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CONTENTS

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BDS

The aims of the **British Dragonfly Society** (BDS) are to promote and encourage the study and conservation of Odonata and their natural habitats, especially in the United Kingdom.

The Journal of the British Dragonfly Society, published twice a year, contains articles on Odonata that have been recorded from the United Kingdom and articles on European Odonata written by members of the Society.

Articles for publication should be sent to the Editor. Instructions for authors appear inside the back cover.

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Cover illustration: Female *Leucorrhinia dubia*. Photograph by Damian Pinguey.

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- Word processed manuscripts may be submitted in electronic form either on disk or by e-mail.
- Manuscripts should be one and a half spaced, on one side of the page only and with margins at least 25mm on both sides and top and bottom. Footnotes should be avoided.
- Use of these terms is acceptable: ‘exuvia’ for cast skin (plural: ‘exuviae’); ‘larva’ (instead of ‘naiad’ or ‘nymph’); ‘prolarva’ to designate the first larval instar.
- Dates in the text should be expressed in the form: 24 July 2010.
- References cited in the text should be in the form ‘(Longfield, 1949)’ or ‘...as noted by Longfield (1949)’. All references cited in the text (and only these) should be listed alphabetically at the end of the article in the following forms:

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

  Longfield, C. 1949. The Dragonflies of the London area. *The London Naturalist* **28**: 90-98.
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- Legends for figures, plates and tables should be presented together in sequence on separate, unnumbered pages.
- The legend for each table and illustration should allow its contents to be understood fully without reference to the text.

Please refer to a recent issue of the journal for further style details.

SCIENTIFIC AND ENGLISH NAMES OF BRITISH ODONATA

ZYGOPTERA	DAMSELFLIES
Calopteryx splendens	Banded Demoiselle
Calopteryx virgo	Beautiful Demoiselle
Ceriagrion tenellum	Small Red Damselfly
Chalcolestes viridis	Willow Emerald Damselfly
Coenagrion armatum	Norfolk Damselfly
Coenagrion hastulatum	Northern Damselfly
Coenagrion lunulatum	Irish Damselfly
Coenagrion mercuriale	Southern Damselfly
Coenagrion puella	Azure Damselfly
Coenagrion pulchellum	Variable Damselfly
Coenagrion scitulum	Dainty Damselfly
Enallagma cyathigerum	Common Blue Damselfly
Erythromma najas	Red-eyed Damselfly
Erythromma viridulum	Small Red-eyed Damselfly
Ischnura elegans	Blue-tailed Damselfly
Ischnura pumilio	Scarce Blue-tailed Damselfly
Lestes barbarus	Southern Emerald Damselfly
Lestes dryas	Scarce Emerald Damselfly
Lestes sponsa	Emerald Damselfly
Platycnemis pennipes	White-legged Damselfly
Pyrrhosoma nymphula	Large Red Damselfly
Sympecma fusca	Winter Damselfly
ANISOPTERA	DRAGONFLIES
Aeshna affinis	Southern Migrant Hawker
Aeshna caerulea	Azure Hawker
Aeshna cyanea	Southern Hawker
Aeshna grandis	Brown Hawker
Aeshna juncea	Common Hawker
Aeshna mixta	Migrant Hawker
Anaciaeshna isoceles	Norfolk Hawker
Anax ephippiger	Vagrant Emperor
Anax imperator	Emperor Dragonfly
Anax junius	Green Darner
Anax parthenope	Lesser Emperor
Brachytron pratense	Hairy Dragonfly
Cordulegaster boltonii	Golden-ringed Dragonfly
Cordulia aenea	Downy Emerald
Crocothemis erythraea	Scarlet Darter
Gomphus flavipes	Yellow-legged Club-tail
Gomphus vulgatissimus	Common Club-tail
Leucorrhinia dubia	White-faced Darter
Leucorrhinia pectoralis	Large White-faced Darter
Libellula depressa	Broad-bodied Chaser
Libellula fulva	Scarce Chaser
Libellula quadrimaculata	Four-spotted Chaser
Orthetrum cancellatum	Black-tailed Skimmer
Orthetrum coerulescens	Keeled Skimmer
Oxygastra curtisii	Orange-spotted Emerald
Pantala flavescens	Wandering Glider
Somatochlora arctica	Northern Emerald
Somatochlora metallica	Brilliant Emerald
Sympetrum danae	Black Darter
Sympetrum flaveolum	Yellow-winged Darter
Sympetrum fonscolombii	Red-veined Darter
Sympetrum pedemontanum	Banded Darter
Sympetrum sanguineum	Ruddy Darter
Sympetrum striolatum *	Common. Darter *
Sympetrum vulgatum	Vagrant Darter

* Includes dark specimens in the north-west formerly treated as a separate species, *Sympetrum nigrescens* Highland Darter

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Population structure of *Leucorrhinia dubia* (Vander Linden) the White-faced Darter in Europe with special reference to the population at Chartley Moss.

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Summary

This article describes the population structure with regard to genetic variation and isolation of *Leucorrhinia dubia* White-faced Darter in Western Europe, with a special focus on the British population at Chartley Moss. The British population is genetically closest to those in Switzerland and France but is genetically isolated from all populations in Europe. Information is also provided about variation in the length of the spines in larvae raised in the absence of fish. This feature is of particular interest because these spines provide protection from fish predators as well as being used for keying out species at the larval stage.

Introduction

Leucorrhinia dubia White-faced Darter is a fairly small dragonfly (Plate 1) that prefers the boreal regions of Europe and, within these regions, it occurs on moors, bogs and ponds (Boudot & Kalkman, 2015). It is an abundant species in North-eastern Europe, probably because this part of Europe has the right kind of habitat. In Western Europe the distribution is more scattered. Beynon (2001) reviewed the status of this species in Britain and concluded that it has declined during the last centuries and now only occurs at about half of the localities where it used to be found in the middle of the 20th Century. The most southern population in Britain is currently at Chartley Moss (Beynon, 2001). Since *L. dubia* in Britain, and especially in England, is rare, it is interesting to examine the population structure across Europe and see how the British population at Chartley Moss is related to populations in other parts of Europe.

The larvae of *L. dubia* have dorsal and lateral spines on the abdominal segments (Plate 2). These spines have been shown to work as protection against predation by fish. Larvae with longer spines have a higher probability of escaping an attack by a predator: the fish seem not to like eating spiny larvae. Interestingly, there is variation in spine length among larvae (Plate 2). This spine length variation is

Plate 1: Male *Leucorrhinia dubia*. Phootgraph by David Kitching.

caused by two factors. First, there are genetic differences between individuals. Second, it is also due to phenotypic plasticity, i.e. the ability of an organism to change its phenotype in response to the environment (Johansson, 2002). In the latter case the presence of fish induce larger spine length.

Material and Methods

In my research group, we have explored the population structure of *Leucorrhinia dubia* using molecular methods. Larvae and/or adults have been sampled from nine localities across Europe (France, Switzerland, Austria, Belgium, Germany, Poland, Sweden, Finland and Great Britain). From each locality 5-13 individuals were used for a molecular analysis. The DNA used for this was extracted either from flight muscle in adults or from the abdominal muscles of last instar larvae. Digest RAD Sequencing (ddRAD-Seq) was used to attain genetic markers. This method has the advantage of providing a large number of markers at a low price. With these genetic markers the genetic structure of the samples was calculated using the program STRUCTURE. From these genetic

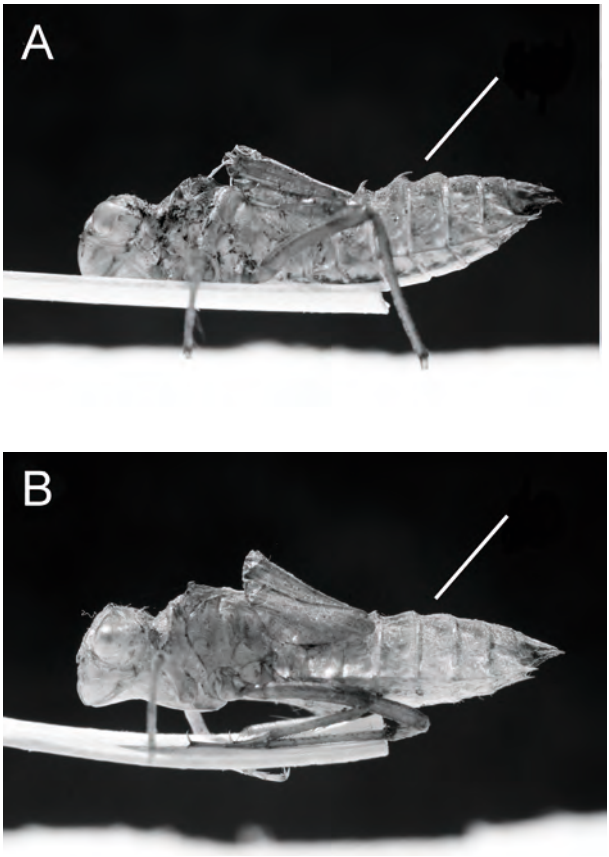

Plate 2. Larval exuviae of *Leucorrhinia dubia*. Note the dorsal abdominal spines and the variation between the larvae in spine length, with (A) having large spines and (B) having very short (almost no) spines.

markers F_{st} values were also calculated, which are measures of the genetic differentiation between populations.

