

A formal five-way division of the Gaboon Viper Species Complex: *Bitis (Macrocerastes) gabonica* (Duméril, Bibron and Duméril, 1854) and a two-way division of the Nose-horned Viper species complex *Bitis (Macrocerastes) nasicornis* (Shaw, 1802) (Serpentes:Viperidae:Bitisini).

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ABSTRACT

The Gaboon Viper *Bitis gabonica* (Duméril, Bibron and Duméril, 1854) as a species complex has had a fairly stable taxonomic history since being described at the species level, although the species as generally recognized was transferred to the genus *Bitis* Gray, 1842 shortly after the original description. Likewise for the Nose-horned Viper species complex *Bitis (Macrocerastes) nasicornis* (Shaw, 1802).

The species known as the Rhinoceros Viper *Bitis rhinoceros* (Schlegel, 1855) was synonymised with *Bitis gabonica* by virtually all herpetologists beyond 1855 until 1999 (see McDiarmid *et al.* 1999), when Lenk *et al.* (1999) provided a molecular basis to recognize the western population, (then known as *Bitis gabonica rhinoceros*) identified in 1999 on the basis of allopatric distribution as opposed to any consistent morphological divergence.

Chippaux (2006), showed that consistent differences in the markings on the side of the head could be used to identify and separate *Bitis rhinoceros* from the nominate species.

Meanwhile the Gaboon Viper as popularly recognized since 1999 comprises the main population centred on the wetter parts of west-central Africa (the type locality Gabon) including several countries and then three quite distant and unconnected outlier populations.

These are each centred on eastern Tanzania along the coastal strip and hills nearby, the eastern escarpments of Zimbabwe and KwaZulu-Natal, north-east South Africa.

Like the disjunct West African population now identified as *B. rhinoceros*, specimens within the three other outlier populations also have consistent phenotypic differences to the main group making them worthy of taxonomic recognition. As all have been reproductively isolated for a long time and clearly form evolutionary species units, each are formally described herein as new species and named according to the Zoological Code.

The species known as the *Bitis (Macrocerastes) nasicornis* (Shaw, 1802), has had a stable taxonomic history at the species level. However phenotypic differences between the nominate western form and that from east of the Dahomey Gap are well known (Phelps 2010), but have not been properly and consistently identified. As they have been reproductively isolated for a long time and clearly form evolutionary species units, the eastern form is described and named according to the Zoological Code.

Keywords: Taxonomic revision; Gaboon Vipers; *Bitis*; *Macrocerastes*; *gabonica*; *rhinoceros*; *nasicornis*; new species; *funki*; *wellsi*; *wellingtoni*; *hoserae*.

INTRODUCTION

The Gaboon Viper *Bitis gabonica* (Duméril, Bibron and Duméril, 1854) is one of the world's icon snakes.

Reputed to be the world's heaviest True Viper, large specimens also have the longest fangs (up to 2 inches or 5.5 cm), and

reputedly the highest venom yield of any venomous snake (Mallow *et al.* 2003).

The Gaboon Viper *Bitis gabonica* as a species complex has had a fairly stable taxonomic history since being described at the species level, although the species as generally recognized was

transferred to the genus *Bitis* Gray, 1842 shortly after the original description.

The species known as the Rhinoceros Viper *Bitis rhinoceros* (Schlegel, 1855), the taxon found west of the Dahomey Gap was synonymised with *Bitis gabonica* by virtually all herpetologists beyond 1855 until 1999 (as indicated by McDiarmid *et al.* 1999).

However in that year Lenk *et al.* provided a molecular basis to recognize the population, apparently identified by these authors in 1999 on the basis of allopatric distribution as opposed to any identified consistent morphological divergence.

Chippaux (2006), showed that consistent differences in the markings on the side of the head could be used to identify and separate *Bitis rhinoceros* from the nominate species (see below for detail).

Meanwhile extensive collecting by herpetologists in Africa over the past 150 years has shown that the Gaboon Viper as popularly recognized comprises the main population centred on the wetter parts of west-central Africa (the type locality Gabon) including several countries and then three quite distant and unconnected outlier populations.

These are each centred in distinct habitat regions, being in eastern Tanzania along the coastal strip and hills nearby, the high rainfall eastern escarpments of Zimbabwe and forested parts of KwaZulu-Natal, north-east South Africa.

Like the disjunct East African population now identified as *B. rhinoceros*, specimens within the three other outlier populations also have consistent phenotypic differences to the main group making them worthy of taxonomic recognition. As all have been reproductively isolated for a long time and clearly form evolutionary species units, each are formally described herein as new species and named according to the Zoological Code (Ride *et al.* 1999).

