Short Note

Capture of smooth newts (*Lissotriton vulgaris*) and great crested newts (*Triturus cristatus*) correlates with the lunar cycle

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This study examined the hypothesis that numbers of newts captured were correlated with the phase of the moon. During the spring of 2008 smooth newts and great crested newts were captured in bottle traps laid in two ponds at Riseholme Park, University of Lincoln, UK. Highest rates of capture for smooth newts were either side of the new moon but for great crested newts the highest rate was immediately before the new moon. Identification of individuals showed that during the observation period smooth newts regularly moved between aquatic and terrestrial habitats, but great crested newts appeared to leave ponds and did not return. This is the first report that numbers of newts captured are affected by the lunar cycle. Activity during the darkest nights may limit the risk of predation as individuals leave breeding ponds to forage on land or to move between ponds. These results have implications for surveys of newt breeding sites because lack of individual identification and trapping events at the wrong time of the month can both seriously undermine estimates of population sizes.

Key words: activity, bottle trapping, phase of the moon, predation, surveys

Monitoring of amphibian populations is becoming increasingly important but long-term studies of individual populations show that the numbers of animals caught are not necessarily constant over time. For example, in the United Kingdom the number of smooth newts (*Lissotriton vulgaris*) caught in pitfall traps varied from week to week (Harrison et al., 1983; Verrell & Halliday, 1985). The reasons for this are unclear but environmental conditions, such as prevailing weather, will be important. Deeming (2009) reported for a population of smooth newts that the median time between recaptures of individuals was 27 days, which approximates to the length of the lunar cycle. The phase of the moon has been shown to determine the activity patterns of a salamander (Ralph, 1957) and so perhaps the numbers of smooth newts caught reflect activity patterns correlated with the lunar cycle. This study examined the hypothesis that the number of newts captured in traps correlated with the lunar cycle. A population of smooth newts (*Lissotriton vulgaris*) and one of great crested newts (*Triturus cristatus*) were studied during the spring of 2008 at a site in Lincolnshire, United Kingdom.

Newt populations in two ponds (A and B) at Riseholme Park, University of Lincoln were studied using a constant monitoring effort. On an approximately weekly basis, ten bottle traps (Griffiths, 1985), with their openings facing into the pond, were placed at the fringes of each pond to capture newts at the water's edge. The traps were in place overnight (= trapping session) and examined before 0900 the following day. For smooth newts in Pond A (approximately 18 m² and lined with uPVC; the same pond described by Deeming, 2009), traps were set between 22 March and 20 June 2008. For great crested newts in pond B (previously unstudied and characterized by being man-made but unlined, well vegetated and approximately 200 m² in area), the traps were set between 2 May and 4 July 2008. Any newts captured were sexed and their ventral spot patterns were photographed following the methodology of Deeming (2009). Correlation and second order linear regression analyses were carried out using Minitab version 13.

In pond A, only adult smooth newts were caught at an average frequency of 14.5 newts per week (SD=11.4). A mean of 11.5 males (SD=10.1) and 3.0 females (SD=1.8) were caught per trapping session with an average sex ratio of 4.5:1 (SD=5.4). A total of 105 different males and 35 different female newts were captured only once during the three-month trapping period. However, 46 male newts were recaptured with a median recapture rate of two (range 2–7). Ten female newts were recaptured, with a median recapture rate of two and a range of 2–4. For both sexes, combined median time between captures was 21 days. The percentage recapture rate increased over time and so the population was considered as being effectively closed (using the criteria of Greenwood & Robinson, 2006; see Deeming, 2009).

