Report on a survey of Dragonflies and Damselflies on the River Kird 2017

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Newly emerged Scarce Chaser Dragonfly on the River Kird in May © A.M. Barker



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Summary

The River Kird is a feeder stream for the River Arun in the Upper Arun Site of Special Scientific Interest (S.S.S.I.) area. Although the latter is designated principally on the richness of its dragonfly and damselfly fauna; the River Kird has not been systematically surveyed for these insects. In the summer of 2017 we were able to survey over 5km of the lower reaches of the River Kird, from Kirdford to the point where it reaches the River Arun. Eight damselfly and 11 dragonfly species were recorded on the river, with a total of 2144 individual records along the surveyed 5610 metre length of the river bank. All but one of these species showed some evidence of male territorial behaviour, and for 11 species we obtained evidence of breeding from observations of mating, oviposition and successful adult emergence. The fauna was typical of small eutrophic lowland waterways in the Arun area, with Azure Damselfly (Coenagrion puella) being the most common species on the wider slowflowing areas and Banded Demoiselle on the narrow, fast-flowing stretches. Notable species were the red data list species Scarce Chaser (*Libellula fulva*), which was present at high densities on many stretches of the River Kird, and the Hairy Dragonfly (Brachytron pratense) and White-legged Damselfly (*Platycnemis pennipes*), both of which need high-quality slow-flowing riverine habitat with lots of emergent vegetation. In addition, the Willow Emerald Damselfly (Chacolestes viridis) was recorded breeding along the river; this is the most westerly Sussex site yet known for this recent British colonist. The complexity of the physical structure of the river and the richness of the flora supported strong numbers and high species diversity. However, there was some nutrient pollution, although this became diluted as the river ran downstream through the grazing pastures, and some sections were too overgrown with trees and scrub to allow enough light to reach the water for Odonata to thrive. Overall though, the River Kird is an important habitat for dragonflies and damselflies and it is hoped that this survey will help provide the evidence needed for its conservation and for the management required to improve the water quality into good condition.

Introduction

The River Arun in West Sussex near Billingshurst and Wisborough Green supports an outstanding dragonfly assemblage for which the 13km section from Stopham Bridge to New Bridge has been designated as the Upper Arun Site of Special Scientific Interest (S.S.S.I.) by Natural England (see website address in Reference list). The River Kird is a small tributary of the Arun which has not been previously surveyed at all for its dragonfly and damselfly fauna. Potentially this river could have many or all of the species present on the main river but it passes almost entirely through private farmland making access difficult. The North East Parishes Wildlife Recording Group, based around Wisborough Green and Kirdford, is concerned about potential threats to this riverine habitat particularly from pollution and wanted a full survey to identify which species of Odonata are present on the River Kird and whether it is of conservation importance.

Introduction to British Dragonflies and Damselflies

Dragonflies and Damselflies belong to the same insect order, the Odonata (from the Latin meaning 'toothed jaw'). Both are colourful insects with four clear or coloured transparent wings that, unlike many insect groups, can be used independently allowing dragonflies and damselflies fast and manoeuvrable flight, rather like the helicopters of the insect world. Dragonflies (Figure 1), classified as Anisoptera or 'unequal wings', are generally larger and more robust and hold their wings open at

rest. Damselflies (Figure 2), classified as Zygoptera or 'equal wings', are smaller and more slender and rest with closed or half-closed wings.



Figure 1 Scarce Chaser Dragonfly, River Kird ©A. M. Barker



Figure 2 Large Red Dragonfly, River Kird © A. M. Barker

There are 46 species of Odonata currently breeding or regularly migrating to the UK according to the British Dragonfly Society (see the list of website references). All of them lay their eggs in or around freshwater, either directly into the water or into underwater plant stems or plants just at the water's edge. These hatch into larvae (Figure 3) which live in water for between 1 and 3 years. The larvae of some species live as ambush predators in the mud or gravel at the bottom or the pond or river; other species have actively hunting larvae that live among submerged water weed. They feed on other aquatic insects and even small fish. When they reach full size, they crawl up out of the water, often onto plants growing up out of the water (emergent plants) or tall herbaceous bankside vegetation, where the adult form moults out of the final larval skin (see Figure 4 below), leaving it behind. This moulted skin is known as an '*exuvia*' and can be identified to species.



Figure 3 Dragonfly larva © A. M. Barker



Figure 4 Newly emerged damselfly above exuvia © A.M. Barker

This makes dragonflies and damselflies very dependent on high-quality freshwater habitats in which to breed, and they are sensitive to water pollution. Some species use lowland streams and rivers;

others prefer still water, still others are found in or heathland or mountain pools and streams. After emergence the adults fly away from water to feed on flying insects and mature for one or two weeks, and they will continue to feed through their comparatively short (1 week to 3 month) adult lifespan (the 'flight period'). So good quality feeding habitats, such as unimproved meadow or open woodland, are also important to these insects. After maturation, males return to water where they hold territories, some by active patrolling over an area and others by defending a patch from a selected perch. Females coming to the water will be mated and will then lay their eggs, often guarded by the male they mated with. Dragonflies and damselflies have a distinctive circular mating position (known as the 'wheel' position – Figure 5), and after mating the males of many species continue to hold onto the back of the female's head in the 'tandem' position (Figure 6) while she lays eggs; this defends her from other males looking for a mate.



Figure 5 Pair of Scarce Chasers mating in the 'wheel' position © A.M. Barker



Figure 6 Azure damselflies in 'tandem', with the male grasping the head of the female while she lays eggs into an underwater plant stem. ©A.M. Barker

Most British species of dragonfly and damselfly can, with practice, be easily identified while alive. A number of field guides to both adults and to older larvae and exuviae exist; references to the ones we used are given at the end. This report uses the English names as given in the recent *Atlas of Dragonflies in Britain and Ireland* (Cham et al. 2014); the scientific Latin names are given in the summary, Table 1 and Appendix 1.

Survey scope and methodology

Surveys were all led by Dr Alison Barker with the participation of members of the North East Parishes Wildlife Study Group. Dr Barker is an entomologist with 30 years' experience of identifying U.K. and continental dragonflies and has been recording regular transects at a Hampshire reserve site since 2009.

In total during the survey we surveyed a total of 5,610m of the River Kird between Kirdford and Wisborough Green, over a straight-line distance of just over 3km. Through our survey area the River Kird runs from west to east to join the River Arun. The survey was spilt into four sites, according to ownership of the land and practical convenience; between them these covered about 5/6 of this section end of the River Kird. All the surveyed sites are on private land with no public access and we would like to thank the landowners for giving us the permission to carry out this work on their land.

We aimed to walk each section of transect on each site at least twice during the dragonfly flight period (May to September), with at least one visit during the flight season of the early-flying species such as Hairy Dragonfly (which peak in June) and one to observe the later flying species such as Southern Hawker (which flies from July - autumn). At one site (Crofts Farm) we were able to do three visits, in late May, late June and September.

Transects were defined by experience on the ground using a combination of the terrain and the time taken to walk them. Obvious changes in the terrain (entering a wooded area, or a new field, or the river changing from being broad and open to narrow and channelled) were marked by a new transect, with the aim of keeping each transect as a section of reasonably uniform habitat. We also aimed to make each transect take about as long to survey, within reason, so that surveyor effort was equal within transects. This meant that longer areas of similar terrain were split into several transects. Most transects were between 250 – 350m long, although there were exceptions where the terrain was uniform but low in odonate numbers, making it very quick to walk and leading to a longer transect, or where an obstacle or endpoint was reached making a transect shorter than average. Most transects took about 40 minutes to an hour to walk and record fully in good weather at the height of the dragonfly season.

Transect start and end points are given here as 6-figure OS Grid References which were obtained using the online grid reference finder website (<u>https://www.gridreferencefinder.com/</u>). This website also enables the user to trace a line between marked points to measure the distance between them. I used this application to estimate the transect lengths in metres following the route of the river (to the nearest 5m) after they had been defined on the ground. Transects were walked following the modified Pollard Walk method laid out in Corbet and Brooks (2008). Ideally all transects would have been walked in perfect weather conditions for Odonata – full sun (<50% cloud), light wind (no more than Force 3 on the Beaufort scale – leaves and branches moving but not trees) and temperature about 17°C. We managed this on most dates but the first survey done at Crofts (18/5/17) was carried out in cloudy conditions that eventually turned to rain, and one or two transects at other sites were carried out during temporarily cloudy or even wet conditions, although we were able to wait these out and finish the survey in suitable weather.

On each transect we walked steadily alongside the river scanning the river surface, any floating or emergent vegetation, and a 2m wide strip of the river bank for Odonata. Most were easily identifiable with the naked eye but we also used binoculars for a closer look. In addition, a small proportion of the blue and black damselflies were netted and examined at close range to double-check that we were not missing any species (the Variable Damselfly, *Coenagrion pulchellum*, is found in the nearby Pulborough Brooks so we thought it important to make sure we were not missing this species). All dragonflies and damselflies seen were noted and their numbers recorded. Any additional behaviours were also noted, in particular successful emergence (which is considered proof of successful breeding), oviposition (which indicates probable breeding, since the eggs may not survive to adulthood) and copulation (mating) which indicates possible breeding (definitions based on those of the Dragonfly Conservation Group of the British Dragonfly Society, 2004, detailed in https://british-dragonflies.org.uk/content/key-sites-criteria#). Territorial behaviour by males was recorded as, while not considered sufficient to prove breeding, it shows that a species is attempting to breed in the habitat rather than simply feeding or passing through. As we were interested in t the

overall dragonfly diversity of the river catchment zone, we also recorded non-territorial dragonflies feeding in the fields immediately adjacent to the river.

As well as recording dragonflies and damselflies we looked for cast skins (exuviae) left by the larvae as they emerged into the adult form, as they can be identified and provide proof of successful breeding. However, the extensive bankside vegetation was difficult to search through effectively, and many suitable emergence sites were inaccessible in fact we observed a number of exuviae on plants emerging in the centre of the river out of our reach. In addition a temporary flood just before 8/6/17 will have swept many of the early season exuviae away before we could get to them.

Potential limitations

It should be noted that there is considerable debate about the limitations of just surveying adult dragonflies, because they may be present or even hold territories in areas that are unsuitable for breeding. Authors have suggested surveying larvae or fully searching all banks for exuviae on a regular basis as being less biased techniques (Raebel et al. 2010); however, these authors were working in ponds where access was less challenging. Personal experience from larval surveying leads me to suspect there are greater biases with this technique than these authors would suggest, with some species moving in and out of deep water or living in less accessible microhabitats where they are in a refuge from net capture (Barker, pers. obs.). Nelson (2014) makes the point that due to the long development times of larvae (up to 3 years), changes in habitats over time may mean that larval and adult habitats may differ within a species. In addition larvae can move and may not stay in the habitat where the eggs were laid. This suggests that a combination of techniques sampling different stages of the life cycle would be ideal to fully understand how Odonata are using a water body. However, we did not have the time or level of site access necessary to attempt any larval surveys.

