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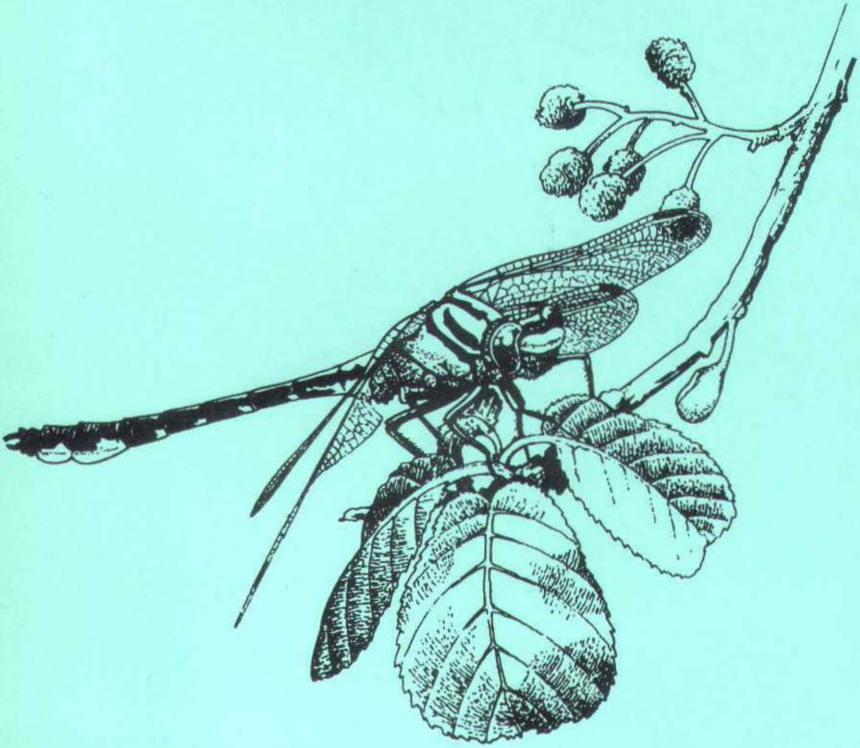

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member of the Societas Internationalis Odonatologica

The *Journal of the British Dragonfly Society*, normally published twice a year, contains articles on Odonata that have been recorded from the United Kingdom. The aims of the British Dragonfly Society (B.D.S.) are to promote and encourage the study and conservation of Odonata and their natural habitats, especially in the United Kingdom. The B.D.S. is a member of the Societas Internationalis Odonatologica (S.I.O.).

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Front cover illustration of *Gomphus vulgatissimus* by Ray Andress.

Guidelines for monitoring dragonfly populations

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Objectives

The populations of certain species of dragonflies in nature reserves, Sites of Special Scientific Interest and other places with outstanding dragonfly faunas should be monitored. Otherwise those responsible for the sites cannot tell if their management is successful or needs to be changed.

If *all* the exuviae at a waterbody could be collected and identified in a year, the total would represent the size of the population emerging in that year. However, dispersal, bad weather and predation may greatly reduce the number of mature adults which subsequently return to the waterbody to breed. Therefore monitoring should include *both* regular collections of exuviae *and* counts of mature adults — in practice adult males — by water. Ideally, exuviae should be collected and adults counted daily. Save in exceptional circumstances, provided for example by small garden ponds, this is impossible in practice: we have to accept that exhaustive monitoring is usually impracticable. Usually this does not matter because managers of reserves etc. are seldom concerned with minor fluctuations, and need only put annual numbers in categories such as zeros, tens, hundreds, and thousands. Less-than-exhaustive monitoring, *if systematically done,* can reveal enough to provide the basis for most management decisions. This note suggests that we regard as the necessary minimum for effective monitoring. Before we describe a practicable system, the following points about dragonfly biology and survey have to be taken into account.

Background considerations

1) Most, but not all, species or individuals emerge on plants or objects standing in the waterbody or close to its edge.
2) Exuviae may remain for weeks on a support but they are often dislodged and lost after a shower of rain or a brisk breeze.
3) It is easy to overlook exuviae, especially those of damselflies. Accuracy of counts depends largely on the nature of the habitat and the accessibility of the water margin to the observer.
4) Almost all teneral adult dragonflies (that is those less than a day old and with the wings and body still soft) have an instinctive urge to fly away from water and usually do not travel far on their maiden flight. Therefore if a teneral adult is

found by one waterbody it is very unlikely to have flown there from another. Thus the presence of a teneral adult by water is virtually a proof of breeding status.

5) Teneral adults are easier to find and count than exuviae but they may be overlooked, especially in cool and/or rainy weather. The time they fly to the hinterland is variable because it is greatly influenced by weather. For these reasons the number of tenerals counted gives only an approximate indication of breeding success.
6) Sexually mature males of most species only take up positions by, or over, water when air temperatures are relatively high. In practice this means that maximal numbers for a given day are present at water only within an hour or two of midday on warm days with little or no wind. Adult males at other times, females for most of the time and immature adults (as distinct from tenerals) of both sexes are normally found away from water, as are tenerals after the maiden flight.
7) Adult females come to water only to mate and lay eggs.

Monitoring surveys: conclusions and minimal requirements

We can conclude from the above that:

1) The survey method of choice for monitoring the emerging population is dictated by the nature of the habitat and especially the accessibility of the water's edge. In general, counts of exuviae provide the preferred method for Anisoptera and counts of teneral adults for Zygoptera.
2) Exuviae, which can be collected under any weather conditions, should be collected as frequently as possible *throughout* the emergence period.
3) Teneral adults should be counted as frequently as possible *throughout* the emergence period.
4) The only meaningful counts of mature adults are of males by water near noon on sunny days with little or no wind.
5) Counts as described in 4) above should be made as frequently as possible.
6) When collections of exuviae or counts of teneral adults and mature males are made, an assessment should be recorded of factors likely to influence the accuracy of the counts, for example, the failure to include part of a pond because it was inaccessible, or the advent of stormy weather since the last count of exuviae. Similarly when adult males are counted, air temperature and strength of the wind should be noted, as well as the time of day.
7) As far as possible, collections or counts at a site should be made at *regular* intervals and at the same time each day. Clearly, irregular collections of exuviae or counts of tenerals and adult males with long and varied intervals between them cannot produce results which can be compared usefully between years.

Experience suggests that the following are the *minimal* requirements for monitoring:

1) Weekly collection of Anisoptera exuviae.
2) Weekly counts of teneral adults.
3) Weekly counts of mature males by water, made within one or at most two hours of solar noon on warm days.
4) Supporting notes on factors likely to influence collections and counts (see 6 above).

Clearly these procedures should be made more frequent and detailed whenever possible.

Finding the time to visit sites is often a limiting factor; so monitoring should be modified to suit special circumstances. If the site manager is concerned about only one or two species, visits can be confined to the emergence and flying seasons of those species. This may allow an increased number of visits within a shorter period. Once the frequency of visits has been decided, it is important to maintain the same schedule in subsequent years. However, annual surveys may not be necessary: a thorough survey made every third year may prove sufficient to provide information needed for management and will be more valuable than less thorough ones made annually.

