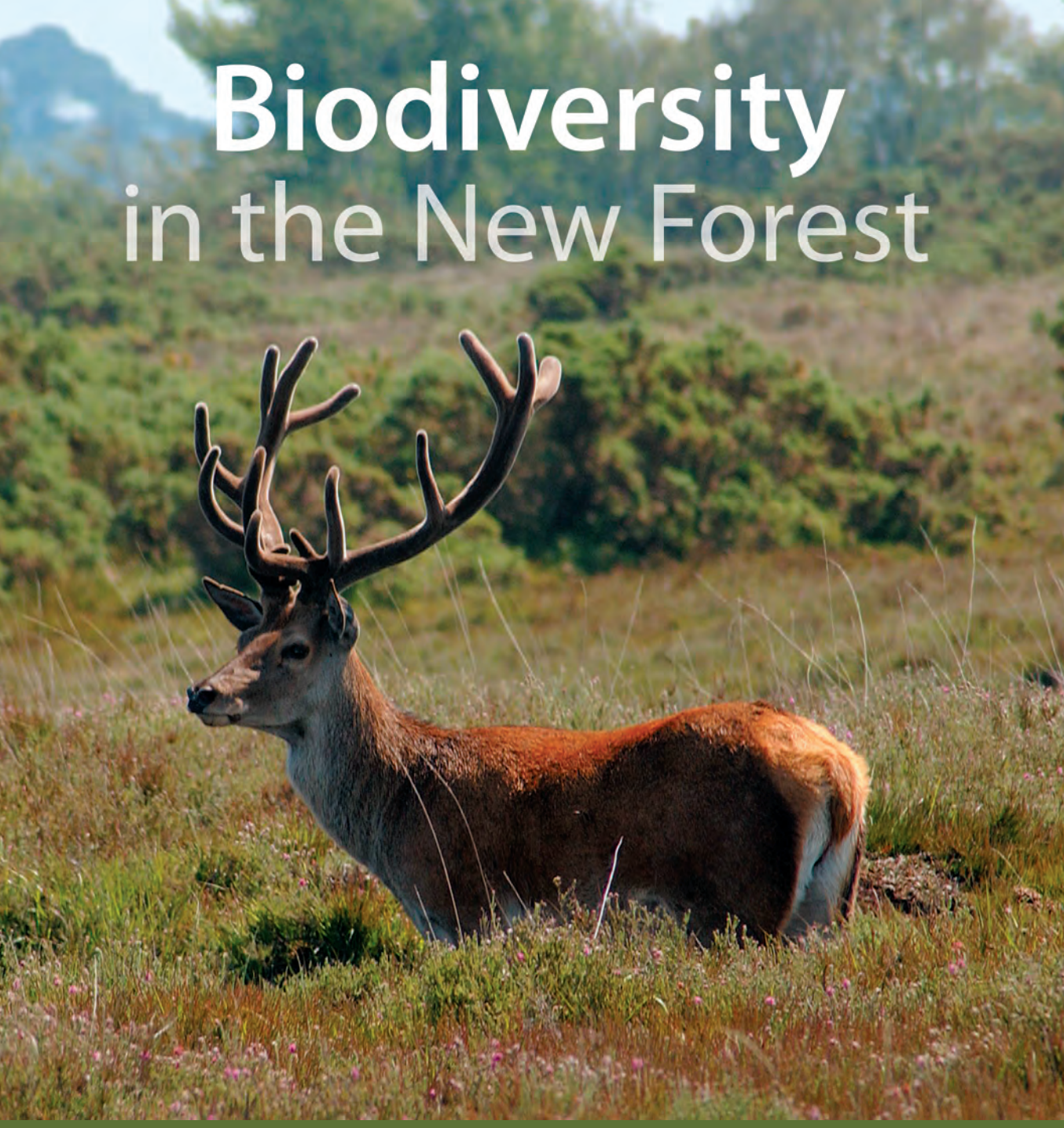
Biodiversity in the New Forest



Edited by Adrian C. Newton

Biodiversity in the New Forest

Edited by
Adrian C. Newton

Centre for Conservation Ecology and Environmental Change,
School of Conservation Sciences,
Bournemouth University,
Poole,
Dorset,
United Kingdom

pisces publications

Newbury, Berkshire

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

First published 2010.

British-Library-in-Publication Data
A catalogue record for this book is available from the British Library.

ISBN 978-1-874357-42-1

Designed and published for Bournemouth University by Pisces Publications

Pisces Publications is the imprint of NatureBureau, 36 Kingfisher Court, Hambridge Road, Newbury, Berkshire RG14 5SJ
www.naturebureau.co.uk

Printed by Information Press, Oxford

Cover photographs
Front cover: Red deer *Cervus elaphus* (Isobel Cameron / Forest Life picture library, Forestry Commission); noble chafer *Gnorimus nobilis* (Matt Smith); Dartford warbler *Sylvia undata* (David Kjaer); wild gladiolus *Gladiolus illyricus* (Adrian Newton)
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

Contents

v **Contributors**

vii **Preface**
Adrian C. Newton

1 **Chapter 1. Birds**

3 **A. Bird monitoring in the New Forest: a review of current and ongoing schemes**
Greg Conway, Simon Wotton and Adrian C. Newton

11 **B. Bird monitoring in the New Forest: raptors**
Andrew Page

21 **Chapter 2. Bats**
Colleen Mainstone

32 **Chapter 3. Reptiles and amphibians**
Martin Noble

36 **Chapter 4. Dragonflies and damselflies**
David J. Thompson and Phillip C. Watts

46 **Chapter 5. Saproxylic beetles**
Keith Alexander

54 **Chapter 6. Butterflies and moths**
Andrew J. Barker and David Green

58 **Chapter 7. The New Forest cicada and other invertebrates**
Bryan J. Pinchen and Lena K. Ward

65 **Chapter 8. Vascular plants**
Martin Rand and Clive Chatters

84 **Chapter 9. Lichens**
Neil A. Sanderson

112 **Chapter 10. Fungi**
Adrian C. Newton

123 **Chapter 11. Bryophytes**
Rod Stern

124 **Chapter 12. The condition of New Forest habitats: an overview**
Elena Cantarello, Rachel Green and Diana Westerhoff