In terms of diagnosing and describing the new species taxa according to the Zoological Code the process (or "materials and methods") was in fact quite simple and straight forward. In fact I am amazed that the division of the Gaboon Vipers into five species groups hasn't been done earlier.

Live specimens with accurate locality information were inspected by myself during a trip to Africa in 2009 and earlier visits to Europe and the United States. Visually they differed by location, but these differences were hard to quantify using the usual characteristics of scalation and the like due to variability in individuals and overlaps between specimens from different regions. But because specimens were photographed as well, I was able to revisit these and ascertain consistent regional differences in markings and the like which indicated taxonomic divergence.

Due to the small size of the sample, I was not confident that the differences I observed were consistent and so I then sought and got numerous images of specimens from throughout the known range of the species group, which had accurate locality data.

This included all taxa identified herein as new species as well as the two forms already with available names.

This material was provided by both herpetologists and non-herpetologists, none of whom sought any payment or gratitude for the time and effort expended by them.

Once the consistent differences were known, it was possible to ascertain the origin of a given specimen based on the head markings even without direct reference to the locality information on hand.

An almost identical situation is seen in the species complex, known as *Bitis (Macrocerastes) nasicornis* (Shaw, 1802). It has had a stable taxonomic history at the species level. However phenotypic differences between the nominate western form and that from east of the Dahomey Gap are well known (Phelps 2010), but have not been properly and consistently identified. As they have been reproductively isolated for a long time and clearly form evolutionary species units, the eastern form is

described and named according to the Zoological Code.

In terms of the nominate form and holotype material the following is noted:

The nominate form of *B. nasicornis* probably comes from Ghana (Hughes and Barry, 1969), meaning that the population east of the Dahomey Gap is that which is unnamed to date.

That the holotype snake is of the western form (that west of the Dahomey Gap) is confirmed by the drawing that accompanies Shaw's original descriptions of the taxon in 1792 and 1802, noting that his written description was vague in terms of the head markings and so reference must be made to the accompanying drawing. The depicted specimen has a distinct white band running along the border of the upper labials. This feature is diagnostic of the western population, but absent in the snakes east of the Dahomey Gap. That the Shaw animal was of the Western form is also confirmed by the presence of the dark patch extending well anterior of the eye, as opposed to only slightly, as seen in the eastern species (see the formal diagnosis for *B. hoserae* sp. nov. below).

The holotype for the species *Vipera hexacera* Duméril, Bibron and Duméril, 1854 is also assignable to the named western species of *B. nasicornis* and is therefore not an available name for the eastern population.

The materials and methods of gathering data for the snakes hitherto known as *B. nasicornis* was as for the *B. gabonica* species group as already outlined. In summary and notwithstanding a range of means to separate the two separate taxa within the *B. nasicornis* group, it was found to be easiest to separate the taxa based on consistent marking differences on the head, as indicated in the relevant description below.

The body of published literature in terms of the *B. gabonica* and *B. nasicornis* species group/s is vast, due to the icon nature of the snakes themselves. Put bluntly, they are large colourful vipers sought after by reptile hobbyists and zoos everywhere.

Important and relevant material published to date includes: Böhme *et al.* (2011), Boulenger (1896), Branch (1993), Broadley and Cock (1975), Broadley and Howell (1991), Broadley and Parker (1976), Broadley *et al.* (2003), Calvete *et al.* (2007), Chippaux (2006), Chirio and Ineich (2006), Chirio and Lebreton (2007), Cope (1859), Critchlow (1998), Daudin (1802), Ditmars (1933), Dobiey and Vogel (2007), Duméril *et al.* (1854), Gray (1842), Hallowell (1847, 1857), Herrmann *et al.* (1999), Hoser (2012), Lenk *et al.* (1999), Linder *et al.* (2012), Loveridge (1936), Mallow *et al.* (2003), Marias (2004), Marsh and Whaler (1984), Marx (1988), Mattison (2007), McDiarmid *et al.* (1999), Mehrtens (1987), Menzies (1966), Mertens (1951), Pauwels and Vande weghe (2008), Peters (1882), Phelps (2010), Pitman (1974), Pyron *et al.* (2011, 2013), Schlegel (1855), Segniagbeto *et al.* (2011), Shaw and Nodder (1792), Shaw (1802), Spawls and Branch (1995), Spawls *et al.* (2004), Sweeney (1971), Warner and Kyle (2010), Wood (1996) and sources cited therein.