Water testing

Water testing was carried out using kits supplied by the Freshwater Habitat Trust as part of their Clean Water for Wildlife initiative (<u>www.freshwaterhabitats.org.uk/projects/clean-water</u>). Each kit contained two small plastic tubes sealed with plastic pins, one with reagent for measuring Nitrate levels and one for measuring Phosphate levels. I used a small bucket on a string to scoop up a sample of water from the selected river site (Figure 7), and used it to fill a small clean, well-rinsed and dry plastic bottle. This was labelled with the site and date and tested later the same day (this was more convenient than testing in the field). Samples were taken in September from the river at Crofts, Montegue Farm and Harsfold Bridge within a two-day period to try and ensure they were comparable across the three sites.



Figure 7 Water sampling equipment © A.M.Barker



Figure 8 Comparing reagent tube colours with the colour chart to determine nutrient pollution concentrations[©] A.M. Barker

The protocol accompanying the kits was used for testing. After removing the pin, each plastic tube was squeezed to remove air and then submerged and allowed to suck up water until it was just over half full. It was shaken to mix water and reagent and then allowed to stand for a given amount of time (Nitrate: 3 minutes, Phosphate 5 minutes). The tubes were then compared with the printed colour chart supplied to determine the level of nutrients (Figure 8). Information on the accompanying leaflet enabled interpretation of the results in terms of the extent of pollution they represented.

Site descriptions

The transects are described in order from the most upstream and westerly to the most easterly at the point where the River Kird flows into the River Arun. The map (Figure 9) shows their positions on the ground.



Figure 9 Map of the Transects walked along the River Kird in 2017. Map data©2018 Google

Crofts Farm Transects – Visited on 18th May, 20th June and 27th September 2017

This was the most westerly site surveyed, close to Kirdford and centred on Crofts Farm. The river is reached just below the farmhouse at a weir (TQ029259). West of the weir the river runs through rough pasture with some mature trees on the near side (grazed by alpacas during our visits) and marsh and rough meadow with tall vegetation backed by woodland on the far side. Here it is quite broad (c. 4-5m) and open. We divided this section into 3 transects. We had one more transect below the weir to the east (downstream) where the river runs through a meadow on the near side with mixed broadleaved woodland behind; here it is in a deep channel carved into the streambed. It is much narrower (1m at the river level) and often shaded by scrub and overhanging trees.

Water quality: water was sampled from the shaded pool under the bridge just below the weir between the eastern and western transects.

Nitrate level: 0.5-1 ppm

Phosphate level: 0.1-0.2 ppm

8-figure Grid Ref for this point: TQ 02982591

This represents moderate nitrate pollution and quite high phosphate pollution.

Western Transects

Transect 1 TQ029259 - TQ030257 240m

Transect 1 ran from the weir for 240m upstream to the round one bend to the left and up to the second bend (where the river bends from south to west). There is a large ash tree at this point. This section of river is broad and appears quite slow-flowing. It is open and sunny with only occasional fringing bushes and small goat willow trees (*Salix caprea*). The first 50m is broadened out into a wider pool above the weir. There are yellow water lilies (*Nuphar lutea*) in the river and duckweed (*Lemna minor*) on the surface; duckweed increasingly covered the surface as the season went on but the surface remained open near the weir. The banks are low with shallow, sloping margins with lots of emergent vegetation including reeds (*Phragmites australis*). The photos show the first bend in the river in May , without duckweed (Figure 10) and September , with duckweed (Figure 11).



Figure 10 Transect 1 in May © A.M. Barker



Figure 11 Transect 1 in September © A.M. Barker

Transect 2 TQ030257 – 027258 (May) 310m or 028257 (June and September) 205m

Transect 2 Started from the bend with the ash tree and ran as a straight and open channel through the pasture. It originally followed the straight river across the field boundary and along a track past a field bridge to the next field, where the river became more meandering and shaded. Unfortunately by mistake on re-walking this transect in June and September we finished it at the field boundary gate and incorporated the next section into Transect 3, making it harder to compare results between transects across the dates.

Like Transect 1 the river in this Transect is open and sunny with only occasional small fringing trees goat willow, ash (*Fraxinus excelsior*), sloe (*Prunus spinosa*) and hawthorn (*Crataegus monogyna*). The banks are low and shallow with emergent vegetation, and in the water there are water lilies and duckweed which gradually covered the water surface between May and September. There is open meadow on either side apart from the last 100m section on the track (included in this Transect in May) where a small broad-leaved woodland lies on the other side of the track.



Figure 12 Transect 2 in June, with water lilies and open water $\ensuremath{\mathbb{C}}$ A.M. Barker

Transect 3 TQ 027258 (May) or 028257 (June and September) to TQ025259 (365m)

Transect 3 ran from the end (May) or the start (June and September) of the track beyond the Field gate and along the river as it wound through the next field. As described in the description of Transect 2, the section by the track was open with a bridge and some small trees, and bordered by a meadow on the other side (Figure 13). Beyond this, the riverbanks became steeper and deeper so that the river flowed through a deepset channel. It was still quite broad but in many places it was shaded by mature trees with a small wood on the far side and occasional large trees, including ash and oak (*Quercus robur*), on the nearside. There were one or open more open areas where sunlight reached the water. This section meandered around the edge of a rough unimproved hayfield right round to the field boundary.



Figure 13 Straight section next to track, with bridge (Transect 2 then Transect 3). By September the water surface was covered by duckweed. © A.M. Barker

Eastern Transect

Transect 1 TQ 030259 - 033260 400m

This transect ran downstream from just past the weir to a fallen tree and fork in the water course. Here the river is reduced to the size of a stream – about 1m across – in a deep narrow channel with steep muddy banks. The flow appears faster here. Access to the river was only possible at intervals; it was backed by woodland and there were overhanging trees, mainly ash and sections of scrub and even a section of hedge along the nearside bank. Where the water was visible it was often in shade, but there were more open patches and these often had slumped banks with emergent and floating vegetation. On the near side of the river was an open meadow where the grass was very tall on 20th June but had been cut by September.



Figure 14 Typical overgrown section of Eastern Transect 1, with just a little clear water showing $\ensuremath{\mathbb{O}}$ A.M. Barker

Montegue Farm Transects – Visited on 5/7/17 and 25/9/17

This stretch of the river was the next one surveyed downstream (to the east) after a gap of about 0.8km in a straight line (but longer in terms of river distance) from Crofts. At this point the river lies at the bottom of a sleep wooded slope to the northwest, with flat pasture fields to the southeast and bounding the river itself. This is close to eastern end of the village of Wisborough Green (the road called 'The Luth'). The river was split into 3 transects for surveying, one upstream and two downstream of our access point from the wood. This section finished at the bridge of the A272 main road; on the other side of the road lay the next surveyed section of river ('Harsfold Lane West').

Water quality

This was sampled from a small farm bridge across the river within the second transect (about 60m from the start of the transect) on 26/9/17.

Nitrate level: 0.5 - 1ppm

Phosphate level: 0.05-0.1 ppm

8-figure Grid Ref for this point: TQ 04182621

This represents moderate level nitrate and phosphate pollution.

Transect 1 TQ040263 -041262 180m

Walked from gate at base of wood west (upstream) to the where the river meets another area of woodland (no access possible beyond this on this side of the river).

Banks of the river here mostly steep and narrow and fringed with trees on the far bank, with many larger trees (oak, ash, field maple (*Acer campestre*)) covering the river and a low hedge on the near side for about one-fifth of length. The middle third of the section was permanently in full shade. There were some sunlit sections, in particular the first 80m where the river was broader and shallower (Figure 15). This section had Yellow Water Llilies (*Nuphar lutea*) and Arrowhead (*Sagittaria sagittifolia*) growing from the water and lots of bankside vegetation including Nettles (*Urticaria dioica*) and Marsh Woundwort (*Stachys palustris*). By our first visit (5th July) the water surface was completely covered in duckweed. It was bordered by improved pasture grazed by cows with small broad-leaved woodlands on the steep slope behind.



Figure 15 The open first section of Transect 1 in September, choked with duckweed $\ensuremath{\mathbb{C}}$ A.M. Barker

Transect 2 TQ041262 – 042261 240m

Walked from gate at base of wood eastwards (downstream) around two river bends to a circle of posts near the end of the field.

River continues to be deep-set in steep-banks, about 2 -3 m wide, and frequently fringed by hedges and scrub with some larger trees (willow (*Salix* sp.) and goat willow, ash and lime (*Tilia x europaea*)) so that here the river was in full shade. There were some open and sunlit stretches of water (about one-third of the total length of the transect). The river surface was covered by duckweed. The river was bordered by a narrow strip of grazed improved pasture backed by woodland (Figure 16).



Figure 16 The line of trees to the left marks the path of the river along Transect 2, with woodland to the right. © A.M. Barker

Transect 3 TQ 042261 – 042256 547m

(On our first visit in July I underestimated the distance left to walk when reaching the start of this transect and it unintentionally became much longer than the rest.)

This transect ran from the posts in the field at the end of Transect 2 to the A272 bridge. The first 340m of it was through similar habitat to transect 2 – meandering river c. 3m wide and quite deep, banks mostly steep and fringed with trees including oak, ash, field maple, willow and alder (*Alnus glutinosa*), with a low hedge on the near side in several places for about one-fifth of the length of this first section. Bankside scrub included sloes and Wild Rose (*Rosa* sp.). About one-third of the river was in shade in this section. In the last 200 m the river broadened and there were some shallower, broad sections with emergent vegetation and water lilies. For most of the last 120m of the transect, high hedges bordered both sides and the river was straight and deep and quite shaded, although it was more open where it reached the bridge. The water surface was covered with duckweed throughout except for a 10 x 5m section in the early part of the transect where there was a patch of the invasive weed Water Fern *Azolla filiculoides.* (Figure 17; See section on Invasive Species in the Analysis and Discussion)

After the first 300m the river meandered away from the wooded slope and the pasture field opened to become much broader (Figure 18). The other side of the river was also pasture apart from the last 50m where there was a house with a lawn and garden with ornamental trees.



Figure 17 Section of Transect 3 overhung by bushes and with the patch of invasive weed *Azolla* © A.M. Barker



Figure 18 Open field with line of river to the left, marked by trees[®] A.M. Barker

Harsfold Lane Transects

In total we surveyed ten transects along the river from the Harsfold Lane bridge, three to the west, following the river for 1250m to its bridge under the A272, and seven to the east, along 2140m of river bank to the River Arun (these are distances following the river, not in a straight line). Due to the distances needing to be covered, we surveyed the west and east sections separately on different dates.

Water quality

This was sampled from the Harsfold Lane Bridge, on the east side, on 27/9/17 (at the start of East Transect 1):

Nitrate level: 0.2-0.5 ppm

Phosphate level: 0.05-0.1 ppm

8-figure Grid Ref for this point: TQ 05145243

This represents low level nitrate and moderate level phosphate pollution.

Harsfold West Transects – Visited on 25th May (Transect 1 and 2, surveyed east to west) and 5th July (Transect 3 surveyed west to east), then again on 31th July (all 3 transects, surveyed east to west). Transect 3 lies immediately downstream of the third Montegue Farm transect.

