# The 2018 status of the blackfly Similium morsitans in the Afon Teifi at Cors Caron National Nature Reserve

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Yn Afon Teifi yng Nghors Caron y mae'r unig gofnod diweddar yn y DU o boblogaeth y pryf du *Simulium morsitans* Edwards (Diptera: Simuliidae). Mae gwir faint ei ddosbarthiad a'i statws ar draws y DU yn parhau'n ansicr, er yr adnabyddir y Simuliidae ar lefel y rhywogaeth yn fwyfwy yn ystod monitro ansawdd afonydd arferol. Mae'r adroddiad hwn yn disgrifio samplau ac arsylwadau o larfâu a chwilerod simuliid a gasglwyd ar ddechrau mis Awst 2018 ac yn cymharu'r canlyniadau ag arolwg tebyg a wnaed ar ddiwedd mis Gorffennaf yn 2008. Yn 2018, cofnodwyd 212 o larfâu a 42 o chwilerod o'i gymharu â 332 o larfâu a 86 o chwilerod yn 2008.

Gallai newidiadau crynswth i Afon Teifi, o ran newid i gynefin torlannol, ansawdd dŵr a phatrymau cyflymder, gael effaith ar rywogaethau fel *S. morsitans*. Yn y cyd-destun hwnnw, ystyriwyd effeithiau tebygol opsiwn adfer yr afon yn y dyfodol yn 2008. Yn 2018, gwnaeth cyfnod o sychder mawr ostwng lefelau dŵr ar draws safle Cors Caron, gan annog da byw a oedd yn pori i newid llystyfiant torlannol ac yn yr afon yn fawr. Darganfuwyd larfâu a chwilerod *S. morsitans* ochr yn ochr â rhywogaethau pryf du cyffredin ar lystyfiant dan ddŵr mewn ardaloedd bach o'r afon gyda llif gweladwy. Ni welwyd oedolion *S. morsitans* yn hedfan ac ni ddaethpwyd o hyd i unrhyw safleoedd dodwy yn ystod yr arolwg hwn yn 2018.

Mae'r boblogaeth leol hon o *S. morsitans* yng Ngwarchodfa Natur Genedlaethol Cors Caron yn ymestyn i fyny ac i lawr yr afon o brosiect adfer afon arfaethedig. Yn 2008, ystyriwyd colled neu ddiraddiad tymor byr cynefinoedd a ffefrir y rhywogaeth a'i gallu i wrthsefyll llygredd ysbeidiol. Yng nghanol haf 2018, amlygwyd effeithiau sychder mawr ac ystyrir y rhain yng nghyd-destun risg difodiant i *S. morsitans*. Ar yr amod nad yw'r rhan i fyny'r afon o'r boblogaeth o *S. morsitans* yng Nghors Caron yn cael ei heffeithio gan weithgareddau lleol i adfer yr afon yn y dyfodol ac nad oes unrhyw newidiadau tymor hir i gynefinoedd yr afon o ganlyniad i'r cyfnod o sychder yn 2018 a difrod cysylltiedig i gynefinoedd gan dda byw a oedd yn pori, teimlid y dylai'r boblogaeth o *S. morsitans* barhau yng Nghors Caron.

# Executive summary

The Afon Teifi at Cors Caron supports the only recently recorded UK population of the blackfly *Simulium morsitans* Edwards (Diptera: Simuliidae). The true extent of its UK distribution and status remain uncertain though Simuliidae are increasingly identified to species level during routine river quality monitoring. This report describes samples and observations of simuliid larvae and pupae collected in early August 2018 and compares the results with a similar survey undertaken at the end of July in 2008. In 2018, 212 larvae and 42 pupae were recorded compared to 332 larvae and 86 pupae in 2008.

Gross changes to the Afon Teifi, in terms of altered riparian habitat, water quality and velocity patterns could have an impact on species such as *S. morsitans.* In that context, the likely effects of a future river restoration option were considered in 2008.

In 2018 a severe drought lowered water levels across the Cors Caron site encouraging grazing stock to greatly modify in-river and riparian vegetation. Larvae and pupae of *S. morsitans* were found alongside common blackfly species on submerged vegetation in small areas of the river with perceptible flow. No adult *S. morsitans* were observed on the wing and no oviposition sites were discovered during this 2018 survey.

This localised population of *S. morsitans* on the Cors Caron NNR extends upstream and downstream of a proposed river restoration project. In 2008 short-term loss or degradation of the species' preferred habitats and resilience to intermittent pollution were considered. In mid-summer 2018 severe drought impacts were evident and are considered in the context of *S. morsitans* extinction risk. Providing that the upstream component of the *S. morsitans* population at Cors Caron remains unimpacted by future localised river restoration activities and no long-term river habitat changes result from the 2018 drought event and related habitat damage by grazing stock, it is felt that the population of *S. morsitans* should persist at Cors Caron.

# Introduction

As outlined in the 2009 report (Bass, 2009), the blackfly *Simulium morsitans* Edwards (Diptera: Simuliidae) is a rare species of large weedy streams and small to medium–sized rivers (Davies, 1968). UK distribution records suggest it has become confined to sites on the rivers Forth (Scotland), Derwent (Yorkshire), By Brook (Gloucestershire) and Teifi in Ceredigion (Bass, 1998). In the last two decades surveys of the known *S. morsitans* localities have confirmed the species persists on the Teifi where the river passes through the raised bog of Cors Caron NNR (Bass, 2009).

*Simulium morsitans* was originally recorded in the Teifi at NGR SN687630 in July 1961 by Lewis Davies and found here again in September 1978 during a survey by IFE (Institute of Freshwater Ecology). Jenkins *et al*. (1984) recorded its presence at Cors Caron and absence at 15 other sites they sampled within the Teifi catchment in September 1981. In 1998, Don Thomas (University of Sussex) recorded *S. morsitans* from two sites, one just downstream from the NNR boundary (Thomas, 2002). More recently, Rory Post (Natural History Museum, London; pers. comm.) found larvae and pupae at two Cors Caron locations (SN687633 and SN688634) on 31st July 2006, with larvae particularly abundant at the former site.

Most records for this species from the Afon Teifi come from a canalised section which may change as the result of a proposed river restoration scheme to divert the river course through some of its former meanders. The 2008 survey and interpretations (Bass, 2009) provided information that could be used to avoid, minimise or mitigate any damaging impacts of river restoration upon *S. morsitans*. Since the 2008 Cors Caron survey, a review of *S. morsitans* occurrence records in Britain has been published (Crosskey & Bass, 2013) and no new UK records were found.

The 2018 survey visit in early August was preceded by several months of very low rainfall resulting in the drying out of many bog pools and most ditches on Cors Caron adjacent to the surveyed reaches of the Afon Teifi. The river itself displayed impacts of the unusually low discharge rate such as:

- extensive shallow water and slow flow areas with fine sediment deposits;
- fast-flow riffle habitat was much sparser than in 2008 with very little aquatic or semi-aquatic vegetation on the river bed or its banks at the prevailing low river level;
- in the absence of water in ditches, bog pools and water troughs the cattle, horses and sheep grazing parts of the Cors Caron NNR entered the river to drink;
- through summer 2018 stock also poached the banks and riverbed whilst browsing the normally inaccessible river vegetation.

