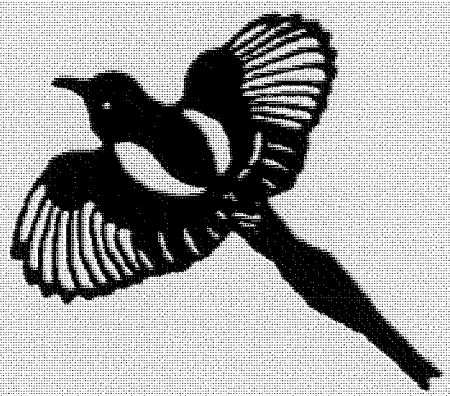
Milton Keynes Natural History Society

Journal 6



1992-1998

Acknowledgements

The Editor would like to thank all contributors of articles for publication. Thanks also are due to Jean Kent for cajoling and persuading those contributors!

Instructions for Contributors

Articles for publication in the Journal should be submitted to The Editor, Milton Keynes Natural History Society Journal, c/o Wildfowl Centre, Great Linford, Milton Keynes. Papers will be accepted on any natural history subject in North Buckinghamshire. Publication is at the discretion of the Editor. Papers from non-members may be accepted, but members' papers will receive preference. Publication of the Journal is irregular but never more frequently than annually.

Manuscripts should be typed, double spaced, on one side of the page only. Machine readable (IBM PC) versions of documents can also be accepted (and are preferred) but please contact the Editor for information on the form these should take. References cited in the text should be in the form '(Bailey, 1987)' or ' . . . as noted by Bailey (1987)'. All references cited in the text should be noted alphabetically at the end of the article in the form:

Baily, B. 1987. *Churchyard Memorials.* Robert Hale Ltd. pp 67-71.

All diagrams and figures should be prepared in black ink, submitted on separate sheets of paper and be clearly labelled. Lettering should be neat and uniform. Please only submit originals of diagrams. Please indicate the approximate position of each figure or table in the text of the article.

MKNHS Journal 6 - Errata

Since going to print with this issue of the Journal a number of spelling and typographical errors have come to light. The most significant ones are listed below.

Inside front cover, Foreword - Wildfowl Centre/ARC Wildlife Centre is now called "ARC Environmental Study Centre"

Page 5 - for Manchantia read Marchantia

Page 6 - for Weissia squarrrosa read Weissia squarrosa

Page 9 - for Plagiotheium read Plagiothecium

Page 10 Map 7 - for Platyphylla read platyphylla

Page 13 Map 13 - for Encylapta read Encalypta

Page 20 Map 85 - for Foninalis read Fontinalis

Page 23 Maps 107, 108, 109, 110 - for Rynchostegium read Rhynchostegium

Page 23 & 24 Maps 111, 112, 113, 114, 115 - for Eurynchium read Eurhynchium

Page 25 Map 116 - for Rynchostegiella read Rhynchostegiella

Page 30 Map 126 - for triquestris read triquestrus

Page 47 Figure 13 - for maritimu read maritimus

Throughout the Journal, Latin names should have been italicised. Unfortunately this has been lost for some of the article on duckweeds.

The Milton Keynes Natural History Society Journal

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Contents

Foreword

by Roy Maycock

1998 sees the thirtieth anniversary of the formation of the Milton Keynes Natural History Society (originally the Bletchley, then Bletchley and Milton Keynes Natural History Society). Of the four 'founders' of the Society, two are still active members - Bernard Frewin with his badgers and auctioneering prowess, and myself. Membership now approaches 100, but we would like to see it increase.

Activities and achievements over the years have been many, but in one area we have not been very forthcoming. That area is in the production of the Society Journal. This issue is just number 6! Inspection of others shows the range and expertise offered by the authors of papers and this edition is equally distinguished. New ground is broached and, hopefully, will stimulate readers into activity for future issues.

The bryophyte work done by Frances Higgs shows what can be done virtually by just one person. Aaron Woods' article on duckweeds is taken from his special study carried out in part fulfilment of his degree requirements. Dragonflies and damselflies have been George Mahoney's interest for several years so it is pleasing to see an account of their distribution in our own area. From further afield, the account of recent discoveries with respect to the fossils of the Burgess Shales in Canada shows that Arthur Whitehouse is never too old to 'go to press'. The Society's much respected President for many years was Gordon Osborn. With help from proceeds of the bequest left to the Society, Linda Piggott has been able to erect a flight and rehabilitation cage for young and/or injured bats. Her paper recounts the success of this project.

Particular thanks for the production of this Journal go to the above authors (together with all who helped them in various ways) and to the Editor (and his assistant who cajoled those authors into activity).

For those to whom this Journal is their first introduction to the Society, we hope you benefit from your reading. If you are able, please consider joining us at 7:30 p.m. on Wednesday evenings throughout the winter months at the ARC Wildlife Centre, Great Linford, Milton Keynes. Summer meetings are all outdoors.

An Introduction to the Bryophyte Flora of Milton Keynes

by Frances Higgs

On 1st April 1997 a part of North Buckinghamshire, comprised of the area designated for new town development plus the remaining villages and surroundings in Milton Keynes borough, was annexed from the rest of the county to become a new unitary authority. It all lies within the Watsonian vice-county 24 (Bucks) which also includes a small area of Salcey Forest. The area of this survey includes all of the new administrative area together with that part of Salcey Forest within v.c.24. The bryophyte records included here were all collected from 5 x 5 km grid squares between 1988 and the present. 134 taxa have been recorded and their distributions are shown on the maps accompanying the text. Factors which appear to affect these distributions include soil type, precipitation, woodlands and pollutants.

Geology

Buckinghamshire's oldest rocks are found in the northern part of Milton Keynes; the youngest in the county are in the Thames Valley. Most are covered with recent, superficial drift deposits. Outcrops run roughly north-east to south-west across Milton Keynes, but few are fully exposed, being mostly covered with Boulder Clay. However, the soils derived from the rocks do impart differences in pH, though most are neutral or alkaline. Only in the Brickhills does one encounter acid soils.

The most northerly areas have Boulder Clay and Lias Clay with Great Oolite to their south. This is a hard limestone and is close to the surface in places and so imparts a highly calcareous nature to the soils. It has been quarried in several places and used for building purposes, including boundary walls. These provide good bryophyte niches - much more so than the smoother bricks with their hard mortar. Bricks were made locally with clay extracted from large areas of the Oxford Clay which lie to the south of the limestone.

The rivers Great Ouse and Ouzel have cut courses through the limestone or clay and their valleys have Alluvium and Glacial Gravels, the latter having been extracted at a number of sites. In a few places the limestone and clay are separated by a narrow band of Cornbrash (a mixture of rubbly limestones).

Within Milton Keynes the escarpment on which Bow Brickhill and Little Brickhill stands is of Lower Greensand, a substrate which is so different from all other formations in that it supports an acid soil and the rock itself is an acid sandstone.

Altitude

Almost the whole of Milton Keynes is below 150m in height, except the hills above Bow Brickhill which rise to 171m to the east of the church. The northern clay areas around Hanslope to the west and Hardmead to the east are next in height, but rarely exceed 100m. The River Great Ouse west of Turvey forms part of the Milton Keynes boundary and is at 45m above sea level. Consequently, the whole area is lowland.

Aquatic Habitats

Just south of Stony Stratford, the River Great Ouse enters Milton Keynes. It then meanders in a more-or-less north-easterly direction to Newton Blossomville and just beyond. Drainage into this river is mainly from the River Tove to the north and the River Ouzel to the south. An extensive network of smaller streams drains into each of these rivers.

The Grand Union Canal runs from the Iron Trunk near Old Wolverton eastward to Great Linford, then turns south to Water Eaton where it leaves Milton Keynes.

Further habitats of importance are water bodies now contained in old gravel workings and clay pits. The series of balancing lakes created within the original designated area to alleviate flooding along the river courses are also valuable sites.

Climate

Milton Keynes lies within that part of England which has no extremes of temperature, precipitation or wind. Precipitation is relatively low, as is humidity, so the area is not very rich in bryophytes.

Pollution

Now that the brickworks have been lost from the area, the main source of pollution is exhaust from motor vehicles. Run-off from cultivated land may contain excesses of fertilisers or herbicides and if these reach the water courses they may be polluted.

Habitats

Samples of habitats surveyed so far include broad-leaved and coniferous woodlands, wet and dry grasslands, heathland, trees, walls and otherwise bare soil. Apart from the one aquatic species recorded, no water habitats have been surveyed.

Several areas of woodland enrich the region and some are of ancient origin, e.g. Little Linford Wood, Howe Park Wood and Shenley Wood. Within the woods are the damp, shady conditions that encourage bryophyte growth - at ground level and on trees. The main area of coniferous woodland is around Bow Brickhill, Back Wood and Wavendon Wood.

The small area of acid heathland in Milton Keynes is also confined to the Brickhills.

The recent (1991) planting of trees at Hazeley for the formation of woodland has temporarily increased bare soil sites. Milton Keynes Natural History Society and The Parks Trust have teamed-up to monitor progress and to keep records of all flora and fauna species encountered. Focus of attention on this site led to the discovery of some mosses which are nationally rare.

Churchyards, which were the original basis of this study, are well worth exploring as some are quite rich in moss growth. Having a wide variety of habitats e.g. walls, stones, grassland, trees, paths and bare soil patches, increases the likelihood of recording a wide range of species.

Parkland has been created to border rivers, streams and lakes and, together with the massive tree planting schemes, all combine to clothe the landscape and play a part in reducing air pollution.

Sources of Information

Herbarium specimens of v.c.24 bryophytes are housed in the Buckinghamshire County Museum's Technical Centre at Halton. Some from Milton Keynes were deposited in 1971 by Mr E. R. B. Little who had conducted surveys in the 1960s and 70s. Milton Keynes Development Corporation commissioned two studies, namely "Bryophyte Studies of Selected Habitats" by R. Mead (summer 1975) and "A Bryophyte Survey of Churchyards" by K. Swabey (October 1978). It is anticipated that, at a later date, records from these sources may be incorporated with current records to give a more complete account of the bryophytes of Milton Keynes.

The records used in this account are mainly those of the author and therefore reflect the extent of her excursions. A few welcome additions have come from Aaron Woods (AW). Nomenclature and order follow that used by Smith, A. J. E. in "The Moss Flora of Britain & Ireland" and "The Liverworts of Britain & Ireland".

The distribution maps accompanying the text show the co-ordinates for 10km squares and the intermediate 5km squares are also indicated. These are referred to by their compass positions i.e. NW, SW, NE, SE within each 10km grid square e.g. Howe Park Wood is in 83SW.

Hepaticae (Liverworts)

Lepidozia reptans (L.) Dum. (Map 1) is a slender plant of acidic habitats such as Wavendon Wood. (93SW) (AW). It was found to be growing over and through the mosses *Pohlia nutans* and *Campylopus paradoxus*.

Lophocolea bidentata (L.) Dum. (Map 2) is frequent in sufficiently damp habitats. Two varieties exist, namely *bidentata* and *rivularis*, both grow within the survey area in churchyards and woods.

Lophocolea heterophylla (Schrad.) Dum. (Map 3) has scattered, mainly woodland locations as it grows on stones, tree boles and rotting wood. There is a small amount in the churchyard of Tyringham-cum-Filgrave (84NE) where suitable conditions exist.

Plagiochila porelloides (Torrey ex Nees) Lindenb. (Map 4) favours well shaded situations. It is often almost concealed and grows in woodland at Oakhill (83NW), Howe Park (83SW), Hollington (84NE) and Great Wood (85SW).

Radula complanata (L.) Dum. (Map 5) forms small patches on a few trunks and exposed roots in Dinglederry (85SE).

Ptilidium pulcherrimum (G.Webb.) Vanio (Map 6) is certainly the most interesting find among the liverworts. The record comes from a dead branch in Little Linford Wood (84NW).

Porella platyphylla (L.) Pfeiff. (Map 7) clothes quite substantial areas of churchyard wall at Olney (85SE) and Loughton (83NW). Smaller patches occur on walls and limestone memorials at Clifton Reynes (85SE), Newton Blossomville, Cold Brayfield (both 95SW), Castlethorpe (74SE) and Calverton (73NE).

Pellia epiphylla (L.) Corda (Map 8) is on damp soil in Howe Park Wood (83SW) and Blackhorse Wood (84SE) (AW).

Pellia endiviifolia (Dicks.) Dum. (Map 9) was recorded on wet soil at Great Linford Lakes (84SW).

Metzgeria furcata (L.) Dum. (Map 10) forms intricate patches on trees, though in Milton Keynes they are small and infrequent. Samples can be found in Howe Park Wood (83SW), Little Linford Wood (84NW), Hollington Wood (84NE) and Dinglederry (85SE).

Lunularia cruciata (L.) Dum. ex Lindb. (Map11). The sole record is from a garden at Heelands (83NE). It is not a rare plant; there must be more sites.

Conocephalum conicum (L.) Underw. (Map 12) forms large mats on the moist, shaded stream banks in Dinglederry (85SE).

Manchantia polymorpha L. (Map 13) occurs in gardens on shaded paths and in plant pots. Garden centres often have pots on display with this as an extra! Many sites must be in existence but at present these are the only records: Heelands (83NE), Frosts Garden Centre (93NW) and Crook's Nursery (84NE).

Musci (Mosses)

Tetraphis pellucida Hedw. (Map 14) has so far only been recorded from Newport Pagnell churchyard, growing on peaty debris in deep shade (84SE).

Polytrichum formosum Hedw. (Map 15) grows on acid soil in Back Wood and Bow Brickhill churchyard (93SW). Small patches on locally acid conditions occur in Hollington Wood (84NE).

Polytrichum juniperinum Hedw. (Map 16) occurs on well-drained acidic soil at the Blue Lagoon Local Nature Reserve (83SE) and Bow Brickhill churchyard (93SW).

Atrichum undulatum (Hedw.) P.Beauv. (Map 17) can be found on banks and ditch sides in most of the woods. It also makes noticeable patches on the wood floor.

Ceratodon purpureus (Hedw.) Brid. (Map 18) is common in churchyards of the area. It grows on rotting wood, bare soil and wall tops where soil and debris collect.

Dicranella schreberana (Hedw.) Dix. (Map 19) grows on damp soil patches. A few plants have occurred at Hazeley Wood (83NW).

Dicranella staphylina Whitehouse (as Map 19) is also at Hazeley Wood on soil patches amongst grass.

Dicranella heteromalla (Hedw.) Schimp. (Map 20) requires some acidity in the substrate. It grows in woodland on humus and in churchyards.

Dicranoweisia cirrata (Hedw.) Lind. ex Milde (Map 21) is found on bark and on stone in woodland, hedgerows and churchyards.

Dicranum scoparium Hedw. (Map 22) grows well on the acid ground at Back Wood and Bow Brickhill churchyard (93SW). Locally acid conditions support it in Howe Park Wood. (83SW).

Dicranum majus Sm. (Map 23) grows in conditions similar to those of the previous species and was found in Wavendon Wood (93SW) (AW).

Dicranum tauricum Sapehin (Map 24) has been found on a tree stump in Howe Park Wood (83SW) and on a tree trunk and a post top in Dinglederry (85SE)

Several plants of *Campylopus paradoxus* Wils. (Map 25) were extracted from the *Lepidozia reptans* found in Wavendon Wood (93SW) (AW).

Campylopus introflexus (Hedw.) Brid. (Map 26) forms patches on peaty material in woods and some churchyards. In Hardmead churchyard (94NW) it grows on crumbling, rotted coniferous wood.

Fissidens incurvus Starke ex Röhl, (Map 27) grows on damp, shaded soil in Great Wood (85SW) and in an open situation in Tyringham-cum-Filgrave churchyard (84NE).

Fissidens bryoides Hedw. (Map 28) at present has only one record and that is from Howe Park Wood (83SW). It grows on damp, shaded soil.

Fissidens exilis Hedw. (Map 29) is a very small plant and only becomes easily visible when a patch of plants bears capsules. In this condition it attracted attention in Shenley Wood (83NW) when growing on a small patch of bare clay under trees.

Fissidens taxifolius Hedw. (Map 30) is widespread in woods, ditches, churchyards and gardens. It forms patches on disturbed soil.

Encalypta streptocarpa Hedw. (Map 31) is a plant of calcareous rocks and walls. It grows well on limestone beside the River Ouse near Olney (85SE).

Tortula ruralis (Hedw.) Gaertn. (Map 32) was recorded after being washed down by rain from a barn roof at Frog Hall (94NE) It is also in several churchyards.

Tortula intermedia (Brid.) De Not. (Map 33) grows in several churchyards on limestone memorials and walls.

Tortula laevipila (Brid.) Schwaegr. (Map 34) is usually found as an epiphyte on trees. In Hanslope churchyard (84NW), and that of Hardmead (94NW) it grows on limestone.

Tortula muralis Hedw. (Map 35) grows commonly throughout the area on stone, concrete, mortar and hard packed soil. A forest of capsules usually makes it very easy to observe.

Tortula marginata (Br. Eur.) Spruce (Map 36) can be found in damp shade on the walls of Olney church (85SE).

Tortula subulata Hedw. (Map 37) was found growing amongst other bryophytes in Broughton churchyard (84SE). It was noted during microscopic study of plants from a soil patch.

Tortula latifolia Bruch ex Hartm. (Map 38) grows on concrete by the river Tove at Castlethorpe (74SE) (AW).

Pottia starkeana ssp. *minutula* (Schleich. ex Schwaegr.) Chamberlain (Map 39) has been found at Hazeley Wood (83NW) growing as a few scattered plants amongst the next species.

Pottia truncata (Hedw.) Fürnr. (Map 40) grows in several locations in the area but it is best seen at Hazeley Wood where it forms large patches in the tree rows. In the autumn, when covered with capsules it is very noticeable.

Phascum cuspidatum Hedw. colonises bare soil patches and frequently mingles with other bryophytes. It is variable and two varieties have been recorded:
Phascum cuspidatum var. *cuspidatum* (Map 41) and var. *schreberanum* (Dicks.) Brid. (Map 42) are both at Hazeley Wood; var. *cuspidatum* is more widely recorded. Var. *schreberanum* is a new record for v.c.24.

Barbula convoluta Hedw. var. *convoluta* (Map 43) is in several churchyards and in crevices in the wall surrounding the ruins of the old church at Stanton Low. (84SW). It also grows on soil patches.

Barbula convoluta var. *commutata* (Jur.) Husn. (Map 44) grows in similar habitats in churchyards at Broughton (84SE) and Calverton (73NE). It is also at Hazeley Wood (83NW).

Barbula unguiculata Hedw. (Map 45) is common throughout Milton Keynes. It colonises patches of bare soil on the ground and where soil collects over other substrates.

Barbula revoluta Brid. (Map 46) grows on a buttress top at Hardmead (94NW), on stony ground at Olney (85SE) and on an ornamental wall top at Gayhurst (84NW). In 1995, at the latter site, the plants were fruiting.

Barbula fallax Hedw. (Map 47) has, so far, only been noted on damp soil on the old railway track near Weston Underwood (85SE).

Barbula rigidula (Hedw.) Mitt. (Map 48) grows on limestone in several churchyards. There is good growth of it on the limestone wall to the left of the road approaching Lathbury church (84NE).

Barbula trifaria (Hedw.) Mitt. (Map 49) grows on the edges of the tarmac path to Emberton church (84NE) and on the churchyard wall at Calverton (73NE).

Barbula tophacea (Brid.) Mitt. (Map 50) forms dark olive-brown tufts in damp, calcareous clay at the Blue Lagoon Local Nature Reserve (83SE) and on a track near Weston Lodge (85SE).

Barbula vinealis Brid. (Map 51) is a frequent churchyard plant favouring stones and walls.

Barbula cylindrica (Tayl.) Schimp. (Map 52) finds its way into soil-filled crevices on stones and at wall bases. Records come from churchyards at Haversham (84SW) and Emberton (84NE). It has also been noted growing in a flower pot at Heelands (83NE).

Weissia microstoma var. *brachycarpa* (Nees & Hornsch.) C.Mull. (Map 53) grows in Hazeley Wood (83NW) on soil patches in grass. Capsules were produced in the winter of 1993/4.

Weissia squarrrosa (Nees & Hornsch) C.Mull. (as map 53) inhabits conditions similar to those of the previous species in Hazeley Wood. Fruiting plants were found in 1993/4.

Weissia sterilis Nicholson, (as Map 53) is also at Hazeley Wood on calcareous clay patches. Capsules were found in February 1994.

Weissia longifolia Mitt. var. longifolia (as map 53) was a new record for v.c.24 when recorded at Hazeley Wood in 1994.

Weissia longifolia var. *angustifolia* (Baumg.) Crundw. & Nyh. (as Map 53) is recorded only from Hazeley Wood. It may require more calcareous conditions than var. *longifolia*.

Oxystegus sinuosus (Mitt.) Hilp. (Map 54) occurs on shaded stones in churchyards, gardens and woods.

Trichostomum brachydontium Bruch. (Map 55) forms scattered patches on the soil in Hazeley Wood (83NW).

Schistidium apocarpum (Hedw.) Br. Eur. (Map 56) can be seen at its best on the roadside wall at Calverton churchyard (73NE). It is frequently found in places where there is stonework, concrete or tarmac.

Grimmia pulvinata (Hedw.) Sm. Map 57) is very common on walls, concrete and stones.

Funaria hygrometrica Hedw. (Map 58) colonises bare soil in open places, woods, gardens, flower pots and on old bonfire sites. Capsules are frequent.

Physcomitrium pyriforme (Hedw.) Brid. (Map 59) requires damp clay and a few scattered plants were found with capsules by Willen Lake (84SE).

Ephemerum serratum (Hedw.) Hampe (Map 60) is a minute, ephemeral plant found during the microscopic examination of *Dicranella* spp. from Hazeley Wood (83NW). It grows in small patches or as scattered plants on damp soil.

Orthodontium lineare Schwaegr. (Map 61) was, until 1922, only recorded from the southern hemisphere. In Milton Keynes it grows in woodland, hedges and on rotting woodwork.

Leptobryum pyriforme (Hedw.) Wils. Map 62) colonises damp soil. It has been recorded on arable land at the edges of Great Wood (85SW), at Hazeley Wood (83NW) and in flower pots at Heelands (83NE).

Pohlia nutans (Hedw.) Lindb. (Map 63) grows in the more acid conditions on a sandy bank at Bow Brickhill and in Wavendon Wood (93SW) (AW).

Pohlia carnea (Schimp.) Lindb. (Map 64) has been found on damp clay soil in Willen churchyard (84SE), beside water in Emberton Park (85SE) and at Great Linford Lakes (84SW).

Pohlia wahlenbergii (Web & Mohr) Andrews (Map 65) grows in wet places on the old railway track beyond Weston Underwood (85SW).

Bryum capillare Hedw. (Map 66) seems common throughout the area on soil, stone, concrete, walls and wood.

Bryum flaccidum Brid. (Map 67) requires high humidity. It grows in a culvert under the old railway track (85SE), on tree trunks in Dinglederry (85SE) and in Hollington Wood (84NE) where there is deep shade.

Bryum caespiticium Hedw. (Map 68) is recorded from old walls at Stanton Low (84SW) and Narrow Leys barn (84NW). It also grows on hard, stony patches in a track near Weston Underwood (85SE).

Bryum bicolor Dicks. (Map 69) is widely recorded from churchyards, woods and soil beside the Grand Union Canal.

Bryum argenteum Hedw, (Map 70) is also widespread in Milton Keynes; its silvery sheen is easily recognisable growing in paths, between paving blocks, crevices in walls and hard soil on tracks. In the gravel path edges approaching the Teardrop Lakes at Loughton (83NW) it grows taller and has a deep green colour.

Bryum ruderale Crundw. & Nyh. (Map 71), another soil colonist, is recorded from Hazeley Wood (83NW) and from the field near Stanton Low church ruins (84SW).

Bryum rubens Mitt. (Map 72) frequently occurs on damp soil in gardens, arable land and churchyards.

Mnium hornum Hedw. (Map 73) requires some acidity and is well distributed through the area on woodland humus.

Mnium stellare Hedw. (Map 74) grows mixed with *Mnium hornum* in Dinglederry (85SE) and its discovery in 1997 was a great delight to the author.

Rhizomnium punctatum (Hedw.) Kop. (Map 75) needs shady and damp conditions. Patches grow in Howe Park Wood (83SW), Dinglederry (85SE) and Blackhorse Wood (84SE) (AW).

Plagiomnium affine (Funck.) Kop. (Map 76) is recorded from gardens, woods and churchyards.

Plagiomnium undulatum (Hedw.) Kop. (Map 77) is common throughout Milton Keynes, in woods and shaded churchyard grass.

Plagiomnium rostratum (Schrad.) Kop. (Map 78) has, so far, only been noted in damp shade near Weston Underwood and Dinglederry (85SE).

Aulacomnium androgynum (Hedw.) Schwaegr. (Map79) is unmistakable when bearing its "drumsticks". Stems end with clusters of gemmae, which are a means of vegetative reproduction. Rotting wood that is wet and shaded seems to be a usual habitat. This moss is recorded from hedgerows, woods and churchyards affording good shade.

Zygodon viridissimus (Dicks.) R. Br. (Map 80) has two known sites in Milton Keynes. It grows on elder (*Sambucus nigra*) as an epiphyte near Great Linford church (84SE) and on stones lining a culvert under the old railway track near Weston Underwood (85SE).

Orthotrichum affine Brid. (Map 81) grows as an epiphyte on shaded branches and sloping tree trunks. Records are scattered through the area from woods, churchyards and lakeside trees.

Orthotrichum anomalum Hedw. (Map 82) is frequent on stones and walls. It features prominently in churchyard lists.

Orthotrichum diaphanum Brid. (Map 83) grows well in Olney churchyard (85SE). It is widely recorded from walls, memorial stones and trees.

Ulota crispa (Hedw.) Brid. (Map 84) is, at present, only recorded from Dinglederry (85SE) where it is epiphytic on elder.

Fontinalis antipyretica Hedw. (Map 85) grows in both still and running water. There are many likely sites for this moss; the lack of records is due to the unsurveyed habitats. The current record was made by Aaron Woods in the course of his Duckweed study.

Leucodon sciuroides (Hedw.) Schwaegr. (Map 86) was a new v.c.24 record when found in Hardmead churchyard (94NW) on a limestone memorial in 1994. Since then it has been noted in similar situations in other churchyards, namely Astwood (94NE), Hanslope (84NW) and Great Linford (84NE).

Neckera complanata (Hedw.) Hüb. (Map 87) also grows in Hardmead churchyard and at Dinglederry (85SE). It is a very filmy, delicate moss requiring moist shade.

Homalia trichomanoides (Hedw.) Br. Eur. (Map 88) grows on shaded tree boles beside water in Dinglederry and Hollington Wood (84NE).

Thamnobryum alopecurum (Hedw.) Nieuwl. (Map 89) is a robust species found in many churchyards and woods throughout the area.

Thuidium tamariscinum (Hedw.) Br. Eur. (Map 90) is plentiful in woods on soil, tree boles and rotting wood. It is a very noticeable and beautiful plant.

Cratoneuron filicinum (Hedw.) Spruce (Map 91) is a plant of wet calcareous habitats, by water and in marshy patches.

Amblystegium serpens (Hedw.) Br. Eur. (Map 92) grows in moist shaded situations on soil, stone, living and dead wood.

The record for *Amblystegium varium* (Hedw.) Lindb. (Map 93) comes from stream-bed stones in Great Wood (85SW).

Amblystegium riparium (Hedw.) Br. Eur. (Map 94) requires moist places. It grows by Willen Lake (84SE) by water in Emberton Park (85SE) and in areas subject to flooding at Hazeley Wood (83NW).

Drepanocladus aduncus (Hedw.) Warnst. (Map 95) is found in marshy and semi-aquatic conditions. The only site known at present is at Great Linford Lakes (84SW).

Calliergon cuspidatum (Hedw.) Kindb. (Map 96) is well distributed throughout the area and favours moist places. It frequently grows on damp lawns.

Isothecium myurum Brid. (Map 97) grows on tree boles in woodland. Three recorded sites are for Little Linford Wood (84NW), Howe Park Wood (83SW) and Dinglederry (85SE).

Isothecium myosuroides Brid. (Map 98) is found in similar woodland habitats. Present records are from Hollington Wood (84NE) and Dinglederry (85SE).

Homalothecium sericeum (Hedw.) Br. Eur. (Map 99) covers large areas on many of the churchyard walls and limestone memorials. It grows well on the Olney churchyard wall bordering Church Street (85SE).

Brachythecium albicans (Hedw.) Br. Eur. (Map 100) colonises sandy or gravely places. Scattered locations have been noted at Back Wood (93SW), Blue Lagoon Nature Reserve (83SE), Broughton churchyard (84SE) and Emberton churchyard (84NE).

Brachythecium rutabulum (Hedw.) Br. Eur. (Map 101) can be found almost everywhere and is very variable. One form veers strongly towards the next species and has to be examined with this in mind.

Brachythecium rivulare Br.Eur. (Map 102) requires ground that is permanently wet. The only recorded site is in Howe Park Wood (83SW).

Brachythecium velutinum (Hedw.) Br. Eur. (Map 103) has its present sites in woodlands and churchyards. It grows on living and dead wood, stones and bare soil.

Brachythecium populeum (Hedw.) Br. Eur. (as Map 102) was growing tightly pressed to bark in Howe Park Wood (83SW).

Small patches of *Pseudoscleropodium purum* (Hedw.) Fleisch. (Map 104) are quite widespread in grass. Records are from woods, churchyards, an old railway track and Willen lakeside where a much larger area grows on a stream bank.

Cirriphyllum piliferum (Hedw.) Grout (Map 105) prefers damp and well shaded situations. Particularly good patches of it occur in Hollington Wood (84NE).

Cirriphyllum crassinervium (Tayl.) Loeske & Fleisch. (Map 106) grows over limestone in Tyringham (84NE) and Calverton (73NE) churchyards.

Where submergence occurs *Rhynchostegium riparioides* (Hedw.) C.Jens. (Map 107) grows over rocks and tree roots. Good patches are on concrete by the Grand Union Canal (84SW) and by stream sides in woodland.

Rhynchostegium murale (Hedw.) Br. Eur. (Map 108) grows in several churchyards on limestone.

Rhynchostegium confertum (Dicks.) Br. Eur. (Map 109) is widely distributed on varying substrates in damp shaded conditions.

Rhynchostegium megapolitanum (Web. & Mohr) Br. Eur. (Map 110) is difficult to determine without capsules and could be in other locations. The sole record is for Sherington churchyard (84NE).

Eurhynchium striatum (Hedw.) Schimp. (Map 111) is well distributed in churchyards and woods.

Eurhynchium pumilum (Wils.) Schimp. (Map 112) is a very slender species; it grows on shaded clay soil in Castlethorpe (74SE) and Calverton (74NE) churchyards.

Eurhynchium praelongum (Hedw.) Br. Eur. (Map 113) flourishes in moist shade and grass on various substrates. It is very common.

Eurhynchium swartzii (Turn.) Curn. (Map 114) grows in damp habitats in churchyards, woods and by water.

Eurhynchium speciosum (Brid.) Jur. (Map 115) favours very wet soil by water. Some stems of this were found amongst other bryophytes beside Willen Lake (84SE).

Rhynchostegiella tenella (Dicks.) Limpr. (Map 116) is quite widely recorded in the churchyards, where it has been found on stones and on bark.

Plagiothecium denticulatum (Hedw.) Br. Eur. (Map 117) has only three records so far. They are for Bow Brickhill (93SW), Great Wood (85SW) and Dinglederry (85SE). It grows on stones and decaying wood.

Plagiothecium curvifolium Schlieph. (Map 118) was found on leaf mould in Kilwick Wood (85SE) and on soil in Tyringham churchyard (84NE).

Plagiothecium nemorale (Mitt.) Jaeg. (Map 119) grows on damp shaded soil in Howe Park Wood (83SW), Hollington Wood (84NE) and Dinglederry (85SE).

Plagiotheium undulatum (Hedw.) Br. Eur. (Map 120) is very pale in colour and forms distinctive patches on soil in Wavendon Wood (74SE) (AW).

Isopterygium elegans (Brid.) Lindb. (Map 121) requires an acidic substrate. With other bryophytes it colonises parts of the steep banks at Bow Brickhill (93SW).

Hypnum cupressiforme Hedw. is an extremely variable plant and grows throughout the area.
var. *cupressiforme* (Map 122) forms intricate mats on stone, soil or bark. It is found in woods and hedgerows.
var. *resupinatum* (Tayl.) Schimp. (Map 123) is very slender and forms patches on bark in woodland and on stones in a few churchyards. Present records are for Shenley Church End churchyard, Shenley Wood and Hazeley Wood where it has a hedgerow site (83NW), Howe Park Wood (83SW), Hollington Wood (84NE), Dinglederry and Olney churchyard (85SE). var. *lacunosum* Brid. (Map 124) is a more robust plant which is in many churchyards on walls or memorials. It also grows on roofs.

Hypnum jutlandicum Holmen & Warncke (Map 125) forms pale open patches on acidic soil and humus in Wavendon Wood. (93SW) (AW).

Rhytidiadelphus triquetrus (Hedw.) Warnst. (Map 126) occurs in one patch on the embankment of the old railway track near the site of Weston Lodge (85SE).

Rhytidiadelphus squarrosus (Hedw.) Warnst. (Map 127) is common in grass, lawns and churchyards; woodland rides frequently support this species.

Pleurozium schreberi (Brid.) Mitt. (Map 128) requires acidity and grows amongst grass in Bow and Little Brickhill churchyards (93SW).

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My thanks are due to:

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Roy Maycock who provided the maps and immense overall help.

