

One or two mutations doesn't make a new species ... The taxonomy of Copperheads (*Austrelaps*)(Serpentes:Elapidae).

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ABSTRACT

In recent years, the Copperheads (genus *Austrelaps* Worrell 1963) has been subdivided into three "species" by most herpetologists, following Rawlinson 1991. This paper shows that the basis for the division of the linked regional populations into species is fundamentally flawed and not supported by the evidence. Snakes formerly assigned to the species "*superbus*" and "*ramsayi*" are shown to be of the same species, with variation being clinal at best, dictated more by local conditions as opposed to relationship history and distribution being continuous.

Allegedly diagnostic characteristics in populations have been historically determined by something as simple as a gene allele, rather than anything more.

The south-east South Australian taxon ("*labialis*") demonstrates important similarities to the other populations including evidence that it has been recently separated from the main population of the genus (less than 12,500 years).

While the small "outlier" population has allowed rapid differentiation, best seen in the strong tendency for lower ventral counts, and a lack of light coloured variants, a strong argument can be put for it to be regarded as either of the same (full species) taxon (*superbus*), as opposed to being a separate species as has been indicated by most recent authors.

On the same basis and for consistency, *Austrelaps superbus paulinus* (Wells and Wellington 1985), the geographically isolated race centred on the New England region of NSW, should also be accorded recognition at least at the subspecies level if the taxon "*labialis*" is to be so recognised.

Keywords: Australia; Copperhead; taxonomy; species; snake; venomous; elapid

INTRODUCTION

Copperheads, Genus *Austrelaps* as first identified by Worrell (1963), have attracted relatively little interest from taxonomists in the past hundred years, save for the erection of the genus name for the known taxa by Worrell in 1963.

This is probably due to the fact that the genus as defined and (alleged) taxa within are confined to a heavily populated part of Australia, were named in the 1800's and due to the absence of newly discovered forms there has been little interest in revisiting the arrangement of the genus.

This situation must also be considered in the context and contrast of other Australian elapid genera, including for example *Acanthophis*, *Pailsus*, *Pseudonaja* and *Oxyuranus*, all of which have had new and easily defined species discovered in remote or relatively uncollected locations in recent years (see for examples Hoser 1998, 2000, 2003, and Doughty et. al. 2007), naming numerous taxa including *Acanthophis wellsi* and others, *Pailsus rossignolli*, *Pseudonaja ellioti* and *Oxyuranus temporalis*.

In the past two decades, most authors have relied on the taxonomy of Rawlinson 1991, who placed all snakes in the genus into three species, namely:

Austrelaps superbus (Gunther 1858)

Austrelaps ramsayi (Krefft 1864)

Austrelaps labialis (Jan 1859)

There has been no evidence at all of acceptance in any way of the Wells and Wellington taxon, "*Austrelaps paulinus*", which is not surprising due to the general hatred and disdain of these two men by most other publishing Australian herpetologists.

With no prospect of extracting further species or "names" from the named or known taxa in *Austrelaps*, active taxonomists have looked elsewhere for "pay dirt" in terms of gaining kudos for naming reptiles and seeing their work cross-cited in other publications.

Austrelaps superbus (Gunther 1858) is the nominate form, often referred to as the "Lowlands Copperhead", defined in most texts as being from Southern Victoria and Tasmania.

Austrelaps ramsayi (Krefft 1864) has become known as the "Highlands Copperhead" referred to in most texts as the taxa from highland areas of Victoria and regions further north.

Rawlinson 1991, decided that the name "*Austrelaps labialis* (Jan 1859)" is known as the Pygmy Copperhead from Kangaroo Island, SA, the Adelaide Hills and immediately adjacent areas, separated by a few hundred km of coastal area from the main population.

No doubt due to the fact that there were no likely unnamed taxa within the genus (all had been named a long time prior) and the general respect of the author of the 1991 paper, (namely Peter Rawlinson), no herpetologists have (in print anyway) dared question the concept of there being three Copperhead species as defined by him.

Assuming that the man who had studied and published on the snakes "knew best" I too accepted this proposition on face value and without reading the paper, until recent years.

However a series of events, including inspection of a large number of specimens of all named taxa in the genus have forced me to rethink the Rawlinson position, with the inescapable conclusion being that to recognise the division of the two main taxa (*superbus* and *ramsayi*) as separate species is not tenable, either on the basis of the accepted definition of a "species" (no interbreeding), the recently popular "Evolutionary Species Concept" (ESC) as defined by Weins (2004) and others, or even in terms of consistent treatment of Australasian herpetofauna by taxonomists.

Also of note, is that when most of the original taxa in the genus were named in the 1800's, they were not identified with or compared to the other named taxa in the genera, thereby meaning that the diagnostic features and comparisons between the "species" only emerged from later studies, including that of Rawlinson 1991, and not necessarily as a result of any original analysis of the group (*Austrelaps*) to work out exactly how many species there were or to accurately define them in the first instance, with reference to a large collection of specimens from a wide geographical area, encompassing all or most of the known range of the genus.

TAXONOMY OF THE GENUS *AUSTRELAPS* – THE RAWLINSON 1991 POSITION

In terms of the genus *Austrelaps*, Rawlinson (1991) published a useful key to separate three forms that he diagnosed as separate species.

Aspects of the key are broadly correct and to aid the following discussion, this key is repeated unaltered below:

"Key to species of *Austrelaps*

1. Supralabials boldly marked, anteroventral quarter cream, remainder dark brown, the two colours meeting at a sharp diagonal demarcation; lower anterior temporal usually in point contact with or failing to contact lower postocular(go to 2)
- § Supralabials with weakly defined narrow whitish anterior margins; lower anterior temporal usually in broad contact with lower postocular; ventrals 143-164 *Austrelaps superbus*.
2. Ventrals 150 or more, eastern Victoria to New England Region of NSW ... *Austrelaps ramsayi*
 - Ventrals 148 or fewer; Kangaroo Island and high rainfall areas in the Mt Lofty Ranges, South Australia ... *Austrelaps labialis*"

The key was somewhat odd in that for the taxon *A. labialis*, Rawlinson later stated in the same paper that of just 30 specimens examined, one had 157 ventrals, but he chose to remove this fact from the key he published at the start of his paper. This fact gives all three named taxa ventral counts that overlapped and were broadly similar, making them indistinguishable from one another on that basis alone, with the possible exception of extremely low ventral count variants that could perhaps be referred to *A. labialis*.

Furthermore, while Rawlinson cites a low average ventral count as being diagnostic for *A. labialis*, his alleged sample sizes for the other taxa (30 *A. ramsayi* and an unknown number attributed to *A. superbus*) are sufficiently small to expect low ventral count specimens to have been possibly omitted.