Where possible a waterbody in which the whole margin is accessible should be chosen for sampling.

Sometimes it is possible to increase the likelihood of finding exuviae and of standardising the method of collection by providing sticks or artificial supports (e.g. screens) for emergence in easily accessible places.

Experience is likely to suggest other aids to monitoring. All who use these Guidelines are asked to report to the Convenor of the Dragonfly Conservation Group of the British Dragonfly Society on their experiences and to monitor the effectiveness of the Guidelines so that future editions can be improved.

Observations on the breeding habits and habitat of *Aeshna caerulea* (Strom) in Scotland

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Introduction

Aeshna caerulea in Britain is confined to Scotland, where it has a scattered distribution in the Highlands and an outpost population in the South West. Under the Odonata Recording Scheme, the species has been noted from some 31 10km grid squares since 1960, but despite this is often considered rare or elusive. Most records refer to males, and then not necessarily from the immediate vicinity of breeding sites. Females, exuviae and living larvae are encountered much more rarely, adding to the debate on the true breeding status and habitat preferences of this insect. This paper reports recent observations and evidence of breeding from widely separated localities in the N.W. and central Highlands, and from S.W. Scotland.

A. caerulea has been known in Britain since 1854. However, it was not until Fraser's account from Perthshire almost a century later (Fraser, 1953), that the larva and larval habitat were reported. The present observations appear to be the first in which breeding activity of the adult insect has been described from this country.

N.W. Scotland (Rosshire)

a) Loch Mareeside (NG96), 10/11 July, EMS & RWJS.

This is a low moor site at c. 20m altitude bordering the large Loch Maree. Except for small groups of Scots Pines *(Pinus sylvestris)* fringing the main loch and streamsides, the site is quite open. The main vegetational cover is low Bog Myrtle *(Myrica gale)*, Heather *(Calluna vulgaris)* and Cotton-Sedges *(Eriophorum* spp.). Bog pools scattered over the area are mainly very small and shallow, exceptionally up to 30m² in area and up to 0.3m deep.

Two exuviae of *A. caerulea* were found beside widely separated pools. Both pools were about 5m x 1.5m (max.), with a sparse cover of floating *Sphagnum*, and emergent Cotton-Sedge *(E. angustifolium)*.

During sunny intervals on 11th July at 11.00hrs BST a male *A. caerulea* was twice seen patrolling at 0.3-0.5m above water. This activity was mainly over a pool c. 10m x 3m x 0.3m deep. From 13.30hrs onwards, a male was seen to patrol extensively for the next hour. Occasionally it rested on sheltered sunlit rocks, or just disappeared from view. It flew low over the water, often almost to the surface, and searched pool margins in detail. From 14.45-15.25hrs a female was observed egg-laying. At first it settled on *Sphagnum*, and then thrust its abdomen under water, turning on the spot and pushing it right out and underneath the moss — presumably to oviposit into soft *Sphagnum* and semi-liquid peat. Oviposition lasted up to three minutes at any one place, though later it spent less time laying and flew further between sites. Other Anisoptera using the general area included *Aeshna juncea, Somatochlora arctica, Libellula quadrimaculata* and *Leucorrhinia dubia*. These observations were made very close to the area from which Gabb (1985) reported the emergence of a female *A. caerulea* on 25th June 1985.

b) Shieldaig Forest, (NG86), 24 July 1989, DJC.

This locality comprises a watershed/valleyside mire of about 12ha extent, in treeless open moorland at 170m altitude. A range of crags rising to 250m, and rocky knolls, are nearby features. Small woods of Birch *(Betula* sp.) occur at 1-2km from the site. The habitat is dominated by Purple Moor Grass *(Molinia caerulea)*, with conspicuous moss hummocks up to 1m high, often capped by *Racomitrium lanuginosum*. *Sphagnum*-lined pools, often elongated or ribbon-shaped, are features of the wetter part of the mire, though water levels had been somewhat lowered by continuous dry weather. All the larger pools have substantial areas of clear open water.

At about 11.45hrs BST in hot, sunny, calm conditions, a pair of *A. caerulea* was found *in cop.* ('wheel position'), resting on a hummock beside a pool. A second female was noted soon afterwards, evidently seeking oviposition sites. It flew very low and landed several times to investigate areas at pool margins. Such sites were often slightly shaded by adjacent vegetation. The female paid particular attention to bare, wet peaty areas beside open water, and probed them with its abdomen. Unfortunately it flew off before any further observations could be made. Males (at least two) were actively searching pool margins, flying very low and not infrequently settling just above the water-line, sometimes onto bare, wet peat. They also used the greyish *Racomitrium* hummocks (which had more than a passing resemblance to the boulders often selected elsewhere). One or two aerial clashes between males were seen over water. Whether these were genuine territorial rivalry, or simply of the process of checking the identity of potential sexual partners, is uncertain. Few other Anisoptera were seen throughout the hour or so of these observations, and rather surprisingly, *A. juncea*, which might have been expected, did not appear.

Central Highlands (Perthshire), 1988/89, SH.

Aeshna cærulea was first recorded for Perthshire in 1865 by R. McLachlan, at the Black Wood of Rannoch (McLachlan, 1865). Late this century, K. J. Morton

(1899) recorded it in several parts of western Perthshire, in the glens of Rannoch, Lyon and Lochay. The species was last recorded in the district in the mid-1970's at sites which have since been modified by drainage and afforestation. Most of these sites now appear unsuitable for it, but in 1988 the sighting of a single male in the Black Wood of Rannoch (NN55) prompted further searches.

On 3rd July 1989 a male *A. caerulea* was observed patrolling the *Sphagnum* fringes of a bog pool at the edge of a conifer plantation just to the east of Rannoch Moor (NN45). This appeared to be searching the pool margins for ovipositing females and frequently stopped to perch on pale hummocks of *Racomitrium lanuginosum*. The pool was also frequented by a number of *Libellula quadrimaculata*. Despite a careful search no exuviae of any species were found. *A. juncea* which was seen in the area was not observed at the pool.

On 5th July 1989 a search was made in an area of blanket bog above Glen Lochay (NN53) at an altitude of 560m. This exposed moorland has several isolated groups of *Sphagnum* pools. The nearest trees are on the sides of the glen some 1.5km away. The moor is not rocky and the best shelter is afforded by eroded peat hags.

In mid-afternoon a single male *A. caerulea* was observed flying around a group of three bog pools. The insect was investigating the *Sphagnum* fringes of the pools, apparently searching for ovipositing females, and regularly stopped to perch on *Racomitrium* hummocks, and on one occasion on my shoulder! It was nonetheless very wary and flew off when approached too closely.

