

Two new tiny *Cophixalus* species with reduced thumbs from the west of New Guinea (Anura: Microhylidae)

Zwei neue kleine *Cophixalus*-Arten mit reduzierten Daumen
aus dem Westen von Neuguinea
(Anura: Microhylidae)

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KURZFASSUNG

Aus dem westlichen Teil der Insel Neuguinea, der heutigen indonesischen Provinz Papua, sind bisher erst drei Arten der Gattung *Cophixalus* bekannt. Hier werden zwei weitere eng miteinander verwandte Arten anhand von Aufsammlungen in den Jahren 1999–2003 beschrieben. Mit Kopf-Rumpf-Längen der Männchen von 14–17 mm gehören beide zu den kleinsten Spezies der Gattung *Cophixalus*. Ihr charakteristischstes Merkmal sind die völlig reduzierten Daumen (erste Finger). Im Gegensatz zu den meisten anderen Arten haben sie schnarrnde (schwirrende) Anzeigerufe, die im Wesentlichen aus Doppelimpulsen bestehen, und sie halten sich nicht auf Gräsern, Kräutern, Büschen oder Bäumen, sondern auf dem Erdboden auf. Beide neuen Arten unterscheiden sich voneinander im Färbungsmuster, in den Anzeigerufen und in der Basensequenz des mitochondrialen 12S rRNS Gens. Am nächsten mit ihnen verwandt ist *Cophixalus bewaniensis* aus dem Westen von Papua Neuguinea. Von ihm unterscheiden sich die neuen Arten durch bestimmte Körpermaße (TL/SUL und END/IND), die Anzeigerufe (*C. bewaniensis* äußert Pfiffe) und den Aufenthaltsort (Erdboden statt Blattwerk).

ABSTRACT

Three species of the genus *Cophixalus* are currently known from the western part of the island of New Guinea, today the Indonesian province of Papua. Here, two new, closely-related species are described based on collections made between 1999–2003. With a snout–urostyle length in males from 14–17 mm, both belong to the smallest species of the genus *Cophixalus*. Their main characteristic is a completely reduced thumb (first finger). In contrast to most other species they have a rattling (whirring) advertisement call consisting mainly of double pulses, and they are not found on grass, herbage, bushes or trees, but rather on the ground. Both new species can be differentiated from one another based on their colour pattern, advertisement call and base sequence of the mitochondrial 12S rRNA gene. The closest related species is *Cophixalus bewaniensis* from western Papua New Guinea. The two new species differ from this one in certain body proportions (TL/SUL and END/IND), their advertisement calls (*C. bewaniensis* utters whistles/peeps) and habits (ground-dwelling rather than climbing in vegetation).

KEY WORDS

Amphibia: Anura: Microhylidae: *Cophixalus*; new species, morphology, osteology, biology, behaviour, advertisement call, habitat, mitochondrial (mt) 12S rRNA, Papua Province, Indonesia, New Guinea

INTRODUCTION

The curious history of the genus name *Cophixalus* was discussed at length in a recent paper by GÜNTHER (2003). Today, 34 species of this genus are recognized (FROST 1998–2004). With a few exceptions, all live in the eastern part of New

Guinea and in north-eastern Australia. One species is known from the island of Halmahera and only three from the Papua Province of Indonesia, the former Irian Jaya (GÜNTHER 2003). The smallest adult size (snout-vent-length) is 14 mm in some spe-

cies and the largest is about 50 mm in *C. riparius* (ZWEIFEL 1962). Almost all species live scansorial, whereby the leaves of bushes in montane tropical rain forests are preferred. Exceptions are *C. saxatilis* which inhabits the interspaces of treeless granite boulders in north-eastern Australia (ZWEIFEL & PARKER 1977) and *C. sphagnicola* which settles leaf litter, moss and fern clumps or grass tussocks in higher altitudes and also outside forests (ZWEIFEL & ALLISON 1982).

