Observations of an aggregation between two species of Australian elapid snakes: the threatened Little Whip Snake *Parasuta flagellum* and Common Eastern Brown Snake *Pseudonaja textilis*

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ABSTRACT

This short note presents field observations of a pair of adult threatened Little Whip Snakes *Parasuta flagellum* and a pair of juvenile Common Eastern Brown Snakes *Pseudonaja textilis* in an aggregation beneath artificially placed Masonite board used in the Turallo Nature Reserve long-term Little Whip Snake monitoring program. The observation represents the first documented record of an interspecific aggregation between these two species. Presumably, there may be thermal or anti-predatory advantages for the Little Whip Snake by aggregating with other snakes, particularly when both species are of a similar size. However, similar behaviours may also have fitness disadvantages including food competition, and potentially predation as the Common Eastern Brown Snake neonates grow and surpass the substantially smaller Little Whip Snake and warrants further experimental research.

Key words: *Parasuta flagellum*, interspecific aggregation, snakes, artificial refugia, threatened species

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Introduction

Understanding snake aggregations

The social behaviour and spatial partitioning of animals has important implications for population dynamics and habitat selection of individuals (Gardner *et al.* 2016; Stephens and Sutherland 1999; Thiele 2012). For many animals, group-based sociality is well regarded for mammal (Koenig *et al.* 2013), bird (Cockburn 1998) and insect (Korb *et al.* 2012; Pamilo and Crozier 1996; Purcell *et al.* 2012) species and can potentially benefit the individual by facilitating thermo and hydro regulation, increasing reproductive success and to deter or evade predators (Krause and Ruxton 2002). Although reptiles are typically regarded as asocial, there are many studies that document complex social systems, from long-term monogamy, gatherings (Graves and Duvall 1995; Giles *et al.* 2009; Davis *et al.* 2011; Clark *et al.* 2012), mating events, kin recognition and grouping (Hoser 1980), material – offspring associations (Aubert and Shine 2009), parental defence (Butler *et al.* 1995; Greene *et al.* 2002) and anti-predator defences (Aubert and Shine 2009).

In the case of snakes, intra and interspecific aggregations are most widely reported within retreat sites (Doody *et al.* 2013; Gardner *et al.* 2016; Gregory 2004; Shine 2005) and mostly associated with reproductive (Michael and Lindenmayer 2010; O'Connor and Shine 2004; Scott *et al.* 2013) and seasonal thermal regulatory events (e.g. overwintering, communal egg-laying; Doody *et al.* 2009). Such behaviour may also be driven by the attraction of individuals to patches of available habitat if it is in short supply, or patchy, within the environment (Gregory 2004). Despite the substantial work on snake interactions within the genera, there is little known about the interaction between the Pseudonaja and Parasuta genera, and even less regarding the interactions between both species sharing artificial refugia.

Habitat and ecology of Little Whip Snakes and Eastern Brown Snakes

The Little Whip Snake *Parasuta flagellum* is a small, skink-eating nocturnal snake, reaching up to 45 cm in length (Figure 1) (Cogger 2014; OEH 2018; Turner 2019). This species is a live bearer, producing between one and seven young in late summer to early autumn (Fyfe and Booth 1984; Shine 1988; Turner 1989; Turner

