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INTRODUCTION

The elapid genus *Pseudonaja* Günther, 1858 comprises nine species (COGGER 2014) of variably-sized (total length 0.5-2.0 m), highly visible, fast-moving, diurnally active, oviparous predators of primarily vertebrate prey, mainly small mammals and reptiles (SHINE 1991), and including other snakes (O'SHEA & WILLIAMS 2009; SHINE 1989). Collectively known as the "brown snakes," although not all specimens have a brown body color, they are highly venomous, and several species are amongst the most medically important snakes on continental Australia, being responsible for a large proportion of Australian snakebite morbidity and mortality (WHITE 1995, 2000).

From a medical standpoint, the most important species are the Eastern brown snake, *Pseudonaja textilis* (Duméril, Bibron &

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Duméril, 1854), the Western brownsnake or Gwardar¹, *P. mengdeni* Wells & Wellington, 1985, the Northern brownsnake, *P. nuchalis* Günther, 1858, and the Dugite, *P. affinis* Günther, 1872 (CURRIE 2000, 2004; JELINEK & BREHENY 1990; YEUNG *et al.* 2004). The combined range of all nine *Pseudonaja* species encompasses almost the entirety of continental Australia, with the exception of the far northern tropical Cape York Peninsula, and extreme southeastern Victoria. The genus is absent from Tasmania, which is inhabited by three ovoviviparous cold-adapted elapid genera (*Austrelaps*, *Drysdalia* and *Notechis*). Brownsnakes of the genus *Pseudonaja* demonstrate a marked preference for dry, well-drained habitats and avoid wetlands or closed-canopy forests (WILSON & SWAN 2013). The genus would, therefore, seem to be an unlikely inhabitant of the lush, wet, tropical island of New Guinea.

CHRONOLOGICAL HISTORY OF *PSEUDONAJA* IN NEW GUINEA

The presence of the genus *Pseudonaja* in New Guinea, and the means by which it came to occur on the world's largest tropical island, has been the subject of considerable discussion over the past half-century (CAMPBELL 1969; KUCH & YUWONO 2002; LALLOO 1994; O'SHEA 1990, 1996; SLATER 1968; WILLIAMS *et al.* 2008; WILLIAMS & WÜSTER 2005). Whilst the distribution of *P. textilis* may be fairly contiguous across eastern continental Australia, the taxon appears to occur in two main blocks in southern New Guinea, separated by the heavily forested river deltas and mangrove swamps of Gulf Province, which should be considered suboptimal habitats for this species. It is also not as visible in its human interactions in New Guinea as it is in Australia, and thus a theory of human-mediated introduction, with snakes occurring only in isolated pockets and near human settlements, held sway for many decades.

¹ The Western brownsnake or Gwardar was originally known as *P. nuchalis* but that taxon is now confined to the north of its former range, where it is correctly known as the Northern brownsnake. The species occupying the remainder of its former range, in western and central Australia, is now recognized as *P. mengdeni* and therefore the names Western brownsnake or Gwardar should be attributed to this taxon, *fide* COGGER (2014) and WILSON & SWAN (2013).

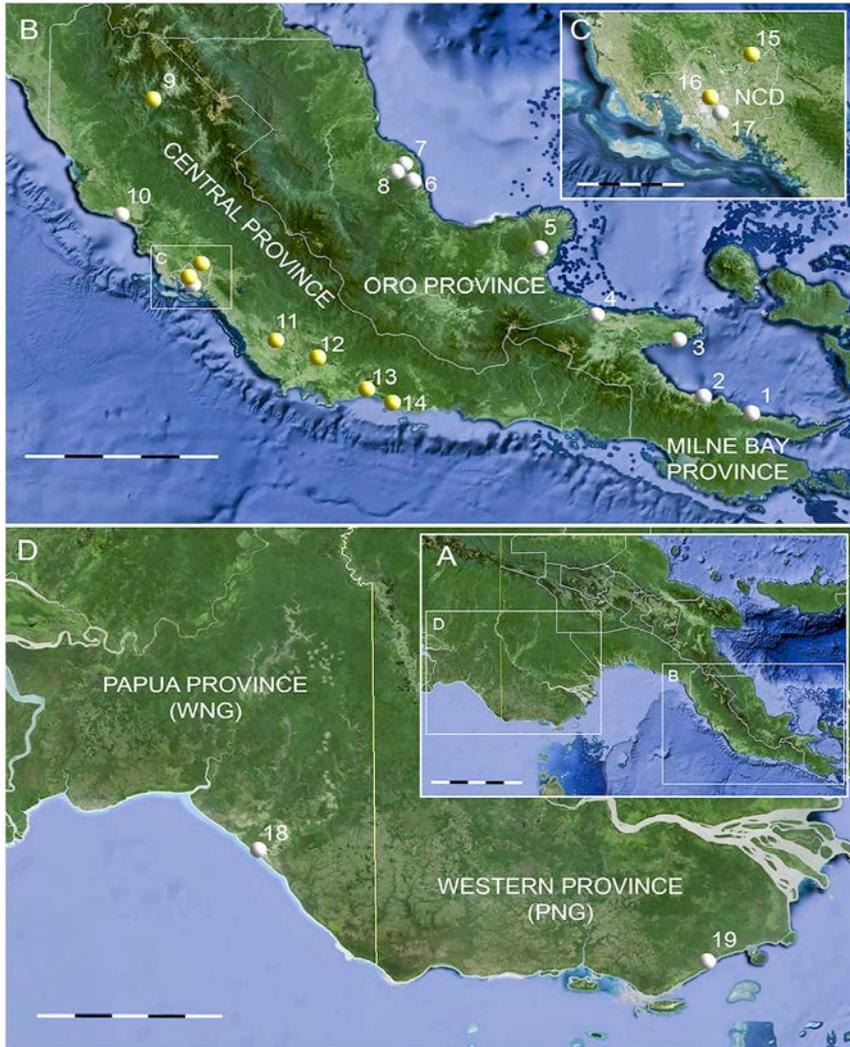


Fig. 1 - (A) Map of Eastern New Guinea. Scale = 300 km. (B) Map of Papuan Peninsula. Localities are identified by numbers as follows: Milne Bay Province: 1=Wamawamana; 2=Dogura; 3=Menapi, Cape Vogel; 4=Baiawa, Moi Biri Bay. Oro Province: 5=Ajoa, Mt Victory; 6=Embogo; 7=Heropa mini-estate; 8=Parahe mini-estate. Central Province: 9=Tapini; 10=Hisui; 11=Kwikila; 12=Imairu; 13=Kupiano; 14=Kapari. Scale = 120 km. White circles: specimen localities; yellow circles: ELISA results. (C) Map of National Capital District. 15=Goldie River; 16=9-Mile; 17=6-Mile. Scale = 20 km. (D) Map of Southern Trans-Fly. Papua Province: 18=Merauke. Western Province: 19=Katau (= Mawatta on the Binaturi River). Scale = 120 km.