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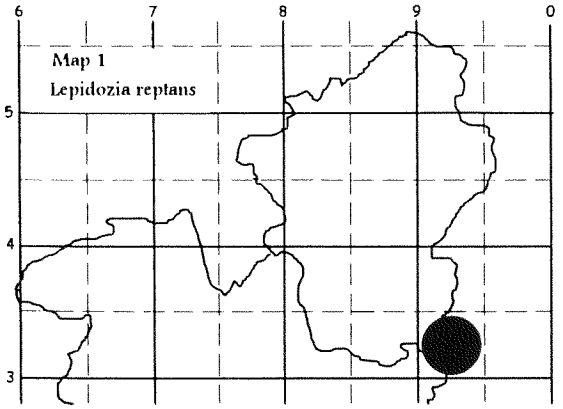
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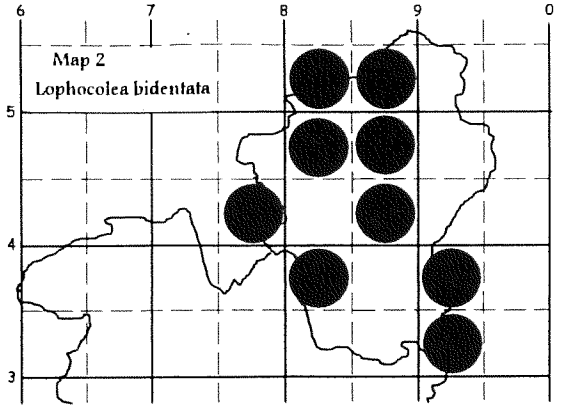
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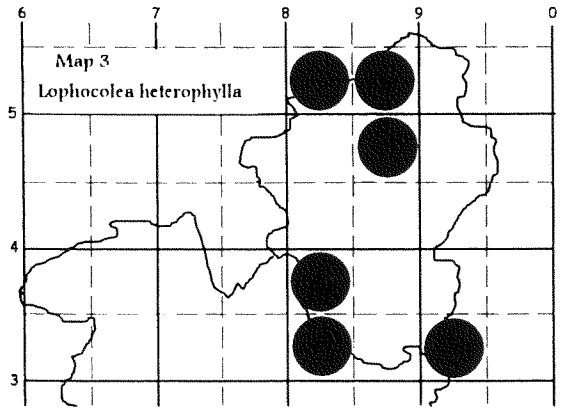
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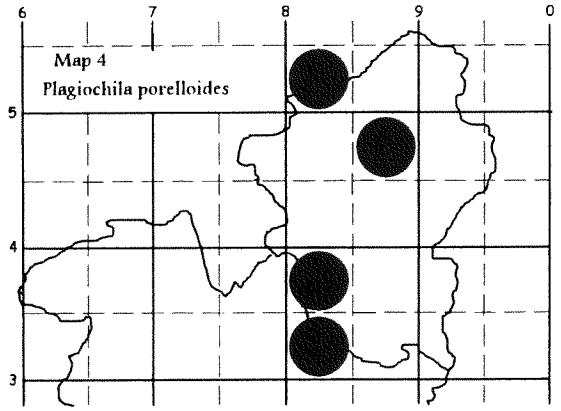
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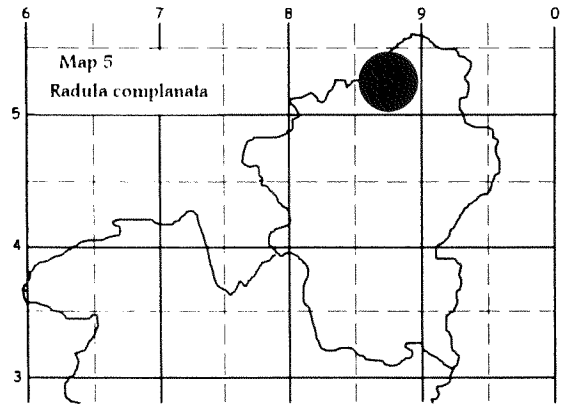
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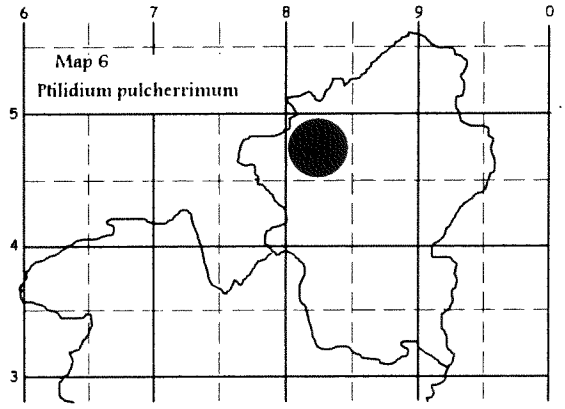
Radula complanata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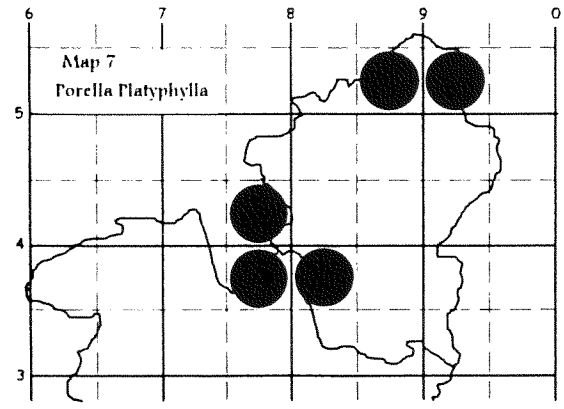
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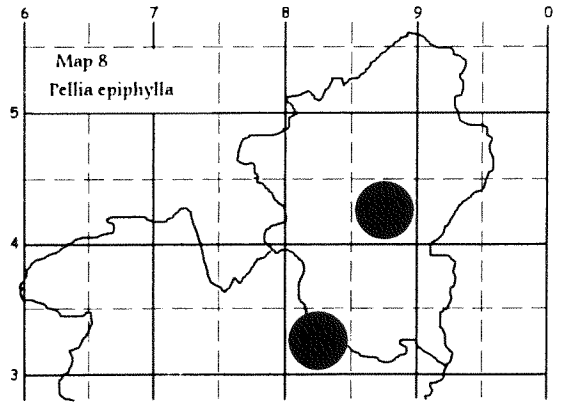
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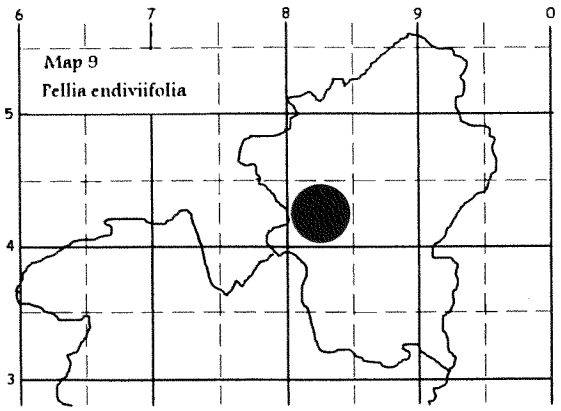
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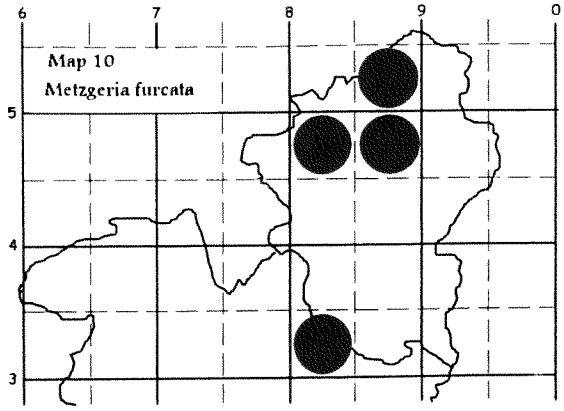
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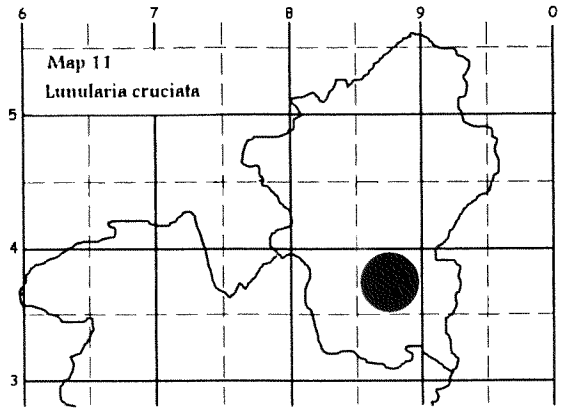
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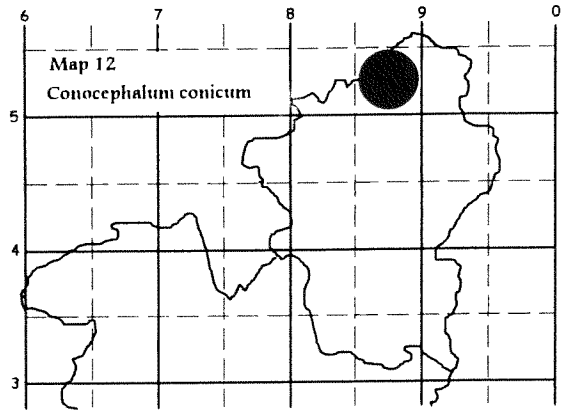
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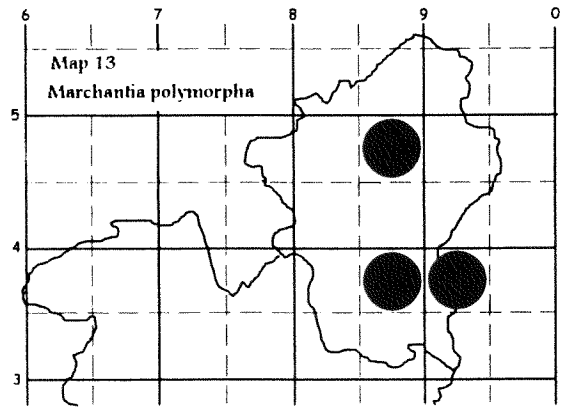
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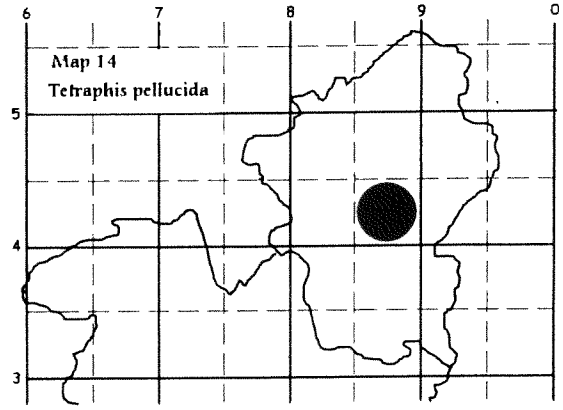
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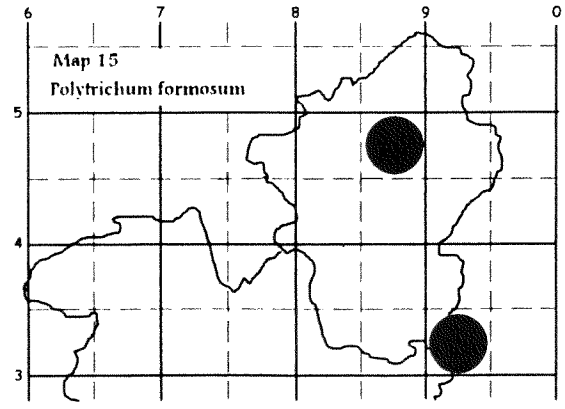
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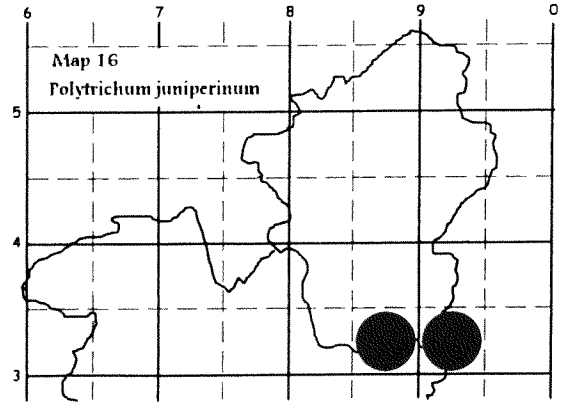
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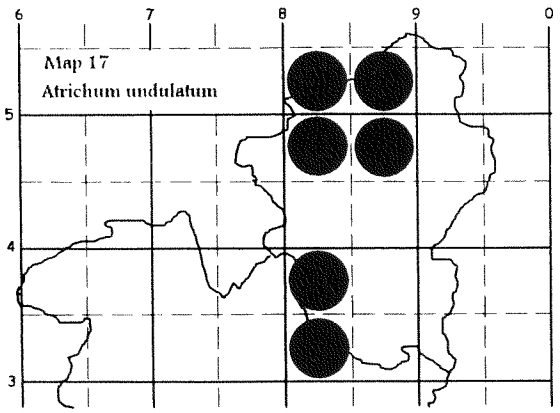
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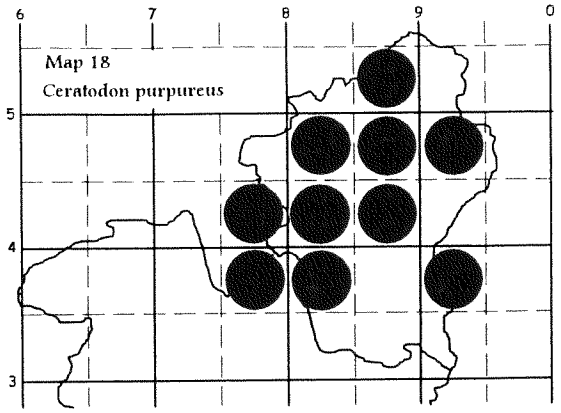
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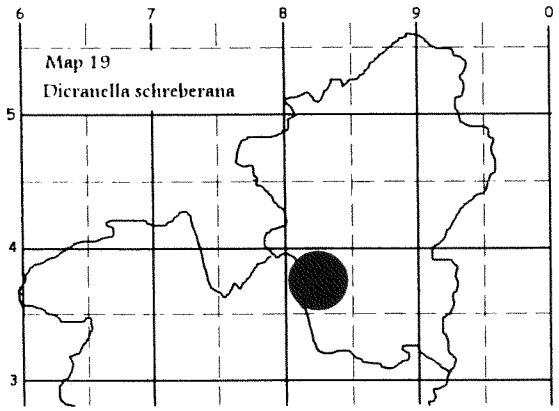
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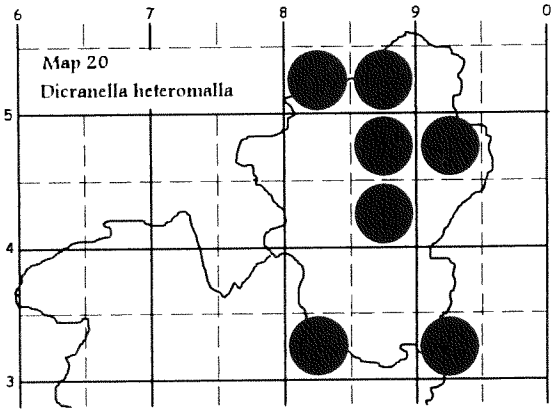
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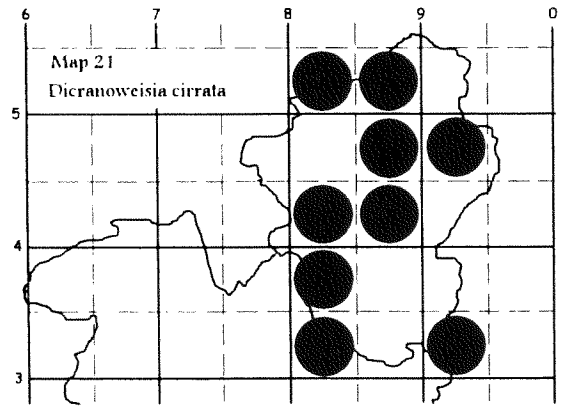
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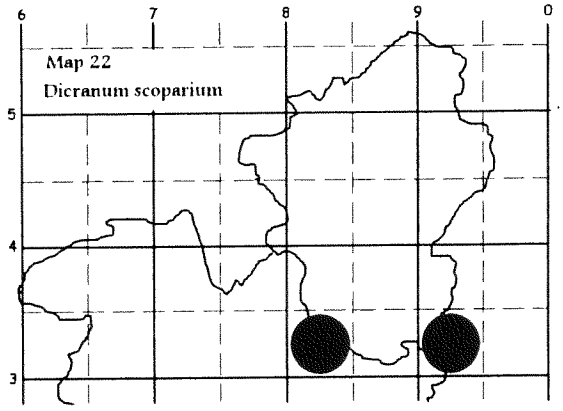
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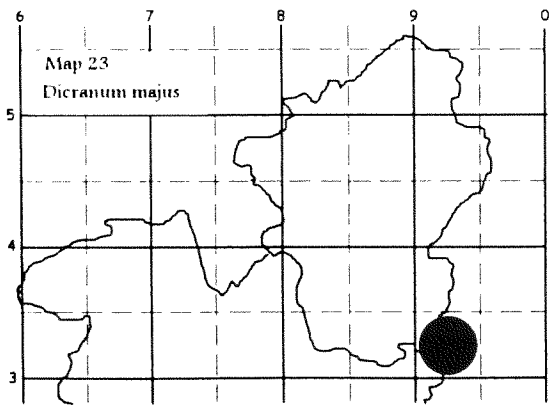
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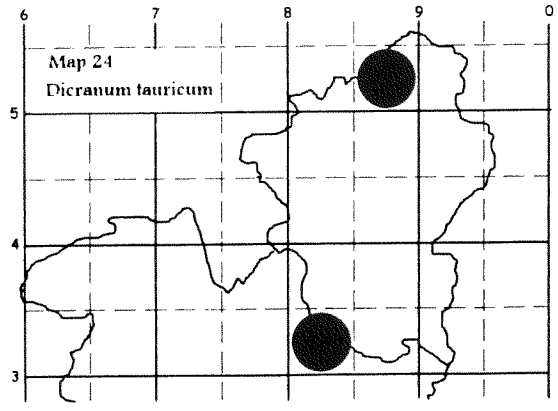
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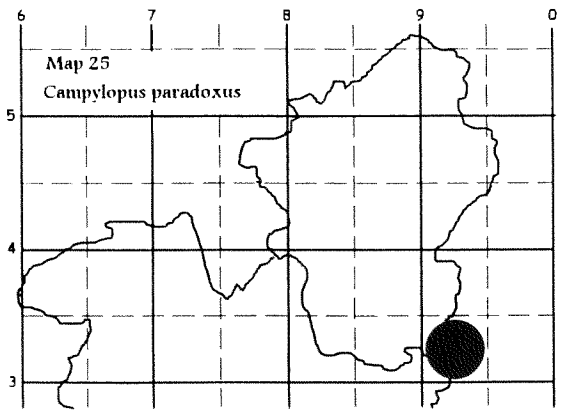
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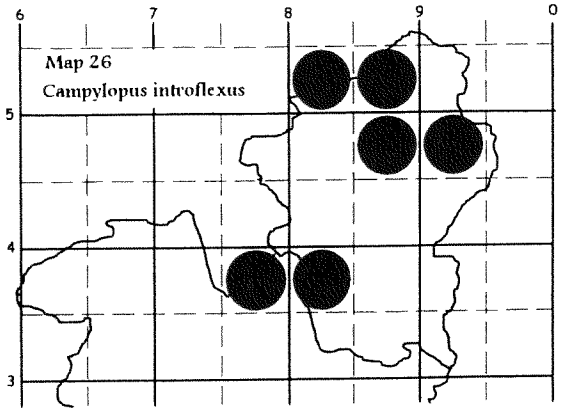
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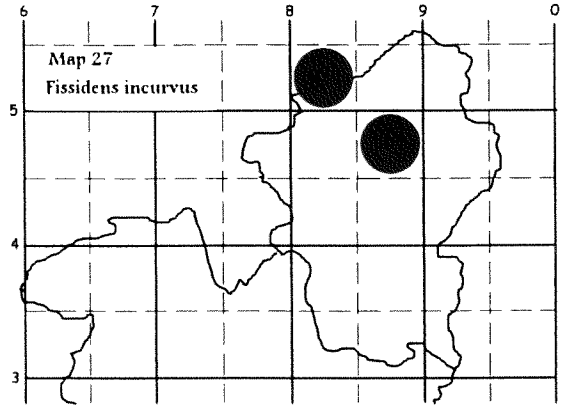
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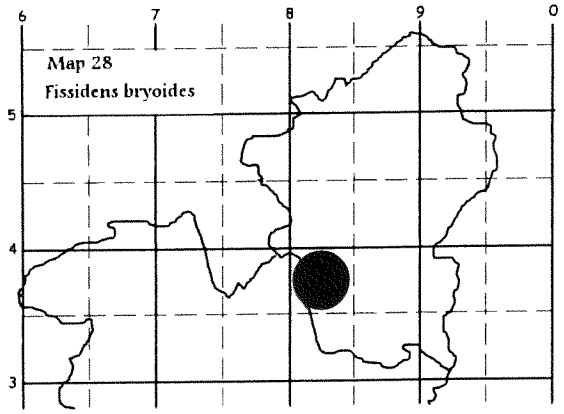
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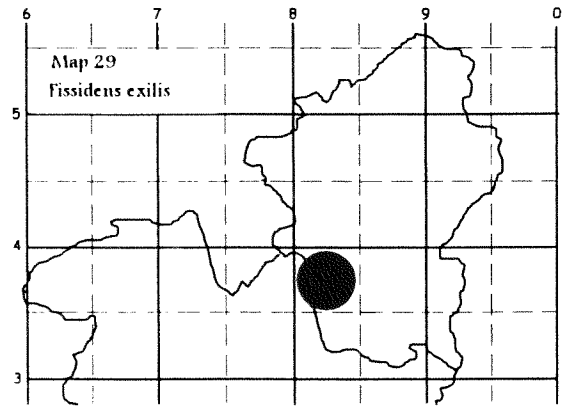
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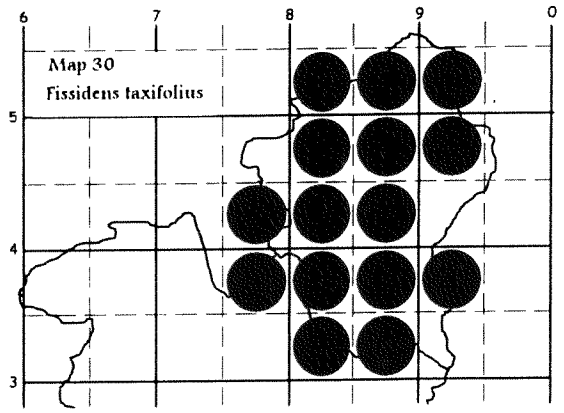
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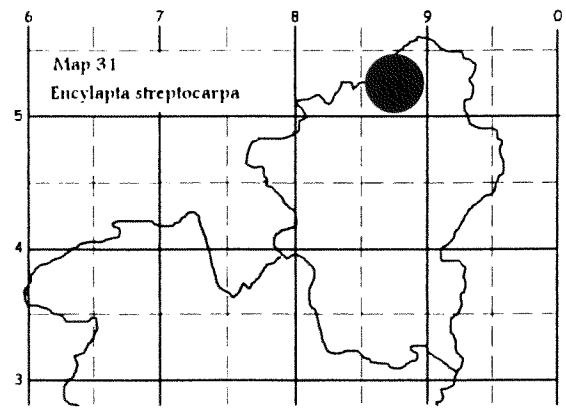
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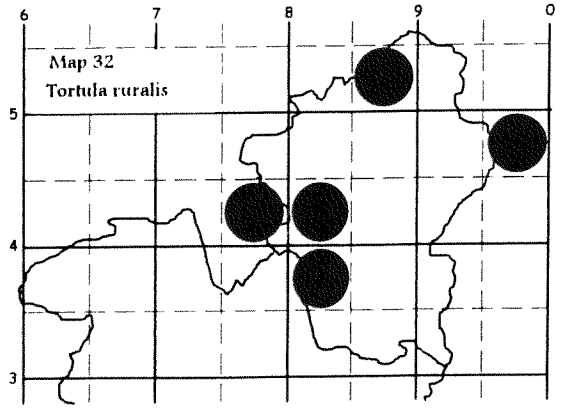
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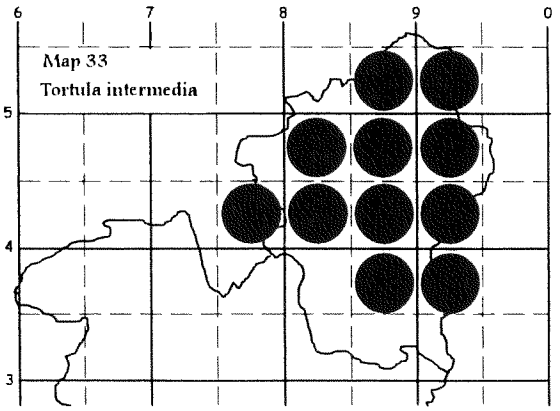
Tortula ruralis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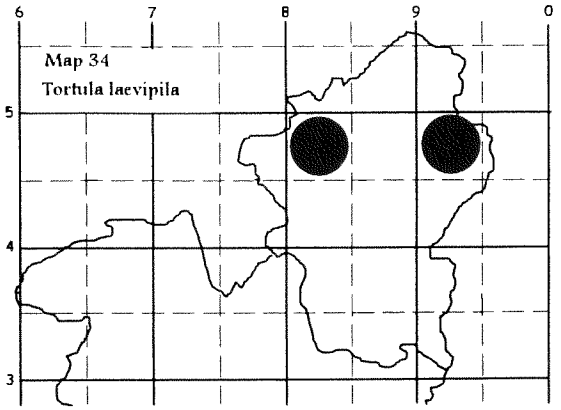
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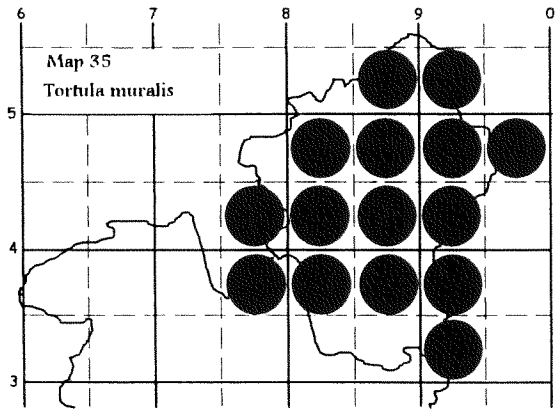
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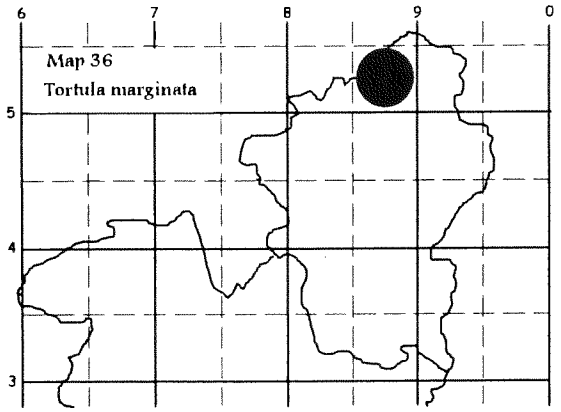
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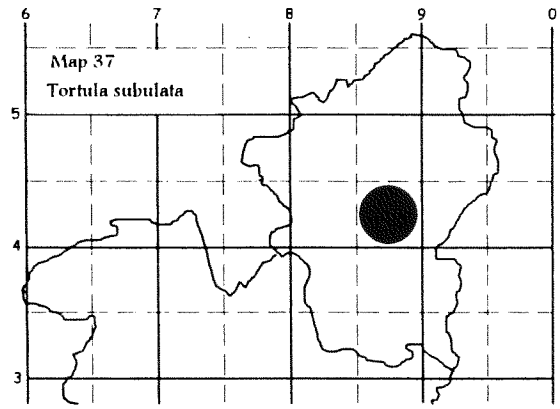
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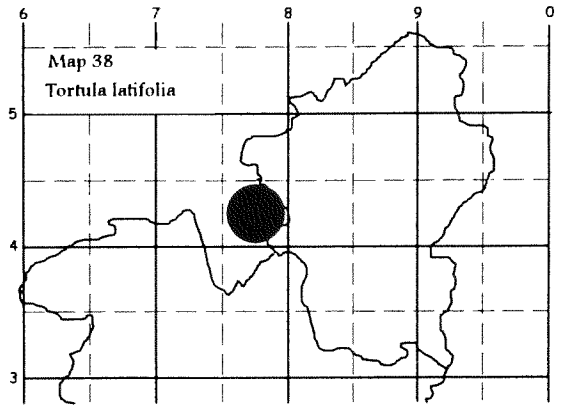
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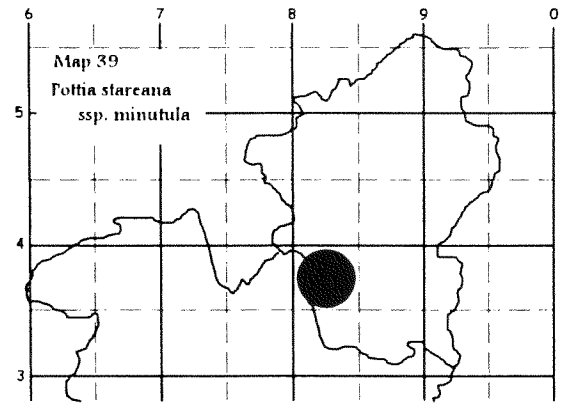
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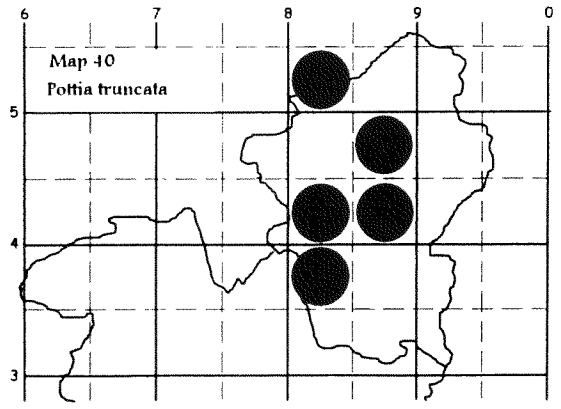
ssp. minutula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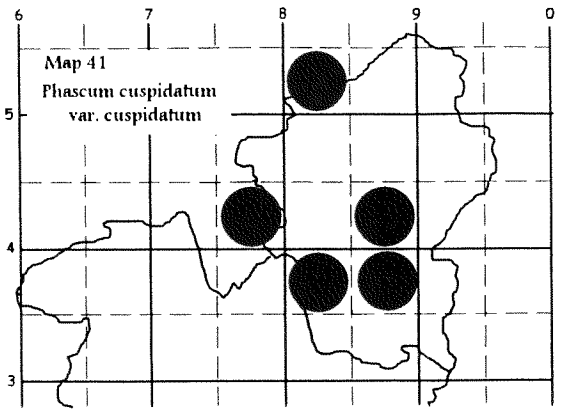
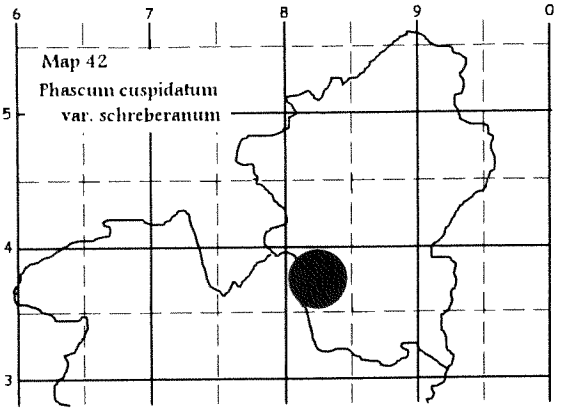
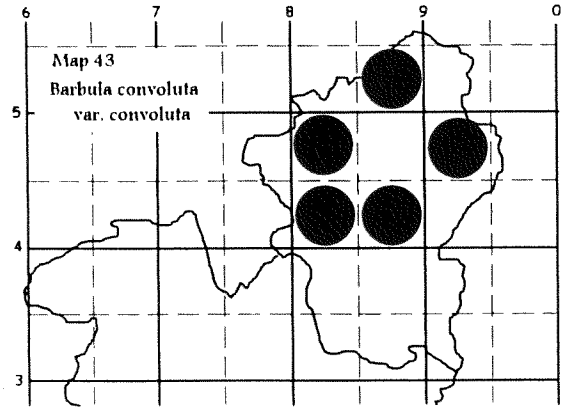
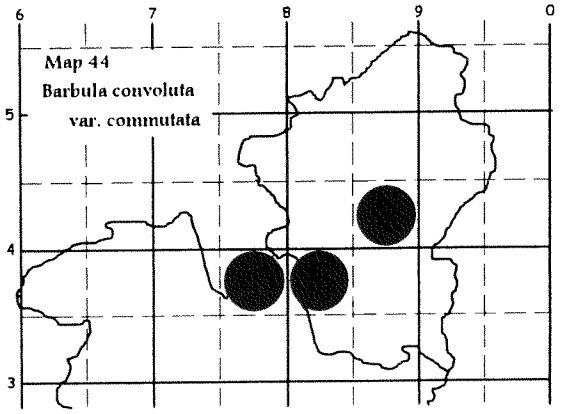
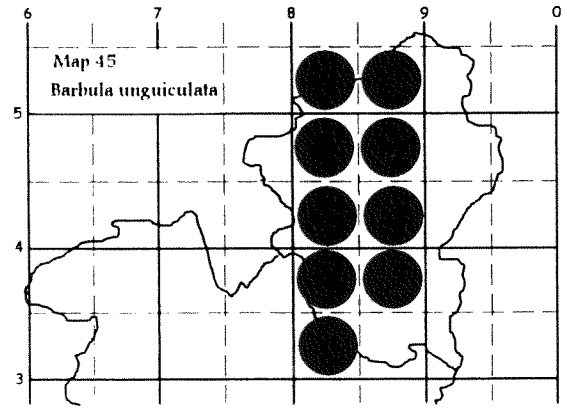
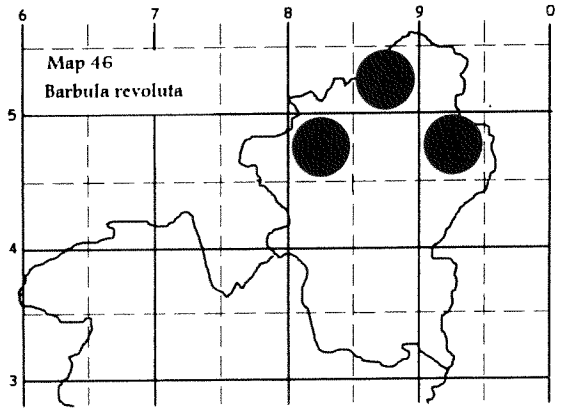