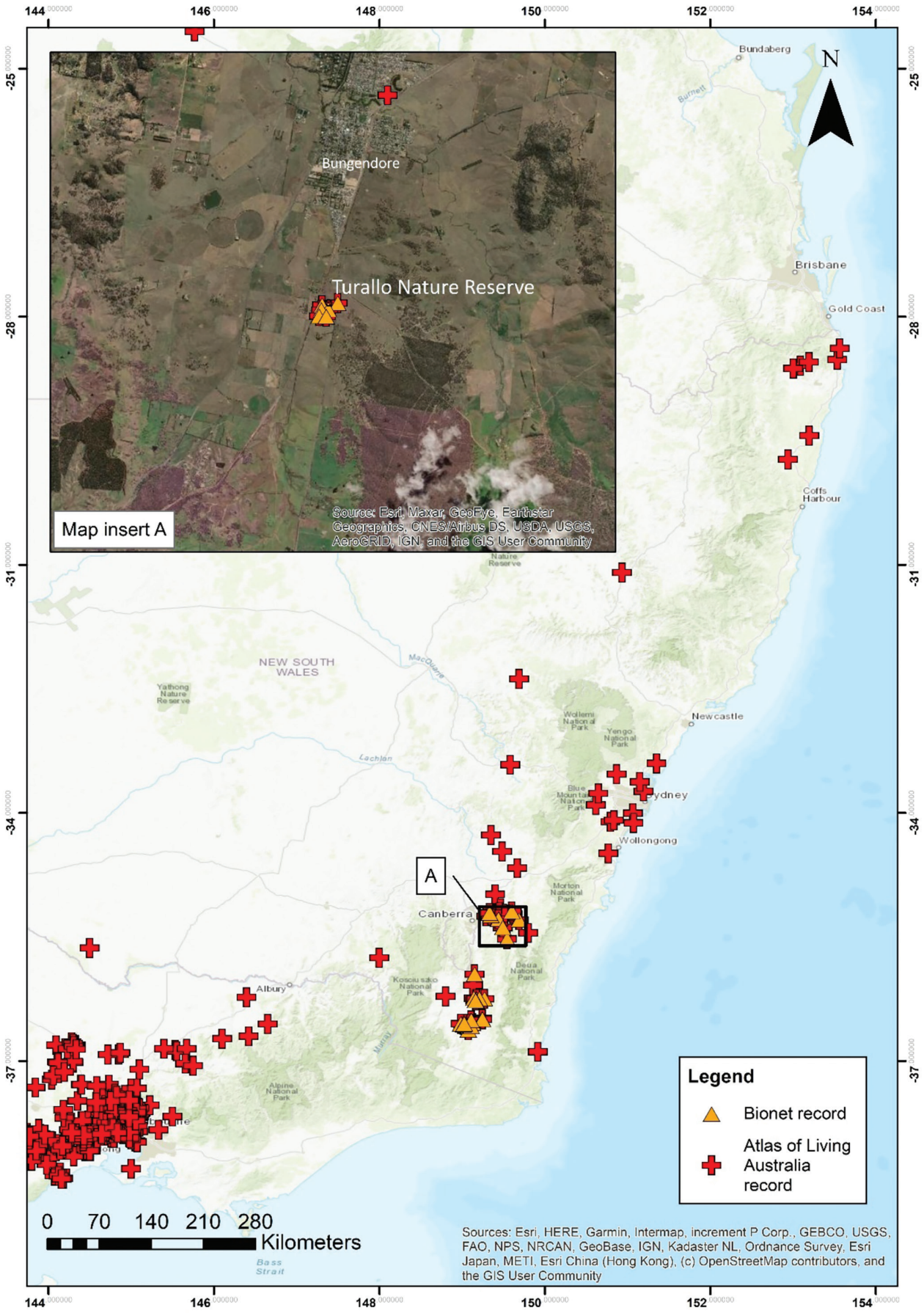

Figure 1. Map of Little Whip Snake records in Turallo Nature Reserve (Map inset A) and across New South Wales from Bionet (orange triangle) (OEH 2020) and Atlas of Living Australia (red cross) (ALA 2018)

2019). P. flagellum is found in New South Wales (NSW), Victoria and South Australia (OEH 2018). The Victorian population is reported to be common and widespread across its distribution (VBA 2019). However, the NSW and South Australian populations are geographically disjunct from the Victoria population and confined to small isolated populations (OEH 2018). In NSW, the species has been recorded within an area between Crookwell, Bombala, Tumbarumba and Braidwood (OEH 2018), however, population has undergone substantial declines throughout its range across the state and is listed as Vulnerable under the Biodiversity Conservation Act (OEH 2018).

