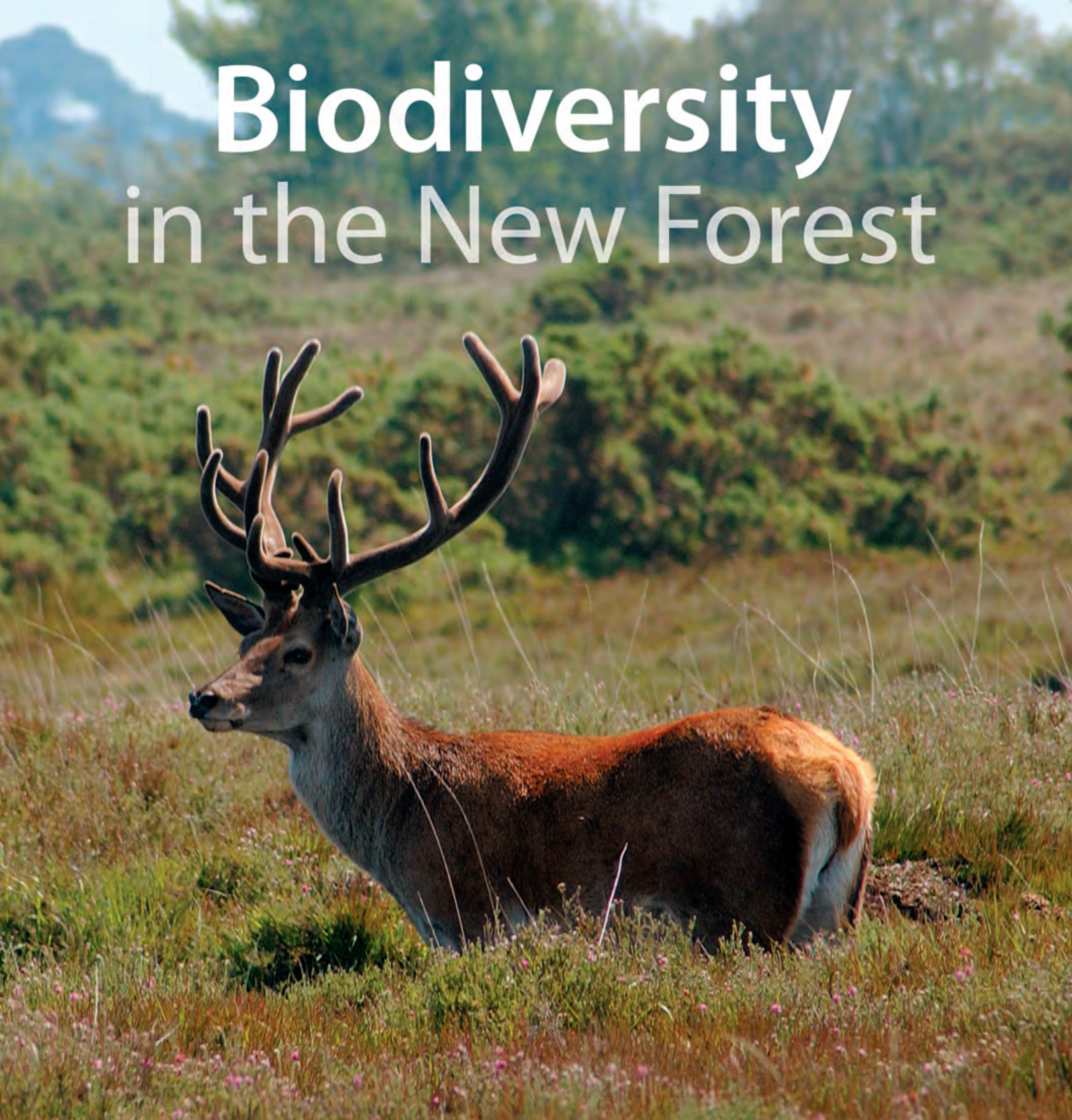
Biodiversity in the New Forest



Edited by Adrian C. Newton



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Dedicated to the memory of
Muriel Eliza Newton (1929–2009),
who loved the New Forest,
especially the donkeys.

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Back cover: Wood Crates (Adrian Newton)

The maps in this book are for illustrative purposes only, and do not represent the legal definition of National Park boundaries or any other feature

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4 Dragonflies and damselflies

David J. Thompson and Phillip C. Watts

In this chapter we discuss the odonate (dragonfly and damselfly) diversity of the New Forest from a UK perspective, specifically addressing the issue of why there are more species than might be expected given the area and latitude of the National Park. Second, we consider those species resident in the New Forest that are of conservation interest nationally. Finally, we examine in detail the jewel in the crown of the New Forest's odonates, southern damselfy *Coenagrion mercuriale*, which is rare, threatened and protected throughout Europe, and for which the New Forest is an internationally important area.

The New Forest as an area for odonate diversity

The New Forest is a hotspot of biodiversity for dragonflies and damselflies, with 31 of the UK's 45 resident species breeding there. These species are listed in Table 10, together with a broad guide to their habitat and their conservation status within the UK and locally. The Odonata is essentially a tropical group of insects so it is not surprising that the numbers of species found in the UK decreases as latitude increases. Figure 18 shows the numbers of species of odonates recorded on the British Dragonfly Society's database per 10 km square. The most diverse 10-km squares, those that contain between 25 and 33 species, are largely found in southern England and include the whole of the New Forest. However, the diversity observed in the New Forest is not solely a function of latitude, but is also determined by the diversity of freshwater habitats found within the New Forest National Park.

