

The distribution of the threatened Black-striped Burrowing Snake (*Neelaps calonotos*) in the Perth region, Western Australia

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The Black-striped Burrowing snake *Neelaps calonotos* is a small fossorial elapid restricted to the coastal habitats of the Swan Coastal Plain between Dawesville and Port Denison in southwestern Australia. A large portion of its range lies within the Perth region, where rapid urban development and associated habitat loss poses the greatest threat to the continued survival of remaining populations. Consequently, populations have been rendered sparse and uncommon, especially within the southernmost limits of its range. This short appraisal of the currently known distribution of *N. calonotos* within the Perth region indicates further surveys would be helpful to conserve the species and expand our understanding of the species' distribution within an increasingly urbanised environment.

Keywords: *Neelaps calonotos*, elapid snake, threatened fauna, urban development

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INTRODUCTION

The Black-striped Burrowing Snake, *Neelaps calonotos*, (Fig. 1) is one of five species of small burrowing elapids in the Perth region and is listed as 'Priority Three' under State legislation (Department of Parks and Wildlife 2015), whereas the International Union for Conservation of Nature (IUCN) lists it as Near Threatened (Gaikhorst *et al.* 2018). The Priority Three listing according to the Department of Biodiversity, Conservation and Attractions (2019, p. 3) is granted for 'species that are known from several locations', where there exists 'significant remaining areas of apparently suitable habitat, much of it not under imminent threat'.

The biology of *N. calonotos* is not fully understood. Females produce clutches of two to six eggs (Bush *et al.* 2010), with hatchlings captured in late summer and autumn suggesting that eggs are laid in late spring to early summer (Shine 1984; How & Shine 1993; Strahan *et al.* 1998). There are no estimates for population trends or lifespan.

Neelaps calonotos feeds exclusively on small fossorial skinks, such as *Aprasia* and *Lerista* spp., which contrasts with other fossorial elapids that consume a broader and less specific assortment of prey species (Shine 1984; Strahan *et al.* 1998). Reflecting the species' specialised diet is its habitat requirements, preferring *Banksia* woodlands atop soft calcareous sand and, to a lesser extent, coastal heathlands and shrublands (Bush *et al.* 2010; Wilson & Swan 2013). Although relatively abundant in both habitats, How & Shine (1993) recorded higher capture rates of *N. calonotos* in *Banksia* woodlands, which are also the preferred habitat for skinks.

Within the Perth region, the majority of records of *N. calonotos* are from coastal locations, whereas the easternmost records are from Forrestdale Lake Nature

Reserve, Ellenbrook and Melaleuca Park (How & Dell 1994; Maryan *et al.* 2002; Glen Gaikhorst, unpublished data; Appendix 1). As with most other fossorial elapids, *N. calonotos* is absent in the Darling Range, where suitable habitat is scarce and coarse heavy soils prevent the species from efficient burrowing.

Neelaps calonotos is rarely found in small urban bushland remnants—many older records from such locations probably represent now-extinct populations, attributed to the species' preference for mature and fire-resistant habitats (Valentine *et al.* 2012). Smaller bushland remnants are more susceptible to weed infestation, bushfires and predation by feral species (Maryan *et al.* 2015; Gaikhorst *et al.* 2018) with weeds having an adverse effect, which can be amplified by bushfires, on the composition of microhabitats required by fossorial species.

DISTRIBUTION WITHIN THE PERTH REGION

Recent records indicate that *N. calonotos* is more abundant north of the Swan River (Fig. 2), particularly in heathland habitats next to the coast, as well as large undisturbed reserves of *Banksia* woodland farther inland (Arnold *et al.* 1991; How & Shine 1993; Maryan *et al.* 2002). Although the threat of urban development remains in this region, some suitable habitats for the species remain relatively intact, most notably the large expanse of *Banksia* woodland that is relatively continuous between Ellenbrook and Yeal where *N. calonotos* has been recorded (Arnold *et al.* 1991; How & Dell 1994; Maryan *et al.* 2002; Robert Audcent, pers. obs). Though the species prefers *Banksia* woodlands, it is most abundant in the extensive coastal heathlands in reserves north of Alkimos (Glen Gaikhorst, pers. comm., August 2020; Brad Maryan, pers. comm., August 2021). Unfortunately, widespread clearing of this region is planned, threatening to extirpate



Figure 1. *Neelaps calonotos* from Whiteman Park, WA; approximately 25 cm long.

these populations. Beyond the Perth region, *N. calonotos* is considerably more abundant in the vast, undisturbed coastal heathland that extends north to Lancelin, and in an outlying population near Port Denison 300 km north of Perth (Storr *et al.* 2002; Euan Kettle, pers. comm. 2020).

