

A Taxonomic Revision of the *Litoria aurea* Complex (Anura: Hylidae) in South-Eastern Australia

GILLIAN P. COURTICE and GORDON C. GRIGG

School of Biological Sciences, University of Sydney, N.S.W., 2006

ABSTRACT

Four subspecies of *Litoria aurea* have been previously recognised in south-eastern Australia. In the present paper it is proposed that two of these subspecies (*Litoria aurea aurea* and *Litoria aurea raniformis*) be raised to specific status as *Litoria aurea* and *Litoria raniformis* respectively; that an isolated population from the New England region of N.S.W. be recognised as a new species *Litoria flavipunctata*; and that the remaining two subspecies, *Litoria aurea ulongae* and *Litoria aurea major* be synonymised with *Litoria aurea* and *Litoria raniformis* respectively.

This revision in taxonomy is proposed on the basis of morphological evidence and the apparent lack of hybridisation in areas of sympatry.

INTRODUCTION

Frogs of the *Litoria aurea* complex, representing a number of taxa, are extensively distributed in the south-east of Australia, including Tasmania, and in the south-west of Western Australia.

The group was first described as a single species, *Rana aurea* (Lesson 1831), the type locality being the Macquarie River at Bathurst, N.S.W. Günther (1858) placed the species in the genus *Hyla*. Keferstein (1867) described *Chirodryas raniformis* from a specimen of unknown locality, but later (1868) sank this species into the synonymy of *Hyla aurea*. Parker (1938) recognised two subspecies of *Hyla aurea* in eastern Australia, the N.S.W. coastal form, *Hyla aurea aurea* and the inland and southern form, *Hyla raniformis*. In Western Australia, Parker recognized *Hyla aurea raniformis* and raised a further subspecies, *Hyla aurea cyclorhynchus* (Boulenger 1882) to specific status. Copland (1957) described the *raniformis* type from Western Australia as a new species, *Hyla moorei*. This was based on cross-fertilisation experiments reported by Moore (1954). *Hyla aurea ulongae* (Loveridge 1950) was described from Ulong, N.S.W. Yet another subspecies was erected when Copland (1957) re-named the Tasmanian group, previously ascribed to *Hyla aurea raniformis*, *Hyla aurea major*. Subsequently, Tyler (1971) has proposed that all Australo-Papuan species of *Hyla* be attributed to the genus *Litoria* Tschudi (1839) because of differences in vocal sac musculature compared with hylids from elsewhere.

Thus, two Western Australian species of the *Litoria aurea* complex are recognised, *Litoria cyclorhynchus* (Parker) and *Litoria moorei* (Copland). Until now, four subspecies of *Litoria aurea* have been recognized in south-eastern Australia, as follows:

Litoria aurea aurea (Lesson), a coastal form in N.S.W. and eastern Victoria,
Litoria aurea raniformis (Keferstein), distributed in southern inland N.S.W.,
Victoria and through the Murray R. Valley into South Australia,
Litoria aurea ulongae (Loveridge), from near Dorrigo, N.S.W.,
Litoria aurea major (Copland), from Tasmania.

There has been uncertainty of the taxonomic status of these south-eastern forms. Moore (1961) and Littlejohn, Martin & Rawlinson (1963) have suggested that the first two taxa may deserve full specific status. *Litoria aurea ulongae* was described from a single preserved specimen (Aust. Mus. No. R13817) (Loveridge 1950). *Litoria aurea major* was differentiated from *Litoria aurea raniformis* only on the basis of size (Copland 1957).

The present taxonomic revision is based on morphological evidence and apparent lack of hybridisation in zones of sympatry. We propose:

- (i) that *Litoria aurea aurea* and *Litoria aurea raniformis* be raised to full specific status as *Litoria aurea* and *Litoria raniformis*,
- (ii) that *Litoria aurea ulongae* and *Litoria aurea major* be synonymised with *Litoria aurea* and *Litoria raniformis* respectively; and
- (iii) that the geographically isolated population of *Litoria aurea raniformis* on the New England tableland be recognised as a new species, *Litoria flavipunctata*.

MATERIAL AND METHODS

Data on morphology and geographic distribution were obtained from our collections made throughout Victoria and New South Wales, and from preserved material in the Australian Museum. In addition, literature records were taken into consideration. Traverses were made near Canberra, Australian Capital Territory, and in East Gippsland, Victoria, to investigate the relationship between *Litoria aurea aurea* and *Litoria aurea raniformis* in sympatry.

In morphological studies, the following measurements were taken using vernier calipers (Peacock); snout-vent length (SV), tibia length (TL), head length (HL), and head width (HW) as defined by Goin and Netting (1940); foot length (FL) measured from outside heel to tip of toe; distance between eye and naris (EN), measured along the canthus rostralis; internarial span, (IN), diameter of the tympanum (T) and diameter of the eye (E). Using an ocular grid in a binocular microscope, the width of the third digit of the hand (DW) at the narrowest part between the digital pad and the next joint, and the width of the third digital pad (PW) were measured.