Rawlinson also failed to provide a list of material examined, or similar identifier making it impossible to check to see if his scale counts were correct.

These facts are related here as in hindsight it appears that Rawlinson's omission of the known scale limits for *A. labialis* in his "key" appears to be a cynical case of making facts suit a pre-determined outcome, rather than as a scientist should act, which is allowing the facts alone to determine the outcome and without fear or favour.

Evidence that the ventral scale counts given above do not delineate the actual limits for the taxa is seen in my own scale counts for the taxa. The first *A. superbus* I counted (from Melbourne) had 165 subcaudals, already outside the limits given above.

Removal of ventral count as a diagnostic characteristic for the *Austrelaps* taxa leaves the other traits (given above) as all that's left and these are examined in the context of this paper.

TAXONOMY OF THE GENUS *AUSTRELAPS* – THE EVIDENCE

In the period, 1972-2008, I have been fortunate to inspect and collect specimens of all three named Copperhead variants from all major parts of the known ranges of each. While this may not include all outlier or island populations, it does include specimens of all three named "taxa" including in areas where ranges of named "taxa" abut as well as New England Tableland *Austrelaps*.

Most significantly in terms of the so-called "Highland" and "Lowland" Copperheads, the distribution of both forms is continuous through Victoria and NSW to the central highlands and any colour or pattern variants are not as a result of speciation or sympatric species, but rather as a result of mutations, sometimes being as little as one colour gene or allele.

Contrary to what Rawlinson wrote in 1991, snakes physically attributable to both taxa (primarily on the basis of labial markings) are in fact found sympatrically in numerous areas north and east of Melbourne in a general arc running from Kinglake through the Black Spur and back into the higher Dandenong Ranges and the ranges east of these (see below).

The scalation characteristics (position of the lower anterior temporal) published in the Rawlinson (1991) paper as being "diagnostic" for the two taxa by his own admission was not consistent for the taxa and hence also could not be taken on its own as being diagnostic or usable to separate the two alleged taxa, especially in the Victorian region where there was uncertainty as to which alleged taxon was present.

Rawlinson's other diagnostic characteristic separating the taxa (ventral colouration) has also been shown to be unreliable for several reasons.

Firstly an important determinant of ventral colour has been the "rinse" or colour running through the snake. Specimens usually have one or more of the following colour allele "rinses" running through them, namely yellow (ish brown), red (ish brown) or

charcoal (black).

Darker snakes usually have darker pigment ventrally. Most have whitish or cream on the anterior ventral scales, with a factor as simple as shedding cycle determining the exact colour tone.

Likewise for the degree of demarcation of light and dark pigment on the belly as identified by Rawlinson.

While the trend of ventral colour darkening as one moves backwards is typical of all *Austrelaps*, the fact is that individual variation is often greater than regional, including across barriers of the named taxa.

Rawlinson's allegedly sharp diagonal demarcation of the light and dark pigment on the venter of *A. ramsayi* is certainly not a consistent trait of the taxon. One such example is seen on page 148 of Hoser (1989), two middle plates, showing a specimen from Tarana, NSW, which based on location and head colour is certainly only referable to "*ramsayi*". However the ventral shot of the same animal does not show any sharp diagonal demarcation of the zones of colour change.

Hence the recent diagnosis to separate the taxa has been shown to be unreliable.

Distribution maps for the alleged taxa "*ramsayi*" and "*superbus*" have broadly defined the ranges of the former to be the high country of the Great Dividing Range in Victoria and north of here, and of "*superbus*" to be lowland areas of Victoria south of here and the Tasmania region.

Rawlinson's 1991 paper gives similar information, stating that the lowland form begins somewhere south-west of the Baw Baw plateau, which equates to the region running along the Monash/South-eastern Freeway to the Latrobe Valley.

This leads to the obvious questions of:

- 1 – Do the ranges of the "taxa" meet and
- 2 – If they do, are the "species" sympatric, or do they interbreed.

In answer to these questions, this paper reports that:

- 1 – the ranges of the "taxa" meet and are continuous and
- 2 – specimens assignable to either "taxa" are sympatric but
- 3 – specimens assignable to either "taxa" may at times breed and produce offspring themselves that are assignable to either taxa and/or apparently intermediate in terms of the defining characters in the wild state.

Adding to the picture is that the character state diagnostic of the "highland" form (more white on the lips) re-appears in populations from other colder or "highland" areas south of the range of the "highland" form.

In areas dominated by "lowland" snakes, the character state formerly regarded as diagnostic of a species in fact appears to be no more than a character state mutation somehow aiding the species in colder areas.

Scalation traits generally attributed to one form or other also overlap and are not consistent.

Specimens assignable to "*ramsayi*" based on the white edging on the labial scales are found in many of the populations of "*superbus*" in Victoria.

Specimens from cooler places sometimes have a greater degree of "white" in the labials, but this relates to local, rather than regional conditions.

Added to this is another unreported character state also seen commonly in "highland" Copperheads, but less common in "lowland" areas and that is melanism.

While the colour genetics of *Austrelaps* has not been studied in detail and is clearly more complicated than will be inferred shortly, melanism in the genus is often determined in given

specimens by no more than a single gene allele.

Specimens lacking the melanism allele, from the same population are not melanistic (called charcoal phase), but rather manifest as a reddish or yellowish phenotype.

Evidence also suggests that in some cases the gene's "dominance" is incomplete, as in melanistic individuals are homozygous, less dark heterozygotes and lightest, homozygotes lacking the gene.

However this is based on observed phenotypes in populations as opposed to controlled breeding experiments.

In most regions of NSW and Victoria (throughout ranges of both "*ramsayi*" and "*superbus*") both melanistic and lighter coloured specimens are found, usually with either a reddish or yellowish colour base.

The common threads include that melanistic specimens are as trend far more common in colder and higher regions and also the white-edging of the labials is also more prominent in colder climate snakes.

In terms of "*A. labialis*" the same trends probably apply, both for colour mutations (melanism or otherwise) and white edging of the labials, but due to the limited known range isn't measurable or seen in extant populations.

Another trend seen is in terms of sizes of adult snakes.

Those from warmer regions tend to be larger on average although a greater factor leading to giantism relates to the presence or absence of competing species.

Where Copperheads are alone, they tend to grow larger than in areas they compete with other taxa, be they Tiger, Brown or other snakes.

With extant populations of *A. labialis* being from colder parts of SA, including the coldest parts of the Mount Lofty Ranges, and consistently competing with Tiger Snakes, it isn't surprising that these specimens demonstrate the three character states associated with colder areas, and competing species, to wit, smaller size, darker colouration (usually melanistic) and well-defined white etching or barring on the labial scales.