A. *PSEUDONAJA* ON THE PAPUAN PENINSULA (Figs. 1B-C)

To date, the earliest specimens of *Pseudonaja textilis* to document its presence in New Guinea are two specimens obtained from villagers by Geoffrey M. Tate, general zoological collector on the Fourth Archbold Expedition² of 1953. They comprise a female (AMNH³ R-73949) from Menapi, Cape Vogel (Camp 1 of the expedition; 21 March-5 May 1953), and a male (AMNH R-73959) from Baiawa, Moi Biri Bay (Camp 2; 27-30 March 1953). Both localities are on the northern coast of the Papuan Peninsula in what was then Milne Bay District, now Milne Bay Province, Papua New Guinea (PNG). However, their identities and importance were not recognized until they were later examined by MCDOWELL (1967). Certainly, Lionel J. Brass, the 4th Archbold Expedition leader and chronicler made no mention of them in the expedition's official report (BRASS 1956), despite commenting on several pythons, *Morelia* (now *Simalia*) *ame-thistina* (Schneider, 1801) and a keelback, *Tropidonophis picturatus* (Schlegel, 1837) from Mt. Dayman.

There was one earlier, pre-MCDOWELL, mention of *Pseudonaja* from New Guinea, which remains unconfirmed. In 1961, Eric Worrell, owner of the Australian Reptile Park located at Gosford, New South Wales, Australia, received a live specimen of *P. textilis* from "Papua" misidentified by the shipper as a Papuan black-snake (*Pseudechis papuanus* Peters & Doria, 1878). In the subsequent fourth edition of his handbook "Dangerous Snakes of Australia and New Guinea" (WORRELL 1961), the author incorrectly reported that *P. textilis* occurred in the "Highlands" of New Guinea. None of WORRELL's live specimens appear to have survived as vouchers, so this identification cannot be confirmed.

Several additional records from southeastern New Guinea emerged during the late 1960s. The agriculturist and herpetologist

² The Archbold Expeditions were a series of seven expeditions to New Guinea, and one to Queensland, Australia, between 1933-1964, with a long hiatus due to the Second World War. The first three expeditions in the 1930s were led and funded by the millionaire philanthropist Richard Archbold (1907-1976), in collaboration with the American Museum of Natural History, which supplied specialist staff and received the specimens.

³ Museum acronyms used in this paper are taken from SABAJ PÉREZ (2014), except AVRU-UPNG which refers to the Australian Venom Research Unit based in the Medical Faculty of the University of Papua New Guinea.

Ken Slater included *Demansia textilis textilis* in the second edition of his "Guide to the Dangerous Snakes of Papua" (SLATER 1968), reporting that the specimens came from a population at Dogura, Milne Bay Province, PNG. He concluded that it was likely "that a batch of eggs was transported from Australia either in war-time equipment or in post-war agricultural produce". This was the first mention of a human introduction mechanism for New Guinea *Pseudonaja*, a concept that prevailed unquestioned for several decades.

A specimen from Dogura was received in Port Moresby in 1965 and sent to Harold Cogger at the Australian Museum, where it was duly identified, although this specimen cannot now be located in the collection. The Australian physician Charles Campbell mentioned this specimen, and two other specimens he obtained at Dogura (AM R.25774-75), in his doctoral thesis on Papuan snakebite (CAMPBELL 1969). He also mentioned a decapitated head from Embogo Mission Hospital (AM R.25880), the first record of the genus from Oro Province (then Northern District), PNG. There are also two Dogura specimens in the National Museum and Art Gallery of PNG, Port Moresby (PNGM 5324, 22295).

This small set of specimens, from Milne Bay and Oro Provinces, constitutes the last series to be collected or identified for some decades, the emerging picture being of a localized population on the northern coast of the Papuan Peninsula, in a region where several prolonged and bloody battles of the Second World War had been fought (e.g., Battle of Milne Bay, August-September 1942; Battles of Buna, Gona, and Sanananda, November 1942-January 1943) with the concomitant deployment of military equipment, and which was probably followed by post-war importation of agricultural machinery. The well-documented story of how the Brown treesnake, *Boiga irregularis* (Bechstein, 1802), arrived on Guam as a consequence of military equipment being transshipped to the island from New Guinea and the Solomon Islands, to await onward shipping to the continental United States (BURDICK 2005; JAFFE 1994; RODDA *et al.* 1999), added credibility to the theory that *P. textilis* reached the Papuan Peninsula from Australia via similar human-mediated means. This scenario appeared to be further supported by the apparent absence of *P. textilis* from the savannas around

Port Moresby, where it would have been expected to occur had the Milne Bay and Oro populations been part of a naturally occurring Australo-Papuan population.

Contradicting the lack of evidence from specimens, it was suspected that *P. textilis* might occur on the southern coastal savannas of the Papuan Peninsula based on an analysis of snakebite data. Snakebites evaluated in Central Province (Goldie River, Tapini⁴, Kapari, and Imairu) and at 9-Mile, in the National Capital District (NCD), all PNG, produced five ELISA⁵ results positive for *Pseudonaja* (LALLOO 1994). This author also suspected that snakebites at Kwikila and Kupiano, in Central Province southeast of Port Moresby, may also have been caused by *P. textilis*. It therefore appeared that a southern coastal population should exist, and all that was lacking was a confirmed specimen (O'SHEA 1996).

