TRANSACTIONS
of
THE NORFOLK & NORWICH NATURALISTS' SOCIETY

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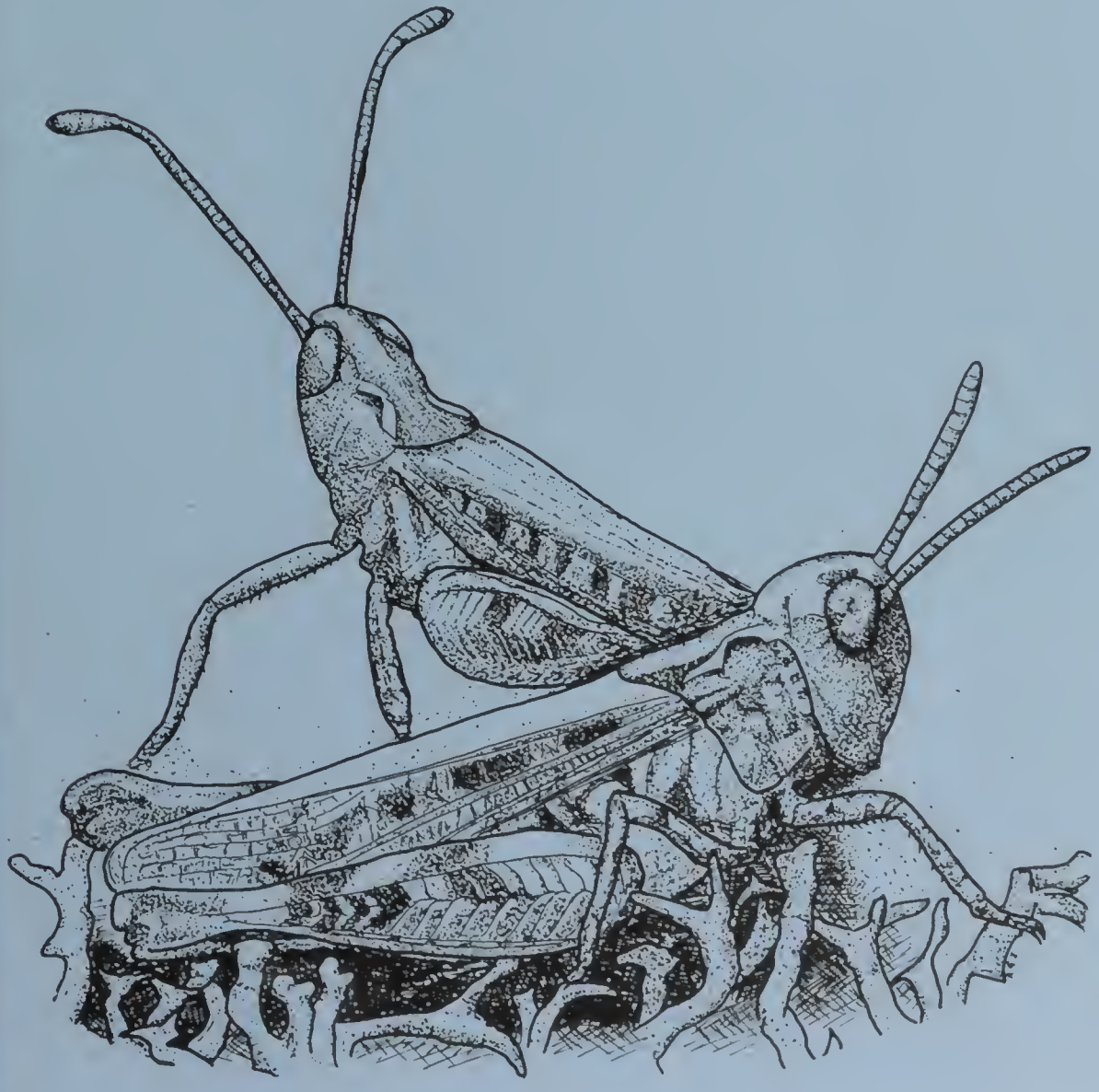

TRANSACTIONS OF THE NORFOLK AND NORWICH NATURALISTS' SOCIETY

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FRONT COVER : Male and female mottled grasshoppers *Myrmeleotettix maculatus* (*A.G. Irwin*)

PLANT GALLS

THE PRESIDENTIAL ADDRESS DELIVERED TO THE SOCIETY ON 27 MARCH 1991

K.C. Durrant

18 The Avenue, Sheringham, NR26 8DG

Being an entomologist but also interested in botany, I feel that I shall be bridging both sciences by giving you an address on British Galls, or cecidology as the study is termed.

The word gall is derived from the latin Galla, meaning a plant gall, and it is defined as an abnormal swelling or protuberance of plant tissue stimulated by parasitic influence or symbiotic organisms. Galls can appear on every part of the host plant from the roots to the topmost leaves and flowers. They are formed entirely by the host plant itself and not by the gall-causer. When insects are involved most of the galls start to form when the larvae emerge from the eggs, but there are exceptions.

The formation of these abnormalities is still not fully understood. Attempts to produce galls artificially by means of experiments have not been successful. It is thought that the larva of the causer produces a stimulus from its salivary secretions which act upon the plant tissue in a similar way to the growth-promoting hormone auxin, but there may be many other factors such as enzymes involved, as complex galls are produced with many layers of different tissues all formed in a definite pattern not found elsewhere on the host plant.

Continental works now give keys to some 7500 separate galls, and there are over 1700 in the British Isles. They can be caused by either bacteria, fungi, mites, eelworms or insects, which include the larvae of moths, beetles, wasps, flies, aphids or plant bugs.

Considering the length of time that galls have been known, it is only about 150 years since they have been studied seriously in the British Isles, then only from a botanical aspect. Gradually it was realised that insects were involved and with the aid of works produced on the continent the study became a science.

The Greeks and Romans used galls in the production of inks and dyes, the greek philosopher Theophates who lived 378 to 286 BC mentioned galls in his writings.

In 1892 the Ray Society began a monograph on British Phytophagous Hymenoptera (Cameron, 1892). This aroused interest amongst entomologists of the day in the gall wasps comprising the family Cynipidae. These insects range in size from 1 to 5 mms. In 1894 Dr Stratton translated into English the 1881 monograph of Dr Adler (Stratton, 1894) and this brought to light the discovery of the alternating generations of these gall wasps. Consequently many names had to be changed when it became clear that most species possessed two distinct forms of insect and gall.

Edward Connold (1901,1908,1909) produced three publications illustrated with photographs of all the then known galls in the British Isles. Soon afterwards other publications followed on other causers, mostly midges and mites. In 1963, the Royal Entomological Society produced in their handbook series keys to the British gall wasps and their galls (Eady & Quinlan, 1963). "Plant galls in Colour" (Darlington, 1968) illustrated and described most of the common galls of the British countryside in a handy pocket-sized volume.

In 1985 a group of enthusiasts formed the British Plant Gall Society, and in the following year published very cheap but valuable provisional keys to all the British

galls (Stubbs, 1986), a great incentive to the budding entomologist and botanist alike. In recent years many publications on general natural history have appeared which contain excellent illustrations of galls. Among them the Blandford Press colour series translated from the original Danish are most impressive.

In the last 50 to 60 years many degrees have been awarded to students who have patiently unravelled the complicated life history of particular gall causers together with their parasites and inquilines. Unfortunately the insects involved do not have English names, and nearly all of them require the aid of a microscope for identification. Imagine for instance an extremely minute mite 120 of which laid end to end would make one inch, with a name like *Eriophyes laevis inagulis*—it is enough to put all but the most enthusiastic student off their study.

One of the most common and easily recognised galls is the oak apple (Plate 4). When mature it does resemble a small apple both in colour and shape. It is caused by a parthenogenetic female wasp called *Biorhiza pallida*. Now Bio means life, Rhiza means root, so how does root-life explain a gall which develops on the end twigs of of the oak? This is a good example of an alternate generation first mentioned by Dr Adler in 1881.

In the early part of the year usually (February or March) one of the largest species of cynipid wasp can be found crawling up the trunk of an oak tree. She is wingless and only 5mm in length. At the turn of the century she was called *Biorhyza aptera* ("the wingless one from the roots"). On reaching a suitable bud she deposits a number of eggs within, usually 30 to 40, repeating the operation in another bud again if she escapes predation by birds. After about a month the heads of the larvae protrude from the eggs and they begin to feed on the contents of the plant cells for some time before finally leaving the eggs. The gall starts to form and reaches maturity in late June. In July fully winged males and females emerge which are considerably smaller than their parent. This form used to be known as *quercus-terminalis* ("from oak terminal buds"). After mating the females penetrate the soil and deposit their eggs on the rootlets of the oak. The galls that eventually form resemble small walnuts about 10mm in length, although many galls may coalesce into a mass up to 60 mm in diameter. After about 16 months wingless parthenogenetic females emerge to complete the two year cycle (Fig. 1).

Another interesting alternate generation concerns much smaller species. If the underside of oak leaves are examined in late summer the number of minute galls which are found to cover the surface is phenomenal. Up to 300 have been recorded from one leaf with more than one species being present. These are called spangle galls and there are four common types. The larger flat galls illustrated are the common spangle and are caused by the bisexual generation of a minute wasp *Neuroterus quercusbaccarum*, while the rounder more beautiful ones are appropriately named silk button galls caused by another wasp *Neuroterus numismatis* (Plate 3).

Despite their size the larvae of these wasps have peculiarities in common with many other cynipid larvae. They possess extremely small mouth parts so that all they can do is pierce the plant cells and imbibe the liquid content, unlike the inquilines which,because of their larger mouthparts, can devour the entire cells. The mid gut of the *Neuroterus* larva is not connected to the hind gut and therefore no excretory matter is passed until it emerges as an adult in the spring of the following year (the ultimate constipated animal). The parasites however excrete just prior to pupating.

When mature all spangle galls fall to the ground to spend the winter in the

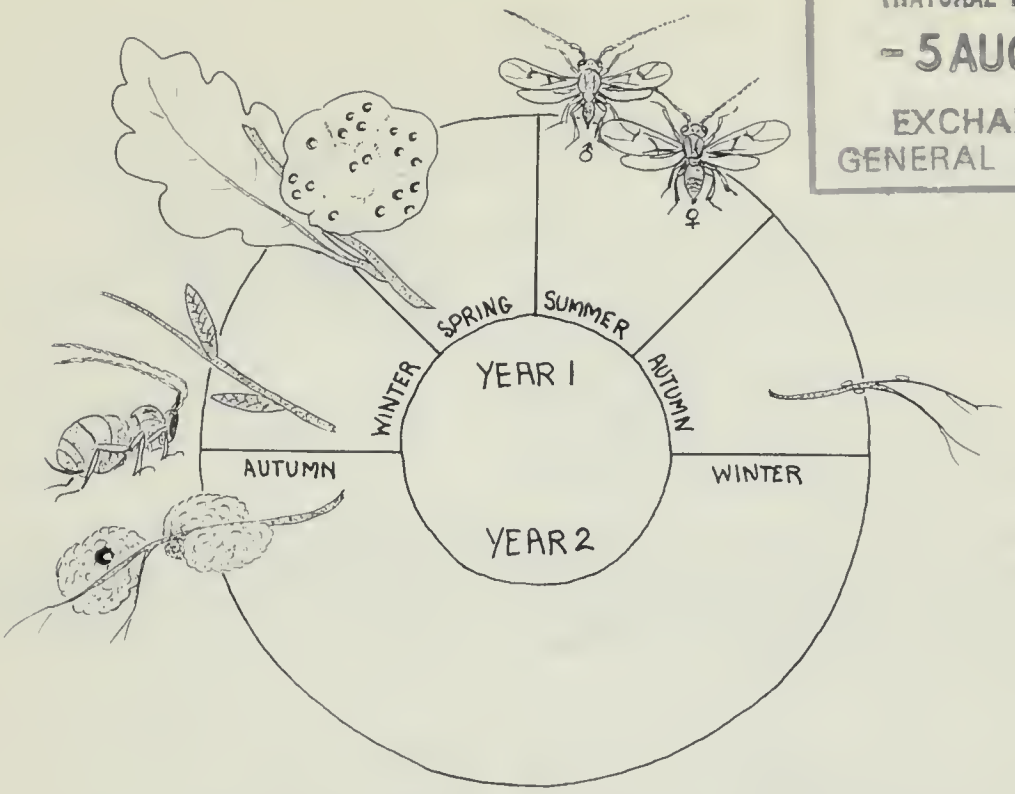


Fig. 1 Life cycle showing alternation of generations in the oak apple gall wasp *Biorhyza pallida.*

leaf litter. Only agamic females emerge in spring, those from the common spangle fly to lay their eggs among the male catkins resulting in galls resembling red currants (Plate 6). If the eggs are deposited in the lower leaf veins juicy pale-coloured galls form. From these galls winged male and female wasps emerge in the following June and after mating the females deposit eggs in the leaf veins which cause the spangle in the late summer.

* * *

The address was illustrated by 120 slides in colour with descriptions and history of the gall causers. Included also were illustrations of malformations often mistaken by the public as galls i.e. various fasciations of plants, leaf broods of weevils and serpentine leaf mines of micro moths. Mention was made of the circular mine in the leaf of holly caused by the larva of the fly *Phytomyza ilicis* which still causes controversy amongst cecidologists as to whether or not it constitutes being classed as a true gall.

The following check-list of Norfolk galls is compiled from collections and lists of the following: N.Carmichael, K.C. Durrant, E.A. Ellis, R.E. & L. Evans, R.C. Hancy, S.A. Manning. Apart from the general works cited above, keys to specific groups may aid identification. These are mentioned at the beginning of the families to which they apply. Although older literature can still be obtained from libraries much of the nomenclature is now well out of date.

CHECK-LIST OF NORFOLK PLANT GALLS

BACTERIA

Agrobacterium radiobacter var. *tumefaciens*	crown gall on bramble
Corynebacterium fascians	leafy gall on Forsythia
Frankia alni	leaf roll of alder

FUNGI

Ellis and Ellis (1985) is the standard work on British plant-parasitic microfungi, including those which form galls. The rusts and smuts cause swellings on stems and leaves, while *Taphrina betulina* and *T. carpina* produce the spectacular "witches brooms" on birch and hornbeam. *Plasmodiophora brassicae* is better-known as "club-root" of cabbages.

Albugo candida
Coleosporium tussilaginis
Cumminsiella mirabilissima
Epichloe typhina
Gymnosporangium clavariiforme
Melampsora caprearum
Melampsora epitea
Melampsora euphorbiae
Melampsora populnea
Melampsoridium betulinum
Melanotaenium lamii
Phragmidium fragariae
Phragmidium mucronatum
Phragmidium tuberculatum
Phragmidium violaceum
Plasmodiophora brassicae
Puccinia aegopodii
Puccinia annularis
Puccinia arenariae
Puccinia buxi
Puccinia calthae
Puccinia caricina
P.caricina var. *ribesii-pendulae*
Puccinia circaeae
Puccinia coronata
Puccinia epilobii
Puccinia galii-verni
Puccinia glechomatis
Puccinia heraclei
Puccinia lagenophorae
Puccinia lapsanae
Puccinia malvacearum
Puccinia menthae
Puccinia poarum
Puccinia polygon- amphibii
Puccinia pulverulenta
Puccinia punctiformis
Puccinia saniculae
Puccinia sessilis
Puccinia variabilis
Pucciniastrum epilobii
Synchytrium mercurialis
Taphrina betulina
Taphrina carpini
Taphrina deformans
Taphrina populina
Taphrina pruni
Taphrina tosquinetti
Triphragmium ulmariae
Urocystis anemones
Uromyces dactylidis
Uromyces ficariae
Uromyces junci
Uromyces limonii
Uromyces polyoni-aviculare
Uromyces trifolii
Ustilago violacea

INSECTA—HEMIPTERA

Psylloidea

White and Hodgkinson (1982), and Hodgkinson and White (1979) give biological information as well as keys to the British species.

Craspedolepta nebulosa	on rose-bay willow herb
Livia juncorum	tassel gall on rush
Psylla buxi	leaf gall on box
Psylla crataegi	leaf roll on hawthorn
Psyllopsis fraxini	leaf-edge roll on ash
Trichochermes walkeri	leaf-edge roll on buckthorn
Trioza alacris	leaf-edge roll on bay laurel

Callaphididae

Phyllaphis fagi	crimple leaf on beech

Aphididae

Brachycaudus cardui	leaf curl on *Prunus*
Brachycolus stellariae	leaf roll on stitchwort
Cryptomyzus ribis	leaf patch on red currant
Cryptospiphum artemisae	thick leaf on mugwort
Dysaphis aucupariae	leaf roll on rowan
Dysaphis ranunculi	leaf curl on hawthorn
Hayhurstia atriplicis	leaf roll on goosefoot
Hayhurstia cucubali	deformed plant of campion
Myzus cerasi	leaf gall on *Prunus*
Rhopalosiphum insertum	leaf pouch gall on hawthorn

Pemphigidae

Eriosoma lanigerum	American blight on apple
Pemphigus bursarius	pouch gall on poplar
Pemphigus spirothecae	spiral pouch gall on poplar
Schizoneura lanuginosa	leaf bladder gall on elm
Schizoneura ulmi	leaf roll gall on elm
Tetraneura ulmi	leaf-pouch gall on elm

Adelgidae

Adelges abietis	pineapple gall or pseudocone on spruce
Adelges cooleyi	pineapple gall or pseudocone on spruce

Asterolecaniidae

Asterodiaspis minus	pit gall on oak

COLEOPTERA

Apion frumentarium	swollen stem on sheep's sorrel
Apion vicinum	swollen stem on mint
Miarus campanulae	swollen caspule on harebell
Saperda populnea	swollen stem on sallow

DIPTERA

Cecidomyiidae

Barnes (1946-1956) and Nijveldt (1969) deal with the gall midges of economic importance, including those on weeds.

Ametrodiplosis thalictricola	swollen fruit on meadow rue
Asphondylia sarothamni	deformed flower on broom
Contarinia craccae	swollen flower on vetch
Contarinia loti	swollen flower on trefoil
Contarinia steini	swollen flower on campion
Contarinia tiliarum	petiole gall on lime
Contarinia tragopogonis	stem gall on goatsbeard
Craneiobia corni	leaf gall on dogwood
Cystiphora sonchi (Plate 1)	leaf blotch on sowthistle
Cystiphora sanguinea	leaf blotch on hawkweed
Dasineura affinis	swollen leaf on violet
Dasineura alni	leaf end curl on alder
Dasineura crataegi	rosette gall on hawthorn
Dasineura engstfeldi	wrinkled leaf on dropwort
Dasineura filicina	little black pudding gall on bracken
Dasineura fraxini	leaf gall on ash
Dasineura glechomae	pouch gall on ground ivy
Dasineura kiefferiana	leaf roll on willow herb
Dasineura mali	leaf roll on apple
Dasineura papaveris	distorted capsule on poppy
Dasineura pratensis	distorted flower on vetch
Dasineura sisymbrii	yellow stalk on cress
Dasineura thomasiana	leaf roll on lime
Dasineura tiliamvolvens	leaf edge roll on lime
Dasineura trifolii	leaf fold on clover
Dasineura ulmaria	leaf gall on meadow sweet
Dasineura urticae	leaf gall on nettle
Dasineura viciae	folded leaf on bean
Dasineura violae	dwarf plant of violet
Didymomyia tiliacea	blister gall on lime
Geocrypta galii	cove ring gall on bedstraw
Harmandia globuli	leaf vein pimple on aspen
Hartigiola annulipes	hairy leaf gall of beech
Jaapiella veronicae	shoot tip gall of speedwell
Kiefferia pimpinellae	swollen seed on carrot

Lasioptera rubi	swollen stem on bramble
Macrodiplosis dryobia	leaf lobe gall on oak
Macrodiplosis volvens	leaf lobe gall on oak
Mikiola fagi	pointed leaf gall on beech
Oligotrophus fagineus	leaf pustule on beech
Phegobia tornatella	nail gall on beech
Planetella granifex	stem gall on sedge
Rhabdophaga heterobia	wooly catkin gall on sallow
Rhabdophaga marginemtorquens	leaf roll on willow
Rhabdophaga rosaria	camelia gall on willow
Rhabdophaga salicis	stem nut gall on willow
Rhopalomyia ptarmicae	stunted plant of sneezewort
Rhopalomyia tanaceticola	flower and axil galls on tansy
Rondaniola bursaria	lighthouse gall on ground ivy
Taxomyia taxi	artichoke gall on yew
Wachtliella persicariae	leaf roll on persicaria
Wachtliella riparia	ovary gall on sedge
Wachtliella rosarum	pod leaf gall on rose
Wachtliella stachydis	swollen leaf on hedge woundwort
Zygiobia carpini	leaf midrib gall on hornbeam

Agromyzidae

Spencer (1972) provides keys to the British species, most of which are stem-or leaf-miners

Agromyza simplicoides	swollen twig on willow
Phytomyza ilicis	holly leaf mine

Chloropidae

Chlorops pumilionis	crinkled leaf on couch and marram grass
Lipara lucens	cigar or torpedo gall on common reed

Tephritidae

White (1988) provides up-to-date keys for all the British species, and Redfern (1983) will also be found useful.

Tephritis bardanae	fruit gall on burdock
Tephritis conura	seed head gall on thistle
Urophora cardui (Plate 5)	swollen stem on creeping thistle
Urophora solstitalis	seed head gall on burdock
Urophora stylata	seed head gall on thistle

Anthomyiidae

Chirosia betuleti	knot gall on ferns
Chirosia parvicornis	frond roll on ferns
Pegomyia hyoscyami var. *betae*	leaf blister gall on sugar beet

HYMENOPTERA

Tenthredinidae

Blennocampa pusilla	leaf roll on rose
Phyllocolpa leucapsis	leaf roll on sallow
Pontania pedunculi	hairy pea gall on sallow
Pontania proxima	bean gall on willow
Pontania vesicator	horse bean gall on willow
Pontania viminalis	pea gall on sallow

Cynipidae

Eady and Quinlan (1963) key all the British species.

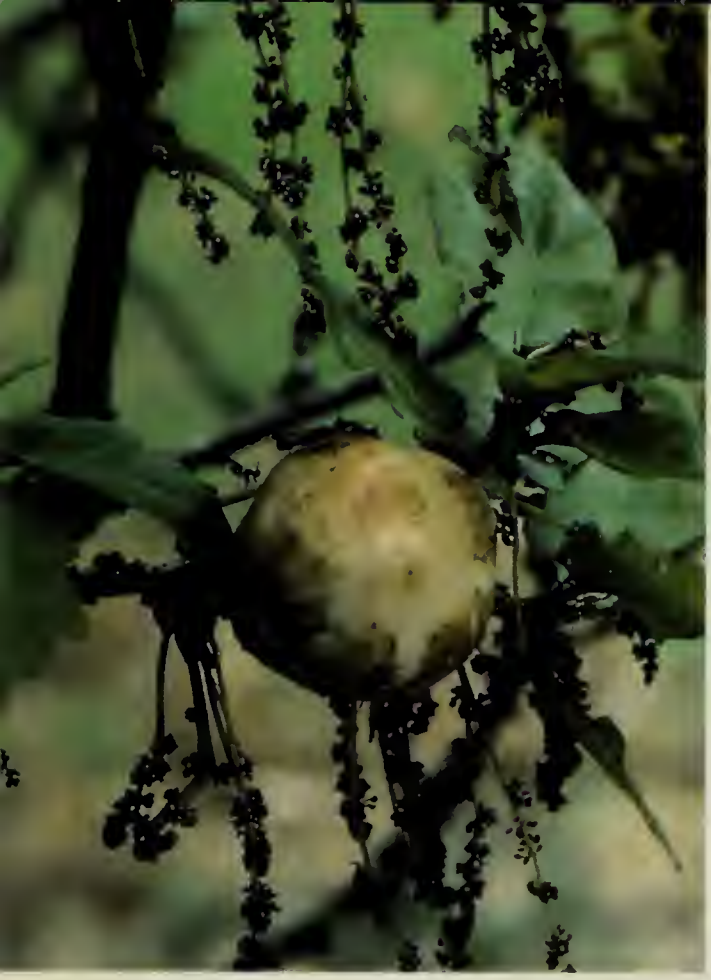
Andricus albopunctatus (agamic)	naked bud gall on oak
Andricus curvator (agamic)	collared bud gall on oak
Andricus curvator (bisexual)	curved leaf gall on oak
Andricus fecundator (agamic)	artichoke gall on oak
Andricus fecundator (bisexual)	hairy catkin gall on oak
Andricus inflator (agamic)	fat bud gall on oak
Andricus inflator (bisexual)	twig gall on oak
Andricus kollari (agamic)	marble gall on oak
Andricus kollari (bisexual)	ant pupa gall on Turkey oak
Andricus lignicola (agamic)	rough marble gall on oak
Andricus ostreus (agamic)	oyster gall on oak
Andricus ostreus (bisexual)	April bud gall on oak
Andricus quadrilineatus (agamic)	ridged catkin gall on oak
Andricus quadrilineatus (bisexual)	ridged leaf gall on oak
Andricus quercuscalicis (agamic)	knopper gall on oak
Andricus quercuscalicis (bisexual)	catkin gall on Turkey oak
Andricus quercusradicis (agamic)	truffle gall on oak
Andricus quercusradicis (bisexual)	knot gall on oak
Andricus quercusramuli (agamic)	autumn bud gall on oak
Andricus quercusramuli (bisexual)	cotton wool gall on oak
Andricus solitarius (agamic)	pointed bud gall on oak
Andricus solitarius (bisexual)	stunted catkin gall on oak
Andricus testaceipes (agamic)	barnacle gall on oak
Andricus testaceipes (bisexual)	swollen leaf vein gall on oak
Aylax minor	seed capsule gall on poppy
Aylax papaveris	swollen copsule on poppy
Aulacidea hieracii	swollen stem on hawkweed
Biorhiza pallida (agamic)	walnut root gall on oak
Biorhiza pallida (bisexual)	oak apple
Cynips divisa (agamic)	red pea gall on oak
Cynips divisa (bisexual)	red wart gall on oak
Cynips longiventris (agamic)	striped pea gall on oak
Cynips longiventris (bisexual)	green velvet bud gall on oak
Cynips quercusfolii (agamic)	cherry gall on oak
Cynips quercusfolii (bisexual)	violet bud gall on oak
Diastrophus rubi	swollen stem on bramble

1. Sow thistle galled by the midge *Cystiphora sonchi* (p.6)

2. Ash flowers and fruit galled by the mite *Aceria fraxinivora* (p.9)

3. Silk button and common spangle galls *Neuroterus numismalis* and *Neuroterus quercusbaccarum* on oak (p.2)

K.C. Durrant



4. Oak apple *Biorhiza pallida* and parasite *Torymus* sp. laying eggs (p.2) *N. Carmichael*

5. Creeping thistle with gall of the fly *Urophora cardui* (p.7) *K.C. Durrant*

6. Currant galls *Neuroterus quercusbaccarum* on oak catkins (p.3) *K.C. Durrant*

Diplolepis eglanteriae	smooth pea gall on rose
Diplolepis rosae	bedeguar or robin's pincushion on rose
Diplolepis rosarum/nervosus	spiked pea gall on rose
Diplolepis spinosissimae	leaf gall on rose
Neuroterus albipes (agamic)	smooth spangle gall on oak
Neuroterus albipes (bisexual)	Schenks gall on oak
Neuroterus aprilinus (agamic)	catkin gall on oak
Neuroterus aprilinus (bisexual)	distorted bud gall on oak
Neuroterus numismalis (agamic)	silk button gall on oak
Neuroterus numismalis (bisexual)	leaf blister gall on oak
Neuroterus quercusbaccarum (agamic)	common spangle gall on oak
Neuroterus quercusbaccarum (bisexual)	currant gall on oak
Neuroterus tricolor (agamic)	cupped spangle gall on oak
Neuroterus tricolor (bisexual)	hairy pea gall on oak
Liposthemus latreillei	bladder gall on ground ivy
Phanacis hypochoeridis	swollen stem on cat's ear
Trigonaspis megaptera (agamic)	leaf kidney gall on oak
Trigonaspis megaptera (bisexual)	pink bud gall on oak
Xestophanes brevitarsis	swollen stem on tormentil
Xestophanes potentillae	swollen stem on cinquefoil
Eurytomidae	
Harmolita hyalipenne	cigar gall on couch grass

LEPIDOPTERA

Epinotia tetraquetrana	terminal leaf curl on alder
Tortrix palaeana	stunted seed-heads on plantain

ACARINA

Aceria eriobia	leaf blister on field maple
Aceria fraxinivora (Plate 2)	flower gall on ash
Aceria galiobia	shoot gall on lady's bedstraw
Aceria origani	terminal bud gall on marjoram
Aceria pseudoplatani	felted pouch gall on sycamore
Cecidophyopsis ribis	big bud gall on blackcurrant
Eriophyes artemisiae	leaf pimple on mugwort
Eriophyes axillare	leaf pustule on alder
Eriophyes brevitarsus	leaf blister on alder
Eriophyes campestricola	leaf pustule on elm
Eriophyes convolvens	leaf roll on spindle
Eriophyes erineus	leaf blotch on walnut
Eriophyes exilis	leaf vein spot on lime
Eriophyes galii	leaf roll on goosegrass
Eriophyes ilicis	leaf gall on Holm oak
Eriophyes iteina	leaf pea gall on sallow

Eriophyes laevis inanguilus	leaf pimple on alder
Eriophyes lateannulatus	leaf nail gall on small-leaved lime
Eriophyes leionota	leaf pimple on birch
Eriophyes leiosoma	hairy patch gall on lime
Eriophyes macrochelus	leaf bead gall on field maple
Eriophyes macrorhynchus	red leaf pimple on field maple
Eriophyes macrotrichus	leaf vein gall on hornbeam
Eriophyes nervisequus	filz gall on beech
Eriophyes nervisequus var. *maculifer*	leaf pouch gall on beech
Eriophyes paderineus	leaf roll on bird cherry
Eriophyes rudis	big bud gall on birch
Eriophyes stenaspis	leaf margin roll on beech
Eriophyes tetanothorax	leaf edge gall on sallow
Eriophyes thomasi	cotton wool gall on thyme
Eriophyes tiliae tiliae	leaf nail gall on lime
Eriophyes tiliae nervalis	leaf spot on lime
Phyllocptes acericola	leaf gall on sycamore
Phyllocoptes goniothorax	leaf edge roll on hawthorn
Phyllocoptes malinus	felted leaf on apple
Phytocoptella avellanae	big bud gall on hazel
Phytoptus padi	leaf pustule on *Prunus*
Phytoptus pyri	leaf blister on pear
Phytoptus pyri var. *crataegi*	leaf pustule on hawthorn
Phytoptus similis	leaf edge gall on blackthorn
Phytoptus tetratrichus	leaf edge roll on lime

NEMATODA

Ditylenchus dipsaci	wrinkled leaf on plantain

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PLANT RECORDS FOR 1990

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The start of tetrad mapping in the Eastern half of the county for the new Flora has seen a great upsurge of activity this year. In the West, recording continues and good finds have been made. It has been a great pleasure to receive many records of less common things such as *Sison amomum, Silaum silaus, Kickxia elatine, Legousia hybrida, Papaver argemone*, and *Misopates orontium* listed by a number of recorders. Our apologies if your names are not mentioned in this account, but they will be duly acknowledged when the time comes and your records are published and filed for posterity! One plant that did appear in many lists was *Amsinckia* and it will be interesting to see how quickly this spreads through the county. *Amaranthus* too persisted in many fields and all the specimens that were sent to the referee for checking turned out to be *A. bouchonii* as we had expected. The number of recorders increases each year, but we can still do with more help. Don't think that our 'square-bashing' is dull, far from it. One non-Norfolk botanist who volunteered a day's help and was inadvertently given a stretch of Hockwold fen (100% cultivation apart from a track and a dyke) found one plant on the scarce list and one new Vice County Record. Quite a reward for virtue! Among those who feel it is all beyond them, I am sure there are many who could easily compile a list of their garden weeds but feel we don't want anything as simple as that. However we do, in fact garden weeds are often a weak spot in the lists as normally only the person who pulls them out notices them! So what about it?

