Translocation of the little whirlpool ramshorn snail: Monitoring Update 2017

Highways England

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Contents

1 Introduction

The little whirlpool ramshorn snail *Anisus vorticulus* is a small, aquatic snail with a dorsoventrally flattened shell approximately 5 mm in diameter. It is a UK Biodiversity Action Plan Priority Species and the only British non-marine gastropod which is a European Protected Species. It is also listed in Annex II of the EU Habitats and Species Directive and therefore requires the designation of Special Areas for Conservation (Annex II). In the UK, populations of *Anisus vorticulus* have been declining since the 1960s and although the precise cause is not clear, it is thought that drainage, over frequent dredging, and eutrophication are all likely to be contributing factors (JNCC, 2007; Van Damme, 2012).

Anisus vorticulus is also challenged by extreme dispersal limitation, which may prevent it expanding its range into suitable habitat even if conditions improve (Niggebrugge et al. 2007). Using translocation to assist with expanding the range of the species may therefore be appropriate, and to this end a Pilot Translocation of *Anisus vorticulus* was conducted in the summer of 2016 to test both the feasibility of such action and the response of the species to it (AECOM/Abrehart Ecology 2016a). The Pilot Translocation involved the movement of 800 *Anisus vorticulus* from [redacted] (Figure 1), following an in-depth analysis of the habitat preferences of *Anisus vorticulus* to identify suitable donor sites (AECOM/Abrehart Ecology 2016b).

An initial monitoring survey of the newly translocated populations, from the Pilot Translocation, conducted in late October 2016, gave promising results regarding the survivorship of *Anisus vorticulus* at the receptor sites in [redacted] (AECOM/Abrehart Ecology 2017b).

Following the Pilot Translocation in 2016 (AECOM/Abrehart Ecology 2016b) and the initial promising monitoring results (AECOM/Abrehart Ecology 2016c), the translocation exercise was extended in line with the original suggestions of the feasibility report (AECOM/Abrehart Ecology 2016b), whereby the translocation could be expanded based on the results of initial translocations, and the methods employed refined according to results. The second translocation involved moving additional *Anisus vorticulus* from the donor ditches at [redacted], and a new donor site at [redacted], [redacted]. This second translocation has been given the working title of Translocation 2017, to differentiate the second phase from the Pilot Translocation. Due to a small number of *Anisus vorticulus* available for Translocation 2017 in June 2017, Translocation 2017 was also conducted in October/November 2017. Translocation 2017 is described in detail under separate cover (AECOM/Abrehart Ecology 2018a). This current report should therefore not be read in isolation and reference should be made to the Translocation 2017 translocation report.

As per the terms of the translocation licence, monitoring surveys will continue every six months over a period of five years post translocation. The findings presented in the current report are from:

- The second monitoring visit to the Pilot Translocation sites (June 2017);
- The third monitoring visit to the Pilot Translocation sites (October/November 2017)
- The first monitoring visit from the Translocation 2017 [June] (October/November 2017)

[redacted]

Figure 1. Location of [redacted] within the wider Broads area.

2 Methods

2.1 Licence requirements

Natural England licences were required for each aspect of this project, including surveying (disturbing *Anisus vorticulus),* collecting full aquatic invertebrate samples for laboratory analysis (killing *Anisus vorticulus*), and for the translocating from the [redacted], to [redacted], further south (translocation of *Anisus vorticulus*).

Translocations of *Anisus vorticulus* were carried out in accordance with Translocation Licence 23292. Subsequent surveys and sample collection were conducted in accordance with Survey Licence 25961.

Fen Raft Spider Licence for disturbing *Dolomedes plantarius* at [redacted] – Survey Licence 2016-26279.

Norfolk Hawker Licence for disturbing Anasaeshna isoceles at all sites in all English Counties – Survey Licence 2017-31348.

Full Licence details are provided in Appendix A.

2.2 Monitoring Method

The Pilot Translocation of 800 *Anisus vorticulus* from [redacted] took place in May 2016, with Translocation 2017 taking place in June and October/November 2017 (AECOM/Abrehart Ecology 2016b). During Translocation 2017, an initial 1,000 *Anisus vorticulus* were moved in June 2017, with a further 2,000 animals moved in October/November 2017.

The monitoring surveys presented here were conducted in June 2017 and October/November 2017, following an initial monitoring survey of Pilot Translocation in late October 2016 as reported in AECOM/Abrehart (AECOM/Abrehart Ecology 2016b).

Data and sample collection was conducted by a pair of surveyors, including an experienced on-site mollusc surveyor ([redacted], Ecologist and National Mollusc Specialist) and a second team member responsible for recording ditch features, abiotic variables, and botanical diversity ([redacted] and [redacted], Ecologists at Abrehart Ecology). At each sample location, ditch characteristics and a range of other environmental features were recorded (as in the 2015 survey, AECOM 2015c). These included exposed and submerged bank profiles, channel width and depth, and levels of grazing, poaching, and shelving. Abiotic parameters were recorded in the surface 10cm of water including pH and conductivity (measured using a HI98129 pH/Conductivity Tester; Hanna Instruments), dissolved oxygen and temperature (measured using a PD0-520 Dissolved Oxygen metre; Lutron). Each sample point was recorded on an Archer2 sub metre dGPS.

2.2.1 Pre-Translocation sampling

Prior to Translocation 2017, sampling surveys were conducted at all donor and receptor sites across [redacted] (Figure 2) as part of the monitoring method. The survey focused chiefly on the presence/absence of live *Anisus vorticulus* at the receptor sites, and the continuing persistence and necessary abundance of *Anisus vorticulus* at the donor sites.

An additional donor site, [redacted], was chosen for Translocation 2017 (location shown in Figure 3). This [redacted] site had a known population of *Anisus vorticulus* within its ditches. Surveys conducted by Abrehart Ecology in 2016 found the snail density at this site to be suitable to act as a donor population. Additionally, it was considered environmentally appropriate to collect donor populations from a wider variety of sites to limit stress on the Acle population.

