Changes in relative abundance of the western green lizard *Lacerta bilineata* and the common wall lizard *Podarcis muralis* introduced onto Boscombe Cliffs, Dorset, UK

SIMON R.C. MOLE

Game and Wildlife Department, Sparsholt College, Hampshire, UK.
simonrcmole@yahoo.co.uk

ABSTRACT - Introduced populations of *Lacerta bilineata* and *Podarcis muralis* were discovered on Boscombe cliffs in 2002. Since then both species have been breeding successfully. This investigation plotted their territory in 2007 and compared their population trends with that of the native *Zootoca vivipara*. Fifteen survey visits were undertaken between April and September 2007 during which time observations were made of 214 non-native and 44 native lizards. The two introduced species dominated the central area of the site with the native species found in substantial numbers only on the periphery. Comparison with previously collected survey data show that the relative abundance of non-native species has increased; between 2002 and 2007 *P. muralis* increased by 40% and *L. bilineata* by 36%; compared with *Z. vivipara* which declined by 75%. Sufficient habitat favourable to the introduced species means that there is the potential for unimpeded range expansion along the cliffs, which raises concern for a sand lizard *Lacerta agilis* population to the west of this site. Eradication of the non-native species may be impractical because they occur on a relatively inaccessible cliff face.

THE second leading cause of biodiversity declines, after loss of habitat, is the impact of introduced species (Meffe et al., 1997). There are numerous examples from around the world of destruction caused by introduced herpetofauna (Savidge, 1988; Patrick, 2001). Great Britain, too, has its own history of non-indigenous reptiles in the wild. Beebee & Griffiths (2000) list six reptile species that are known escapees or releases in the UK.

The two species of lacertid introduced at Boscombe, Bournemouth (50º43'N, 1º49'W) are the common wall lizard (*Podarcis muralis*) and the western green lizard (*Lacerta bilineata*) (Gleed-Owen, 2004). Both of these species occur naturally on the northwest coast of France, where they are at the northern edge of their range (Arnold & Ovenden, 2002). There is no fossil evidence to suggest that they colonised Great Britain after the last glaciation. Genetic analysis indicates that Boscombe populations of both species originated from northern Italy close to the Slovenian border (Deichsel et al., 2007). The viviparous lizard (*Zootoca vivipara*) is the only native lizard found within the survey area, although a population of sand lizards (*Lacerta agilis*) is present west of this site. There have been numerous, deliberate attempts to introduce *L. bilineata* and, more frequently, *P. muralis* into Great Britain with varying degrees of success (Quayle & Noble 2000; Wycherley & Anstis, 2001; Lever, 2009). *P. muralis* has proved to be a successful coloniser in other countries, too (Münch, 2001; Walker & Deichsel, 2005; Allan et al., 2006; Burke & Deichsel, 2008). *L. bilineata* has become established in Kansas, USA (Gubanyi, 2000; Burke & Deichsel, 2008).

Since the discovery of the introduced lacertids in 2002, surveys have been undertaken annually with differing degrees of survey effort (C. Gleed-Owen, pers. comm.). The current study aimed to determine the recent extent of the range of introduced *P. muralis* and *L. bilineata*, to determine habitat preferences and possible impacts on *Z. vivipara*.

METHODS AND MATERIALS

The survey location was selected around the suspected introduction site for both *P. muralis* and *L. bilineata*. A preliminary visit to the site determined where suitable habitat was located

Figure 1. An aerial photograph of the survey site (outlined) showing locations of sightings of *Lacerta bilineata* (green dots), *Podarcis muralis* (yellow dots) and *Zootoca vivipara* (brown dots).

and this information was transposed onto an aerial photograph. Suitable habitat comprised mature gorse (*Ulex europaeus*) thickets, marram grass (*Ammophila arenaria*) tussocks and herbaceous vegetation covering the cliff edge. Between these habitat patches comprised open, short sward grassland which is unfavourable for the species in question. A transect was plotted to cover as much of the suitable habitat as possible and 15 surveys were carried out from April to September 2007. For each lizard observed, location was recorded using a hand-held global positioning system (GPS). Four age cohorts were identified: neonate (juveniles born in 2007), juvenile (less than a year old, but excluding neonates), immature (over one year but not showing full adult markings) and adult. When species identification could not be made positively, sightings were not recorded. Lizard sightings were plotted onto the geographical information system software MapInfo© to illustrate the number of individuals seen and their location within the survey area (Fig. 1).

