

Two new species of desert burrowing frogs of the genus *Neobatrachus* (Anura: Myobatrachidae) from Western Australia

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Abstract

Species of the genus *Neobatrachus* are an important part of the frog fauna of Western Australia, occurring in the sub-humid, semi-arid and arid zones. They are desert burrowing frogs with very similar external morphology, and without mating call data they are difficult to distinguish. Two new species of *Neobatrachus*, *N. fulvus* and *N. kunapalari*, are described from Western Australia. Specimens of these species previously have been misidentified as *N. centralis* (Parker). The two new species can be distinguished by the structure of the inner metatarsal tubercle and the attachment of the skin between the legs and flank of the body. In *N. fulvus* the inner metatarsal tubercle is rectangular shaped with rounded edges, and the skin of the flank extends across to the knee so that the groin is not distinct. In *N. kunapalari* the tubercle is semi-circular in shape and the skin extends only slightly from the side of the body to encompass the groin. *N. fulvus* is diploid ($2n = 24$) and *N. kunapalari* tetraploid ($4n = 48$). Differences in chromosome morphology enable these species to be distinguished from diploid and tetraploid congeners. Mating calls are a soft trill in these species. Differences in pulse number and rate enable *N. kunapalari* to be distinguished from congeners in the same geographic range. The mating call of *N. fulvus* differs from the only other species of *Neobatrachus* (*N. sutor*) that is found in the same geographic region, but its call is very similar to a number of other species of *Neobatrachus*.

Introduction

Australian frogs of the genus *Neobatrachus* are a conspicuous element of the Western Australian frog fauna, particularly in the semi-arid and arid zones. Five species are currently recognised as occurring in Western Australia: *N. aquilonius* Tyler, Davies and Martin, *N. centralis* (Parker), *N. pelobatoides* (Werner), *N. sutor* Main and *N. wilsmorei* (Parker). Features of the biology of these species have been the subject of numerous studies, including habitat and breeding biology (Main *et al.* 1959; Main 1968), male mating calls (Littlejohn and Main 1959), physiology (Bentley *et al.* 1958), and karyology (Mahony and Robinson 1980).

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The external morphology of these species shows little variation, due presumably to the strong selective pressures which determine optimum body shape for water storage and the minimisation of water loss in the harsh desert environment. Several of the species are sympatric over large areas, but without biological information such as mating call or karyotype they are often difficult to distinguish morphologically.

The karyology of this genus is particularly interesting due to the occurrence of bisexual polyploidy in several species (Mahony and Robinson 1980). During chromosomal studies aimed at determining the origin of polyploidy and the relationship between species in this genus, it has become apparent that differences between specimens currently referred to *N. centralis* warrant recognition at the species level. Here we describe two new species previously referred to *N. centralis*.

Materials and methods

Material cited here is deposited in the following collections: Australian Museum, Sydney (AM), British Museum (Natural History), London (BMNH), Western Australian Museum, Perth (WAM).

Measurements of specimens follow Tyler *et al.* (1981), except that foot length (FL) was measured from the proximal end of the inner metatarsal tubercle to the tip of the fourth toe.

Mating calls

Calls were recorded on a Sony TC-510-2 reel to reel tape recorder with a Beyer M101 microphone using a tape speed of 19 cm s^{-1} . Oscillographs were prepared on a SanEi SM28 Oscillograph for analysis of temporal pattern in call structure. Pulse durations and dominant frequencies were analysed on a Norland 3001 Processing Digital Oscilloscope. Six call characteristics were analysed: call duration (s), pulse duration (ms), pulse rate (pulses s^{-1}), pulse number, dominant frequency (Hz) and pulse rise time as a percentage of pulse duration. Rise time for pulses was measured as the time from pulse initiation to maximum amplitude. Pulses in calls of *Neobatrachus* are simple with no internal amplitude modulation (Roberts 1978, see Figure 4) so this parameter simply gives a measure of the sharpness of the attack phase of the pulse.

Calls from frogs in the Exmouth area were recorded by H. Ehmann using a National Panasonic RQ 339 recorder with inbuilt condenser microphone. For analysis these recordings were played back on a Sony TC-D5 Pro cassette recorder.

Three calls were analysed for each frog. For frequency and pulse characteristics two pulses were analysed from the centre of each call. Pulse rate was measured over pulses 7-10 following Roberts (1978).

All data from an individual frog were averaged and each frog therefore contributes only one datum to overall averages reported later. Sample sizes are given in Table 2.

Cytology

Due to the unusual form of chromosome evolution and speciation involving polyploidy in several species of the genus *Neobatrachus*, the karyotypes of live specimens were examined and the ploidy of preserved specimens determined using cytological techniques outlined by Mahony and Robinson (1980).

Systematics

Neobatrachus fulvus sp. nov.

Figures 1-4

Holotype

WAM R52994, an adult female of 48.0 mm S-V collected at Exmouth, near North West Cape, WA ($21^{\circ}56'S$, $114^{\circ}07'E$) by G. Harold and G. Barron on 8 March 1976.