Map 41
Phascum cuspidatum
var. cuspidatum

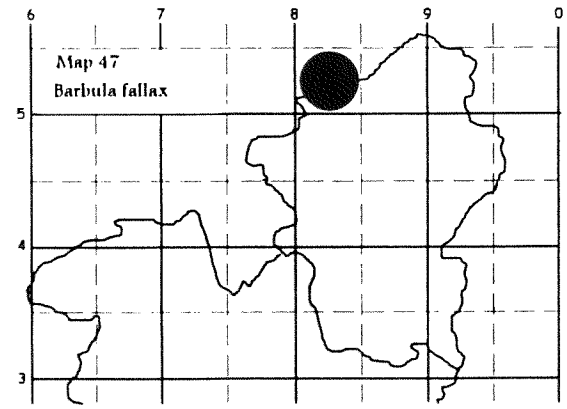

Map 42
Phascum cuspidatum
var. schreberanum

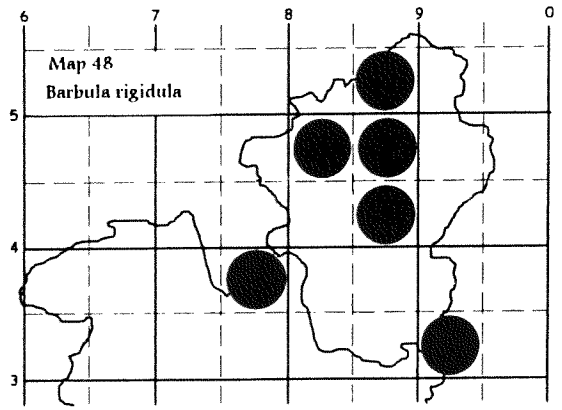

Map 43
Barbula convoluta
var. convoluta

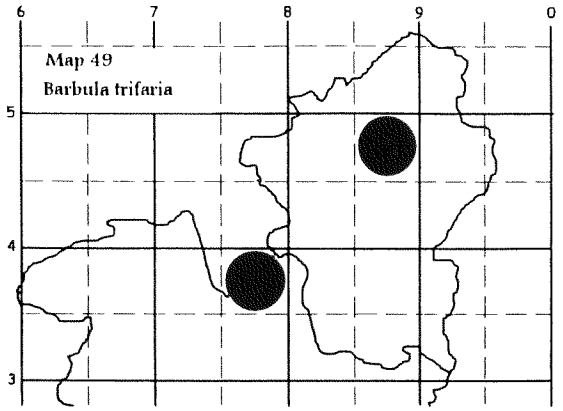

Map 44
Barbula convoluta
var. commutata

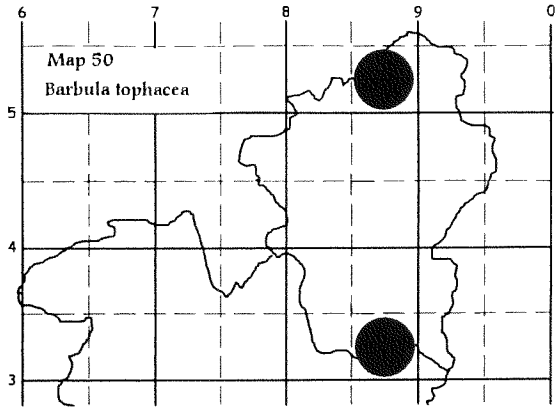

Map 45
Barbula unguiculata

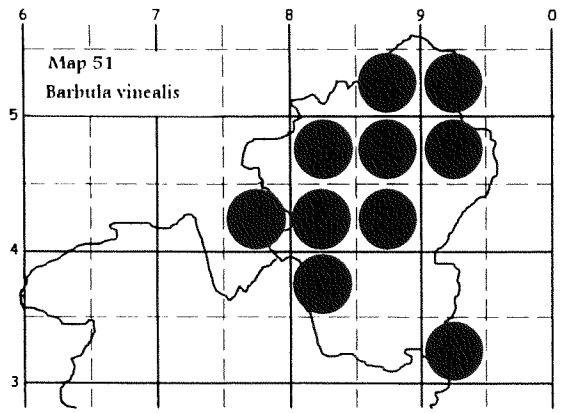

Map 46
Barbula revoluta

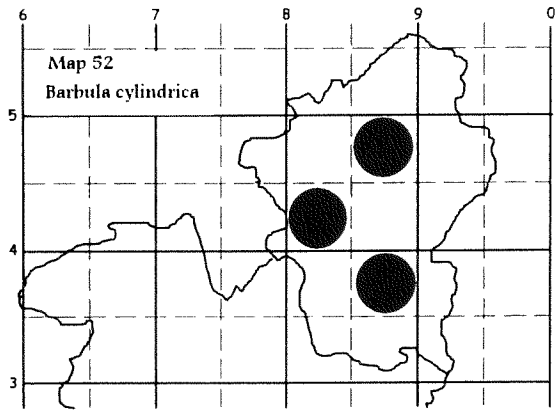

Map 47
Barbula fallax

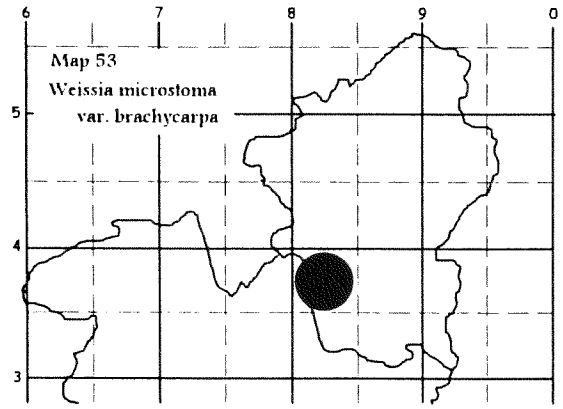

Map 48
Barbula rigidula

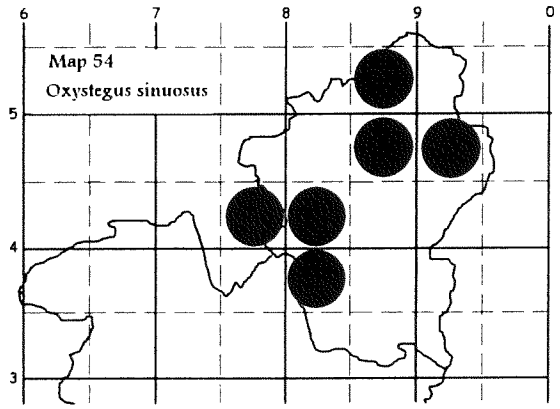

Map 49
Barbula trifaria

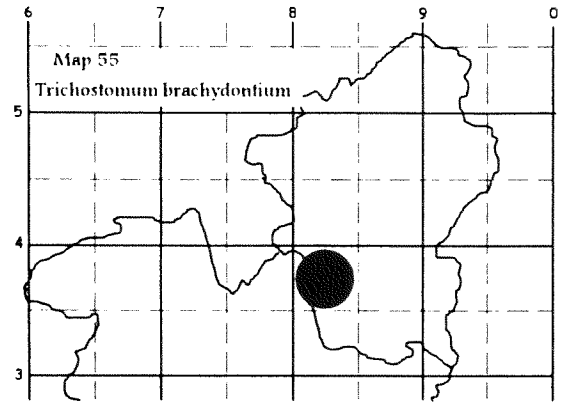

Map 50
Barbula tophacea

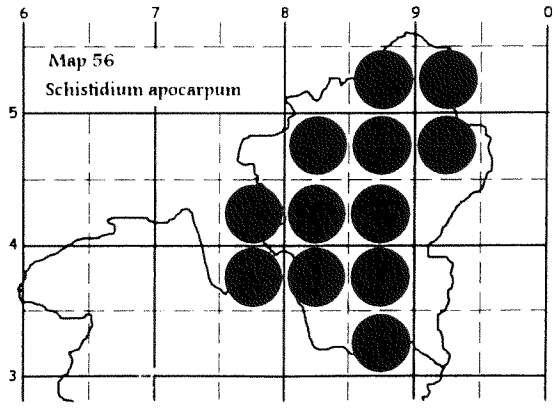

Map 51
Barbula vinealis

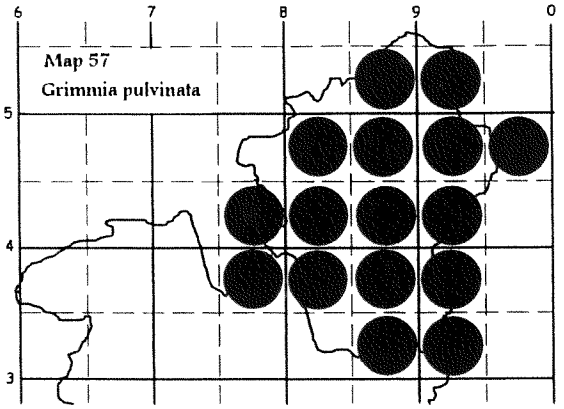

Map 52
Barbula cylindrica


Map 53
Weissia microstoma
var. brachycarpa


Map 54
Oxystegus sinuosus


Map 55
Trichostomum brachydontium


Map 56
Schistidium apocarpum


Map 57
Grimmia pulvinata
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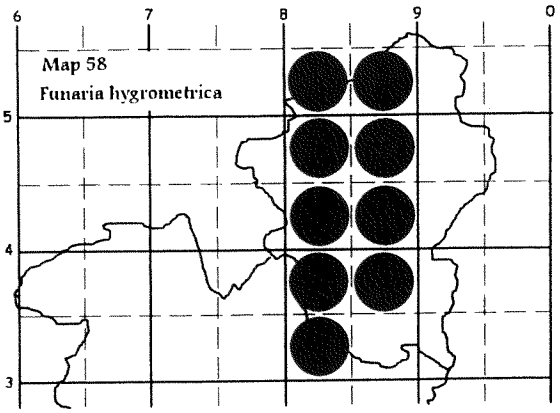
Map 58
Funaria hygrometrica
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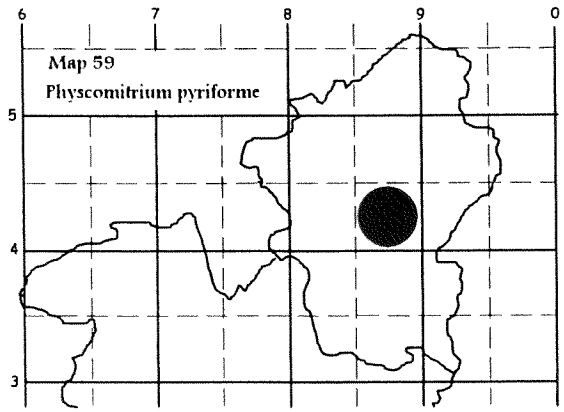
Map 59
Physcomitrium pyriforme
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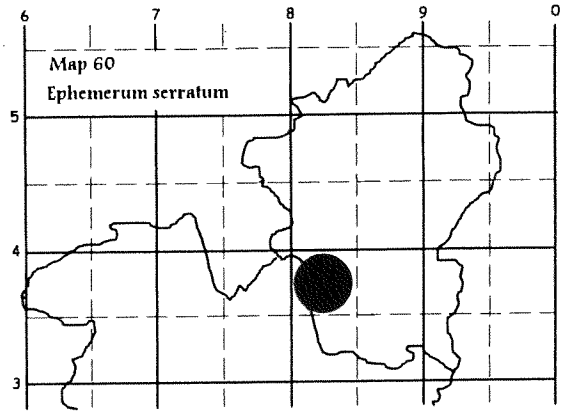
Map 60
Ephemerum serratum
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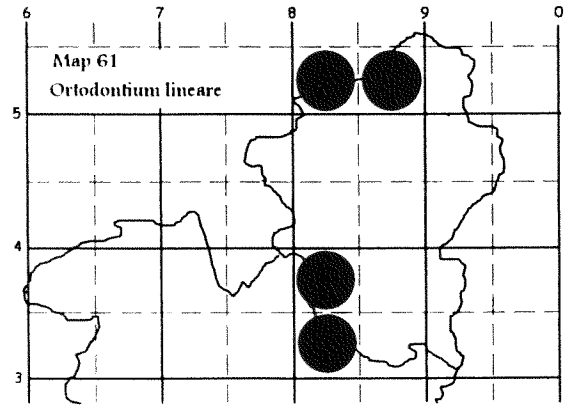
Map 61
Ortodontium lineare
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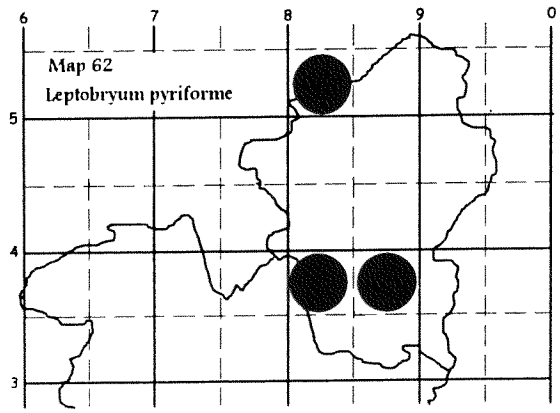
Map 62
Leptobryum pyriforme
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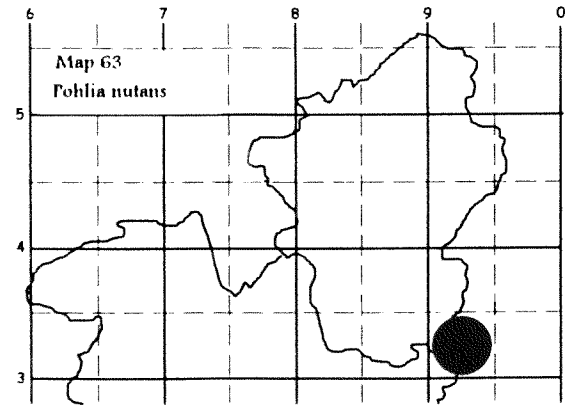
Map 63
Pohlia nutans
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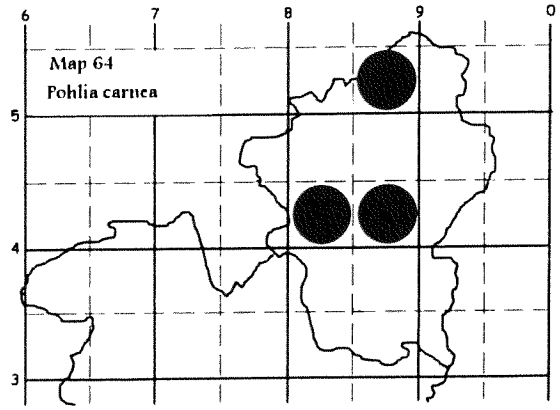
Map 64
Pohlia carnea
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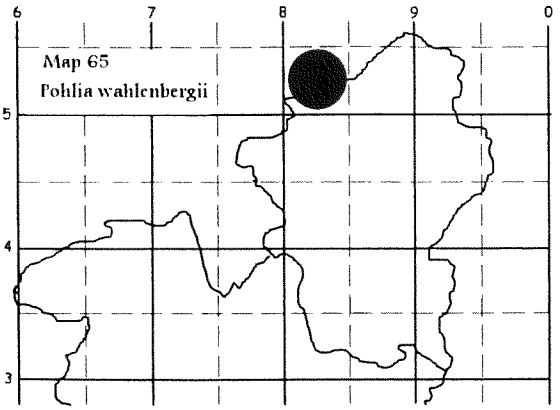
Map 65
Pohlia wahlenbergii
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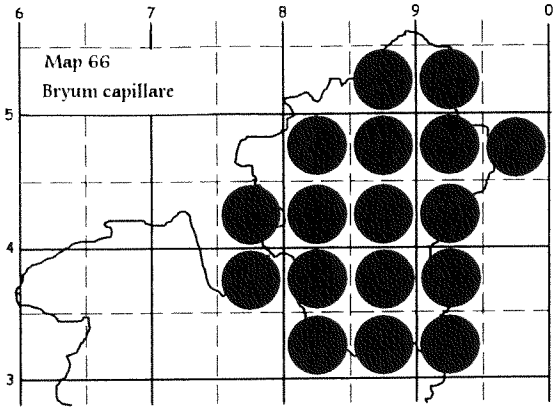
Map 66
Bryum capillare
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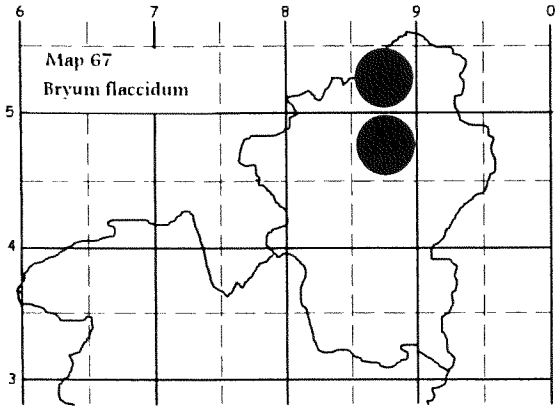
Map 67
Bryum flaccidum
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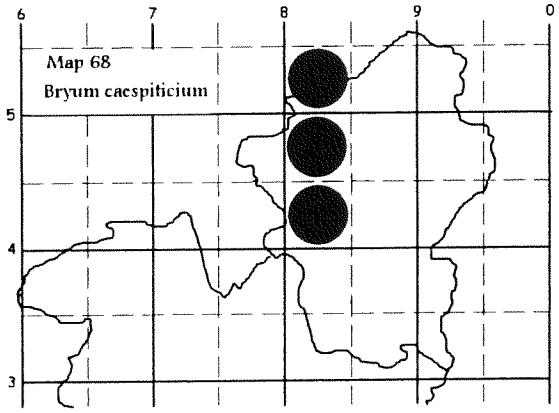
Map 68
Bryum caespiticium
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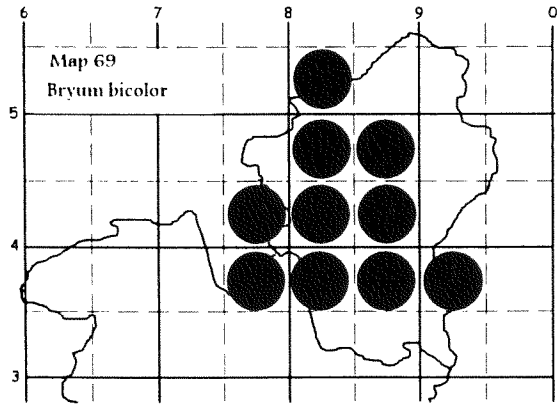
Map 69
Bryum bicolor
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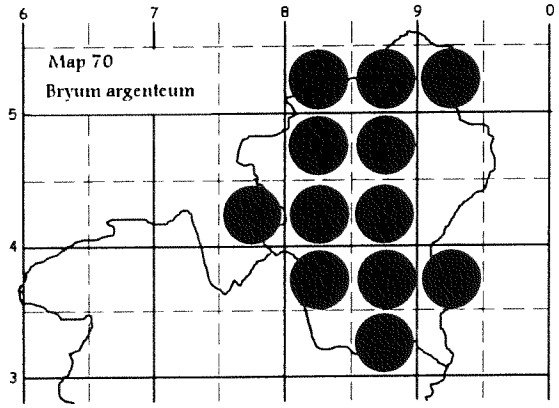
Map 70
Bryum argenteum
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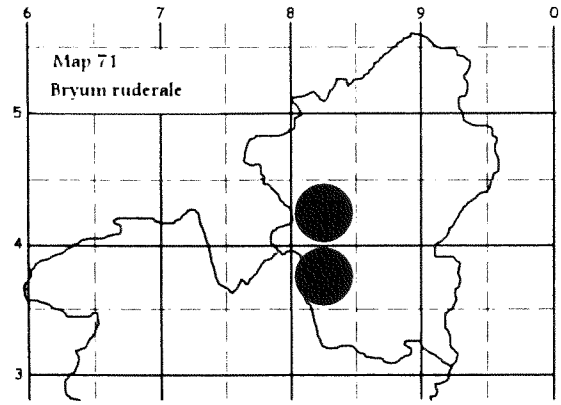
Map 71
Bryum ruderale
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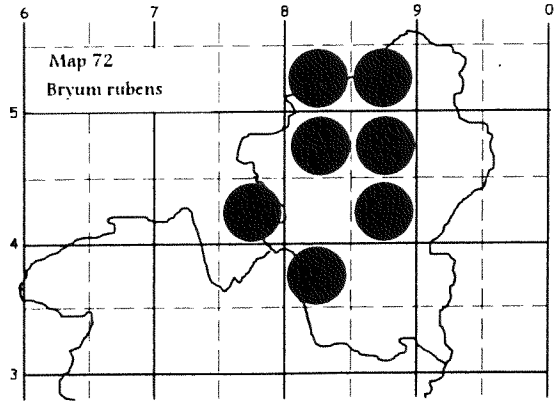
Map 72
Bryum rubens
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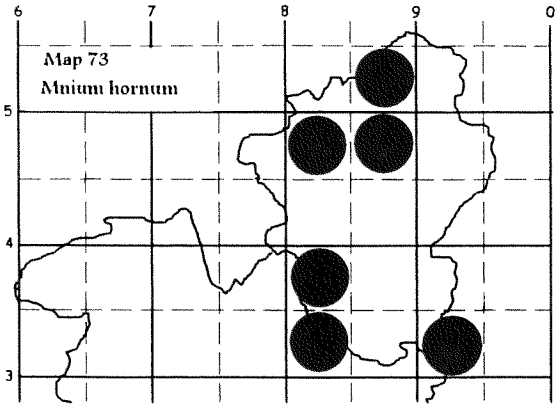
Map 73
Mnium hornum
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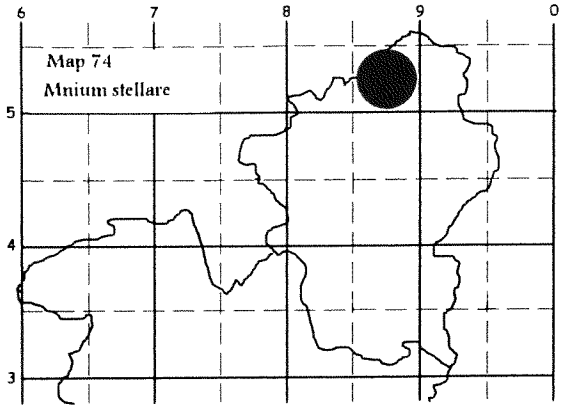
Map 74
Mnium stellare
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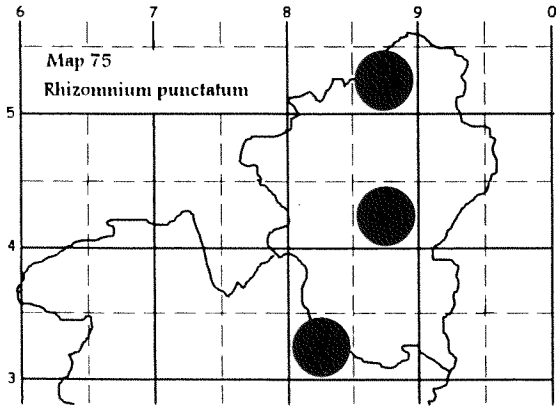
Map 75
Rhizomnium punctatum
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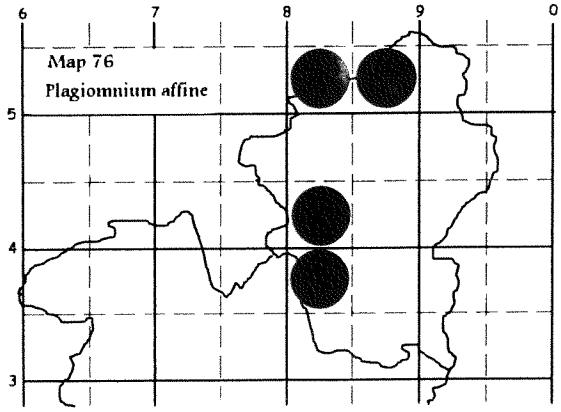
Map 76
Plagiomnium affine
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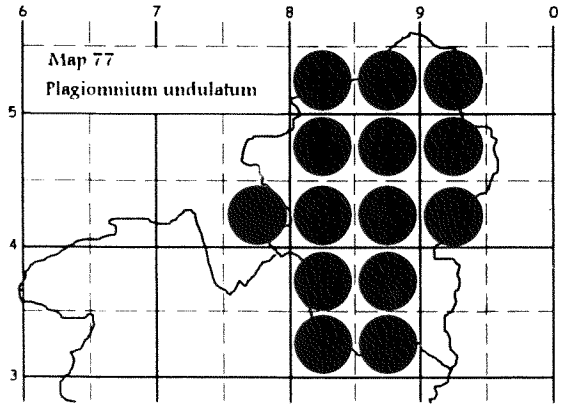
Map 77
Plagiomnium undulatum
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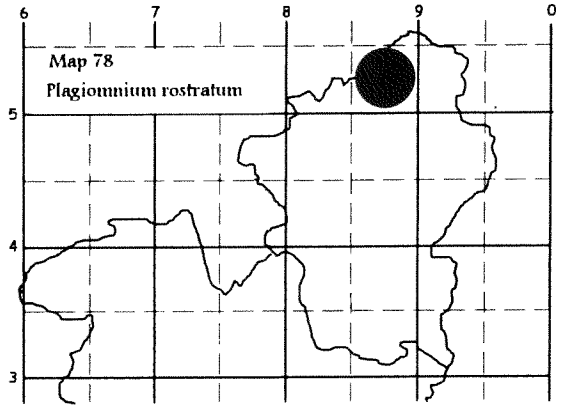
Map 78
Plagiomnium rostratum
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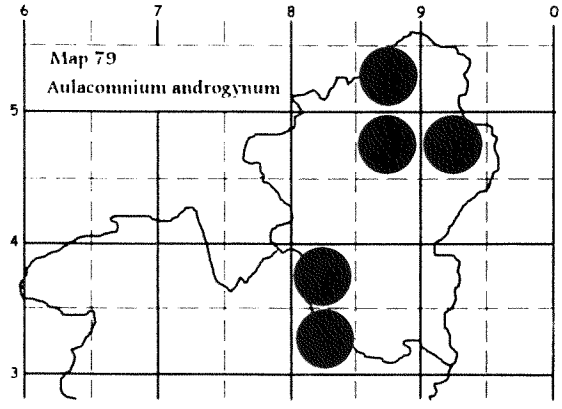
Map 79
Aulacomnium androgynum
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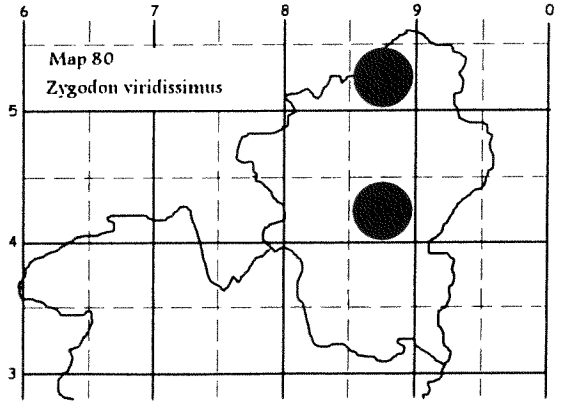
Map 80
Zygodon viridissimus
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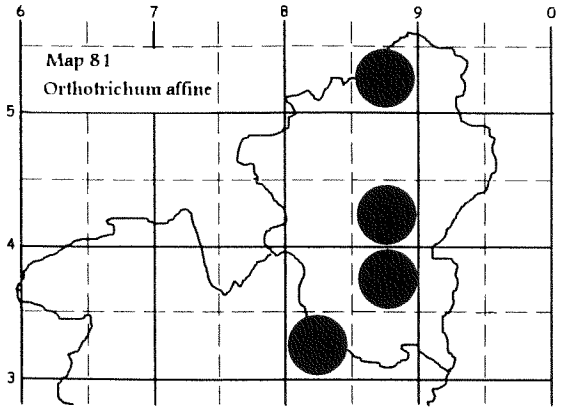
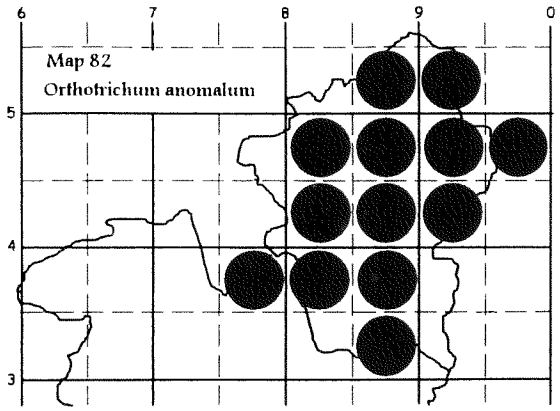
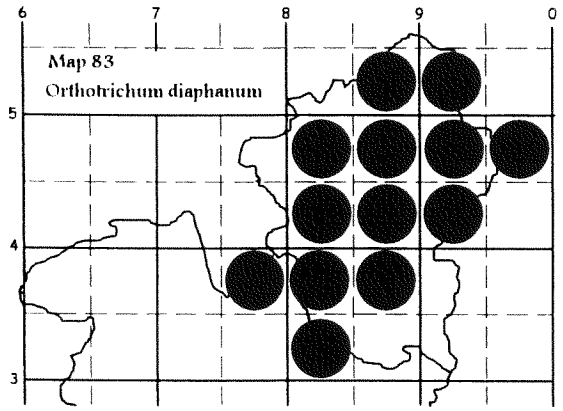
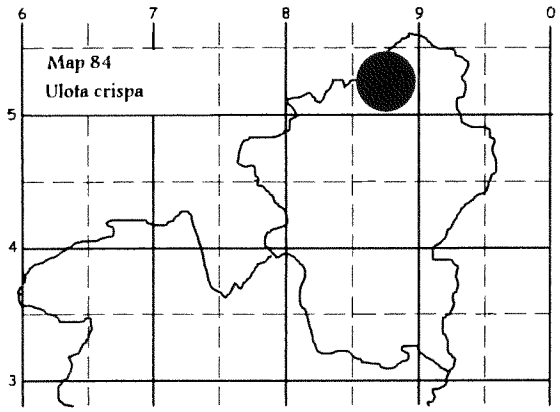
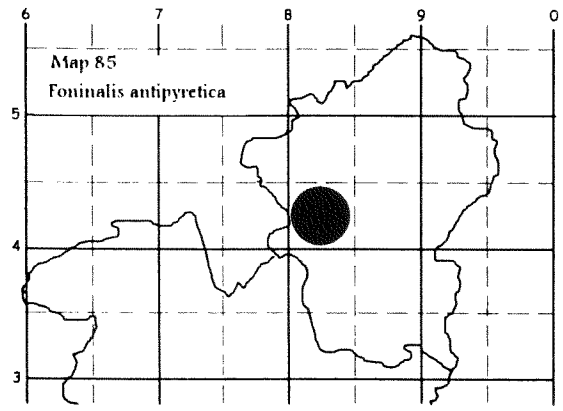
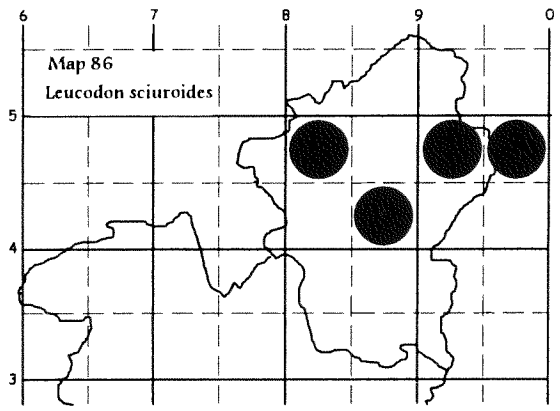