This 2018 Cors Caron survey on the Afon Teifi investigated the current status and distribution of the aquatic stages of *S. morsitans*. Results were compared with the survey conducted in 2008 (Bass, 2009). The potential risks relating to long-term persistence of this species in the Afon Teifi are considered.

The initial plan in 2008 was to take samples at six sites along the Afon Teifi (within the NNR), spanning the locations of previous records of larvae and pupae of *S. morsitans*. The first sampling visit was timed to coincide with the expected maximum abundance of larvae and pupae in late July 2008, with a second visit in August 2008 to observe oviposition behaviour and establish the location of eggs, with egg survey activities informed by the July visit. Plans changed in 2008 when it became clear that the *S. morsitans* population was relatively small in July and consisted of larvae of all sizes, plus pupae and some emerging adults. This meant a second visit in August would give little chance of observing a peak in oviposition behaviour. Therefore the July 2008 survey activities were extended to incorporate:

- additional sampling sites for the aquatic stages;
- mapping of the within-river habitats used by simuliids, particularly in relation to adjacent relict meanders that may in future be re-connected to the river;
- examination of potential oviposition substrates for *S. morsitans* at the Cors Caron NNR.

The 2018 survey re-visited and sampled simuliids from the same river zones, providing direct comparisons with the July 2008 survey results.

# 1. Survey strategies and methods

As described in Bass (2009), few longitudinal surveys of freshwater macroinvertebrates in the Afon Teifi have identified simuliids to species level. Exceptions are surveys in 1978 by IFE (later to become the Centre for Ecology and Hydrology), Jenkins *et al*. (1984) and Thomas (2002). All involved standard pond net sampling of aquatic invertebrates. Their results from the Teifi indicate *S. morsitans* has been largely confined to the Cors Caron area over the past 40 years.

## 1.1 Life stages

Larvae (1-5 mm) and pupae (2-3 mm) of *S. morsitans* have been recorded predominantly from submerged plant surfaces. Adult (c.3mm) behaviour is poorly known though in Europe the female fly has been recorded as a biting nuisance when attempting to take a human blood meal. The only record (from Germany) of *S. morsitans* eggs relates to a description of egg masses found on trailing grass at the river margin (Timm, 1987). These factors were taken into account during the 2008 and 2018 surveys.

The aquatic larvae and pupae of simuliids are restricted to flowing water, where they attach to clean surfaces on the river bed and submerged plants. Simuliids are generally absent from slow-flowing (<0.2m $sec^{-1}$) areas and aggregate where the water velocity is relatively high (0.3-1.0m $sec^{-1}$). Emerging flies rise to the water surface in a small air bubble and are capable of immediate flight. Adults may remain near the river or disperse over several miles. In some species the female takes a blood meal, and a range of hosts are used, sometimes including man. The behaviour, requirements and longevity of adults are not known for the majority of simuliid species.

Female flies return to the river for oviposition, and this involves species-specific cues that stimulate the release of eggs in a watercourse with characteristics suited to the particular species. For the majority of simuliids, their oviposition requirements are unknown but three main strategies are recognised:

- release of eggs directly onto the water surface (abdomen-dipping);
- firm attachment of eggs in one mass, or small aggregations, to objects such as exposed rocks and trailing grass at or near the air/water interface;
- selection of damp crevices or dense moss in the river bank above the present water level, but subject to inundation during high river flows.

Peak oviposition activity is usually at dawn and dusk, though in some species it occurs in the middle of the day.

## 1.2 Timing

UK records indicate that *S. morsitans* has one or two generations each year (late spring/early summer and mid/late summer), whilst in Europe one summer generation has been reported. The majority of records from the Afon Teifi are of larvae in mid/late summer and this informed the timing of the surveys in 2008 and 2018.

# 2. Sampling/Surveying Methods

## 2.1 Larvae and pupae

Standard kick-samples and pond net sweeps recover a small proportion of simuliids as many specimens remain firmly attached to surfaces in the river. A more rewarding approach is to remove and examine submerged weed and individual large stones. Slow velocity areas are unsuitable for filter-feeding simuliid larvae and developing pupae, so sampling activity focused on surfaces in the highest velocity at each sampling point. Adoption of a 'fixed-point' sampling technique (resampling precisely at 2008 sampling locations) was considered unrealistic as mesohabitat extent and position within the river channel varies between years and would generate many zero counts where prime simuliid habitat is highly restricted. The river bed was predominantly hard clay and sand with silt deposits in slack areas. Gravel and larger stones were infrequent, therefore submerged plants yielded most simuliids. These samples consisted of lengths of plant stem and linear leaves collected by hand or with a small grapnel when in deep water (>0.7m).

During the 2008 sampling exercise, material was transferred to labelled polythene bags for later examination. In 2018, the simuliid larvae and pupae were so sparse it was simpler to transfer them direct to labelled tubes and preserve (70% ethanol) in the field. Samples were non-quantitative but provide information on presence/absence plus the proportions of different simuliid species present at the time of sampling. In 2018, no live pupae were retained to yield adults and no systematic searches made for adults or eggs along the river.

## 2.2 River habitat cover assessment and sampling locations

The reach selected for sampling extended both upstream and downstream of the old cut-off river meanders that are currently by-passed by the main channel of the Teifi.

As in 2008, percentage mesohabitat area cover was assessed in 2018 on the river banks and within the river channel (summarised in Tables 1 & 2). The two main vegetation types plus bare soil were recorded along both banks and types of aquatic plant plus riverbed material in the river channel. These features were recorded at the mid-point of each reach (A-V) proceeding upstream. National Grid References of reach mid-points are given (Table 3). The selection of potential sampling sites focused on locations judged most suitable for simuliids, i.e., sample locations were non-random within reaches A-V and extended both upstream and downstream of the adjacent cut-off meanders, opposite reaches B-G . A hand-held GPS was used to track the survey/sampling route and locations (Figure 1).

## 2.3 River Habitat Survey data

The NRW will hold River Habitat Survey (RHS) data for the Teifi at Cors Caron. These standard surveys (first initiated by the Environment Agency) include

information on a wide range of river habitat variables and can be used to derive scores for habitat quality and habitat modification, both within the channel and along the banks. Some components of RHS data for Cors Caron could be compared with the features recorded in 2008 and 2018.

## 2.4 Simuliid, species, numbers and percentage composition

The identification of simuliids can be uncertain particularly for young larvae and between some closely related simuliid species. The more easily identified pupae can confirm the range of species present and has in some cases guided the larval identification (e.g., all *Wilhelmia* group pupae were *Simulium equinum*, so it is assumed *Wilhelmia* group larvae are also *S. equinum* and not the closely related S*imulium lineatum* or *Simulium pseudequinum*).