GENERAL DESCRIPTION OF ALL SPECIES WITHIN THE *BITIS GABONICA* SPECIES COMPLEX

As a description, these snakes are typical of the True Viper's, the most notable feature being their massive adult size.

Adults average 122-152 cm (4 to 5 feet) in length with a maximum of 205 cm (81 in) reported a specimen collected in Sierra Leone. The sexes are most readily distinguished by the length of the tail in relation to the total length of the body: approximately 12 percent for males and 6 percent for females, with males having a considerably larger tail by mass. Sexual dimorphism is obvious with females being considerably heavier and more stout in build.

Mallow *et al.* (2003) reported that a particularly large female had the following dimensions: Total length 174 cm (69 in); Head width 12 cm (4.7 in); Girth 37 cm (14.65 in); Weight (empty stomach) 8.5 kg (19 lbs).

In their description of "*B. gabonica*", Spawls *et al.* (2004) give

an average length of 80-130 cm (32 to 51.5 in), with a maximum size of 175 cm (69.3 in), saying the species may possibly grow larger still. They acknowledged reports of specimens over 1.8 m (6 ft), or even over 2 m (6.5 ft) in length, but claim they had no evidence to support this. A large specimen of exactly 1.8 m (5.9 ft), caught in 1973, was reported to have weighed 11.3 kg (25 lb) with an empty stomach (Wood, 1983). Very large specimens may possibly weigh up to 20 kg (44 lb), which would rank them as the world's heaviest venomous snake ahead of the Eastern diamondback Rattlesnake *Hoserea (Edwardsus) adamanteus* (Palisot de Beauvois, 1799) of the United States of America, but these masses are not known to have been verified (Wood, 1983).

In form the head is large and triangular, while the neck is greatly narrowed: almost one-third the width of the head. A pair of horns is present between the raised nostrils and these regionally vary in size and by individual specimen. As a rule these horns are tiny in all snakes referred to *B. gabonica* (including outlier populations), but much larger in most but not all snakes herein referred to as *B. rhinoceros*. The species *B. (Macrocerastes) nasicornis* is sometimes confused with *B. gabonica* (including *B. rhinoceros*), but is most readily identified by the large lance-shaped marking on the head and neck, not seen in the other species.

In terms of the *B. gabonica* species group, the eyes are large and moveable, set well forward, and surrounded by 15-21 circumorbital scales. There are 12-16 interocular scales across the top of the head. Four or five scale rows separate the suboculars and the supralabials. There are 13-18 supralabials and 16-22 sublabials. The fangs may reach a length of 55 millimetres (2.2 in), believed to be the longest of any venomous snake.

There are 28-46 dorsal mid-body scale rows, all of which are strongly keeled except for the outer rows on each side. The lateral scales are slightly oblique. The ventral scales number 124-140, rarely more than 132 in males, rarely less than 132 in females. The anal scale is single. There are 17-33 paired subcaudals, males have no fewer than 25, females no more than 23.

The color pattern consists of a series of pale, subrectangular blotches running down the center of the back, interspaced with dark, yellow-edged hourglass markings. The flanks have a series of fawn or brown rhomboidal shapes, with light vertical central bars. The belly is pale with irregular brown or black blotches.

The head is white or cream often with a fine, dark central line commencing from the back of the eyes and running to the top of the neck, black markings or spots on the rear corners, and a dark blue-black bar, triangle or diamond behind and below each eye, the front one being absent in *B. rhinoceros* and diagnostic for that taxon (see detail below). The iris color is cream, yellow-white, orange or silvery.

The species group is found in the following places: Guinea, Ghana, Togo, Sierra Leone, Liberia, Nigeria, Cameroon, Democratic Republic of Congo, Central African Republic, South Sudan, Uganda, Kenya, eastern Tanzania, Zambia, Malawi, eastern Zimbabwe, Mozambique, and northeast KwaZulu-Natal Province in South Africa.

In terms of preferred habitat, these snakes are typically found in rainforests, similar wet habitats and nearby woodlands and the edges of them, mainly at low altitudes, but sometimes as high as 1500 m. Spawls *et al.* (2004) mention a maximum altitude of 2100 m. Broadley and Cook (1975), mentioned the well-known fact that this species group is generally found in environments that are parallel to those occupied by the considerably more widespread Puff Adders (Subgenus *Bitisin*), which are normally found in drier and more open habitats.

Due to their cryptic colouration and lack of movement by day in warm weather they are generally hard to find. Most are caught

by herpetologists when crossing roads at night using the collecting methods described by Hoser (1989).

