

# A new species of the *Litoria gracilentata* group from Irian Jaya (Anura: Hylidae)

Eine neue Art der *Litoria gracilentata*-Gruppe aus Irian Jaya  
(Anura: Hylidae)

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## KURZFASSUNG

Auf der Basis von kürzlich im nordwestlichen Irian Jaya gesammelten Material wird eine neue Art aus der *Litoria gracilentata*-Gruppe als *Litoria elkeae* sp. nov. beschrieben. Von *L. gracilentata* mit der Typuslokalität in Nordost-australien läßt sie sich sowohl morphologisch als auch bioakustisch abgrenzen. Wichtige morphologische Unterschiede sind die geringere Körpergröße der neuen Art (Kopf-Rumpf-Länge der Männchen 27,5-30,4 mm gegenüber 31,6-35,6 mm), ihre größeren Augen (Augendurchmesser/KRL 0,117-0,151 gegenüber 0,096-0,111 bei *L. gracilentata*) und anders gefärbte Körper- und Oberschenkelseiten. Während die Rufe von *L. gracilentata* aus einer relativ schnellen Folge von Einzelsilben bestehen, äußert die neue Art vorwiegend aus zwei Silben bestehende Rufe, die in weiteren Abständen aufeinander folgen. Die neue Art wird auch mit *L. aruensis* und weiteren Vertretern der *L. gracilentata*-Gruppe verglichen und von diesen abgegrenzt. Im westlichen Papua Neu Guinea gefundene Vertreter der *L. gracilentata*-Gruppe unterscheiden sich in ihren Paarungsrufen auch deutlich von *L. gracilentata* aus Australien. Wegen der geringen Materialbasis bleibt ihre taxonomische Einstufung aber noch offen.

## ABSTRACT

*Litoria elkeae* sp. nov. (Anura: Hylidae) is described from the north-western lowlands of Irian Jaya, Indonesia. Morphologically the new species is similar to *L. gracilentata* from northeastern Australia. It differs from *L. gracilentata* in a number of features including smaller size (SUL of males 27.5-30.4 vs 31.6-35.6 mm) and larger eyes (ED/SUL 0.117-0.151 vs 0.096-0.111), and in having a different advertisement call. The identity of New Guinea frogs currently identified as *L. gracilentata* is discussed.

## KEY WORDS

Amphibia: Anura: Hylidae; *Litoria elkeae* new species, *Litoria gracilentata*, *Litoria aruensis*, morphology, advertisement calls, Irian Jaya, New Guinea, Indonesia, Australia.

## INTRODUCTION

The hylid frog *Litoria gracilentata* (PETERS, 1869) is a small species (males to 42 mm, females to 45 mm) with extensively webbed fingers, a green dorsum, and a pale yellow venter (BARKER et al. 1995). This beautiful species was originally described from Mackay, north-eastern Queensland and in Australia it is widely distributed in lowland coastal habitats from eastern Cape York Peninsula to north-eastern New South Wales (BARKER et al. 1995).

The first record of this species from New Guinea was a small series of males that TYLER (1968) reported from the southern highlands of Papua New Guinea. Although the specimens are morphologically similar to Australian *L. gracilentata* they are much smaller (27-28 mm) and TYLER noted that the habitat of these specimens (in the

highlands, "250 miles from the portion of the coast opposite to Australia") may suggest the likelihood of "biological differentiation" from Australian populations.

In contrast MENZIES (1976) argued that based on morphological similarity and advertisement call characteristics, New Guinea "*L. gracilentata*" are not only conspecific with Australian populations but also with *L. aruensis* (HORST, 1883), a small green hylid frog known from widely scattered localities across the island of New Guinea.

On 27 September 1997, the senior author (R.G.) collected a female specimen of an undescribed *Litoria* resembling *L. gracilentata* in a muddy oxbow of the river Kalibumi in northwestern Irian Jaya. Three males were collected from the same locality

about one year later (7-10.08.98) and recordings of advertisement calls were obtained. During a 1998 biodiversity survey of rainforests in the vicinity of Siewa, about 80 km NE of the Kalibumi locality, the junior author (S.J.R.) collected eight additional specimens of the new species and obtained recordings of advertisement calls.

S.J.R. also collected specimens, and recorded advertisement calls, from two New Guinea populations of *L. cf. gracilentata*. Here we describe and illustrate the new species, and assess the status of *L. aruensis* and New Guinea populations of *L. cf. gracilentata*.

## MATERIALS AND METHODS

Description of the new species is based on three males (ZMB [Zoological Museum Berlin] 59374 cleared and stained) and one female from rain forest near the river Kalibumi, about 20 km SE of Nabire at km 35 along the Nabire-Mapia road, and on four males (Field number 4132 cleared and stained) and four females from rain-forest surrounding the mineral exploration camp at Siewa (3° 02.202' S, 136° 22.515' E), about 100 km NE of Nabire. Frogs from Kalibumi were preserved in the field in a solution of 2% formalin and were transferred to 70% ethanol in the laboratory. Frogs from Siewa were anaesthetised in chlorobutanol, fixed in 5% formalin and preserved in 70% ethanol, or fixed and preserved in 70% ethanol to permit future DNA extraction.

Because the new species is morphologically similar to *L. gracilentata* (terra typica: northeastern Australia) and *L. aruensis* (terra typica: Aru Islands), we examined the holotype of *L. gracilentata* (female, ZMB 6618), five males from Townsville, Queensland (170 km north of the type locality), and two syntypes of *L. aruensis* (RMNH [Rijksmuseum van Natuurlijke Historie, Leiden] 4416 A and 4416 B). To assess the status of *L. cf. gracilentata* in New Guinea we examined specimens collected by S.J.R. from populations at Ok Tedi in Western Province, Papua New Guinea, and at Herowana, Eastern Highlands Province, Papua New Guinea. These frogs were compared to *L. gracilentata* and to the new species.

We analyzed advertisement calls of the new species, and of *L. gracilentata* from Townsville (Queensland) and Herowana, Eastern Highlands Province, Papua New Guinea. Recordings of frogs from Ok Tedi are of insufficient quality for meaningful

analyses. Advertisement calls were recorded with a digital compact cassette recorder DCC 170 and Sennheiser® microphone MKE 300 (R.G.) and with a Sony® WMD-6C Professional Walkman and ECM-Z200 microphone (S.J.R.). Calls were analyzed with Avisoft-SAS® Lab software.

The following measurements were made with Vernier callipers (> 10 mm) or with a binocular dissecting microscope fitted with an ocular micrometer (<10 mm):

- SUL length from tip of snout to distal tip of urostyle;
- TL length of tibia, from heel to knee;
- T4L length of fourth toe, from tip of toe to proximal end of inner metatarsal tubercle;
- T4D horizontal diameter of disk of fourth toe;
- T1L length of first toe, from tip of toe to distal end of inner metatarsal tubercle;
- MTL length of metatarsal tubercle;
- F3D horizontal diameter of disc of third finger;
- HL head length, from tip of snout to posterior margin of tympanum;
- HW head width, taken at the level of the tympana;
- END distance from anterior corner of orbital opening to centre of naris;
- IND internarial distance (measured as distance between centres of nares);
- ED eye diameter, from anterior to posterior corner of orbital opening;
- TyD horizontal diameter of tympanum;
- FD distance between the supratympanic folds, immediately behind eyes.

Specimens are deposited at Museum für Naturkunde, Berlin (ZMB), the Museum Zoologie, Bogor, (MZB) and the Queensland Museum (QMJ).

Table 1. Measurements of various body parts of 11 *Litoria elkeae* spec. nov. from about km 35 along the Nabire-Mapia road (ZMB numbers with 59375 as holotype) and from Siewa, about 100 km NE of Nabire (Siewa field numbers). These specimens are finally deposited in the following institutions: 4132 as bone preparation in ZMB with number 59377. 4126, 4128, 4129, and 4157 at the Museum Zoologie, Bogor, and 4130, 4131, 4133 at the Queensland Museum.