Since there is large variation in the length of the abdominal mid-dorsal spines among population and individuals it is interesting to examine how spine length differs in different localities. Thus eggs were collected from females in six population across Europe (Austria, Germany, Poland, Sweden, Finland and Great Britain), and the offspring raised in the laboratory in the absence of fish (Johansson *et al*., 2017b). Eggs were collected by catching mating females and then holding the mated females gently at the base of the wings and simulating egg deposition by dipping the abdomen repeatedly in a jar with water.

Results

DNA Analysis

The results from the structure analysis of the DNA suggest that there are three distinct genetic groups (clusters) of *Leucorrhinia dubia* in Europe (Johansson et al., 2017a). One group consists of the individuals sampled in Great Britain (Chartley Moss), one of the individuals sampled in Switzerland and France (Alpd and Pyrenees respectively), and the third consisting of the rest of the individuals sampled (from Austria, Belgium, Germany, Poland, Sweden and Finland). However, it must be noted that each sample is from only one locality in each country; if more samples were to be included the results might change. Nevertheless, the results suggest that the British population is fairly isolated from the rest of Europe, the F_{st} values varying between 0.22 and 0.39 between all comparisons with the other eight sample sites across Europe (Johansson *et al*., 2017a). These values are very high, suggesting a reasonable degree of genetic isolation.

Our molecular data also allowed us to construct a phylogenetic tree, which shows the inferred evolutionary relationships between the sampled populations (Fig. 1). The phylogeny showed that the British individuals group together on the same branch as individuals from Switzerland and France.

Abdominal spines

The results showed large and significant variation in the mean length of the abdominal mid-dorsal spines between the localities sampled (Fig. 1). Larvae from the Swedish locality had the largest spines, followed by the Finnish locality. The other four localities sampled, including the British one, had short spines.

Discussion

Since the DNA study shows that the individuals of *Leucorrhinia dubia* from Chartley Moss in England are closest to the individuals in Switzerland and France (Fig. 1), it can be hypothesized that Britain was colonized from the south-western part of Europe after the retreat of the ice from the last ice age.

The length of the mid-dorsal abdominal spines was estimated in the absence of fish predatory cues and therefore the effect and variation of plasticity is not included. Thus, the results showed that populations differ significantly in genetic difference in larval spine length across Europe. Hence, carefulness is urged in using spine length to key out larvae of *Leucorhinia dubia*. Other characters

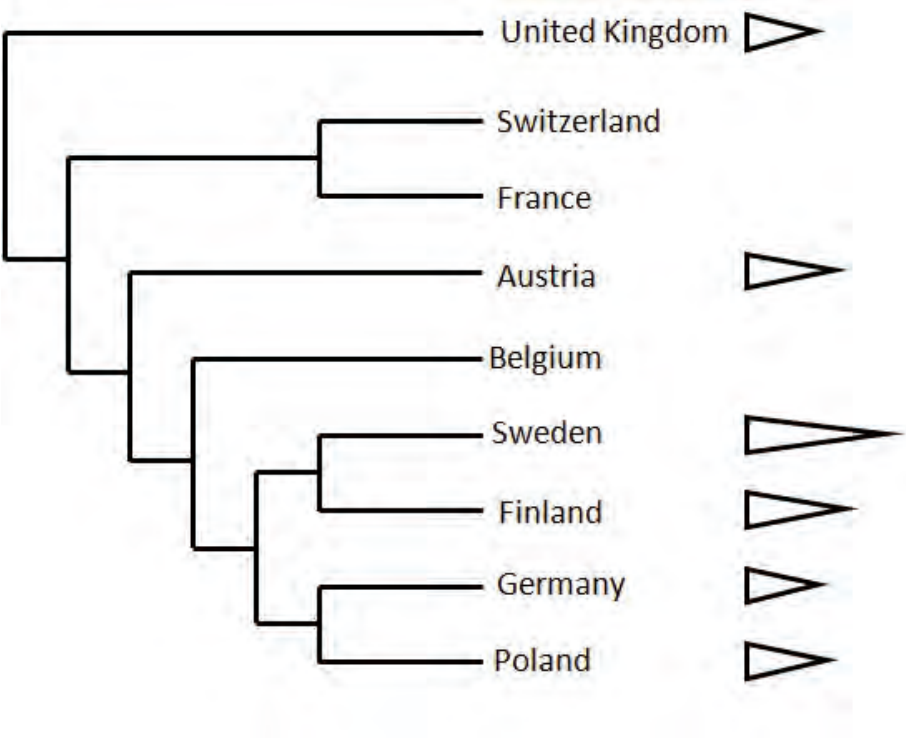

Fig. 1. A simplified phylogeny based on the results from Johansson et al. (2017b). Note that the United Kingdom samples from Chartley Moss sit on an isolated branch, suggesting that this locality is not nested within the other localities sampled. The horizontal triangles on the right symbolize relative larval spine length: the longer the triangle the longer the spine length of the larvae.

should also be considered.

In summary, our study has shown that The British population sampled at Chartley Moss is fairly isolated from the other populations sampled in Europe. However, more samples are required to confirm the pattern of isolated *L. dubia* populations in Britain. It is particularly important to preserve the English populations and the two reintroductions in north-west England (Clarke, 2014; Meredith 2017) are an important step in this direction.

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Odonata monitoring for the Scottish Beaver Trial 2009-2014 with notes on the post-trial period

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Summary

The British Dragonfly Society surveyed *Brachytron pratense* Hairy Dragonfly and *Calopteryx virgo* Beautiful Demoiselle for Scottish Natural Heritage (SNH) as part of the monitoring for the Scottish Beaver Trial 2009-2014. The beavers drastically reduced the aquatic vegetation in some lochs and constructed dams, increasing the size of one loch four-fold. At the end of the survey *B. pratense* was still breeding at the affected lochs. The study period was too short to evaluate the full effects on this species. Although there was a decline in the numbers of larvae and exuviae at one of the lochs where there was high beaver activity there were no obvious trends at the other three. Since the trial, beavers have moved into new lochs and built dams on one burn. In 2016 *B. pratense* was seen at all lochs and larvae found at the main lochs sampled. The Scottish Government's decision is to allow beavers to remain in Scotland and spread naturally. Results from the survey of *C. virgo* have not been included as the beavers did not use the burns during the survey period. However, these data will be important for future monitoring.

Introduction

In May 2008, the Scottish Government approved a licence for a five-year trial reintroduction of the European beaver *Castor fiber* to Knapdale, Argyll. The licence prescribed an extensive, independent monitoring program. The first beavers were released in the spring of 2009 with a second release in 2011. A total of sixteen beavers in five families or pairs were released during the trial. The aim was to establish a minimum of four breeding pairs in the release area. During the trial, kits were born annually; there was also some adult and kit mortality and dispersal. At the end of the trial 14 animals remained (see Harrington *et al*., 2015, for full details). The release site was in Knapdale (Fig. 1).

Two species of odonate, *Brachytron pratense* Hairy Dragonfly and *Calopteryx virgo* Beautiful Demoiselle were monitored by the British Dragonfly Society in

Figure 1. Sampling sites for *Brachytron pratense* and *Calopteryx virgo* within the beaver trial area. Map reproduced with permission of the Geographic Information Group, Scottish Natural History.

order to detect any effects of beaver activity. These species have a restricted distribution in Scotland and their habitat requirements potentially make them susceptible to beaver activity. Full details of the BDS monitoring report can be found in Batty (2015).

Knapdale is an exceptional part of Scotland for dragonflies and damselflies and Knapdale Woods SSSI supports an assemblage of 13 species.

Willby *et al.* (2014) used various indices to assess beaver usage of the lochs, including lodge occupation and presence during the growing season. Their classification of low or zero, medium and high usage was used to analyse possible impacts of beavers on dragonflies (Table 1).