Historical data of lizard sightings between 2002 and 2006 were supplied by the Herpetological Conservation Trust (now Amphibian and Reptile Conservation). These records are, however, random sightings rather than data gathered during systematic survey.

RESULTS

During fifteen surveys two hundred and fifty-eight lizard sightings were recorded. (*L. bilineata* n = 104, *P. muralis* n = 110, *Z. vivipara* n = 44). For a clearer geographic representation thematic maps were generated in MapInfo©. The survey area was arbitrarily split into polygons with smaller polygons near the centre where the greatest concentrations of sightings occurred (Fig. 2). These maps show *Z. vivipara* at the periphery of the survey area, whilst higher counts of both *L. bilineata* and *P. muralis* are concentrated around the centre.

The numbers of juveniles observed (Table 1) suggest that *L. bilineata* and *P. muralis* reproduced successfully the previous year, although in 2007 *Z. vivipara* showed the highest breeding success; there were no observations of juvenile *L. bilineata* and few *P. muralis* from that year.

Examination of the historical and current data reveals changes in the relative abundance of *Z. vivipara* and introduced lacertids (Fig. 3). In 2002 *Z. vivipara* made up 93% of all lizard sightings (mean 5.29 sightings per survey visit) but in 2007 this decreased to 17% (mean 2.93 sightings per survey visit). *L. bilineata* rose from 33% of all sightings in 2003 (no observations of this species were made in 2002) (mean 1.45 sightings per survey visit) to 40% (average 6.8 per survey visit) in 2007 and *P. muralis* increased from 7% in 2002 (mean 0.43 per survey visit) to 43% in 2007 (mean 7.47 per survey visit).

DISCUSSION

Analysis of data has revealed that both *L. bilineata* and *P. muralis* are firmly established at Boscombe