Paratypes

There are 12 paratypes: WAM R93494-96, and AM R119438-39, collected at Learmonth by H. Ehmann on 22 May 1984; WAM R76583, collected 18 km E of Gnaraloo ($23^{\circ}49'S$, $113^{\circ}41'E$) by G. Harold and C. Winton on 21 May 1982; and WAM R52937-42 collected at Exmouth by G. Harold and G. Barron on 10 March 1976. The series AM R119438-39 and WAM R76583 have been karyotyped and the ploidy level of two preserved specimens WAM R52938-39 determined. One of these paratypes, an adult female, WAM R76583, is photographed (Figure 1).

Diagnosis

(1) Adults moderate to large (males 38-42 mm; females 42-48 mm S-V) and of robust habitus; (2) hind limb short (T/S-V mean 0.34), with a large inner metatarsal tubercle, rectangular shaped with rounded edges and with a black keratinised cap; (3) mating call consisting of a short high-pitched trill; (4) dorsal coloration chocolate brown with small spots or variegations of mustard yellow particularly posteriorly and on flanks; (5) karyotypically diploid ($2n = 24$). Most closely related in appearance to *N. aquilonius* which is a slightly larger species (males 48-54 mm) with a tetraploid chromosome number ($4n = 48$).

Description of holotype

Head deep and semi-circular when viewed from above, and rounded in profile. Snout high. Eye large and prominent, its diameter (5.9 mm) equivalent to one and one-half times eye-to-naris distance (4.1 mm). Pupil vertical. Palpebral membrane with a yellow pigmented upper border. Canthus rostralis poorly defined and slightly curved. Nostrils inclined antero-dorsally and separated from one another



Figure 1 Photograph of paratype WAM R76583 of *N. fulvus* in life.

by a distance (4.35 mm) slightly greater than eye-to-naris distance (E/IN 1.11). Tympanum not visible.

Tongue broad and circular. Choana small, oval, and vomerine teeth (directly between choana) in a relatively long row divided medially.

Fingers cylindrical, unwebbed and without lateral fringes; in decreasing order of length $3 > 1 > 2 > 4$ (Figure 2). Moderately developed subarticular and palmar tubercles. Foot wide and moderately long (FL 17.0 mm) with an inner metatarsal tubercle but no outer metatarsal tubercle. Inner metatarsal tubercle prominent with a keratinised black cap which is broad and slightly flattened in profile (Figure 2). Tips of first and second fingers with a small, black, keratinised cap. Toes flattened slightly and with very small subarticular tubercles and approximately one half webbed (Figure 2). Toes in decreasing order of length $4 > 5 = 3 > 2 > 1$. Hind limbs short and very robust (TL 15.9 mm, TL/S-V 0.34).

Ventral surface of body and limbs entirely smooth. Short row of raised tubercles extending from above posterior margin of mandibular joint angled downwards to above arm.

Dorsal surface including limbs and thighs chocolate brown with lighter yellowish variegation. Dark interorbital bar and a distinct large unvariegated butterfly-shaped area in post-scapular region.

Ventral surface of body white except for diffuse light brown markings beneath mandibular articulation and around mandibular margin.