Two days later I paid a return visit to the pools and at 12.45hrs BST, in calm sunny weather, a female *A. caerulea* arrived. For 15 minutes it was seen to oviposit in all three pools, although the largest of them was clearly preferred. The pool area is c. 25-30m^2, with a 20cm depth of water and a further 20cm of soft mud beneath this. *Sphagnum cuspidatum* (with hummocks of *S. subnitens*, *Eriophorum angustifolium* and *Trichophorum caespitosum)* forms dense fringes and there is a considerable area of loose uncompacted *S. cuspidatum* floating in the open water. It was into this loose floating *Sphagnum* that the female oviposited, perching either on the denser fringing *Sphagnum* or on floating stems of *Eriophorum*. In contrast to the male, the female was very tolerant and could be approached closely. Despite an exhaustive search, only one odonate exuvia could be found, and this was of *A. juncea*. Several exuviae of *A. juncea* and two of *Somatochlora arctica* were found at another group of pools on the same moor that day.

S.W. Scotland (Kirkcudbright), 1988/9, DJC.

Present observations refer to the Silver Flowe NNR (NX48), from which *A. caerulea* has been known since 1949 (Ratcliffe, 1949). The site consists of some 190ha of relatively undisturbed *Sphagnum* bogs in a broad open valley at 250m altitude. It is bounded to the west by a range of acid cliffs rising to 500m, and on the east by a river. Beyond the river the valleyside has extensive modern conifer forests (planted c. 1964-78). The mire expanse has much *Molinia*, with Deer-sedge *(Trichophorum caespitosum)* and Cotton-sedges. There are well-developed pool and hummock complexes, with the pools on some bogs exhibiting elongated or branched forms aligned with the general contours of the site. The nearest semi-natural woodland is some 5km away and the valley itself is likely to have been devoid of native forest for well over a century. A comprehensive biogeographical review of the site is given by Boatman (1983).

On 3rd May 1988, two mature larvae of *A. caerulea* were found in pools on adjacent bogs. The two pools differed somewhat in size and appearance, one being only c. 5m² in area and virtually obscured by floating litter of *Molinia* and *Eriophorum*. The other was considerably larger, had much open water and also *Sphagnum* rafting at one end. Both pools had at least 30cm depth, and thick, loose bottom deposits of *Sphagnum* debris. On 10th July 1988, one exuvia and a half-sized larva were found at a third pool. This pool was much more channel-like than the other two, up to c. 2.5m in width, extending (and branching) for several tens of metres. On the same visit, some 30 males of *A. caerulea* were seen in the forest edge rides, their boulder-perching behaviour making them particularly easy to locate. On 8th July 1989, in warmer, calmer weather, males were much less inclined to use boulders and apparently therefore less abundant. However, for the first time in five season's visits, a male (or males) was seen in mid-morning, searching low over bog pools, occasionally settling. Females (singles) were found in the forest edge on 10th July 1988 and on 7th July 1989, but we have yet to find any on the bog systems.

The locality is shared with *A. juncea*, which is much the more abundant species. No other notable 'northern' species occur. *A. caerulea* has also been observed at other sites in the nearby uplands, with one proven breeding record from 10km square NX56.

Discussion

With so few instances of confirmed breeding (i.e. emergence, oviposition, presence of larvae or exuviae), firm conclusions on habitats and distribution of *A. caerula* remain difficult. In the meantime we would make the following comments.

a) The breeding records noted here all relate to sites having groups of shallow bog pools, in relatively open situations. So far *A. caerulea* has only been found using pools which have at least some margins with a *Sphagnum* carpet or soft peat grading gently into standing water. As far as we are aware, references to breeding in boggy seepages (e.g. Hammond, 1983) have yet to be confirmed.

b) The significance of trees as a habitat component has perhaps been overstressed in earlier accounts. Like other odonate species, *A. caerulea* uses woodland opportunistically for feeding and sheltering, but as the long-term absence of woodland from the Silver Flowe area before 1964 shows, the species can persist without it.

c) *A. caerulea* probably shares most of its Scottish localities with the widespread and more ecologically tolerant *A. juncea*. Both species will breed, or attempt to do so, over a wide range of altitudes, from near sea level to at least 550m. It is clear from Silver Flowe evidence that larvae of both species can occur in the same pools. The critical factors making sites attractive for oviposition by *A. caerulea* and *A. juncea* still require investigation.

d) So far, the *A. caerulea* breeding sites that we have studied are in or close to rocky or mountainous terrain. Captive rearing (DJC) suggests that *A. caerulea* can complete emergence in much less time than *A. juncea* which is a possible advantage in exposed and windswept localities.

e) We suspect *A. caerulea* may yet prove to be more widespread than previously thought in the cool-oceanic regions of Scotland wherever suitable habitat remains. For example, there are virtually no records from the vast open boglands of the Caithness/Sutherland 'Flow Country', which may simply reflect a lack of recording. Potentially suitable habitats also exist in Ireland, where it has yet to be found. Afforestation and drainage would seem to pose the greatest threat to breeding sites, and have certainly destroyed some already.

f) Given the apparent importance of fine weather for the breeding activity of this species, the most effective means of establishing its presence is likely to remain that of searching for larvae and/or exuviae. We suggest that early May to mid-June may be the best time to look for mature larvae, though they may be present for much of the year. Mid-June to early July is probably the best time to look for exuviae. We have noted adults on the wing from mid-June until early August.

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The breeding dragonflies of the Bristol area

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Within the Bristol region (1) lie some of the largest remaining tracts of low-lying wetland habitat in England — the Somerset Levels and Moors. About 75% of these extensive wetlands (perhaps 350 km^2) fall within the B.R.E.R.C. area.

Although serious ecological damage has been brought about on the Levels through a combination of intensive farming practices, large scale peat digging and major drainage schemes over the last 30 or so years, the Levels still form a landscape that contains a rich diversity of drainage ditches, rhynes, flooded peat workings and slow-moving rivers and streams which provide a highly attractive range of aquatic habitats for many species of dragonfly. It has been estimated that there are in the region of 4000 miles of drainage channels across the whole of the Levels (Storer, 1990). The fragments of relict raised bog and associated heathland in this area are undoubtedly of major significance for the conservation of dragonflies both at a local and a national level.

(1) The 'Bristol region' refers to that area covered by the Bristol Regional Environmental Records Centre (B.R.E.R.C.) based at the City of Bristol Museum and Art Gallery. This area includes the whole of North Somerset (V.C. 6) and the major part of West Gloucestershire (V.C. 34) but excluding that part of V.C. 34 on the western side of the River Severn. The B.R.E.R.C. area therefore also subsumes the relatively new County of Avon.

Within the County of Avon itself, smaller stretches of levels-type habitat are to be found. Puxton and Nailsea Moors and the moors of the Gordano Valley are of prime importance for dragonflies. Indeed, some of the pioneering studies on dragonfly behaviour and ecology were carried out on the Portbury River in the Gordano Valley (Moore, 1952).