132 **Chapter 13. The condition and dynamics of New Forest woodlands**
Adrian C. Newton, Elena Cantarello, Gillian Myers, Sarah Douglas and Natalia Tejedor

148 **Chapter 14. The effects of grazing on the ecological structure and dynamics of the New Forest**
Rory Putman

157 **Chapter 15. Biological diversity in New Forest streams**
Terry Langford, John Jones, Samantha Broadmeadow, Patrick Armitage, Peter Shaw and John Davy-Bowker

173 **Chapter 16. A pooled history of temporary pond research in the New Forest**
Naomi Ewald, Sue Hartley and Alan Stewart

183 **Colour plates**

199 **Chapter 17. The contribution of the LIFE II and III projects to wetland conservation in the New Forest**
Tim Holzer and Maxine Elliott

202 **Chapter 18. Biodiversity in the New Forest: a National Park perspective**
Stephen Trotter and Ian Barker

212 **Chapter 19. Managing the New Forest's Crown lands**
Jane Smith and Libby Burke

218 **Chapter 20. Synthesis: status and trends of biodiversity in the New Forest**
Adrian C. Newton

229 **Afterword**
Clive Chatters

232 **Index**

Contributors

Keith Alexander, 59 Sweetbrier Lane, Heavitree, Exeter, Devon EX1 3AQ.

Patrick D. Armitage, Freshwater Biological Association, Moor House, Field Station, Garrigill, Alston, Cumberland DL12 0HQ.

Andrew J. Barker, 13 Ashdown Close, Chandler's Ford, Eastleigh, Hampshire SO53 5QF.

Ian Barker, New Forest National Park Authority, South Efford House, Milford Road, Everton, Lymington, Hampshire SO41 0JD.

Samantha Broadmeadow, Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH.

Libby Burke, Forestry Commission, The Queen's House, Lyndhurst, Hampshire SO43 7NH.

Elena Cantarello, Centre for Conservation Ecology and Environmental Change, School of Conservation Sciences, Bournemouth University, Poole, Dorset BH12 5BB.

Clive Chatters, c/o Hampshire and Isle of Wight Wildlife Trust, Beechcroft, Vicarage Lane, Curdridge, Hampshire SO32 2DP.

Greg Conway, British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU.

John Davy-Bowker, Centre for Ecology and Hydrology, c/o Freshwater Biological Association, East Stoke, Wareham, Dorset BH20 6BB.

Sarah Douglas, Centre for Conservation Ecology and Environmental Change, School of Conservation Sciences, Bournemouth University, Poole, Dorset BH12 5BB.

Maxine Elliott, Environment Agency, Solent and South Downs Office, Colvedene Court, Colden Common, Hampshire SO21 1WP.

Naomi C. Ewald, Department of Biology and Environmental Science, School of Life Sciences, University of Sussex, Falmer, Brighton, Sussex BN1 9QG.

David Green, Butterfly Conservation, The Cottage, West Blagdon, Cranborne, Dorset BH21 5RY.

Rachel Green, Natural England, 1 Southampton Road, Lyndhurst, Hampshire SO43 7BU.

Sue E. Hartley, Department of Biology and Environmental Science, School of Life Sciences, University of Sussex, Falmer, Brighton, Sussex BN1 9QG.

Timothy Holzer, Environment Agency, Solent and South Downs Office, Colvedene Court, Colden Common, Hampshire SO21 1WP.

John G. Jones, Centre for Environmental Sciences, School of Civil Engineering and the Environment, University of Southampton, Highfield, Southampton, Hampshire SO17 1BJ.

Terry Langford, Centre for Environmental Sciences, School of Civil Engineering and the Environment, University of Southampton, Highfield, Southampton, Hampshire SO17 1BJ.

Colleen Mainstone, Hampshire Bat Group, 42 Saxon Way, Halterworth, Romsey, Hampshire SO51 5QY.

Gillian Myers, Centre for Conservation Ecology and Environmental Change, School of Conservation Sciences, Bournemouth University, Poole, Dorset BH12 5BB.

Adrian C. Newton, Centre for Conservation Ecology and Environmental Change, School of Conservation Sciences, Bournemouth University, Poole, Dorset BH12 5BB.

Martin Noble, New Forest Ecological Consultants, Keepers Cottage, Holmsley, Burley, Ringwood, Hampshire BH24 4HY.

Andrew Page, Forestry Commission, The Queen's House, Lyndhurst, Hampshire SO43 7NH.

Bryan J. Pinchen, 7 Brookland Close, Pennington, Lymington, Hampshire SO41 8JE.

Rory Putman, Keil House, Ardgour by Fort William, Inverness-shire PH33 7AH.

Martin Rand, South Hampshire Vice-county Recorder, Botanical Society of the British Isles, email: vc11recorder@hantsplants.org.uk.

Neil A. Sanderson, Botanical Survey and Assessment, 3 Green Close, Woodlands, Southampton, Hampshire SO40 7HU.

Peter Shaw, Centre for Environmental Sciences, School of Civil Engineering and the Environment, University of Southampton, Highfield, Southampton, Hampshire SO17 1BJ.

Jane Smith, Forestry Commission, The Queen's House, Lyndhurst, Hampshire SO43 7NH.

Rod Stern, British Bryological Society, 15 Selham Close, Chichester, West Sussex PO19 5BZ.

Alan J. A. Stewart, Department of Biology & Environmental Science, School of Life Sciences, University of Sussex, Falmer, Brighton, Sussex BN1 9QG.

Natalia Tejedor, Centre for Conservation Ecology and Environmental Change, School of Conservation Sciences, Bournemouth University, Poole, Dorset BH12 5BB.

David J. Thompson, School of Biological Sciences, University of Liverpool, Crown Street, Liverpool, Lancashire L69 7ZB.

Stephen Trotter, New Forest National Park Authority, South Efford House, Milford Road, Everton, Lymington, Hampshire SO41 0JD.