Nomenclature in these records follows Clapham, Tutin and Warburg (1985).

Abutilon theophrasti TF60 Downham Market, waste ground GM
Agrostis castellana TM08, TM18 roadside pavements in Roydon where it has escaped from lawns AC
A. canina ssp. *montana* TM39 Broome GM
Alisma lanceolata TF61 Watlington, pond edge HW
Allium oleraceum TG10 eight to ten groups in grass, Cow Lane, Norwich PC
Ambrosia trifida TF70 Marham, roadside verge where plane spotters park HW
Apera interrupta TF70 field edge JG & GB; TF61 Bawsey, sand pits KB & GB
Aquilegia vulgaris TF93 Hindringham, apparently native KB & GB
Artemisia absinthium TF61 Blackborough End HW
Aster lanceolatus TM18 Large colony at Roydon first East Norfolk record AC
Astragalus glycyphyllos TG14 Weybourne where last seen c.1953 MC
Azolla filiculoides TM39 among duckweed, R.Waveney at Ellingham ETD; TG14 Blakeney KF
Berteroa incana TG20 still in ground of derelict abbatoir where first seen by John Silverwood c.1962 ETD; TL88 waste ground near Thetford NG MG & DB
Betonica officinalis (no grid ref.) disused railway track, Norwich to Hellesdon AC
Bidens cernua (rayed form) TF61 Watlington, pond edge HW
Brassica fruticulosa ssp. *fruticulosa* TG20 Riverside, Norwich, one plant ETD
Bromus carinatus TF80 Cressingham, roadside, third West Norfolk record JG
Bromus rigidus TF62 Roydon, track side RS

Callitriche hamulata TG31 dried up pond at Salthouse MH, Det. R.Driscoll
Centaurea cyanea TM29-39 about 20 plants on a roadside bank where it had been newly cut into arable field RML
Colchicum autumnale TM18 considerable numbers in grassland on what was formerly Scole Common MRH
Colchicum sp. TG31 many planted on Blofield Estate by Judge Blofield's father, they have now become established MH
Crassula helmsii TF61 Watlington, pond, first West Norfolk record HW
Crassula tillaea TF61 Bawsey, sand pits KB & GB; TF62 Hillington, sandy track RS
Cynosurus echinatus TF62 King's Lynn, waste ground RS
Cystopteris fragilis TG21 now appears to have gone from Salhouse Station platform RML
Daphne laureola TM17, TM18 Scole, in two places MRH; TG11 JH; TG14 Weybourne FF In West Norfolk this plant occurs all along the ridge, just inland from the sea, as this site is.
Diplotaxis erucoides TL68 Hockwold, edge of ditch and field, first West Norfolk record TCGR
Elymus repens ssp. *arenosus* TF84 Holkham, on recent dunes PJOT
Epipactis palustris TM08-18 Roydon fen, now only two plants AC
Fumaria muralis ssp. *boraei* TG13 Corpusty, MAB Conf. ETD
Galium parisiense TL79 Methwold, walls in village RT
Geranium pyrenaicum var. *pallida* TG20 increasing and spreading from its site at Lakenham ETD
Gymnocarpium dryopteris TL88 Weeting, several plants under conifers in forest, first West Norfolk record MK
Iris germanica TM39 Broome GM
Jasione montana TL98 Harling Fen NG & MG
Juncus tenuis TL89 Weeting, in damp forest ride, second West Norfolk record KB GB & JG
Lamiastrum argentatum TL79 naturalised by forest ride JG (This is the variegated archangel grown in gardens.)
Leucojum aestivum TG10 4 or 5 plants in spinney near Earlham Fiveways garage PC; TG 20 continues to spread in the Eaton area near the river ETD
Linum bienne TF94 Wells sea bank, known since 1922 but thought lost in 1978 floods, refound in some quantity PB
Lychnis coronaria TM39 Broome GM
Medicago falcata TF72 Grimston to Massingham roadside, its most northerly station HW
Melampyrum cristatum TF91 Beetley, near an old site thought lost DMM
Myosurus minimus TL68 Hockwold, public footpath TCGR
Nigella damascena TG03 Letheringsett, on a stone heap for second year ETD
Nymphoides peltata TM39 Broome GM; TG01 Lyng PWL; TG33 Happisburgh RML; TF50 Outwell where it was last recorded in 1819! DM
Ornithogalum nutans TG10 Bluebell Lane, Norwich 8 plants on road bank PC
Orobanche purpurea TG33 Mundesley churchyard, one plant PWL; TG24 Sidestrand 65 plants counted PWL
Oxalis articulata TG03 Holt, sward along side of car park, one with white flowers ETD

O. incarnata TG03 Holt, former site paved over but still growing around margins ETD
Papaver lecoqii TF59,TF70,TF50 replaces *P. dubium* as a weed throughout much of the fens. MK KB GB & RT
Polypogon monspeliensis TG04 Cley, still occurs on the reserve KH
Polygonum bistorta TM18 Shelfanger, Lammas meadows PWL; TM17 Billingford, Lower Common MRH
Potamogeton × *salicifolius* TG41 Martham South Broad leading towards East Somerton, some quantity in dyke, first recent record Det. C.Preston GK
Potentilla anglica this record for 1989, Norwich, was in error and should have read *P. norvegica*
Prunus domestica ssp. *institia* T12 Booton clay pits 3 or 4 trees with a heavy crop of berries (In spite of the information in the standard flora, Clapham, Tutin and Warburg (1985), this is in my experience the true old fashioned bullace which used to grow widely on the mid Suffolk clay. Apart from the annoyance of the small stones, bullace jam is among the tastiest I know.) ALB
Rosa 'Hollandica' TG10 a few bushes in Cantley Lane, Cringleford, formerly wrongly named as *R. rugosa*, now corrected ETD
Salix aurita × *cinerea* TM39 Broome GM
Salix calodendron TM18 Roydon AC conf. R. Meikle
S. × *meyerana* TG10 dense stand by river at Marlingford ETD
Sambucus ebulus TM18 Scole MRH; TF71.West Acre, 25m suckering stretch JG
Solanum rostratum TG02 Thurning, bird seed alien in garden with *Galinsoga* and *Setaria* MAB
Thymus praecox TM18 beside new piece of road at Roydon where a single plant in ten years has made a mat 50cm across.
Tragopogon porrifolius TG10 Hethersett JM
Trifolium glomeratum TM39 Broome GM
T.ornithopodioides TM39 Broome GM
T.suffocatum TM39 Broome GM
Vaccinium myrtillus TG11 the colony at Attlebridge persists beside the disused railway in spite of intense competition from shading plants, a few berries were found ETD
Vitis vinifera TG20 large plant on the old gasworks site, Norwich ETD & Dr Gilbert
Zostera marina TG40 Breydon Water LS
Zostera noltii TG40 Breydon Water LS

Contributors:

PB	Paul Banham	MG	Molly Gibbons	DM	David Mathias
MAB	Anne Brewster	NG	Nick Gibbons	GM	George Maybury
DB	David Buckingham	MRH	Michael Hall	DMM	Dorothy Maxey
PC	Phillip Cambridge	KH	Kerry Harrison	JM	John Mott
MC	Mary Cooper	MH	Marie Helliwell	TCGR	Tim Rich
AC	Arthur Copping	JH	Joyce Humphris	RS	Robin Stevenson
ETD	Ernest Daniels	MK	Michael Keene	LS	Les Street
FF	Francis Farrow	GK	Garry Kennison	RT	Richard Tofts
KF	Kathleen Ferrousat	PWL	Peter Lambley	PJOT	John Trist
JG	Jean Gaffney	RML	Bob Leaney	HW	Heather Wiliamson.

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RUBUS FISSUS LINDL.—FIRST CONFIRMED RECORD IN NORFOLK:—Whilst plant recording on Honing Common (TG329275) on 13 June 1990 I encountered a bramble with a number of puzzling characteristics. It was obviously one of the Suberecti group of species these all being plants intolerant of disturbance and good indicators of an ancient site. This particular bush bore some resemblance to *Rubus plicatus* as to stem armature etc., but the leaves were the wrong shape and the flowers were pink. Pink flowers can occur in *R. plicatus* though this is very rare. *R. arrheniiformis* which occurs at nearby Crostwight has pink flowers but weaker armature and different shaped leaves. *R. vigorosus* also has pink flowers and leaf shape similar to this plant but it is more robust with much stronger armature. After much hesitation a specimen was sent to Alan Newton for his appraisal and I was much surprised when he named the specimen as a good one of *R. fissus*. He pointed out that though recorded widely in England and Wales it is now quite rare south of the Scottish border. However, checking with the old list in Petch and Swann (1968, Flora of Norfolk) I found that the Rev. E. F. Linton is credited with having named this species, as *R. rogersii*, from Westwick. As the latter is only five km from Honing Common the present record is not claimed as a new county record, especially as Westwick has areas of damp woodland which may still be suitable for *R. fissus*.

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HOOKERIA LUCENS (HEDW) SM.—A SECOND NORFOLK STATION:—William Jackson Hooker found this species on Holt Heath (Holt Lowes) in 1805, the first time it had been discovered in Britain. In 1808, Hooker's friend, Sir James E. Smith, erected a new genus for the species and named it after him. Though it has since been found to be quite common in moist, shady situations in the north and west of Britain, Holt Lowes, where it still persisted until quite recently and may still do so, has remained its only Norfolk site.

On 6 March 1990 I was collecting mosses and liverworts for identification on the banks of a tiny stream in deep shade at Honing Common (TG3227). I took a specimen of a *Pellia* to check and noticed that I had what appeared to be a leafy liverwort growing amongst it. As I had collected *Chiloschyphus pallescens* (Ehrh.) Dum. not far away some years back I gave the matter no further thought until I examined a piece under the microscope. This revealed large hexagonal cells looking rather like wire netting mesh and I discovered that these were even discernable under the hand lens. Checking back with specimens I had from Holt and western Britain I realised that this could only be *Hookeria lucens*. A specimen was sent to C.R. Stevenson who confirmed the name.

As the Honing Common site is an ancient one, and the distance from Holt Lowes is one of about 20km, there is no reason to suppose that the Honing plant is a recent introduction.

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THE DISTRIBUTION AND STATUS OF THE COMMON FROG AND COMMON TOAD IN NORFOLK

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Introduction

One species of frog and two species of toad are native to England and all three are found in Norfolk (Buckley, 1975). The natterjack toad is a rare species only found at a few sites (Buckley, 1985) and introduced species of water frog are known at just a few localities (Buckley, 1986). In contrast the common frog *Rana temporaria* (Linn.) and the common toad *Bufo bufo* (Linn.) are found throughout the county and are the most numerous members of the herpetofauna. The maps presented in this paper show the Norfolk distribution of the frog and toad on a tetrad basis for the first time and it is hoped that they will act as a stimulus for further recording. The paper also provides information for interested persons to be able to find and identify common frogs and toads within the county.

Fig. 1 Common Frog.

Identification and habits

Frogs and toads belong to the group of amphibians which have no tail when adult, the Anura. The subclass is also known as the Salientia because of the ability of its members to leap or jump to a greater or lesser extent. They are fatter in the body than newts with long powerful hind legs and no obvious neck. Both genera are widespread in temperate and tropical regions of the world.

The frog has smooth moist skin and a distinct glandular fold down each side of the back starting at the shoulders (Fig. 1) The back is angular or humped when

Fig. 2 Common frogs and frogspawn.

the frog is sitting. A dark patch covers the ear drum region behind the eye and there is often a dark Λ - shaped mark between the shoulders. These characteristics serve to identify the frog which grows to a maximum body length of about 100 mm but typically 60-70 mm. Frogs are variable in colour, the upper surface being grey, yellow, reddish to dark brown mostly blotched with a darker shade. The lower side is whitish, mostly grey in the male and brown to reddish in the female. Breeding males have strong forearms which look flabby due to the looseness of the skin. The nuptial pads on the thumb of the male which help it to grip the female during amplexus are black.

Albinism has been recorded in the county (Ellis, 1984a). Albino frog tadpoles collected from a pond at Sprowston metamorphosed into orange coloured froglets with eyes which lacked dark pigment. Normally frogs have a golden coloured iris speckled with brown. A coloured photograph of an albino frog illustrates the note by Mendel (1990).

In the breeding season, usually March, the males croak with a dull rasping call which is often inaudible more than a few metres from the spawning site. The size of frog colonies has been investigated by Cooke (1975a). Most (50.2%) were in the size range 10-99 individuals and very few (0.5%) exceeded 1,000. Frogs spawn in shallow water (Fig. 2) and Cooke (1975a) records 48% of frog colonies using water up to six inches and 13% water thirteen to eighteen inches. Similar results have been obtained for colonies in the parish of Corpusty with Saxthorpe where 86% used water up to six inches to spawn in and the remaining 14% water seven to twelve inches deep (M. A. Brewster pers. comm.). After being laid the jelly around the eggs takes in water and expands to separate the eggs which are black in colour. The number of eggs per clump has been investigated by Cooke (1975b) and a mean of

1,329 was obtained for the seven clumps examined. The eggs took two to three weeks to develop at a normal March/April temperature and they hatched over a period of 4-7 days. The hatching rate for six of the seven clumps was 96 % in the case of the other clump it was only 20%. The date for first spawning of frogs becomes progressively later in Britain from the south-west of the country to the north-east (Cooke, 1976). Very rarely mild autumn weather may induce breeding activity (Ellis, 1984b).

Frog tadpoles are able to swim soon after hatching and they complete development in about twelve weeks or more. When large enough they can be distinguished from toad tadpoles by their olivaceous colour with lighter markings which give a speckled appearance rather than uniform black. The tail tip is pointed not rounded as in the case of toad tadpoles. A closer examination reveals a difference in the number of labial tooth rows. Frog tadpoles have three above and three below the horny mandibles whereas toad tadpoles have just two above and three rows below. Newly metamorphosed froglets remain in the wet areas of the pond margin feeding upon small invertebrates until weather conditions make it damp enough for them to disperse into the surrounding vegetation. It takes two years for both males and females to reach maturity.

Outside the breeding season frogs live on the land amongst herbage in damp places which may be some distance from the breeding site. They are most active at dusk when they feed. Some frogs stay in the water a month or two after the breeding season coming out onto the land to feed.

The common toad has a dry warty skin which is tougher and thicker than that of the common frog. They are adapted to life in drier habitats than the frog. Locomotion is by crawling rather than hopping. When alarmed they hop but in a much more laboured way than that of the frog and for shorter distances. The body is squat and plump and the head rounded (Fig. 3). There is a distinct gland behind the eye on both sides of the head. When sitting the back is only slightly curved or humped. The pupil is horizontal and the iris a coppery red colour. Male toads grow to a maximum body length of 7 cm and females to 10 cm. The upper surface of the body and head is coloured grey, reddish or blackish brown with a few indistinct darker markings, and closely covered in warts. The underside is off white flecked with grey-brown. The nuptial pads of the male develop on the thumb and inner fingers and are particularly noticeable during the breeding season. Albino toads have been recorded in Britain on less that half a dozen occasions. Albino tadpoles have been found in Suffolk but there are no records for this county (Ellis, 1984a).

When frightened the toad may adopt what is called the defence posture (Fig. 4). It inflates itself with air and stretches up on tip toe to appear as big as possible. Thus the toad may avoid being eaten if appears to a snake to be too large to swallow.

Common toads spawn later in the year than frogs but the time difference becomes less the further north and east the breeding site is in the country (Cooke, 1976). Toads assembled for spawning at a site in Cambridgeshire when daytime temperatures were a least 10°C and night time minima at least 5°C (Cooke, 1982). These temperatures are approximately 5°C more than those required by the frog. Gittins (1983) found that whilst most toads move towards their breeding site in the early part of the night 8% of males and 28% of females travel during the day. Toads tend to form large colonies more often than frogs (Cooke, 1975a).

Toads spawn in deeper water than frogs. Cooke (1975) records 13% of toad colonies using water up to six inches deep and a further 27% water thirteen to eight-

Fig. 3 Common toads mating underwater.

een inches in depth. In the parish of Corpusty with Saxthorpe 23% of the colonies used water up to six inches deep and the remaining 77% water seven to twelve inches in depth (M. A. Brewster, pers. comm.). The eggs are deposited in two long strings laid simultaneously by the female. As the pair of toads moves forward the spawn is extruded, fertilized and entwined around submerged vegetation. A study of 26 female toads in mid-Wales by Gittins, Kennedy and Williams (1984) produced a mean value of eggs per female of 1,344, range 450-4796. A smaller sample from Cumbria revealed an average of 1759, range 993—2999 (Banks and Beebee, 1986). The eggs hatch after about ten days and the embryos are in a rudimentary state lacking external gills and the ability to swim. Only after a further ten days can they swim freely. Toad tadpoles are distasteful to most predators e.g. fish and newts (Cooke, 1974) but larval mortality is usually high. Only a few percent survive to metamorphose in June or July. The toadlets remain around the pond margins before dispersing into the surrounding vegetation under suitable weather conditions. During the non-breeding time of the year toads inhabit drier habitats than frogs such as rough grassland and scrub, hedgerows, dry banks, walls etc. Sexual maturity is achieved after at least two years by males and three years by females (Gittins, Kennedy and Williams, 1985). The general biology of frogs and toads is described in Smith (1951), Frazer (1983) and Beebee (1985).

Frogs and toads are most likely to be encountered between March and October during their active period of the year (Table 1). Probably the easiest ways to discover the presence of frogs is to walk along pond edges searching for the familiar clumps of spawn in the shallow water. Toad spawn is less easy to find because it is laid as long strings in deeper water below the surface. Male toads are however very

Fig. 4 Common toad showing defence reaction to grass snake.

active at the height of the breeding season and these together with a few pairs of toads in amplexus can usually be found at larger colonies during daylight. Better results can however be obtained when visits are made at dusk, and a powerful torch used to search carefully on land and in the water. At the peak of the season 75% of the males of a colony may be in the pond but even the most observant of recorders may locate only half of them (British Herpetological Society, no date). Another good way of finding toad colonies is to look for corpses on roads near ponds in the early part of the breeding season. Toads are particularly vulnerable to motor traffic and whilst the odd carcass may indicate a distant colony a hundred or so indicates the proximity of an important breeding site. Later in the season when the adults have left the water and the spawn hatched well developed tadpoles can be taken with a hand net and identified relatively easily. During the terrestrial phase of the year adults and juveniles can be located by searching likely areas of short vegetation after dusk with a broad-beamed torch. This method can be particularly rewarding after rain preceded by a dry period (Ellis, 1982). In the daytime frogs can be found by

Table 1. Number of sightings of frog and toad per month (data from all years 1960-1990).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Frog	3	8	85	135	48	57	68	62	39	20	10	4
Toad	0	11	142	187	48	59	80	73	68	21	7	1

walking through herbage in damp habitats looking for movement of the vegetation caused by the frog jumping. Toads are more likely to be found by looking under discarded objects or logs in suitable areas.

The common toad is the host of a greenbottle, the toad-fly *Lucilia bufonivora* Moniez, and parasitized individuals may be encountered during late spring and summer. The maggots of this fly develop in one or both of the toad's nostrils and eventually lead to the death of the host. Infected toads are usually encountered unexpectedly in the open and they can be recognized by the way they have to gulp for air instead of being able to use their nostrils. In the later stages of the infection maggots are visible within the enlarged nostrils. Parasitized toads have been found at Thompson Common (A. G. Irwin pers. comm.).

Records and distribution

Records sent to the society and others since 1960 have been copied onto edge-notched cards for ease of storage and retrieval. The records are also held on 'Recorder', a computer package for biological recording at the Norwich Castle Museum. Post 1970 records have been plotted as tetrad (2 km x 2 km) maps. There has been little systematic attempt to survey the whole county for frogs and toads and to some extent the distribution maps reflect the distribution of recorders. There is scope for our knowledge of the species distribution to be updated and extended. Doubtful records have been omitted from the maps together with some where the precise locality could not be determined. Full details have been supplied to the Biological Records Centre at Monks Wood.

Both species are widespread in the county and there are few 10 km squares where neither has been recorded. The frog has more tetrad records in the south-east of the county and the toad more along the north coast. A marked difference between the two species is shown in Breckland, where toad records predominate, a pattern of distribution which extends into Suffolk (Jones, 1988).

Changes in status and conservation

There can be no doubt that the frog and toad have declined in abundance since the middle of the last century when Southwell (1871) commented upon their status. He simply recorded them both as common, and in common with most of the early authors he gives no figures or observations to illustrate his use of the term. Ellis (1965) recorded frogs as generally distributed in the broads but scarcer, notably in the Yare valley since the 1930's. He noted them spawning in ponds, dykes and occasionally in pulks and shallow bays of broads. The common toad was also widely distributed but had become scarcer at many localities in the last 25 years. He suggested that road deaths could be a possible cause of the decline at some places but at others it was unknown.

Cooke and Scorgie (1983) conducted a survey of the status of the commoner amphibians and reptiles in Britain. They used a questionnaire and asked recorders to give the status of the various species in 1980, the change since 1970, if any, and the reason for any changes in status. The responses were then processed to give indices of abundance (range 0 to 1) and changes of status (range -1 to + 1) on a regional basis. In East Anglia the frog was considered to be widespread and fairly common; local and rather scarce in E. Norfolk, S. Suffolk and N.E. Essex; reported to be common in suburban areas and gardens (index 0.70). The toad was considered to be widespread and common or abundant, rather more local in E. Norfolk (index

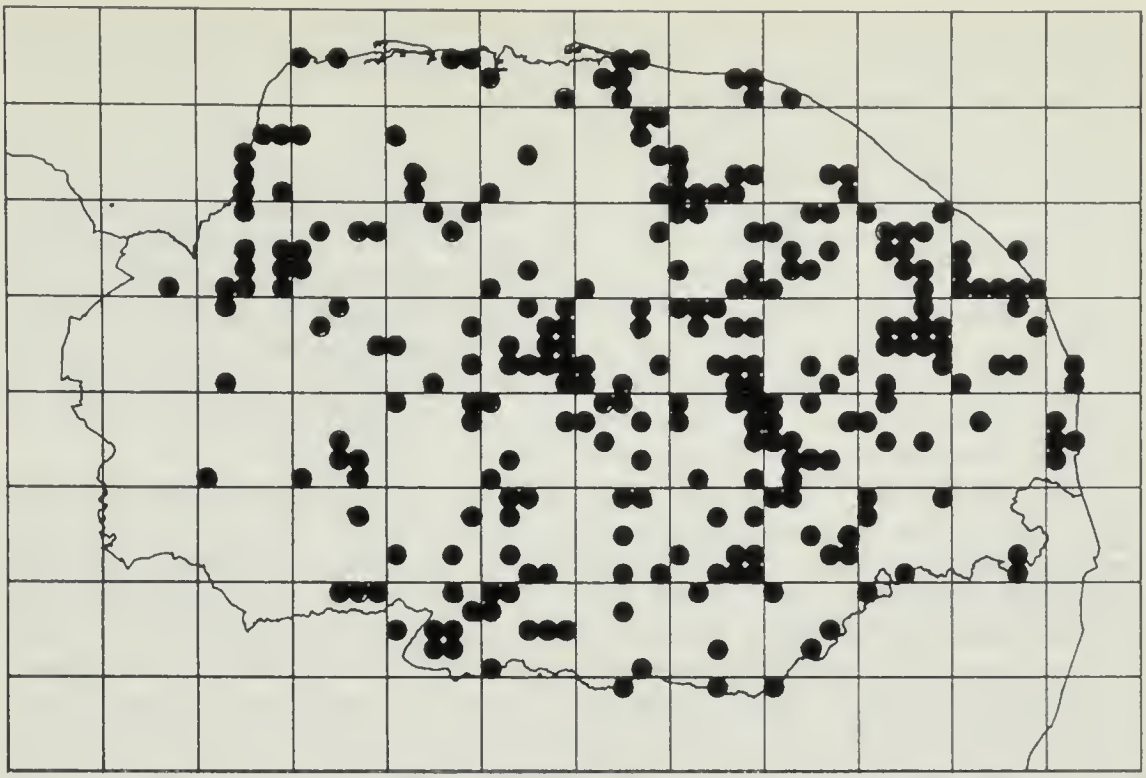

Fig. 5 Common frog. Post-1970 tetrad distribution map.

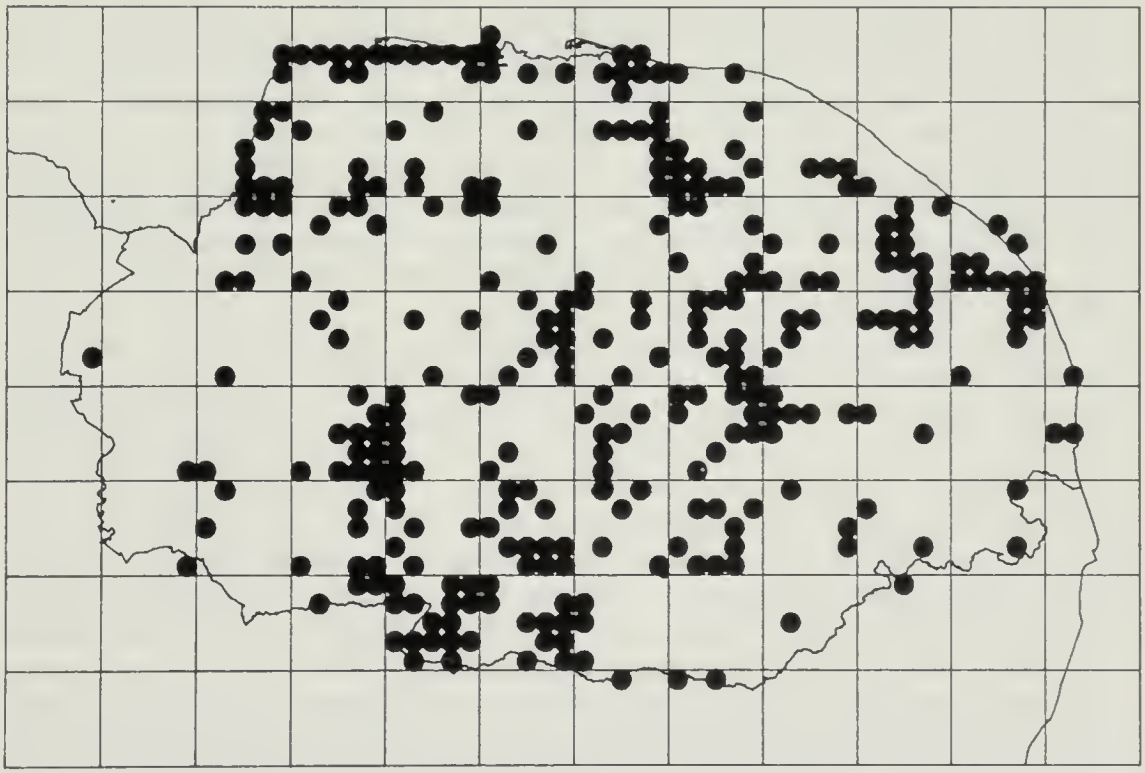

Fig. 6 Common toad. Post-1970 tetrad distribution map.

0.81). The responses and the ten East Anglian recorders indicated that both anurans had declined in abundance since 1970, the toad (index of change -0.21) slightly more than the frog (index of change -0.18).

By using the same methodology as Cooke and Scorgie (1983), Hilton-Brown and Oldham (1991) assessed the status of the widespread amphibians and reptiles in 1990 and recorded changes in their status during the 1980's. The responses of the five East Anglian recorders suggest that there has been little or no change in the status of the common frog and common toad since 1980 (indices of change: common frog +0.07, common toad -0.03). The common frog is now considered to be generally widespread, common in towns, local in rural areas (index of status 0.64). The common toad is described as widespread and relatively common, abundant in certain areas. In both surveys the major reason for decline in the status of these amphibians was considered to be loss of habitat.

The loss of either terrestrial or aquatic habitat will eventually lead to the extinction of a frog or toad colony. Bull (1988) describes how frog and toad breeding sites were lost to changes in farming practice at his study site. Many such losses occur without being recorded at the time and only by studying large scale maps can the magnitude of such habitat losses be appreciated. Tuxworth, Crane and Morris (1985) estimated that since 1905 about 75% of ponds have been lost with the greatest loss being in recent years. About 88% of the loss was attributable to "farming practice", which generally refers to the removal of field boundaries and the filling of associated ponds or to the filling of old marlpits located in the centre of fields. Urban growth accounted for 10% of the total loss. The Norfolk Naturalists Trust's phase 1 habitat survey recorded a rather depressing picture of the remaining ponds. Most were graded as small (87.2%), eutrophic (95.3%) and of poor nature conservation value (87.5%). Within Broadland the loss of former grazing marshes to arable farming has resulted in not only the loss of terrestrial habitat but also breeding sites. The number of dykes has been reduced and they are less suitable (George, 1977; Driscoll, 1985). The lowering of the water table by water abstraction has not only caused ditches and ponds to become dry for much of the year but in some cases has caused a change in the water chemistry. At Calthorpe Broad there was an abrupt change in pH of the broad from near neutral to acidic, just above pH 3, in November 1970. In the spring of 1971 all frog and toad spawn became opaque and failed to develop. Similar failures in 1977 and 1978 were almost certainly caused by the low pH of the water (Gosling and Baker, 1980).

Although so much has changed since the halcyon days of the 1920's and 30's (Ellis, 1987) it is still possible to encounter large numbers of frogs and toads. In 1987 401 toads were rescued from road drains on Colney Lane, Norwich. New seven inch high kerb stones had blocked their route to the gravel pits and many had fallen down the drains. At the end of March 828 individuals were moved from a marsh being cut for reed at Sutton Broad and many thousands occur on the Bure marshes National Nature Reserve. The largest reported count of breeding toads was at Beetley Common when at least 537 were seen after dusk. Peak frog counts are just under 100 and the highest spawn clump count was 140 at New Buckenham Common.