Eighteen species are known to breed on these Avon levels, including two species, *Coenagrion pulchellum* and *Lestes sponsa*, which have yet to be discovered as breeding on the North Somerset Levels. *Brachytron pratense* also has one of its local strongholds on the Avon levels. Reference to the national distribution maps of this scarce species shows how important the B.R.E.R.C. area is for ensuring its survival. Depressingly, recent plans for further urban development in Clevedon and Portishead and the development of the Portbury Docks scheme are posing serious threats to the future of these Levels. However, some success is being achieved through the action of local and national conservation organisations in saving some of the land that is most attractive and valuable for wildlife (Barker, 1988).

A large section of the B.R.E.R.C. area is taken up by the Mendip Hills. Being composed largely of limestone, there is little in the way of standing water or rivers over much of this area. However, in two places Old Red Sandstone deposits have been exposed and small patches of upland heath with boggy, peaty pools have developed. These have proved to be extremely attractive to dragonflies and 16 species are known to breed in the largest of the pools at North Hill near Priddy (Boyd, 1988).

The most important riverine habitat in the survey area is provided by the mainly slow-flowing River Avon. This has eight breeding species, including *Platycnemis pennipes*, which is almost entirely confined to this river and the adjacent Kennet and Avon canal in the Bristol area. Upstream in Wiltshire, the rare *Libellula fulva* is known to breed, but although dispersing individuals have been seen flying along the river within the Avon boundary, there is no evidence so far to indicate it has started breeding within the B.R.E.R.C. area.

The River Chew, the River Frome and the Cam and Wellow brooks running north-eastwards off the Mendip Hills are the only significant stretches of faster flowing water, which explains the scarcity of *Calopteryx virgo* in the survey area. This damselfly is almost entirely limited to the latter three rivers, though often common along the stretches where it occurs.

Strangely perhaps, another species often associated with faster flowing waters, *Cordulegaster boltonii* is not breeding in the B.R.E.R.C. area, despite being a common species in neighbouring south Somerset, Devon and Dorset. However, intruiging sightings have been made (of males only) over several seasons along a stream running off Mendip.

Recording in the B.R.E.R.C. area has now been carried out over a period of eight or nine years. During that time, records have accumulated for 365 different 1km squares. Over a dozen individual recorders have contributed to this total, but the majority of records have been produced by myself and only three others. This has meant that while the main breeding sites and potentially important habitats have been identified and generally well surveyed, there are many small streams, ponds and rhynes which still remain to be searched. Thus while it can be claimed that the overall distribution pattern of each species has been reasonably well established, the fine detail for many species has still to be filled in.

Current status

There are 23 breeding species in the area (Table 1) — perhaps a slightly disappointing number, given the potential promised by the large expanses of Levels and the diversity of its aquatic habitats. However this total compares favourably with other recent county survey results such as Gloucestershire, with 25 species (Holland, 1983); Oxfordshire, 22 (Campbell, 1983); New Forest, 27 (Welstead, 1984); Derbyshire, 18 (Dunn, 1984); Worcestershire, 21 (Kemp, 1981); Essex, 22 (Benton, 1988) and Dyfed, 25 (Coker, 1985).

Fourteen species can be considered as widespread and common or locally common. I shall not comment further on these, but provide more information on the less common species, which have not been mentioned above.

Lestes sponsa has only been found in about 20km squares, most sites being associated with peaty pools, though exceptions to this include Chew and Blagdon reservoirs and several W. Gloucestershire sites. Strangely, it has not yet been discovered on the Levels.

In England, the B.R.E.R.C. area appears to mark the south-western limit of the range of *C. pulchellum.* There are two discrete populations, one centred on a small area of the Avon Levels between Clevedon and Yatton (6km squares) while the majority of records (20) are scattered across the N. Somerset levels. The N.C.C. Survey (Drake *et al.,* 1984) has identified further scattered breeding sites around West Sedgemoor, which is just outside the official recording area. This species is so extremely localised, often limited to one small stretch of one particular drainage ditch, that it is almost certainly under-recorded.

Records during the 1980's would seem to support the view that *E. najas* is a species that is extending it national range westwards, through the B.R.E.R.C. area. Each year, additional new breeding sites have been discovered. The most westerley site was found in 1988, and by 1989, numbers on this main drainage canal in the Shapwick area had increased sufficiently for the colony to successfully extend along

Table 1. Summary of status of breeding species in the Bristol district.

Calopteryx splendens	Locally common, widespread.
Calopteryx virgo	Very local, restricted to about three rivers.
Lestes sponsa	Rather local.
Platycnemis pennipes	Mainly restricted to R. Avon near Bath.
Pyrrhosoma nymphula	Common and widespread.
Ischnura elegans	Very common and widespread.
Coenagrion puella	Common and widespread.
Coenagrion pulchellum	Restricted to the Levels, where widely scattered but very localised.
Enallagma cyathigerum	Fairly common and widespread.
Erythromma najas	Locally common, but widely scattered, appears to be extending its range.
Brachytron pratense	Strong westerly distribution, being largely confined to but quite widespread on the Levels.
Aeshna juncea	Very local, mainly on Mendip.
Aeshna grandis	Widespread but rather local.
Aeshna cyanea	Common and widespread.
Aeshna mixta	Widespread but somewhat localised.
Anax imperator	Widespread but not as common as might be expected.
Cordulia aenea	Rare. Only two breeding sites, both with small numbers.
Libellula depressa	Widespread, quite common.
Libellula quadrimaculata	Mainly restricted to the Levels where it is often common.
Orthetrum cancellatum	Sparsely distributed, but often in large numbers where it does occur.
Sympetrum striolatum	Very common and widespread.
Sympetrum sanguineum	Somewhat patchy distribution but well represented and in good numbers on N. Somerset Levels.
Sympetrum danae	Restricted to about six sites. Our second rarest dragonfly.

the South Drain channel for a further 1¼ miles (Boyd, pers. comm.).

Brachytron pratense has been recorded as likely to be breeding in over 50km squares. Most of these sites occur on the Avon and N. Somerset levels, where drainage ditches on peat seem to be particularly attactive to this species. However, the recent N.C.C. survey (Drake *et al.*, 1984) found nymphs of this species in all types of ditches and on all soils in the areas they surveyed. Further localised breeding sites are almost certain to be found with further searching.

Aeshna juncea is one of our least common dragonflies, confined to breeding at a few localities in the Mendip area. Here, it is very successful. Over 200 exuviae were found in one season at just one of the Mendip pools.

Our rarest dragonfly is *Cordulia aenea*, known to be breeding at just two widely separated sites in the area, one on a peaty pool on Mendip, the other being a lake on the edge of the Cotswolds. Apart from water, there seems no obvious common denominator shared by these two highly disparate sites! Both colonies are small. On Mendip, numbers dropped perilously low after the consecutive dry summers of 1983 and 1984, though subsequently the species seems to have recovered from this. It is possible that there is still a private lake, or stretch of disused canal somewhere in the area that harbours this dragonfly.

Our second rarest dragonfly is *Sympetrum danae*. Only six breeding sites have so far been noted, four of these in the peaty pools on Mendip, where good numbers are found. This is another species that apparently finds the N. Somerset Levels unsuitable for breeding purposes though it is possible that a small population is established in the Westhay area.