Lena K. Ward, 53 Miles Avenue, Sandford, Wareham, Dorset BH20 7AS.

Phillip C. Watts, School of Biological Sciences, University of Liverpool, Crown Street, Liverpool, Lancashire L69 7ZB.

Diana Westerhoff, Natural England, 1 Southampton Road, Lyndhurst, Hampshire SO43 7BU.

Simon Wotton, Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL

3 Reptiles and amphibians

Martin Noble

Introduction

Geographically, the New Forest is situated in one of the warmest parts of the United Kingdom. However, it has a very poor reptilian and amphibian fauna when compared with the rest of Europe. Even countries with a climate similar to that of the UK, such as The Netherlands, have more species. This of course is mainly due to the fact that the UK is an island, and the natural return of animals exterminated during the last Ice Age was prevented when the land bridge with Europe was finally flooded by rising sea levels, roughly 7,000 years ago. As well as being relatively warm, the New Forest has another advantage in that much of its vegetational structure is relatively stable. This particularly suits the native herpetofauna, which does not cope well with dramatic changes in habitat. The Forest is also well protected by UK legislation, although local constraints on management do not always work in favour of the herp species.

This chapter provides an overview of the current status and trends of reptiles and amphibians in the New Forest. As well as containing 12 of the 13 native herp species (Table 9), there have been several introductions of European species to the New Forest in recent years, a few of which have become well established; these are also considered below.

Table 9
Reptiles and amphibians recorded in the New Forest.

Amphibians
Native species
Common frog *Rana temporaria*
Pool frog *Pelophylax lessonae*
Common toad *Bufo bufo*
Natterjack toad *Epidalea calamita***
Smooth newt *Lissotriton vulgaris*
Palmate newt *Lissotriton helveticus*
Great crested newt *Triturus cristatus*
Non-native species
Marsh frog *Pelophylax ridibunda*
Edible frog *Pelophylax esculenta*
American bull frog *Lithobates catesbeianus***
European tree frog *Hyla arborea***

** species thought now to be extinct in the New Forest

Reptiles
Native species
Slow worm *Anguis fragilis*
Common lizard *Zootoca vivipara*
Sand lizard *Lacerta agilis*
Adder *Vipera berus*
Grass snake *Natrix natrix*
Smooth snake *Coronella austriaca*
Non-native species
European wall lizard *Podarcis muralis*
Red-eared slider *Trachemys scripta*

The following non-native species have been recorded in the UK but not so far recorded in the New Forest

Amphibians
Yellow-bellied toad *Bombina variegata*
European midwife toad *Alytes obstetricans*
Alpine newt *Mesotriton alpestris*

Reptiles
European green lizard *Lacerta bilineata*
Aesculapian snake *Zamensis longissima*

Amphibians

Common frog

This species is widely distributed throughout the New Forest. It has been recorded as breeding in c. 70 ponds in the Forest and often spawns in garden ponds. Males and females gather together in large numbers in breeding ponds in February or March. One or two of the ponds have large aggregations in excess of 2,000 individuals but usually numbers are much lower. Spawning ponds are often ephemeral and dry up during summer. However the water in these ponds heats up more quickly than the deeper, more permanent ponds, and development of the tadpoles is much faster. In addition ponds that dry up seasonally generally have fewer predators, such as water beetle and dragonfly larvae, and the tadpole metamorphosis success rate is therefore higher. A wide range of pond pH of 4.5–8.5 has been recorded.

Pool frog

The pool frog was not recognised as a native species in the UK until 2000. Sadly the one and only native population, in Norfolk, became extinct at the same time. Since then English Nature (now Natural England) have established a reintroduction programme at the last known UK site, using stock from Scandinavia. In the meantime, unofficial introductions have been occurring for many years elsewhere in England, and the species is fast becoming established in the UK. Some of these introductions have resulted in breeding success in the New Forest, where it coexists with the closely related edible frog.

Common toad

The common toad is locally common in the New Forest, recorded as breeding in c.50 ponds. It is rather more particular about the water quality of its breeding ponds, where a pH range of 5.5–8.0 has been recorded. The tendency of toads to return to breed in the pond where they were born themselves results in some very large mating aggregations. Over 1,000

individuals have been recorded in one pond, most of which were males. In common with many other parts of the UK, numbers have fallen since 1990 for reasons as yet unknown, although research into the possibility of a chytrid fungus being a cause is ongoing.

Natterjack toad

A few early records exist of this species, from Beaulieu and Holmsley in 1946 (B.R.C.) and c.1980 near Burley (D. Thomson, pers. comm.). However, there have been no recent records and the species is now believed to be extinct in the New Forest. There is good terrestrial habitat with sandy substrate and short grazed grass in many places in the Forest, but sadly most ponds on sandy habitat are very acidic and are consequently unsuitable for natterjack breeding. Colonies have been successfully re-established in nearby parts of Dorset, so there may be some prospect of a reintroduction in the New Forest.

Smooth newt

The smooth newt is not common in the New Forest. It has been recorded from only 24 of 144 ponds surveyed. It is far more common in gardens on the more fertile soils around the perimeter of the Forest. Most of the records are from the south-west corner of the Forest where the Headon Clay beds lie close to the surface. A water pH range of 5.6–8.5 has been recorded in inhabited ponds.

Palmate newt

This is by far the most common newt in the New Forest and it is also the smallest of the three native species. It can tolerate a wide range of water quality and has been found in ponds ranging between pH 4.5 and 8.0. Often it is the only amphibian found in valley mire ponds. Some ponds on the more fertile soils may contain many hundreds of individuals.

Great crested newt

The great crested newt is the largest and rarest of the three native species of newt. It has been recorded from 17 ponds in the New Forest plus two on private land. Most of the breeding ponds are on the Headon Clay beds, especially in old marl pits, where a water pH range of 5.6–8.5 has been recorded. The largest population recorded was c.100 individuals.

