third digit the bone measures 47.2 mm and the width and thickness of the shaft 30 mm from the base of the trochlea is $84 \times 58 \text{ mm}$.

BLACKBIRD Turdus? merula (or T. merula/boulboul superspecies). Right humerus, from the Upper Freshwater Bed, West Runton, Norfolk, collected and presented by P. Andrews, 1976, BMNH A4957. Distal end of a left coracoid, from same locality, Savin no. 620, BMNH A3381 (part). The humeri of the likely Recent species of Turdus can be identified by their size and this one corresponds to those of the species.

- ? STARLING Sturnus ? vulgaris, (or S. vulgaris/unicolor superspecies). imperfect distal end of a left humerus, distal ends of right and left tarsometatarsi, proximal end of left carpometacarpus, from the Upper Freshwater Bed, West Runton, Norfolk, Savin no. 620, BMNH A3381 (part).
- ? JAY Garrulus ? glandarius (or Garrulus superspecies). Distal end of a left tibiotarsus with part of the shaft, Upper Freshwater Bed, West Runton, Norfolk, Savin no. 1638, BMNH A652. Distal end of a left tarsometatarsus lacking trochlea, from the same stratum, Savin no. 620,BMNH A3381 (part). The first specimen lacks the internal condyle but agrees with the above species in all its characters.

Discussion

For specimens collected in the 19th Century the data on the strata from which they originate tends to be inadequate. The specimens under discussion, with the exception of those from the Chillesford Crag, are said to be from the 'Forest Bed' of the locality of origin. Information on the various main collecting sites and their ages has been assembled by Stuart (1974, 1975) and some information on the flora of the period is available (Stuart 1975, West 1977).

The present specimens are mainly referable to two consecutive temperate stages within the Cromer Forest Bed Series — the Pastonian and the Cromerian. These are separated by the cold Beestonian stage. In the following list indicating periods of occurrence the localities have been added.

STAGE UNCERTAIN.

Cormorant *Phalacrocorax carbo*, Red-crested Pochard *Netta rufina*, Pochard *Aythya ferina*, Common Scoter *Melanitta nigra*, European Junglefowl *Gallus europaeus*. (The cormorant is from Overstrand, Common Scoter from both Mundesley and Ostend, the others from Ostend).

PASTONIAN.

Bewick Swan Cygnus bewickii, Mallard Anas platyrhynchos, ? Common Buzzard Buteo ! buteo, Guillemot Uria aalge, Razorbill Alca torda, Eagle Owl Bubo bubo. (The Guillemot is from Chillesford Crag, Buzzard and Razorbill from Bacton, others from East Runton).

CROMERIAN.

Cormorant, Phalacrocorax carbo, Bewick Swan Cygnus bewickii, Grey-lag Goose Anser anser, Mallard Anas platyrhynchos, Wigeon Ansa penelope, Teal Ansa crecca, Red-crested Pochard, Netta rufina, Pochard Aythya ferina, Tufted Duck Aythya fuligula, Mandarin Duck Aix galericulata, Thick-legged Eider Somateria gravipes, Moorhen Gallinula chloropus, Green Sandpiper Tringa ochropus, Goldeneye Bucephala clangula, Smew Mergus albellus, Red-breasted Merganser Mergus serrator, ?Blackbird Turdus ? merula, ?Starling Sturnus ? vulgaris, ?Jay Garrulus ? glandarius (all Upper Freshwater Bed, West Runton, except for Cormorant and Green Sandpiper which are West Runton, with bed not specified).

Stuart (1975) describes the vegetation of the Upper Freshwater Beds at West Runton, which are Cromerian (zone Cr II), as that of a mixed oak forest flanking a river valley, with fens and areas of open herbaceous vegetation on the floodplain. The general picture during the early Cromerian as indicated by pollen studies (Duigan 1963) is of pine Pinus and birch Betula as the early dominant trees, gradually giving way to oak Quercus, elm Ulmus, lime Tilia, hazel Corylus and alder Alnus. The Pastonian has been less studied but pollen evidence shows a similar type of vegetation (West and Wilson 1966) with the addition of hornbeam Carpinus.

Most of the birds identified are associated at the present day with temperate conditions in this region and many with fresh water. The Grey-lag

Goose feeds by water in open places, and ducks of the genera Anas, Netta and Aythya are dabbling and diving species of fresh water. The Goldeneye, Smew and Merganser nest in Boreal forest regions and migrate to these parts in winter, while the Bewick Swan is a migrant from the Siberian tundra. Most of these species may occur at times on brackish waters of estuaries or coastal lagoons. The Moorhen lives on the borders of fresh waters, as does the Green Sandpiper which like some of the ducks nests in the boreal forest regions and migrates south in winter. The Cormorant is equally at home on fresh or salt water.

The Common Scoter nests on fresh water in the boreal regions but further south occurs only as a seabird, and both Razorbill and Guillemot are normally confined to salt water. The new species of eider presents a problem of interpretation. The Recent eider species are all associated with salt water seacoasts. It could be argued that the development of the leg shown in this species indicated that it had evolved as a strong swimmer, with an inference that it might be adapted for deep or rough seas. However, it has been mentioned that there is a morphological analogy with the Australian Musk Duck, a species in which similar stout tarsometatarsi are associated with feeding on inland fresh waters. Apart from the eider all other species listed for the Cromerian could occur on fresh waters.

There is an unexpected duck species; this is the Mandarin Duck which at the present day is restricted to eastern China and Japan where it is typically a bird of mixed oak forest near water. It could have occurred across Eurasia when suitable forest conditions were present. The fragmentation of forest during the glaciations must have adversely affected a number of forest species. As D. Goodwin (pers. comm.) suggests, there is a similar situation in the case of the Azure-winged Magpie Cyanopica cyanea. The latter occurs in China and Japan at present, and had it not been for the isolate population in the Iberian peninsula it might have been regarded as an eastern Asiatic endemic rather than the relics of an earlier distribution that spanned Eurasia.

Of the three Recent species of *Buteo*, the Common Buzzard *B. buteo* is the only one normally associated with forest and forest edge. The point in time at which the three species diverge is not known, and while specific separation may already have occurred by this period in the Pleistocene we do not have enough evidence to make any decisions on this. Mayhew (1977) detected evidence of erosion due to digestion by accipitrine birds of prey as opposed to owls on the teeth of small rodents from the Upper Freshwater Bed at West Runton. He believed such remains came from pellets cast by the birds and suggested buzzards and kestrals as possible raptors at this period.

We know nothing of the extinct European Junglefowl, but extrapolating from other, Recent *Gallus* species it was probably a bird of forest or forest edge. At the present day the Eagle Owl occurs through a wide range of habitats from subarctic to subtropical regions. The small, slender tarsometatarsus of the present specimen is typical in Recent times of the form found in warmer and more arid areas of North Africa and the Middle East. This is a paler and smaller bird which has been separated in the past as a species, *Bubo ascalaphus*. The size of the fossil bird does not appear to be correlated with the apparent

conditions during the Pastonian as indicated by the flora. The larger and more northerly forms of the species now in existence may be examples of Bergmann's rule that within species size increases in colder regions, but these could have evolved during later glaciations. It is possible that the fossil bird is closer to an ancestral form.

The identification of the Jay is tentative, being based on incomplete specimens, but it appears to match Recent specimens closely. At present the distribution of this species is closely correlated with that of the oak, and it extensively utilises acorns for food in winter. Assuming that its habits have not changed during the intervening period it is a likely species to have occurred in a mixed oak forest. The Blackbird and Starling are widespread species of temperate conditions, the former occurring in forest and forest edge, the latter often nesting in trees but usually occurring only where there are open grassy areas nearby.

Although the last three birds have been referred to Recent species there is a taxonomic problem involved with fossil birds of this period. The three genera concerned also contain, in addition to these widely distributed species, osteologically similar isolate species with smaller populations. The Lance-olated Jay G. lanceolatus occurs in a limited area of the Western Himalayas and the Lidth's or Loochoo Jay G. lidthii in the Riu-Kiu Islands. The Greywinged Blackbird T. boulboul occurs along the Himalayas and the Spotless Starling S. unicolor is confined to the Iberian Peninsula.

These species differ from those listed mainly in minor characters of plumage markings and colour, and do not appear to be separable osteologically from their congeners when only a few bones are available. A similar problem exists with the buzzards, *Buteo* species, of Eurasia. The close similarities and the patterns of distribution suggest a fairly recent speciation, probably during the later Pleistocene glaciations. Therefore, in referring birds from the Cromer Forest Bed Series to Recent species we cannot be certain at present that we are not dealing with ancestral forms from which these similar species evolved.

