

Acknowledgements

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The distribution of *Bufo poweri* in southern Africa

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Bufo poweri is shown to be distinguishable from *B. garmani* on the basis of different male advertisement calls. A survey of published and unpublished sonagrams, and data summarizing sonagrams of calls, was used to determine the geographic ranges of the two species. *B. garmani* is found in the north and east, and *B. poweri* in the south and west of Africa. Further fieldwork is required at the boundary between the two species.

Bufo poweri kan van *B. garmani* onderskei word op grond van die verskil in hul manlike advertensieroep. 'n Opname van gepubliseerde en ongepubliseerde sonagramme, en data wat sonagramme opsom, is gebruik om die geografiese verspreiding van die twee spesies te bepaal. *B. garmani* kom in die noorde en ooste voor, en *B. poweri* in die suide en weste van Afrika. Verdere veldwerk word benodig by die grens tussen die twee spesies.

The cosmopolitan genus *Bufo* has been divided into a number of species groups (Frost 1985). The *Bufo regularis* species group is African and, along with other species of the *regularis* complex, is remarkable for its chromosome number of $2n = 20$, while all other species of *Bufo* examined have 22 chromosomes (Bogart 1968). The *regularis* species group presently consists of *B. brauni*, *B. garmani*, *B. gutturalis*, *B. kisoensis*, *B. poweri*, *B. rangeri*, and *B. regularis* (Frost 1985).

Bufo garmani was described from Somalia (Meek 1897), while the morphologically similar *B. poweri* was described from Kimberley (Hewitt 1935). A long-standing problem has been to determine the status of *B. poweri*, based on preserved material. These two species are so similar in body proportions and colour pattern, characters often used to identify toads, that previous workers have been unable to separate them reliably. It is not surprising that until 1972 *B. garmani* and *B. poweri* were regarded as one species, *Bufo garmani* (Poynton 1964a; Tandy & Keith 1972). However, Tandy subsequently regarded them as distinct, largely on the basis of different advertisement calls (Tandy 1972; Tandy, Bogart, Largen & Feener 1982; Largen, Tandy & Tandy 1978). The call of *B. poweri* was described by Tandy *et al.* (1982), and that of *B. garmani* from Kenya by Largen *et al.* (1978). Most later workers have retained only the name *B. garmani* for southern African material (Passmore & Carruthers 1979; Poynton & Broadley 1988; Lambiris 1989).

The problem of how many species comprised '*B. garmani*' and their distribution, was investigated by analysing available advertisement calls. Although the members of the *regularis* species group are morphologically very similar, each species possesses a distinct call (Poynton 1964a: 11). Advertisement calls of male frogs have been demonstrated

to be species specific, and to function to attract conspecific females (Duellman & Trueb 1986, and references therein). Calling toads may be thought of as advertising their species identity (see also Paterson 1985).

I measured call duration and number of pulses from sonagrams of male advertisement calls. Sonagrams were made of field recordings (on a Kay 7029A Sonagraph), and additional data were taken from published sonagrams or from published details of calls. Sources of *B. garmani* calls were (n = number of calls): Marsabit, 02°18'N / 38°00'E, Kenya, n = 33, (Keith 1968); Isiolo, 00°24'N / 37°33'E, Kenya, n = 8, (Keith 1968); Kibwezi, 02°25'S / 33°57'E, Kenya, n = 10, (Largen *et al.* 1978); Birchenough Bridge, 19°57'S / 32°20'E, Zimbabwe, n = 12, (Keith 1968); Skukuza, Kruger National Park, 31°40'S / 24°59'E, South Africa, n = 1, Braack (recording); Letaba, Kruger National Park, 23°50'S / 31°40'E, South Africa, n = 1, (Tandy 1972). *B. poweri* calls came from Gwaai River, 17°59'S / 26°53'E, Zimbabwe, n = 1, Keith (recording); Stella, South Africa, 26°33'S / 24°53'E, n = 10, (Tandy *et al.* 1982); Kimberley, 28°44'S / 24°46'E, South Africa, n = 3, Channing (recording); Grootfontein, 19°33'S / 18°04'E, Namibia, n = 3, Channing (recording); Maun District, 19°59'S / 23°25'E, Botswana, n = 9, Balinsky (sonagrams); Naboomspruit, 24°33'S / 28°32'E, South Africa, n = 26, Passmore (sonagrams); Groenkloof, 25°43'S / 28°11'E, South Africa n = 1, Passmore (sonagrams); Okapaue, 21°52'S / 16°05'E, Namibia n = 16 (Van den Elzen & Van den Elzen 1977).