The rate of capture revealed a cyclical pattern over the period studied for all newts (Fig. 1) and for the ratio of male to female newts caught. The periodicity in the number of newts caught exhibited peaks during the dark phase of the lunar cycle, i.e. the time of the new moon (Fig. 1) with the average time between the three peaks being 31.5 days. In contrast, during the period of the full moon fewer newts were caught in traps. There was a significant curvilinear relationship (Fig. 2) between the number of days (Days) after a full moon and the number of newts caught per trapping session:

$$\text{Newts} = 0.589\text{Days} + 0.0101\text{Days}^2 \ (F_{2,12}=9.98, P=0.003).$$

In pond B, both adult and immature (approximately 5–7 cm total length) great crested newts were caught. The mean total capture rate was 3.3 (SD=3.2) individuals per week but examination of belly spots revealed that only one juvenile newt was caught twice and a total of 32 dif-

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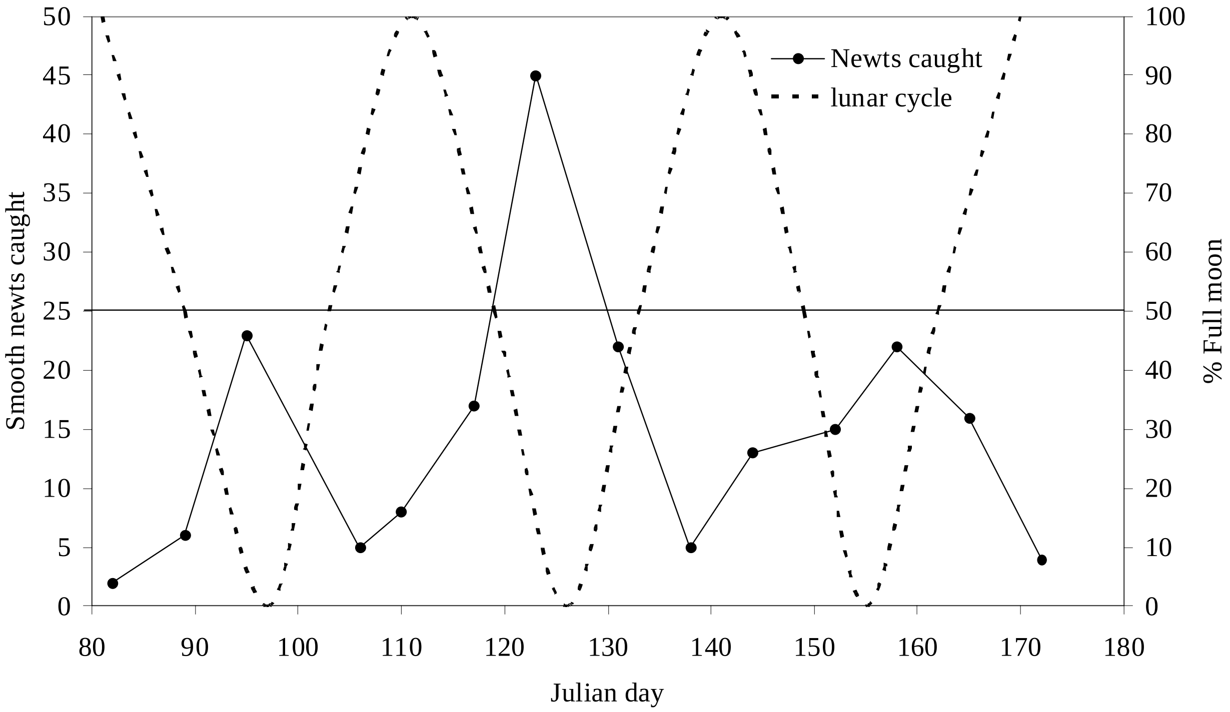

Fig. 1. The number of newts caught between March and June 2008 in 10 bottle traps plotted together with the phase of the moon.

ferent newts were caught in this pond (10 adult males, 10 adult females and 12 juveniles). The pattern of capture was cyclical with 29 and 27 days between three peaks of capture. There was a highly significant correlation between the number of newts caught and the number of days after the new moon (Fig. 3; Spearman's ranked correlation, ρ=0.788, P=0.007).

