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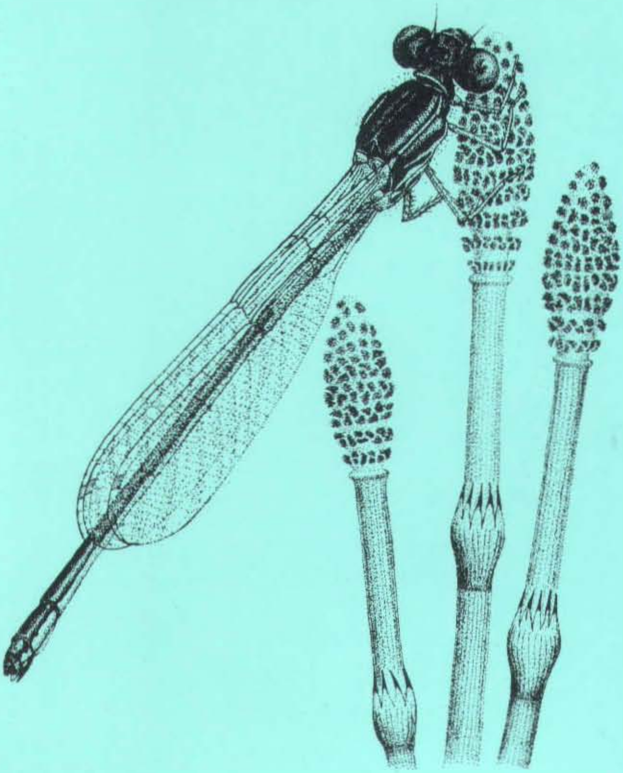

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ADDRESSES

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Front cover illustration of female *Ceriagrion tenellum* by S. Jones.

An early emergence (one year life-cycle) of *Libellula depressa* Linnaeus and *Anax imperator* Leach

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In the winter of 1984–85, a pond was constructed on a reclaimed rubbish tip in Stockwood on the south-east outskirts of Bristol, Avon. The pond is approximately 20m x 10m, being generally shallow and not quite a metre deep at its deepest point.

During the summer of 1985, numbers of males and females of *Libellula depressa* and *Anax imperator* visiting the pond were recorded on several occasions over a period extending from the end of June to the end of August. A summary of these dates is given in Table 1. During the following summer of 1986, adults of both species emerged. Between the beginning of June and the middle of July, exuviae of the two species were searched for, collected and counted. The results of these counts are given in Table 2. The following year, from May to early July 1987, further searches were made for the exuviae of these two species. Results of these counts are given in Table 3.

These two counts of adults of both species emerging after one and two years of development clearly demonstrate that of the adults known to have emerged, the vast majority (94 per cent) of the population of *Libellula depressa* larvae and all *Anax imperator* larvae completed their life history within a one year period. These results are almost completely at variance with the information on the life-cycles of these two species in Corbet et *al.* (1960) where the length of life-cycle for *Libellula depressa* is given as 'usually more than two years'. With reference to *Anax imperator,* it is stated that 'In Britain, it is probable that about 90 per cent of *Anax imperator* adults emerging each year are two year olds which have spent their second winter in diapause'.

In the context of the emergence data given above, it is useful at this point to summarize briefly some of the salient points of what is known of the life-cycle of *Anax imperator* resulting from the research of P. S. Corbet which was originally published in 1957 and which is discussed in Corbet *et al.* (1960).

The period of diapause which the majority of *Anax imperator* larvae undergo after reaching the final instar stage is believed to be a mechanism which allows a levelling-out of the variable growth rates that have occurred amongst the larval population during the preceding eleven to thirteen months. This diapause, which persists during the second winter, thus ensures that the advantageous event of a synchronised emergence takes place in the following summer.

The remaining 10 per cent of the adult population in any given year are one year olds that have emerged just a little later in the season than the majority which spent two years as larvae. These one year olds metamorphosed from the relatively small proportion of rapidly growing individuals in their generation that managed to achieve their final instar larval stage before the critical point in the season, which is apparently the beginning of June. This is when increases in day length begin to fall below two minutes, this being the stimulus which is believed to bring about the onset of diapause. These precocious larvae are able to continue

Table 1. Summary of male and female dragonflies of two species noted at the Stockwood pond in the summer of 1985.

Date of Observation	*Libellula depressa* Male	*Libellula depressa* Female ovipositing	*Anax imperator* Male	*Anax imperator* Female ovipositing
June 29	5	small no.	1	-
July 2	-	1	1	-
July 7	2	-	2	1
July 13	4	small no.	3	2≠
July 20 ≠≠	3	1	-	-
July 23	4	1	3	1
August 10	-	-	1	1
August 17	1	-	2	1
August 29	-	-	1	-

≠ 1 female was ovipositing for at least 30 minutes

≠≠ Large numbers of young larvae (probably second instar) of *Libellula depressa* were seen in the shallows around the edge.

Table 2. Summary of numbers of exuviae of two species of dragonfly collected at the Stockwood pond in the summer of 1986.

Date exuviae collected	Exuviae *Libellula depressa*	Exuviae *Anax imperator*
June 1	16	-
June 2	29	-
June 5	15	-
June 8	22	-
June 10	27	-
June 11	30	-
June 13	58	-
June 16	71	-
June 20	20	24
June 28	26	25
July 12 ≠	4	8
Totals	318	57

≠ It is unfortunately not possible to be completely certain after 6 years, but the observer believes that, though not actually recorded as such, subsequent searches were made after 12 July but no exuviae of either species was found.

immediately into the final stage of metamorphosis, thereby avoiding the diapause of their slower developing neighbours. In this way, survival to the adult stage for these fast developers will be much more certain than if they were to spend at least a further twelve months in the larval stage.

This inbuilt plasticity in the life history of *Anax imperator,* achieved through a facultative diapause which thus permits both semivoltine and univoltine cycles, is an adaptation which would seem to allow this species to extend its range into more northern temperate regions where aquatic habitats are often insufficiently benign to guarantee the achievement of a univoltine cycle. While Corbet *et al.* (1960) state that 'it seems likely, for instance, that *Anax imperator* completes its life history in one year', it would be interesting to know if subsequent research has confirmed this prediction.

*Anax parthenope (*Selys*)* is a species whose distribution in Europe and North Africa overlaps much of that of its congener, *Anax imperator,* though its range does not extend as far north, for it is absent from much of France, the Netherlands and central Europe (Askew, 1988). It might be predicted from this that the apparent inability of this species to extend its range as far north as that of *Anax imperator* is because it lacks a diapause stage in its life history. Again, it would be interesting to know if this has been shown to be the case.

In the light of this somewhat limited knowledge of the biology of *Anax imperator* and *Libellula depressa,* is it possible to explain data for the pond in Stockwood, Bristol? How could *Anax imperator* achieve what would appear to be a total reversal of its normal pattern of emergence by demonstrating a 100 per cent univoltine life-cycle? It should be noted however, that these one year olds emerged about three weeks later than the recorded average emergence date of two year olds maturing in the same season. This is not surprising, perhaps, given the limited time they have to achieve their complete cycle. What allowed *Libellula depressa* to speed up its development so much faster than its more typical rate? (It is interesting to note here that *Libellula depressa* was also seen to complete its life-cycle in under one year in a new pond at Braunton Burrows NNR (Breeds, 1992)). The simplistic answer to both these questions must surely rest on the basic proposition that near optimum conditions were prevalent during the first season (July – October (?) 1985) and again for the second period of growth (May – June 1986). What constituted these optimum conditions is far less easy to answer.