Marsh and edible frogs

These frogs are natives of Europe but not of the UK. The edible frog is a hybrid between the native pool frog and the marsh frog. Both have been introduced, sometimes in large numbers, to various parts of England over many years and they are now well established, especially in parts of the south-east. There are small populations of each in various ponds in the New Forest. In Western Europe the edible frog tends to coexist with the pool frog, and there is some suggestion that the same scenario is developing in the New Forest.

European tree frog

The tree frog is another introduced species, although there have been claims that it may be native to the New Forest. Anecdotal records suggest that it was brought from somewhere in Europe to a property on the edge of Beaulieu in the early part of the last century, but the first written record is from a Forest pond near Beaulieu in 1962. Between 1962 and 1986 it occurred regularly in or near this pond, but since then there have been no sightings there. However between 1986 and 1993 there were a number of confirmed sightings in various other parts of the Forest. As its name suggests, the species is largely arboreal, favouring thorny shrubs, presumably for protection from predators. The males have a very loud call and gather around the breeding ponds at night during May and June. In Europe it is a great traveller, and populations tend to move frequently from pond to pond. It now appears to be extinct in the New Forest.

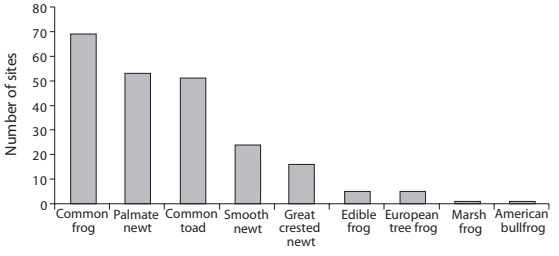
American bull frog

The bull frog was introduced in large numbers, mainly as tadpoles, into the pet trade during the 1980s. Unfortunately, while attractive as tadpoles, they are more of a problem when fully grown adults, and many were simply released once they matured. There were a number of reports from garden ponds in the Lymington area during the 1990s, although no evidence of breeding there. However the species appears to have bred successfully on one occasion in a fish hatchery near Sway. Fortunately the owners of the property soon recognised the problem and dealt with it in a rather extreme but effective manner, by draining the breeding pond and later by shooting the returning adults. Importation to the UK is now banned except under licence but individuals may still survive, although there has been no evidence of breeding in recent years. They are large and effective predators and can pose a serious problem for native wildlife. There have been very few reports from the New Forest proper, but one was heard calling from Setley Pond in 1998.

Pond surveys

Between 1986 and 1990, I surveyed some 144 ponds for the presence or absence of amphibians. Measurements of the pH of the water in some of the ponds were taken at the same time. Figure 17 shows the number of ponds occupied by each of the species identified.

Figure 17
Amphibians recorded in a survey of 144 ponds in the New Forest in the years 1986–1990.



Reptiles

Slow worm
The slow worm is probably the most common reptile in the UK. Recent clearance work involving reptiles on building development sites indicates that even quite small suburban gardens can contain as many as 50 individuals. It is also common in the New Forest, although probably at relatively low densities owing to the poor quality of the soils.

Common lizard
This species is the most frequently seen reptile in the New Forest, although its elusive nature makes it difficult to spot. It is easiest to see in the spring when the males spend more time basking in the sun. It is most frequently found on heathland or woodland margins and is a swift coloniser of clear-fell woodland sites. Females retain their fertilised eggs within the body until they are ready to hatch, which insulates them from many of the adverse environmental factors that affect egg-laying species.

Sand lizard
The sand lizard was extinct over most of its natural range in the UK, including the New Forest, by c.1970. It survived only in parts of Dorset, Surrey and coastal Lancashire. Inappropriate habitat management, principally large-scale heather burning, has been identified as the main cause of its demise in the New Forest. Other factors include afforestation of its heathland habitat and loss of open sand needed for egg-laying. In some parts of the Forest these adverse factors have been eliminated, and a captive breeding programme funded by Natural England and administered by the Herpetological Conservation Trust has now enabled it to be reintroduced to most of its former range. Lizards are bred in captivity and 950 young animals have been released at six selected sites in the south-west of the Forest. These emerging populations are closely monitored with regular transects being walked at each site at three key times of the year. The continued survival of the species has been boosted by strong legal protection and extensive habitat management.

European wall lizard
This species is very common throughout mainland Europe where, as its name implies, it is often associated with man-made structures. More close to home it is native to Jersey and Guernsey in the Channel Islands, and there is a population at Ventnor on the Isle of Wight where written records go back as far as 1841. Colonies elsewhere appear to be of more recent origin, for example Isle of Portland, first recorded in 1986; and Canford Cliffs, Poole, first recorded in 1992. It is now widespread along the Dorset coastline between Southbourne and Portland, with many other smaller colonies scattered throughout England and Wales. Its presence in the New Forest is confined to several gardens, but with no indication so far of colonisation of the surrounding habitat.

European green lizard
This species is native to mainland Europe and Jersey and many attempts have been made over the years to introduce it to England. Most of these have failed, but an attempt at an introduction onto the cliffs at Bournemouth appears to have been more successful. The first recorded breeding there was in 1998. It is an impressive-looking lizard, although surprisingly elusive for such a large animal. So far there have been no records from the New Forest.

Red-eared slider
The red-eared slider, sometimes called the red-eared terrapin, is a North American species that was introduced to the UK via the pet trade around the time of the childrens' craze of *Mutant Ninja Turtles* on television. Most imports were of hatchlings that often quickly outgrew their accommodation and were released by their owners into the countryside. Importation is now controlled, but many already exist in the wild in the UK. There have been no reported cases of successful breeding in the wild but the species is regarded by many as an unwanted predator of native wildlife, especially aquatic larvae. It has been recorded from most of the larger ponds in the New Forest.

Adder
The adder is the only venomous snake in the UK and is locally common in the New Forest. Its bite, although painful and potentially fatal, usually responds well to modern treatments, provided that medical attention is sought at the earliest opportunity. Local hospitals claim not to keep records of people bitten by snakes but telephone discussions I had a few years ago with their registrars suggested that fewer than 50 people were admitted with adder bites in any one year. None of these was reported to have died. However, dogs are more frequently bitten and there are a number of fatalities each year, despite warnings from the Forestry Commission about keeping dogs on leads. The adder's habitual use of traditional hibernating sites makes it relatively easy to locate in the spring. It also exhibits regular seasonal movements between winter and summer areas, which assist monitoring (Dr D. Bull, pers. comm.).