The one sonagram of a *B. poweri* call from Groenkloof appears to be typical of the species. This call is one of many Passmore used in his study of toad hybridization at Groenkloof (Passmore 1972). None of the toads presumed to be hybrids on the basis of vocalization in Passmore's study were of known parentage. I make the parsimonious assumption that a toad which has an advertisement call typical of *B. poweri*, is in fact that species. The other calls from Groenkloof are all intermediate in structure.

The calls of the two species *B. garmani* and *B. poweri* may be distinguished by a combination of call duration and pulse rate (Figure 1). The calls were recorded at temperatures ranging from 18°C to 25,5°C. The graph shows that as duration increases the pulse rate decreases, although the relationship is not linear. There is variation in the number of pulses per call, with some overlap between species. Temperature and size of calling male are known to produce variations in call parameters (Zweifel 1968; Duellman & Trueb 1986), but the calls of the two species vary similarly (Figure 1), and no overlap in the combination of parameters was found. The distribution of these two cryptic species can be discovered on the basis of the male advertisement call.

The southern African toads previously called *Bufo garmani* belong to two taxa, a northern and eastern species, *Bufo garmani*, and a southern and western species, *Bufo poweri*. At the moment the nature and position of the geographic boundary between these species is uncertain. The specific status of *Bufo poweri* has been overlooked by many workers, partly owing to the lack of a direct morphological comparison between the species.

Hulselmans (1969) described *Bufo pseudogarmani* from

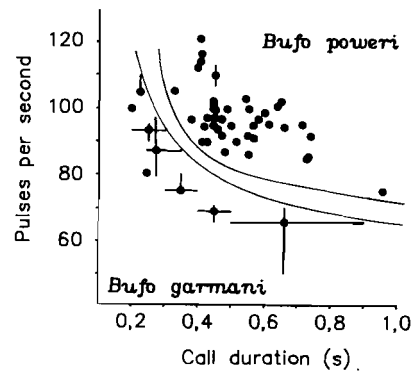


Figure 1 Advertisement call analysis for *Bufo garmani* and *Bufo poweri*. Pulse rate is plotted against call duration. Ranges of values taken from the literature are indicated as bars.

Namibia, based on small morphological differences from *B. garmani*. I showed that these specimens represented part of the range of variation of the common Namibian toad (*B. poweri*), then called *Bufo garmani* (Channing 1972). It is now apparent that *B. pseudogarmani* is a synonym of *B. poweri*, which explains why Hulselmans found it different from *B. garmani*. He showed a biometrical difference between *B. garmani* and *B. poweri* (as *B. pseudogarmani*) in a paper investigating the biometry of the *Bufo regularis* complex (Hulselmans 1977a), using a canonical analysis with 18 variables. The Mahalanobis distance between *B. garmani* and *B. poweri* was 18,9068.

Distribution. *Bufo poweri* appears to be distributed over the central and western parts of southern Africa, from the Karoo through the Transvaal highveld to Botswana and central and northern Namibia. *Bufo garmani* is known from disjunct populations from Somalia through eastern Zimbabwe to the Kruger National Park in the eastern Transvaal, and northern Natal (Tandy 1972; Frost 1985; Lambiris 1989) (Figure 2).