Map 81
Orthotrichum affine

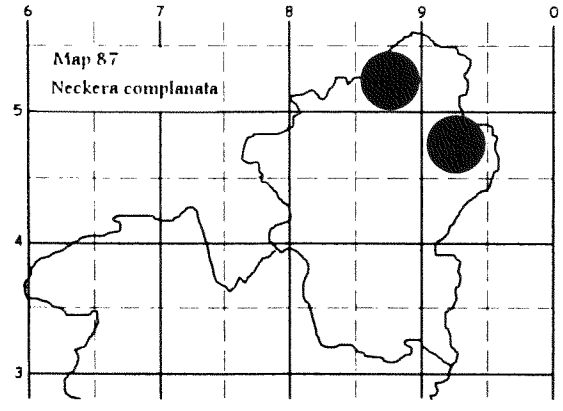

Map 82
Orthotrichum anomalum

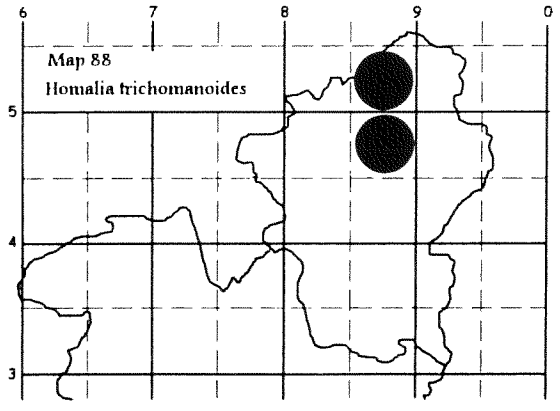

Map 83
Orthotrichum diaphanum

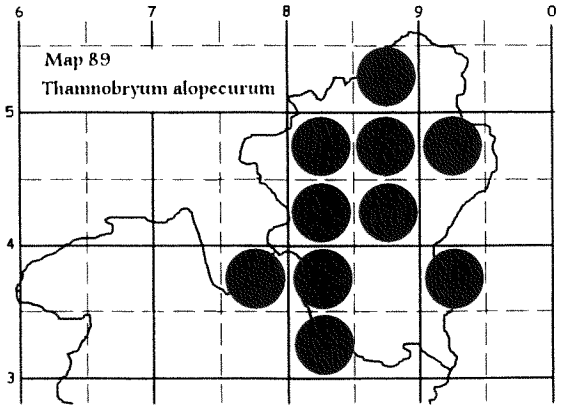

Map 84
Ulota crispa

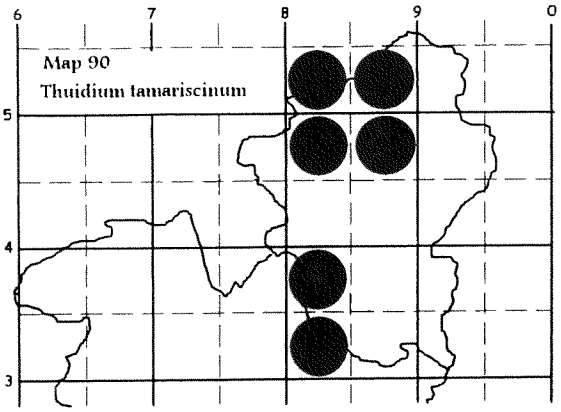

Map 85
Fontinalis antipyretica

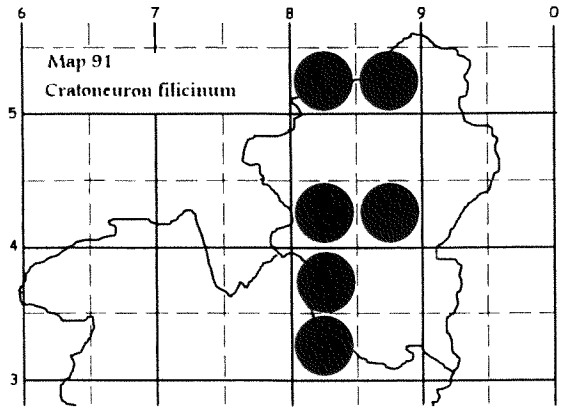

Map 86
Leucodon sciuroides

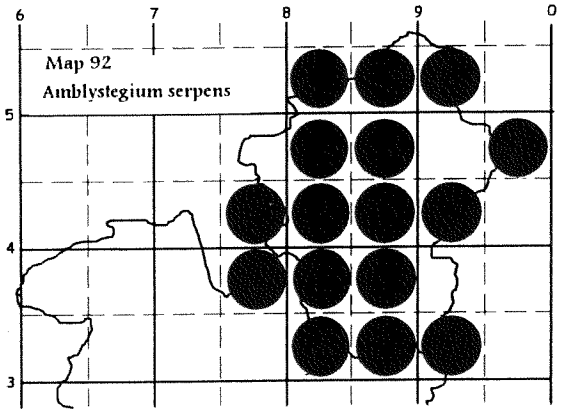

Map 87
Neckera complanata

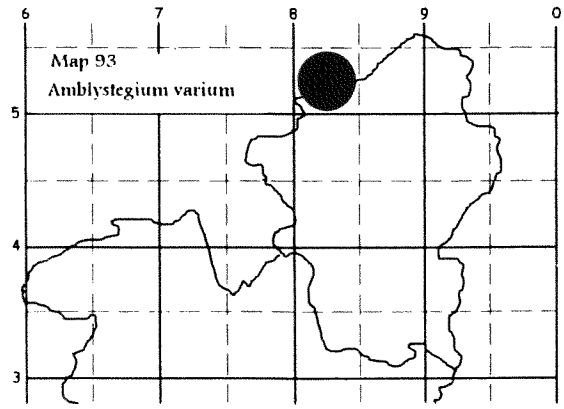

Map 88
Homalia trichomanoides

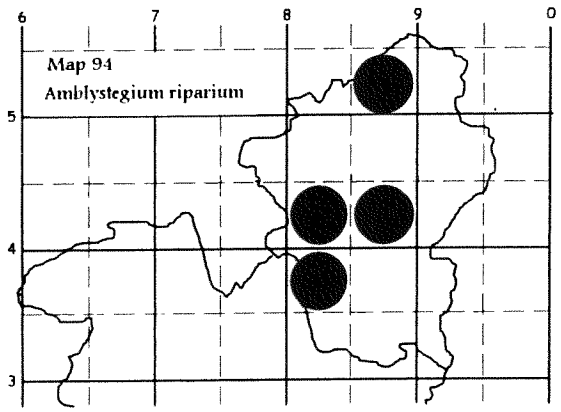

Map 89
Thamnobryum alopecurum

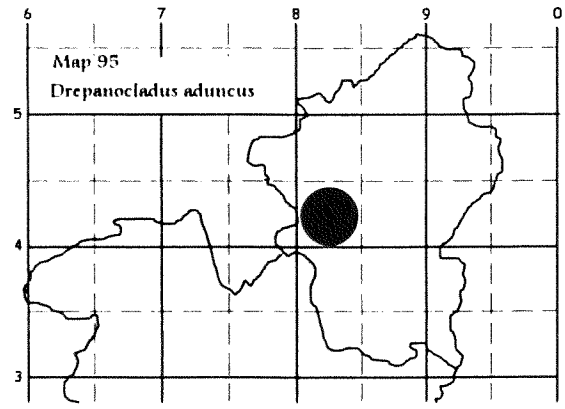

Map 90
Thuidium tamariscinum

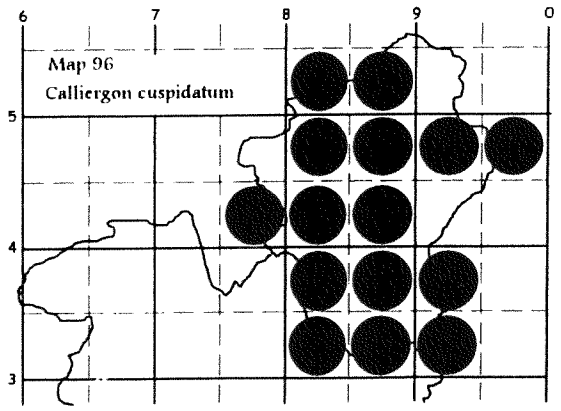

Map 91
Cratoneuron filicinum


Map 92
Amblystegium serpens


Map 93
Amblystegium varium


Map 94
Amblystegium riparium


Map 95
Drepanocladus aduncus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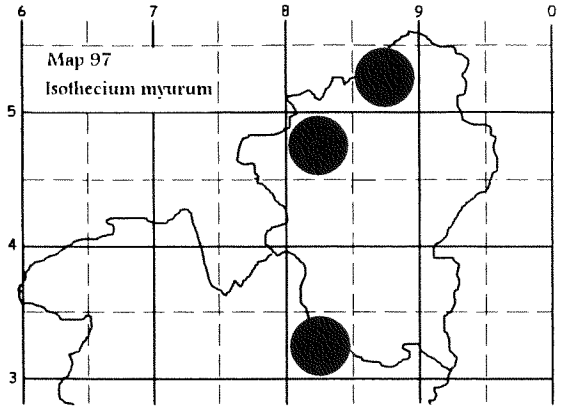
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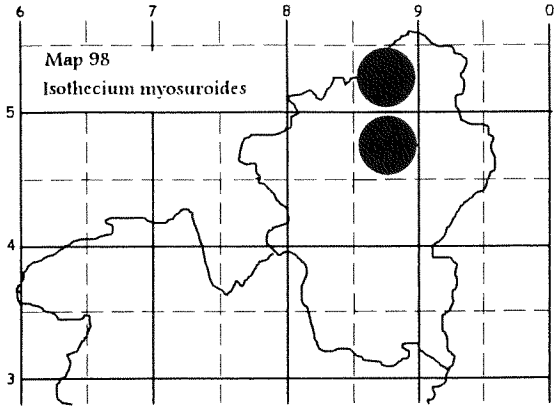
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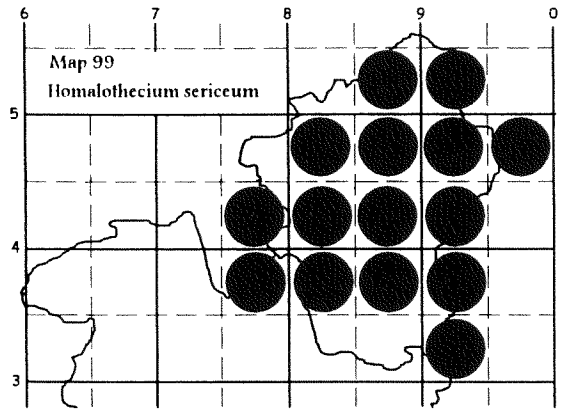
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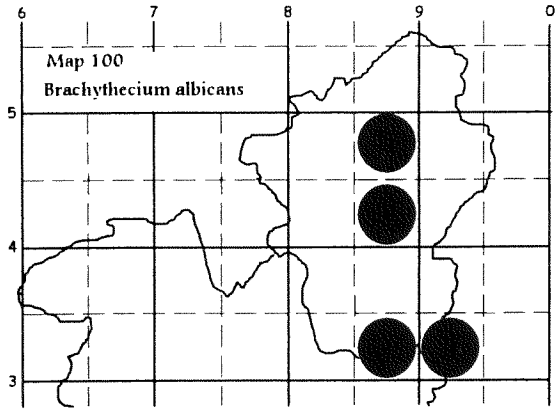
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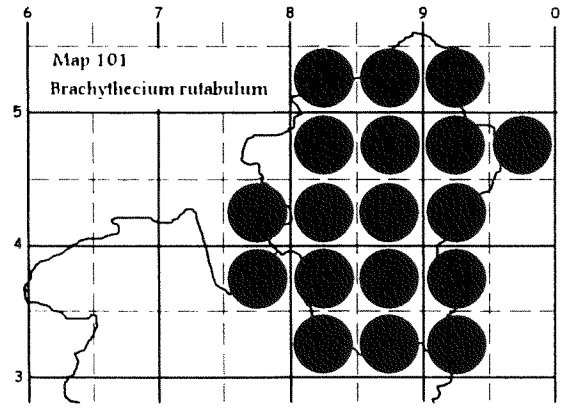
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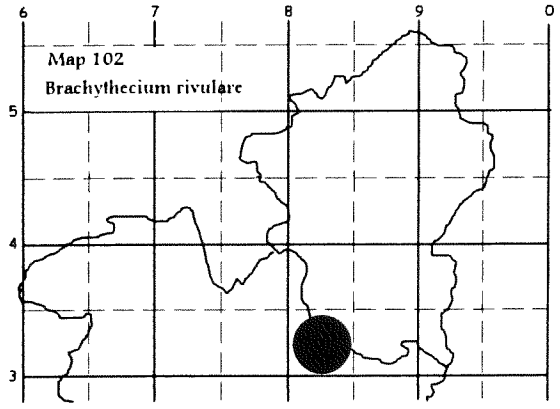
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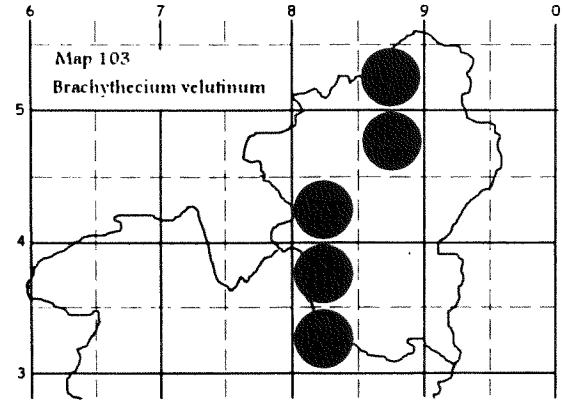
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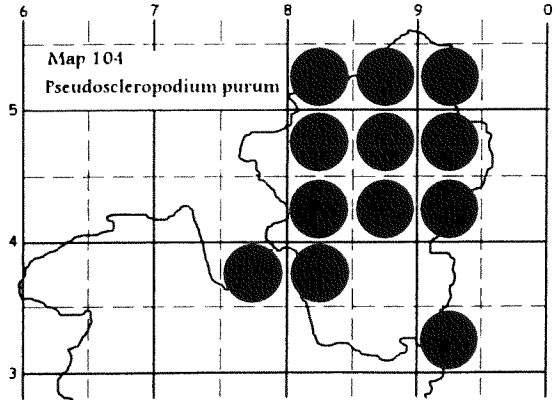
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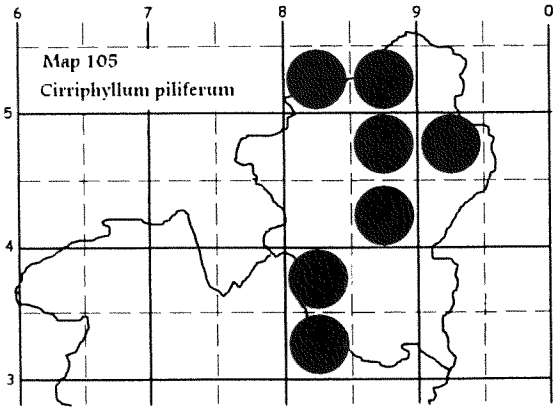
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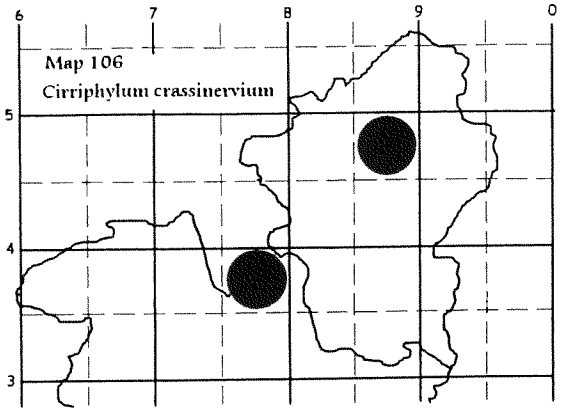
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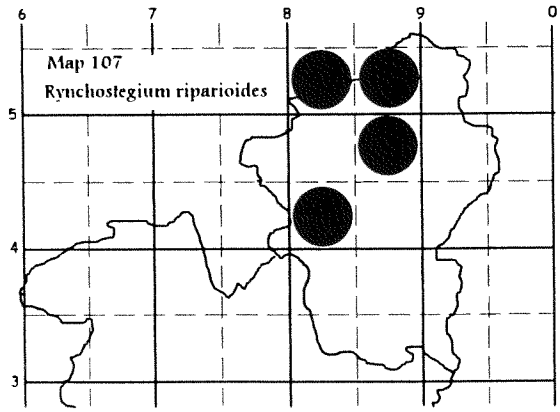
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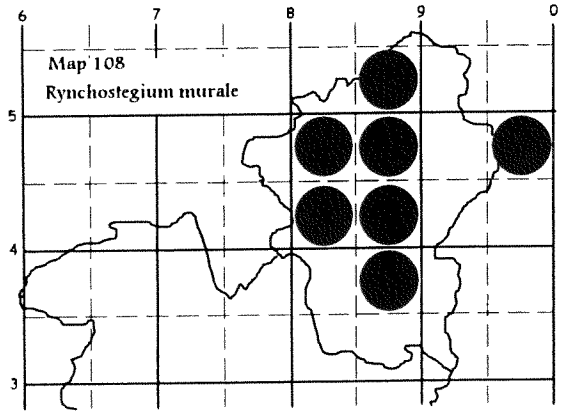
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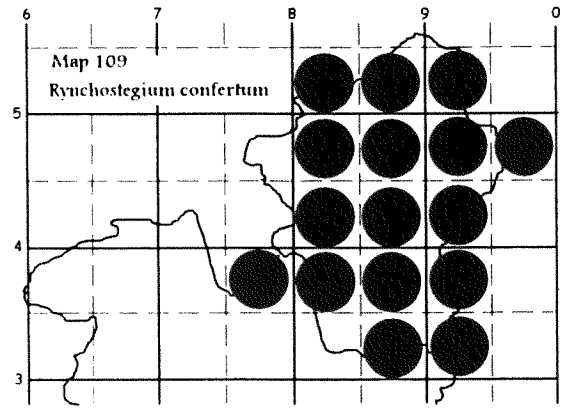
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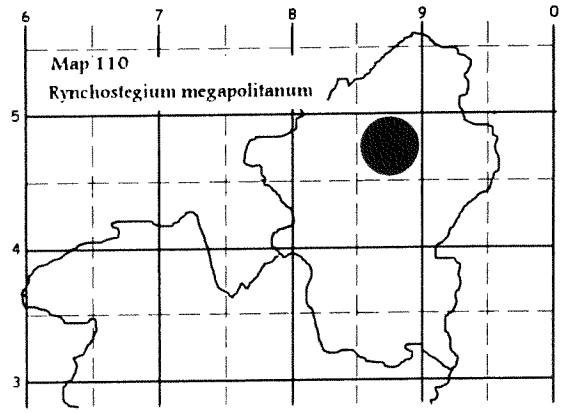
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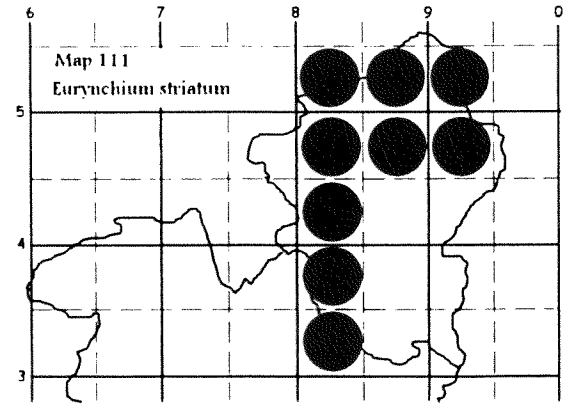
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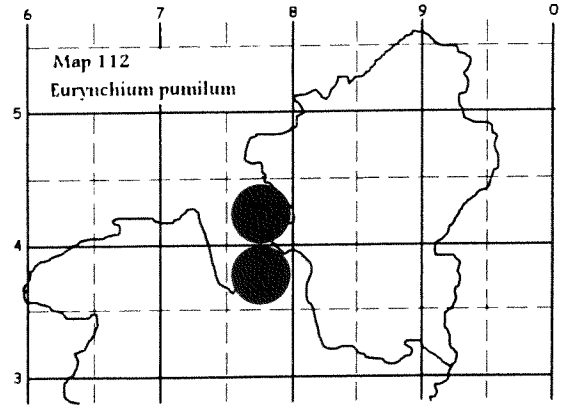
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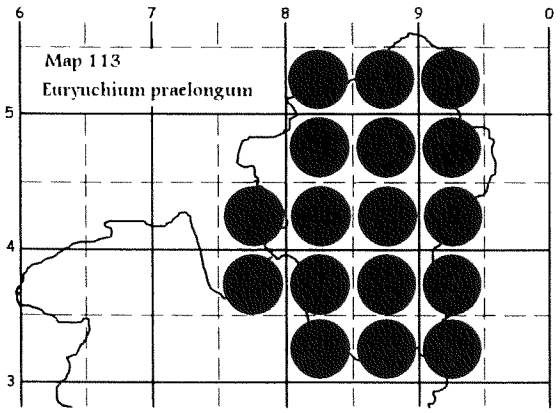
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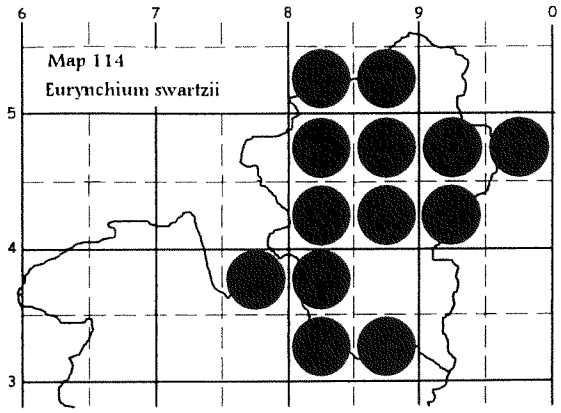
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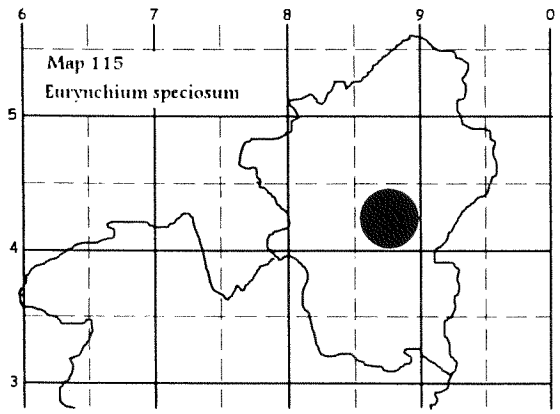
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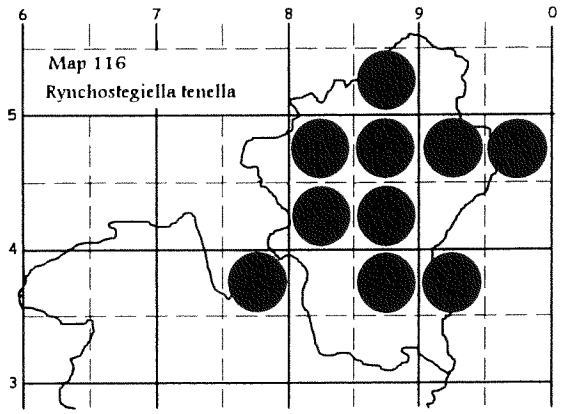
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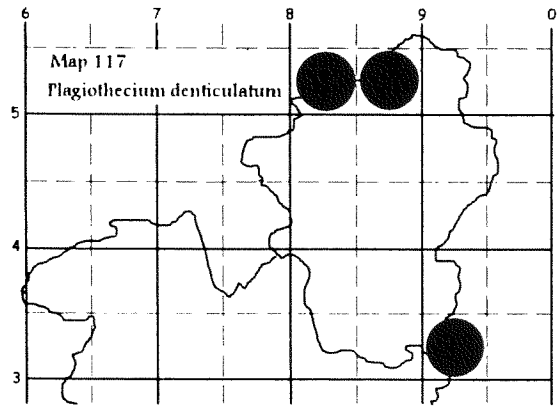
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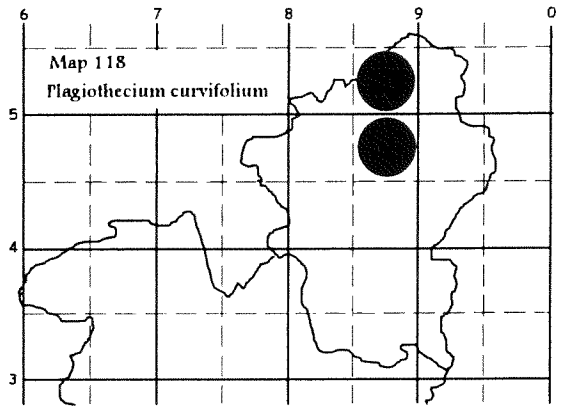
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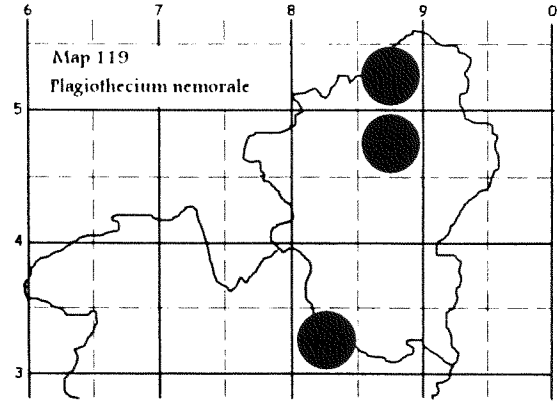
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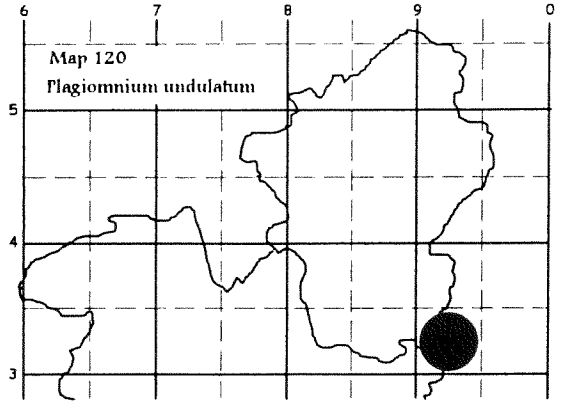
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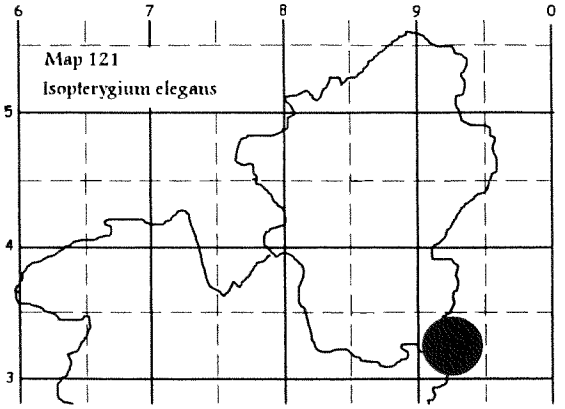
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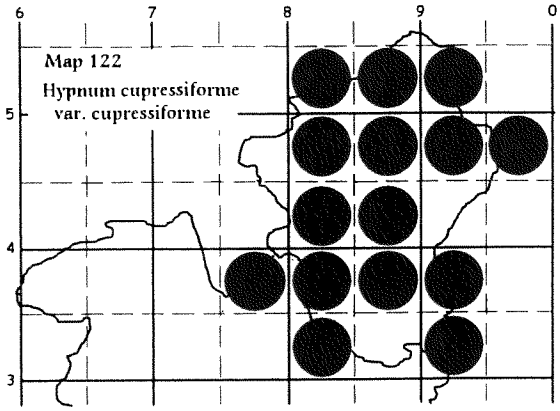
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Hypnum cupressiforme
var. cupressiforme
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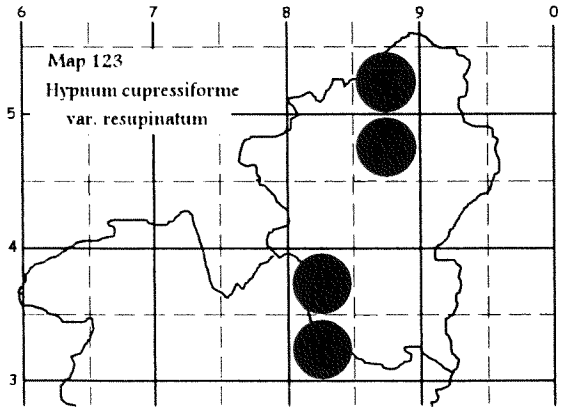
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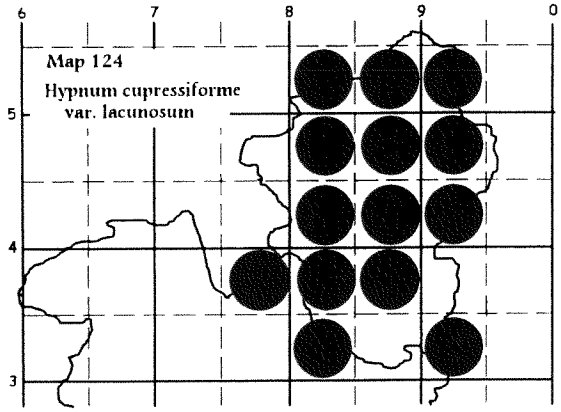
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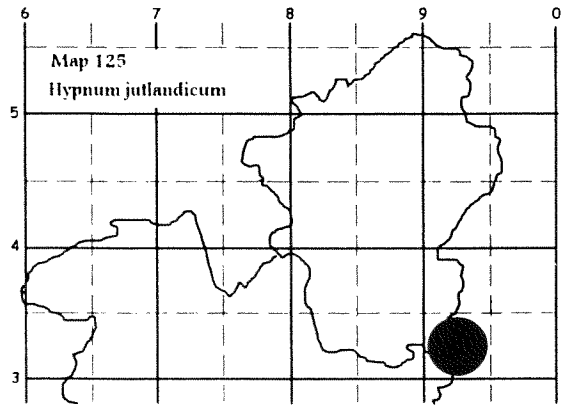
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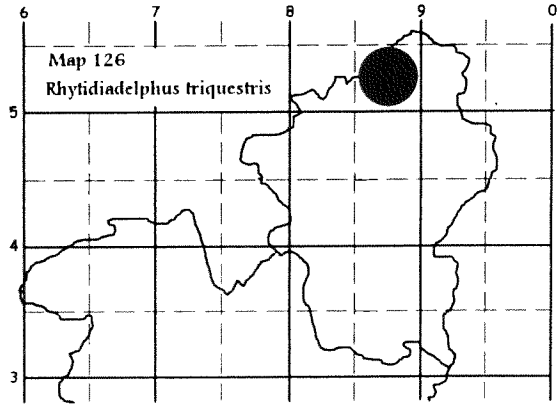
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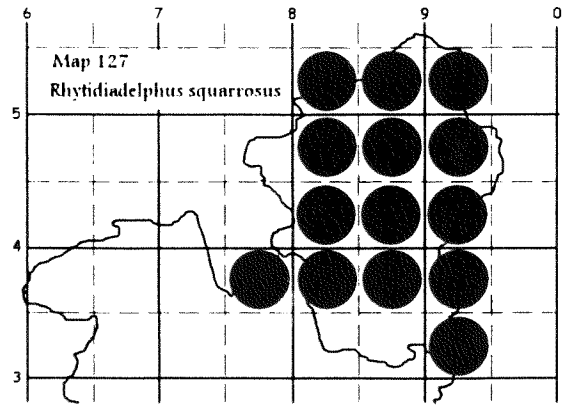
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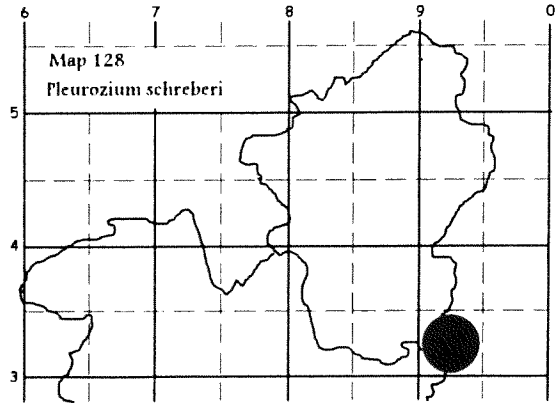
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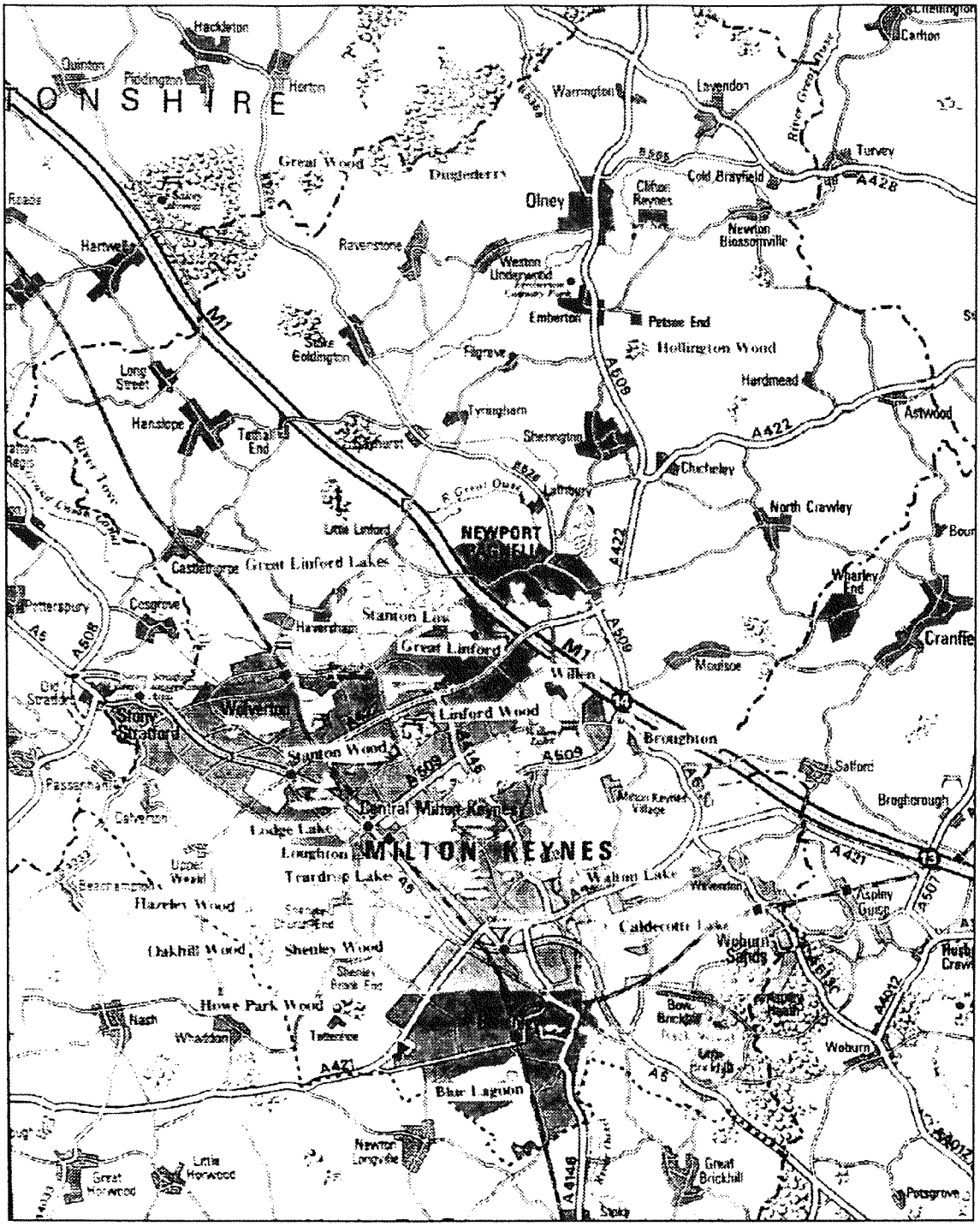
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Turvey
Clifton Reynes
Newton Blossomville
Ravenstone
Weston Underwood
Emberton
Petsoe End
Hollington Wood
Hardmead
Astwood
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Chicheley
North Crawley
Wharley End
Cranfield
Moulsoe
Newport Pagnell
Great Linford Lakes
Castlethorpe
Stanton Low
Great Linford
Wolverton
Stony Stratford
Linford Wood
Stanton Wood
Broughton
Salford
Brogborough
Central Milton Keynes
MILTON KEYNES
Lodge Lake
Loughton
Teardrop Lake
Walton Lake
Caldecotte Lake
Aspley Guise
Woburn Sands
Woburn
Oakhill Wood
Shenley Wood
Howe Park Wood
Tattenhoe
Blue Lagoon
Great Brickhill
Little Horwood
Great Horwood
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The Burgess Shale

by Arthur Whitehouse

This fascinating deposit is widely known to palaeontologists, but not so much by others interested in Natural History. It is of prime interest for the strange and indeed bizarre creatures which are preserved as fossils in it. How did these animals come to evolve, what succeeded them and what light do they shed on the evolutionary process as a whole? Why were some of them wrongly identified at first?

The Burgess Shale is a small deposit, only 50 meters long and less than 3 meters thick in the Canadian Rockies of Eastern British Columbia. It lies high up in the Yoho National Park above the small town of Field on the Canadian Pacific Railway and is snow bound except for a short time in the late summer. It is in the Middle Cambrian and dates from about 530 million years ago. It follows only shortly after the so-called Cambrian explosion of some 550 million years ago when animal life forms diversified into the thirty or so phyla into which they are now classified. The phyla include big groups such as molluscs, arthropods and chordates and a number of smaller groups. There were no vertebrates at this time. They evolved later, within the chordate phylum as fishes, to be followed by amphibians, then reptiles leading eventually to birds and mammals (including man). Many whole groups of animals have become extinct since Cambrian times, such as the trilobites, ammonites and dinosaurs, and innumerable new animals have evolved, but no new phylum has appeared since that time. Thus all new forms fit into the existing pattern of life forms already found in the Cambrian.

The Cambrian is the first of the fifteen periods or era which contain fossils of hard-bodied animals. Before that, in the vast Precambrian era, there was at first no life, then micro-organisms and soft-bodied animals and plants. There was no life on the land in Cambrian times, not even any soil as we know it. The only plants were seaweed and the like.

That is the setting in which the Burgess Shale was formed in the Middle Cambrian sea. It is rare for living things to be preserved. Mostly they are eaten when they die, or their bodies decay and are broken down to the elements of which they are composed and these are recycled. Occasionally the hard parts are preserved as fossils, often after being transformed into different minerals by percolating solutions. Much more rarely the soft parts may be preserved. What seems to have happened in the case of the Burgess Shale is that the animals preserved were living on or near a mud-bank in a shallow sea at the base of a reef made by calcareous algae. Then mud-slides and turbidity currents carried them further down into a stagnant anaerobic basin where the lack of oxygen would have prevented decay. Their whole bodies buried in soft mud could then have been slowly mineralised forming exquisitely preserved fossils.

The Burgess Shale was discovered in 1909 by the eminent, indeed pre-eminent, American palaeontologist C. D. Walcott. He made extensive collections in the next four years and brought back 80,000 specimens to the National museum of Natural History at the Smithsonian Institution in Washington, D.C. Some of his early classifications of these animals were wrong.

Surprisingly, this large collection was not re-examined in detail for sixty years. In the last two decades, detailed work by Whittington, Briggs and Conway-Morris has thrown new light on this astonishing marine fauna. The animals found in the Burgess Shale show a surprising diversity of 120 different genera with representatives of eleven of the phyla which still exist today, including *Pikaia,* the world's first known chordate. There were many different classes of arthropod. In addition there are some 18 species that do not fit into any existing phylum. These include *Opabinia* a segmented animal with five separate eyes and a proboscis like feeding nozzle; *Wiwaxia* a scaly animal with two rows of flattened spines; *Nectocaris* looking something between an arthropod and a chordate; *Amiskwia* a flattened soft-bodied swimming animal with fins on the body and a pair of tentacles on the head; *Anomalocaris* a ferocious looking carnivore 50 cm long with large eyes, a pair of feeding appendages and a circular mouth. Some of these animals are bizarre, and some have now been found from other parts of the world such as Greenland, China and Australia. As a result of these new finds some have been re-interpreted such as *Hallucigenia* a weird worm-like creature with paired legs and paired spines on the back, instead of the other way up, walking on stilts with tentacles on the back!

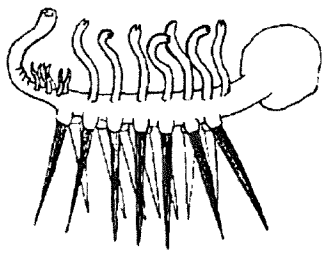

Figure 1 - *Hallucigenia* depicted as originally believed to exist in life. Now believed to have been oriented the other way up, with spines on its back.

About 85% of the animals found in the Burgess Shale are soft-bodied and would not normally be preserved as fossils. It would be hard to judge without hindsight which of these animals would evolve into successful life forms and which would succumb.