Transect 1 TQ 051254 – 049256 375m

This transect runs from Harsfold bridge Lane round a tight right-hand curve and then a long left curve. It ends at a tight left bend in the river with an open area by a large ash tree, opposite the start of a wood on the far bank. Here the river was running through improved grazing meadow, which had cows in it on our second visit. This stretch of river had steep and deep earth banks with shallower sections at meanders. It was very overgrown with trees and shrubs (Figure 19) and the water was shaded with only small open areas; these had lush emergent plants (Figure 20) including purple loosetrife (*Lythrum salicaria*) lesser reed mace (*Typha latifolia*) and floating water lilies. On our first visit the grass fringing the river was long; on our second visit when the cows were present it had been partly grazed but there was still tall vegetation on the banksides.



Figure 19 The line of the river along Transect 1 was marked by trees and bushes with occasional open gaps © A.M. Barker

Transect 2 TQ 049256 - 046254 540m

This transect ran from the end of Transect 1 round the final edge of the same grazing pasture, though a constriction with a wet runnel draining across the path into the river, along a short track between fields and round the edge of a second field. It ends where the river runs into a wood. It

was similar in character to Transect 1 – a meandering, muddy-bottomed small river set in deep banks with trees or shrubs fringing about 80% of its length (Figure 20). In places the trees were open enough to allow sunlight to reach the river, although sometimes this was from the opposite bank and our view of the river was restricted. There were more open areas including a long stretch towards the end of the transect with a small footbridge; here there were emergent plants (Figure 21) including arrowhead (*Sagittaria sagittifolia*), purple loosestrife (*Lythrum salicaria*) and reeds (*Phragmites australis*). By midsummer (5th July) the river at this point had reduced to a trickle following a hot dry spell.

Again, the grass in the bordering meadow was tall on our first visit but part grazed at the end of July when cows were in the fields.

Due to time pressures combined with lack of knowledge of the route we had to stop the survey here on our first visit (25/5/17) leaving a section beyond the wood running up to the A272 which was surveyed later on 5/7/17 (Transect 3).



Figure 20 Much of the river in Transect 2 was also bordered by trees and scrub© A.M. Barker



Figure 21 However there were areas of open water with a variety of submerged and emergent vegetation © A.M. Barker

Transect 3 TQ 045255 - 042256 335m

This transect did not run consecutively from Transect 2 as there was a small broadleaved woodland at the end of Transect 2 which was fairly difficult to access and did not allow good views of the river, which was in any case shaded here. So Transect 3 ran from the western edge of the wood to the A272, through ungrazed pasture. The river here was broader and more open than in Transects 1 and 2; the eastern part was covered over with duckweed by July and hard to see well due to high fringing vegetation, but about 100m further west there was a weir with a fish ladder where the river was briefly enclosed within concrete walls. Upstream of the weir the river widened into a broad sunny pool (Figure 22) with shrubby vegetation behind and lots of floating plants (lilies and pondweed as well as duckweed) Beyond this it narrowed again to about 3m wide but was still much more open and accessible than the previous two transects, with some trees but most of the water surface in the sunshine. The banks were broad with extensive vegetation including Meadowsweet *Filipendula ulmaria*, Water Forget-me-not *Myosotis scorpoides*, Water Woundwort *Stachys palustris*, Water

Dropwort *Oenanthe crocata*, Docks (*Rumex* spp.), Reeds *Phragmites australis*, Lesser Reedmace *Typha latifolia*, Figwort *Scrophularia aquatica*, and Nettles *Urticaria dioica*.



Figure 22 Open pool upstream of weir, Transect 3 © A.M. Barker

Harsfold East Transects – Visited on 8th June (Transects 1-4 surveyed east to west) and 15th June (Transects 5-7 east to west), then again on 13th July (surveyed east to west).

Because this was a very long section (2140 m) there was not time to do all 7 transects in full detail on a single visit, so we surveyed the first four transects on 8th June and the final three on 15th June. On 8th June the water levels were very high following a sustained rain storm, and the water was very fast flowing. By the 15th the water levels had fallen by about 50cm, exposing large areas of flattened vegetation and reducing the water flow in some sections to a comparative trickle. The repeat survey was completed in a day on 13th July but to cover the full section in this time we sampled Transects 7, 5 and 1 with full counts and 6,4,3,2 with presence/absence data.

Transect 1 TQ051254 - TQ053254 240m

This transect (Figures 23 and 24) ran from Harsfold Bridge East to an old hedge line dividing the first pasture in two. From the bridge it opened into a wide pool c. 10 m wide with lush fringing and emergent vegetation and lots of yellow water lilies and pondweed leaves (*Potamogeton* species) on the water surface. Duckweed also built up on this pool over the season although even in September it was not quite covered. After this the river narrowed to about 2 – 3m wide, with scrub and trees on the opposite bank and the water sometimes shaded. There was pasture with cows on either side of the river and some poaching (where the cattle had trodden the bank down) to far bank.



Figure 23 Transect 1 with Wisborough Green Church behind[®] A.M. Barker



Figure 24 On 8th June the R. Kird was swollen with rainwater – this is Transect 1 with the bank flooded© A.M. Barker

Transect 2 TQ 053254 - 053251 330m

This ran from the old hedge line to the field boundary gate through improved grazed pasture. It was mostly wooded on one side, including a line of poplars and some willow trees, and open on the other. There were some wholly open areas with emergent vegetation. Near the beginning of this section there was an outflow pipe from the Wisborough Green sewage works (Figure 25).



Figure 25 Outflow from Wisborough Green sewage works in Transect 2 $\ensuremath{\mathbb{C}}$ A.M. Barker

Transect 3 TQ 053251 - 053248 - 635m

Picture: outflow

From the wooden gate at the field boundary across open improved pasture at the base of a slope with some arable fields and a pasture field with alpacas. After an initial section with a meader and some mature trees, here the river was largely open with very few trees or bushes (Figure 26). It was sunken into a narrow meandering channel, with banks in places poached by cattle, and covered with knee-high herbs and grasses. Due to the flood, on our first visit the water level was high, and had clearly nearly reached the level of the field itself, judging by the flattened plants. This was a long transect section but it was very uniform and due to low numbers of Odonata it was quite fast to survey.



Figure 26 River in open channel through the field on 8th June, with high water© A.M. Barker

Transect 4 TQ 053248 -054248 150m

This short transect ran from the field gate along a short open section then through alongside the river through woodland, where the water was largely hidden by scrub and the banks inaccessible. On

the other side Transect 4 extended for about 15m with some more open sections in between sloe and rowan scrub.

Transect 5 TQ 054248 - 056247 260m

The river in Transect 5 had open banks with occasional willow scrub. Grazed pasture with cows on either side of the river meant that there was some poaching of the banks giving lower, flatter areas. Some sections were very narrow and overgrown with reeds, reedmace and grasses. Although the river level had subsided when we surveyed this section evidence of the flood remained as debris stranded into the bottom sections of some of the bushes.

Transect 6 TQ 056247 - 056246 370m

River runs in a deep bed through grazing pasture, meandering with some areas overgrown with scrub including willows and dogrose. These were interspersed with open patches and one section was bordered on the far side by a marshy area with wet runnels flowing into the Kird. Here the river was open with water lilies and arrowhead (Figure 27). Near the end there was an additional side channel providing an extra inflow of water.



Figure 27 Arrowhead with Banded Demoiselle © A.M. Barker

Transect 7 TQ 056246 - 055246 150m

Transect 7 started at the field gate and passed through a wooden and concrete bank revetment that stabilised a 10m section of bank. Bankside vegetation here was still showing signs of the flood from 8th June on our first visit. Downstream of this the river formed a narrow open channel with bushes on the far bank and emergent vegetation. After 150m the River Kird flowed into the River Arun. On 15th June there were damselflies visible on the Arun itself so we recorded a snapshot view of what was there for comparison.

Results

Species recorded

During the course of the survey, 8 damselfly and 11 dragonfly species were recorded on the River Kird (see Table 1), with a total of 2144 individual records along 5610m of the river bank. Of these, evidence of successful breeding was obtained from observations of emergence of the Beautiful Demoiselle (Figure 28), the Azure Damselfly and the Scarce Chaser (Figure 29). All three of these species were also seen mating (e.g. Figure 5) and the Azure Damselfly and Scarce Chaser were seen ovipositing (egg-laying) on the river. Willow Damselflies, a new colonist for the area, were also confirmed to be breeding from observations of ovipositing females and the presence of series of egg-scars on willow (Figures 30 and 31) for this species. In addition evidence of probable breeding on the Kird was obtained for a further 4 damselflies, the Large Red Damselfly, Blue-tailed Damselfly, Red-eyed Damselfly and White-legged Damselfly, all seen mating and ovipositing. Evidence of possible breeding was obtained for the Banded Demoiselle, seen mating. Among dragonflies, individuals of the Emperor and Common Darter dragonflies were both seen ovipositing. For 7 of the 8 other dragonfly species males were seen defending territories. Records of all species across the full survey are summarised in Appendix 1.



Figure 28 Beautiful Demoiselle exuvia from Transect 2, Harsfold Lane East, 8th June 2017. Arrow points to characteristic thorn-like spike behind the eye© A.M. Barker



Figure 30 Ovipositing Pair of Willow Emerald damselflies, Transect 3, Crofts Farm, 27th September 2017. Male is at the top holding female (curled round and laying an egg) behind the head in the tandem position.[©] A.M. Barker



Figure 29 Newly-emerged Scarce Chaser with exuvia, Transect 2, Crofts Farm , 18th May 2017© A.M. Barker



Figure 31 Willow Emerald Oviposition Scars, Transect 1, Crofts Farm, 27th September 2017© A.M. Barker

Table 1 List of all the damselflies (Zygoptera) and dragonflies (Anisoptera) seen on the River Kird during the 2017 surveys, with English and Latin names.

Damselflies		Dragonflies	
English name	Latin name	English name	Latin name
Banded Demoiselle	Calopteryx splendens	Hairy Dragonfly	Brachytron pratense
Beautiful Demoiselle	Calopterx virgo	Migrant Hawker	Aeshna mixta
Large Red Damselfly	Pyrrhosoma nymphula	Southern Hawker	Aeshna cyanea
Azure Damselfly	Coenagrion puella	Brown Hawker	Aeshna grandis
Blue-tailed Damselfly	Ischnura elegans	Emperor Dragonfly	Anax imperator
Red-eyed Damselfly	Erythromma najas	Downy Emerald	Cordulia aenea
White-legged	Platcynemis pennipes	Scarce Chaser	Libellula fulva
Damselfly			
Willow Emerald	Chalcolestes viridis	Four-spotted Chaser	Libellula
Damselfly			quadrimaculata
		Broad-bodied Chaser	Libellula depressa
		Common Darter	Sympetrum striolatum
		Golden-ringed	Cordulegaster boltonii
		Dragonfly	

Site-by-site observations

Our results from the individual survey sites are summarised in Tables 2a – 2d. In detail, starting from the west and working east (downstream), we found:

Crofts Farm - Western section

The first two Transects of this section of river covered the broad open section upstream of the weir, with shallow sloping margins, floating water lily and pondweed leaves, emergent vegetation and well-vegetated banks with occasional small trees. This open habitat continued into the next 100m section with a bridge and some more mature trees next to the track that was initially included in Transect 2 and then in Transect 3. This open section of the river was extensively used by a range of damselflies and dragonflies (Table 2a).