Tab. 1: Körperabmessungen von 11 *Litoria elkeae* spec. nov. Die Exemplare stammen aus dem Bereich von km 35 entlang der Straße Nabire-Mapia (ZMB-Nummern, mit 59375 als Holotypus) sowie aus Siewa, etwa 100 km NE von Nabire (Siewa-Feldnummern). Diese Exemplare werden letztlich in folgenden Einrichtungen deponiert werden: 4132 als Knochenpräparat im ZMB unter der Nummer ZMB 59377. 4126, 4128, 4129, und 4157 am Museum Zoologie, Bogor und 4130, 4131, 4133 am Queensland Museum.

Parameter	Specimens measured / Vermessene Exemplare											
	ZMB 59375	ZMB 59377	ZMB 59376	Siewa 4157	Siewa 4133	Siewa 4126	Siewa 4132	Siewa 4128	Siewa 4130	Siewa 4129	Siewa 4131	
SUL	27.5	29.8	34.5	30.0	29.0	28.4	30.4	33.8	35.2	36.0	34.2	
TL	15.9	16.2	18.8	16.3	15.9	15.8	17.0	17.6	18.5	19.9	18.2	
T4L	10.6	11.8	13.5	11.8	11.6	11.2	12.2	13.1	14.0	14.1	14.2	
T4D	1.3	1.5	1.8	1.5	1.8	1.3	1.8	1.8	1.9	1.9	1.8	
T1L	2.6	3.0	3.5	3.0	2.9	2.9	3.1	3.8	4.0	3.8	3.7	
MTL	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.5	1.5	1.3	1.3	
F3D	1.3	1.5	1.8	1.5	1.8	1.5	1.6	2.0	2.0	2.0	1.9	
HL	9.9	10.7	12.8	10.8	10.1	9.6	10.4	12.3	11.7	12.2	11.2	
HW	10.2	11.2	12.8	10.8	10.9	9.8	10.4	12.4	12.8	13.0	12.1	
END	2.8	2.9	4.0	3.4	3.1	3.0	2.9	3.6	3.5	3.5	3.7	
IND	2.8	2.9	3.4	2.9	2.9	2.8	2.9	3.3	3.1	3.1	3.2	
ED	3.9	4.5	4.4	4.0	4.1	3.9	3.7	4.5	4.4	4.3	4.0	
TyD	1.5	1.6	2.1	1.7	1.6	1.6	1.8	1.9	2.0	2.0	1.9	
FD	9.6	10.9	12.0	10.7	10.2	9.9	11.0	11.6	11.7	12.1	11.4	

## DESCRIPTION OF THE NEW SPECIES

### *Litoria elkeae* spec. nov.

**Holotype:** ZMB 59375 (fig 1). Adult male collected by R. GÜNTHER and I. TETZLAFF, 100 m from the river Kalibumi at km 35 along the Nabire to Mapia road, Irian Jaya, Indonesia on 9 August 1998. Altitude 100 m asl.

**Paratypes:** ZMB 59377, adult male, same details as holotype; ZMB 59376, adult female (fig 2), collected by R. GÜNTHER on 27 September 1997 in a muddy oxbow at the same locality; MZB 3866 i.e. Siewa 4126, MZB 3869 i.e. Siewa 5157, and QMJ 70492 i.e. Siewa 4133 are adult males; MZB 3867 i.e. Siewa 4128, MZB 3838 i.e. Siewa 4129, QMJ 70490 i.e. Siewa 4130 and QMJ 70491 i.e. Siewa 4131 are adult females, all collected by S. RICHARDS at Siewa (3° 02. 202' S, 136° 22.515' E), about 100 km NE of Nabire at an altitude of 60 m asl on 3 April 1998.

Two additional specimens [ZMB 59378 and ZMB 59377 formerly Siewa 4132] were cleared and stained and are also regarded as a paratypes.

**Diagnosis:** A small species (snout-urostyle length of seven males 25.5 - 30.4 mm and five females 33.8 - 36.0 mm) with large eyes and head about as broad as long. Dorsal coloration uniform green with or without small whitish spots (fig. 3) and a whitish cantho-rostral stripe. Supratympanic fold paler than dorsum. Flanks and anterior and posterior parts of thighs yellowish, venter whitish without markings. Advertisement call normally biphasic, occasionally one or three notes, with long intervals between calls.

**Etymology:** The specific epithet is a noun in genitive gender honoring the first author's wife, ELKE GÜNTHER.

**Distribution:** The new species is known only from the type localities in the lowlands of north-western Irian Jaya (for the habitat see fig. 4).

**Description of holotype:** The holotype is an adult male the measurements of which are listed in table 1 under ZMB 59375. Its biometric ratios are: TL/SUL = 0.58, T4L/SUL = 0.39, T4D/



Fig 1: Holotype (ZMB 59375) of *Litoria elkeae* spec. nov. in life.  
Abb. 1: Holotypus von *Litoria elkeae* spec. nov. im Leben.

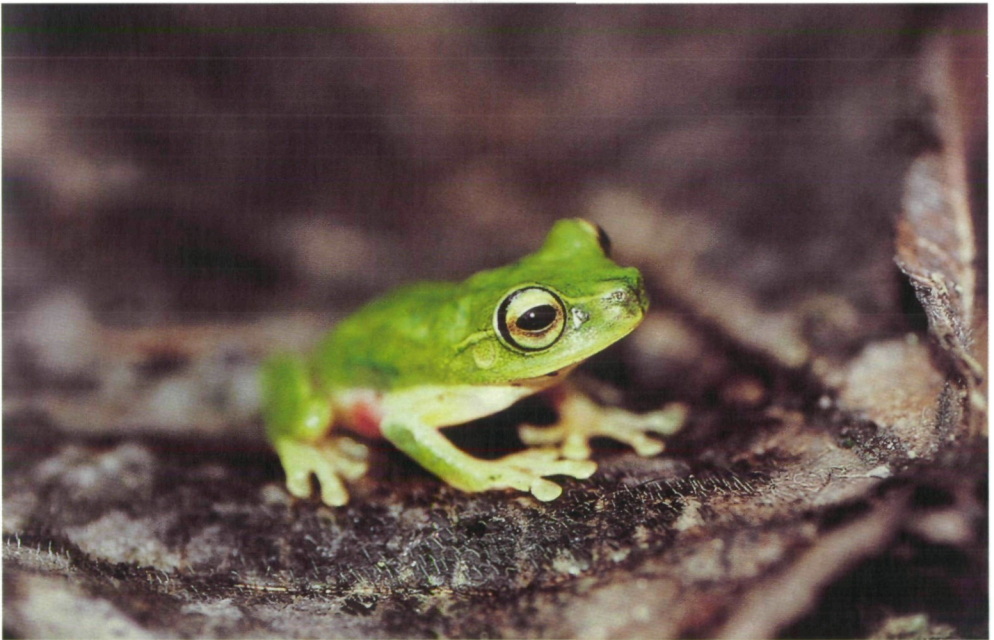


Fig 2: Female paratype (ZMB 59376) of *Litoria elkeae* spec. nov. in life.  
The ovaries of this female are full of dark brown (animal half) and whitish (vegetative half) ripe eggs, indicating that reproduction was occurring around September.  
Abb. 2: Weiblicher Paratypus (ZMB 59376) von *Litoria elkeae* spec. nov. im Leben.  
Die Ovarien sind gefüllt mit reifen Eiern (animale Hemisphäre: dunkelbraun, vegetative Hemisphäre: weißlich), was auf eine Fortpflanzungszeit (auch) im September hinweist.