KRAUS & ALLISON (2000), on the basis of two specimens, recently described the new tiny species *C. bewaniensis* with only three fingers and a characteristic colouration from central northern New Guinea. During short periods of field work in western New Guinea in the years between 1999 and 2003 I found among others two microhylid forms which are very similar to *C. bewaniensis*. Some conspicuous differences prompted me, however, to describe them as two new species here.

MATERIALS AND METHODS

Most frogs were collected at night after locating them by their advertisement calls. A few specimens were collected during the day or at night when they were accidentally found. Some specimens were photographed in life and many specimens were fixed in 2 % formalin. Part of the frogs were stored in about 80 % ethanol to enable later DNA sequencing. All specimens were transferred to 75 % ethanol in the museum's collection. Two specimens were cleared and stained as osteological preparations according to a method modified from DINGERKUS & UHLER (1977).

The following measurements were taken with a sliding calliper (> 10 mm) or with a binocular dissecting microscope fitted with an ocular micrometer (< 10 mm) to the nearest 0.1 mm:

SUL - snout-urostyle length: from tip of snout to distal tip of urostyle-bone; SUL is about 1 mm shorter than snout-vent length (SVL). As the measurement error is higher in the latter, I prefer the former characteristic. In general, both measurements can be treated as more or less identically; TL - tibia length: external distance between knee and ankle; TaL - length of tarsus: external distance, tarsal and ankle joints held at right angles; T4D - transverse diameter of disc of 4th toe; F3D - transverse diameter of disc of 3rd finger; TyD - horizontal diameter of tympanum; HL - head length: from tip of snout to posterior margin of tympanum; HW - head width, taken in the region of tympana; SL - snout length: from an imaginary line connecting centres

of eyes to tip of snout; END - distance from anterior corner of orbital opening to centre of naris; IND - internarial distance between centres of nares; ED - eye diameter: from anterior to posterior corner of orbital opening; OCD - distance between posterior orbital "corners".

Advertisement calls were recorded under natural conditions with a Sony® Digital Audio Tape (DAT) Walkman TCD-D 100 and a Sennheiser® microphone MKE 300 and analysed with Avisoft-SAS® Lab software. All specimens are currently stored in the Museum für Naturkunde Berlin (ZMB) and bear registration numbers of this institution. Part of the type series will be transferred to the Museum Zoologicum Bogoriense (MZB) after completion of the studies.

For morphological comparisons were studied: the holotype and one paratype of *Cophixalus bewaniensis* (BPBM 13740 and 13741) stored in the collection of the Bernice Bishop Museum in Honolulu; a series of 8 specimens of *C. shellyi* (AMNH 67610-12, 81147, 81654, 87202-04), of 4 *C. pipilans* (AMNH 83000, 83001, 83003 and 83006), of 10 *C. cheesmanae* (AMNH 74916-20, 101882-886) and of 5 *C. biroi* (AMNH 78108-112) stored in the American Museum of Natural History in New York and specimens of *C. balbus*, *C. tetzlaffi* and *C. riparius* in the ZMB-collection.

Figures 1 and 7 were drawn and fig. 11 was digitised by NILS HOFF (ZMB), all others are by the author.

DESCRIPTION OF THE NEW SPECIES

Cophixalus tridactylus spec. nov.

Holotype: ZMB 62338 (field number = FN 7044). Adult male, collected by R. GÜNTHER and S. MARANI in the Wondiwoi Mountains 7 km west of the coast of the Umar Bay, base of the Wandammen Peninsula, 540 m a.s.l., 2°58'S and 134°38'E, Papua, Province of Indonesia, 28 August 1999.

