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Taxonomic status of the Australian burrowing frogs *Neobatrachus sudelli, N. centralis* and *Neoruinosus* and clarification of the type specimen of *N. albipes*

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Abstract – I review genetic and call structure data available to define species boundaries in the genus *Neobatrachus*, synonomise *N. centralis* with *N. sudelli*, synonomise the genus *Neoruinosus* Wells and Wellington with *Neobatrachus* and correct an error in the registration number for the type specimen of *N. albipes*.

INTRODUCTION

The genus *Neobatrachus* is notable for the occurrence of at least three tetraploid taxa of burrowing frogs in the Australian arid zone: *N. aquilonius*, *N. kunapalari* and *N. sudelli* with the remaining species all diploid (Mahony and Robinson 1980, 1986; Mahony and Roberts 1986; Roberts *et al.* 1991). Data on call structure variation, karyotypes and on relationships and species boundaries defined by mitochondrial DNA have contributed important data relevant to taxonomy in the genus *Neobatrachus* (Mahony *et al.* 1996; Mable and Roberts 1997; Roberts 1997a,b).

Despite these data being available, several problematic (but solvable) issues in *Neobatrachus* taxonomy remain. First, the application of the names *N. centralis*, *N. sudelli* and *N. aquilonius* seems to cause considerable confusion (see discordant distribution maps in Barker *et al.* (1995); Tyler *et al.* (2000) and Anstis (2002)). Related to this issue is the validity of the genus *Neoruinosus* that Wells and Wellington (1985) erected for *Neobatrachus sudelli*, and this action is clearly linked to the status of *N. sudelli* vis-à-vis *N. centralis*. Lastly, a contribution to taxonomy in this genus accidentally included incorrect details on the type specimen of *N. albipes* (Roberts *et al.* 1991).

I review the status of names used to describe *Neobatrachus* species in Australia, discuss the status of the genus *Neoruinosus*, make taxonomic recommendations based on those reviews and correctly define the type specimen of *Neobatrachus albipes*.

NEOBATRACHUS SPECIES NAMES AND PLOIDY STATUS

albipes Roberts, Mahony, Kendrick and Majors, 1991 (diploid)
aquilonius Tyler, Davies and Martin, 1981 (tetraploid)
centralis (Parker, 1940) (tetraploid)
fulvus Mahony and Roberts, 1986 (diploid)
kunapalari Mahony and Roberts, 1986 (tetraploid)
pelobatoides (Werner, 1914) (diploid)
pictus Peters, 1863 (diploid)
sudelli (Lamb, 1911) (tetraploid)
sutor Main, 1957 (diploid)
wilsmorei (Parker, 1940) (diploid)

TAXONOMIC RECOMMENDATIONS

Neobatrachus centralis and *N. sudelli*

Parker (1940) did not examine specimens from within the known range of *N. pictus* (Roberts 1978). Moore (1961) and Hosmer (1958) both considered *N. sudelli* was a junior synonym of *N. pictus*, but Parker (1940) was less confident of that synonomy. Roberts (1978) redefined *N. pictus*, resurrected *N. sudelli* from the synonomy of *N. pictus* and argued that *N. centralis* may be a junior synonym of *N. sudelli.* Parker (1940) did distinguish two forms of *Neobatrachus* – from southeastern and inland eastern Australia: *N. centralis* and what he referred to as *N. pictus* (i.e. actually *N. sudelli*). There is no question about the status of *N. pictus* or of the status of *N. sudelli* (Roberts 1978). What is uncertain is the status of *N. centralis* relative to *N. sudelli.* The data reviewed below suggest there is no compelling reason to split *N. sudelli* and *N. centralis* despite some variation across the range of the two taxa.