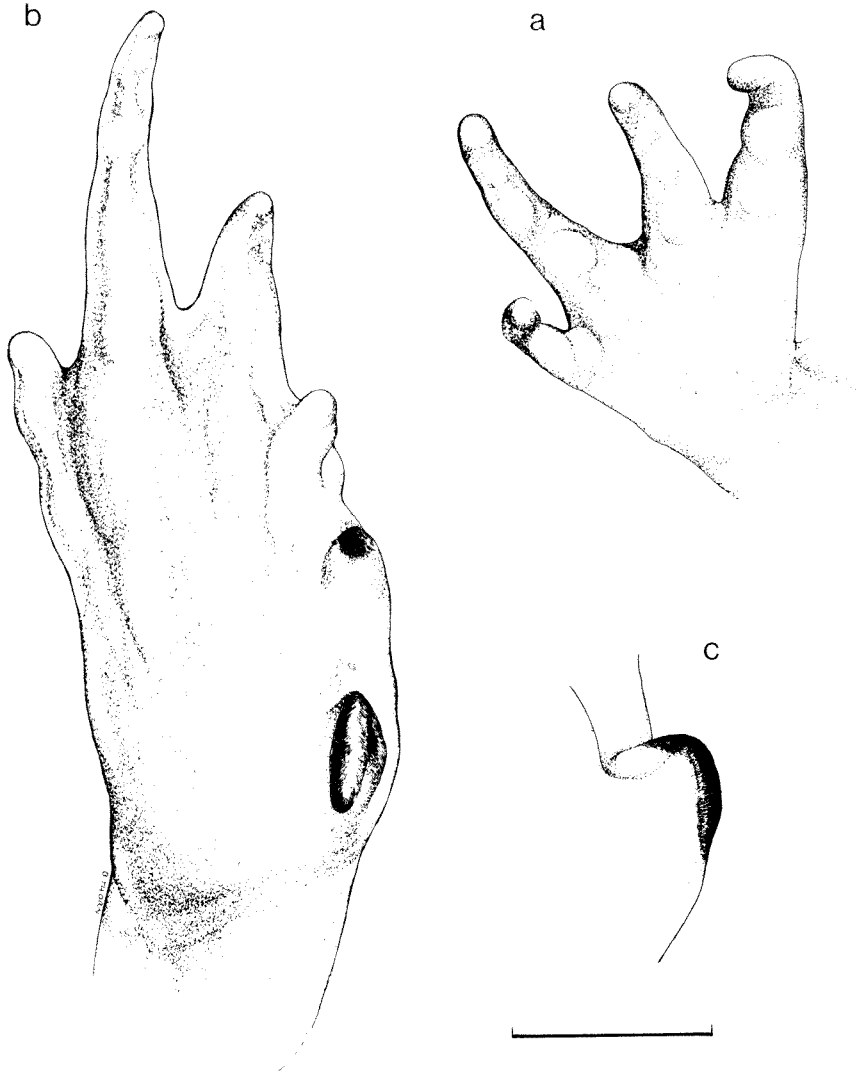


Figure 2 Diagram of (a) hand, (b) foot, and (c) metatarsal tubercle of *N. fulvus*. Bar 1 mm.

Variation

S-V length of adult males 38.2-42.0 mm, females 42.7-48.2 mm. Body round and globose, hindlegs very short (TL/S-V 0.34) (Table 1). Ratios of head measurements show little variation between specimens. Eyes large and prominent (E/EN 1.38). Males with diffuse nuptial pads extending from base of first and second fingers to tips.

Table 1 Proportions of 10 *N. fulvus* from Exmouth.

Ratio	Mean	Range (mm)
Head width/Head length	1.46	1.39 - 1.60
Eye/Eye-naris	1.38	1.34 - 1.50
Eye-naris/Internarial span	1.11	0.94 - 1.23
Head length/Snout-vent length	0.27	0.24 - 0.30
Tibia length/Snout-vent length	0.34	0.30 - 0.37
Foot length/Snout-vent length	0.39	0.34 - 0.43

Skin of side of body extends across to knee so that groin is not distinct. (see Figure 5 of Roberts 1978).

All 12 paratypes similar to holotype in dorsal markings. A faint, interrupted mid-dorsal line apparent in several specimens.

In life, ground colour of dorsal surface dull claret, variegated with small light yellow reticulations. Darker inter-orbital band and a post-scapular butterfly-shaped area. Bright yellow band bordering superior edge of palpebral membrane. Under surface of limbs white, upper surface variegated with yellow and brown. Ventral surface of body white, mandibular edge diffuse brown.

Mating call

Only one frog was recorded with sufficient clarity to allow detailed analysis. However, there were numerous calls (from several frogs) in the background chorus and these do not differ qualitatively from those analysed.

The call consists of 13-14 pulses repeated relatively slowly giving a call duration of just over 0.75 sec. Dominant frequency is about 1.5 kHz. Pulse durations are relatively long, and the pulse has a soft sound as rise and decay times are approximately equal.

Details of call structure are given in Table 2. A representative oscillogram is given in Figure 3a.

Table 2 Call structure data for trilling species of *Neobatrachus* from Western Australia. Values given are mean \pm S.E. When only one frog has been recorded no error data are given. For *N. kunapalari*, temperature range is 21.2–21.5°C. For *N. pelobatooides*, temperature range is 12.0–12.5°C.

Species	n	Pulse number	Pulse rate (s ⁻¹)	Pulse duration (ms)	Call duration (s)	Dominant frequency (Hz)	Rise time as % pulse duration	Water temperature (°C)
<i>N. aquilonius</i> ¹	1	11.0	18.3	25.0	.565	1500	-	25.5
<i>N. aquilonius</i> ²	1	14.7	18.2	16.1	.773	1750	43	24.0
<i>N. fulvus</i>	1	13.7	14.2	16.6	.780	1503	50	23.2
<i>N. kunapalari</i>	4	19.6 \pm .6	23.4 \pm .4	10.7 \pm .8	.820 \pm .07	1224 \pm 27	18.8 \pm 1.1	21.4 \pm 1.1
<i>N. pelobatooides</i> ³	3	59.8 \pm 7.6	18.9 \pm 1.6	11.2 \pm .9	3.230 \pm .32	816 \pm 28	48.3 \pm 3.8	12.3 \pm 2

¹ Data from Tyler *et al.* (1981). ² Recorded 2.8 km SE of Turner River on North West Coastal Highway, 11.i.83. ³ Recorded on Brookton Highway, 42 km WSW of Beverley, 23.vi.78.