Paratypes: ZMB 62331 (FN 6999, now an osteological preparation), ZMB 62332 (FN 6935), ZMB 62333 (FN 6954), ZMB 62334 (FN 6972), ZMB 62335 (FN 6980), ZMB 62336 (FN 6981), ZMB 62337 (FN 6998) and ZMB 62339 (FN 7048); these paratypes were collected between 22 and 29 August 1999. ZMB 62594 (FN 7209), ZMB 62595 (FN 7210), ZMB 62596 (FN 7211) 62597 (FN 7235), all collected on 7 and 8 May 2000. ZMB 69696 – 69703 (FN 7615, 7630, 7631, 7632, 7726, 7727, 7728 and one specimen without FN), collected from 23 June to 26 June 2003. All paratypes lived on the eastern slopes of the Wondiwoi Mountains at the base of the Wandammen Peninsula between 400 and 800 m a.s.l. Collectors were R. GÜNTHER, M. KAPISA, S. MARANI and G. MAREKU. Most specimens are adult males (n = 16), ZMB 62333, 62594 and 62596 are adult females, ZMB 62339 is a juvenile of 10.4 mm SUL.

Diagnosis: With 14.3-16.2 mm SUL in males (n = 17) and 18.3-20.1 mm SUL in females (n = 3) the new species belongs to the smallest of its genus. The complete absence of first fingers (thumbs) in combination with toe tips wider than finger tips and a terrestrial pattern of life distinguishes the new species from all other members of the genus except *Cophixalus bewaniensis*. The latter has longer tibiae (TL/SUL 0.52-0.53 vs 0.45-0.52) and a lower ratio END/IND (0.74-0.75 vs 0.83-1.00). Moreover, the new species is a ground dweller and utters fast rattling (whirring) advertisement calls whereas *C. bewaniensis* climbs in the vegetation and has peeping calls (KRAUS & ALLISON 2000).

Description of the holotype (fig. 1): The holotype has the following measurements (in mm) and body ratios:

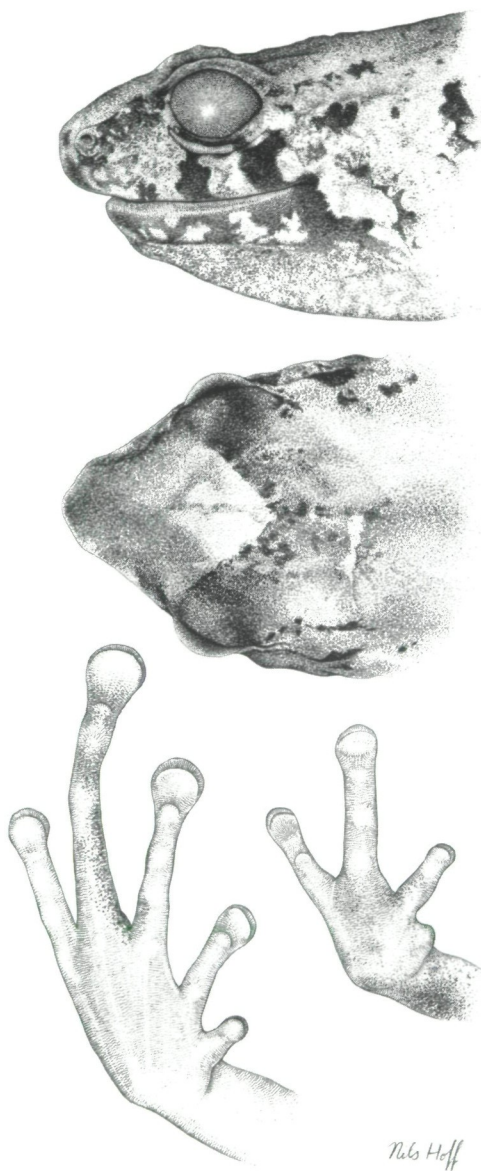


Fig. 1: Holotype of *Cophixalus tridactylus* spec. nov. (ZMB 62338); head in lateral and dorsal view, right foot and right hand in ventral view.

Abb. 1: Holotypus von *Cophixalus tridactylus* spec. nov. (ZMB 62338); Kopfregion in Lateral- und Dorsalansicht, rechter Fuß und rechte Hand in Ventralansicht.