***Brachytron pratense* - Hairy Dragonfly,**

Brachytron pratense has specific habitat requirements. Sites need to have a rich complex of submerged and emergent vegetation, and semi-decomposing floating detritus of rushes, sedges and reeds. The emergent vegetation can vary but in Scotland *Cladium mariscus* Saw-sedge and *Schoenoplectus lacustris* Common Club-rush are associated with *B. pratense* breeding sites (Smith & Smith, 1984; Batty, 1998; Perrin, 1999).

Most, but not all, Knapdale sites have one or both of these plants. Some have high banks which, along with the above plant species, trap floating detritus. Female *B. pratense* oviposit into this detritus and into the fleshy lower leaves of *Cladium mariscus* (Merritt *et al.*, 1996; Batty, 1998; Corbet, 1999; Perrin, 1999). Larvae cling to the underside of floating stems and detritus. *Brachytron pratense* is not found in wetlands with limited vegetation, and clearance of ponds can cause a decline in numbers (Tyrrell, 2011). *Brachytron pratense* is usually an indicator of a rich assemblage of dragonfly species.

***Calopteryx virgo* - Beautiful Demoiselle**

Calopteryx virgo breeds exclusively in running water, typically fast flowing streams with a bed of sand or gravel and sections with overhanging trees and luxuriant growth of bankside vegetation. It likes dappled sunlight in which it conducts courtship displays (Nelson & Thompson, 2004; Corbet & Brooks, 2008).

Prendergast (1988) found that *C. virgo* increased in abundance with decreasing water depth and increasing shade when compared with sections of completely open banks. He linked the river depth and current speed to the oxygen requirements of *C.* virgo, which is possibly why it is never found in standing

Table 1. Comparison of the numbers of larvae and exuviae found in *Brachytron pratense* transects during the survey years 2009-2014. *Sites with main beaver activity from 2009. The other sites only had beaver activity from 2011 onwards.

Beaver usage	2009		2010		2012		2014	
	larvae	exuviae	larvae	exuviae	larvae	exuviae	larvae	exuviae
Low/Zero								
Barnluasgan	4	7	2	4	4	2	0	4
Un-named (South)	1	0	0	2	0	0	0	4
Losgunn	0	0	0	0	0	0	0	0
Total	**5**	**7**	**2**	**6**	**4**	**2**	**0**	**8**
Medium								
Ford Lochan	1	0	0	1	0	0	0	0
Coille-Bharr	0	0	0	0	0	0	0	2
Creagmhor	1	0	2	2	4	0	3	3
Un-named (North)	2	0	0	0	0	0	0	1
Total	**4**	**0**	**2**	**3**	**4**	**0**	**3**	**6**
High								
Buic	1	6	1	4	1	3	0	5
Dubh*	4	2	0	3	0	0	0	3
Fidhle*	6	4	2	3	0	1	0	0
Linne*	1	0	0	3	1	0	0	0
Total	**12**	**12**	**3**	**13**	**2**	**4**	**0**	**8**
Total all sites	**21**	**19**	**7**	**22**	**10**	**6**	**3**	**22**

water (Corbet & Brooks, 2008; Brownett, 1994).

Methods

Eleven Knapdale lochs and the three main river systems were surveyed in 2009, 2010, 2012 and 2014 (Fig. 1).

Transects of up to 100 metres long were established, the length depending on the terrain. The edge of the loch or burn was followed as closely as possible but some detours had to be made. A hand-held GPS was used to record locations. Counts were made of adults of both *Brachytron pratense* and *Calopteryx virgo* during the main flight time in favourable weather conditions, i.e. a temperature of over 17°C with over 60% sun during the survey period. For *B. pratense* the water was sampled for larvae and the bank vegetation searched for exuviae (Batty, 2015). Due to size and accessibility of the trial area it was only possible to make two visits to each loch in each survey year. Although the Beaver trial was from 2009-2014, the dragonfly surveys were only made in 2009, 2010, 2012 and 2014.

At Dubh Loch, the water level was higher from 2010 onwards due to a beaver dam. Hence new sampling sites had to be established at the water's edge for adults and a canoe was used to monitor for larvae and exuviae.

The recording sites were divided in terms of the level of beaver activity: zero or low, medium and high (Willby *et al*., 2014).

Results

Beavers were only significantly present at three lochs (Dubh, Fidhle and Linne) for the whole survey period. The additional beavers released in 2011 used Loch Buic, Ford Lochan and un-named (North) loch from this date and Creagmhor Loch from 2013. It is unlikely that beavers would have any effect on dragonflies during the first two weeks of their release in 2009 when the first annual survey took place.

Brachytron pratense - Hairy Dragonfly

Larvae and exuviae The combined numbers of *Brachytron pratense* larvae and exuviae were recorded along the transects for each site during the survey (Table 1). Numbers of larvae represent the maximum found at a site. A small area of Loch Barnluasgan was part of an emergence survey (Plate 1) (Batty, 2015) where additional visits were made and the size position and sex of the larvae were noted to avoid double counting.

The number of larvae found varied between years (Table 1) and was dependent on the timing of counts in relation to emergence. Most larvae found were at the pre-emergent stage. They were mainly found clinging to the underside of floating stems in areas with plentiful detritus (Plate 2) and became more difficult to find in areas where floating detritus had disappeared. They were not found in areas where dense mats of over 30cm thick had accumulated as a result of beaver grazing.

The maximum number of larvae was recorded in 2009, including six small larvae found at Loch Fidhle. There appears to have been an overall reduction in larval numbers during the trial (Fig. 2) but this should be viewed together with the numbers of exuviae (Fig. 3). Thus, in 2014, few larvae were present as early emergence had taken place but a greater number of exuviae were found than in 2012.

Larvae and exuviae were rarely found at Ford Lochan and never found at Loch Losgunn (Table 1). The edges of these lochs are either unstable or difficult to

Plate 1. Exuvia of *Brachytron pratense* on S*choenoplectus lacustris* at Loch Barnluasgan.

Plate 2. Floating detritus in Creagmhor Loch.

access and search because of the rough heather banks. Furthermore, results from Dubh Loch are not directly comparable with the other lochs since, as noted above, although the same general area was sampled from 2010 onwards, it was from a canoe not from the bank. Six species of dragonflies were breeding at the new loch edge in 2012 and an additional four species were found in 2013. However, the accessible new edge remained fairly open with a small number of plants and little plant detritus (though decaying twigs and branches were present) and no *B. pratense* larvae or exuviae were found there. However, exuviae were found at Dubh Loch in 2014 on *Cladium mariscus* and *Carex paniculata* growing in deeper water (Plate 3).

Although the presence of larvae indicates that breeding has taken place, exuviae give the strongest (and only absolute) proof of breeding (Plate 1). Exuviae were found in a variety of situations but mainly in areas with some floating detritus or where *Cladium mariscus* was present (Plate 3). They are hard to find and can easily be dislodged by rain or wind. The total numbers of exuviae at all sites were similar for all years, apart from 2012, though their distribution varied (Table 1). In 2012 there was cool, wet weather during the emergence period. One larva started emergence on 24 May, was still in the same position 24 hours later, but had disappeared completely two days later.

There was little change during the study period in the number of larvae plus exuviae in those sites where there was zero or low beaver activity and in those where beaver activity was rated as medium. However, in those sites where beaver activity was high the results were mixed. Thus there was a notable reduction in the number found at Loch Fihle and a slight reduction at Loch Linne (of exuviae) but no clear change at Dubh Loch and Loch Buic.

Exuviae were found in a variety of emergent vegetation, often on *Schoenoplectus lacustris* (Plate 1), *Cladium mariscus* (Plate 3), *Phragmites australis* (Common Reed), sedges and rushes. They were frequently found in areas with floating detritus (Plate 2). They were also found on *Myrica gale* (Bog Myrtle) and willow and on the bank itself. In 2014 exuviae were found at Loch Coille-Bharr (a site of medium beaver activity) for the first time during the survey period. They were in an area where there was a lot of floating detritus caused by beaver activity.

Adults Quantifying population changes for Odonata is difficult because of sampling limitations and variability of factors such as the weather, so the aim was to detect whether any substantive change was taking place. Adult counts are weather dependent and it is not always possible to get favourable conditions in Western Scotland. In 2009 the lower numbers (Table 2) may reflect the time available to take advantage of the best conditions.