The first confirmed southern coastal specimen of *P. textilis* (PNGM 24583) was located by Mark O'Shea and David Williams in 1996. It had been collected at 6-Mile in the outskirts of Port Moresby and misidentified as a taipan, *Oxyuranus scutellatus* Peters, 1867 (O'SHEA 2008). A decapitated head (PNGM 25305) from Hisiu, approximately 60 km northwest of Port Moresby was also located in the same collection. In 1992 O'Shea had interviewed an Australian expatriate living at Hisiu, who reported encountering two snakes in his garden, one of which advanced on him adopting the classic *Pseudonaja* elevated-S posture. He killed the snake with a bush-knife while the other escaped. It is possible that this is the origin of the museum voucher. Four further snakebites caused by *P. textilis* were detected by David Williams, using the Snake Venom Detection Kit (SVDK), Commonwealth Serum Laboratories, Melbourne, Victoria, Australia, amongst patients reporting at Port Moresby General Hospital in 2006 (WILLIAMS *et al.* 2008). From the two PNGM speci-

⁴ Tapini is located at 945 m elevation in the Owen Stanley Range, which would seem high for *Pseudonaja textilis*, although WALLACH *et al.* (2014) provided elevations of 0-1235 m for *P. textilis*.

⁵ ELISA = Enzyme-linked immunosorbant assay, a means of determining the identity of venom in samples of blood or urine from snakebite victims, pioneered by the Liverpool School of Tropical Medicine (LSTM), United Kingdom and introduced as a Snake Venom Detection Kit (SVDK) for clinical use by the Commonwealth Serum Laboratories, Melbourne, Australia. Lalloo's ELISA tests were conducted by Dr David Theakston at LSTM.

mens, the ELISA results, and the anecdotal evidence it is clear that *P. textilis* is present on the southern coast of the Papuan Peninsula, but has long been overlooked. It appears to occur over a distance of at least 200 km (Kapari to Hisui), even if the high elevation Tapini ELISA result is excluded.

In recent years further specimens were collected on the north coast of the Papuan Peninsula, three specimens at Wamawamana, Milne Bay Province, in 2008 by Louisiana State University herpetologist Christopher Austin (LSUMZ 90636–37, AVRU-UPNG PT001), and three specimens (AVRU-UPNG PT002–04), from six sighted in an oil palm mini-estate at Heropa, Oro Province, by O’Shea, also in 2008. Another specimen was collected at the nearby Parahe mini-estate, Oro Province, in 2009 by David Williams and Owen Paiva from the Australian Venom Research Group, University of Melbourne. These specimens were collected for the antivenom research program and were not vouchered as museum specimens.

B. *PSEUDONAJA* IN THE SOUTHERN TRANS-FLY (FIG. 1D)

Although encounters with *P. textilis* are still relatively rare events in PNG, the situation in the Southern Trans-Fly around Merauke, southeastern Papua Province, West New Guinea (WNG), seems to be different. The Fly River has its origin in the Star Mountains on the Western Province-Sandaun Province border in the Central Cordillera of New Guinea. From there it flows south and then southeast, for part of its journey delineating the border between PNG and adjacent Indonesian West New Guinea, across a huge low-lying flood plain, the largest area of seasonally-flooded savanna, swamps, and monsoon forest on the island of New Guinea. The Southern Trans-Fly section of this lowland is primarily savanna and seasonally flooded grassland that exhibits a climate similar to that of northern Australia. It covers an area of 26,600 km² (WIKRAMANAYAKE *et al.* 2002), from the Bian River, Papua Province, Indonesia, to the Fly River delta, Western Province, PNG, and inland to the Fly-Strickland confluence and Lake Murray. Most of this habitat would appear to be suitable for *P. textilis*, just as it is for many other taxa shared between northern Australia and southern Papua. Amongst the elapids, this diversity includes the genera *Acanthophis*, *Cryptophis*, *Demansia*, *Furina*, *Oxyuranus*, and *Pseudechis*.

Pseudonaja textilis was first formally recorded as present around Merauke, southeastern Papua Province, Indonesian West New Guinea, by KUCH & YUWONO (2002) who also reported that since 1993 numerous specimens of *P. textilis* had been collected around Merauke for the live reptile trade, with the second author reportedly having kept 40 live specimens from the Merauke region in his collection between 1993-2000, while a further ten live specimens from the same locality were reportedly housed in Germany. The specimen they deposited in the Senckenberg Museum, Frankfurt, Germany (SMF 81544) cannot now be located (Linda Acker, pers. comm.), although J. Scott Keogh deposited two Merauke specimens in the Australian Museum, Sydney in 1995 (AM R.147652, R.147659). The population around Merauke would appear to be relatively large and healthy and, importantly, unlikely to have been influenced by shipment of arms, armour, or agricultural equipment from continental Australia before, during or after the Second World War. It is worth mentioning that the Southern Trans-Fly Region in Western Province, PNG, is sparsely populated in comparison with the corresponding region across the border in Indonesia⁶, where development and large-scale rice-paddy irrigation in the rural and suburban areas probably brings the populace into contact with snakes more frequently than the riverine-coastal-dwelling hunting, fishing, and gardening population of Western Province.

At least 60% of the suitable Southern Trans-Fly habitat lies in Western Province, PNG, yet there have been no records of *P. textilis* from the province, despite the extensive collections made by the "kiap"⁷ Fred Parker between 1968-1973, which were deposited in the Museum of Comparative Zoology (MCZ), Cambridge, Massachusetts, the American Museum of Natural History (AMNH), New

⁶ The 2001 census for the South Fly, Western Province, PNG, obtained a population of 59,152 in an area of 31,864 km², a density of 1.9 people per km² with approximately 33% (20,053 in 2013) living on Daru Island. The 2014 census of the Merauke Regency, Papua Province, Indonesia, returned a population of 240,826 in 44,071 km², a density of 5.5 people per km², with 87,634 people living in Merauke city (2010 census), a product of the Indonesian Trans-Migration program.

⁷ "Kiap", a Tok Pisin word derived from the German word "Kapitän", used to describe a pre-Independence Government Patrol Officer, usually an Australian.

York, New York, and the California Academy of Sciences (CAS), San Francisco, California. PARKER (1982), in his “Snakes of Western Province”, wrote (p. 11): “The Australian Brown Snake, *Pseudonaja textilis*, [...] has been recorded from a few localities in the Northern and Milne Bay Provinces, as well as being widespread in Australia. However, it has never been found along the south coast of New Guinea. It would therefore seem to have been introduced from Australia, probably during the Second World War”.