Fig. 2: Paratype of *Cophixalus tridactylus* spec. nov. with a grey-orange dorsal surface, collected in June 2003.
Abb. 2: Paratypus von *Cophixalus tridactylus* spec. nov. mit grau-orangefarbiger Oberseite, gesammelt im Juni 2003.



Fig. 3: Paratype of *Cophixalus tridactylus* spec. nov. with a light gray-brownish dorsal surface, collected in August 1999.
Abb. 3: Paratypus von *Cophixalus tridactylus* spec. nov. mit grau-bräunlicher Oberseite, gesammelt im August 1999.



Fig. 4: Paratype of *Cophixalus tridactylus* spec. nov. with orange dorsal surface, collected in August 1999.

Abb. 4: Paratypus von *Cophixalus tridactylus* spec. nov. mit orangefarbiger Oberseite, gesammelt im August 1999.



Fig. 5: Paratype of *Cophixalus tridactylus* spec. nov. with light brown dorsal surface, collected in May 2000.

Abb. 5: Paratypus von *Cophixalus tridactylus* spec. nov. mit hellbrauner Oberseite, gesammelt im May 2000.

Table 1: Body ratios of 17 males and 3 females of the type series of *Cophixalus tridactylus* spec. nov. SD = standard deviation, explanation of other abbreviations in paragraph "Materials and methods".

Tab. 1: Körperproportionen von 17 Männchen und 3 Weibchen der Typenserie von *Cophixalus tridactylus* spec. nov. SD = Standardabweichung, Erklärung der übrigen Abkürzungen im Abschnitt "Materials and methods".

Ratio / Verhältnis	Mean / Mittelwert	SD	Range / Spannweite
TL/SUL	0.49	0.021	0.45-0.52
TaL/SUL	0.31	0.023	0.26-0.35
T4D/SUL	0.054	0.007	0.043-0.067
T4D/F3D	1.77	0.24	1.40-2.25
HL/SUL (n = 6)	0.33	0.017	0.31-0.35
HL/HW (n = 6)	0.89	0.048	0.83-0.95
OCD/SUL	0.29	0.040	0.26-0.31
END/IND	0.91	0.044	0.83-1.00
ED/SUL	0.129	0.007	0.109-0.138
TyD/ED (n = 6)	0.38	0.046	0.30-0.45
SL/SUL	0.167	0.009	0.146-0.184

SUL 15.5, TL 7.5, TaL 5.1, T4D 0.9, F3D 0.4, HL 5.0, HW 5.5, SL 2.8, END 1.6, IND 1.7, ED 2.1, TyD 0.8, OCD 4.8; TL/SUL 0.48, TaL/SUL 0.33, T4D/SUL 0.058, T4D/F3D 1.80, HL/SUL 0.32, HL/HW 0.91, END/IND 0.94, ED/SUL 0.135, TyD/ED 0.38, SL/SUL 0.181 and OCD/SUL 0.31. Snout subelliptical in dorsal view and protruding in profile, canthus rostralis rounded, loreal region oblique, tongue large, bulky and half free behind, its posterior margin thin and not notched, prepharyngeal ridge inconspicuous and barely serrated, vocal slits not clearly discernible. Horizontal eye diameter greater than eye-naris distance, small tympanum barely visible and near the eye, supratympanic fold faintly developed, dorsal and ventral surfaces smooth, except two V-shaped tubercles in the scapular region and two very small tubercles not far behind eyes. Legs moderately long, no webs between fingers or toes. First finger completely reduced, tips of other fingers with terminal grooves and only somewhat broader than penultimate phalanges, their relative length III>IV>II, no subarticular tubercles. First toe very small, its tip not wider than penultimate phalanx but with terminal groove, other toes with dilated tips clearly wider than that of fingers, relative length of toes IV>III>V>II>I, no clearly demarcated subarticular or metatarsal tubercles. Dorsal ground colour in fixative grey with brownish tinge, dark brown spots in the scapular region surrounding posterior ends of the V-shaped tubercles, similarly coloured spots between eye and insertion of forelimb,