Fig 3: *Litoria elkeae* spec. nov. from Siewa with spotted dorsum.  
White spots are more clearly expressed when specimens are in preservative.  
Abb. 3: *Litoria elkeae* spec. nov. aus Siewa mit geflecktem Rücken.  
Die weißen Flecken sind bei konservierten Exemplaren deutlicher ausgeprägt.



Fig 4: Habitat of *Litoria elkeae* spec. nov. near the river Kalibumi at km 35 along the Nabire-Mapia road.  
Abb. 4: Lebensraum von *Litoria elkeae* spec. nov. nahe dem Kalibumi Fluß bei km 35 der Straße Nabire-Mapia.

F3D = 1.00, HL/HW = 0.97, END/IND = 1.00, ED/SUL = 0.141, TyD/HL = 0.15, MTL/T1L = 0.38, FD/SUL = 0.35. Head broad, snout short, truncate in dorsal view, rounded and somewhat projecting in profile; nostrils close to tip of snout and more lateral than superior, distance between nares equals distance between eye and naris; canthus rostralis slightly curved, gently rounded, loreal region shallowly concave. Tympanum covered with skin but clearly visible, its superior edge covered by a slightly curved supratympanic fold; tympanum diameter less than half the eye diameter. Eye large, prominent, with horizontal pupil. Upper jaw with numerous teeth, vomerine teeth in two small groups close together, between and below posterior borders of the small choanae. Tongue oval with slightly notched posterior border. Vocal slits on both sides of mouth close to posterior of lower jaw. Fingers short with narrow lateral fringes (except on thumb), relative lengths  $3 > 4 > 2 > 1$ . Webbing between second and third, and between third and fourth fingers reaching half the length of third finger; only a trace of webbing between first and second finger. Terminal discs with circummarginal grooves, nearly twice as broad as penultimate phalanx. Subarticular tubercles very weakly developed. A finely structured, dark brown nuptial pad on first finger extends distally to base of terminal disc. Hind limbs relatively long and slender; toes in decreasing order of length  $4 > 5 > 3 > 2 > 1$ . Webbing between toes does not extend to discs. Webbing on fourth toe reaches subarticular tubercle at base of penultimate phalanx;

webbing between first and second toe basal. A small bean-shaped inner metatarsal tubercle at base of first toe; subarticular tubercles scarcely visible. Tips of toes slightly smaller than tips of fingers (fig. 5). Dorsal and ventral surfaces of body finely granular, region around vent coarsely granular, throat and lower surface of thighs smooth.

Dorsal surface of head, body, forearm, thigh and tarsus pale green in life, dorsum with indistinct whitish spots (fig. 1). A whitish stripe commences above naris and extends to posterior end of supratympanic fold. Flanks, anterior and posterior parts of thighs yellowish; ventral surface of head, body, limbs and dorsal surface of upper arms cream. Dorsal sides of thighs with narrow greenish stripe. In preservative all greenish body parts appear blue-grey, dorsal surface of limbs appear speckled.

**Morphological variation in the type series:** The type series consists of seven males and five females. Two males were cleared and stained and one of them is included in the following calculations. Measurements of all specimens are listed in table 1. Males are smaller than females. The mean snout-urostyle length of males is 29.2 mm (range 27.5 - 30.4 mm), and of females is 34.7 mm (range 33.8 - 36.0 mm) (fig. 6). Variation in body proportions is similar in both sexes, therefore male and female data is merged together in table 2.

Some of these ratios can be used to discriminate the new species from its closest relatives (see below). In body proportions and coloration there is only minor

Table 2: Variation of body proportions (mean, standard deviation, range) in the type series of *Litoria elkeae* spec. nov. (6 males and 5 females).

Tab. 2: Variabilität der Körperproportionen (Mittel, Standardabweichung, Variationsbreite) in der Typenserie von *Litoria elkeae* spec. nov. (6 Männchen und 5 Weibchen).

Body proportions / Körperproportionen	Mean ± Standard Deviation / Mittel ± Standardabweichung	Range / Variationsbreite
TL/SUL	0.55 ± 0.017	0.52 - 0.58
T4L/SUL	0.40 ± 0.009	0.39 - 0.42
T4D/F3D	0.98 ± 0.067	0.87 - 1.13
HL/HW	0.96 ± 0.033	0.91 - 1.00
END/IND	1.09 ± 0.069	1.00 - 1.18
ED/SUL	0.131 ± 0.0011	0.117 - 0.151
TyD/HL	0.161 ± 0.0083	0.150 - 0.170
MTL/T1L	0.38 ± 0.034	0.31 - 0.42
FD/SUL	0.35 ± 0.013	0.33 - 0.37

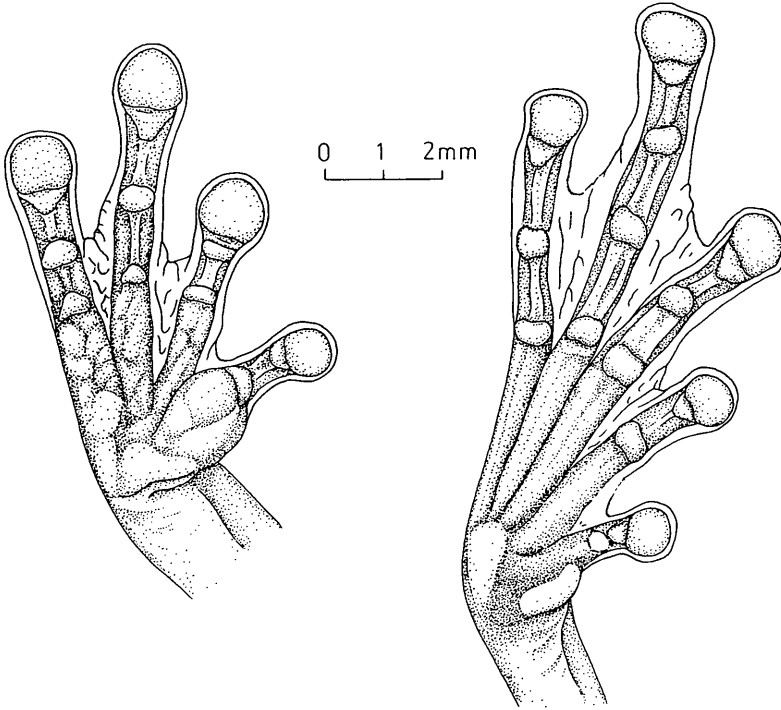


Fig 5: Ventral view of right hand (left) and right foot (right) of *Litoria elkeae* spec. nov.  
 Abb. 5: Ventralansicht der rechten Hand (links) und des rechten Fußes (rechts) von *Litoria elkeae* spec. nov.