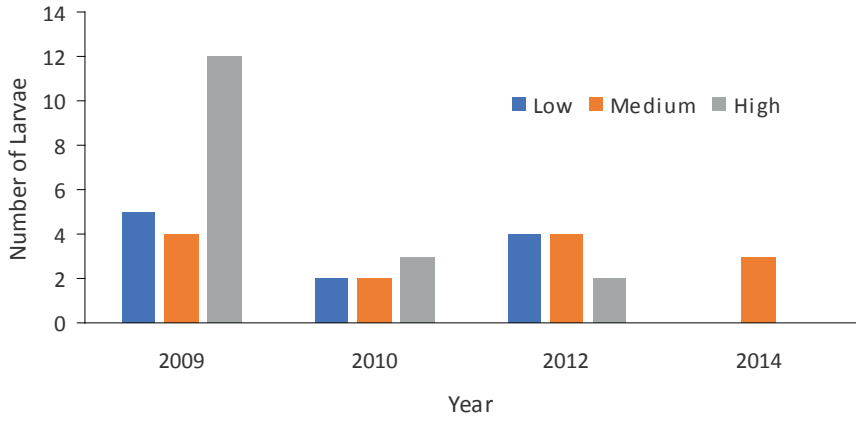

Figure 2. Number of *Brachytron pratense* larvae recorded in lochs with low, medium and high beaver usage during 2009-2014.

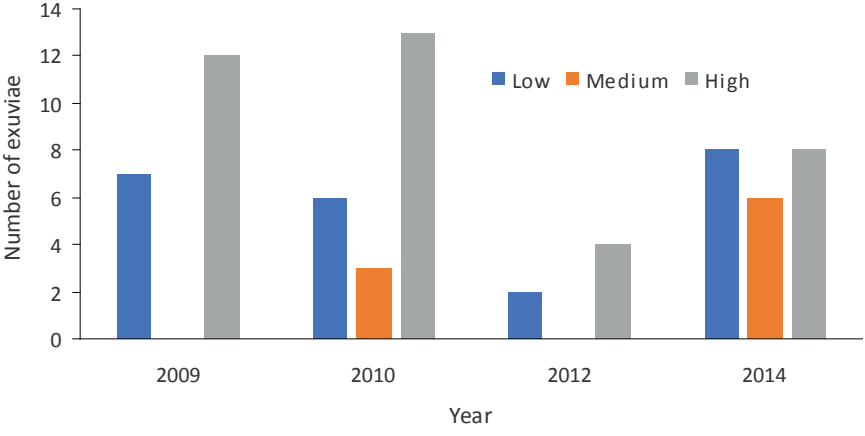

Figure 3. Number of *Brachytron pratense* exuviae recorded in lochs with low, medium and high beaver usage during 2009-2014.

Plate 3. *The Cladium mariscus area where exuviae were found at Dubh Loch.*

In 2010 and 2012, repeat adult counts were made on certain lochs, for which only peak counts are included (Table 2). Most adults seen were territorial males. Many lochs had a peak in adult numbers in 2010 (Figs 4-6) and this included lochs with all three levels of beaver activity, i.e. Loch Barnluasgan (zero or low activity), Lochs Creagmhor and Ford Lochan (medium activity) and Loch Buic (high activity). Un-named (South) Loch and Loch Coille-Bharr showed a steady increase in numbers between 2009 and 2014 (Figs 4, 5). Lochan Buic showed a marked decrease in numbers from 2010 when the beavers became present (in 2011) (Fig. 6) and, in Dubh Loch, where beaver activity was also high, there was a decrease in numbers from 2010. In contrast, in Loch Fidhle there was a slight increase in the number of adults in 2014 (Fig. 6) in marked contrast to the reduction in larvae plus exuviae (Table 1). It should be noted that the 2009 results at Dubh Loch are not directly comparable with the later surveys because the original transects were under water and new survey points were established. From 2010 onwards adults were counted from the new edge, observing as much of the original area as was visible from the sampling points.

At Loch Buic, which has a gently shelving edge, where beavers had eaten the *C. mariscus* (Willby *et al.*, 2014) there was nothing to trap the detritus. When the

Table 2. Total number of *Brachytron pratense* adults (males and females) recorded during 2009-2014 for sites with zero to low, medium and high beaver usage. Numbers in brackets are the female only counts.

Site	2009	2010	2012	2014
Low or Zero	12(2)	24(2)	21(3)	15
Medium	4(1)	14	13(4)	17(4)
High	15(1)	44(3)	27(4)	22(1)
Total all sites	**31(4)**	**86(5)**	**61(11)**	**55(5)**

water level was high the detritus was washed up on the shore (Plate 4) and thus not available to *B. pratense*. Males were no longer seen patrolling areas where *C. mariscus* had been removed by the beavers and the numbers of adults at Loch Buic declined considerably between 2010 and 2014, after beavers were introduced, whilst in the adjacent loch Un-named (South) with no beavers at that time (and which was visited on the same day under the same weather conditions) numbers increased slightly (Fig. 4).

Plate 4. Lochan Buic showing the washed up detritus.

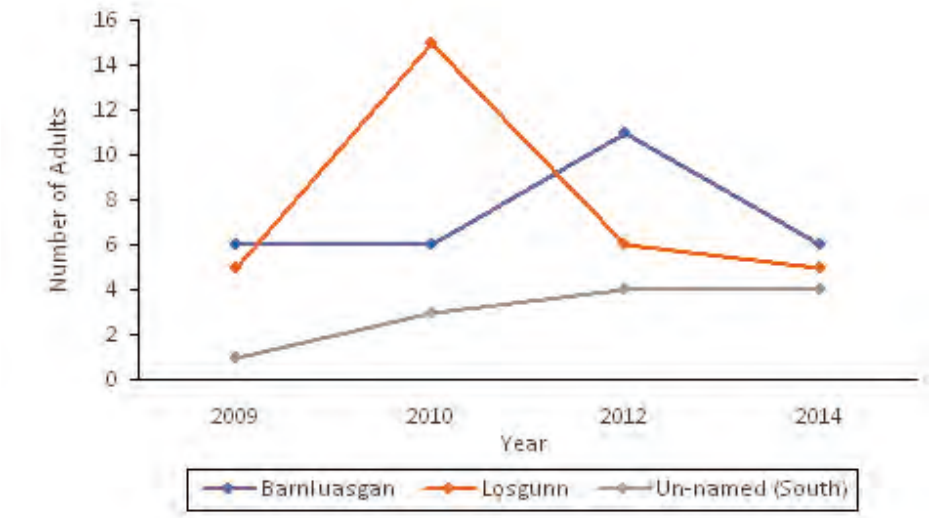

Figure 4. Number of *Brachytron pratense* adults recorded in lochs with zero or low beaver usage during 2009-2014.

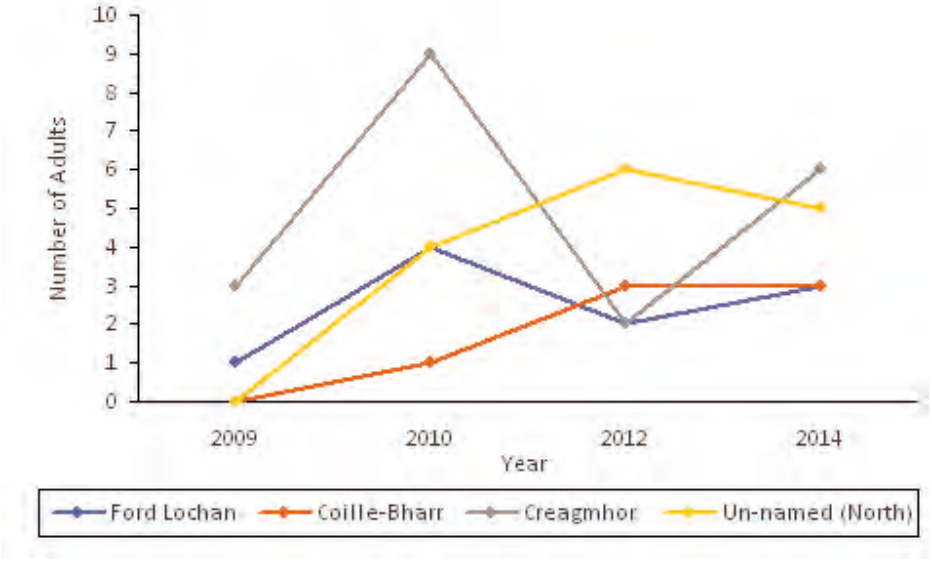

Figure 5. Number of *Brachytron pratense* adults recorded in lochs with medium beaver usage during 2009-2014.