LOCAL VARIANTS

Perusal of Coventry and Robertson (1991) yields a wide range of sympatry for "*ramsayi*" and "*superbus*" based on their published distribution maps.

This is reflected in all other texts, save for the map published by Rawlinson in 1991.

While the maps in the Coventry and Robertson 1991 book for other taxa (e.g. *Pseudonaja textilis*) and *Pseudechis porphyriacus*) are woefully inaccurate and overstate the ranges of those taxa, it is reasonable to assume that the distribution map/s for the genus *Austrelaps* (both named taxa) for the state of Victoria is broadly accurate. This is because it fits within my own collection data.

Most importantly however, is the following evidence that shows the population of Copperheads across Victoria including both named "taxa" to be continuous and with no evidence of non-breeding sympatry or allopatry between individuals.

As a licenced snake "controller" for the Department of Sustainability and Environment (DSE) I have been fortunate to have collected and relocated 82 Copperheads in the period Jan 2001 to end June 2008 in Melbourne and environs.

This number actually understates the total number of snakes inspected as for one reason or another some snakes were not recorded. Included were roadkills seen and inspected at various times and places, snakes presented to me as caught by others, preserved reptiles in jars from schools and the like and so on.

All these aforementioned snakes are mentioned in that location data is absolutely reliable and the pool of live specimens (or freshly killed) allowed for inspection of relevant character states in-situ, rather than as may be distorted by long preserved and perhaps



All photos in this paper are by the author.
Shown above and below are “Black” Lowlands Copperheads, including characteristic neck flattening behaviour. Next page is an “amelanistic” specimen in this case being a “red” individual. All snakes are males.



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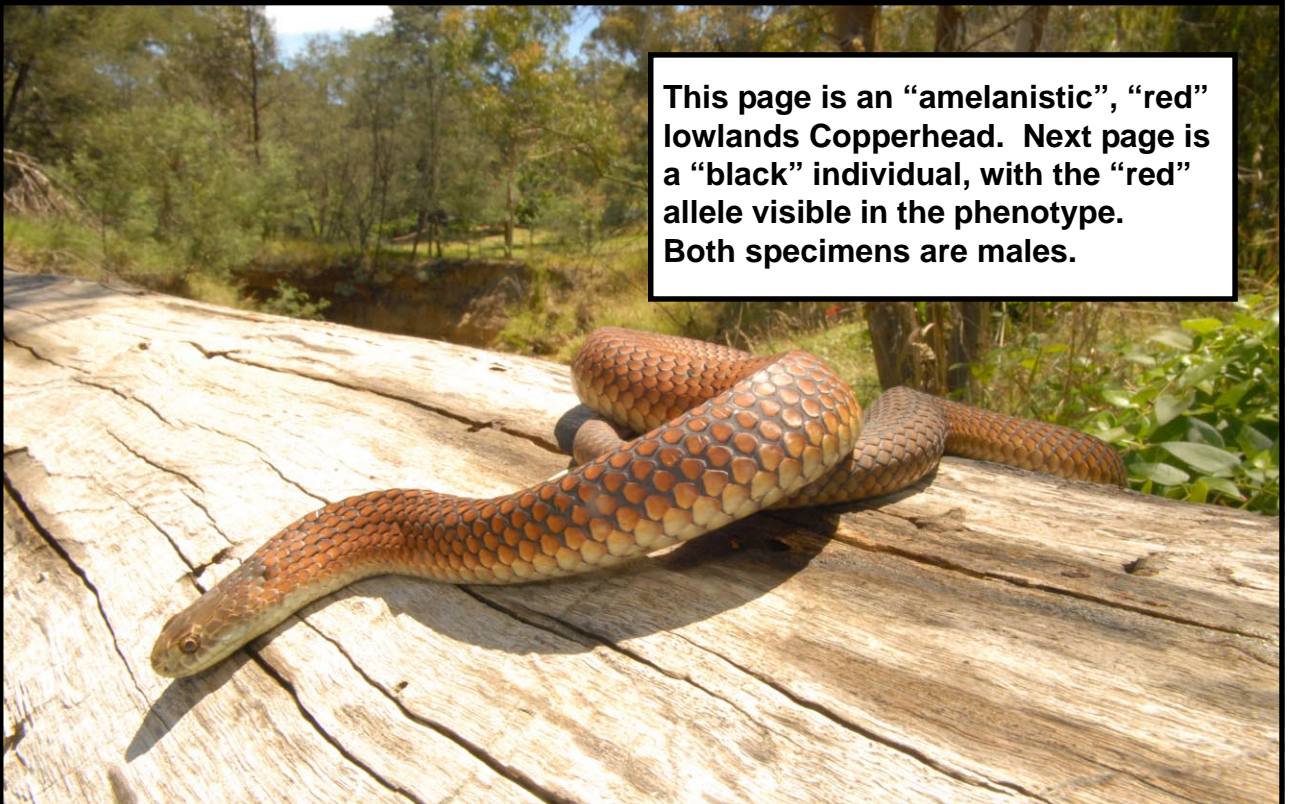
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Above and next page are “amelanistic”, “yellow”, male lowlands Copperheads. Below is a “black” male lowlands Copperhead, with yellow as opposed to red phenotype.



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faded museum specimens which may also have unreliable collection data.

Specimens have been collected from most Melbourne suburbs, including those named as follows.

Included are the arc, running from Westmeadows, Broadmeadows, Roxburgh Park and Cragieburn, through Somerton, Doreen, Whittlesea, Kangaroo Ground, Panton Hill (and Kinglake), North and south Warrandyte, Warranwood, North Ringwood, (including Chirnside Park, Lilydale, Wandin, Coldstream, Warburton, Healesville, Buxton and Taggerty), South Ringwood/Wantirna, Mount Evelyn, Rowville (and Ferntree Gully and other suburbs in the Dandenong Ranges, including Upper Ferntree Gully, Olinda, Belgrave, Cockatoo and Gembrook), Dandenong North, Endeavour Hills, Berwick (and Pakenham, Koo-wee-rup, Drouin, Moe, Mirboo North, Leongatha and Wonthaggi), Cranbourne, Langwarrin, Seaford, Frankston and most parts of the Mornington Peninsula south of Frankston, including Tooradin.

Further specimens have been caught in the arc running west from Westmeadows, including Greenvale, Mickleham, Gisbourne, Mount Macedon, Kyneten, Pentland Hills and west of there to Ballarat, then more-or-less continuously south from there to the coast and along all coast areas in both directions including most areas from Geelong to Mount Gambier.