TAXONOMY OF *LITORIA AUREA* COMPLEX

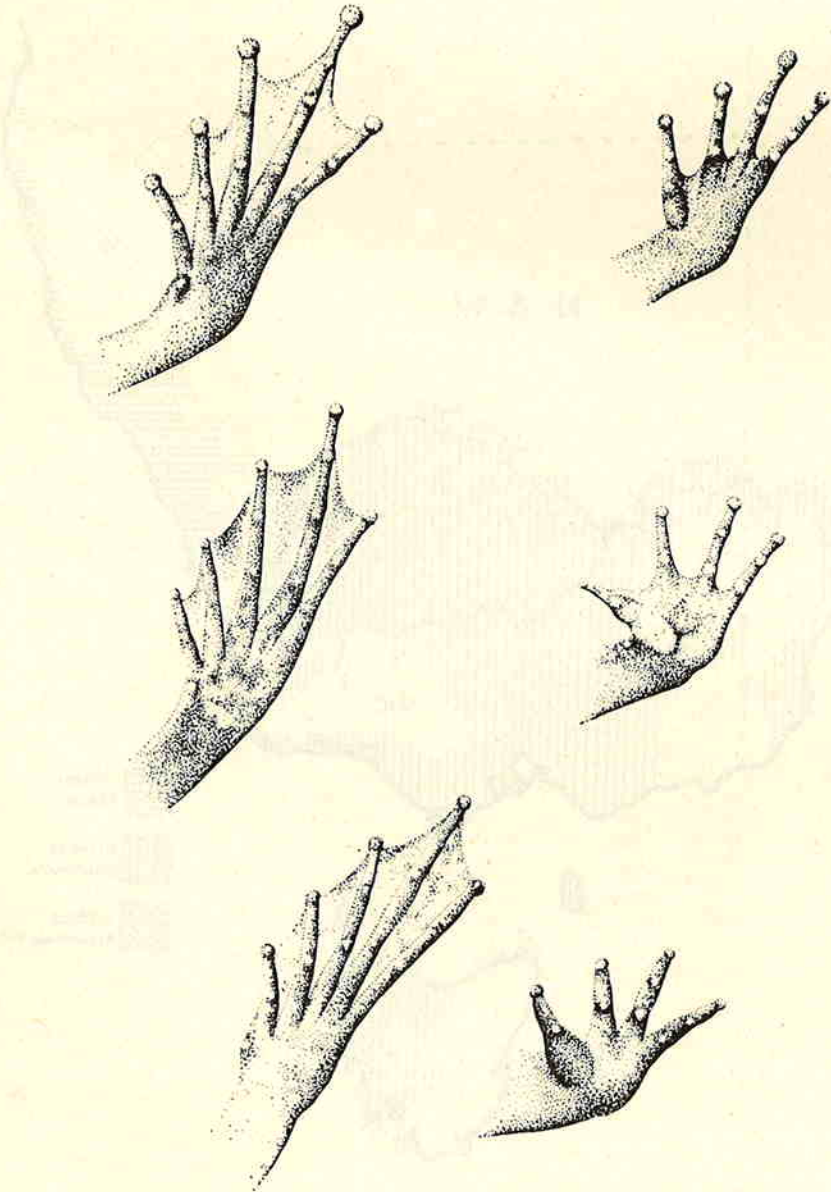


Fig. 1. View of foot and hand of *Litoria aurea* (top), *Litoria raniformis* (centre) and *Litoria flavipunctata* (bottom).