As in 2008, small samples (<100g, dry weight) of submerged vegetation were taken from the best available simuliid habitat in 2018, within each reach sampled. Numbers and percentage species composition of simuliid larvae and pupae were recorded. This approach maximises information gained within a short time-frame, but should not be regarded as a fully representative or quantitative snapshot of a rapidly changing simuliid community that includes some species with several generations within a year.

# 3. Results

## 3.1 Distribution and quality of simuliid habitat

### Submerged plants

As noted in the previous survey report (Bass, 2009), plant growth forms with a high surface area exposed to the strongest flow are covered with minimal biofilm and support the highest densities of simuliid larvae and pupae. In 2008, suitable plants for simuliid attachment included:

- Water Crowfoot (*Ranunculus* sp.)
- broad-leaved pondweed (*Potamogeton* sp.)
- Reed Canary Grass (*Phalaris arundinacea*)
- a bur-reed (*Sparganium emersum*).

In general, *P. arundinacea* grows above the water, with some leaves trailing in fast flow. In 2018, it was immediately apparent that optimal habitat for simuliid larvae and pupae at Cors Caron was extremely restricted. Long-impounded reaches with very slow water velocity had led to the complete absence of submerged *Ranunculus* sp. and very few *P. arundinacea* leaves trailing in the river. The latter are used for oviposition by some simuliid species. Contrasts in the river vegetation present

between 2008 and 2018 are illustrated in Tables and images (Plates 1-6). The % cover of riverbed mesohabitats in each survey year are summarised (Table 1). These percentages reflect visual assessments near the mid-point of each river reach (A-V) with full details provided for each reach (Tables 3 & 4). 'A' being downstream of the relict meanders and extending about 2km upstream to reach 'V'.

Table 1. Cors Caron Afon Teifi summary % cover of riverbed mesohabitats recorded (2018) and in the previous survey (2008).

| Mean cover % | *Ranunculus* | *Sparganium* | *Potamogeton* | *Callitriche* | *Nuphar lutea* | Unvegetated |
|---|---|---|---|---|---|---|
| **2018** | 0 | 24 | <1 | <1 | 1.5 | 74 |
| **2008** | 18 | 10 | 3.5 | 3 | 0 | 64 |

As mentioned in the 2009 report, *S. morsitans* occurs in weedy rivers alongside other simuliid species with no clear segregation of species within plant stands, though pupae of all species tend to be attached to surfaces in slightly lower velocities.

## River bed substrates

The extensive hard clay of the river bed and banks, also the deposits of sand and silt are generally not used by simuliid larvae and pupae. Fine gravel is quite sparse and more frequent along the most upstream reaches surveyed at Cors Caron (reaches T & V). In 2018, clean gravel was largely absent, most was draped with a thin layer of fine silt and yielded no simuliid larvae or pupae.

## River bank

The percentage cover of the three main riparian habitats in 2018 was assessed and compared with the data collected at Cors Caron in 2008, The extent of these riparian zone broad habitats are summarised for both survey years (Table 2) and detailed reach scale results presented for 2018 (Table 5) and 2008 (Table 6). There was a strong contrast in bank vegetation related to access for grazing farm stock (Table 4). Coarse tussock grasses predominate at the river edge on the east bank which is grazed, whilst Reed Canary Grass (*P. arundinacea*) dominated along the ungrazed west bank. A short upstream section of the surveyed length (reaches T-V) had grazing on both banks resulting in a low percentage of trailing vegetation on both banks. The high and steep clay banks include some areas of erosion and slumping which were more evident in 2018 than in 2008. As the river water level was so low in summer 2018 easy stock access permitted grazing of bank vegetation from within the river at many points (e.g. Plates 4 & 6).

Table 2. Cors Caron Afon Teifi summary % cover of riparian zone broad habitats recorded along both banks (2018) and in the previous survey (2008).

| Bank: broad habitat type | West bank: trailing grass | West bank: bare earth | West bank: tussock grass | East bank: trailing grass | East bank: bare earth | East bank: tussock grass |
|---|---|---|---|---|---|---|
| **2018** | 19 | 75 | 6 | 22 | 71 | 6 |
| **2008** | 84 | 15 | 1.5 | 5.5 | 56 | 38 |

Plates 1-6. Images from reaches D, J, L and U (with 1 & 2 taken in 2008)

Reach D 2008

2018

Reach J 2008

2018

Reach L 2018

Reach U 2018

## 3.2 Simuliid larvae/pupae

Samples of submerged plants with simuliid larvae and/or pupae were only collected from the very limited areas with detectable flow and simuliids were recorded present in less than half the survey reaches (A-V) in 2018. These locations rarely coincided exactly with the same areas occupied by simuliids in the 2008 survey. Numbers of each species and species composition (%) within 2018 samples are presented for larvae (Table 7) and displayed as maps (Figures 2 & 3). Comparatively few pupae were found in 2018 (Table 9) compared with the 2008 survey (larvae - Table 8 and pupae – Table 10) with a wide size range of larvae present. As in 2008, there was no indication that *S. morsitans* had a distinct larval cohort that would produce

synchronised adult emergence. The 2018 simuliid numbers taken at carefully selected sample locations were only slightly lower than in 2008. However, the extremely low river flow conditions (Figure 4) greatly restricted the areas suitable for simuliids and therefore the overall population size at Cors Caron was probably much smaller in 2018 than in 2008.

## 3.3 Adults and potential oviposition sites

Given the lack of success in sampling adult and egg life stages of *S. morsitans* in 2008 and in the face of even smaller numbers of simuliid larvae and pupae present in 2018, no attempts were made to collect adults or systematically search for potential simuliid oviposition sites in 2018.

# 4. Discussion

The 2018 survey of *Simulium morsitans* at Cors Caron was carried out after an extremely dry summer. Water levels for 2015-2018 for the period April to August are provided in Figure 4 for the gauging weir at Pont Llanio on the Afon Teifi about 5km downstream of Cors Caron. Though this provides no direct information on the water levels at the study site the data do illustrate the extreme low water levels experienced during the summer of 2018, reflecting the situation at Cors Caron. In typical years, higher flows occur in late spring and summer providing suitable conditions to support a high abundance of simuliids. Despite the low flow of the Afon Teifi in the study area, targeted sampling of suitable *Simulium* habitat in 2018 produced similar numbers as in 2008 but it is likely that "*suitable habitat*" was greatly reduced in 2018, though no direct measure of this reduction was made. This supports the use of targeted rather than random or fixed-point sampling for Simuliidae in a river with very patchily distributed prime habitat, which can give rise to many zero counts and large error estimates.

## 4.1 *Simulium morsitans*: National, UK and European context

Rarely recorded within the UK and possibly declining, *S. morsitans* is a qualifying feature of the Cors Caron SSSI which supports the only currently known UK population (Bass, 2010). The true extent of its UK distribution and status are uncertain because simuliid species have only recently been identified during routine river quality monitoring. However, the distinctive narrow 'H' – shaped mark on the larval head capsule ensures it is unlikely to be mis-identified when simuliid larvae are identified to species. In Europe, *S. morsitans* is widespread but uncommon and generally a minor component of the simuliid community. Some biting problems have been reported from Europe, as female flies bite when seeking a blood meal for egg production, generally from farm stock but occasionally from man.