Grass snake
The grass snake is the largest British snake, females often growing up to 1 m in length. It is common throughout the New Forest but is rather elusive and well camouflaged. It is generally associated with aquatic habitats where its prey, predominantly amphibians, can be found. Its habit of seeking out warm places such as compost heaps in which to lay its eggs means that the females are often found in gardens in the summer, where they are often mistaken for adders. They are great travellers and are known to travel considerable distances annually between feeding, egg-laying and hibernating areas.

Smooth snake
This species is widely distributed throughout dry heathland habitats in the New Forest, although

nowhere is it very common. It does not compete well with other predators in woodland edge habitats where small mammals are relatively common, but it finds less competition in the extensive dry heathlands where the common lizard is the main vertebrate source of food. The Herpetological Conservation Trust are undertaking a Forest-wide survey of the species, as yet unpublished, which is producing some very useful information on distribution and population size.

New Forest habitats for reptiles and amphibians

Introduction

It is believed by many that the vegetation structure of the UK in Mesolithic times, largely unaltered by humans and extensively grazed by large herbivores, would probably have resembled parts of the present-day New Forest with its patchwork mosaic of woodland, scrub, heathland, grasslands and valley mires. The open structure produced by grazing provides a superb range of habitats for most reptile and amphibian species. In Open Forest areas the vegetation is largely managed by the grazing animals, with minimum need for human interference. However, human intervention still plays a part, for example:

- Most of the amphibian breeding ponds are the result of past human activity, mainly resulting from extraction of minerals such as gravel and marl.
- The present area of heathland is heavily managed by cutting and burning to maintain its existing form.
- Formation of emergent woodland is discouraged by regular felling of pioneer tree species.
- In the Inclosures, management for commercial tree growing has a major impact on the natural vegetation.

However, most of these activities have a beneficial or neutral effect on our native reptiles and amphibians, with the exception of heathland management, which can be very damaging if carried out to excess.

Heathland

Arguably heathland is the most important single habitat, especially for the rare reptiles. It suffers considerable extremes of weather conditions but this is not a problem for reptiles, which can hibernate during the cold periods in winter and take advantage of the extreme heat for developing their embryos. Botanically it has low species diversity but the open structure of the dwarf shrub vegetation provides ideal reptile habitat. On the other hand, poor quality soils result in low productivity of prey, except in late summer when the heather comes into flower. Again this is not necessarily a problem for reptiles, which concentrate their feeding to this time of year.

In the New Forest the two rarest reptiles are dependent on areas of dry heathland. Management techniques of cutting and burning this habitat are controversial and can adversely affect reptile populations. Insensitive burning can be damaging and has already arguably caused the extinction of the sand lizard. However, recent interpretation of the European Habitat Regulations by Natural England suggests that future management of the habitats of the two rare reptiles will need to be much more focused in the New Forest than at present.

Wetlands

In general, the extensive valley mires are too acid for amphibian breeding. Few ponds occur naturally since the extinction of the beaver several hundred years ago; however, the ponds created in the more recent past by the digging of marl or gravel have assumed greater importance for amphibian breeding. Ponds on the Open Forest are well maintained by regular grazing, avoiding the need for much human interference (see also Chapter 16). However, some of the marl pits have become overgrown in recent years and an ongoing programme of scrub and tree clearance has been instigated by the Forestry Commission in association with Natural England and the Hampshire Wildlife Trust. A few new ponds have been created in suitable areas, mainly to benefit the populations of great crested newts. The day-to-day management of the Forest is carried out by the Forestry Commission with advice and support from Natural England and the New Forest Verderers.

Conclusions

The New Forest is one of the most important areas for reptiles and amphibians in the UK, with all except one of the native species present in good numbers. The mosaic of different habitats provides a wide variety of opportunities for both reptiles and amphibians. However, over management of habitats for other species groups can and does impact adversely on reptile population size and may be in breach of the European Habitat Regulations. Heathland management programmes in particular need refining to ensure minimum damage to habitat structure and to minimise the killing of reptiles. Continued grazing by large herbivores is, however, recognised as an essential element of the management programmes for all habitats. The proposed reintroduction of the beaver to England will hopefully in the future provide a wealth of new ponds suitable for amphibian breeding sites.