These areas are all mentioned as between them, they include the main Great Dividing Range (e.g. Black Spur near Healesville and Kinglake and both sides of these points as in south and north drainages) and show a continuous and uninterrupted population of Copperheads with a modern-day distribution running to all major regions of southern and coastal Victoria from the Great Dividing Range running through to the NSW central highlands, with those snakes being generally defined as co-specific with the isolated populations of Tasmania and adjacent (and Bass Strait) islands, separated from the mainland only since the last glacial period (12,500 YBP).

With just one exception, all of over 10 specimens caught in the Dandenong Ranges proper have been melanistic in colour. The exception was a bright red individual, obviously being amelanistic, that had entered a house.

I have seen similarly amelanistic (red) specimens in the following Melbourne suburbs, Berwick (1), Chirnside Park (1), Braeside Park (1), and about 10 in an arc running from Kangaroo Ground (where they dominate) across to about Cragieburn, with another one seen dead on the road at Gisbourne.

Amelanistic (yellow) specimens are also common (see below).

Melanistic specimens with red bellies or flanks are often mistaken for Red-bellied Black Snakes, a taxon I have since discovered is not native to Melbourne (which is contrary to most previous texts) and is subject of other papers by myself, either in press or published after mid 2008.

Some Copperhead specimens appear to have a yellowish "rinse" through them as opposed to red, and if melanistic have a whitish or yellowish belly and flanks (as opposed to red), and the amelanistic specimens are usually yellowish brown as opposed to reddish.

These yellowish specimens are common in the lowland areas south of the Dandenong ranges, such as the suburbs along the south-eastern (Monash) freeway, including Berwick, Pakenham and Koo-wee-rup.

Note that pre-slough specimens are often darker than would otherwise be the case.

Hence across Melbourne the melanistic or "charcoal" specimens dominate, with the other morphs each occupying a broad average of about 10-20 per cent for each.

Most notably, is that in the region north of Kangaroo Ground, the relative frequency of darker specimens increases as one heads north and towards the cooler high-altitude town of Kinglake, at the summit of the Great Dividing Range.

At Kinglake proper where I have seen about 10 live Copperheads, all but one were melanistic.

Also at Kinglake and significant in the context of this paper, was a freshly killed Copperhead melanistic Copperhead which was gravid melanistic female of small adult size (and had been due to give birth at that time) and yielded 8 specimens, four of which were melanistic and four which were dark in colour but clearly a yellowish brown.

The dark colour would have lightened after the first slough and it was evident that these snakes were not melanistic, but of the yellowish morph.

In terms of the white edging and markings on the labial scales, this varied in the young from bold to indistinct, with some of the bold-marking snakes having triangular shapes consistent with "*A. ramsayi*", while other snakes were more like "*A. superbus*", indicating that the character state is not specific to a given taxon, but rather it varies, with local trend differences at best.

Also of note is that the largest Copperheads seen by myself as a controller have consistently come from warmer lowland areas and/or areas without competing species, such as Berwick.

This indicates that where the species competes with taxa such as Tiger Snakes, character displacement may lead to smaller snakes evolving in the location over a relatively short time.

While Copperhead colour alleles will vary in given locations, with myself sometimes removing multiple colour variants from a single address or street, there are trends in terms of abundance.

North Ringwood, Warranwood, consistently produces a majority of melanistic individuals. Around Lilydale, no colour dominates, but towards Healesville/Yarra Glen, the reddish colour dominates.

Over the Black Spur and along the Acheron Valley, melanistic specimens dominate, but in all materially relevant respects are no different to melanistic specimens from Melbourne or the Mornington Peninsula. Based on appearance of their labials, most specimens from the north draining Acheron Valley I have seen, conform to the "lowland" *Austrelaps*.

In Warrandyte North, yellowish brown specimens dominate, while a few km up the road at Kangaroo Ground and Wattle Glen, the reddish phenotype dominates.

As mentioned earlier, around Panton Hill, both black and red are in similar numbers, with the charcoal phenotype dominating at Kinglake.

In terms of the white etching of the labials, the trend is also that snakes from cooler areas have more distinct markings.

In the Dandenong Ranges at Emerald, I have caught specimens with both distinct white barring on the labials and ones where the markings are relatively indistinct.

Having said this, there are pockets of populations where the white markings on the labials do become relatively indistinct, including around Gisbourne and some from Mount Gambier (SA).

However almost all in between populations are dominated by snakes with the distinct white lines edging the labial scales, with populations from colder areas such as the Otway Ranges, again having more distinct markings on the labials and a greater percentage of melanistic snakes.

Put simply, the colour variants seen in Copperheads are local variations based on local climatic conditions as manifesting in a very elastic species and based on a small number of common mutations seen across the population.

The variation seen is not however sufficient to delineate a separate species.

All described forms of Copperhead are actually in a similar ballpark when it comes to adult size.

Adults of "*labialis*" seen by myself have certainly been no smaller than a number of reproductive female *A. superbus* I have seen from Kinglake or elsewhere around Victoria, making adult size a poor indicator of whether or not there is more than one species of

Austrelaps.

With colour variation within the known main continuous population of *Austrelaps* also being of no help in terms of delineating different forms, I have looked at other indicators.

That there is a clinal variation between north and south may be possible.

Unfortunately this again seems to be a function of local climatic variations (cold) as opposed to any well-defined speciation process arising through long-term genetic isolation of populations.

Similar is seen in Blotched Bluetongue's *Tiliqua nigrolutea*, of the same faunal suite and similar distribution, with highland and cool climate specimens tending to be darker black with brighter pink blotches than those from warmer and lowland areas.

However as with the Copperheads, the trend is general only and aberrant specimens typical of other areas are common.

With authors such as Glen Shea and others recognising just one species of "*T. nigrolutea*" it becomes inconsistent to not do the same for *A. superbus*.

With *Notechis scutatus*, similar is also seen in that cold places tend to have darker snakes.

For some years *N. scutatus* was referred to two species, namely *N. scutatus* and *N. ater*, being a generally more southern or dark form.

The differentiation has been observed to break down in areas that the known ranges abut, with it becoming difficult to assign snakes to one or other taxa, leading to many workers to conclude all are just one highly variable species.

That darkening in *Notechis* is a local trait, as opposed to one that determines species is seen in specimens from the Yarra Valley.

Melbourne and near Melbourne specimens to Lilydale conform to typical *N. scutatus* and are generally a brownish grey base colour dorsally.