South of the Swan River, in contrast, recent records of *N. calonotos* are scarcer and originate from larger inland reserves such as around Jandakot Airport and Forrestdale Lake Nature Reserve, as well as coastal heathland between Peron and Mandurah (Bamford Consulting Ecologists 2003; GHD Pty Ltd 2014, 2018; Glen Gaikhorst, pers. comm., August 2021; Brad Maryan, pers. comm., August 2021). Whereas little to no suitable habitat remains in these areas due to urban development, there are some older records from reserves where suitable habitat remains, such as Coo loongup Lake, Woodman Point Regional Park and Naval Base (Department of Biodiversity, Conservation and Attractions 2021), warranting further surveys to confirm the species' continued presence.

The southernmost limit of *N. calonotos*'s distribution is typically cited as Mandurah (Storr *et al.* 2002; Wilson & Swan 2013; Gaikhorst *et al.* 2018); however, suitable habitat is now scarce in this region, and it is likely that the Mandurah records represent a now-extirpated population (Gaikhorst *et al.* 2018). A 2009 record from Dawesville, south of Mandurah, currently marks the species' southernmost limit (Department of Biodiversity, Conservation and Attractions 2021).

DISCUSSION

Detecting *N. calonotos* can be a problematic and laborious task, as is common with other small burrowing reptiles that are rarely observed in situ. Pitfall trapping is the most frequently employed method used to survey for small vertebrate fauna, although it has its limitations, especially when it is the sole survey method. During their 11-year pitfall trapping study across 34 locations around Perth, How & Dell (2000) found that capture rates for all five fossorial elapids were relatively low. Other species often were not detected for several years, underpinning the limitations of pitfall trapping and stressing the importance of supplementary search methods, especially when surveys are time constrained, such as those preceding land clearing. Although actively

