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RESEARCH ARTICLE

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Persistence of a population of palmate newts *Lissotriton helveticus* in a saline environment on the west coast of Scotland

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ABSTRACT - A six year survey of a palmate newt (*Lissotriton helveticus*) population in rock pools on the west coast of Scotland indicates that this species has some tolerance of saline conditions. The newts were living with a mean salinity (conductivity) of 382 ppm (range 30.7 ppm to >4995 ppm). Other interesting observations include a variation in mating behaviour, in which normal open water behaviour is confined to crevices, and the occurrence of 'pelvic bumps' in some individuals that may indicate reduced body condition.

INTRODUCTION

Amphibians are at a significant disadvantage in saline environments as their highly permeable skin and eggs make them sensitive to water loss by osmosis. Nevertheless, 144 species of amphibian have been recorded in saline habitats worldwide (Hopkins & Brodie, 2015). Of those 144 species only 24 passed all their life history stages in saline waters; *Lissotriton helveticus* does not appear in this group. It is best known as an opportunistic inhabitant of neutral to weakly acidic waterbodies in northern Europe. There are a limited number of observations of other newt species in coastal environments, notably the smooth newt (*Lissotriton vulgaris*) in sand dunes in northern England (Hardy, 1943) and in a range of habitats on the coast of Croatia (Popovic & Veletanlic, 2018). However, the only record of *L. helveticus* in a saline environment is from Smith (1951) who associated the species with coastal brackish pools.

The present study was initiated following casual observations in the West Highlands of Scotland by Deichsel and Bennon (pers com.). On 25th August 2010, Deichsel observed both adult and larval *L. helveticus* in a supra-tidal pool by Loch Linnhe (56° 48' 59.33" N: 5° 06' 43.49" W), while on 15th September 2010, Bennon recorded adult newts in a pool one metre above the High-Water Spring tide mark at Kirton Bay near Lochalsh (57° 16' 17.1775" N: 5° 35' 39.2322" W). Such single observations raise many questions concerning inter-annual and intra-annual variability of a population in a habitat generally considered marginal for *L. helveticus*. These populations were still present when the sites were visited in July 2011 prompting a roughly monthly sampling survey for six years at the Lochalsh site.

MATERIALS AND METHODS

Survey site

The survey site was a complex of pools on a rocky platform of Torridonian sandstone. It sits one metre above the mean High Water Spring tide mark on Kirkton Bay, Lochalsh, West Highlands. The platform is backed by cliffs rising to 50 m above sea level and faces the Kylerhea narrows, Loch Alsh (Fig. 1). The surveyed pools ranged in surface area from 0.5 m^2 to 3 m^2 with depths of 0.25 m to 0.5 m; both surface area and depth varied greatly throughout the year. During the hot dry summer of June 2012 the pools were reduced to a few centimetres in depth. After high tides with storms and heavy rainfall the pools were overflowing and ran into each other.

Figure 1. The survey site showing the complex of rock pools on a Torridonian sandstone platform at Kirkton Bay

Newt population survey

The site was surveyed from 26th February 2012 to the 21st October 2017 with one visit each month, weather permitting. On the first survey every pool on the rocky platform was surveyed for *L. helveticus* activity. Those pools with adults or larvae received an identification number painted on a marker beside the pool and each pool was geolocated. On each survey the pools were watched for any signs of life: swimming adults or movements beneath rocks or within crevices. Notes were made on water clarity, vegetation growth (mostly filamentous green algae), presence or absence of any decaying seaweed (post extreme high tide and storm events), breeding and egg laying behaviour.