There have been at least five major mass extinctinons since Cambrian times. These are probably caused by impact with some extra-terrestrial body or other catastrophe. The extinction at the Permo-Triassic boundary, about 250 million years ago, destroyed 96% of life forms. The most recent one, at the Cretaceous-Tertiary boundary 65 million years ago, destroyed the dinosaurs and other life forms. These mass extinctions are such

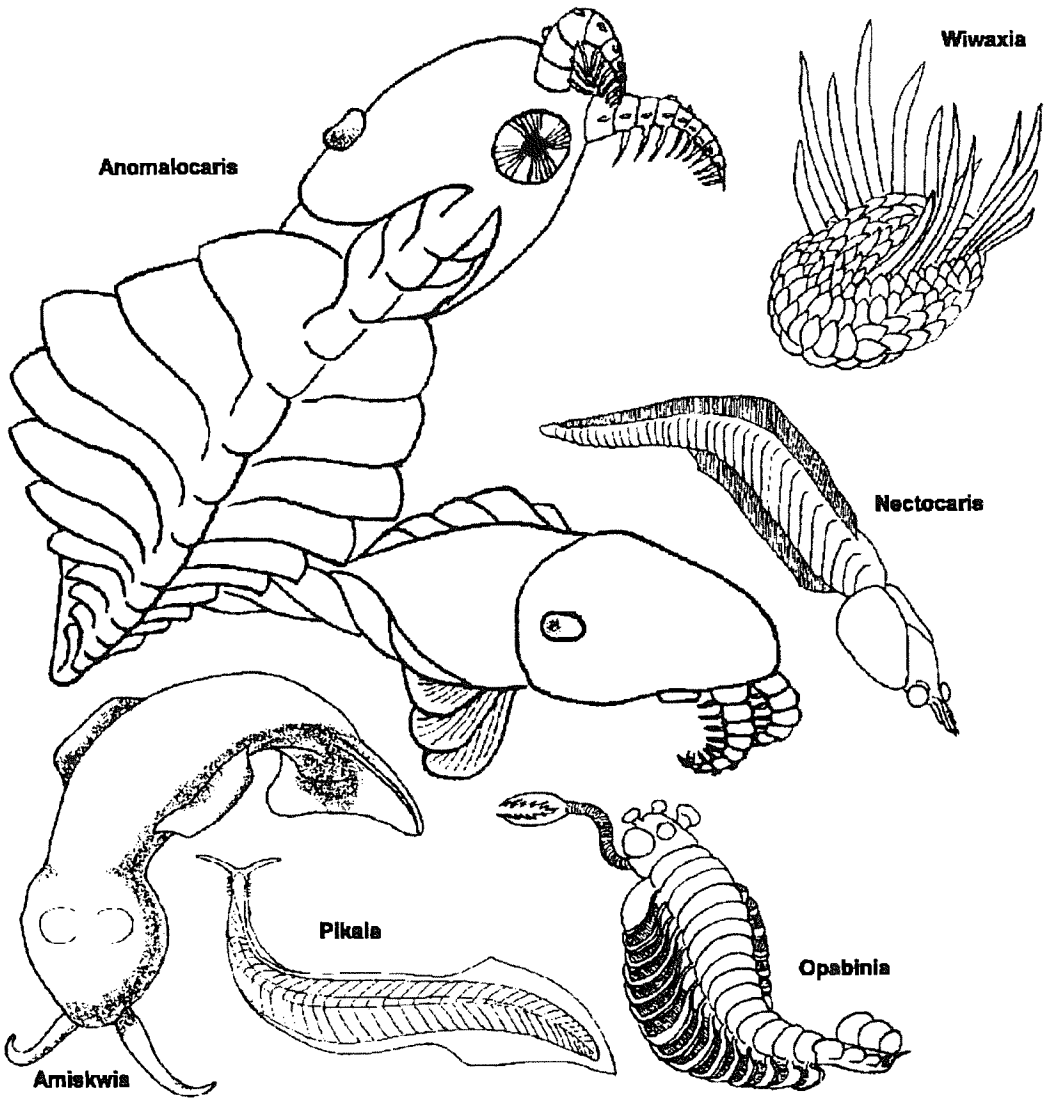

Figure 2 - Reconstructions of creatures from the Burgess Shales. (Not all to same scale).

rare events that natural selection cannot have determined which species would have survived, and extermination must have been at random. It seems likely that many of the diverse life forms found in the Burgess Shale may have disappeared by such a random event rather than by the normal evolutionary process of natural selection.

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Acknowledgements

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Duckweeds: frequency, growth rates and effects of competition from three habitats at Great Linford, Buckinghamshire

by Aaron Woods

Introduction

Duckweeds are tiny aquatic plants, of the family Lemnaceae and are found over most of the world. The family consists of four genera: Lemna; Spirodela; Wolffia; and Wolffiella although some recent authors still recognise other genera including Pseudowolffia and Wolffiopsis (Heywood, 1993, Griffiths, 1992). The number of species recognised also varies with the author and ranges from 28 to 43.

The Lemnaceae is most closely related today to the Araceae, a family which in Britain has only two native species of the genus Arum, the commoner being A. maculatum (Lords-and-ladies). This genus in no way resembles any of the Lemnaceae, but the genus Pistia, a now monotypic genus, does.

The general evolutionary trends seem to be those of reduction of structure, both vegetative and reproductive. The differentiation of stem and leaf has been lost and roots are reduced in number or absent. The resulting structure is known as either a thallus or frond. The minute flowers, which are rarely produced, are situated either in hollows on the surface of the thallus or in a sheath at the side of the thallus (Ross-Craig, 1973). The plant usually consists merely of a flat, or swollen rounded thallus floating on the water surface (Ross-Craig, 1973) and from which roots may project. Some species pass the winter as specialised buds, called turions, which sink into the bottom mud and start growing when the temperature rises. As seed is so infrequently produced, reproduction is mainly vegetative, by daughter plants being produced from pouches at the base of the thallus. This allows extremely rapid increase to occur.

Because of their rapid growth, some duckweeds are considered pests in waterways, as well as in rice crops in some areas. Despite weed status, some duckweeds are cultivated or collected from the wild in some parts of the world as they have valuable properties as animal fodder (Lautner & Müller, 1954) and in some areas they are used as human food (Livingston, 1996) They can also help to remove toxins from polluted waters and are very important food sources for many species of wildlife. Many water birds, such as ducks and swans, eat large quantities of duckweeds and in North America it has been shown that they are an important part of the diet of the coypu (Wilsey et al, 1991). The dense duckweed carpets are likely to harbour large numbers of invertebrates such as the collembolan, Smithurides aquaticus, which feeds on the thalli (Garmroudi, 1984) and it is also known that some fish lay their eggs amongst the plants.

In Britain there are five native species of duckweed, one of which, Lemna minor, is a very common and familiar plant. Over time, the group has been given a variety of English names including: boggart, creed, dig meat, duck's meat, duckpond weed, groves, grozens, Jenny Greenteeth, mardlens, toad spit, as well as the widely used "duckweed" (Grigson, 1958). In former times, British herbalists used duckweed as a medicinal plant (Culpeper, 1661, Gerard, 1597), but today it is no longer used as such. In parts of northern England children used to regard duckweed-covered ponds with fear, owing to the water hag "Jenny Greenteeth" who was supposed to live under its surface. This belief probably started as a deterrent to prevent children straying too near to dangerous ponds (Mabey, 1996).

The commonest British duckweed is Lemna minor, the common duckweed, a species that occurs throughout the whole of the British Isles. Other species are more local. L. gibba, the fat duckweed, is found in central and southern Britain and also more rarely in Ireland and the Channel Isles. L. trisulca, the ivy duckweed, is found frequently in England, Wales and Ireland, but is rare in Scotland. Spirodela polyrhiza, the greater duckweed, is generally locally distributed, being rare in the north and in Ireland. The smallest British duckweed is also the rarest: Wolffia arrhiza, the rootless duckweed, occurs in a few areas in southern England and Wales (Stace, 1991). An alien species, L. minuta, the least duckweed, from North America, is now found in many areas of England and Wales, since its discovery in Cambridge in 1977 (Leslie & Walters, 1983). Occasionally, this species can take over large areas of a waterway to the exclusion of other species (Oliver, 1991). It is very hardy and passes the winter as surface thalli.

The six British duckweeds have all been recorded from Buckinghamshire. As elsewhere, the commonest species in Bucks is L. minor. This species was recorded from a total of 284 of the 550 tetrads in a survey carried out between 1965 and 1985 (R. Maycock, personal communication). During the same survey L. gibba was found in 14 tetrads, L. trisulca in 63 tetrads and S. polyrhiza in 4 tetrads. W. arrhiza was also recorded from 1 tetrad during this survey, but the record is very doubtful. L. minuta was first recorded in the south of the county in 1990 and has been recorded

several times since from other parts of the county and appears to be increasing. It covered large areas of Arboretum Lake at Great Linford in 1994.

Duckweed species can be difficult to identify. The most distinctive species is L. trisulca. It is unique in its genus in not floating on the water surface, but hanging suspended in the water. The thalli are thin and angular. As the daughter plants tend to remain attached they give the appearance of an ivy leaf. S. polyrhiza is also distinctive. The thalli are much larger than the other species, being up to 10mm long. It is also distinct in that each thallus has around 7 to 26 roots, all the other species having one or no roots. The thallus is often also purple on the underside. W. arrhiza, in contrast, has a spherical thallus only 1.5mm in diameter at the most and there are no roots. Where the plant grows in abundance it gives the water a distinctive pea-green colour (Lousley, 1976). The remaining Lemna species are more difficult to separate. L. gibba, in its typical form, is reasonably distinctive in that the lower side of the thallus is markedly swollen. Starved thalli, or those produced in autumn are often flat. The thallus, however, is distinct in possessing four or five veins. The thallus grows up to 8mm long. L. minor is always flat and is of a similar size to L. gibba. The thallus possesses three veins. The rather similar L. minuta has thalli which are always less than 4mm long and can be separated from small specimens of L. minor by the presence of only one vein.

A study of the duckweeds in and around Linford Pits, a group of gravel pits situated between the River Great Ouse and the Grand Union Canal just north of Milton Keynes was carried out. The gravel pits were originally excavated from the river's flood plain from the late 1950's to 1979. The pits have now been flooded and most are used for recreational purposes. The remainder have been developed into a nature reserve and serve as a resource in association with a research centre which was established to examine the relationships between fish and bird feeding. The reserve is surrounded by a boundary ditch, formerly part of a tributary of the river and is separated from the canal and river by grazing pastures.

The habitats studied were the River Great Ouse, the Boundary Ditch and three Experimental Ponds.

The stretch of the River Great Ouse sampled ran from the raised pipe over the river to Haversham Mill weir. The banks of the river are uneven, being variously steep and shallow. The steeper banks are much subjected to erosion, mainly due to cattle attempting to get to the water to drink. The river, being in its lower reaches, has a moderate flow and is fairly deep and wide. Sampling was done well upstream of the weir at Haversham Mill and its margins are well vegetated with a variety of emergent and floating-leaved plants, allowing colonies of duckweed to thrive without being lost to the current.

The banks of the Boundary Ditch are steep as they are well eroded and poached by cattle. A thick growth of vegetation grows in its deep water. This water no longer flows into the river, so there is little or no flow. This allows large colonies of duckweeds to survive.

The Experimental Ponds are entirely artificial, some of the vegetation having been introduced. However, many other species have colonised naturally. Two of the ponds have deep water and are steep sided but, owing to the lack of grazing animals, the sides are relatively stable. One edge of the lake adjacent to the research centre is a vertical concrete wall. The shallower pond has a marshy edge. There is an abundance of vegetation in all three ponds, including duckweeds.

Methods:

A vegetation survey of the three sites recorded all plant species present in the water, on the banks and overhanging trees and shrubs. The structure of the plant communities was gained by taking a series of 1m2 quadrats at the waters' edge allowing the aquatic plants, as well as those immediately adjacent on the bank, to be included. Each plant species in the quadrat was assigned a DOMIN value in order to assess its abundance.

The results were used to determine the closest matching National Vegetation Classification (NVC) for each sample site and the duckweed data extracted.

Experiments using four duckweed species were carried out. Samples of L. gibba, L. minor, L. trisulca and S. polyrhiza were collected from healthy populations. Firstly, numbers of each species were grown alone in river, ditch and pond waters and secondly numbers of pairs of species were grown in the same three water types. Counts of numbers of thalli in all samples were made each day over a period of one month. Growth rates were calculated from the results.

Measurements of pH and conductivity were also made of each water type.

Results

The vegetation survey of the River Great Ouse had a total of 69 species, plus some unidentified species of alga. Of these, six were submerged aquatic plants, including Callitriche platycarpa (Various-leaved Water-starwort), Myriophyllum spicatum (Spiked Water-milfoil) and Elodea nuttallii (Nuttall's Waterweed). In addition, five floating species were present including Nuphar

lutea (Yellow Water-lily) and the duckweeds L. gibba, L. minor and S. polyrhiza, all in reasonable quantity. There were also many emergent species, such as Butomus umbellatus (Flowering Rush) and Sparganium erectum (Branched Bur-reed). One moss species was recorded in the river - Fontinalis antipyretica (Willow Moss). Overhanging trees were present in a few places and included Tilia vulgaris (Lime) and five species of willow. One species recorded is nationally scarce; this is Cuscuta europaea (Greater Dodder) which is parasitic on bankside stinging nettles.

In the Boundary Ditch 49 species were recorded, plus some unidentified species of alga. These included six species of submerged aquatic plants and six floating species. The submerged plants included large quantities of the alien Elodea nuttallii and native species such as Myriophyllum spicatum and four species of Potamogeton, including the uncommon P. friesii (Flat-stalked Pondweed). Five floating plants included Nuphar lutea and the duckweeds L. gibba, L. minor, L. trisulca and S. polyrhiza. A range of emergent and bankside plants was present including the locally very rare Samolus valerandi (Brookweed). The only tree species recorded was Salix fragilis (Crack Willow) and the only moss was Rhynchostegium confertum.

The Experimental Ponds had the greatest number of plants recorded, 81 species being present, plus some unidentified species of alga. Eight species of submerged flowering plants were recorded, plus the algae Chara vulgaris (Moore, 1986), Anabaena sp. and Hydrodictyon sp. (Chapman, 1968). Other submerged plants included Potamogeton pusillus (Lesser Pondweed) and a batrachian Ranunculus, most likely R. peltatus (Pond Water-crowfoot). Also present was Crassula helmsii (New Zealand Pigmyweed), an alien plant from Australasia, which spreads at an alarming rate. As yet, only a small quantity was present. Floating plants included Nuphar lutea and the duckweeds L. minor, L. trisulca and S. polyrhiza, only the first being in any quantity. Several species had been introduced to these ponds, including Nymphoides peltata (Fringed Water-lily), Ranunculus lingua (Greater Spearwort) and Althaea officinalis (Marsh-mallow). Three species of moss were recorded, Amblystegium fluitans, Drepanoclados aduncus and Brachythecium rutabulum. Trees were represented by five species of willow.

Of the total of 123 taxa recorded, 29 species were present in the three areas; all being common aquatic or marginal species in North Bucks.

The quadrat results from the River Great Ouse included 37 species, plus some unidentified species of alga. Five of these species were recorded in over 50% of the quadrats. These were Glyceria maxima (Reed Sweet-grass)(84.2%), Lemna gibba (84.2%), L. minor (100%), Myosotis scorpioides (Water Forget-me-not)(89.5%) and Nuphar lutea (52.6%). Apart from the two duckweeds only one of these species, Nuphar lutea, is a floating-leaved species. The other two species are emergents.

In the Boundary Ditch 37 species, plus unidentified algae, were recorded in the quadrats. Eight of these were recorded in over 50% of the quadrats. These were Butomus umbellatus (78.9%), Elodea nuttallii (84.2%), Lemna gibba (57.9%), L. minor (100%), Myosotis scorpioides (57.9%), Potamogeton friesii (57.9%), Sparganium erectum (78.9%) and species of alga (100%). Except for the two duckweeds and some of the algal species, no floating species were a major component of the quadrats. However, two of the species, E. nuttallii and P. friesii, were submerged species, surviving under the duckweeds and algal mats.

The Experimental Ponds quadrats contained a total of 47 species, plus some unidentified species of alga. Of these species, four were recorded in over 50% of the quadrats. These were Alisma plantago-aquatica (Water-plantain), Eleocharis palustris (Common Spike-rush), Glyceria maxima and Lemna minor. Apart from L. minor no other floating species was a significant component of the quadrats. The other species mentioned are all emergents.

Results from the quadrat analyses are summarised in the table below:

	Lemna gibba	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*
River	84.2	100	0	26.3
Ditch	57.9	100	10.5	5.3
Ponds	0	98.2	36.8	15.8

Percentage occurrence of duckweeds in the quadrats.

Results of the cultivation experiments showing increases in individual rates of growth are summarised in the table below:

	Lemna gibba	Lemna minor	Lemna trisulca	Spirodela polyrhiza
River	383	583	550	1033
Ditch	483	250	883	967

Pond	483	267	417	1133

Percentage increase in thallus numbers.

The increases in thallus numbers when two species are grown together are summarised in the tables below:

(The figures refer to the percentage increase in thallus numbers of species shown in the left hand column when grown with the species shown in the top row.)

RIVER	Lemna gibba	Lemna minor	Lemna trisulca	Spirodela polyrhiza
Lemna gibba		14.3	10.7	25.7
Lemna minor	14.2		12.0	13.0
Lemna trisulca	8.1	10.0		13.4
Spirodela polyrhiza	105.6	138.2	160.6	

Percentage increase in thallus numbers with two species grown together in river water.

DITCH	*Lemna gibba*	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*
Lemna gibba		14.2	16.9	24.1
Lemna minor	22.5		11.6	17.1
Lemna trisulca	5.2	8.4		13.9
Spirodela polyrhiza	90.9	153.3	160.9	

Percentage increase in thallus numbers with two species grown together in ditch water.

POND	*Lemna gibba*	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*
Lemna gibba		14.4	24.3	36.7
Lemna minor	20.7		9.8	21.4
Lemna trisulca	11.3	8.7		11.4
Spirodela polyrhiza	110.6	131.6	109.1	

Percentage increase in thallus numbers with two species grown together in pond water.

Using the above quadrat information the closest NVC communities are shown in the table below:

Site	Closest NVC Community	Coefficient
River	S4 (*Phragmites australis* reedbed)	44.1
Ditch	S5 (*Glyceria maxima* swamp)	45.0
Pond	S14 (*Sparganium erectum* swamp)	45.5

All NVC communities selected had coefficients of less than 50, therefore none is a good match.

The results of the pH and conductivity tests are shown in the table below

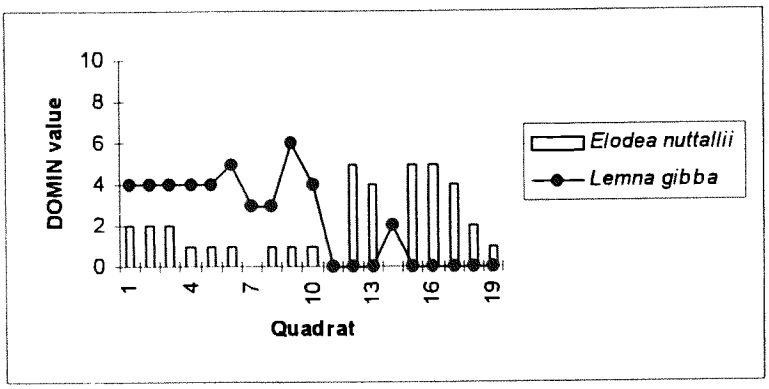
	pH	Conductivity (micromohs/cm^2)
River	8.05	12.5×10^2
Ditch	7.7	8×10^2
Pond	8.8	3.5×10^2

Discussion

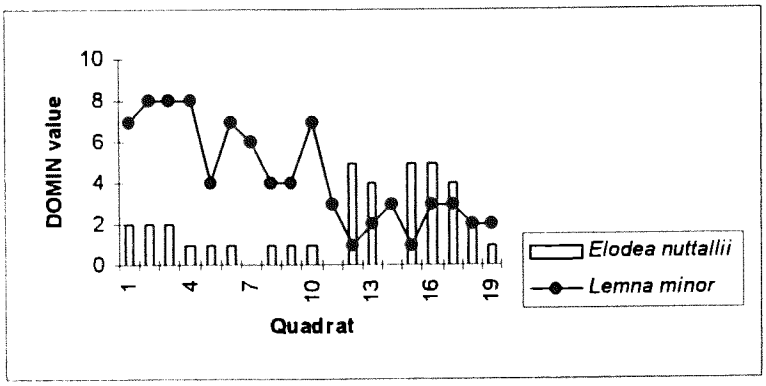
Several of the species which occurred regularly in the quadrat samples are likely to have had an effect on the quantities present *e.g.*

Butomus umbellatus (78.9% of ditch quadrats) is an emergent species which usually occurs as individual plants or in small stands. This growth habit prevents it from being a successful competitor against more vigorous marginal species (Preston & Croft, 1997). The clumps are not dense enough to prevent the growth of duckweeds between the stems, so it is unlikely to be a significant competitor.

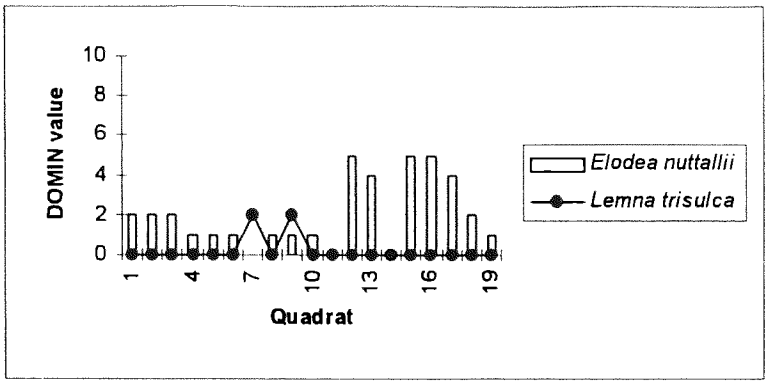
Elodea nuttallii (84.2% of ditch quadrats; 47.4% of pond quadrats) is a submerged plant native to North America. It has spread throughout lowland Britain since its initial discovery in 1966 in Oxfordshire (Preston & Croft, 1997) and often forms dense colonies in still water habitats. Here it may be a serious competitor with other underwater species, but it is unlikely to have any effect on duckweed species. However, where large amounts of *E. nuttallii* were present, *L. gibba* and *L. minor* were generally present in low quantities only. This may indicate that *E. nuttallii* cannot survive where there are mats of *Lemna* species covering the water surface. *E. nuttallii* only occurs in small quantities in the quadrats where *L. trisulca* was present. This may indicate that *L. trisulca*, itself being a submerged species, cannot compete with the dense clumps of *E. nuttallii*. The graphs below summarise these relationships:



Distribution of *Elodea nuttallii* and *Lemna gibba* in the ditch.

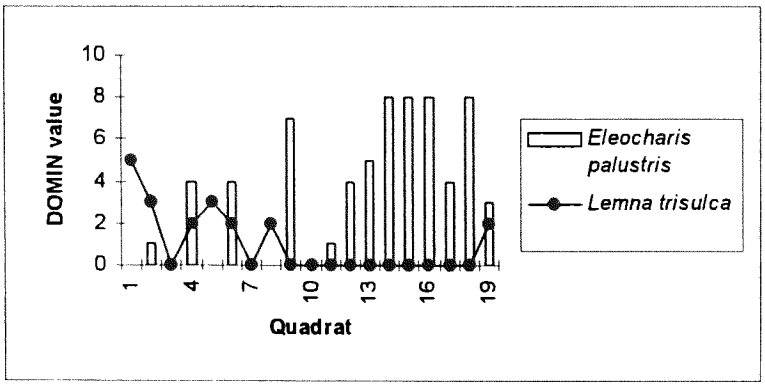


Distribution of *Elodea nuttallii* and *Lemna minor* in the ditch.



Distribution of *Elodea nuttallii* and *Lemna trisulca* in the ditch.

Eleocharis palustris (68.4% of pond quadrats) typically grows as an emergent in still and slow-flowing water (Preston & Croft, 1997). It generally occurs in patches, although the stems are rather distantly spaced. This allows mats of duckweeds to grow between the thin stems. However, the graph below shows that *L. trisulca* was only found where there were small quantities of *E.palustris*. This may indicate merely that the two species have different habitat preferences.



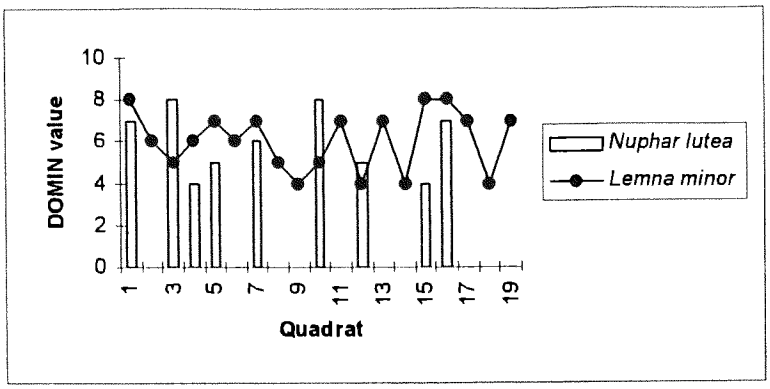
Distribution of *Eleocharis palustris* and *Lemna trisulca* in the ponds.

Glyceria maxima (84.2% of river quadrats; 57.9% of pond quadrats) is a tall grass, which is a common emergent species in most lowland waterways. It forms dense stands which extend from the bank into water up to 0.7 metres deep (Hubbard, 1984). The dense stands may exclude duckweed species from areas close to the bank, but these species are often abundant in the edges of the stands and on the downstream side of the clump.

Mentha aquatica (31.6% of river quadrats; 42.1% of pond quadrats) grows either on a bankside or as an emergent species in very shallow water. As it rarely extends far into the water it is unlikely to show any importance in providing shelter for, or as a competitor with, duckweeds.

Myosotis scorpioides (89.5% of river quadrats; 57.9% of ditch quadrats). This is a species frequently found on the very edges of banks but occasionally, as here, it can grow as a floating or submerged species (Preston & Croft, 1997). As a floating species, it forms mats on the water surface. These mats cover areas which may otherwise have been occupied by duckweed species. However, as the plant does not form a solid cover on the water surface, it may benefit the duckweeds by providing shelter against wind and water currents.

Nuphar lutea (52.6% of river quadrats) was the most abundant floating-leaved plant. It produces both floating and submerged leaves, the floating leaves being pressed close to the water surface and often positioned very close together. This can leave little space for duckweed colonisation and stands of this plant are known to be poor in other species (Preston & Croft, 1997), although any spaces left between the leaves are generally protected from the water flow and duckweeds may colonise. The graph below shows that, where there were large amounts of *N. lutea*, there was generally a reduction in the amount of *L. minor* present. The noticeable exception is in quadrat number 16 where both species were abundant. This may mean that, in this quadrat, *N. lutea* was existing just as submerged leaves and therefore not monopolising the water surface.



Distribution of *Nuphar lutea* and *Lemna minor* in the river.

The Duckweeds

With *Lemna gibba* in cultivation, the rate of increase in growth was low, whilst in the wild it performed well. It seems likely that, if this species is present, in a wild site then it will grow well. Although the species in cultivation did not reflect these results, it may be that the time allowed for the experiment was inadequate for it to achieve its highest rate of growth.

This species starts to grow later in the year than the other species, as it will not tolerate an average winter temperature of less than -1°C. This is probably because it spends the winter on the water surface as special thalli. These resting thalli are flat and are difficult to distinguish from *L. minor*. Although absent from the Experimental Ponds, the species grew well in pond water in cultivation. The most likely means of dispersal for duckweeds in general is for thalli to be carried from site to site by waterfowl, *e.g.* on their feet or feathers. As far as can be ascertained, the adhesive properties of duckweeds have not been studied. However, it is noticeable that, when handled, they are extremely tenacious and difficult to remove or separate. It is likely that the thalli remain in groups owing to surface tension forces, rather than the possession of secreted adhesives. At Great Linford, waterfowl are frequent visitors to the river and ditch, but only rarely visit the ponds. So, this may help to account for the lack of *L. gibba* there.

Experimental evidence shows that in competition with other duckweeds, *L. gibba* is not, on the whole, very successful. However, where established in the wild, it holds its own and is often present in large quantities, *e.g.* in the river it was recorded in 84.2% of the quadrats.

With *Lemna minor* in cultivation, the rate of increase in growth was relatively low but, in the wild, it was the most abundant species. It grew well in all of the three sample sites.

This species can start to grow earlier in the year than *L. gibba* as it can tolerate an average winter temperature of -15°C. Like *L. gibba* it passes the winter as special resting thalli which float on the water surface.

Experimental evidence shows that, in competition with other duckweeds, *L. minor* is not on the whole, very successful. However, in the wild, *L. minor* holds its own and is often present in large quantities, *e.g.* in the river it was present in 100% of the quadrats, where this abundance may be owing to the constant introduction of new colonies, carried by the water from further upstream, or by successful growth of those colonies already present.

With *Lemna trisulca* in cultivation, its rate of increase in growth was relatively high in all water types, but in the wild it performed rather poorly. It seems that, even when present at a site, it will remain in low numbers. This is demonstrated by its presence in only 10.5% of the quadrats in the ditch samples and 36.8% of the quadrats in the pond samples. The species in cultivation did not reflect these results.

This species can tolerate a lower average winter temperature than the previous two species, probably because it spends the winter months as special thalli that sink to the bottom (Preston & Croft, 1997). This suggests that it could therefore have a longer growing season although this does not seem to result in large numbers of thalli. Whilst this species was absent from the river, it grew well in river water in cultivation. It may be assumed that this is due to an intolerance to water flow. The thalli of *L. trisulca* are not free-floating, as in the other duckweeds, and so may not be able to take advantage of the still water between the floating-leaved and emergent plants.

Experimental evidence shows that, in competition with other duckweeds, *L. trisulca* is not, on the whole, very successful, although more so that the previous two species. Where present in the wild, *L. trisulca* never seems to be abundant, *e.g.* in the ponds it was present in only 36.8% of the quadrats.

With *Spirodela polyrhiza* in cultivation, its rate of increase in growth was very high, irrespective of water type, but in the wild the species performed rather poorly, thallus numbers always being low. This is shown by its presence in just 26.3% of the quadrats in the river samples, 5.3% of the quadrats in the ditch samples and 15.8% of the quadrats in the pond samples. The species in cultivation did not reflect these results.

The above results suggest that *S. polyrhiza* is more tolerant of high temperatures than the three *Lemna* species. This is supported by the fact that *L. gibba*, *L. minor* and *L. trisulca* are restricted to the temperate regions of the world, while *S. polyrhiza* occurs in both temperate and tropical regions of the world. They are also indicative of the fact that *S. polyrhiza* requires more days with temperatures above 10°C for active growth than do the other species. Despite its high temperature requirements during the growing season, *S. polyrhiza*, like *L. trisulca*, can tolerate an average winter temperature of -40°C. This is likely to be because it spends the winter as turions beneath the water surface. This survival technique does not, however, seem to give it any great advantage during the summer growing season when compared to the other species. This may be as a result of the relatively low summer temperatures.

Experimental evidence shows that, in competition with other duckweeds, *S. polyrhiza* is very successful, although it grows better on its own.

From field observations, it is clear that all duckweed species do not occur at the same frequency in all habitats. Their association varies with other plants, but with no obvious links. The experimental data show unequivocally that all of the duckweeds grow better on their own than in competition *e.g. S. polyrhiza* on its own is very successful, but is most affected by other species growing with it. *L. trisulca* does not compete well with *L. gibba* or *L. minor*. Where larger areas of free water were available in the field and when other duckweeds were absent each species was at its best.