As one moves up the Yarra Valley to Warburton and beyond, specimens tend to become (on average) darker, so that most found beyond Warburton are sufficiently dark as to be easily referable to *N. ater* in the absence of locality data.

In these same areas, including Warburton, a limited number of typical phenotype *N. scutatus* are seen.

As Western Australian and Eastern Australian *N. scutatus* hybridise in captivity (one such case happened at the facility of Fred Rossignoli in 2002-3), it must be concluded that in the real world of Warburton, all locally occurring *Notechis* must be referable to the same taxon.

HIDING THE WHITE LINES

Blackish coloured snakes will as a matter of course have the white etchings of the scales strongly contrasting. Red-phenotypes from the same areas with similar markings on the labials will often not be seen to have as distinct markings.

Notwithstanding this, there is also a trend seen in colder and higher altitude places for these markings to be broader, as depicted on page 49 of Worrell 1972.

However, as already inferred this trend is by no means universal or consistent across a population, or even litter of snakes.

THE EXTREMES OF LABIAL MARKINGS

Among the *Austrelaps*, there are extreme positions in terms of the character state of the white markings or lines etching the labial scales.

Most specimens have white etching of the labials and in specimens usually referable to *A. ramsayi* and *A. labialis*, these are expanded somewhat to form thickened lines as seen in the image number 386 of Hoser 1989 (page 148), or beyond that to triangles as seen in image 385 of Hoser 1989 (page 148) or even more dramatically on page 49 of Worrell 1972.

Notable is that the specimens with the most white on the labials

are also melanistic (see Hoser 1989 and Worrell 1972 again), with the specimen in Hoser 1989 coming from a particularly cold location.

Hence it appears that the benefit of whitening of the labials as seen is an adaptation to cold, although at this stage no reason for the trait is known.

As mentioned in the vicinity of Kinglake and the Dandenongs, both in Victoria, the degree of whitening of the labials is seen to vary, ranging from typical *A. ramsayi* to that of *A. superbus*, the more common state in these areas.

This state is where the labials tend to have a white etching, but not any discernable thickening.

This is typical of most snakes referred to *A. superbus*, including in Tasmania.

However this is not the extreme position for the genus.

Some specimens, usually of lighter colour variants and from warmer locations appear to have effectively lost this white etching of the scales.

In replacement is a distinct general lightening of the lower labials, with the upper labials remaining an even colour and no scale etching.

In Melbourne, both such colour variants (etched scales and unetched scales) occur and including in the exact same locations (such as Berwick).

The same is seen elsewhere, including in Tasmania.

As one moves west to the Otway Ranges, there appears to be a trend of thickening of the labial etching to form white triangles or lines as seen in "*A. ramsayi*", although not to the same degree, which wanes again as one moves west beyond that region.

The snake depicted in image 389, page 148 of Hoser 1989, from Mount Gambier, SA, demonstrates this thickening of the white in the labials.

In terms of labial markings, this specimen roughly equates with the *Austrelaps* from the New England region in Cogger 1967, which based on the range maps of Rawlinson would be extremes of two separate taxa (*superbus* and *ramsayi*).

Hence the inescapable conclusion that the trait is too variable to be diagnostic of taxa in the absence of other data.

Outside of *Austrelaps*, distinct white etching of upper labial scales and/or thickening of this to form white lines or triangles is seen in other snake taxa.

Well-known examples are *Leiopython hoseerae*, *Leiopython albertisi* and *Lenhoserus boeleni*.

Two areas worthy of investigation is:

- 1 – The benefits of these markings to the snake (or their use).
- 2 – The speed and mechanism of the evolution and control of these markings.

Also relevant to *Austrelaps*, and worthy of investigation is:

- 1 – What are the benefits of whitish colouration immediately above the jawline (in the lower part of the upper labials) (or their use).

CHARACTER DISPLACEMENT AND THE SNAKE HIERARCHY

Counter to the above observations are large numbers of non-melanistic specimens seen in Tasmania and also islands of Bass Strait.

Red coloured snakes are common in these areas.

Based on local climate and when compared to areas including Melbourne, the first expectation would be a preponderance of melanistic individuals. But this is not seen.

However in contrast to most of Melbourne in particular, the Tiger Snakes from these places tend to be "black" in colour (as opposed to brownish or grey), or far more commonly than seen elsewhere.



This page is a female “black” with red phenotype lowlands Copperhead. Next page is a male amelanistic “red” lowlands Copperhead.



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This page are amelanistic yellow, male lowlands Copperheads.
Next page top is an adult male "black" lowlands Copperhead with yellow phenotype.
Next page lower is an amelanistic red male lowlands Copperhead.



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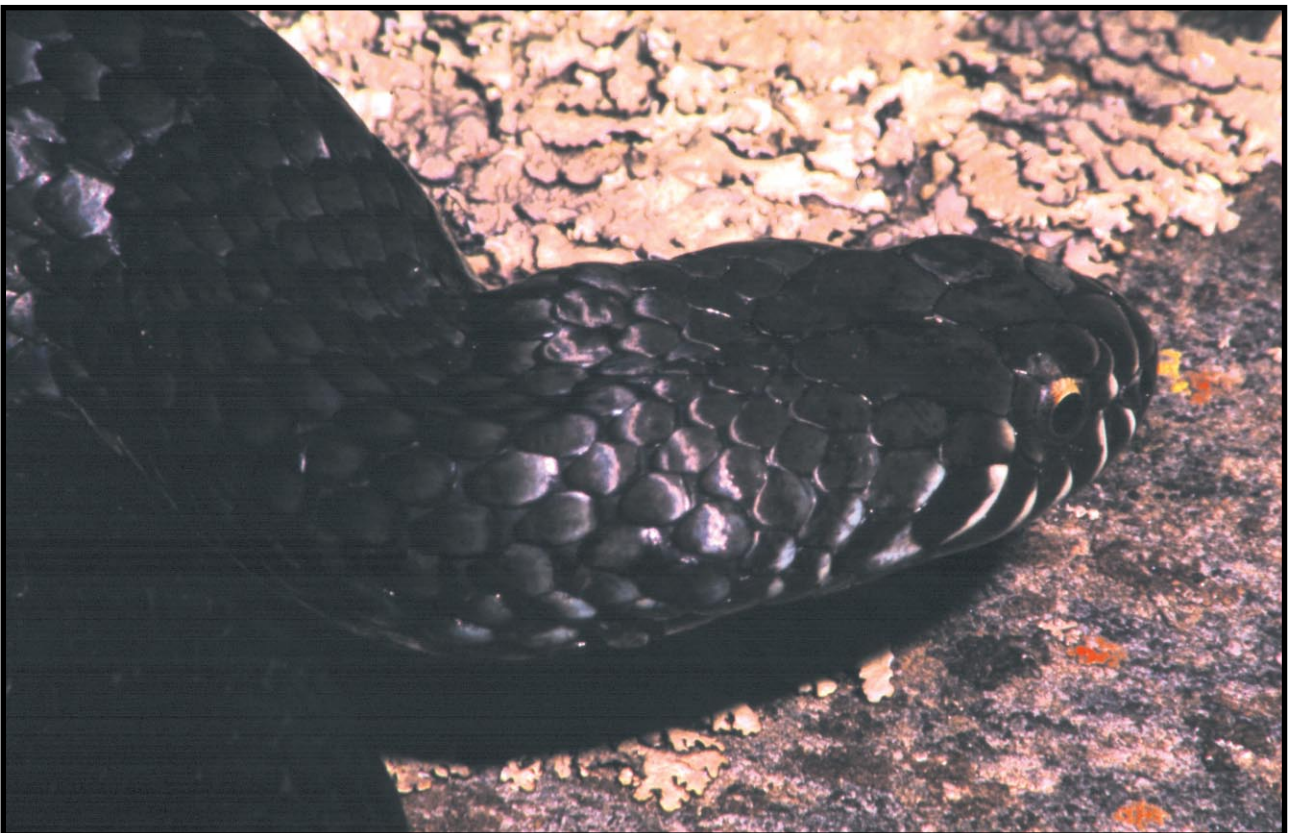
This page and next page top are Highlands Copperheads.
This page from Tarana, NSW. Next page from Wentworth Falls, NSW.
Next page lower is a Pygmy Copperhead from Forrest, SA.