Parasuta flagellum occurs in a variety of habitats from dry sclerophyll forest to open heath where surface rock or rocky outcrops are present (Jenkins and Bartell 1980; Ehmann 1992; Cogger 2014). This species typically shelters beneath surface rock on soil or on other rock (Turner 2019), or partially embedded logs and fallen timber on temperate grasslands, grassy woodlands and secondary grasslands derived from clearing of woodland (Turner 2011, OEH 2018). This species has also been found in Natural Temperate Grasslands where there is little surface rock such as Turallo Nature Reserve, New South Wales (DECCW 2009).

In contrast to the life history, localised distribution and specialised habitats of the Little Whip Snake, the Eastern Brown Snake *Pseudonaja textilis* is a large, diurnal snake reaching up to two metres in length (Figure 2) (Michael and Lindenmayer 2010). This species is common and widespread across eastern Australia and inhabits a broad range of habitats, particularly open grassland, pastures and woodlands (Cogger 2014; Michael and Lindenmayer 2010). It primarily feeds on small mammals, particularly rodents but also on reptiles, birds and frogs (Michael and Lindenmayer 2010).

Whilst the species is very common in basalt plains grassland and grassy woodlands across Victoria (James 1979 Turner 2001, 2011, 2014 and 2019) and South Australia (ALA 2018), very little is known about the distribution, ecology and behaviour or threats (although grass fire may pose a risk to the species; see Turner 2019; Schultz 1985) of this species in NSW where it is listed as 'Data-Deficient' (DPIE 2020).

Existing accounts of overwintering aggregations (Turner 2019), repeated refuge use in burrow cavities beneath stone (both juveniles and adults; Turner 2014 and 2019) and temporarily stable aggregations around refuge sites between gravid females (up to seven adults; Turner 2001) have been described for Little Whip Snakes. Eastern Brown Snakes have also been recorded aggregating in adult only nests (Hoser 1997) and large mixed (juvenile and adult) aggregations (up to thirteen adults in a single group; Hoser 1980).

