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INTERACTIONS BETWEEN PYGMY BLUETONGUE LIZARDS AND CO-EXISTING SPECIES

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Abstract

This paper describes observations of interactions between endangered pygmy bluetongue lizards (*Tiliqua adelaidensis*) and other species that co-occur in their native grassland habitat in the mid-north region of South Australia. The lizard lives in spider burrows, and rarely moves away from the burrow entrance. We viewed over 16,000 h of video recording of occupied pygmy bluetongue lizard burrows, taken over five 10 day periods throughout one complete lizard activity season, and documented all cases in which these endangered lizards interacted with co-existing species. We found that these interactions were infrequent. We observed potential competition over burrow resources with lycosid spiders (*Lycosa spp*), centipedes, and a house mouse, and potential competition over invertebrate prey with a predatory wasp. We also observed unsuccessful predation attempts on lizards in burrows by ravens and brown snakes. We suggest that conservation management might have proceeded effectively without this information, but that it provides useful background information for informed decision making.

Key words: Lizard, Conservation, Competition, Predation

Introduction

Endangered species remain part of the ecological community where their populations persist. Management plans to conserve these species needs to be include any impacts of interactions with co-occurring species. Particularly in cases where a species is rare or inconspicuous, competitive, mutualistic and predatory interactions are often difficult to observe and document. Thus, if we have little information about those interactions, including them into recommended management actions is problematic. Here we use 16,000 h of video footage from across one entire activity season to document the interactions of an endangered lizard species with coexisting animal species.

The pygmy bluetongue lizard (*Tiliqua adelaidensis*) is the smallest member of the scincid genus *Tiliqua* with an average adult snout-to-vent length (SVL) of 95 mm (Armstrong & Reid 1992; Armstrong *et al.* 1993; Hutchinson *et al.* 1994). It was thought to be extinct until 1992, when a male was found in the stomach of a dead brown snake near Burra, South Australia (Hutchinson *et al.* 1994). Subsequent surveys have documented its limited geographical range in a few isolated remnant patches of native grassland in the mid-north region of South Australia, an area that is now extensively fragmented by agricultural activities, and have assessed it to be an endangered species (Milne *et al.* 2003a). Individual lizards are solitary and spend most of their time associated with single entrance, vertical burrows constructed by lycosid and mygalomorph spiders (Milne *et al.* 2003b; Fenner *et al.* 2007; Ebrahimi *et al.* 2012).

Our study takes advantage of the fact that a single camera positioned above an occupied burrow can record almost all of the activity of a pygmy bluetongue individual. Lizards occasionally move out of their burrows to defecate, lunge at passing invertebrate prey, or to seek mating partners for a brief period in the spring, but otherwise are almost entirely confined to their burrows, the burrow entrances and an extremely small area around the burrow entrance (Milne *et al.*, 2003b; Fenner *et al.*, 2007; Fenner and Bull, 2011; Schofield *et al.*, 2012; Ebrahimi *et al.*, 2014). As a consequence, we assume that most of their interspecific interactions also take place around the burrow entrance.

We used video recordings to determine whether there was any direct interaction between lizards and spiders, since lizards occupy spider burrows, or whether lizards simply locate and use already vacated burrows. We also documented other interactions between potential competitors and predators that might influence lizard population dynamics.

Methods

Data for this study were based on video camera recordings of 23 burrows that were occupied by adult pygmy bluetongue lizards within a 1 ha plot of native grassland located in the Tiliqua property

of the Nature Foundation of South Australia, near Burra (33.67°S; 138.93°E), South Australia. We attached 23 CCTV cameras (SONY Effio 2.8mm-10mm, 30 fps) to poles so they were positioned 100 cm above the entrances of burrows occupied by pygmy bluetongue lizards. The cameras recorded a field of view of 60 x 60 cm centered on a burrow entrance. They recorded for 14 h from 0500 – 1900 h for 10 days of 16-25 October, 16-25 November, 11-20 December, 10-19 January and 6-15 February. This period included most of the 2011/2012 spring and summer lizard activity season.

We made 700 h of recording per burrow, and over 16,000 burrow-hours in total. Each four cameras were connected to a four channel DVR (DVRH04 H264 Pentaplex 4ch) and we used sixteen 140AH lead acid batteries with 8 solar panels (250W 280AH solar panel kit) for powering these cameras and DVRs. One of us (ME) viewed all of the recordings.