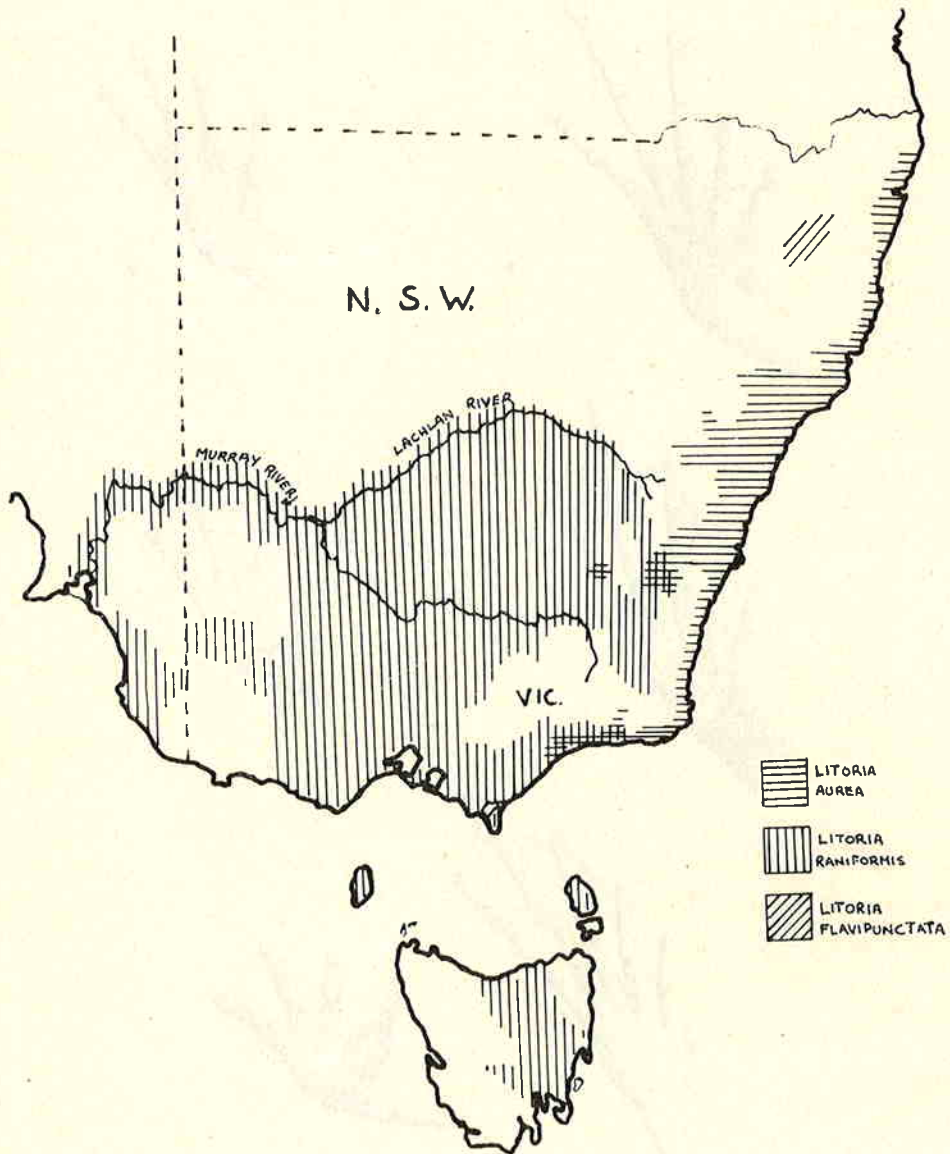
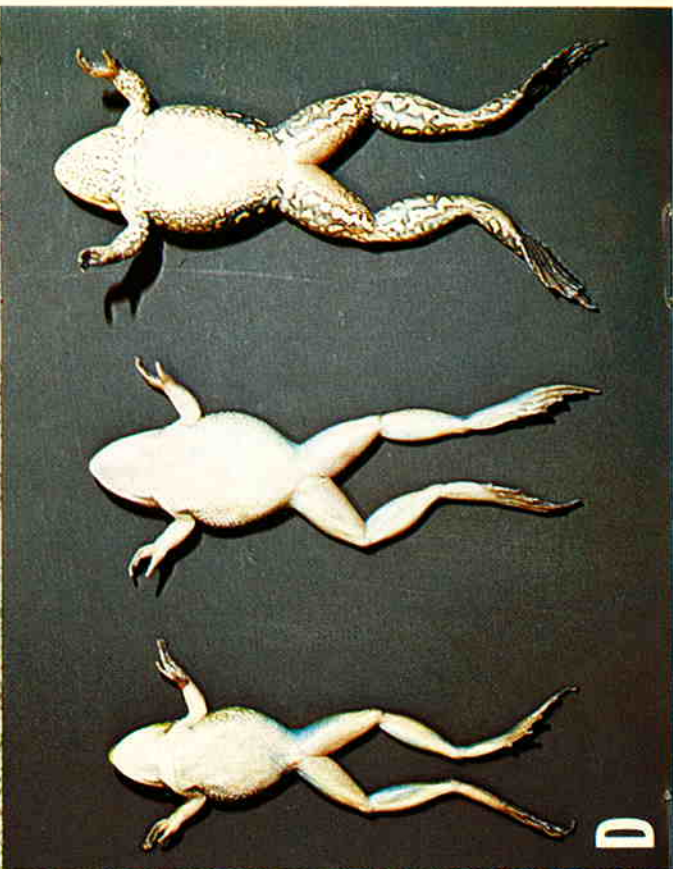


Fig. 2. Map of south-eastern Australia showing distribution of the *Litoria aurea* complex. The distribution of *L. raniformis* in Tasmania is based on Littlejohn (1967).



A

D

COMPARISONS BETWEEN TAXA

To avoid confusion in the ensuing discussion, we will use the proposed names *Litoria aurea*, *Litoria raniformis* and *Litoria flavipunctata*.

(a) *Morphology*

(i) Dorsal stripe. *Litoria raniformis* and *Litoria flavipunctata* have an obvious mid-dorsal stripe. This is absent in *Litoria aurea* (Plate I).

(ii) Digital pads (Fig. 1). *Litoria raniformis* and *Litoria flavipunctata* have digital pads the same widths as the digits, whereas the pads of *Litoria aurea* are wider than the digits.

(iii) Colouration. *Litoria flavipunctata* is characterised by having large yellow spots in the groin and on the ventral surfaces of the legs. Smaller yellow spots are usually evident on the posterior surface of the thigh. Individuals of *Litoria raniformis* occasionally have a few small yellow spots on the posterior surface of the thigh. *Litoria aurea* never has yellow spots in these regions. In preservative, these spots are white.

(iv) Webbing (Fig. 1). The extent of foot webbing is consistently different in each of the three species. The fullest web is seen in *Litoria flavipunctata* where webbing extends to the tip of each toe. This webbing is usually covered with large yellow spots as found on the ventral surfaces of the hind limb. In *Litoria raniformis* the webbing is somewhat reduced, whereas in *Litoria aurea* the foot is only one half to three quarters webbed.

(b) *Zones of Sympatry*

The population on the New England tableland (*Litoria flavipunctata*) is geographically isolated from related taxa, so no interactions can occur.

Between *Litoria aurea* and *Litoria raniformis* however, two limited areas of sympatry are known. These areas are near Canberra, A.C.T. and on the Gippsland coast of Victoria near Orbost (Fig. 2). In both these areas, specimens of each species were collected, often in the same pond and even within less than a metre of each other. Using the morphological criteria given earlier, each species was clearly recognisable and no evidence of hybridisation was apparent. Littlejohn, Martin and Rawlinson (1963), from collections in East Gippsland between Metung and Orbost, noted that both types occurred in sympatry, without hybridisation

CAPTION TO COLOUR PLATE

- Plate I: A. *Litoria aurea*.
B. *Litoria raniformis*.
C. *Litoria flavipunctata*.
D. Ventral views of *Litoria aurea* (left), *Litoria raniformis* (centre) and *Litoria flavipunctata* (right).