We here present information regarding the earliest voucher specimen of *P. textilis* from the Southern Trans-Fly of Western Province, PNG, a specimen that pre-dates all other known New Guinea vouchers for the taxon by almost eighty years, and which also pre-dates the 1942 Japanese invasion of New Guinea and the subsequent conflict by seventy years, providing absolute confirmation that populations of *P. textilis* are naturally occurring in New Guinea.

RESULTS

THE FIRST WESTERN PROVINCE SPECIMEN OF *PSEUDONAJA TEXTILIS* AND ALSO THE FIRST SPECIMEN OF THE TAXON COLLECTED IN NEW GUINEA

During a visit to the Museo Civico di Storia Naturale, Genova (MSNG), Italy in November 2015, the senior author was invited to examine a small snake specimen to confirm its identity. Despite severe head trauma this specimen (MSNG 54621; Fig. 2) could be readily confirmed as a juvenile specimen of *Pseudonaja textilis*.

The specimen had been collected by the Italian explorer-naturalist Luigi Maria D’Albertis (1841-1901) at “Katau” and was accessioned into the Genoa collection in 1876. Katau, or Katow⁸, is the name of a river, now known as the Binaturi River, a small tidal river that flows into the Torres Strait 25 km W of Daru Island.

⁸ D’ALBERTIS (1880) used “Kataw” when he wrote about this locality. He referred to the provisions and guides as coming from Moatta but he referred to the locality where he was based as Kataw, probably because his expeditions was moored off-shore, in the mouth of the Katau (Binaturi) River, and not quartered in Moatta village.

D'Albertis used a settlement at the mouth of the Kataw, which he called Moatta (now Mawatta, Fig. 1D, locality 19, 9°7'53" S, 142°57'12" E, elev. 2-3 m), as a re-provisioning stop, and to hire guides, for his voyages up the Fly River (D'ALBERTIS 1880).

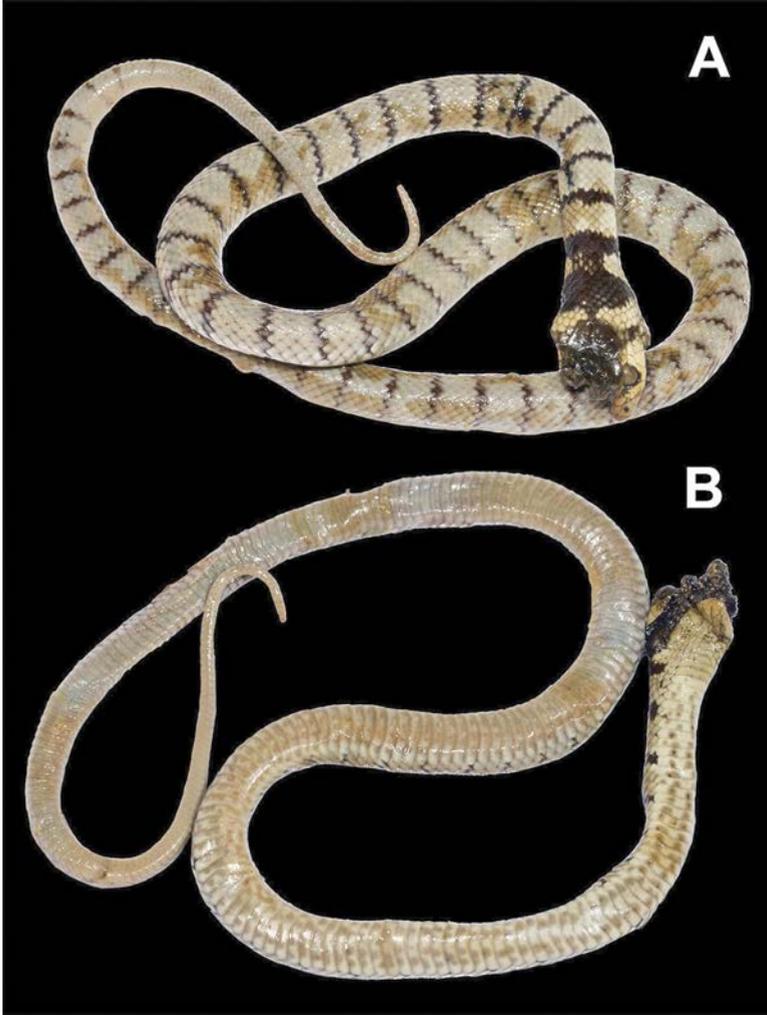


Fig. 2 - The juvenile *Pseudonaja textilis* (MSNG 54621), collected by Luigi Maria D'Albertis in 1876. (A) Dorsal view of body showing black banding, cap and nape markings. (B) Ventral view of body showing 216 ventrals and 68 paired subcaudals.