During the Victorian heydays of insect collecting the New Forest was largely famed, with respect to

Table 10
The breeding dragonflies and damselflies of the New Forest together with their broad habitat type and their current UK IUCN threat category, after Daguet *et al*. (2007) and an assessment of their national and local status after Taverner *et al*. (2004)

Family	Species	Habitat	2007 IUCN threat category	2004 status
Calopterygidae	Banded demoiselle *Calopteryx splendens*	Stream		
	Beautiful demoiselle *Calopteryx virgo*	Stream/river		
Lestidae	Emerald damselfly *Lestes sponsa*	Pond		
Platycnemidae	White-legged damselfly *Platycnemis pennipes*	River		CR
Coenagrionidae	Azure damselfly *Coenagrion puella*	Pond		
	Variable damselfly *Coenagrion pulchellum*	Pond	NT	NS, CR
	Southern damselfly *Coenagrion mercuriale*	Stream/valley mire	EN	IR, CS
	Common blue damselfly *Enallagma cyathigerum*	Pond		
	Blue-tailed damselfly *Ischnura elegans*	Pond		
	Scarce blue-tailed damselfly *Ischnura pumilio*	Stream/valley mire	NT	NS, CS
	Large red damselfly *Pyrrhosoma nymphula*	Pond		
	Red-eyed damselfly *Erythromma najas*	Pond		
	Small red-eyed damselfly *Erythromma viridulum*	Pond		
	Small red damselfly *Ceriagrion tenellum*	Valley mire		NS
Aeshnidae	Emperor dragonfly *Anax imperator*	Pond		
	Common hawker *Aeshna juncea*	Pond		
	Southern hawker *Aeshna cyanea*	Pond		
	Brown hawker *Aeshna grandis*	Pond		
	Migrant hawker *Aeshna mixta*	Pond		
	Hairy dragonfly *Brachytron pratense*	Pond		NS, CS
Cordulidae	Downy emerald *Cordulia aenea*	Pond		NS
Gomphidae	Club-tailed dragonfly *Gomphus vulgatissimus*	River	NT	NS County extinct?
Cordulegasteridae	Golden-ringed dragonfly *Cordulegaster boltonii*	Stream		
Libellulidae	Four-spotted chaser *Libellula quadrimaculata*	Pond		
	Broad-bodied chaser *Libellula depressa*	Pond		
	Scarce chaser *Libellula fulva*	River	NT	NR, CR
	Keeled skimmer *Orthetrum coerulescens*	Valley mire		
	Black-tailed skimmer *Orthetrum cancellatum*	Pond		
	Common darter *Sympetrum striolatum*	Pond		
	Ruddy darter *Sympetrum sanguineum*	Pond		
	Black darter *Sympetrum danae*	Pond		

2007 IUCN threat category: EN=endangered, NT=near threatened,
2004 status: NR=nationally rare, NS=nationally scarce, CR=county rare, CS=county scarce and IR=internationally rare; blank indicates 'least concern' (2007) or 'not listed' (2004).

aquatic insects, for species occupying running water. In the 1920s and 1930s manual drainage schemes and in the 1950s and 1960s mechanical drainage schemes changed the character of many New Forest streams for the worse (see also Chapter 15). The canalisation of streams and the formation of levees were detrimental to several odonate species, most notably club-tailed dragonfly *Gomphus vulgatissimus* and white-legged damselfly *Platycnemis pennipes*.

The New Forest also contains a selection of other good odonate habitats. The Forest never contained natural large ponds or lakes. Three of the most notable large water bodies are all artificial. Eyeworth Pond was constructed in the early part of the 18th century to provide a head of water for a gunpowder mill (see Chapter 15). Hatchet Pond, probably the best known of the Forest's large ponds, was constructed at the end of the 18th century by building a causeway to dam Hatchet Stream, which runs off Beaulieu Heath. The original aim was to flood a series of gravel and marl pits (see below) and provide another hammer mill. Sowley Pond began life as a 14th century monastic fish pond. By the 18th century it, too, served as a hammer pond for an ironworks. Sowley Pond occurs on a private estate and even the eminent entomologist Col. F.C. Fraser feared being 'pulled over as a trespasser' if he ventured too close (cited in Taverner *et al*. 2004). Each of these ponds contributes to the odonate diversity of the Forest. Eyeworth and Sowley are to a large extent wooded (as is Hatchet to a lesser extent), and all three hold good populations of downy emerald *Cordulia aenea*. In addition Eyeworth holds the Forest's largest population of red-eyed damselfly *Erythromma najas*, while Sowley is the only known site in the Forest for the nationally declining variable damselfly *Coenagrion pulchellum*; it also contains the scarce but increasing hairy dragonfly *Brachytron pratense*.