Extensive fieldwork is required to determine the ranges of the two species along the eastern border of South Africa, and the south-western areas of Zimbabwe, along the plateau escarpments. Call analysis may be particularly difficult here, as toads are notorious for their ability to hybridize, especially in disturbed habitats. Molecular techniques would appear to be ideally suited to investigate this genetic boundary and the interactions occurring where these two species may overlap.

The identification of Angolan material is uncertain, as I have been unable to obtain calls from the area. However, *Bufo poweri* occurs along the northern border of Namibia, and I expect that *B. poweri* is present throughout Angola.

Synonymy. Practically all the toads in the *regularis* species group have at one time or another been included in *Bufo regularis*. Earlier confusion has been discussed by Poynton (1964a), Keith (1968), and Tandy & Keith (1972). I list recent uses of names assignable to *Bufo poweri* and *Bufo garmani* in southern Africa, below.

Bufo poweri Hewitt 1935

Bufo regularis poweri Hewitt 1935

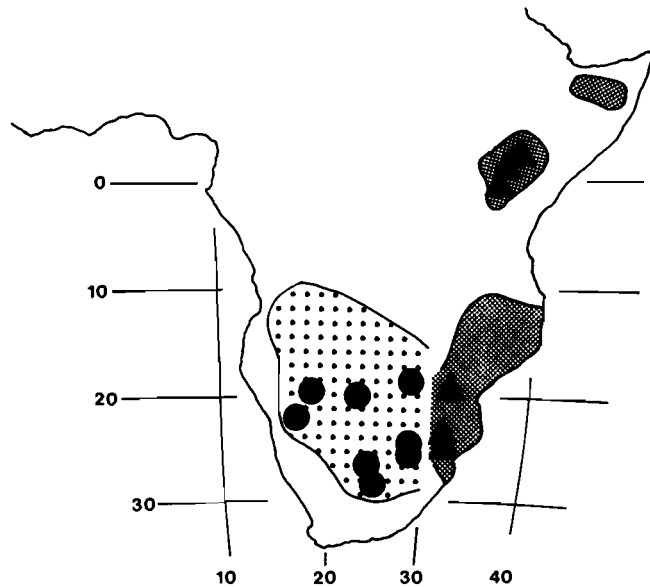


Figure 2 Localities from which sonagrams of advertisement calls were obtained. Triangles — *Bufo garmani*, circles — *Bufo poweri*. The presumed distributions of *Bufo garmani* (dark shading) and *Bufo poweri* (light shading) are indicated. Northern distributions after Tandy (1972).

Bufo garmani Meek. Poynton 1964a (part); Poynton & Broadley 1988 (part); Tandy & Keith 1972 (part); Passmore & Carruthers 1979 (part); Channing 1972; Channing & Van Dijk 1976; Van Dijk 1971.

Bufo poweri Hewitt. Tandy 1972; Bachman, Hemmer, Konrad & Maxson 1980.

Bufo pseudogarmani Hulselmans. Hulselmans 1969; Hulselmans 1977a.

Bufo garmani humbensis Monard 1937. Van den Elzen 1978.

Bufo garmani pseudogarmani Van den Elzen & Van den Elzen 1977.

***Bufo garmani* Meek 1897**

Bufo garmani Meek. Keith 1968; Bachman *et al.* 1980; Hulselmans 1977a, 1977b; Poynton 1964a (part), 1964b; Pienaar, Passmore & Carruthers 1976; Stewart 1967; Lambiris 1989; Poynton & Broadley 1988 (part); Bogart 1968; Tandy 1972; Tandy & Keith 1972 (part); Passmore & Carruthers 1979 (part).

Bufo bisidanae Hulselmans. Hulselmans 1977b.

Bufo poweri Hewitt. Pienaar 1963.