In cool weather, snakes are more likely to be seen by day either on top of ground cover or moving about, although never as easy to find in numbers as in perfect conditions in warm weather by road cruising.

While physically slow-moving and placid they can strike at speed and are typical in form for ambush predators.

As a rule, they are good captives choosing not to strike when handled. They should not be handled with so-called "snake tongs" as they have been known to fatally injure these snakes by breaking bones or damaging internal organs.

As a rule, locomotion is mostly rectilinear, in a sluggish "walking" motion of the ventral scales, the scales and venter giving a similar appearance at a distance to the legs of a millipede as it moves forward. They may writhe from side to side when alarmed, but only for short distances. Ditmars (1933) even described them as being capable of sidewinding, but this is in fact the case only in small and young specimens and again for only a very short distance.

Usually, these snakes give birth in late summer or at the end of the wet season, with an average litter of about 20 young. In line with other snakes, larger individuals are prone to having litters considerably larger than the average.

Neonates are reported by Spawls and Branch (1995), to be 25-32 cm in length and weigh 25-45 g.

The venom of these snakes is not particularly toxic, but due to volume released, the snakes are dangerous to humans.

THE SEPARATION OF EACH OF THE GABOON VIPER TAXA

Preceding the formal descriptions of the three new species taxa according to the Zoological Code (Ride *et al.* 1999), I herein give an overview of how the regional species of the *Bitis gabonica* species complex are separated from one another most easily.

Diagnosis of each species level taxon is most easily done by viewing the black to dark brown markings on the head that run from the eye to the (supra) labials, which are distinct from the otherwise lighter scales (pigment) on the rest of the head, which are a creamish-white to yellowish in colour. In the nominate form from central-west Africa (Type locality Gabon, Africa), there are two such lines, one running from the front of the eye to the labials (more-or-less running straight down, though angled slightly backwards) and the other from the rear of the eye in an expanding and descending triangle to the labials and back of the head. The size, shape and configuration of these bars (or their absence) and the white bar between them are diagnostic for the regional species within this species complex.

Of note is that many specimens (in particular younger ones) have a mid-dorsal stripe running from behind the nostrils to the beginning of the neck, but this is not diagnostic of any forms, although is by far most prevalent in nominate species *B. gabonica* and *B. wellingtoni sp. nov.* from Tanzania.

The diagnostic characters of the nominate form *Bitis gabonica* are as follows: The front stripe or bar running down from the eye to the labials has a thick zone of contact with the eye (giving it a distinctive U-shaped appearance), and always includes more than 2 labials wide of dark pigment at the base (on the bottom of the labials), the light bar behind this is irregular edged and is not in a straight line.

Bitis rhinoceros is diagnosed by the fact that it lacks a front stripe down from eye. The pigment where this would be is all light coloured as for the rest of the head. There is occasionally a small black "tear drop" seen running down from the eye.

In specimens of the species *B. funki sp. nov.* from north-east South Africa, the black bar at the front is narrow at the labials and two or less labials wide, in most cases being 2 labials wide with lightening apparent at the edge of one or other of the darkened labials. This species is the only one in the complex that has such a reduced width in the base of the front black bar.

The front stripe down from eye has a narrow zone of contact with the eye, occasionally not quite making it to the eye (giving it an inverted "V" shape). In some specimens this anterior dark bar also reduces at the bottom, giving it a diamond-shaped or oversized "tear drop" shape/appearance (not to be confused with the small tear drop-sized marking sometimes seen in *B. rhinoceros*). Occasionally no dark pigment reaches the bottom of the supralabials (the jawline). Due to reduction of black pigment at the base of the labials, the irregular white bar running from the labials to the eye has a distinctly triangular appearance with a wider base at the labials.

In specimens of *B. wellsi* sp. nov. from Zimbabwe, the black of the front and rear bars is so great as to merge, so that the front bar is usually 3 labials wide at the base and the white between the front and back bars forms a line up from the labials, but does not meet the eye, this being surrounded at the bottom with black pigment, or if it does contact the eye, does so as a tiny white line only (a sliver). Young specimens may have tiny black specks in front of the eye, which become indistinct with age.

In *B. wellingtoni* sp. nov. from eastern Tanzania, the first black bar from the eye is triangular in appearance, is at least 2.5 labials wide at the base (the bottom of the supralabials) and up to 3.5 labials wide; the white line between the two dark bars is of even thickness along its length, or rarely widens slightly at the labials and there is an elongate black bar in front of each eye that is not seen in any other species in the complex.

BITIS FUNKI SP. NOV.