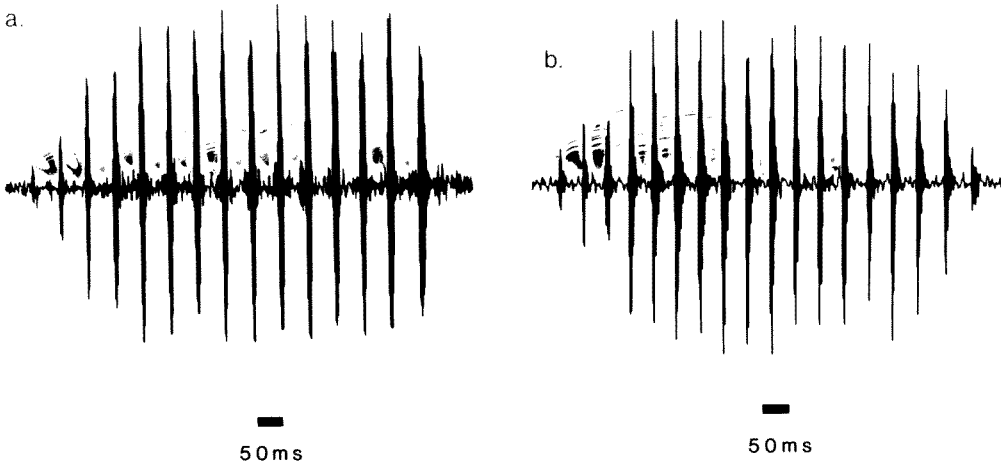


Figure 3 Oscillograms of *Neobatrachus* calls. (a) *N. fulvus*, (b) *N. kunapalari*.

Distribution

Currently known only from Exmouth, Learmonth and Gnarlloo in the North West Cape area of Western Australia.

Breeding biology

Following rain on 28 May 1984, H. Ehmann observed this species breeding in large flooded claypans. Details of the number of eggs laid or larval life are not known. *Neobatrachus sutor* and a *Cyclorana* species (probably *C. maini*) were breeding in the same body of water.

Habitat

Specimens collected at Learmonth were breeding in flooded claypans, and one specimen was foraging on red soil dunes. Specimens from Exmouth were foraging on a cleared area of red soil with surrounding vegetation of open mulga over dense grass. The Gnarlloo specimen was in an area of open *Acacia* and spinifex on pale brown sandy loam (G. Harold and G. Barron, field notes).

Karyotype

N. fulvus is diploid ($2n = 24$) (Figure 4), and the chromosome relative lengths and centromere positions are very similar to those of both diploid and tetraploid species of this genus (see Mahony and Robinson 1980). It can be distinguished readily from diploid congeners by the distinctive terminal location of the nucleolar organiser region (NOR) on the long arm of chromosome 5.

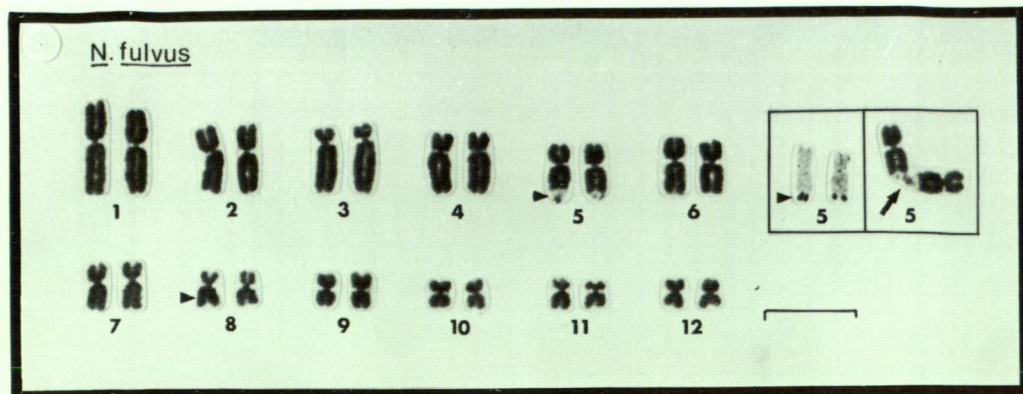


Figure 4 Karyotype of *N. fulvus*. Inset, silver-stained NOR. Bar 10 μ m.

Comparison with other species

N. aquilonius is larger (S-V length: 59 mm compared with 48.00 mm) and tetraploid. Based on the information given in the type description of *N. aquilonius* and one additional recording of *N. aquilonius*, the calls of *N. fulvus* and *N. aquilonius* are similar (Table 2, Figure 3). Without additional data there is no way of reliably differentiating the calls of these two species.

N. pelobatoides is only slightly shorter but it is a less robust animal. Its dorsal surface is covered by numerous small even tubercles, its metatarsal tubercle is rounded and not strongly keratinised, and the upper legs are not enclosed within a skin fold. The call has a much higher pulse number, probably a higher pulse rate (when allowance is made for temperature effects; see Roberts 1978) and a dramatically lower dominant frequency (Table 2).

N. sutor is slightly smaller but of similar habitus. It can be distinguished clearly by its dorsal pattern and coloration which is golden overall or light brown with small dark spots or circles. Its inner metatarsal tubercle is shorter and less robust. The call is a single note repeated rapidly rather than a trilling sound (Littlejohn and Main 1959). At present this is the only congener recorded within the geographic range of *N. fulvus*.