Data on male call (Roberts 1997a,b) and relationships based on mitochondrial DNA indicate there is a single taxon, *N. sudelli*, ranging from southeast Queensland to western Victoria and southeastern South Australia, west to Menzies in

Western Australia and north into the Tanami desert in the Northern Territory. This set of populations showed remarkably little variation in mitochondrial DNA (Mable and Roberts 1997) but the specimens in that clade had been variously designated in museum collections as *N. sudelli, N. centralis* and *N. aquilonius* (e.g. see names used in museum collections in sample details in Mable and Roberts 1997). There was some variation in male call across the range defined by the mtDNA clade (Roberts 1997b) but the species was well differentiated from calls of most other species except *N. aquilonius* (Roberts 1997a,b). The call and mtDNA data sets included material from close to the type locality for *N. sudelli* (Warwick in southeast Queensland) where only a single *Neobatrachus* species has been reported (e.g. Robinson 1993; Barker *et al.* 1995; Cogger 2000). There is some evidence of hybridization between *N. sudelli* and *N. kunapalari* near Menzies in Western Australia and probable strong selection against hybrids given that some hybrid frogs exhibited severe abnormalities (Roberts 1997b). Tetraploid species of *Neobatrachus* may also hybridise with diploid species at geographic contact points (Mahony *et al.* 1996) but the occurrence of hybrids is not necessarily an indication of any close relationship as the capacity to hybridise may be a retained, primitive character (Wiley 1981).

I refer the name *Neobatrachus centralis* (Parker, 1940) to the synonomy of *N. sudelli* (Lamb, 1911). *Neobatrachus sudelli* is a tetraploid taxon with the nucleolar organiser region (NOR) subterminal on chromosome 5 (Mahony and Robinson 1980, 1986; Mahony and Roberts 1986). It ranges from Queensland to Western Australia across areas with primarily winter to high summer rainfall as well as arid areas with upredictable precipitation. This species can be distinguished from *N. kunapalari*, also a tetraploid species, by the location of the nucleolar organiser region (NOR): the NOR is medial on chromosome 7 in *N. kunapalari* (Mahony and Roberts 1986).

Distinction of *N. sudelli* from *N. aquilonius* is less clear cut but the separate status of *N. sudelli* is strongly supported by the exclusion of *N. sudelli* from clades including *N. aquilonius* and *N. fulvus* based on mtDNA. A close relationship between *N. fulvus* and *N. aquilonius* is indicated by mtDNA sequence data (Mable and Roberts 1997) and a strong similarity in male call (Roberts 1997a,b). *Neobatrachus aquilonius* and *N. sudelli* (as defined above) are likely to meet in inland northern Australia somewhere between the Tanami Desert and the northwest coast. Geographically *N. aquilonius* and *N. sudelli* may overlap or abut and they may hybridise. However, there are insufficient voucher specimens and associated tissue samples from these areas to test these ideas.

The use of mtDNA sequence to define relationships may not be reliable if the same female line hybridised with different male lineages to generate distinct allopolyploid lineages: the lineages would share mtDNA phenotypes but have different, mixed nuclear genotypes. Multiple hybridisation events leading to numerous similar but distinct allopolyploid lineages have been reported in *Hyla versicolor* with subsequent hybridisation between tetraplopid lineages leading to a single interbreeding species (e.g. Holloway 2007). The occurrence of hybrids between diploid and tetraploid species where their ranges meet potentially allowing cross-species transfer of mtDNA might also complicate interpretation of mtDNA trees (cf. Mahony *et al.* 1996).

In contrast, although there is considerable variation revealed by allozyme analysis in *Neobatrachus*, those data found unique alleles (particularly in geographically remote populations) but not fixed differences between populations attributed to *N. centralis* and *N. sudelli* (Mahony *et al.* 1996) supporting the uniformity suggested by call and a naive interpretation of the mtDNA data (Mable and Roberts 1997; Roberts 1997a,b).