In such circumstances it can be argued that a form which existed prior to some separation and speciation in one part of its range requires a different name from the form subsequently present, even though the two may be osteologically inseparable and apparently represent a direct lineage. Currently, in ornithological studies, groups of very similar and often allopatrically distributed species of this type, which have obviously evolved from an earlier form in response to conditions of isolation and selection, are often referred to as superspecies. The term was created to assist in the study of the taxonomy and zoogeography of Recent birds but should indicate the existence of an equivalent form during the palaeontological history of the genus.

The superspecies may have a wider connotation than the context in which I have used it here. For example, the Blackbird superspecies would probably usually include the montane Ring Ousel T. torquatus and the North American Robin T. migratorius, although both are osteologically distinct in some characters from the species at present under consideration. However, in view of uncertainty about the status of the Cromer Forest Bed

Series forms, and the lack of more certain views of the probably period of speciation in these genera, I prefer to use a modified superspecies concept rather than propose new names for putative ancestral forms.

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A STUDY OF VERONICA TRIPHYLLOS L., VERONICA PRAECOX A11. AND VERONICA VERNA L. AT WEETING HEATH ARABLE RESERVE, NORFOLK

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Introduction

Weeting Heath Arable Reserve (National Grid Reference TL/762882) is an area of eleven acres immediately to the east of the Weeting Heath National Nature Reserve. The Weeting-Hockwold road forms the southern boundary of the arable reserve, which slopes gently upwards to the north, where it is bordered by Belvedere Wood, a mixed coniferous/deciduous plantation. On the west it is bordered by the heathland of the N.N.R., and on the east by several rows of recently planted Scots pine seedlings and a narrow belt of gorse (Ulex europaeus), broom (Sarothamnus scoparius) and bracken (Pteridium aquilinum); this belt separates it from arable fields (see fig. 1). The land belongs to Mr. Parrott of Fengate Farm, Weeting; it was by agreement with him that the reserve was set up in 1969 with the help of Mr. Christopher Cadbury and the co-operation of the Norfolk Naturalists' Trust and the Nature Conservancy.

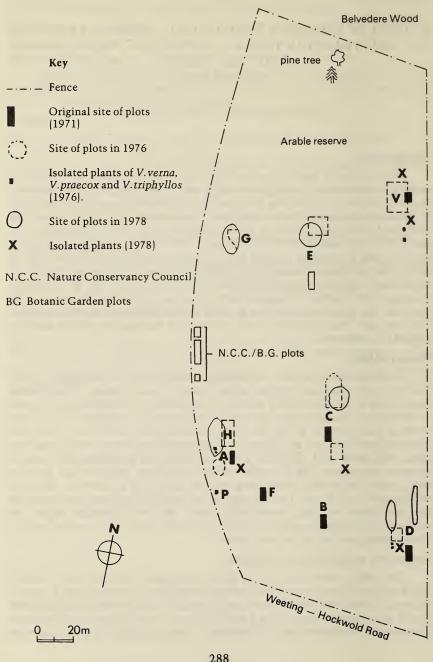
History of Site

As indicated in the paper on Weeting Heath by Mrs. G. Crompton (1974), the area now occupied by the arable reserve was covered by deciduous plantations in the nineteenth century. The period of woodland cover lasted for almost one hundred years; the area must have lost its tree cover by the first years of this century, as on the 1905 edition of the 1/2500 O.S. map the northern part is shown as "furze" and the southern part as "rough pasture, heath and moor". At this time a belt of coniferous woodland still existed between the reserve and the arable fields to the east, but this had gone by 1963, as on the Nature Conservancy map of that date it is shown as "bracken and broom", as it is now. Cereal crops were probably grown on the area during the First World War and sporadically since; the last cultivation before the setting up of the arable reserve in 1969 was in 1962, when the area was heavily limed and a good crop of rye was grown.

Reasons for establishment of Reserve

The arable reserve was set up firstly as a refuge area and study site for rare Breckland plants, especially *Veronica triphyllos*, *V. praecox* and *V. verna*. Although these three species were not known from the reserve or the adjacent area it was thought that it was a suitable area in which they would survive if introduced from elsewhere in Breckland. *Veronica triphyllos* and *V. praecox*

FIG. 1: POSITION OF PERMANENT PLOTS AT WEETING HEATH ARABLE RESERVE IN 1971, 1976 AND 1978



occur in arable fields and other areas of disturbed ground e.g. gravel pits (often old arable land). V vema is found in arable fields but more often now in open habitats in dry grassland. It is occasionally found in young open coniferous plantations, but this is more common on the Continent than in Britain. V. praecox and V. verna are confined to Breckland in Britian, and V. triphyllos is almost confined to this area. All three species, especially V. triphyllos, are becoming increasingly rare. It is thought that this decline has two causes (i) loss of suitable sites because of building and development on arable land (ii) recent changes in farming practice. Until recently rye was the traditional Breckland cereal crop, the autumn sowing and subsequent lack of soil disturbance providing suitable conditions for the survival of the winter annuals V. triphyllos, V. praecox and V. verna. The plants flower in the spring and set seed by the end of May, before the rye produces too dense a shade and well before harvest time, when the fallen seeds may be dispersed partly by the soil disturbance. Open patches in crops growing badly on the dry sandy Breckland soils were probably features of many fields and provided suitable sites for these species. Now, much spring barley is grown and many overwintering Veronica rosettes must be destroyed by the spring ploughing. Modern fertilisers and varieties of cereal especially suited to the sandy soils and dry Breckland climate mean not only that the poorest fields will produce a reasonable crop but also that their continuous cultivation makes economic sense. Previously many fields were only cultivated sporadically and the open but undisturbed conditions in these so-called "brecks" in the two or three years after ploughing must have been very favourable to many weed species, including the rare annual Breckland Veronicas. It was thus decided to recreate conditions in the arable reserve similar to those in Breckland thirty or forty years ago, in the hope that this would favour growth of V. triphyllos, V. praecox and V. verna. It was decided to do this by using traditional crops and by cultivating only every few years, when colonisation by weeds made a further ploughing necessary in order to provide open areas of soil for seedling establishment. Use of herbicides, another reason for the decline of many weed species, was to be avoided. Secondly, the reserve would provide habitats for insects associated with the weed species expected to colonise the area after ploughing.

Experimental Work 1969—1971

In summer 1969 the new reserve consisted of a more or less closed turf composed of grasslands B-D of Dr. Watt's classification (Watt, 1940). the more calcareous grasslands were on the west and south of the area.

The whole eleven acres was ploughed, with interruptions due to bad weather, during the period December 1969—February 1970. It was decided to leave the northern part of the reserve unsown and to observe the colonisation of this by weed species. The southern eight acres on slightly better soil was sown with spring barley (Sultan), as it was then too late to sow the traditional Breckland crop of rye as originally intended. 1 cwt 20 lbs—1 cwt 45 lbs of seed per acre was sown in the first week of April, after rolling and harrowing. 2½ cwt per acre of fertiliser (20 parts N:10 parts P:10 parts K) was put on at the same time but no lime was used although on previous cultivations of the field it was considered necessary. It was thought that the poor patchy crop

which might result would favour the growth of the Veronicas to be sown in permanent plots in the field, and this did in fact happen as the barley was adversely affected by a long drought after planting and was very poor in places. The barley was harvested in the third week of August and the stubble, together with some regrowth which had occurred, left unploughed.

At the western edge of the field a strip six metres wide was left ploughed but unsown. A pilot plot (plot P in fig. 1) of size $1m \times 1m$ containing seeds of V.triphyllos, V.praecox and V.verna (seed sources as for other plots, given below) was set up on 28.3.78 but no germination was recorded in this plot.

Plots were also set up in this western strip by other workers; a fencedin plot containing Artemisia campestris, Silene otites and Veronica spicata
was set up in 1970 by Mrs. G. Crompton and Mr. P Wright; to the north of
this a demonstration plot containing Veronica triphyllos, V.praecox, V.verna
and Silene conica was set up by the Nature Conservancy Council; to the south
of it two small trial plots containing Veronica triphyllos, V.praecox and
V.verna were set up by Mr. D. Donald of the Cambridge University Botanic
Garden in 1977. These plots are labelled "N.C.C. and Botanic Garden plots"
in Fig. 1.

Soil Survey

In Breckland the chalk is overlain by sandy drift of varying thickness; in many places a mosaic of deep acid sandy soils and shallower calcareous soils where the chalk is nearer the surface is found (Watt, 1936). In places soil stripes and polygons can be seen (Watt, Perrin and West, 1966). In 1970 and 1971 striping became evident in the pattern of weed colonisation in the unsown area at the north end of the reserve, Reseda lutea dominated stripes alternating with Rumex acetosella/Holcus mollis dominated stripes. Considerable soil heterogeneity was indicated in the reserve both by the variation in the vegetation before ploughing and by the appearance of the field after ploughing, the soil varying from dark friable material in which pieces of chalk were visible to yellowish-brown or reddish sandy soil. Small dark humusrich areas were visible where the turves from the 1962 ploughing had been turned in. After the 1969 ploughing the turf was not completely covered in places, especially at the southern end where the taller grassland C had been.