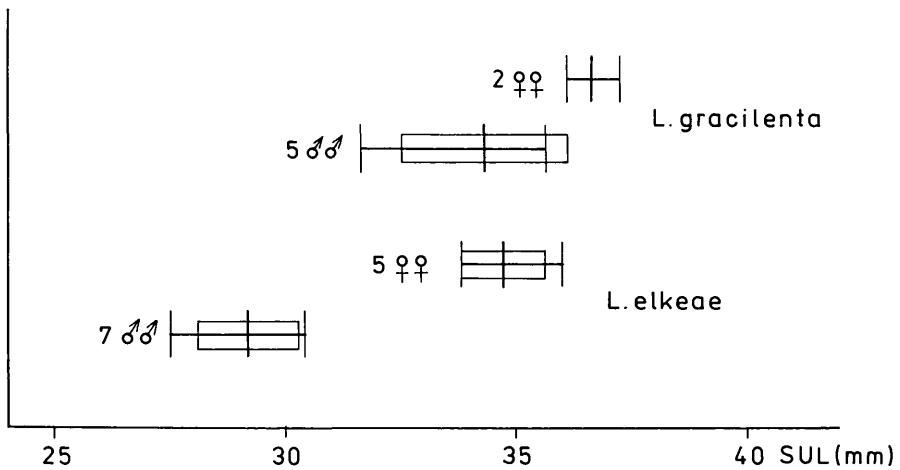


Fig 6: Mean (vertical line), standard deviation (rectangle) and range (horizontal line) of the snout-urostyle length (SUL) of 7 male and 5 female *Litoria elkeae* spec. nov. and 5 male and 2 female *L. gracilentia*.  
 Abb. 6: Mittel (vertikale Linie), Standardabweichung (Rechteck) und Variationsbreite (horizontale Linie) der Kopf-Rumpf-Länge (SUL) von 7 männlichen und 5 weiblichen Individuen von *Litoria elkeae* spec. nov. sowie von 5 männlichen und 2 weiblichen Individuen von *L. gracilentia*.

variation within the type series. The dorsal surface of all specimens in life was pale leaf-green (blue-grey in preservative). One male and one female have clearly demarcated white spots on the head and body. In three males and four females the spots are present but less clearly defined. Two males and one female lack pale dorsal spots. Most frogs have a narrow green stripe on the dorsal surface of the thigh. This stripe may be partially interrupted on one or both sides. In all frogs the upper arms are unpigmented or the pigments are visible only under high magnification. All specimens have a whitish stripe along the canthus, over the eye and along the supratympanic fold. The iris was yellowish to brownish in life. The flanks and posterior surfaces of the thighs were cream to slightly yellow; the throat, belly and ventral surfaces of the limbs were whitish without markings. One female had a purplish spot on the flanks in life (fig. 2).

**Vocalization:** We recorded the advertisement calls of three individuals of *L. elkeae*, two from the river Kalibumi and one from Siewa. Calls at Kalibumi were recorded between 09:00 and 10:30 p. m. on 9<sup>th</sup> August 1998 at an air temperature of 27 °C. Calls at Siewa were recorded at 10:00 p. m. on 3<sup>rd</sup> April 1998 at an air temperature of 25 °C. There were no significant differences among structural features of the calls of the three males and the calls are therefore treated as one sample. Typical advertisement calls are biphasic with the two notes separated by a short interval (fig. 7). Calls with a single note were uncommon and triple-note-calls were heard only rarely. Males usually called while perched on leaves 1-2 m above the ground. Most calling sites were adjacent to or overhanging small puddles (Kalibumi) or larger pools in the rainforest. Vocalizing males

occurred at moderately high densities. At Kalibumi 10 males were calling along a 200 m ditch and the shortest distance between two calling males was 6 m. Calls were usually uttered in short series, with intervals of several minutes between each series. Within series the intervals between calls were at least 6 seconds. The first note of double-note-calls is consistently longer than the second. Single-note-calls were slightly longer than the first note in double-note-calls, but small sample sizes of the former (n=4) prevent useful statistical comparisons. Because of the similarity of these notes we combined single notes with first notes of double-note-calls. Fourteen first notes and four single notes had a mean duration of 1310 milliseconds (ms) (SD 200.66, range 853-1660 ms). Fourteen second notes had a mean duration of 741 ms (SD 59.70, range 653-860 ms). Mean duration of intervals between notes in 14 two-note-calls was 221 ms (SD 31.27, range 214-239 ms). The oscillogram of a double-note-call (fig. 8) shows that the first note has the shape of a bell with a high number of pulses. The weak initial pulses are irregular, but pulses are then produced very regularly. The second note is characterized by a much quicker ascent of the amplitude, which reaches its maximum sooner. There were no significant differences between the pulse rate in first and second notes. At an air temperature of 27 °C, 19 notes had a mean pulse rate of 88.6 pulses/s (SD 4.8; range 80-101 pulses/s). Figures 9 and 10 illustrate an audiospectrogram and a frequency distribution respectively. The spectral band width is from 1.5 to 3.8 kHz, with the fundamental frequency around 2 kHz. The dominant frequency is between 2.8 and 3.5 kHz with two peaks at 3.0 and 3.3 kHz. There is an additional peak at 2.5 kHz. Harmonics are not recognizable.

## MORPHOLOGICAL COMPARISONS

In its general morphology *Litoria elkeae* spec. nov. closely resembles *L. gracilentia*, which was described by PETERS (1869) from NE Australia. According to TYLER (1968) and MENZIES (1976) *L. gracilentia* also occurs in various parts of New Guinea. On the basis of a suite of os-

teological, myological and external characters TYLER & DAVIES (1978) recognized 37 intrageneric "species-groups" within the genus. They arranged *L. gracilentia* together with *L. aruensis*, *L. chloris* BOULENGER, 1893, *L. graminea* BOULENGER, 1905, and *L. multiplica* TYLER, 1964 into



Table 3: Body proportions (mean, standard deviation, range) of 6 specimens of *Litoria gracilentia* which, based on T test comparisons revealed significant differences to corresponding ratios of 11 specimens of *L. elkeae* spec. nov. (T and P values).

Tab. 3: Die Körperproportionen (Mittel, Standardabweichung, Variationsbreite) von 6 Exemplaren von *Litoria gracilentia*, bei denen sich im T-Test mit den entsprechenden Quotienten von 11 Exemplaren von *L. elkeae* spec. nov. signifikante Unterschiede ergaben (T- und P-Werte).

Body Proportions / Körperproportionen	Mean ± Standard Deviation / Mittel ± Standardabweichung	Range / Variationsbreite	T	P
ED/SUL	0.106 ± 0.005	0.096 - 0.111	5.39	0.00005
T4D/F3D	0.878 ± 0.062	0.78 - 0.95	2.97	0.0047
FD/SUL	0.321 ± 0.025	0.28 - 0.35	2.97	0.0047
TyD/HL	0.173 ± 0.008	0.17 - 0.19	2.96	0.0048
TL/SUL	0.523 ± 0.014	0.50 - 0.54	2.73	0.0076
END/IND	1.008 ± 0.069	0.91 - 1.09	2.46	0.0142

the *Litoria aruensis* group. Because *L. gracilentia* was described before *L. aruensis* and antedates description of all other taxa in this group, it should more properly bear the name *Litoria gracilentia* group.

*Litoria elkeae* differs consistently from *L. gracilentia* in adult body size and in various body proportions (figs. 6 and 11). Snout-urostyle length of seven *L. elkeae* males was 27.5 - 30.4 mm, whereas that of five *L. gracilentia* males from near the type locality was 31.6 - 35.6 mm. Five *L. elkeae* females were 33.8 - 36.0 mm and two *L. gracilentia* females were 36.1 - 37.2 mm long. According to BARKER et al. (1995) the size of *L. gracilentia* males is between 31 and 42 mm and that of females 32 to 45 mm. A useful morphometric trait to differentiate between *L. elkeae* and *L. gracilentia* is the size of the eyes. *Litoria elkeae* has distinctly larger eyes than *gracilentia* (fig. 10). Table 3 shows those body proportions of six *L. gracilentia* that are significantly different (T-test) from the ratios of 11 *L. elkeae*.

Interdigital webbing is slightly more developed in *L. gracilentia* than in *L. elkeae*. There are also consistent differences in coloration. The upper arm, flanks and dorsal surface of the thighs are straw yellow and the posterior surface of the thighs is purple-brown to bluish in *L. gracilentia*, while these surfaces are cream-coloured or slightly yellow in *L. elkeae*.