N. wilsmorei is distinguished readily by its characteristic chocolate brown colour with, on each side, a pair of diverging, bright yellow stripes commencing behind the eye. It is larger (S-V length: 63 mm compared with 48 mm). Call is a single note of about 0.04 s duration repeated at 1.4 s intervals (Littlejohn and Main 1959).

N. kunapalari (= *N. centralis* in part, see below) is larger (males 48-58 mm, females 53-59 mm) with a distinctive inner metatarsal tubercle (Figure 6). Dorsal surface is yellowish to bronze with darker markings rather than chocolate brown with yellowish variegation. The call has a higher pulse number than that of *N.*

fulvus, a higher pulse rate and lower frequency. The form of the repeated pulse also differs (Table 2, Figure 3).

Etymology

From Latin *fulvus* meaning 'reddish yellow or tawny', thus describing the colour of this species.

Neobatrachus kunapalari sp. nov.

Figures 3, 5-7

Holotype

WAM R93485, an adult male of 51.0 mm snout-vent length collected 8.9 km S of Merredin, WA (31°33'S, 118°15'E) by J.D. Roberts and D. Cale on 26 May 1985. A photograph of the holotype in life is presented in Figure 5.

Paratypes

There are 11 paratypes: WAM R93486-92, AM R119436-37 collected between 7 and 18 km S of Merredin by J.D. Roberts and D. Cale on 26 May 1985; and WAM R93493, AM R118104, two adult males collected 15.1 km SSW of Narembeen, WA by J.D. Roberts on 25 January 1982.

Diagnosis

(1) Adults moderate to large (males 48-58 mm; females 53-59 mm S-V) and of robust habitus; (2) hind limb short (T/S-V mean 0.33), with a large inner metatarsal tubercle, of semi-circular shape in profile and invariably with a black keratinised cap; (3) mating call consisting of a relatively short high-pitched trill; (4) dorsal surface of males, particularly on anterior half of body, covered with numerous, fine, small tubercles which are spinose in breeding males; (5) dorsal coloration variable but usually yellowish to dull bronze variegated with irregular dark patches of black; (6) karyotypically tetraploid ($4n = 48$). Distinguished from related species by either its distinctive call, karyotype or shape of metatarsal tubercle.

Description of holotype (Figure 5)

Head deep and semi-circular viewed from above, and slightly flattened in profile. Nostrils inclined dorsally, internarial span (3.6 mm) slightly less than eye-to-naris distance. Eye large and prominent, its diameter (7.5 mm) equivalent to one and three-quarters times eye-to-naris distance (4.2 mm) (Table 3). Pupil vertical in life; iris two-toned, upper half golden and lower silver, and covered with fine black lines. Tympanum not readily visible externally but present and roughly circular. Vomerine teeth in a straight row, divided medially; their posterior margin in line with anterior margin of choanae which are small and oval. Tongue broad and circular.



Figure 5 Photograph of holotype of *N. kunapalari* (WAM R93485) in life.

Fingers short and cylindrical; in decreasing order of length $3 > 1 > 2 > 4$ (Figure 6). No interdigital webbing; second and third fingers fringed slightly (Figure 6). Nuptial pads extend from base of first and second fingers to tip. Subarticular tubercles well developed, with two large, flat palmar tubercles.

Hind limbs short with tibia averaging one-third of snout-vent length (Table 3). Foot long (FL 22.3 mm) being 43 per cent of snout-vent length. Toes short, slightly flattened and in decreasing order of length $4 > 3 > 5 > 2 > 1$. Subarticular tubercles poorly developed except on 3 and 4. No outer metatarsal tubercle, but large, semi-circular shaped, inner metatarsal tubercle, edged with black (Figure 6). Webbing between toes extensive, extending to tip of each toe, although as a fringe past last joint.

Dorsal surface covered by numerous, fine, small warts, which are spinose, particularly on head, eyelids and scapular region. Ventral surface, top of foot, femur and under side of arm smooth. Above articulation of jaw and extending back to above arm a roughly linear line of tubercles partly fused and forming a distinct stripe. Ventral surface smooth. Dorsal surface in preservative light yellowish grey with numerous dark rounded and separate patches of black, occasionally lighter coloured centrally. A distinct interorbital bar but no mid-dorsal stripe. Upper surface of arms and legs mottled but ground colour darker

than dorsum. In life bright yellow background with black spots. Ventral surface white, but chin grey, and ventral surface of foot, arms and hand plum colour.

Skin extending only slightly from side of body to encompass groin.