After observation, the pools were sampled with a pond net with fives sweeps and the contents of each netting placed in white trays with pool water. After the final netting, the trays were inspected, and the number of larvae and adults recorded. Larval data included the length and stage of growth in terms of number of legs and the presence or absence of external gills. Adult sex and body length were recorded, plus breeding condition and any obvious injury. Adult body length was measured in the surveys of 2015 and 2016 using a wide bore glass tube with a millimetre scale printed onto it. The glass tube method for measurement provides greater accuracy than a ruler and is faster so resulting in less stress to the newts. The tail filament of the adult male was not included in recording body length. Adults and larvae were returned to their pool immediately after assessment. Over time, the number of pools on the platform containing newts increased. In the first years, six pools were surveyed which had been observed to contain newts, over the years of surveying more pools were observed to have gained newts and by the time the surveys concluded an additional seven pools had adults and larvae being recorded on a regular basis.

Salinity and temperature measurements

To gauge variations of salinity and temperature over time and between pools, the conductivity and temperature of pools was measured using a HM Digital Combo Meter Com-100 multimeter. For conductivity measurements the multimeter was set for microsiemens with readings autocorrected to 25 °C and to salinity on the ppm500 (NaCl) scale (where conductivity reading is multiplied by 500 to give a guide as to the NaCl concentration). This is an approximation as true salinity can only be determined by chemical analysis. The multimeter could not record above 4995 ppm and any results above this were recorded as out of range of the meter. On the ppm500 scale, sea water is typically 27,000 ppm and drinking water less than 50 ppm. It should be noted that different salts will give different conductivities. Pools may contain dissolved salts from the surrounding rock and soil other than NaCl, but these are not necessarily taken into account when the multimeter is set on the ppm500 scale. From 2015 to 2017, 267 recordings of both temperatures and conductivity were made of 11 rock pools.

Water temperatures peaked in June, July and August, with a maximum of 25 °C recorded in July 2017. The lowest water temperature recorded was 5 °C below the surface in February 2016, when all the pools had full or partial surface ice.

RESULTS

Newt population survey

The results are based on those months when pools were accessible; accessibility was limited especially in some winter months. Adults are found in greatest number between April and June (Fig. 2) although a small number of individuals were found occasionally throughout the year. Larvae were encountered in small numbers primarily from May increasing in abundance to July and then slowly declining in abundance towards the end of the year (Fig. 2). In 2015, conditions permitted a survey in December and a small population of larvae was recorded (Fig. 2). In 2016, when surveying was possible in January, again a small population of larvae was found (Fig. 2). In the first year of surveying, six pools were observed to have *L. helveticus*, over six years four further pools were observed to have *L. helveticus* and included in the survey.

Body length measurements were made in 2015 and 2016 and the mean (± standard deviation) of males (n=67) was 70.3 ± 0.6 mm and females (n = 72) was 75.69 ± 0.67 mm. The majority of larvae recorded in October and later surveys possessed four legs and external gills, with a minority in the earlier metamorphic stage of two legs and external gills.

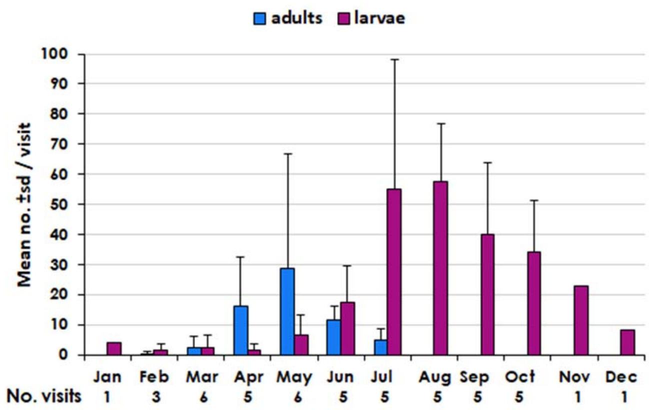

Figure 2. Mean (±sd) monthly catch of adults and larvae of *Lissotriton helveticus*, 2012 to 2017