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

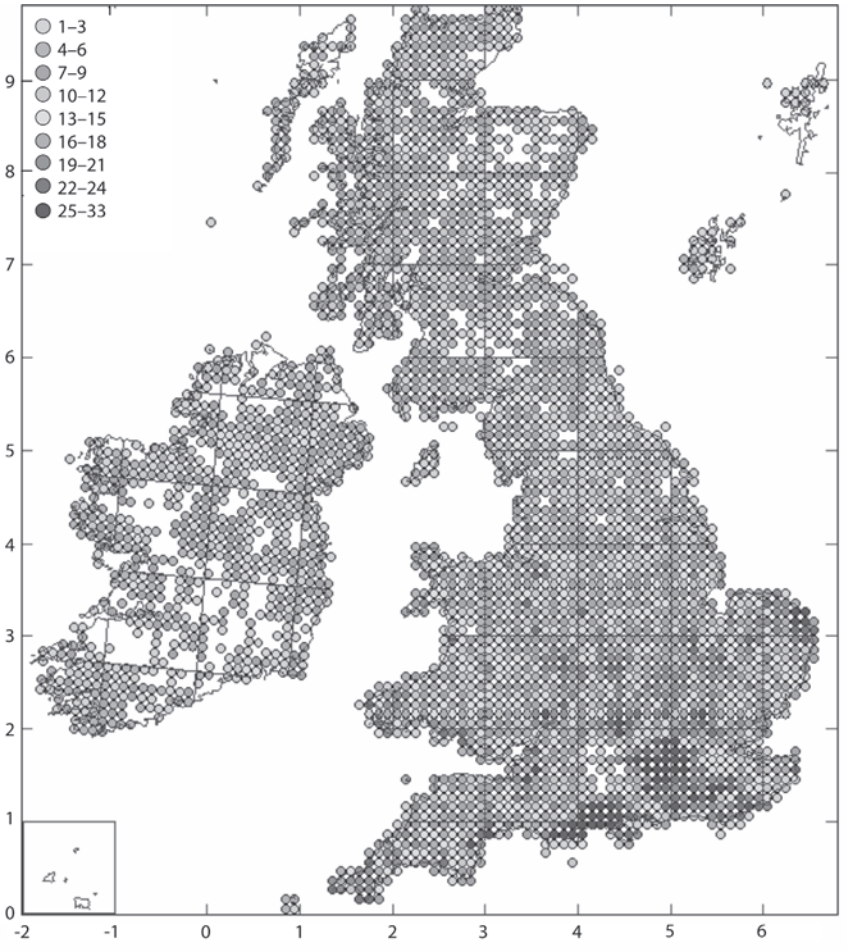


Figure 18
The diversity of odonate species in the British Isles by 10-km square (from the British Dragonfly Society database, with permission).

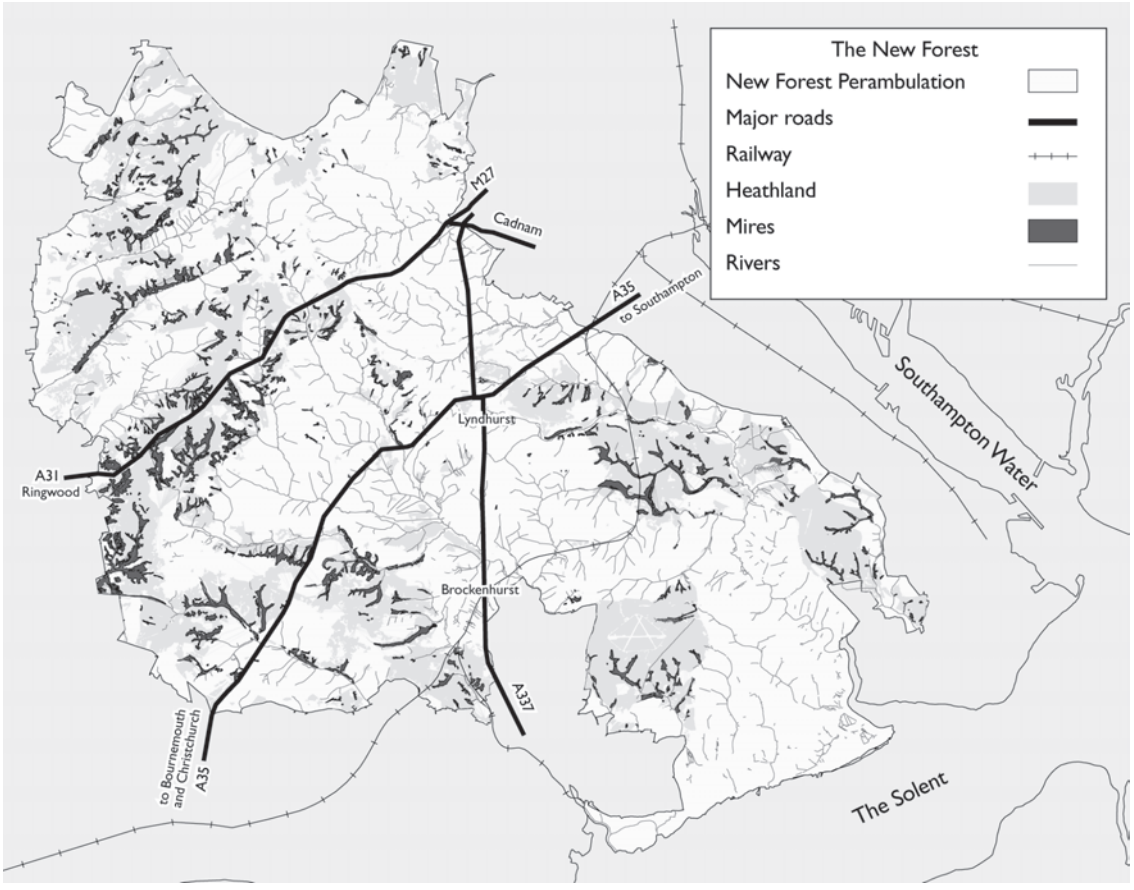


Figure 19
The distribution of heathland, valley mires and major streams within the New Forest. From Taverner *et al*. (2004).

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

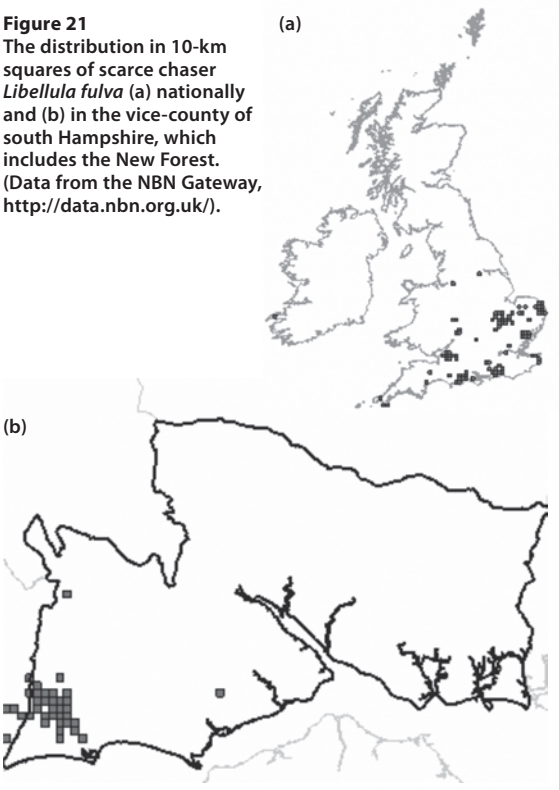


Figure 21
The distribution in 10-km squares of scarce chaser *Libellula fulva* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

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/).