Of another collection made in East Gippsland, Littlejohn (1969) writes: "specimens may be assigned to the subspecies *H. aurea aurea* with the exception of a series from Orbost in which there are indications of *raniformis* characteristics". The *raniformis* type is common to the east of 148°E, well within East Gippsland as defined by Littlejohn (1969) and yet no further mention of it appears in his checklist. Therefore we consider his statement indicative of his uncertainty of the taxonomic relationship between these taxa rather a clear implication that hybridisation occurs near Orbost. Moore (1961) refers to specimens that he considered to be intermediates between the two taxa. We have examined some of these specimens in the Australian Museum (R.9482-9484 from Koonadon near Leeton, R.7344 from Emu Plains near Urana, R. 5233 from Berridale, Monaro and the series R.5959-5962, R.6683 from Narracoorte, S.A., two of which Moore suggested may be intergrades). By our criteria these are all specimens of *Litoria raniformis*. Furthermore, these four localities are far distant from any known area of sympatry so that occurrence of intergrades at these localities is unlikely. Another specimen mentioned by Moore (1961) as a possible intergrade is in the British Museum (No. 96.6.17.17). It was collected from the Yarra River, Victoria. Unfortunately we have been unable to examine it.

In our view, the evidence suggests that *Litoria aurea* and *Litoria raniformis* maintain their distinctiveness in sympatry. The isolating mechanisms which operate to maintain this situation are, at present, unknown.

(c) *Litoria aurea ulongae*

This subspecies was described by Loveridge (1950) from a single preserved specimen from Ulong, N.S.W. No other specimen is known. Loveridge based its validity as a separate taxon on the lack of a dorso-lateral fold and the presence of an undivided ridge of vomerine teeth. Collections made in the area by one of us (G.P.C.) revealed no further specimens. The type specimen in the Australian Museum (R.13817) was examined carefully and it appears to be a somewhat unusual specimen of *Litoria aurea*. Hence we consider that *Litoria aurea ulongae* should be placed in the synonymy of *Litoria aurea*.

(d) *Litoria aurea major*

Copland (1957) ascribed the Tasmanian frogs of the "*raniformis*" type to a new subspecies, *Litoria aurea major*, solely on the basis of their supposed larger size. He wrote that "In large series of *raniformis* 60 mm was only exceeded in about 6% of specimens, and 70 mm only once (about 1%), and then only by 1 mm (71 mm). It must be noticed, however, that Keferstein gave the body length of his type of *raniformis* at 82 mm, which can only be regarded as very exceptional." (Copland 1957, p. 80.) Moore (1961) questioned the validity of this sub-species. He reported that several *raniformis* individuals which he had collected exceeded 72 mm, the length of the largest *major* referred to by Copland (1957).

In the present study, 66% of those *Litoria raniformis* measured exceeded 60 mm (compare 6% recorded by Copland, 1957) and one female caught at Nar-

TAXONOMY OF *LITORIA AUREA* COMPLEX

randera, N.S.W. was 90 mm in length. It would seem that no basis exists for retaining the Tasmanian frogs in a separate taxon and we propose that *Litoria aurea major* should be placed in the synonymy of *Litoria raniformis*.

SYSTEMATICS

The observations in the previous section support the validity of recognising three separate species within the *Litoria aurea* complex in south eastern Australia. Full descriptions of the three species will now be given.

Litoria aurea (Lesson 1831)

Synonymy:

- Rana aurea* Lesson 1831 (1830);
- Ranoidea jacksoniensis* Tschudi, 1839;
- Ranoidea resplendens* Girard, 1853;
- Hyla jacksonii* Bibron & Dumeril, 1854;
- Hyla castanea* Steindachner, 1867 (1869);
- Fanchonia elegans* Werner, 1893;
- Hyla blandsuttoni* Proctor, 1924.
- Hyla aurea ulongae* Loveridge, 1950;
- Hyla aurea ulongensis* Loveridge, 1950;
- Hyla aurea major* Copland, 1957.

Type Locality: Macquarie River, Bathurst, N.S.W.

Diagnosis: This species can be recognised in life by the following characteristics: smooth green band with irregular gold spots, yellow dorsolateral fold and a brilliant turquoise colour in the groin and on the back of the thigh.

In preservative the green and gold colours of the dorsum become smoky grey and light brown respectively. The dorsolateral fold becomes white. The groin colouring is grey.

Description of a female collected from Ourimbah, N.S.W. in October 1972. Australian Museum No. R42156.

The dorsal surface is smooth and green with irregular gold spots. A yellow dorsolateral fold extends from the eye to the groin. Another short yellow line extends from under the eye to above the shoulder.

The belly and ventral surfaces of the thighs are white and coarsely granulate. The skin is more finely granulate under the forelimbs and the throat. The groin, the posterior surface of the thigh and the ventral surfaces of the tibia are coloured brilliant turquoise.