The donor ditch monitoring was carried out in June and October/November 2017; all ditches that had been identified as being suitable donor ditches for *Anisus vorticulus* were revisited for the purposes of monitoring. The ditches surveyed included both those part of the Pilot Translocation and the additional ditches included in Translocation 2017. Monitoring at the donor ditches aimed to ensure that the translocation has caused no long-term negative effects on *Anisus vorticulus* populations. In addition to checking the abundance of *Anisus vorticulus*, the wider mollusc community was assessed to ensure that the disturbance has not caused any long-term shifts in species composition and / or abundance.

Samples were collected using the same sweep net method described in Section 2.2.2. Samples were taken at either end of the original donor ditch sections. As at the receptor sites, all mollusc species were identified in the field, and abundance of each was quantified. Any *Anisus vorticulus* present were individually counted and photographed for later age class assessment (methods described in Section 2.3).

2.2.2 Receptor ditch monitoring

In June and October/November 2017 all ditches that had received a population of *Anisus vorticulus* were revisited for the purposes of monitoring. The ditches surveyed included both those part of the Pilot Translocation and the additional ditches included in Translocation 2017. For consistency and repeatability, samples were collected using the same sweep netting method as the Pilot Translocation monitoring report (AECOM/Abrehart Ecology 2016c, first described in AECOM/Abrehart Ecology 2016a). This method was developed to minimise disturbance at the receptor sites, by taking smaller samples than using a typical sweep net protocol (as was used in the detailed surveys described in AECOM/Abrehart Ecology 2015c, 2016a, and 2017b). It is acknowledged that the simplification of the sweep technique may result in a slightly lower detection rate for *Anisus vorticulus* than the method described in AECOM/Abrehart Ecology 2016a. However, minimising disruption of translocated populations during monitoring was considered a priority.

Beginning directly next to [redacted], a 0.5mm mesh net was drawn towards the bank in a single sweep, covering 0.25m^2 to a depth of 25cm. The vegetation was gently agitated during the sweep, but any surrounding vegetation was disturbed as little as possible. Samples were also taken from 1m either side of the original placement points to assess whether the translocated individuals had begun to disperse within the ditch. In the October/November 2017 re-survey additional samples were taken at mid points in between these main receptor sites.

The material collected during the sweep was placed in a white gridded tray filled with water from the same ditch area. Molluscs were released from the collected vegetation by agitating the contents of the tray, after which excess vegetation was then removed. The floating contents of the tray (chiefly vegetation and larger invertebrate species) were poured back into the ditch, with molluscs retained in the bottom of the tray; it is accepted that a small proportion of molluscs may be lost at this stage, attached to some of the floating vegetation, but previous tests of this method have shown such losses to be negligible ([redacted], pers. obs.). The material remaining was then evenly distributed across the tray for assessment. Any *Anisus vorticulus* present were individually counted and photographed for subsequent estimation of age (see Section 2.3). After identification, the sample was carefully replaced at the point of collection.

Figure 2. Locations of donor and receptor sites at [redacted] Pilot Translocation (2016).

[redacted]

Figure 3. Location of donor sites at [redacted] for Phase 2 of Translocation 2017.

[redacted]

Figure 4. Locations of receptor sites at [redacted] for phase 2 of *Anisus vorticulus* Translocation in 2017.

[redacted]

Figure 5. Locations of receptor sites at [redacted] for phase 2 of *Anisus vorticulus* translocation in 2017.

[redacted]

2.3 Life stage classification

All *Anisus vorticulus* that were found at the receptor sites and collected from the donor sites were photographed to allow the subsequent assessment of the age profile of the population. The animals at each receptor site were grouped together on a laminated sheet of gridded paper, which was appropriately labelled. Using the photographs, the shell diameter of each individual was measured using ImageJ software (v1.50i; Rasband 1997-2016). The scale for measurements was set using the grid squares of the paper in each photograph. Shells were measured from the edge of the shell aperture, through the central point of the whorl of the shell, to the opposite outer edge of the shell (Figure 6). All measurements were taken in mm.

The *Anisus vorticulus* were classed by age according to their size following the guidelines devised by Glöer & Groh (2007). Those with a diameter <2.5mm were classed as juveniles; small adults were classed as between 2.5-3mm (this was the size at which copulation was first observed; Glöer & Groh 2007); large adults were classed as having a diameter >3mm.

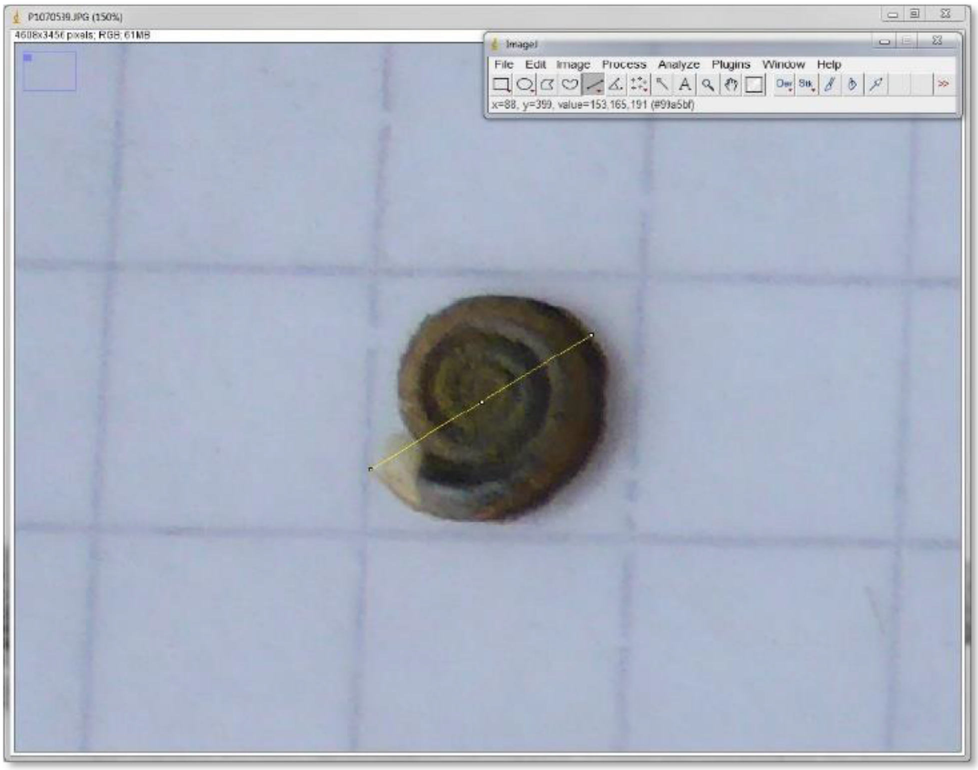

Figure 6. Measurement of shell diameter using Image J software. The full diameter of the shell was measured in each case, from the outer edge of the aperture, passing through the central whorl, to the opposite edge.