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APPENDIX 1

Associated Plant Species at River Great Ouse, Linford Pits

Agrostis stolonifera var. *palustris* (Huds.) Farw.	Creeping Bent
Alga species	
Alisma plantago-aquatica L.	Water Plantain
Angelica sylvestris L.	Wild Angelica
Apium nodiflorum (L.)Lagasca	Fool's Watercress

Arctium lappa L.	Greater Burdock
Atriplex prostrata L.	Spear-leaved Orache
Barbarea vulgaris R. Br.	Wintercress
Berula erecta (Hudson) Cov.	Lesser Water-parsnip
Bidens tripartita L.	Trifid Bur-marigold
Brassica rapa ssp. *campestris* (L.) Clapham	Wild Turnip
Butomus umbellatus L.	Flowering Rush
Callitriche platycarpa Kuetz.	Various-leaved Water-starwort
Carex hirta L.	Hairy Sedge
Carex riparia Curtis	Great Pond-sedge
Cirsium arvense (L.) Scop.	Creeping Thistle
Cirsium palustre (L.) Scop.	Marsh Thistle
Conium maculatum L.	Hemlock
Cuscuta europaea L.	Greater Dodder
Deschampsia cespitosa ssp. *cespitosa* P.Beauv.	Tufted Hair-grass
Dipsacus fullonum L.	Teasel
Elodea nuttallii (Planchon) H. St. John	Nuttall's Waterweed
Epilobium hirsutum L.	Great Willowherb
Festuca gigantea (L.) Villars	Giant Fescue
Filipendula ulmaria (L.) Maxim.	Meadowsweet
Fontinalis antipyretica Hedw.	Willow Moss
Galium palustre ssp. *elongatum* Arcang.	Marsh Bedstraw
Glyceria fluitans (L.) R. Br.	Floating Sweet-grass
Glyceria maxima (Hartman) O. Holmb.	Reed Sweet-grass
Juncus effusus L.	Soft Rush
Juncus inflexus L.	Hard Rush
Lycopus europaeus L.	Gipsywort
Mentha aquatica L.	Water Mint
Myosotis scorpioides L.	Water Forget-me-not
Myosoton aquaticum (L.) Moench	Water Chickweed
Myriophyllum spicatum L.	Spiked Water-milfoil
Nuphar lutea (L.) Smith	Yellow Waterlily
Persicaria amphibia (L.) Gray	Amphibious Bistort
Persicaria hydropiper (L.) Spach	Water-pepper
Persicaria maculosa Gray	Redshank
Phalaris arundinacea L.	Reed Canary-grass
Plantago major L.	Greater Plantain
Poa trivialis L.	Rough Meadow-grass
Potamogeton perfoliatus L.	Perfoliate Pondweed
Potentilla anserina L.	Silverweed
Ranunculus penicellatus (Dumort.) Bab. ?	Chalk-stream Crowfoot
Ranunculus repens L.	Creeping Buttercup
Ranunculus sceleratus L.	Celery-leaved Crowfoot
Rorippa amphibia (L.) Besser	Great Yellow-cress
Rumex conglomeratus Murray	Clustered Dock
Rumex hydrolapathum Hudson	Water Dock
Rumex obtusifolius L.	Broad-leaved Dock
Rumex sanguineus var. *viridis* (Sibth.) Koch	Wood Dock
Sagittaria sagittifolia L.	Arrowhead
Salix alba L.	White Willow
Salix caprea L.	Goat Willow

Salix cinerea ssp. *oleifolia* Macreight	Grey Willow
Salix fragilis var. *fragilis* L.	Crack Willow
Salix viminalis L.	Osier
Schoenoplectus lacustris (L.) Palla	Bulrush
Scrophularia auriculata L.	Water Figwort
Scutellaria galericulata L.	Skullcap
Sisymbrium officinale (L.) Scop.	Hedge Mustard
Solanum dulcamara L.	Bittersweet
Sparganium erectum L.	Branched Bur-reed
Stachys palustris L.	Marsh Woundwort
Tilia x *vulgaris* Hayne	Common Lime
Urtica dioica L.	Stinging Nettle
Veronica anagallis-aquatica L.	Blue Water-speedwell
Veronica beccabunga L.	Brookline
Veronica catenata Pennell	Pink Water-speedwell

Associated Plant Species at Boundary Ditch, Linford Pits

Agrostis stolonifera var. *palustris* (Huds.) Farw.	Creeping Bent
Alga species	
Alisma plantago-aquatica L.	Water-plantain
Alopecurus geniculatus L.	Marsh Foxtail
Apium nodiflorum (L.) Lag.	Fool's Watercress
Bidens tripartita L.	Trifid Bur-marigold
Butomus umbellatus L.	Flowering Rush
Carex hirta L.	Hairy Sedge
Carex otrubae Podp.	False Fox-sedge
Deschampsia cespitosa ssp. *cespitosa* P. Beauv.	Tufted Hair-grass
Eleocharis palustris ssp. *vulgaris* Walters	Common Spike-rush
Elodea nuttallii (Planchon) H. St. John	Nuttall's Waterweed
Epilobium hirsutum L.	Great Willowherb
Epilobium tetragonum L.	Square-stalked Willowherb
Equisetum fluviatile L.	Water Horsetail
Equisetum palustre L.	Marsh Horsetail
Galium palustre ssp. *palustre* L.	Marsh Bedstraw
Glyceria maxima (Hartman) O. Holmb.	Reed Sweet-grass
Juncus articulatus L.	Jointed Rush
Juncus inflexus L.	Hard Rush
Lycopus europaeus L.	Gipsywort
Mentha aquatica L.	Water Mint
Myosotis scorpioides L.	Water Forget-me-not
Myriophyllum spicatum L.	Spiked Water-milfoil
Nuphar lutea (L.) Smith	Yellow Waterlily
Persicaria amphibia (L.) Gray	Amphibious Bistort
Phragmites australis (Cav.) Trin ex Steudel	Reed
Potamogeton friesii Rupr.	Flat-stalked Pondweed
Potamogeton pectinatus L.	Fennel Pondweed
Potamogeton perfoliatus L.	Perfoliate Pondweed
Potamogeton pusillus L.	Lesser Pondweed
Potentilla anserina L.	Silverweed

Ranunculus repens L.	Creeping Buttercup
Ranunculus sceleratus L.	Celery-leaved Crowfoot
Rhynchostegium confertum (Dicks.) Br. Eur.	Clustered Feather-moss
Rorippa amphibia (L.) Besser	Great Yellow-cress
Rorippa nasturtium-aquaticum (L.) Hayek	Watercress
Rorippa palustris (L.) Besser	Marsh Yellow-cress
Rumex conglomeratus Murray	Clustered Dock
Sagittaria sagittifolia L.	Arrowhead
Salix fragilis var. *fragilis* L.	Crack Willow
Samolus valerandi L.	Brookweed
Schoenoplectus lacustris (L.) Palla	Bulrush
Solanum dulcamara L.	Bittersweet
Sparganium erectum L.	Branched Bur-reed
Stachys palustris L.	Marsh Woundwort
Trifolium repens L.	White Clover
Urtica dioica L.	Stinging Nettle
Veronica beccabunga L.	Brooklime
Veronica catenata Pennell	Pink Water-speedwell

Associated Plant Species at Experimental Ponds, Linford Pits

Agrostis stolonifera var. *palustris* (Huds.) Farw.	Creeping Bent
Alga species	
Alisma plantago-aquatica L.	Water-plantain
Althaea officinalis L.	Marsh-mallow
Amblystegium riparium (Hedw.) Br. Eur.	a Moss
Anabaena sp.	a Blue-green Alga
Angelica sylvestris L.	Wild Angelica
Arrhenatherum elatius (L.) P. Beauv.	False Oat-grass
Berula erecta (Hudson) Cov.	Lesser Water-parsnip
Bidens tripartita L.	Trifid Bur-marigold
Bolboschoenus maritimus (L.) Palla	Sea Club-rush
Brachythecium rutabulum (Hedw.) Br. Eur.	Rough-stalked Feather-moss
Callitriche platycarpa Kuetz	Various-leaved Water-starwort
Callitriche stagnalis Scop.	Common Water-starwort
Cardamine pratensis L.	Cuckooflower
Carex hirta L.	Hairy Sedge
Carex otrubae Podp.	False Fox-sedge
Carex riparia Curtis	Great Pond-sedge
Chara vulgaris var. *vulgaris*	Stonewort
Conium maculatum L.	Hemlock
Crassula helmsii (Kirk) Cockayne	New Zealand Pigmyweed
Deschampsia cespitosa ssp. *cespitosa* P. Beauv.	Tufted Hair-grass
Dipsacus fullonum L.	Teasel
Drepanoclados aduncus (Hedw.) Warnst.	a moss
Eleocharis palustris ssp. *vulgaris* Walters	Common Spike-rush
Elodea canadensis Michaux	Canadian Pondweed
Elodea nuttallii (Planchon) H. St. John	Nuttall's Waterweed
Epilobium hirsutum L.	Great Willowherb
Epilobium parviflorum Schreber	Hoary Willowherb

Epilobium tetragonum L.	Square-stalked Willowherb
Equisetum fluviatile L.	Water Horsetail
Filipendula ulmaria (L.) Maxim.	Meadowsweet
Galium aparine L.	Cleavers
Galium palustre ssp. *palustre* L.	Marsh Bedstraw
Glyceria fluitans (L.) R. Br.	Floating Sweet-grass
Glyceria maxima (Hartman) O. Holmb.	Reed Sweet-grass
Hydrodictyon sp.	Water-net
Hypericum tetrapterum Fries	Square-stalked St John's Wort
Iris pseudacorus L.	Yellow Flag
Juncus articulatus L.	Jointed Rush
Juncus effusus L.	Soft Rush
Juncus inflexus L.	Hard Rush
Lolium perenne L.	Perennial Rye-grass
Lotus pedunculatus Cav.	Greater Bird's-foot-trefoil
Lycopus europaeus L.	Gipsywort
Lythrum salicaria L.	Purple Loosestrife
Medicago lupulina L.	Black Medick
Mentha aquatica L.	Water Mint
Myosotis laxa Lehm	Tufted Forget-me-not
Myosotis scorpioides L.	Water Forget-me-not
Myosoton aquaticum (L.) Moench	Water Chickweed
Myriophyllum spicatum L.	Spiked Water-milfoil
Nuphar lutea (L.) Smith	Yellow Waterlily
Nymphaea alba L.	White Waterlily
Nymphoides peltata Kuntze	Fringed Waterlily
Persicaria amphibia (L.) Gray	Amphibious Bistort
Persicaria maculosa Gray	Redshank
Phragmites australis (Cav.) Trin ex Steudel	Reed
Potamogeton pusillus L.	Lesser Pondweed
Potentilla anserina L.	Silverweed
Ranunculus lingua L.	Greater Spearwort
Ranunculus peltatus Schrank ?	Pond Water-crowfoot
Ranunculus sceleratus L.	Celery-leaved Crowfoot
Rorippa amphibia (L.) Besser	Great Yellow-cress
Rubus species	Bramble
Rumex conglomeratus Murray	Clustered Dock
Rumex hydrolapathum Hudson	Water Dock
Salix alba L.	White Willow
Salix caprea L.	Goat Willow
Salix cinerea ssp. *oleifolia* Macreight	Grey Willow
Salix purpurea L.	Purple Willow
Salix viminalis L.	Osier
Schoenoplectus lacustris (L.) Palla	Bulrush
Scrophularia auriculata L.	Water Figwort
Scutellaria galericulata L.	Skullcap
Solanum dulcamara L.	Bittersweet
Sparganium erectum L.	Branched Bur-reed
Stachys palustris L.	Marsh Woundwort
Typha latifolia L.	Greater Reedmace
Urtica dioica L.	Stinging Nettle

Veronica beccabunga L.	Brooklime
Veronica catenata Pennell	Pink Water-speedwell

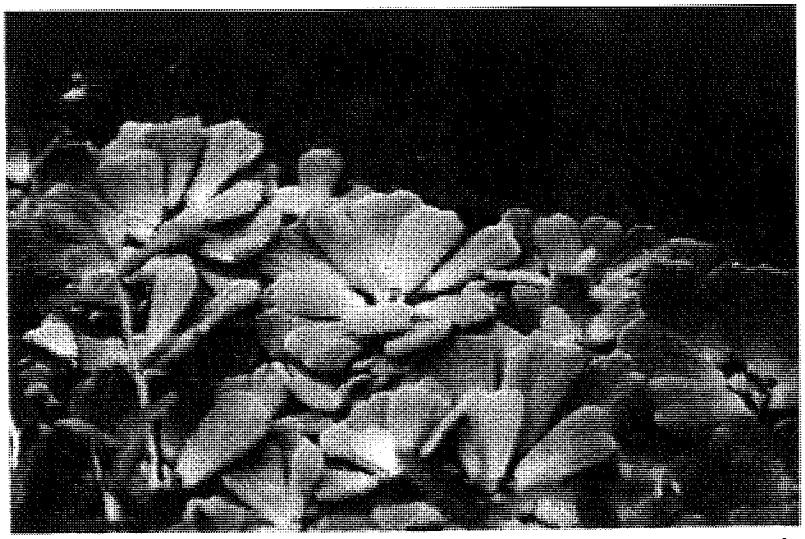

Figure 1 - The water lettuce *Pistia stratiotes* is a member of the family Araceae, from which the duckweeds evolved. Like the duckweeds, it is free-floating and shows reduction in some of its parts. (Oxford, 1996)

Figure 2 - Duckweeds can rapidly cover large areas of water. Here duckweeds (centre), the fern *Azolla* (background) and *Eichhornia crassipes* (foreground) are covering a swampy lake. (Five-acre Lake, Brazos Bend, Texas, 1997)

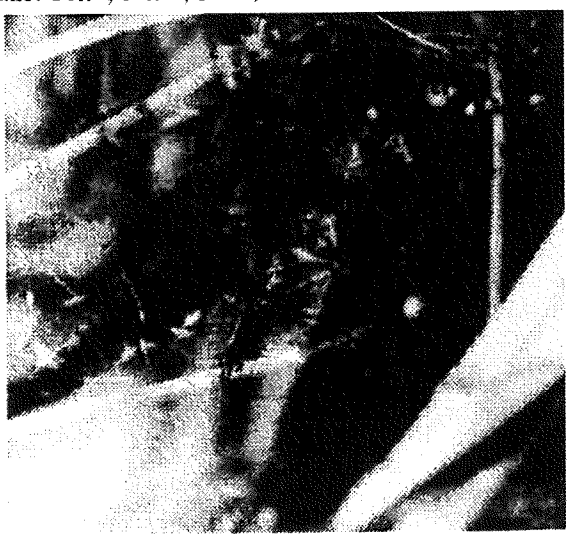

Figure 3 - *Lemna triscula* showing the ivy-leaf arrangement of the joined thalli. (Experimental Ponds, 1996)

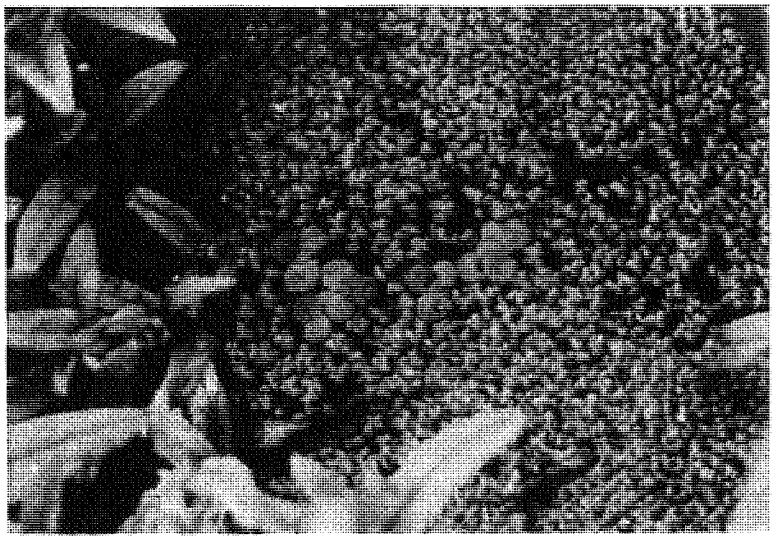

Figure 4 - The large thalli of *Spirodela polyrhiza* dwarf the thalli of *Lemna gibba* and *L. minor*. The black spots on the thalli are aphids, probably *Rhopalosiphum nymphaeae.* (River Great Ouse, 1996)

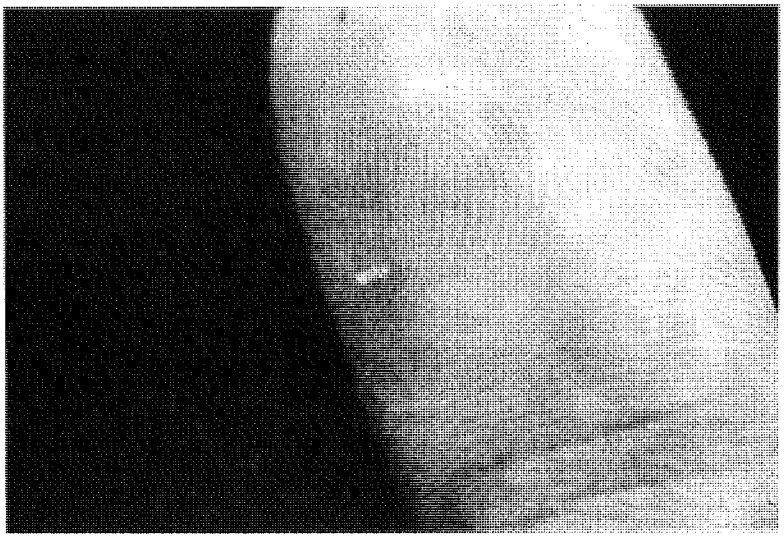

Figure 5 - The minute thalli of *Wolffia columbiana* are among the world's smallest flowering plants. This species is very similar to the native *W. arrhiza.* (Near Tivoli, Texas, 1997)

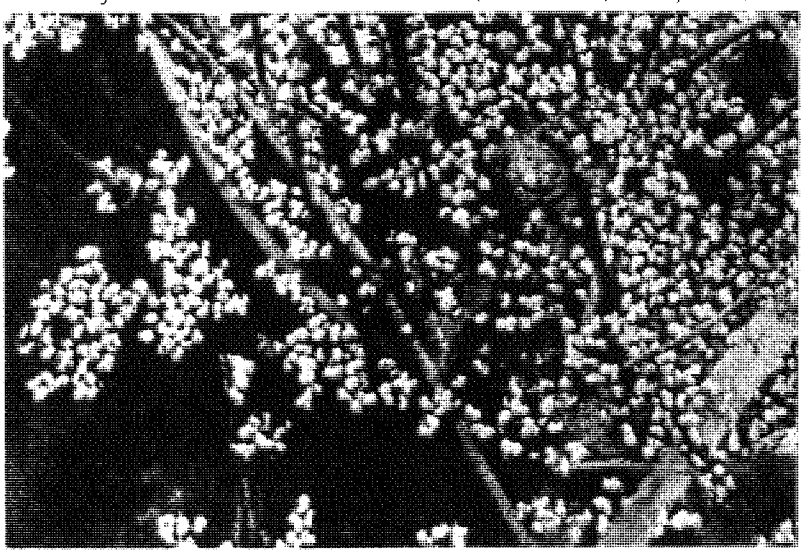

Figure 6 - The duckweeds *Lemna gibba* and *L. minor* are superficially very similar. In this photo *L. gibba* can be recognised by its swollen look, due to its thalli sitting higher in the water. The flatter thalli are *L. minor.* (Boundary Ditch, 1996)

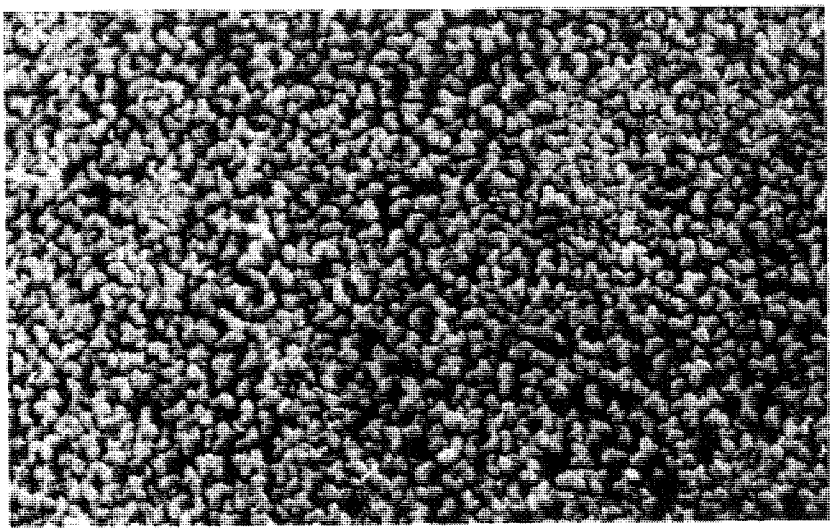

Figure 7 - The North American immigrant *Lemna minuta*. The small thalli of this species look large compared to the *Wolffia columbiana*, which is growing amongst it. (Near Tivoli, Texas, 1997)

Figure 8 - The River Great Ouse showing its steep banks and the patches of *Glyceria maxima* and *Schoenoplectus lacustris* growing along its margins. The duckweed mats in the centre of the river are being carried by the current. (1996)

Figure 9 - The Boundary Ditch showing the dense marginal stands of *Sparganium erectum* and thick mats of floating duckweeds and algae. (1996)

Figure 10 - View of the Boundary Ditch showing the deep water full of submerged plants, such as *Elodea nuttallii* (centre), *Potamogeton friesii* (bottom left) and *P. pectinatus* (bottom right). (1996)

Figure 11 - The steep banks of the Boundary Ditch have been severely poached by cattle. (1996)

Figure 12 - One of the deeper of the Experimental Ponds showing the steep banks and dense stands of *Sparganium erectum* and *Typha latifolia*. (1996)

Figure 13 - The shallower of the Experimental Ponds showing the marshy edge and dense stands of *Bolboschoenus maritimu* and *Typha latifolia.* (1996)

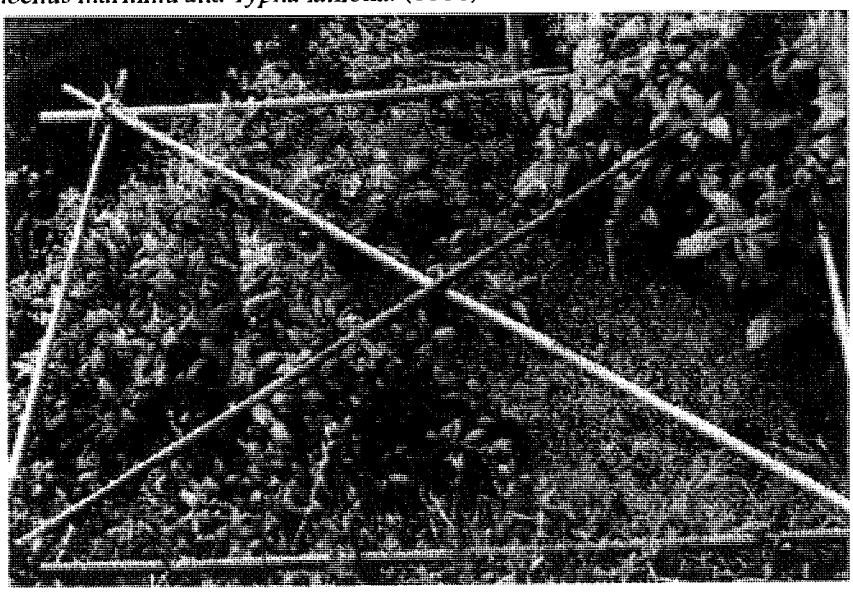

Figure 14 - The 1 meter square quadrat was placed so as to include aquatic and marginal species. (River Great Ouse, Linford Pits, 1997)

Dragonflies and Damselflies in Milton Keynes

by George Mahoney

A Preliminary Report

Introduction

About eight years ago I decided to concentrate on one group of animals and try to get to know them well. All sorts of possibilities crossed my mind. Beetles? No, there are too many different sorts, thousands in the UK. Butterflies? No, everybody does them. Birds? Can't afford the telescope and the instant, drop everything trips to Fair Isle or the Scillies. After a little thought I decided to try dragonflies. I have always found them interesting to watch but didn't have a clue about identification and only knew a little about their habits and biology.

Dragonflies are probably the ideal insect to begin with to learn identification skills. There are only 38 breeding species and two regular migrants found in the British Isles. They are relatively large and usually brightly and distinctively coloured. They can be observed easily with the naked eye or a pair of close focus binoculars on warm summer days. I'm not saying that identification is trivially easy, many of the damselflies need close inspection to be sure of the species, but they are certainly easier to identify than, say, beetles many of which look very similar indeed.

After several years of watching dragonflies I have become reasonably competent at identifying most species. I'm not an expert, that becomes obvious when in the company of members of the British Dragonfly Society. One of the problems I found when starting serious study of dragonflies was that the books and keys available were not very easy to use. I found that I spent much of my time trying to match the observed insect against a drawing or photograph and never being 100% certain that I had got the identity correct. As only eighteen species have been recorded from Milton Keynes, I decided to try to put together a key to help others to identify these beautiful creatures. This key was published in the Milton Keynes Natural History Society newsletter ("The Magpie") a couple of years ago.

I have recently decided to try to focus my attentions on detailed recording of important dragonfly sites in Milton Keynes. This article summarises the data I have collected to date and gives an outline of the work I intend to carry out over the coming years. To begin, I have written a brief introduction to the characteristics, life cycle and habitat requirements of the Dragonflies and Damselflies.

The Odonata - their characteristics, life cycle and habitat requirements

Dragonflies and Damselflies belong to the order of insects known as the Odonata, which means "toothed jaws". About 5000 species have been described worldwide, but most of these are tropical. Only 38 species breed in the British Isles. The Odonata are divided into three groups: the *Anisoptera* or Dragonflies, the *Zygoptera* or Damselflies and the *Anisozygoptera* - a primitive group with no representatives in Britain or Ireland. As the term "Dragonfly" is commonly used to refer both to the order Odonata as a whole and to the anisopteran suborder, I intend to follow the convention of using "dragonfly" (with a small "d") to refer to the order, and "Dragonfly" (with a capital "D") when referring to an anisopteran. I'm sorry if this seems a little confusing but it does help to avoid the clumsy repetition of "dragonflies and damselflies"!

Dragonflies belong to a very ancient group of flying insects. Fossils have been found from the Carboniferous period - 300 million years ago - that have quite similar characteristics to the modern insects. The main difference is that some of these fossils were huge with a wingspan of up to 70 cm. The largest species found in Britain today have a wing span of about 10 cm. Adult dragonflies are exceptionally good flyers. Each of their wings can move independently allowing them to hover like a helicopter, fly backwards, and perform spectacular feats of aerobatics. These abilities are of the utmost importance to dragonflies because they are aerial predators - the "raptors" of the insect world. All dragonflies are exclusively carnivorous, catching and often eating their prey in mid air. When at rest, Dragonflies hold their wings out flat, at right angles to the body. Damselflies usually rest with the wings held together along the line of the body. The adult form that we associate with warm summer days represents only a part of their overall life cycle. The larval stage lives underwater and it too is carnivorous.

The adult female dragonfly lays its eggs in, or near, water. The eggs hatch, sometimes after overwintering, into a small, grub-like prolarva which quickly transforms into a tiny larva. The larva has six legs, powerful jaws and breathes by the use of gills - internal for Dragonflies, external for Damselflies. The larva hunts water invertebrates and moults its skin to grow. This process may take anything from a few months in the case of Damselflies to five years in some of the larger

Dragonflies. Eventually, the larva reaches its maximum size. The large eyes and wing cases can clearly be seen by this stage. The larva climbs out of the water onto emergent vegetation or some other support. The larval skin splits along the back and the adult insect emerges and, after resting to dry its wings, flies off. The adults mate near water, often in a characteristic "mating wheel", and the female lays her eggs by broadcasting them on the water surface or by placing them carefully into the tissues of water plants, depending upon the species. The male and female may remain coupled in tandem while egg-laying takes place.

Dragonflies are generally quite good indicators of water quality. Only a few species can tolerate any level of pollution (for example the Blue-tailed Damselfly). The particular type of water body that is preferred is dependant upon the species. Some species require ponds or lakes with good marginal vegetation, some require floating plants, some require rivers or streams with muddy bottoms while others require gravel bedded streams.

Eighteen species of dragonfly have been recorded in Milton Keynes. This total includes seventeen potentially breeding species and one infrequent visitor, the Yellow-winged Darter. This number represents a fairly good cross-section of the species on the British list. Many of the species are widely distributed throughout the Borough, for example the Common Blue and Blue-tailed Damselfly, and the Common Darter and Brown Hawker Dragonflies. Other species have more specific habitat requirements, an example is the Red-eyed Damselfly which only occurs where there is floating vegetation such as water lilies. The next section lists all the species recorded from Milton Keynes.

Species by species summary - characteristics, current known status, distribution and flight period

Each species recorded in the Borough is named and briefly described. Some notes are given about habitat requirements, distribution in Milton Keynes and flight period. All comments here are from personal observations except where noted otherwise.

Calopteryx splendens (Harris) - Banded Demoiselle

This is the easiest to identify damselfly in Milton Keynes. The male has an electric blue abdomen and dark blue "splodges" on each wing. The female has a metallic green abdomen and transparent, greenish wings. This is the largest damselfly species in Milton Keynes. It prefers rivers with abundant marginal vegetation and is tolerant of silty, but not polluted, water. It is common, and found along most rivers and streams in Milton Keynes. The flight period is from mid May to mid September.

Lestes sponsa (Hansemann) - Emerald Damselfly

Unlike all other damselflies found in Milton Keynes, this species rests with its wings held at 45 degrees to the body line. Both sexes are metallic, emerald green in colour but the male has powdery blue patches on the thorax and at both extremes of the abdomen. *L. sponsa* requires profuse marginal vegetation and is a reluctant flyer, spending much of the days hidden among the plant stems. Although probably widely distributed in Milton Keynes, I have only recorded this species from a few of the gravel pits, balancing lakes and smaller ponds. The flight period is from mid June to mid September.

Platycnemis pennipes (Pallas) - White-legged Damselfly

Males of this species are pale blue with noticeable white legs which are used in a mating display. Females begin adult life pale cream in colour but gradually mature to become pale green. This damselfly is usually found among luxuriant vegetation along the banks of slow flowing rivers. It is very vulnerable to pollution and to bank disturbance and, as a result, was for many years absent from the River Ouzel. It is now found along both the main river systems in Milton Keynes, in some places in good numbers. The flight period is from late May through to late August.

Pyrrhosoma nymphula (Sulzer) - Large Red Damselfly

Milton Keynes' only red damselfly, the Large Red can be found on most water bodies but never in very high numbers. The female may be distinguished from the male in that she has more black towards the rear of the abdomen. It is usually the first species to be seen in spring with a flight period from early May to mid July.

Erythromma najas (Hansemann) - Red-eyed Damselfly

This robust damselfly is mainly dark grey with a blue and bronze-black thorax and, in the male, a blue tip to the abdomen. The eyes are noticeably dark red in colour, particularly in the male. This species is usually seen patrolling over water with floating vegetation. The males vigorously defend their territories from a regular resting place on water lily pads or similar rafts. Red-eyed Damselfly is found on most of the balancing lakes and gravel pits in Milton Keynes and on some of the slower moving stretches of river. The flight period is from mid May to early August.

Coenagrion puella (L.) - Azure Damselfly

One of the two, easily confused, blue and black damselflies found in Milton Keynes. The male Azure Damselfly may be distinguished by its thin "shoulder" (antehumeral) stripes and by a "U"-shaped mark on the second segment of the abdomen (compare with the next species). The females of both this and the next species are quite difficult to separate as both are dark bodied with some insignificant greenish or blue markings on the thorax. They may be encountered on any water bodies, usually perched on, or patrolling, vegetation at the water's edge. The flight period is from mid May to the end of July.

Enallagma cyathigerum (Charpentier) - Common Blue Damselfly

The male of this species can be distinguished from the preceding species by the wider antehumeral stripes and the ball shaped mark on the second segment. The female is dark bodied with green, blue or brown markings. This damselfly, as its name suggests, is very common in Milton Keynes and can be found on any watery habitat. The males often patrol lazily over the water, keeping about 10-15 cm from the surface. When resting, males often "line up", one above the other, on reeds all facing into the breeze. The flight period is from mid May to mid September.

Ischnura elegans (Vander Linden) - Blue-tailed Damselfly

One of the commonest British damselflies, the Blue-tailed is found throughout Milton Keynes. Mature males have a blue striped thorax and a blue spot near the end of the abdomen. Females are very variable in colour with several named colour forms. The distribution of colour is like the males but may be green thorax and blue spot, violet thorax and spot, brown thorax and spot or pink thorax with blue spot. This damselfly could be seen almost anywhere in Milton Keynes and is one of the few to be tolerant of some pollution, sometimes it is the only species occurring in a location. The flight period is from mid May to the end of August.

Aeshna mixta (Latrielle) - Migrant Hawker

This is a late summer Dragonfly, often seen in large numbers flying over woodland glades or hedgerows. The males are mainly blue with some yellow on the thorax. Females are brown with yellow spots. Both sexes have a yellow "golf-tee" shaped mark on the second segment of the abdomen which is quite noticeable when at rest. This species used to be an uncommon migrant from the continent but is now common in south and east England. It may be found well away from water during the day, sometimes in large swarms. Some years ago I observed between 1000 and 2000 individuals at one time in a field corner near Shenley Wood. The flight season is from the end of July to mid October.

Aeshna cyanea (Müller) - Southern Hawker

This large, usually solitary, Dragonfly has bright green spots, turning to blue on the last few segments, on a dark background. All spots on females are green. Both sexes have broad green, or yellow-green, antehumeral stripes. Males are very territorial and can be seen defending small woodland, or even garden, ponds. Both sexes may be encountered on woodland rides. The flight season is from mid June to the end of August.

Aeshna grandis (L.) - Brown Hawker

This Dragonfly is unmistakable. It is the only Dragonfly found in Milton Keynes with amber/gold coloured wings. The overall appearance is brown, the male having blue spots on the abdomen and lemon bars on the thorax, the female with yellow markings. This insect is encountered widely in Milton Keynes during its flight season being found at gravel pits and well away from water in woodland, along hedgerows and in gardens. The females can often be seen ovipositing (egg-laying) in floating logs at the edges of lakes and ponds. The flight season is from mid June to the end of September.

Anax imperator (Leach) - Emperor Dragonfly

This is, perhaps, the most impressive Dragonfly found in Milton Keynes. On warm summer days this magnificent insect can be seen patrolling over most of the ponds and lakes. The males are large (up to 8 cm) with a sky-blue abdomen and green thorax and huge green and blue eyes. The females are similar in size but mainly green (some older individuals do develop a bluish tinge). Oviposition occurs on floating/emerging vegetation. The flight period is from mid June to the end of August.

Libellula quadrimaculata (L.) - Four-spotted Chaser

This medium-sized Dragonfly is widely distributed in Milton Keynes. It is mainly brown, the male having yellow spots along the sides of the abdomen. The name comes from the markings on the wings. Each wing has two obvious brown spots, one half way along (at the nodus) and the other near the wing tip (the pterostigma). There is also a dark patch at the base of the hind wing. It can be found on ponds, gravel pits, rivers and canals, often returning to a favourite perch on marginal vegetation. The flight period is from mid May to mid August.

Libellula depressa (L.) - Broad-bodied Chaser

This is the fat, blue Dragonfly that is so familiar on shallow ponds and lake margins. The females have a fat brown body with yellow spots along the sides. It prefers comparatively newly created

ponds and lakes and is often the first species to colonise a pond. Like the preceding species, the male often returns to a prominent, sunny perch on the pond margin. The flight period is from late May to the end of July.

Orthetrum cancellatum (L.) - Black-tailed Skimmer

A low flying species often seen resting on bare earth or gravel in full sunshine. The male has a powdery blue abdomen with a noticeable black tip and yellow spots along the sides. The females are yellow-brown with two black lines running the length of the abdomen. This Dragonfly can be found on lakes and ponds and on the banks of slow moving rivers. The flight period is from June to mid August.

Sympetrum striolatum (Charpentier) - Common Darter

The Darters (this and the next two species) are the smallest of the Dragonflies found in Milton Keynes. They are also all very similar and careful observation is necessary to be certain of identity. The Common Darter is widespread on ponds and lakes and sometimes found on canals and rivers. The male has a bright orange-red abdomen, yellow striped thorax and brown/green eyes. The female is yellow, pale orange or brown, darkening with age. It perches either on the tops of plants or on the ground depending on the temperature. In late summer, pairs in tandem can be seen ovipositing by the female dipping the tip of her abdomen into the water surface. This species has a long and late flight season, from mid June well into October.

Sympetrum sanguineum (Müller) - Ruddy Darter

The mature male has a bright crimson or blood red abdomen with a dark red thorax and eyes. The abdomen is noticeably "waisted" - an hour-glass figure. The females are very similar to the previous species. This species is less common than the preceding but can be found around many of the well vegetated ponds in Milton Keynes. As its flight season and distribution is coincident with the Common Darter, careful observation is required to confirm identification. Flight season is from early July to the end of September.

Sympetrum flaveolescens (L.) - Yellow-winged Darter

This species is very similar to the Common Darter but the wing bases in both sexes are suffused with amber coloration. It is an infrequent visitor to Britain and has been recorded only during a large "invasion" in August, 1995 from several sites in Milton Keynes. Unfortunately, I did not observe this interesting species myself.

Dragonfly Sites in Milton Keynes - site types, examples (rivers and streams, gravel pits and balancing lakes, garden, field and woodland ponds)

By their nature, dragonflies are most commonly found near water. Water is essential for the main part of their lives, the larval stage, and all dragonflies return to water to breed even if they hunt well away from it. Many of the larger Hawker and Darter Dragonflies can be found some considerable distance from water. This is particularly true for the Migrant Hawker, Southern Hawker and Brown Hawker.

Milton Keynes is well provisioned with suitable sites for dragonflies. These are summarised below and split into several categories. Only those sites from which I personally have collected records are listed here but there are many more. Over the next few years I hope to be able to put together a more comprehensive list and also to assess the relative value (for dragonflies) of the various sites in the Borough.

Gravel/brick pits

Gravel pits are potentially always good sites for dragonflies. As they are usually sited next to rivers, many of the riverine species are recorded along with those that prefer still water. Newly worked gravel pits can be particularly attractive to several species, e.g. Black-tailed Skimmer, Emperor Dragonfly and Broad-bodied Chaser.

Emberton Park

This is a very good site because of varied types of lake together with the River Ouse and the water meadows. 14 species of dragonfly have been recorded, but it should be possible to find all 17 species here.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna mixta*
Platycnemis pennipes	*Aeshna grandis*
Pyrrhosoma nymphula	*Anax imperator*
Erythromma najas	*Libellula quadrimaculata*

Coenagrion puella	*Orthetrum cancellatum*
Enallagma cyathigerum	*Sympetrum striolatum*
Ischnura elegans	*Sympetrum sanguineum*

Blue Lagoon, Bletchley

The shallow ponds in the nature park area are the most productive. To date 14 species have been recorded here but one could expect all Milton Keynes species but *Platycnemis pennipes* to be found.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna mixta*
Lestes sponsa	*Aeshna grandis*
Pyrrhosoma nymphula	*Anax imperator*
Coenagrion puella	*Libellula quadrimaculata*
Enallagma cyathigerum	*Libellula depressa*
Ischnura elegans	*Orthetrum cancellatum*
	Sympetrum striolatum
	Sympetrum sanguineum

Great Linford

This site is similar in many ways to Emberton Park. It has both an assortment of lakes and ponds together with the River Ouse. 13 species have been recorded here but there is no reason why all 17 should not be present.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna grandis*
Lestes sponsa	*Anax imperator*
Platycnemis pennipes	*Libellula quadrimaculata*
Erythromma najas	*Orthetrum cancellatum*
Coenagrion puella	*Sympetrum striolatum*
Enallagma cyathigerum	*Sympetrum sanguineum*
Ischnura elegans	

Stony Stratford Nature Reserve

I have not spent much time surveying this site for dragonflies. Only 4 species have been recorded by me. Many other species must exist here.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna grandis*
Coenagrion puella	
Ischnura elegans	

Balancing lakes

The balancing lakes in Milton Keynes provide a similar habitat to gravel pits. Most of the lakes have very good marginal vegetation which helps to provide cover for damselflies.