The head is obtusely pointed and slightly longer than broad (HL/HW ratio 1.15). The head length is approximately 1/3 of the snout to vent length (HL/SV

ratio 0.34). The snout is not prominent and does not project conspicuously beyond the anterior limit of the mandible. The distance between the eye and the naris is greater than the internarial span. The canthus rostralis is distinct and straight; the loreal region is concave.

The tympanum is distinct and gold in colour. Its diameter is 0.72 x that of the eye. The vomerine elevations are large, paired and obliquely convergent posteriorly; they lie between the choanae. The tongue is broad, free and nicked posteriorly.

Fingers are long and free from webbing. They are, in order of length, $3 > 4 > 2 = 1$. Terminal discs are wider than the digits.

The hind limbs are long and slender (TL/SV ratio 0.50). Toes are, in order of length, $4 > 3 = 5 > 2 > 1$. They are approximately 3/4 webbed (see Fig. 1).

In preservative, the dorsal surface is a greyish green and the ventral surfaces and the yellow lines become immaculate white.

Dimensions

SV 76.9 mm; TL 38.7 mm; FL 55.1 mm; HL 26.3 mm; HW 23.0 mm; IN 4.2 mm; E 8.7 mm; T 6.3 mm.

Variability

The snout to vent distances of 24 frogs of this species had a mean of 58.3 mm and a range of 46.9-76.8 mm. The amount of gold colouring on the dorsal surface varied greatly; this variation seemed to be unrelated to any geographic pattern.

Specimens examined

Australian Museum, N.S.W.; R18484, Wollongong, N.S.W.; R19424-7, (1890) Richmond, N.S.W.; R19643-5, (1890) Manly, N.S.W.; R4194-6, 4198-203, 4205, (1908) Maroubra, N.S.W.; R4452, (1909) Sans Souci, N.S.W.; R4665-8, (1910) Woonona, N.S.W.; R3388-9, (1911) North Sydney, N.S.W.; R5849, (1912) Cooks River, N.S.W.; R7325, (1921) Capertree, N.S.W.; R7376 (1921) Burrawang, N.S.W.; R7446-1, (1922) Pambula, N.S.W.; R7974, (1922) Upper Colo, N.S.W.; R8454, 8456, 8483, (1924) Sydney, N.S.W.; R9424, R9426-7, (1928) Wentworthville, N.S.W.; R9532, (1928) Botany, N.S.W.; R9558, (1928) Five Dock, N.S.W.; R9644, Tumut, N.S.W.; R18768, (1957) Shoalhaven Heads, N.S.W.; R19669-81, (1958) Singleton, N.S.W.; R2455, (1965) Londonderry, N.S.W.; R27635, (1968) Cobargo, N.S.W.; R29446, (1972) Lake Lidell, N.S.W.; R29441-3, (1972) French's Forest, N.S.W.

Author's collections

Goulburn, N.S.W. (4 specimens); Pearl Beach, N.S.W. (50 spec.); Tomerong, N.S.W. (3 spec.); nr. Jacqua, N.S.W. (2 spec.); Liddell Lake, N.S.W. (4 spec.); Cann River, Vic. (4 spec.); 12 m E. of Orbost, Vic. (10 spec.); 1 m E. of Orbost,

TAXONOMY OF *LITORIA AUREA* COMPLEX

Vic. (4 spec.); 5 m SE of Orbost, Vic. (2 spec.); Marlo, Vic. (6 spec.); Foxlow, N.S.W. (1 spec.); near Maclean, N.S.W. (2 spec.); Bungonia, N.S.W. (20 spec.); 12 m NE Canberra, N.S.W. (4 spec.); 12 m NE Tarago, N.S.W. (2 spec.).

Literature records

These records do not include material in the Australian Museum which has been examined by the authors.

Lower Clarence River, N.S.W.; Gurravembi, Nambucca River, N.S.W.; Warrell Creek, Nambucca River, N.S.W.; Nambucca River, N.S.W.; Botany Bay, N.S.W.; Bulahdelah, N.S.W.; Sydney, N.S.W.; East Lakes, Sydney, N.S.W.; Burradoo, N.S.W.; Bodalla, N.S.W.; Eden, N.S.W.; Nowra, N.S.W.; (Moore 1961). Jarvis Bay, N.S.W.; (Fletcher 1894, cited in Moore 1961). Razorback Mt., near Picton, N.S.W.; Bundanoon, N.S.W.; Tallong, N.S.W.; Fitzroy Falls, N.S.W.; Barrengarry Mt., N.S.W.; Waverley, N.S.W.; (Copland 1957). Thirroul, N.S.W.; (Harrison 1922). Gipsy Point, Vic.; Orbost, Vic.; Corringale Beach, Vic.; 6 miles N of Lake Entrance, Vic.; Metung, Vic.; Genoa, Vic.; Nowa Nowa, Vic.; (Littlejohn *et al.* 1963). Goongerah, Vic.; Fairhaven, Mallacoota Inlet, Vic.; 1 ml N of Marlo, Vic.; 11 miles E of Orbost, Vic.; 8 miles E of Bendoc, Vic.; (Littlejohn 1969).

Biology

This species inhabits permanent ponds, farm dams and the still backwaters of rivers. Their habitat usually can be identified by the presence of beds of tall reeds. The frogs can be found on these reeds at night, feeding. They call in open water, and eggs are laid on top of the water but later sink (Littlejohn 1971).