On our first visit, on a cloudy day in mid-May, there were already Large Red damselflies, Azure damselflies, Blue-tailed damselflies and Red-eyed damselflies here; these continued to be common on this site during their flight periods with high peak densities, especially of Azure damselflies (58 adults /100m in the Transect 1 on 20th June). All these species were seen mating and all apart from the Red-eyed Damselflies were observed laying eggs on this stretch of river.

On 20th June along this whole section we also saw an additional damselfly species, the White-legged damselfly, which was mating and laying eggs on the straight stretch of river alongside the track between the fields. We also observed one Banded Demoiselle and 2 Beautiful Demoiselles near the weir, but they were uncommon on this section of river.

The last visit, on 27th September, was past the flight periods of all these damselflies apart from a couple of late-flying blue-tailed damselflies, but I located an autumn-flying species, the Willow Emerald Damselfly. This is a recent immigrant to Britain, spreading from colonies established on the

east coast in 2009, and is probably the western-most record of this species to date (Parr 2016). The individuals observed were resting on bankside vegetation and also ovipositing (egg-laying) into small goat willow trees; the characteristic oviposition scars were observed on all the goat willows on this stretch of river and adults were seen in all three transects (Figure 31).

Date		18/5	5/17			20/6	/17	27/9/17				
Transect	Transect 1W 2W 3W 1		1E	1W	2W	3W	1E	1W	2W	3W	1E	
Damselfly Species												
Banded Demoiselle					1			7				
Beautiful Demoiselle				1	2			46 ^m				
Large Red Damselfly		2	1	1	4°		5	7°				
Azure Damselfly	17	17	2	1	140 ^{mo}	151 ^{mo}	88°	8				
Blue-tailed	1	4			7 ^m	10 ^m	4 ^m	2 ^m	2°			
Damselfly												
Red-eyed Damselfly	2	1			25	31	22 ^m					
White-Legged					8	2	17 ^{mo}	27 ^{mo}				
Damselfly												
Willow Emerald									5 ^{os}	2 ^s	6 ^{os}	
Damselfly												
Dragonfly Species												
Hairy Hawker	4 ^t	3 ^t										
Migrant Hawker									6 ^t	1 ^t		
Southern Hawker									1 ^t		1 ^t	
Brown Hawker												
Emperor					4 ^{to}	2 ^t	3 ^{to}					
Downy Emerald							1 ^t					
Scarce Chaser	2	9 ^e			10 ^t	3 ^t	1 ^t	8 ^t				
Four-spotted Chaser					2 ^t	2 ^t	2 ^t					
Broad Bodied								1				
Chaser												
Common Darter									7 ^{to}	1 ^t		1
Golden-ringed												
Dragonfly												

Table 2a Damselflies and Dragonflies recorded at Crofts Farm on each of three visits in 2017. Key to annotations given below table.

e = Including 6 newly emerged adults with exuviae

t = Territory-holding males present (shown for dragonflies only as unlike damselflies they may have been recorded feeding in adjacent fields rather than on the river itself)

m = Mating observed, o = Oviposition observed, s = Oviposition scars observed

On the open sections of the three western transects we observed 7 species of dragonflies. In the early part of the season (May and June) there were Hairy Dragonflies and Emperor Dragonflies holding territories on the river; we also saw a female Emperor laying eggs into waterlilies on the first transect and on the section of the river parallel to the track. Here we also saw a Downy Emerald, again a territory-holding male.

On our first visit on 18th May 2017 we found Scarce Chaser adults all along the open section of river. They were still in immature orange colouration (they mature to a powder blue colour in the weeks after emergence). We found a group of 6 newly-emerged (teneral) adults and their exuviae in a bay full of young reeds in the second transect that proved that they were successfully breeding in this stretch of the River. By our next visit on 20th June there were territory-holding males of this species along this open section, as well as small numbers of males of the related Four-spotted Chaser holding territories on plants emerging from the river (Figure 32). This species was not seen anywhere else on the surveyed sections of the river.



Figure 33 Southern Hawker, Transect 1, Crofts Farm, 27th September 2017© A.M. Barker

Figure 32 Four-spotted chaser, Transect 2, Crofts Farm, 20th June 2017[©] A.M. Barker

Late in the season, on 27th September, there were territory-holding Southern Hawkers on the large pool near the weir (Figure 33) and by the bridge on the straight section of river. Migrant Hawkers and Common Darters were also spread out along the river margins.

In contrast, the more deep-set western end of Transect 3 was shaded by trees and was found to be poor for both dragonflies and damselflies. A few of the common damselfly species occurred in low numbers on the small open sections of this part of the river, but no dragonflies. However, we did observe an Emperor dragonfly feeding out over the open field here.

Crofts Farm - Eastern section

In the fields below the weir the river is much narrower, and flows rapidly through a deep narrow channel fringed with trees and scrub with occasional sunny patches. The character of the dragonfly fauna on this section is very different (Table 2a). On our first visit the weather had deteriorated by the time we reached this section and we found only one Beautiful Demoiselle, one Large Red Damselfly and one Azure Damselfly. On 20th June numbers of Demoiselles had built up, with 7

Banded and 46 Beautiful Demoiselles including one mating pair (this was the only transect on the river where there were many more Beautiful than Banded Demoiselles). These were mostly holding territories on occasional open and sunny spots at the bottom of the steep banks, where there was some emergent vegetation. There were also a few Large Red, Azure and Blue –tailed damselflies, but at much lower densities than on the upper river. White-legged Damselflies were common on this stretch, however, including a mating pair and some ovipositing females. On visiting in September I did not find Willow Emerald Damselflies on this transect, but it was hard to see or search all the suitable trees adequately to confirm whether it was present or not.

This section of the river did not have the same diversity of dragonflies as the more open western transects, but was quite good for Scarce Chaser, with 8 individuals seen along the transect on 20th June. One female Broad-bodied chaser was seen feeding along the river margin on 20th June and a single Common Darter was also seen hunting for food in this area on 27th September.

Montegue Farm

The next section of the river that we surveyed is about 0.8 miles downstream. Here the river is about 3-5 metres wide, meandering and set into deep tree-fringed banks, and much of it is shaded. Only the most eastern transect had some sections of shallower and more open river with emergent vegetation.

This part of the River Kird was the last one we visited, on 5th July 2017. It was comparatively low in damselfly and dragonfly diversity (See Table 2b); the predominant species on all transects was the Azure Damselfly, which was seen mating and ovipositing in sunny spots along this stretch. There were very small numbers of Banded Demoiselles, and one Large Red Damselfly. On the more open sections of the last transect, about 120 metres from the bridge over the A272 where the section ended, there were also Blue-tailed, White-legged and Red-eyed Damselflies. Red-eyed damselflies were seen ovipositing in the more open stretches of the third transect.

Early July is relatively late for the flight period of some of the early-season Odonata such as Hairy Dragonfly, Scarce Chaser and Downy Emerald, which are all species that emerge and fly mainly in May and June. It is possible that if we had made an earlier visit we would have found some of these species present, although it is notable that at later dates in July we still found Scarce Chaser and Downy Emerald further downstream where they had been common in June. On our July visit we did see Brown Hawker and Common Darter dragonflies making quite an early appearance for the year; these are species that fly mainly from mid-July through to the end of September and beyond.

Our second visit to the Montegue Farm survey site was on the 25th September in very good weather. Disappointingly, only one dragonfly, a Migrant Hawker found on Transect 3, was seen on the river on this visit, and there were no damselflies seen, although I might have missed Willow Emeralds as I was not specifically searching for them on this date (I found them at Crofts farm two days later and until then they had not been recorded that far west). There was one Southern Hawker feeding over a field. I was puzzled by the low number of Hawker Dragonflies and the lack of Common Darters on this visit, especially since the latter were seen on the site on 5th July.

Date	5/7/17			25/9/1		
Transect	1	2	3	1	2	3
Damselfly Species						
Banded Demoiselle	2	5				
Beautiful Demoiselle						
Large Red Damselfly	1					
Azure Damselfly	31 ^{mo}	24°	29°			
Blue-tailed Damselfly			4			
Red-eyed Damselfly		1	11°			
White-Legged Damselfly			2			
Willow Emerald Damselfly						
Dragonfly Species						
Hairy Hawker						
Migrant Hawker						1 ^t
Southern Hawker						1
Brown Hawker		1	1 ^t			
Emperor						
Downy Emerald						
Scarce Chaser						
Four-spotted Chaser						
Broad Bodied Chaser						
Common Darter	1	2				
Golden-ringed Dragonfly						

Table 2b Damselflies and Dragonflies recorded at Montegue Farm on each of two visits in 2017. Keyto annotations given below table.

t = Territory-holding males present (shown for dragonflies only)

m = Mating observed, o =Oviposition observed

Harsfold Lane Transects – West

These three transects lie immediately downstream from the Montegue Farm transects, but were mainly approached from the east and walked in an upstream direction, so that Transect 3 is the westernmost transect.

Our first two transects started from the bridge over the Kird in Harsfold Lane and followed the river upstream (west). The river here was quite narrow with comparatively low water level in a channel about 2 – 3m wide. There were occasional wider spots in sunny places, but much of the water was shaded by tree cover. The river wound through cattle- grazed improved pasture; on our first visit on 25th May the grass was long but by our return visit on 31st July the cows were grazing the field. On both visits, the predominant damselflies seen were Banded and Beautiful Demoiselles, which were present in similar numbers on the more open spots along these two transects (Table 2c). Densities were quite low, e.g. just over 1 Beautiful Demoiselle per 20m of river, but this conceals the patchiness of the distribution, with clusters of individuals in the most suitable areas. Large Red

Damselflies were nearly as common as the two Demoiselle species, and Azure Damselflies which were widespread but less common. We also spotted our first couple of White-legged Damselflies of the year. In addition, this survey date pre-dated the peak flight period of all these species except the large Red. By 31st July the Demoiselles, which have a late flight period, remained in similar numbers, and there were still a few White-legged Damselflies including one ovipositing female, but there were no Large Red or Azure damselflies still on the wing.

During our May visit we saw one Scarce Chaser on these transects – there were not as many as at Crofts Farm the week before. There was also one immature male Broad-bodied Chaser holding a territory on an open spot by a plank bridge where there was sunlight and lots of emergent vegetation. In July there were a small number of Common Darters and also one Golden-Ringed Dragonfly along the river itself, and in the neighbouring field Migrant Hawkers, Southern Hawkers and Brown Hawkers were feeding.