The death of toads on roads has prompted some individuals or local groups to help toads across roads where high mortality would occur. At its simplest toads are collected as they approach or arrive at the road and are released at a safe place nearer the breeding site. Since 1985 the Fauna and Flora Preservation Society (FFPS) has coordinated this activity as part of its herpetofauna conservation programme.

Whilst it is not claimed that it saves colonies from extinction it certainly reduces mortality near breeding sites. Cooke (1988) has estimated that at a site in Cambridgeshire one toad in every eight moved across the road was saved from being killed.

For the past two years the Norfolk Naturalists Trust have operated a 'HOP-LINE' as part of the Royal Society for Nature Conservation enquiry into the status of frogs and toads. It has helped to raise the interest of the general public in this group and has produced some information about breeding sites. It has also helped to bring together those people wishing to start frog colonies in the garden ponds and those with surplus spawn. The extent to which spawn has been translocated within the county is not known. The only documented successful reintroductions of frogs has been at Woodton and Bedingham using tadpoles from Hempnall (R. Hadman pers. comm.).

The most interesting case of toad conservation in Norfolk has been that of the colony on the Thetford Golf Course and Marsh SSSI and the effect of the A11 Thetford bypass (Gibbons, 1988, 1989). Despite the matter of the colony being raised at the Public Enquiry in March 1985 it was confirmed in January 1987 that the road would pass straight through the breeding pond. Tom Langton (1987) on behalf of the FFPS drew up proposals for the conservation of the colony including a timetable for fencing, toad tunnels, creating a new breeding site and restoring breeding water, but in March 1988 the breeding pond was half filled in. It was learned that the Department of Transport had decided not to take up the FFPS proposals but to contract Dr R. Oldham (Leicester Polytechnic) to carry out a survey of the toad population and migration habits and make recommendations. The remaining part of the pond was fenced with toad proof material and pitfall traps sited along it. The first toad arrivals were recorded on 12 March and by 19 March 138 had been collected. On the night of 19/20 and 20/21 March the main movement of individuals took place and 2,492 toads were trapped and transferred to holding pens. This number was far in excess of what was expected as the maximum number of individuals seen in previous years had been 250. Road casualties on those two nights totalled 182 of which about 60% were females. The trapping was stopped on 21 April by which time 4,084 toads had been taken from the pitfall traps. The male/female ratio was 1.5 to 1, a higher ratio than expected based on the results of other studies. The toads were released on 6 May after the time they would have bred. It was not until the autumn of 1988 that new breeding areas were created on the site. During 1989 two toad tunnels and associated fencing were constructed across the Brandon Road to try to reduce casualties in this part of the site. These tunnels together with the pipe passing beneath the Thetford bypass and associated toad fencing closely resemble Langton's original proposal and provide a partial solution to the problem of conserving the toad colony.

The outcome of the public enquiry into the alignment of the A11 near Wymondham will have to be awaited to find out how the road will affect a site with common toads and great crested newts (Herpetofauna Consultants International, 1989).

Much has been made of the use of garden ponds by amphibians and that they provide an alternative habitat to rural ponds, ditches, etc. Studies have shown that the frog is the most abundant breeding species in garden ponds, the common newt second and the toad third (Mathias, 1975; Beebee, 1979). Whilst toads may be present in gardens quite frequently they often do not breed and there is a need to make garden ponds more attractive to toads. Beebee (1979) suggests that whilst it has been shown that toad tadpoles are more or less immune to predation by newts and fish

(Cooke, 1974) they may be subject to predation by frog tadpoles. This predation is enhanced by the long period of immobility of the toad tadpole following hatching and at a time when frog tadpoles are free swimming. It would seem that tadpole interactions could be limiting the success of toads in garden ponds. As these ponds are smaller, on the whole, than rural ones it is not possible for toads to spawn away from frogs. The answer to this problem could be to construct ponds at least three feet deep and without shallow edges.

Garden ponds have become a notable feature of suburban areas in some parts of the country and they do provide a useful habitat for frogs and common newts. They do not however compensate for the loss of wetland, drainage dykes, field ponds and other amphibian breeding sites (Beebee, 1981). Landowners and farmers should receive real financial incentives to retain countryside features important to amphibians. Whilst these species are relatively widespread and common, consideration should be given to their conservation by all those involved in deciding the future of our countryside.

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I am particularly grateful to those who have collected together records from other observers and forwarded them to me: notably J. G. Goldsmith (Norwich Castle Museum), R. E. Jones (Lynn Museum), N. Gibbons (Thetford Natural History Society) and M. Jones (Suffolk Naturalists' Society). Thanks are also due to Stephen Bolwell for the use of his photographs, John Goldsmith and Joan Saul for putting all the records into the 'Recorder' system and Sue Goldsmith for typing the manuscript.

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J. Barrett
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L. Bensley
D. Billings
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E.F. Boosey
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E.C. Combe
B. Comford
H. Cooper
G. Coupland
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C. Cuthbert
E.T. Daniels
M. Danvers
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E.M. Daws
J. Dawson
L. Dearsley
H. Dollman
D.A. Dorling
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K.C. Durrant
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E.A. Ellis
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F.J.L. Farrow
J.L. Fenn
M.W. Ferguson
K.M. Ferroussat
A. Foster
S. Foster
C. Fowler
O. Fowler
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M. Gibbons
N. Gibbons
C. Gibson
N. Gibson
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M. Gosling
P.J. Gotham
N.E. Gotts
W. Grayson
C. Green
T.G. Green
B. Gregory
J.L. Gregory
E.M. Griffin
C. Gurney
R. Hadman
C. Haines
A.J. Hall
L.P. Hall
M.R. Hall
D. Hamond
P. Hardie
P. Hart
R. Harvey
G. Haslewood
M. Hassell
P.J. Heath
R. Hobbs
R.M. Holmes
M.D. Hooper
R. Hornby
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S. Kemp
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P. Keymer
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M. Lambert
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J. Larman
B.H. Lawfield
B.R. Lawrence
A.R. Leach
R. Leaney
T. Lemmon
B. Levey
S. Linsell
J. Lunn
R. Maidstone
R. Malt
R. Martins
D. Maxey
J. Mayhew
D. Mears
W. McMillan
M. Mills
P.D. Moore
R.M.C. Moore
C. Neale
G. Nobes
D. L. Ovenden
M. Parker
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D. Procter
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P. Riches
D.I. Richmond
R.M. Richmond
M.A. Robinson
R. Rose
J.H. Rounce
F.J. Russell
M. Rust
I. Sadd
J.J. Sambroke
K.G. Saul
H. Scott
A. Scowen
P. Scowen
S. Scowen
R. Scowen
D. Shynn
K. Siliprandi
K.C. Simmonds
I.J. Simper
K. Sims
I. Simpson
J.M. Sisley
D. Smith
J.E. Smith
P. Smith
R. Southwood
W. Squires
D. Stapleford
R. Starling
P.J. Steele
R. Stevenson
A.J. Stuart
V. Stuart
R.W. Thomas
N. Thompson
K. Thomson
R. Tilbrook
A.K.G. Tilford
S. Tolhurst
A. Tuck
T.J. Turner
M. Walker
R. Walker
R. Washbourn
G.D. Watts
M. Webber
S. Went
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I. White
M. White
H. Whitelegg
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RECENT CENTIPEDE RECORDS—Three records have been of note. In the first a long wait outside a house in Sedgeford, West Norfolk (TF7236), on 6 March 1991, prompted me to turn my attention to the rocks lining the drive. Under one were two individuals of *Brachyschendyla dentata* Brolemann & Ribaut, the second record for the vice-county.

The second is a new record for the county in the shape of *Cryptops parisi* Brolemann collected at South Creake (TF864356) on 5 March 1991. This species is much larger than the common *Cryptops hortensis* Leach which is widespread. It was under some rubbish which was dumped in a chalk pit. Its larger size and its distinctive deep amber colour made it obviously different when recognised as a scolopendromorph. Probably introduced and spreading, this species has not been recorded so far north before.

The third occurence also refers to a new county record. While collecting in a Norwich garden (TG223071) on 10 March 1991 I noticed a small geophilid with very long antennae which rolled into a ball. On examination it proved to be *Henia brevis* (Silvestri). It was found under some bricks along with *Haplophilus subterraneus* (Shaw) and the millipedes *Blaniulus guttulatus* (Fab.), *Allajulus* (formerly *Cylindroiulus*) *nitidus* (Verhoeff) and *Macrosternodesmus palicola* Brolemann. This is also the farthest north record of this species to date.

R.E. JONES, 14 Post Office Road, Dersingham, Norfolk PE31 6HP.

A CHECK LIST OF NORFOLK WATER MITES (HYDRACARINA)

R.K.H. Jones

"Broadlands", Station Road, Potter Heigham, Norfolk.

The only published work dealing specifically with water-mites in Norfolk is Soar (1905). The three volume Ray Society monograph by Soar and Williamson (1925-1929) gives the known distribution details for all the species that they mention.

From these volumes it is possible to find 86 species recorded from sites in Norfolk. Many of the names of water-mites have changed since these works were published and in this paper I have used the modern names as given in Gledhill and Viets (1976) throughout. Where species have been described in Soar and Williamson (1925-1929) under different names or by more than one name, I have listed the alternative names in brackets.

There are however three major changes in nomenclature which are confusing and need to be mentioned. The modern genus *Torrenticola* appears in Soar and Williamson as *Atractides*, *Atractides* appears as *Megapus*, and *Typhis* and *Pionopsis* will be found under the old generic name of *Acercus*. There are so many changes since 1905 that I have not drawn attention to them!

Of the species previously recorded I have been able to confirm the continued presence of 48 and have added a further 32, from collections made in 1984—1990. The following table gives the records of Soar and Williamson and myself in abbreviated form. A list of the abbreviations used is given at the end of the paper. A full list of records has been deposited in the Norfolk Biological Records Centre at the Castle Museum, Norwich.

	S. & W.	Jones
Super Family HYDRACHNOIDEA.		
Family Hydrachnidae.		
Hydrachna (Hydrachna) cruenta (H.scutata)	Ca,Hi,Wr	LM,SP
H. (H.) skorikowi (H.schneideri)	NB	
H. (Diplohydrachna) conjecta	N	LM,PH
H. (D.) georgei	NB	
H. (D.) globosa	Ca,Hs,In,Wr	
H. (Rhabdohydrachna) bivirgulata	Wr	
H. (R.) comosa	NB	
H. (R.) geographica		DP
H. (R.) halberti	NB	
H. (R.) leegei		FP
H. (R.) levis	NB	
H. (R.) williamsoni	NB	
Super Family EYLAOIDEA.		
Family Limnocharidae.		
Limnochares aquatica	NB	

Family Eylaidae.

Eylais bisinuosa	NB	
E. discreta		
(E. spinipons)	NB	
E. extendens (E. soari, E. similis,		
E. undulosa, E. triarcuata)	Ca	PH,SP
E. gigas	NB	SP
E. hamata	BM,Hi,PH,Wr	
E. infundibulifera	Ca	SP
E. koenikei	NB	
E. mulleri	Wr	

Family Piersigiidae.

Piersigia intermedia	NB	WT

Super Family HYDRYPHANTOIDEA

Family Hydryphantidae.

Hydryphantes dispar	PH,Wr	
H. ruber	Ca,Hs,In	FP,TC
Panisus michaeli		WT
Thyas pachystoma		
(T. venusta)	Sa,Wr	TC
Parathyas thoracata		
(T. thoracata.)	N	
Euthyas truncata		
(T. truncata.)	Ca,Hi,Ra	

Family Hydrodromidae.

Hydrodroma despiciens	NB	DP,SP

Super Family LEBERTOIDEA.

Family Sperchonidae.

Sperchonopsis verrucosa		BW,Rn
Sperchon clupeifer	NB	Bu,BW,Gl,Rn
S. glandulosus		HC
S. setiger		Bu,Rn
S. squamosus	Ra	HC
S. violaceus		Wo

Family Anisitsiellidae.

Bandakia concreta		WT

Family Lebertiidae.

Lebertia (Lebertia) fimbriate		RS
L. (Pilolebertia) insignis		BW,Ts
L. (Pilolebertia) porosa		Wi,RS
L. (Pseudolebertia) glabra		Ts,WT
L. (Hexalebertia) sefvei		HL
L. (Hexalebertia) stigmatifera		HC

Family Oxidae.		
Frontipoda musculus	PH,Su	
Oxus ovalis	NB	
O. strigatus	OB	
Family Torrenticolidae		
Torrenticola anomala		Wi
Super Family HYGROBATOIDEA.		
Family Limnesiidae.		
Limnesia fulgida	NB	FP,PH,WT
L. koenikei	OB	WT
L. maculata	Ca,Cl,Hi,Su,Wr	FP,LM,OB,RB, WT
L. undulata	Ca,Su	Su,WT
Family Hygrobatidae.		
Hygrobates calliger		BW,Gl,Th
H. fluviatilis (H. naicus)	PH	Bu,BW,Rn,RS, Wi
H. longipalpis	Ca,PH	Bu,BW,Th
H. nigromaculatus		Bu,Gl,Rn,SP, RS,Th
H. trigonicus	Ra	RS,Th
Atractides gibberipalpis		BW,Wi
A. nodipalpis		Rn,SM,Wi
A. spinipes	PH	Gl,Th
Family Unionicolidae.		
Unionicola (Unionicola)crassipes	PH,Su,Wr	BB
U. (Pentatax) aculeata		BB
U. (P.) bonzi	PH	
U. (P.) figularis	NB,PH	FP,WT
U. (P.) intermedia	PH	
U.(Parasitatax) ypsilophera	PH	BB
Neumania spinipes	In,PH	
N. vernalis	Su	
Family Pionidae.		
Huitfeldia rectipes	NB	
Piona alpicola (P. uncata)	BM,Ca,Hn	PH,RB
P. ambigua laminata (P. laminata)	Ca,NB	TC
P. carnea	PH,Sal,St,Wr	DP,OB,TC
P. clavicornis	Ca,NB	FP,TC,WT
P. coccinea	NB,PH	OB,PH,WT
P. conglobata	BM	FP,TC

P. longipalpis	Ca,PH	TC
P. neumani	NB	SP
P. nodata	Ca,Cl,PH,Su	TC,WT
P. obturbans	BM,Ca	TC
P. paucipora		FP
P. pusila (*P. rotunda, P. rotundoides*)	NB,Su	TC
P. variabilis	PH,Su	
Hydrochreutes ungulatus		SP,WT
Typhis latipes	Di	TC,WT
T. ornatus	Hi	FP,TC,WT
T. torris		FP,TC
T. (Pionides) ensifer	Ca,NB	
Pionopsis lutescens	Ca,PH,Su	FP
Pionacercus vatrax	PH	

Family Aturidae.

Brachypoda versicolor	OB,PH,Su,Wr	WT
Ljarnia bipapillata		HL,WT
Aturus scaber		BW,SM,RS,Wi

Super Family. ARRENUROIDEA.

Family Mideidae.

Midea orbiculata	Hn,PH,Su	OB

Family Mideopsidae

Mideopsis orbicularis	PH	

Family Arrenuridae.

Arrenurus (Arrenurus) affinis		DP,WT
A. (A.) albator	PH,Wr	DP
A. (A.) batillifer		WT
A. (A.) bruzelii	PH,Wr	WT
A. (A.) claviger	Hi,In,PH,Ra,Su	TC
A. (A.) compactus	Su	WT
A. (A.) crassicaudatus	OB,PH,RB	BB,WT
A. (A.) cuspidifer		WT
A. (A.) latus	PH	WT
A. (A.) leuckarti	Ra,Su	
A. (A.) maculator	Ca,NB,Su,Wr	TC,WT
A. (A.) ornatus	Su	
A. (A.) robustus	Ca	
A. (A.) tricuspidator	Ca,Su	
A. (A.) virens	Hi,Ra	
A. (Megaluracarus) adnatus freemani	Su	
A. (M.) buccinator (*A. caudatus*)	Ba,PH,Ra,Su,Wr	FP,TC,WT
A. (M.) globator (*A. tubulator*)	Ca,PH,Ra,Su,Wr	FP,TC,WT

A. (Truncaturus) fontinalis		HL
A. (T.) truncatellus		TC,WT
A. (Micruracurus) bifidicodulus		FP,TC,WT
A. (M.) brittanorum		
(A. novus)	Sh	
A. (M.) forpicatus	Su	
A. (M.) inexploratus		FP
A. (M.) integrator	Ra,Wr	
A. (M.) sinuator	Ca,Su	FP

Sites mentioned by Soar (1905) and Soar and Williamson (1925-1929):
Ba Barton, BM Burgh St. Margaret, Cl Calthorpe, Ca Catfield, Di Ditchington, Hi Hickling, Hn Horning, Hs Horsey, In Ingham, N Norfolk, NB Norfolk Broads, OB Ormesby Broad, PH Potter Heigham, Ra Ranworth, RB Rollesby Broad, Sa Salhouse, Sh Sheringham, St Stalham, Su Sutton, Wr Wroxham

Sites worked by the present author from 1984—1990.

BB	Black Horse Broad. TG3317
Bu	River Bure. TG1630
BW	Bylaugh Weir TG0218
DP	Devils Punch Bowl TL8789
Gl	River Glaven TG0603,TG0938
FP	Fritton Ponds TM2292
HC	Honing Common TG3326
HL	Holt Lowes TG0837
LM	Ludham Marshes TG
OB	Ormesby Broad TG4614
PH	Potter Heigham TG41,TG42
RB	Rollesby Broad TG4615
RN	River Nar TF7815
RS	River Stiffkey TF9235
SM	Swanton Morley weir TG0218
SP	Selbrigg Pond, Holt TG1039
Su	Sutton TG3823
Ts	Tiver Tas, Mill Lane ford TM2299
TC	Thompson Common TL9396
Th	River Thet TL9886
Wi	River Wissey TL8194
Wo	stream at Woodton TM2893
WT	West Tofts battle area TL89

There must be many more species yet to be found in the county and of the 118 species and sub-species in the above list, the full life-histories are known for a mere 53. There is therefore a great deal of scope for further work on the group.

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FURTHER RECORDS OF *DOLICHOVESPULA* WASPS IN NORFOLK INCLUDING A SECOND BRITISH RECORD OF *D. SAXONICA*.

A.G. Irwin

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Last year the large social wasp *Dolichovespula media* (Retzius) was added to the Norfolk List (Irwin, 1990). News of the Reedham nest was soon followed by a report of one in Norwich (Tilbrook, 1990). I observed this nest regularly during the summer and at the end of the season acquired it for the Castle Museum collections (Accession no. 191.990.109.1). Like the Reedham nest, it was constructed in a *Viburnum tinus* bush.

In addition, a further E. Norfolk site for *D. media* was discovered on 17 August 1990 by C. Reader and G. Coupland beside the R. Bure near Cockshoot Broad in the Bure Marshes NNR (TG344163). On 21 August 1990, I visited the site and observed workers of *D. media* feeding on *Angelica sylvestris* flowers with *D. sylvestris* (Scop.), *Vespula vulgaris* (L.) and *V. rufa* (L.). The large and often mainly black appearance of *D. media* is so characteristic that I am certain that it has not been overlooked previously and is undoubtedly a new arrival in the county. Its establishment should be welcomed, for it is a relatively docile species, much like the hornet, *Vespa crabro* L., in that respect.

On 20 August 1990, I received a package in the post containing a squashed male *Dolichovespula* which the sender's son had killed because he is allergic to wasp stings. It landed on him outside his grandparent's house in North Walsham (TG275305) on 17 August 1990. They noticed that the wasp was rather large, but only when they had been home, and read Rosemary Tilbrook's article did they return to the spot to search the pavement for the specimen. Luckily they found it and sent it to me in the hope that it might be *D. media*. Reference to the figures and key in Allen and Archer (1989) revealed it to be not *D. media*, but *D. saxonica* (Fabr.). This species was added to the British list on the basis of a single male found in Surrey on 31 July 1987 (Allen and Archer, 1989), but no further specimens have been recorded. It is widely distributed on the continent.

Hipperson (1991) records that the summer of 1990 involved an large immigration of moths, thus lending support to the idea that this male was a lone vagrant. A search of the area on 21 August 1990 revealed no evidence of a nest or females. The specimen is now in the Castle Museum collections (Accession no. 25.991).

Acknowledgements

Mrs Rosemary Tilbrook kindly put me in touch with Rad Spassitch, who protected the *D. media* nest in his Norwich garden and generously allowed me to collect it as well as tolerating my frequent visits. Charles Reader and Garth Coupland provided prompt and accurate details about the Bure Marshes site. I also thank Mrs M.P. Ghullam, and her son Zohair for taking the trouble to find the squashed *D. saxonica* without knowing what an exciting find it would be. Mike Archer kindly confirmed my identification of this specimen.

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THE ECHINODERMS OF NORFOLK

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Introduction

The echinoderms (the phylum Echinodermata = 'spiny-skinned' animals) have no collective English name, although each of the constituent classes does. These are the Crinoidea (crinoids, sea-lilies or feather-stars), Asteroidea (asteroids or starfishes), Echinoidea (echinoids or sea-urchins), Ophiuroidea (ophiuroids or brittlestars), and Holothuroidea (holothurians or sea-cucumbers), the basic differences between the classes being explained in most textbooks on seashore life and in greater detail in textbooks of invertebrate zoology. The most generally familiar are starfishes and sea-urchins, members of the other classes being often overlooked or misunderstood when caught. All British echinoderms are exclusively marine, although some of the hardier species can withstand brief and slight reductions in salinity. Mortensen (1927) is still adequate for the identification of all the echinoderms dealt with here, except *Henricia* spp, whose taxonomy has been revised by Rasmussen (1965). Mortensen's names are used here except where otherwise indicated.

Of the above classes, the crinoids have only one species that enters the shallower parts of the North Sea (apart from around Norway and Denmark), namely *Antedon bifida*, whose known distribution (Mortensen, 1927; Clark, 1970) does not yet include Norfolk waters, and probably never will under existing oceanographic conditions. Most Norfolk representatives of the other classes can be recognised at sight, although low-power to medium-power microscopy is needed to see the finer details of certain starfishes (*Henricia* spp.) and of most brittlestars and sea-cucumbers.

The Norfolk area and its echinoderm fauna

The Norfolk marine area (Fig. 1) was originally defined by Hamond (1969, p. 213) as extending eastwards from the coast of England, between the limits of 52°30'N and 54°00'N, to an easterly boundary at 03°00'E; this is here shifted westwards to 02°30'E to make it agree exactly with Marine Census Area 12 as described on p. 28 of Lincoln (1979) and p. 6 of Ingle (1980), but the maps (Figs. 1 to 3) have been drawn to include the 'lost slice' because of the many interesting records in or near it. The map-area is flanked closely along its northern and eastern sides by the records of Ursin (1960) and at some distance to the southeast by those of Wolff (1968). Taken together, these two surveys give a pretty good idea of what to expect here. For other records see below.

Reading anti-clockwise from the northwest corner of Fig. 1, the salient geographical features shown lettered are FH (Flamborough Head), HE (the Humber Estuary), W (the Wash), NFK (Norfolk), BW (the Blakeney-Wells area, defined by Hamond (1961, p.211 and Fig.1) as extending from the coast to 53°10'N between 00°50'E and 01°10' E), SK (Smith's Knoll), OB (the collective area of the Outer Banks), and OSP (the Outer Silver Pit). The narrow channels, running parallel to one another between the Outer Banks in the direction, but not with the spacing, indicated by dashed lines, make it difficult and dangerous to manoeuvre in them a vessel large enough to work a trawl, grab, or dredge of a suitable size, which accounts for the dearth of records in the OB area. The outlines of OB and SK are at 20 metres depth (maximum), and that of OSP is a minimum depth of 50 metres.

For the arrow on the eastern edge of Fig. 2, see *Amphiura*; in Fig. 3, the dashed line curving through the middle of the BW area is the approximate limit (northern extent unknown) of the fine sand and intermittently turbid water characteristic of the Wash and nearby.

Previous records of adult echinoderms in our area (for larval records see below) are cited individually only when necessary. Intertidally in the Scolt Head area, the records of Serventy (1934) and Gilson *et al.* (1944) are repeated, along with their own subsequent records, by Pantin *et al.* (1960). Offshore, Dipper *et al.* (1989) briefly surveyed the Wash, and Ursin (1960) cited the records due to Möbius and Bütschli (1875), Blegvad (1922), and Davis (1925), along with a great many more recent Danish records, but omitted those of Garstang (1901), Redeke and van Breemen (1904), Redeke (1907), and Anon. (1909). For Ellis (1968) see below, under "Other starfishes". In the present paper all the above are collated with the unpublished East Norfolk records in the late A.H. Patterson's notebooks (now in the Norfolk County Library, see Hamond 1971), as well as those of P.G.W. Trett and the late E.A. Ellis (all mainly from the Yarmouth and Lowestoft area) and the late R.A. Todd (see *Psolus*). My own unpublished records fall largely into two categories:

1. Intertidally between Cromer and Hunstanton. Of the collecting-sites described by Hamond (1963), Wells Rocks has been largely ruined for marine life by being concreted over, though chronic pollution in the adjacent Wells Quay may also be implicated (Hamond, 1972). The "Hjördis" has also suffered through natural decay aided by attempts to blow it up, so that at present neither of these places has anything like the wealth of marine life that it had in the 1950's and early 1960's.
2. Offshore, immediately north or northeast of the BW area (Hamond, 1963, 1969, for details and pre-1968 station-list) but most often within it. To the above list must be added several post-1985 dredge (D) and whelk-pot (W) stations, as well as a new series, BD, of samples taken from April 1989 onwards with a small box-dredge (to be described elsewhere); only D.60 and BD.10 (Appendix 1) contained echinoderms. The positions of all post-1985 stations were fixed by means of the Decca system. At D.60 the only echinoderms were *Henricia* spp., and the accompanying fauna and substrate differed so greatly from those taken at D.18, which was supposedly at exactly the same position on 2.9.1957, that either the sea-bed there has been drastically altered by waves and currents in the intervening period (which seems perfectly possible in such a wide expanse of shallow water exposed to strong winds at times), or the alleged co-ordinates for D.18 were mistaken. The latter seems unlikely because D.18 was taken only about 200-300 yards north of the Blakeney Overfalls Buoy in its position on that date, although it has since been re-positioned about 2.5 to 3.0 km (roughly 1.5 miles) further south-east.

My remaining unpublished offshore records were from rubbish trawled on either side of the northern boundary of our area by the Grimsby trawler "Romilly" in May 1950 and the King's Lynn beam-trawler "Seagull" on 15 and 16.6.1989. Detailed station-lists of both these trips will be published elsewhere. All Norfolk offshore records (except from the Wash and the BW area, where dense records would produce overcrowding on the maps), published and unpublished, are shown in Figs. 1 to 3, and the data for all these records (except from the above two trips by me) are listed in Appendix 1. A further reason for not mapping the Wash records is that Dipper *et al.* give very few precise localities except for one or two of the

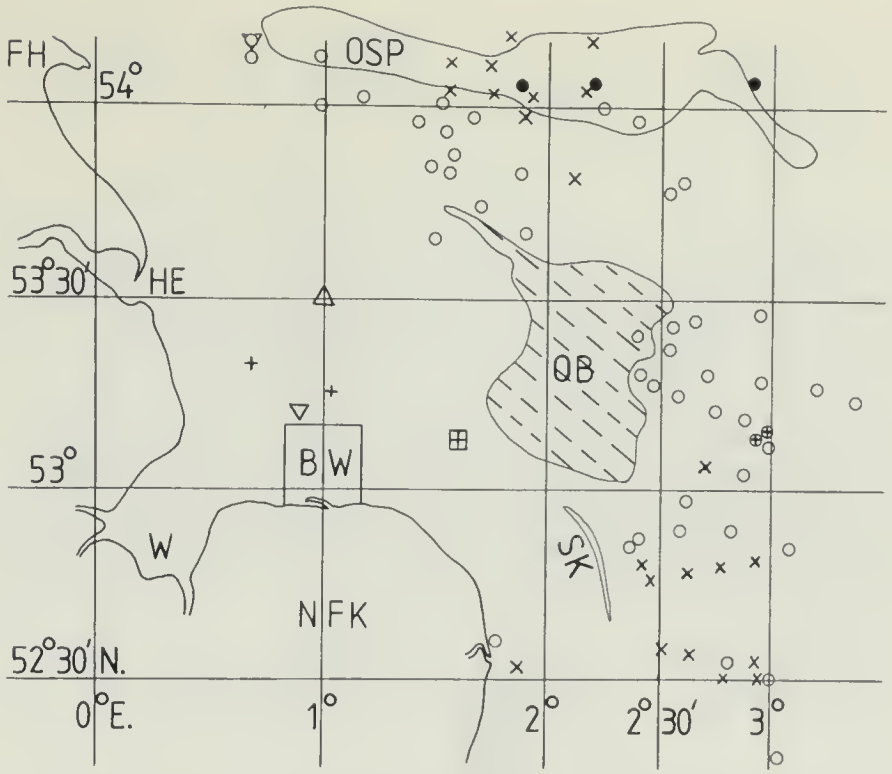

Fig. 1 ○ *Astropecten*, × *Echinocyamus*, □ *Psolus*, ● *Brissopsis*
+ unidentified *Henricia*, △ *H. perforata*, ▽ *H. sanguinolenta*

commonest species. The various species are allocated to Figs. 1, 2, or 3 in such a way as to minimise clashing (i.e. the superimposition of symbols belonging to more than one species taken in the same haul), although its complete elimination would have needed several more maps.

Apart from my stay in Australia (1968 to 1985) my records extend from 1949 to the present day, so that this paper refers to pre-1968 records except where specifically indicated, but has been brought up to date overall. Only those species, which I regard as reliably recorded (by myself or others) from within the Norfolk area, are numbered. At the end of each class are given the names of those whose identifications are either doubtful, or reliable but from outside the Norfolk area. The numbered species are listed in the order given by Mortensen (1927) and Ursin (1960). Where an echinoderm is referred to simply by its generic name, this means that there is only the one species of that genus in our area anyway, and likewise the reference to an author's name without a date implies that only one paper by him is cited here. In either case the text is considerably lightened without any risk of confusion.

The foregoing refers entirely to adults; larvae are seldom numerous in the BW area (the only inshore part of the Norfolk area in which many plankton hauls have been taken, all by me), and, given the difficulty of identifying many of them, agree fairly well with the descriptions and figures of Rees (1953) and Mortensen. Ursin describes the young bottom-stages of certain species, which may differ considerably from their respective adults.