*Litoria aruensis* has been recorded from the Aru Islands (terra typica), Waigeo, Misool, the Vogelkop Peninsula, southern lowlands of New Guinea (Alkmaar), and the Louisiade Archipelago (TYLER

1968). We have examined two syntypes of *L. aruensis* (RMNH 4416 A, a female and RMNH 4416 B, a male) from the Aru Islands and found the following differences in comparison to *L. elkeae*: (1) SUL is 32.5 mm in the male and 41.8 mm in the female syntype of *L. aruensis* and, thus, is clearly larger than in *L. elkeae*; (2) *L. aruensis* has broad lateral fringes on the fingers, while *L. elkeae* has small fringes; (3) webbing is generally more extensive in *L. aruensis*, especially between the 2<sup>nd</sup> and 3<sup>rd</sup> finger and the 2<sup>nd</sup> and 3<sup>rd</sup> toe; webbing between 2<sup>nd</sup> and 3<sup>rd</sup> toe reaches the toe disc of the 2<sup>nd</sup> toe in *L. aruensis* but not in *L. elkeae*; (4) the snout of *L. elkeae* is shorter and higher; (5) the tibia is longer in *L. aruensis* (mean of TL/SUL is 0.54 vs. 0.57); (6) nuptial pads of *L. aruensis* are yellowish and those of *L. elkeae* are brown in preservative; (7) no whitish canthal stripe and no whitish spots on the dorsum in the two syntypes of *L. aruensis*, (8) posterior surface of the thigh is violet in *L. aruensis* and yellowish in *L. elkeae*; (9) bones of the legs and the mandible, which are visible through the skin, are of intense green in *L. aruensis* and yellowish in *L. elkeae*.

Morphological differences between *L. aruensis* and *L. gracilentia* are less well expressed than those between *L. elkeae* and *L. aruensis*. Principally because of the following features we regard *L. aruensis* as systematically distinct from *L. gracilentia*: (1) green bones only in *L. aruensis*, (2) longer tibiae in *L. aruensis* (mean of TL/SUL of six *L. gracilentia* specimens 0.52, range 0.50-0.54, mean of two *L. aruensis* syntypes 0.57, range 0.56-0.58); (3) larger

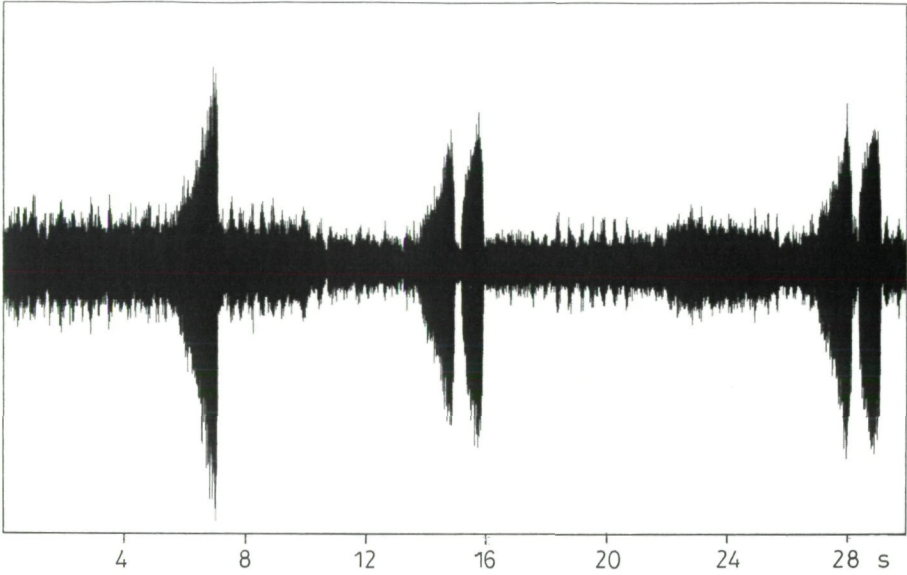


Fig 7: Sequence of 3 advertisement calls (first consisting of one and two others of two notes) of *Litoria elkeae* spec. nov. This and the following figures of *L. elkeae* calls are from males at the same locality as the holotype.  
Abb. 7: Eine Folge von drei "Paarungsrufen" (der erste besteht aus einer, die beiden anderen aus je zwei Silben) von *Litoria elkeae* spec. nov. Diese und die folgenden *L. elkeae* - Rufdiagramme stammen von Männchen der Holotypuslokalität.

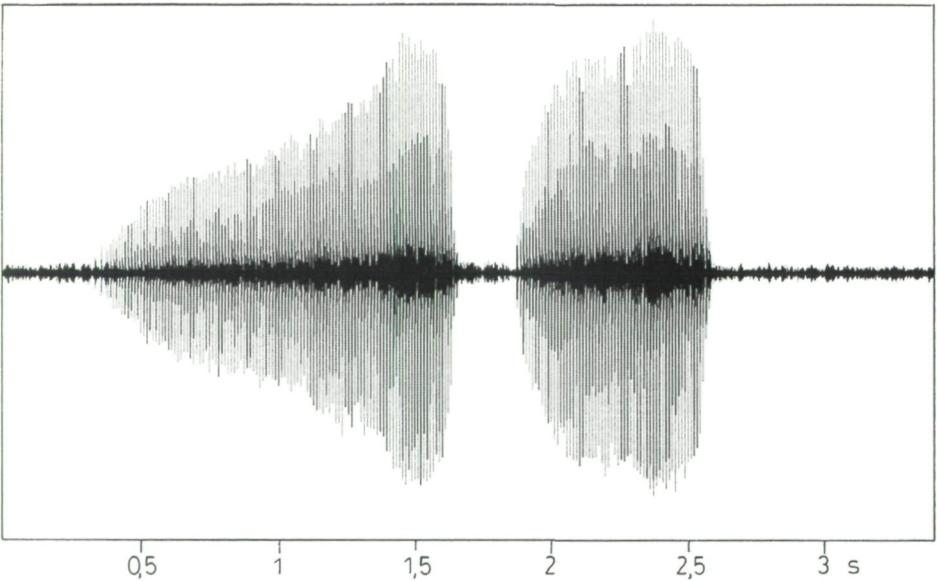


Fig 8: Oscillogram of a double-note advertisement call of *Litoria elkeae* spec. nov.  
Abb. 8: Oszillogramm eines aus zwei Silben bestehenden "Paarungsrufes" von *Litoria elkeae* spec. nov.

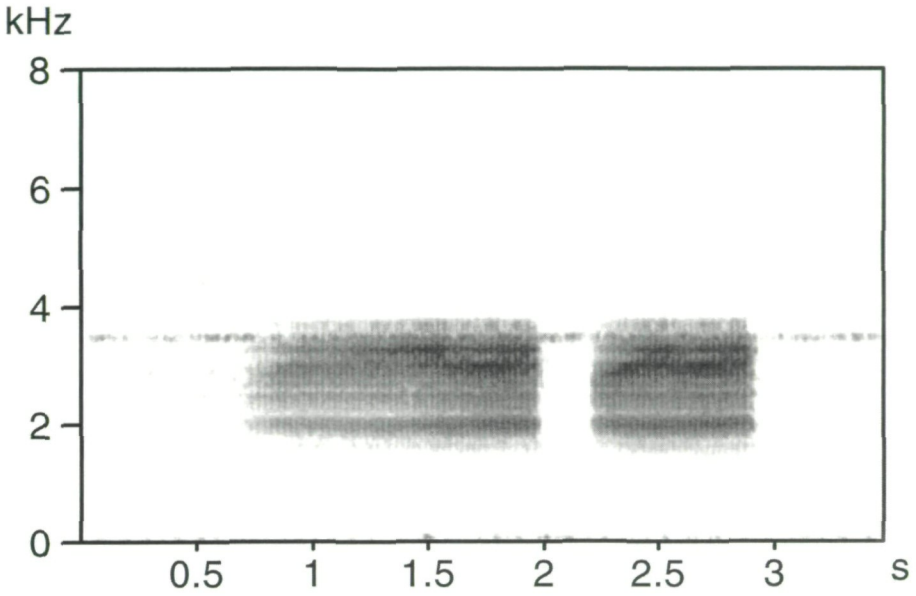


Fig 9: Audiospectrogram of a double-note call of *Litoria elkeae* spec. nov.