from sacral to inguinal region (shape of an inverse V), around vent, across forelimbs, on upper and lower jaw and a large discontinuous semicircular blotch on anterior flank. Less intense spots and bands on dorsal surface of hind limbs. Dorsal surface of snout lighter than upper eye lids and the area between eyes and scapular tubercles. Belly cream coloured and reticulated with brownish towards flanks and chest, throat and lower surface of extremities densely reticulated with brownish colour.

Morphological variation in the paratypes (figs. 2-6): 17 adult males exhibit a SUL between 14.3-16.2 mm, mean 15.3 mm, SD 0.51. Three adult females measure from 18.3-20.1 mm, mean 19.1 mm, SD 0.91. The size difference between both sexes is (despite the low sample size of females) highly significant ($t = 10.7$, $p = 1.5 \cdot 10^{-9}$). There were no clear differences between males and females in body ratios, therefore sexes were pooled in table 1 where means and ranges of various body ratios are listed. Tympanum was covered by skin in most specimens; therefore the number of measurements including this organ are comparatively low (see table 1). Dorsal ground colour of the preserved specimens is from pale grey to darker grey, about half of them show a brownish tinge. All dark brown spots which were mentioned for the holotype also occur in the paratypes; their intensity and shape vary. The dark sacral spots or stripes continue in many specimens as dark stripes on femora and tibiae. A broad light

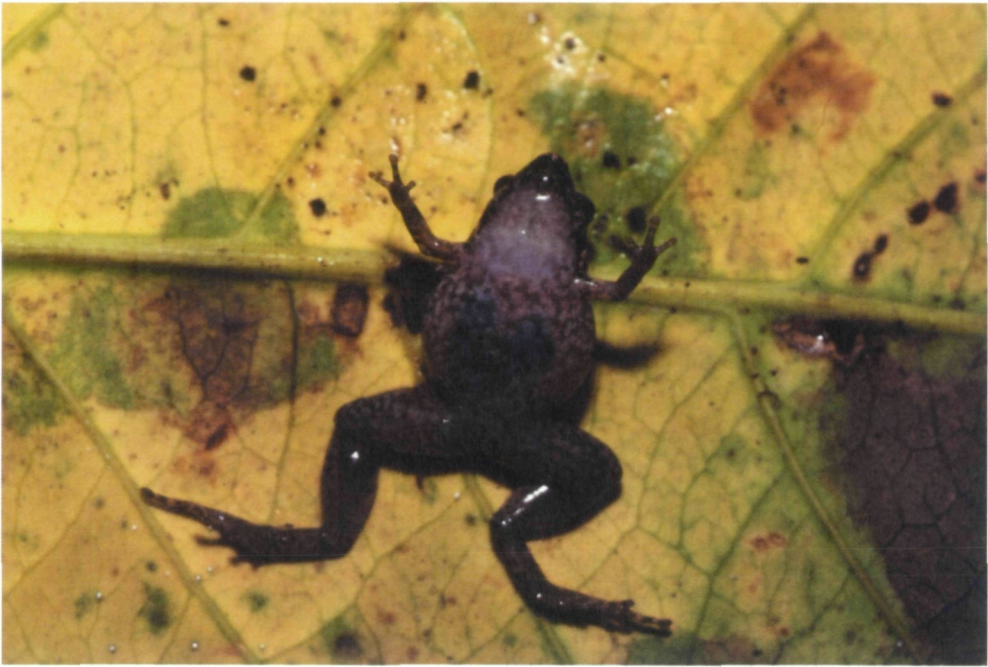


Fig. 6: Ventral surface of a paratype of *Cophixalus tridactylus* spec. nov., collected in June 2003.