Holotype: Specimen number FMNH no. 205789 from Natal, Zululand District, South Africa, (Collected by John Visser in 1973), held at the Field Museum of Natural History at 1400 S Lake Shore Drive, Chicago, IL 60605, United States of America. This is a government-owned facility that allows access to its material by scientists.

Paratype No. 1: Specimen number FMNH no. 205790 from Natal, Zululand District, South Africa, (Collected by John Visser in 1973), held at the Field Museum of Natural History at 1400 S Lake Shore Drive, Chicago, IL 60605, United States of America. This is a government-owned facility that allows access to its material by scientists.

Paratype No. 2: A specimen number: CM Herps 69392 obtained from St. Lucia, Dukuduku Forest, KwaZulu-Natal, South Africa held at the Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15213, United States of America. This is a facility that allows access to its material by scientists.

Diagnosis: Diagnosis of each species level taxon in the *Bitis gabonica* species complex is most easily done by viewing the black to dark brown markings on the head that run from the eye to the (supra) labials, which are distinct from the otherwise lighter scales (pigment) on the rest of the head, which are a creamish-white to yellowish in colour. In the nominate form from central-west Africa (Type locality Gabon, Africa), there are two such lines, one running from the front of the eye to the labials (more-or-less running straight down, though angled slightly backwards) and the other from the rear of the eye in an expanding and descending triangle to the labials and back of the head. The size, shape and configuration of these bars (or their absence) and the white bar between them are diagnostic for the regional species within this species complex.

Of note is that many specimens (in particular younger ones) have a vertebral stripe running from behind the nostrils to the beginning of the neck, but this is not diagnostic of any forms, although is by far most prevalent in nominate species *B. gabonica* and *B. wellingtoni* sp. nov. from Tanzania.

The diagnostic characters of the nominate form *Bitis gabonica* are as follows: The front stripe or bar running down from the eye to the labials has a thick zone of contact with the eye (giving it a distinctive U-shaped appearance), and always includes more than 2 labials wide of dark pigment at the base (on the bottom of the labials), the light bar behind this is irregular edged and is not in a straight line.

Bitis rhinoceros is diagnosed by the fact that it lacks a front stripe down from eye. The pigment where this would be is all light coloured as for the rest of the head. There is occasionally a small black "tear drop" seen running down from the eye.

In specimens of the species *B. funki* sp. nov. from north-east South Africa, the black bar at the front is narrow at the labials and two or less labials wide, in most cases being 2 labials wide with lightening apparent at the edge of one or other of the darkened labials. This species is the only one in the complex that has such a reduced width in the base of the front black bar. The front stripe down from eye has a narrow zone of contact with the eye, occasionally not quite making it to the eye (giving it an inverted "V" shape). In some specimens this anterior dark bar also reduces at the bottom, giving it a diamond-shaped or oversized "tear drop" shape/appearance (not to be confused with the small tear drop-sized marking sometimes seen in *B. rhinoceros*). Occasionally no dark pigment reaches the bottom of the supralabials (the jawline). Due to reduction of black pigment at the base of the labials, the irregular white bar running from the labials to the eye has a distinctly triangular appearance with a wider base at the labials.

In specimens of *B. wellsi* sp. nov. from Zimbabwe, the black of the front and rear bars is so great as to merge, so that the front bar is usually 3 labials wide at the base and the white between the front and back bars forms a line up from the labials, but does not meet the eye, this being surrounded at the bottom with black pigment, or if it does contact the eye, does so as a tiny white line only (a sliver). Young specimens may have tiny black specks in front of the eye, which become indistinct with age.

In *B. wellingtoni* sp. nov. from eastern Tanzania, the first black bar from the eye is triangular in appearance, is at least 2.5 labials wide at the base (the bottom of the supralabials) and up to 3.5 labials wide; the white line between the two dark bars is of even thickness along its length, or rarely widens slightly at the labials and there is an elongate black bar in front of each eye that is not seen in any other species in the complex.

Distribution: KwaZulu-Natal, South Africa and nearby areas.

Etymology: Named in honour of Mesa, Arizona, USA based herpetologist and veterinary surgeon, Dr. Richard Funk, (formerly of Florida USA), in recognition of a lifetime's service to herpetology and reptile medicine and surgery in a career spanning more than 60 years and starting as a child.

BITIS WELLSI SP. NOV.

Holotype: Specimen number, YPM HERR 006212 at the Yale University Peabody Museum, 170 Whitney Ave, New Haven, Connecticut, United States of America, collected from Zimbabwe. This is a facility that allows access to its material by scientists.