Abb. 9: Audiospektrogramm eines aus zwei Silben bestehenden Rufes von *Litoria elkeae* spec. nov.

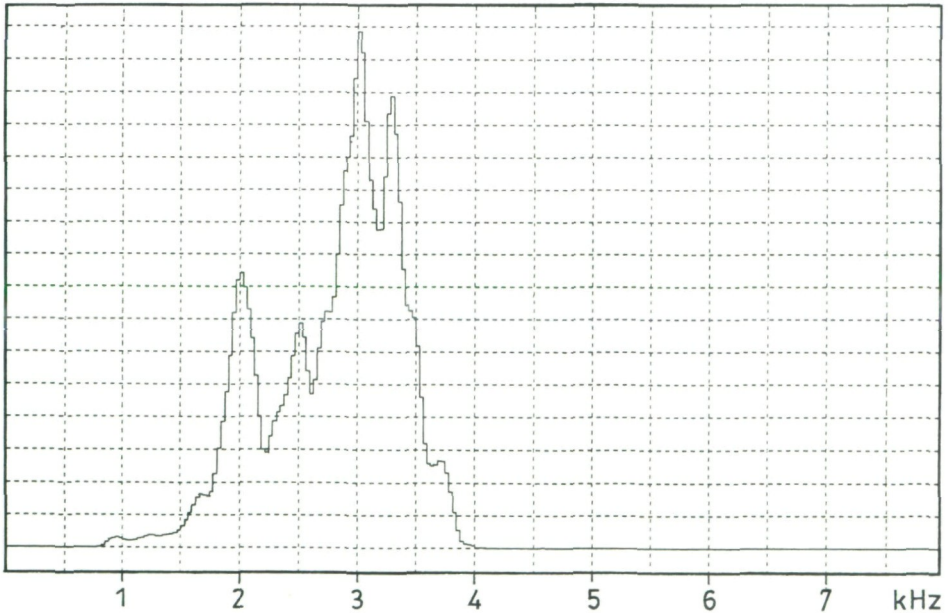


Fig 10: Frequency spectrum of a double-note call of *Litoria elkeae* spec. nov.

Abb. 10: Frequenzspektrum eines aus zwei Silben bestehenden Rufes von *Litoria elkeae* spec. nov.

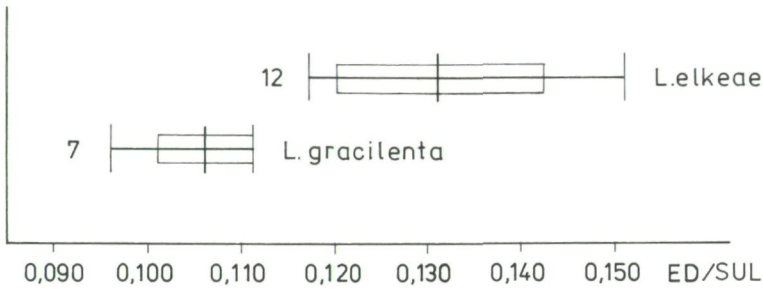


Fig 11: Ratios of eye diameter/snout-urostyle length (ED/SUL) of 12 *Litoria elkeae* spec. nov. and 7 *L. gracilentia*.  
 Abb. 11: Die Quotienten Augendurchmesser / Schnauzen-Urostyl-Länge (ED/SUL) von 12 *Litoria elkeae* spec. nov. und 7 *L. gracilentia*.

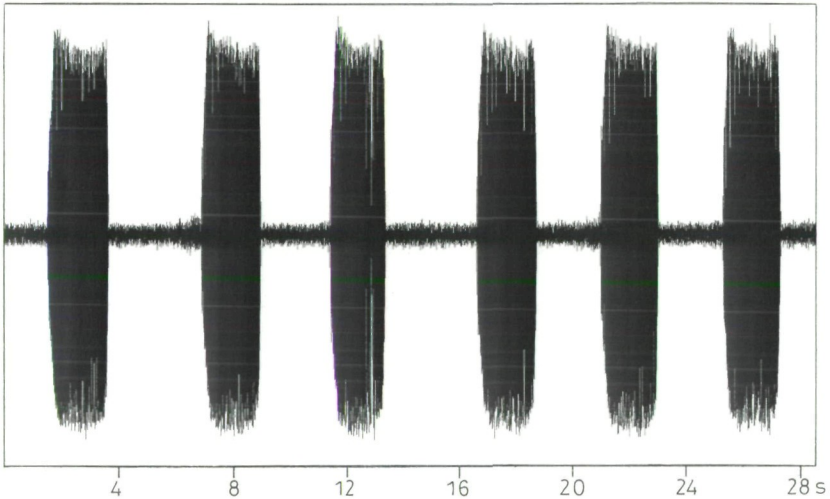


Fig 12: Oscillogram of a sequence of 6 single-note advertisement calls of *Litoria gracilentia* from Townsville/Queensland, Australia.  
 Abb. 12: Oszillogramm einer Folge von sechs einsilbigen "Paarungsrufen" von *Litoria gracilentia* aus Townsville/Queensland, Australien.

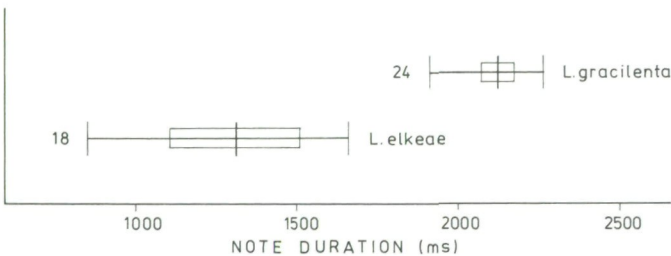


Fig 13: Note duration of single notes and first notes within double-note calls (n=18) of *Litoria elkeae* spec. nov. compared with note duration in *L. gracilentia* (n = 24). See fig. 6 for explanation of symbols.  
 Abb. 13: Die Silbendauer bei einsilbigen Rufen sowie der ersten Silbe zweisilbiger Rufe (n = 18) von *Litoria elkeae* spec. nov. im Vergleich zur Silbendauer von *L. gracilentia* (n = 24). Die Symbole sind in Abb. 6 erläutert.

eyes in *L. aruensis* (ED/SUL 0.115-0.123), (4) webbing slightly more expanded in *L. aruensis*.

*Litoria chloris* is known only from eastern Australia. It is a moderately large species, males measuring 54 - 62 mm and females 58 - 68 mm SVL (BARKER et al. 1995; S. J. RICHARDS, pers. obs.). This taxon and a recently described sibling species - *Litoria xanthomera* DAVIES, McDONALD & ADAMS, 1986 - are much larger than *L. elkeae*. *Litoria graminea* is a green species from the lowlands of New

Guinea but is also much larger than the new species (males to 65 mm; TYLER 1968) and has fully webbed fingers. *Litoria multiplica* is larger than *L. elkeae* (males of *L. multiplica* to 42 mm and females to 48 mm SVL). It is further distinguished from *L. elkeae* in having a lower END/IND ratio (more than 1.0 in *L. elkeae* and less than 1.0 in *L. multiplica*), prominent dermal ridges on the outer edge of the forearm and tibia, and blue spots on the lateral and ventral surfaces of the body.