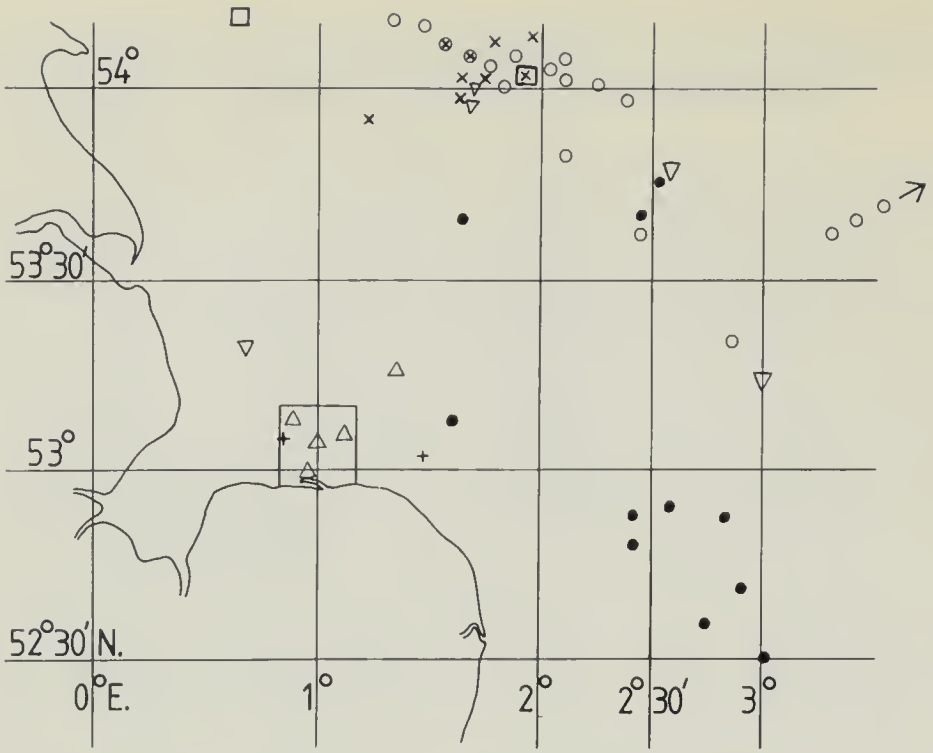

Fig. 2 ○ *Amphiura*, ● *Spatangus*, × *Acrocnida*, ▽ *Ophiothrix* + *Ophiopholis*, □ *Luidia sarsi*, △ *Amphipholis*

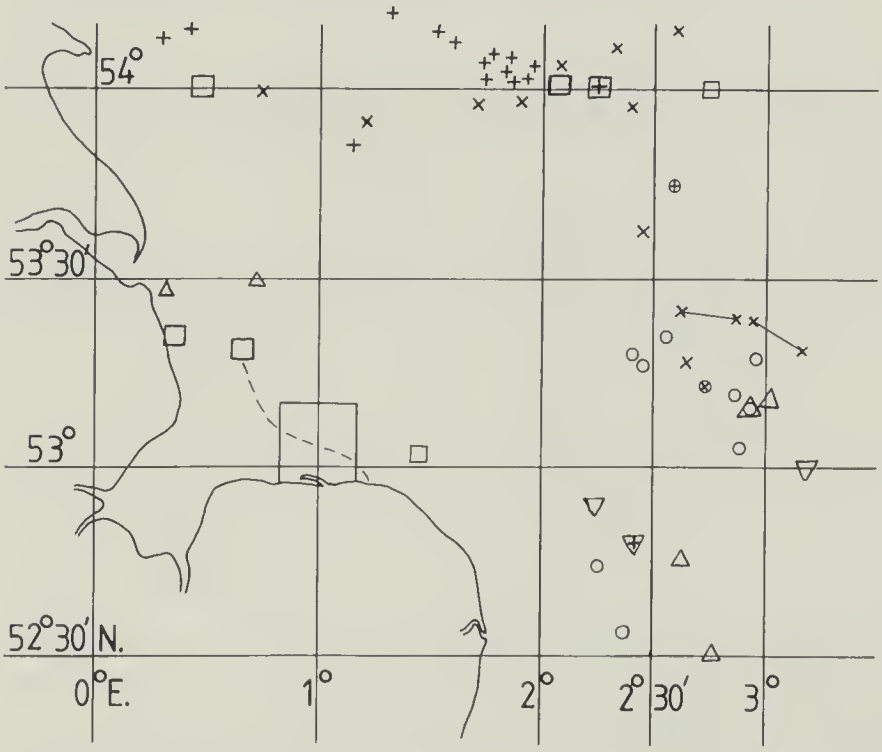

Fig. 3 ▽ *Ophiura affinis*, ○ *O. texturata*, + *O. albida* × *Echinocardium*, △ *Echinus*, □ *Crossaster*

SYSTEMATIC LIST
(for ecological details see next section)

Asteroidea

1. *Astropecten irregularis* (Pennant) Figs 1 & 4.

The only inshore Norfolk record is that of a specimen washed up on Yarmouth beach on 24.11.1893, of which Patterson gives a clearly identifiable coloured sketch in his notes. All the offshore Norfolk records (which lie east of a line from 52°30'N 02°30'E to 54°00'N 00°40'E) fall into two groups separated by an apparently empty area just east of the northernmost part of the Outer Banks, and the records of the southern group in Fig. 1 also show how this species does not overlap to any great extent with *Echinocyamus*. Numerous evenly-spread samples, all over the Norfolk area and beyond, with comprehensive and commensurate details of the substrate at each sampling site, are needed to confirm the possibility that certain echinoderms (such as *Astropecten*) have very limited substrate preferences, and if possible to explain why.

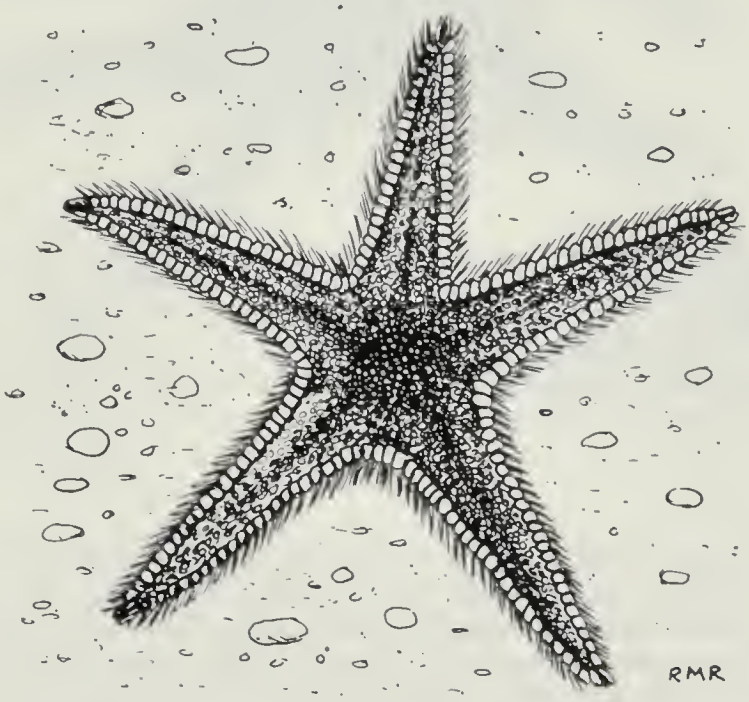

Fig. 4 *Astropecten irregularis*

2. *Crossaster papposus* (L.) (=*Solaster papposus* in Mortensen) Figs 3 & 5.

Intertidally, this species may be cast ashore anywhere even if only seldom, but it is found living only at extreme low water along the western edge (rarely elsewhere) of Hunstanton Scaup (Hamond, 1963, pp. 6,7), usually in company with one of its favourite foods, the common starfish *Asterias*, in what may more accurately be regarded as the uppermost limit of the subtidal. Offshore in the Norfolk area it may

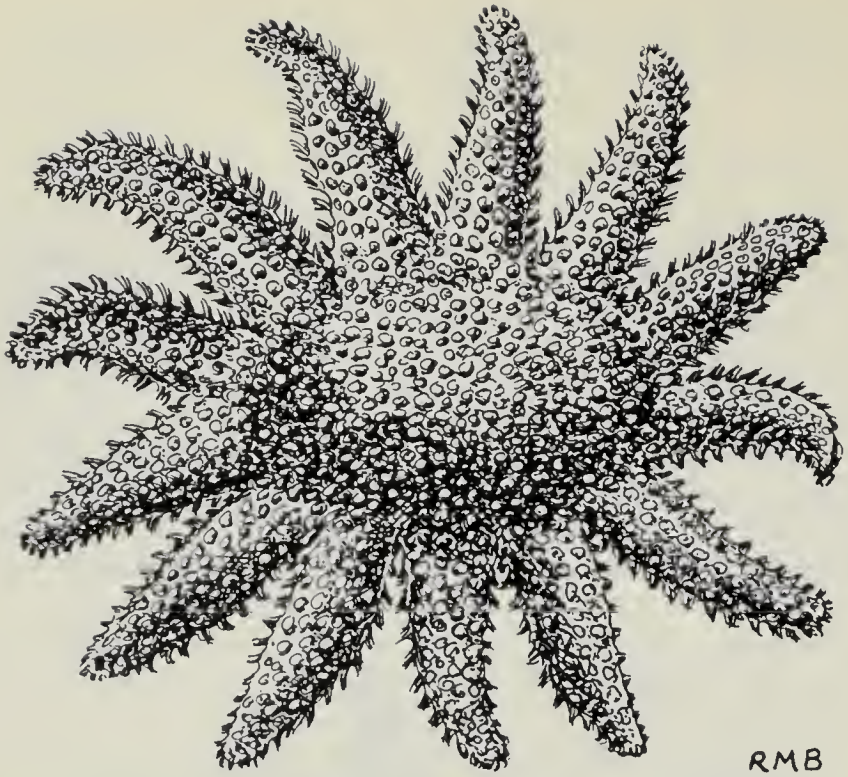

Fig. 5 *Crossaster papposus*

be dredged on almost any bottom except pure sand. Among a working day's catch of whelks (Hamond, 1969, p.216) any number from 1 to 20 (or sometimes even more) *Crossaster* may be taken in a single day, or on a succession of days, all in the same restricted offshore area, after which no more will be caught there for perhaps several weeks, suggesting that *Crossaster* tends to move about in droves.

[*Solaster endeca* (L.)

Previously recorded at several places off the east coasts of Scotland and England, the furthest south of these being off Scarborough (Ursin, Fig. 21), and therefore may perhaps occur in Norfolk waters on rare occasions. However, the record of Dipper *et al.* from an unspecified locality in the Wash is unverifiable because the specimen was not preserved and may even have been identified on the bottom by a diver without being collected (a most unreliable procedure in an area known to be inhabited by an allied species, *Crossaster*).]

3 & 4. *Henricia* spp. Fig. 1.

In Fig. 1, only those post-1985 specimens identified by me using Rasmussen (1965) are recorded as *perforata* (O.F. Müller) or the true *sanguinolenta* (O.F. Müller). My pre-1968 records included both species, but must be regarded as indeterminate. (They were all from within the BW area, and a selection of them was preserved in one jar, without regard as to whether they came from East or West Runton or offshore.)

The record of Dipper *et al.* from somewhere in the Wash and almost all those recorded by previous authors must also be considered indeterminate. A single specimen taken by Ursin (pers. comm.) in an unnumbered sample from a herring-trawl in search of whiting in 1956 (no date) at 53°30'N 01°00'E was accompanied by "a rich and varied fauna, apparently similar to that found more northerly on the British coast " (Ursin, 1960, p. 34), and was subsequently identified by Rasmussen as *perforata*. The record of *sanguinolenta* just outside the northern edge of the BW area refers to a large specimen (now in the Norwich Castle Museum, accession number 27.991) collected on 29.9.1989 by A. Randell from a crab-pot very close to 53°13'N 00°52'E in 10 to 13 metres on an irregularly sloping bottom of shells and stones with some sand. I did not consider it worth assigning a station number to this find of just a single specimen.

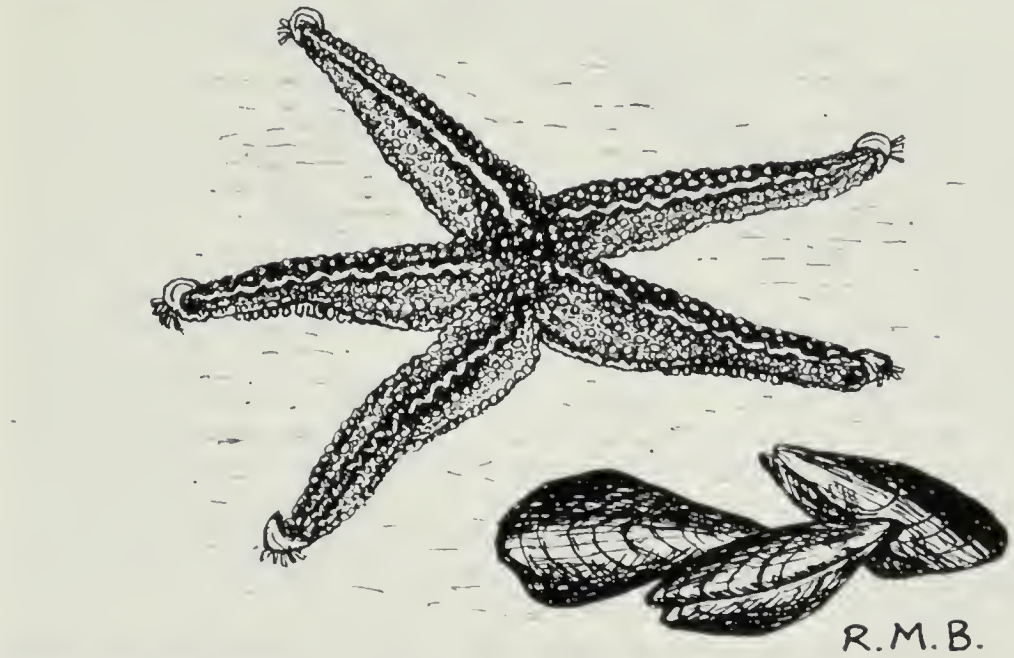

Fig. 6 *Asterias rubens*

5. Asterias rubens L., not mapped, Fig.6.

Records of this species are not shown in Figs. 1 to 3 because the maps would be overcrowded if they were. This commonest of all shallow-water northwest-European starfishes was found in almost every one of Ursin's trawl catches all over the North Sea in less than about 100 metres, but surprisingly seldom in his grab hauls. In the Norfolk area it is widespread offshore on any substrate having rocks, stones, or shells to which it can cling, being recorded on such substrates there by all previous authors. Intertidally it cannot survive exposure for more than about an hour, except by keeping cool and moist under rocks, stones, shells, or thick mats of algae. In these circumstances it may be found on the shore anywhere between Cromer and Hunstanton except on clean sand or where (as in or near estuaries) the salinity is markedly less than fully marine. It is never more than moderately numerous except at West Runton, or on Hunstanton Scaup at extreme low water where it may sometimes be abundant.

Other starfishes

For reasons explained on pp. 209 and 210 of Hamond (1969), marine invertebrates which are common near the Norfolk marine area but have so far been found within it seldom or not at all, are mainly of northern (i.e. Northumbrian), rather than of southern (i.e. Channel), origin. Ursin's collated records show the southern limits of several species of echinoderm which are common further north. These limits are at about 55°N for *Leptasterias mülleri* and *Stichastrella rosea*, 54°30'N for *Hippasteria phrygiana* and *Anseropoda placenta* (= *Palmipes membranaceus* in Mortensen, but see e.g. Gouillou and Diop, 1988), and 54°N for *Luidia sarsi* and *L. ciliaris*. In Fig. 2 the record of *L. sarsi* east of Flamborough Head is based on a specimen that I found in the scuppers shortly after the "Romilly" had trawled at or near 54°10'N 00°40'E on 1.5.1950. Ellis (1968) recorded two specimens of the deep-water starfish *Ceramaster granularis* and one of the ophiuroid *Gorgonocephalus caput-medusae* cast ashore at Pakefield, perhaps after drifting from their normal habitat around the Shetlands but more likely after being thrown overboard not far away by a trawler having a final clean-up before entering Lowestoft. These specimens are now in the Norwich Castle Museum collections, accession numbers 2.990.2 and 2.990.1. As Pakefield lies just south of 52° 30'N, these are, strictly speaking, Suffolk rather than Norfolk records. The same applies to the specimen of *A. placenta* taken off Lowestoft on 8.1.1949 and presented to Southwold Museum by George Quantrill, and to a fine preserved specimen of the same species which was in the old Fisheries Laboratory at Lowestoft in the early 1950's before that institution, in the course of moving to its present site in Pakefield, discarded a great deal of old preserved material. This latter specimen, too, was from an unspecified locality not far from Lowestoft. With records of *A. placenta* from either side of the Norfolk area, it is perhaps only a question of time before this species is found within it.

Ophiuroidea

6. *Ophiothrix fragilis* (Abildgaard) Figs 2 & 7.

Very common sublittorally west of the dashed line in Fig. 3, including the Wash (Dipper et al.), and extremely abundant off Yarmouth (*fide* P.G.W. Trett); in small numbers all over the BW area and sporadically beyond it (Fig. 2). Widespread in nearly all the shallower parts of the North Sea (Ursin) except where unable to find a firm support (Wolff). Intertidally it is found most often under stones, shells, or (preferably) green clumps of the sponge *Halichondria panicea*, at extreme low water on Hunstanton Scaup; it is less common at West Runton and (before 1968) under Wells Rocks. Its association here, as elsewhere, with *Alcyonium* as well as with *H. panicea*, indicates its preference for a strong current from which it can filter its food (cf. Ursin, p. 39), although it can feed by other means if necessary (Roushdy and Hansen, 1960).

7. *Ophiopholis aculeata* (L.) Fig. 2.

Apart from Möbius and Bütschli's record in Appendix 1, and an arm-fragment with the characteristic hooked spines (Mortensen's Fig. 116/3) at D.57, there are no records of adults on or near the east coast of England south of 54°N. Many plutei (larvae), possibly but not certainly of this species, were taken in Blakeney Harbour plankton on 19.7.1957.

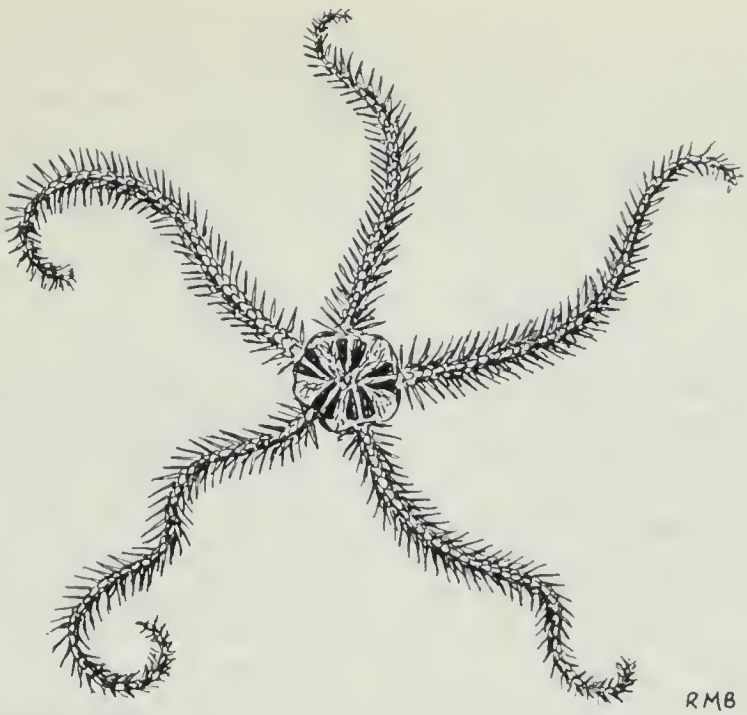

Fig. 7 *Ophiothrix fragilis*

8. *Amphiura filiformis* (O.F. Müller) Fig. 2.

The distribution of this species is very similar to that of *Astropecten*. They prefer the same range of substrates and are often caught together. The finds in Fig. 2 are the southernmost in this predominantly central and northern North Sea species (Ursin) which probably does not reach Dutch waters (Wolff). The arrow on the right of Fig. 2 means that the line of records continues further northeast as in Ursin's Fig. 30.

9. *Acrocnida brachiata* (Montagu) Fig. 2.

Ursin's Fig. 34 shows how the undoubted records of this species are largely confined to two patches in the North Sea, one off the west coast of Jutland and the other (of very numerous records densely packed together) curving round the southwest end of the Dogger Bank so that its southern tip just reaches into the north of our area, where the distribution of *Acrocnida* is very like that of *Astropecten* and *Amphiura*. However, from the table on Ursin's p. 51, it seems that *Acrocnida* occurs "primarily on fine sand and muddy sand, whereas *Amphiura filiformis*. . . is confined to muddy sand and clayey sand".

The suggestion by Ursin (p.43), that many North Sea records of alleged *Amphiura chiajei* on more or less sandy substrates in depths of less than about 40 or 50 metres (his Fig. 29, open symbols) might have been due to confusion with *Acrocnida*, may well have been true of the supposed *A. chiajei* found off Sizewell (Suffolk) on a mixture of sand and gravel in 1—12 metres by Bamber and Coughlan (1980). Unfortunately this material is now lost (Bamber, pers. comm.). Genuine *A. chiajei* is found in the North Sea only on soft mud bottoms in northern waters 120

to 150 metres deep (Ursin, filled-in symbols in Fig. 29), whence on the west side it extends southwards to off Northumberland in depths of 60 to 100 metres (Buchanan, 1963). It has never been found among the numerous samples in the Outer Silver Pit, the only place near the Norfolk area where it is even marginally likely to occur. All future specimens of ophiuroids taken in or near the Norfolk area (and elsewhere in the North Sea) will have to be examined very carefully if this confusion is to be cleared up.

10. *Amphipholis squamata* (delle Chiaje), Fig. 2.

Common in Blakeney Harbour (under stones and mussels on the Strond, in the Strond Pool Dam pre-1968, around the Freshes Stake, and on the Freshes Lays) and at West Runton (under rocks and among *Corallina*); also one at East Runton on 11.7.1959, and occasionally at Hunstanton (a few under shells and stones on the Scaup on 31.7.1969, and a tiny one on 2.4.1957 under the Pier which was demolished in the great storm of 1977). The offshore records in Fig. 2, from west to east, refer to one specimen at D.15, 4 in bottom plankton at 52°59'45"N 00°58'24"E on 14.9.1963; 6 at D.18; 6 at W.30; and 7 at BD.10. The last named haul is well to the northeast of the BW area, whereas the others are all inside it. The largest specimen at W.30 contained 7 or 8 embryos, and another rather smaller one bore what is still the only recorded Norfolk specimen of *Cancerilla* (Hamond, 1961, Fig.1, and 1973, p.343). All the offshore specimens were otherwise far too small to be capable of breeding. Dipper *et al.* record it from the Wash.

11. *Ophiura texturata* Lamarck Fig. 3.

Mainly offshore, where it seems to prefer somewhat muddy sand, usually among much larger numbers of *O. albida*, at least west of the dashed line in Fig. 3 (Dipper *et al.*; own records), whereas in the eastern and northern parts of our area *O. albida* is found mostly north, but *O. texturata* south-east, of the Outer Banks (OB in Fig. 1). Ursin (Fig. 37) records it from most of the shallow North Sea except on top of the Dogger Bank, and Wolff records it at more sites within the Dutch deltaic system than in the open sea nearby. Intertidally, the occasional specimen may be found at extreme low water anywhere from just west of Blakeney Harbour to Hunstanton, including the outside of Scolt Head (Pantin *et al.*) It always occurs on sand, except on the stony flats of Hunstanton Scaup where it may be found with scattered *O. albida*.

12. *Ophiura albida* Forbes Fig. 3.

This species is enormously abundant in certain dredgings in the BW area (Hamond, 1963, pp. 5 and 18), very common in many parts of the Wash (Dipper *et al.*), and widespread around the Dogger Bank as well as to the northeast, east, and south of it, as far as the Outer Silver Pit (compare Fig. 3 with Fig. 1), but is much scarcer to the north and northwest of it except along the east coast of Scotland (Ursin, Fig. 57). Intertidally it is found only at extreme low water on Hunstanton Scaup, mainly along the west side. The very distinctive larva (Mortensen, Fig. 88/4) has been taken several times in June and July (in spite of the plankton-net being clogged with the alga *Phaeocystis*) and once in October, all in or near Blakeney Harbour.

13. *Ophiura affinis* Lntken Fig. 3.

So far there are only two records in the Norfolk area, east of Norfolk, and just outside it a third further east again. There are many records around the Dogger Bank (Ursin) and in offshore Dutch waters (Wolff, Fig. 7), but only a few off Northumberland (Buchanan, 1966), and the few specimens found off Sizewell by Bamber and Coughlan have since been lost (cf. *Acrocnida*, above). Of these authors Wolff is the only one who directly relates the abundance of this species to coarse sands lying well offshore, in contrast to *O. albida* which he finds almost entirely inshore and on finer sands. This entirely agrees with the finds in the Wash (Dipper *et al.*), off North Norfolk (by me) (both of *O. albida* only, and on fine sands), and off Sizewell of both species on patches of coarse and fine sand. Lack of data makes it impossible here to suggest any plausible explanation for the remarkable agreement between the respective distributions of three of Ursin's species (*O. affinis* in Fig. 44, *Echinocyamus* in Fig. 50, and *Echinocardium flavescens*, a species not otherwise mentioned in the present paper, in the right hand half of Fig. 55), in being thickly distributed all over the northern slope of the Dogger Bank but only sparsely so elsewhere.

Other brittlestars

There are two species most likely to occur, although very rarely at best. The first is *Ophiura sarsi* known from the Cullercoats Marine Area (off the Farne Islands in Ursin's Fig. 42, although it is not mentioned by Buchanan, 1966) and from two records (doubtful until confirmed) of single specimens dredged respectively by Bamber and Coughlan off Sizewell and by Newell (1954) off Whitstable. The other is *Paramphiura punctata*, known from only two specimens, one from the Dogger Bank area and the other from the Straits of Dover. A further three species (*Ophiactis balli*, *Ophiocomina nigra*, and *Ophiura robusta*) are not known on the east coast further south than the Cullercoats Marine Area (Ursin, Figs. 26 and 42; Buchanan, 1966).

Echinoidea

14. *Psammechinus miliaris* (Gmelin) not mapped.

As with *Asterias*, to include all the very numerous records would be to clutter up the map to such an extent as to make it impossible to include any other species, without serving any useful purpose. However, it is much more common west of the dashed line in Fig. 3 than east of it, preferably on sand with shells and stones to which it can adhere, often so as to cover itself more or less completely. Intertidally it has been found occasionally (sometimes in large numbers) near low water on Hunstanton Scaup, and singly or in small numbers in the western part of Blakeney Harbour wherever shelly and stony ground is kept permanently wet by outflowing sea-water draining from the Pit at low tide (thus mainly in the Freshes Lays and the Run). The only record from West Runton is by H.D. Geldart (in Garstang, 1901). The records of Cranmer (1985), Ursin, and earlier authors entirely bear out the offshore habitat-preferences given above, and Wolff's finding that in Dutch waters this species prefers firm hard substrates is probably due to a lack offshore of loose hard substrates, and not to inadequate sampling as he suggests. However, this species

can (albeit rarely) be found on almost any other substrate except pure sand or thick mud. Planktonic larvae have been seen here in May, June (sometimes numerous),and July.

15. *Echinus esculentus* (L.) Fig. 3.

Very scarce in the BW area in dredgings and whelkpots, exclusively on the harder substrates, where it overlaps with *Psammechinus*, although the only time I ever found them together was at D.15 (one *Echinus* with a few *Psammechinus*). However, as many as 20 or 30 were taken during June, July and August 1960 in whelkpots between the Blakeney Overfalls Buoy and the Sheringham Shoal Buoy. Divers (*fide* P.G.W. Trett and others) find scattered specimens on stones or on hard chalk, within about 5 km of the shore, and numerous specimens in wrecks (mostly further offshore than this) from Yarmouth to Sheringham. In Fig. 3, the record off the mouth of the Humber is due to Cranmer (1985, Fig. 1C), and that east of it refers to about 10 of middling size, trawled in 24 metres over rough ground with coarse shells at 53°30'N 00°42'E, in the Inner Silver Pit, on 16.6.1989 (my last haul on board the "Seagull"). This species is the converse of *Psammechinus* in that it prefers firm (as opposed to loose) hard ground, does not cover itself up with shells and stones, never occurs above low-water mark on Norfolk shores, and is commoner east of the dashed line in Fig. 3 than west of it (being unrecorded from the Wash). The only larva seen here was a stage II pluteus after dark in high-tide plankton in the Pit of Blakeney Harbour on 19.7.1957.

16. *Echinocyamus pusillus* (O.F. Müller) Fig. 1.

Both in the Norfolk area (Figs. 1 and 3) and in the North Sea as a whole (Ursin, Figs. 44 and 50; Wolff, figs. 7 and 9) the distribution of this species agrees closely with that of *O. affinis*, both having apparently much the same preference for coarse sand (but see Ursin p. 73 for a discussion of the apparently variable substrate-preferences of this species) as well as a tendency to be more numerous along the northern slope of the Dogger Bank (see under *O. affinis*). As with *Astropecten* (q.v.), all its Norfolk records lie east of the line mentioned under that species, and the records are divided into two groups separated by the area of the Outer Banks. On the other hand *Echinocyamus* and *Astropecten* seldom occur together in our area.

17. *Spatangus purpureus* O.F. Müller Fig. 2.

The scattered distribution (Ursin's Fig. 52) and apparent substrate preferences in the open North Sea are very much as for *Echinocyamus*, but with many more records in the northern than in the southern half, except for the cluster of records between East Anglia and Holland (where, however, Wolff recorded it only once, 30 km offshore on coarse sand), and without any tendency for its records to be denser along any given slope of the Dogger Bank although they are conspicuously lacking on top of it. All the Norfolk records lie east of the line mentioned under *Astropecten*. Of the two furthest west, that slightly east of the BW area was of a single specimen taken with *Psolus* (see below) and the other, due north of it, of another single specimen trawled on hard ground with sand and some mud by the "Romilly" in 15 fathoms at 53°39'N 01°39'E.

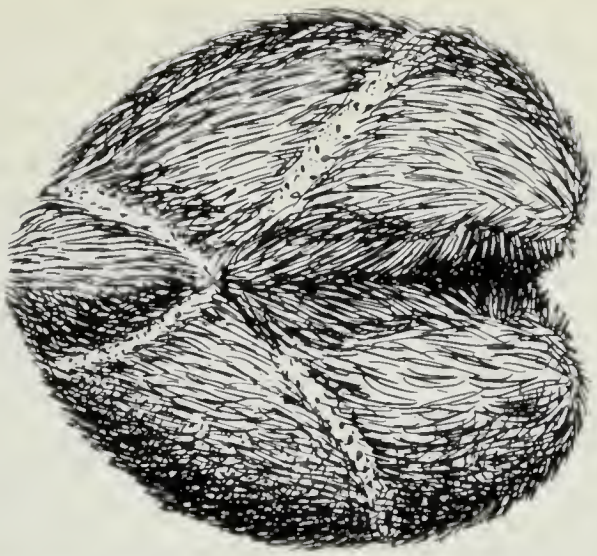

Fig. 8 *Echinocardium cordatum*

18. *Echinocardium cordatum* (Pennant) Figs 3 & 8.