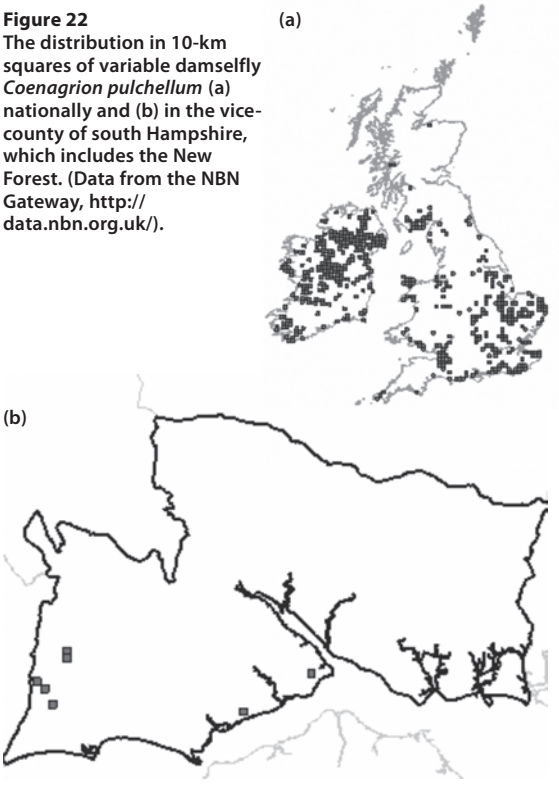


Figure 22
The distribution in 10-km squares of variable damselfly *Coenagrion pulchellum* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

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

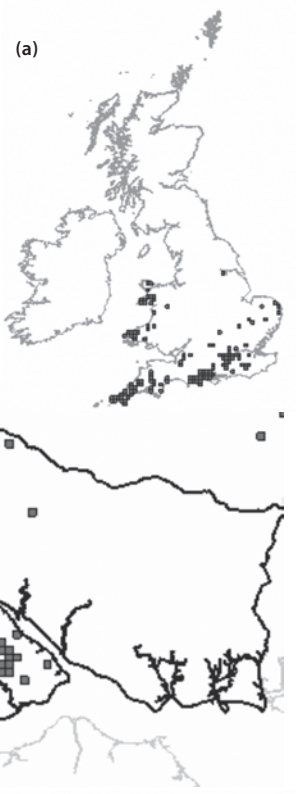


Figure 24
The distribution in 10-km squares of small red damselfly *Ceriagrion tenellum* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

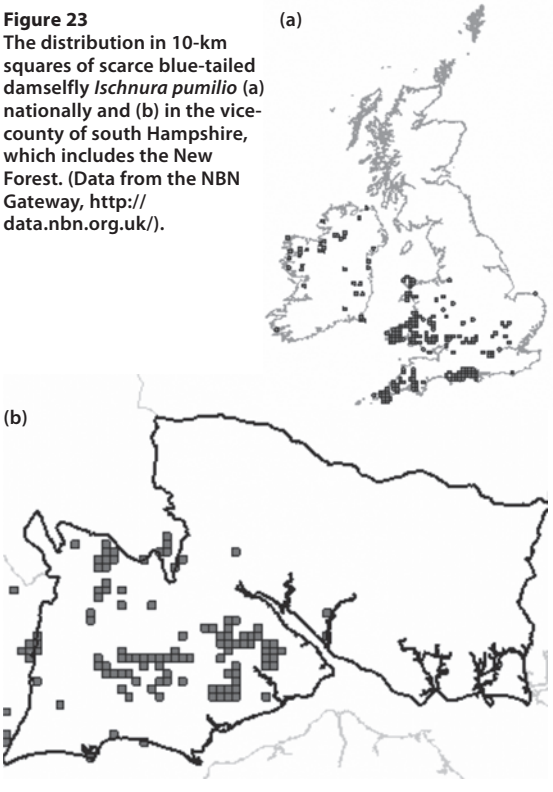


Figure 23
The distribution in 10-km squares of scarce blue-tailed damselfly *Ischnura pumilio* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

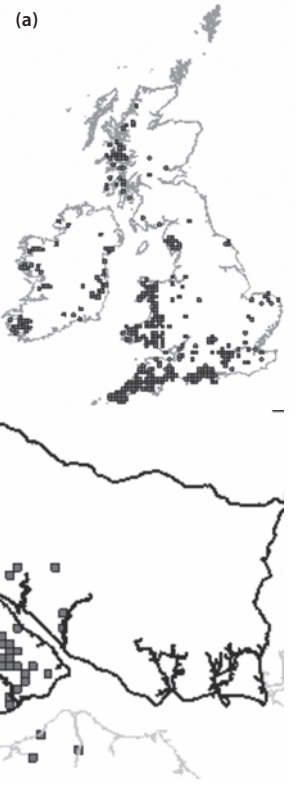


Figure 25
The distribution in 10-km squares of keeled skimmer *Orthetrum coerulescens* (a) nationally and (b) in the vice-county of south Hampshire, which includes the New Forest. (Data from the NBN Gateway, http://data.nbn.org.uk/).