There are many collections of marl pits scattered around the Forest. A loamy clay was extracted from these pits, but the practice effectively ceased at the beginning of the 20th century and the pits, once excellent habitat for odonates, generally became covered by scrub unless actively managed. During World War II more small ponds were created by German bombers depositing unused bombs prior to leaving England. Their fate mirrors that of the marl pits; they are extant if managed. A further source of small ponds appeared in the 1960s when 'flight' ponds

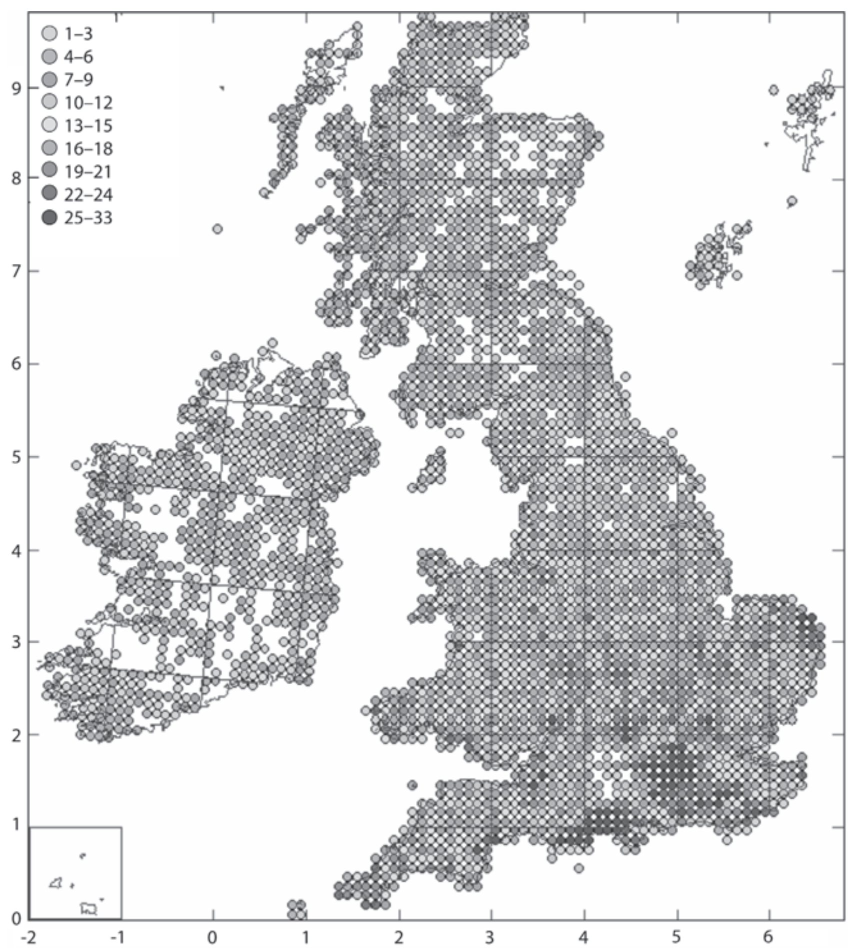


Figure 18
The diversity of odonate species in the British Isles by 10-km square (from the British Dragonfly Society database, with permission).

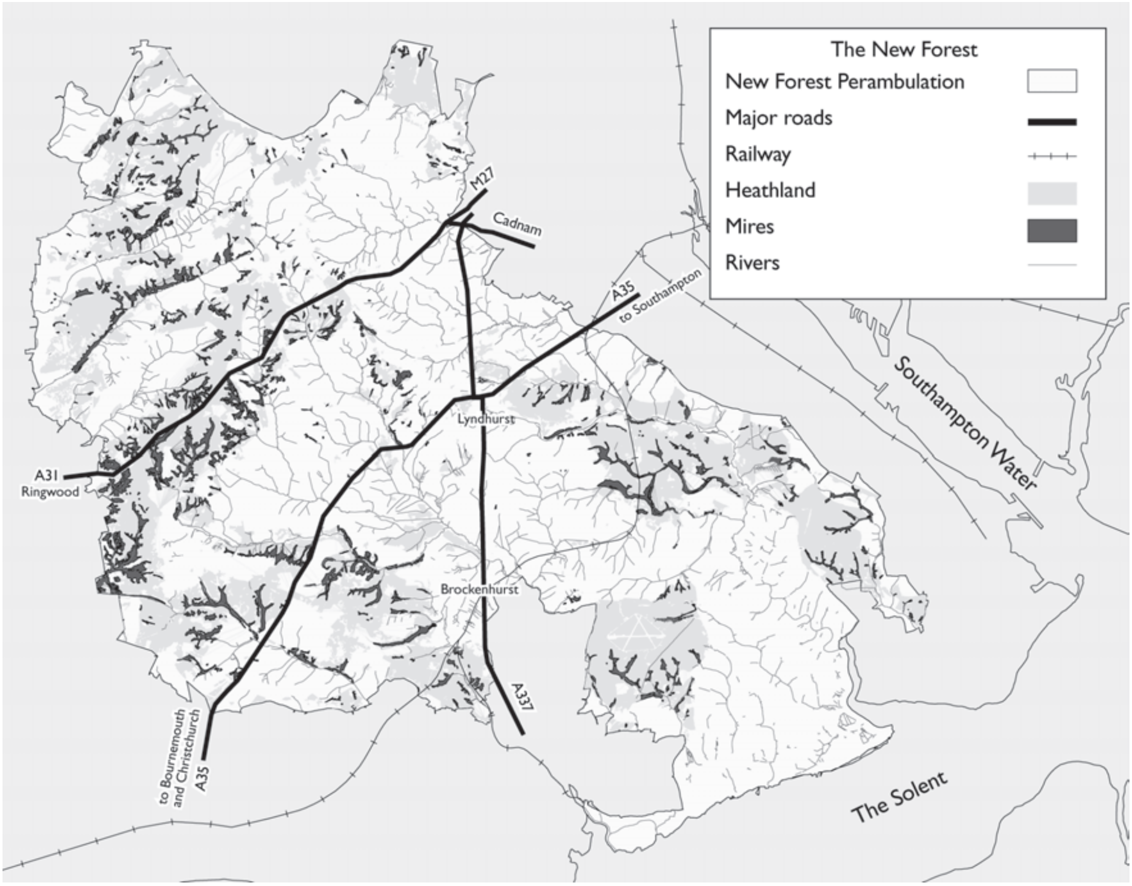


Figure 19
The distribution of heathland, valley mires and major streams within the New Forest. From Taverner *et al*. (2004).