A soil survey was carried out in March 1970 before siting the permanent plots. A sampling grid was set up and seventy-five 100g samples of the top 20cm of soil were collected; samples were collected at 15m intervals along lines 25m apart. The pH of the fresh soils was determined on the day of collection, using a pH meter. Values of 9.0 in some of the samples were probably due to lumps of calcium carbonate brought up by ploughing; it was thought that in the first year much leaching might occur and the survey was therefore repeated in November/December 1971, using the same sampling sites. Both sets of pH readings are shown in Table 1. A similar range of pH was found on both occasions (5.8—9.0 in 1970 and 6.0—8.9 in 1971), with differences of 2.0—2.4 pH units between some adjacent samples. Some disturbance of the soil had taken place during harvesting of the barley, so direct comparisons of the two readings for each sample site are of little value, but there were fewer high pH values in 1971, indicating that leaching had occurred.

The % organic content of eleven soil samples was also determined by measuring loss on ignition, and was found to be very low, ranging from 1.16 -2.47%.

Permanent Plots for Veronica triphyllos, V.praecox and V.verna (see Fig. 1)

It was decided to site the plots in areas of varying soil pH and in both the sown and the unsown areas to find out if any difference in the performance of the Veronicas resulted. In fact the different conditions did not produce very great differences.

On 28.4.70 six plots were set up; plots A—D were in the barley crop and plots E and V were in the unsown ploughed area. Plots A and C were in calcareous areas, plot V was in an acid area and plots B, D and E were in intermediate to acid areas. Plot D was in a slight hollow and was damper and later more moss-grown than the other plots. The plots were sown as follows:—

PLOT A: 200 seeds of *V. triphyllos* and 200 seeds of *v. praecox*PLOTS B—E: 100 seeds of *V. triphyllos* and 100 seeds of *V. praecox*PLOT V: 100 + seeds of *V. verna*

A few surplus seeds of *V. praecox* and *V. triphyllos* were sown to the N.E. of plot E. Seed sources were:

V. triphyllos: collected from Green lane, Thetford, Norfolk in 1969. V. praecox: from Broom Road, Lakenheath, Suffolk via Dr. Watt's garden in Cambridge.

V.verna: from Cherry Hill, near Tuddenham, Suffolk, via Dr. Watt's garden.

It was intended to make a comparison between the rare Breckland *Veronica* species and certain widespread species, so *V.hederifolia* and *V.arvensis* were sown in plot E and *V.hederifolia* and *V.persica* in plots A—D.

On 15.9.70 two further plots were set up, plot F in the barley crop and plot G in the unsown area; both were in calcareous soil. The plots were sown as follows:

PLOT F: 100 seeds of V. triphyllos, V. praecox and V. verna.

PLOT G: 100 seeds of V. triphyllos and V. verna.

Seed sources were:

V. triphyllos: collected from Green lane, Thetford, 1968 & 1969.

V.praecox: Broom Road, Lakenheath, Suffolk, via Dr. Watt's garden. V.verna: Cherry Hill, near Tuddenham, Suffolk, via Dr. Watt's garden.

Seeds of Veronica persica and V. arvensis were also sown in both plots. the seeds of V. persica, V. hederifolia and V. arvensis were in all cases collected from Green Lane, Thetford, Norfolk in 1968.

Permanent Plots 1970-1978:-

Time of Germination and Flowering 1970—1971. No germination of V.triphyllos, V.praecox and V.verna was recorded in the spring and summer following planting (1970) but all three species germinated in the autumn of that year and there was some further germination in spring 1971:

V.praecox: some germination in September, most October/November 1970; some March/April and the first fortnight in May 1971. Flowered March—May 1971.

V.triphyllos: 2 Plants germinated in August, some in September, most in October/November 1970 and some in March/April 1971. Flowered March—May 1971.

V. verna: germinated in August in 1970 and 1971 with some germination in April, October and November in 1971. Flowered April—May 1971.

No *V. verna* seeds were sown in plot D but one seedling was seen there in March and April 1971; this probably came from a seed dropped during sowing of other plots.

All three species set ripe seed. In all three species there was variation from small unbranched plants 2—4cm high with only one or two flowers per plant to large well-branched plants up to 22cm high; these had up to 80 flowers and fruits per plant in *V. praecox* and up to 59 in *V. triphyllos*. The plants in the autumn sown plots were almost all very small, with one or two flowers per plant, whereas where were many more medium to large plants in the spring sown plots. In places the larger more strongly growing plants were growing up through a mat of clover and grasses e.g. *Holcus mollis*. Striking variation in size was also noticed in *V. triphyllos* and *V. praecox* at Green Lane, Thetford, often in adjacent plants.

The largest *V.persica* plant seen had 44 flowers and fruits; the largest *V.hederifolia* had 67 flowers and fruits plus developing buds.

Surprisingly the common Veronicas did not germinate in very large numbers, especially *V. arvensis*. However *V. persica* germinated in all months of the year and was in flower from February to July and in September, October and January. *V. hederifolia* germinated in September—November and March—April, and flowered from February to May and in October. These species thus seem to germinate over a wider range of conditions than the rare species, and the time of flowering and seed production is not so limited. The numbers of plants in each plot are given in Table 2.

Plants of all the *Veronica* species studied, except *V.arvensis*, were nibbled by animals, probably rabbits.

Time of Germination and flowering 1971—1973: no cultivation. The site was not visited between Nov. 1971 and April 1976.

Time of Germination and Flowering 1974—1976: rye was grown on the whole eleven acres. Fertiliser, and possibly 2, 4 D in 1975, was put on. In 1976 the *Veronica* plots were remapped and the populations of plants estimated (see Table 2). It was found that the position of the main groups of plants had shifted slightly (see Fig. 1) because of soil disturbance following cultivation operations.

Time of Germination and Flowering 1977: with the help of Nature Conservancy Council staff and Mr. D. Donald the field was resurveyed and permanent wooden marker posts were put in at 50 metre intervals along the eastern and western margins of the field in order to facilitate re-finding the permanent plots.

It was thought that a combination of barley and sainfoin would favour the Breckland Veronicas, as large populations of *V.triphyllos* and *V.praecox* had been seen in other legume crops such as lucerne on occasion (e.g. at Maid's Cross Hill, Suffolk). Unfortunately bad weather delayed drilling until 4th May, and *Veronica* plants in the permanent plots were probably destroyed. No *Veronica* plants, and very few weeds of any kind, were seen in the crop on 19th May, but *Veronica verna* plants were in flower at the edge of the field near plot V and a few small plants of *V.verna* and *V.praecox* were seen in the N.C.C. and Botanic Garden plots. The barley was then about 8cm tall and the sainfoin was at the cotyledon stage. At the southern end of the reserve a two-acre strip of sainfoin and clover was sown. During the summer there was a severe drought, and the barley growth was very poor.

Time of Germination and flowering 1978: It was decided to grow a combination of rye and kidney vetch. The rye was sown on 28th October 1977 and the kidney vetch on 18th April 1978. The kidney vetch was sown 1—2 inches deep using an old-fashioned drill. 50Kg of seed was sown on eight acres of the field; a strip on the western edge of the field, and the southern two acres which were carrying sainfoin and clover, were not sown with kidney vetch. The field had a top dressing of 50 units of nitrogen per acre in mid-March. The numbers of *Veronica* plants in the permanent plots were recorded in May. The rye was harvested in late August; after the rye harvest the kidney vetch was well-established. There was no flowering of the vetch in 1978 but it is hoped to crop it for seed after flowering in 1979.

Conclusions

Although the positions of the permanent plots have shifted slightly since 1971 because of soil disturbance caused by cultivation operations, it can be seen from Table 2 that the numbers of *Veronica triphyllos* and *V. praecox* in the reserve have increased. Although there were no *V. verna* plants in plot V in 1978, it is thought that this was a temporary set-back; plants were found elsewhere in the field. The arable reserve does thus appear to be a suitable site for *Veronica triphyllos*, *V. praecox* and *V. verna*, and the present management policy of re-creating conditions as under old-fashioned Breckland farming practice appears to be successful.