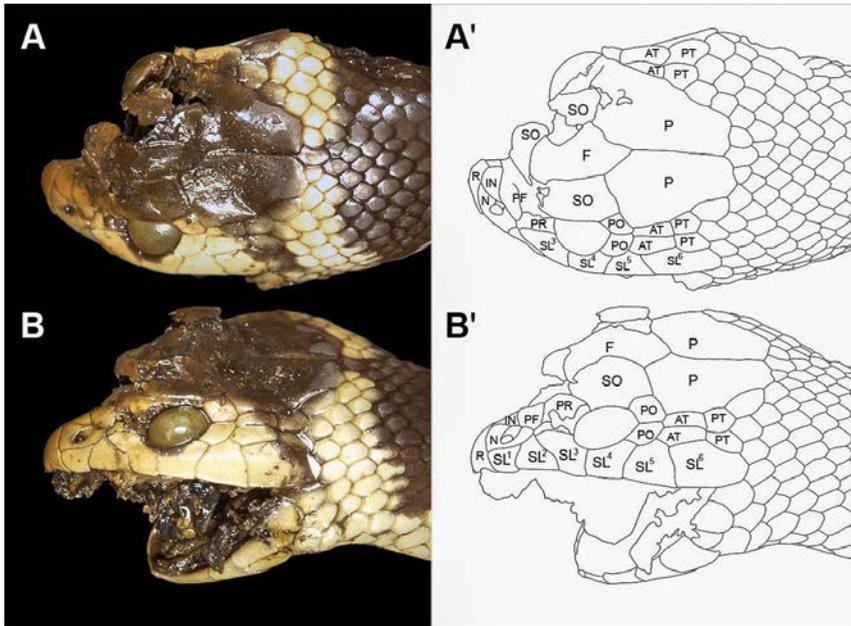


Fig. 3 - Detailed views of the dorsal and lateral scalation of the head of a juvenile *Pseudonaja textilis* (MSNG 54621), presented as photographic and labeled line drawings for clarity. (A, A') Dorsal view. (B, B') Left lateral view (usual right side too damaged for use). Dorsal and lateral head scutes visible: paired anterior temporals (AT), frontal (F), paired internasals (IN), nasal (N), paired parietals (P), paired prefrontals (PF), paired postoculars (PO), single preocular (PR), paired posterior temporals (PT), rostral (R), six supralabials (SL¹-SL⁶) with 3rd-4th contacting orbit.

MSNG 54621 is an unsexed juvenile (314 mm snout-vent length + 63 mm tail length = 377 mm total length) that exhibits the classic juvenile banding of *P. textilis* (Figs. 2A, B)⁹. The head is severely crushed but it exhibits the black cap present in juvenile *P. textilis* and also the broad black band across the neck (Fig. 3A, A', B, B'). The patterning is strikingly similar to that of the juvenile *P. textilis* illustrated by COGGER (2014: 928) and to one

⁹ MSNG 54621 appears to be the only specimen of *P. textilis* originating from New Guinea that exhibits the juvenile livery.

we illustrate herein from Agnes Bank, Sydney, New South Wales, Australia (Fig. 4).

Scale characteristics for MSNG 54621 include 17-17-15 middorsal scales, enumerated at one head length posterior to the head, at midbody, and one head length anterior to the cloaca; 216 ventrals; divided cloacal plate; 68 paired subcaudals; 6 supralabials (left side only, right side damaged), with the 3rd-4th supralabial contacting the orbit. The absence of a temporolabial scale distinguishes *Pseudonaja* from all other terrestrial Papuan elapids except *Toxicocalamus*. The observed pholidosis conforms to descriptions of *P. textilis* in every respect except one. The specimen MSNG 54621 possesses two narrow anterior temporal scales on both sides of the head (Fig. 3A, A', B, B'), but all other Papuan *P. textilis* examined, from Oro and Milne Bay Provinces, and the National Capital District (NCD), PNG, exhibit only a single anterior temporal. A single anterior temporal was also noted in all photographs of living Papuan *P. textilis* available, including a specimen from Merauke, Papua Province, WNG.



Fig. 4 - Juvenile *Pseudonaja textilis* from Agnes Bank, Sydney, New South Wales, Australia, illustrating black banding, cap and nape markings. Photograph by David Nixon.

WHERE DID D'ALBERTIS OBTAIN THE JUVENILE *PSEUDONAÏA TEXTILIS* (MSNG 54621)?

Luigi Maria D'Albertis (Fig. 5A) visited Kataw/Moatta five times. His first visit was in 1875 (2-3 December), at the start of his first ascent of the Fly River aboard the SS *Ellengowan* with the Reverend Samuel MacFarlane of the London Missionary Society.

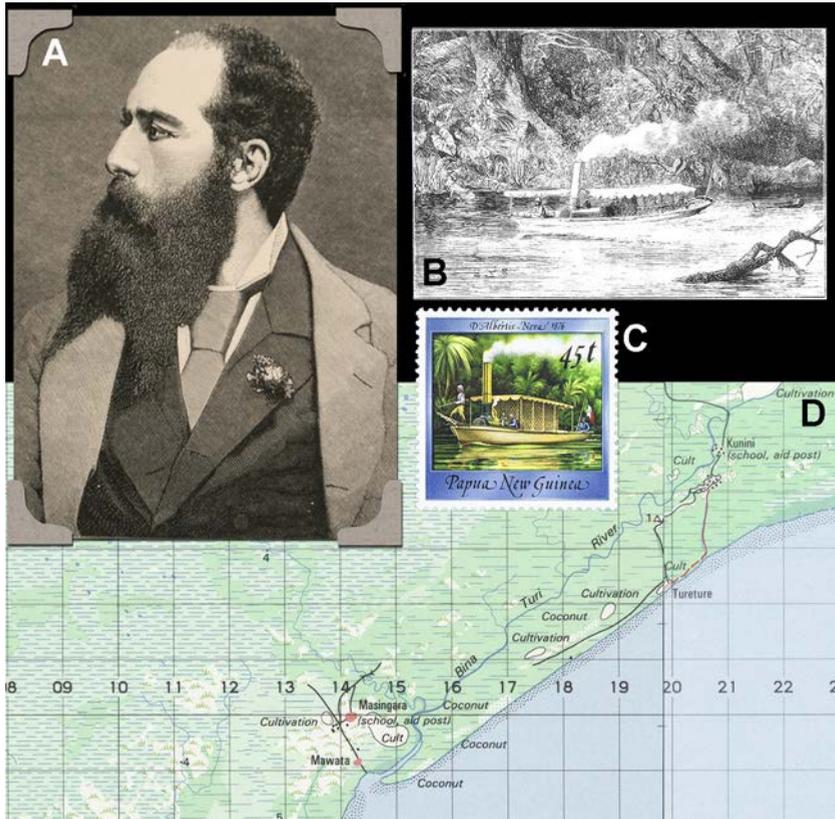


Fig. 5 - Luigi Maria D'Albertis and his research vessel the *Neva*. (A) Luigi Maria D'Albertis (1841-1901). (B) An artist's impression of D'Albertis aboard the steam launch *Neva*, on the Fly River. (C) 1987 45t Papua New Guinea postage stamp of D'Albertis and the *Neva* on the Fly River, in 1876, from the series of 15 stamps commemorating the captains and their ships that explored New Guinea during the 16th-19th Centuries. (D) Map of the Binaturi River showing the current locations of Mawatta, Masingara, Tureture, and Kunini. Royal Australian Survey Corp. 1981 Series T601. Composite map from sheets 7479 Saibai & 7579 Daru. Scale: 1:100,000. 1 km square grid.