were dug, usually at the head of valley mires, in order to attract wildfowl. Some of these proved to be excellent ponds for odonates. Finally, gravel extraction for building work around the periphery of the Forest has left a large number of gravel pits, many of which have become excellent wildlife habitat. Some of these lakes provide a source of dragonflies that would otherwise be rare in the Forest (Taverner *et al.* 2004), notably brown hawker *Aeshna grandis* and migrant hawker *A. mixta*.

Since the onset of Inclosures in the Forest in 1851, odonate habitats have been in something of a state of flux. The one constant feature of the New Forest's odonate habitats has been the valley mires. Figure 19 shows the distribution of streams and valley mire habitat. It is within these mires that the species of highest conservation value are to be found, and are what really separates the New Forest from the rest of southern Britain.

Odonates of national conservation interest

Taverner *et al.* (2004) quote Fraser in stating (of club-tailed dragonfly *Gomphus vulgatissimus*) *'its true home is in the New Forest where, in the course of a morning's walk, more specimens may be seen than the total records for the whole of the other localities'*, meaning the rest of the UK. As if to demonstrate that fact, he took 120 specimens himself in 1935! The last substantial records came in 1959, when 38 exuviae were found upstream of Puttles Bridge. It is considered extinct in the Forest at present, although there are three records that date back to as recently as 1990–1996 (Figure 20). The canalisation and levees referred to above gave rise to scrub along the most appropriate streams for this species and rendered them unsuitable. The same is also true for another riverine/stream species, white-legged damselfly, which Fraser also described as a common insect in the Forest, particularly on the Ober Water and parts of the Avon Water. This species is still hanging on at one or two locations on the Ober Water.

Scarce chaser *Libellula fulva* is essentially a species of river floodplains, water meadows and, increasingly frequently, gravel pits. It is not mentioned at all by Fraser (1950), but there have been more records in the New Forest in recent years (Figure 21). Unlike club-tailed dragonfly, which is declining nationally, scarce chaser is increasing and the extensive gravel pits referred to above have probably contributed to the number of sightings within the Forest. The stronghold for scarce chaser in the region is the Moors River, which is just outside the National Park to the west.

Variable damselfly is a nationally scarce species and is declining. Its UK distribution (Figure 22) is patchy, scattered over many parts of England and Wales, and extending into Scotland (Brooks and Lewington 2002). Often colonies are restricted to small areas that seem outwardly no different to the surrounding countryside. Water quality is thought to be a determining factor in their long term persistence. Goodyear (1989) found variable damselfly on Sowley Pond and this remains the only Forest record, though there are occasional records from sites bordering the Forest. Although there has been speculation that its decline is the result of hybridisation with azure damselfly *C. puella*, this is considered highly unlikely (Lowe *et al*. 2008).

Scarce blue-tailed damselfly *Ischnura pumilio* occurs in shallow water with a low flow-rate, at a variety of natural and man-made sites. It is an enigmatic damselfly. Fraser (1941) commented: '*I do not know of any other British dragonfly which has offered so much difficulty in identification or over which so many errors have been made*'. At the end of the 19th century, it was considered by Lucas (1900) to be almost extinct in Britain. However, records suggest that historically it was more widespread than records account for, owing

Figure 21
The distribution in 10-km squares of scarce chaser *Libellula fulva* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

(a)

(b)

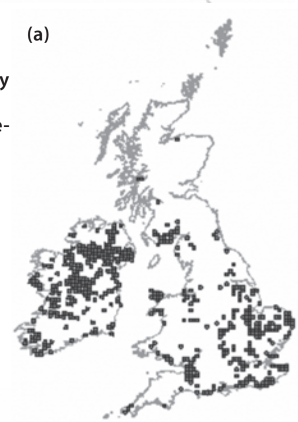
Figure 20
The distribution in 10-km squares of club-tailed dragonfly *Gomphus vulgatissimus* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

(a)

(b)

Figure 22
The distribution in 10-km squares of variable damselfly *Coenagrion pulchellum* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

(a)



(b)

to the small-scale and transient nature of its preferred habitat (Figure 23).

Fox and Cham (1994) concluded that the important habitat features for scarce blue-tailed damselfly in the UK are low water velocity, a limited amount of emergent vegetation for oviposition without the water becoming 'choked' with plants, and a varying but considerable degree of habitat disturbance. In fact it seems this species responds exceptionally well to disturbance, particularly that caused by human activity. Numerous colonies have been recorded in areas of mineral extraction, where shallow springs and pools are formed with little vegetation cover, but conditions can be highly unstable (Fox and Cham 1994). In these artificially created sites, colonies rarely persist for more than a few years as vegetation soon encroaches, particularly where water flow is low. However, where there is a continual supply of water and a degree of openness is maintained, persistence is increased (Fox and Cham 1994). The openness is maintained in the Forest by grazing by ponies, deer and cattle. What some see as overgrazing in the Forest, and therefore a bad thing, is advantageous to those species whose abundance depends on the prevalence of early successional habitat. Scarce blue-tailed damselfly is one such species.