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Table 1: Weeting Heath Arable Reserve: Soil pH measurements in 1970 & 1971

a) March 1970:-

m from W edge m from S edge	15	30	45	60	75	90	105	120
300	_	7.2	_	6.5	_	_	_	_
275	-	7.5	_	7.4	-	6.0	_	_
250	-	7.1	_	6.4	_	8.9	_	_
225	_	7.5	_	5.7		6.1	_	_
200	_	6.4	_	8.8	_	6.1	_	
175	_	9.0	_	8.8	_	8.4	_	7.8
150	_	8.8	_	8.9	_	8.8	_	8.7
125	8.7	7.0	8.8	9.0	8.9	8.7	7.3	6.8
100	8.9	7.0	8.9	8.2	8.9	6.9	8.6	7.3
75	8.8	8.9	8.9	7.3	8.9	8.3	8.5	7.9
50	6.9	8.8	6.7	8.8	8.5	7.2	8.2	5.8
25	7.9	8.7	7.7	8.3	6.5	8.8	8.9	_
0	8.6	8.1	6.7	6.4	7.9	6.4	_	_

B) NOVEMBER-DECEMBER 1971:—

m from W edge m from S edge	15	30	45	60	75	90	105	120
300	1	1	-	_	_	_	-	-
275	-	8.0	-	_	_	6.0	1	_
250	-	6.7	_	6.4	-	_	_	_
225	_	6.5	_	7.7	_	6.1	_	_
200	_	8.3	_	7.7	_	8.3	1	-
175	_	1	1	1	1	I	-	-
150	8.7	8.3	7.5	8.9	7.3	7.7	8.5	8.6
125	_	_	_	_	_	_	-	_
100	8.6	7.3	8.8	8.9	8.5	6.9	8.9	7.8
75	8.9	8.9	7.7	8.4	8.3	7.5	7.9	6.9
50	7.2	8.8	7.5	8.3	8.5	7.4	8.5	6.6
25	6.9	8.8	7.5	6.9	6.2	7.0	8.3	6.2
0	8.2	6.9	6.3	6.4	6.7	6.3	7.9	

Table 2: Weeting Heath Arable Reserve: Numbers of Veronica Plants in the permanent plots in 1970—1, 1976 and 1978.

A) SPRING 1971: VERONICA PRAECOX, V. TRIPHYLLOS AND V. VERNA

Plot	Veronica praecox	Veronica triphyllos	Veronica verna
A	40 plants flowered	l plant flowered	_
В	-	No plants flowered but 2 unhealthy vegetative plants present Aug. 1970	
С	40 plants flowered	21 plants flowered + 1 vegetative (51 germin- ated).	_
D	33 plants flowered	24 plants flowered	1 seedling March—April
E	49 plants flowered + 6 vegetative	28 plants flowered	_
F	39 vegetative plants in April, some flowered April—May	5 plants flowered + 10 vegetative (55 germinated)	35 seedlings present Feb., some flowered May
G	50 seedlings present Jan, some flowered May	70 plants flowered (90 germinated)	300 vegetative plants April, some flowered May
V	_	-	22 plants flowered (50 germinated)

If many seedlings died, the number of plants which germinated is shown as well as the number which flowered.

In Oct.—Nov. 1971: V. praecox seedlings were present in plots B, C, D, E, G.

V. triphyllos seedlings were present in plots A, B. C, D, E, F, G.

V. verna seedlings were present in plots F, G, V.

B) 1970—1971: VERONICA PERSICA, V. HEDERIFOLIA AND V. ARVENSIS

Plot	Veronica persica	Veronica hederifolia	Veronica arvensis		
A	No plants flowered but 4 vegetative present in April 1971	but 4 vegetative flowered + 1 seedling			
В	No plants flowered,; 3 seedlings present in November 1970		_		
С	20 plants flowered Nov. 1970, 15 in April 1971	8 plants flowered + 6 vegetative in April 1971			
D	25 plants in fruit Nov. 1970, 9 flowered + 1 vegetative Jan. 1971 & 13 flowered May 1971	Several plants flowered Oct. 1970; 20 vegetative Nov. 1970; 4 flowered + 7 vegetative Feb. 1971; 5 flowered April 1971	-		
E	2 plants in fruit + 4 vegetative Nov. 1970; 1 plant flowered + 9 vegetative Feb. 1971; 5 plants flowered May '71		<u> </u>		
F	2 vegetative plants April 1971	-	4 vegetative plants March 1971; plants in fruit July 1971		
G	<u>-</u>	-	A few plants in fruit July—Sept. 1971		

In Oct.—Nov. 1971: V. persica seedlings were present in plots B,C,D,E.

c) 7—8th April 1976: Veronica Praecox, V. Triphyllos and V. Verna

Plot	Veronica praecox	Veronica triphyllos	Veronica verna
A	41 seedling and vegetative plants	2 medium-sized plants, 1 flowering and 1 veget- ative + 1 ?seedling	_'
Н	57 + seedling and vegetative plants	1 flowering plant	_
В	37 seedling and vegetative plants	52 + medium sized flowering plants	_
С	192 seedling and vegetative plants	18 medium-sized veget- ative and flowering plants	_
D	61 seedling and vegetative plants	40 vegetative and flowering plants	_
E	78 + vegetative plants	9 small-medium veget- ative and flowering plants	
F	_	_	-
G	5 vegetative plants (4 small, 1 larger); ?other seedlings	23 very small vegetative and flowering plants	
v	- . j	_	100—200 small seed- lings, some nearly sand-covered

A group of *V. praecox* and *V. triphyllos* plants which did not appear to correspond with any of the original permanent plots was found on the western side of the field near plot A; these are recorded in the table as plot H.

d) 18—19th May 1978: Veronica praecox, V. Triphyllos and V. verna

Plot	Veronica praecox	Veronica triphyllos	Veronica verna
A & H	709 plants in flower and unripe fruit	1 plant in flower and unripe fruit	_
В	l plant in flower and unripe fruit	1 plant in fruit	_
С	359 plants in flower and unripe fruit	5 plants in flower and unripe fruit	-
D	108 plants in flower and unripe fruit Also 11 plants nearby in strip at field edge	25 plants in flower and fruit Also 1 plant nearby in strip at field edge	15 vegetative plants nearby in strip at field edge
E	64 plants in flower and unripe fruit	3 plants in flower and fruit	_
F	1 plant in flower and unripe fruit, probably from this plot	_	_
G	237 plants in flower and unripe fruit	51 plants in flower and unripe fruit	2 vegetative plants
V	2 plants in flower and unripe fruit	_	_

2 plants of *V.praecox* were also present in the extreme S.W. corner of the field. The number of plants may have been under-estimated, particularly in plot B, because the rye was already 60—90cm tall in places, although very patchy.

Plots A and H of 1976 appear to have amalgamated.

The disappearance of *V.verna* from plot V was possibly due to cultivation operations just after germination had occurred. However *V.verna* appears to have spread to the south-eastern edge of the field near plot D. This may be because seeds were shifted by cultivation operations, although in 1971 one *V.verna* seedling was found near plot D; this was thought to have been dropped when the permanent plots were set up, and other seeds may have been dropped at the same time and lain dormant until this year. Most of the *V.praecox* and *V.triphyllos* plants were well-branched medium to large plants, with flowers, unripe fruit or ripe fruit. The *V.verna* plants were young vegetative plants.

NORWICH BIRD-SEED MIXTURES AND THE CASUAL PLANTS OF HARFORD TIP

by Nicholas S. Watts and Geoffrey D. Watts

Introduction

Municipal refuse tips provide many opportunities for colonisation by native plant species, but typically they also support a wide range of casual plant species from a variety of sources. Some casuals are clearly ornamental plants derived from gardens, while others are edible species transported with refuse from the garden or with garbage, and others originate in agricultural, commercial or industrial waste. Petch and Swann (1968) connect the numbers and variety of one group of casual plants recorded from the chief tip for Norwich domestic rubbish at Harford Bridges with the large numbers of bird fanciers for which the city of Norwich has long been famed. The proof of such a relationship demands a tracing of the connecting chain and a testing of each of its links.

Thus: (a) to investigate the number, variety and relative sales of bird-seed mixtures available in Norwich;

(b) to analyse samples of these mixtures to determine the species of plants represented in each;

(c) to determine the proportions of seeds of different species in the mixtures by weight and by number;

(d) to determine the germinative capacities of the components of the mixtures;

(e) to study cage-bird feeding preferences to establish which species of seeds are more likely to be neglected;

(f) to consider the removal and disposal of unwanted bird-seed by cage-bird owners;

(g) to observe the refuse handling procedures from house to the tipping site:

(h) to monitor the conditions for plant growth at the tip surface;

(i) to survey material recently deposited at the tip to establish the presence of casual plant species;

(j) to relate the numbers of plants and the variety of species found to the potential casual colonisers determined in (a) to (e);

(k) to survey older tip areas to establish that these casuals fail to persist and so need constant re-introduction.

Barnes (1960, 1967), Petch and Swann (1968) and Swann (1975) report surveys of refuse tip vegetation and, in general terms, relate some of the species found to their probable origins in bird-seed mixtures, thus testing links (i) and (j). This paper sets out the results of an attempt to test links (a), (b), (c), (d), (h), (j), (k). The remaining links, (e), (f) and (g), have still to be tested.

The Bird-Seed Mixtures Available

In May, 1969, visits were made to six bird-seed shops in Norwich, ranging from multiple stores to pet shops. A total of thirteen different bird-seed mixtures were purchased — five intended for budgerigars, four for canaries, two for finches, one for parrots and one for pigeons. Shopkeepers were unable or unwilling to gauge the relative popularity of mixtures in each range, or to indicate the volume of sales involved, although some indication of popularity might be drawn from the frequency with which mixtures were encountered in different shops.