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

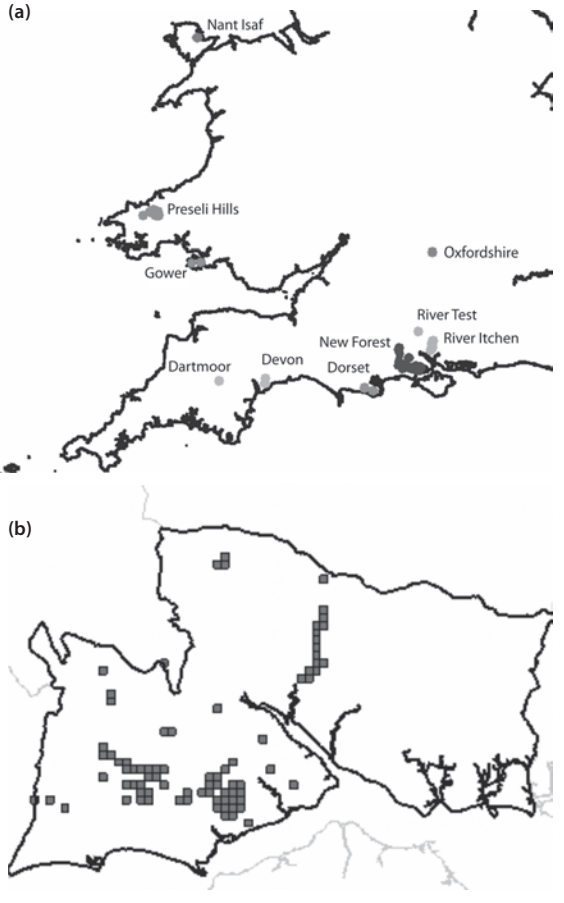
This section is concerned with the population structure of southern damselfly in its UK stronghold, the New Forest. This species has a somewhat fragmented population structure throughout its European range and this is even more apparent at its range margin in the UK. Some preliminary results from a multi-site 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.

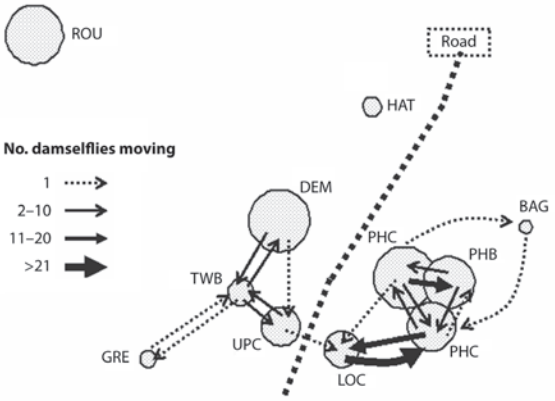
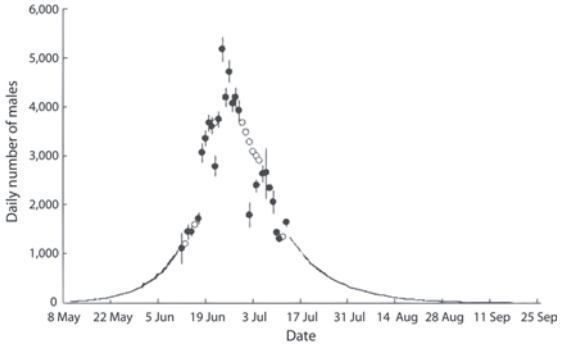


Figure 28
Daily estimates (± standard errors) of male population size of southern damselfly *Coenagrion mercuriale* on Beaulieu Heath, New Forest, southern England. Estimates were made by using a full Jolly–Seber model. Open circles and solid line are estimated data extrapolated from the daily estimates.



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

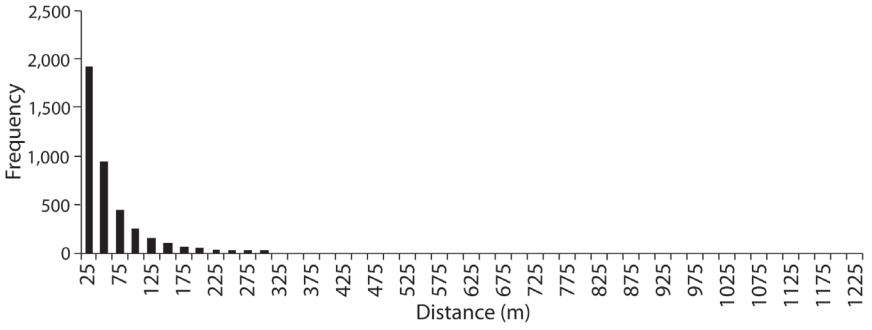


Figure 29
Net lifetime movement in mature adult southern damselfly *Coenagrion mercuriale* on Beaulieu Heath in the New Forest.

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

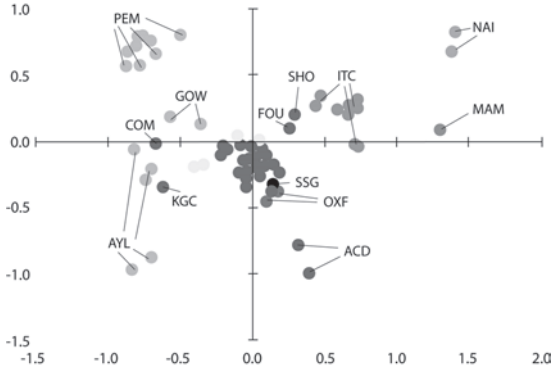
We took tissue samples from up to 90 individuals from all of the UK's southern damselfly populations. One hind leg per individual was taken and stored in 100% ethanol until analysis. Full details of the PCR and genotyping procedures using an automated sequencer are given by Watts *et al*. (2004a, b, 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

The work on southern damselfly described in this chapter was funded by the Natural Environment Research Council (grant no. NER/A/S/2000/01322) and the Environment Agency. Southern damselfly is protected under Schedule 5 of the 1981 Wildlife and Countryside Act in the UK. All work was carried out under licence from Natural England. We thank Alan Hold, Derek Jenkins and Dave Winsland for welcoming us onto their patch and Tim Sykes for his energetic and creative chairmanship of the *Coenagrion mercuriale* BAP Steering Group. We are grateful to the British Dragonfly Society for permission to use the distribution maps supplied to the NBN Gateway and for providing Figure 1.

References

Angelibert, S. and Giani, N. (2003). Dispersal characteristics of three odonate species in a patchy habitat. *Ecography*, 26, 13–20.

Askew, R. R. (1988). *The dragonflies of Europe*. Harley Books, Colchester.

Brooks, S. and Lewington, R. (2002). *Field Guide to the dragonflies and damselflies of Great Britain and Ireland*. British Wildlife Publishing, Hampshire.