We document in this paper all observations in which another species came into the camera field of view, dividing these observations into possible competition for burrows, competition for food, and predation attempts.

Results

Interactions with other species were extremely rare, and we recorded only 14 interactions between pygmy bluetongue lizards and other species, or an average of one interspecific interaction per lizard every 82 days. Six different species were identified in these interactions: lycosid spider (n = 2), centipede (n = 2), house mouse (n = 1), wasp (n = 1), brown snake (n = 3) and little raven (n = 5).

Competition for burrows

Five interactions involved three other species potentially competing for burrow refuges. Two indirect interactions, both in October, were between lycosids (wolf spiders) and pygmy bluetongue lizards. The species of lycosid could not be identified from the videos, but the two most common species at the study site were *Lycosa stirlingae* and *L. gilberta* (J. Clayton pers. comm.). In each

case a wolf spider occupied a burrow that was being filmed (because it had previously housed a pygmy bluetongue lizard). In the first case, although an adult pygmy bluetongue lizard of unidentified sex had been detected inside the burrow a day before filming started, that lizard had probably left the burrow before filming started on the next day (16 Oct). No occupants were detected at the burrow entrance, or arriving or departing, in the filming of that day, but a lycosid spider was detected inside the burrow during inspection at the end of the day. By the second day of filming (17 Oct) an adult pygmy bluetongue lizard was seen basking at the entrance of the burrow from 0922 h, and was seen at the burrow for three days (until 19 Oct). There was no subsequent vision of the spider. We did not observe any vision of the arrival of the lizard, or of any interaction with the spider, and we assumed that the lizard took over burrow ownership late in the evening of 16 Oct (after 1900 h) or early in the morning of 17 Oct (before 0500 h) in times when there was no filming. We could not determine if there was a direct lizard-spider interaction, or whether the spider had already departed when the lizard arrived.

In the second case, a burrow was occupied by a female adult pygmy bluetongue lizard for the first three days of the ten day October filming period but, during filming on day 3, this lizard was observed to leave the burrow, and there were no observations of her returning. The burrow remained apparently empty during filming for the next five days. Then, late on day eight (1822h on 23 Oct) a wolf spider was observed approaching the burrow. It moved directly to the burrow and entered the burrow without any hesitation or inspection of the burrow entrance. During filming on day nine and ten there was no sign of the spider (or of a lizard) although the spider may have been refuging in the burrow and foraging at night when the cameras were not activated. Before filming started in the next month (November) this burrow was identified as unoccupied, and the camera was moved to a different burrow.

Scolopendrid centipedes were also recorded attempting to interact with lizards over burrows, although we were unable to identify the centipede species from the video images. In one case we observed a centipede that appeared to try to take over ownership of a burrow that was already

occupied by a male adult pygmy bluetongue lizard. This lizard was observed in filming on days four to seven (13-16 Jan) of the January (2012) filming session. The centipede, around 12 cm long, approached at 0542 h on day eight (Jan 17), before the lizard had emerged for the morning and it entered the burrow entrance until about one of third of its body was inside the burrow. It then remained stationary for 4 seconds. We could not see the lizard inside the burrow but we assumed that it blocked the centipede from getting further inside the burrow. The centipede emerged from the burrow and moved out of the camera field of view.

The second observation was a reverse situation. A centipede occupied a burrow for the first nine days (6 – 14 Feb) of filming in February (2012). We observed the centipede at the burrow entrance, usually early in the morning (0456-0515 h) on days one, four, six and nine of the filming, and assumed it was present throughout that period. Because we never saw the complete centipede we could not assess its size, but the head appeared similar in size to the first filmed individual. On day ten (15 Feb) we first observed an adult pygmy bluetongue lizard emerging to bask at the burrow entrance at 1129 h. That lizard was last observed retreating into the burrow at 1237 h of the same day, and stayed in the burrow all of the rest of that day. We do not know when the centipede left the burrow, but assume it was sometime between when filming stopped on day 9 (1900 h) and when it started again on day 10 (0500 h). We do not know when the pygmy bluetongue lizard arrived, but it must have been during that same period. It is unlikely that there would have been enough room in the burrow for both the lizard and the centipede to co-occupy it for the first nine days of filming. We do not know whether the lizard interacted with the centipede during the transition of burrow ownership.