It seems unlikely that any specimen collecting could have been achieved during this brief stop, the purposes of which were expedition re-provisioning and the hiring of guides.

In 1876 D'Albertis returned to New Guinea to make his second ascent of the Fly River, this time in command of his own vessel, a nine-tonne Australian steam launch he had christened the *Neva*. As previously, he visited Moatta at the beginning of his expedition, but again the visit was brief (21-22 May). However, his return to Moatta, at the end of the expedition, resulted in a much longer stay (7 August-3 November) and it seems that this was when he carried out most of his "Katau" specimen collecting.

In 1877 D'Albertis made his third ascent of the Fly River, again aboard the *Neva*, and again with stops at the beginning (18-19 May) and end (23 November-5 December), of the expedition. Although his final sojourn at Moatta lasted almost two weeks, and he did conduct some collecting, specimen MSNG 54621 was accessioned into the Genoa collection in 1876 and could not have been collected on D'Albertis's third expedition.

D'Albertis's launch, the *Neva*, (Figs. 5B, C) had a draft of only 1.2 m, and it often had difficulty navigating the tidal Kataw as far as Moatta (Fig. 5D). According to his own record (D'ALBERTIS 1880) he only made two brief excursions up the Kataw itself: a journey of 2 miles (3.2 km) using "little more than a third of a canoe" on 17 September 1876, "to try fishing with dynamite", and one of 3 miles (4.8 km) on 3 November 1876¹⁰, aboard the *Neva* when he ran aground and was forced to overnight, although he did remark that "[t]he forest here is richer in insects than near Moatta, and I made a nice collection".

It therefore seems likely that herpetological specimens collected and labeled "Katau" did not originate from these short trips upstream, and given that he collected in the riverine forest, the habitat is entirely unsuited for *P. textilis*. Indeed, D'Albertis does not mention any village on the Kataw other than Moatta at its mouth, yet today the largest village in the area is called Kunini (Fig. 5D), located approximately 10 km upstream on the Binaturi River, and it seems unlikely that no settlement existed there in the 1870s. D'ALBERTIS (1880) did mention the village of Tureture (Fig. 5D),

¹⁰ D'ALBERTIS (1880) chronology of this excursion is a little confused because the dates of his notes run November 3rd, 1st, 2nd, 4th.

which is approximately 7 km east of Moatta along the coast, but less than 2 km south of Kunini today. Our conclusion is that these short excursions up the Kataw/Binatari, were either fishing expeditions, in the literal sense, or insect, rather than reptile, collecting trips.

Mawatta (Moatta) is located within 100 m of the shoreline where the Binatari (Kataw) River enters the Torres Strait (Fig. 6A). Most of the villages in the southern Trans-Fly are located either along the coast (e.g., Tureture), or on the rivers (e.g., Kunini and Girigarande; Fig. 6B) and many are subject to extensive and prolonged periods of flooding during the wet season (December-May). D'Albertis's 1875 and 1876 visits to Kataw/Moatta took place at the beginning and end of the wet season and in the middle of the following dry season. The habitat directly behind the beach, and on the lower reaches of the rivers, often comprises mangrove or monsoon forest (Fig. 6C), and further inland the coastal rivers are fringed by gallery forest (Fig. 6D). The habitat where D'Albertis made his Kataw insect collecting trip (3 November 1876) was probably very similar to that illustrated in Fig. 6C, and clearly unsuitable for *P. textilis*. Large stands of paperbark trees (Fig. 6E) are flooded throughout the wet season, when they would also be unattractive habitats for *P. textilis*, but other southern Trans-Fly habitats are suitable for reptiles with a preference for dry, open-canopy habitats. These include huge swathes of eucalypt-dominated savanna-woodland (Fig. 6F) and kunai grassland (Fig. 6G), with termitaria (Fig. 6H) that are similar to habitats in northern Australia.

During his lengthy stay at Kataw, at the end of his second Fly River expedition, D'ALBERTIS (1880) made several references to being visited by "bushmen" (villagers from the interior), from Matzingare (now Masingara), a village he wrote was "about ten miles [16 km] from Kataw". Today Masingara is little more than 1 km N of Mawatta¹¹ but it does lie on the edge of open eucalypt savanna-woodland country (Fig. 6F-H), which would be more suitable for the presence of *P. textilis*.

D'ALBERTIS wrote:

(p. 200) *October 16th*. "About 200 natives of Matzingare arrived at Moatta to-day. Some of these Bushmen brought me some

¹¹ Villages in New Guinea frequently move but retain their old names.



Fig. 6 - Habitats in the Southern Trans-Fly: (A) Mawatta (= Moatta) in 1986, 110 years after L. M. D'Albertis visited and collected the juvenile *Pseudonaja textilis* (MSNG 54621). (B) Village habitat, Kunini 8.5 km NE of Mawatta on the Binaturi River, dominated by coconut palms (*Cocos nucifera*) and screw palm (*Pandanus*) and subject to extensive annual flooding. (C) Monsoon forest and mangrove forest S of Oriomo, dominated by sea poison tree (*Barringtonia asiatica*) and mangroves (*Rhizophora*). (D) Gomoni Creek, Girigarande, gallery forest. (E) Seasonally flooded freshwater swamp habitat near Girigarande, dominated by paperbark trees (*Melaleuca*). (F) Savanna woodland habitat near Girigarande 9.5 km NNE of Mawatta, dominated by gum trees (*Eucalyptus*). (G) Extensive kunai grasslands (*Imperata cylindrica*) near Oriomo, 40 km NNE of Mawatta. (H) Large termitaria, offering shelter to reptiles, abound in the southern Trans-Fly.

fine reptiles, for which I immediately paid with tobacco.” (p. 203) *October 17th*. “Attracted by the smell of tobacco, [...] the natives of Matzingara come to me every day, bringing animals, especially reptiles.”

(p. 204) *October 17th*. “Meanwhile, my collection of reptiles is increasing; specimens like those I found at Naiabui and Yule Island, which I have previously described, but which were lost in the shipwreck, often come into my hands.”

(p. 204) *October 26th*. “During the last few days I have continued to receive specimens from the people of Matzingare.”