Dead tests may be found at high-water mark along most Norfolk shores, but the living animal must be dug for in clean sand at extreme low-water mark, certainly at Holkham (where I found it buried about 15 to 20 cms deep) and possibly all along the coast from just west of Blakeney Harbour to east of Hunstanton Scaup. Dipper *et al.* found occasional specimens in a wide variety of sublittoral sandy bottoms mixed with mud, gravel, or shells, agreeing closely with the findings of Ursin, Wolff, and myself (one at D.31 and about a hundred, none more than about 10 mm long, at D.36).

The closely related *E. flavescens* (O.F. Müller) also occurs over much of the central North Sea (Ursin, Fig. 55), but has not yet been found in the Norfolk area, the most southwesterly records being in the Outer Silver Pit (omitted from Figs. 1 to 3 because of lack of room for them). Most specimens of *Echinocardium* are unambiguously identifiable at sight according to whether the frontal ambulacrum is flush with the test (*flavescens*) or sunk in a distinct groove (*cordatum*); but in a minority of specimens from the North Sea north of the Dogger Bank (where both species occur) this groove is poorly defined, making it necessary to examine the minute but very reliable characters of the pedicellariae under the microscope (a delicate and time-consuming process). Fortunately this was not necessary with any of the Norfolk specimens seen by me, in all of which the groove was quite distinct.

[*Brissopsis lyrifera* (Forbes) Fig. 1.

The Outer Silver Pit is the only place anywhere near the Norfolk area where this species can find its strongly preferred substrate of thick clay. However it is included here because such a substrate may be found within our area one day, and also because plutei, tentatively ascribed to this species, were taken in Blakeney Harbour plankton on 5.6.1954 (exceedingly abundant, and luminescent), a few on 22.6.1954, and many on 19.7.1957.]

Holothuroidea

19. *Thyone fusus* (O.F. Müller), not mapped.

All those dredged by me in the BW area consist either of very small ones which had only just metamorphosed and were therefore unidentifiable save for the definitively characteristic bodywall deposits (5 at D.20, 3 at D.23, one at D.45, and one at D.52), or small adults about 30 mm long when extended (one at D.52 and one at D.54). However, Mortensen says that it can grow to a maximum length of about 200 mm, and that its southern limit along the east coast is Northumberland. It is rare in most of the North Sea. Ursin's Fig. 59 shows only two records close together at about the middle of the three records of *Brissopsis* in the present Fig. 1, two near the east coast at unspecified localities near Newcastle and St. Abbs respectively, two more together west of Denmark, and one near Helgoland. Wolff (p. 81) excludes it from the Dutch fauna. Dipper *et al.* recorded it from the Wash by name only. Buchanan (1966) records it as common in 20 to 40 fathoms on stones and gravelly sands off Northumberland. This almost exactly describes the substrate at D.52 and D. 54, whereas the three preceding stations had rather few stones but abundant coarse dead bivalve-shells such as *Ostrea* and *Modiolus*. This suggests that large dead shells provide shelter for the young stages, whereas larger ones require heavier objects (stones rather than shells) to stick to, in order to withstand the strong tidal currents that bring them the food-quantities they require.

20. *Psolus phantapus* (Strussenfeldt) Fig. 1.

Cited by the late R. A. Todd in an unpublished manuscript (now in Norwich Castle Museum) from station HXX (see Fig. 1 and p. 214 of Hamond, 1969); otherwise only from off Northumberland (Buchanan, 1966), between there and the Dogger Bank as well as northwest of Denmark (Ursin, Fig. 59), and as far south as Yorkshire (Mortensen).

Other sea-cucumbers

Ursin's Figs. 58, 59 and 60 show the central part of the Outer Silver Pit as containing *Cucumaria elongata* and *C. planci* (this record being the first for the North Sea of this species). Of several other North Sea species not yet found so near our area, *Thyonidium commune* deserves a special mention in that one of its recorded finds (in Ursin's Fig. 59) lies far to the north, and the other (in Wolff's Fig. 4, cf. also his p. 79) fairly far to the south, of our area (cf. *Paramphiura*, above). Wolff had more than one specimen with his single specimen of *Spatangus*, but their respective records in Ursin's Figs. 52 and 59 do not coincide, although they are not far apart.

Summary of ecological preferences.

Substrate:

1. Pure thick clay:
   Brissopsis, *Cucumaria elegans*, *C. planci.*

2. Mostly clay or mud, with a small proportion of coarse sand:
   Echinocyamus.

3. Mostly clay or mud with a small proportion of fine sand:
Amphiura, *O. texturata*, *O albida*.
4. Mostly clay or mud with some sand (coarse or fine):
Astropecten, *Amphiura*.
5. Fine sand with a small amount of mud (often as suspended silt whose degree of precipitation varies with the tidal cycle):
Acrocnida, *O.albida*, *O. texturata*, *Echinocardium*. It is possible that *Acrocnida* should be described as preferring a small amount of clay rather than silt.
6. Shells and stones with some coarse sand:
Anseropoda, *Spatangus*, *O. affinis*, *Echinocyamus*.
7. Shells and stones with some fine sand:
Asterias, *Henricia*, *Psammechinus*, and less often *Crossaster*, *Ophiopholis*, *Amphipholis*, *Echinus*, and *Thyone*.
8. Solid hard ground, especially wrecks:
Echinus, *Ophiothrix*, and in smaller numbers *Asterias*, *Crossaster*, and *Psammechinus*
9. Uncertain preferences:
Luidia, *Solaster*, and *Psolus*.

Other ecological factors:

1. Salinity, temperature, and water characterised by *Sagitta elegans* or *S. setosa*, are discussed vis-à-vis the North Sea echinoderms by Ursin and in more general terms for the Norfolk area by Hamond (1967, 1969).
2. Depth. Only *Amphipholis* is almost entirely restricted to the shore, and only *Brissopsis* prefers really deep water (though this may well be a function of substrate as much as, or more than, one of depth). All the others can live in almost any depth available in the Norfolk area, and, with the exception of *Astropecten*, *Ophiopholis*, *Amphiura*, *Acrocnida*, *O. affinis*, *Echinus*, *Echinocyamus*, *Spatangus*, *Thyone*, and *Psolus*, may occur intertidally.
3. Rheophile species, i.e. those which need a strong current to bring a continuous supply of food, are *Henricia* (both species), *Ophiothrix*, *Ophiopholis*, and possibly *Thyone*.
4. High tolerance of turbidity, due to waterborne silt-content. Those recorded from the Wash by Dipper *et al.*, namely *Asterias* and *O. albida*, and to a lesser extent *Amphipholis*, *Crossaster*, *Echinocardium*, *Henricia* (both species), *Ophiothrix*, *O. texturata*, *Psammechinus*, *Solaster* (if valid), and *Thyone*.

These preferences are not binding, but merely hint at the animals' most obvious requirements. Some species appear in more than one category.

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Appendix 1

This lists the stations mentioned in this paper from in or near the Norfolk area at which were taken echinoderms (cited here under their modern names) other than the two most widespread ones, *Asterias* and *Psammechinus*. Most records in our area of these two species occur west of the dashed line in fig. 3, as do most of those of *Crossaster*, *Ophiothrix*, *Ophiura albida*, *O. texturata*, and *Echinocardium*. Also included are some records of certain other species recorded individually from the Wash by Dipper *et al.*, or from the north coast of Norfolk (intertidally or offshore) as indicated above. References are given in chronological order, and vessels' names are in inverted commas.

Möbius & Bütschli (1875), "Pommerania" (see Ursin's Fig. 11):P.105 *Astropecten*, *Crossaster*, *Amphiura*, *O. albida*.
P.107 *Crossaster*, *Ophiopholis*.
No echinoderms at P.106 or at P.108 to P.112.

Redeke & van Breemen (1904), "Nelly", station E, 53°52'N 01°10'E, coarse sand with shells and stones in 36 metres on 3.8.1901. A few *O. albida*.

Redeke (1907), "Wodan" stn. 60, 54°05'N 02°57'E, thick clay in 68 metres on 3.8.1906 (see Ursin's Fig. 12). 3 large *Brissopsis*.

Anon. (1909), "Huxley". Trawl-hauls containing echinoderms; only the mean positions of hauls are shown in Figs. 1 to 3, except for two unusually long-distance hauls in Fig. 3 (for *Echinocardium*). Abbreviations (mostly of characters of the substrates) are—NTD, no towing data; SNR, substrate not recorded; bk, black; br, brown; c, coarse; cl, clay; d, dark; f, fine; g, grey; gv, gravel; h, hauled (the trawl aboard); l, light; m, mud; s, sand; sh, shells; spk, speckled; st, stones. Ooze = "fine mud of little tenacity" (Anon.), and ross = the aggregated sandy tubes of the worm *Sabellaria spinulosa*.

XXVIII (15) (= Voyage XXVIII, stn. 15) on 14.3.1904. Shot 53°19'N 02°42¾'E on f.d.s. in 16 fathoms, towed mainly in 16 fms (SNR), h. 53°17⅜'N 02°26¾'E in 14½fms on f.s. *Echinocardium* sp. (presumably *cordatum*).
XXX (4) on 9.4.1904. Shot 53°19½'N 00°24'E on gv. in 7½ fms, NTD, h. 53°22⅝'N 00°21½'E on d.s. in 8 fms. *Crossaster*.
XXX (6) on 9.4.1904. Shot 53°21¾'N 00°21½'E on d.s.sh. in 8 fms, towed in 8 fms (SNR), h. 53°22¼'N 00°23⅞'E on d.s.sh. in 8½ fms. *Crossaster* (recorded also near this position on four later visits, omitted below, within the limits of its symbol in Fig. 3).
XXXVIII (26) on 2.9.1904. Shot 53°46'N 02°34'E on f.d.g.s. in 19 fms, NTD, h. 53°39'N 02°39½'E on f.d.g.s. in 19 fms. *O. albida* fairly common, *O. texturata* also present.
XXXVIII (29) on 2. and 3.9.1904. Shot 53°29'N 02°51¼'E on f.d.s. with ooze in 17 fms, towed in 16 fms (SNR), h. 53°22'N 03°10½'E on f.d.g.s. in 15 fms. *Astropecten*.
XL (1) on 27.9.1904. Shot 53°06½'N 02°51¼'E on f.d.g.s. in 17 fms, NTD, h.

53°02'N 02°47'E on f.d.g.s. in 15 fms. *Astropecten, O. texturata.*
XL (2) on 27. and 28.9.1904. Shot 53°02'N 02°47'E on f.d.g.s. in 15 fms, NTD, h. 53°11'N 02°50½'E on f.d.g.s. in 16 fms. *Astropecten.*
XL (4) on 28.9.1904. Shot 53°10½'N 02°54⅝'E on f.d.s. in 17 fms, NTD, h. 53°11½'N 03°01½'E on f.d.s. in 17 fms. *Astropecten, Henricia* sp. (fairly common), *O. texturata.*
XL (5)on 28.9.1904. Shot 53°11½'N 03°01½'E on f.d.s. in 17 fms, NTD, h. 53°11¼N 02°56¼'E on f.d.s. in 17 fms. *Astropecten* and *O. texturata* both fairly common.
XL(8) on 28.9.1904. Shot 53°10½'N 02°55'E on f.d.s. in 17 fms, NTD, h. 53°16½'N 02°46'E on f.d.s in 16 fms. *Astropecten* and *O. texturata* both fairly common.
XL(10) on 28.9.1904. Shot 53°17¼'N 02°43¾'E on f.d.s. in 16 fms, NTD, h. 53°21½'N 02°35¾'E on f.d.s. in 16 fms. *Astropecten.*
XL (11) on 28.9.1904. Shot 53°21½'N 02°35¾'E on f.d.s. in 16 fms, NTD, h. 53°26'N 02°31⅜'E on f.d.s. in 15 fms. *Astropecten, O. texturata.*
XL (13) on 29.9.1904. Shot 53°26'N 02°31⅜'E on f.d.s. in 15 fms, towed on f.spk.s. in 12 fms, h. 53°25¼'N 02°34¾'E on f.d.s. in 15 fms. *Astropecten.*
XL (14) on 29.9.1904. Shot 53°25¼'N 02°34¾'E in 15 fms, towed in 17 fms (SNR), h.53°24¾'N 02°39'E in 14 fms, all on f.d.s. *Astropecten* fairly common.
XL (45) on 5.10.1904. Shot 53°19¾'N 00°35½'E on c.s. in 11½ fms, NTD, h. 53°22¾'N 00°40½'E on c.s.& m. in 14 fms. *Crossaster, Henricia* sp., *Ophiothrix.*
XLVII (26) on 25.1.1905. Shot 53°29¼'N 03°01'E on f.s.& m. in 19 fms, towed in 20 fms (SNR), h. 53°27½'N 02°54¾'E on f.s.& m. in 17½ fms. *Astropecten, Ophiothrix.*
XLIX (3) on 1.3.1905. Shot 52°39½'N 02°50⅜'E on bl.spk.s. in 19½ fms, NTD, h. 52°41¼'N 03°06¼'E on bl.spk.s. in 16 fms. *Spatangus.*
XLIX (10) on 2. and 3.3.1905. Shot 53°45¼'N 02°32½'E on f.s. in 20 fms, towed over s.& m. in 33 fms, h. 53°47½'N 02°26'E on sharp.s in 19 fms. *Spatangus.*
LV (2) on 10.5.1905. Shot 53°28¾'N 02°34¾ on f.d.s. in 15½ fms, NTD, h. 53°25⅝'N 02°52'E on f.d.s. in 16 fms. *Echinocardium* very abundant, *Astropecten* common.
LV (3) on 10.5.1905. Shot 53°25⅝'N 02°57'E on f.d.s. in 16 fms, NTD, h. 53°18⅜'N 03°12'E on f.d.s. in 13½ fms. *Echinocardium* very abundant, *Astropecten* common.
LVI (33) on 30.5.1905. Shot 53°57½'N 00°39¾'E on c.d.s. in 25 fms, NTD, h. 53°58½'N 00°44'E on f.d.s. in 26 fms. *Ophiothrix.*
LVI (34) on 30.5.1905. Shot 53°58½'N 00°44'E on f.d.s. in 26 fms, NTD, h. 54°05¾'N 00°44½'E on f.d.s. in 27 fms. *Ophiothrix* (common), *Echinocardium.*
LVIII (32) on 23.6.1905. Shot 52°42⅞'N 02°25¼'E on c.s.& ross in 27 fms, NTD, h. 52°35¾'N 02°39'E on c.s.& ross in 25 fms. *Astropecten, Spatangus.*
LXI (36) on 8.8.1905. Shot 53°20⅜'N 02°23¾' E on f.d.s. in 17 fms, NTD, h. 53°15⅞'N 02°27¼'E on f.s. in 13 fms. *Astropecten, O. texturata.*
LXII (1) on 5.9.1905. Shot 53°20½'N 02°26¼E on f.g.s. in 17 fms, NTD, h. 53°18'N 02°38¾'E on f.g.s. in 15½ fms. *Astropecten.*
LXII (3) on 5.9.1905. Shot 53°19½'N 02°38½'E on f.g.s. in 15½ fms, NTD, h. 53°19½'N 02°25'E on f.d.g.s. in 17 fms. *Astropecten, O. texturata, Echinocardium.*
LXII (5) on 6.9.1905. Shot 53°13¼'N 02°54½'E on f.d.g.s. in 16 fms, NTD, h. 53°10½'N 03°08⅞'E on f.d.g.s. in 15½ fms. *Astropecten.*

LXIV (18) on 27.9.1905. Shot 52°26'N 02°47¾'E on f.g.s, NTD, h. 52°38½'N 02°42'E on f.g.s.+ bk.cl., both in 24 fms. *Astropecten*, *Echinus*.
LXIV (20) on 27.9.1905. Shot 52°38'N 02°41¼'E on f.g.s.+ bk.cl. in 24 fms, NTD, h. 52°47'N 02°31½'E on f.g.s. in 22½ fms. *Echinus*.
LXIV (22) on 27.9.1905. Shot 53°16½'N 02°28¼'E on f.g.s. in 17 fms, NTD, h. 53°17'N 02°36¼'E on f.g.s. in 17 fms. *Astropecten* and *O. texturata*, both fairly common.
LXIV (23) on 27.9.1905. Shot 53°16'N 02°42'E on f.g.s. in 17 fms, NTD, h. 53°13⅜'N 03°04'E on f.g.s. in 15 fms. *O. texturata* (fairly common), *Astropecten*, *Echinus*.
LXIV (24) on 28.9.1905. Shot 53°13⅜'N 03°04'E on f.g.s. in 15 fms, NTD, h. 53°25⅝'N 02°58½'E on f.g.s. in 17 fms. *Echinus*.
LXVI (5) on 20.10.1905. Shot 54°04½'N 00°38'E on f.g.s. in 26 fms, NTD, h. 53°59¼'N 00°36'E on f.g.s. in 26 fms. *Crossaster*.
LXVI (7) on 25.10.1905. Shot 53°43⅜'N 02°40½'E on spk.s. in 20 fms, towed in 23 fms (two soundings while towing), SNR, h. 53°49'N 02°34½'E on s.m. in 33 fms. *Ophiothrix* abundant; *Astropecten*.
LXVI (9) on 25.10.1905. Shot 53°24⅝'N 02°23½'E on f.g.s. in 10 fms, towed in 14 fms, SNR, h. 53°24⅜'N 02°24¼'E on f.g.s. in 12 fms. *Astropecten* common.
LXVI (10) on 25.10.1905. Shot 53°24⅜'N 02°24¼'E on f.g.s. in 12 fms, towed on f.g.s. in 14 and 15 fms, h. 53°13⅝'N 2°42⅜'E on f.g.s. in 18 fms. *Astropecten* fairly common.

Blegvad (1922), "George Bligh" stn.5 (see Ursin's fig. 13), 53°00'N 03°10'E approx., no details of haul. 2 *O. affinis*.

Davis (1925), "George Bligh" (see Ursin's fig. 13), no details of hauls:- XXXIII(4), 53°37'N 02°28'E in 15 fms. 1 *Amphiura*.
XXXIII(8), 53°49'30"N 02°08'E in 16 fms. 1 *Amphiura* and 2 *Echinocyamus*.
LXXVI(37), 52°52'N 02°16'E in 26 fms. 1 *O. affinis*.

Ursin (1960) Appendix 1, "Dana" grab stations:—
Stn.4339, on 28.5.1932 at 53°55'N 01°13'E on f.s. with a few sh. in 35 metres. 1 *Acrocnida* and 1 *Echinocardium*.
Stn.7963, on 3.5.1952 at 53°59'N (not 53°39'N as in Hamond (1969) fig.1) 01°40'E on m.s. in 34 metres. 1 *Astropecten* and 1 *Acrocnida*.
Stn.9418(1), on 21.4.1955 at 52°48'N 02°25'E on c.s.& many sh. and cl. in 48 metres. 1 *O. affinis*, 3 *O. albida*, 7 *Echinocyamus*, 1 *Spatangus*.
Stn.9418(2), identical with (1) but no cl. 2 *O. affinis*, 1 *Echinocyamus*.
Stn.9419, at 52°32'N 01°52'E on c.s. & sh.st. in 29 metres. 2 *Echinocyamus*.

The author's own post-1985 offshore stations in which echinoderms were found: D.60, at 53°04'N 01°00'E on 24.5.1989; dredge full of small pebbles of all sizes (most of the larger ones covered with encrusting Bryozoa), with quite a few long-dead and crumbling shells (mostly *Modiolus*, but a few *Ostrea*) and some sand and silt, in 17 metres. 1 *Henricia perforata* and 2 *H. sanguinolenta*.
BD.10, at 53°17.75'N 01°19.26'E on 25.9.1989; a sample of fairly coarse sand with many small stones and numerous dead bivalve shells (mostly *Ensis siliqua* about 90 mm long) in 19 metres. 7 small *Amphipholis*.

RECENT BRYOPHYTE RECORDS (1989—1990), INCLUDING TWO SPECIES NEW TO NORFOLK.

R. Stevenson

111, Wootton Road, King's Lynn, PE30 4DJ

Brachythecium mildeanum (Schimp.) Milde TF94 Holkham, 1989 RS; TF 62 Roydon, 1989 RS. First recorded for the county in 1983 it is obvious that this species is fairly widespread but has been much overlooked.
Bryum dunense Smith & Whitehouse TF71 Swaffham, 1989 RS.
Bryum violaceum Crundw. & Nyh. TM39 Raveningham, 1988 RJF. New to Norfolk (VC 27). TG04 Holt, 1989 HLKW & CDP; TG13 Saxthorpe, 1989 HLKW & CDP; TL59 Hilgay, 1989 RS. New to VC 28. Another probably overlooked species.
Cryphaea heteromalla (Hedw.) Mohr. TL99 Cranberry Rough, 1990 RCS.
Fossombronia pusilla (L.) Nees. TG04 Holt, 1989 HLKW & CDP.
Herzogiella seligeri (Brid.) Iwats. TM07 Blo' Norton Fen, 1989 ACS. New to VC 27.
Hookeria lucens (Hedw.) Sm. TG32 Honing Common, 1990 ALB. Only the second site in the county for this interesting plant.
Hypnum imponens Hedw. TF62 Roydon Common, 1990 RS.
Moerckia hibernica (Hook.) Gott. TM19 Flordon Common, 1990 RS.
Orthotrichum cupulatum Brid. TG02 Billingford, 1990 RS.
Orthotrichum obtusifolium Brid. TM07 Blo' Norton Fen, 1989 ACS. New to Norfolk. This was a most remarkable find. In recent years this plant has only been seen in two Scottish vice-counties; all records from England were over 50 years old.
Physcomitrium eurystomum Sendtn TL88 Home Mere, 1990 ALB.
Platygyrium repens (Brid.) Br. Eur. TF91 Scarning Fen, 1990 PJW & RJF.
Pohlia lutescens (Limpr.) Lindb. TG04 Holt, 1989 HLKW & CDP.
Pseudephemerum nitidum (Hedw.) Reim. TF62 Roydon Common, 1990 RS.
Ptilidium pulcherrimum (Web.) Vanio. TF91 Scarning Fen, 1990 RS.
Rhynchostegiella tenella (Dicks.) Limpr.TG02 Billingford, 1990 RS.
Sphaerocarpos michelii Bellardi TG04 Holt Hall, 1990 RJF; TG13 Saxthorpe MAB.
Sphaerocarpos texanus Aust. TG04 Holt Hall, 1990 RJF.
(In addition indeterminate specimens of *Sphaerocarpos* were found in TG03 Briston & TG13 Itteringham, by MAB, and TG02 Tyby by HLKW & CDP.)
Sphagnum teres (Schimp.) Angst. TG12 Buxton Heath, 1990 DS.
Ulota phyllantha Brid. TL99 Cranberry Rough, 1990 CDP.
Zygodon viridissimus var. *stirtonii* (Stirt.) Hagen. TG03 Holt Hall, 1990 RS. New to VC 27.
ALB AL Bull; MAB MA Brewster; RJF RJ Fisk; CDP CD Preston; ACS AC Smith; DS D Strauss; RS R Stevenson; RCS RC Stern; HLKW HLK Whitehouse; PJW PJ Wanstall.

THE GRASSHOPPERS AND CRICKETS OF NORFOLK

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A G Irwin

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Abstract

Records of Orthoptera for the decade 1981-90 are combined with older records to present an account of the distribution and status of native grasshoppers, bush-crickets, other crickets and groundhoppers in Norfolk. Factors affecting the distribution of two species are discussed in detail.

Introduction

The Orthoptera are a small group of insects comprising the grasshoppers (Acrididae), bush-crickets (Tettigonidae), true crickets (Gryllidae), mole-crickets (Gryllotalpidae) and groundhoppers (Tetrigidae). Until recent years, they have not received the degree of attention that has been given to other prominent members of the insect fauna such as butterflies and dragonflies. This under-recording is surprising when one considers that, almost uniquely among insects, many of the group produce audible songs or contact notes by the process of stridulation—rubbing their notched femur over raised veins on the wings, or rubbing together the wings themselves. In some species this song can be very far carrying, but in others it can be so high pitched as to be inaudible to the human ear.

Most species are associated with established, stable habitats. They are unusual in arable landscape, or shaded woodland, but can survive as remnant populations in clearings and wide sunny rides of forestry plantations. Like birds, different species of Orthoptera have preferred habitats and it is often possible to anticipate which species will be present in a locality, and to seek out particular micro-environments to which a particular species may be restricted.

Also like birds, the Orthoptera have their own distinctive 'jizz' which identifies a species in the field and tells the observer which particular feature to look for to confirm identification. Jizz is a combination of habitat, snatches of song, posture, willingness to jump or fly or a habit of shuffling backwards down leaf stems or of hiding behind them. It is these aspects of jizz which give the insects their individuality and renders them attractive to study.

Notes on habitat, song and appearance in this paper should enable identification of the Norfolk species. For a fuller account of the British Orthoptera, Marshall and Hayes (1988) should be consulted although Ragge (1965) still covers the Norfolk species adequately. A cassette tape of the songs of British Orthoptera is available from Harley Books, Martins, Great Horkesley, Colchester, Essex CO6 4AH.

Nomenclature in this paper follows the checklist given in Marshall and Haes (1988). Scale bars on illustrations represent 10 mm.

Earlier studies of Orthoptera in Norfolk

Among the earliest references to Orthoptera in Norfolk is the list of six species in the Yarmouth area given in Paget and Paget (1834). Of particular interest are records of the mole cricket *Gryllotalpa gryllotalpa* and great green bush-cricket *Tettigonia viridissima* from Caister as well as large marsh grasshopper *Stethophyma grossum*

(as *Locusta flavipes*) from Belton (in Suffolk).

Edwards (1900) lists eighteen species including the migratory locust *Locusta migratoria* and a southern European cricket *Oecanthus pellucens* but this latter record is considered to refer to a mislabelled or misidentified specimen. Morley (1930) published an account of Suffolk Orthoptera which included frequent references to Norfolk records. A supplementary paper (Morley, 1947) refers to a specimen of *Omocestus rufipes* from Ringstead, but this record is based on an immature specimen, now in Ipswich museum, and is almost certainly a misidentification (H. Mendel, pers.comm.).

E.A. Ellis (1934) collated records of eighteen species from Norfolk, adding *Stenobothrus lineatus* and *Metrioptera brachyptera* to Barrett's (1900) list. A.E. Ellis (1943) listed a few records of various species, and added *Tetrix ceperoi* (Bolivar) on the basis of specimens from Wheatfen. More detailed regional studies included that of Payne (1959) on grasshoppers from Breckland, and E.A. Ellis (1965) included a section on Orthoptera in his book on the Broads.

In 1975 a small-scale survey of Norfolk Orthoptera was undertaken by J.W. Ismay (Norwich Museum) and J.A. Buckley, with the intention of discovering the status of *Stethophyma grossum* and *Metrioptera brachyptera*. An unpublished report (Ismay, 1974) on *M. brachyptera* sites was produced, but no *S. grossum* were found.

The National Recording Scheme

The Institute of Terrestrial Ecology co-ordinates a number of invertebrate recording schemes, including one for Orthoptera. A species distribution atlas for this group is to be published after the end of the 1990 recording season. Because of the under-recording of the Norfolk species during the early years of this project, a special effort was made to secure as many records as possible during the final season and also to submit into the central recording system, any archive data held at Norwich Castle Museum or by individual recorders. The results of these efforts are reproduced in the distribution maps of this paper. Full data upon which the maps are based are held at the Norfolk Biological Records Centre, Castle Museum, Norwich. The open circles on the maps represent pre-1981 records, the filled circles 1981-1990.

Future Recording

The species accounts which follow highlight the current state of knowledge of Orthoptera distribution within the county, and identify where further effort is required to fill in our knowledge of even some of the more common species. A watchful eye needs to be kept on isolated colonies which are at risk of habitat degradation, such as the extension of bracken or scrub across heathland sites, or the improvement of ancient grassland, which can produce a dense sward of grass unsuited to grasshopper species. The sedentary nature of most Orthoptera means there is little opportunity for local extinctions to be reversed by natural recolonisation.

Habitat preferences

The restricted powers of dispersal of most of the Orthoptera means that many of the habitats that they now occupy must have experienced little change over many centuries. Only a small number of species are sufficiently opportunistic to exploit newly emerging habitats. Thus one finds apparently suitable haunts devoid of an

expected inhabitant—witness the absence of the dark bush-cricket *Pholidoptera griseoaptera* from most of west Norfolk, where hedgerows date only from the times of the parliamentary enclosures, and the absence of the meadow grasshopper *Chorthippus parallelus* from the recently (in biogeographical terms) drained marshes of Broadland and the Fens.

Thus in searching for Orthoptera, the recorder looks first of all for ancient countryside: heaths, commons, mixed-species hedgerows, unimproved pasture, fen and marshland and stable dune systems. All of these habitats are rich in species. The modern 'planned' countryside which followed from the drainage of the fens and the enclosure movement of the 18th and 19th centuries has a much lower density of Orthoptera, and a lower diversity of species. Perversely it also receives much less recording effort so that our knowledge of these areas is far from complete.

Grasshoppers—Acrididae

Grasshopper species cannot be reliably separated by colour. Even within the same locality, individuals of the same species can show substantial variations in colour form. There may also be male/female colour differences. Nor is size a reliable determinant as males and females exhibit such size differences as to appear to be separate species.

The Norfolk species are best separated by a combination of song (Fig. 1), and markings on the pronotum. The pronotum is the saddle shaped protective casing covering the first segments of the thorax, and the side keels of this vary from being almost parallel to being strongly inflexed. Conveniently, where Norfolk species have superficially similar songs, the markings on the pronotum are quite different.