In this brief review of the breeding dragonflies of the Bristol region, it has only been possible to indicate in broad outline the occurrence, status and distribution of our 23 breeding species. Further information with detailed distribution maps for each species can be found in (Randolph, 1990).

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Records of larval *Lestes dryas* Kirby in Essex during 1987

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Introduction

Lestes dryas Kirby has become well established in the south and east of Essex since its rediscovery in 1983 (Benton, 1988). This has allowed some generalized descriptions of the adults' habitat requirements in Britain, (Benton & Payne, 1983; Benton, 1988), adding to the observations by Moore (1980) undertaken before the species' presumed extinction. Gardner (1952) provides some ecological data for the eggs and larval stages and d'Aguilar *et al.* (1986) summarise the larval ecology in Europe where the species occupies a broader range of habitats than in Britain. The present paper reports some results for *L. dryas* larvae obtained during a survey of the aquatic invertebrates of ditches within areas of permanent pasture on the coastal marshes of Essex (Drake, 1988 a & b).

Methods

One hundred and twelve ditches were sampled from Tilbury to the River Stour (Fig. 1) during the period 30 April-30 May 1987. Fifteen ditches were also rapidly surveyed on Rainham and Wennington Marshes on the Essex-Greater London boundary in May 1988 but the detailed results of this survey have not been used in the analysis. A stretch of ditch was searched using a pond net to probe all the major microhabitats. The length of ditch searched varied from c. 20-50m, depending on the sparseness of the vegetation, and about 50 minutes were spent at each ditch. The abundance of each species was assessed on a scale of 1 (present), 2 (frequent) or 3 (common). The physical structure of the ditches and features of the aquatic vegetation

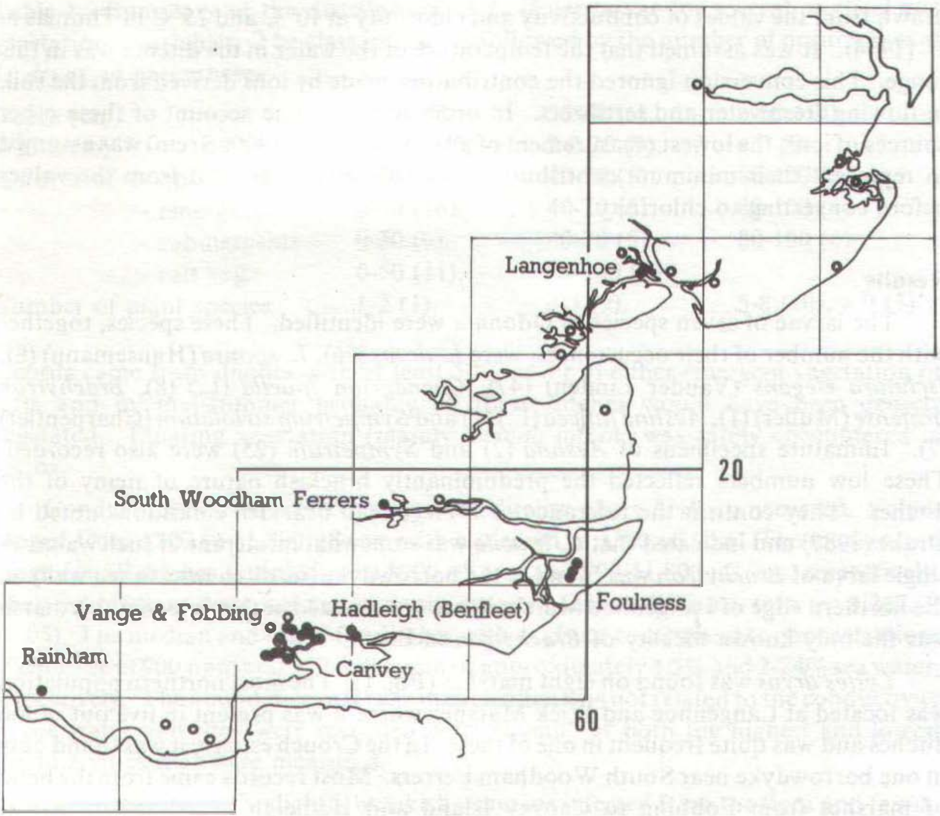

Figure 1. Locations in Essex where *L. dryas* was found (closed circles with place name) and not found (open circles).

were recorded. The abundance of each plant was assessed on the DAFOR scale (Dominant, Abundant, Frequent, Occasional, Rare) and the percentage cover was recorded for four classes of vegetation: submergent, emergent, floating and rafts. These terms described the structure of the vegetation regardless of the constituent species.

Conductivity of the water was measured at 34 ditches between June and September during a botanical survey (Wolfe-Murphy & Leach, 1989). The readings were converted to approximate chloride concentrations which could then be expressed as a percentage concentration of sea water. This was done using a graph drawn from the values of conductivity and chlorinity at 10° C and 15° C in Thomas *et al.* (1934). It was assumed that the temperature of the water in the ditches was in this range. This conversion ignored the contribution made by ions derived from the soil, in-flowing freshwater and fertilizers. In order to take some account of these other sources of ions, the lowest measurement of all the Essex sites (900uS/cm) was assumed to represent their minimum contribution and this was subtracted from the values before converting to chlorinity.

Results

The larvae of seven species of Odonata were identified. These species, together with the number of their occurrences, were *L. dryas* (26), *L. sponsa* (Hansemann) (8), *Ischnura elegans* (Vander Linden) (47), *Coenagrion ?puella* (L.) (8), *Brachytron pratense* (Muller) (1), *Aeshna juncea* (L.) (1) and *Sympetrum striolatum* (Charpentier) (7). Immature specimens of *Aeshna* (2) and *Sympetrum* (25) were also recorded. These low numbers reflected the predominantly brackish nature of many of the ditches. They confirm the tolerance of *I. elegans* to brackish conditions noted by Drake (1987) and indicated that *C. ?puella* was somewhat intolerant of such water. A single larva of *Brachytron* was found in the borrowdyke (ie. ditch next to sea wall) on the northern edge of Langenhoe Marsh; it was not realized at the time that this marsh was the only known locality of *Brachytron* in Essex.

Lestes dryas was found on eight marshes (Fig. 1). The most northern population was located at Langenhoe and Wick Marshes where it was present in five out of ten ditches and was quite frequent in one of these. In the Crouch estuary it was found only in one borrowdyke near South Woodham Ferrers. Most records came from the band of marshes from Fobbing to Canvey Island and Hadleigh Marsh where it was widespread and found in 17 of the 34 ditches sampled in this area, being frequent in seven of these and abundant in one ditch on Vange Marsh and in a ditch and a pond on Canvey Island. The ditch on Canvey Island was revisited in mid-November the following year when it was found to contain only wet mud and no water. The most southerly record came from one ditch on Rainham Marshes, Greater London, in 1988.