Adults were observed with evidence of having survived an attack by a predator with partial limbs or missing parts of their tails. Adults were also found dead (9 on the 15th April 2012 and 1 on the 21st April 2014). Some adults were observed with a pair of raised white bumps, one on either side of the pelvis (Fig. 3). These were not obviously wounds or the blistered lesions typical of Amphibiocystidium infection that are distributed randomly over the body. In every other respect the affected individuals appeared healthy, with no discoloration anywhere else on their body or languor. The first observation of pelvic bumps was made 22nd May 2016 on a warm and dry day with an air temperature of 19.2˚ C. Out of ten pools sweep netted, six pools each had one adult newt with pelvic bumps, so that six newts (one male and five females) were affected from a total capture of 71 adults. The salinity of the six pools ranged from 81 ppm to 273 ppm. There were no further records of adults with pelvic bumps in any of the subsequent monthly surveys. However, in a separate rock pool survey beside the Coral Beach, Plockton (57° 20’ 11” N: 5° 41’ 04” W) on 25th June 2016, a single male was captured that exhibited exactly the same pattern, shape and form of pelvic bumps. There had been heavy rain the day before, but the pool was much reduced in size and had obviously dried out in the period of hot dry weather of the month before. The pool had a salinity of 1,100 ppm and the air temperature was 26.3˚ C. The pool had been surveyed on the 19th May 2016 where 12 larvae and 6 adults had been netted, at a pool salinity of 1070 ppm and an air temperature

Figure 3. Adult female *Lissotriton helveticus* with two white bumps (arrows) in the pelvic region

of 19.0˚ C with no individual showing pelvic bumps. The symmetrical position of the pelvic bumps suggests that they are most likely to be part of the bone structures of the hip (the ileum). This would be indicative of reduced body condition resulting from lowered food supply and/or stress from the effects of excessive salinity.

Newt behaviour

Males arrived at the site before females and could be observed even when the pools still had surface ice. Observations of *L. helveticus* mating behaviour were made on the 21st April 2014 mid-afternoon in full sunshine; the males occupied a rock crevice on the side of the pool. They stayed by the crevice opening and when a female approached, they actively tail fanned towards her, sometimes leaving the opening to U-turn with a tail fan and go back to the entrance of their crevice. Females entered the crevice and the pair disappeared from view so that the final act of the courtship sequence and spermatophore transfer were not visible. This behaviour shows some differences from what is perceived as normal for adult palmate newts where the male initiates a courtship sequence by pursuing a female and uses a combination of tail fanning, waves and whips, followed by a series of movements by the male and female on the pool bottom and where mating is more prevalent at night (Halliday, 1977).

Females were commonly seen wrapping eggs in decaying vegetation that had fallen into the pools. They left these folded packages on the floor of rock pools. Other females were seen to lay their eggs in sediments at the bottom of pools. Newt eggs were found in the sediments recovered during netting.

Salinity measurements

From 2015 to 2017, at Kirkton Bay the salinity ranged between 30.7 ppm to greater than 4995 ppm (i.e. exceeding the scale reading of the multimeter) with an average of 382 ppm (not including any out of range meter readings). Five percent of pools had salinities that were out of the multimeter range, one such pool had a larval record, and 47.2 % of the pools within the range of 555 ppm to 3050 ppm had adults and/or larvae present. Salinity varied over the year with the potential for it to vary considerably according to the weather and tides. Salinities increased during periods of drought or extreme high tides. The survey shows that the larval and adult populations survived fluctuating salinity, but extremes of salinity over 500 ppm occurred only rarely (Fig. 4).