There is a single German report of *S. morsitans* oviposition (Timm, 1987) stating egg-masses are laid on trailing vegetation. This behaviour occurs in many simuliids that have several generations each year, where the eggs develop and hatch over a few days (e.g. Welton & Bass, 1980). Species that lack an over-wintering larval population (those with dormant eggs) are less likely to oviposit on short-lived and easily degraded surfaces such as plant leaves. It is possible such egg-masses fragment and disperse, but generally eggs laid in masses are strongly attached to each other and the oviposition substrate and single eggs of these species are rarely recorded. Over-wintering eggs have to avoid the effects of desiccation, freezing and flood events (downstream displacement) and are sometimes found in river bed sediment. Three UK species are known to deposit eggs above the water surface; *Simulium posticatum* uses desiccation cracks in the river bank (Welton *et al*., 1987), *Prosimulium hirtipes* (Zwick & Zwick, 1990) and *Simulium juxtacrenobium* (Bass & Brockhouse, 1990) lay their eggs in damp moss.

## 4.2 Remaining knowledge gaps

As noted previously (Bass, 2009), *S. morsitans* oviposition behaviour and location of resting eggs at Cors Caron remains unknown. Direct observations of adult simuliids is hampered both by their small size and because the population is relatively small. Addressing this gap would require intensive observations over a period of several weeks in mid/late-summer and success is uncertain. It should be noted that studies on *Simulium posticatum* (Hansford, 1978) and *Simulium nigrum* ( Bass & Werner, 2006; Werner, 2003) took several years to discover oviposition behaviour, despite much higher population densities.

## 4.3 Potential river restoration impacts on *S. morsitans* – short term

### Release of fine organic and inorganic sediment particles

Potential impacts include: disruption of larval filter-feeding behaviour; fouling of attachment surfaces used by larvae and pupae (also, possibly oviposition surfaces); and clogging of pupal respiratory gill filaments. The removal of semi-liquid peat deposits, prior to re-opening old meander channels presents a challenge. Pumping and settlement on land dominated by *Juncus* spp adjacent to the river may be practicable.

### Exposed compacted clay surfaces

Channel excavation and bank re-profiling will provide unsuitable attachment surfaces for simuliid larvae and pupae, these are also unsuitable surfaces for the quick re-establishment of riverine aquatic plants.

### Lack of riparian grasses (e. g. Phalaris arundinacea)

Potential oviposition sites would be greatly restricted until riparian grasses became established.

### Lack of submerged macrophytes typical of flowing waters

Absence of the main surfaces used for attachment by simuliid larvae and pupae.

## 4.4 Potential river restoration impacts on *S. morsitans* – medium to long-term

### Establishment of characteristic river channel features

To an extent, the creation of natural bank and riverbed features can be designed and incorporated in newly cut channels, but where old channels are reconnected the former banks may have slumped in the absence of erosion/deposition processes. Large quantities of peat particles may have accumulated. A series of natural high flow events will re-establish vertical banks, re-sort bed sediments, generate gravel shoals and create fine sediment deposits. The timescale for such changes will probably extend to several years and impose localised effects on the biota. Providing these medium to long-term effects remain localised (within restored river reaches), the flora and fauna can persist in adjacent reaches and eventually colonise restored reaches.

## 4.5 Perceived resilience of *S. morsitans* at Cors Caron

The Teifi population of *S. morsitans* has persisted in the vicinity of Cors Caron over a number of decades, including periods of sheep-dip contamination that damaged freshwater invertebrate communities (Rutt, 2004; Rutt & Griffiths, 2004). There are apparently no documented records of *S. morsitans* in adjacent catchments or tributaries that could act as refugia to 're-seed' the reach in the event of localised serious pollution. If *S. morsitans* produces eggs that remain dormant for weeks to months before hatching, then both the egg and adult stages are at lower risk of direct impacts from water-borne pollutants than the larvae and pupae. This may be a major factor in long-term population survival and persistence at Cors Caron.

Gross changes to the Afon Teifi, in terms of altered riparian habitat, water quality and velocity patterns could have an impact on species such as *S. morsitans* which depend on fast velocities in the larval and pupal stages to deliver suitable suspended food particles and maintain clean attachment surfaces. Oviposition requirements and

behaviour remains uncertain, but if (as recorded in Germany) trailing vegetation is used for egg-laying, any dramatic alteration or removal of trailing vegetation by grazing stock, as noted during the exceptional 2018 drought conditions, may have an impact on the *S. morsitans* population and its persistence at Cors Caron. In the absence of an alternative water supply for grazing stock, the unfenced river and its inhabitants are vulnerable to future damage in extreme summer droughts.

Larvae and pupae of *S. morsitans* have been recorded along several kilometres of the Teifi at Cors Caron (present survey and previous published studies). Therefore, providing that a proportion of the *S. morsitans* population is upstream and not impacted by any short-term river restoration activities and the recent drought influences are short-lived, no major long-term population impacts are anticipated.

# 5. Acknowledgements

In 2008 Rory Post (Natural History Museum, London) provided his recent records of *S. morsitans* at Cors Caron and suggested I might undertake the initial survey. Dr Mike Howe oversaw commissioning of the CCW 2008 and NRW 2018 surveys and improved the report text. I am grateful to Lin Baldock for providing the photographs, GPS locations and assistance with all sampling and recording activities. NRW funded the travel and accommodation costs for the survey.

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# Appendix

## Table 3. Cors Caron Afon Teifi riverbed mesohabitats 2018 (% cover), proceeding upstream down the table.

| Reach | Grid reference | *Ranunc.* sp | *Spargan. emersum* | *Potamog.* spp | *Callitriche* spp | *Nuphar lutea* | Unvegetated surfaces |
|---|---|---|---|---|---|---|---|
| A | SN 6863 6300 | 0 | **5** | 0 | 0 | **15** | **80** |
| B | SN 6867 6306 | 0 | **8** | 0 | 0 | **12** | **80** |
| C | SN 6869 6309 | 0 | **35** | 0 | 0 | 0 | **65** |
| D | SN 6872 6315 | 0 | **35** | 0 | 0 | 0 | **65** |
| E | SN 6875 6324 | 0 | **15** | 0 | 0 | 0 | **85** |
| F | SN 6876 6330 | 0 | **30** | 0 | 0 | 0 | **70** |
| G | SN 6878 63 33 | 0 | **40** | 0 | 0 | 0 | **60** |
| H | SN 6880 6337 | 0 | **45** | 0 | 0 | 0 | **55** |
| I | SN 6885 6341 | 0 | **10** | 0 | 0 | 0 | **90** |
| J | SN 6885 6347 | 0 | **15** | **5** | 0 | 0 | **80** |
| K | SN 6889 6350 | 0 | **30** | 0 | 0 | 0 | **70** |
| L | SN 6890 6353 | 0 | **18** | 0 | 0 | 0 | **82** |
| M | SN 6894 6357 | 0 | **5** | **2** | 0 | 0 | **93** |
| N | SN 6894 6358 | 0 | **85** | 0 | 5 | 0 | **10** |
| O | SN 6899 6363 | 0 | **90** | 0 | 0 | 0 | **10** |
| P | SN 6891 6377 | 0 | **1** | 0 | 0 | **10** | **89** |
| Q | SN 6889 6383 | 0 | **10** | 0 | 0 | 0 | **90** |
| R | SN 6884 6382 | 0 | **5** | 0 | 0 | 0 | **95** |
| S | SN 6881 6385 | 0 | **15** | **10** | 0 | 0 | **85** |
| T | SN 6896 6400 | 0 | **5** | 0 | 0 | 0 | **95** |
| U | SN 6943 6425 | 0 | **2** | 0 | 0 | 0 | **98** |
| V | SN 6964 6439 | - | **-** | - | - | - | **-** |