The association of *L. dryas* larvae with the physical and floristic variables listed in Table 1 was tested using a x^2-test on the null hypothesis that the proportion of ditches in which *L. dryas* occurred in the classes of each variable was the same as the proportions of ditches for the whole data set. The only significant result was that for water depth, there being more occurrences than expected by chance in water that was 50cm or more deep and few in water 20cm or less deep (x^2 = 5.71, $P<0.05$).
specimens were found in one ditch with a water depth of only 10cm and in four with 20cm of water. The relatively high proportion of records from ditches with a rather open structure was a result of measuring percentage cover early in the season. Most

Table 1. Summary of the distribution of *L. dryas* larvae for several physical and vegetational variables. The class interval is followed by the number of occurrences of *L. dryas,* in parentheses.

Depth (cm)	10-20 (5)	30-40 (6),	> 50 (10)
Width (m)	0-1.75 (4),	2-2.75 (9),	> 3 (8)
% cover of :- open water	0-30 (11),	40-70 (5),	80-100 (6)
:- emergents	0-30 (16),	40-70 (5),	80-100 (1)
:- submergents	0-30 (9),	40-70 (5),	80-100 (6)
:- raft veg.	0-50 (11),	60-100 (9)	
Number of plant species	1-2 (1),	3-4 (9),	5-8 (10), > 9 (3)

records came from ditches with at least 50% cover of either emergent vegetation or rafts and by mid-summer probably all these ditches would have been densely vegetated. Floating vegetation (mainly *Lemna minor)* was rarely encountered in spring.

Conductivity was measured in 11 of the ditches where *L. dryas* occurred. Values ranged from 1700 to 11,800 uS/cm with a median of 3300 uS/cm. The median and range for all ditches sampled were 5000 uS/cm and 900-11,800 uS/cm, respectively. The two medians were not significantly different (Mann-Whitney test, t = 0.267, P >0.05).
of chloride of 900 ppm and 350-4600 ppm or approximately 4.5% and 2-24% sea water, respectively. The abundance of larvae in each ditch was not related to the conductivity of the water and they were recorded as "frequent" at both the highest and lowest conductivities that were measured.

Freshwater or only slightly brackish water, as inferred from the flora and fauna, was recorded in only one fifth of the ditches surveyed, and most of these were on the marshes of Brightlingsea and St. Osyth just beyond the known northern extremity of the range of *L. dryas* in 1987 (Benton, 1988). Larvae were found in only one ditch, on Hadleigh Marsh, near Benfleet, which appeared to be fresh on the basis of its flora and fauna although the conductivity here was 2100 uS/cm in August. Two ditches, on Hadleigh and Fobbing marshes, where larvae occurred appeared to be only slightly brackish. These occurrences were too sparse to test statistically but were probably what would be expected if *L. dryas* was distributed randomly in ditches spanning the entire range of salinities from fresh to brackish water. Although this evidence is not conclusive, it does suggest that the distribution of *L. dryas* is not influenced by the presence of brackish water but that its euryhaline biology allows it to occupy the ditch systems on the Essex coast which it finds conducive for some other reason.

As the occurrence of *L. dryas* larvae has been shown to be correlated with water depth but probably not with salinity, the interaction of these variables may be important, especially as high rates of evaporation in summer may produce a disproportionate increase in salinity in shallow ditches compared to deep ones. Using data collected by Wolfe-Murphy and Leech (1989), there was no relationship between water depth and conductivity in mid- to late-summer on individual marshes from Fobbing to North Fambridge (there were no data collected at this time of year for other marshes in the range of *L. dryas).* The correlation of the combined data was just significant ($r = 0.26$, $P < 0.05$, $n = 90$) but the variance in conductivity was poorly explained by differences in water depth ($r^2 = 0.07$). There were, unfortunately, only nine *L. dryas* ditches where both conductivity and water depth were measured. These limited data showed a significant negative correlation ($r = 0.73$, $p < 0.05$) but the regression coefficient was not different to that of the relationship for the 90 ditches from Fobbing to North Fambridge. These results suggest that summer evaporation was not a major factor in creating the range of brackishness, although it was undoubtedly locally important, and that any interaction between the occurrence of *L. dryas,* water depth and salinity was unlikely.

Many aquatic plant species were dominant or abundant where *L. dryas* larvae were found although the first four species listed in Table 2 held these ranks at all but one site. It may appear on first inspection of Table 2 that *Scirpus maritimus* was strongly associated with *L. dryas* but, despite being present at nearly all *Lestes* sites, it was often present only at low densities. There was no relationship between the abundance of larvae in a ditch and the DAFOR rating of abundance for *S. maritimus.*

Discussion

From the results of this survey it is not easy to characterise the habitat.

Table 2. Dominant or abundant species of plants and the number of occasions they rated thus at *L. dryas* ditches. The percentage occurrence of each species in 518 ditches in Essex was obtained from Wolfe-Murphy & Leach (1989).

	Dom.	**Ab.**	**% in Essex**
Agrostis stolonifera L.	3	5	70.5
Scirpus maritimus L.	2	10	71.2
Glyceria fluitans (L). R. Br.	3	2	10.2
Alopecurus geniculatus L.	2	2	35.3
Phragmites australis (Cav.) Trin. ex Steud	1	0	34.2
Potamogeton pectinatus L.	1	4	10.6
Ranunculus baudotii Godr.	1	3	20.5
Lemna trisulca L.	1	1	14.3
Ceratophyllum submersum L.	1	0	2.3
Nasturtium officinale R. Br.	0	1	2.3

requirements of *L. dryas* larvae within the grazing marsh system. Ditches where they occurred were mostly deeper than 20cm in May and had at least 50% cover of emergent or raft-forming vegetation. No dominant or abundant species of plant was consistently associated with their presence.

The dominant plants previously recorded at *L. dryas* sites are *Scirpus maritimus* in Essex (Gardner, 1952; Benton & Payne, 1983) and *Equisetum fluviatile* L., *Scirpus lacustris* L. and *Typha* species (Moore, 1980). Gardner and Benton & Payne implied a strong association with *S. maritimus*. This may be true for the adults, which I have not observed myself, but it is likely to be due to *Scirpus* being the only conspicuous vegetation in an otherwise exposed and featureless landscape on many of the brackish Essex marshes, so that the adults had little choice in the provision of shelter. *Phragmites* was the only other frequently occurring tall emergent plant but it was rather less frequent than *S. maritimus*. A preference for *S. maritimus* over *Phragmites* may be inferred from the lack of published references to any association between the adults and *Phragmites* and from the far greater number of occurrences of larvae in ditches with abundant *S. maritimus* than in those with abundant *Phragmites* (Table 2). A stiff-stemmed plant that remains upright from the time the eggs are laid in its stem until winter or spring when they hatch may also be a requirement. Among the more common emergent plant species on the Essex marshes, *S. maritimus* and *Phragmites* fulfil this requirement. The distribution of hard strengthening tissue within the stems differs between these two plants. In *Phragmites* it is more or less even around the stem whereas in *S. maritimus* it is concentrated at the stem's triangular corners, leaving soft regions between them that, compared to the hard surface of *Phragmites*, a female *L. dryas* may find easy to penetrate. This may be another reason for an association between adults and *S. maritimus*. However, the distribution and abundances of larvae in the Essex ditches did not support the notion. As far as the larvae were concerned, any moderately dense vegetation would appear to suffice. It is possible that *L. dryas* was responding to some other feature of the ditches and the presence of *S. maritimus* was incidental.