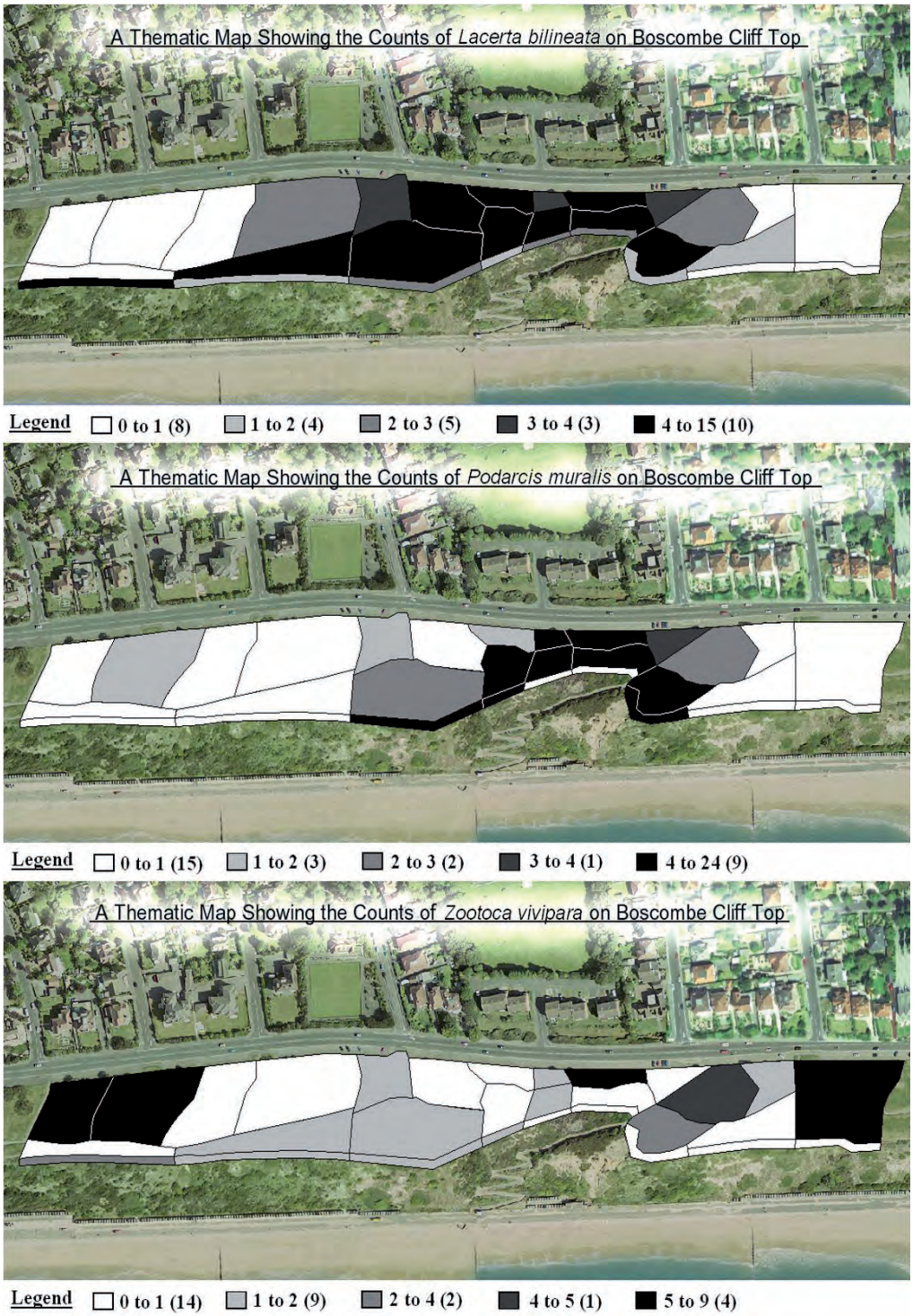

Figure 2. Thematic maps of (top) *Lacerta bilineata*, (middle) *Podarcis muralis*, and (bottom) *Zootoca vivipara* counts. Numbers in brackets indicate frequency of counts.

	Born/hatched				
Species	**2007**	**2006**	**Immature**	**Adult**	**Total**
Zootoca vivipara	7	2	5	30	44
Lacerta bilineata	0	11	7	84	102
Podarcis muralis	4	18	12	78	112

Table 1. Age cohorts of lizards observed in 2007.

and have been breeding successfully and increasing their range since their introduction in 2002. The optimal habitat within close proximity to the survey site, for all three lacertid species, is likely to be the cliff face, which is south-facing, at a 45º angle, supporting heterogeneous vegetation interspersed with patches of bare sand. *L. bilineata* is most likely moving along the cliff face and spreading from there onto the cliff top, as indicated by the distribution to the west of the site where it has colonised the marram grass verges to the path adjacent to the cliff edge (Fig. 1). *L. bilineata* is more widely distributed over the study area than *P. muralis*. *P. muralis* has not spread far along the cliff top from the original introduction site. Short distances between gorse patches have been traversed, but not longer distances, over open ground. Nevertheless, additional sightings of *P. muralis* have shown that it has spread further west, and east, of this investigation's boundary, along the cliff face.

It may be argued that the current observations were biased towards seeing *L. bilineata* and *P. muralis* due to the time of day and relatively warm air temperatures under which the surveys were completed i.e. warm sunny days that were ideal for both introduced species. Previous data were collected, however, with the intent of observing non-native species, too. So past observations, and those of this investigation, were conducted under similar conditions, making data comparable.