Small red damselfly *Ceriagrion tenellum* is the third damselfly species, along with scarce blue-tailed and

Figure 24
The distribution in 10-km squares of small red damselfly *Ceriagrion tenellum* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

(a)

(b)

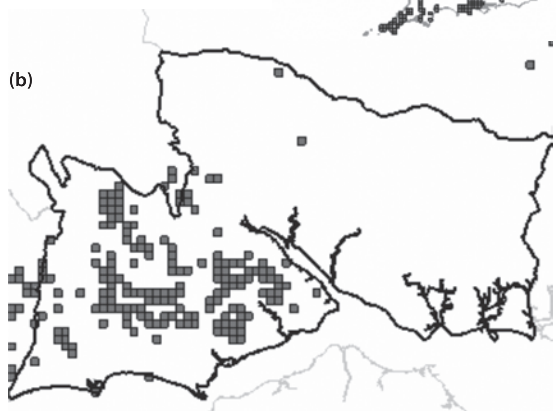
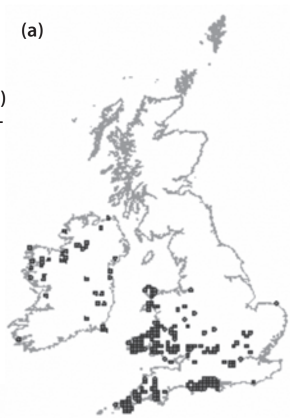


Figure 23
The distribution in 10-km squares of scarce blue-tailed damselfly *Ischnura pumilio* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

(a)



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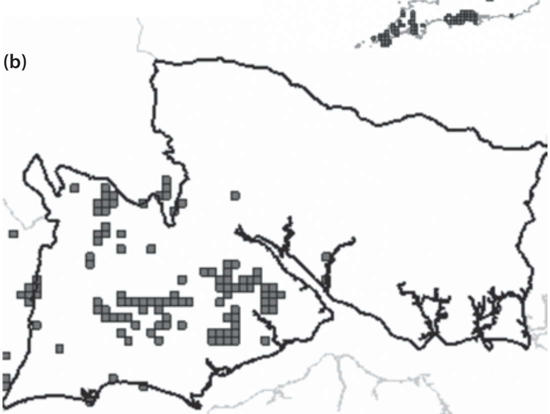
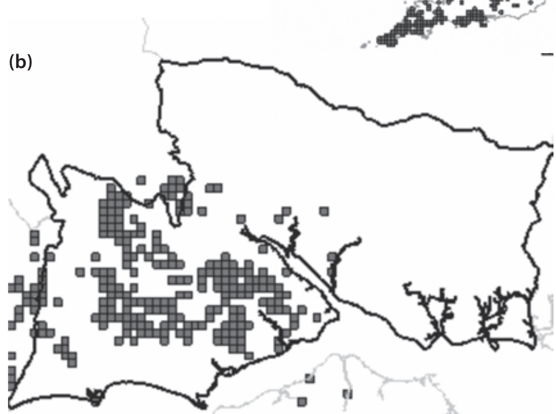


Figure 25
The distribution in 10-km squares of keeled skimmer *Orthetrum coerulescens* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

(a)

(b)



southern damselflies, that is found in the Forest's valley mires. Its distribution in the UK (Figure 24) indicates that it is nationally threatened, and its distribution within the Forest follows closely that of the valley mires (Figure 19). Like southern and scarce blue-tailed damselflies, it is essentially a Mediterranean species, which is on the edge of its range in the UK. Unlike the other two its larvae are often found among *Sphagnum* mats, so that it can emerge from areas without standing water.

Keeled skimmer *Orthetrum coerulescens* is the dragonfly most closely associated with the valley mires and found with the three damselflies described above (Figure 25). It is locally common in the Forest and forms an important food source for one of the Forest's specialist birds of prey, the hobby (see Chapter 1).

The most important odonate species in the New Forest from a national and international perspective is southern damselfly. This species has been the subject of intensive research in the past 10 years, some of which is summarised in the next section.

Southern damselfly

This section is concerned with the population structure of southern damselfly in its UK stronghold, the New Forest. This species has a somewhat fragmented population structure throughout its European range and this is even more apparent at its range margin in the UK. Some preliminary results from a multi-site mark–release–recapture (MRR) project are discussed together with genotype data at 14 genetic markers (microsatellite loci). Together, the results give an indication of the likely structure of the New Forest populations both from short-term (ecological) and historical (genetic) perspectives. They also point the way towards resolving potential conservation problems in the medium to long term.