## Table 4. Cors Caron Afon Teifi riverbed mesohabitats recorded in previous survey (2008) % cover, proceeding upstream down the table.

| Reach | Grid reference | *Ranunculus* sp | *Sparganium emersum* | *Potamogeton* spp | *Callitriche* spp | Unvegetated surfaces |
|---|---|---|---|---|---|---|
| A | SN 6863 6300 | 20 | 25 | 5 | 1 | 43 |
| B | SN 6867 6306 | 35 | 20 | 5 | 2 | 38 |
| C | SN 6869 6309 | 20 | 15 | 2 | 1 | 62 |
| D | SN 6872 6315 | 30 | 20 | 1 | 5 | 44 |
| E | SN 6875 6324 | 12 | 30 | 0 | 0 | 58 |
| F | SN 6876 6330 | 5 | 10 | 0 | 0 | 85 |
| G | SN 6878 63 33 | 0 | 25 | 0 | 5 | 70 |
| H | SN 6880 6337 | 5 | 15 | 5 | 0 | 75 |
| I | SN 6885 6341 | 10 | 10 | 10 | 5 | 65 |
| J | SN 6885 6347 | 10 | 5 | 10 | 10 | 65 |
| K | SN 6889 6350 | 15 | 0 | 5 | 15 | 65 |
| L | SN 6890 6353 | 65 | 0 | 0 | 5 | 30 |
| M | SN 6894 6357 | 40 | 5 | 15 | 5 | 35 |
| N | SN 6894 6358 | 25 | 5 | 15 | 5 | 50 |
| O | SN 6899 6363 | 30 | 0 | 0 | 0 | 70 |
| P | SN 6891 6377 | 10 | 0 | 0 | 0 | 90 |
| Q | SN 6889 6383 | 5 | 0 | 0 | 0 | 95 |
| R | SN 6884 6382 | 10 | 0 | 0 | 0 | 90 |
| S | SN 6881 6385 | 20 | 10 | 0 | 0 | 70 |
| T | SN 6896 6400 | 10 | 10 | 0 | 3 | 77 |
| U | SN 6964 6439 | 10 | 10 | 5 | 2 | 73 |

## Table 5. Broad habitat types recorded in 2018, Cors Caron Afon Teifi West bank/East bank (% cover), progressing upstream down the table.

| Reach | Grid reference | West bank: trailing grass | West bank: bare earth | West bank: tussock grass | East bank: trailing grass | East bank: bare earth | East bank: tussock grass |
|---|---|---|---|---|---|---|---|
| A | SN 6863 6300 | **40** | **60** | 0 | **25** | **75** | 0 |
| B | SN 6867 6306 | **75** | **25** | 0 | **15** | **85** | 0 |
| C | SN 6869 6309 | **50** | **50** | 0 | **45** | **55** | 0 |
| D | SN 6872 6315 | **10** | **90** | 0 | **10** | **90** | 0 |
| E | SN 6875 6324 | **85** | **15** | 0 | **80** | **20** | 0 |
| F | SN 6876 6330 | **15** | **85** | 0 | **65** | **35** | 0 |
| G | SN 6878 63 33 | **10** | **90** | 0 | **25** | **70** | **5** |
| H | SN 6880 6337 | **5** | **90** | **5** | 0 | **100** | 0 |
| I | SN 6885 6341 | **25** | **75** | 0 | **5** | **90** | **5** |
| J | SN 6885 6347 | 0 | **100** | 0 | 0 | **100** | 0 |
| K | SN 6889 6350 | **25** | **45** | **30** | **10** | **90** | 0 |
| L | SN 6890 6353 | **15** | **65** | **20** | **5** | **80** | **15** |
| M | SN 6894 6358 | **2** | **93** | **5** | **20** | **65** | **15** |
| N | SN 6894 6358 | **2** | **98** | 0 | **35** | **55** | **10** |
| O | SN 6899 6363 | 0 | **95** | **5** | **5** | **85** | **10** |
| P | SN 6891 6377 | **5** | **90** | **5** | **15** | **70** | **15** |
| Q | SN 6889 6383 | **10** | **80** | **10** | **75** | **15** | **10** |
| R | SN 6884 6382 | **2** | **83** | **15** | **10** | **85** | **5** |
| S | SN 6881 6385 | **10** | **80** | **10** | **10** | **75** | **15** |
| T | SN 6896 6400 | **10** | **80** | **10** | **15** | **55** | **30** |
| U | SN 6943 6425 | **6** | **84** | **10** | 0 | **100** | 0 |
| V | SN 6964 6439 | - | - | - | - | - | - |

## Table 6. Broad habitat types recorded in 2008, Cors Caron Afon Teifi West bank/East bank (% cover), progressing upstream down the table.

| Reach | Grid reference | West bank: trailing grass | West bank: bare earth | West bank: tussock grass | East bank: trailing grass | East bank: bare earth | East bank: tussock grass |
|---|---|---|---|---|---|---|---|
| A | SN 6863 6300 | 95 | 5 | 0 | 30 | 30 | 40 |
| B | SN 6867 6306 | 100 | 0 | 0 | 10 | 60 | 30 |
| C | SN 6869 6309 | 90 | 10 | 0 | 2 | 68 | 30 |
| D | SN 6872 6315 | 100 | 0 | 0 | 5 | 20 | 75 |
| E | SN 6875 6324 | 100 | 0 | 0 | 25 | 15 | 60 |
| F | SN 6876 6330 | 100 | 0 | 0 | 5 | 80 | 15 |
| G | SN 6878 63 33 | 100 | 0 | 0 | 0 | 20 | 80 |
| H | SN 6880 6337 | 100 | 0 | 0 | 0 | 50 | 50 |
| I | SN 6885 6341 | 100 | 0 | 0 | 0 | 10 | 90 |
| J | SN 6885 6347 | 80 | 20 | 0 | 0 | 30 | 70 |
| K | SN 6889 6350 | 80 | 20 | 0 | 0 | 70 | 30 |
| L | SN 6890 6353 | 85 | 15 | 0 | 0 | 65 | 35 |
| M | SN 6894 6357 | 95 | 5 | 0 | 0 | 60 | 40 |
| N | SN 6894 6358 | 95 | 5 | 0 | 0 | 70 | 30 |
| O | SN 6899 6363 | 95 | 5 | 0 | 0 | 85 | 15 |
| P | SN 6891 6377 | 100 | 0 | 0 | 30 | 70 | 0 |
| Q | SN 6889 6383 | 80 | 20 | 0 | 0 | 80 | 20 |
| R | SN 6884 6382 | 60 | 40 | 0 | 0 | 80 | 20 |
| S | SN 6881 6385 | 70 | 30 | 0 | 0 | 80 | 20 |
| T | SN 6896 6400 | 30 | 70 | 0 | 10 | 70 | 20 |
| U | SN 6964 6439 | 0 | 70 | 30 | 0 | 70 | 30 |