Date	25/	5/18	5/7/18		31/7/	18
Transects	1	2	3	1	2	3
Damselfly Species						
Banded Demoiselle	18	12	1	27	8	
Beautiful Demoiselle	25	17 ^m	1	9	12	1
Large Red Damselfly	18 ^m	9	1			
Azure Damselfly	6	7	38 ^{mo}			3
Blue-tailed Damselfly			7	2		18
Red-eyed Damselfly			30 ^{mo}	1		13°
White-Legged Damselfly		2	4 ^{mo}		3°	6°
Willow Emerald Damselfly						
Dragonfly Species						
Hairy Hawker						
Migrant Hawker				1	6	4 ^t
Southern Hawker				1	1	
Brown Hawker			3 ^t		3	5 ^t
Emperor			1 ^t			
Downy Emerald			2 ^t			1 ^t
Scarce Chaser	1 ^t					
Four-spotted Chaser						
Broad Bodied Chaser		1 ^t				
Common Darter				1 ^t	4 ^t	
Golden-ringed Dragonfly				1		

Table 2c Damselflies and Dragonflies recorded at the western Harsfold Lane Transects on three dates in 2017 - our first visit to Transect 3 was much late than to Transects 1 and 2. Key to annotations given below table.

t = Territory-holding males present (shown for dragonflies only)

m = Mating observed, o =Oviposition observed

Beyond the wood that separated Transect 3 from the first two, the river was quite different in character. It was deeper and wider, and the surface covered with a lot of duckweed. About half-way along it there was a weir and a fish ladder, above which the river widened into a pool with emergent and floating vegetation. Our first visit to this Transect was immediately after surveying the three Montegue Farm transects on 5th July, when it was walked downstream (west to east). At that point it had high numbers of Azure Damselflies, including mating pairs and egg-laying females, and of Red-Eyed Damselflies on floating leaves on the broad pool, some of which were also mating and laying eggs. There were a few White-Legged Damselflies, including a mating pair and a tandem pair with an egg-laying female, and some Blue-tailed Damselflies. There was a Banded Demoiselle, a Beautiful Demoiselle and a solitary late-flying Large Red Damselfly. There were also three dragonfly species: Brown Hawkers holding territories over the water (Figure 34), a single territory-holding Emperor Dragonfly, and two Downy Emeralds with territories at the weir end of the pool.



Figure 34 Brown Hawker, Transect 3, Harsfold Lane West, 5th July 2017 © A.M. Barker

After this survey I carried on through the wood and walked through the fields bordering Transects 1 and 2 to reach Harsfold Lane; although there was not time to survey them I did notice high numbers of Banded Demoiselles, and at the small plank bridge there were Banded Demoiselles, White-legged Damselflies and ovipositing Azure Damselflies.

On 31st July, when all three of the Harsfold Lane West transects were walked in sequence, there were three late-season Azure Damselflies still on the wing on Transect 3. Numbers of Red-eyed Damselflies and Blue-tailed Damselfly were still high, and there were a few White-Legged Damselflies and one Beautiful Demoiselle. The Red-eyed and White-Legged Damselflies were ovipositing. Two dragonfly species were seen on the river, territory-holding Brown Hawkers and Downy Emerald. This was surprisingly late in the summer for this species and I checked it carefully to make sure it was not the related Brilliant Emerald. Brown and Migrant Hawkers were also feeding over the adjacent grass field and the river channel.

Harsfold Lane Transects - East

Downstream of the bridge over the river in Harsfold Lane we walked 7 transects, a total of 2.1km of river bank, finishing where the River Kird flows into the River Arun. The first four of these were first visited on 8th June, following a period of very heavy rain that had left the river level extremely high with unusually fast flow. The weather was warm and sunny and there were good numbers of Odonata present. The remaining three transects were surveyed on a hot sunny day in the following week on 15th June, by which time the water level had returned to normal with much slower water flow. All 7 transects were walked on 13th July, in this case in the reverse direction starting at the Arun and walking back. However, there was not time to do full counts on all transects so alternate transects were simply recorded as presence or absence of each species.

The first transect started at a wide pool just downstream from the bridge, with floating yellow water lilies and broad-leaved pondweed, and lots of emergent vegetation fringing the pool. Here in June there were high numbers of Azure Damselfly (Table 2d), and a variety of species with Large Red, Red-eyed and White-Legged Damselflies as well as Banded and Beautiful Demoiselles. Downstream this transect included a broad open section of river bordered in places by trees and scrub, including a belt of poplar trees (*Populus* sp.). One bend in the river formed a separate deep pool overhung by a large willow tree where a Downy Emerald Dragonfly was holding a territory.

On our second survey visit in mid-July most of the same damselflies were still present on the first transect, apart from the Large Red Damselfly which usually has an April-to-June flight season. The Azure, Red-eyed and White-legged Damselflies were all ovipositing into floating vegetation in the pool near the bridge. Scarce Chasers were present at this pool on both dates; by July there was also a Brown Hawker and an Emperor Dragonfly. A Hairy Dragonfly was also seen here when we passed the bridge on 8th June on route to survey the western transects.

Downstream from Transect 1, there were several Transects where the River was about 2m wide, partly open with trees and scrub at intervals, and with emergent vegetation such as Reeds, Lesser Reedmace and Floating Sweetgrass (*Glyceria fluitans*) along the banks and in occasional shallower and wider small pools. Transects 2, 5, 6 and the sections of 4 bordering the wood were like this. These transects all had high densities of Banded Demoiselles (up to 4.6 individuals per 10m stretch of river, although they tended to be clustered in the more open areas at much higher densities than this implies), with lower numbers of Beautiful Demoiselles. Large Red Damselflies occurred in small numbers on all Transects apart from the largely wooded Transect 4. This group of transects had much lower densities of Azure Damselflies and White-Legged Damselflies than occurred on the broad pool in Transect 1, and very few Red-eyed Damselflies, which prefer to be on floating vegetation in the centre of an open water body. A Beautiful Demoiselle was seen on Transect 2 half-emerged from its exuvia (Figure 29).

This stretch of river was also the best for Scarce Chasers, which were present in all transects at densities of up to 0.9 individuals per 10m (Table 2d). Of the other dragonfly species, Brown Hawkers were seen on Transects 4 and 5 and a Downy Emerald on Transect 4 on 13th July. Transect 6 had an early Common Darter on this date; this transect was partly bordered by a small wet marsh with vegetated runnels coming into the river, and here we saw a Golden-Ringed Dragonfly (Figure 35).

		8/6	/17		1	5/6/17	7	13/7/17						
Transect	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Damselfly														
Species														
Banded	11	93	58	22 ^e	72 ^m	59	4	27	Р	Р	15	120	Р	42
Demoiselle														
Beautiful	5	9 ^e	11	3	5	3	1	3		Р				
Demoiselle														
Large Red	10 ^m	8°	9°		9 ^m	2	1		Р					
Damselfly														
Azure Damselfly	30 ^m	15 ^{mo}	32 ^{mo}		3 ^m	4 [°]		18°	Р					
Blue-tailed	10	2			1	1	1	10	Р	Р		1		2
Damselfly														
Red-eyed	11 ^m	2	10 ^m					23 ^m						1
Damselfly														
White-Legged	12	2	3		6 ^{mo}	3°		43 ^{mo}	P ^m	P°		3		1
Damselfly														
Willow Emerald														
Damselfly														
Dragonfly Species														
Hairy Hawker					2 ^t									
Migrant Hawker														
Southern Hawker														
Brown Hawker								1 ^t			1 ^t	2 ^t		3 ^t
Emperor			2 ^t					1 ^t	P ^t					1 ^t
Downy Emerald	1 ^t			1 ^t								1t		
Scarce Chaser	2 ^t	12 tm	10 ^t	3 ^t	23 tm	23 tm	2 ^t	1 ^t		P ^{tmo}		3 ^t		
Four-spotted														
Chaser														
Broad Bodied														
Chaser														
Common Darter													P ^t	
Golden-ringed													1	
Dragonfly														

Table 2d Damselflies and Dragonflies recorded at the western Harsfold Lane Transects on two visitsin 2017 (first visit split across two dates). Key to annotations given below table.

e = Adult(s) seen emerging from exuvia

t = Territory-holding males present (shown for dragonflies only)

m = Mating observed

o = Oviposition observed

P = Present (where presence/absence rather than counts recorded)



Figure 35 Golden-ringed Dragonfly, Transect 6, Harsfold Lane East, 13th July 2017, ©A.M. Barker

Apart from the first 100m, which ran round a long curve edged with mature trees, the river in Transect 3 formed a deep meandering unfenced channel 1 – 2m across. Here the river runs through improved pasture at the base of a slope. It was fringed in tall marginal herbs and grasses which on our first visit had been flattened by the flood water to above the depth of the channel, although this had since subsided. Water flow was brisk on this June visit, but by our return trip water levels had fallen as a result of low rainfall for most of June and early July. In places by then this section of river seemed to be a series of isolated pools rather than a flowing watercourse. Also, cattle were in the field and much of the vegetation had been grazed, and the channel margins poached by cattle coming to drink. Two Emperor dragonflies were seen on this Transect, a female flying over the river surface, and a second individual that flew over. But on neither visit was the very exposed open section of transect as good for dragonflies as on the more sheltered sections; the same range of species was present as in the surrounding transects but at a notably lower density. For example, the density of 9 Banded Demoiselles was only 9 per 100m compared to 28 per 100m on Transect 2.

The final Transect (7) was quite short and led to the point where the River Kird merged with the River Arun. It held Banded and Beautiful Demoiselles, Large Red Damselflies, Blue-tailed, White-legged and Blue-tailed Damselflies, and Scarce Chasers, Brown Hawkers and an Emperor Dragonfly. For 20m it had concrete-reinforced banks that looked promising as a possible emergence point, but the flood had washed the banks and no exuviae could be seen. An interesting yellow and black dragonfly was glimpsed here but not for long enough to identify it.

On 15th June we scanned the River Arun itself with binoculars at the point where the River Kird flows into it; there were 6 Banded Demoiselles, 2 Red-eyed Damselflies and 1 White-legged Damselfly visible.

Analysis and Discussion

The Lower Kird as a habitat for Damselflies and Dragonflies.

If we consider the whole length of the River surveyed, just over 5km of the Lower reaches of the Kird, it is possible to pick out some patterns of how the habitat is used by different species. One of the striking things about the River was that it actually comprised a series of different types of habitat. At one extreme were the large, deep, wide and open slow-flowing stretches with floating leaves of water lilies and pondweed typified by the two transects upstream of the weir at Crofts Farm (Transects 1W and 2W), part of Montegue Farm Transect 3, the westernmost Harsfold Lane transect near the A272 (Transect 3 West) and the pool downstream of the bridge at Harsfold Lane (Transect 1 East). These were dominated by populations of the Azure Damselfly, a common and widespread species which prefers sheltered ponds and small lakes with abundant submerged, floating and emergent vegetation and which is also recorded from slow-flowing stretches of rivers and streams (Cham et al. 2014). These were also the preferred sites for the Red-eyed Damselfly (Figure 36), a species that is normally found on floating vegetation in the centre of eutrophic lakes, ponds and slow-flowing waterways (Cham et al. 2014). Males hold territories on floating leaves where females come to lay eggs; individuals of this species are rarely seen at the water's edge, so these broad sections were ideal for them.



Figure 36 Male Red-eyed Damselfly on a water-lily leaf, Transect 3, Harsfold Lane west, 31st July 2017 © A.M. Barker

The commonest large dragonflies, the Southern and Brown Hawkers and the Emperor Dragonfly were also mainly observed holding territories over the larger, slow-flowing and more 'pool' –like regions of the river, such as the pool upstream of the weir at Harsfold Lane West Transect 1 and the one downstream of the bridge at Harsfold East Transect 1 (see Tables 2c and 2d). Male Emperors were observed patrolling the river and holding territories on all three open sections upstream of the weir at Crofts Farm, with ovipositing females observed at 2 of these sections (Table 2a); in September, Southern Hawkers were holding territories over two of these sections. Both Emperors and Brown Hawkers were also seen holding territories on the pools upstream of the weir at Harsfold Lane Transect 3 and the pool downstream of the Harsfold Lane Bridge (Transect 1 East). However, these areas were not used exclusively, and males of both Brown Hawker and Emperor were observed on occasion patrolling on smaller open sections of the river. For large species such as these, which hold an extensive territory, competition for breeding space will be intense and some males are likely to be pushed into more marginal areas.