There are data suggesting that introduced *P. muralis* competitively exclude *Z. vivipara* when the latter is present at a low population density (Münch, 2001). The changes in abundance of introduced lacertids and *Z. vivipara* in the current study are consistent with interspecific competition, as are the thematic distribution maps, which indicate that *Z. vivipara* has been forced to the periphery of the site (Fig. 2). Fig. 4, showing the west of the survey site in 2004 and 2007, demonstrates the displacement of *Z. vivipara* from the centre of the survey area

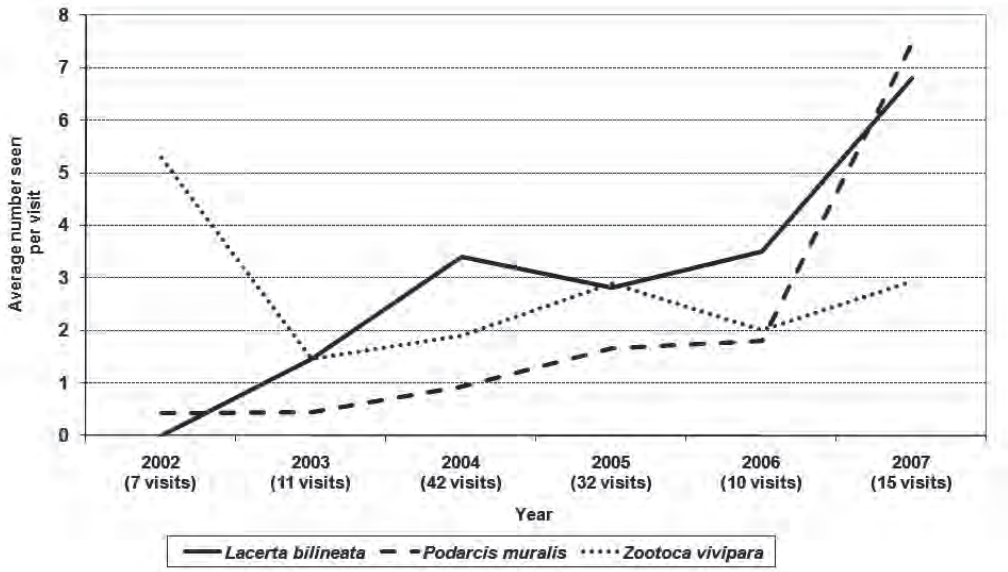

Figure 3. The average numbers of *Lacerta bilineata*, *Podarcis muralis* and *Zootoca vivipara* seen per visit from 2002 to 2007.

Figure 4. Map showing the displacement of *Zootoca vivipara* (brown dots) by *Lacerta bilineata* (green dots) between 2004 (top) and 2007 (bottom).

towards the periphery over this time period.

Climate is likely to affect the future relative success of the lacertids studied. Viviparity gives *Z. vivipara* an advantage in colder climates as it can reproduce more successfully even under poor summer conditions (Uller & Olsson, 2003), but climate change may favour the two non-native lacertids, increasing incubation success, possibly increasing their competitive impacts on *Z. vivipara.* Colonisation of new areas by the non-native species does not bode well for *Z. vivipara*, nor for the *L. agilis* population further to the west, where it is present only in small numbers.

In 2007 three surveys were conducted in September, when juveniles may be expected to be evident. However, no *L. bilineata* juveniles were recorded and very few *P. muralis*; in contrast to juvenile *Z. vivipara* which were seen in greater numbers (Table 1). This contrasted with the sightings of first year juveniles; of lizards presumed to have hatched in 2006 (which was an especially dry summer), both *L. bilineata* and *P. muralis* were more abundant that *Z. vivipara*. If climate change brings hotter, drier summers it seems likely that recruitment among the non-native populations will continue to be successful and increase, leading to territory expansion, but if summers turn wetter they are unlikely to fare as well.