Many authors seem able to distinguish *N. sudelli* from *N. centralis* or understand there is either a morphological or geographic distinction as both names are widely used, but the basis of those designations has never been critically tested (e.g. Robinson 1993; Barker *et al.* 1995; Cogger 2000; Tyler *et al.* 2000; Anstis 2002). There may be some support for ultimate subdivision of *N. sudelli* as defined here based on more detailed analyses of morphology, call or genetic data. Given the published data, however, subdivision is not reasonably justified at present.

The distinction of all other *Neobatrachu*s species is clear based on morphology, external colouration and pattern, karyotype (particularly NOR position), allozyme phenotype, ploidy level, and/or male call (Mahony and Robinson 1980, 1986; Mahony and Roberts 1986; Mahony *et al.* 1996; Roberts 1997a,b; Roberts *et al.* 1991).

Status of *Neoruinosus* Wells and Wellington, 1985

Wells and Wellington (1985) introduced the genus name *Neoruinosus* distinct from *Neobatrachus* for a single species, *Neoruinosus sudelli*, and claimed this might be a complex of several species but did not describe any characters that exclusively defined the genus or excluded this species from the genus *Neobatrachus*. They claimed *Neoruinosus* was 'readily identified by the following combination of characters: Skin possessing numerous warts dorsally and smooth ventrally; groin skin very loose; toes nearly fully webbed; eye about equal to the distance to the tip of the snout; inner metatarsal tubercle black; indistinct tympanum; reaches about 40mm total length' (p. 3). The genus was monotypic containing only *Neoruinosus sudelli* (Wells and Wellington 1985). With the exception of the loose groin skin and body size, this combination of character states is also a very good description of *Neobatrachus kunapalari* (cf. Mahony and Roberts 1986).

Wells and Wellington gave no characters or combination of characters to uniquely define *Neoruinosus*. Based on available phylogenetic data (Mable and Roberts 1997) there is no compelling reason to suspect *N. sudelli* is anything other than a *Neobatrachus* species with which it shares common call structures and breeding biologies, and can hybridise successfully (Roberts 1997b), although it may be a basal lineage in the genus (Mable and Roberts 1997, figure 3A). Interestingly, Wells and Wellington left *N. centralis* in *Neobatrachus* suggesting they felt *N. centralis* and *N. sudelli* were distinctive, contrary to the data reviewed above.

Based on available data on male call, karyotype, NOR position and capacity to hybridise, I therefore refer *Neoruinosus* to the synonymy of *Neobatrachus* Peters, 1863.

Type specimen of *Neobatrachus albipes*

In the original description of *Neobatrachus albipes* by Roberts *et al.* (1991), the type specimen of *N. albipes* was defined two ways: by a Western Australian Museum (WAM) register number (WAM R101178) and by a recording number as Frog #3 on JDR Tapes 79 and 80 referring to reel-to-reel recordings in the J.D. Roberts recording collection.

WAM R101178 is a specimen of *N. pelobatoides* collected 20.5 km west of Jerramungup by C.M. Majors on 25 May 1989 and recorded as Frog #10 on JDR Cassette 29 in the J.D. Roberts recording collection. The animal described in the type description of *N. albipes* does not match WAM R101178 in any morphological characters.

The defining feature for the type of *N. albipes* is the field recording number, Frog #3, JDR Tapes 79 and 80 recorded by J.D. Roberts and P.G. Kendrick on May 3 1988, 4.2 km north of Hopetoun, Western Australia. In the Western Australian Museum register this recording number is associated with a frog, WAM R101182, that fits the published type description of *N. albipes* in all details.

The correct assignation of the type specimen of *N. albipes* should be WAM R101182, as defined by the field recording number.

Frogs in the genus *Neobatrachus* seem to cause many field workers considerable taxonomic difficulty. The realisation that there may be one tetraploid species, *N. sudelli*, ranging over much of inland and southeastern Australia, may limit some of the difficulty in making taxonomic decisions. Cryptic species of nearly all *Neobatrachus* species can be readily recognised by a combination of male call and geographic location if practitioners make use of the available, detailed literature.

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