Sampling, Sorting and Analysing

From each bird-seed mixture a 10-gram sample was weighed out using a laboratory balance. Each sample was hand-sorted on sheets of paper into piles of distinct species, separate piles being transferred to individual envelopes. The contents of each envelope were weighed, counted and provisionally identified.

Each seed sample contained not only the major components of the mixture but a small fraction of other material, notably 'weed' seeds, additives and inanimate material. The identification of the 'weed' seeds was considered to be particularly relevant to the study. Samples of the seeds that could be germinated were grown on in 1970 and 1971 to permit identification, and much help was given by the Official Seed Testing Station at Cambridge.

The constituents of a 10-gram sample of each of the mixtures were as follows:

MIXTURE A (Budgerigar)

Phalaris canariensis (Canary Grass)	4.74 g.	595 seeds
Panicum miliaceum (White Millet)	5.16 g.	789 seeds
Other:	0.10 g	
Polygonum convolvulus (Black bindweed)		2 seeds
Helianthus sp. (Sunflower)		1 seed
Solanum rostratum		1 seed
Salvia sp.		2 seeds

MIXTURE B (Budgerigar)

Phalaris canariensis (Canary Grass)	6.08 g.	722 seeds
Panicum miliaceum (White and Red Millet)	3.46 g.	704 seeds
Other:	0.46 g	
Lolium temulentum (Darnel)		7 seeds
Triticum aestivum (Wheat)		2 seeds
Brassica sp.		1 seed
Bupleurum lancifolium		1 seed
Centaurea diluta		1 seed
Sinapis arvensis (Charlock)		1 seed
Vaccaria pyramidata		1 seed
Unidentified		3 seeds

Mixture C (Budgerigar)		
	4.00 -	500 1-
Phalaris canariensis (Canary Grass) Panicum miliaceum (White and Red Millet)	4.80 g. 5.01 g.	588 seeds 932 seeds
Other:	0.19 g.	752 secus
Centaurea diluta	0.17 8.	2 seeds
Lolium temulentum (Darnel)		2 seeds
Triticum aestivum (Wheat)		1 seed
Capnophyllum dichotomum		1 seed
Hibiscus trionum Bupleurum lancifolium		1 seed 1 seed
Polygonum convolvulus (Black bindweed)		1 seed
1 orygonam convolvarias (Black Blindweed)		1 3000
MIXTURE D (Budgerigar)		
	5.04 g.	594 seeds
Phalaris canariensis (Canary Grass) Panicum miliaceum (White and red Millet)	4.31 g.	877 seeds
Other:	0.65 g.	077 50005
Lolium temulentum (Darnel)	2.22 8.	14 seeds
Triticum aestivum (Wheat)		4 seeds
Sorghum halepense (Johnson Grass)		2 seeds
Bupleurum lancifolium		1 seed
Centaurea diluta		1 seed
Mixture E (Budgerigar)		
Phalaris canariensis (Canary Grass)	6.09 g.	728 seeds
Panicum miliaceum (White Millet)	2.86 g.	498 seeds
Setaria viridis (Green Bristle-Grass) Other:	0.95 g.	303 seeds
Lolium temulentum (Darnel)	0.10 g.	2 seeds
Medicago lupulina (Black Medick)		2 seeds
Bupleurum lancifolium		1 seed
Sorghum halepense (Johnson Grass)		1 seed
Ononis sp.		1 seed
Rapistrum rugosum		1 seed
Linum sp.		1 seed
MIXTURE F (Canary)		
Phalaris canariensis (Canary Grass)	5.41 g.	675 seeds
Brassica napus (Rape)	1.51 g.	453 seeds
Cannabis sativa (Hemp)	1.07 g.	62 seeds
Linum usitatissimum (Linseed)	0.95 g.	163 seeds
Guizotia abyssinica (Niger) Other:	0.83 g.	217 seeds
Other: Dipsacus fullonum (Teasel)	0.23 g.	3 seeds
Triticum aestivum (Wheat)		1 seed
Lolium temulentum (Darnel)		1 seed
Unknown		3 seeds

MIXTURE G (Canary)		
Phalaris canariensis (Canary Grass)	6.87 g.	957 seeds
Brassica napus (Rape)	1.57 g.	402 seeds
Linum usitatissimum (Linseed)	0.74 g.	122 seeds
Cannabis sativa (Hemp)	0.29 g.	14 seeds
Guizotia abyssinica (Niger)	0.17 g.	39 seeds
Other:	0.36 g.	
Setaria glauca (Yellow Bristle-Grass)		1 seed
Sorghum vulgare (Sorghum)		1 seed
Unknown		2 seeds
Mixture H (Canary)		
Phalaris canariensis (Canary Grass)	6.36 g.	945 seeds
Brassica napus (Rape)	1.68 g.	429 seeds
Linum usitatissimum (Linseed)	0.80 g.	132 seeds
Cannabis sativa (Hemp)	0.38 g.	25 seeds
Guizotia abyssinica (Niger)	0.14 g.	31 seeds
Other:	0.64 g.	
Alopecurus myosuroides (Black Grass)		1 seed
Triticum aestivum (Wheat)		1 seed
MIXTURE I (Canary and Finch)		
Phalaris canariensis (Canary Grass)	4.85 g.	559 seeds
Papaver somniferum (Opium Poppy)	1.67 g.	3065 seeds
Guizatia abyssinica (Niger)	1.27 g.	354 seeds
Linum usitatissimum (Linseed)	1.09 g.	184 seeds
Brassica napus (Rape)	0.51 g.	141 seeds
Dipsacus fullonum (Teasel)	0.28 g.	80 seeds
Other:	0.33 g.	1 seed
Triticum aestivum (Wheat) Lolium temulentum (Darnel)		2 seeds
Centaurea diluta		1 seed
Alopecurus myosuroides (Black Grass)		1 seed
moreculus myosuroides (black Glass)		1 3000
MIXTURE J (British Finch)		
Brassica napus (Rape)	4.35 g.	966 seeds
Phalaris canariensis (Canary Grass)	2.97 g.	363 seeds
Linum usitatissimum (Linseed)	0.95 g.	155 seeds
Cannabis sativa (Hemp)	0.78 g.	41 seeds
Guizotia abyssinica (Niger)	0.61 g.	152 seeds
Other:	0.34 g.	
Lolium temulentum (Darnel)		2 seeds
Panicum miliaceum (White millet)		2 seeds
Galium aparine (Cleavers)		1 seed
Unknown		1 seed

MIXTURE K (Foreign Finch)

THAT ONE IT (I GIOIGHT I HOIL)		
Panicum miliaceum (White and Red Millet)	4.98 g.	1062 seeds
Phalaris canariensis (Canary Grass)	2.94 g.	338 seeds
Setaria viridis (Green Bristle-Grass)	1.95 g.	831 seeds
Other:	0.13 g.	
Lolium temulentum (Darnel)	0.10 8.	2 seeds
Sorghum halepense (Johnson Grass)		1 seed
Rapistrum rugosum		1 seed
Setaria italica (Foxtail Millet)		1 seed
Bupleurum lancifolium		1 seed
•		
Mixture L (Parrot)		
Helianthus annuus (Sunflower)	7.82 g.	90 seeds
Zea mays (Maize)	0.96 g.	4 seeds
	0	2 seeds
Arachis hypogaea (Groundnut)	0.89 g.	2 seeds
Other:	0.33 g.	
Capsicum sp. (Red Pepper)		1 seed
Galium aparine (Cleavers)		1 seed
Polygonum convolvulus		1 seed
Sinapis alba (White Mustard)		1 seed
Siliapis alba (Willic Mustard)		1 3000
Marrows M /Discoul		
Mixture M (Pigeon)		
Pisum sativum var. arvense (Maple Peas)	3.55 g.	16 seeds
Vicia faba var. equina (Tick or Horse Beans)	2.65 g.	9 seeds
Triticum aestivum (Wheat)	1.83 g.	44 seeds
	0	8 seeds
Zea mays (Maize)	1.74 g.	o seeds
Other:	0.23 g.	-21
Hordeum distichon (Barley)		1 seed
Avena fatua (Wild Oat)		1 seed
Galium aparine (Cleavers)		1 seed
Guitain aparino (Greavers)		1 5000

Determining Germinative Capacity

A sample of 50 seeds of each species in each mixture was space-sown into fine sterilised garden soil in 3½" or 5" plastic pots on July 13th, 1969. The pots were watered, glass covered and kept in a shaded cool greenhouse. Germination was recorded at weekly intervals for four weeks.