Abb. 6: Unterseite eines Paratypus von *Cophixalus tridactylus* spec. nov., gesammelt im Juni 2003.

band across the back between scapular and sacral spots is characteristic for most specimens, the same applies to a dark brown spot inferior of the nostril which may include the nostril and may also extend anteriorly as well as posteriorly along the canthus rostralis. These “nostril spots” often meet one another anteriorly but leave free a whitish spot on the tip of snout in nearly all specimens. Ventral colouration of most paratypes very similar to that of the holotype. Whitish belly, chest and throat are more or less densely speckled with reticulate brownish spots. Lower flanks, chin and ventral surfaces of hind limbs most strongly pigmented. No sexual dimorphism in colouration. Ground colour of dorsal surfaces of living frogs had different tones of grey, brown or orange, dark spots were from light brown to blackish (mostly dark brown).

Osteology (based on two cleared and double stained specimens (ZMB 62331 and ZMB 69708): Maximal width of frontoparietals about three quarter of their length,

they are fused to sphenethmoid anteriorly. Nasals covering nasal capsule and having a tapered posterior tip (fig. 7a). Squamosal without zygomatic ramus, its otic ramus broad and rather short, no quadratojugal. Parasphenoid difficult to demarcate, its cultriform process less ossified than its alae. Palatines fused to sphenethmoid medially, they are small bones and do not reach maxillaries laterally. Prevomers (sensu TRUEB 1973) tiny with a bifurcated anterior and a single posterior tip and not coalesced with palatines (fig. 7b)! This alignment does not correspond to the definition of the genus *Cophixalus* for which PARKER (1934) specified a large and undivided prevomer (prevomer + palatine sensu TRUEB 1973). Hyoid apparatus with broad anterolateral and long tapered posterolateral processes, posteromedial processes ossified and with forked anterior ends, their anteriormost tips connected to one another via a cartilaginous bridge, this part is not attached to hyoid plate (fig. 7c). Ventral elements of pectoral girdle with-