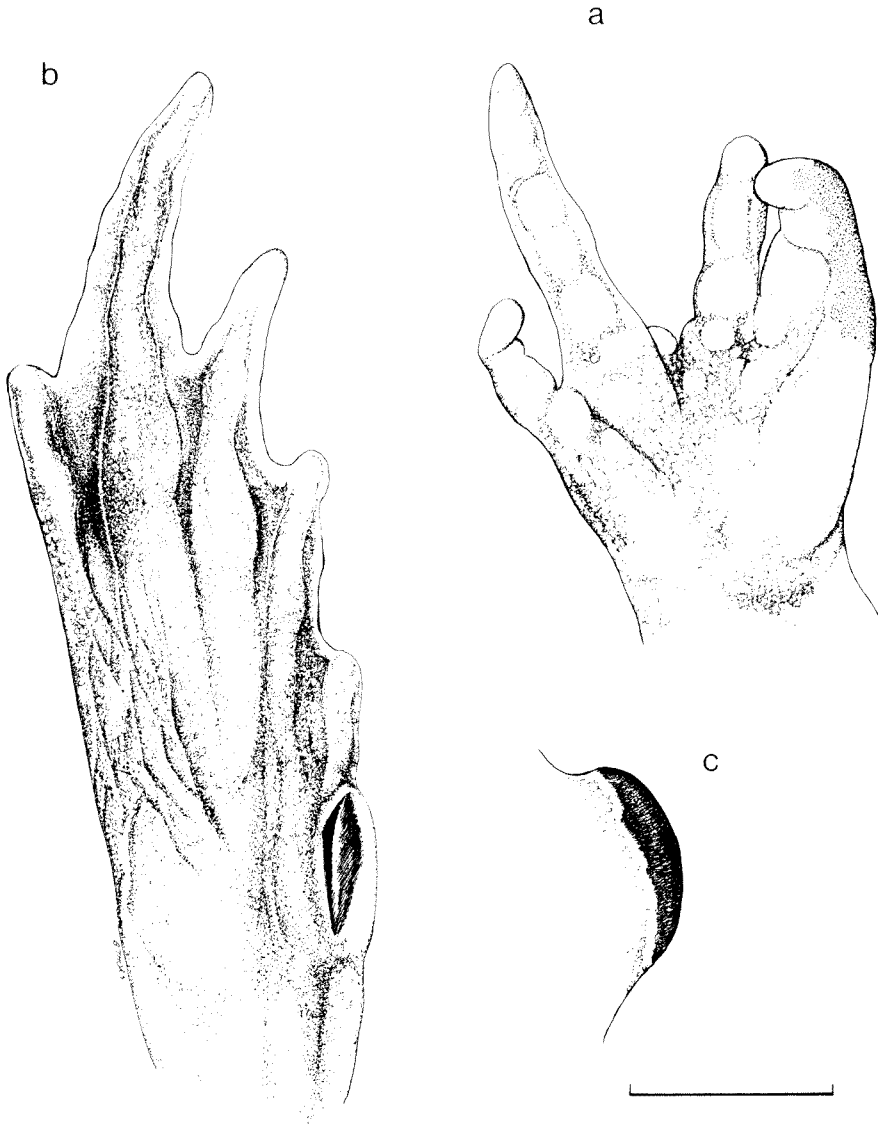


Figure 6 Diagram of (a) hand, (b) foot, and (c) metatarsal tubercle of *N. kunapalari*. Bar 1 mm.

Table 3 Proportions of 6 *N. kunapalari* from near Merredin.

Ratio	Mean	Range (mm)
Head width/Head length	1.43	1.39 - 1.54
Eye/Eye-naris	1.78	1.67 - 2.02
Eye-naris/Internarial span	1.16	0.94 - 1.18
Head length/Snout-vent length	0.28	0.24 - 0.30
Tibia length/Snout-vent length	0.33	0.31 - 0.36
Foot length/Snout-vent length	0.43	0.38 - 0.44

Variation

The type series consist of seven males and three females. Females having numerous small warts or smooth dorsally and lacking small spines present in breeding males. Skin between posterior side of body and upper leg enclosing groin looser than in males.

Background colour yellowish to dull bronze with dark black or brown blotches. Dark interorbital bar variable in size. A pale, narrow mid-vertebral stripe in two specimens.

Mating call

Calls were not recorded when the holotype was collected. However, call data are available from two paratypes and from two other frogs recorded on the same occasion. These recordings were made on 25 January 1982, 15.1 km SSW of Narembeen, Western Australia at approximately 70 km south of the type locality.

The call of *N. kunapalari* consists of 18-21 slowly repeated pulses giving a call duration of about 0.8 s. Dominant frequency is about 1.2 kHz. Pulse durations are low and the pulse has a sharp sound as the rise time is short relative to the decay time.

Details of call structure are given in Table 2 and a representative oscillogram is given in Figure 3b. These calls are similar to those figured and analysed by Littlejohn and Main (1959) as *N. centralis*.