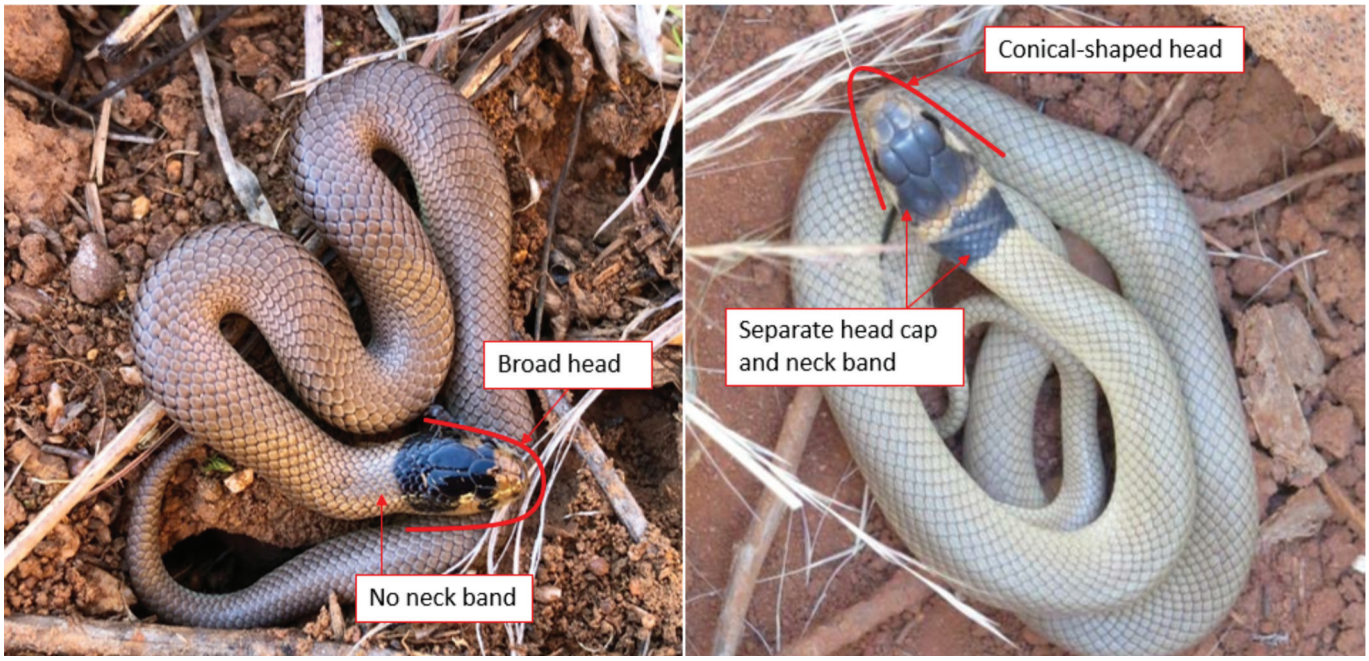

Figure 2. The Little Whip Snake (left) may be misidentified for a juvenile Eastern Brown Snake (right) as both species share a similar half-glass shaped black patch on the top the head, and broadly similar tan – orange body colour. The Little Whip Snake is distinguished physically from the juvenile Eastern Brown Snake by an unbroken black patch extending from neck to between the eyes and a broad ("boof") head (left photo). Whilst, in addition to the black head, juvenile Eastern Brown Snakes have a black neck band (right photo), not present in the Little Whip Snake, and a conical shaped head. Behaviour also separates the species. We observed, in defence, the Little Whip Snake will curl into a coil or knot its body and may throw a few bluff strikes, while the Eastern Brown Snake will take a more aggressive posture and raise its entire forebody and form a "S" position. Meristic differences also separate the two species. Eastern Brown Snakes have a divided anal scale and paired subcaudal scales, whilst the Little Whip Snake has a single anal scale and single subcaudal scale (Cogger 2014).

Figure 3. Grassland habitat within Turallo Nature Reserve, New South Wales, Australia (Photo credit: Rainer Rehwinkel)

During long term monitoring at a site in south-eastern Australia, we describe the first field observation of aggregations between the poorly known and threatened Little Whip Snake *Parasuta flagellum*, and Common Eastern Brown Snake *Pseudonaja textilis*; hereafter, 'Eastern Brown Snake' (Figure 2).

Methods

In 2009 a monitoring program for the Little Whip Snake was established in the Turallo Nature Reserve, located in the southern Tablelands of New South Wales near the township of Bungendore (Figure 1). The reserve is approximately 25 hectares and was historically used as a travelling stock reserve and camping area, but was gazetted in February 2003 as it supports a rare example of Natural Temperate Grassland community of the Southern Tablelands (listed as Endangered under the Environmental Protection and Biodiversity Conservation Act (EPBC Act 1999; DECCW 2009) (Figure 2). Most of the surrounding area has been extensively modified by agricultural land use, although there is a Travelling Stock Reserve immediate across the road from Turallo that comprises natural temperate grassland and grassy woodland that is likely to be Little Whip Snake habitat.

Reptile surveys involved the deployment of house roof tile arrays, each comprising a cluster of five tiles (300mm x 400mm). Each tile was placed flat on the ground and spaced two to three metres apart. A total of 20 sites (arrays) were established across the reserve totalling 100 tiles. The ground cover under each tile was reduced, and using a post hole digger, a small hole was punched into the soil underneath to provide additional shelter (see Figure 4B). A single Masonite board (likely left over from other site works) was retained near to one of the roof tile arrays. Targeted surveys for Little Whip Snakes at Turallo NR commenced in 2009 and have been conducted biannually (during early spring and late autumn). All surveys were undertaken on clear days between 0800 and 1200, and involved inspection of the tile arrays for sheltering individuals and all other herpetofauna.

Observations

The first interspecific observation of the two species occurred during autumn surveys on the 3rd of May 2018 at 09:00am. Conditions were warm, windless and dry with temperatures between 12-18°C. Two adult Little Whip Snakes were observed aggregating with two juvenile Eastern Brown snakes under a Masonite board. We observed both species sharing human-made holes and communal space (Figure 4A). Both species were of a similar length and size (ranging between 20 to 30 cm) (Figure 4A). The two species were observed again under the same tile on the 23rd of October 2018 at 09:20am with only one adult Little Whip Snake and one juvenile Eastern Brown Snake (Figure 4B). Conditions were warm, dry, with light winds, and temperatures between 14-21°C.