Lodge Farm Lake

This lake has good marginal vegetation and the Loughton Brook flowing into and out of it. Species numbers have fluctuated because of extensive clearance work along the banks in the past. Nine species have been recorded from this site.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna grandis*

Erythromma najas	*Anax imperator*
Coenagrion puella	*Libellula depressa*
Enallagma cyathigerum	*Sympetrum striolatum*
Ischnura elegans	

Walton Balancing Lake

This lake is very shallow, in parts reverting to scrub, with wooded edges. This is a good place to see the Emerald Damselfly. There are also many Chasers to be found. 12 species recorded.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna mixta*
Lestes sponsa	*Aeshna grandis*
Coenagrion puella	*Anax imperator*
Enallagma cyathigerum	*Libellula quadrimaculata*
Ischnura elegans	*Libellula depressa*
	Orthetrum cancellatum
	Sympetrum striolatum
	Sympetrum sanguineum

Teardrop Lakes - Loughton

This is a very interesting and productive site with the chain of ponds with ample emergent vegetation. There is also the stream outflow and a shallow, marshy area. 15 species have been recorded including White-legged Damselfly - this is not a typical site for this species as it usually prefers slow flowing rivers or canals.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna grandis*
Lestes sponsa	*Anax imperator*
Platycnemis pennipes	*Libellula quadrimaculata*
Pyrrhosoma nymphula	*Libellula depressa*
Erythromma najas	*Orthetrum cancellatum*
Coenagrion puella	*Sympetrum striolatum*
Enallagma cyathigerum	*Sympetrum sanguineum*
Ischnura elegans	

Ponds

There are many ponds remaining in Milton Keynes despite the tendency over the past few decades to fill in many farm ponds. Garden ponds also provide a very valuable habitat for dragonflies. Even the large Emperor Dragonfly will investigate and occasionally lay eggs in a comparatively small garden pond.

Howe Park Wood

The three ponds near the car park/picnic area are exceptionally productive for Dragonflies. There are also ponds within the wood. 14 species have been recorded with personal records of breeding behaviour for 12 species. This site is very good for Ruddy Darter in late summer.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna cyanea*
Lestes sponsa	*Aeshna grandis*
Pyrrhosoma nymphula	*Anax imperator*
Coenagrion puella	*Libellula quadrimaculata*
Enallagma cyathigerum	*Libellula depressa*
Ischnura elegans	*Orthetrum cancellatum*

	Sympetrum striolatum
	Sympetrum sanguineum

Rivers

The river systems in Milton Keynes are all quite similar; slow flowing and muddy bottomed. This determines the type of dragonflies to be found. The River Ouzel suffered greatly from bank clearance and canalisation in the early years of the development of Milton Keynes. Much of this river has now recovered and supports an interesting and varied collection of species.

River Ouse

This is the main water course through the North of Milton Keynes. It is a slow flowing, muddy bottomed river. Various sites along the river (Stony Stratford, Haversham, Great Linford, Gayhurst, Emberton) return records for most of the 17 species. White-legged Damselfly and Banded Demoiselle particularly notable.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna mixta*
Platycnemis pennipes	*Aeshna cyanea*
Pyrrhosoma nymphula	*Aeshna grandis*
Erythromma najas	*Anax imperator*
Coenagrion puella	*Libellula quadrimaculata*
Enallagma cyathigerum	*Sympetrum striolatum*
Ischnura elegans	

River Ouzel

Near to the Open University is the best site in Milton Keynes for seeing White-legged Damselfly. Thousands can be seen in early to mid July ovipositing in Water Crowfoot.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna mixta*
Platycnemis pennipes	*Aeshna grandis*
Pyrrhosoma nymphula	*Anax imperator*
Coenagrion puella	*Libellula quadrimaculata*
Enallagma cyathigerum	*Libellula depressa*
Ischnura elegans	*Sympetrum striolatum*

River Tove

This river flows into River Ouse near Cosgrove. Within Milton Keynes it provides a similar habitat to the Ouse but, much further upstream, above Greens Norton, this is the only river flowing into the North Sea with a population of Beautiful Demoiselle (*Calopteryx virgo*). Unfortunately this is outside the Milton Keynes Borough boundary!

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
No formal records	

Canal

Canals are rather like a cross between a river and a long, narrow lake. Therefore many different species of dragonfly can be recorded.

Grand Union

The Grand Union canal flows right through Milton Keynes from its entry at Cosgrove to its exit at Fenny Stratford. Various sites surveyed have returned 12 species to date.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)

Calopteryx splendens	*Aeshna mixta*
Platycnemis pennipes	*Aeshna grandis*
Pyrrhosoma nymphula	*Anax imperator*
Erythromma najas	*Libellula depressa*
Coenagrion puella	*Sympetrum striolatum*
Enallagma cyathigerum	
Ischnura elegans	

Streams

To date, records have been kept for only one of the streams in Milton Keynes. I hope to record from more in the future.

Linford Brook

Not recorded as a separate site but included with Teardrops and Lodge Farm. Adds Banded Demoiselle to their species list and may account for presence of White-legged Damselfly at Teardrops.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Calopteryx splendens	*Aeshna grandis*
Platycnemis pennipes	*Libellula quadrimaculata*
Pyrrhosoma nymphula	*Libellula depressa*
Coenagrion puella	*Sympetrum striolatum*
Enallagma cyathigerum	
Ischnura elegans	

Woodland and Countryside

Many of the Hawker Dragonflies prefer to hunt for food away from the water. Woodland and open countryside can be good habitats to see Southern, Migrant and Brown Hawkers.

Shenley Wood

This site is near where I work and so is frequently visited. It is very good for all Milton Keynes Hawker Dragonflies in late summer. There is a small pond on the North edge of the wood where Southern Hawker is regularly seen. Occasionally huge swarms of Migrant Hawker can be seen, about 2000 individuals one August lunch time in 1990.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Lestes sponsa	*Aeshna mixta*
Ischnura elegans	*Aeshna cyanea*
	Aeshna grandis
	Anax imperator
	Libellula quadrimaculata
	Sympetrum striolatum
	Sympetrum sanguineum

Howe Park Wood

Noted before under 'Ponds'. Southern Hawker regularly seen in wood in late summer and known (from exuviae) to breed in pond in the wood.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Coenagrion puella	*Aeshna mixta*
Enallagma cyathigerum	*Aeshna cyanea*
Ischnura elegans	*Aeshna grandis*
	Anax imperator
	Sympetrum striolatum

	Sympetrum sanguineum

Little Linford Wood

There is very little open water here so the range of species is restricted, but trees catch the evening sun in late summer and large numbers of Brown Hawkers and Common Darters have been seen sunning themselves on tree trunks there. Some work has been carried out recently to open out one of the ponds which may encourage more species.

Zygoptera (Damselflies)	Anisoptera (Dragonflies)
Coenagrion puella	*Aeshna cyanea*
Enallagma cyathigerum	*Aeshna grandis*
	Orthetrum cancellatum
	Sympetrum striolatum

Future work - systematic survey of sites, collection of water quality data, collection of records from other sources.

The recording carried out so far has been done on a rather informal basis. Sites have been visited when time permits, no specific schedule has been followed. Many sites have not been visited for recording purposes at all. For example, two of the larger balancing lakes, Caldecotte and Furzton, have not been recorded from at all. In the case of the linear sites, rivers, streams and canals, it might be desirable to split them into sections and keep separate records for each section. Populations of dragonflies are often quite localised therefore it would be useful to be able to determine the richest sections of these habitats. No attempt has been made to date to record from the many field ponds within the Borough. These could provide rich pickings.

No attempt has been made to evaluate the water bodies and water courses for quality, pH etc. This data may help to explain distribution of species, their absence from sites where the habitat appears suitable.

The assessment of the value of a particular site with respect to dragonflies depends on being able to prove that it is being used for breeding. Proof of breeding is only accepted when larvae, exuviae or emerging adults are recorded. This is an area that I will begin to investigate this summer. Mating behaviour and oviposition can be good indicators of breeding but do not constitute proof of success.

Over the next five years, I intend to start more systematic recording of sites with a view to creating a local "atlas" of valuable dragonfly habitats together with flight periods and relative abundance of species present. This is quite a major undertaking and I would appreciate help from other dragonfly enthusiasts. Do you have records from any of the above mentioned sites, or from other sites within the Borough? Would you be interested in helping me to compile formal records from sites? Do you know of the existence of historical records relating to dragonflies within Milton Keynes? If you can help me with any of the above it would be greatly appreciated.

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The design and building of a Rehabilitation Flight Cage for a controlled study on the ability of orphan and long-term captive pipistrelle bats (*Pipistrellus pipistrellus*) to learn or re-learn to hunt and to survive release into the wild. (Including some data on the feeding and growth of five orphan *Pipistrellus pipistrellus* during the summer of 1997.)

by Linda Piggott

I have been involved in the care and rehabilitation of sick, injured and orphaned British bats since 1989 and I have often thought that there must be a way in which we can better prepare rescued bats for release into the wild.

I have been able to provide them with the right conditions to thrive in captivity. However, their opportunity for exercise whilst in my care has had to be more limited than I would like. The alternatives until now have been:

a. to allow the bats to fly singly in our living room for up to an hour at a time, or

b. to leave several bats at a time in a home-made "flight net" overnight.

The first option has disadvantages. It is necessary for someone to watch each bat constantly while it is flying, to ensure that it does not become lost behind furniture when it lands. There is an increased risk of losing a bat if more than one fly at the same time. The main advantage of the living room is that, at 23 feet long by 11 feet wide, it allows a bat the size of a pipistrelle plenty of room for manoeuvre and uninterrupted flight.

Whilst the flight net can accommodate several bats at a time and, because supervision is unnecessary, they can be left for long periods, the net itself is only 7 feet long by 4 feet wide. The bats are unable to sustain flight in this relatively confined area, only flying one or two lengths before landing on the net.

A disadvantage of both alternatives is that no flying insects are available for the bats to practise hunting.

The orphans in particular pose a further problem. Every baby bat rescued must be returned to its roost if at all possible. However, every year we receive babies whose roosts cannot be found or whose mothers have died. These 'genuine' orphans can often be reared successfully but there remains a question mark over whether they should or should not be released.

It is not an offence under the Wildlife and Countryside Act, 1981, Section 10 (3) to take or keep a bat for the "sole purpose of tending and releasing it when no longer disabled." However, the plight of orphans is not specifically covered by the act and the keeping of fit and healthy bats in captivity just because they are orphans could arguably be seen as contravening it. An article in the January 1990 edition of Batchat warns that "it could be very difficult indeed to justify the possession of apparently healthy bats and so every effort should be made to return the bats to the wild as quickly as possible."

On the other hand, the Bat Worker's Manual (1987) states that "bats born or raised in captivity or held in captivity for long periods are not suitable for release to the wild for a number of reasons, for example their lack of contact with conspecifics, lack of detailed knowledge of any area, inability to forage successfully, lack of experience of dealing with many insects and inexperience in selecting suitable roost sites. For these reasons It has generally been considered that the survival rate of these bats would be so low that it is more appropriate to retain them permanently in captivity." Indeed, "to release an animal which suffers unnecessarily because it is not competent could be interpreted as abandonment as defined by the Protection of Animals Act 1911 and the Abandonment of Animals Act 1960, which [...] only protect animals which are or have been in captivity."(Stocker,L. 1987).

Apart from a reference in Bat Care News to a study by M. Fry in the United States, the final results of which are not yet known by the editor, I have been unable to find data on the release of orphaned bats. However, I know from my work with other wild animals that the practice of "hacking back" is widely used to introduce or re-introduce captive animals to the wild. This usually involves feeding the animal for some time in an enclosure from where it will eventually be released. After release food continues to be left regularly in or near the enclosure so that, during the early stages of learning or re-learning to hunt or forage, when the animal's chances of success are probably lowest, extra food and water are available if necessary. Hopefully, as the animal becomes more successful it relies less and less on the provided food.

I believe that the practice of "hacking back " could be adapted for use with orphaned and long term captive bats.

At present I have eighteen pipistrelle bats in my care, six of which are this year's orphans. The remainder are orphans from previous years or long term captives. I hope to be able to use these bats, and any orphans which I raise in future years, in a controlled study, to discover whether they can be successfully returned to the wild.

The Flight Cage

Before the study could commence it was necessary to erect a suitable flight cage. Criteria which this cage needed to satisfy were:

1. Enough space to fly and manoeuvre freely.
2. Somewhere to roost, preferably a choice of roosts for different conditions.
3. A means of attracting insects into the cage as food for the bats to hunt.
4. A suitable place for a "feeding station" for the extra food and water to be provided.
5. Protection from predators.
6. Protection from the elements.
7. A means of observing the bats' flying and hunting ability without disturbing them.
8. Easy access for collecting data.
9. No means of escape until any individual may be deemed fit for release.
10. A means of allowing egress from the cage, whilst confining those bats not considered ready for release.

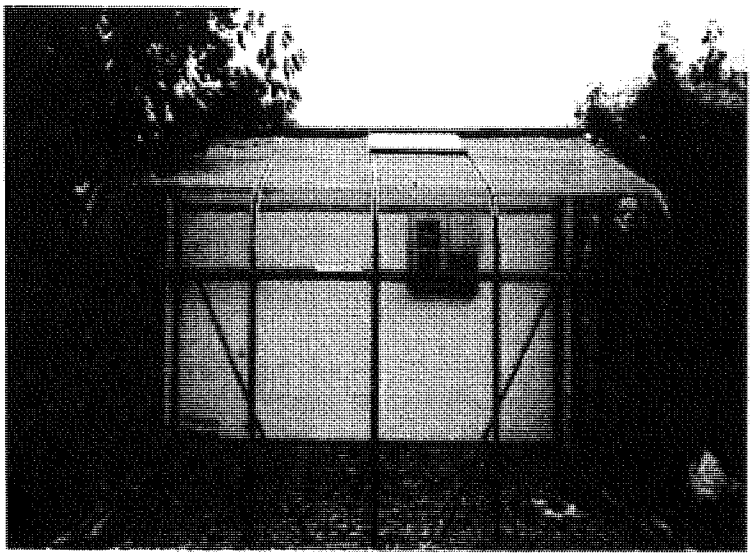


Figure 1 - The flight cage, view from west

In the autumn of 1996 Carol Watts., a member of Milton Keynes Natural History Society, and her husband offered us their old conservatory for conversion to a bat flight cage. so bringing nearer the possibility of a controlled study.

Whilst this conservatory was a good starting point, it needed adaptation to make it suitable for a flight cage.

The original frame was eight feet long by six feet wide by up to eight feet high. We did not think this would be big enough for pipistrelles to manoeuvre and sustain flight comfortably.

We wanted to build the cage as large as possible but were limited by the size of the original frame and by space in the garden. In order to avoid having to apply for planning permission the cage could not be less than five metres from the house or garage. There was therefore only one position in the garden where we could erect it. Fortunately this appeared to be a good location from the bats' point of view. The cage would be sheltered from the north by a mature tree and from the south by high bushes. By constructing the eastern side with wooden panelling the bats would be sheltered on three sides. The cage would be near our small pond, which should provide some insects. If a roosting box were put on the panelled side of the cage we estimated that, whilst it would be exposed to the early morning sun, it would have protection from the sun at its hottest, either by the trees or bushes or by its own shadow or that of our house.

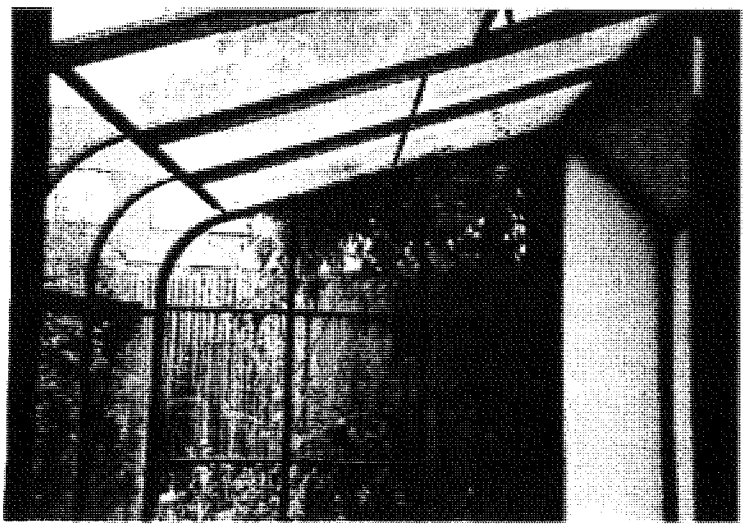


Figure 2 - Flight cage, view from south

We tested our captive pipistrelles while they were being allowed to fly in our living room, to see how much space they needed to manoeuvre. We did this by introducing obstacles to reduce the available flying space in the room. The bats we tested were able to manoeuvre and maintain flight within an area ten feet long by six feet wide. We did not need to measure the height they would need because it was easy to see that they were able to manoeuvre within the height which would be provided by the cage.

We calculated that we could increase the size of the cage to ten feet long by eight feet wide without overburdening the framework or causing planning problems. This should be a large enough area for the pipistrelles, though not necessarily for other British bat species.

A special bat box was designed, constructed and attached to the panelled side of the flight cage. The design would allow bats to enter from one end and roost close to, even touching, bats confined in the other end of the box. The two ends would be separated only by a piece of one quarter inch square wire netting, which was removable.

A strip light, powered by a car battery outside the cage, would be attached to the panelling, some distance from the bat box. It was hoped that this would attract insects into the cage for the bats to hunt. Plants known to attract night-flying insects would be grown in the cage for the same reason.

The panelled side of the cage would be painted with a matt, non-poisonous paint in a pale colour. Non-treated sawdust would be added to the paint so that the surface of the panelling would be slightly rough. The light surface should increase the effectiveness of the light in attracting insects and make visual observation easier at night. The addition of sawdust to the paint should result in a surface which would be easy for the bats to climb.

The south end of the cage, containing a sliding door, would remain glazed. The non-grip surface should deter the bats from roosting near the door mechanism, which could be dangerous. Hooks would be attached outside the door for a sheet to be hung, preventing bats from escaping if it should be necessary to enter the cage while they were flying.

The remainder of the cage would be covered with one quarter inch square wire mesh. This should prevent the bats escaping and predators entering the cage, while allowing insects in.

The perimeter of the cage would be mounted on concrete to prevent predators from digging under the sides.

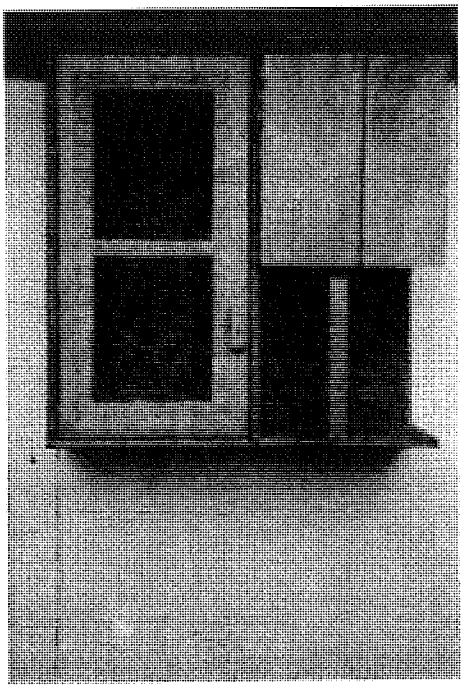


Figure 3 - Bat roosting box and feeding station

It was hoped that an ultrasonic microphone and video monitor would be installed eventually, for observation of possible hunting behaviour and listening for "feeding buzzes". (When a bat hunts, its echolocating calls become extremely rapid as it homes in on its prey, being heard as a characteristic buzz on a bat detector.)

The original opening window would be left in the flight cage, for use as a point of egress for any bats which may be deemed fit for release.

Erection of the cage was completed in August 1997.

The main frame of the cage is aluminium, with additional timber supports and exterior plywood for the western side. Weatherproofing on the exposed areas of wood is green Cuprinol, which is not poisonous to bats. The interior surface of the western side was painted with magnolia "bat friendly" exterior paint, into which untreated sawdust was mixed.

The quarter inch square wire mesh was attached to the framework with Multigrip filling adhesive, which was also used to fill any holes large enough for a bat to escape through.

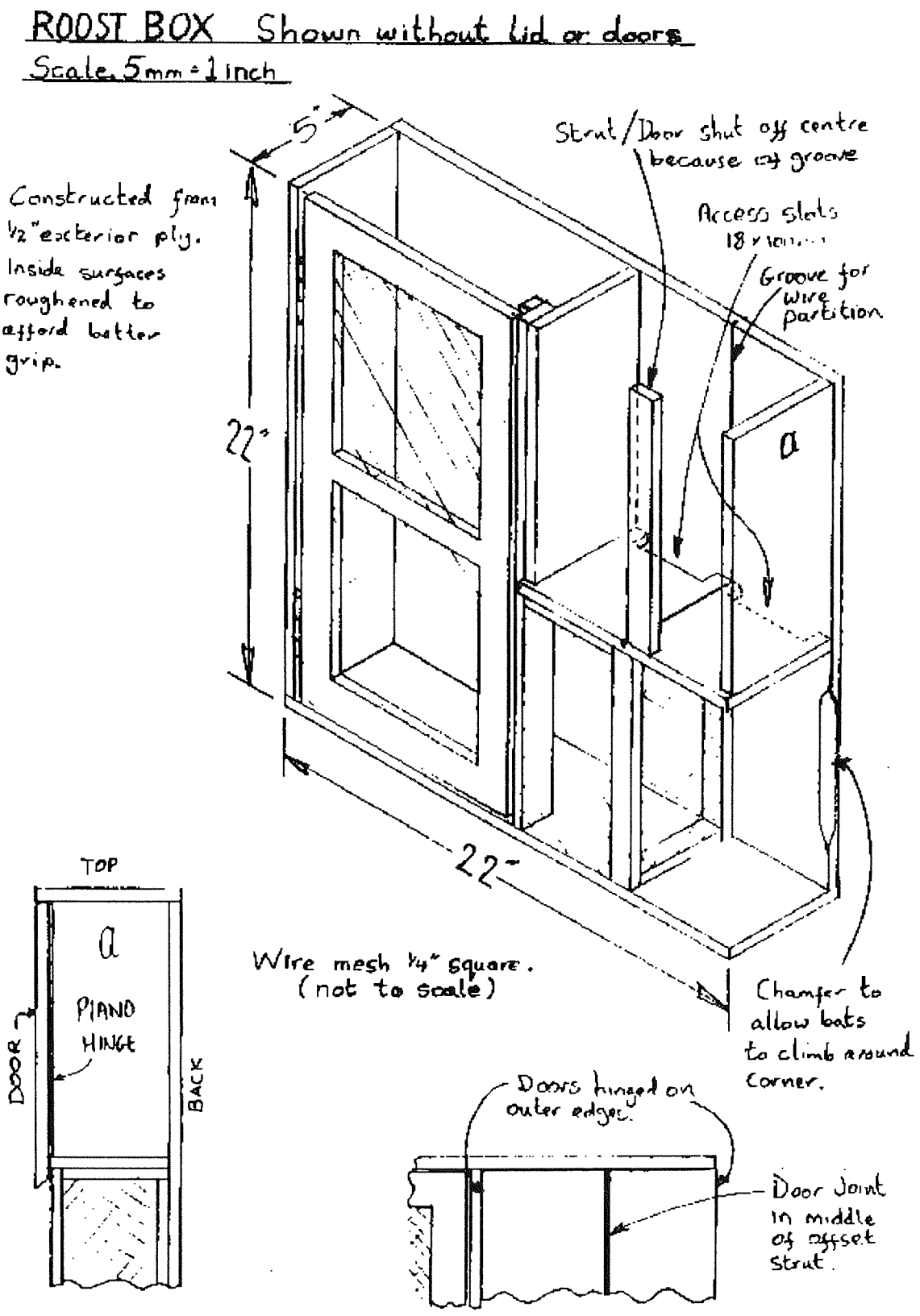
Home produced chippings were spread across the floor of the cage, to deter unwanted weeds and to provide a soft landing for inexperienced bats.

A shallow dish of water was placed on the floor so that the chippings were level with the rim. The dish was filled with stones, so that the water level would not be deep enough for a bat to drown.

A purpose-built bat box was fitted to the panelled side of the cage.

Initially an eighteen inch fluorescent strip light, powered by a car battery, is being used to attract insects. However, I am investigating alternative forms of lighting, since I do not think this system is likely to attract enough insects.

(Haffner and Stutz, in a study of the abundance of *Pipistrellus pipistrellus* and *Pipistrellus kuhlii* foraging around street lamps, found that the bats concentrated around the street lamps which were brightest and emitted most ultra-violet.)



I am also investigating the possibility of installing a thermostatically controlled device to keep an area of the cage at a suitable temperature for the bats to survive the winter. If I do not find anything suitable in time they may have to spend the winter indoors again this year.

We have not yet installed a video monitor or ultrasonic microphone but hope to do so before the arrival of any 1998 orphans.

We also hope to install alternative roosting sites.

The Study

For the first part of the study, initially the six orphan pipistrelles which were raised this year (including one orphan raised by Connor Kelleher of the Northamptonshire Bat Group) would be introduced to the enclosed side of the bat box and confined there for several days, food and water being provided daily. It is hoped that they would become accustomed to finding food and water at the "feeding station" and would return there when necessary when released into the main area of the flight cage. Food and water would continue to be left at the "feeding station" in the bat box.

Once the bats had the freedom of the whole cage they would be observed for flying ability and signs of feeding activity. They would be weighed regularly and droppings would be collected from individuals for analysis.

Criteria to be satisfied before release to the wild was contemplated would be:

1. Evidence of non-mealworm prey in each individual's droppings, as well as observation of hunting behaviour while flying.
2. Ability to maintain flight and manoeuvre well over long periods.
3. Ability to seek out alternative roost sites within the cage.

When, or if, these criteria were satisfied, the second part of the study would involve ringing the bats and granting them egress from the flight cage. Should any return then their progress could be monitored and proof of survival in the wild would be established.

Steve Kourik, who has built a bat rehabilitation flight cage in Hertfordshire, has anecdotal evidence of a brown long-eared bat returning regularly to the flight cage to feed for several weeks after release.

If those bats not fit for release were confined to the enclosed side of the bat box, they would provide the nucleus of a familiar "cluster" for the released bats to return to. Indeed, bats in our care have always returned to the box containing their companions overnight on the rare occasions when they become lost while flying in our living room.

The hand rearing of orphan pipistrelles during 1997

During the summer of 1997 I successfully reared five orphan pipistrelles. In order of arrival these were named Parsons (male 45khz "bandit" pipistrelle), Joe (male 45khz "bandit" pipistrelle), Clapham (female 45khz "bandit" pipistrelle), Maulden (female 45khz "bandit" pipistrelle) and Chestnut (male 55khz "brown pipistrelle).

Three different milk replacers were used, in the hope that a comparison would show the best bat milk substitute of the three. The products used were Esbilac and Zoologic 33/40, both manufactured in the United States, and Di-Vetelact, manufactured by Sharpe Laboratories in Australia. It was intended that each orphan should be reared using one of these products and great care was taken not to mix them up.

Obviously data from the rearing of five bats is unlikely to provide enough information to show a clearly superior product. However, Maggie Brown, editor of Bat Care News, has asked other bat carers to compare feeds and keep notes. Hopefully, if several carers keep notes for some years and all the data is brought together, a fair comparison will be possible.

The bats were given diluted feeds at first to avoid digestive problems. Then, depending on each bat's signs of physical well being and ability to digest the milk substitute, the feeds were gradually brought up to the recommended strength.

I kept records at each feed until the bats were completely weaned. In addition to recording the amount and type of food and the body weight of the bat, I kept notes of droppings and urine passed and made comments on progress. These were used on an ongoing basis to show early signs of any digestive or other problems.

The babies were housed in perspex "pet carrier" type tanks in our airing cupboard between feeds. This provided adequate warmth (between 30 and 38 degrees Celsius) and humidity. The tanks were large enough to allow the bats plenty of exercise and their floors were lined with kitchen paper. This was changed regularly, making it easy to check for droppings and urine passed between feeds. A soft cloth was hung at one side of the tank to allow the bats to hang upside down if they wished. As well as catering for their comfort, somewhere to hang upside down may reduce the risk of lung problems if some of the feed is accidentally inhaled.

While the bats were small a "hot water bottle" was placed securely in each tank, so that it could not roll over and squash a baby bat. This was a small pill bottle or similar waterproof container, filled with hot water, sealed in a plastic bag and placed inside a clean cotton sock, the sock being twisted and pulled back again over the container. This resulted in the container being wrapped in a double thickness of sock, with nowhere for the babies to squeeze into and get too hot. Baby bats seem to like this type of "hot water bottle" when very young and spend most of their time stretched across it.

When the babies were well enough grown not to be at risk of drowning, a small plastic bottle top full of water was also placed on the floor of each tank, to provide drinking water and possibly increase the humidity.

Several bats were kept in each tank and individuals were only kept in a tank on their own if I needed to check their droppings and/or urine more thoroughly, for example if they showed signs of digestive trouble.

While the bats were young I fed them using a "teat" made from an inch square piece of kitchen roll, folded to a point in the middle. They could then suck the feed at their own rate without their mouths becoming flooded, with consequent risk of inhalation. Holding them head-down while feeding also reduced the risk of inhalation. As they sucked the feed from the tissue I slowly added more to it with my clean index finger, a single drop at a time.

Using fresh kitchen roll each time was hygienic and most of the babies adapted well to using this type of "teat". I think that the sucking action also aided the digestive process. However, because some of the food was absorbed into the kitchen paper, it was not possible to measure accurately the amount consumed at each feed. I therefore made approximate calculations, using a figure of 0.1 ml wastage.

As the bats grew I began using a 1ml hypodermic syringe instead of the kitchen paper "teats". Accurate measurements of feed consumed were possible from this point.

Weaning was very gradual to reduce the risk of digestive problems. I have in the past seen digestive problems and signs of calcium deficiency in bats weaned early, so I prefer to wean them late rather than early to be on the safe side. Each baby was given its milk feed before being introduced, first to mealworm insides with their gut removed and later insides complete with gut. Next they were able to tackle whole mealworms which had just shed their skins and then normal skinned mealworms, eventually being able to help themselves to live ones from a dish.

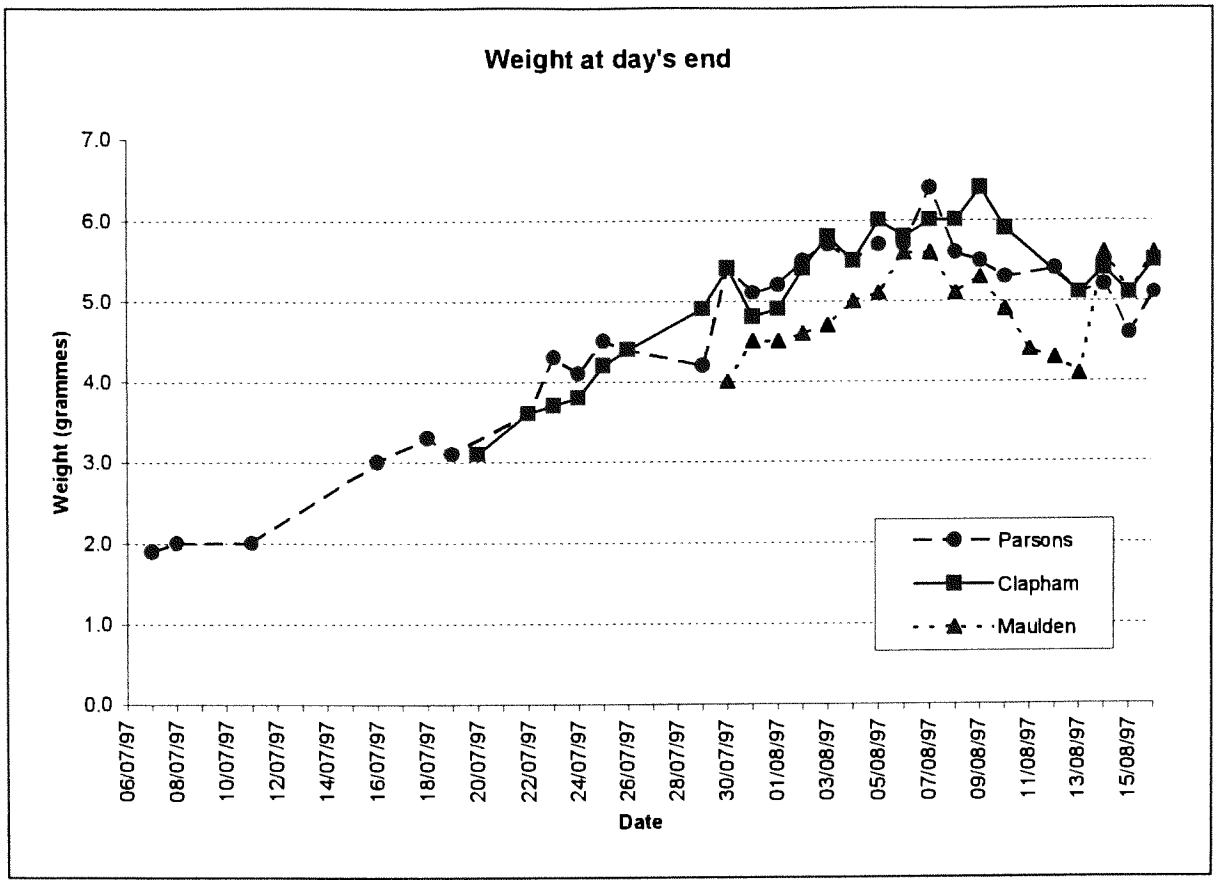
Unless I thought there might be a problem, I gave each orphan as much milk feed as it wanted at each feeding session. I only stopped giving the milk feed when the bats stopped taking it. While they were still taking the milk feed I only offered water after milk and/or mealworms.

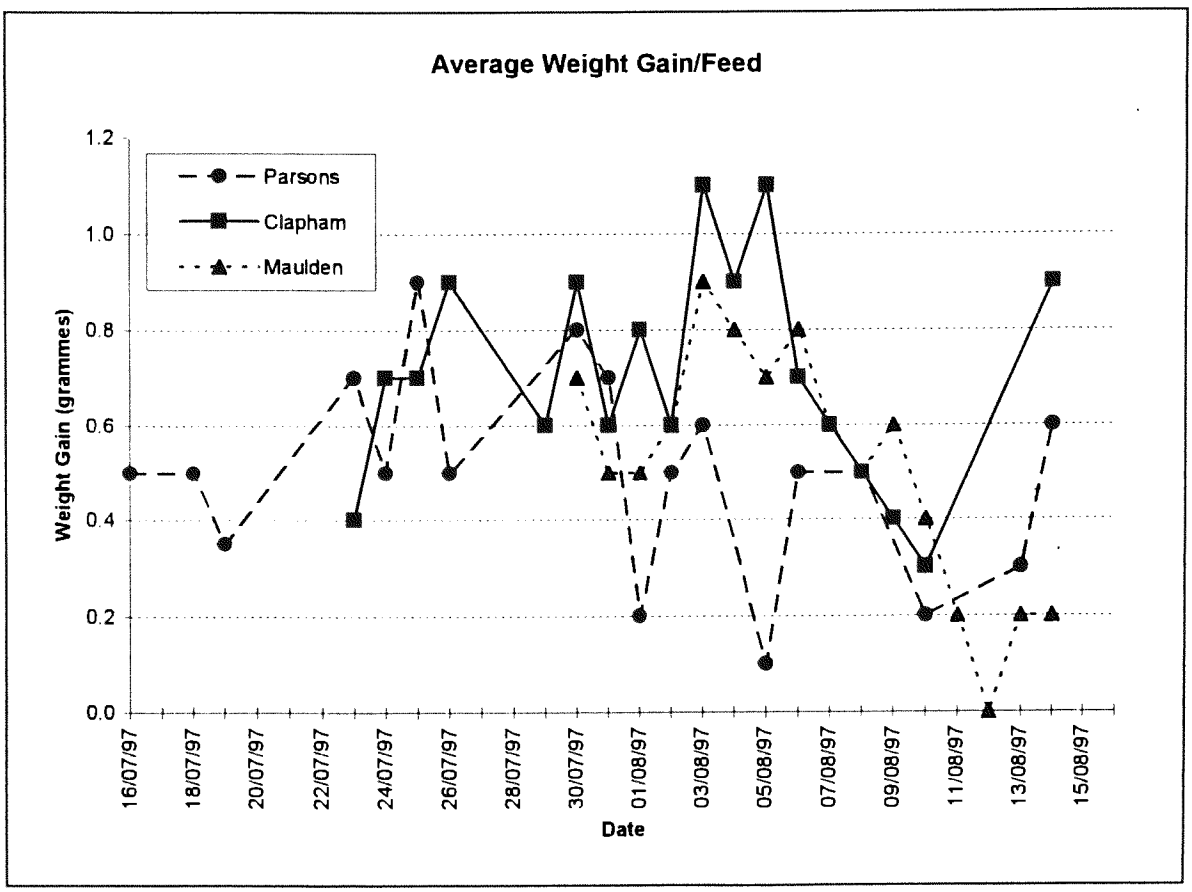
Once the bats were eating mealworms on their own, I continued to leave mealworms and water in their tanks regularly between feeds. Where they have gained weight between feeds this indicates that they have been feeding themselves. After they have been feeding themselves and taking vigorous exercise for some days their weight drops.