Larvae

The tadpoles are large and dark. The anus is dextral; the spiracle sinistral; eyes lateral. The dorsal fin extends nearly halfway up the back. The mouth disc has two rows of upper labial teeth, and three rows in the lower labium. The inner row in each labium is divided. A narrow row of papillae extend around the lateral and posterior margins of the mouth.

Litoria raniformis (Keferstein 1867).

Synonymy:

Chirodrias raniformis Keferstein 1867.

Hyla aurea major Copland 1957.

Diagnosis: This species can be recognised by its green and gold warty back with a green middorsal stripe. The groin and back of thigh are coloured blue, slightly less brilliant than that of *Litoria aurea*. There are sometimes small yellow spots on the back of the thigh.

In preservative the mid-dorsal stripe and the dorsolateral folds stand out as pale grey markings against a darker grey back, on which longitudinal rows of darker warts are seen.

Description of a male collected from Narrandera, N.S.W., August, 1972. Australian Museum No. R42155.

The dorsal surface is green and brown with rows of black spots and a distinct green mid-dorsal stripe extending from between the eyes to the cloaca. There is a dorsolateral gold line which starts on the eye and fades out just before the groin. There is another line from below the tympanum to the shoulder.

The belly and most of the ventral surfaces of the thighs are coarsely granulated. The region of the vocal sac has a yellow tinge. The groin, the posterior surface of the thigh and the inner surface of the tibia and foot are blue in colour.

The head is obtusely pointed and approximately as long as it is broad (HL/HW ratio 1.02). The head approximately 1/3 of the snout to vent length (HL/SV ratio 0.37). The snout is not prominent and does not project conspicuously beyond the anterior limit of the mandible. The distance between the eye and naris is greater than the internarial span. The canthus rostralis is distinct and straight, the loreal region is concave.

The tympanum is distinct and gold in colour. Its diameter is 0.59 x that of the eye.

The vomerine elevations are paired, and are slightly convergent posteriorly. The anterior ends are directly between the choanae. The tongue is broad, free and indented posteriorly.

Fingers are long and free from web. Fingers are, in order of length $3 > 4 > 2 = 1$. Terminal discs are approximately the same width as the digit.

The hind limbs are long and robust (TL/SV ratio 0.50). Toes are, in order of length, $4 > 3 = 5 > 2 > 1$. They are extensively webbed (see Fig. 1).

In preservative the dorsal surfaces become a dirty green or brown and the ventral surfaces and the dorsolateral lines become dirty white.

Dimensions

SV 60.3 mm; TL 30.3 mm; FL 42.8 mm; HL 22.5 mm; HW 22.0 mm; EN 4.5 mm; IN 3.2 mm; E 7.8 mm; T 4.6 mm.

Variability

Members of this species usually have a green dorsum with brown and black warts arranged in longitudinal rows. Some individuals have a few small yellow spots on the posterior surfaces of the thighs. Males have a yellow tinge in the region of the vocal sac.

TAXONOMY OF *LITORIA AUREA* COMPLEX

Specimens examined

Australian Museum: R3121-3, (1900) Fish River, Tarana, N.S.W.; R5233, (1911) Berridale, N.S.W.; R7344, (1921) Emu Plains, Urana, N.S.W.; R8421, (1924) Tumut, N.S.W.; R10661-8, (1932) Yanco, N.S.W.; R10669-88, (1932) Tubbo Stn., Riverina, N.S.W.; R25852-55, (1966) Bombala, N.S.W.; R26181, (1966) Tumbarumba, N.S.W.; R27605, (1967) Mt. Beauty, Vic.; R5959-62, R6683 (1912) Narracoorte, S.A.

Author's collection

Bywong, N.S.W. (1 specimen); Boorowa, N.S.W. (2 spec.); Narrandera, N.S.W. (15 spec.); Morundah, N.S.W. (1 spec.); Wagga, N.S.W. (5 spec.); Delegate, N.S.W. (2 spec.); 12 m NE Canberra, N.S.W. (15 spec.); near Bungendore, N.S.W. (2 spec.); Booligal, N.S.W. (10 spec.); Saucy Ck., Bombala, N.S.W. (2 spec.); MacLaughlin R. nr. Nimmitabel, N.S.W. (4 spec.); Swan Hill, Vic. (2 spec.); Whittlesea, Vic. (3 spec.); 10 m SE Orbost, Vic. (8 spec.).

Literature records

These do not include specimens in the Australian Museum already examined by the authors.

Albury, N.S.W.; Delegate, N.S.W.; Canberra, A.C.T.; Gunbower, Vic.; Melbourne, Vic.; Healesville, Vic.; Yarra River, Vic.; Millgrove, Vic. (Moore 1961). Tocumwal, N.S.W.; Gol Gol, N.S.W.; Darlington Point, N.S.W.; Balranald, N.S.W.; 10 m W of Narrandera, N.S.W.; 8 m S of Bombala, N.S.W.; Adaminaby, N.S.W.; Bacchus Marsh, Vic.; 13 m SE of Horsham, Vic.; Cobungra, Vic.; Macedon, Vic.; 18 m W of Bairnsdale, Vic.; Brighton, Vic.; Mordialloc, Vic.; Tailem Bend, S.A. (Copland 1957). Lock No. 9, Murray R.; 3 m E of Mildura, Vic.; Lake Cullulleraine, Vic.; 6 m SE of Red Cliffs, Vic.; Carwarp, Vic.; Nangiloc, Vic.; Boundary Bend area, Vic.; Nyah, Vic.; Sea Lake, Vic.; Wyche-proof, Vic.; 16 m W of Nhill, Vic.; Kaniva, Vic.; Mildura, Vic.; Lake Boga, Vic.; 5 m NW of Dimboola, Vic.; Wail, Vic.; 15 miles W of Kaniva, Vic. (Littlejohn 1966). Flinders Is., Bass Strait; King Island, Bass Strait (Littlejohn and Martin 1965).