The observation that the number of newts trapped is affected by the phase of the moon has not been reported in the literature for either species but it is not without precedent. For urodele species, Ralph (1957) showed that the salamander *Plethodon cinereus* exhibited depressed locomotor activity during periods of the full moon, which would have presumably affected the probability of capture in a natural environment. Both Harrison et al. (1983) and Verrell & Halliday (1985) used drift fencing to provide data for migration of smooth newts at ponds in the United Kingdom through a breeding season. Reference to the lunar calendar shows that, in these studies, peaks in numbers caught arriving at, or leaving, the pond were associated with the new moon. By contrast, netting or searching for newts does not reflect the normal behaviour of the animals and cyclical periodicity is not evident (e.g. Griffiths, 1984).

In various anuran species behaviour and reproductive activity have been correlated with the lunar cycle. In Mississippi, USA, Ferguson (1960) reported that adult *Bufo fowleri* were not seen during times of the full moon and clear skies and Fitzgerald & Bider (1974) showed that *Bufo americanus* is less active during periods of the full moon. In Indonesia, numbers of *Bufo melanostictus* found in amplexus were higher (Mann–Whitney analysis of published data has shown that this is significant at P<0.05; Deeming, personal observation) during periods of the waxing moon (Church, 1961). Moreover, during the full moon more *B. melanostictus* females ready to ovulate, or that had just ovulated, were collected than when there was no moon, although there appeared to be little effect on the number of males (Church, 1960a). By contrast, ovary size in the Javanese frog *Rana cancrivora* was greater during periods when the moon was new (Church, 1960b). Robertson (1978) showed that locomotor activity of *Rana pipiens* was affected by both the lunar cycle and the time of year. During periods of lunar high transit during daylight hours frog activity was depressed in April to June but stimulated during the period between October and March.

In this study darker skies around a new moon were associated with a greater chance of catching newts, which implies greater activity at this time. It is interesting that for the smooth newt the greatest chance of capture was either side of the new moon but in the great crested newt most individuals were caught immediately before the new moon and not as the moon began to wax. In either species the greatest activity was during the darkest phase of the moon. The bottle traps were facing into the pond and so it is assumed that they were catching newts as they moved towards the shore to leave the pond. That median time between capture and recapture of a smooth newt was three weeks suggests that the newts are not utilizing the fringes of the pond as a preferred habitat; if that were the case then time between captures would be much shorter. Rather, data suggest that both species of newts were caught as they moved out of the pond. For smooth newts this occurred on a regular monthly basis, which correlated with phase of the lunar cycle. Deeming (2009) found that

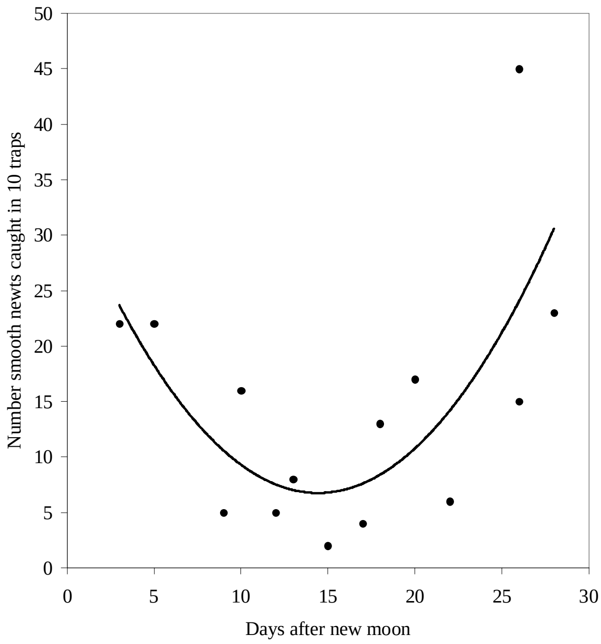

Fig. 2. The curvilinear relationship between numbers of smooth newts caught and days after the new moon.

the median time between captures in Pond A was 27 days, which would correlate with a lunar periodicity of individual newts being present in the pond. When the moon was new and the nights were dark there was movement of smooth newts out of the pond and when the moon was full and the nights were light then this activity was very much lower. Smooth newts were recaptured over time so it can only be assumed that they returned to the aquatic habitat to spend the nights in the water when the moon is full. In great crested newts, departure from the pond appeared to be timed to precede the new moon and the individuals did not return.