Among the factors which must have played an important part, it would seem reasonable to assume that an ample food supply and suitably warm temperatures would have been essential minimum requirements. Would these conditions have been present in the new pond at the time? The pond was shallow, so presumably warmed up quite quickly as ambient air temperatures increased. Local weather records indicate that throughout most of the period from June 1985 to the end of June 1986, mean monthly temperatures were generally below average (Weeks, 1987, 1988). However 'September's day temperatures were about 1.5°C above average and October's little above, but after a fair start (and although it remained sunny), November become cold and ended nearly 2°C below average'. It may be that these slightly above average temperatures at the end of this first season were just sufficient to allow the growth period to be extended beyond the time normally available for development in a more typical year. But over the whole period it would seem fair to conclude that little significance can be attributed to the overall role of water temperatures in affecting the precocious larval development of either *Anax imperator* or *Libellula depressa.*

No data are available on food availability, and it is doubtful if there is much to be

Table 3. Summary of numbers of exuviae of two species of dragonfly collected at the Stockwood pond in the summer of 1987.

Date exuviae collected	Exuviae *Libellula depressa*	Exuviae *Anax imperator*
May 10	11	-
May 26	7	(several very young larvae noted)
June 21	-	-
June 28	-	-
July 5	-	-
Totals	18	0

gained in conjecture on this aspect. However, these two dragonfly species are noted pioneers, willing to exploit new habitats. There must have been relatively little competition from other predators in this new pond and yet conversely there must also have been healthy populations of pioneer herbivore and smaller carnivore invertebrate species. It was also noted that newt and frog tadpoles were present. All of these would provide ample suitable prey items for the dragonfly larvae.

Whatever the optimum conditions must actually have been, they resulted in the mass emergence of *Anax imperator* after only 10 – 11 months of development, most individuals (86 per cent) emerging within nine days of each other. This emergence (of an admittedly small population) looks very similar to the typical synchronized emergence pattern seen at the end of the semivoltine cycle. It is tempting to wonder if a modified diapause of reduced length was still operating even within this univoltine cycle in order to bring about this apparent synchrony of emergence in *Anax imperator*.

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Notes on the larva and generation time of *Aeshna caerulea* (Ström) in Scotland, with particular reference to the south-west

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Introduction

Until very recently, larvae of *Aeshna caerulea* have rarely been encountered in Britain. This doubtless reflects the restricted distribution of this species and the remoteness of many of its localities, most of which are in the Scottish Highlands. British material of the final instar of this species was first described and figured by Fraser (1953). The absence of illustrations from earlier literature (e.g. Lucas, 1930; Longfield, 1949) clearly reflects the difficulties of finding larvae. This is further shown by a recent survey of biological collections in a selection of major British museums (Clarke, unpublished), which has revealed only two *A. caerulea* larvae. One of these derives from the activities of Fraser *(op. cit.)*; the other was collected in 1982.

During the period 1988–93 I collected data on larvae at the outpost population in SW Scotland (55° 8'N, 4° 25'W). As well as providing an opportunity to have high quality illustrations prepared, it has enabled close comparison to be made with the larvae of *A. juncea* (L.), the only aeshnid sharing the habitats of *A. caerulea* in Britain.

As visits to the south-west Scotland site were made at various times of year, a preliminary assessment of generation time has been attempted. I have also had the benefit of the results of extensive sampling carried out in the north-west Highlands (Lochmareeside) by E. M. and R. W. J. Smith in 1993. Captive rearing which I have undertaken on a very limited scale has also provided useful additional data.

General description of larva

A. caerulea has a typical aeshnid larva (see Fig. 1). The larva is noticeably slimmer in build than that of *A. juncea*, and this is especially obvious when comparison of live material is made. Known instars are specified here by reference to the final instar (F). (i.e. F–1 is the penultimate instar).

Length of the living final instar (F) ranges from c.38 to 39mm (n = 18). This instar may be confirmed by the length of the wing cases, the tips of which reach well beyond the distal margin of the third abdominal segment. (The F–1 instar may sometimes reach lengths within the above range, but its wing-cases reach, at most, to the base of segment three).

Coloration is variable, as would be expected. Most instars are usually shades of olive-green or olive-brown. Such coloration may be retained through to the last few instars, but equally these may be an overall grey-brown or charcoal colour. The overall pattern is rather uniform, with a somewhat dappled, almost herring-bone, appearance. Small, paired, dark spots and transverse bars (shown in Figs 1 & 2) are visible unless obscured by the depth of colour. Most instars before the final one (especially F–3 and earlier) often show a thin mid-dorsal yellow line on the anterior abdominal segments. This broadens into a diffuse pale spot on segment 7, which can be quite conspicuous. Well-marked final instars may show a median