3 Results

3.1 Survivorship of translocated *Anisus vorticulus* [redacted]

3.1.1 Overview of results

Three monitoring (post translocation) surveys were undertaken from June 2016 to November 2017, at roughly six-month intervals, at [redacted]. In the June 2017 (12 months post translocation) re-survey live *Anisus vorticulus* were only found at three of the eight receptor sites from the Pilot Translocation. In the November 2017 (18 months post translocation) re-survey 98 live *Anisus vorticulus* were found at seven of the eight sites.

Table 1. Numbers of *Anisus vorticulus* placed during Pilot Translocation to [redacted], and subsequently found during six, twelve and eighteen-month surveys post-translocation.

Receptor site number	Number of *Anisus vorticulus*			
	Number Translocated	Six-month check October 2016	Twelve-month check June 2017	Eighteen Month Check November 2017
1	100	10	2	25
2	100	6	2	17
3	100	39	0	9
4	100	29	0	29
5	100	10	3	2
6	100	18	0	6
7	100	2	0	0
8	100	11	0	10

3.1.2 June 2017

In June 2017, the second monitoring visit to [redacted], live *Anisus vorticulus* were only found at three of the eight receptor sites from the Pilot Translocation. Where live specimens were found, the numbers encountered were very low, typically only 1-2 snails in a sweep, indicating a downward trend in numbers of *Anisus vorticulus* at all receptor sites.

In contrast to the 18-month check conducted in November 2017, where high numbers of juveniles were found at the receptor sites (AECOM/Abrehart Ecology 2018a), only large adult snails were found in the twelve-month (June 2017) check. This may reflect seasonal variation in the age structure of *Anisus vorticulus* populations (Willing 1998; Killeen 1999; Willing & Killeen 1999), as large adults were also the most frequently encountered age-class in donor ditches during the twelve-month check.

3.1.3 November 2017

The November 2017 (18 month), re-surveys at [redacted] receptor sites showed promising results with 98 *Anisus vorticulus* found across the receptor sites (129 were found in the October 2016 resurvey). As shown in Figure 7, live *Anisus vorticulus* were found at seven of eight release points, compared to only 3 receptor sites in June 2017. The results have shown that, as in 2016 resurvey, the sites with the lowest numbers re-recorded were from the populations collected from the same receptor ditch (Donor ditch 3 within [redacted]).

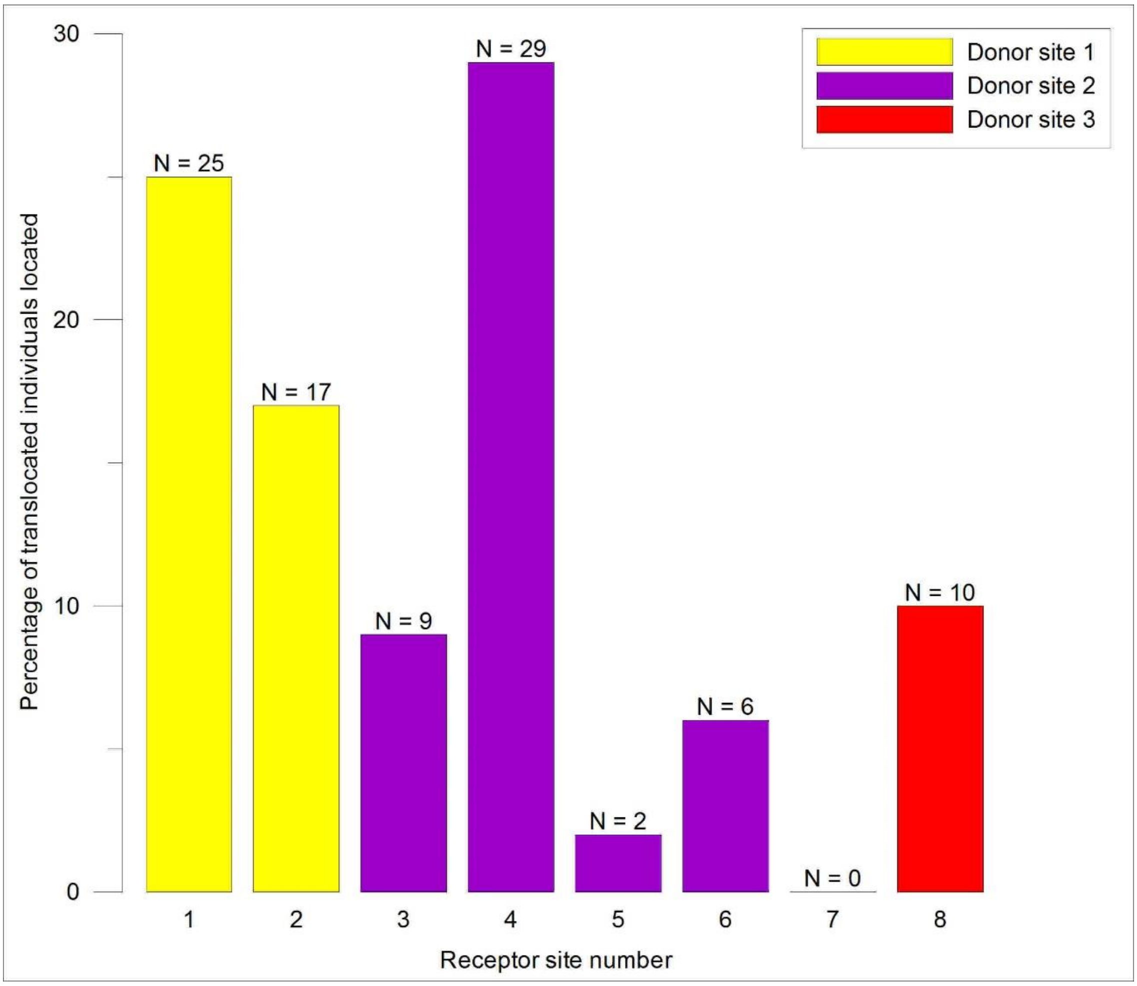

Figure 7. Frequency of living *Anisus vorticulus* observed at each receptor site at [redacted] **in October 2017.**