Biology

These frogs occupy a similar habitat to *Litoria aurea*. However, they are often found during the day on a grassy bank near water, basking in the sun. This habit is not usually observed in *L. aurea*.

Larvae

Martin (1965) has described the tadpole of this species.

Litoria flavipunctata sp. nov.

Synonymy:

Hyla aurea raniformis Moore 1961 *partim*.

Holotype

A male, No. R40676 in the Australian Museum, from a swamp on the Booralong Creek Road, 12.8 km west of Guyra, N.S.W. (30° 16'S. 151° 33'E). (Paratypes Aust. Mus. R40677-82).

Derivation of name

The name *flavipunctata* is from the Latin meaning "yellow spots". This refers to the large yellow spots found in the groin and on the ventral surfaces of the hind limb of these animals. The presence of these spots is a distinguishing feature of this species.

Diagnosis: This species can be recognised by its dorsal colouration: green with small brown and black spots and a green mid-dorsal stripe, together with large and conspicuous yellow spots in the groin and on the ventral surfaces of the hind limb. These large yellow spots are not found in *Litoria aurea* or *Litoria raniformis*.

In preservative the dorsum appears very similar to that of preserved *Litoria raniformis* with a slightly less obvious mid-dorsal stripe. Spots in the groin and on the legs are white.

Description of the type specimen

The dorsal surface is green with brown and black spots, giving it a warty appearance. There is a distinct green mid-dorsal stripe extending from between the eyes to the cloaca.

The belly and part of the ventral surface of the thigh are white and coarsely granulate. The skin is more finely granulate under the forelimbs and the throat, and there is a hint of pale yellow in the region of the vocal sac. In the groin, on the ventral surface of the thigh and the ventral surface of the tibia and the foot, there are very large, distinct, yellow spots. Smaller yellow spots are found on the posterior surfaces of the thighs.

A gold line extends dorsolaterally from behind the eye to behind the shoulder, where it continues as a series of gold warts almost to the groin. Another short yellow line extends from under the tympanum to above the shoulder.

The head is obtusely pointed and slightly longer than broad (HL/HW ratio 1.15). The head length is approximately 1/3 of the snout to vent length (HL/SV ratio 0.27). The snout is not prominent and does not project conspicuously beyond the anterior limit of the mandible. The distance between the eye and the naris is greater than the internarial span (IN/EN ratio 0.70). The canthus rostralis is distinct and straight; the loreal region is concave.

The tympanum is distinct, gold in colour with a green centre. Its diameter is 0.6 x that of the eye. The vomerine elevations are paired, obliquely convergent

TAXONOMY OF *LITORIA AUREA* COMPLEX

posteriorly. The anterior ends are directly between the choanae. The tongue is broad, free and nicked posteriorly.

The fingers are long and free from web. Fingers are, in order of length, $3 > 4 > 2 = 1$. Terminal discs are approximately the same width as the digit.

The hind limbs are long and robust (TL/SV ratio 0.53). Toes are, in order of length, $4 > 3 = 5 > 2 > 1$. They are fully webbed (see Fig. 1).

In preservative the dorsum becomes a dark grey colour with a lighter grey stripe. The large yellow spots become white.

Dimensions

SV 64.3 mm; TL 34.1 mm; FL 46.8 mm; HL 23.9 mm; HW 20.7mm; EN 5.3 mm; IN 3.7 mm; E 6.9 mm; T 4.1 mm.

Variation

There is a variable amount of gold on the dorsal surfaces of these frogs, but the dorsal stripe remains distinct at all times. The ventral yellow spots are sometimes outlined in black. The size of the digital pad in relation to the digit on the hand and the amount of foot webbing were the same in every frog examined. A series of 21 adult specimens had a range of SV lengths from 52.6-84.8 mm.

Biology

This species occupies a similar habitat to *Litoria aurea* and *Litoria raniformis*. It is found also in ponds or slow moving streams with overhanging grassy banks in the absence of reed beds.

It has been found to overwinter in the hollow centres of rotting logs and in the earth surrounding the roots of uprooted trees.

Specimens examined

Australian Museum, N.S.W. R32183-9, (1971) Guyra, N.S.W.; R32560, (1971) Llangothlin Lagoon, N.S.W.; R32547, (1971) Llangothlin Lagoon; R34814-7; (1972) Black Mt. Lagoon, nr Guyra, N.S.W.; R33816, (1972) Sattern Gully, nr Armidale, N.S.W.; R34937, (1972) Abby Green Stn., nr Guyra, N.S.W.

Author's collection

Black Mt., near Guyra, N.S.W.; Llangothlin Lagoon, N.S.W.; 4 m S of Guyra, N.S.W.; Booralong Ck., New England, N.S.W.

Literature records

Booralong Ck., N.S.W. (Moore, 1961), recorded as *Hyla aurea raniformis*.

To our knowledge, this is the only reference in the literature which specifically refers to the individuals on the New England tableland.