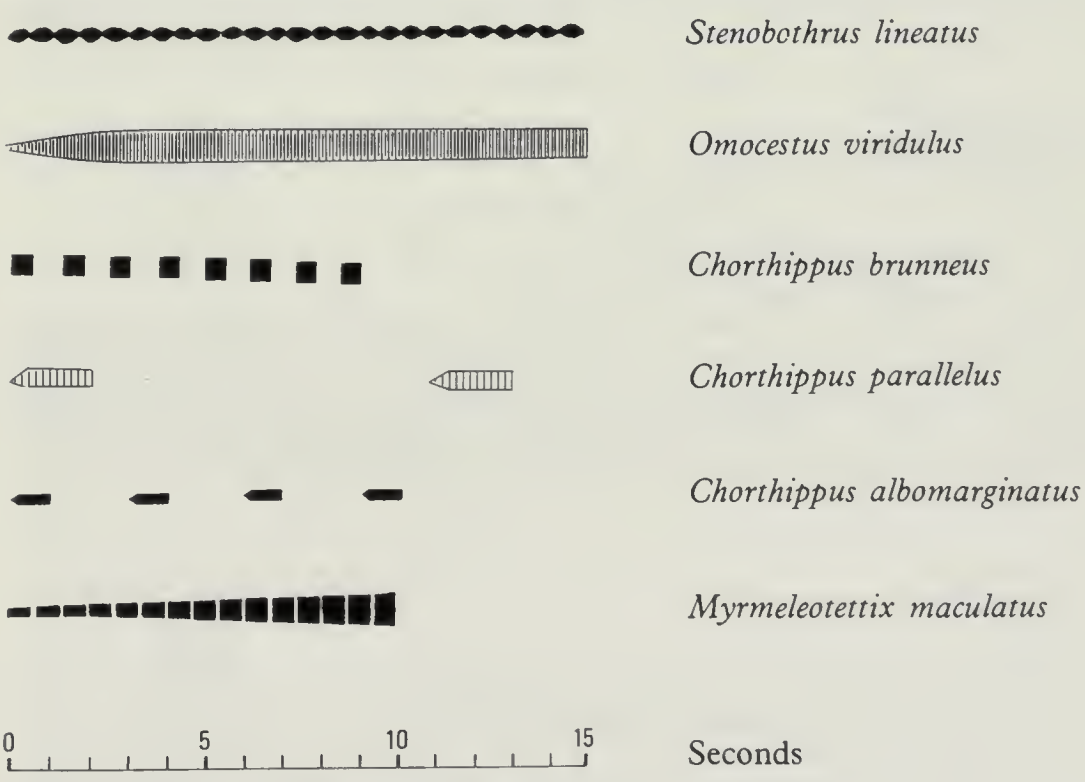


Fig. 1 Diagrams of grasshopper songs.

A loud continuous stridulation audible up to 10 metres and lasting for 15 seconds or more immediately betrays the common green grasshopper *Omocestus viridulus*, while a weak, wheezy song produced by very slow leg movements uniquely identifies the stripe-winged grasshopper *Stenobothrus lineatus*. A pulsing, buzzing song, building up to a crescendo is produced by the mottled grasshopper *Myrmeleotettix maculatus*, confirmed by strongly inflexed side keels, while a rattling song with a more modest crescendo is that of the meadow grasshopper *Chorthippus parallelus*, whose side keels are only gently incurved. Brief chirps betray either the field grasshopper *Chorthippus brunneus*, with strongly inflexed side keels, or the lesser marsh grasshopper *Chorthippus albomarginatus* with parallel side keels.

As it is usually song that betrays the presence of grasshopper species, this is a useful classification to adopt, though it must be stressed that the descriptions given here are the most usually heard songs of isolated males. Different calls are used in courtship or during copulation. The system also breaks down outside Norfolk where a wider range of species may be present.

Stethophyma grossum

Large marsh grasshopper

S. grossum is presumed extinct in the county. It was formerly present in the fens of Norfolk and Cambridgeshire and in the Broads. It is an insect of quaking bogs, or very marshy areas with sedge and grass tussocks.

In the west of the county it was recorded from the King's Lynn area and from Stow Bardolph Fen, the most recent record being a specimen found by Ken Durrant at Wolferton Marshes in 1968. In the Broads there are records from Horning, Barton, Irstead, Catfield, Sutton and Woodbastwick. The last East Norfolk specimen was found by S.A. Manning at How Hill in 1939. There are no subsequent documented records, and all searches of former haunts have proved fruitless.

Stenobothrus lineatus

Stripe-winged grasshopper

Map—Fig. 2.

Moderately inflexed side keels to pronotum, white stigma on wings. Orange abdomen and legs in mature adult. Wheezy song produced by slow leg movements.

The preferred habitat of *S. lineatus* is chalk grassland. In Norfolk it is found in the brecks around Santon Downham and Grimes Graves, westward to the edge of the Fens with a record from a chalk drainage channel at Feltwell, and northward to Narborough where it is present on the disused railway line. There are also unsubstantiated records from Blakeney and Winterton, but these may refer to misidentified *C. albomarginatus*.

Omocestus viridulus

Common green grasshopper

Map—Fig. 3.

Slightly inflexed side keels to pronotum. No orange on abdomen or legs. Loud, continuous song (up to 15 secs) produced by rapid leg movements.

This grasshopper is abundant on old commons, brecks and unimproved grassland, and can also be found in woodland rides and on roadside verges throughout

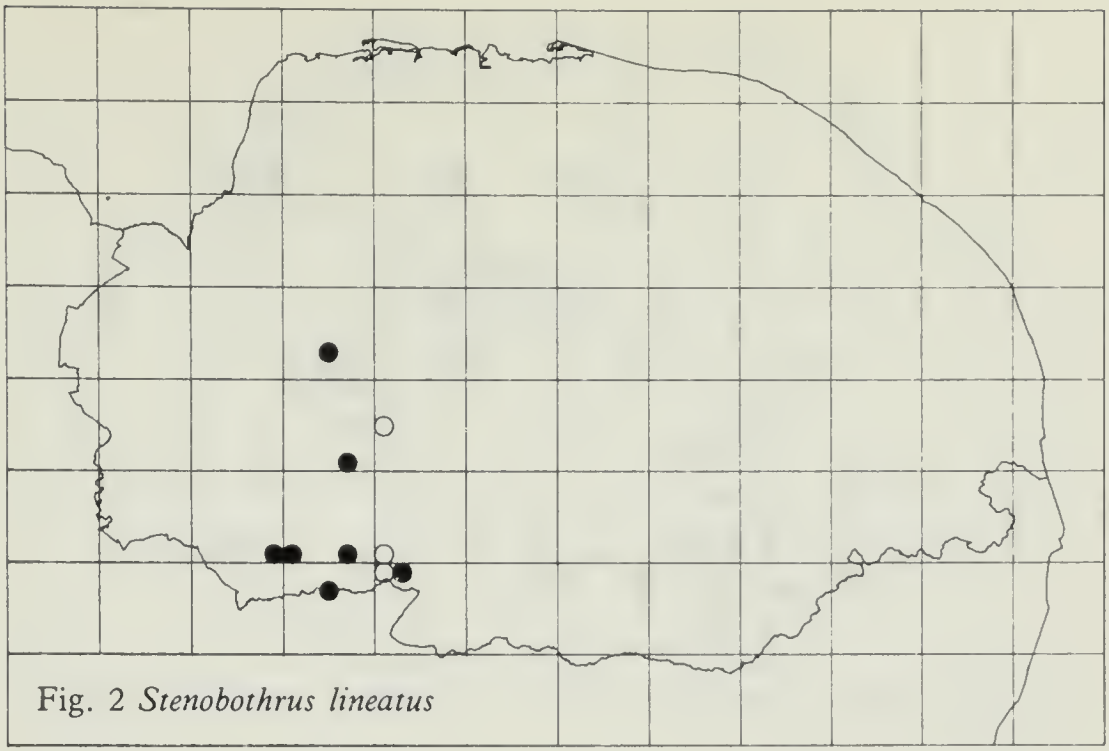


Fig. 2 *Stenobothrus lineatus*

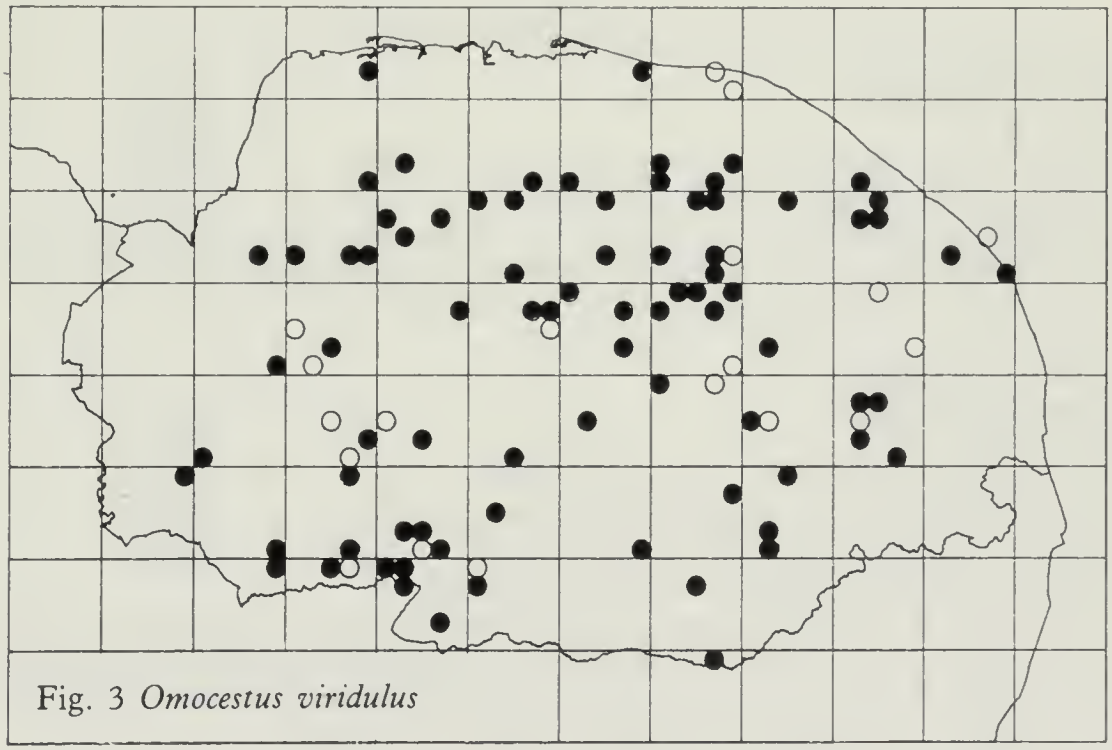


Fig. 3 *Omocestus viridulus*

Norfolk. It is less common on the north Norfolk coast and on the high ground of west Norfolk, and is mainly absent from the Fens.

Its loud, continuous song, audible at 10 metres or more, makes it an easy grasshopper to census. This and its preference for unimproved grasslands, makes it a valuable indicator species for the quality of small-scale habitats.

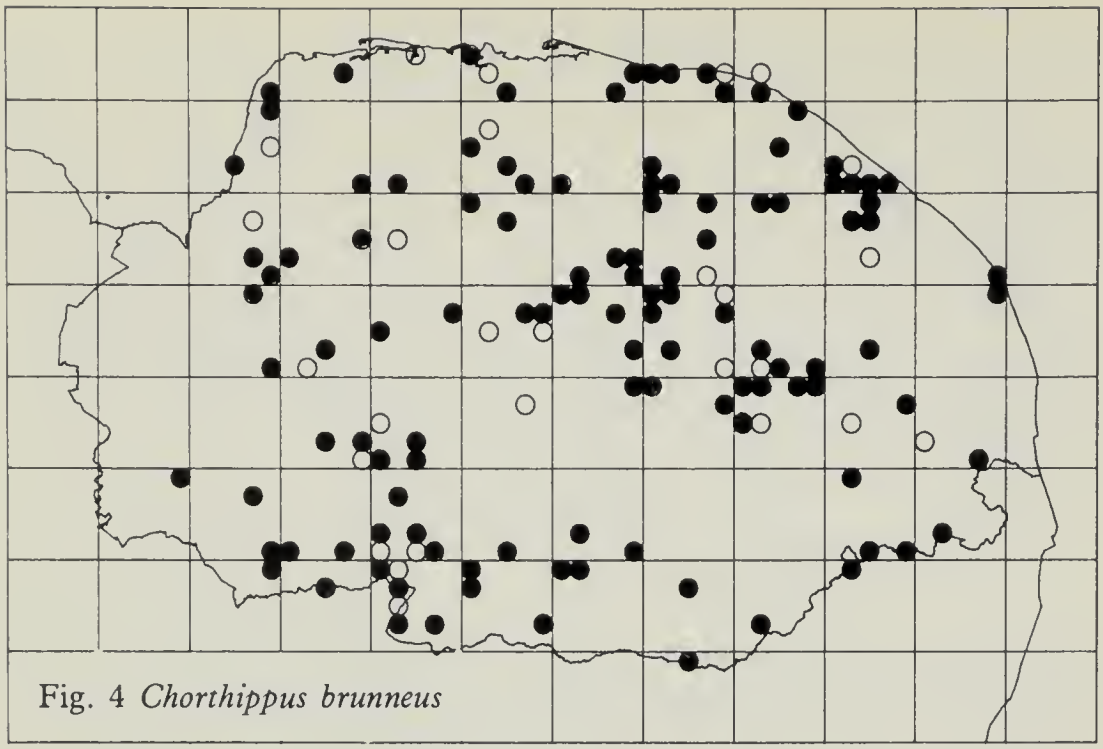


Fig. 4 *Chorthippus brunneus*

Chorthippus brunneus
Field grasshopper
Map—Fig. 4.

Strongly inflexed side keels to pronotum, very variable in colour. Song consists of loud brisk chirps.
This is a large, robust insect, tolerant of a wide range of habitats. It has strong powers of dispersal and is quick to exploit new habitats on waste ground, disused railways, cleared forestry, roadside verges and agricultural set aside.

Chorthippus parallelus
Meadow grasshopper
Map—Fig. 5.

Gently inflexed side keels to pronotum. Hind wings absent, and forewings not extending to the tip of the abdomen in males, and only half the length of the abdomen in females. A rattling song of 1-2 secs duration.
C. parallelus is a flightless insect, though fully winged forms can develop at times of population explosion, with a preference in Norfolk for damp meadows. Its apparent absence from the Fens and from the east of the county is intriguing. A possible explanation is advanced in a later section of the paper.

Chorthippus albomarginatus
Lesser marsh grasshopper
Map—Fig. 6.

Side keels of pronotum straight. Song consists of sequences of brisk chirps.

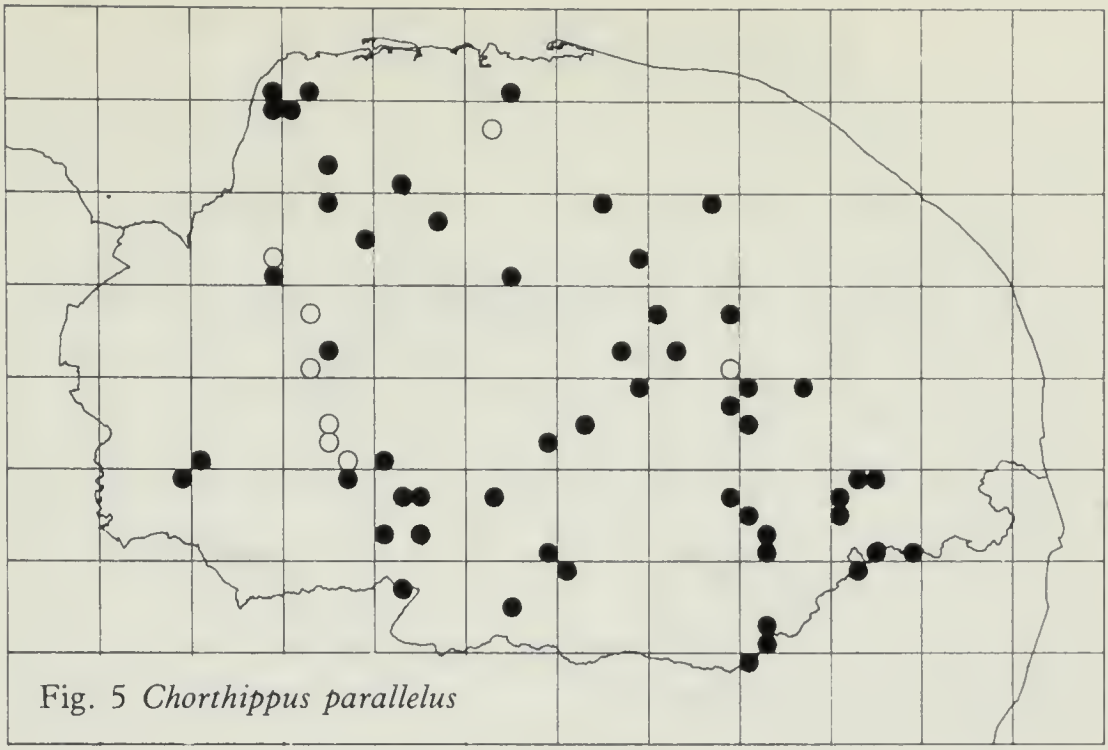


Fig. 5 *Chorthippus parallelus*

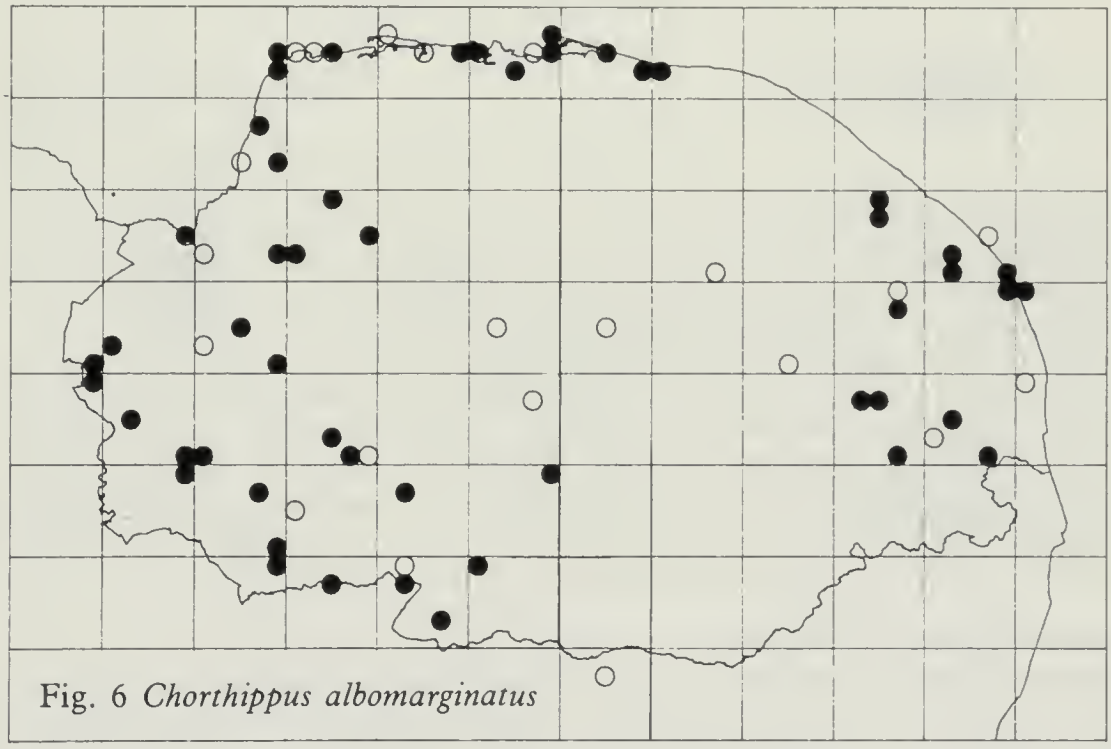


Fig. 6 *Chorthippus albomarginatus*

C. albomarginatus is widespread in the fens of Cambridgeshire, Lincolnshire and Norfolk. It is present around the coast from the Wash to the beginning of the cliffs at Weybourne. It is then absent until the start of the dune systems at Horsey/Winterton. Inland it is found along the Little Ouse valley as far as Thetford, and along the Yare valley as far as Strumpshaw. There are many other inland colonies suggesting that the full extent of its distribution is not yet known.

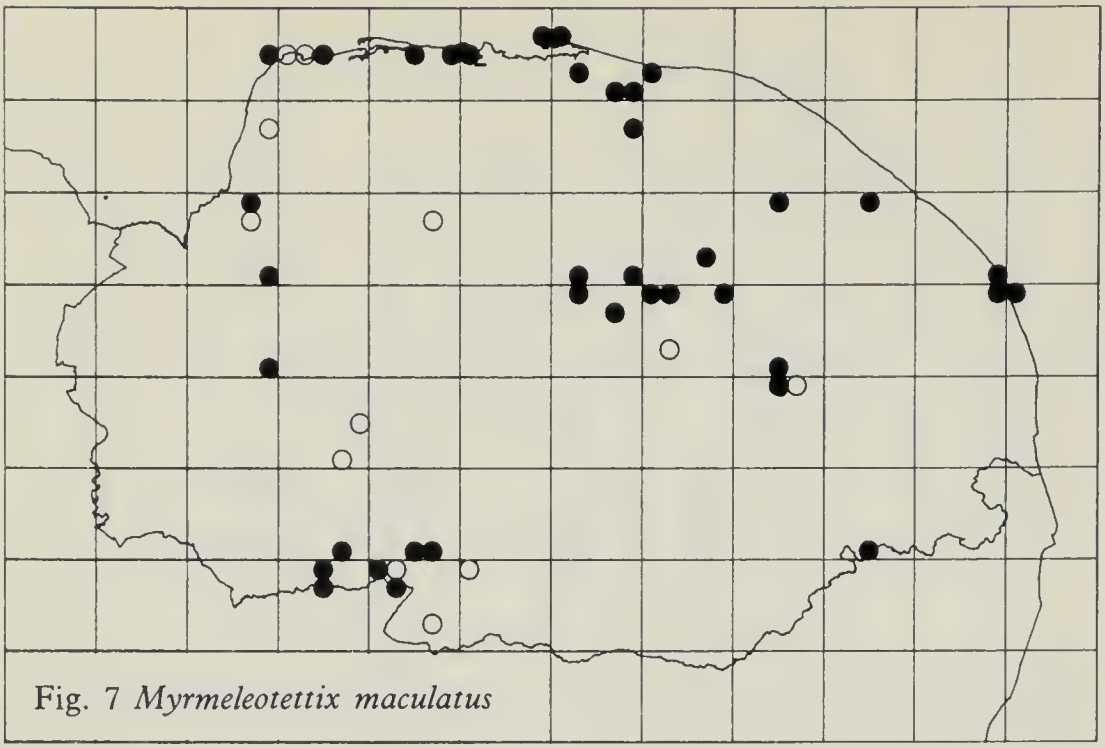


Fig. 7 *Myrmeleotettix maculatus*

Myrmeleotettix maculatus
Mottled grasshopper
Map—Fig. 7.
Strongly inflexed side keels to pronotum, clubbed antennae. Bursts of song, rising to a crescendo.
M. maculatus is found throughout the brecks, on dune systems around the coast, and on the heathlands north-west of Norwich. It is often abundant on lichen covered ground, where the vegetation is sparse, and worth looking for wherever there is sandy heath and heather. It is rare in south Norfolk, being known only from Broome Heath near Ditchingham, a site which may have been continuously open for several thousand years (Dymond, 1985 p.41).

Groundhoppers—Tetrigidae

The groundhoppers are diminutive members of the Orthoptera, easily separated from the others by a backward extension of the pronotum covering the abdomen and the wings. Two species are found in Norfolk, the slender groundhopper *Tetrix subulata* which is restricted to damp habitats where there is moss and exposed mud, and common groundhopper *Tetrix undulata* which is tolerant of both wet and dry conditions so long as there is a substantial moss flora.

In contrast to the other Orthoptera, the eggs of groundhoppers do not undergo diapause but hatch in the same season as they are laid, the insects overwintering in a dormant state as adults or nymphs.

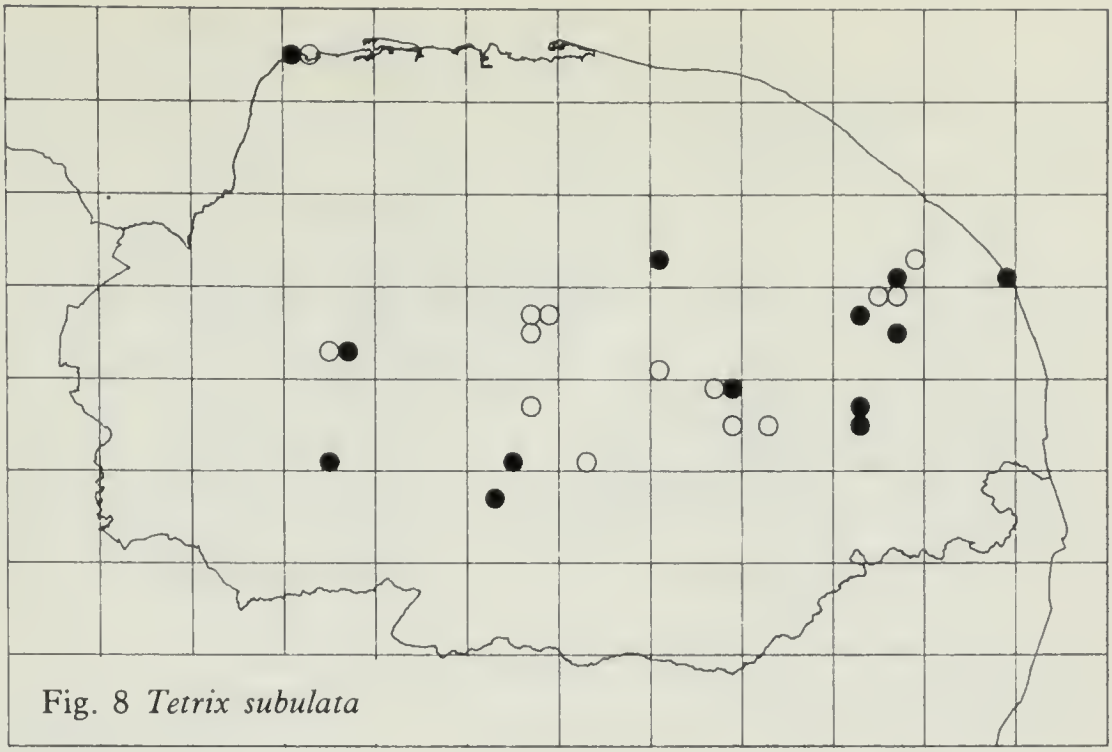


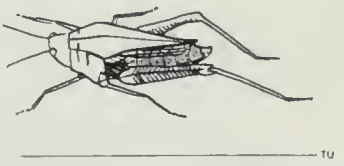
Fig. 8 *Tetrix subulata*

Tetrix subulata
Slender groundhopper
Map—Fig. 8.

Wing tips visible below pronotum, which extends beyond tip of abdomen.

T. subulata is widely distributed across the county, being recorded from a range of fen-like habitats and from damp commons. Most records are from Broadland, with Wheatfen, Strumpshaw Marsh and Mills Marsh being typical sites. In the west of the county it is recorded from Thompson Common, Foulden and Narford. It is recorded from both Winterton dunes and Holme dunes suggesting that it might be worth searching other coastal localities.

Tetrix undulata
Common groundhopper
Map—Fig. 9.



Pronotum with a prominent central keel, extending only as far as the tip of the abdomen.

T. undulata is recorded from heaths, commons and woodland, principally in the north-east quadrant of the county. Most records are from Broadland, but this could be a reflection of recording effort rather than of true distribution. Because of its inconspicuous nature, and ability to survive on just a few square metres of suitable terrain it could easily have been overlooked elsewhere. It is worth searching all old commons and remnant areas of heathland. Check the exposed earth around rootstocks of fallen trees in marshy areas, also clearings in forestry plantations on former heathland sites. There are also records from old woodlands such as Blickling and Swanton Novers. As with all Orthoptera, it is the stability of the habitat in a time scale measured in centuries that is the most important determinant of distribution.

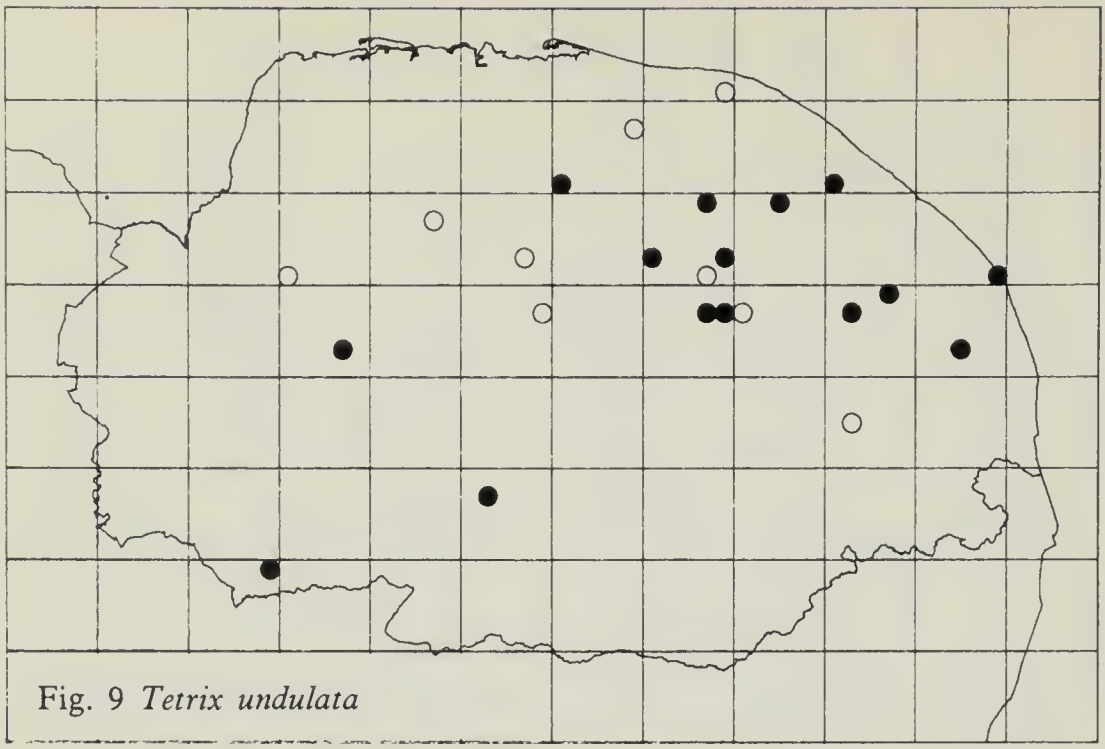


Fig. 9 *Tetrix undulata*

[*Tetrix ceperoi*

Cepero's groundhopper

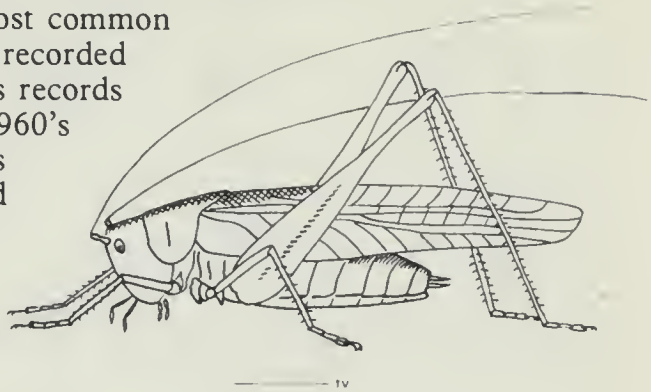
A.E. Ellis (1943) records this species on the basis of specimens from Wheatfen which were identified by B.P. Uvarov, who first recorded the species in Britain (Uvarov, 1940). The species is very similar to *T. subulata*, and in the absence of any extant specimens or further records, we hesitate to include it in the Norfolk list.]