Southern damselfly is one of Europe's highest-profile damselfly species from a conservation perspective. It is restricted at both global and national scales. It is mainly limited to the south and west of Europe and has populations of unknown status in northern Africa. Populations in Italy and northern Africa consist of different subspecies (*Coenagrion mercuriale castellani* and *C. m. hermeticum*, respectively) to those found in the rest of Europe (Askew 1988). Southern damselfly is protected within Europe as a whole and several European countries have taken complementary legislative measures for protection at a national or regional level. The UK distribution of southern damselfly is shown in Figure 26. There are population strongholds in the New Forest, the Test and Itchen Valleys, the heathlands of Dorset and the Preseli hills of Pembrokeshire, with isolated populations in Anglesey, the Gower, Oxfordshire, the east Devon pebble beds and Dartmoor. The species has suffered a 30% decline in UK distribution since 1960 (Thompson *et al.* 2003). It has been lost from Cornwall, some Devon and Dorset sites and from St. David's peninsula in Pembrokeshire. Even within the New Forest it has disappeared from some sites (Blackwell Common, Rowbarrow Pond, Applemore Stream, the Forest's most easterly sites) since the last exhaustive survey (Stevens and Thurner 1999).

Estimates of population size

Southern damselfly on Beaulieu Heath inhabits a network of small flushes, runnels and streams that may be subdivided into seven central areas and four peripheral sites (Figure 27). A mark–release–recapture (MRR) programme was undertaken on Beaulieu Heath in 2002. It operated over five weeks during the peak of the flight season and employed 16 field assistants. It was the largest odonate MMR study ever attempted. As well as marking animals by writing numbers on the wing at each capture and subsequent recapture, the

Figure 26
The distribution in 10-km squares of southern damselfly *Coenagrion mercuriale* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. Note that *C. mercuriale* also occurs in the water meadows surrounding the Rivers Test and Itchen, its only riverine UK sites. The different shades of the symbols represent different centres of population and are retained in later analysis (see Figure 30). (Data for (b) from the NBN Gateway, http://data.nbn.org.uk/).

exact location of each animal was recorded using a Global Positioning System (GPS) calibrated to the UK Ordnance Survey. The estimates of daily population size (±SE) at Beaulieu Heath are shown in Figure 28. The numbers of males reached a maximum of some 5,000–6,000 individuals per day (during late June). Using a mean mature adult lifespan of 5.93 days provided an estimate of the total number of individuals on Beaulieu Heath during the summer of 2002 of 39,913. This calculation is based on the 10,259 (4,158) individuals actually marked (and recaptured) during the study. The relative population sizes at each Beaulieu Heath sub-site (Figure 27) were estimated as the proportion of marked animals at each site. The smallest populations were at the peripheral sites Bagshot Moor, Greenmoor and Hatchet Stream.

Figure 27
Location and movement of southern damselfly *Coenagrion mercuriale* between subsites on Beaulieu Heath, New Forest. The diameter of the circles represents the estimated population sizes of the sites. The arrows indicate the direction and the number of individuals that moved.

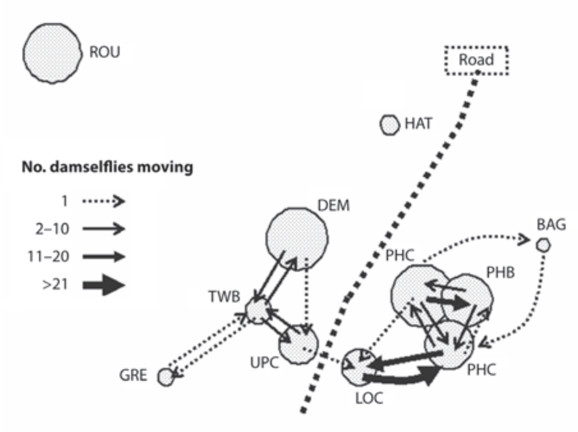
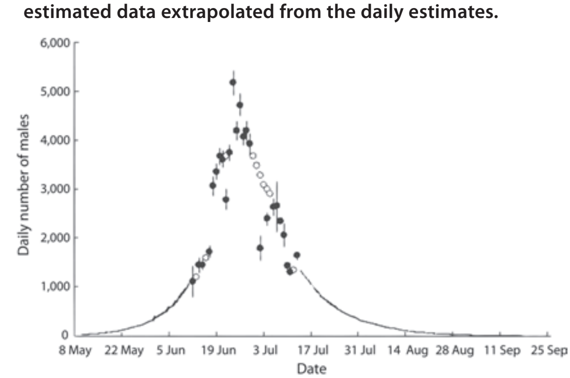


Figure 28
Daily estimates (± standard errors) of male population size of southern damselfly *Coenagrion mercuriale* on Beaulieu Heath, New Forest, southern England. Estimates were made by using a full Jolly–Seber model. Open circles and solid line are estimated data extrapolated from the daily estimates.



These data suggest that the Beaulieu Heath metapopulation is relatively healthy. It is likely that habitat loss/degradation poses a more immediate threat to the persistence of this species at Beaulieu Heath. These data on Beaulieu Heath are the only quantitative estimates of the abundance of southern damselfly anywhere in the UK (or indeed the rest of its European range). There is a clear need for future work to correlate these estimates of population size with standardised transect counts so that the population demography of this species may be monitored with some quantitative meaning.