KEY TO SOUTH-EASTERN SPECIES

- 1 (a) Mid dorsal stripe present
 Digital pads same width as digits 2
 (b) Mid dorsal stripe absent
 Digital pads $1\frac{1}{2}$ times width of digits *Litoria aurea*
- 2 (a) Large yellow spots (white in preservative) in groin and ventral surfaces of
 legs
 Toes completely webbed *Litoria flavipunctata*
 (b) No large yellow spots covering groin and ventral surfaces of legs
 Toes less than completely webbed *Litoria raniformis*

ACKNOWLEDGEMENTS

Financial assistance from a University of Sydney Research Grant is gratefully acknowledged. In addition we wish to express our gratitude to Dr. Harold Cogger at the Australian Museum for his advice and assistance throughout and for reading and commenting on the manuscript. The problem crystallised in its early stages from discussions with Mr. John Barker, and thanks are due to Miss Christine Lehmann for her enthusiasm and assistance in the fieldwork. The artwork is by David Stanley.

REFERENCES

- BIBRON, G. & A. M. C. DUMERIL (1854). *Erpétologie générale ou Histoire naturelle complete des Reptiles*. Paris. 9, 409.
- BOULENGER, G. A. (1882). *Catalogue of the Batrachia salientia s. Ecaudata in the collection of the British Museum*. 2nd ed. London.
- COPLAND, S. J. (1957). Presidential address. Australian tree frogs of the genus *Hyla*. *Proc. Linn. Soc. N.S.W.* 82, 9-108.
- GIRARD, C. (1853). Descriptions of new species of reptiles collected by the U.S. Exploring Expedition, under the command of Capt. Charles Wilkes, U.S.N. Second Part. Including the species of batrachians exotic to North America. *Proc. Acad. nat. Sci. Philad.* 6, 420-424.
- GOIN, C. J. & M. G. NETTING (1940). A new gopher frog from the gulf coast, with comments upon the *Rana areolata* group. *Ann. Carneg. Mus.* 28, 137-168.
- GÜNTHER, A. (1858). *Catalogue of the Batrachia salientia in the collection of the British Museum*, London xvi + 160 pp.
- HARRISON, L. (1922). On the breeding habits of some Australian frogs. *Aust. Zool.* 3, 17-34.
- KEFERSTEIN, W. (1867). Ueber einige neue oder seltene Batrachier aus Australien und dem tropischen Amerika. *Nachr. Ges. Wiss. Göttingen* 18, 341-361.
- KEFERSTEIN, W. (1868). Ueber die Batrachier Australiens. *Archiv. fur Naturg. Berlin* 34 (1): 253-290.
- LESSON, R. P. (1831 (1830)). *Zoologie in Duperrey's 'Voyage autour du monde, sur la corvette de la majeste, La coquille'*. 2, 59-61.
- LITTLEJOHN, M. J. (1966). Amphibians of the Victorian mallee. *Proc. R. Soc. Vict.* 79 (2), 597-604.

TAXONOMY OF *LITORIA AUREA* COMPLEX

- LITTLEJOHN, M. J. (1967). Patterns of zoogeography and speciation in south eastern Australian Amphibia. In 'Australian Inland Waters and Their Fauna'. (Ed. A. H. Weatherley). (Australian National University Press: Canberra).
- LITTLEJOHN, M. J. (1969). Amphibia of East Gippsland. Proc. R. Soc. Vict. 82 (1), 105-112.
- LITTLEJOHN, M. J. (1971). Amphibians and Reptiles of Victoria. Part 1. Victorian Year Book No. 85.
- LITTLEJOHN, M. J. & A. A. MARTIN (1965). The vertebrate fauna of the Bass Strait Islands: 1. The Amphibia of Flinders and King Islands. Proc. R. Soc. Vict. 79, 247-256.
- LITTLEJOHN, M. J., A. A. MARTIN & P. A. RAWLINSON (1963). New records of frogs in East Gippsland. Victorian Nat. 80, 225-226.
- LOVERIDGE, A. (1950). New frogs of the genera *Cyclorana* and *Hyla* from south-eastern Australia. Proc. biol. Soc. Wash. 63, 131-138.
- MARTIN, A. A. (1965). Tadpoles of the Melbourne area. Victorian Nat. 8 (5), 139-149.
- MOORE, J. A. (1954). Geographic and genetic isolation in Australian amphibia. Amer. Nat. 88: 65-74.
- MOORE, J. A. (1961). The frogs of eastern N.S.W. Bull. Am. Mus. nat. Hist., 121, 149-386.
- PARKER, H. W. (1938). The races of the Australian frog *Hyla aurea* Lesson. Ann. Mag. Nat. Hist. (11) 2: (9): 302-305.
- PROCTER, J. B. (1924). Unrecorded characters seen in living snakes and description of a new tree frog. Proc. zool. Soc. Lond. 1924 (4), 1125-1129.
- STEINDACHNER, F. (1867 (1869)). Amphibien. In 'Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857-1859'. (Vienna) Zool. Theil 1 (4), 1-70.
- TSCHUDI, J. J. (1839). Classification der Batrachier mit Berücksichtigung der fossilen Thiere dieser Abtheilung der Reptilien. Mém. Soc. Sci. Nat. Neuchatel 2, 30-75.
- TYLER, M. J. (1971). The phylogenetic significance of vocal sac structure in Hylid frogs. Univ. Kansas Publications Museum of Natural History. 19 (4): 319-360.
- WERNER, F. (1893). Herpetologische nova. Zool. Anz. 16, 81-84.