Table 7. Numbers of simuliid larvae identified and species composition (%) along the Afon Teifi at Cors Caron in 2018 (reach locations A-V see Table 3 for grid references).

| Reach - Sequence of samples (upstream to the right) | D | H1 | J | L | M | T2 | U | U1 | V | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Taxon counts | - | - | - | - | - | - | - | - | - | - |
| ***morsitans*** | **0** | **9** | **34** | **55** | **12** | **27** | **22** | **12** | **41** | **212** |
| *reptans* | 0 | 0 | 5 | 20 | 0 | 1 | 2 | 7 | 16 | **51** |
| *equinum* | 0 | 1 | 44 | 43 | 2 | 6 | 9 | 6 | 27 | **138** |
| *ornatum* gp | 0 | 8 | 2 | 15 | 0 | 1 | 0 | 0 | 5 | **31** |
| Juvenile | 0 | 0 | 34 | 13 | 0 | 0 | 0 | 3 | 19 | **69** |
| **Totals** | **-** | **18** | **119** | **146** | **14** | **35** | **33** | **28** | **108** | **501** |
| - | - | - | - | - | - | - | - | - | - | - |
| Percentage | - | - | - | - | - | - | - | - | - | Mean |
| ***morsitans*** | **0** | **53** | **29** | **38** | **86** | **77** | **77** | **43** | **38** | **55.1** |
| *reptans* | 0 | 0 | 4 | 14 | 0 | 3 | 3 | 25 | 15 | - |
| *equinum* | 0 | 6 | 37 | 29 | 14 | 17 | 17 | 21 | 25 | - |
| *ornatum* gp | 0 | 41 | 2 | 10 | 0 | 3 | 3 | 0 | 5 | - |
| Juvenile | 0 | 0 | 28 | 9 | 0 | 0 | 0 | 11 | 27 | - |

Table 8. Numbers of simuliid larvae identified and species composition (%) along the Afon Teifi recorded in the 2008 survey (reach locations A-U see Table 3 for grid references).

| Reach - Sequence of samples (upstream to the right) | A | A | D | H | J | K | R | T | U | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Taxon counts | - | - | - | - | - | - | - | - | - | - |
| ***morsitans*** | **23** | **79** | **1** | **21** | **24** | **5** | **130** | **21** | **18** | **322** |
| *reptans* | 30 | 50 | 2 | 6 | 14 | 4 | 39 | 1 | 56 | **202** |
| *equinum* | 9 | 10 | 0 | 2 | 8 | 0 | 37 | 5 | 15 | **86** |
| *ornatum* gp | 3 | 10 | 0 | 1 | 1 | 0 | 13 | 15 | 22 | **65** |
| *argyreatum* gp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** |
| Totals | **65** | **149** | **3** | **30** | **47** | **9** | **219** | **42** | **112** | **676** |
| - | - | - | - | - | - | - | - | - | - | - |
| Percentage | - | - | - | - | - | - | - | - | - | Mean |
| ***morsitans*** | **35.4** | **53.0** | **33.0** | **70.0** | **51.1** | **55.6** | **59.4** | **50.0** | **16.1** | **47.0** |
| *Reptans* | 46.2 | 33.6 | 66.0 | 20.0 | 29.8 | 44.4 | 17.8 | 2.4 | 50.0 | - |
| *Equinum* | 13.9 | 6.7 | 0.0 | 6.7 | 17.0 | 0.0 | 16.9 | 11.9 | 13.4 | - |
| *ornatum* gp | 4.6 | 6.7 | 0.0 | 3.3 | 2.1 | 0.0 | 5.9 | 35.7 | 19.6 | - |
| *argyreatum* gp | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | - |

Table 9. Numbers of simuliid pupae identified and species composition (%) along the Afon Teifi in 2018 (%) (for reach locations A-V see Table 3 for grid references).

| Reach - Sequence of samples (upstream to the right) | D | H1 | J | L | M | T2 | U | U1 | V | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Taxon counts | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| ***morsitans*** | **0** | **0** | **7** | **22** | **9** | **1** | **0** | **3** | **0** | **42** |
| *Reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** |
| *Equinum* | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | **3** |
| *ornatum* gp | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | **7** |
| **Totals** | **0** | **0** | **7** | **32** | **9** | **1** | **0** | **3** | **1** | **53** |
| - | - | - | - | - | - | - | - | - | - | - |
| Percentage | - | - | - | - | - | - | - | - | - | **Mean** |
| ***morsitans*** | **0** | **0** | **100** | **69** | **100** | **100** | **0** | **100** | **0** | **78** |

Table 10. Numbers of simuliid pupae identified and species composition (%) along the Afon Teifi recorded in the 2008 survey (for reach locations A-U see Table 3 for grid references).

| Reach - Sequence of samples (upstream to the right) | A | A | D | H | J | K | R | T | U | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Taxon counts | - | - | - | - | - | - | - | - | - | - |
| ***morsitans*** | **16** | **19** | **1** | **25** | **4** | **3** | **3** | **6** | **9** | **86** |
| *reptans* | 8 | 5 | 0 | 3 | 3 | 0 | 0 | 9 | 6 | **34** |
| *equinum* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | **6** |
| *ornatum* gp | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | **8** |
| *argyreatum* gp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| **Totals** | **25** | **24** | **1** | **29** | **7** | **3** | **7** | **19** | **19** | **134** |
| - | - | - | - | - | - | - | - | - | - | - |
| Percentage | - | - | - | - | - | - | - | - | - | **Mean** |
| ***morsitans*** | **64** | **79** | **100** | **86** | **57** | **100** | **43** | **32** | **47** | **67** |