	Mean	% 29	62 %	53 %	78 %	% 65	46%	20 %	36 %	%0	72 %	44 %	% 08	%98	%86	%9	
	W	ı	ı	1	ı	ı	ı	ı	ı	ı	ı	72	80	98	86	9	
	7	1	ı	4	1	1	'n	1	1	1	72	17	1	1	ı	1	
	×	72	54	99	ı	1	1	1	1	1	1	1	1	1	1	1	
	_	98	1	1	9/	44	7.2	30	1	1	1	1	1	1	1	1	
	-	72	1	1	80	78	0	1	36	0	1	1	1	ı	1	1	
Mixture	H	36	1	1	93	26	74	52	1	ı	1	1	1	ı	ı	1	
M	G	62	1	1	70	58	80	0	1	J	1	1	1	ı	1	1	
	H	44	1	1	74	06	4	0	1	ı	1	1	1	1	ı	1	
	E	98	72	40	1	1	1	1	1	_1	1	1	ı	ı	1	1	
	D	78	99	1	1	1	1	T	1	1	1	1	1	1	ı	1	
	၁	82	9/	1	1	1	1	1	1	1	1	1	ı	1	1	ı	
	B	06	34	1	Τ	1	1	1	1	1	1	1	1	1	1	1	
	A	34	70	1	1	1	1	1	1	1	1	1	1	1	1	ı	
	Species	Phalaris canariensis L.	Panicum miliaceum L.	Setaria viridis (L.) Beauv.	Linum usitatissimum L.	Guizotia abyssinica (L.f.) Cass.	Brassica napus L.	Cannabis sativa L.	Dipsacus fullonum L.	Papaver somniferum L.	Helianthus annuus L.	Zea mays L.	Triticum aestivum L.	Pisum sativum L.var arvense Poir	Vicia faba L. var equina Pers.	Arachis hypogaea L.	

Percentage Germination of Constituents of Mixtures

Survey Areas

During February, 1969, three survey areas were marked out on the surface of Harford tip. Each area was a triangle of side 5 metres. Area A was sited to the east of the Tip on ground where no refuse had been deposited for at least ten years. Area B was sited to the north of the Tip on the surface of refuse deposited during the previous year, 1968. Area C was sited in the centre of the Tip on ground used for dumping several years previously and due for re-use in 1969. During February 1969 soil temperatures were taken at the surface, 15 cm. deep and 30 cm. deep at the points of the survey area triangles. The areas were observed intermittently through the year 1969, and plant species present in the areas on October 5th, 1969, were recorded.

Soil Temperatures and Snow Depth in Survey Areas, 9 February 1969

Site	Temperature (deg. C.) at surface	Temperature (deg. C.) at depth of 15 cm.	Temperature (deg. G.) at depth of 30 cm.	Depth of snow
A1	0	0	0	12 cm.
A2	0	2	2	7 cm.
A3	7	18	29	_
B1	0	0	0	4 cm.
B2	0	4	16	1 cm.
В3	14	39	46	_
C1	0	1	1	10 cm.
C2	0	0	0	7 cm.
C3	5	12	31	_

PLANT SPECIES IN SURVEY AREA A (No refuse deposited for at least ten years)

Epilobium hirsutum (Gt. hairy willow- Polygonum aviculare (Knotgrass) herbl

Rumex obtusifolius (Broad-leaved dock) Cirsium vulgare (Spear thistle) Senecio jacobaea (Ragwort) Cirsium arvense (Creeping thistle)

Dactylis glomerata (Cocksfoot) Agrostis stolonifera (Creeping bent)

Ranunculus acris (Meadow buttercup) Malva sylvestris (Common mallow) Plantago major (Great plantain) Agropyron repens (Couch grass) Agrostis gigantea (Black bent)

PLANT SPECIES IN SURVEY AREA B (Refuse deposited during the previous year, 1968)

Capsella bursa-pastoris (Shepherd's purse)

Euphorbia helioscopia (Sun spurge) Urtica dioica (Stinging nettle) Plantago lanceolata (Ribwort plantain) Senecio jacobaea (Ragwort)

Sonchus oleraceus (Sow-thistle) Poa annua (Annual meadow-grass)

(Horticultural aliens)
Lobularia maritima (Sweet Alison)

(Bird-seed aliens)
Panicum miliaceum (White millet)

117 plants Setaria italica (Foxtail millet)

6 plants Setaria viridis (Bristle-grass)

1 plant

Chenopodium album (Fat hen) Rumex obtusifolius (Broad-leaved dock) Solanum nigrum (Black nightshade) Plantago major (Great plantain) Senecio vulgaris (Groundsel) Agropyron repens (Couch grass)

Solanum tuberosum (Potato)

Phalaris canariensis (Canary grass) 78 plants

Lolium temulentum (Darnel)
3 plants

Centaurea diluta (Desert knapweed)
1 plant

PLANT SPECIES IN SURVEY AREA C (Refuse deposited during the current year, 1969) (Recorded 5 October 1969)

Capsella bursa-pastoris (Shepherd's purse)

Chenopodium album (Fat hen)
Anagallis arvensis (Scarlet pimpernel)
Senecio vulgaris (Groundsel)
Picris echioides (Bristly ox-tongue)
Plantago major (Great plantain)
Phalaris canariensis (Canary grass)

Stellaria media (Chickweed)
Trifolium repens (White clover)
Solanum nigrum (Black nightshade)
Matricaria matricarioides (Pineapple weed)
Sonchus oleraceus (Sow-thistle)

Poa annua (Annual meadow-grass)

Discussion

The series of chance events that allows a component of a packet of bird-seed to escape its many possible fates and eventually arrive within the top two or three centimetres of deposited refuse and in a benign situation seems sufficiently unlikely to happen more than rarely. The fact that botanical surveys of harford Tip regularly include records of species unlikely to have been introduced in any other way suggests otherwise. All but two or three of the species encountered in this study have been recorded from Harford Tip during the last fifteen years of its use until it was closed in 1973, and some of them are recorded regularly and in quantity.

To judge by the number and variety of bird-seed mixtures on display in the shops visited, the authors' samples were roughly representative in kind and frequency of mixtures being sold. Not surprisingly the analysis of mixtures intended for particular kinds of bird by different producers were very similar, the same species in similar proportions by weight and by seed number occurring in several related samples. Most of the chief components of the mixtures had good rates of germination.

Given the slight information about the relative sales of various mixtures (sales factor) and the average number of seeds of a given species in a 10-gram sample (frequency factor) together with the average percentage germination of the species in all samples (viability factor) it was possible to calculate a product for each species which should bear some relationship to the frequency with which these species were encountered on Harford Tip. The results of such calculations place the chief species in the following order: (1) Phalaris canariensis (2) Panicum miliaceum (3) Brassica napus (4) Setaria italica (5) Linum usitatissimum (6) Guizotia abyssinica (7) Helianthus annuus (8) Triticum aestivum (9) Dipsacus fullonum (10) Cannabis sativa. These results are in broad agreement with surveys of Harford Tip vegetation recorded here and elsewhere showing that in this class of casual plants the millets and canary grass are predominant, whereas plants of linseed and niger are uncommon, and plants of hemp and teasel are rare. The position of Brassica napus in the list suggests that rape plants might be expected to occur more frequently than they are reported, a circumstance which may reflect cage-bird feeding preferences or particular germination requirements among other possible explanations.

Without reference to the producer, it is not always possible to differentiate between the intended and the unintended components of a mixture. Conceivably producers may incorporate very minor components into their mixtures, but it seems more likely that species occuring in minute frequencies — one or two seeds in a 10-gram sample — are accidental inclusions entering the mixtures as seeds of weeds in the crops of the main components. Some of these 'weed' seeds occur fairly regularly in the mixtures and on Harford Tip, such as the darnel (*Lolium temulentum*) and the pale blue cornflower or desert knapweed (*Centaurea diluta*). Others which have occurred in our samples have never been recorded from Harford Tip, and it seems not unlikely that some of the wide range of casuals recorded from Harford Tip have been introduced as 'weed' seeds in bird-seed mixtures.

The controlled tipping at this site involved the deposition of refuse in a layer one to two metres deep followed by capping with a layer of soil 10 to 30 cm. deep, although the movement of vehicles over the surface inevitably mixed the top refuse and the covering soil. The first plant colonisers of this surface are species characteristic of disturbed ground and waste places introduced with the capping soil. In area C, surveyed not many weeks after tipping, the surface was largely uncolonised but carried a number of young plants, all indigenous except for a few plants of Phalaris canariensis. In another area sited to the west of the Tip and on refuse deposited about six months prior to the survey there were, in an area of the same size as the survey areas, 65 plants of Panicum miliaceum (Millet), 7 plants of Echinochloa frumentacea (Sanwa millet), 3 plants of Setaria italica (Foxtail millet), 1 plant of Echinochloa crus-galli (Cockspur grass) and 1 plant of Setaria viridis (Green bristlegrass). In area B, where refuse had been deposited between twelve and eighteen months prior to survey, there was also a good range of bird-seed casuals as well as other introduced and indigenous species. The findings in these last two areas confirm the impression previously gained by the authors that mature bird-seed casuals recorded in late summer or autumn usually originate

in material deposited between the spring of that year and the previous summer.