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Pygmy Copperhead from Forrest, SA.



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This page. Male combat in lowland Copperheads.

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With two similar species (Tiger Snakes and Copperheads) competing in the same close habitat, it is not surprising that they have differentiated themselves (character displacement), with Copperheads having a greater tendency for the lighter morphs and any benefits this confers and the Tiger Snakes adopting the darker hues.

Noting that in the cooler areas, one would expect black to be the preferred morph, the question then obvious is why don't both taxa become darker.

Part or all of the explanation may lie in the hierarchy between specimens of the two taxa of similar size when together.

Hoser 2006 detailed the hierarchy and significantly placed Tiger Snakes as dominating Copperheads. Also in the same paper was Red-bellied Black Snakes as dominating Copperheads.

Significant here is that Red-bellied Black Snakes are a common taxa in the New England Region and therefore it is not surprising that the character displacement theory favours a strong tendency towards non-black specimens there.

In other words, when similar and competing species occur together and one has a shift in a character, while another doesn't, it may be indicative that the non-shifting taxon dominates the other.

Noting that where Copperheads are common they tend to eat competitors and often become the only elapid taxa present, it makes sense for all available morphs to be able to utilize all niches.

Hence the colour genetics as observed, yellow, red or black base colours in most populations can be seen as an adaptation to very localised conditions and rapid local shifts an aid to potentially rapidly changing conditions.

From a taxonomists point of view, this means that observed differences may in fact be due to rapid changes in abundance of mutants as opposed to any significant long-term speciation process.

All this further points to all south-east Australian *Austrelaps* being of a single variable species, rather than three or four named species, as is generally regarded at present.

ALBINOS

Three albino's have been caught to my knowledge and all from the general region around Langwarrin, in the Frankston Shire. All have died shortly after capture.

At least one died from wounds inflicted on the snake when picked up with metal tongs used to grab the snake and the subsequent infection from injury and broken bones and internal organs.

Put simply the death was avoidable.

Tongs are illegal under the Victorian "Prevention of Cruelty to Animals Act 1986" (POCTA), Sections 9 (1) a and 9 (1) c, due to the heightened risk of injury to the affected snakes and it is unfortunate that the Victorian wildlife authorities have not prosecuted licenced snake controllers for the illegal use of them to catch snakes.

The albinos were typical of albinos seen in other snake taxa, in that their colour was whitish pink and the eyes were pink.

These snakes are not the amelanistic reddish snakes mentioned elsewhere in this paper, which are common in many areas.

BREEDING ANOMALIES

In terms of breeding *Australaps*, I have had some experience. In 1973, I successfully bred Copperheads from Oberon NSW. Two females produced 13 and 14 live young respectively (no stillborns from either).

Around Oberon all of about 30 specimens I have seen have been either yellowish brown or melanistic, which seems no different to the pattern for southern Victoria.

For some time and without exception, all Melbourne and Southern Victorian Copperheads for which I had breeding data (usually wild-caught/killed by cats and the like), the number of offspring was without exception 8.

The sample size was about 10 gravid females.

This did indicate some difference with specimens of *Australaps* from the NSW Central Highlands (see above).

However on 20 Feb 2007, I bred a female "Lowlands Copperhead" that yielded 18 young (one live and 17 stillborn). Before any doubts are raised, let me re-assure all readers that the number is correct and that it came from just one female in a cage on it's own.

Hence even in terms of breeding and local variations, there was nothing that could be used to reliably separate northern and southern Copperheads with a view to separating species.

PRE-MATING ISOLATION MECHANISMS

A logical experiment not performed as part of this research was the attempted cross-breeding of "Highland" and "Lowland" Copperheads.

The impediments to such an experiment would be of legal interpretation (is it legal to hybridise taxa? ... are they different taxa ? and thus the first question needs re-asking), as well as availability of stock.

In the period 2004-8, I held about 10 "lowland" Copperheads for much of this time and in 2006/2007 managed to breed them (venomoids)(see Hoser 2004).

However, it is also fair to assume that there is no pre-mating isolation mechanisms between specimens from different regions or phenotypes.

The basis of this assumption is as follows:

- 1 – death Adders of different colour phenotype mate readily (see images in Hoser 1989 and Hoser 1983,1985) and are comparable on the basis that they are Australian elapids derived from similar stock
- 2 – the evidence of young from a killed adult female at Kinglake showing different phenotypes in the unborn young
- 3 – in captivity male copperheads in my possession would also try to mount and mate specimens of their own taxon (both sexes), Death Adders (*Acanthophis* spp.) (of both sexes) and Eastern Brown Snakes (*Pseudonaja textilis*) (of both sexes).

PREHISTORY

So far I have established that with the exception of the "*labialis*" snakes, all Copperheads from Victoria and NSW form one more-or-less continuous population, with no physical or breeding separation between the "highland" and "lowland" Copperheads, with the apparent exception of the New England population.

Hence "*Austrelaps ramsayi*" becomes a junior synonym of "*Austrelaps superbus*" at the species level.