A large proportion (76%) of the *Anisus vorticulus* found across the receptor sites were juveniles, with only 5% large adults. These were similar proportions to those seen in the October 2016 re-survey

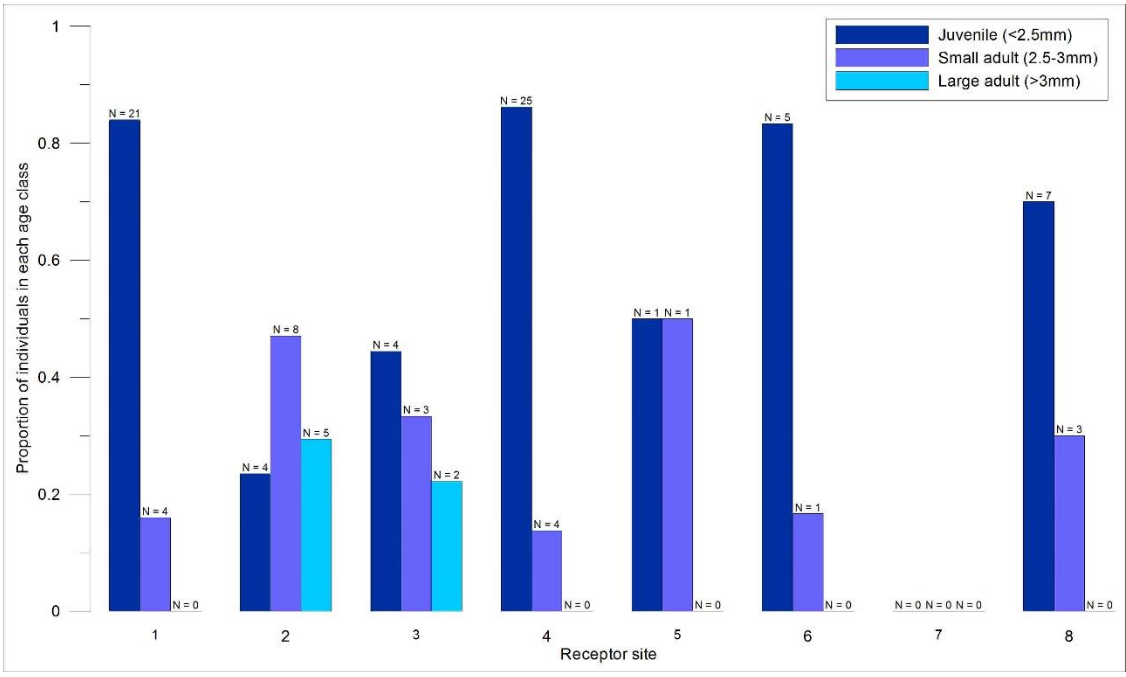

Figure 8. Age class of living *Anisus vorticulus* observed at each receptor site at [redacted] in November 2017.

Considering the size of the sweep samples taken, it appears that there is a considerably larger population within the sample sites than was originally placed there. The sweeps collect specimens through an area of approximately 100cm by 25cm, from one side of the ditch only. Taking this into account, it is reasonable estimate that in a 100cm width of ditch there are eight times the numbers collected within the receptor sites. Indicating that there is a self-sustaining population within the sites.

3.2 Survivorship of translocated *Anisus vorticulus* to [redacted] in October/November 2017

In October 2017, a monitoring survey of the Translocation 2017 receptor sites at [redacted] that had received a translocated population in June 2017 was carried out.

Samples were taken 1m either side of the original placement points, as well as at the five release sites. A single sweep was taken at each location, as described in section 2.2.2. This reduced size sweep had shown to collect *Anisus vorticulus* at sites in Norfolk and Suffolk, but it may not always pick up very low numbers of *Anisus vorticulus*. This reduced sweep effort was important so as not to overly disturb the translocated population which had been moved within six months.

Results here showed that there was a continued presence of *Anisus vorticulus* within the ditches; however, numbers recorded were low. Just 15 No. *Anisus vorticulus* were found in three samples of a total of five receptor sites, with a maximum of 11 found in sample Location 1. These were mainly juveniles and large adults, with an average size of 3.1 mm. The average of those translocated in June was also 3.1mm. The presence of a juvenile indicated that there was breeding on the site, although limited at this time.