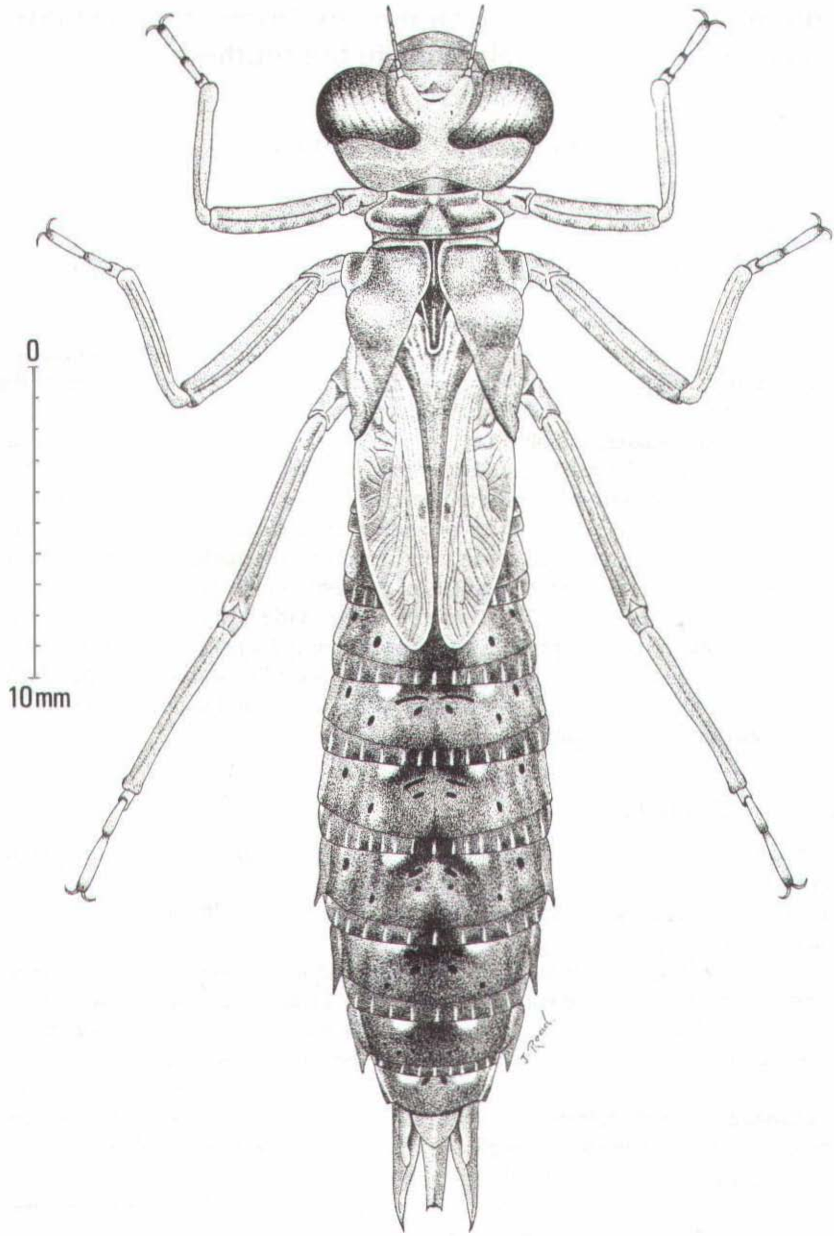

Figure 1. *Aeshna caerulea*: final instar larva, SW Scotland, 29 April 1990

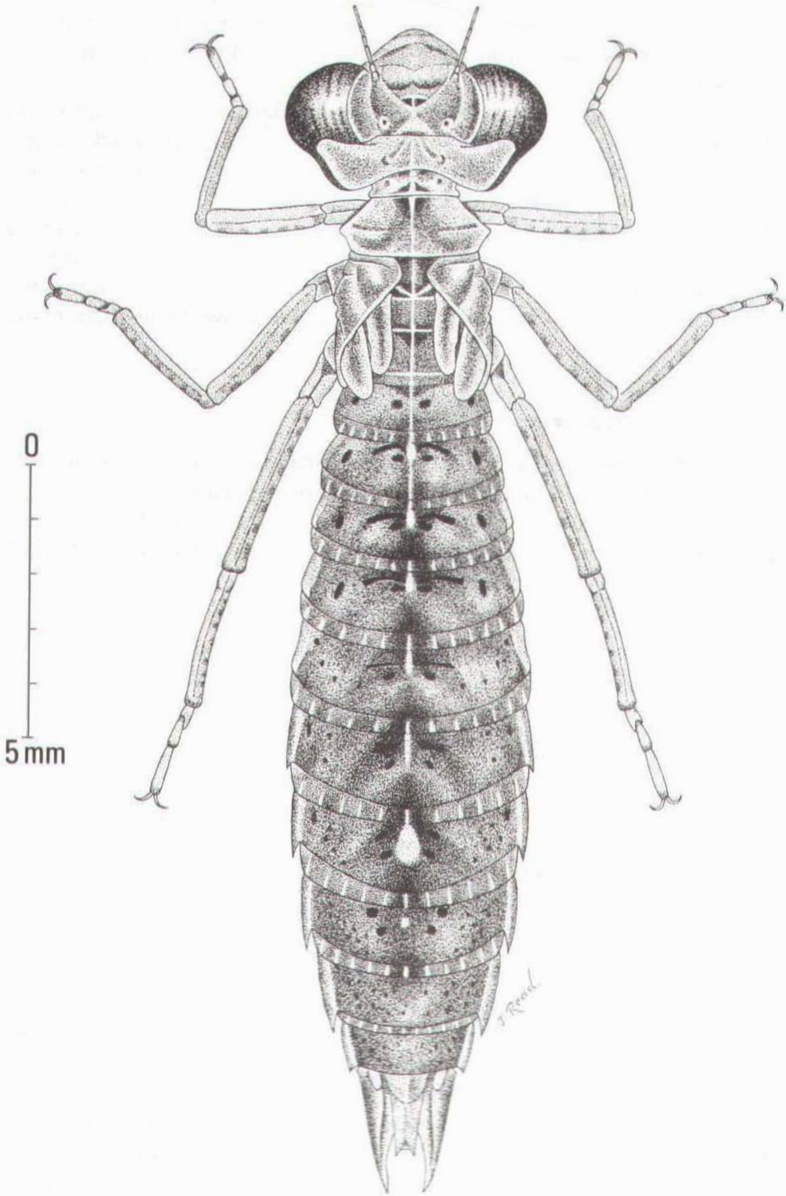

Figure 2. *Aeshna caerulea*: instar F–3, SW Scotland, 29 April 1990

series of dark chevrons on the segments preceding this. The mid-dorsal areas of segments 8 and 9 are always virtually unmarked, though in late instars may be distinctly darkened centrally. The emergence exuviae usually shows traces of the pale area on segment 7 and the dark areas on 8 and 9.

The contrast with *A. juncea* is quite marked, the larvae and exuviae of the latter tending to appear quite strongly longitudinally striped by virtue of broad sub-dorsal pale areas on most abdominal segments. These contrast with much darker centre-line and lateral areas of the abdomen. This is particularly noticeable in the early instars (size c. 4–12mm). As with *caerulea,* dark coloration may obscure the pattern in later instars. Very small hatching larvae of both species are semi-transparent, but have begun to assume their characteristic patterning by the time they have grown to c. 3–4mm. The two species seem distinct even at this stage, *caerulea* being a fairly uniform, light brown, whereas *juncea* shows heavy dark markings on the head capsule.

Key field identification features

Overall length: This has been used in some recent publications as a character for keying out mature larvae. In habitats in Britain appropriate to both species, any live aeshnid larva measuring 40mm or over is almost certain to be *A. juncea.* However, the two species can overlap in their size ranges by some 5mm or more. (In practice, length can be difficult to measure accurately, since it may be affected by recent food intake, imminence of moult, state of alarm, etc).

Abdominal pattern: The contrast in pattern with that of *A. juncea* is described above. Normally, this alone is sufficient for the identification of most instars. Indeed, it is such that larvae seen on the bottom of a shallow sunlit bog-pool may be readily identified without capture. The early instars are the most distinctive.

Labium (Fig. 3): The smaller labial 'mask' with the basal area tapering evenly towards a narrow 'hinge' with the post-mentum is characteristic of *caerulea.* My findings agree with Carchini (1983) in that the proportions L:B range up to 2.5:1 in *juncea* and are greater than this (typically between 2.7:1 and 3.0:1) in *caerulea.* L ranges 5.3–6.1mm in *caerulea (n = 18),* and 6.3–7.5mm in *juncea (n = 21).* The difference in the proportions of the labium are less distinct in earlier instars.