Distribution

This species is distributed widely in the semi-arid and arid zones of Western Australia south of about latitude 25°S and into the south-west on the eastern side of Darling Range. Virtually all records of *N. centralis* in south-western Australia (e.g. Main 1965, 1968; Tyler *et al.* 1984) are likely to refer to this species. However, without details of call or karyotype identification of preserved material is difficult (see below) so we cannot be more precise in defining the range. This species was not found in the Port Hedland area (Mahony and Roberts, unpublished data), or in the region of North West Cape (H. Ehmann, unpublished data), following suitable rains in which other frog species, including several

belonging to *Neobatrachus* bred. Similarly, in the vicinity of Ayers Rock and the Olgas in south-western Northern Territory this species was not detected (Mahony, unpublished data). Lindgren and Main (1961) did not detect this species at Jigalong (23° 22'S, 120° 47'E) following summer rains, and the northern localities depicted for this species (as *N. centralis*) by Tyler *et al.* (1984) may represent *N. aquilonius*. The boundaries of the distribution of this species to the north and east are therefore somewhat uncertain.

Breeding biology

One of the paratype females laid 1096 eggs on 30 May 1985. The diameter of a sample of 10 ova averaged 1.6 mm and the capsule diameters averaged 2.5 mm. Main (1968) gives details of the general breeding biology and habitat of this species (as *N. centralis*), including details of egg deposition sites, and length of larval life.

Karyotype

N. kunapalari is a tetraploid ($4n = 48$) (Figure 7). The chromosomes of this species have been figured and discussed by Mahony and Robinson (1980), but referred incorrectly to *N. sutor*. *N. kunapalari* can be distinguished readily by the distinctive location of the NOR, medially on the long arm of chromosome 7, whereas in all the other congeners it is on chromosome 5.

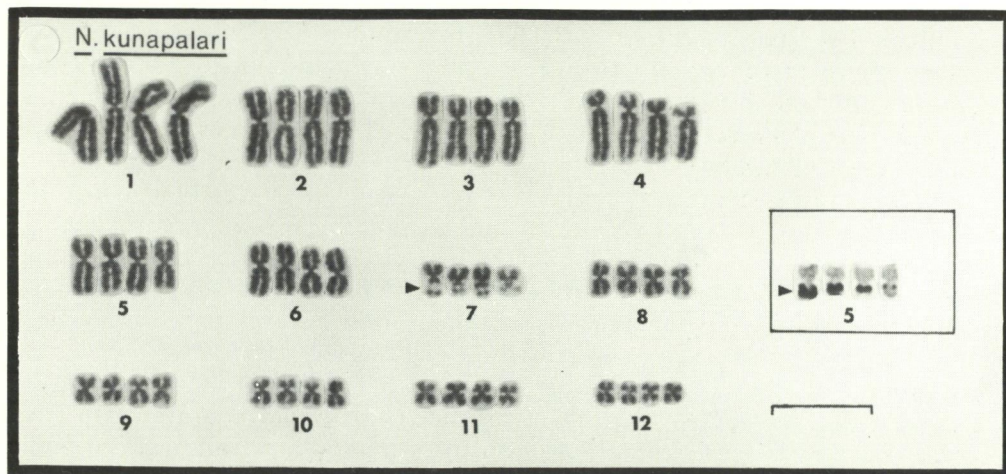


Figure 7 Karyotype of *N. kunapalari*. Inset, silver-stained NOR. Bar 10 μ m.

Comparison with other species

N. aquilonius differs in aspects of chromosome morphology, particularly location of the NOR (both species are tetraploid) and mating call. The groin area is enclosed by skin from the flank.

N. pelobatoides is smaller (S-V, 44 mm compared with 51 mm), with a longer mating call (Table 2; Littlejohn and Main 1959), and is karyotypically diploid.

N. sutor is of similar size but usually is more robust in appearance, with the skin of the side of the body enclosing the groin. The dorsal surface is smooth and males do not have small spinose tubercles on the dorsum. Its metatarsal tubercle is pointed rather than semi-circular and its call is a distinctive short tap repeated at approximately 0.4 s intervals rather than a trill. It is diploid karyotypically. The dorsal markings and coloration of *N. sutor* and *N. kunapalari* are often similar, and caution should be exercised when identifying preserved specimens of these two species.

N. wilsmorei is distinctive in size, dorsal coloration and mating call, and is diploid (see comparison with *N. fulvus*).

N. fulvus is smaller, has a distinct coloration and call and is diploid. The metatarsal tubercle is also distinct (Figures 2 and 6) and the eye/eye-naris ratio is larger (1.38 compared to 1.78, Tables 1 and 3).

Etymology

The name applied to this species by Aborigines of the Gugadja tribe (Peile 1978).

Discussion

Desert frogs are typically robust animals with rounded bodies and short limbs, which represents the most adaptive morphology for a life which contains long periods beneath the surface. External morphology therefore shows very little variation, and it is often difficult to delimit species by traditional means such as external features and body measurements. Furthermore, remoteness and inaccessibility during suitable weather conditions have meant that field observations and the recording of mating calls, which may distinguish species, are not readily obtained. In view of all this the use of karyotypic data has proved to be most valuable in distinguishing different species of *Neobatrachus*. This approach has been particularly useful because of the unusual form of chromosomal evolution involving polyploidy, observed in several species.