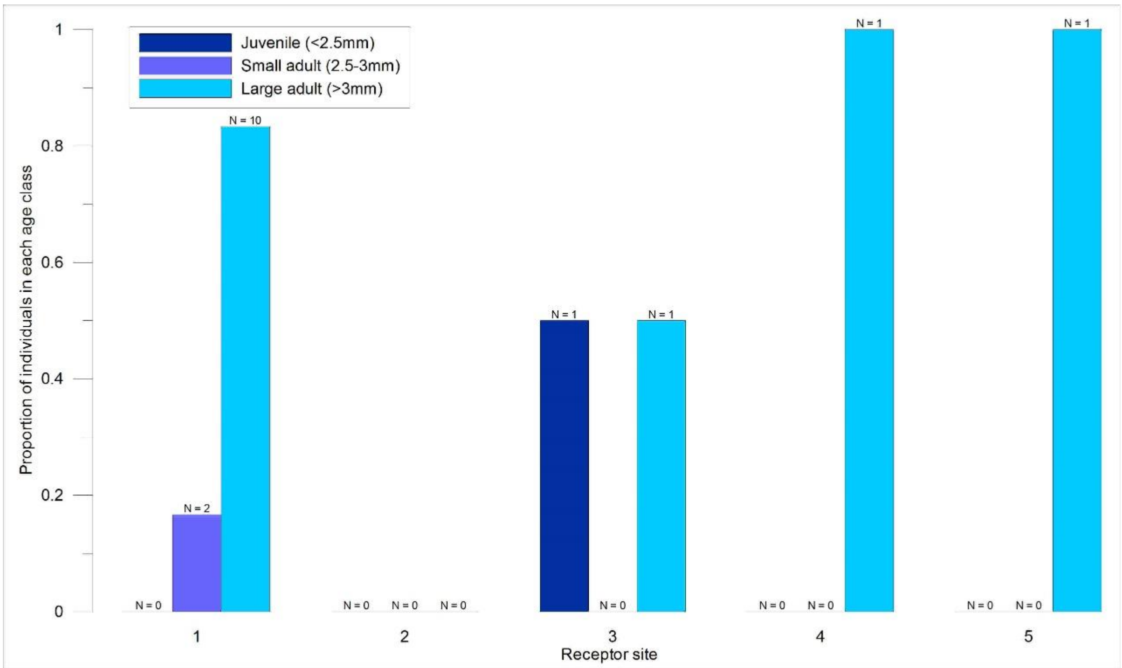

Figure 8. Age class of living *Anisus vorticulus* observed at each receptor site at [redacted] in October 2017. Shading indicates the number of individuals in different age classes.

3.3 Survivorship of translocated *Anisus vorticulus* to [redacted] in October/November 2017

In October 2017, a re-survey of the June 2017 Translocation 2017 receptor sites at [redacted] was carried out. No *Anisus vorticulus* were found during the October monitoring visit.

Even though no *Anisus vorticulus* were found during the re-survey the site was still considered suitable to support this species and possible reasons for absence during the survey are discussed in Section 4.

3.4 Re-survey of *Anisus vorticulus* donor sites in June and October/November 2017

A re-survey of the three donor sites (four samples from two ditches at [redacted], and two samples from one ditch at [redacted]) was undertaken in June and October/November 2017, to determine age class and population size. This survey showed that there was still a high density of *Anisus vorticulus* within each of the donor ditches. Over 100 *Anisus vorticulus* were found in individual samples within Donor ditch 1. This showed that there has been no discernable effect on the populations following the removal of *Anisus vorticulus* for the translocations. All other samples taken indicate that there were still strong populations at each site.

Although June surveys found only very low numbers in the ditches at [redacted] (the site of Donor 4 samples), surveys in October /November and translocation sample collection showed much higher numbers – over 100 snails in each sweep.

3.5 Colonisation of wider ditch areas

3.5.1 June 2017

As part of the monitoring survey of [redacted] receptor sites, samples were taken one metre either side of the original translocation release points. This showed that *Anisus vorticulus* was dispersing from the initial sites with animals being found at each of these samples over the two visits. Evidence for dispersal was found six months post-translocation within the [redacted] receptor sites, as *Anisus vorticulus* were found in the 1m^2 areas immediately adjacent to the original translocation points (AECOM/Abrehart Ecology 2018b).

However, it was not possible to determine whether this had continued 12 months post-translocation, due to the very low number of individuals found during the survey. No animals were found in any of the intermediate sample points.

3.5.2 October/November 2017

As part of the monitoring survey of [redacted] receptor sites, samples were taken one metre either side of the pilot translocation release points. This showed that *Anisus vorticulus* was dispersing from the initial sites with animals being found at each of these samples over the three visits (6, 12 and 18 months post Pilot Translocation). Following this, a further assessment of dispersal along the ditch was undertaken. During the monitoring, samples were taken at a mid-point between the or pilot translocation points; two samples were taken at each mid-point and any *Anisus vorticulus* were picked out of the sample and photographed for later age-classification.

In the ditch running north-south (locations 1, 3, 5 and 7) none were found in the mid points.

Four of the six sub-samples in the ditch running east-west (locations 2, 4, 6 and 8) held a low number of *Anisus vorticulus*, with a maximum of three found in a sub-sample.

Results showed that in the wider ditches (2-2.5m wide) with less dense surface vegetation there was more movement of snails within the water channel. In the north-south ditch there was less potential for movement as it was more heavily choked with vegetation and narrower (1.5 – 2m wide).

This wider colonisation after only 18 months indicates that there may be a much larger population within the receptor sites, than recorded.