The villagers of Moatta became jealous of the Matzingare villagers’ trading with D’Albertis and they set out to prevent any further interaction with threats of violence to their neighbours, the result being that the supply of reptile specimens dried up, and being virtually unable to inspire the Moatta villagers to supply specimens, and unable or unwilling to make an expedition to the savanna habitat himself, he wrote:

p. 206 *November 3rd*. “Seeing that the weather is becoming calm, and that without the help of the Bushmen I can do little towards my collection, I thought to-day that it was time to get the “Neva” in readiness for her return voyage.”

It seems highly likely, therefore, that D’Albertis’s juvenile *P. textilis* originated from the vicinity of Matzingare (= Masingara) village to the N of Moatta (= Mawatta). The condition of the specimen, head crushed flat with stones and dirt embedded in the mouth, also suggests that the specimen was killed by someone who did not have an immediate interest in it as a valued biological specimen. That someone may then, as an after-thought, have supposed to exchange it for tobacco with the Italian naturalist moored off Moatta.

DISCUSSION

The presence of this juvenile specimen, the first in juvenile livery, collected 140 years ago, pre-dates all other specimens of this taxon collected in New Guinea. Its age provides direct evidence to support the argument put forward by KUCH & YUWONO (2002) and WILLIAMS *et al.* (2008) that New Guinea populations of *P. textilis*

did not originate as circum-World War II introductions from Australia, but rather constitute widely distributed, albeit discrete and fragmented, naturally occurring populations.

Today shallow seas separate northern Australia from southern New Guinea, which are both located on the Sahul Shelf, but this has not always been the case. At current sea-levels the Torres Strait is only 12 m deep, while the Arafura Sea occupies a 53 m deep sill (TORGERSEN *et al.* 1988). During glacial periods, when sea levels were 75 m or more below their current levels, vast areas of the Sahul Shelf were exposed subaerially and provided land-bridge connections for faunal migration between the two landmasses. The 30,000 km² freshwater Lake Carpentaria (TORGERSEN *et al.* 1988) was located in the centre of today's Gulf of Carpentaria, into which rivers flowed from Arnhem Land, Cape York Peninsula, and southern Papua. The homologous nature of elements of the modern freshwater fish faunas in these three localities illustrates the mixing of Pleistocene ichthyofaunas in Lake Carpentaria (WOINARSKI *et al.* 2007) and the strong biogeographical links between the land masses today. The Lake Carpentaria outflow comprised a river flowing northwest to the edge of the Sahul Shelf and into the deep-water Banda Sea.

The shortest route between Australia and New Guinea, the Trans-Torresian route discussed by WÜSTER *et al.* (2005), runs from Cape York Peninsula, Queensland, via the stepping-stone islands of the Torres Strait and around the Gulf of Papua, avoiding the deep-water Coral Sea, to the Papuan Peninsula (Fig. 7, Route A). A second, longer route runs from Arnhem Land, Northern Territory, across the Sahul Shelf to the west of Lake Carpentaria, to the southern Trans-Fly region of southern New Guinea. This could be termed the Trans-Arafura route, and it involves crossing the river flowing northwestwards out of Lake Carpentaria (Fig. 7, Route B).

With two routes of dispersal available, many snake taxa appear to have used the shorter, eastern Trans-Torresian route, including the *Liasis fuscus-mackloti* complex (RAWLINGS *et al.* 2004), *Morelia viridis* (Schlegel, 1872) (RAWLINGS & DONNELLAN 2003), the *Simalia amethystina* complex (HARVEY *et al.* 2000), and the elapid genera *Acanthophis*, *Cryptophis*, *Demansia*, *Furina*, *Oxyuranus*, and *Pseudechis* (WÜSTER *et al.* 2005). In contrast, *Acanthophis rugosus* Loveridge, 1948 may have arrived in New Guinea by way of the

western Trans-Arafura route (WILLIAMS *et al.* 2008), an hypothesis strengthened by its presence on the Tanimbar Islands of Maluku Province, Indonesia, located at the western edge of the Sahul Shelf, approximately 500 km N of Darwin, Northern Territory. WILLIAMS *et al.* (2008) ventured that *Pseudonaja textilis* utilized both routes to reach New Guinea as evidenced by the close molecular relationship between Oro-Milne Bay specimens and *P. textilis* from northern Queensland, Australia, and a similar closeness between the Merauke specimens and *P. textilis* from central and northern-central Australia (*P. textilis* is today absent from Australia's 'Top End'). The Katau specimen should probably fall into this latter group, the first



Fig. 7 - Proposed dispersal routes between Australia and New Guinea. Yellow arrows = dispersal routes. (A) Trans-Torresian Route (eastern route) from Cape York Peninsula to the Papuan Peninsula; (B) Trans-Arafura Route (western route) from Arnhem Land to the Southern Trans-Fly. Pale blue sea area encompassing Arafura Sea, Timor Sea, Gulf of Carpentaria, Torres Strait and Gulf of Papua = Sahul Shelf at 75 m below current sea-levels. Blue arrow = route of outflow river from 300,000 km² Lake Carpentaria. Figure based on the map in WILLIAMS *et al.* (2008).

PNG specimen of the western population, but 140 years of preservation makes additional molecular analysis impossible and the juvenile livery does not allow any comparison of adult dorsal colouration with Merauke or Papuan Peninsula specimens.

Clearly the presence of *P. textilis* as a widely distributed venomous snake has been largely overlooked, with specimens sighted briefly in the field perhaps being consistently misidentified as young taipan (*Oxyuranus scutellatus* Peters, 1867), but *Pseudonaja textilis* does not appear to have the same medical importance in New Guinea as it does in Australia, where the species is one of the most common causes of snakebite morbidity and mortality (SUTHERLAND 1992; SUTHERLAND & LEONARD 1995). The fact that snakebites occur has been proven by the ELISA results, but given the much greater threat posed by *O. scutellatus* it would seem to present a relatively minor public health risk in New Guinea. In addition the New Guinea specimens observed, captured, or examined appear to be much smaller than their Australian conspecifics. However, medical professionals working in New Guinea would be wise to consider the proven capacity of New Guinea *P. textilis* to cause death, as reported by WILLIAMS *et al.* (2008), especially in late-presenting patients (18-24 h) exhibiting coagulopathy and neurotoxicity, and take this into account when treating snakebites that could have resulted from encounters with this species. The CSL Snake Venom Detection Kit (SVDK) is a rapid, inexpensive, and reliable method that uses a small blood or urine sample to identify the snake responsible as belonging to *Acanthophis*, *Notechis* (not required in New Guinea), *Oxyuranus*, *Pseudechis* and *Pseudonaja*. CSL Brownsnake Antivenom is not currently registered for use in Papua New Guinea but CSL Polyvalent Antivenom should prove effective.