Antennae (Fig. 4): Final instars of *A. caerulea* have six antennal segments, in contrast to all other British aeshnids, which have seven. In effect this appears to be due to the failure of segments 6 and 7 to differentiate in *caerulea*, making the terminal segment twice as long as the penultimate (they are subequal in *A. juncea).*

Although a useful absolute, the value of this for identification is limited by the fact that antennae are quite often damaged and deformed during the long larval life, and are often lost from exuviae. (The necessity to use at least x10 magnification and good illumination to verify this character also limits field use). *A. caerulea* instars before F–3 have incompletely developed antennae.

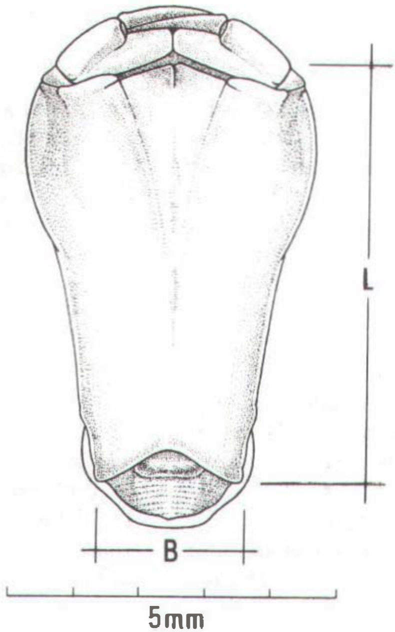

Figure 3. *Aeshna caerulea*: labium of final instar larva

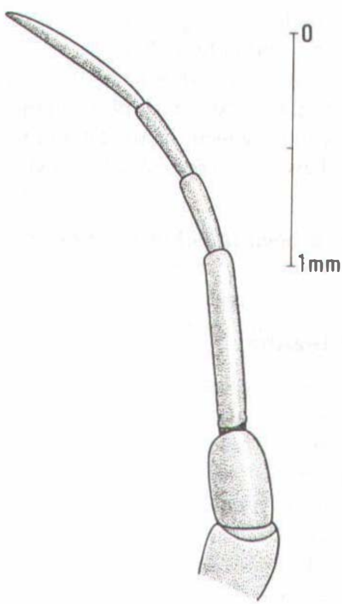

Figure 4. *Aeshna caerulea*: antenna of final instar larva

Generation time: sampling results

Sampling for larvae has variously been by sieving with a colander or a garden riddle, or by using a water-net and then sorting the contents in a white tray. The latter has proved particularly effective in finding small larvae, which tend to cling to floating *Sphagnum* and other vegetation. The largest sizes of larvae have proved surprisingly difficult to find at most seasons. This may partly reflect the fact that these are at the least numerous stage, but may also indicate their behaviour makes them less susceptible to these collecting techniques.

Although a comprehensive programme of sampling has not been possible, surveys have covered all months from late April to mid-October. In all, over one hundred larvae have been examined from the south-west and rather more from the north-west - the outcome of at least two hundred person-hours in the field.

Both in the south-west and north-west, particular pools at any one time have quite often contained a preponderance of larvae of roughly the same size. This may simply indicate intermittent use by *caerulea* in a situation of excess available sites. Monitoring of larval development at marked pools has been started in NW Scotland by the Smiths.

Interpretation of these results, together with limited captive rearing, suggests the following as the typical life-cycle - at least in SW Scotland. It is stressed that until much more data are available this must be considered as no more than provisional:

Year 1 Eggs laid in June and July and enter a diapause phase.
Year 2 Eggs hatch in spring (probably late May) and larvae develop to approximately 5-10mm length before overwintering.
Year 3 Larvae continue growth; faster growing larvae may attain the final instar stage before overwintering, and enter a diapause phase.
Year 4 Larvae which have overwintered as final instars metamorphose and emerge. Other larvae attain final instar. Those which do so immediately after winter may proceed to metamorphosis; those which mature later enter a developmental diapause.
Year 5 Overwintered final instars of more slowly growing larvae metamorphose and emerge.

Final instar larvae have been found in most months, but not yet between late June and mid-July.

Generation time: captive rearing

Limited captive rearing has shown that wide variations in rates of development can occur. Larvae (size 12mm to F—1) have shown instar durations varying from 25-100 days. Individuals which have exhibited very long instar durations have included both extremes of this size range. One F—1 larva from early May, remained in this stage until early September. Another, which entered this instar in July, showed a much more 'normal' duration of 37 days. Observed moults into the final instar in captivity have been in May and between mid-August and mid-September. A final instar collected in NW Scotland on 24 July metamorphosed in the following season. Overwintered F—1 instars, which attained the final instar late in May, proceeded to metamorphosis the same season.

Variability in growth increments per moult suggests that the number of instars may not be absolutely constant; the usual number is probably close to 14 (plus the prolarval instar).

Generation time: discussion

The main SW Scotland site is at 300m, whilst most sites in the NW were at under 50m. This may cancel out any effects of the latitude difference of some 320 km. (*A. caerulea* is known to occur at up to at least 500m at other sites in the Highlands, and here some effect on generation time might be expected, although in the above scenario there is some apparent 'spare capacity' in Year 4).

The existence of egg diapause in *Aeshna* species is well known (see for example Corbet (1980)). This is viewed essentially as an adaptation which permits occupation of regions with cold winter climates. The vulnerable young larval stages are thus confined to the most favourable period of the year. The precise timing of the hatch of *A. caerulea* eggs has yet to be established, but the essential conclusions are unaffected.

Captive rearing results, insofar as these can be safely applied to the field, seem to indicate some fundamental variability which is more difficult to detect in the wild. The notion of variable rates of development requires much more study, but would certainly help to account for the plethora of sizes which can occur at most times of year, particularly in the NW. The existence of cohort groups of larvae, developing at different rates, has been established for some species (e.g. *Coenagrion hastulatum* (Charpentier) (Norling, 1984)) and could conceivably be a factor here.

The possibility that under some circumstances the F–1 instar may undergo a diapause phase is another aspect for future study. The more certain features of final instar diapause and a relatively synchronized, early emergence (usually late May to late June), appear to fulfil the criteria for a 'spring species' as defined by Corbet (1954). This is a situation which might have been expected in *A. caerulea*.

Habitat and other ecological factors

Clarke et *al.* (1990) describe some of the areas concerned. Bog pools are (so far) the only habitat in which *A. caerulea* larvae have been found. In SW Scotland all pools used by *caerulea* are apparently shared with *A. juncea*. This is less certainly the case in some NW sites. Pools (or areas within larger pools) which have yielded most *A. caerulea* tend to have 15–20cm water depth over thick, soupy bottom-deposits of a buff/orange coloration. There is usually some open water, and always floating *Sphagnum*. Typical 'good pools' are usually quite narrow (1–3m across). They can be parts of extensive ribbon-like systems, but (as especially noted in the NW) may sometimes be very small indeed (c.2m x 1m).

The discovery-rate in locating larvae of *A. caerulea* in bog systems is generally very low compared to that with *A. juncea*, except at bog pools of the type described above. Here the apparent proportion of *A. caerulea* may on occasions be very high—sometimes approaching 100 per cent. In the NW, the Smiths have found that the best *caerulea* pools have tended to be well away from the centres of bog-pool complexes. It is clear that the question of oviposition site preferences is one which would repay further study.