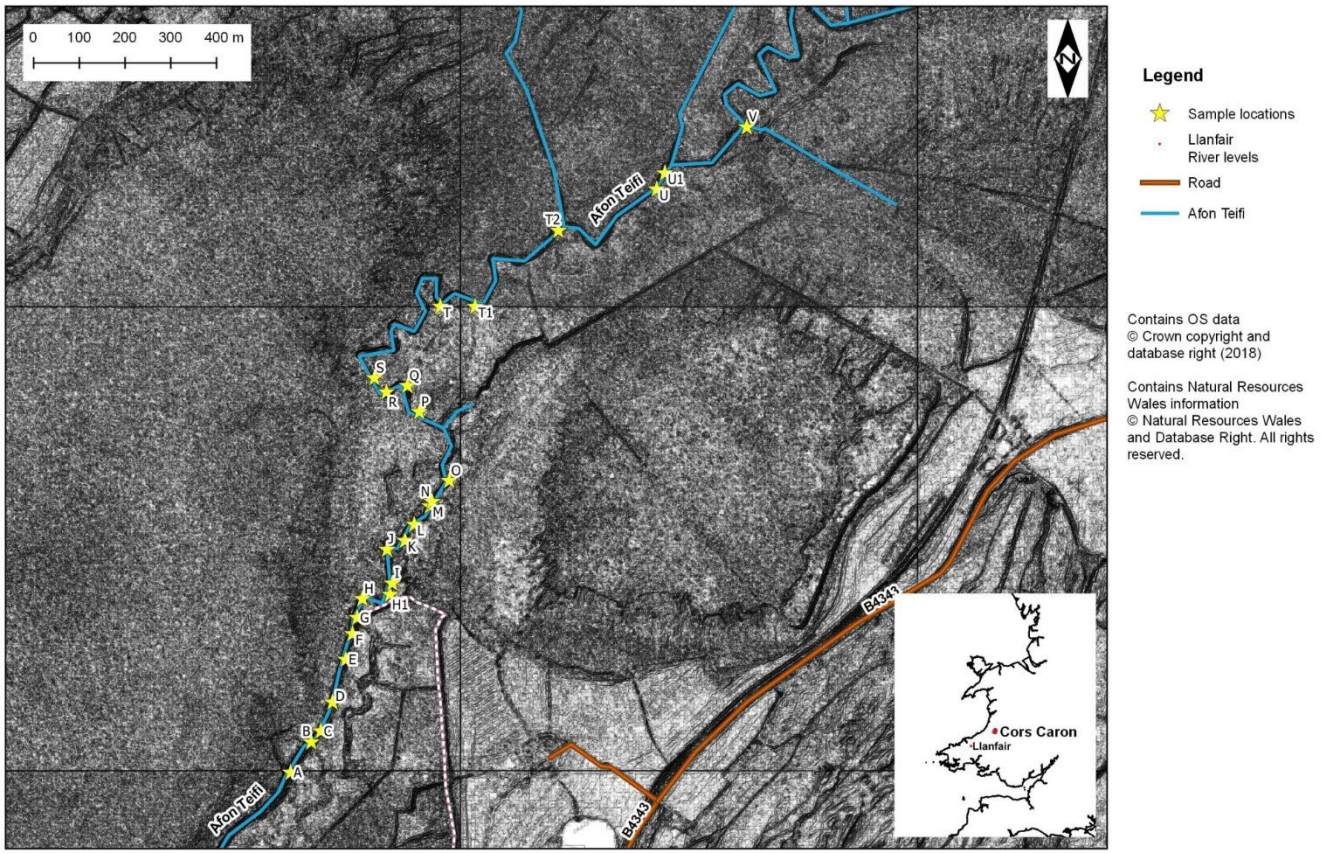


Figure 1. Map of surveyed reaches at Cors Caron including 2018 sampling locations (A-V).

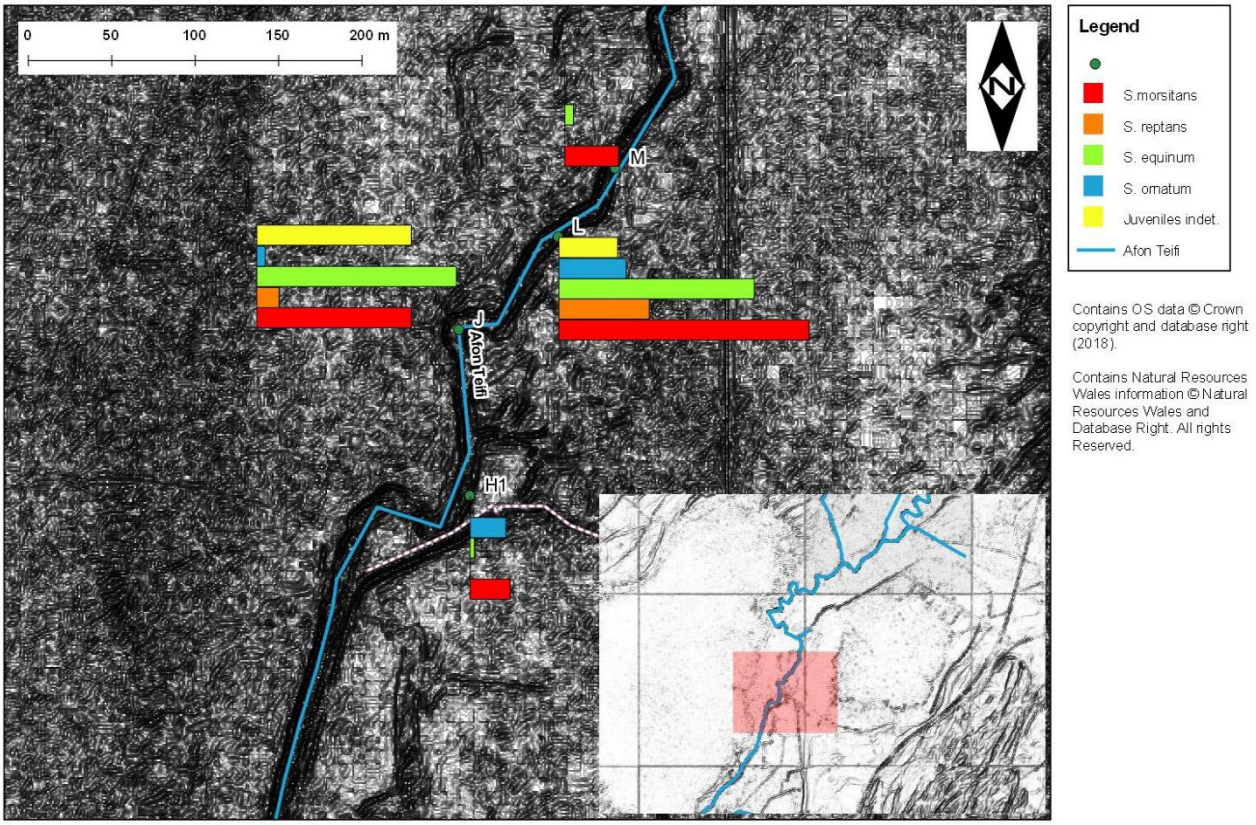


Figure 2. Map displaying numbers of *Simulium* larvae at reaches H, J, L & M at Cors Caron in 2018.