Bush-crickets—Tettigonidae

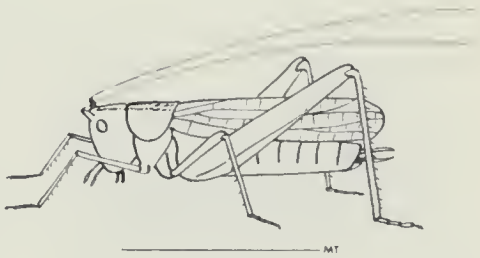
Bush-crickets are readily separated from grasshoppers by their stouter appearance, long slender antennae, prominent female ovipositor and by their preference for coarser vegetation including shrubs and trees. The species do not exhibit much colour variation and are reliably separated by colour and shape. Six species have been recorded in Norfolk, though one of them, the great green bush-cricket *Tettigonia viridissima* is at the limit of its range and is known from only a handful of records. It has a loud strident song and is therefore unlikely to have been overlooked.

Of the remaining five species, two have audible songs and are probably well recorded over their range. One is the dark bush-cricket *Pholidoptera griseoaptera* whose brisk chirp, usually delivered from deep in nettles or brambles, is a familiar sound by day and night in East Norfolk where it is ubiquitous in hedgerows and scrub. The other is the bog bush-cricket *Metrioptera brachyptera*, which is restricted to heaths to the north of Norwich where its incessant stridulation can be heard from areas of gorse or cross-leaved heath *Erica tetralix* on warm sunny days. The three remaining Norfolk bush-crickets, the speckled *Leptophyes punctatissima*, oak *Meconema thalassinum* and short-winged conehead *Conocephalus dorsalis* produce no generally audible song, and are in consequence under-recorded throughout the county, being found by chance rather than systematic discovery.

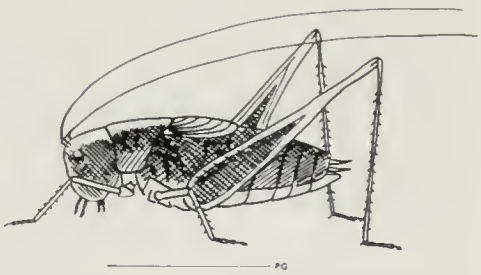
Tettigonia viridissima
Great green bush-cricket
Large green insect with brown dorsal stripe, and wings extending well beyond tip of abdomen. Song is loud, continuous and far carrying. *T. viridissima* is an insect of wasteland with rough herbage including thistles, bramble and scrub. It seems to require warm situations and is most common long the Channel coast. It has been recorded irregularly from Norfolk with 1920's records from Caister-on-Sea and Hickling, 1960's records from Reedham, and a 1970's record from near Diss. One attracted to a mercury-vapour lamp in Brandon Country Park (Suffolk) in 1990 confirms the continued presence of a small population along the Norfolk/Suffolk border.



Meconema thalassinum
Oak bush-cricket
Map—Fig. 10.
A slender, pale green insect with yellowish legs. Fully winged, attracted to light. No audible song. Cryptic colouration, lack of audible song and nocturnal habits make this a difficult insect to survey. It is widespread over much of southern England, and also recorded from Wales, the Midlands and Yorkshire. It is without doubt under-recorded in Norfolk, and should be searched for by beating young oaks or birch. It is also attracted to light, occasionally being found indoors.



Pholidoptera griseoaptera
Dark bush-cricket
Map—Fig. 11.
A robust insect, male grey/brown, female yellow/brown. Underside yellow in both sexes, wings vestigial. Song consists of brisk chirps delivered from dense cover.



P. griseoaptera is common along overgrown ditches and hedges, and in patches of brambles and nettles throughout mid- and south Norfolk, where it is often called the bush-cheep. It appears to be absent from the Broads and the Fens, probably for the same reasons as *C. parallelus*. It is also absent from most of west Norfolk where landscape characteristics are dominated by the geometrical designs of parliamentary enclosures. The possible influence of ancient and planned countryside on species distribution are discussed in more detail later.

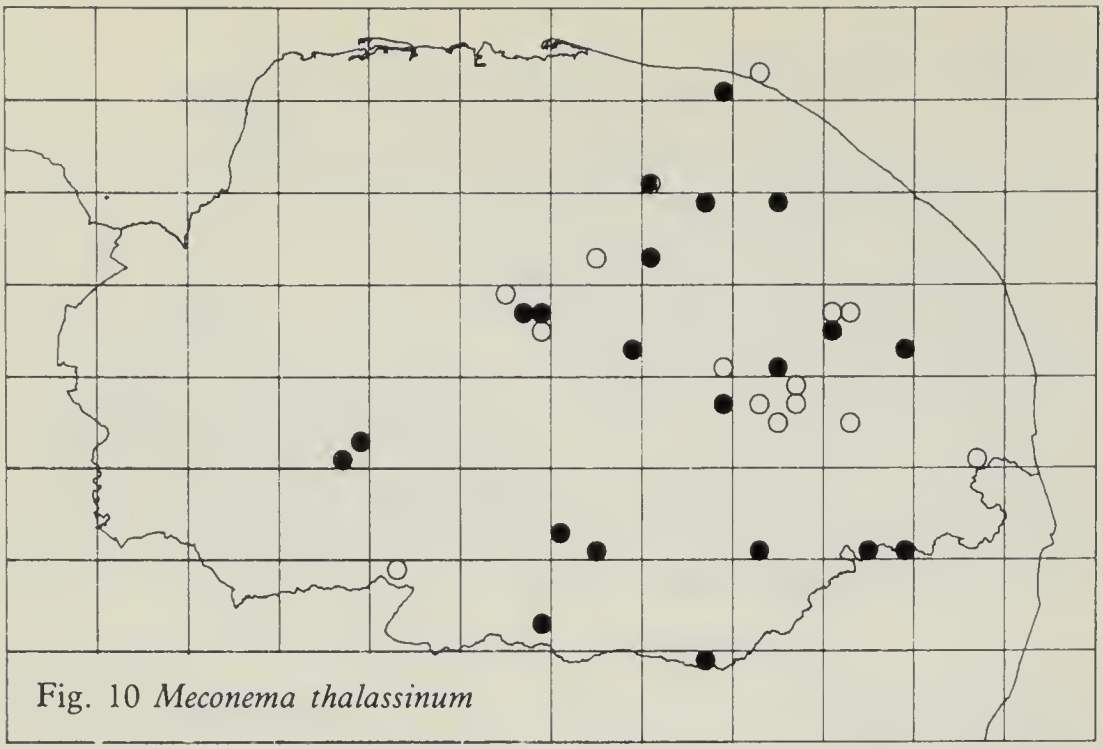


Fig. 10 *Meconema thalassinum*

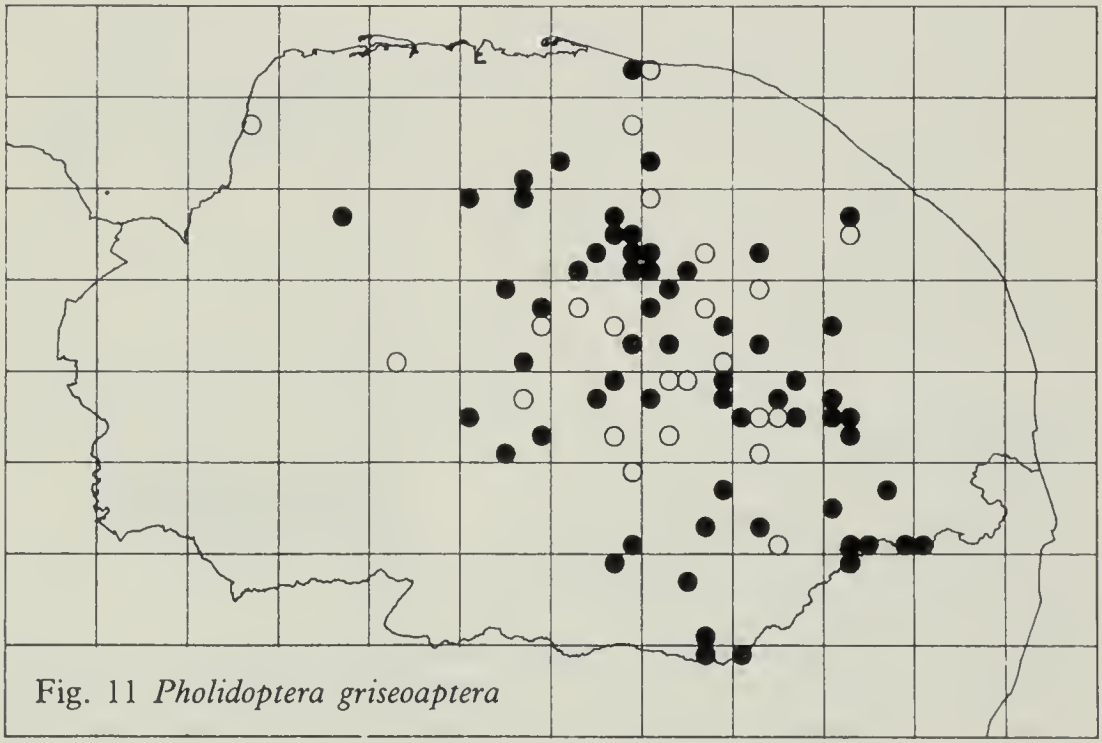


Fig. 11 *Pholidoptera griseoaptera*

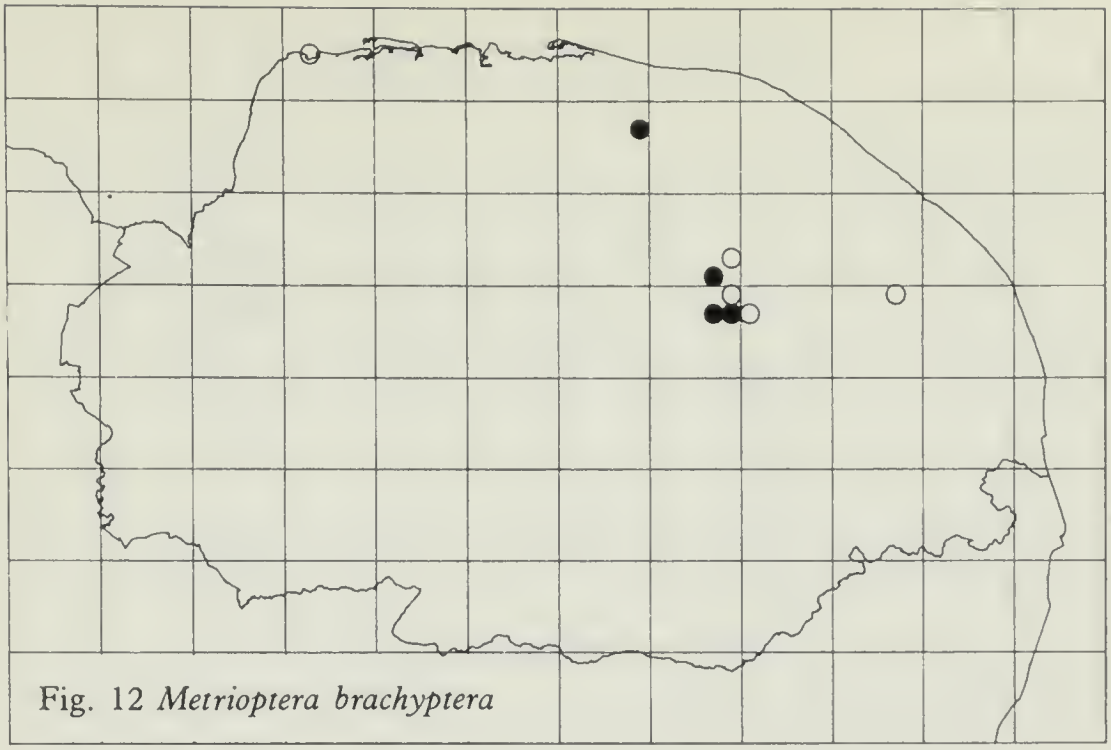
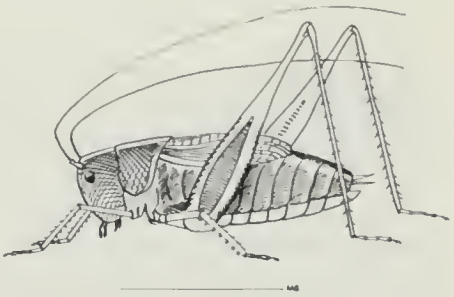


Fig. 12 *Metrioptera brachyptera*

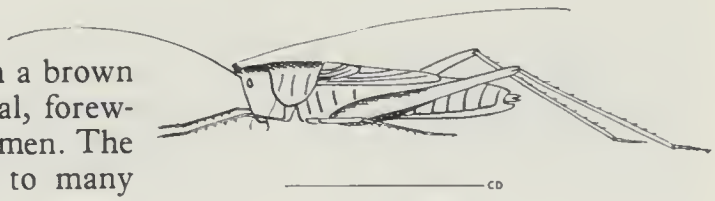
Metrioptera brachyptera
Bog bush-cricket
Map—Fig. 12.



A dark brown insect with green ventral surface to abdomen, and with green (or occasionally light brown) on top of the head and pronotum and on the shortened forewings. Hind wings vestigial. Continuous, shrill stridulation can be heard at all times of day in hot weather.

M. brachyptera is restricted to damp clearings on the former Horsford and Newton Heaths, and to areas of Buxton Heath and Holt Lowes which are dominated by gorse and cross-leaved heath *Erica tetralix*. There are also older records from the King's Lynn area (1920), Thornham (1952) and How Hill (1969). Recent searches of Roydon Common where *E. tetralix* is abundant have failed to produce any records.

Conocephalus dorsalis
Short-winged conehead
Map—Fig. 13.



A small, green bush-cricket with a brown dorsal stripe. Hindwings vestigial, forewings extending over half the abdomen. The high-pitched song is inaudible to many people.

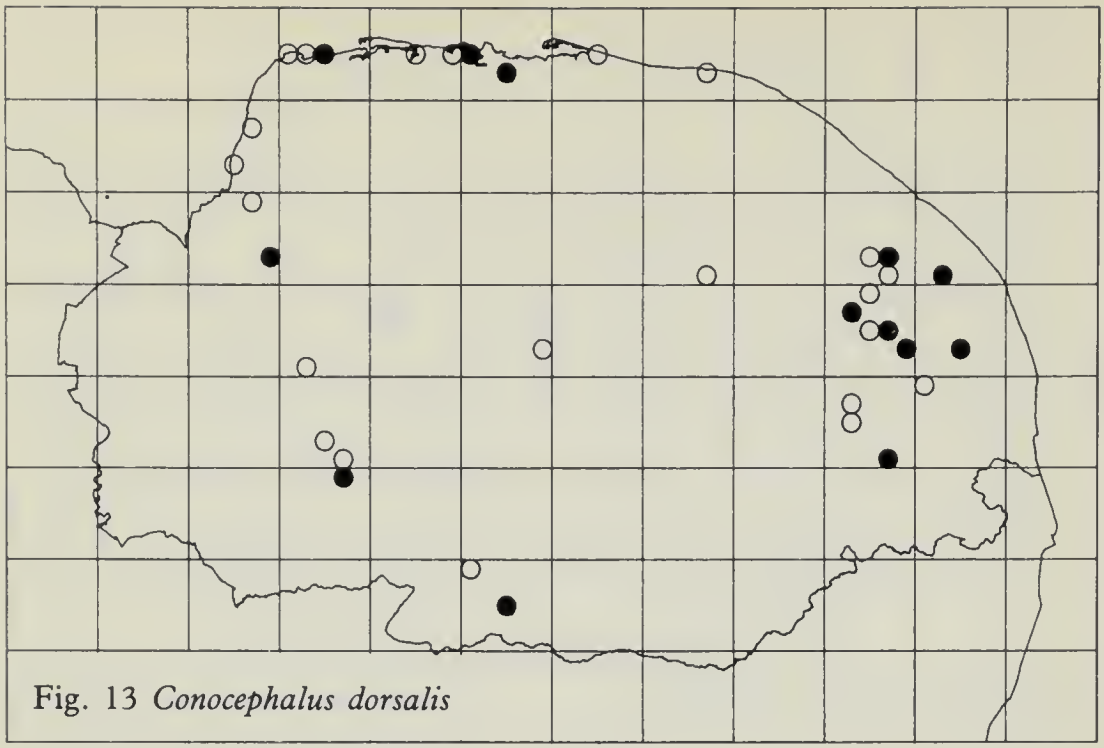


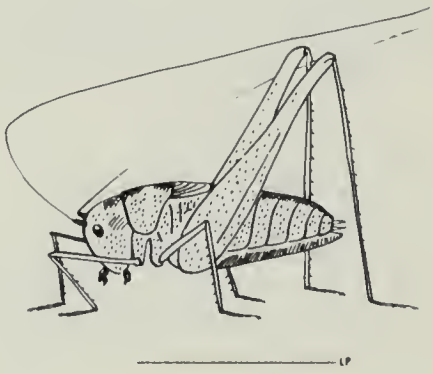
Fig. 13 *Conocephalus dorsalis*

C. dorsalis has been recorded in Norfolk from coastal dunes and saltmarsh, and from damp heaths and inland fens, particularly in the Broads area. It is probably under-recorded in the county because of its confiding habits, and should be looked for along river valleys, and on old commons especially where there are rushes and sedges.

The long-winged form of *C. dorsalis* (var. *burri*) has been taken on a few occasions in Norfolk, the most recent being a specimen from East Wretham Heath in 1960. This form is easily confused with a closely related species, *C. discolor*, which has not been recorded from Norfolk.

Leptophyes punctatissima
Speckled bush-cricket
Map—Fig. 14.

A plump, green insect with brown dorsal stripe, covered in minute dark spots. Hindwings absent, forewings vestigial. No audible song. The cryptic colouration, and lack of audible song make this a most difficult insect to census reliably. It frequents rough herbage in a wide range of habitats. Norfolk records come from gardens, cemeteries, parkland, heaths and commons. As a flightless insect, it is probably restricted to the same areas of ancient countryside as *P. griseoaptera*.



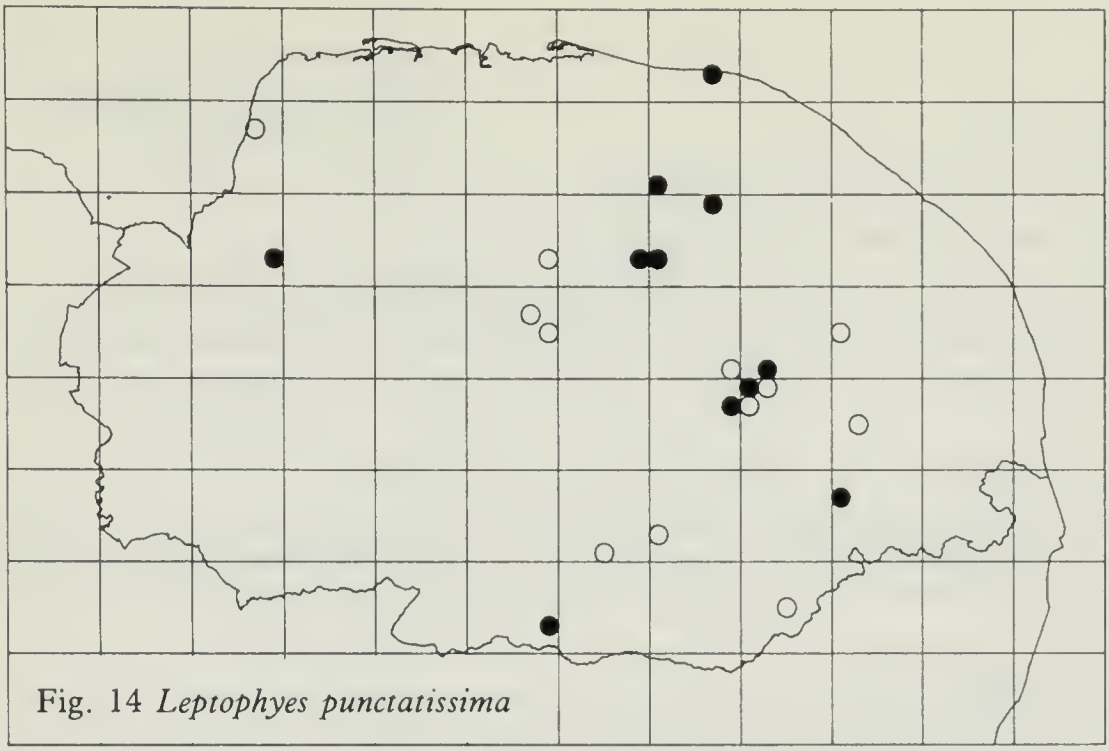
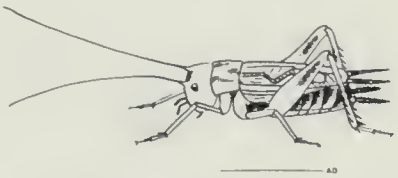


Fig. 14 *Leptophyes punctatissima*

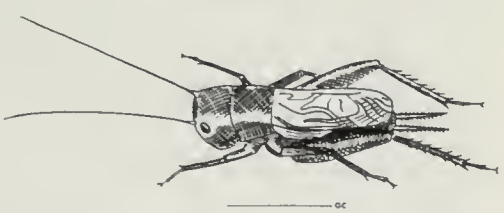
True crickets—Gryllidae

Acheta domesticus
House-cricket



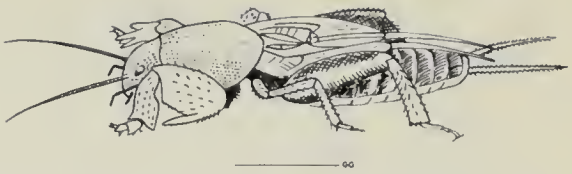
A pale mottled brown insect with a loud, monotonous chirp. Forewings and hindwings reaching the end of the abdomen.
Although not a native of Britain, *A. domestica* has been established in Norfolk for several centuries and was common in heated buildings throughout the county. With improvements in domestic hygiene, it became rare in houses and for the last forty years most records have been from rubbish tips (e.g. Harford, Strumpshaw, Ludham, Acle) where the heat of decomposition is sufficient to keep populations going. However the species continues to infest institutional buildings, including some hospitals, and is now enjoying a come-back in domestic premises where its use as food for exotic pets is encouraging the establishment of colonies by 'escapees'. In warm summers the species will wander out-of-doors, two females being found in the middle of Wayland Wood in 1990.

Gryllus campestris
Field-cricket



The field cricket has become extremely rare throughout Britain, and there are no records for the species in Norfolk this century. Ellis (1934) mentions an unlocalised record by Edwards, and Barrett (1900) also lists it as a Norfolk insect.

Mole-crickets—Gryllotalpidae



Gryllotalpa gryllotalpa
Mole-cricket
This distinctive, large, burrowing insect has been rarely found in Norfolk and was probably never very common. Nineteenth century records are from Caister, Castleacre, Catton and Stoke Holy Cross. This century Thouless (1921) recorded it from Shotesham Common, but now the species must be considered extinct in Norfolk. The prefered habitat is wet meadows but several recent records in Britain are from allotments where people are digging and likely to come upon *G. gryllotalpa* damaging their plants.

Historical factors as determinants of distribution.
This paper has made frequent reference to the habitat requirements of Orthoptera, and to the stability of that habitat in historical terms. This correlation is explored in more detail below for two species whose flightless nature limits their powers of dispersal.
Chorthippus parallelus
Fig. 5 shows *C. parallelus* to be widely distributed in Norfolk, but tantalisingly absent from the grasslands of the Fens and the Broads.

When the distribution is related to the underlying topography of rivers and to the former pattern of marine transgression, the observed distribution becomes less enigmatic (Fig. 15). In the west it is absent from the fens which were subject to

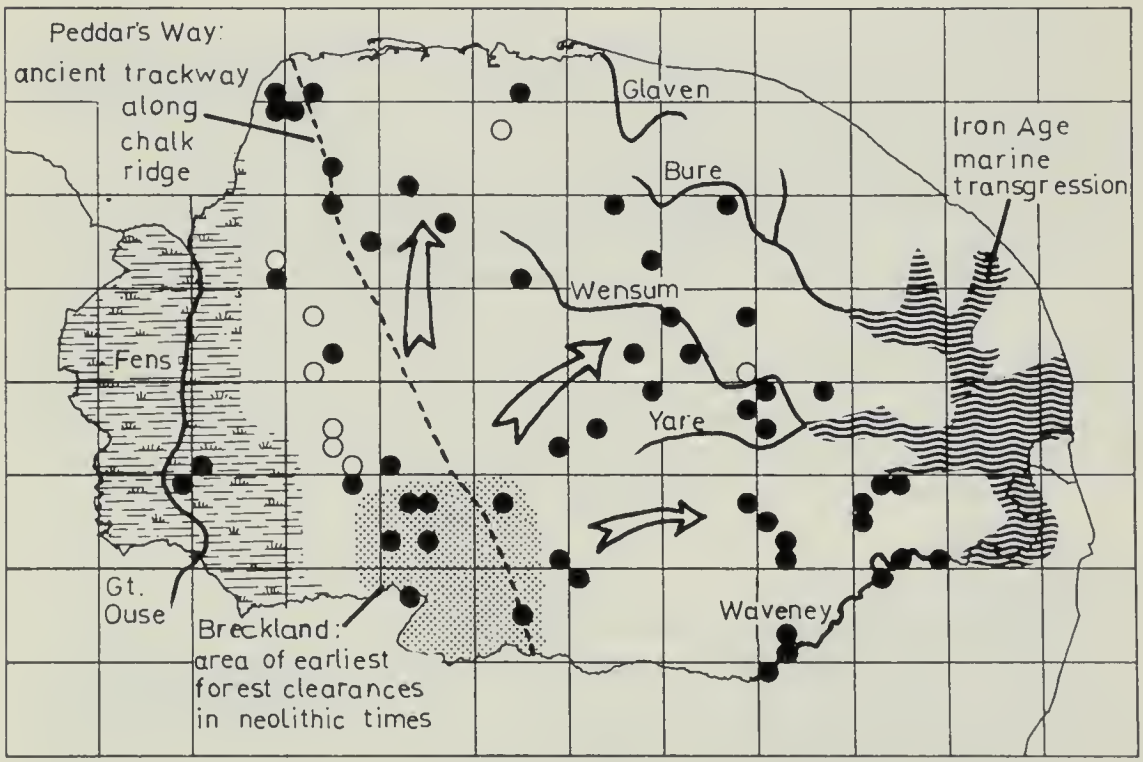


Fig. 15 Possible spread of *C. parallelus* in Norfolk.

seasonal flooding and salt water incursion until the drainage schemes of the 1600's, while in the east it is absent from areas covered by the estuarine river systems which persisted until post-Roman times.

Looking back into prehistory, the earliest forest clearances were on the light Breckland soils, and it is tempting to speculate that *C. parallelus* spread northwards and eastwards from this centre, following the progress of man's forest clearance, but constrained always by the major river systems. The clustering of records between the rivers Yare and Wensum, and between the Wensum and Bure would support this theory. The absence of records from the north-east of the county suggest it may never have penetrated the narrow watershed between the Bure and the Glaven.

Pholidoptera griseoaptera

The preferred habitat of *P. griseoaptera* is tangled hedgerows and rough herbage including nettles and brambles. It is common in mid- and south Norfolk where there is a legacy of old commons and small field systems surrounded by ancient mixed-species hedges. It is not found in the agricultural areas of the north and west of the county where the majority of hedgerows are of relatively recent origin, or in the more open countryside of the Fens and the Brecks.

Rackham (1986) has discussed the distinction between these two types of landscape. He describes a "planned countryside" evolving from the parliamentary enclosures of the 18th and 19th centuries, typified by the geometrical layouts of neatly trimmed hawthorn hedges, such as are found in west Norfolk and contrasting with an "ancient countryside" of copses, spinneys, small ponds and mixed species hedgerows, largely unchanged since Saxon times.

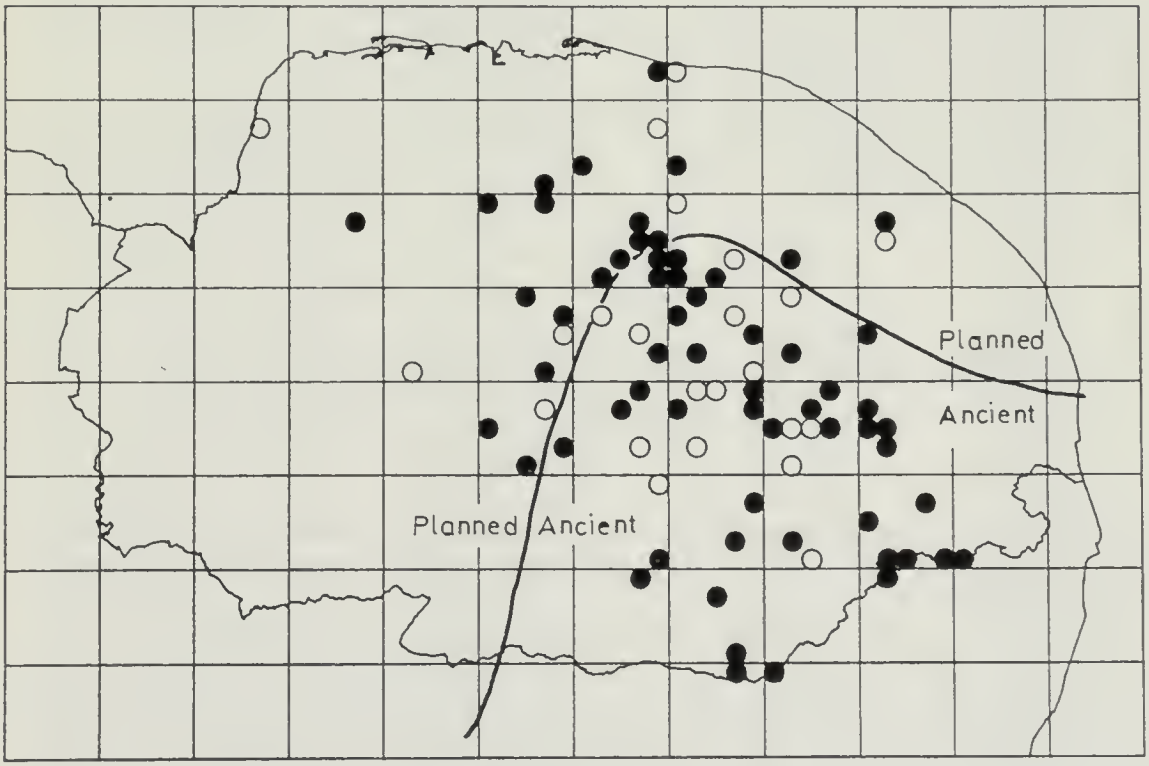


Fig. 16 "Ancient countryside" and *P. griseoaptera*

The correlation between Rackham's ancient countryside and the distribution of *P. griseoaptera* in Norfolk is illustrated in Fig. 16. That ancient countryside provides the ideal habitat requirements for *P. griseoaptera* is undeniable. That the insect has been unable to exploit the hedgerows of west Norfolk is a pointer toward the continuity which is required for the more sedentary Orthoptera to become established and to persist.