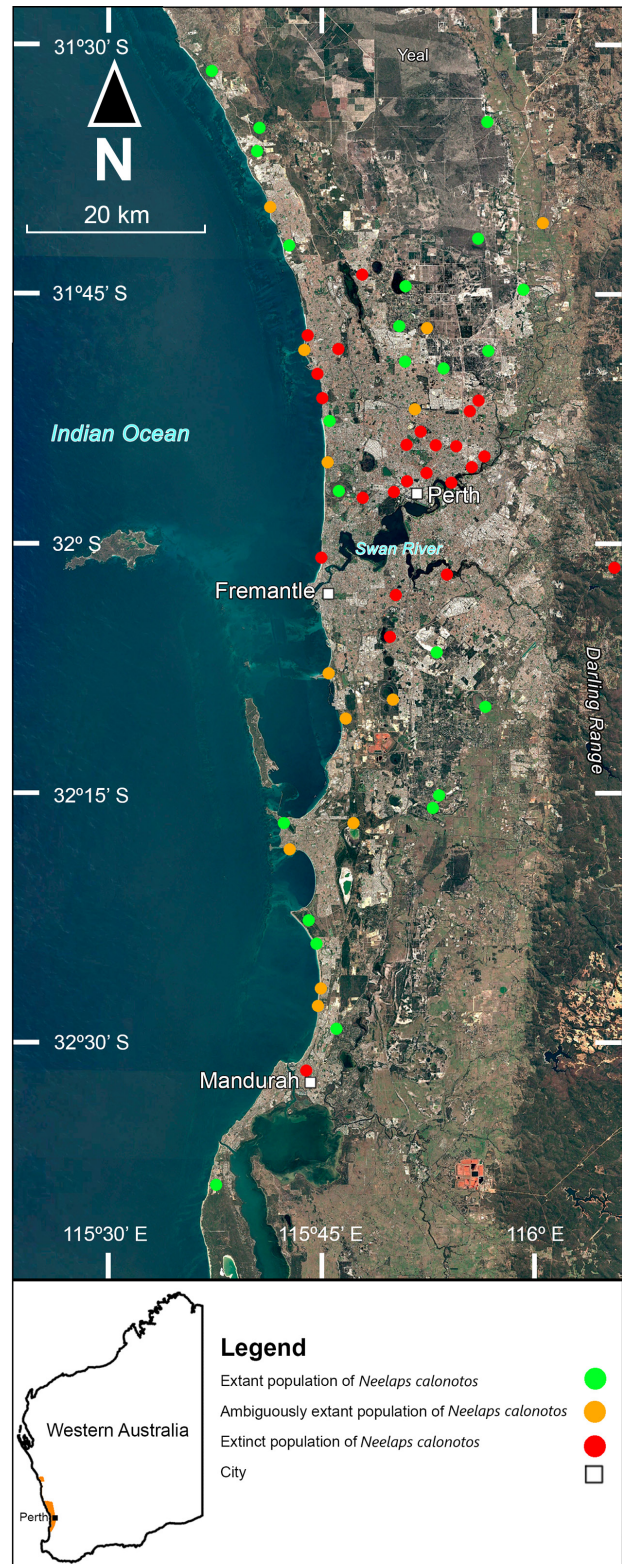


Figure 2. *Neelaps calonotos* populations within the Perth region. Green circles denote likely extant populations confirmed by records after 1990; orange circles, possibly extant populations with records predating 1990, where suitable habitat remains but where further surveying is required to confirm their presence; and red circles indicate populations that are likely extirpated due to urbanisation and land clearing. The species' overall distribution is shown in orange on the inset map. Sources for localities are summarized in Appendix 1.

searching habitats is more laborious, it is also less time-consuming as it relies less on the movement of target species, whereas passive methods such as pitfall trapping are less likely to locate seasonally inactive species. A popular method among both professional and amateur herpetologists is to use a pronged cultivator to rake through spoil heaps, soil mounds and leaf litter, beneath which fossorial reptiles seek shelter (Bush *et al.* 2007; Cogger 2014). This method is particularly productive during cooler months, when most reptiles exhibit decreased levels of activity.

Neelaps calonotos is evidently more abundant north of the Swan River, whereas records are comparatively scarcer to the south. This aspect of its distribution also applies to the four other burrowing elapids in the region of which the Jan's Banded Snake *Simoselaps bertholdi* is the most abundant. This species persists in extremely small bushland remnants north of the river (How & Shine 1993), but is scarce between Perth and Mandurah, even in larger bushland reserves. By comparison, the Narrow-banded Shovelnose Snake *Brachyurophis fasciolatus fasciolatus* is completely absent south of the river, with only two historical records suggesting its previous presence there (Department of Biodiversity, Conservation and Attractions 2021). This may be attributed to more widespread historical urban development south of the river where expansive industrial, residential and agricultural complexes replaced, and thereby destroyed, degraded or fragmented, formerly large bushland reserves. The largest remaining bushland reserves consist primarily of large swamps and lakes, such as the Beelie Wetlands, which are ill suited for fossorial species such as *N. calonotos* and susceptible to heavy pollution due to their proximity to urbanised areas (Department of Conservation and Land Management 2006). In contrast, although urban development is rapidly consuming large bushland remnants north of the river, sizeable expanses of habitat remain intact and protected, such as Trigg Bushland, Melaleuca Park, Whiteman Park and Yanchep National Park, which are recognised for their conservation significance and accordingly protected from development.

With new populations of *N. calonotos* being discovered as a result of recent surveys (GHD Pty Ltd 2014; Glen Gaikhorst, pers. comm. 2020), it is pertinent that surveys should continue, particularly in reserves that have not been extensively investigated recently, such as Naval Base, Leda Nature Reserve, Lakelands and the southernmost network of reserves within Jandakot Regional Park. Regrettably, recent land clearing around Eglinton and Alkimos has destroyed or fragmented bushland where *N. calonotos* was recorded as locally abundant (Glen Gaikhorst, pers. comm., August 2020; Brad Maryan, pers. comm., August 2021), calling into question the value of the species' conservation status to government agencies. Nevertheless, if the species is to be conserved, it is crucial that new extensive and targeted surveys are undertaken to better understand its true extent within the Perth region.