Two smaller dragonflies where the males hold territories through active patrolling are the Hairy Dragonfly and the Migrant Hawker, and these mainly also used broader open areas of river. The Hairy Dragonfly is an early spring species with quite a restricted flight period; males patrol their territory along the bank about half a metre above the river surface. We found three males doing this along the river west of the weir at Crofts farm, along with a female, and again noted a territorial male on the pool east of the Harsfold Lane bridge on 25th May (observed in passing on returning from surveying the western transects) and later one patrolling on Transect 5, Harsfold Lane East. I was expecting to find slightly more of this species, and I wonder if, having a short and very early emergence window in June and early May, it was adversely affected by the heavy rain and storms that occurred at the beginning of June, something I have observed at other field sites for Hairy Dragonfly. In contrast Migrant Hawkers are a late-summer and autumn-flying species. Not many of these were observed holding territories, but one was seen doing so at the Harsfold Lane West Transect 3 open river area upstream of the weir, and one on the open section of Montegue Farm Transect 3.

At the other habitat extreme were narrow sections of river where the river flowed in a deep channel, usually with much faster rates of flow and often bordered by stretches of scrub and mature trees. Crofts Transect 1 West, Harsfold West Transects 1 and 2, and Harsfold East Transects 2, 4 (in part) 5, 6 and 7 fell into this category. The principal damselfly species in these habitats was the Banded Demoiselle, along with (usually) smaller numbers of Beautiful Demoiselles. Both these species prefer flowing water. Typical habitat for the Banded Demoiselle is described as slow-flowing rivers and streams with a muddy or silty bottom with lush emergent and herbaceous vegetation bordered by open meadow. It avoids shaded areas and needs aquatic plants in which to lay its eggs (Cram et al. 2014). Beautiful Demoiselles are supposed to favour shallow fast-flowing streams, preferring sandy or gravelly bases to muddy ones, but are more tolerant of wooded margins with occasional open areas (Cram et al. 2014); they can occur together but where both occur the Banded Demoiselle is usually dominant (Belden et al. 2005). In the open transects this was the case on the Kird but in the more shaded transects at Crofts and Harsfold West Beautiful Demoiselles outnumbered the Banded ones. As well as these two damselflies, sections with this habitat also held quite a number of dragonflies, but these were not usually species restricted to this narrow-channel habitat. Instead they were species with a widespread distribution such as the Scarce Chaser.

There were a few sections of the river, particularly for much of Crofts Transect 3 West, Montegue Farm Transects 1 and 2 and parts of 3, and some sections of the western Harsfold Lane Transects 1 and 2, that fell somewhere in between these two habitat types. Here the river was quite deep, set within steep banks, and largely shaded by bordering trees and scrub. There were only short sections with emergent vegetation. This combination of characteristics was good neither for dragonflies nor damselflies, and diversity and numbers were lowest on these sections; they tended to have mainly Azure Damselflies with a few Large Red and Blue-tailed Damselflies, all concentrated where there were sunny spots, and no large dragonflies. This can be seen most clearly in the data for the Montegue Farm transects; it is somewhat masked for the Crofts and Harsfold Transects as these had better sections within them.

Of course, there were some species of Odonata that were not specific to either the broad open or narrow fast-flowing and tree-lined habitats of the river. Some were widespread across all habitats on the river; others had requirements for more specific microhabitats. Widespread species included

the Large Red Damselfly, individuals of which were observed in 14 of the 17 transects (see Tables 2a – 2d), and also Blue-tailed and White-legged Damselflies found in 13 of 17 transects at low densities but fairly even distributions. White-legged Damselflies are reported to be disappearing from river systems across southern Britain (Colver 2018) but they occurred all along the Kird and were observed ovipositing in a range of sunny open sites (Figure 37).



Figure 37 Pair of White-legged Damselflies ovipositing on a Yellow Water Lily, Transect 1, Harsfold Lane east, 13th July 2017 © A.M. Barker

The Scarce Chaser dragonfly was thriving on the River Kird, with strong territory-holding populations in most transects surveyed. It is a species associated with mature slow-flowing river systems requiring lush emergent vegetation and adjacent rough meadows and scrub (Cham et al 2014) which is one of the specialities of the Upper Arun S.S.S.I. (see Natural England S.S.S.I. citation <u>https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1000768.pdf</u>). In sunny lush stretches of the later section of river, particularly in Harsfold Lane East Transects 5 and 6, there were male Scarce Chasers holding territories every 3m from bankside perches on tall vegetation. This species was also confirmed to be breeding successfully, with adult emergence observed on 18th May at Crofts Farm, and mating and oviposition observed at transects all along the river east of the Harsfold Lane bridge. The only transects where it was not found were the 3 Montegue Farm transects and the adjacent third transect of Harsfold Lane West. These were not surveyed until 5th July, and it may be that the late first survey date meant that we simply missed the Scarce Chaser at these transects, although we saw it at later dates elsewhere (Figure 38).



Figure 38 Old and battered male Scarce Chaser, Transect 1, Harsfold Lane east, 13th July 2017 © A.M. Barker

In contrast, two close relatives of the Scarce Chaser were much less widespread. The Broad-bodied Chaser is a common species often found on newly created pond and lake habitats (Cham et al. 2014). It was seen holding territory only on one small open area next to a plank bridge on Harsfold Lane Western Transect 2; a feeding female was seen at the western Crofts Farm transect. The Fourspotted Chaser is more commonly associated with acidic water habitats but is occasionally recorded breeding in slow-flowing rivers (Cham et al. 2014), and this species seemed to have a healthy breeding colony on the open stretch of river north of the weir at Crofts Farm, where they were defending territories from perches on water lilies at the centre of the stream.

The most particular species found was probably the Downy Emerald, a species known to prefer woodland pools and lakes and needing deep slow-flowing or still water with tree-lined margins (Cham et al. 2014). This was seen displaying territorial behaviour in sunny spots near tree-fringed sections of the river, for example a deep pool at the corner of a meander on the first Transect to the east of Harsfold Bridge. Although we cannot prove that this species is breeding on the Kird, it was seen holding territories at five different places on the river which is encouraging.

Not all the dragonfly species we recorded were necessarily using the river as breeding habitat. Two male Golden-Ringed Dragonflies were seen, one at the edge of a wet marsh in Harsfold Lane East Transect 6 on 13th July (Figure 35), and one at the first Harsfold Lane West Transect on 31st July. This species is associated with streams and fast flowing-rivers and sometimes drainage ditches; like the Four-spotted Chaser it is often but not exclusively associated with acidic water (Cham et al. 2014). It might be breeding on the Kird (or perhaps on the wet marsh running into it), but equally it is known to be a wide-roaming species that might have been visiting. No females of this species were seen.

Many of the Brown, Migrant and Southern Hawkers recorded in late summer and autumn were feeding in the fields around the river rather than holding territories. These dragonflies are all active flyers that range widely across the habitat to feed and find breeding sites, so their presence, while indicating a healthy environment for dragonflies, is not proof that they are breeding on the river. I noted how individuals were behaving so it was possible to distinguish between local feeding activity and territorial and breeding behaviour on the river itself (see annotations in Tables 2a – 2d). Over half of the Brown Hawkers seen were territory – holding males; however most of the Migrant and Southern Hawkers were feeding over fields rather than showing breeding activity, with only a two of each of these species seen holding a territory. No ovipositing females were seen, but they can be very discrete so that finding them requires a better long-term knowledge of the site and some luck!

The Common Darter is another common late summer species that can also range over long distances before finding territories and may be seen feeding well away from water. Common Darters hold territories from a perch or even a patch of open ground, with forays over the water surface; the ones at Crofts on 27th September seemed to be displaying this behaviour, and were accompanied by an ovipositing female. The ones seen at Montegue Farm on 5th July and Harsfold Lane East on 31st July were in bushes by the river but not holding territories.

The Odonata of the River Kird in the context of the Upper Arun S.S.S.I. and the wider Rother and Arun area

In 1988 the Upper Arun, a 13km length of the River Arun from Billingshurst south to Stopham Bridge, was designated as a Site of Special Scientific Interest (S.S.S.I.) under section 28 of the 1981 Wildlife and Countryside Act. The following extract from the original citation

(<u>https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1000768.pdf</u>) gives the rational for this:

Reasons for Notification:

The Upper Arun consists of a 13km length of the River Arun, flowing south across the weald clay and lower greensand between New Bridge, Billingshurst and Stopham Bridge, Pulborough. It supports an outstanding assemblage of breeding dragonflies including a number of rare species.

The Upper Arun is relatively unpolluted and supports a diverse riverine flora. This, together with a varied river structure caused by cattle trampling and other erosion, has resulted in an extremely complex habitat upon which the dragonflies depend for breeding, feeding and resting sites......

Whilst lying outside the designated S.S.S.I. area, the River Kird is a tributary of this section of the River Arun. It has the potential to be a satellite 'feeder' habitat supporting important populations of some of the Odonate species referred to in the citation. In particular, it is clear that the Kird supports important breeding populations of the Scarce Chaser, a species that, due to its preferred habitat requirements for smaller quieter streams and areas of low water flow (Goodyear 1995), may well breed on the smaller tributary at even higher densities than on the larger River Arun. In a visit to the Arun at New Bridge, a noted site, on 5/6/16 we found 0.6 Scarce Chaser adults per 100m of transect section, whereas on the Kird visits on 8th and 15th of June 2017 regularly recorded densities over 1 and up to 9 per 100m. The Scarce Chaser is the one species so far observed on the River Kird that is on the British Red List, where it is categorised as Near Threatened (Daguet, French and Taylor 2008, see also https://www.british-dragonflies.org.uk/content/conservation). Although this species is currently increasing its range across Britain, the rivers of West Sussex remain an important stronghold for it. Factors that put it at risk include excessive shading from trees, clearance of bankside vegetation and clearance of vegetation and mud from within the watercourse.

We also found the Hairy Dragonfly on the River Kird. Males were holding territories at several sites and it may be breeding on the river. In total we were able to confirm breeding in 3 species, find evidence of probable or possible breeding for a further 8 species, and identify a further 7 that were holding territories on the river. This gives at least 11 breeding species, and potentially as many as 18, with one other species (Golden-ringed Dragonfly) also observed twice in our survey but probably not breeding. The reasons for this high diversity are similar to those quoted in the citation for the Upper Arun S.S.S.I. Like the River Arun, the Kird is relatively unpolluted – we found moderate pollution from nitrate and phosphate runoff but this decreases as the river runs downstream through non-arable grazed pastures. The habitat around the surveyed 5km stretch of the River Kird is relatively varied and includes a variety of floating water plants and emergent riverine plants. The Kird is structurally complex with meanders, pools, and straight sections and a variety of flow rates, depths and widths due to a system of occasional weirs and a lack of canalization or excessive engineering of the river's course. The surrounding habitats are varied and include woodland, scrub, unimproved meadow, grazed improved meadow and wet marsh.