The third species to interact over burrows was a wild house mouse (*Mus musculus*), an introduced invasive species in the native grassland habitat. The interaction occurred in a burrow that was occupied by a juvenile pygmy bluetongue lizard for the entire ten day filming period in February 2012. The lizard was recorded at the burrow entrance on each of the ten days, but on the second day (7 Feb 2012) at 0503 h, a mouse approached the burrow, and entered the burrow until it was half

way in. It then stopped, came out, waited for 4 sec then tried to enter the burrow a second time. On each occasion the mouse spent only about 3 sec partially inside the burrow, apparently blocked by the lizard from entering further, before re-emerging. After the second attempt the mouse left the field of view of camera. The lizard then emerged to bask at the burrow entrance at 0801 h.

Competition for food

We observed only one case in which an adult pygmy bluetongue lizard (of unknown sex) interacted with another species over a prey item. On 23 Nov 2011 we observed a predatory wasp (of unknown species) struggling to fly while holding onto a locust prey. The locust appeared to have been paralysed by the wasp since it was not moving, and it was about 10% longer than the wasp.

Between 1700 – 1701 h the wasp rested about 30 cm above the ground surface on a grass tussock 20 cm from where the pygmy bluetongue lizard was basking at its burrow entrance. When the wasp fell off the tussock and onto the ground, still holding the locust, the lizard emerged from its burrow and approached to within about 3 cm of the wasp and its prey. After pausing for a second the lizard lunged towards the locust, took the locust in its mouth and pulled it away from the wasp. Then the wasp, without its prey, appeared to attack the lizard and tried to sting it around the neck. We are not sure if the wasp stung the pygmy bluetongue lizard or not, but for about 2 sec the lizard wriggled its body rapidly apparently in some discomfort, while the wasp was hovering close by. Then the wasp flew around the prey and the lizard for 12 sec and tried to approach the lizard two more times before flying away and out of the field of view of the camera. It reappeared after 10 sec and flew around the lizard again for 20 sec, but without attacking it, before flying away again. Over this period (and for a total time of 2 min 18 sec) the lizard remained stationary on the ground outside its burrow, trying to ingest the locust. Because the locust was large, this attempt was unsuccessful and the lizard discarded its inert prey and returned to its burrow at 1704 h. The wasp (we assumed it was the same individual) returned 19 sec later, flew around the locust without landing or touching it for only 7 sec, before flying away again. About 12 min later, at 1716 h the lizard re-emerged from its

burrow, moved directly to the still inert locust, and this time succeeded in ingesting it, a process that took 74 sec.

Predation attempts

We observed five cases in which little ravens (*Corvus mellori*) appeared to inspect inside occupied burrows. All of these observations were on the same day (24 Nov 2011) and the first four happened within one 20 min period. The first bird appeared in the camera field of view at 0725 h while the pygmy bluetongue lizard was inside its burrow. It twice used an approximately 6 cm long dead grass stalk to probe the burrow, each time for 5 sec, then pushed its beak inside the burrow for 3 sec. A second raven came into the camera field of view at 0726 h and after a scuffle with the first arrival, it also pushed its beak into the burrow for 9 sec before flying away. The third raven then arrived at the same burrow entrance at 0730 h and again probed inside the burrow with a 6 cm long grass stalk for 2 sec and its beak for 7 sec. The resident lizard was observed alive and at its burrow entrance later on that day.

In the fourth case, at 0744 h on the same day, a raven arrived at a different burrow. Although an adult female pygmy bluetongue lizard occupied the burrow, it had been a trapdoor spider burrow and the silk lid of the burrow remained in place. The raven pulled away the burrow lid, pushed its beak once inside the burrow for 3 sec, before flying away.

The fifth and last observation was again on the same day, but nearly 3 h later and at another different burrow occupied by another pygmy bluetongue lizard. At 1043 h the raven arrived at the burrow, pushed its beak into the burrow for 2 sec and then left the camera field of view.

Finally, on three occasions we observed brown snakes, *Pseudonaja textilis*, near to the entrances of occupied burrows. In each case the occupant was a different adult female pygmy bluetongue lizard. At 1149 h on 20 Oct 2011 a female lizard was basking at the burrow entrance but quickly retreated into the burrow when the snake reached 20 cm away. The snake stopped about 10 cm from the burrow entrance and waited there for about 60 sec in an S shape appearing to be poised to strike if

the lizard re-emerged. It then moved forward and inspected the burrow entrance with tongue flicks for 6 sec, and finally left the camera field of view. The resident lizard started basking again after 2 h.