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Appendix 1. All locations within the Perth region where *Neelaps calonotos* has been recorded based on archives from the Western Australian Museum (WAM), and published and unpublished sources, including the year of the most recent record and the current status of each population. Records after 1990 are considered ‘Extant’, whereas those predating 1990 are considered ‘Ambiguous’, if from a suitable habitat, although further surveys may be needed to confirm this. In areas where records predate 1990, and where little or no suitable habitat remains, it is highly likely that the species is now extirpated.

Location name	Latitude & Longitude	Most recent record	Reference/source	Status
Alkimos	31°37'55"S, 115°40'21"E	1998	Glen Gaikhorst, pers. obs.	Extant
Badgerup Lake	31°46'59"S, 115°50'27"E	2015	Thompson (2015)	Extant
Ballajura	31°49'34"S, 115°53'41"E	2005	Brad Maryan, pers. obs.	Extant
Banksia Conservation Reserve	32°15'54"S, 115°52'54"E	2013	GHD Pty Ltd (2014)	Extant
Bassendean	31°54'00"S, 115°57'00"E	1947	Western Australian Museum (R9228)	Extinct
Bateman	32°02'56"S, 115°50'02"E	1979	Western Australian Museum (R62170)	Extinct
Bayswater	31°55'00"S, 115°54'00"E	1950	Western Australian Museum (R9762)	Extinct
Bedford	31°54'26"S, 115°53'28"E	1951	Western Australian Museum (R10154)	Extinct
Beechboro	31°52'00"S, 115°56'00"E	1916	Western Australian Museum (R555)	Extinct
Bibra Lake	32°05'40"S, 115°49'52"E	unknown	Emerge Associates (2015)	Extinct
Bickley	32°00'21"S, 116°05'29"E	1931	Western Australian Museum (R3827)	Extinct
Bold Park	31°56'48"S, 115°45'49"E	1994	How (1998)	Extant
Casuarina	32°15'15"S, 115°53'19"E	2014	Brad Maryan, pers. obs.	Extant
Caversham	31°51'54"S, 115°57'49"E	1936	Western Australian Museum (R5940)	Extinct
Cooloongup Lake	32°17'00"S, 115°47'00"E	1968	Western Australian Museum (R9311)	Ambiguous
Cottesloe	31°59'00"S, 115°45'00"E	1930	Western Australian Museum (R3736)	Extinct
Dawesville	32°38'41"S, 115°37'36"E	2009	Department of Biodiversity, Conservation and Attractions (2021)	Extant
Dianella	31°53'00"S, 115°52'00"E	1969	Western Australian Museum (R34376)	Extinct
Eglinton	31°35'00"S, 115°40'47"E	2020	Brad Maryan, pers. obs.	Extant
Ellenbrook	31°44'42"S, 115°59'04"E	2020	Brad Maryan, pers. obs.	Extant
Embleton	31°54'00"S, 115°54'00"E	1962	Western Australian Museum (R16911)	Extinct
Forrestdale Lake Nature Reserve	32°09'53"S, 115°56'40"E	2020	Brad Maryan, pers. obs.	Extant
Gnangara Lake	31°47'11"S, 115°52'38"E	1983	Western Australian Museum (R88057)	Ambiguous
Inglewood	31°55'09"S, 115°53'10"E	1952	Western Australian Museum (R10598)	Extinct
Jandabup Lake	31°44'24"S, 115°51'21"E	2017	Department of Biodiversity, Conservation and Attractions (2021)	Extant
Jandakot Airport	32°06'30"S, 115°53'08"E	2002	Bamford Consulting Ecologists (2003)	Extant
Landsdale Park Conservation Reserve	31°49'09"S, 115°51'01"E	1994	How & Dell (1993)	Extant
Leederville	31°56'00"S, 115°50'00"E	1923	Western Australian Museum (R967)	Extinct
Madora Bay	32°28'00"S, 115°45'00"E	1977	Western Australian Museum (R30048)	Ambiguous
Mandurah	32°32'23"S, 115°44'25"E	unknown	Wilson & Swan (2013)	Extinct
Maylands	31°56'00"S, 115°54'00"E	1949	Western Australian Museum (R9558)	Extinct
Melaleuca	31°41'54"S, 115°56'30"E	2012	Department of Biodiversity, Conservation and Attractions (2021)	Extant
Mirrabeeka*	31°51'46"S, 115°51'40"E	2012	Department of Biodiversity, Conservation and Attractions (2021)	Ambiguous
Mount Lawley	31°56'00"S, 115°52'00"E	1965	Western Australian Museum (R25362)	Extinct
Muchea	31°35'01"S, 115°57'00"E	1999	Department of Biodiversity, Conservation and Attractions (2021)	Extant
Mullaloo	31°46'48"S, 115°44'00"E	1978	Western Australian Museum (R61769)	Extinct
Naval Base	32°10'40"S, 115°46'46"E	1968	Western Australian Museum (R12312)	Ambiguous
North Beach	31°51'40"S, 115°45'10"E	1959	Western Australian Museum (R13324)	Extinct
Padbury	31°49'00"S, 115°46'00"E	1986	Western Australian Museum (R96383)	Extinct
Parklands	32°29'11"S, 115°46'00"E	2011	Department of Biodiversity, Conservation and Attractions (2021)	Extant