In fact, the most recent published resurveying of the Arun by Natural England in 2011 (https://designatedsites.naturalengland.org.uk/ReportUnitCondition.aspx?SiteCode=S1000768&Rep ortTitle=Upper%20Arun%20SSSI) has raised concerns about the lack of grazing or vegetation management that has led to overgrowth of 'weedy' vegetation such as nettles, thistles, docks and brambles and a lack of patches of bare ground. The banks of the lower Kird are in general in better condition than this with a greater variety of emergent and meadow vegetation.

However, two of the dragonflies specifically mentioned in the Upper Arun S.S.S.I. citation, the Clubtailed Dragonfly (*Gomphus vulgatissimus*) and the Brilliant Emerald (*Somatochlora metallica*) were not found in our survey of the River Kird. Both species are quite hard to observe. The Club-tailed Dragonfly is often surveyed by finding evidence of emergence sites; it tends to emerge *en masse* on selected bridges and other hard surfaces at the river bank during a short window in spring. For us this possibility was removed before we had the chance to check all suitable substrates by the heavy flooding that occurred between 8th and 15th June, that was liable to have swept exposed exuviae away. Once emerged this dragonfly is quite elusive at the river itself, spending much time away from it. We found no evidence that the Club-tailed Dragonfly is present on the Kird, but would not rule it out on the evidence of a one-year survey. The other species, the Brilliant Emerald, prefers woodfringed lakes as a primary habitat, but will sometimes take up territories on slow-flowing canals and rivers. It can sometimes be found on the Arun and the parallel section of canal at New Bridge (Sadler 2014, Barker pers. obs. 2016). Neither of these habitats matches the River Kird very well, although we did see several individuals of the Downy Emerald, which has similar habitat requirements, so again it cannot be wholly ruled out that this species sometimes occurs on the Kird.

A survey of the waterways of the wider Arun and Rother area was carried out in 2014 by David Sadler (*ARC Report*, Sadler 2014). This was a much wider-ranging survey that included a number of additional habitats as well as the main rivers themselves, including the wet-meadow system of Amberley Wildbrooks, ponds and lakes in woodland, and open heathland with boggy pools. Unsurprisingly therefore this survey recorded a higher total number of species (27) and breeding species (16) – but many of these, such as the Common Blue Damselfly (*Enallagma cyathigerum*), the Emerald Damselfly (*Lestes sponsa*) and the Black-tailed Skimmer (*Orthetrum cancellatum*) have a strong preference for lakes and larger ponds, whilst the Black Darter (*Sympetrum danae*) was found only at an acid heathland. This survey found Club-tailed Dragonflies on the main rivers and Brilliant Emerald from its known site on the river north of New Bridge and the Wey and Arun Canal. It also found Variable Damselfly (*Coenagrion pulchellum*), which has a population hotspot at Amberley Wildbrooks but was found at other sites around the River Arun. I looked carefully for this species, with a policy of regularly netting a small number of blue damselflies for close examination, but did

not find it on the River Kird. Descriptions of its habitat suggest that it prefers ditches and dikes within grazing marsh or fen, which is a somewhat wetter and more lush habitat than that surrounding the River Kird. However pollution may also have been a factor in the absence of this species (see below).

One species recorded in good numbers on some transects in this survey, the Beautiful Demoiselle, seems to be more abundant on the River Kird than the River Arun, at least as recorded in the 2014 ARC Survey (Sadler 2014). Sadler suggested that this species would be more common on shadier, faster-flowing tributaries; this is a good match for the description of those transects in our study where it was most common. We also recorded one species not found in the area in 2014, the Willow Damselfly. The nearest record for this species is from Woods Mill in east Sussex (Parr 2016) and ours would appear to be the most westerly observation so far.

Water quality and Odonata on the River Kird

Like most lowland rivers (Freshwater Habitats Trust 2017, leaflet and website), the River Kird is polluted by nutrients. At the most upstream of our sites, Crofts, there were moderate levels of nitrogen pollution (0.5 -1ppm) and quite high levels of phosphate pollution (0.1 - 0.2 ppm), classified according to the Freshwater Habitats Trust definitions. These levels dropped further downstream; in the Montegue Farm section there was moderate nitrogen pollution and moderate phosphate pollution (0.05-0.1 ppm), and at the Harsfold Lane Bridge there was only low level nitrate pollution (0.2 - 0.5) and phosphate pollution. These samples were all taken within a 24 hour window on 26th and 27th September so represent a snapshot view of the river at one time; the change as the water flows downstream suggests that the nutrients are coming from somewhere upstream of Crofts, perhaps from arable farming. It would appear that as the surveyed length of the Kird is grazed rather than bordered by arable land no further pollution is being added and the nutrients are being diluted or removed by plants between Crofts, Montegue Farm and Harsfold.

These nutrient levels do not appear to be having a big impact on dragonfly diversity. Some species such as the Scarce Chaser are in any case tolerant of eutrophic water and favour the rich plant growth that results (Goodyear 1995). The two Demoiselle species are reported to be sensitive to pollution (Cham et al 2014) but appeared to be thriving in the Kird; they need high dissolved oxygen levels which presumably the fast flows on some sections of the river were maintaining. There were higher concentrations of these two species in the lowest reaches of the river where the water was cleanest; however, this was also where the best habitat for them was located in terms of the availability of open areas of flowing water. We cannot therefore separate the two factors to be sure whether they were adversely affected by the measured nutrient pollution.

We noted that as the season goes on the majority of the river surface becomes covered in duckweed as a result of the eutrophic conditions. This can out-compete the submerged vegetation on which many of the damselflies depend for oviposition sites and can also reduce the underwater oxygen levels, endangering larval survival.

One question is whether any species were absent as a result of the nutrient levels recorded. One possibility is the Variable Damselfly (*Coenagrion pulchellum*), which breeds on the nearby Pulborough Brooks grazing meadows and by some stretches of the River Arun. I looked carefully for

this species and did not find it. It is noted as needing oligotrophic habitats and being very sensitive to water pollution (Cham et al. 2014).

One thing we were not able to test was the impact of the Wisborough Green Sewage Works, which has an outflow in Transect 2 of the Harsfold Lane East section. This is another potential source of high nitrate and phosphate input to the river, although levels presumably vary. There is another sewage works upstream at Kirdford; a pollution incident from a sewage works could have a serious impact on the Odonata of the River Kird. There are other potential major sources of pollution; in 2013 for example a farm near a feeder stream of the Kird had a slurry spillage which contaminated the stream and ultimately the Kird itself affecting fish and invertebrate life over a 13 kilometre length of waterway (Wynn-Davies 2016).

The Environment Agency has designated the wider Upper Arun area, including the S.S.S.I. and the River Kird, as part of a Nitrogen Vulnerable Zone, an area that due to land use and known discharges of nitrogen-rich water is subject to or at risk of nitrogen pollution (Environment Agency 2016, http://apps.environment-agency.gov.uk/static/documents/nvz/NVZ2017_S523_Datasheet.pdf). They are continuing to monitor at three designated points on the River Kird and in Wisborough Green. In the past the water at some of these has reached nitrogen levels above their threshold of pollution but the water nitrogen levels at all three are now stable at concentrations below this. However, although the Environment Agency, working on 2016 data, consider the chemical pollution status of the Kird to be good (i.e. low chemical pollution) they rate the ecological status as poor (Environment Agency 2018, http://environment.data.gov.uk/catchment-planning/WaterBody/GB107041012300) with, among other problems, poor phosphate levels and moderate invertebrate status. They plan for it to be improved to 'good' status by 2027 under the Water Framework Directive.

As the Kird is a tributary of the upper Arun, any pollution event affecting the river would also reach the Upper Arun S.S.S.I. Additional nutrient or other chemical pollution from upstream of the section surveyed, as well as potential pollution from the Wisborough Green sewage works and the Kirdford sewage works upstream, could all have a serious impact on the rich and diverse dragonfly and damselfly fauna of both rivers.

Conservation of the River Kird for Dragonflies and Damselflies- Potential Threats and Management Guidance

As well as avoiding pollution, there are other factors that need to be avoided in order to maintain the habitat quality of the Kird for Odonata. Consideration needs to be given to:

- Management of trees on the river banks
- Management of vegetation on the river banks
- Management of the surrounding habitat
- Maintenance of river habitat diversity
- Keeping invasive species under control

Trees

The biggest factor in managing the river banks is controlling the extent to which they are planted with fringing trees and shrubs. The presence of trees and shrubs within the river landscape is

important. Some species such as the Downy Emerald and its relative the Brilliant Emerald, which occurs nearby to the Kird, are reliant on tree-lined slow flowing water for breeding, and the newly arrived Willow Emerald actually oviposits into the bark of small waterside willows and other trees. Species such as the Hairy Dragonfly and Scarce Chaser benefit from the shelter provided by nearby trees and scrub. However all dragonflies and damselflies, even those that are tolerant of shade such as the Beautiful Demoiselle, need open sunny patches of water in which to hold territories and lay eggs. It is therefore important to achieve a balance and avoid long stretches of shaded water by periodically cutting back young trees and shrubs at intervals to let light onto at least half the water surface. In general, transects that had over 50% tree cover lower densities of Odonata. This can be seen from a plot of the recorded peak numbers of the most common species in each transect (Figure 39); for all three species densities decline with increasing levels of cover.

Figure 39 Estimated tree cover (categorised at up to 25%, 25-50%, 50-75% and 75-100%) and recorded numbers of the three most common species of dragonfly and damselfly per 100m of transect.



Influence of Tree Cover on Densities of 3 Odonate species in transects on the River Kird

Areas within the survey where dragonflies and damselflies would particularly benefit from some thinning out of the scrub are the Montegue Farm transects and the first and second transects to the west of Harsfold Bridge.

Vegetation and bank structure

Species accounts (e.g. those in Cham et al 2014) for most of the dragonfly and damselfly species seen stress the importance of having submerged and floating vegetation within the water and lush emergent vegetation at the water's edge and on the banks. The sections of the River Kird being surveyed were mainly very good in this regard, with species such as yellow water lilies, pondweed

and arrowhead common in the more open stretches of water, and most open sunny sections having extensive fringing vegetation such as reeds, reed mace, sedges and rushes. In many places the banks were uncut and ungrazed with diverse damp meadow vegetation such as purple loosestrife and meadowsweet, and there were open bare areas too, although in some places there were banks of nettles. As mentioned above, the River Kird seems to be in better condition than the River Arun in this respect. The exceptions were the heavily shaded sections where no vegetation could grow.

Increased pollution would decrease the diversity of vegetation, shifting it towards more duckweed and more rank vegetation. The fact that the fields are grazed pasture rather than arable therefore helps maintain the quality of the river habitat. Allowing cattle access to rivers can lead to overgrazing of the bank vegetation, but at the stock density present on the surveyed sections of the Kird we did not observe this, apart from possibly on Harsfold East Transect 3. There appears to be no need to fence off sections of the river to exclude cattle from the banks of the Kird. Also, cattle trampling the banks can lead to 'poaching', where the banks break down and fall into the river'. A study of sections of the River Arun where the banks had been lowered by cattle trampling found that if anything these sections actually benefited Odonata, especially where the river had been canalized with steep straight banks (Iles 1998); larvae often live in the shallow edges and are able to emerge more easily as shallow water will have more emergent vegetation for them to climb for their final moult into the adult.