In area A where no material had been tipped for over ten years, no casuals were found; the vegetation was closed and entirely indigenous and perennial. Earlier studies have suggested that *Phalaris canariensis* (Canary grass) sets seed in most seasons and will therefore persist for several years after introduction, but that almost all other bird-seed casuals flower too late (September—October) to ripen viable seed and so cannot persist without constant reintroduction.

A feature of refuse tips containing organic matter and insulated by a capping of soil is the relatively high temperature of the interior generated by putrefaction. In some cases this is sufficient to ignite combustible refuse giving rise to very persistent tip fires. Local heating of a less extreme kind may still be enough to prevent the growth of vegitation for a period of months or years. The soil temperature at the A3 site was still high enough to maintain an area free of both snow and vegetation more than ten years after the last refuse had been deposited. In moderation, however, the increased temperatures may provide habitats for both plants and animals of an exotic kind. The house cricket (Acheta domestica = Gryllulus domesticus), from very dry parts of south-west Asia and north Africa, survives at Harford Tip in some numbers, and it is probable that soil temperatures play some part in the germination and limited persistence of casual plant introductions.

Acknowledgements

We are most grateful to Dr. Christine Quartley of the Official Seed Testing Station at Cambridge for identifying a number of the 'weed' seeds in the bird-seed mixtures. We are also grateful to the Chief Public Health Inspector of Norwich, Mr. J. H. Smellie, for permission to work on Harford Tip.

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1978 WEATHER SUMMARY by T. B. Norgate

In order to prevent repetition, monthly details are restricted to salient weather features. Anomalies are given in the tables at the end of this report.

January. Sunshine hours amounted to 15% of the maximum possible against an average of 16%. There were 13 sunless days. It was a cold month with 22 ground frosts, the highest for a January since 1964 when 26 were recorded in central Norfolk. On Jan. 3rd the temperature in the Norwich area dropped 6C° (11F°) in under ten minutes, soon after 9.0 a.m., accompanied by thunder, lightning and some snow.

There were only 8 completely dry days, the wettest being the 23rd when almost 20mm (over ¾'') of wet snow and rain fell.

Very high barometer readings were recorded early in the month, 30.56" (1034.9 mb.) but dropping to below 29" at the end (982 mb.) and accompanying N & N.W. gales with hail and snow.

February. Again a cold month, the coldest February since 1969. On the 11th the ground minimum reached 18.4°C (—1°F) with snow to a depth of 150 mm (6"). It was probably the coldest night in East Anglia since before World War I. Snow remained on the ground from the 8th to the 22nd when the temperature rose rapidly. It touched a maximum of 12°C (53½°F), the warmest day since Christmas.

More than half the precipitation was snow, total amounts varying from 34mm (1½") to double this on the higher ground facing the North Sea. Though there were only 7 sunless days, mostly at the beginning of the month, total amounts were about normal. ("Rainfall" includes melted snow).

March. The month started cold and wet but ended in a "blaze of glory" with almost as much sunshine in the last week as in the rest of the month. Rainfall tended to be on the high side towards the Suffolk border but the pattern otherwise was irregular. The wettest day was the 20th with amounts varying from $12\frac{1}{2}$ to 25 mm ($\frac{1}{2}$ "). Some of this was snow which fell on two other days.

Though on the warm side, as was March last year, maximum temperatures were very variable from 15.8°C (60.4°F) on the 11th to just below freezing on the 17th.

April. This month was even colder than March with more air frosts too, a complete reversal of the trend a few weeks earlier. It was the coldest April in East Anglia for 22 years. Rainfall was rather less than usual and included snow twice which came after a dry week at the beginning of the month.

It was a dull month too; not since 1965 have we had under 120 hours sunshine in April. Despite this there were over 10 hours bright sunshine on four days in the first half of the month.

May. All the rain was confined to the first fortnight, to be followed by an absolute drought of 19 days into June. Amounts of rain were variable in the county, down to 15 mm (.60'') in the Norwich area and up to 73 mm (nearly 3'') in West Norfolk. The range was thus under 50% to over 100% of normal.

With only two sunless days, the number of hours of bright sunshine improved throughout the month, exceeding 14 hours on four days in the last week.

Despite this the month was slightly on the cold side, clear skies being responsible for three ground frosts. The shade temperature touched 26.6°C (almost 80°F) on the 31st which turned out to be the second warmest day in the Year.

June. The month began with the hottest day of the year, 27.5° C ($81\%^{\circ}$ F). But the only real warm days, i.e. above 24° C (75° F), were the first four. After this the maxima dropped below $12\%^{\circ}$ C ($54\%^{\circ}$ F) two or three times by the middle of the month.

Cloudy conditions, by preventing evapouration and radiation, kept mean temperatures up to normal. But sunshine did not help and the total hours were 20% below normal and nearly as low as 1977.

Rainfall varied from about 25 mm (1'') above normal in the centre of the county to nearly double in the north west. Thunder was recorded on 4 days; a house in New Costessey was struck by lightning on the 22nd.

July. It was the coldest July for 13 years and only produced 3 days above 24°C which is less than half the usual number.

Rainfall was largely derived from thunderstorms during the last week-end of the month when a wide belt from Thetford to Sculthorpe recorded over 50 mm (2'') in one day. The writer has yet to measure this amount in 24 hours in 46 years recording.

Despite only three sunless days it was the dullest July for 10 years and only 80% of normal.

August. This was the fifth consecutive month on the cool side but marginally warmer than July. There was but one day with a maximum above 24°C (75°F) compared with an average of about six.

Rainfall amounts were erratic over the county, thanks to two or three local thunderstorms. Most fell in the first half of the month, total amounts varying from under 40 mm (1.6'') to 100 mm (4'') at Loddon.

Despite only two sunless days it was the fifth month in succession on the dull side and the dullest August since 1969, though 1972 ran it close.

September. It was marginally warmer than August whereas it would on average be 2°C cooler. There were two slight ground frosts, however, but 9 with maxima over 21°C (70°F) and more than August. Sunshine hours were on the high side for the first time since March and almost reaching the August total. On average it would expect to have 30 or 40 hours less than August.

The wind had a westerly component most days but despite this, rainfall amounts were on the low side. There were at least 12 days in the middle of

the month, with hardly any rain at all. Totals were almost half the normal in the middle of the county.

October. This was the third successive October to be warmer than average, whereas sunshine was on the low side, largely due to the last week yielding only 3½ hours. Surprisingly the barometer was on the high side throughout; only once did it drop below 30" (1016 mb.), on the 17th.

As a result of anti-cyclonic conditions rainfall totals were one of the lowest on record for the county. Raveningham measured only 2.6 mm (1/10'') and at least a third of the county had under 10 mm (.40'').

The mean temperature was above normal, rising to a maximum of 23°C (73½°F) on the 11th. But there were 11 days when it failed to reach 13°C (55°F), the lowest being 10.3°C (50½°F) in the middle of the month. The overall mean was boosted by the absence of air frosts and only two very slight ground frosts.

November. It was appreciably warmer, drier and sunnier than usual for November which is apt to be "the odd man out". Only a few coastal and Broadland areas had over 38 mm (1½") and it was the second driest month of the year. Much of the county had half their usual rainfall and it was the driest November for over 20 years. Most of what did fall came in the second half of the month and included three snowfalls during the last few days. It did not last very long.

The mean temperature of 8.2° C ($46\frac{1}{2}^{\circ}$ F) has not been reached in November since 1968 and not exceeded for over 20 years. But the weather turned much colder during the last few days with ground and air frosts during most of the last week.

As in October the barometer remained high throughout the month, only once dropping below $30^{\prime\prime}$ (1,016 mb.) on the 19th. It was altogether a very pleasant month.

December. The year ended with a dull wet month and though the mean temperature was just about average, it had a "sting in its tail". The last two days had maxima below freezing, with snow, though earlier there were six days when it exceeded 10°C (50°F).

It was the wettest month of the year with something to measure on 25 days. Many parts of the county had over 100 mm (4"), including snow, some of which probably escaped measurement owing to drifting conditions. Snow fell to a depth of 100—125 mm (4"—5") and remained on the ground for several days.

The Year. Despite fluctuations in monthly temperatures and in rainfall from average, their annual means agreed very well. However, sunshine hours were 9% on the low side and it was the dullest year since 1968. This is further highlighted by the absence of hot days. There were but 7 with maxima above 25°C (77°F) and compares with a 10-year average of almost 12 days. The year 1972 may be mentioned since it had no such days and 1974 only one. The months April to August inclusive, had a deficiency of 120 hours or about 13% below normal. Such a reduction over several successive months is quite significant.

Wider discrepancies become apparent when the year's weather is studied on a seasonal basis. Winter is considered as Dec., Jan. & Feb.; Spring is March, April & May, et seq.