Mini mealworms *(Tenebrio molitor)* were used as food for the young bats. The mealworms themselves were fed on dried complete dog food, vegetables and fruit, so that they would provide a good, nourishing meal for the bats. In addition, Nutrobal calcium and vitamin supplement was sprinkled on slices of apple and fed daily to the mealworms.

For the purpose of comparing the data collected, I have taken 1st July 1997 as the approximate birth date of Parsons, Clapham and Maulden. Although they came to me on different dates and at different ages., from their size and physical development on arrival I estimate that they must have been born within a few days of each other. Joe was probably born earlier and Chestnut later.

Where data was not recorded it was due to my either running out of time or being too tired to put off going to bed any longer.


Weight at day's end
Weight (grammes)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Parsons
Clapham
Maulden
06/07/97
08/07/97
10/07/97
12/07/97
14/07/97
16/07/97
18/07/97
20/07/97
22/07/97
24/07/97
26/07/97
28/07/97
30/07/97
01/08/97
03/08/97
05/08/97
07/08/97
09/08/97
11/08/97
13/08/97
15/08/97
Date


Average Weight Gain/Feed
Weight Gain (grammes)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Parsons
Clapham
Maulden
16/07/97
18/07/97
20/07/97
22/07/97
24/07/97
26/07/97
28/07/97
30/07/97
01/08/97
03/08/97
05/08/97
07/08/97
09/08/97
11/08/97
13/08/97
15/08/97
Date

Data on the feeding and progress of Parsons (male orphan 45khz "bandit" Pipistrelle.

Arrival Date: 06.07.97

Estimated Age: Approximately 6 days (eyes not yet open, fur just beginning to show through skin as "stubble".)

Estimated Birth Date: 1st July 1997.

Type of Feed: Zoologic 33/40 fed initially. Changed to Esbilac on 20.07.97 after call from Maggie Brown.

Date	Time	Feed Strength	Amount Consumed	Weight	Comments
06.07.97	12.30 p.m.	Plain boiled water.			Thin but not emaciated before feed, slightly plump after.
	6.15 p.m.	1 part feed/6 parts boiled water	0.7 ml		
	8.50 p.m.	"	0.3ml		
	midnight	1 part feed/5 parts boiled water	0.3ml		Feeding well
07.07.97	7.00 a.m.	"	0.3ml		"
	8.30 a.m.	1 part feed/3 parts boiled water	0.35 ml		"
	1.10 p.m.	"	0.3 ml	1.9g	after feed
	4.10 p.m.	"	0.35 ml		
	6.30 p.m.	"	0.2 ml		
	9.30 p.m.	"	0.35 ml		
	11.15 p.m.	"	0.3 ml		
08.07.97	6.30 a.m.	"	0.4 ml		
	8.30 a.m.	"	0.24 ml		
	1.00 p.m.	"	0.3ml		
	5.30 p.m.	"	0.5ml		
	8.10 p.m.	"	0.35ml		
	10.50 p.m.	1 part feed/2.5 parts boiled water	0.3ml	2g	
09.07.97	7.30 a.m.	"	0.35ml		
	8.45 a.m.	"	0.1ml		
	1.00 p.m.	"	0.32ml		
	4.30 p.m.	"	0.375ml		
	9.30 p.m.	"	0.1ml		
	10.30 p.m.	"	0.4ml		
10.07.97	7.00 a.m.	"	0.3ml		
	1.00 p.m.	"	0.35ml		
	3.50pm	"	0.47ml		
	7.30pm	"	0.15ml		
	11.05	"	0.3ml		
11/7/97	7.00am	"	?		
	1.30pm	1 part feed/2 parts boiled water	0.85ml		
	4.10pm	"	0.2ml		
	6.00pm	"	?		
	10.30pm	"	0.85ml	2g	
12/7/97	9.00am	"	0.75ml		
	1.30pm	"	0.58ml		
	5.30pm	"	?		
	8.30pm	"	?		

	11.30pm	"	?		
13/7/97	7.30am	"	0.25ml		
	12.30pm	"	0.25ml		
	3.00pm	"	0.45ml		
	6.30pm	"	0.5ml		
	9.30pm	Water	nil		Very fat. I only offered him water but he did not drink.
	11.00pm	"			Drank some water.
14/7/97	9.00am	1 part feed/2parts boiled water	0.9ml		Looked much better. Not so fat and fed well.
	12.30pm	"	1.7ml		Fed well
	7.00pm	"	0.3ml		"
	10.30pm	"	0.4ml		
15/7/97	7.00am	"	0.3ml		
	1.30pm	"	0.3ml		
	4.30pm	"	?		
	7.00pm	"	0.4ml		
	10.30pm	"	0.4ml		
16/7/97	7.00am	"	0.5ml		
	1.00pm	"	0.6ml		
	5.00pm	"	1.0ml	2.8g	after feed
	10.00pm	"	0.65ml	2.5g 3.0g	before feed after feed
17/7/97	7.00am	"	0.37ml		
	1.00pm	"	0.65ml		
	4.00pm	"	0.45ml		
	7.45pm	"	0.75ml		
	10.45pm	"	?		
18/7/97	7.00am	"	1.0ml		
	1.30pm	"	0.45ml		
	4.30pm	"	0.67ml	2.8g 3.3g	before feed after feed
	10.00pm	"	0.3ml		
19/7/97	8.00am	"	0.32ml	2.5g 2.9g	before feed after feed
	1.00pm	"	?		
	5.00pm	"	0.69ml	2.8g 3.1g	before feed after feed
	10.00pm	"	?		
20/7/97	7.30am	1 part feed/1.5 parts boiled water	1.00ml		
	11.30am	"	0.55ml		
	2.30pm	"	0.65ml		
	6.30pm	"	0.1ml		
	10.45 p.m.	"	0.95ml		
21/7/97	7.45 am	"	1.0ml		
	1.45pm	"	0.3ml		

After the last feed I had a call from Maggie Brown, telling me that she was having problems with some of her orphans which were receiving Zoologic milk replacer. I therefore changed immediately to Esbilac as a precaution. I started feeding Parsons a weaker mixture than the Zoologic mixture I had been giving him but he did not seem to suffer any ill effects from the change.

	5.00pm	Esbilac 1 part feed/4 parts	0.6ml

		boiled water			
	11.00pm	1 part feed/3 parts boiled water	0.95ml		
22/7/97	8.00am	1 part feed/3 parts boiled water	0.6ml		

At the next feed I began feeding with a hypodermic syringe instead of the tissue "teat". Amount consumed figures are therefore fairly accurate from this point.

	1.30pm	1 part feed/3 parts boiled water	0.6ml		
	5.45pm	"	0.5ml	3.6g	after feed
	10.30pm	1 part feed/2 parts boiled water	1.0ml		
23/7/97	7.30am	"	0.6ml		
	1.15pm	"	0.46ml		
	6.05pm	"	0.72ml	3.6g 4.3g	before feed after feed Ate 8 degutted mwm insides
	11.00pm	"	?		Ate 8 degutted mwm insides
24/7/97	7.00am	"	0.77ml		Ate 8 degutted mwm insides
	1.45pm	"	0.4ml	3.6g 4.1g	before feed after feed Ate 7 mwm insides inc. gut & 1 whole "new-skin" mealworm.
	5.00pm	"	?		
	11.00pm	"	?		
25/7/97	7.00am	"	0.7ml		
	2.00pm	"	0.84ml	3.6g 4.5g	before feed after feed Ate 8 mwm insides inc. gut
	5.00pm	"	?		
	11.00pm	"	?		
26/7/97	7.50am	"	0.32ml	3.9g 4.35g	before feed after feed Ate 11 mwm insides inc. gut
	5.00pm	"	?	3.8g 4.5g	before feed after feed Ate mwm insides inc. gut
	11.00pm	"	0.2ml	4.0g 4.4g	before feed after feed Ate mwm insides inc. gut
27/7/97	Three feeds given but no records kept				
28/7/97	Three feeds given but no records kept				
29/7/97	7.00am	1 part feed/2 parts boiled water	0.45ml	4.2g	before feed Ate 15 mwm insides inc. gut
Did not feed during day, instead left Clapham, Parsons and Joe in exercise net from 1.00pm to 11.00pm					
	11.00pm	"	?		Ate mwm insides
	Left "new-skinned" mealworms and water in tank overnight				
30/7/97	7.00am	"	?		
	Spent afternoon and evening in exercise net again				
	10.00pm	1 part feed/3 parts boiled water	0.4ml	4.6g 5.4g	before feed after feed Ate 21 mwm insides inc. gut Baby coat moulting
31/7/97	8.30am	"	0.34ml	5.1g 5.7g	before feed after feed

					Ate mwm insides
	3.00pm	no feed		5.35g	Observed eating "new-skin" mwms in tank.
	Left in flight exercise net in afternoon with Clapham and Joe				
	6.00pm	1 part feed/3 parts boiled water		5.1g	Returned to tank with mwms and water
	10.30pm	"	0.2ml	4.6g 5.1g	before feed after feed Ate mwms.
1/8/97	7.30am	none	none	5.1g	Had eaten mwms in night.
	10.30pm	1 part feed/2 parts boiled water	?	5.0g 5.2g	before feed after feed Ate mwms.
2/8/97	noon	"	0.15ml	5.25g 5.7g	before feed after feed Ate mwms.
	9.30pm	"	0.4ml	5.0g 5.5g	before feed after feed Ate mwm ins.
3/8/97	9.45am	"	0.1ml	5.1g 5.6g	before feed after feed Ate "new-skin" mwms.
	9.10pm	"	0.2ml	5.0g 5.7g	before feed after feed Ate "new-skin" mwms.
4/8/97	8.30am	"	?	5.6g	before feed Ate mwms
	11.30pm	"	?	5.5g	before feed Ate mwms
5/8/97	7.20am	"	?	5.9g	before feed Ate mwms
	10.40pm		none	5.6g 5.7g	before feed after feed Ate mwms and water
6/8/97	7.10am	"	?	5.85g	before feed
	9.45pm	"	?	5.2g 5.7g	before feed after feed Ate mwms
7/8/97	7.30am	"	None	5.9g	
	5.45pm	"		6.4g	Not hungry. Obviously eating mwms and water in tank.
8/8/97	7.45am	"	0.55ml	4.6g 5.3g	before feed after feed Ate mwms
	midnight	"	0.1ml	5.35g 5.6g	before feed after feed
9/8/97	11.00am			5.5g	Obviously feeding self
10/8/97	noon	"	0.03ml	5.1g	
	8.00pm	"	?	5.1g 5.25g	before feed after feed Ate mwms
11/8/97	No records				
12/8/97	7.30am	"	?	5.6g	
	midnight	"	?	5.4g	
13/8/97	10.30pm	water		4.8g 5.1g	before feed after feed Ate mwms

I stopped offering a milk replacer at this point, as Parsons would no longer take it. I continued to offer water.

14/8/97	7.30am	4.3g	before feed
		4.9g	after feed
	11.00pm	5.2g	
15/8/97	3.10pm	4.4g	
	10.30pm	4.6g	
16/9/97	10.30pm	5.1g	

Data on the feeding and progress of Clapham (female orphan 45khz "bandit" Pipistrelle).

Arrival Date: 20.07.97

Estimated Age: Approximately 20 days (Eyes open. Baby fur, still quite smooth.)

Estimated Birth Date: 1st July 1997.

Type of Feed: Was fed a semi-skimmed milk/water mix at first, as this was what she had been given before she came to US. Then changed to Esbilac.

Date	Time	Feed Strength	Amount Consumed	Weight	Comments
20/7/97	4.00pm	1/1 ss milk/water	0.52ml		Very thin. Lively, but not feeding well.
	5.45pm	"	0.8ml	3.1g	after feed Not feeding well. Lively.
	10.30pm	1 part Esbilac/4 parts water	0.65ml		"
21/7/97	8.00am	"	1.15ml (inaccurate due to a lot of wastage)		Fed better. Lively, exercised wings.
	1.30pm	"	0.86ml		Fed well. Thin before feed, plump after.
	4.30pm	"	0.75ml		"
	11.30pm	1 part Esbilac/3 parts boiled water	1.2ml		"
22/7/97	7.30am	"	0.75ml		"
At the next feed I began feeding with a hypodermic syringe instead of the tissue "teat". Amount Consumed figures are therefore fairly accurate from this point.					
	1.15pm	"	0.6ml		"
	5.30pm	"	0.8ml	3.6g	after feed
	9.30pm	"	?		Fed well.
23/7/97	6.50am	1 part Esbilac/2 parts boiled water	0.7ml		Ate 5 de-gutted mwm insides
	1.00pm	"	0.59ml		Ate 1 de-gutted mwm insides
	5.20pm	"	?	3.3g 3.7g	before feed after feed No mwms.
	11.00pm	"	?		Fed well. No mwms.
24/7/97	7.45am	"	0.4ml		Ate 6 de-gutted mwm insides
	1.30pm	"	0.6ml	3.1g 3.8g	before feed after feed Ate 12 mwm insides inc gut.
	5.00pm	fed but no records			
	10.30pm	fed but no records			
25/7/97	7.30am	1 part Esbilac/2 parts water	0.65ml		
	2.30pm	"	0.75ml	3.5g 4.2g	before feed after feed Ate 11 mwm insides inc gut.
	5.00pm	fed but no records			
	11.00pm	fed but no records			
26/7/97	8.00am	1 part Esbilac/2 parts water	0.5ml	3.8g 4.2g	before feed after feed
	5.00pm	"	0.7ml	3.6g 4.5g	before feed after feed

					Ate 12 mwm insides inc gut.
	11.00pm	"	0.4ml	4.0g 4.35g	before feed after feed
27/7/97	Three feeds given but no records kept				
28/7/97	Three feeds given but no records kept				
29/7/97	7.00am	1 part Esbilac/2 parts water	0.4ml	4.25g 4.85g	before feed after feed Ate 15 mwm insides inc gut.
Did not feed during day, instead left Clapham, Parsons and Joe in exercise net from 1.00pm to 11.00pm.					
	11.00pm	"	?	?	
30/7/97	7.00am	"	?	?	
	Spent afternoon and evening in exercise net again.				
	9.45pm	1 part Esbilac/3 parts water	0.5ml	4.5g 5.4g	before feed after feed Ate 23 mwm insides inc gut. Moulting baby fur.
31/7/97	8.15am	"	0.65ml	4.5g 5.3g	before feed after feed Ate 15 mwm insides inc gut.
	3.00pm	Put in net. No feed.		4.8g	
	6.00pm	Put in tank in airing cupboard with water and mealworms with freshly shed skins.		4.5g	
	10.30pm	1 part Esbilac/3 parts water	0.28ml	4.35g 4.8g	before feed after feed Ate 15 mwm insides inc gut. Observed drinking water.
1/8/97	7.30am	No milk feed given.		4.6g	All mwms had been eaten. Observed eating mwms.
	10.20pm	1 part Esbilac/2 parts water	?	4.1g 4.9g	before feed after feed Ate 15 mwm insides inc gut.
Continued to leave mealworms and water in tank overnight from this time.					
2/8/97	11.45am	1 part Esbilac/2 parts water	0.2ml	4.4g 5.0g	before feed after feed Ate 15 mwm insides inc gut.
	9.40pm	"	?	5.4g	after feed Ate 20 mwm insides inc gut.
3/8/97	9.45am	"	0.15ml	4.6g 5.35g	before feed after feed Ate 20 mwm insides inc gut and 5 whole "new-skin" mwms.
	9.10pm	"	0.5ml	4.6g 5.8g	before feed after feed Ate 20 mwm insides inc gut.
4/8/97	8.30am	"	0.67ml	4.7g 5.7g	before feed after feed Ate 20 mwm insides inc gut.
	11.30pm	"	0.2ml	4.7g 5.5g	before feed after feed Ate 22 mwm insides inc gut and 2 "new-skin" mwms.
5/8/97	7.30am	"	0.55ml	5.0g 6.1g	before feed after feed Mwms eaten.
	10.40pm	"	?	5.0g 6.0g	before feed after feed Mwms eaten.

6/8/97	7.10am	"	?	5.35g 6.0g	before feed after feed Mwms eaten.
	9.50pm	water	?	5.1g 5.8g	before feed after feed Ate 18 mwm insides inc gut.
7/8/97	7.30am	none		5.5g 6.1g	before feed after feed Mwms eaten.
	5.30pm	1 part Esbilac/2 parts water	0.25ml	5.5g 6.0g	before feed after feed Mwms eaten.
8/8/97	8.00am	"	0.45ml	4.9g 5.6g	before feed after feed Mwms eaten.
	midnight	"	0.06ml	5.7g 6.0g	before feed after feed Mwms eaten before & at feed
9/8/97	11.00am	"	0.05ml	6.0g 6.35g	before feed after feed Mwms eaten.
10/8/97	12.15pm	"	0.1ml	5.6g 5.9g	before feed after feed Mwms eaten.
	8.30pm	"	?	5.6g	before feed
12/8/97	7.30am	"	?	?	
	midnight	"	?	?	
13/8/97	10.30pm	water	?	5.1g	
14/8/97	8.00am	"	?	4.85g 5.3g	before feed after feed Mwms eaten.
	11.00pm	"	?	5.35g	
15/8/97	3.15pm	"	?	4.7g	
	10.45pm	"	?	5.1g	
16/8/97	10.15pm	"	?	5.5g	

Data on the feeding and progress of Maulden (female orphan 45khz "bandit" Pipistrelle.

Arrival Date: 30.07.97

Estimated Age: 30 days (Eyes open, fur well grown. May be adult coat. A bit shaggy. Starting to eat mealworm insides.)

Estimated Birth Date: 1st July 1997.

I fed this bat with a syringe from the start, so the figures for the amount consumed should all be fairly accurate.

Date	Time	Feed Strength	Amount Consumed	Weight	Comments
30/7/97	4.30pm	1 part Esbilac/3 parts boiled water	0.65ml	3.2g 4.0g	before feed after feed Ate 20 de-gutted mealworm insides. Very sluggish.
	10.45pm	"	0.34ml	3.5g 4.0g	before feed after feed Ate 14 de-gutted mealworm insides. Very sluggish.
31/7/97	7.00am	"	0.3ml	3.5g 4.0g	before feed after feed Ate 18 de-gutted mwm insides.
	3.30pm	"	0.57ml	4.3g	before feed after feed Ate 20 de-gutted mwm insides. Less sluggish.
	7.30pm	"	0.5ml	3.8g 4.4g	before feed after feed Ate 20 de-gutted mwm insides. More lively.
	11.00pm	"	0.3ml	4.1g 4.5g	before feed after feed Ate 7 mwm insides inc. gut.
1/8/97	7.15am	1 part Esbilac/2 parts boiled water	0.36ml	3.6g 4.2g	before feed after feed Ate 13 mwm insides inc. gut.
	6.30pm	"	0.37ml	3.6g 4.1g	before feed after feed Ate 7 mwm insides inc. gut.
	10.10pm	"	0.4ml	4.0g 4.5g	before feed after feed Ate 12 mwm insides inc. gut.
2/8/97	11.00am	"	0.42ml	3.6g 4.1g	before feed after feed Ate 7 mwm insides inc. gut.
	7.00pm	"	0.5ml	3.8g 4.4g	before feed after feed Ate 12 mwm insides inc. gut.
	10.45pm	"	0.25ml	4.1g 4.6g	before feed after feed Ate 10 mwm insides inc. gut.
3/8/97	9.20am	"	0.47ml	3.85g 4.5g	before feed after feed Ate 10 mwm insides inc. gut.
	8.30pm	"	0.48ml	4.0g 4.7g	before feed after feed Ate 20 mwm insides inc. gut.
4/8/97	8.30am	"	0.6ml	4.0g 4.85g	before feed after feed

					Ate 20 mwm insides inc. gut.
	6.00pm	"	0.6ml	4.1g 5.1g	before feed after feed Ate 17 mwm insides inc. gut.
	midnight	"	0.27ml	4.3g 5.0g	before feed after feed Ate 15 mwm insides inc. gut.
5/8/97	8.05am	"	0.35ml	4.1g 5.0g	before feed after feed Ate 17 mwm insides inc. gut.
	4.45pm	"	0.4ml	4.5g 5.3g	before feed after feed Ate 16 mwm insides inc. gut.
	11.30pm	"	-	4.6g 5.1g	before feed after feed Ate 12 mwm insides inc. gut.
6/8/97	7.30am	"	0.45ml	4.4g 5.1g	before feed after feed Mwms ?
	2.45pm	"	0.35ml	4.6g 5.5g	before feed after feed Mwms ?
	9.15pm	"	0.4ml	4.6g 5.6g	before feed after feed Ate 18 mwm insides inc. gut.
7/8/97	7.25am	"	0.3ml	4.6g 5.2g	before feed after feed Ate 11 mwm insides inc. gut.
	5.00pm	"	0.4ml	4.85g 5.5g	before feed after feed Ate 15 mwm insides inc. gut.
	11.00pm	"	0.35ml	4.8g 5.6g	before feed after feed Mwms ?
8/8/97	7.15am	"	0.2ml	4.7g 5.1g	before feed after feed Ate 8 mwm insides inc. gut.
	11.45pm	"	0.3ml	4.6g 5.1g	before feed after feed Ate 10 mwm insides inc. gut.
9/8/97	10.00am	"	0.25ml	4.6g 5.2g	before feed after feed Ate 11 mwm insides inc. gut.
	6.15pm	"	0.3ml	4.7g 5.25g	before feed after feed Ate 10 mwm insides inc. gut.
10/8/97	11.45am	"	0.1ml	4.5g	before and after feed. More interested in flying than feeding.
	10.00pm	"	0.2ml	4.5g 4.9g	before feed after feed Ate 6 mwm insides inc. gut.
11/8/97	7.00am	"	0.25ml	4.7g 5.1g	before feed after feed Ate whole mwms with newly shed skins overnight.
	7.00pm	"	0.15ml	4.4g 4.4g	before feed after feed Not hungry.
12/8/97	8.00am	"	0.05ml	4.9g	before feed

				4.9g	after feed Not hungry. Ate mwms overnight.
	midnight	-	none	4.25g 4.25g	before feed after feed

Is obviously able to eat live mealworms and drink on her own now and prefers to do so. No longer taking any milk feed. Still offering her mealworms at feed times but she is not always interested.

13/8/97	7.30am			4.6g 4.75g	before feed after feed
	11.00pm			4.1g	after feed
14/8/97	8.00am			4.4g 4.6g	before feed after feed
	11.00pm			5.6g	no food taken
15/8/97	3.10pm			4.6g	no food taken
	10.30pm			5.1g	no food taken
16/8/97	10.30pm			5.6	no food taken

Data on the feeding and progress of Joe (male orphan 45khz "bandit Pipistrelle).

Arrival Date: 10.07.97

Estimated Age: 25 to 30 days (Very well-grown compared with the other orphans this year. Fur quite shaggy, probably adult coat. Looks ready to wean.)

Type of Feed: Di-Vetelact (Australian milk replacer)

Date	Time	Feed Strength	Amount Consumed	Weight	Comments
10/7/97	7.00pm	1 part feed/4 parts boiled water	0.5ml		
	10.45pm	"	0.45ml		
11/7/97	6.15am	"	0.85ml		
	1.15pm	"	?	2.9g 3.0g	before feed after feed
	4.30pm	"	0.6ml		
	6.00pm	"	?		
	10.45pm	"	?		
12/7/97	9.00am	"	0.4ml		Ate 1 de-gutted mwm & wanted more.
	1.30pm	"	0.8ml		
	5.30pm	"	0.6ml		Ate 1 de-gutted mwm.
	8.30pm	"	?		
	11.30pm	"	?		
13/7/97	7.30am	"	1.2ml		
	noon	"	0.4ml		
	3.00pm	"	0.55ml		
	7.00pm	"	0.57ml		
	9.30pm	"	1.3ml		Ate 1 de-gutted mwm inside. Very hungry.
	11.00pm	"	0.85ml		
14/7/97	9.00am	"	1.7ml		Ate 1 de-gutted mwm inside.
	1.00pm	"	0.55ml		Ate 1 de-gutted mwm inside.
	7.00pm	"	0.85ml		
	10.00pm	"	1.2ml		Ate 1 mwm inside inc. gut.
15/7/97	7.15am	"	1.2ml		Ate 1 mwm inside inc. gut.
	1.15pm	"	0.24ml		Ate 2 mwm insides inc. gut.
	4.45pm	"	0.4ml		Ate 2 mwm insides inc. gut.
	7.00pm	"	0.35ml		no mwms
	10.00pm	"	0.525ml		2 mwms
16/7/97	7.00am	"	0.85ml		Still hungry
	1.00pm	"	?		Still hungry
	5.00pm	"	?	3.0g	after feed
	10.15pm	"	1.15ml		Ate 4 mwms
17/7/97	7.00am	"	1.0ml	2.5g	before feed Ate 6 mwms
	1.00pm	"	0.4ml		Ate 3 mwm insides & 1 whole "new-skin" mwm.
	4.00pm	"	?		Ate 6 mwm insides
	8.00pm	"	0.6ml		Ate 6 mwm insides & 1 whole "new-skin" mwm.
	10.30pm	"	?		No mwms
18/7/97	7.00am	"	0.4ml		Ate 6 whole "new-skin"

					mwms
	2.00pm	"	0.5ml		Ate 6 whole "new-skin" mwms
	4.45pm	"	0.8ml	3.0g 3.4g	before feed after feed
	10.00pm	"	0.3ml		No mwms
19/7/97	8.30am	"	0.95ml	3.3g	after feed
					Ate 6 whole "new-skin" mwms
	1.15pm	"	?		No mwms
	5.30pm	"	1.1ml	3.0g 3.7g	before feed after feed
					6 "new-skin" mwms
	10.00pm	"	?		6 "new-skin" mwms
20/7/97	8.00am	"	0.6ml		7 "new-skin" mwms
	noon	"	0.55ml		7 "new-skin" mwms
	2.45pm	"	1.35ml		No mwms
	6.45pm	"	0.6ml		3 "new-skin" mwms
	11.45pm	"	0.4ml		7 "new-skin" mwms
21/7/97	7.30am	"	0.5ml		
	2.00pm	"	0.33ml		6 "new-skin" mwms
	5.15pm	"	0.45ml		No mwms
	10.45pm	"	0.45ml		Ate mwms

At the next feed I began feeding with a hypodermic syringe instead of the tissue "teat". Amount consumed figures are therefore fairly accurate from this point.

22/7/97	8.00am	"	0.5ml		Ate mwms
	1.45pm	"	0.5ml		Ate mwms
	6.00pm	"	0.55ml	5.0g	after feed
					Ate mwms
	10.45pm	"	0.35ml		Ate mwms
23/7/97	7.45am	"	0.48ml		Ate mwms
	1.20pm	"	0.3ml		Ate mwms
	6.25pm	"	0.37ml	4.2g 4.8g	before feed after feed
	11.00pm	"	none		Ate mwms & water
24/7/97	7.30am	"	0.25ml		Ate mwms
	1.40pm	"	?	4.5g	before feed
	5.00pm	"	?		
	11.00pm	"	?		
25/7/97	7.15am		none		
	2.45pm		none	5.1g	after feed
					Just mwms and water
	5.00pm	"	?		
	11.00pm	"	?		
26/7/97	8.00am		none	4.5g 5.5g	before feed after feed
					Just mwms and water
	5.00pm	"	?	4.6g 5.9g	before feed after feed
	11.00pm	"	?	4.8g	before feed
27/7/97	Three feeds today but no records				
28/7/97	Three feeds today but no records				
29/7/97	7.00am			none	Ate 10 mwms.

		11.00pm		?	
30/7/97	7.00am		none		Just mwms and water
	9.30pm	1 part feed/3 parts boiled water	1.0ml	5.4g 5.6g	before feed after feed Left mwms in tank overnight.
31/7/97	8.30am		none	5.5g	after feed Had eaten mwms in night
	3.00pm		none	5.3g	Had fed self during morning
	Left to fly in exercise net during the afternoon				

From this point I stopped offering a milk feed as Joe would no longer take it.

31/7/97	6.00pm	5.0g	Left mwms in tank overnight
1/8/97	7.30am	5.4g	Mwms in tank had been eaten.

From this point I left mealworms and water in his tank and let him feed himself. He also spent a lot of time in the exercise net.

1/8/97	2.30pm	5.5g
2/8/97	noon	5.2g
3/8/97	9.45am	5.2g
	9.10pm	5.35g
4/8/97	8.30am	5.6g
	11.30pm	5.35g
5/8/97	7.15am	5.6g
	11.00pm	5.4g
6/8/97	7.00am	5.2g
	10.00pm	5.2g
7/8/97	7.00am	5.5g
	6.00pm	5.3g
8/8/97	7.30am	4.8g
	midnight	5.0g
9/8/97	11.00am	5.1g
10/8/97	noon	5.0g
	8.00pm	4.8g
11/8/97	no records	
12/8/97	7.30am	5.2g
	midnight	4.6g
13/8/97	10.30pm	4.6g
14/8/97	8.30am	4.5g
	11.00pm	4.6g
15/8/97	3.15pm	4.2g
	10.30pm	4.6g
16/8/97	10.30pm	4.7g

Data on the feeding and progress of Chestnut (male orphan 55khz "brown" Pipistrelle)

Arrival Date: 30 07.97
Estimated Age: Approximately 20 - 25 days. (Fur quite shaggy but quite small compared with the other orphans.)
Type of Feed: Esbilac

Date	Time	Feed Strength	Amount Consumed	Weight	Comments
30/7/97	4.30pm	1 part feed/3 parts boiled water	0.55ml	3.0g 3.7g	before feed after feed Ate de-gutted mwm insides.
	11.15pm	"	0.45ml	3.3g 3.85g	before feed after feed Ate 14 de-gutted mwm insides.
31/7/97	7.15am	"	0.3ml	3.5g 3.9g	before feed after feed Ate 15 de-gutted mwm insides & 2 whole "new-skin" mwms.
	3.45pm	"	0.25ml	4.1g	after feed Ate 11 de-gutted mwm insides
	8.10pm	"	0.25ml	3.7g 4.0g	before feed after feed Ate 13 de-gutted mwm insides.
	11.00pm	"	0.18ml	3.7g 3.9g	before feed after feed Lively but not very hungry.
1/8/97	7.30am	1 part feed/2 parts boiled water	0.38ml	3.5g 3.9g	before feed after feed Ate 16 de-gutted mwm insides.
	6.30pm	"	0.4ml	3.35g 3.85g	before feed after feed Ate 10 de-gutted mwm insides.
	9.45pm	"	?	3.6g 3.9g	before feed after feed Ate 12 de-gutted mwm insides.
2/8/97	10.45am	"	0.6ml	3.1g 3.85g	before feed after feed Ate 15 de-gutted mwm insides.
	6.45pm	"	0.7ml	3.5g 4.2g	before feed after feed Ate 15 de-gutted mwm insides & 2 whole "new-skin" mwms.
	10.30pm	"	0.15ml	3.8g 4.1g	before feed after feed Ate 15 de-gutted mwm insides.
3/8/97	9.00am	"	0.3ml	3.4g 4.1g	before feed after feed Ate 15 de-gutted mwm insides.

	8.45pm	"	0.37ml	3.5g 4.2g	before feed after feed Ate 15 de-gutted mwm insides & 2 whole "new-skin" mwms.
4/8/97	7.10am	"	0.6ml	3.5g 4.4g	before feed after feed Ate 20 de-gutted mwm insides.
	6.15pm	"	0.4ml	3.7g 4.4g	before feed after feed Ate 12 de-gutted mwm insides.
	11.45pm	"	0.3ml	3.7g 4.5g	before feed after feed Ate 15 de-gutted mwm insides.
5/8/97	7.45am	"	0.45ml	3.9g 4.7g	before feed after feed Ate 20 de-gutted mwm insides.
	5.00pm	"	0.45ml	4.1g 4.6g	before feed after feed Ate 6 de-gutted mwm insides & 2 whole "new-skin" mwms.
	11.15pm	"	?	4.0g 4.7g	before feed after feed Ate 16 de-gutted mwm insides.
6/8/97	7.30am	"	0.35ml	4.0g 4.6g	before feed after feed Ate 15 de-gutted mwm insides.
	2.30pm	"	0.5ml	4.1g 4.9g	before feed after feed Ate 16 de-gutted mwm insides.
	9.00pm	"	0.5ml	4.0g 4.2g	before feed after feed Not very hungry.
7/8/97	7.00am	"	0.27ml	4.1g 4.5g	before feed after feed Ate 9 de-gutted mwm insides.
	4.50pm	"	0.3ml	4.0g 4.6g	before feed after feed Ate 17 de-gutted mwm insides.
	10.45pm	"	0.3ml	4.0g 4.8g	before feed after feed Ate 20 mwm insides.
8/8/97	7.15am	"	0.55ml	4.35g 5.1g	before feed after feed 13 mwm insides & 1 whole "new-skin" mwm.
	11.30pm	"	0.4ml	4.0g 5.0g	before feed after feed 17 mwm insides.
9/8/97	10.00am	"	0.55ml	4.35g 5.2g	before feed after feed

					15 mwm insides & 2 whole "new-skin" mwms.
	6.50pm	"	0.25ml	4.5g 5.0g	before feed after feed 20 mwm insides.
10/8/97	11.30am	"	0.4ml	4.1g 5.0g	before feed after feed 14 mwm insides & 4 whole "new-skin" mwms.
	8.00pm	"	0.45ml	4.25g 5.1g	before feed after feed 14 mwm insides & 2 whole "new-skin" mwms.
11/8/97	8.00am	"	1.15ml	4.1g 4.8g	before feed after feed Ate "new-skin" mwms left in tank overnight.
	6.30pm	"	0.25ml	4.3g 4.9g	before feed after feed
12/8/97	8.00am	"	0.15ml	4.2g 4.8g	before feed after feed 20 mwm insides.
	midnight	"	none	3.9g	Ate mwms left in tank.
13/8/97	7.30am	"	none	3.9g 4.9g	before feed after feed 23 mwm insides.
	10.30pm	"	none	4.0g 4.4g	before feed after feed Ate 10 "new-skin" mwms.
14/8/97	7.30am	"	none	3.6g 4.1g	before feed after feed Ate mwm insides.
	11.00pm	"	none	3.8g 4.6g	before feed after feed
15/8/97	3.15pm	"	none	3.7g	
	10.30pm	"	none	3.6g 4.4g	before feed after feed
16/8/97	10.15pm	"	"	3.6g 4.3g	before feed after feed
17/8/97	9.00am	"	"	3.9g 4.6g	before feed after feed Ate "new-skin" mwms.

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