### BIOACOUSTIC COMPARISONS

Based on the morphological comparisons above it is clear that the closest relatives of *Litoria elkeae* are *L. gracilentata* and *L. aruensis*. Although there are no data available on the advertisement calls of *L. aruensis*, the second author recorded calls of two male *L. gracilentata* in Townsville, Queensland (Australia) on March 24, 1999 at an air temperature of 26 °C. There are consistent differences between the structure of these calls and those of *L. elkeae*. The calls of *L. gracilentata* are always single notes uttered in rather long series (fig. 12). The intervals between calls are 2-3 seconds: distinctly shorter than those of *L. elkeae* (minimum 6 s) at similar air temperatures. Twenty-four calls of *L. gracilentata* had a mean duration of 2123 ms (SD 91.51, range 1913 - 2257 ms) (fig. 13). Mean duration of 21 intervals was 2602 ms (SD 411.79, range 1989 - 3481 ms).

The mean duration of *L. gracilentata* calls is therefore much longer than both the

single notes, and first notes in double-note-calls, of *L. elkeae*. They are approximately the same length as full double-note-calls produced by *L. elkeae*. An oscillogram of a *L. gracilentata* call shows a spindle-shaped form (fig. 14). The mean pulse rate of 27 calls was 108 pulses/s (range 102 - 118 pulses/s), and is higher than the pulse rate of *L. elkeae* at nearly the same temperature range (80 - 101 pulses/s) (fig. 15). Figures 16 and 17 show the audiospectrogram and frequency distribution of a single call of *L. gracilentata*. The spectral band width is similar to that of *L. elkeae*. Main differences are in the distribution of the fundamental as well as of the dominant frequencies. The former is mainly distributed between 1.4 and 1.7 kHz and the latter, which shows only one peak, between 2.5 and 3.0 kHz. Presumably the two-note calls of *L. elkeae* are derived character states in comparison to the simpler one-note calls of *L. gracilentata*.

### FROGS OF THE *LITORIA GRACILENTATA* GROUP IN WESTERN PAPUA NEW GUINEA

TYLER (1968) examined three specimens from the southern flanks of the Eastern Mountains (Hoiebia near Tari) which he believed to be the first records of *L. gracilentata* in New Guinea. Their small size (males 27.0-28.0 mm SVL) and "large and extremely prominent" eyes lead us to doubt that they really belong to that taxon. MENZIES (1976) considered that frogs from Daru Island, the middle Purari River re-

gion, and at various localities in the Southern Highlands at altitudes up to 1500 m, belong to *L. gracilentata*. Moreover, he regarded *L. aruensis* as a probable synonym of *L. gracilentata*. Consequently he argued that *L. gracilentata* occurs from one end of the Papuan region to the other.

S.J.R. collected three *gracilentata*-like males at Herowana, Eastern Highlands Province, Papua New Guinea on 24-25



Table 4: Body proportions (mean, range) of 3 males of the *Litoria gracilenta* group from Herowana compared with corresponding ratios of 2 males of the *L. gracilenta* group from Ok Tedi.

Tab. 4: Körperproportionen (Mittel, Variationsbreite) von 3 Männchen der *Litoria gracilenta* - Gruppe aus Herowana im Vergleich zu den Körperproportionen von 2 Männchen der *L. gracilenta* - Gruppe aus Ok Tedi.

Body proportions / Körperproportionen	3 males from Herowana / 3 Männchen von Herowana	2 males from Ok Tedi / 2 Männchen von Ok Tedi
	Mean; Range / Mittel; Variationsbreite	Mean; Range / Mittel; Variationsbreite
TL/SUL	0.51; 0.49 - 0.54	0.59; 0.57 - 0.62
T4D/SUL	0.40; 0.38 - 0.43	0.42; 0.42 - 0.42
T4D/F3D	0.92; 0.90 - 0.95	0.90; 0.90 - 0.90
HL/HW	0.97; 0.95 - 0.98	1.00; 0.96 - 1.03
END/IND	1.16; 0.16 - 0.16	1.10; 1.03 - 1.16
ED/SUL	0.123; 0.117 - 0.129	0.127; 0.125 - 0.128
TyD/HL	0.150; 0.14 - 0.16	0.175; 0.17 - 0.18
MTL/T1L	0.42; 0.41 - 0.42	0.38; 0.37 - 0.39
FD/SUL	0.34; 0.33 - 0.34	0.36; 0.36 - 0.36

November 1998 and two *gracilenta*-like males at Ok Tedi, Western Province, Papua New Guinea on 11<sup>th</sup> November 1991 and 10<sup>th</sup> November 1994. The small sample sizes preclude robust comparisons and our results should be treated with caution. However, some general trends are apparent. Body proportions are given in table 4.

The mean body length of the three males from Herowana is 34.1 mm (range 33.5-34.8) and so are closer to the values of *L. gracilenta* than to those of *L. elkeae*. However all but one ratio of body measurements of *L. elkeae* and males from Herowana coincide. Significant differences exist only in the ratio TL/SUL ( $t = 2.88$ ;  $p = 0.008$ ) at the 95% confidence level. Significant differences between *L. gracilenta* and Herowana-males were found in the ratios END/IND ( $t = 4.98$ ;  $p = 0.0015$ ), ED/SUL ( $t = 4.45$ ;  $p = 0.0014$ ) and TyD/HL ( $t = 3.78$ ;  $p = 0.0034$ ). Thus morphologically the males from Herowana show more affinities to *L. elkeae* than to *L. gracilenta*.

The two males from Ok Tedi have SULs of 31.8 and 31.9 mm, respectively and their coloration is similar to *L. elkeae* and frogs from Herowana. Comparisons of body ratios are presented in tables 1 to 4.

Five advertisement calls of a male from Herowana were recorded at an air temperature of 22 °C. Four of these calls contain two notes and one is a single-note-call. Intervals between the calls are rather long (minimum 5 seconds). These calls (fig 18) clearly differ from those of *L. gracilenta* (compare figs 12 and 18), indicating that frogs from Herowana belong to an-

other taxon. Although their calls are similar to that of *L. elkeae* there are two striking differences (1) the second note of the calls is significantly shorter in *L. elkeae*; (mean 741 ms, range 653-860 ms) compared with 1081 ms (mean) and 1016-1138 ms (range) in the Herowana frog; and (2) intervals between notes in double-note-calls are significantly longer in calls from Herowana-frogs (mean 458 ms, range 412-506 ms) in comparison to *elkeae*-calls (mean 221 ms, range 214-239 ms). Moreover, call duration of double-note-calls is higher in Herowana-males (mean 2884 ms, range 2720-3080 ms) than in *L. elkeae*-males (mean 2217 ms, range 1788-2412 ms) and the pulse rate with 59.6 pulses/s (SD 1.39) is lower in Herowana-males than in *L. elkeae* (80-101 pulses/s). Although call duration and pulse rate are strongly influenced by temperature and differences should be examined under the same temperature conditions, there is no doubt that duration of the second note as well as internote interval duration are different in these taxa.

There is only one triple-note-call available for males from Ok Tedi. This call differs clearly from that of *L. gracilenta* and shows some general similarities with that of *L. elkeae*. However the poor quality of the recording precludes an assessment of the relationships of the call of this species to *L. elkeae* and males from Herowana.