Paratypes: Three specimen numbers, YPM HERR 006213, YPM HERR 006214, YPM HERR 000020 at the Yale University Peabody Museum, 170 Whitney Ave, New Haven, Connecticut, United States of America, collected from Zimbabwe. This is a facility that allows access to its material by scientists.

Diagnosis: Diagnosis of each species level taxon in the *Bitis gabonica* species complex is most easily done by viewing the black to dark brown markings on the head that run from the eye to the (supra) labials, which are distinct from the otherwise lighter scales (pigment) on the rest of the head, which are a creamish-white to yellowish in colour. In the nominate form from central-west Africa (Type locality Gabon, Africa), there are two such lines, one running from the front of the eye to the labials (more-or-less running straight down, though angled slightly backwards) and the other from the rear of the eye in an expanding and descending triangle to the labials and back of the head. The size, shape and configuration of these bars (or their absence) and the white bar between them are diagnostic for the regional species within this species complex.

Of note is that many specimens (in particular younger ones) have a vertebral stripe running from behind the nostrils to the

beginning of the neck, but this is not diagnostic of any forms, although is by far most prevalent in nominate species *B. gabonica* and *B. wellingtoni* sp. nov. from Tanzania.

The diagnostic characters of the nominate form *Bitis gabonica* are as follows: The front stripe or bar running down from the eye to the labials has a thick zone of contact with the eye (giving it a distinctive U-shaped appearance), and always includes more than 2 labials wide of dark pigment at the base (on the bottom of the labials), the light bar behind this is irregular edged and is not in a straight line.

Bitis rhinoceros is diagnosed by the fact that it lacks a front stripe down from eye. The pigment where this would be is all light coloured as for the rest of the head. There is occasionally a small black "tear drop" seen running down from the eye.

In specimens of *B. wellsi* sp. nov., from Zimbabwe, the black of the front and rear bars is so great as to merge, so that the front bar is usually 3 labials wide at the base and the white between the front and back bars forms a line up from the labials, but does not meet the eye, this being surrounded at the bottom with black pigment, or if it does contact the eye, does so as a tiny white line only (a sliver). Young specimens may have tiny black specks in front of the eye, which become indistinct with age.

In specimens of the species *B. funki* sp. nov. from north-east South Africa, the black bar at the front is narrow at the labials and two or less labials wide, in most cases being 2 labials wide with lightening apparent at the edge of one or other of the darkened labials. This species is the only one in the complex that has such a reduced width in the base of the front black bar. The front stripe down from eye has a narrow zone of contact with the eye, occasionally not quite making it to the eye (giving it an inverted "V" shape). In some specimens this anterior dark bar also reduces at the bottom, giving it a diamond-shaped or oversized "tear drop" shape/appearance (not to be confused with the small tear drop-sized marking sometimes seen in *B. rhinoceros*). Occasionally no dark pigment reaches the bottom of the supralabials (the jawline). Due to reduction of black pigment at the base of the labials, the irregular white bar running from the labials to the eye has a distinctly triangular appearance with a wider base at the labials.

In *B. wellingtoni* sp. nov. from eastern Tanzania, the first black bar from the eye is triangular in appearance, is at least 2.5 labials wide at the base (the bottom of the supralabials) and up to 3.5 labials wide; the white line between the two dark bars is of even thickness along its length, or rarely widens slightly at the labials and there is an elongate black bar in front of each eye that is not seen in any other species in the complex.

Distribution: Restricted to the moister parts of the eastern escarpments of Zimbabwe and immediately adjacent Mozambique.

Etymology: Named in honour of Richard Wells, now of Grafton, New South Wales, Australia in recognition of a lifetime's valuable contributions to herpetology that go well beyond the various taxonomic works he is most famous for, many of which were co-authored with Ross Wellington (see below).

BITIS WELLINGTONI SP. NOV.

Holotype: Specimen number R-54449 at the MCZ (Museum of Comparative Zoology, Harvard University, USA), collected from Mtwara, Tanzania, Lat 10.933333, Long 39.3. This is a facility that allows access to its material by scientists.

Paratype: Specimen number R-53980 at the MCZ (Museum of Comparative Zoology, Harvard University, USA), from Mtwara, Tanzania, Lat 10.933333, Long 39.3. This is a facility that allows access to its material by scientists.