Management of the surrounding habitat

Dragonflies and damselflies need not only high quality water habitats, but also places to feed, shelter and mate in the surrounding habitat. The wider landscape along the River Kird provides open grazed and ungrazed meadow, wet meadow, scrub and broadleaved woodland and must be considered to be contributing significantly to the recorded diversity. Conservation of the river should extend to maintaining this surrounding habitat.

River habitat diversity and river management

Following on from this is the fact that the surveyed stretch of the River Kird is in itself a diverse habitat with meanders and straight sections, broad open pools and fast narrow sections. In general active management of the river should be avoided if possible for the conservation of dragonflies and damselflies. Attempts to canalise the river or to clear vegetation and dredge the mud from the watercourse where many of the larvae live would be seriously detrimental to the Odonata of the river. Where localised clearance may be necessary, for example to counteract a section of bank collapse, it should be undertaken on a small scale and cleared mud and vegetation should be left on the river bank for a few days to allow any larvae to return to the river.

Another risk lies in over-extraction of water; low flows can result in deoxygenation and concentration of nutrient and other pollutants or even lead to complete drying of the river bed with negative consequences for larvae. In places the water flow in the Kird is very low so this does present a potential problem.

Invasive species

The biggest current threat observed during the current survey comes from the presence of a patch of the invasive weed Water Fern *Azolla filiculoides* in a 10 x 5m section in part of the Montegue Farm Transect 3 (at TQ04372592, near where the powerlines cross the river), recorded on 26th September (Figure 40). Originating in the Americas this plant grows rapidly in eutrophic (nutrient-rich) conditions to form an impenetrable mat on the water surface with decaying leaf and root matter at the base of the mat (see http://theazollafoundation.org/azolla/azolla-as-an-invasive-species/azolla-filiculoides/). Light and even oxygen cannot pass through, creating dark anaerobic water that invertebrates cannot survive in. This weed was formerly sold for ponds and often gets into waterways but could have a serious impact on the health of the River Kird. It is possible to reduce it with mechanical removal but it is difficult to remove with herbicide as there is only one herbicide licensed for aquatic use. It has been controlled by introducing specific beetles species that specialise on it in South Africa and CABI have been trialling this in the UK (see

<u>http://www.cabi.org/isc/datasheet/8119</u> and <u>http://www.azollacontrol.com/about/</u>. I recommend that the landowner should urgently contact the Environment Agency to see if help is available with this problem before it spreads further downstream.



Figure 40, Close-up shot of Azolla in Transect 3, Montegue Farm. See also Figure 17. © A.M. Barker

The invasive weed Giant Hogweed (*Heracleum mantegazzianum*) was also recorded growing on the west bank of the river in Montegue Farm Transect 3 at TQ04282579 on 5th July.

Conclusions

Based on the survey of a 5km section of the lower river in 2017, the River Kird is an excellent habitat for dragonflies and damselflies. 19 species were recorded, for 11 of which we found evidence of breeding through observing mating, oviposition and emergence and a further 7 of were actively displaying territorial behaviour. The variety of physical habitats provided by the river and the favourable structure of the riverine and bankside vegetation strongly support this species diversity.

A single year survey based on 2 or 3 repeat visits to each site will not capture the full diversity of species present at each site. There may be more species, including the elusive Arun-area specialities the Club-tailed Dragonfly and Brilliant Emerald, which further survey work might find. And more

detailed work would build on our knowledge of the breeding status of those species found; further recording of exuviae would be especially valuable. Visiting a few key sites, particularly the weirs and bridges along the Kird in the early part of the season, would help in contributing to this aim.

As it stands, the Kird does not need much active management for dragonflies and major change should be avoided. Some sections would benefit from scrub reduction to let more light reach the water, and there is an urgent need to control the invasive Water Fern before it can spread. The River is moderately eutrophic; landscape-scale management is necessary to avoid more damaging pollution from farm run-off, sewage contamination or industrial processes. A wider awareness of the value of the site is necessary; the data from this study will be entered into the Sussex and National Recording Databases.

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Glossary

Terms for the Dragonfly and Damselfly Life Cycle

Adult – recognisable winged phase of the life cycle. Adults mate and lay eggs; they need to feed but do not grow. Adults will live a comparatively short time – typically a few weeks, although larger species can live for longer.

Emergence – full grown larvae will move to the edge of the waterbody, stop feeding, and crawl up the bank or vertical vegetation. They will then shed their skins for one final time; from the shed skin or 'exuvia' will come the winged adult (Figure 4). The adult has to wait while its wings expand and harden before it can fly off. The process of change from an underwater larva to a winged adult is known as emergence.

Exuvia - skin left behind by emerging adult. Plural 'exuviae'. See Figure 4.

Flight period – Period during which the adults of any one species are on the wing after emergence, typically between May to July for the spring-flying species and July to October for the summer-flying species. Note that this does not mean all individuals will live this long, as emergence time and mortality will be staggered and subject to random changes.

Larva – The second stage of dragonfles' and damselflies' life cycle, the larva hatches out of the egg into fresh water and is predatory, eating small invertebrates and, as it grows, tadpoles and fish fry.

This is the growth stage of the life cycle; larvae may live in water for 2 or 3 years, periodically moulting into a larger size. Dragonfly and damselfly larvae can identified to species; most dragonfly larvae are quite squat with internal gills (see Figure 3 for an example) whereas damselfly larvae are long and narrow with gills on the tip of their abdomen.

Tandem Position – After mating many male dragonflies continue to hold the female behind the head while she lays her eggs, enabling him to guard her from being mated with other males. The pair are described as being 'in tandem'. See Figure 6.

Teneral – newly emerged adults usually do not have their full colour and and are often soft with a shiny, translucent appearence. ' These are described as teneral'. See Figure 4

Wheel position – Mating position adopted by dragonflies and damselflies. The male stores sperm in a special sac, the secondary genitalia, at the base of his abdomen. He grasps the female behind the head with special claspers on the tip of his abdomen (or tail end) and she curls her abdomen tip round to the secondary genitalia, making a loop or 'wheel' See Figure 5.

Botanical terms

Emergent – Plants with their roots in water but the majority of the stems and leaves habitually growing up above the water surface, such as reeds.

Floating – Plants or parts of plants habitually floating on the water surface, such as duckweed and water lily leaves.

Submerged – Plants or parts of plants that habitually live wholly underwater, such as Canadian pondweed.

Water Quality

Eutrophic – water rich in nutrients, particularly dissolved nitrogen and phosphorus compounds, that enable the abundant growth of plants , especially algae. Tends to have low oxygen content

Oligotrophic - water with low nutrient content, tending to have few submerged and floating plants and low levels of algal growth. Has a high concentration of dissolved oxygen.

Other

Invasive species – introduced species not native to the U.K. that has no natural predators to control it, so that it tends to breed and spread unchecked.

N.V.Z. – Nitrogen Vulnerable Zone – wider area of water catchment monitored for nitrogen inputs by the Environment Agency.

S.S.S.I. – Site of Special Scientific Interest - an area designated by the Natural England as being protected by law to protect its wildlife or geology.

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https://www.british-dragonflies.org.uk

https://british-dragonflies.org.uk/content/uk-species-checklists

Definition of Breeding Criteria

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https://freshwaterhabitats.org.uk/projects/clean-water/

Environment Agency Datasheet designating the Upper Arun as a Nitrate Vulnerable Zone and giving levels of inorganic nitrogen at sampling points on the River Kird and surrounding river waterbodies.

http://apps.environment-agency.gov.uk/static/documents/nvz/NVZ2017 S523 Datasheet.pdf

Invasive Water Fern *Azolla filiculoides* – sites listing the problem and a potential means of biological control

http://theazollafoundation.org/azolla/azolla-as-an-invasive-species/azolla-filiculoides/

http://www.cabi.org/isc/datasheet/8119

http://www.azollacontrol.com/about/

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Appendix 1 Presence /absence of all odonate species seen in the 17 transects surveyed, arranged from west to east (upstream to downstream), plus a snapshot view of the River Arun. x in black = recorded on first visit (May – early July, see methods for dates), x in red = recorded on second visit (July – September), x in blue –third visits (Crofts only – late September), space = not recorded, * seen at site but not during a formal transect. See next page for key to species names.

	Damsel	flies							Dragonflies										
	C.splen	C.virg	P.nymp.	C.puel	I.eleg	E.najas.	P.penn.	Ch.vir.	B.prat	C.bolt	A.mixt	A.cyan	A.gran	A.imp	C.aen	L.fulv	L.quad	L. dep.	S.strio
Crofts																			
W1	Х	Х	Х	XX	XXX	XX	Х	Х	Х		Х	Х		Х		XX	Х		Х
W2			Х	XX	XX	XX	Х	Х	Х		Х			Х		XX	Х		Х
W3			XX	XX		Х	Х	Х				XX		Х	Х	Х	Х		
E1	Х	XX	XX	XX	X		Х									Х		Х	Х
Montegue																			
Farm																			
1	Х		Х	Х															Х
2	Х			Х									Х						Х
3				Х	Х	Х	Х				Х	Х	Х						
Harsfold																			
W1	XX	XX	Х	Х	Х		Х			Х	Х	Х				Х			Х
W2	XX	XX	Х	Х			XX				Х	Х	Х					Х	Х
W3	Х	XX	Х	XX	XX	XX	XX				Х		XX	Х	XX				
E1	XX	XX	Х	XX	XX	XX	XX		*				Х	Х	Х	XX			
E2	XX	Х	XX	XX	XX	Х	XX							Х		Х			
E3	XX	XX	Х	Х	Х	Х	XX						Х	Х		Х			
E4	XX	Х													Х	XX			
E5	XX	Х	Х	Х	XX		XX		Х				Х		Х	XX			
E6	XX	Х	Х	Х	Х		Х			Х						Х			Х
E7	XX	Х	Х		XX	Х	Х						Х	Х		Х			
R. Arun	Х					Х	Х												

Key to species names:

Damselflies		Dragonflies	
Code and Latin name	English Name	Code and Latin name	English Name
C. splen = Calopteryx splendens	Banded Demoiselle	B. prat = Brachytron pratense	Hairy Dragonfly
C. virg = Calopteryx virgo	Beautiful Demoiselle	C.bolt = Cordulegaster boltonii	Golden-ringed Dragonfly
P.nymp = Pyrrhosoma nymphula	Large Red Damselfly	A.mixt = Aeshna mixta	Migrant Hawker
C.puel = Coenagrion puella	Azure Damselfly	A.cyan = Aeshna cyanea	Southern Hawker
I eleg. = Ischnura elegans	Blue-tailed Damselfly	A.gran = Aeshna grandis	Brown Hawker
E. najas = Erythromma najas	Red-eyed Damselfly	A.imp = Anax imperator	Emperor Dragonfly
P. penn = Plactycnemis pennipes	White-legged damselfly	C.aen = Cordulia aenea	Downy Emerald
Ch. V. = Chacolestes viridis	Willow Emerald Damselfly	L.fulv = <i>Libellula fulva</i>	Scarce Chaser
		L.quad = Libellula quadrimaculata	Four-spotted Chaser
		L.dep = Libellula depressa	Broad-bodied Chaser
		S.strio = Sympetrum striolatum	Common Darter