Pattern of movement

In the MRR study we were looking primarily at the dispersal potential of southern damselfly in heathland. The overall pattern of movement between the sub-sites on Beaulieu Heath (Figure 27) resulted in a limited interchange among most pairs of populations, except among the three Peaked Hill sites and Lower Crockford. Interchange was limited to neighbouring areas in almost all cases. The large population at Round Hill (NW of Beaulieu Heath) and the next most northerly population at Hatchet Stream proved to be isolated, at least during the present study. The central sites on Beaulieu Heath are bisected by a road (Figure 27) that did not prevent movement. This finding was in agreement with Purse *et al.* (2003) who also recorded movement across the road. However, dispersal was limited to a single individual and only in the direction indicated. Single damselflies were observed moving in and out of the small, isolated populations at Greenmoor and Bagshot Moor.

Figure 29 shows net lifetime movement (defined as the distance between first and last sighting) of mature adult (both sexes) of southern damselfly on Beaulieu Heath in the New Forest. Seventy per cent of mature adults moved less than 50 m in their mature adult lifetimes and 85 % moved less than 100 m. However, five individuals (0.12 %) moved more than 1 km, with 1.25 km the greatest distance moved in this study. In a parallel study in the more linear habitat of water meadow ditch systems the pattern was generally similar, with the longest recorded distance being 1.79 km (Watts *et al.* 2004c).

Southern damselfly is a species that occurs in an even more fragmented landscape than most other damselfly species because of its rather particular habitat requirements (Thompson *et al.* 2003). It is one of the smallest of the blue damselflies and body size has been correlated with dispersal capability in some odonates (Conrad *et al.* 1999, Angelibert and Giani 2003). From the present study and that of Purse *et al.* (2003) it is clear that most individuals do not move more than 100 m during their mature adult lifespans. There was relatively little movement between many of the patches of suitable habitat connected by the same stream (which provided a corridor for movement), and where movement was observed, it was almost exclusively between adjacent sites (Figure 10). Given that many sites are separated by more than several kilometres of unsuitable (forested) habitat, we would

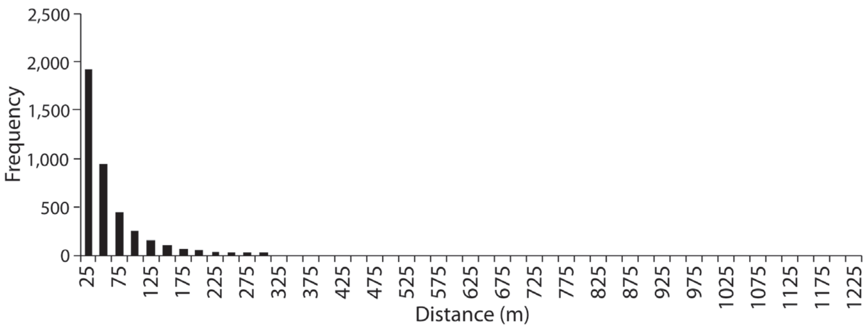


Figure 29
Net lifetime movement in mature adult southern damselfly *Coenagrion mercuriale* on Beaulieu Heath in the New Forest.

expect to find a large number of more or less isolated populations within the New Forest and this is supported by genetic analysis (see below). On the other hand, although most individuals do not move far, a small percentage does move up to about 1.2 km; if these animals breed then gene flow between sites separated by 1–2 km seems assured. Rouquette and Thompson (2007) in a parallel study in the Itchen Valley, in a water meadow ditch system surrounding chalk streams, found similar patterns of movement. Hunger and Röske (2001) also observed limited movement by adult southern damselflies.

Population genetic structure

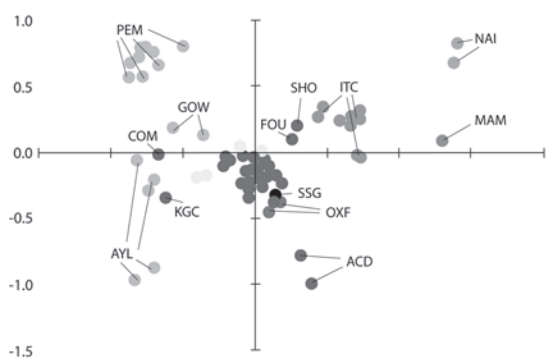
We took tissue samples from up to 90 individuals from all of the UK's southern damselfly populations. One hind leg per individual was taken and stored in 100% ethanol until analysis. Full details of the PCR and genotyping procedures using an automated sequencer are given by Watts *et al*. (2004a, b, c). We have used the microsatellite data in two ways. First, by principal components analysis (PCA). A plot of the sample scores (eigenvectors) of significant principal components offers a convenient representation of the overall spatial variation in data as long as the principal components still account for a significant amount of the total between-sample variation. Second, the population genetic structure of the New Forest samples was assessed in more detail using the model-based clustering approach implemented by STRUCTURE v. 2.0 (Pritchard *et al*. 2000). This approach simultaneously identifies clusters (populations) and assigns individuals to populations using a Bayesian approach.

The first two principal components (Figure 30) accounted for 24% and 17% of the variation within the data and were significant ($P < 0.001$ for each axis). The PCA plot is based on allele frequencies, that is, shared or similar alleles. It has little real 'genetic interpretation' other than that more closely related populations might be expected to share alleles. The New Forest populations generally occur in the centre of the plot because they contain more genetic variation than other populations. Those from Dorset are the closest in allele frequencies to the majority of the New Forest populations and there is some overlap. In general, populations from similar geographical areas have, for the most part, clustered together (Figure 30). For example, the Pembrokeshire populations are grouped in the top left quadrant, while small, isolated populations fall furthest away from the New Forest, for example, with the Anglesey population (2002 and 2003 datasets) falling in the top right of the top right quadrant. There are, however, some exceptions whereby some New Forest populations are separate, notably Acres Down, Shobley, Common Moor and Kingston Great Common, while at least one isolated population, Oxfordshire (2002 and 2003 datasets), is positioned with the main New Forest cluster (Figure 30).