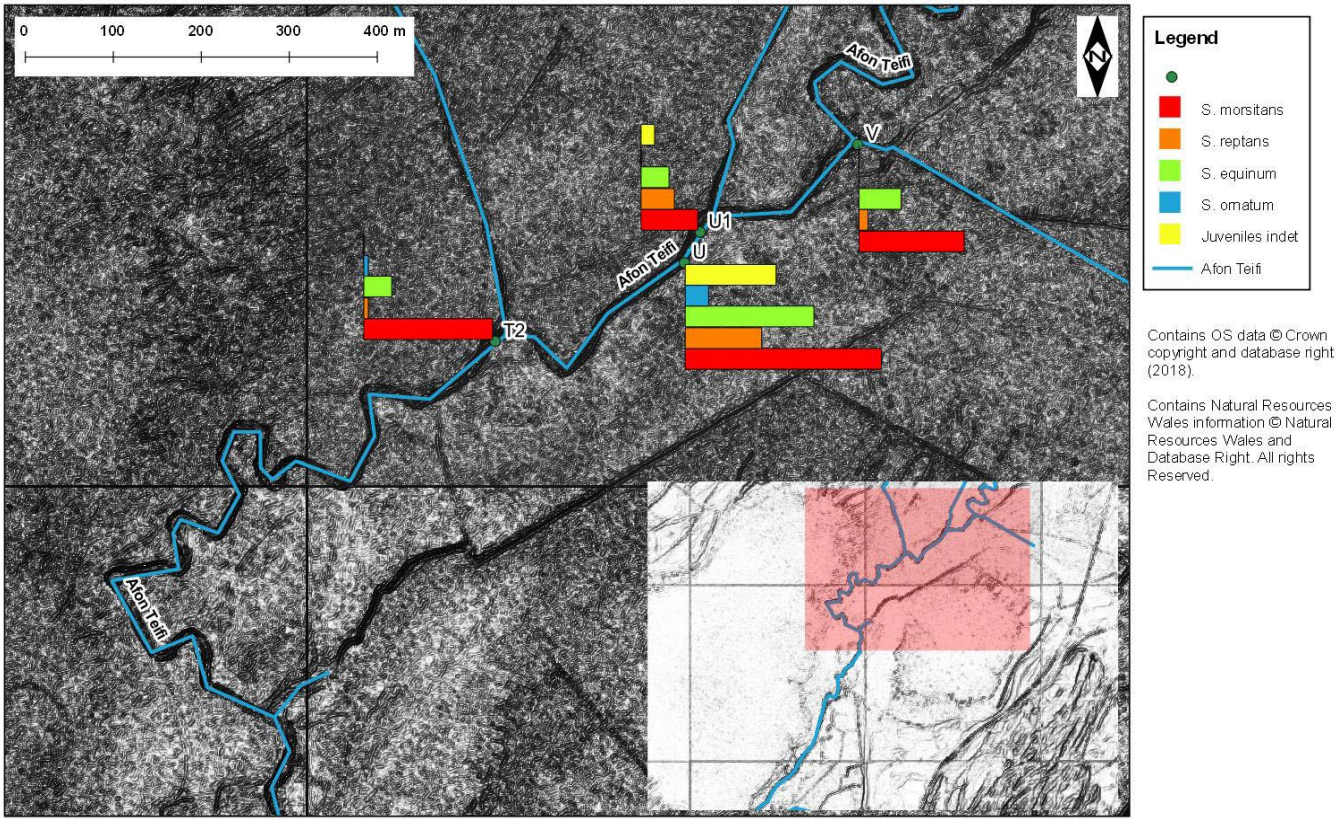


Figure 3. Map displaying numbers of *Simulium* larvae at reaches T2, U, U1 & V at Cors Caron in 2018.

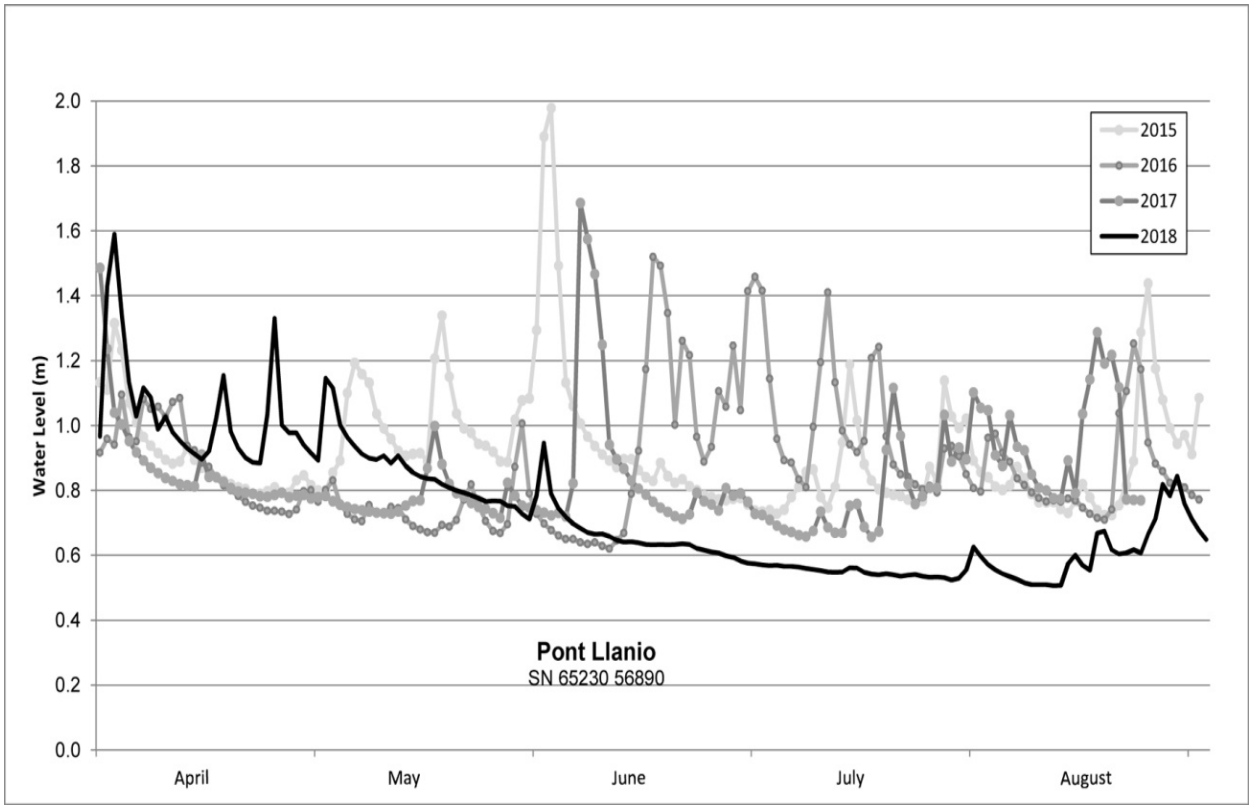


Figure 4. Spring and summer water levels in the Afon Teifi at Pont Llanio 2015-2018.
Data source: https://riverlevels.uk/teifi-llanddewi-brefi-community-pont-llanio#.XBepnc2nyUk derived from data provided by Natural Resources Wales

# 3 Data Archive Appendix

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] Species records, which are held on the NRW Recorder 6 database.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://libcat.naturalresources.wales or http://catllyfr.cyfoethnaturiol.cymru by searching 'Dataset Titles'. The metadata is held as record no 122295.