Diagnosis: Diagnosis of each species level taxon in the *Bitis gabonica* species complex is most easily done by viewing the black to dark brown markings on the head that run from the eye to the (supra) labials, which are distinct from the otherwise lighter scales (pigment) on the rest of the head, which are a creamish-white to yellowish in colour. In the nominate form from

central-west Africa (Type locality Gabon, Africa), there are two such lines, one running from the front of the eye to the labials (more-or-less running straight down, though angled slightly backwards) and the other from the rear of the eye in an expanding and descending triangle to the labials and back of the head. The size, shape and configuration of these bars (or their absence) and the white bar between them are diagnostic for the regional species within this species complex.

Of note is that many specimens (in particular younger ones) have a vertebral stripe running from behind the nostrils to the beginning of the neck, but this is not diagnostic of any forms, although is by far most prevalent in nominate species *B. gabonica* and *B. wellingtoni* sp. nov. from Tanzania.

The diagnostic characters of the nominate form *Bitis gabonica* are as follows: The front stripe or bar running down from the eye to the labials has a thick zone of contact with the eye (giving it a distinctive U-shaped appearance), and always includes more than 2 labials wide of dark pigment at the base (on the bottom of the labials), the light bar behind this is irregular edged and is not in a straight line.

Bitis rhinoceros is diagnosed by the fact that it lacks a front stripe down from eye. The pigment where this would be is all light coloured as for the rest of the head. There is occasionally a small black "tear drop" seen running down from the eye.

In *B. wellingtoni* sp. nov. from eastern Tanzania, the first black bar from the eye is triangular in appearance, is at least 2.5 labials wide at the base (the bottom of the supralabials) and up to 3.5 labials wide; the white line between the two dark bars is of even thickness along its length, or rarely widens slightly at the labials and there is an elongate black bar in front of each eye that is not seen in any other species in the complex.

In specimens of the species *B. funki* sp. nov. from north-east South Africa, the black bar at the front is narrow at the labials and two or less labials wide, in most cases being 2 labials wide with lightening apparent at the edge of one or other of the darkened labials. This species is the only one in the complex that has such a reduced width in the base of the front black bar. The front stripe down from eye has a narrow zone of contact with the eye, occasionally not quite making it to the eye (giving it an inverted "V" shape). In some specimens this anterior dark bar also reduces at the bottom, giving it a diamond-shaped or oversized "tear drop" shape/appearance (not to be confused with the small tear drop-sized marking sometimes seen in *B. rhinoceros*). Occasionally no dark pigment reaches the bottom of the supralabials (the jawline). Due to reduction of black pigment at the base of the labials, the irregular white bar running from the labials to the eye has a distinctly triangular appearance with a wider base at the labials.

In specimens of *B. wellsi* sp. nov. from Zimbabwe, the black of the front and rear bars is so great as to merge, so that the front bar is usually 3 labials wide at the base and the white between the front and back bars forms a line up from the labials, but does not meet the eye, this being surrounded at the bottom with black pigment, or if it does contact the eye, does so as a tiny white line only (a sliver). Young specimens may have tiny black specks in front of the eye, which become indistinct with age.

Etymology: Named in honour of Cliff Ross Wellington now of Woy Woy, New South Wales, Australia in recognition of a lifetime's valuable contributions to herpetology that go well beyond the various taxonomic works he is most famous for which were co-authored with Richard Wells (see previous).

BITIS HOSERAE SP. NOV.

Holotype: A specimen number: SMNS 8360 at the Staatliches Museum Fur Naturkunde Stuttgart, Germany, from the Democratic Republic of Congo. This is a facility that allows access to its material by scientists.

Paratype: A specimen number: SMNS 4852 at the Staatliches Museum Fur Naturkunde Stuttgart, Germany, from Congo. This is a facility that allows access to its material by scientists.

Diagnosis: The species taxon *Bitis hoserae* sp. nov. has until now been identified by herpetologists as the eastern form of *Bitis* (*Macrocerastes*) *nasicornis* (Shaw, 1802) and the diagnosis for that taxon applies to this new species in addition to the characters identified herein that separates the two taxa.

Bitis hoserae sp. nov. is most easily separated from *B. nasicornis* by the markings on the head. In *B. nasicornis* there is a semicircular dark brown patch running from at or near the bottom of the supralabials to just below the eye, but with the lighter white marking bordering the semi-circle separating the eye from the brown patch below. At the level of the eye, there is the dark bottom of a dark stripe or bar (indistinct at the top boundary) that runs from the snout to the back of the head.

This bar does cut under the eye (just) and means that the scales beneath the eye are usually also dark.

At the bottom of the dark semicircle and along the line of the bottom of the upper labials is a continuous and narrow white strip connecting lighter areas to the front and rear of the dark semicircle.