When the board was lifted on the first occasion, as shown in Figure 4A, both species were loosely coiled, moving across one another and in visual and physical contact. Although, over time, both species became more tightly coiled around one another until the board was repositioned over the snakes. In Figure 4B, under the

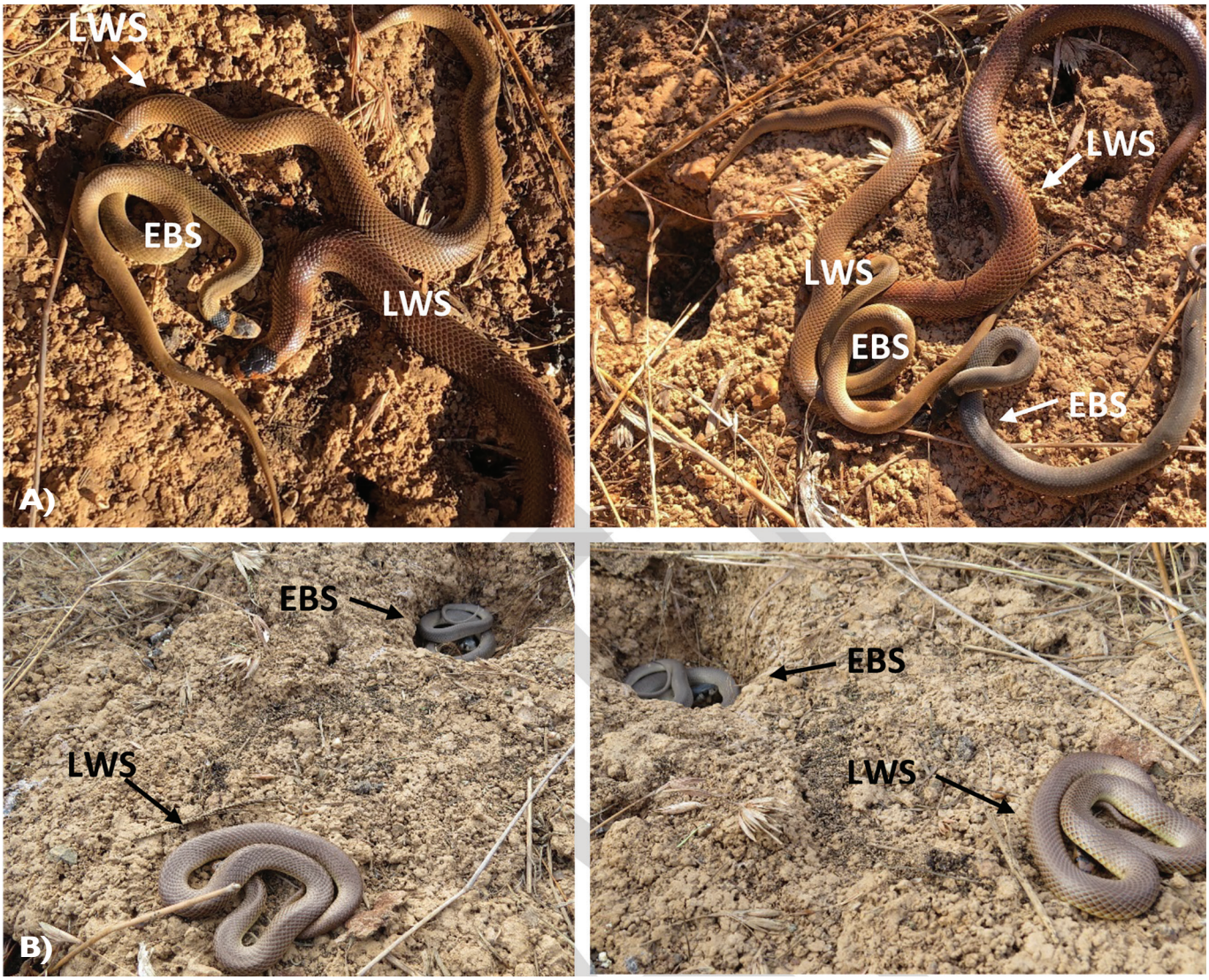

Figure 4. Little whip snake (LWS) and Eastern brown snake (EBS) aggregation observed at Turallo Nature Reserve, New South Wales. (A) Photo showing the initial observation of the aggregation and, (B) Photo showing the same survey board four weeks later.