Recognition of the two new species described here relies in particular on the correct identification of *N. centralis* (Parker). This species was formerly considered to have an extensive distribution in the semi-arid and arid zones of Australia (from the west coast through central Australia to north-western Victoria, western New South Wales and south-western Queensland, Barker and Grigg 1977, Cogger 1983, Cogger *et al.* 1983, and Tyler *et al.* 1984). The precise locality from which the holotype of *N. centralis* was collected is uncertain, but, Ledo and Tyler (1973) indicate that it was most likely in the vicinity of Coopers Creek where it is crossed by the Birdsville Track, in the north-east of South Australia. Karyotypic examination of specimens from various localities in this

area, including two specimens collected on the Birdsville Track near Marree (approximately 50 km S of Coopers Creek), indicates that only one species of *Neobatrachus* occurs there. It is tetraploid ($4n = 48$) and can be distinguished from Western Australian specimens referred to *N. centralis*, by differences in chromosome morphology, particularly the location of the NOR. The external morphology of these specimens agrees closely with that of the holotype of *N. centralis* (BMNH 1905. 10. 31. 47), which we have examined, and is different to that of Western Australian specimens included here in *N. kunapalari*. We note that Tyler *et al.* (1984) also felt *N. centralis* from Western Australia was morphologically distinct from *N. centralis* in South Australia.

Roberts (1978) considered that *N. centralis* may be a junior synonym of *N. sudelli*. We do not address that issue here. We have both call and karyotype data (unpublished) to suggest that two distinct tetraploid forms occur in south and eastern Australia.

The chromosome number and morphology of specimens referred to *N. centralis* from Western Australia previously have been discussed by King *et al.* (1979) and Mahony and Robinson (1980). Both reports indicated that animals so identified were diploids ($2n = 24$). Following morphological examination of the holotype of *N. sutor* (WAM R3892), and the karyotypic analysis of material identified by mating call to be *N. sutor*, it is apparent that both reports actually referred to *N. sutor*.

An adequate understanding of the distributions and life histories of both newly described species will require extensive field work in the semi-arid and arid zones of Western Australia.

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Guide to Authors

Subject Matter

Reviews, observations and results of research into all branches of natural science and human studies will be considered for publication. However, emphasis is placed on studies pertaining to Western Australia. Full length papers should not normally exceed 30 typed pages. Short communications should not normally exceed three typed pages and this category of paper is intended to accommodate observations, results or new records of *significance*, that otherwise might not get into the literature, or for which there is a particular urgency for publication. All material must be original and not have been published elsewhere.

Presentation

Authors are advised to follow the layout and style in the most recent issue of the *Rec. West. Aust. Mus.* including headings, tables, illustrations and references.

The title should be concise, informative and contain key words necessary for retrieval by modern searching techniques. Names of new taxa must not be included. An abridged title (not exceeding 50 letter spaces) should be included for use as a running head.

An abstract must be given in full length papers but not short communications, summarizing the scope of the work and principal findings. It should normally not exceed 2% of the paper and should be suitable for reprinting in reference periodicals. Contrary to Recommendation 23 of the International Code of Zoological Nomenclature it may include names of new taxa.

Footnotes are to be avoided, except in papers dealing with historical subjects.

The International System of units should be used.

Numbers should be spelled out from one to nine in descriptive text; figures used for 10 or more. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

Spelling should follow the *Concise Oxford Dictionary*.

Systematic papers must conform with the International Codes of Botanical and Zoological Nomenclature and, as far as possible, with their recommendations.

Synonymies should be given in the short form (taxon, author, date, page) and the full reference cited at the end of the paper.

Manuscripts

The original and two copies of manuscripts and figures should be submitted to the Editorial Committee, c/- Publications Department, Western Australian Museum, Francis Street, Perth, Western Australia 6000. They must be in double-spaced typescript on A4 sheets. All margins should be at least 30 mm wide. Tables plus headings and legends to illustrations should be typed on separate pages. The desired positions for insertion of tables and illustrations in the text should be indicated in pencil. Tables should be numbered consecutively, have headings which make them understandable without reference to the text, and be referred to in the text.

High quality illustrations are required to size (13.5 cm x 18 cm) or no larger than 32 cm x 40 cm with sans serif lettering suitable for reduction to size. Photographs must be good quality black and white prints, 13 cm x 18 cm (5 inches x 7 inches). If scale line and lettering are required on photographs *do not* place directly on to print. They should be positioned on a clear paper or film overlay. Scale must be indicated on illustrations. All maps, line drawings, photographs and graphs, should be numbered in sequence and referred to as Figure/s in the text and captions. Each must have a brief, fully explanatory caption.

In papers dealing with historical subjects references may be cited as footnotes. In all other papers references must be cited in the text by author and date and all must be listed alphabetically at the end of the paper. The names of journals are abbreviated according to *World List of Scientific Periodicals*. The use of 'unpublished data' or 'personal communication' is discouraged.

Processing

Papers and short communications are reviewed by at least two referees and acceptance or rejection is then decided by an editorial committee.

The senior author is sent two sets of galley proofs (one to be retained) and one set of page proofs which must be returned promptly.

The senior author will receive fifty free offprints of the paper. Additional offprints can be ordered at page proof stage.

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