A FINAL COMMENT ON THE TAXONOMIC STATUS OF NEW GUINEA *PSEUDONAJA TEXTILIS*

Although older (late Miocene to Pleistocene) radiations between Australia and New Guinea, may have resulted in the presence of endemic New Guinea species (e.g., *Acanthophis laevis* Macleay, 1878, *Pseudechis papuanus* Peters & Doria, 1878, *P. rosignolii* Hoser, 2000) belonging to erstwhile widely distributed Australian genera (WÜSTER *et al.* 2005), the radiation and divergence of *Pseudonaja* and *Oxyuranus* fide WÜSTER *et al.* (2005) is more recent and of

Pleistocene origin (WILLIAMS *et al.* 2008). There are obvious differences in colouration (adult Papuan Peninsula *P. textilis* are dark grey, Merauke specimens are light brown, and Australian adults may be any shade from brown to almost black), and also apparent differences in size (all New Guinea *Pseudonaja* examined to date have a total length < 1.5 m when compared to Australian specimens, which may achieve at least 2.2 m in total length; WILSON & SWAN 2013). The only discontinuous and discrete morphological difference between New Guinea and Australian populations appears to be the variation in solid maxillary tooth counts documented by McDOWELL (1967). Both specimens he examined (AMNH R-73949, 73959) had twelve solid maxillary teeth, in contrast to his small sample (“no more than eight”) from Queensland and Northern Territory, for which he reported 9-11 solid maxillary teeth. However, WILLIAMS *et al.* (2008) provided additional data for two Milne Bay specimens (LSUMZ 90636-37) that also exhibited eleven solid maxillary teeth, and this overlap for the populations makes this characteristic unreliable for taxonomic purposes. These data support the belief that New Guinea populations are conspecific with those found in Australia, and there is currently no evidence to support a distinct taxonomic status at either the specific or subspecific levels.

SPECIMENS EXAMINED

Pseudonaja textilis ($N = 9$)

PAPUA NEW GUINEA

Milne Bay Province: Menapi, Cape Vogel, elev. 14 m [9°45'S, 149°28'E], AMNH R-73949. Baiawa, Moi Biri Bay, elev. 34 m [9°36'S, 149°28'E], AMNH 73959. Dogura, elev. 26 m [10°06'S, 150°05'E], PNGM R22295. Wamawamana, elev. 9 m [10°12'S, 150°21'E], AVRU-UPNG PT001.

Oro Province: Ajoa, Mt Victory, elev. ca. 400 m [9°14'S, 149°08'E], BPBM 37609, 37611. Heropa mini-estate, Dobodura, elev. 25 m [8°45'S, 148°23'E], AVRU-UPNG PT002-04.

National Capital District: 6-Mile, Port Moresby, elev. 66 m [9°14'S, 149°08'E], PNGM R24583.

Western Province: Katau (= Binaturi River), in error, probably Masingara, elev. 17 m [9°07'S, 142°57'E], MSNG 54621.

WEST NEW GUINEA

Papua Province: Merauke, photograph by Klaus Römer in WILLIAMS *et al.* (2008 p. 57 Fig. 3C).

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ABSTRACT

The medically important Australian elapid *Pseudonaja textilis* was first documented for the island of New Guinea in the 1950s, when specimens from the northern coast of the Papuan Peninsula were collected and identified. It was initially believed that these snakes were from an invasive population that established post-World War II, a concept generally accepted over following decades. More recently molecular evidence and additional specimens, from West New Guinea and the southern coast of the Papuan Peninsula, have suggested that the New Guinea populations are indigenous. However, no pre-World War II specimens have been found to dismiss the human-mediated introduction argument. We here present the earliest known Papuan voucher specimen of *P. textilis*, a juvenile from collections housed in Genoa made by Luigi Maria D'Albertis in 1876 that pre-dates all other vouchers and the New Guinea Campaign (1942-1945) of World War II by 77 and 66 years, respectively. We also discuss the origins of *P. textilis* in New Guinea, the history of its discovery, and the Pleistocene routes of its invasion from Australia.

RIASSUNTO

La presenza in Nuova Guinea del serpente bruno orientale, *Pseudonaja textilis* (Serpentes, Elapidae, Hydrophiinae) non è dovuta a un'introduzione in periodo bellico o post bellico, come testimoniato da un esemplare raccolto 140 anni fa nella regione meridionale dell'oltre Fly.

L'elapide australiano *Pseudonaja textilis*, importante dal punto di vista medico, venne segnalato per la prima volta in Nuova Guinea negli anni 50 del Novecento quando alcuni esemplari della costa settentrionale della penisola papuana vennero raccolti e identificati. Per alcuni decenni si ritenne che questi esemplari derivassero da una popolazione, di origine alloctona, stabilitasi dopo la seconda guerra mondiale. Recenti prove molecolari e ulteriori esemplari, dalla Nuova Guinea occidentale e dalla costa meridionale della penisola papuana, hanno suggerito l'origine autoctona delle popolazioni della Nuova Guinea. La mancanza di reperti precedenti la seconda guerra mondiale non ha permesso di confutare l'ipotesi di un'introduzione mediata dall'uomo. In questo lavoro viene illustrato il più antico campione papuano di *P. textilis*; si tratta di un giovane esemplare, conservato nel Museo di Genova, raccolto da Luigi Maria D'Albertis nel 1876, quindi 77 anni prima degli altri serpenti e 66 anni prima della campagna in Nuova Guinea (1942-1945) durante la seconda guerra mondiale. Vengono anche discusse l'origine di *P. textilis* in Nuova Guinea, la storia della sua scoperta e le vie di colonizzazione dall'Australia durante il Pleistocene.