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A quantitative analysis of the marked asymmetry existing between some muscle partners in the pelvic girdle of southern African species of the genus *Mabuya* (Reptilia: Scincidae)

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The pelvic girdle musculature of eleven of the eighteen southern African *Mabuya* species described by Branch (1988) was examined, using differences in mass to emphasize the marked asymmetry existing between partners of certain muscle pairs. The lighter muscles expressed as indices of their heavier partners gave a mean value of 0,38 ($n = 27$) with a range of 0,11 to 0,75. The mean value obtained for a symmetrical control pair was 0,95 ($n = 27$) with a range of 0,90 to 0,99. The arrangement of the asymmetric pairs was the same for all the species, irrespective of sex. The partners of a pair differed in size and the manner in which they originated on the pelvic girdle but showed agreement as far as their insertion on the head of the femur was concerned.

Die bekkenwykspiere van elf van die agtien Suider-Afrikaanse *Mabuya* spesies wat deur Branch (1988) beskryf is, is ondersoek. Verskille in massa is gebruik om die duidelike asimmetrie tussen paargenote van sekere spiere aan te dui.

Die ligter spiere uitgedruk as indekse van hulle swaarder paargenote het gemiddelde waardes van 0,38 ($n = 27$) gelewer, met 'n meetgrens van 0,11 tot 0,75. Die gemiddelde waarde verkry vir 'n simmetriese kontrole-paar was 0,95 ($n = 27$) met 'n meetgrens van 0,90 tot 0,99. Die rangskikking van die asimmetriese pare was dieselfde vir al die spesies, ongeag die geslag. Die paargenote het verskil ten opsigte van hulle grootte en die wyse waarop hulle op die bekkengordel ontspring het, maar het ooreengestem sover dit hulle aanhegting aan die kop van die femur betref het.

The earliest documentation of the existence of marked asymmetry between certain muscle pairs of the lacertilian pelvic girdle appears to be that of Sukhanov (1957)*. *(This paper was not seen in its entirety as the author could only obtain a summary of it.) He found it to exist in genera of the families Gekkonidae, Lacertidae and Scincidae but not in genera of the families Agamidae and Iguanidae. A detailed description of the asymmetric condition in *Mabuya capensis* was given by Heideman (1987). Tiedeman & Tiedeman (1975) examined the pelvic girdle musculature of *Mabuya quinquetaeniata margaritifera* but did not mention anything about the existence of muscle asymmetry. This prompted the author to check and quantify its existence in this and other southern African species of the genus. The system used to identify and group the individual muscle pairs was that of Romer (1942).

Ten freshly collected specimens now in the collection of the University of Namibia and 17 preserved specimens obtained from the National Museum Bloemfontein, the Transvaal Museum and the Windhoek State Museum, were examined. In seven of the 11 species both males and females were dissected, in three only females were dissected and in the remaining one only a male specimen was examined. A list of all the voucher specimens is provided in Appendix 1. Dissections were carried out with the aid of a Vickers stereomicroscope using an Intralux 5000 Volpi cold light to prevent the muscles from drying out. The method for staining muscle fibres devised by Bock & Schear (1972) proved useful in the identification of individual muscles. The muscles were removed by cutting them loose at their origins on the pelvic girdle and at the point where they merged with their inserting tendons. In the fresh specimens the muscles were weighed immediately after their removal while those from the preserved specimens were first blotted with Whatman filter paper until no moisture showed on the paper and then weighed. Weighing was done with a Sartorius analytical balance with a lower limit of 0,1 mg. In the case of *Mabuya capensis* and *Mabuya varia* both viviparous and oviparous specimens were examined. The asymmetric condition in the oviparous specimens was checked without weighing the individual muscles.

The species all showed a pattern of muscle asymmetry similar to that described for *M. capensis* by Heideman (1987). In both sexes both the weakly and the well-developed muscles of each asymmetric pair originated in the same manner on the pelvic girdle. This was also the case in the oviparous *Mabuya capensis* and *Mabuya varia* specimens. The indices calculated from the mass values obtained for each asymmetric pair are given in Table 1. In some specimens the mass of certain muscles could not be