The second incident started at 0738 h on December 16 2011. An adult female lizard had been basking at its burrow entrance since 0727 h when a snake appeared in the camera field of view about 30 cm away. The lizard quickly retreated into its burrow while the snake approached and inserted its whole head inside the burrow, remaining there for 9 sec. Then the snake re-emerged and left the camera field of view. The lizard started basking again after just over 2 h.

In the third observation on 13 Feb 2012, the lizard was inside its burrow when the snake came into the camera field of view at 1634 h. It moved past the burrow entrance without paying any apparent attention, although it stopped for 2 sec when it had moved past the burrow entrance and was 20 cm beyond it. It then moved on and exited the camera field of view. The lizard in that burrow did not re-emerge on that day, but was observed basking normally on the next day.

Discussion

There are five main conclusions that can be derived from these observations. The first is that incidents of interactions between pygmy bluetongue lizards and other co-existing species are relatively rare. We observed only 14 cases over 50 days of filming of 23 burrows, covering the majority of the annual activity period of the lizards. Feeding interactions with prey species are not reported here, and conspecific interactions observed in the same video recordings, mainly during the mating season, are reported by Ebrahimi *et al.* (unpublished data). Despite there being 12 other common reptile species co-occurring with pygmy bluetongue lizards (Pelgrim *et al.* 2014), we found no evidence of any contact or direct interactions with them, apart for the brown snakes. This confirms an observation by Pelgrim *et al.* (2014) that competitive interactions between pygmy bluetongue lizards and other co-existing reptiles are unlikely to have a major impact on pygmy bluetongues.

The second conclusion is that the nature of the interaction between the spiders that build the burrows and the lizards that take over the burrows, remains unresolved. We did not observe any direct interaction where a previous occupant (lizard or spider) was evicted by a new occupant of the other species. We only observed two cases where one species was in the burrow at one time, and subsequently the other species occupied the burrow, and in each case the critical transition period happened outside of the 14 h of daily filming. It seems most likely that lizards locate and occupy vacated spider burrows. However, it could be argued that, because our focus was largely on burrows that were already occupied by lizards, and because lizards tend to remain resident in burrows for some time, our filming was biased against recording the transition from spider to lizard occupancy. In that case we may have underestimated the frequency of spider and lizard interactions generated by more mobile subadults and juveniles in the lizard population (Schofield *et al.* 2012).

Third we observed how successful a lizard can be at repelling potential rivals for burrow occupancy. Previously, (Fenner & Bull 2011) suggested that lizards will be most successful in defending their burrows against rival conspecifics if they remain inside the burrow, blocking access to the invader. The narrow shaft and the single entrance of the spider burrows make that blocking strategy successful. In this study we observed a similar success when a centipede or a mouse tried to enter an occupied burrow. The resident lizard seemed to be able to repel any takeover attempt, probably by simply blocking the entrance.

Fourth, and related to our third conclusion, we observed that the burrow appeared to represent a safe haven from predation. In none of eight observed encounters with potential predators was the lizard in a burrow captured. This result contrasts previous observations of snake predation on pygmy bluetongue lizards (Fenner *et al.* 2008b; Fenner & Bull 2012), and a high incidence of tail damage in live lizards, that suggested risk from avian predators (Fenner *et al.* 2006; Fenner *et al.* 2008a). Those previous reports have suggested a high rate of predation or of close escapes from predation in the population. But it is likely these predation risks happen when lizards are on the surface seeking new burrows or mating partners, and that once in a burrow, lizards are relatively safe. Nevertheless

our observations indicated that predators were aware of pygmy bluetongue lizards, with snakes responding when they encountered basking lizards, and with ravens probing lizard burrows, even though that behaviour was only observed on one day.

Our fifth and final conclusion is that the lizards are not completely diurnal. Although our cameras were switched on and off at 0500 h and 1900 h, in two cases a lizard took up residency or moved away from a burrow at times when we were not filming.

From a broader conservation perspective we can deduce from these observations that predation is likely to remain a significant interaction that will influence lizard population dynamics, but that if there are adequate burrows available, resident lizards will be able to reduce predation risk by staying in a burrow. We can also deduce from our video records that direct competition with other species for burrows or for invertebrate prey will be only of minor importance, although our observations do not reflect indirect depletion of prey by the rest of the ecological community. Importantly we found no visual evidence of any competitive interaction with other co-existing reptile species.

We argue that our study, showing relatively rare interactions with co-existing species in the native grassland habitat, provides important background knowledge for more informed management decisions concerning this endangered lizard species.

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