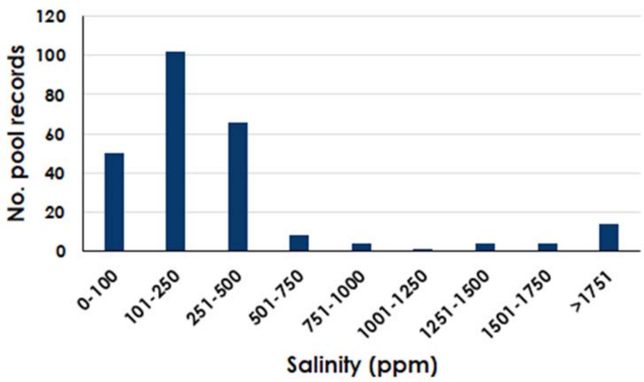

Figure 4. Frequency distribution of salinity ranges (derived from conductivity measurements) of Kirkton pools, 2015 to 2017

DISCUSSION

Over six years of surveying the rock pools at Kirkton Bay, it was observed that adult *L. helveticus* regularly visit the pools during the spring and that a larval population was observed to be present throughout each year of the study, peaking in the summer months. This suggests that *L. helveticus* have a persistent breeding population in this location.

The mating behaviour observed shows certain differences from the recognised courtship sequences for newts of the genus *Triturus* (Halliday, 1977; Arntzen & Sparreboom, 1989). Specifically, males occupied crevices in the rock pool sides and positioned themselves to look out into open water and tail fanned towards females. Females would then enter the rock crevice of the male of her choice, where the pair would disappear from view and any further mating behaviour and the act of spermatophore transfer could not be observed. These differences in behaviour may be related to the extremes of the physical conditions on site, but predation may also be a factor. The predators observed included otters and dragonfly nymphs that were seen in increasing numbers over the six years of surveying. The adult newts were possibly using the crevices as refuges from them. Nevertheless, there were adult newts with the signs of predator attack such as missing limbs and sections of tail. The presence of dragonfly nymphs in increasing numbers in these pools also questions their tolerance of salinity and how this may impact *L. helveticus* in this habitat. A low number of predators may be of vital advantage to a species with vulnerable small larvae (Beebee, 1992) and many of the predators of amphibian larvae are not found in the Kirkton Bay pools. Irregular seawater inundation prevents the establishment of most freshwater or marine species, invertebrate species diversity is minimal and macrophytes are mostly absent (Nicol, 1935). The crustacean

Gammarus duebeni was common in 7 out of the 11 pools; it is a species well known for its exceptional wide-ranging tolerance of salinity (Sutcliffe, 2000).

In terms of possible physical environmental stress, the multimeter showed a wide and fluctuating salinity in the pools, especially in the shallower rock pools. Pool salinity changes appeared to follow changes in weather conditions, storms and hot weather producing a rise in salinity and heavy rain lowering the salinity. In this fluctuating environment it was observed that a pool of high salinity that had no larval record one month could have larval records the next. Indicating larvae may escape exposure to higher salinities, possibly by physically moving into pockets of less saline water in the cracks and crevices of the rock pools. This migration would be worthy of further study.

Amphibians are particularly vulnerable to osmotic stress of saline conditions at all their life stages. Nevertheless, it is on record that the Lancashire coastal dune slacks have long been inhabited by the smooth newt (*Lissotriton vulgaris*), common frog (*Rana temporaria*), common toad (*Bufo bufo*), and the natterjack toad (*Epidalea calamita*) (Hardy, 1943). Furthermore, the closely related *L. vulgaris* is known to be tolerant of brackish waters as an adult (Speybroeck et al., 2016; Popovic & Veletanlic, 2018). *Lissotriton vulgaris* and *L. helveticus* overlap in range and although *L. helveticus* is more tolerant of acidic conditions it does share many habitat preferences with *L. vulgaris* (Cooke & Fraser, 1975). Neil (1958) inferred that salt tolerance may be widespread in amphibian species and Balinsky (1981) identified 61 species in 13 families of anurans and 12 species in four families of urodeles that inhabit or tolerate a moderately saline environment. *Epidalea calamita* on the North Solway coast salt marshes successfully bred within pools of 0.22 % to 14 % seawater that were not subject to seawater inundation (Beebee et al., 1992). It seems probable that palmate newts exhibit a similar range of tolerance although the observation of occasional individuals with pelvic bumps may indicate that this environment is not always conducive to good body condition.