Of note in terms of *B. nasicornis* is that the bottom dark semicircle does not connect with the eye or dark region that runs across or through it.

In very unusual cases, the dark semicircle may connect with either the eye or the dark bar running through it, but this is never more than a single dark scale in width.

Bitis hoserae sp. nov. is separated from *B. nasicornis* by the fact that the dark patch below the eye is not of an obvious semicircle in shape, being effectively an irregular band instead, running from the eye down, being marginally wider at the labials, and effectively merging with the area of dark pigment, defined here as a dark stripe or bar, that runs through the eye and side of the head. The narrowest point of where the dark bar from the labials joins the dark patch or eye above is at least three scales wide, averages 5-7 scales wide and may be up to 9 scales wide. This feature enables the two species to be separated with ease, including from photographs.

Along the line of the upper labials there is as a rule, little if any white pigment forming a line bordering the darker pigment patch running down from the eye, as seen in *B. nasicornis*.

There are however some specimens of *Bitis hoserae* sp. nov. which do have some white marks on the upper labials and in some cases partial formation of a white strip as seen in *B. nasicornis*, however it is never a continuous strip as seen in *B. nasicornis*.

Also of note is that the dark patch under the eye of *B. nasicornis* advances considerably anterior to the eye, as opposed to only slightly forward of the eye in *Bitis hoserae* sp. nov..

It should also be noted that *Bitis hoserae* sp. nov. from Nigeria sometimes have a triangular patch under the eye (not the semicircle of *B. nasicornis*), the base of the triangle being at the labials, but with the dark upper tip intersecting the orbit and dividing lighter areas into two. At the labials, there may be some lighter scales, but these do not form a continuous strip as seen in *B. nasicornis*.

Bitis hoserae sp. nov. has on average a greater preponderance of green and yellow through the scales than seen in *B. nasicornis*, which in turn has a greater preponderance of blue and red, however this is both hard to quantify and use for diagnostic purposes when one factors in such variables as age and shedding cycle.

Bitis hoserae sp. nov. also tend to have longer horns than seen in *B. nasicornis* but this trait is not diagnostic as it also varies both with age and with individual snakes.

Both *B. hoserae* sp. nov. and *B. nasicornis* are diagnosed as follows: They are a large and stout True Viper, similar in many respects to *B. gabonica* as already described above.

B. hoserae sp. nov. and *B. nasicornis* range in length from 72 cm to 107 cm. Spawls *et al.* (2004) mentioned a maximum

length of 120 cm, but admitted this is exceptional, quoting an average length of 60-90 cm. Females grow larger than males.

The head is narrow, flat, triangular and relatively small compared to the rest of the body. The neck is thin. These snakes have a distinctive set of two or three horn-like scales on the end of their noses, the front pair of which may be quite long. The eyes are small and set well forward. The fangs are not large, in contrast to the *B. gabonica* species complex and are rarely more than 1.5 cm in length.

There are 31-43 dorsal midbody scale rows. These are so rough and heavily keeled that they occasionally inflict cuts on handlers when the snakes struggle. There are 117-140 ventrals, single anal and 16-32 subcaudals, with males having a higher count (25-30) than females (16-19).

The distinct dorsal color pattern consists of a series of 15-18 blue or blue-green, oblong markings, each with a lemon-yellow line down the center. These are enclosed within irregular, black, rhombic blotches. A series of dark crimson triangles run down the flanks, narrowly bordered with green or blue. Many of the lateral scales have white tips, giving the snake a velvety appearance. The top of the head is blue or green, overlaid with a distinct black arrow mark. The belly is dull green to dirty white, strongly marbled and blotched in black and gray.

Distribution: *Bitis hoserae* sp. nov. occurs in eastern, central and western Africa, from southern Sudan, western Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, across to Nigeria to the Dahomey Gap. The populations east of the Dahomey Gap, from Ghana, west to Guinea are of the species *B. nasicornis*.

Etymology: Named in honour of my mother, Katrina Hoser, now of Lane Cove, New South Wales, Australia in recognition of many contributions to herpetology spanning more than 40 years as well as her great support for the footwear industry world-wide.

FIRST REVISOR NOTE:

In the event that two or more of the new species level taxa described herein are sought to be merged by a later author, the name to be taken and used is in the order as described within this paper, (*funki*, *wellsi*, *wellingtoni*, *hoserae*). That is the first printed name takes priority over a later one in event of conflict involving two names for allegedly one taxon.

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CONFLICT OF INTEREST

The author has no conflicts of interest in terms of this paper or conclusions within.

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