With respect to the New Forest itself, the lowest posterior probability of the data (PPD) indicate that the New Forest appears to contain five distinct genetic 'clusters' (average Ln PPD = -30,991 for K=5). The three 'best defined' clusters (with regard to the proportion of membership of individuals) include samples identified by PCA (Figure 30) as being quite distinct: Acres Down, Shobley and Common Moor. Also similar to the latter sample are other populations that drain into

Figure 30
Principal components analysis plot showing spatial pattern of allele frequencies in the UK southern damselfly *Coenagrion mercuriale* populations. The coloured symbols reflect different centres of population. One French population (from Normandy – SSG) is also plotted. Two Devon populations (Moortown Gidleigh Common and Aylesbeare Common), the Anglesey and Oxfordshire populations have two points representing sampling across two years.

PEM=Pembrokeshire, GOW=Gower, FOU=Foulford, SHO=Shobley, ITC=Itchen Valley, NAI= Anglesey, MAM=Mariner's Meadow, COM=Common Moor, KGC=Kingston Great Common, OXF=Oxfordshire, AYL=Aylesbeare Common, ACD=Acres Down.



Mill Lawn Brook (the Ober Water) plus Stony Moors. The fourth cluster comprises populations at Setley Plain, Three Beech Bottom, Widden Bottom, and also Kingston Great Common. The final cluster includes samples from Gypsy Hollies and Foulford and almost 'by default', a poorly defined group comprising all Beaulieu Heath sites that were included in the MRR study. Future analyses will determine whether the northern populations flowing into Millersford Brook and Latchmore Brook proves to be distinct or not. With caution, these data may be summarised by the proportion of membership of individuals from each of the predefined populations to each of the five model clusters. Again, the most distinct populations are Acres Down, Common Moor and Shobley where 82%, 78% and 67 % of individuals respectively are assigned to a particular cluster. Individuals from three sites (Mill Lawn, Stag Brake Bog, Stony Moors) near Common Moor are also predominantly assigned (26–37%) to the 'Common Moor' cluster, while those from Setley Plain form the fourth group whereby 42–48% of individuals from the samples are assigned to that cluster. In contrast, both Foulford and Kingston Great Common sites show genetic differences to nearby populations. The Beaulieu Heath samples are similar in that they all show no strong affinity to any of the five model clusters; hence, while two Peaked Hill sites appear to be similar to the 'Acres Down' cluster this simply reflects some 3% of the sample (c.1 individual) clustering with Acres Down rather than within the 'Foulford – Kingston Great Common' group.

A more detailed look at the New Forest highlights the effects of genetic drift, but at a more localised scale. The Beaulieu Heath sites, separated by several kilometres, were not all linked during the MRR study but are indistinguishable genetically. This indicates that this population is behaving like a metapopulation with the strong central sub-sites providing a source for the smaller peripheral sites. It is important to recognise that apparently separated populations will not show substantial genetic divergence when there is gene flow between intermediate populations. Appropriate management of streams (cutting down trees and shrubs) so that ponies can get closer to graze, at further peripheral subsites, is likely to lead to re-establishment of southern damselfly there. The population at the apparently isolated site of Round Hill does not show substantial genetic differentiation, probably because it is large and also as there has been insufficient time for substantial genetic drift. We do not exclude the possibility (more so for Hatchet Stream) that there is occasional immigration from the main Beaulieu Heath populations. The Setley Plain and Mill Lawn clusters probably behave in a similar way.

The two populations that seem not to resemble any others, Acres Down and Shobley, are particularly interesting. Acres Down is a small isolated population, at a higher altitude (70 m) than any of the other New Forest populations. The site is small, never likely to have held a large population, and was probably founded by a few individuals and seldom replenished genetically, if at all. We do not know whether southern damselfly in this or even other small, isolated sites (Watts *et al*. 2005) suffer from inbreeding depression, but if so its long-term survival would probably be enhanced by translocation of individuals from the nearest, genetically similar populations at Beaulieu Heath. The Shobley population is more 'problematic'. Although no MRR study or monitoring work has ever been carried out there (the site was only discovered in 2002), it is a large population. It is less than 1 km from the Foulford site (also discovered in 2002) but separated by a long high ridge carrying the main trunk road through the New Forest. The Shobley and Foulford sites are genetically dissimilar. Some combination of the ridge and road are evidently a barrier to movement between these two sites. Here, the effect of the road as a barrier contrasts with movement observed on the Crockford stream (see also Watts *et al*. 2004c) where water flow was still maintained between 'separated' sites by a bridge.

To summarise, in the UK southern damselfly exists as a number of isolated population fragments at the northern edge of its distribution. This species is a relatively sedentary damselfly, a characteristic that combined with specialised habitat requirements makes it susceptible to the detrimental effects of habitat loss and fragmentation. Despite concerns about its conservation, MRR data reveal the New Forest to sustain a large population. Bayesian genetic analysis provides evidence that the New Forest stronghold is subdivided into several distinct genetic units and this needs to be considered for future biodiversity management.

Acknowledgements

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