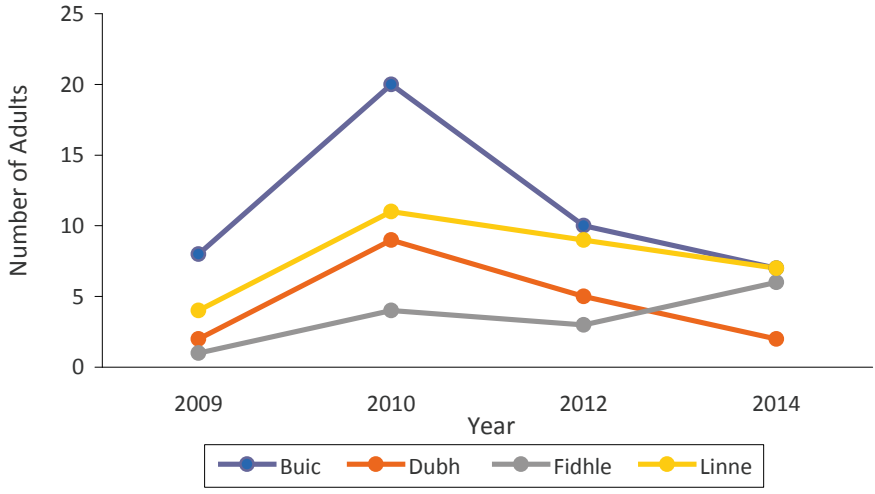

Figure 6. Number of *Brachytron pratense* adults recorded in Lochs with high beaver usage during 2009-2014.

Females are less obvious than males and were often detected by a rustle of wings. Only three to five females in total were usually seen at the lochs each year. However, 2012 was the exception, when eleven females were recorded (Table 2).

Calopteryx virgo - Beautiful Demoiselle

Beavers made little significant use of the burns and therefore there are no data on the impact of beavers on *Calopteryx virgo*. The transect results for this species can be found in Batty (2015). This information will be useful for future monitoring when beavers start to use this area

Other Species

All species seen were recorded and full surveys of adults were carried out in 2002 and 2013 (Fig. 7) (Batty, 2013). These species included *Lestes sponsa* (Emerald Damselfly), *Pyrrhosoma nymphula* (Large Red Damselfly), *Enallagma cyathigerum* (Common Blue Damselfly), *Coenagrion puella* (Azure Damselfly), *Ischnura elegans* (Blue-tailed Damselfly), *Aeshna juncea* (Common Hawker), *Aeshna cyanea* (Southern Hawker), *Cordulegaster boltonii* (Golden-ringed Dragonfly), *Libellula quadrimaculata* (Four-spotted Chaser), *Sympetrum striolatum* (Common Darter) and *Sympetrum danae* (Black Darter). There were

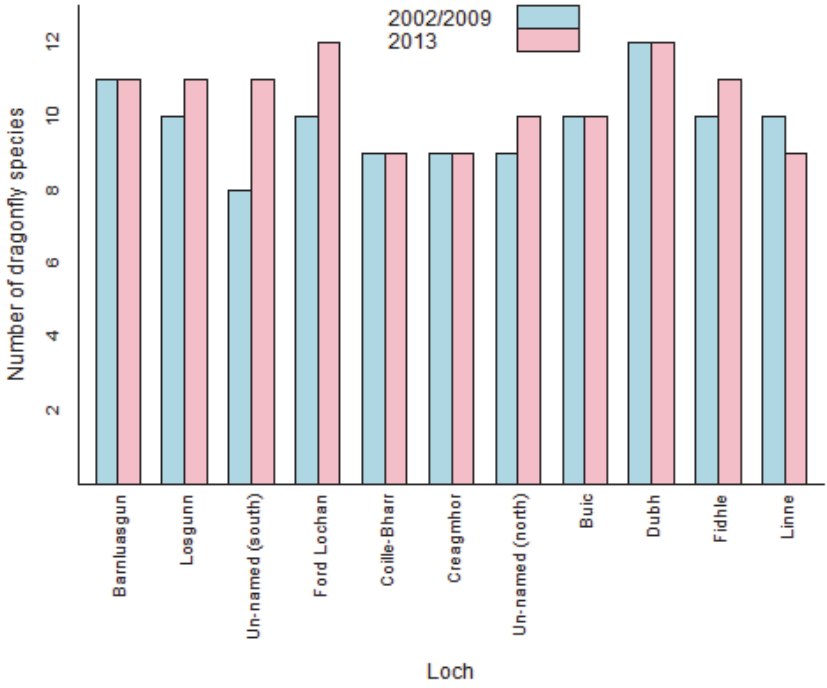

Figure 7. Number of dragonfly species pre (2002/2009) and post (2013) the introduction of beavers at Knapdale lochs.

no changes in the number of species found at the lochs as a result of beaver activity (Fig. 7) (Batty, 2015), though *Aeshna cyanea* spread into additional lochs in the area, part of a general spread of the species in Scotland (Cham, 2014).

Discussion

Weather conditions are likely to be a factor influencing the inter-annual numbers of adult *Brachytron pratense*. The low adult numbers in 2009 could have been influenced by the changeable weather in that year. In 2010 the weather was exceptionally warm for the area with temperatures over 20°C for several days and with full sun during the main flight time. The numbers of adults peaked at all lochs this year (only three lochs had beavers at this time) with a maximum of 86 adults seen (Table 2). In 2012 wet weather during the emergence period could have reduced the number of exuviae found (Table 1) since they can be dislodged during wet and windy weather. Weather also affects the chance of

finding larvae as they retreat from the shallows when the water is cold.

Beaver grazing

Beavers (Plate 5) are herbivores, well known for felling trees to feed on the bark and leaves or for construction purposes. They also graze a variety of aquatic vegetation. Willby *et al.* (2014) found that beavers had an effect on two plants favoured by *Brachytron pratense* in the Knapdale study sites: *Cladium mariscus* and *Schoenoplectus lacustris.* In this study *C. mariscus* and *S. lacustris* had an overall decline of 81% and 39% respectively in the beaver occupied lochs (Wilby *et al*., 2014). This decline was most evident in lochs with occupied lodges and was particularly marked in lochs Linne and Fidhle (Plates 6 - 9). Thus, in Loch Linne *S. lacustris* declined by 95% and in Loch Fidhle *C. mariscus* declined by 83%. These species were also considerably reduced in Loch Buic and in Loch Creagmhor. Conversely, Willby *et al.* (2014) found the density of macrophytes increased at all lochs with low or zero beaver usage, e.g. *S. lacustris* increased at Un-named (South) by 88% and at Loch Barnluasgan by 66%.

Beavers eat the rhizomes of *S. lacustris,* leaving behind cut stems. Normally the stems die off in the autumn, creating an annual supply of floating material that can be trapped at the water's edge and to which larvae of *B. pratense* cling. As the resource has been depleted by beaver grazing, there has been less detritus in a number of lochs.

Plate 5. Beaver family in Knapdale. Photograph by the Beaver Trial Team.

Plate 6. Loch Linne before the start of the trial in 2008.

Plate 7. Loch Linne at the end of the trial in 2014 showing the increase in open water.

Plate 8. Loch Fidhle at the start of the trial in 2009.

Plate 9. Loch Fidhle at the end of the trial in 2014 showing the increase in open water.

Plate 10. Dubh Loch before the start of the trial in 2008.

Beaver dams

A large dam was constructed on Dubh Loch and this resulted in the surface area of the loch increasing to over four times its original size by 2012. This extended the loch edge and increased water depth to over 1.5 m. The loch was originally lush with abundant vegetation (Plate 10). However, the water level rise had a marked effect on the aquatic vegetation (Plate 11), much of which was lost through submersion or grazing (Willby *et al.*, 2014). In 2009/2010 the flooded edge was bare and shaded by standing trees and unsuitable for dragonflies. Between 2011 and 2013, it was rapidly colonised by aquatic vegetation.

At the Dubh Loch *Brachytron pratense* was found mainly along the edge of the original fringing vegetation which was flooded and was over ten metres from the new loch edge by 2012. Water level rise and grazing caused a loss of 58% vegetation cover (Willby *et al.*, 2014). However, water depth is not critical for larvae of *B. pratense* as they survive in water over a metre in depth (Perrin, 1999; Tyrrell, 2011). The inaccessible flooded southern end of the loch, where *C. paniculata* was dominant, still provided some suitable conditions for *B. pratense* and exuviae were found in 2014 on *Cladium mariscus* (Plate 2) and *Carex paniclutata* in this area. The beavers abandoned the Dubh Loch in 2013

Plate 11. Dubh Loch at the end of the trial in 2014 showing the raised water level.

and moved to the adjacent Loch Coille-Bharr. In 2014 water levels in Dubh Loch started to drop gradually as the dam was not maintained and started to leak (pers. com).