Salinity *per se* did not appear to influence the distribution of *L. dryas* on the Essex marshes. The species is known from truly freshwater sites in East Anglia (Merritt, 1986) and in Ireland (Moore, 1980), and on the continent it occurs in a wider range of biotopes, mainly mesotrophic fens and pools, than in the British Isles. However, it shares a similar distribution pattern with some other insects that are widespread on the continent but reach their greatest densities at, or are restricted to, the coast in Britain (eg. Balfour-Brown, 1960).

Both salinity and *Scirpus maritimus* are rejected as primary factors in the explanation of the attraction of the Essex marshes to *L. dryas*. A more likely factor is the position along the hydrosere of the majority of ditches, most being shallow, often drying up in summer and representing a late stage in the succession to dry land. Moore (1980) pointed out the preference shown by *L. dryas* for such ponds and ditches. Along with several other species of *Lestes, L. dryas* is unusual among dragonflies in laying its eggs within plant stems above water level. *Lestes dryas* has been observed laying a few centimetres above water level in *S. maritimus* (Gardner, 1952), although McGeeney (1986) says that sometimes they are placed below the water surface. This is presumably an adaptation to summer-dry conditions such as those noted at Canvey Island and by Gardner in the ditches nearby at Benfleet where he made his observations on oviposition behaviour. The results of the 1987 survey showed that larvae were more frequently found in water deeper than 50cm than in water 10-20cm deep but about 20% of the records fell into this latter category. It is very likely that these ditches would be dry by late summer in a normal summer's drought. On true freshwater grazing marshes, ditches with such shallow water would not be expected to support an aquatic fauna of national interest although the terrestrial fauna of such ditches may well contain uncommon species. This highlights a major difference between these eastern brackish marshes and freshwater grazing marsh: shallow, often ephemeral ditches on brackish marsh may be of great conservation value by virtue of their restricted and specialised fauna, including *L. dryas,* whereas freshwater ditches need to be at least 30cm deep and permanent in summer to support an interesting fauna. If this conclusion is correct, it implies that large areas of superficially low quality grazing marsh need to be protected in Essex to conserve species such as *L. dryas* which are adapted to summer drought. An important corollary is that winter drying due to land drainage is likely to be far more damaging to this fauna than would be normal summer drought. For example, the period *L. dryas* spends in the larval stage is quoted by d'Aguilar *et al.* (1986) as c. 50 days and by Gardner (1952) as 195 days. In order for the larvae to survive, it is therefore essential that ditches contain water from about December until at least mid-June but preferably a month later to encompass the range of possible dates when *L. dryas* is in this stage. The effect of the drought in 1989 may have provided a useful, if somewhat severe test of the hypothesis presented here.

Acknowledgements

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A study of *Ischnura pumilio* (Charpentier) with particular reference to the state of maturity of the female form *aurantiaca*

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Ischnura pumilio is a national and notable rarity, with a predominantly south-western distribution in the British Isles. It has been much less studied than the closely related and more widely distributed *I. elegans.* The various colour forms of *I. elegans* have been carefully studied and documented (Killington, 1924; Parr, 1973) and most of the currently available field guides indicate the state of maturity of these. The colour forms of *I. pumilio,* on the other hand, appear to be less well understood. The literature describes two colour forms amongst females, the typical or homeochrome form has a yellowish-green pale colouration in contrast to the dramatic bright orange of the f. *aurantiaca* or heterochrome female, but no reference has been made to their state of maturity (Askew, 1988). Jurzitza (1970) does refer to *aurantiaca* females as "subadult".

I. pumilio has been studied over the last three years at two locations in Bedfordshire (Houghton Regis chalk pit and Sundon Springs chalk quarry) following their discovery in 1987. Over the course of the study, observations were made which suggested that f. *aurantiaca* maybe an immature form of the female. At each of the study sites *I. pumilio* is restricted to small areas of spring-fed seepages (Cham, in prep.) and this greatly facilitated observations of reproductive behaviour.

I. pumilio begins to emerge towards the end of May and continues through into July. Early in the 1988 and 1989 flight seasons, f. *aurantiaca* females were the most prevalent form, yet only typical forms persisted through into mid- and late-July. In addition, typical females were regularly observed *in tandem* and *in copula* yet f. *aurantiaca* were only rarely observed *in tandem* (three times out of more than one hundred observed pairings) and never *in copula.* These findings were supported by similar observations in south-west England and south Wales (A. D. Fox, pers. comm.). However, Jurzitza (1970) does document copulation with f. *aurantiaca.*

The 1990 flight season provided ideal conditions in which to test these earlier observations. *I. pumilio* started to appear at Sundon Springs during warm, dry weather at the end of May. During prolonged cold, wet weather which followed into June these early specimens had all disappeared and new emergence did not resume until sunny weather returned on 16th June. On 17th June *pumilio* was observed emerging on the stems of *Juncus inflexus* and each female was carefully examined. Females on the wing were also caught and examined. All the females (n = 39) were f. *aurantiaca* and no typical forms were found. The area was revisited four days later when a mix of the two forms were found (typical, n = 14. f. *aurantiaca, n* = 27).

Only typical females were ever observed ovipositing. This was further supported by an unreported phenomenon which appears to be unique to the Sundon Springs site. *I. pumilio* females oviposit on the stems of *Juncus inflexus* and on Stonewort *(Chara* sp.) which grow in the seepage areas. In these areas there are several inches of chalk sludge into which the females go during egg laying. Following oviposition females are covered in a layer of chalk which leaves a white dusty deposit on the abdomen and wing tips when dry. The white appearance of the females readily allows estimates to be made of those which have laid eggs. All 'white' females which have been examined (n = > 63) have been typical forms.

During two visits in June 1990 three females were caught and photographed which exhibited an intermediate colour form. Overall these specimens had the appearance of the typical form but abdominal segments two and three were orange as in f. *aurantiaca.* The top of the thorax had also retained a hint of orange colouration. This intermediate form has never been reported before and suggests that the colour change is a rapid one.

Following this discovery, ten f. *aurantiaca* females were marked on the wings with waterproof ink and monitored over the following days. On the second and third days after marking, three marked females were recaptured each of them exhibiting the typical colour form. This appears to confirm that f. *aurantiaca* females are indeed an immature form of *I. pumilio* which undergoes a rapid transformation into the typical form.