The cliff habitat from Poole Harbour eastwards to Hengistbury Head is similar to that adjacent to

the current study area, providing ample potential habitat for the non-native lacertids. It was however apparent that there were some areas avoided by the non-native species. When a map of vegetative structure is overlaid with the locations of lizard sightings (Fig. 1), it is clear that the taller scrub patches supported the higher numbers of non-native lacertids. Both species require hot, dry areas where they can thermoregulate and oviposit. As gorse matures it becomes leggy, which in turn opens up the ground to the sun creating warm microhabitat whilst still providing the protection of cover. This structural nature of the gorse has allowed the spread of the non-native lacertids from the central introduction site on the cliff top. The gorse on site is cut back when it is deemed too big, but this is not done to an annual management plan. Due to financial constraints the gorse has been allowed to 'overgrow'. This 'overgrown' state appears to be the preferred successional stage of the non-native lacertids. Gorse management may affect the success of the introduced lacertids at Boscombe.

It would appear that these unintentional invaders are here to stay and it is extremely unlikely that they could now be eradicated from the cliffs at Boscombe. Even if all the scrub were to be removed from the cliff top, the cliff face would act as a source population for re-colonisation.

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REFERENCES

Allan, G.M., Prelypchan, C.J. & Gregory, P.T. (2006). Population profile of an introduced species, the common wall lizard (Podarcis muralis), on Vancouver Island, Canada. *Can. J. Zool*. **84**, 51-57.

Arnold, N.E. & Ovenden, D.W. (2004). *A Field Guide to the Reptiles and Amphibians of Britain and Europe, 2nd Edition*. Great Britain: Harper Collins Publishers Ltd.

Beebee, T.J.C. & Griffiths, R.A. (2000). *Amphibians and Reptiles*. Great Britain: Harper Collins Publishers Ltd.

Burke, R.L. & Deichsel, G. (2008). Lacertid lizards introduced into north America: history and future. In: *Urban Herpetology*. Mitchell, J.C., Jung Brown, R.E. & Bartholomew, B. (Eds.), pp. 347-345. Salt Lake City, Utah: Soc. Stud. Amph. and Rept..

Deichsel, G., Gleed-Owen, C.P. & Mayer, W. (2007). *Lacerta bilineata* (western green lizard) and *Podarcis muralis* (common wall lizard) United Kingdom, Dorset. *Herpetol. Rev.* **38** (1), 100-101.

Gleed-Owen, C.P. (2004). Green lizards and wall lizards on Bournemouth cliffs. *Herpetol. Bull.* **88**, 3-7.

Gubanyi, J. (2000). A breeding colony of western green lacertas (*Lacerta bilineata*) confirmed in southwestern Topeka (Kansas). *Trans. Kansas Acad. Sci.* **103** (3-4), 191-192.

Lever, C. (2009). *The Naturalized Animals of the Britain and Ireland.* London: New Holland Publishers (UK) Ltd.

Meffe, G.K. & Carroll, C.R. (1997). *Principles of Conservation Biology, 2nd Edition*. Sunderland: Sinauar Associates Inc.

Münch, D. (2001). Do allochthone common wall lizards jeopardize autochtone sand and viviparous lizards? *Dort. Beiträge Landess.* **35**, 187-190.

Patrick, L. (2001). Introduced species summary project, brown tree snake (*Boiga irregularis*). www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_ spp_ summ/boiga_irregularis.html [Accessed: November 2007].

Quayle, A. & Noble, M. (2000). The wall lizard in England. *British Wildlife* **12** (2), 99-106.

Savidge, J.A. (1988). Food habits of *Boiga irregularis*, an introduced predator on Guam. *J. Herpetol.* **22** (3), 275-282.

Uller, T. & Olsson, M. (2003). Life in the land of the midnight sun: are northern lizards adapted to longer days? *Oikos* **101** (2), 317-322.

Walker, Z & Deichsel, G. (2005). *Podarcis muralis* (common wall lizard). *Herpetol. Rev.* **36** (2), 202.

Wycherley, J. & Anstis, R. (2001). *Amphibians and Reptiles of Surrey.* Great Britain. Surrey Wildlife Trust.