Potential effects of beavers on *Brachytron pratense*

In 2014, exuviae were found in five of the eight Knapdale lochs that were used by beavers, proving that *Brachytron pratense* continued to breed in these lochs. Given the difficulty of finding either larvae or exuviae, their absence does not necessarily mean that breeding had not taken place. A female was observed ovipositing at a sixth loch, Un-named (North) in 2013 and 2014, another indication of breeding. There was breeding at the other two lochs, Linne and Fidhle in 2013 (Batty, 2013) and 2015 (pers. obs.) as larvae were found.

There is likely to be a delay in response to the effects of beaver grazing on *B. pratense* because of the time taken for larval development and for the disappearance of floating detritus. Larvae take at least two years to develop (Corbet & Brooks, 2008; Tyrrell, 2011; Perrin, 1999) and, from the size of the larvae found in Knapdale, some take three years. The detritus is eventually unavailable to *B. pratense* as it decays and is not being replaced when all the

vegetation is eaten. Only three lochs had beavers present from 2009; beavers used the others from 2011 onwards. In Lochs Creagmhor and Coille-Bharr beaver grazing did not take place until 2013. There seemed to be an increase in the numbers of exuviae or larvae found at lochs where there was a rise in debris after grazing, i.e. lochs Fidhle and Linnie in 2010 and lochs Coille-Bharr, Creagmhor and Buic in 2014. (Table 1). There may have been greater survival of larvae with increased cover. This was then followed by a fall in numbers when there was little floating detritus, as shown in lochs Fidhle and Linnie, which were used by beavers for the whole trial period.

Suitable habitat remained at the lochs though much reduced. At Loch Linne *B. pratense* male territorial activity was concentrated in the areas where some *C. mariscus* still remained. With a further reduction of habitat *B. pratense* could have fewer territories, which could lead to smaller numbers and possibly local loss. The reduction of emergent macrophytes had not had a major impact on *B. pratense* by 2014 but the study period may have been too short to show the full effects, particularly as many lochs were only inhabited by beavers from 2013.

Beavers also feed on the riparian woodland, which produces woody detritus at the loch edge (Willby *et al.*, 2014). This is much paler in colour than the plant detritus and does not provide as good a camouflage for *B. pratense* larvae. No larvae have been found amongst this woody detritus. Adults have been seen using the small clearings created near the lochs.

Dubh Loch experienced a major change in size and habitat due to dam building. All *Brachytron pratense* exuviae were found amongst the remaining *Cladium mariscus* with none at the new loch edge. There are some indications that the population of *B. pratense* may be falling at this site, but it is difficult to be conclusive because of access to the original transects due to increased water levels.

Beavers are likely to have positive effects for dragonflies as they create a variety of wetland habitat. However, beavers are herbivores and graze aquatic vegetation and thus may have an adverse impact on dragonfly species that need well-vegetated water bodies

Possible future effects on *Calopteryx virgo*

To date the beavers have had a limited effect on the Knapdale burns (Perfect & Gilvear, 2011) and any changes seen in *Calopteryx virgo* numbers have been mainly influenced by other factors.

As beavers start to use the burns in Knapdale and to build dams, the habitat

will change from flowing water to still or slow moving water behind the dams (MacDowell & Naiman, 1986; Redin & Sjöberg, 2012). The Odonata species will then change from flowing water to still water species (Arndt & Domdei, 2011).

From experiences elsewhere, flowing water species such as *C. virgo* and *Cordulegaster boltonii* will continue to breed in the unaffected sections of water courses (Arndt & Domdei, 2011; Schloemer *et al.,* 2012). Conditions at the beaver dam itself are similar to those in running water (Rolauffs *et al.,* 2001) and the dam structure increases habitat diversity (Arndt & Domdei, 2011).

Beaver grazing is likely to open up scrub allowing more sunlit areas (Schloemer *et al.*, 2012). Indeed *C. virgo* was seen using some clearings created at Knapdale. Thus the negative effect of reducing the area of flowing water could be offset by the creation of sunlit sections.

Other Studies

Beavers are generally thought to increase the number of dragonfly species because of the increased diversity of habitats created. However, there have been no directly comparable studies on the effect of beavers on dragonflies in standing water, although there have been studies concentrating on the effects of beavers on river systems.

Several studies have been carried out in Germany. In Saxony, *Brachytron pratense* individuals were found at beaver ponds, amongst reeds and reed fragments, in slow flowing water and also in beaver back waters (Günther, 2005). In a river system in the northern Eifel region 29 species of dragonflies were associated with beaver ponds and the surrounding wetland. In comparison, only four species were found in the streams and seven species at abandoned beaver pools (Schloemer *et al.*, 2012). These differences are not surprising, as the number of dragonfly species that breed in flowing water is far fewer than those breeding in still waters. The surrounding wetlands also contain runnels and small beaver canals which can attract different odonate species (Schloemer, pers. com). In the Spessart mountains in Hesse, it has been determined that the presence of beavers in streams resulted in an increase in the heterogeneity of the river system, providing an environment in which flowing and still water species can coexist and leading to an increase in the number of odonate species (Harthun, 1999). Similarly, in Bavaria, beaver-dammed waters showed a significant increase in the number of species. Thus 38 odonate species were present at monitored sites, 26 of which directly benefited from beaver activity, including rare species (Messlinger, 2012). This is because beavers were continually creating and changing habitats, providing areas with bare ground which favour pioneering species and areas with more vegetation for species

typical of the later stages of succession (Messlinger, 2012).

In Virginia, North America 66 species of dragonflies were found in river systems with beaver ponds, and in one area numbers fell from 61 to four when beavers left the area (Roble *et al.*, 2009). However, species that require more vegetation than is found in beaver ponds were not present in this study site (Roble *et al*., 2009).

Changes Post-Trial

Visits have been made to the Knapdale study area since the end of the trial. Beavers have abandoned some lochs and moved to lochs not previously used. Here they have built lodges and a new small dam. Now all lochs in the area have or have had beavers present. Where beavers continued to be active, the aquatic vegetation has been further reduced and these lochs are now more open than previously. Apart from Dubh Loch, *Cladium mariscus* has virtually disappeared, with only a small area remaining at Loch Linne. Similarly, only small areas remain of *Schoenoplectus lacustris*. There has also been a reduction in the amount of floating plant detritus. However, in 2016 *Brachytron pratense* was seen at all lochs and larvae found at the main lochs sampled (pers. obs).

As lochs are abandoned the aquatic vegetation will probably recover but this may take decades for *C. mariscus,* and 5-10 years for *S. lacustris* and *Nymphaea alba*, especially if residual populations of beavers remain (Willby *et al.*, 2014). Following the departure of beavers from Dubh Loch there has been rapid recolonisation by vegetation and the remaining vegetation, including *C. mariscus,* is starting to recover. The dam has not been maintained and the loch has settled at a lower level but is still higher than the original level (pers. obs.).

The beavers are now using the Loch Coille Bharr outflow burn and built two small dams in 2016, which hardly impede the water. Record numbers of *Calopteryx virgo* were seen along this burn in 2016 (as a result of good weather) and some were congregating by the dams where there was faster water flow. Since then, three larger dams have been built and these have had a greater effect on water depth and flow. Future surveys will be needed to see the effects of this on *C. virgo*.

On Tayside there is a second much larger population of beavers (an estimated 148 individuals in 38-39 groups) (Campbell *et al*., 2012). The origin of this population is unclear; it may have originated from beavers which escaped from private collections.

The Scottish Government are minded to allow beavers to remain in Scotland

and to spread naturally. They should be actively managed to minimise adverse impacts, (Scottish Government, 2016). This decision could have implications for beavers in the rest of the UK as they will receive legal protection subject to the EU Habitats Directive.

Conclusions

There was evidence in 2014 that *Brachytron pratense* continues to breed at six of the eight lochs used by beavers, and is breeding at the other two lochs, as larvae were found in 2013 and 2015 (Batty, 2013, pers obs.)

At the end of the trial there did not appear to be clear differences in numbers of adults, larvae and exuviae of *B. pratense* between lochs with and without beavers. However, based on counts of only larvae and exuviae, there were some indications of a small reduction in their numbers in lochs with high beaver usage; this was particularly noticeable at Loch Fidhle. However, weather is likely to be a factor influencing differences in *B. pratense* adult numbers.

The Dubh Loch experienced substantial increase in size and reduction of vegetation due to dam building. All *B. pratense* exuviae were found amongst the remaining *Cladium mariscus* in the inundated area with none at the new edge following the rise in water level. There were some indications that the population of *B. pratense* was falling at this site, but the vegetation has since started to recover as beavers have abandoned the site.