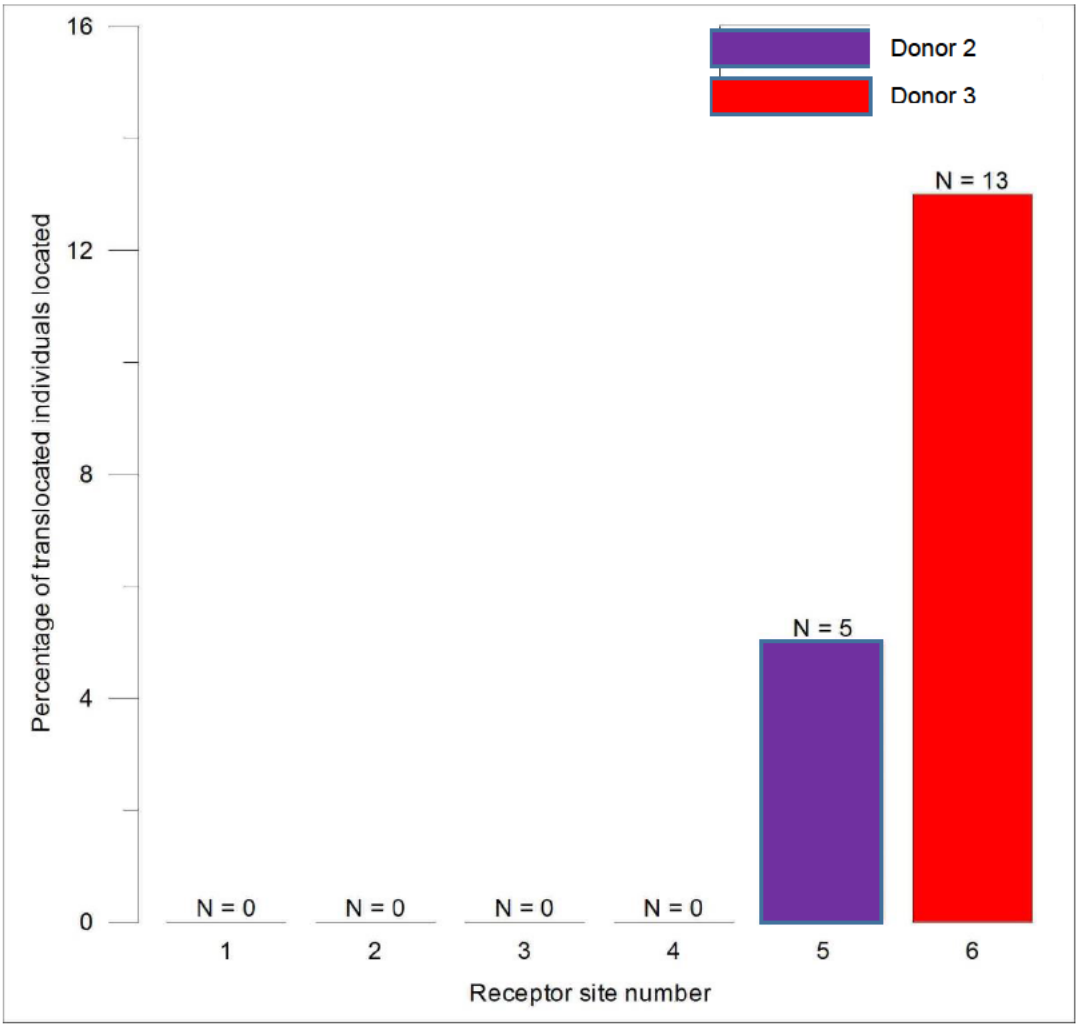

Figure 9. Frequency of living *Anisus vorticulus* observed at each mid-point between each receptor site

4 Discussion

4.1 2017 Monitoring results

The Pilot Translocation sites at [redacted] were re-surveyed, as part of the monitoring indicating that the effects of removing animals from Acle had no discernible effect on the donor populations. It also showed that there was a continuing presence in all the receptor sites at [redacted] i.e. sites to which *Anisus vorticulus* that had been moved.

The receptor sites at [redacted] and donor site at [redacted] were surveyed following Translocations 2017 (June 2017) and prior to introduction of snails during Translocation 2017 (October/November 2017). The results of these are discussed below:

Following the Translocation 2017 of 1,000 snails in June 2017 (500 to [redacted] and 500 to [redacted] samples were taken at the release points (to study establishment) and 1m adjacent to end points (to assess if snails had dispersed along the bank/channel). These samples were taken prior to the introduction of more snails in October/November 2017, Translocation 2017 (Oct/Nov), to ensure the ditches were still appropriate receptor sites. A single sweep was taken at each location as first described in AECOM/Abrehart Ecology 2016a. As previously discussed, this reduced size sweep had shown to collect *Anisus vorticulus* at sites in Norfolk and Suffolk, but it may not always pick up very low numbers of *Anisus vorticulus*. This reduced sweep effort was important so as not to disturb any developing populations.

Results demonstrated that there was a continued presence of *Anisus vorticulus* at [redacted] with 16 animals found in three samples, with a maximum of 12 found at Sample Point 1 (Figure 7). These were mainly young and large adults with an average size of 3.1mm; the average size of those translocated in June was also 3.1mm. A juvenile snail was identified within the samples, indicating that there has been breeding on the site - though limited at this time, and may be a stress reaction. At the time of the monitoring survey in October 2017 there had been a considerable reduction in the vegetation within the channel, so the reduced sweeps were taken on the edge of the sample sites. This may account for the lower numbers recorded.

[redacted]:

Following initially promising results regarding the success of translocated *Anisus vorticulus* populations within the [redacted] systems (as described in AECOM/Abrehart Ecology 2016c) after the Pilot Translocation, the June 2017 re-survey of the new populations shed doubt on their long-term viability. *Anisus vorticulus* were found alive at less than half of the receptor sites, and only in very low numbers, when present. This appeared to suggest that, after initially persisting, the populations went into decline. However, the October/November 2017 monitoring survey showed that the numbers of *Anisus vorticulus* were still present and in good numbers at 16 of the 32 sample points. In addition, *Anisus vorticulus* was found at several of the mid-points on the southern ditch. There are several potential explanations for the observed trends, which are discussed below.

[redacted]:

The first monitoring survey of [redacted] was carried out in October 2017, this showed that there was still a low density of *Anisus vorticulus* surviving in three of the five receptor sites. The snails were present in low (1) to moderate (11) numbers in three of the seven sample points, demonstrating that the site has some suitability to support the species. Furthermore, at the time of the survey there had been a considerable reduction in the vegetation within the waterbody, so the small reduced sweeps were taken on the edge of the sample sites, potentially accounting for the lower numbers recorded. The average size of those found in the re-survey were 3.1mm, which was the average size of those originally released within the ditch in June 2017. In the six months between the translocation and the re-survey it is assumed the younger *Anisus vorticulus* have grown and the older *Anisus vorticulus* had died, with no indication of breeding at this time; an the absence of juvenile *Anisus vorticulus* size class.

[redacted]:

The first monitoring survey of [redacted] was undertaken in October 2017, no *Anisus vorticulus* were found. The habitat had not changed significantly (from surveys conducted in early summer) and as such the site is still considered suitable to support *Anisus vorticulus*. It was an early succession ditch and may need a couple of years before it becomes optimal. The margins of the ditch were heavily poached giving wide late marginal habitat, which may be where *Anisus vorticulus* was residing.