As yet the effects of other factors such as food competition and predators are unknown. Palmate Newts (*Triturus palmatus*) and large water beetles (*Dytiscus* spp.) are among potential predators at some sites. The effects of other Odonata species (particularly *A. juncea)* are of particular interest.

The isolated edge-of-range situation in SW Scotland *may* be atypical in some respects. Certainly the variety of competitor species, and predators, seems less than at the sites in NW Scotland. The extent of suitable habitat and potential oviposition sites must also be much more limited.

Acknowledgements

I am pleased to acknowledge the painstaking work of John Read, who prepared the original drawings for the text figures from my photographs of live material and exuviae. Betty and Bob Smith kindly read and commented on draft versions of this paper. They generously made available all the results of their sampling in NW Scotland. The draft was also discussed with Professor Philip Corbet. I should like to thank Stephen Hewitt for his comments, and for joining me on various field visits and adding significantly to their outcome.

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Headless 'life' of female Southern Hawker *Aeshna cyanea* (Müller)

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Recently I was told by Sue Langdon of Timsbury, near Bath, Avon, of a large dragonfly which had 'lived' for six days in her garden after loss of its head. Apparently, on 10 October 1993, a cat captured the dragonfly, which was near a pond in the garden, and bit off its head. The insect's decapitated body, after being placed in position, then clung to the side of a coal-bunker, where it remained for six days. If touched, the dragonfly's legs would be adjusted to preserve its position and balance. The insect eventually 'died' during the frosty night of 16 October.

I was sent the intact thorax and abdomen of the insect and also the head; the identification was that of a mature female Southern Hawker *Aeshna cyanea*. I thought that the dragonfly had probably been attempting to egg-lay at the garden pond when it became the cat's victim.

Presumably, reflex nerve activity was sufficient to enable the insect to respond to being touched and to cling to a vertical surface; moreover, the nature of the injury could not have permitted much loss of essential body fluids, and tissue respiration, through spiracles, was probably little affected. Even so, six days of headless life does seem rather remarkable.

On describing members of the insect order Odonata

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Silsby (1992, 1993) has been conducting her own debate as to how members of the insect order Odonata should be referred to. We have read this correspondence with interest.

For us the situation is quite simple. The order Odonata is divided into three sub-orders, of which the two that concern us most are the Anisoptera and the Zygoptera. Members of the sub-order Anisoptera can be referred to as anisopterans and members of the sub-order Zygoptera as zygopterans. For the (somewhat pompous) science writer, the debate ends here. If there is a need to provide further description then the Anisoptera can be referred to as dragonflies and the Zygoptera as damselflies. (Dragonfly and damselfly need capital letters only if they come at the beginning of a sentence.) Anyone wishing to refer to any member of the order can use the term odonate (as many already do in the U.S.A.).

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A new look at *Brachytron pratense* (Müller) in the New Forest

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Brachytron pratense has long been known as a New Forest breeding-species (e.g. Fraser, 1950; Welstead, 1984) but confined to only one large pond. My own very fallible observations over many years do not alter this.

However, on 3 May 1993 in purely fortuitous circumstances, I happened to spot exuviae of a male *Brachytron* on an old stem of Bulrush (*Typha latifolia*) in a small New Forest woodland pool, 150mm above water-level. This plant formed the main emergent vegetation with the principal aquatics being buttercups (*Ranunculus* spp.) and Bogbean (*Menyanthes trifoliata*). An enthusiastic search at the time produced no further specimens, but on 9 May, I found two female *Brachytron* exuviae in the same area of dead stems, one at 75mm and the other at 200mm above the water. This visit followed substantial rain the previous night, so it is quite probable others could have been washed off. Thorough searches were then made on 16, 22, 23 and 31 May, with a final visit on 6 June, all without success. At no stage did I ever catch a glimpse of an imagine, and but for a lucky chance this site would have been missed completely. I certainly failed to find, on my occasional visits, the total emerging.

If fellow members of the B.D.S. can keep a lookout for large exuviae in early May, particularly in ponds and pools in the southern part of the Forest, I think more breeding sites for this species will probably be revealed. Any large exuviae found this early in the season will almost certainly be of *Brachytron*; on closer inspection the narrow, almost tubular abdomen easily separates that of *Brachytron* from exuviae of *Aeshna* species. By this means the status of *Brachytron* can be ascertained before other species have appeared or vegetation obscured the view.

This new, small pool is in complete contrast to the known headquarters of *Brachytron*, measuring only about 30m x 17m as opposed to a maximum diameter of about 1000m. The maximum depth is 600mm, with a base of thick sediment and Tertiary Clay, on Osborne and Headon beds, as is the north shore of its headquarters. Both sites are closely bordering more recent Plateau Gravels. The pH of the bed was 6.75 and that of the open water 6.60 which is slightly more acidic than the main pond which averages 7.25 in summer and 7.01 in October.

No adult Anisoptera were recorded throughout my visits, and the only Zygoptera were *Coenagrion puella* and *Pyrrhosoma nymphula*, both plentiful.

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The predation of *Sympetrum sanguineum* (Müller) by *Vespula germanica* (Fabricius) (Hymenoptera, Vespidae)

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During August 1990, at Woodwalton Fen NNR, the predation of an adult *Sympetrum sanguineum* by *Vespula germanica* was observed and photographed. The victim, a male specimen of *S. sanguineum*, was flying and apparently healthy when it was attacked in mid-air by a single worker *V. germanica*. After a brief aerial combat, both insects fell to the ground. At this point the wasp repeatedly stung its victim until it was paralysed. Using its mandibles the wasp decapitated the dragonfly and severed the thorax from the abdomen. The attacker then took the victim's thorax into its jaws and flew off. The duration of this sequence of events was less than five minutes.

It is well known that vespids are predators of other insects, but there are relatively few records of their attacking Odonata. Spradberry (1973) lists species of nine insect orders that are known to have been predated. These include fifteen species of Diptera, as well as species of Lepidoptera, Coleoptera, Hemiptera, Orthoptera and a single species of Odonata. Robins (1938) and Clarke (1942) reported similar behaviour to that described here. Robins (1938) observed the fatal attack of *Sympetrum striolatum* (Selys) by a single specimen of a *Vespula* species and Clark (1942) witnessed the predation of an *Aeshna* species by an unidentified wasp. Similarly, Paine (1992) described the killing of a male *Aeshna mixta* Latreille by a Hornet *(Vespa crabro* L.). It may seem that the thorax of an anisopteran is an unusually large food item for a wasp to carry back to the nest. Research work suggests, however, that carrying a load this large is not unusual. In a review of feeding and foraging by wasps, Spradberry (1973) quoted research work that showed that a worker of *V. germanica* is capable of carrying a load equal to half its body weight. During three days of predation on *Pieris* species larvae, two worker *V. germanica* collected 15 to 20g of butterfly meat.

It is noteworthy that all of the attacks on anisopterans described above occurred during July, August or September. This may reflect the abundance of Anisoptera and Vespidae species that are present in late summer, and also the high requirement for protein by a wasp colony during this period. From these observations it is clear that vespids can be efficient predators of at least medium-sized Anisoptera. It seems probable that the predation of Odonata by wasps may be more common than is suggested by the literature.