The trial period has been too short to show the full effects of beaver reintroduction on *B. pratense* and *Calopteryx virgo.* At present the effects on *B. pratense* are neutral to somewhat negative. Both *B. pratense* and *C. virgo* have been using the terrestrial clearings created by beaver activity. Since the trial, beavers have moved sites on several occasions and *B. pratense* is still present at all sites.

Beavers made little use of the outflowing burns during the study period and therefore there are no data from this study on the impact of beavers on *C. virgo.* However, since the end of the trial, beaver dams have been seen on one of them (pers. obs.).

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Scottish Government 2016 https://news.gov.scot/news/beavers-to-remain-in-scotland

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Migrant and dispersive dragonflies in Britain during 2016

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Summary

The year 2016 was a relatively quiet one for migrant dragonflies in Britain, at least in terms of the volume of migration. *Anax parthenope* (Lesser Emperor) thus had no more than an 'average' season with reports from fourteen sites, while *Sympetrum fonscolombii* (Red-veined Darter) had one of its quietest years for some time. Some small scale arrivals of *S. fonscolombii* were never-the-less still observed. Despite the generally low numbers of migrants, a few highlights did, however, stand out. In particular, *Anax ephippiger* (Vagrant Emperor) was noted at five sites during the autumn, with individuals being photographed on the Scilly Isles (2 sites), the Orkneys (2 sites) and in coastal Norfolk.

Our recent colonist species in general seemed to fair well. In particular, *Chalcolestes viridis* (Willow Emerald Damselfly) continued its range expansion with sightings from no less than four new counties during the season, namely Bedfordshire, Buckinghamshire, Lincolnshire and Northamptonshire. A new breeding site for *Lestes barbarus* (Southern Emerald Damselfly) was discovered on the Isle of Wight during June, while in Essex not only did *Aeshna affinis* (Southern Migrant Hawker) appear in numbers at its strongholds along the greater Thames Estuary, but what seems likely to be a new breeding site was discovered near St Osyth, well away from sites in the south of the county.

Other events of note during the year involved important 'extralimital' sightings of a number of our more established resident species that are currently undergoing range expansion. In particular, *Libellula fulva* (Scarce Chaser) produced several unexpected sightings, including reports from Leicestershire and Lincolnshire. *Aeshna isoceles* (Norfolk Hawker) also continued to be seen in new areas.

Account of species

Notable sightings reported to the BDS Migrant Dragonfly Project during 2016 are detailed below; for information on events during 2015, see Parr (2016).

Chalcolestes viridis (Vander Linden) – Willow Emerald Damselfly

Since its first appearance in Suffolk a decade ago (Brame, 2008), this species has successfully colonised and appears to be thriving, with range expansion continuing apace. During 2016, *Chalcolestes viridis* not only strengthened its position in recently-colonised counties such as Cambridgeshire and Surrey, but it was also found in no less than four new counties, namely Bedfordshire, Buckinghamshire, Lincolnshire and Northamptonshire. The most northerly British record is currently from Gibraltar Point in Lincolnshire, while the most westerly is from Milton Keynes.

In Northamptonshire, individuals were to be noted at Boardwalks Nature Reserve near Peterborough from 24 August (PTh), while further west records were made at Finedon Pocket Park from 7 September (MTy). In Bedfordshire records came from Flitton Moor Nature Reserve on 7 September (per RM) and from Duck End Nature Reserve on 18 & 23 September (per RM), while in Lincolnshire sightings were made at Baston Fen on 11 September (PTh) and at Gibraltar Point on 18 September (CB). Finally, in Buckinghamshire records were to come from Tattenhoe Valley Park, Milton Keynes, on 28 September and over the following few days (HA).

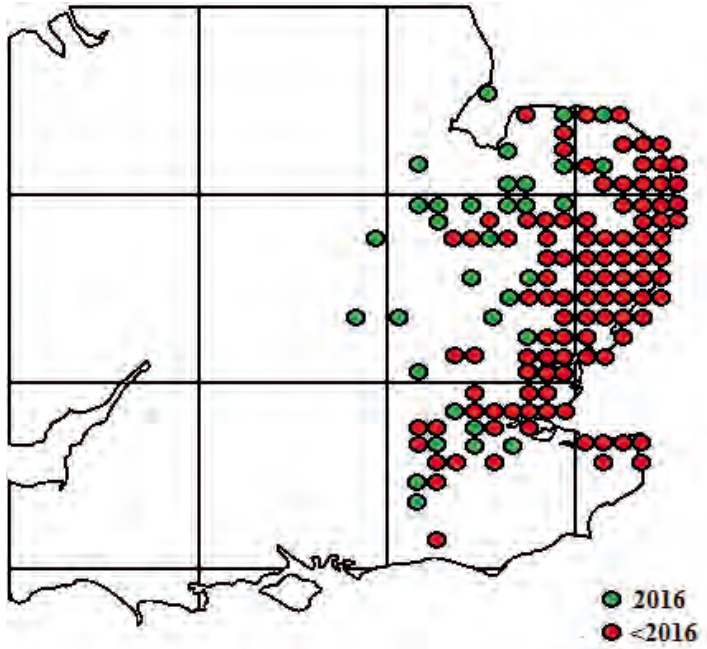

Figure 1. The current distribution of *Chalcolestes viridis* in southeast England, showing dates of first appearances.

Lestes barbarus (Fab.) – Southern Emerald Damselfly

The well-known colony at Cliffe in Kent remained stable, with several adults being noted and with exuviae even being found (JGB). However, at the species' other traditional site at Winterton in Norfolk just a single record was received, that being of a lone male seen on 18 August some distance from the species' "usual" pools (PHe). The precise status of the species at Winterton has never been fully resolved, and it is possible that the damselfly seen in 2016 was a fresh immigrant rather than a locally-bred individual. Elsewhere, a new breeding site for the species was discovered on the north coast of the Isle of Wight, when a mixture of teneral and more mature individuals was photographed on 16 June (PHn); clearly the species must have also been present there during 2015, if not earlier. Hopefully this recent colonist will continue to arrive at, and colonise, yet further sites in the coming years, and so develop a stronger foothold in Britain.

Erythromma viridulum (Charp.) – Small Red-eyed Damselfly

Only limited range expansion by this relatively recent colonist was noted during the season, the species having seemingly now come close to equilibrium. Similarly, there were few signs of fresh immigration reported. Some 20+ individuals were, however, seen at Winterton Dunes in coastal Norfolk on 12 August (PHe); they had not been present earlier in the week and had gone by the following day, so clearly some sort of movement was involved.

Aeshna affinis (Vander Linden) – Southern Migrant Hawker

There were numerous records received during the summer from the species' known strongholds in the greater Thames Estuary area, with Wat Tyler Country Park in Essex being particularly favoured. There were also several records from Hockley Woods, a rather different habitat type to the coastal grazing marsh where the species is most frequently encountered. Elsewhere, a male reported from Kew Gardens, Richmond, Greater London, on 1 September (CE) was perhaps a wandering or dispersing individual from the Thames Estuary population. More significantly, several individuals were also seen and photographed in the St. Osyth area of north Essex over the period 31 July–31 August (CA *et al*.), with mating even being observed on 28 August. In the absence of any clear influx from the Continent during 2016, these records potentially relate to an already-established local breeding site. Perhaps the Thames Estuary population is now starting to expand its range. Alternatively, it is possible that the influxes noted in 2015 (Parr, 2016) may have established new breeding sites in southern England away from the Thames Estuary. An individual was indeed noted during late August 2015 at Bawdsey in Suffolk – not too far from St Osyth (Parr, 2016).

***Aeshna mixta* Latreille – Migrant Hawker**

Some large concentrations were noted in southern England during early August. A hundred were thus seen on the Blickling Estate, Norfolk, on 3 August (JM), with roughly 200 noted in the Halesworth area of Suffolk on the same day (DB). Some 300 were then seen at Hatch Hill, Somerset, on 7 August (MHt). Whether this represents synchronised local emergences or immigration is currently unknown (see Parr (2015) for a discussion of similar events in 2014). Apart perhaps from these events, it seemed a relatively quiet year for movements of *A. mixta*, though small numbers were reported from Skokholm Island, Pembrokeshire, between 29 August and 14 September (SIBO) and 'possibles' were reported unusually far north off Rhum in the Inner Hebrides on 13 & 20 September (per PB). Individuals attracted to UV moth traps at Burwardsley, Cheshire, on 1 September (MW) and at Landguard, Suffolk, on 22 September (NO) are also perhaps potentially migrants (Parr, 2006).