[redacted]

Monitoring conducted in June 2017 found limited numbers of *Anisus vorticulus* within the proposed donor ditch, therefore translocation effort was postponed until autumn 2017. Surveys in October/November 2017 found high population densities and so 1,500 animals were collected and translocated to [redacted]. Furthermore, this ditch was to be cleared in the winter of 2017/8 and as such it was considered important to collect as many of the *Anisus vorticulus* as possible before this event occurred.

4.1.1 *Anisus vorticulus* population and habitat changes

Seasonality

The abundance of *Anisus vorticulus* and the age profile in populations can vary considerably from month to month within the same ditch. Studies in a small number of populations have observed that the number of large adults drops sharply in June-July, followed by an increase in the number of juveniles present from August-October; although precise timings may vary between populations and depending on environmental conditions such as temperature (Willing & Killeen 1998; Willing 1999; Killeen 1999; Glöer & Groh 2007). The variation can be so pronounced that, even for strong populations, sampling at the wrong time of the season can fail to find any *Anisus vorticulus* (Willing & Killeen 1998). These surveys were only carried out over a limited portion of the year (six months) and full monthly assessment would be advantageous to determine a full picture of the seasonal variability.

In the case of the work reported here, the slight delay in fieldwork from May to June may have resulted in sampling being attempted during this “trough” period i.e. once large adults have died off post-breeding, but before juveniles are large enough to be detected using net sampling. This effect may have been enhanced by very warm weather in the weeks leading up to fieldwork, as *Anisus vorticulus* are thought to grow and develop more quickly in warmer conditions (Killeen 1999) – a combined effect of earlier maturation of *Anisus vorticulus*, combined with slightly later sampling, may have resulted in the optimal survey window being missed. The low numbers found could therefore be a simple artefact of sub-optimal sampling time, rather than reflecting a true decline in the populations.

It should be noted that reasonable numbers of *Anisus vorticulus* were still found in one of the original donor ditches (Donor 2, Figure 2), but seasonal monitoring of populations at other sites has suggested that population dynamics are not always synchronized between different ditches or populations (Killeen 1999, reviewed in Terrier 2006).

The November 2017 monitoring survey once again showed a high number of *Anisus vorticulus* across all the sites with a high proportion of those found being juveniles. This indicates that the seasonal variability is an important factor in the survey period for this species and thus when survey should be conducted in order to assess the presence/ likely absence of this species at a potential development site.

Inter-annual variability

Although the population levels in the donor ditches seemed consistent with previous surveys at [redacted] there also appeared to be reduced numbers at some of the potential donor sites that were monitored for the Translocation 2017. Assuming that the observed levels are not the result of seasonal variability in population numbers (particularly following potential over-winter juvenile mortality and post-breeding adult mortality), the differences may reflect natural annual variability in population numbers – 2017 may simply have been a “bad year” for the species, resulting in lower than expected numbers of *Anisus vorticulus* during surveys. There is little data available regarding the inter-annual fluctuation of absolute numbers of *Anisus vorticulus* within sites, and such information would be useful to know when planning conservation translocations. For example, knowing the extent to which population levels can vary could help to determine what level of buffering is needed in terms of numbers to allow a population to persist in the longer term.

Insufficient population size

It is likely that the population had not truly declined over the twelve-month period since the Pilot Translocation was conducted, as there was a large number of *Anisus vorticulus* recorded in the October 2017 monitoring survey across two sites ([redacted]). At present, it appears that the sample numbers placed at each location (50 per sub sample) was sufficient to produce a viable population - following the latest re-survey results.

Future re-surveys will show continued trends across the sample sites.

Abiotic variables

It has been noted that *Anisus vorticulus* builds up numbers very quickly under optimal conditions but does not thrive under sub-optimal conditions (Glöer & Groh 2007). It may therefore be the case that the environment in the receptor ditches are not fully appropriate to support a long-term population of *Anisus vorticulus*.

For the initial Pilot Translocation, receptor sites were chosen based on a multivariate analysis of the vegetation and mollusc communities present (see AECOM/Abrehart Ecology 2016a, 2016b, 2016c), which indicated a strong association of *Anisus vorticulus* with certain groups of plants and other mollusc species.

Some preliminary tests of abiotic factors were conducted during the initial analysis, including neighbouring land use and ditch profile, but water chemistry was not initially considered as it was believed that variations in plant communities would reflect the underlying abiotic variables. However, samples were collected for water chemistry analysis during the summer of 2016. Subsequent analysis of the data indicates that water chemistry is an important factor to consider in relation to *Anisus vorticulus* going forward. For example, a strong inverse correlation was found between the presence/absence and abundance of *Anisus vorticulus* and calcium concentrations (one-way ANOVA: $F_{1,41}=10.16$, $p<0.005$), in agreement with the findings of Watson & Ormerod (2004). There is also a suggestion of a strong correlation of the presence/absence of *Anisus vorticulus* with levels of total organic carbon (one-way ANOVA: $F_{1,41}=10.57$, $p<0.005$). While a relationship with calcium concentration is most likely to be a product of underlying geology and hydrology, the latter may relate to factors such as ditch clearance frequency and adjacent land use. It was also noted that the receptor locations appear to be located in areas of sub-optimal levels for these two variables. This may have contributed to the apparent lack of success of the newly established populations over a longer time period.

5 Future Work

The relatively poor understanding of the requirements of *Anisus vorticulus* as a species make it difficult to determine the precise reason (or reasons) for the declines and increases observed, and more research is needed to shed light on the problem. A further translocation of *Anisus vorticulus* was carried out in October/November 2017 - however, additional information is required to better inform the selection of suitable receptor sites and the optimal timings for translocation and monitoring in the future.