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Evidence for pH insensitivity in Odonata of peat pools

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Summary

There were no significant differences between odonate larval numbers in peat pools in a Galloway peat bog subject to liming and in the surrounding, untreated area. It appears that species typical of acidic conditions are insensitive to pH. The study also demonstrated the association of odonate larvae with steep-sided peat pools as opposed to shallower pools and flushes.

Introduction

Loch Fleet (National Grid Reference NX 559699) is a small loch on the granite massif of the Fell of Fleet. It is in an area of high acid deposition (United Kingdom Acid Waters Review Group, 1988), almost certainly as a result of which the loch lost its trout fishery in the early 1970s. The aim of the Loch Fleet project was to demonstrate that the water chemistry of a loch can be returned to a range suitable for trout to breed by liming the catchment rather than the loch waters direct, thus reversing the effects of acidification (Howells & Dalziel, 1992). One of the treatments, in April 1986, entailed distribution of 106 tonnes of limestone dust on to a bog (NX 561706) above the loch. This bog, at about 440m above sea-level, is 16km south-east of the Silver Flowe National Nature Reserve and has a similar insect fauna, though not *Aeshna caerulea* (Ström), a species that should have been detected during the frequent visits had it been there. This particular liming activity was most effective in maintaining the pH of the main feeder stream for the loch, which was the main spawning area for the newly established trout. It also provided an opportunity to study the effects of raised pH on the insect fauna of peat pools in the area.

Sphagnum species had been killed where directly exposed to limed water, but most of the *Sphagnum* above the usual level of standing water, and most other bog plants including the moss *Racomitrium lanuginosum*, Bog Heather (*Erica tetralix*), Bog Cotton (*Eriophorum vaginatum*), Round-leaved Sundew (*Drosera rotundifolia*) and Bog Asphodel (*Narthecium ossifragum*) were surviving three years after liming (Clymo *et al.*, 1992). Death of the *Sphagnum* had resulted in some erosion within gullies in the peat bog by 1992, but the pools of standing water retained a surface mat of disintegrated *Sphagnum* overlying peat, from which milky water with pH exceeding 8 exuded when disturbed by the weight of the observer. Otherwise the water was extremely clear, without the brownish 'humic' colouring of typical peat pool water. In 1990 it was noted that many supposedly acidophilous species of invertebrate were abundant in peat pools still subject to the effect of liming, and this observation initiated a study of insect abundance in limed and unlimed pools.

Methods

Using aerial survey photographs taken in 1981, a suite of untreated peat pools was identified from the surrounding fell for comparison with the limed peat bog. Methods of sampling invertebrates were compared in 1990. Timed sampling was found to be more practicable than area/volume sampling, as attempted by extraction of the material from large plastic cylinders (dustbins with their bottoms removed) driven into the bottoms of the pools. A 30-second sample with a 1mm mesh D-frame pond net produced sufficient data for analysis of the common species, whereas one-minute samples were too large for small peat pools and flushes, took too long to extract and reduced replication.

In August 1991 and August 1992 invertebrates were sampled in a total of 119 half-minute samples from pools and flushes in the treated area and from the surrounding area. The pH of the pools was tested to confirm that they were either affected by liming or untreated. The pH of some pools exceeded 8, and lime from partly emptied bags of dust was still present in and around several pools in 1992. The pH of untreated pools was generally about 4. Site descriptions were based on the depth of open water, pools readily dividing into those with steep, wind-eroded sides, and those shallower pools and gullies with thick beds of *Sphagnum*. Specific identifications were mainly of adult beetles and odonate larvae. Counts included prolarvae. No attempt was made to measure the age structure of the larval populations but it was noted that the largest counts, up to 70 individuals from a 30-second sweep, mainly comprised early instars. Adult Odonata were also noted from the area. Identification was achieved mainly in the field, but voucher samples of invertebrates were kept, a large sample of odonate larvae being checked by Mrs E. M. Smith, the Scottish National Recorder for Odonata.

Results

Adult Odonata in the area included *Libellula quadrimaculata* L., *Enallagma cyathigerum* (Charpentier) and *Lestes sponsa* (Hansemann) but only three species (*Aeshna juncea* (L.), *Sympetrum danae* (Sulzer) and *Pyrrhosoma nymphula* (Sulzer), were identified as larvae from

Table 1. Summary of counts of odonate larvae in 30-second net samplings of limed and unlimed peat pools, 1991 and 1992.

Treatment	Deep-edged pools						Shallow pools			
	Limed			Unlimed			Limed		Unlimed	
Total samples 1991	22			16			4		6	
	Total	Mean	S.E.	Total	Mean	S.E.	Total	Mean	Total	Mean
Pyrrhosoma nymphula	15	0.7	0.26	7	0.5	0.18	0	0	0	0
Sympetrum danae	8	0.4	0.20	3	0.2	0.01	0	0	0	0
Aeshna juncea	191	8.7	1.24	64	4.0	0.95	0	0	0	0
Total samples 1992	20			18			10		23	
	Total	Mean	S.E.	Total	Mean	S.E.	Total	Mean	Total	Mean
Pyrrhosoma nymphula.	9	0.4	0.18	26	1.4	0.34	1	0.1	0	0
Sympetrum danae	2	0.1	-	0	0	-	0	0	0	0
Aeshna juncea	36	1.64	0.20	163	9.1	4.02	0	0	0	0

timed samples (Table 1). *Lestes* larvae were detected in one large, unlimed pool in 1990 during development of the timed sampling method. No *A. caerulea* could be detected among the aeshnid larvae.

Detrended correspondence analysis (DECORANA) (Hill, 1979) of the data for all taxa identified two main types of community, that of the steepedged, deeper pools and that of flushes, gullies and shallow pools. Odonate larvae were almost entirely absent from the shallow pools (Table 1), the fauna of which was dominated by small beetles. Limed and unlimed site lists did not appear to form discrete groups on the basis of DECORANA site scores.

Single taxon data for limed and unlimed areas were compared within the two main community types. There were no significant differences in the counts of 47 invertebrate taxa (Odonata, Hemiptera and Coleoptera) between the limed and unlimed pools. Detailed analysis of the odonate larval counts included estimates of standard errors of the mean (Table 1) but these were inappropriate as the raw data were not normally distributed. Analysis of variance using counts transformed to logarithms also appeared inappropriate as the type of distribution, and the associated within-year, within-treatment variances could not be considered the same (Table 2). Thus the only method of analysis open was a non-parametric test; the H statistic of the Kruskal-Wallis test was non-significant for *Pyrrhosoma nymphula* and *Aeshna juncea*.

Table 2. Distributions of counts of larvae of *Aeshna juncea* in 30-second net samplings of limed and unlimed peat pools, 1991 and 1992.