Appendix 1 (cont.)

Location name	Latitude & Longitude	Most recent record	Reference/source	Status
Pearce	31°40'44"S, 116°00'34"E	1960	Western Australian Museum (R13439)	Ambiguous
Peron	32°16'57"S, 115°42'19"E	2014	Brad Maryan, pers. obs.	Extant
Port Kennedy Scientific Park	32°22'34"S, 115°44'00"E	2012	Brad Maryan, pers. obs.	Extant
Quinns Rocks	31°41'00"S, 115°42'00"E	1967	Western Australian Museum (R29017)	Ambiguous
Riverton	32°02'00"S, 115°53'00"E	1958	Western Australian Museum (R12720)	Extinct
Safety Bay	32°18'19"S, 115°42'45"E	1968	Western Australian Museum (R6888)	Ambiguous
Scarborough	31°53'00"S, 115°46'00"E	1970	Western Australian Museum (R36158)	Ambiguous
Secret Harbour	32°23'57"S, 115°44'35"E	2019	Anonymous pers. obs.	Extant
Shenton Park	31°56'59"S, 115°48'06"E	1936	Western Australian Museum (R6054)	Extinct
Singleton	32°27'00"S, 115°45'00"E	1977	Western Australian Museum (R62263)	Ambiguous
Sorrento	31°49'00"S, 115°45'00"E	1971	Western Australian Museum (R40287)	Extinct
Tamala Park	31°42'06"S, 115°42'31"E	2015	Brad Maryan, pers. obs.	Extant
Trigg Bushland	31°52'42"S, 115°45'18"E	1995	How & Dell (1993)	Extant
Wanneroo	31°45'00"S, 115°48'00"E	1982	Western Australian Museum (R81980)	Extinct
West Perth	31°57'00"S, 115°50'00"E	1947	Western Australian Museum (R9176)	Extinct
Whiteman Park	31°48'16"S, 115°56'52"E	2021	pers. obs. 2021	Extant
Whitfords Beach	31°48'23"S, 115°43'45"E	1971	Western Australian Museum (R25065)	Ambiguous
Woodman Point Regional Park	32°07'53"S, 115°45'33"E	1965	Western Australian Museum (R25065)	Ambiguous
Yanchep	31°32'01"S, 115°38'47"E	2005	ATA Environmental (2007)	Extant
Yokine	31°54'00"S, 115°51'00"E	1954	Western Australian Museum (R11264)	Extinct

* This relatively recent record is from a private property rather than a reserve; although unconfirmed, *N. calanotos* may be present in nearby bushland remnants.