Given the conclusions from previous continuous monitoring surveys of *Anisus vorticulus* populations (Willing 1998, Killeen 1999, Willing & Killeen 1999), it is possible that the very low number of individuals found during the June 2017 fieldwork reported here are the result of seasonal variation. Monitoring at six-monthly intervals will continue as per terms of translocation licence, but more regular (monthly) monitoring of a subset of ditches (at [redacted], and another reference site) will give a clearer indication of the annual population dynamics of the study populations. This will then help to inform the optimal times for translocations to take place. This will also shed light on whether the lack of snails reported here is due to simple seasonal variation, inter-annual population fluctuations, or a longer-term negative trend. The variability of the species in terms of population fluctuation and consistency of breeding times (as illustrated in the review by Terrier et al. 2006) make it difficult to generalise across populations without substantially more information.

Further insights into the role of water chemistry on the distribution of *Anisus vorticulus* are also needed. In addition to the strong relationships observed between calcium and total organic carbon and the presence/absence of *Anisus vorticulus* at [redacted], studies on other populations in the UK have indicated that water chemistry plays an important role in site suitability (e.g. Watson & Ormerod 2004). Assessment of the levels of these and other chemical components may therefore provide vital information as to the potential suitability of sites as receptor locations for future translocation, as closer matches could be made between environmental conditions. By taking water samples at all sites surveyed to date, levels of different chemical components (such as calcium, nitrates, and phosphates) could be assessed in relation to the presence/absence of *Anisus vorticulus* identified during detailed surveys in 2016-2017. This would give a better indication as to whether relationships with certain chemicals are consistent across a wider area and may indicate much better suitability for the species at some sites than others - this could streamline the selection process for choosing future receptor sites. Sampling water from multiple ditches may also indicate certain portions of different sites that are more or less suitable. For example, when mapped out the data from [redacted] showed variability at a fine scale within the site, resulting in some ditches being occupied by *Anisus vorticulus* while other remained vacant, despite apparently suitable vegetation communities.

At present, there is insufficient information available to fully interpret the data obtained, but many potential explanations for the observed results. Further research is needed to understand the biology and population dynamics of *Anisus vorticulus* in the study area, so that future monitoring and translocation work can be planned more effectively. Without this information, designing an informed mitigation strategy for *Anisus vorticulus* will not be possible.

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7 References

This report to be cited as: AECOM/Abrehart Ecology, 2017. Translocation of the little whirlpool ramshorn snail – Monitoring Update 2017. Report to Highways England.

AECOM.,2015a. Feasibility study on the translocation of the little whirlpool ramshorn snail. Report to Highways England.

AECOM, 2015b. Translocation of the little whirlpool ramshorn snail – scoping survey. Report to Highways England.

AECOM/Abrehart Ecology, 2015c. Translocation of the little whirlpool ramshorn snail – detailed surveys. Report to Highways England.

AECOM/Abrehart Ecology, 2016a. Translocation of the little whirlpool ramshorn snail – pilot translocation 2016. Report to Highways England.

AECOM/Abrehart Ecology, 2016b. Translocation of the little whirlpool ramshorn snail: multi-variate community analysis 2016. Report to Highways England.

AECOM/Abrehart Ecology 2016c. Translocation of the little whirlpool ramshorn snail: Initial update 2016. Report to Highways England.

AECOM/Abrehart Ecology 2017a. Translocation of the little whirlpool ramshorn snail: Scoping survey 2016. Report to Highways England.

AECOM/Abrehart Ecology 2017b. Translocation of the little whirlpool Ramshorn snail: Detailed surveys 2016/2017. Report to Highways England.

AECOM/Abrehart Ecology 2018a. Scoping and detailed site surveys 2017 to identify Translocation 2018 sites of the little whirlpool Ramshorn snail: Report to Highways England.

AECOM/Abrehart Ecology 2018b. Translocation Update of the little whirlpool Ramshorn snail: Report to Highways England.

English Nature, 2000. Norfolk Biodiversity Action Plan Little Whirlpool Ram's-horn Snail (*Anisus vorticulus*), Available at: http://www.norfolkbiodiversity.org/actionplans/speciesactionplans/littlewhirlpoolsnail.aspx. (updated 2012).

Glöer, P. & Groh, K., 2007. A contribution to the biology and ecology of the threatened species *Anisus vorticulus* (Troschel, 1834) (Gastropoda : Pulmonata : Planorbidae). *Mollusca*, 25(1), pp.33–40.

IUCN/SSC, 2013. Guidelines for Reintroductions and Other Conservation Translocations, Gland, Switzerland.

Joint Nature Conservation Committee. 2007. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough, UK.

Killeen, I.J., 1999. The freshwater snail *Anisus vorticulus*: 1998 monitoring survey of ditches in East Anglia. *English Nature Research Reports,* No. 311.

Myzyk, S., 2008. Life cycle of *Anisus vorticulus* (Troschel, 1834) (Gastropoda: pulmonata: planorbidae) in the laboratory. *Folia Malacologica* 16.4.

Niggebrugge, K. et al., 2007. Applying landscape ecology to conservation biology: spatially explicit analysis reveals dispersal limits on threatened wetland gastropods. *Biological Conservation* 139.3 (2007): 286-296.

Rasband, W.S., 1997-2016, ImageJ, U. S. National Institutes of Health, Bethesda, Maryland, USA, http://imagej.nih.gov/ij/

Terrier, A. et al., 2006. Species account for *Anisus vorticulus* (Troschel, 1834)(Gastropoda: Planorbidae), a species listed in Annexes II and IV of the Habitats Directive. *Journal of Conchology* 39 (2), pp. 193-206.

Van Damme, D. 2012. *Anisus vorticulus*. The IUCN Rd List of Threatened Species 2012: e.T155966A738056. http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T155966A738056.en. Downloaded on 20 October 2015.

Watson, A.M. & Ormerod, S.J. 2004. The distribution of three uncommon freshwater gastropods in the drainage ditches of British grazing marshes. *Biological Conservation* 118, pp. 455-466.

Willing, M.J. & Killeen, I.J., 1998. The freshwater snail *Anisus vorticulus* in ditches in Norfolk and West Sussex. *English Nature Research Reports,* No. 287.

Willing, M.J., 1998Monitoring populations of *Anisus vorticulus* (the little whirlpool Ramshorn snail) in West Sussex. *English Nature Research Reports*, No. 229.

Appendix A - Licences