Number in sample		0	1	2	3	4	5	>5
Year	Treatment				Frequency			
1991	limed	1	0	1	3	4	1	12
1991	unlimed	4	1	0	4	2	1	4
1992	limed	3	8	7	2	2	0	0
1992	unlimed	5	1	1	2	2	0	6

Discussion

Many of the taxa in this survey are generally considered to be 'acidophilous', including the Odonata. Water acidity is the one environmental variable that has consistently been reported as of prime importance in dictating the invertebrate communities associated with running water (e.g. Sutcliffe and Hildrew, 1989). Studies of stagnant water communities are less advanced, but the commonest physico-chemical variable measured in ecological studies is pH, the presumption being that it is in itself a crucial determining factor. Miller

(1987) identified pH as a major factor affecting the distribution of dragonflies, and he specifically mentioned the three species that were found in the timed samples of bog pools as being associated with acid bogs and peaty areas. Such species have continued to breed successfully in alkaline, calcium-rich habitats. Their association with acid water is not therefore because they are 'acid-loving' but because of some other factor, or combination of factors. One explanation would be that these species are dependent on a peat substrate. Two further explanations would be based on tolerance of either cool or nutrient-poor conditions. If one accepts that the three primary strategies for plant survival (competitiveness, and tolerance of either stress or disturbance, *sensu* Grime, 1977) also dictate invertebrate survival, then the stress-tolerant 'acidophiles' survive, or even benefit from, an episode of base and nutrient enrichment until or unless competitor species colonize the area. Some pioneer species of beetle and spider have occurred on the limed peat bog, along with some 'ruderal' plant species colonizing the dead *Sphagnum*. Assuming that deposits of lime associated with incompletely emptied sacks continue to affect the pH of the pools, it will be interesting to see if the pools are eventually occupied by species that out-compete the stress-tolerant species presently taking advantage of the moderated conditions of the bog.

There is surprisingly little information about the precise requirements of insects within bog pool complexes. The most detailed analysis is by Larson and House (1990), who identified two principal communities associated with a domed, ombrotrophic bog in Newfoundland. In large pools, odonate larvae were the dominant predators and comprised the majority of the standing crop, whereas the fauna of smaller pools was dominated by oligochaetes, beetles and mosquito larvae. Larson and House suggest that the difference is mainly due to the need for odonate larvae to take two or more years to complete their development, necessitating occupation of permanent water, as opposed to the temporary waters of shallow pools. The powerful predation pressure that they exert in these larger pools dictates the occurrence of other members of that community. This same major division between permanent and temporary pools (i.e deep-edged versus shallow pools) appears to occur in Scotland.

Acknowledgements

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Steve Brooks of the Natural History Museum, London originally suggested that these notes should be published and I take this opportunity to apologise to him for having delayed his own publication in an attempt to produce a joint communication. Graeme Ligertwood helped with the initial fieldwork and much of the rest of the fieldwork was done by Mrs Aileen Kelly, Mrs Susan Bone and Mlle Marie-Christine Paternelle. Finally, I am grateful to Mrs Betty Smith for help in identifying Odonata.

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Predation of a freshly-emerged zygopteran by a social wasp

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On 16 June 1990 I visited a well-established, artificially excavated pond at Castor Hanglands National Nature Reserve. While there, I noticed an unflown, recently-emerged damselfly which seemed to have not yet separated its wings. Within seconds of my seeing this individual, an unidentified social wasp (Vespidae) seized it and carried it high into the crown of a nearby tree. The wasp continued to manipulate the damselfly whilst perched and severed its wings which I saw flutter away.

I did not see what happened next but presumably, since social wasps feed their larvae on other insects and themselves on sugary substances, the wasp would have carried the damselfly back to the nest.

During the next forty-five minutes a social wasp was observed to fly in and out of the emergent vegetation in a pattern that suggested searching behaviour. Indeed this was almost certainly confirmed by the interest shown in any exuviae it encountered. Whilst the flight pattern threading through the emergent vegetation was a constant feature, it would also fly irregularly up and down individual stems. During this detailed searching, any exuviae found were approached closely and the wasp then hovered briefly, presumably whilst making a judgement on the nature of the exuviae. Whilst it was impossible to be absolutely certain that a single wasp was involved, only one individual was seen at a time, so it seems likely. No other captures were witnessed but after forty-five minutes, when I left the pool, the wasp was still searching.

Odonata face many hazards when emerging, and, if the regularly recorded predation by birds, spiders and ants were not enough, it appears that social wasps also take advantage of their vulnerability at this time.

Notes and observations

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My thanks to all who have contributed to this section; your records are much appreciated. Could I please have all records for the next Journal by 10 January 1995.

[To relieve pressure on space, the list of first and last dates of sightings has been omitted from this section on the recommendation of the Board of Trustees. It will appear, instead, in the Newsletter - Editors]

Odonata as predators and prey

On 28 June 1993 at Troy Mill GP, Hertfordshire, a male Black-tailed Skimmer *(Orthetrum cancellatum)* was seen eating a male Common Blue Damselfly *(Enallagma cyathigerum)*. (E)

On 16 July 1993 a teneral Black Darter (*Sympetrum danae*) flushed from vegetation at Latchmore Bottom, New Forest, was seized in flight by a male Stonechat. (E)

On two separate occasions on 31 May 1994 at Batchworth Heath, Hertfordshire, Large Red Damselflies (*Pyrrhosoma nymphula*) seized recently emerged Azure Damselflies (*Coenagrion puella*), and on one occasion the *Pyrrhosma* was seen to start eating the *Coenagrion*. (E)

Behaviour

At Hookagate near Shrewsbury, Shropshire, on an early morning (05.30) in June 1992, a male Banded Demoiselle (*Calopteryx splendens*) was found low down on heavily dewed grass. The insect had obviously been there all night as it too was covered in dewdrops. It was perched with its wings open flat, an attitude which the observer had not seen before or since. Photographs were taken. Other individuals were found perched in nearby vegetation with wings folded normally. How unusual is this phenomenon, and can anyone suggest a reason for this behaviour? The observer wonders if it is a mechanism to prevent the wings becoming stuck together and damaged. (F)

Range expansion

A Red-veined Darter *(Sympetrum fonscolombei)* was present at the Kenfig NNR on 1 July 1993. (C)

[Following the number of observations that were made of *fonscolombei* in 1993 and especially in 1992, observers should keep a good lookout as it would appear oviposition occurred.]

Records of a Beautiful Demoiselle *(Calopteryx virgo)* at Stover Lake, Devon on 4 September 1993, and Banded Demoiselle *(Calopteryx splendens)* at Chudleigh Knighton Heath, Devon, on 28 August 1993 and at Stover Lake on 4 September 1993, were from areas where these species are not normally noted. Two ovipositing Common Hawkers *(Aeshna juncea)* at Chudleigh Knighton Heath on 28 August 1993 were also unusual at this locality. (B)

The Red-eyed Damselfly *(Erythromma najas)* has been seen in 1994 at four sites in the Kidsgrove area of North Staffordshire, following a report of its presence in the area in 1993, which could mean a range expansion to this part of the county. (A)

In the review of *Suffolk Dragonflies* in the last Journal, mention is made of a colony of White-faced Darter *(Leucorrhinia dubia)*. Regrettably, there seem to have been no further reports from this Suffolk locality.