Activity during the periods when the moon is waning may reduce the potential risk of predation for newts moving out of the pond and living and feeding in the terrestrial habitat (Ralph, 1957). The higher proportion of male smooth newts captured in Pond A could reflect the fact that reproduction in this species involves the females laying eggs in the pond over an extended period of time over much of the summer and so remaining in the pond (Verrell & Halliday 1985; Griffiths, 1996; Arntzen, 2002). By contrast, sperm storage by the females (Sever et al., 1999) may mean that males are not restricted to the aquatic environment and can utilize terrestrial habitats for foraging. If this idea is correct then it can be predicted that once the females have completed their egg laying they should be caught moving out of the pond in late summer and early autumn, which has been shown to occur (Verrell & Halliday, 1985). Why individual great crested newts appeared to move out of the pond and not return is unclear but may reflect movement to other ponds (Griffiths, 1996). Perhaps such movement is synchronized within the local metapopulation. This hypothesis requires further investigation.

These observations lead to other interesting questions about the size and bodily condition of newts moving in and out of the pond. Are males caught leaving a pond heavier than when they arrived? If they are, does time of year affect this? Do females lose weight whilst breeding and feeding in the pond? Are there differences between these and other species? Such detail about the reproductive ecology of newts has not been documented and future research will investigate these hypotheses in order to answer some of these questions.

Finally, these results have important implications for ecological surveys of newt breeding habitats. That the phase of moon affects the probability of trapping newts in bottles is important because surveying a site at the wrong time of the month could lead to a seriously low assessment of the population size. In addition, in both species described here mean capture rates were only about 10% of the known population size (i.e. newts photographed), which is comparable to previous records for pond A (Deeming, 2009). Therefore, reliance on single or repeated counts at any particular pond, but without identification of individuals, could lead to unrealistically low estimates of population size and misinterpretation of the value of the particular site for breeding in these newt species.

Acknowledgements. Trapping of great crested newts was carried out under licence from Natural England. Many thanks go to Katherine, Emily and Roslyn Deeming for helping sort out newt traps and being so understanding. Thanks also go to Paul Eady for his conversations about these results. I am grateful to three anonymous referees for their constructive comments on a previous draft of this manuscript.

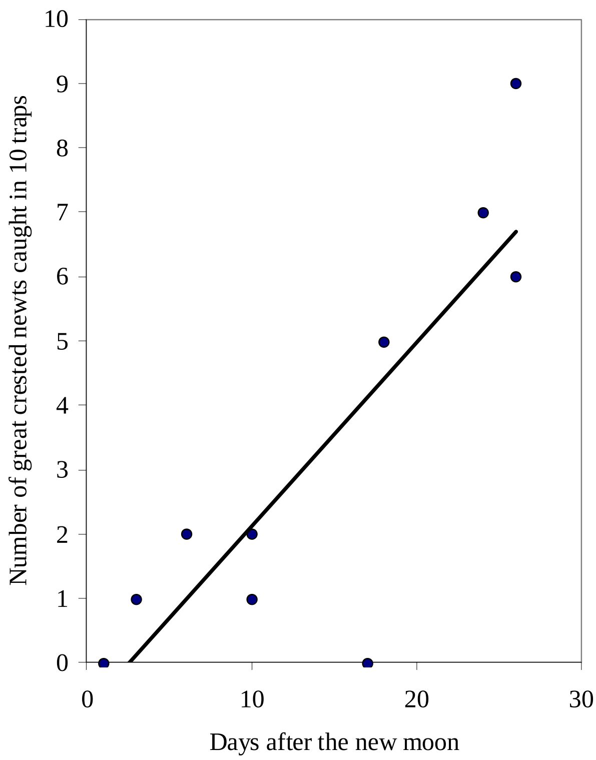

Fig. 3. Relationship between the numbers of great crested newts caught in ten bottle traps and the number of days after the new moon.

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Accepted: 8 January 2009