Thus, winter 1977/8 was only ½°C cooler than average but there was 8% more sunshine, a matter of 12 hours extra. Rainfall was a still more noticeable anomaly with an excess of 30%, nearly 50 mm (2'') in central Norfolk.

Spring was much nearer normal in all respects, only ½ °C cooler, sunshine 4% down and rainfall very slightly on the high side.

Summer was much more divergent from normal, with a mean temperature a full 1°C (2°F) down, rainfall just over 25% up and the highest since 1969 but sunshine was 21% deficient. It was the lowest summer total since 1965 which only managed to record 367.5 hours compared to 441.8 in 1978.

Autumn made some amends for the miserable summer. The mean temperature was 1°C up compared to the average, sunshine hours were 8% on the high side but rainfall was 40% below normal. It was the lowest for an autumn season since 1947. These particular autumns were the only two with less than 75 mm (3'') in 46 years of measurement. Incidently, the average for this period is 192.8 mm (over 7½'').

1978 Weather

			NO. OF A	IR AND		
	MEAN TEMPE	RATURE	GROUND	FROSTS	SUNSHINE HOURS	
	°C	°C				
	1978	Avg.	1978	Avg.	1978	Avg.
Jan.	2.4	3.6	13/22	10.4/17.6	37.7	41.9
Feb.	1.6	3.6	18/20	10.0/18.1	56.9	61.2
March	6.3	5.3	3/14	6.7/16.9	112.8	108.0
April	6.1	7.4	7/13	3.0/11.8	121.1	143.0
May	10.4	11.2	0/3	.5/4.5	187.3	189.6
June	13.7	14.0	_	.1/1.0	159.7	196.7
July	14.5	15.8	_	0/.2	137.2	183.0
Aug.	14.8	15.9	_	0/.1	144.9	180.6
Sept.	14.0	13.7	0/2	.1/1.0	166.8	149.1
Oct.	11.5	10.7	0/3	.3/5.8	93.6	100.8
Nov.	8.2	6.6	0/6	5.6/12.1	83.5	67.4
Dec.	3.9	4.0	11/16	9.1/17.3	38.0	43.3
Year	9.0	9.3	52/99	45.8/106.4	1333.8	1464.6

	DAYS WITH HA	IL/SNOW DA	UNDER	RAINFALL MM'S		
1978	Avg.	1978	Avg.	1978	Avg.	
Jan.	8/2	2.0/2.7	1	.1	81.5	58.4
Feb.	9/0	1.4/3.0	_	.3	62.1	45.0
March	4/0	2.3/3.1	_	.5	50.8	42.2
April	2/0	2.3/1.9	_	1.3	44.5	39.9
May	-	.2/.2	_	2.6	31.9	41.7
June	-	.3/.3	4	2.2	72.2	43.2
July	_	_	2	2.3	65.9	57.9
Aug.	_	_	2	2.6	58.0	54.6
Sept.	_	.1/.1	_	1.8	34.2	53.6
Oct.	0/1	1.0/1.3	_	.8	8.1	62.2
Nov.	3/1	3.1/2.9	_	.6	32.1	70.1
Dec.	2/0	3.0/3.2	_	2.2	94.6	56.7
Year	28/4	24.5/19.1	9	15.1	635.9	626.1

Averages are for the last 15 years except Rainfall which is for 46 years.

T. B. Norgate Norfolk Rainfall Organisation

TWO NEW NORFOLK ROSES by E. L. SWANN

In December 1975 a letter was received from M. J. Wigginton reporting the occurrence of a large population of a wild rose near the chalk pit in Donkey Lane, Eaton. He took it to be R. rubiginosa agg., and he sent material to Dr. R. Melville at Kew who determined it as the hybrid R. agrestis Savi x R. canina L. Later, in August 1976, neither the finder nor the Rev. G. Graham was able to find anything that could be R. agrestis. A. H. Wolley-Dod does not include this hybrid in his British Roses (J. bot., 1910, 1911) and Dr. Melville makes no mention of it in his account of the roses in Hybridization and the Flora of the British Isles (C. A. Stace ed., 1975). This is not surprising as there are other hybrids in Norfolk not appearing in the latter work although it is possible that the hybrid was unknown until its discovery at Eaton.

The puzzle of the missing parent remained unsolved until July 1977 when E. T. Daniels wrote "We have found R. agrestis on the site where the hybrid occurs". Accompanied by P. G. Lawson several bushes were examined with obvious mixed characters of both R. canina and R. agrestis and "while we were pursuing our separate searches I came across a small bush with white flowers and leaves heavily glandular beneath". Material was duly confirmed by Dr. Melville as R. agrestis Savi; vouching material has been deposited at Kew; the Castle Museum, Norwich; and in Hb. Swann.

It is strange that the Rev. E. F. Linton who held the living at Sprowston in 1878 and during his ten years in Norfolk devoted considerable time to the flora, specialising in *Rubus*, *Rosa* and *Salix*, did not record either *R. agrestis* or *R. sepium* Thuill., under which latter name our rose was formerly known. This suggests it is a recent introduction.

So far as can be ascertained it is a rare species but the Atlas of the British Flora (1st ed., 1962) is of little help on distribution as R. rubiginosa L., R. micrantha Borrer, R. elliptica Tauschaand R. agrestis Savi are inextricably mixed under R. rubiginosa agg.

In view of the confusion about this species a description follows taken from Savi's original work, Fl. Pisana (1798), and quoted by Wolley-Dod. (1.c., 1910, 122): "Rose with germen and peduncles glabrous. Flowers subumbellate. Leaflets oval, dentate-serrate. Stem and petioles prickly. The stems rise to 8 or 10 feet, and are strong enough to support themselves, with many diffuse interlacing branches, covered with very strong curved prickles. Leaflets 3—5 or 7, oval or oval-lanceolate; dentate, with saw-like teeth, hairy and deep green above, glandular and reddish beneath. Petioles minutely prickly on the lower side. Flowers scented, in an umbel, 3 or 4 together, petals white, slightly emarginate. Peduncles and germen glabrous. The glands in this species are reddish and pedicellate, giving a reddish colour to the under surface of the leaflets, and emitting a smell. These glands are situated on the

serratures of the leaflets, on the bracts, stipules and on the edges of their segments. Flowers in June; fruit, which is an inch long, and elongate-oval, ripens in September'.

The Eaton plant agrees closely with this description and Daniels remarks on salient characters, "the very narrow leaflets which are cuneate-based, the glands so thickly peppered on the undersides of the leaflets that from a distance the whole bush has a reddish tinge", and the small ellipsoid fruit, white flowers and glabrous styles are further similarities.

Whereas Savi's description relates to a mature plant the Eaton bush, by reason of its much smaller stature, must be a young plant and further indication of a recent introduction.

Miscellaneous Notes

Rhagium bifasciatum F.. A specimen of this 'Longhorn' beetle was found at Aylmerton, near Cromer in July 1978. This beetle is rarely found in Norfolk. Thouless records it from Brundall and Horsford at the turn of the century.

K. C. Durrant

Whilst investigating a piece of woodland at Hockham recently an infertile litchen was noted growing on the leaves and stems of a large box plant. This was the pycnidial form of *Catillaria bouteillei*, a species which normally grows on box and which is the only British lichen regularly found on leaves. This is the first Norfolk record for this species which is considered to be an uncommon species of the west and south of Britain.

P. W. Lambley

In 1978 the Museum was presented with a specimen of the rare fish burbot by Mrs E. C. Alston. It was caught by her husband, the late Rev. E. C. Alston, in about 1936 in the stream flowing out of Stanford Water. This is an additional record to those in the comprehensive paper by Malborough (J. Fish Biol., 1970). The last recorded sighting of burbot in Norfolk was in 1969 in the River Waveney.

P. W. Lambley



NOTES TO CONTRIBUTORS

- 1. All manuscripts submitted for publication should be sent to Dr. E. A. Ellis, Wheatfen Broad, Surlingham, Norwich.
- 2. Manuscripts should be typed double spaced on one side of the paper. Latin names of genera and species should be underlined. Dates should be in the form 1 January 1972. Text figures should be referred to as Fig. 1, etc.
- 3. All Latin names should be followed by the authority when the name is first mentioned in the text or table.
- 4. References should be in alphabetical order at the end of the paper, in the form of:

Bloomfield, E. N., 1905. Fauna and flora of Norfolk. Trans. Norfolk & Nor. Nat. Soc., 8. 117-37.

- 5. Tables should be set on separate sheets and numbered in arabic numerals.
- 6. Drawings should be in jet-black indian ink. Shading should be in lines or dots but not in half-tone washes.
- 7. Page-proofs only will be sent. They should be returned with the least possible delay, and the minimum of essential correction should be made.
- 8. Authors are supplied with 15 offprints gratis. Additional copies may be ordered when the proofs are returned.