Mixed pairings

On 28 June 1994 at a pond in Elstree, Staffordshire, a Four-spotted Chaser *(Libellula quadrimaculata)* suddenly arrived and began flying around the pond, which measures c. 9m x 12m. Within a few seconds it was grabbed by the resident male Broad-bodied Chaser *(Libellula depressa)*, and attempted mating took place. The *quadrimaculata* then oviposited, with the *depressa* hovering above for part of the time. After this she perched for about a minute but as soon as she took flight the mating and ovipositing process was repeated. After this the *quadrimaculata* flew off. (D)

Requests for information

Work is in progress on compiling an atlas of the Odonata of Staffordshire, and any records of Odonata in the county, of any species and date, would be welcomed and appreciated. Please send all records to Neil Collingwood, 20 Dorridge Grove, May Bank, Newcastle, Staffordshire ST5 OHX.

Similar work is in progress in Surrey, and for this county please send records to Peter Follett, 105 Rickwood Park, Beare Green, Dorking, Surrey RH5 4PR.

List of observers

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(C) O. Leyshon, 55 Bowham Avenue, Bridgend, Mid-Glamorgan, Wales CF31 3PA.
(D) S. H. Murray, 184 Thirsk Road, Borehamwood, Hertfordshire WD6 5BD.
(E) J. Spooner, 41 Cranley Drive, Ruislip, Middlesex HA4 6BZ.
(F) I. Thompson, 6 Elstree Close, St. Peters Park, Meole Brace, Shrewsbury, Shropshire SY3 9QF.

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Book Review

Leicestershire Dragonflies. Steve Grover & Helen Ikin.
Leicestershire Museums Publication (1994)

64 pp. £6.50 (cheque made out to Leicestershire County Council). Available from Leicestershire Museum, Arts & Records Service, The Rowans, College St., Leicester LE2 0JJ.

Leicestershire Dragonflies concentrates on the county's sixteen breeding species and claims to be 'user friendly': a claim that is undoubtedly justified. Aimed at the novice, it could also be useful to the more knowledgeable. It includes a number of original features: simple symbols designed to give advice as to the habitat in which each species is most likely to be found; a 'rarity score' which gives an immediate indication of how common each species is within the county; and a simple but effective identification key.

While the illustrations are hardly works of art, their detail is good and they show and stress the important identification features of each of the county's common species. The rarer species are dealt with less fully but with sufficient detail to allow separation from the common ones. The distribution maps are a good size and the various other charts - some giving annual fluctuations in numbers, some the flight periods and others the percentage records per habitat - are definitely helpful.

The section on Life History is basic but adequate; that on Conservation contains much that is interesting, including good news regarding the slow but steady increase in the number of species in the county. It is a pity that, in the section on how to record and where to send records, readers are not encouraged to send records to the national recording scheme (O.R.S.) via the official Regional Recorder for Mid-east England (Steve Cham) as well as to the county records centre.

Twenty-two of the United Kingdom's 39 species of Odonata have been recorded from Leicestershire, sixteen of which occur regularly and are known to have bred. The county provides a good number of excellent habitats (lakes and reservoirs, ponds, flowing water, canals) and boasts the largest number of BDS members living in a single county. It was time that Leicestershire was represented in the ranks of regional books and the authors are to be congratulated on providing such a welcome addition to the list.

Jill Silsby

INSTRUCTIONS TO AUTHORS

Authors are asked to study these instructions with care and to prepare their manuscripts accordingly, in order to avoid unnecessary delay in the editing of their manuscripts.

Manuscripts should be typewritten using black ribbon, double-spaced, on one side of the page only and with margins at least 25 mm at the left, top and bottom; text pages should be numbered. Footnotes should be avoided.

Words that are to appear in italics (e.g. names of genera and species, though not of families) should be underlined.

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

Dates in the text should be expressed in the form: 24 July 1994.

References cited in the text should be in the form '(Longfield, 1949)' or '...as noted by Longfield (1949).' All references cited in the text (and only these) should be listed alphabetically at the end of the article in this form:

Hammond, C.O. 1983. *The dragonflies of Great Britain and Ireland*. 2nd edition (revised by R. Merritt). Harley Books, Colchester. 116 pp.

Longfield, C. 1949. The dragonflies of the London area. *The London Naturalist* 28: 90–98.

Titles of journals should be written out in full.

Tables should be typed, each on a separate, unnumbered page.

Legends for illustrations should be typed together in sequence on a single unnumbered page.

Illustrations (figures) should be prepared in black ink, and scaled to allow a reduction of 1.5 to 3 times. Lettering should be neat and uniform.

The legend for each table and illustration should allow its contents to be understood fully without reference to the text. The approximate position of each table and figure should be indicated in the text.

SCIENTIFIC AND ENGLISH NAMES OF BRITISH ODONATA

ZYGOPTERA	DAMSELFLIES
Calopteryx virgo	Beautiful Demoiselle
Calopteryx splendens	Banded Demoiselle
Lestes sponsa	Emerald Damselfly
Lestes dryas	Scarce Emerald Damselfly
Platycnemis pennipes	White-legged Damselfly
Pyrrhosoma nymphula	Large Red Damselfly
Erythromma najas	Red-eyed Damselfly
Coenagrion mercuriale	Southern Damselfly
Coenagrion scitulum	Dainty Damselfly
Coenagrion hastulatum	Northern Damselfly
Coenagrion lunulatum	Irish Damselfly
Coenagrion armatum	Norfolk Damselfly
Coenagrion puella	Azure Damselfly
Coenagrion pulchellum	Variable Damselfly
Enallagma cyathigerum	Common Blue Damselfly
Ischnura pumilio	Scarce Blue-tailed Damselfly
Ischnura elegans	Blue-tailed Damselfly
Ceriagrion tenellum	Small Red Damselfly

ANISOPTERA	DRAGONFLIES
Aeshna caerulea	Azure Hawker
Aeshna juncea	Common Hawker
Aeshna mixta	Migrant Hawker
Aeshna cyanea	Southern Hawker
Aeshna grandis	Brown Hawker
Anaciaeschna isosceles	Norfolk Hawker
Anax imperator	Emperor Dragonfly
Hemianax ephippiger	Vagrant Emperor Dragonfly
Brachytron pratense	Hairy Dragonfly
Gomphus vulgatissimus	Club-tailed Dragonfly
Cordulegaster boltonii	Golden-ringed Dragonfly
Cordulia aenea	Downy Emerald
Somatochlora metallica	Brilliant Emerald
Somatochlora arctica	Northern Emerald
Oxygastra curtisii	Orange-spotted Emerald
Libellula quadrimaculata	Four-spotted Chaser
Libellula fulva	Scarce Chaser
Libellula depressa	Broad-bodied Chaser
Orthetrum cancellatum	Black-tailed Skimmer
Orthetrum coerulescens	Keeled Skimmer
Sympetrum striolatum	Common Darter
Sympetrum nigrescens	Highland Darter
Sympetrum fonscolombei	Red-veined Darter
Sympetrum flaveolum	Yellow-winged Darter
Sympetrum sanguineum	Ruddy Darter
Sympetrum danae	Black Darter
Leucorrhinia dubia	White-faced Darter

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