For the time being, and in the absence of any discernable differences, the populations from Tasmania and islands in between are regarded as the same as the southern Victorian and hence also referable directly to *A. superbus*.

However due to the relatively consistent differences seen between the specimens generally referred to *ramsayi* throughout many parts of their range in Victoria and NSW to the NSW central highlands, I regard it as prudent to retain the name *ramsayi* at the subspecies level and with the caveat that there will be "intermediate" specimens unable to be accurately referred to either the subspecies *ramsayi* or *superbus*, even with accurate locality data, where their known distributions abut.

In terms of the status of "*A. labialis*", it is perhaps worth looking outside the genus *Austrelaps* for the answer in terms of the status of the "taxon".

MtDNA could be analysed and would no doubt show that the population had been separated from the main population since no longer than the last glacial period, or 12,500 years ago.

In actual fact, the two populations may have been connected considerably more recently as inferred by the known southerly migration rate of the invasive *P. textilis* (see another Hoser paper



Above: Copperheads are commonly misidentified as Red-bellied Black Snake, shown here.

Below: Found in the same regions as Copperheads, Tiger snakes are a direct competitor and their evolution has been shaped by the same barriers and ecological constraints. Both snakes shown on this page are adult venomoid males.

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This page: Seven stillborn lowland Copperhead young produced in 2009 from a female, as a result of world first artificial insemination for this taxon. Young measure just over 15 cm at birth.



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in press or published and not cited here).

The small size of the "*labialis*" populations would also indicate a rapid rate of potential change (or speciation) in these snakes.

However based on the inherent conservatism of snakes, it would be fair to assume that extant "*A labialis*" would still be able to breed with other *Austrelaps* as is the case seen in other allopatric Australian elapids such as *Acanthophis* (Hoser 2002) including taxa known to be distinct for long periods (see Hoser 2002).

With taxonomists recognising the relative plasticity of another southern taxon, namely *Notechis scutatus*, in particular the repeated change of phenotype in response to food, climate and other local variants, and most herpetologists now placing all snakes in the genus into the single variable species "*Notechis scutatus* (Peters 1861)", it seems inconsistent to split an equally conservative group of snakes into three species as has been done up until now.

However as the "*labialis*" population/s is geographically and reproductively isolated from other *Austrelaps superbus*, and is potentially under threat from several human factors, I hereby propose that these populations continue to be recognised as different, under the category of "subspecies", as these specimens clearly fit this criteria.

Finally, Rawlinson 1991, groups Tiger Snakes, *Notechis* in two two species, namely *scutatus* from most of Victoria, NSW and north and *ater*, or the "black" Tiger Snakes from most of the rest of the genus's natural range.

Part of his basis for this split is a claim that *scutatus* have colonised the Victorian region from further north.

Based on the mobility of the taxon (less than for *P. textilis*) and the fact that their present range occupies all suitable areas in the state (as opposed to *P. textilis*, notably absent from suitable areas in the south), as well as similar regions north (NSW) and south (Tiger Snakes throughout Tasmania), the only reasonable conclusion is that *N. scutatus* as defined by Rawlinson have been present in Victoria all the time, or at least well and truly preceding the end of the last glacial period.

As there is no strong evidence of any long term break between the populations of Tiger Snakes beyond the last 12,500 years and the general view is that 12,500 years is not sufficient time for formation of new species from isolated populations, unless gene pools are particularly small and selection pressures particularly unusual, my own view is that all Tiger Snakes should be regarded as being a single species, but that local variants should be regarded as different at the subspecies level.

Also add these comments to the known fact that upland Tiger Snakes east of Melbourne also tend to be darker, easily identified as "black" as compared to those from suburban Melbourne.

AUSTRELAPS SUPERBUS PAULINUS WELLS AND WELLINGTON 1985

The historical animosity between Wells and Wellington and most other publishing herpetologists in Australia is well-known and been the subject of petitions to the ICZN (Hoser 2007).

The senior author of the papers, Richard Wells has spent much of the last 30 years attacking me in various manifestations and in a related vein, I most certainly do not endorse all his work, conclusions he's drawn and so on.

I deplore and find offensive some of the abominable names he has assigned to various reptile taxa, nor do I recognise or endorse all his taxonomic and nomenclatural acts.

As a rule his publications are sloppy and arbitrary judgements made apparently on whim and in the absence of hard evidence, often with the name to securing "naming rights" to potentially undescribed taxa.

Many of his taxonomic and nomenclatural acts have evidently been made with the view to "getting in first" in terms of naming species, often without research, the result being that a large number of his named "taxa" simply are not new species as described, but rather they are variants of extant taxa.

As a common rule, Wells renamed known species as new species, using holotype specimens from as far as possible from the original holotype in the hope that later workers would confirm these outlier population/s did in fact constitute a new taxon.

Wells was (and still is) a holotype pioneer in the concept of "taxonomic exaggeration" as described by Pilon and Chase 2006.

Due to the large number of taxa named for the first time, even with a large number declared invalid, Wells managed to score for himself the probable distinction of having named more valid taxa than any other herpetologist in Australian history.

That's because the fact remains that if and when he has properly named taxa for which there were no previously available names, then his names have become "available" under the ICZN code (ICZN 1999), or previous edition of the code and thus should be used.

Put bluntly, we are stuck with them.

The New England population of Copperheads is seen to be geographically separated from the main population. Rawlinson's 1991 distribution map confirms this fact and my own collecting experience corroborates that.

Wells and Wellington published a "diagnosis" of the taxon, but the "diagnosis" does not in any way separate this taxon from any other.

While it is arguable that the authors have failed to comply with the ICZN code at the time, my own view is that they have crossed the line and satisfied it.

Their diagnosis does not have to be "good", or even "correct".

In fact it can be totally wrong!

Under the (current) ICZN code (article 13(1)), it merely has to "purport" to be a diagnosis, which it clearly does. This is essentially an unchanged requirement from the earlier code in force at the time of the Wells and Wellington descriptions.

Glen Shea had the same issue in terms of his revisiting Wells and Wellington taxa in the genus *Cyclodomorphus* and had to use their names, even though the Wells and Wellington diagnoses were effectively rubbish (Shea 1995).

Hence at the present time, geography is the only consistent character that separates the Wells and Wellington taxon from the other *Austrelaps*. However at the present time, little more (if any) separates the "*labialis*" taxon, and on that basis it is my considered view that the taxon "*paulinus*" should be recognised and used when describing relevant specimens, even though my view is that both *labialis* and *paulinus* should only be recognised at the subspecies level.