same board and four weeks later, we observed only two snakes (one Little Whip Snake and one juvenile Common Eastern Brown Snake) at opposite ends of the survey tile, and tightly coiled. The Common Eastern Brown Snake became defensive within its burrow, while the Little Whip Snake began to move slowly into the grassland.

Discussion

The observations reported here are the first report of an aggregation between Little Whip Snakes and Eastern brown snakes since surveys began in 2009 and, to our knowledge, it is also the first field observation of the two species aggregating beneath the same cover within the published literature (Figure 4).

The cause of the aggregation between the two species is beyond the scope of these field observations, and with no existing accounts found in the literature for comparison, the discussion is kept brief. The aggregation between the adult Little Whip Snakes and juvenile Eastern Brown Snakes under the same shelter site, may be an interspecific trophic response, opportunistic or due the appropriate thermal condition of the shelter. However, other causal factors cannot be excluded without further empirical testing. For example, chemical cues, mate guarding or predator avoidance (Scott *et al.* 2013; Doody *et al.* 2013; Fyfe and Booth 1984; Clark 2012; Hoser 1980).

Thermoregulatory requirements of snakes may be related to body size. Larger snakes can control their body temperature more efficiently then smaller sized snakes, which may favour differential use of thermal environments including artificial shelter (Gregory 2004; Leon *et al.* 2019). Both species in the group were of a similar size and the loose spatial arrangement of snakes shown in Figure 4A shows both species in close visual and physical contact. This finding may suggest that the shelter was thermally appropriate for the small sized snakes and the interaction providing some mutual benefits such as heat exchange.

Further, the lack of ground cover habitat (such as soil

cracks, invertebrate burrows) for thermoregulation may be a key driver for the observed aggregative behaviour. At Turallo Nature Reserve, tiles may provide refuge for thermoregulation for snakes (and other reptiles; N A Hansen pers. obs.) during the cooler temperatures overnight and in the morning, compared to the surrounding exposed and open, grassland habitat. Later in the day, the dense tussock-forming grasses such as Kangaroo Grass Themeda australis (Figure 3) surrounding the tiles, or soil cracks and cavities and burrows created by other organisms (Turner 2014; although availability of either in close proximity to tiles are limited; N. A. Hansen pers. obs.) may provide alternative retreat sites when tiles become too hot to maintain critical thermal maximum.

The similarity in body size between the species under the shelter may represent an anti-predator strategy. A cluster of snakes could represent a larger (and more difficult) looking prey item, or greater numbers may maximise predator detection abilities.

Little Whip Snakes may be a potential predator of juvenile P. textilis and were attracted to the shelter site by their scent. However, predation among the species is more likely to occur when one individual is larger than the other. Eastern Brown Snakes occasionally eat other snakes (Gardner *et al*. 2016) and may present a potential key predator of the Little Whip Snake when it becomes an adult. Cannibalism is a clear disadvantage of the aggregation and warrants further investigation.

Little is known about the interactions between the two species and given the potential negative implications on a threatened species survivorship or habitat selection, we suggest experimental studies are needed. A mark-recapture and movement study (e.g. radio telemetry) would clarify the extent of seasonal movements, repeated refuge use, whether the aggregation is non-random and how the dynamic changes over time. The observed patterns presented here represent an important area of research which may be critical to the long-term conservation and management of this threatened species. Little Whip Snakes, in particular, are ideally suited to the suggested demographic studies given their ease of handling, easily locatable and not dangerously venomous (also supported by Turner 2019). Further, given the Little Whip Snake is classified as data-deficient in New South Wales (OEH 2018), a mark recapture study would also be useful in resolving many of the knowledge gaps pertaining to v requirements and population dynamics (OEH 2018a).

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