***Aeshna isoceles* (Müller) – Norfolk Hawker**

New site records from Wicken Fen, Cambridgeshire, on 24 July (PTa) and from Thompson Common, Norfolk, on 26 July (JH) provide further evidence of the ongoing internal dispersal and range expansion that this species is currently showing.

***Anax ephippiger* (Burmeister) – Vagrant Emperor**

This highly migratory Afro-tropical species is currently being seen in Britain with some regularity. Although it may potentially appear at any time of year (Cham *et al*., 2014), all 5-6 records during 2016 came during the autumn, a period which coincides with emergences taking place in West Africa (Dumont & Desmet, 1990). Records began on 15 September, when a male was photographed on St Agnes in the Scilly Isles (MHd). A female was later photographed on nearby St Mary's on 25 September (WS) and there was also a report of a 'probable' from Tresco on 8th October. Elsewhere in the country, a male was photographed on South Ronaldsay in the Orkney Islands on 18 September (KM), with another male photographed on Birsay, also in the Orkney Islands, on 13 October (SGW). The final record of the year, and the only one from mainland Britain, was a female photographed at Burnham Overy Dunes, Norfolk, on 25 October (RC).

***Anax imperator* Leach – Emperor Dragonfly**

Movements of this species can be hard to detect due to it also occurring in England and Wales as a common resident. A total of eight seen at Landguard Bird Observatory on the Suffolk coast on 12 August (NO) is potentially of some

significance, this being an unusually high count for the site and over twice the number recorded on any other date in 2016. Perhaps it represents a small arrival.

***Anax parthenope* Sélys – Lesser Emperor**

The species had a fairly average year, with records from 14 sites in nine counties; reports spanned the period 20 June – 29 August, peaking in the second half of July. Although most sightings were from southeast England (Berkshire, Essex, Hampshire, Hertfordshire, Kent, Suffolk, Norfolk), they also included reports from Fenemere in Shropshire on 20 June (PHo) and from Drakelow Nature Reserve, Derbyshire, on 23 July (HJM). As seems to be the norm, records once again appeared to refer mainly to primary immigrants, though a few locally-bred individuals might also potentially be involved. One such candidate was a male seen at the Trinity Broad complex in Norfolk over 22–25 July (PHe *et al*.), this being a site where several *A. parthenope* had similarly been noted in both 2014 and 2015 (Parr, 2016). There were also sightings from Dungeness in Kent on 31 July and 9 August, this being a site where records have long been annual, and where breeding may thus be taking place (but which equally is a prime locality for intercepting immigrants). The precise breeding status of *A. parthenope* in Britain is an area that clearly warrants further study.

***Libellula fulva* Müller – Scarce Chaser**

This once rather localised species has been significantly expanding its British range over recent years, and 2016 saw some important new discoveries. These included sightings from Ratcliffe-on-Soar, Leicestershire (significantly outside the range shown in Cham *et al*. (2014)) on 8 & 10 July (SM), the first records for Lincolnshire (near Throckenholt) on 22 June (KD), and a sighting at Scotney Castle, East Sussex, on 23 July (APl). An immature found in woodland on the outskirts of Newmarket, Suffolk, on 29 May (APa), some way from potential breeding habitat, is also of interest.

***Orthetrum coerulescens* (Fab.) – Keeled Skimmer**

Three males were noted at Winterton Dunes in coastal Norfolk on 15 & 18 August (BJ, PHe), some way from known breeding sites in the county.

***Sympetrum danae* (Sulzer) – Black Darter**

A degree of dispersal was noted during the year. A male seen at Pooley Fields in Warwickshire on 21 September (JB) was thus the first county record for four years, while small numbers seen in the Ainsdale area of Lancashire between 17

August and 9 October (AS, PK) are also away from known breeding sites. The above records no doubt refer to dispersing British individuals, but an additional sighting at Spurn, East Yorkshire, on 6 August (SBO) is perhaps potentially an immigrant from the Continent.

Sympetrum fonscolombii (Sélys) – Red-veined Darter

Once just a very scarce and irregular immigrant, *Sympetrum fonscolombii* has now become a regular visitor to Britain, often in some numbers. The 2016 reporting year was, however, to be one of the species' quieter years by modern standards. The first report of the season was of a female on Bardsey Island, Gwynedd, on 11 May (SS), and sightings of singletons from Skokholm Island, Pembrokeshire, and from two sites on the Isle of Wight followed in the next few days. As these were all fully mature individuals, it is likely that a small arrival of migrants took place. After a brief lull, the last days of May and the first week of June then saw another run of sightings of mature individuals, principally from Cornwall (three sites) and Glamorganshire (two sites), though there was also a record from Sandwich Bay in Kent. Again, the numbers seen were low, with typically only singletons being involved, though up to 4-5 were reported from Windmill Farm, Cornwall (AB) and Kenfig, Glamorgan (CL).

In addition to the sprinkling of immigrants, a few British-bred individuals were also observed during the spring and early summer. A teneral was seen at Dozmary Pool, Cornwall, on 6 June (KP) and a potentially 'newly emerged' individual was reported from Spurn, East Yorkshire, on 22 May (SBO). Occasional immatures seen elsewhere, e.g. at Severn Beach in Gloucestershire (MHt) and at Beeston Common in Norfolk (SC) during late June, and at Flamborough Head, East Yorkshire, on 19 July (AA) could perhaps also be locally-bred, though there is no firm proof of this and they could alternatively be primary immigrants. A record of a 'pristine' individual unusually far north at Millar's Moss in the Scottish Borders on 23 July (DG) is also of some interest, ovipositing having been observed there during 2015 (per PB).

In contrast to the situation in many recent years, there were to be no reports of locally-bred second-generation individuals seen emerging during the autumn, though given the rather low level of immigration during the spring, this is perhaps not too surprising. A very few *S. fonscolombii* were never-the-less observed during the late summer and autumn period, for example at Filey, North Yorkshire, on 13 August (DL), on the Lizard, Cornwall, on 24 August (MTu) and at up to three sites in Somerset/south Gloucestershire during late August–September (MHt). These are perhaps either dispersing individuals from transient breeding sites elsewhere in northern Europe or else fresh immigrants from the south.

***Sympetrum sanguineum* (Müller) – Ruddy Darter**

Because of it also occurring as a common resident, migrations of this species can be hard to detect. There was, however, some sign that small arrivals may have taken place along the east coast in late July/early August. Two seen at Bempton Cliffs RSPB Reserve, East Yorkshire, on 31 July were thus the first reserve records, and the very next day two were seen nearby at Flamborough Head (AA), despite the species being less than annual there. Further south on the east coast, singles noted daily at Landguard Bird Observatory in Suffolk from 4–6 August (NO) could potentially be part of the same movement, particularly as there were then to be no further records from the site until the end of the month.

***Sympetrum striolatum* (Charp.) – Common Darter**

Little sign of major movement was reported during the year, though some 50+ suddenly appeared in a garden at Benhall, Suffolk, on 28 September (PHm). Along the south and east coasts there were, however, a number of late summer records of individuals attracted to UV moth traps, many of which may refer to migrants (Parr, 2006). At Portland, Dorset, singles were thus caught on 20 August and 11 & 14 September (MC), while at Bawdsey, Suffolk, singles were caught on 9, 21 & 22 September and 11 October (MD).

Exotics

At least two individuals of *Ischnura senegalensis* (Marsh Bluetail) emerged from a tropical aquarium in Hampshire during mid April 2016. The species is clearly now being accidentally imported into Britain on quite a regular basis (see e.g. Parr, 2010).

Conclusions

By modern standards, the 2016 reporting year was a relatively unspectacular one for many migrant and dispersive species in the UK, though there were exceptions. Some of our new colonist species – most notably *Chalcolestes viridis* and *Aeshna affinis* – thus faired well and, while traditional migrants such as *Anax parthenope* and *Sympetrum fonscolombii* had, at best, an average season, *A. ephippiger* continued its recent run of good showings. A series of unexpected sightings of various more common species along the east coast of England during early August perhaps also hints at migrations whose full extent went under-appreciated. When summarising the events of the year and their overall significance, it does, however, also need to be borne in mind that

everything is relative, and only as little as 20 years ago many of even the 'low-key' events reported during the season would have made major headlines. This just goes to show how much the British Odonata have been affected by recent environmental changes taking place both at home and abroad (for example the well-documented climatic shifts). It also begs the question as to how much further change is to be expected in the short- to medium-term future. Clearly, continued monitoring, not only of our established breeding species but also of our recent colonists and of our immigrant species, is to be encouraged.

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