During the 1990 flight period, five *pumilio* males were found which exhibited what is also probably an immature colour form. These individuals appeared to be exactly the same as typical males except that the typically blue markings on abdominal segments 8 and 9 were light brown. Other males which were examined showed varying intensity blue on the 'tail' and this would suggest that the blue develops from the brown form by intensifying the blue pigment. Colour transparencies of the intermediate female colour form and the immature male form are deposited in the Natural History Museum, London.

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Footnote

During the course of this study, *aurantiaca* females were often more difficult to follow than the normal females particularly when flying through patches of *Juncus inflexus* in the seepage areas. At this time of year some of the stems begin to die back and exhibit shades of brown and orange. These areas are favoured resting areas of *pumilio*. The dramatic transformation between the two female colour forms maybe of some adaptive value in offering a degree of cryptic colouration at different stages of the life cycle. It is hoped that somebody may take up the challenge to study this further.

Dragonflies and sound

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No species of Odonata is known to vocalise at any stage of its life cycle. Even so, most odonatists will recall occasions when their dragonfly observations have been linked with sound and, in some cases, it has been of sufficient amplitude to draw their attention to the insects.

The obvious example is the buzzing or rustling of a large Zygoptera species in flight or of any of the Anisoptera. Somehow there is something quite characteristic about the sound of dragonfly flight; after all, the insects fly using anterior and posterior pairs of wings independently and which beat by means of contraction of attached muscles. Moreover, the frequency of Odonata wing-beating is little more than 25 beats per second while bees (Hymenoptera) have a figure of 250 to 300 per second, caused by rapid changes in thoracic shape, so that the quality of sound is different in the two insect groups.

Amongst Zygoptera, I recall particularly the thin, buzzing sound of *Calopteryx virgo* in flight, when there is little wind and there is not too much water flow in nearby streams. Males of this species will hover and display before females preparatory to mating: these sounds are especially attractive if several males are involved. *Lestes sponsa* is another common damselfly which, if disturbed in marsh vegetation, will take off with flight sounds of unexpected loudness.

With Anisoptera, the species I associate most with sound is *Aeshna cyanea.* A male patrolling a woodland glade or visiting a pond when sexually mature is always ready to investigate a human intruder, perhaps hovering and buzzing just before the face. As an example, on 17th August 1988, I was watching eight males which were flying rapidly over a small pond in Somerset when two of them suddenly flew at a female in the air. One of them seized the female and the tandem pair, closely followed by the second male, flew at speed within one metre of my head with a remarkably loud buzz. Dragonfly flight-sounds can certainly draw the attention of naturalists. Thus, rustling flight noise coming from a patch of stinging nettles *Urtica dioica* in the early morning caused Cham and Banks (1986) to investigate: the sound was made by a male *Aeshna grandis* as it flew and caught chironomid midges which had been roosting in the nettles.

No doubt most dragonfly observers have their own memories of whirring, vibrating wings prior to take-off. I remember one dull, misty and cool morning in Somerset in late September when I came across two teneral *Sympetrum striolatum* imagines clinging low in rushes *Juncus effusus.* Their wings were beaded with moisture and, perhaps because of my approach, vibration was started; this continued for three or four minutes when, with dry wings, the insects flew off. The sound was quite significant.

Sometimes the reason for wing-vibration can be puzzling. For instance, on moorland at 11.45 GMT on 4th September 1987, I saw a female *Cordulegaster boltonii* vibrating its wings while perched on a bush; the dragonfly was quite mature and the temperature was average for the season. After about a minute, a male conspecific flew to attack the wing-whirring female and eventually seized her to assume the tandem position; however, the female was so active that the insects soon disengaged and flew off separately.

Corbet (1962) discusses wing-vibration as a means of raising a dragonfly's temperature, although warming up can hardly have been the reason in the case of the female *C. boltonii* just mentioned. More dramatically, Corbet *et al.* (1960) describe the sound of multiple wing-whirring from newly-emerged *Anax imperator* imagines at one site around sunrise in June; apparently the noise continued for about 20 minutes before the first dragonfly climbed to become airborne.

Noises produced when large dragonflies buffet each other can be surprisingly loud and may be heard at a distance of several metres. For example, on 21st August 1989 I saw a patrolling male *A. cyanea* clash repeatedly with a male *C. boltonii* but, first of all, I had been alerted by the knocks. Corbet (1962) confirms that such clashes during fighting can be noisy; he gives an example of a male *A. imperator* attacking other large dragonflies in its patrolling zone.

At times, ovipositing female dragonflies are involved in noisy buffeting. At 11.00 GMT on 9th September 1986, in Somerset, I was watching a female *C. boltonii* ovipositing in mud by the side of a stream when it was attacked by a male *A. cyanea*. The larger insect was knocked, floundering, onto the mud surface and, on rising, it was again buffeted down by the same *A. cyanea*. Eventually, but with difficulty, the female *C. boltonii* again became airborne and resumed ovipositing — by this time its assailant had disappeared. The episode had been particularly noisy throughout.

The sound was commented on by Cross (1987) in his account of a male Pied Wagtail *Motacilla alba* catching flying adults of *Libellula depressa;* the bird took the females when in the tandem position. The Pied Wagtail was also attracted by noisy clashes between *L. depressa* males; here, the sounds resembled those of males seizing females.

Mechanical sound must also be produced by dragonflies chewing prey insects. As an example, on 30th June 1987 I saw a female *Ischnura elegans* perched on a Reedmace *Typha latifolia* stem and eating the abdomen of a male *Coenagrion puella*. The day was still and the damselfly pre-occupied so, by close listening, I was able to hear munching sounds. Food crunching as a sound source was mentioned by Corbet *et al.* (1960); there is a description of an adult *Libellula quadrimaculata* biting up the chitinous exoskeletons of gnats (Culicidae) or small beetles (Coleoptera) with its toothed jaws. As another example of a dragonfly being concerned in sound production, Khan (1983) heard a Wood Mouse *Apodemus sylvaticus* biting off the wings of a newly-emerged *A. imperator* and then chewing up the insect in the eating process.

Again, the underwater feeding of a dragonfly larva must give rise to some sound, although of small amplitude. The rapid protrusion of the hooked labium to catch swimming animal prey cannot be silent; presumably the sounds could be tape-recorded using a microphone situated below the surface of the water. Another possible larval sound might be caused by the rectal expulsion of water during forward movement, although this only applies to the larvae of Anisoptera. But an entirely different method of sound production from a dragonfly larva has been mentioned by Corbet (1962). It appears that stridulatory organs have been found in larvae of *Epiophlebia superstes* and that, if disturbed, these larvae at least may stridulate instead of feigning death. Of course, such a mechanism may be quite exceptional amongst dragonflies.

However, the association of sound with dragonflies, albeit mechanical, is probably commoner than is generally realised in Britain. Perhaps dragonfly-watchers should be urged to carry a portable tape-recorder as well as a camera when they go on field expeditions!

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Use of these terms is acceptable: 'exuvia' for cast skin (plural 'exuviae'); 'larva' (instead of 'naiad' or 'nymph'); 'prolarva' to designate the first larval instar.

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