Acknowledgements

The authors would like to acknowledge the support of E.C.M. Haes, the national Orthoptera recorder, who has made available all of the Norfolk records held by the national scheme. These include field, literature and museum sources. Howard Mendel (Ipswich Museum) kindly checked the '*Omocestes rufipes*' specimen in Morley's collection.

The following recorders have contributed post-1981 records to the national and local recording schemes. K.N.A. Alexander, M. Barker, H. Bowell, M.A. Brewster, A.L. Bull, L. Dear, K.C. Durrant, W.A. Ely, R.E. Evans, A.P. Fowles, R.S. George, D. Gibbs, J.G. Goldsmith, S.V. Green, M.R. Hall, P. Heath, A.G. Irwin, B.J. Irwin, R. Land, G.W. Maybury, M.J. Morgan, J. Paul, C.W. Plant, D.G. Rands, F.J.P. Reynolds, D.I. Richmond, R.M. Richmond, S.E. Richmond, J. Rix, P. Rudkin.

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IMMIGRANT MOTHS IN NORFOLK DURING 1990.

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This article is an attempt to establish times of immigratory activity during the year 1990 using records of probable immigrants received from contributors to the Norfolk Moth Survey.

Study of the dates of records, seems to indicate nine periods when the prevailing weather conditions would seem to have been favourable and an extended period from 23 September to 8 October during which only records for humming-bird hawk moth *Macroglossum stellatarum* were received. This latter can probably be explained as a second emergence of adults, derived from earlier immigrant moths, and would fit in with the record of a late instar larva of this species recorded on 30 August.

Table 1. Probable immigrant species recorded and suggested date groups.

Date	Common Name	Specific Name	Location	Recorder	
07 July	humming-bird hawk	*Macroglossum stellatarum*	Surlingham	T. Baker	
08 July		*Evergestis extimalis*	Burgh common	K.G. Saul	
18 July	humming-bird hawk	*Macroglossum stellatarum*	Whitlingham	A.P.Foster	
26 July	white-point	*Mythimna albipuncta*	West Lynn	R. Wesley	
28 July	humming-bird hawk	*Macroglossum stellatarum*	How Hill	T. Baker	
30 July	bedstraw hawk	*Hyles gallii*	Scole	M.R. Hall	
30 July	white-point	*Mythimna albipuncta* (X 2)	West Lynn	R. Wesley	
31 July	death's head hawk	*Acherontia atropos*	Hoveton	J. Parmenter	
31 July	Vine's rustic	*Hoplodrina ambigua*	Winterton	K.G. Saul	
01 Aug	white-point	*Mythimna albipuncta*	West Lynn	R. Wesley	
12 Aug	dark sword-grass	*Agrotis ipsilon*	Weeting Heath	J. Fisher	
14 Aug	convolvulous hawk	*Agrius convolvuli*	Reedham	T. Moore	
21 Aug	Blair's mocha	*Cyclophora puppillaria*	Weeting Heath	P.G. Cardy	
23 Aug		*Nomophila noctuella*	Burgh common	K.G. Saul	
23 Aug	dark sword-grass	*Agrotis ipsilon*	Burgh common	K.G. Saul	
29 Aug	dark sword-grass	*Agrotis ipsilon*	Holt	D. Hipperson	
29 Aug		*Ancylosis oblitella*	Burgh common	K.G. Saul	
30 Aug	convolvulous hawk	*Agrius convolvuli*	Filby	K.G. Saul	
30 Aug	convolvulous hawk	*Agrius convolvuli*	Sheringham	M.P. Taylor	
31 Aug	convolvulous hawk	*Agrius convolvuli*	Holt	G. Carrick	
01 Sep	convolvulous hawk	*Agrius convolvuli*	Hardingham	G. Haggett	
01 Sep	humming-bird hawk	*Macroglossum stellatarum*	Caston	G. Haggett	
01 Sep	dark sword-grass	*Agrotis ipsilon*	Weston	J. Fisher	
01 Sep	dark sword-grass	*Agrotis ipsilon*	Filby	K.G. Saul	
01 Sep	Vine's rustic	*Hoplodrina ambigua*	Filby	K.G. Saul	
07 Sep	convolvulous hawk	*Agrius convolvuli*	Congham	R. Wesley	
11 Sep	convolvulous hawk	*Agrius convolvuli*	Blundeston	M. Gould	
12 Sep	pearly underwing	*Peridromia saucia*	Buxton	J. Abbott	
17 Sep	convolvulous hawk	*Agrius convolvuli*	Weybourne	K.C. Durrant	
23 Sep	humming-bird hawk	*Macroglossum stellatarum*	Framlingham Earl	J. Vincent	
26 Sep	humming-bird hawk	*Macroglossum stellatarum*	Waxham	P. Cawley	
27 Sep	humming-bird hawk	*Macroglossum stellatarum*	Langley	Mrs Baird	
29 Sep	humming-bird hawk	*Macroglossum stellatarum*	E. Ruston	S. Pendle	
02 Oct	humming-bird hawk	*Macroglossum stellatarum*	E. Ruston	S. Pendle	
08 Oct	humming-bird hawk	*Macroglossum stellatarum*	Harleston	T. Harris	
17 Oct	death's head hawk	*Acherontia atropos*	Winterton	A.P. Foster	
17 Oct	Tunbridge Wells gem	*Chrysodeixis acuta* (X 2)	Overstrand	R. Cox	(1)
18 Oct	dark sword-grass	*Agrotis ipsilon*	Winterton	A.P. Foster	
18 Oct	pearly underwing	*Peridromia saucia*	Winterton	A.P. Foster	
18 Oct	rusty pearl	*Udea ferrugalis*	Winterton	A.P. Foster	
18 Oct	rusty pearl	*Udea ferrugalis*	Burgh common	K.G. Saul	
18 Oct		*Palpita unionalis*	Scole	M.R. Hall	
19 Oct	white-point	*Mythimna albipuncta*	Scole	M.R. Hall	
19 Oct	golden twin-spot	*Chrysodeixis chalcites*	Brundall	A.P. Foster	
19 Oct	dark sword-grass	*Agrotis ipsilon*	Winterton	A.P. Foster	
19 Oct	rusty pearl	*Udea ferrugalis*	Winterton	A.P. Foster	
20 Oct	scarce bordered straw	*Heliothis armigera*	Caston	G. Haggett	
20 Oct	gem	*Orthonama obstipata*	Filby	K.G. Saul	
20 Oct	dark sword-grass	*Agrotis ipsilon*	Filby	K.G. Saul	
25 Oct	Mediterranean brocade	*Spodoptera littoralis*	Winterton	D. Hipperson	

27 Aug	bedstraw hawk	*Hyles gallii*	Toftwood	G. Haggett	(2)
30 Aug	humming-bird hawk	*Macroglossum stellatarum*	Weeting Heath	P.G. Cardy	(3)
— Aug	death's head hawk	*Acherontia atropos*	Catfield	A.G. Irwin	(4)
01 Sep	death's head hawk	*Acherontia atropos*	Titchwell	D.I.Richmond	(5)

Notes:
1. Having heard that specimens of *Chrysodeixis acuta* captured in this country were now thought to be probably referable to *C. chacites*, Andy Foster (Nature Conservancy Council) had the specimen he caught on 19 October together with one previously captured in 1988 examined by an expert and both were pronouced to be *C. chalcites*. It would therefore seem probable that the two specimens listed as *C. acuta* in the table are likely to be the same although I have not yet been able to obtain confirmation of this.
2. 12 last instar larvae on Fuschia.
3. single late instar larva.
4. found dead in a beehive and brought to the Castle Museum.
5. single larva.

The period 26 July—1 August produced a record of one of our rarer immigrant hawk moths namely bedstraw hawk moth *Hyles gallii* (a gravid female from which larvae were reared: Feral larvae of this species were also recorded in August) together with death's head hawk moth *Acherontia atropos* among others. 29 August—1 September produced, as well as more common immigrants, four records for convulvulous hawk moth *Agrius convolvuli* and a single record of the pyrale *Ancylosis oblitella* . However, the most exciting period was undoubtedly from 17 to 25 October when records included two specimens of Tunbridge Wells gem *Chrysodeixis acuta* (if genuine, see note 1) and single records of golden twin-spot *Chrysodeixis chalcites*, death's head hawk moth *Acherontia atropos*, white-point *Mythimna albipuncta*, gem *Orthonama obstipata*, Mediterranean brocade *Spodoptera littoralis* and the pyrale *Palpita unionalis*.

Note should also be made of a record of death's head hawk moth *Acherontia atropos* which was found, in early August, dead and denuded of scales in a beehive. This probably arrived between 28 July—1 August, during which time another specimen of this species was recorded.

Although one cannot say with any degree of certainty from where immigrant moths began their journeys, examining weather data for the three main activity periods shows that:During 26th July to 1st August the wind direction began ENE, turned S before turning E again and would indicate France, Belgium and Holland as the likely source of immigrants.

Wind direction for the period 29th August—1st September varied from S to W and make it seem likely that immigrants came into SW Britain from France and Spain and continued travelling overland before reaching Norfolk.

The time of greatest recorded activity for Norfolk was from 17th—20th October and saw relatively calm conditions with light winds varying from NW through E to NE indicating the probable source of immigrants as France and Central Europe. Minimum nightime temperatures, for the above, averaged 12.4, 14.3 and 11.5 degrees Celsius respectively.

Acknowledgements
I thank the Norfolk Moth Survey recorders, without whose efforts this article would not have been possible, and N.W.K. Brooks who provided me with meteorological data from his records.

7. Speckled bush cricket *Leptophyes punctatissima*, Reepham, 1989 (p.66) *D.I. Richmond*

8. *Fumaria muralis* ssp. *boraei* (p.12) *G. Beckett*

9. Half-grown caterpillar of bedstraw hawk moth *Hyles gallii* from eggs laid by a female trapped at Scole, 1990 (p.71) *M.R. Hall*

10. Sea urchins *Psammechinus miliaris* (p.43) *R. Hamond*

11. Sun star *Crossaster papposus (p.37)* *R. Hamond*

12. Golden twin-spot *Chrysodeixis chalcites* male, Brundall, 1990 (p.71) *A.P. Foster*

SPIDERS OF EAST ANGLIAN FENS: SOME RECENT RESULTS.

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Introduction

The results presented here represent some of the preliminary findings from a three year research programme set up in 1988 by the Nature Conservancy Council, now English Nature to investigate the terrestrial invertebrate fauna of selected East Anglian fens.

Our research was designed to determine what characteristic terrestrial invertebrate assemblages are associated with a variety of fen habitat types throughout East Anglia, ranging from those of established high conservation value to those of marginal interest—a total of 42 sites. We have also gathered three years of data to assess the effects of fen vegetation management, by cutting and to a limited extent burning, on terrestrial invertebrate assemblages at eight of our sites.

Most of the results presented here are from samples collected in 1988: 31 sites, 70 sample stations. The remaining material is in the process of being sorted and identified.

Nomenclature in this account follows Roberts (1987).

Methodology

The methods used were designed to obtain the maximum amount of data from as many sites as possible covering approximately the same time span. To do this required a standardised and simple survey method. A standard sample unit comprising 5 pitfall traps (plastic beakers, 65mm top diameter, 87mm deep) placed in a transect at 1m intervals and two water traps (200mm diameter bulb bowls) placed at either end of the transect; one placed on the ground, one placed on a 50cm stake. These traps were half-filled with a solution of 70% ethylene glycol with a drop of detergent and left in place for periods of two weeks at a time during June/July and August/September. At those sites being investigated to assess management effects, the traps were left in place throughout the year and in addition to being emptied at the two week intervals specified above were also emptied at approximately monthly intervals.

Results and Discussion

As the work is not yet complete this paper deals only with a few of the spider species found so far. This information has been gleaned from amongst a total of approximately 14,800 individual spiders of 160 species.

The most exciting find so far is a single male specimen of *Robertus insignis*, a small spider (2—3 mm) until recently feared extinct in Britain. It was originally described by the Reverend O. Pickard-Cambridge in 1907, from a single male sent to him from Norwich. This spider is apparently very rare in Europe, and has only ever been found in limited numbers at single sites in Sweden, East Germany and Estonia. This new record, from a commercially cut sedge bed at Catfield Fen reestablishes the existence of this species in Britain (Procter, 1990). *R. insignis* is designated RDB1 i.e. endangered, in the forthcoming Non-insect Invertebrate Red Data Book (Bratton, in press). Why it is so rare is a mystery, the only common factor in its distribution seems to be a requirement for high humidity at some or

all stages of its development. The sedge beds at Catfield are flooded to ground level or just above for much of the year, and drain down in late summer and early autumn. As sedge is cut on a 3-4 year cycle, litter accumulates during this time, and a low, increasingly dense canopy develops. The sedge in this compartment was last cut in 1987, and has since been harvested again (1990). The pattern of sedge cutting is such that adjacent areas usually remain uncut. This may be a crucial factor in allowing *R. insignis* to persist at this site.

New sites have also been found for three other small, rare spiders: *Baryphyma gowerense*, *Carorita paludosa* and *Centromerus incultus*, all designated RDB2 (vulnerable).

Individual specimens of *Baryphyma gowerense* were found in mid June at Sutton and Woodbastwick Fens. The former site is adjacent to Sutton Broad amongst depauperate tall fen vegetation—primarily weak reed *Phragmites australis* and orange balsam *Impatiens capensis*. The site is more or less floating on the Broad and is frequently very wet. The site at Woodbastwick is a small sedge bed cut on a commercial cycle. It too is often flooded. *Baryphyma gowerense* was first discovered in Wales by Eric Duffey from Whitford dunes Glamorgan in 1967. It was found again at Oxwich, also Glamorgan, in 1971 and then from Ruston Common, Norfolk in 1974. It has recently been found in numbers from another NCC survey, similar to ours, which investigated mire sites (including fens) throughout Wales (P. Holmes, pers. comm.)

Reasonable numbers of both *Carorita paludosa* and *Centromerus incultus* were found in litter samples taken in February 1989 from Catfield Fen and extracted using a heat gradient apparatus. *C. paludosa* has since been found in a pitfall trap catch from Sutton Fen in June 1989 at the same site as that described above. *C. paludosa* was previously known only from Reedham and Hickling in Norfolk (1970) and Westhay Moor in Somerset (1973). *C. incultus* had previously only been found at two sites, both in East Anglia—Wicken Fen (1913) and Woodbastwick Fen (1970).

Another RDB2 species, *Clubiona juvenis* has been found at all sites surveyed in the Broads except Strumpshaw Fen, and at Foulden Common, a pingo site in Breckland. The individual found at Foulden Common represents a westward extension of the species range within Norfolk, for it had previously only been known from sites in the Broads. Elsewhere it has been found in Essex, Dorset and southern Ireland. *C.juvenis* is a larger (4-6mm), more obvious species than those described above. It is found in reed or tall sedge, in association with *Clubiona phragmitis* its bigger, more common relative. This spider seems to require tall vegetation which may explain why we only caught this species in water traps i.e. above ground structures, and not in pitfall traps.

In addition to the RDB species given above, nine notable species—six Na and three Nb, as defined by Merrett (1990)—were found.

Notable 'a' species

Marpissa radiata (Salticidae) was found at Wangford Fen in June and Kenninghall Fen, Roydon Common & Swangey Fen in September (all caught in water traps). This is a relatively large jumping spider which spins a cocoon in reed heads.

Hygrolycosa rubrofasciata (Lycosidae) was found amongst reed at Kenninghall Fen, Tuddenham Fen, Wangford Fen and Chippenham Fen, and saw-sedge at Foulden Common, Chippenham Fen and Boughton Fen, in June/July and September.

Entelecara omissa (Linyphiidae), a small ground-dwelling spider, was recorded from 14 sites, mainly in sedge and reed beds. Most records are in June and July with one in August.

Hypomma fulvum (Linyphiidae) was only found in reed beds (10 sites), often in association with its relative *H. bituberculatum*. Adults were found throughout the sample period (May to September).

Maso gallicus (Linyphiidae) was caught at two sample stations on Foulden Common. The majority were water-trapped from a sedge bed in July. Two were pitfall-trapped from a reed fringed pingo, one in July and one in September.

Donacochera speciosa (Linyphiidae). Adults were found throughout the trapping period (June to October). This is a very mobile spider and was captured in all trap types, in all ages of reed and sedge beds (11 sites). It was also found amongst reed stem samples and in the abandoned galls of *Lipara lucens* (Diptera, Chloropidae).

Notable 'b' species

Crustulina sticta (Theridiidae) was found in low numbers at four sites in mid- and west Norfolk (Foulden, Kenninghall, Roydon and Scarning).

Theridiosoma gemmosum (Theridiidae) was found at three reedbed sites in the Broads (Reedham, Strumpshaw and Sutton) and a sedge (*Carex elator*)-filled pingo at Thompson Common. The single records are from June, July and August.

Gongylidiellum murcidium (Linyphiidae) is a small ground-dwelling species which was found at East Harling, Scoulton and Thompson. It was caught in pitfall and water traps during June.

Acknowledgements

We wish to thank all those land owners who gave us permission to work on their land and the wardens and keepers who facilitated our access to the various sites. We also thank Dr M. Hassall of the University of East Anglia for allowing us to make use of the heat gradient extractor.

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UNCOMMON EARWIGS IN NORFOLK AND SUFFOLK.

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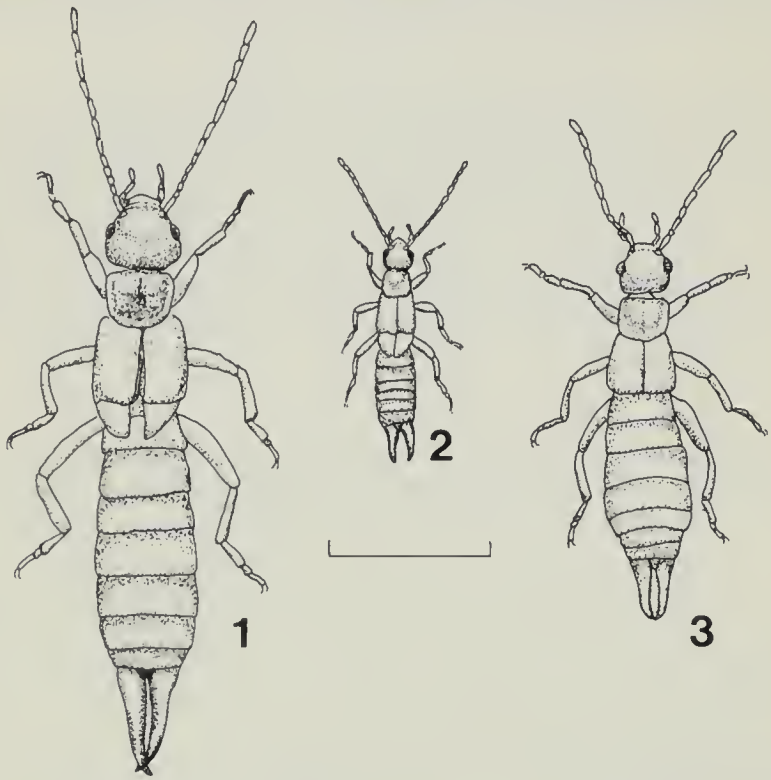
The common earwig, *Forficula auricularia* L. (Fig. 1), is one of the best known British insects. Its relatives, however, are little known, even among entomologists, and only two other species are reliably recorded from Norfolk and Suffolk—the lesser earwig *Labia minor* (L.) and the short-winged, or hop-garden earwig *Apterygida media* (Hagenbach). A fourth species, *Forficula lesnei* Finot, was recorded by Morley (1930) from Gisleham, Suffolk, but Mendel (pers.comm.) informs me that the specimen, which is immature, is almost certainly *F. auricularia* and was determined as such by Blair. Morley himself appears to have redetermined the specimen as *A. albipennis* (= *A. media*) in 1930, but never published a correction of the record.

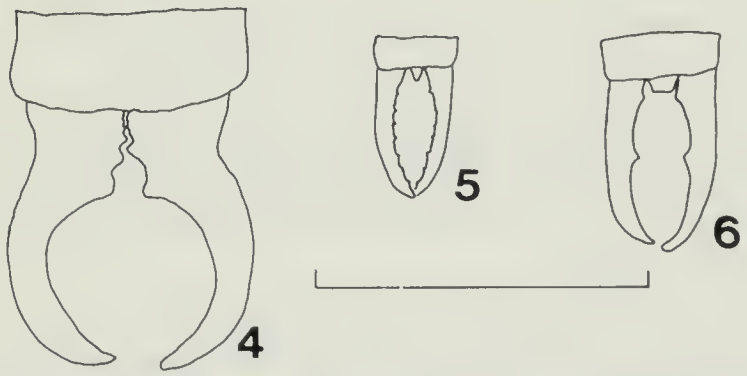


Figs 1,2 & 3. Female earwigs. 1 *Forficula auricularia*; 2 *Labia minor*; 3 *Apterygida media*. (Scale lines = 5 mm).

Labia minor (Fig. 2) is a very small species, about half the length of *F. auricularia*, and is the only species that readily flies, sometimes forming swarms such as those described by Ellis (1938) at Gorleston, Horning and Wheatfen in 1937. There are earlier Norfolk specimens from Hoveton, Mousehold and Norwich in the Castle Museum collections, but the only recent records for the species in this county are from a compost heap at Wheatfen (TG325056) found by J.G. Goldsmith and myself on 2 October 1981, and one in a *Calystegia sepium* flower at Wheatfen in July 1982 (photographed by E.A. Ellis). In Suffolk, the most recent records are from Monks Soham and Foxhall in 1947 (Morley, 1947), though it had been recorded more widely in the past (Morley, 1930).

Specimens of *Apterygida media* in the Norwich Castle Museum collections are from Arminghall (TG20) found by James Edwards on 15 September 1890 and by H.J. Thouless on 22 August 1904. In addition, K.C. Durrant took a female *A. media* in Great Yarmouth (TG523074) in August 1939. Suffolk records include those listed by Morley (1930, 1947) from Sudbury, Corton, Westleton and Monks Soham, and a recent specimen from Brampton (TM4280) taken by B.H. Cogan in 1981 (Haes,1985).

On 14 August 1981, I was searching for woodlice in shingle above the high-water mark beneath a vegetated portion of cliff at Kessingland, E.Suffolk (TM5387). As well as the woodlice (Irwin, 1982), I found one adult male and three immature *A. media*. This second recent Suffolk record is only 12 km from the previous one. Almost nine years later, on 9 August 1990, I was searching for bush crickets in an oak tree on Gissing Common, E.Norfolk (TM147876), when a female *A. media* fell on to my beating tray. A few weeks later, on 2 September, a male *A. media* dropped on to a tea tray in my garden in Norwich (TG213086). Further searching revealed a thriving colony of *A. media* in honeysuckle growing over an old pear tree, which goes to prove that taking tea in the garden can be just as effective as beating oaks—and a good deal less effort!



Figs 4, 5 & 6. Male cerci. 4 *Forficula auricularia*; 5 *Labia minor*; 6 *Apterygida media*. (Scale lines = 5 mm).

Adult *A. media* (Fig. 3) are readily separated from *F. auricularia* (Fig. 1) and *Labia minor* (Fig. 2), the hindwings being vestigial and thus not protruding beyond the wingcases . In addition the shape of the male cerci or forceps is quite distinctive (Figs 4,5 & 6). Female *A. media* can be confused with *Forficula lesnei*, a species which could occur in the area but is easily overlooked. Reference should be made to Marshall and Haes (1988) if there is any doubt.

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1990 WEATHER SUMMARY

N.W.K. Brooks

79 The Street, Old Costessey, Norfolk.

January - The third very mild January in succession, with a mean temperature nearly 3°C above normal. It was a windy month with winds between west and south on as many as 26 days. The gales on the 25th—26th were less marked in Norfolk than in western parts of the United Kingdom. The same sheltering effect caused the county to receive only 80% of the normal rainfall.

February - With a mean temperature 4.1°C above normal this was the warmest February this century. Indeed, every day throughout the month was warmer than normal, due in no small measure to winds between south and west almost the entire month. On the 23rd the temperature reached 17.9 °C—a reading typical of early June! It was the wettest February since 1977 with most of the county receiving double the average rainfall. Snow lay briefly on the 24th and there was some 'blowing' of topsoil in the Brundall area on the 5th. A tornado caused some damage at Thurton on the 28th and was described by an eye-witness as 'a wierd smoky-grey shape, looking like a Michelin man and spinning like a top, with lightning-like bolts flashing within it'. This tornado was also seen from Bergh Apton, Norton Subcourse and Loddon.

March - With a mean temperature over 3°C above normal, this was the mildest March since 1957 and was warmer than an average April. Again, winds were predominantly between south and west, and maxima reached the 'summer levels' of 21.9°C and 22.3°C on the 17th and 18th. Sunshine was excessive and it was the driest March since 1973.

April - This was the sunniest on record, and although with a mean temperature a little above normal, it was the second April in succession to be colder than the preceeding March. During the early hours of the 5th the screen temperature fell to -5.9°C, the lowest temperature recorded in 1990.

May - This was yet another warm month with the first week being exceptionally hot with maximum as high as 25.1°C on the 5th. As many as 11 days recorded maxima in excess of 21°C. Rainfall was only 40% of average. Ingham suffered a severe hailstorm on the 10th with considerable damage to crops, still apparent in early June.

June - This was a disappointingly dull, at times cool, but rather dry month. It was so cool between the 10th and 14th that domestic heating again became necessary! It was the first month in 1990 with below average sunshine. Lightning from a brief thunderstorm on the 22nd killed a strawberry picker in an exposed situation at Old Costessey. Diss reported the earliest pea crop on record.

July - Although the month had a mean temperature very close to normal, days were warmer than average and nights were cooler—with a ground frost narrowly escaped on the 25th. Nine days had maxima in excess of 25°C, and on the 20th, 31.5°C was reached. Rainfall was only 37% of average. A small tornado vortex on the 24th deposited straw over an area extending from Spixworth to Costessey.

August - This was the hottest month in Norfolk since July 1976, but was not as hot as August 1975. The monthly mean maximum of 25.2°C was 4°C above normal, and 30°C was reached or exceeded on five days, and only three failed to reach 21°C. The most intense heat occurred during the first few days, with the 3rd recording a remarkable 34°C at Costessey, 34.5°C at Morley, and 34.6°C at Pulham St. Mary. (It is likely that this was the hottest August day in Norfolk since 19th August 1932). There was a complete absence of thunder and much of the county was very dry with only about 30% of the normal rainfall. However some parts of north west Norfolk experienced a very wet day on the 19th, with falls of 65.2 mm at Hempstead by Holt, 57.8 mm at Briston, 53.4 mm at Syderstone, and 52.6 mm at Dunton.

September - This was a cool month, all the more noticeable after the great heat of August. The hot weather persisted until the 3rd, but thereafter with an unusual frequency of days with winds between north-west and north-east the summer was effectively at an end. An early air frost on the 27th caused damage to tender plants. Although rainfall was only 80% of average it was sufficient to restore a welcome shade of green to the parched landscape.

October - This was the mildest October since 1969, (the last significantly warm October this century in Norfolk being 1921). Night temperatures on average were actually higher than those of September. Rainfall was very close to normal, although Santon Downham recorded a notable monthly total of 123.8 mm. On the 15th there was one of the few 'summer' thunderstorms of 1990 with a most spectacular display of lightning observed during the early evening.

November - This month had a mean temperature virtually normal and at last brought welcome rains to much of Norfolk, although some western parts of the county remained rather dry. In contrast some eastern and south-eastern localities were very wet with over double their normal monthly rainfall—making it the wettest November since 1974 in these areas. There was an unusual frequency of winds between north and east but their generally cloudy nature averted any excessive frost.

December - This was the coldest December since 1982, although the mean temperature was actually slightly above normal. Surprisingly it was the coldest month over most of the county since March 1987. It was generally quiet and rather cold until the 20th, with the remainder of the month unsettled and milder. There was a sudden fall of snow in inland areas of the county on the 8th, with an accumulation by the early afternoon of between 3-7 cm causing some disruption to traffic for the first and only occasion in 1990. Rainfall was generally a little below average.

The Year - with a mean temperature of 10.7°C 1990 was warmer than the two warmest years locally this century, (1921 and 1938), and was possibly the hottest year in Norfolk since at least 1659. It was the driest year since 1976, and the sunniest in the region since records started in 1925. Although slight snow was observed to fall on 15 days, it lay thinly on only one morning — compared with 1989 when no snow lay whatsoever. The year's lowest temperatures were recorded on the 5th April with -5.9°C in the screen and -8.1°C on the grass.

1990 WEATHER

	MEAN TEMPERATURE °C		NO. OF AIR AND GROUND FROSTS		SUNSHINE HOURS	
	1990	Avg.	1990	Avg.	1990	Avg.
Jan.	6.3	3.5	3/16	11/19	67.2	51.2
Feb.	7.7	3.2	2/11	12/18	100.9	66.8
March	8.7	5.3	4/16	7/17	152.7	100.6
April	8.0	7.3	9/21	4/14	242.7	154.2
May	12.4	10.9	1/6	1/6	282.7	193.5
June	14.1	14.0	—	rare	164.3	202.6
July	16.5	16.0	—	very rare	270.9	193.9
August	18.7	16.2	—	very rare	262.6	186.7
Sept.	13.1	13.9	1/1	rare/1	125.3	149.8
Oct.	12.5	10.4	0/2	1/6	138.9	109.1
Nov.	6.5	6.5	7/13	5/12	56.2	67.6
Dec.	4.5	4.2	9/18	9/17	48.0	50.5
Year	10.7	9.3	36/104	49/109	1912.0	1526.5

	RAINFALL mm		DAYS WITH SNOW/HAIL		DAYS WITH THUNDER	
	Costessey	Taverham				
	1990	Avg.	1990	Avg.	1990	Avg.
Jan.	48.3	58.4	1/0	5/1	0	rare
Feb.	87.1	45.0	5/3	4/1	3	rare
March	19.3	42.7	3/2	3/1	0	rare
April	49.9	39.9	1/3	1/1	4	1
May	17.4	41.7	0/0	rare	1	2
June	42.3	43.2	0/0	very rare/rare	1	3
July	21.9	57.9	—/0	—/rare	3	3
August	15.6	54.9	—/0	—/rare	0	3
Sept.	43.9	53.6	—/0	—/rare	0	2
Oct.	61.7	62.5	0/0	rare	2	1
Nov.	91.6	71.1	0/1	2/1	0	rare
Dec.	56.9	57.7	5/2	3/1	0	rare
Year	555.9	628.6	15/11	18/6	14	15

Averages quoted above are for 46 years to 1984 for rainfall, otherwise for 17 years to 1984.

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