When the weather and safe access did allow for winter surveys, larvae were found in the pools that had some vegetation growth or were more sheltered from high storm surge tides. This strongly suggests that larvae can survive in these pools in winter. It is known that larvae complete their metamorphosis by the end of summer, but it is also known that in years when environmental conditions are harsh, larvae experience a reduced growth rate (Speybroeck et al., 2016). Therefore, larvae can survive a slow growth rate by overwintering and resuming growth to adulthood when conditions allow in spring. The data shows larval numbers fall from July onwards, this is presumed to be due to predation and juveniles leaving the pools after metamorphosis. *Lissotriton helveticus* in this location appear capable of surviving in an environment that has varying salinity and is highly exposed to extremes of weather conditions. Their survival may be due to both physiological and/or behavioural adaptations although it is unknown whether these populations are specifically adapted to the harsh conditions on the coast. Interestingly, the adult body length data shows that males and females of this site achieve average body lengths greater than those found in the Weald of Kent in both heathland and non-heathland pools (Beebee, 1983). Adults in the Kirkton Bay pools appear to tolerate a relatively extreme coastal breeding site with no sacrifice in body length. However, 50 to 80 m above the survey site there is moorland with small freshwater bog pools and it is unknown what influence these may have on the wellbeing of the rock pool population. It would be useful to investigate whether there are movements of adult newts between the rock pools and bog pools and if so what benefits this may confer.

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REFERENCES

Arntzen, J.W. & Sparreboom, M. (1989). A phylogeny for the Old World newts, genus *Triturus*: biochemical and behavioural data. *Journal of Zoology* 219: 645-664.

Balinsky, J.B. (1981). Adaptations of nitrogen metabolism to hyperosmotic environment in Amphibia. *Journal of Experimental Zoology* 215: 335-350.

Beebee, T.J.C. (1983). Habitat selection by amphibians land-transect in Britain. *Biological Conservation* 27: 111-124

Beebee, T.J.C. (1992). Characteristics of Natterjack toad (*Bufo calamita*) breeding sites on a Scottish saltmarsh. *Herpetological Journal* 3: 68-69

Cooke, A.S. & Frazer, J.F.D. (1975). Characteristics of newt breeding sites. *Journal of Zoology* 178: 223-236.

Halliday, T.R. (1977). The courtship of European newts: an evolutionary perspective. In *The Reproductive Biology of Amphibians*, pp. 185-232. Taylor, D.H. & Guttmann, S.I. (Eds). New York: Plenum Press.

Hardy, E. (1943). Newt larvae in brackish water. *Nature* 151: 226.

Hopkins, G.R. & Brodie, E.D. (2015). Occurrence of amphibians in saline habitats: A review and evolutionary perspective. *Herpetological Monographs* 29:1-27.

Neill, W.T. (1958). The occurrence of amphibians and reptiles in saltwater areas, and a bibliography. *Bulletin of Marine Science of the Gulf and Caribbean* 8: 1–97

Nicol, E.A.T. (1935). The ecology of a salt-marsh. *Journal of the Marine Biological Association of the United Kingdom* 20: 203-261

Popovic, N. & Veletanlic, V. (2018). Initial study on the presence of the smooth newt (*Lissotriton vulgaris*) in ponds on the island of Krk, Croatia. 8th European Pond

Conservation Network Workshop (Poster). https://www.bib.irb.hr/980458?rad=980458 (accessed December 2020)

Smith, M. (1951). *British Amphibians and Reptiles*. Collins New Naturalist No. 22, 318 pp.

Speybroeck, J., Beukema, W., Bok, B. & van der Voort, J. (2016). *Field Guide to the Reptiles and Amphibians of Britain and Europe*. Bloomsbury Publishing, London, UK, 432 pp.

Sutcliffe, D. (2000). Subspecies, morphs and clines in the amphipod *Gammarus duebeni* from fresh and saline waters. *Freshwater Forum* 13: 60-75.

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