Because of the scarcity of the material from Herowana and Ok Tedi, it is premature to draw final taxonomic conclusions. Whether these populations are taxonomi-

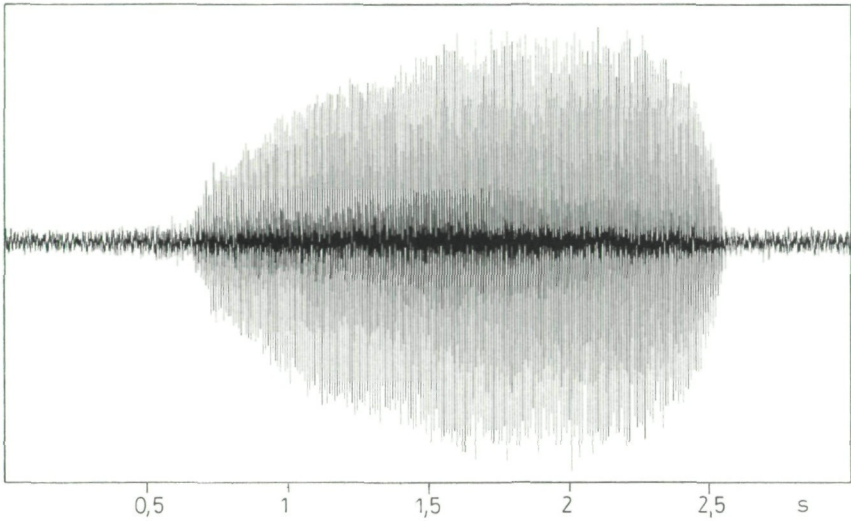


Fig 14: Oscillogram of a note or call within an advertisement call series of *Litoria gracilentia*.  
Abb. 14: Oszillogramm einer Silbe bzw. eines Rufes innerhalb einer Rufreihe von *Litoria gracilentia*.

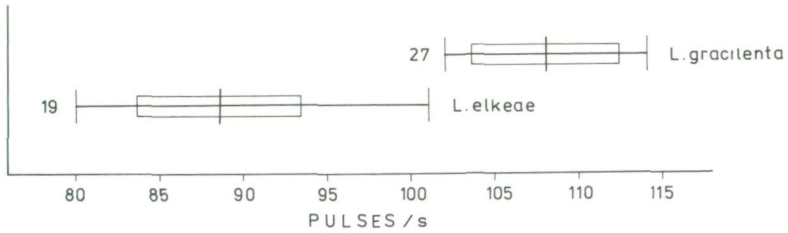


Fig 15: Pulse rate of 19 notes of *Litoria elkeae* spec. nov. in comparison to pulse rate of 27 notes of *L. gracilentia*.  
Abb. 15: Pulsrate bei 19 Silben von *Litoria elkeae* spec. nov. im Vergleich zur Pulsrate bei 27 Silben von *L. gracilentia*.

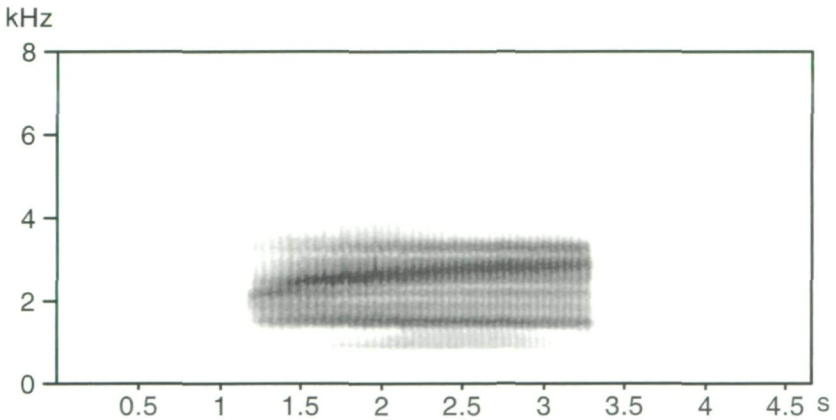


Fig 16: Audiospectrogram of a note (or call) of *Litoria gracilentia*.  
Abb. 16: Audiospektrogramm einer Silbe (oder eines Rufes) von *Litoria gracilentia*.

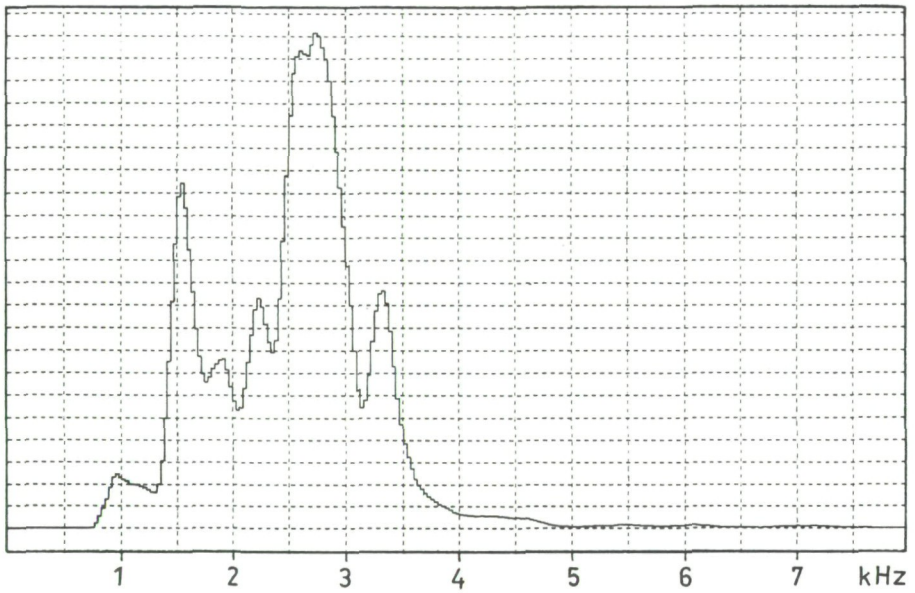


Fig 17: Frequency spectrum of one note (or call) of *Litoria gracilentia*.  
Abb. 17: Frequenzspektrum einer Silbe (oder eines Rufes) von *Litoria gracilentia*.

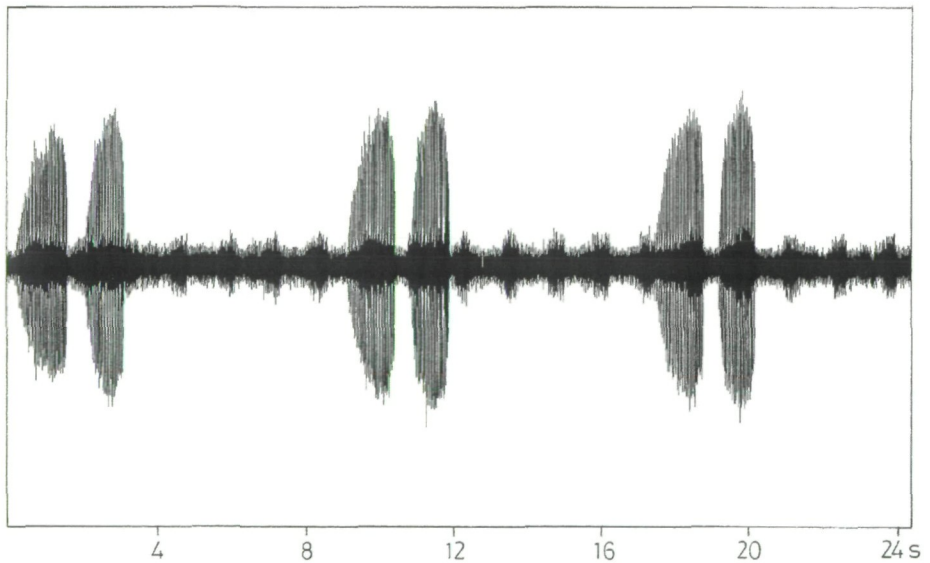


Fig 18: Sequence of 3 double-note advertisement calls of a male of the *gracilentia* group from Herowana, Eastern Highlands Province, Papua New Guinea.  
Abb. 18: Folge von drei zweisilbigen "Paarungsrufen" eines Männchens der *gracilentia*-Gruppe von Herowana, Eastern Highlands Province, Papua Neuguinea.

cally distinct from *L. elkeae* remains to be clarified. It seems clear, however, that neither population should be referred to *L.*

*gracilent*a and the existence of this species on New Guinea remains to be confirmed.

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