However in line with southern Victorian (lowland) Copperheads, there is a trend for more northern specimens of *A. superbus paulinus* to have reduced white markings on the upper labials as compared to specimens from further south, or for that matter the Alps region.

Somewhat reduced white on the labials as compared to *A. superbus ramsayi* as a trend, is certainly an added and herein first time reported diagnostic character of this Wells and Wellington named taxon.

A typical example of a reddish specimen of this taxon, demonstrating the relatively reduced white marks on the labials is seen in the specimen of "*A. superbus*" (as identified in the book) from the New England region of NSW depicted in Cogger 1967.

At the time, Cogger recognised all *Austrelaps* as being a single species.

THE TAXONOMIC HISTORY OF AUSTRELAPS SUPERBUS LABIALIS

Rawlinson 1991 sets out what he interprets as the taxonomic history of the taxon as a follow-on from the position of Shine 1987.

Jan's holotype from "New Holland" in the Zoologisches Museum in Gottingen has been apparently lost.

Rawlinson asserts that the low quoted ventral count of 136 as



Captive husbandry of Copperheads.

While this paper isn't about this, the basics are worth noting.

Put simply it is as for other elapids (or pythons for that matter).

Wild-caught snakes are usually riddled with parasites and must be treated aggressively for them.

Captive-bred young do well, graduating from assist to voluntary feeding readily

and usually within a few months of birth, becoming ravenous within a year. Adults take mice readily.

Housing is best in a rack system as shown above. Caging itself is sparse, clean and with hide, heat at the opposite end to the water (via "heat mat") and the water bowl is unspillable. Plastic tubs work well. See image at top right.

Copperheads are generally not aggressive to humans, but are to one another and other snakes. Hence should be housed individually.

As for other snakes, these snakes do not like to be stick-handled and free handling is best for the snake's welfare if one ignores risks to the handler. The specimens shown on the next page are "venomoid" and hence harmless.





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Copperheads eat any vertebrates they are able to swallow, but are best known for feeding on frogs and skinks where they occur. Their smaller heads and gape as compared to other snakes places some restrictions on what they eat. Frogs such as that depicted above (*Limnodynastes tasmaniensis*) are common prey. The lung-worm depicted below is from a wild-caught Copperhead and a common parasite of both wild and captive snakes. Treatment for these parasites is via a number of drugs, including Panacur, Cydectin and even Dichlorvos (all names registered).



reported by Jan 1859, means that the taxon could only have been "*labialis*".

However this may not be the case. Equally likely is that Jan miscounted the ventrals and that the holotype actually had a higher count.

Rawlinson even notes other obvious errors and inconsistencies in various papers by Jan adding credence to the view that the ventral count quoted may have been in error.

Noting that most (but not all) of the taxa described by Jan came from Eastern Australia, it seems likely that so too did his original *Austrelaps*.

However in order to stabilize the name "*labialis*" Rawlinson designated a neotype, namely SAM R26414 from Kangaroo Island.

However the process was in my view contrary to the rules of the ICZN's code at the time (in terms of designating neotypes) and therefore probably invalid.

Hence a logical alternative from this point could be to rename the taxon, using the same specimen as a holotype.

However as the name "*labialis*" has been in use for the taxon for decades, a case could be successfully mounted to retain the name (and neotype) making the exercise of redescribing the taxon pointless in the long term.

This is particularly so, noting that the ICZN's underlying aim is to maintain stability of names where possible.

Hence in spite of the potential errors in the naming process thus far, I suggest that herpetologists use the name "*labialis*" if and when recognising the relevant taxon.

SUMMARY

As a result of the data presented and it's objective analysis, the genus *Austrelaps* is currently recognised as consisting of a single, yet variable species, namely *Austrelaps superbus*. Only four subspecies are recognised, namely, *Austrelaps superbus labialis* and *Austrelaps superbus paulinus* as well as *Austrelaps superbus superbus* and *Austrelaps superbus ramsayi*, with the caveat that for the latter two taxa specimens from some locales are apparent hybrids or intermediates.

However, due to the plasticity of the species in relation to local situations, casual identification of all Tasmanian, Victorian (and near SA) and NSW *Austrelaps* is perhaps best done by way of locality of origin as is current practice by hobbyist breeders of pythons in Australia and elsewhere.

APPENDIX 1: A NEW KEY FOR THE GENUS *AUSTRELAPS*

Based on the preceding information, the Rawlinson 1991 key (as used by most herpetologists since then) is no longer suitable or best for identifying taxa within the genus.

As a result a new key has been devised.

Based on what's already known, the key will break down for some specimens, particularly from parts of Victoria. However it will be reliable most of the time and is the best currently available.

It is presented here:

Key to the subspecies of *Austrelaps superbus*.

1a. Supralabials boldly marked with etchings expanded to form stripes or triangles, lower anterior temporal usually in point contact with or failing to contact lower postoculargo to 3

1b. Supralabials usually with whitish etchings, or if absent, lower margins lighter than above; lower anterior temporal usually in broad contact with lower postocular; ventrals approximately 143-165 Go to 2.

2a. Victoria, Tasmania, South Australia ... *A. superbus*

superbus

2b. New South Wales ... go to 4

3a. Ventrals 150 or more ... go to 4

3b. Ventrals approximately 157 or fewer; Kangaroo Island and high rainfall areas in the Mt Lofty Ranges, South Australia ... *A. superbus labialis*

4a. New England Region ... *A. superbus paulinus*

4b. Elsewhere in NSW or Victoria ... *A. superbus ramsayi*

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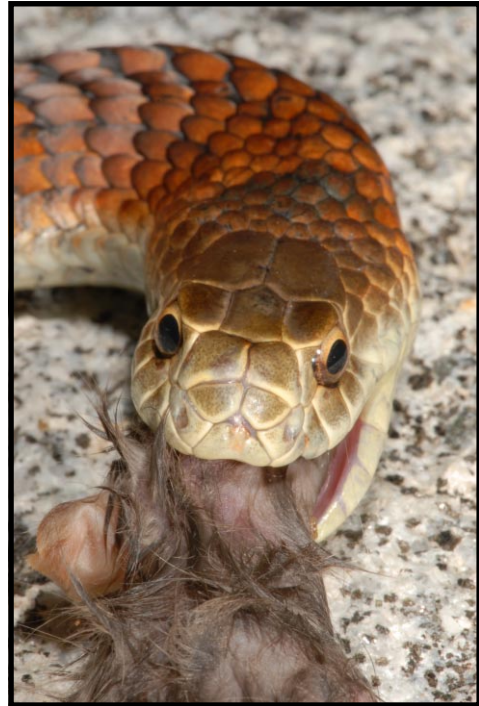
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