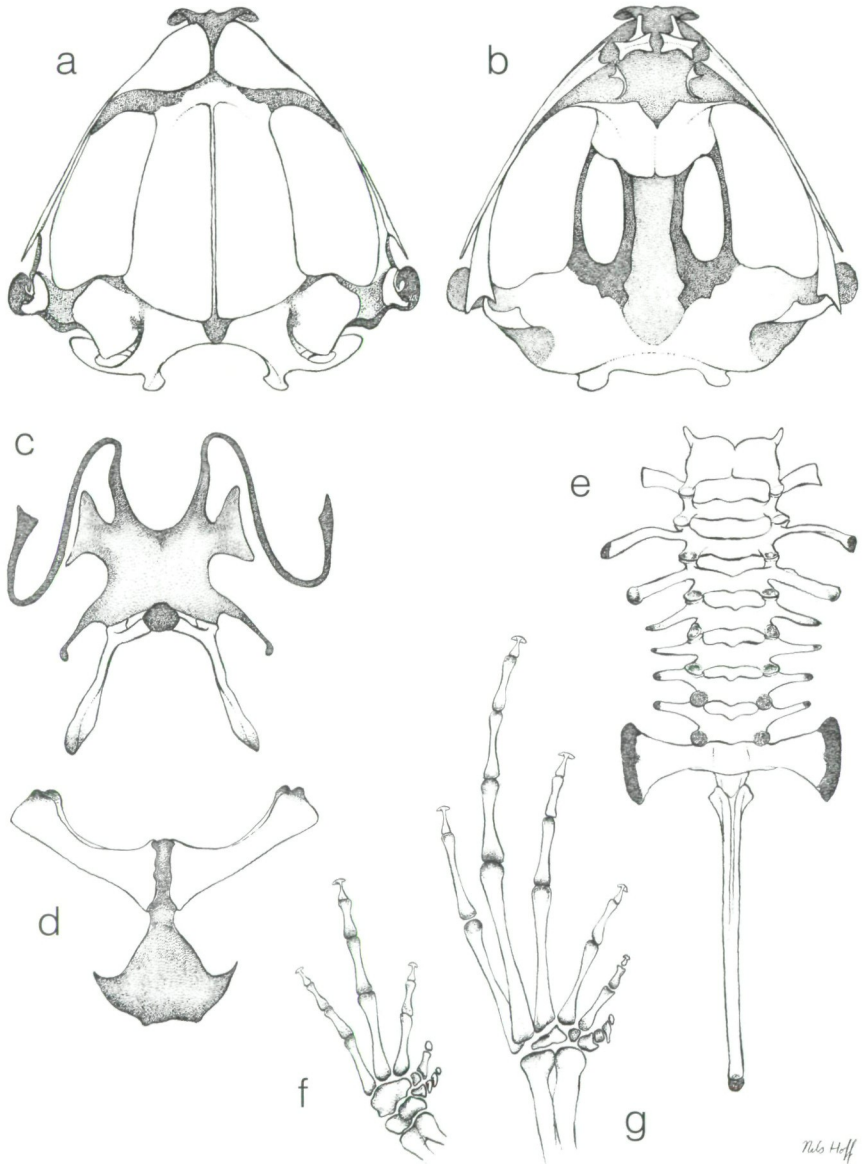


Fig. 7: Skeletal elements of *Cophixalus tridactylus* spec. nov. (combination of ZMB 62331 and ZMB 69708): a – dorsal view of the skull; b – ventral view of the skull, lower jaw removed; c – ventral view of the hyoid apparatus; d – ventral view of the pectoral girdle; e – dorsal view of the vertebral column; f – dorsal view of left hand; g – dorsal view of left foot.

Abb. 7: Skelettelemente von *Cophixalus tridactylus* spec. nov. (gezeichnet nach einer Kombination der Präparate ZMB 62331 und ZMB 69708): a – Dorsalansicht des Schädels; b – Ventralansicht des Schädels (ohne Unterkiefer); c – Ventralansicht des Hyoidapparates; d – Ventralansicht des Schultergürtels; e – Dorsalansicht der Wirbelsäule; f – Dorsalansicht der linken Hand; g – Dorsalansicht des linken Fußes.



Fig. 8: Camp site on the Maja stream at 550 m a.s.l. in the Wondiwoi Mountains at the base of the Wandammen Peninsula, habitat of *Cophixalus tridactylus*.

Abb. 8: Camp in 550 m ü. M. am Bach Maja in den Wondiwoi Bergen an der Basis der Wandammen Halbinsel, Lebensraum von *Cophixalus tridactylus*.

out procoracoid or clavícula, coracoid with dilated ends, anterior and posterior head of scapula separated by a deep gap. Sternum entirely cartilaginous and with anchor-shaped “xiphisternum” (fig. 7d). Vertebral column with eight nonimbricate presacral vertebrae, all but the first bear transverse processes. Relative width of transverse processes: sacrum>III>IV>II>V-VIII about same width, number one with rather long anterolateral processes. Urostyl bears a vestigial pair of transverse processes anteriorly and a longitudinal ridge up to the middle of the bone (fig. 7e). Humerus with conspicuous crest, phalangeal formula of hands 1, 2, 3, 3; reduction of first finger phalanges is exceptional in microhylids. Fingers 2, 3 and 4 with T-shaped terminal elements, no expansion in the terminal phalange of first finger, no intercalary structures. Prepollex consists of three small elements (fig. 7f). Phalangeal formula of feet 2, 2, 3, 3, 2, representing less phalanges than in most other anurans according to TRUEB

(1973). Prehallux also consists of three small elements (fig. 7g).

Distribution: We found this new species on the eastern slopes of the Wondiwoi Mountains at the base of the Wandammen Peninsula between 400 and 800 m a.s.l.

Habitat and habits: All specimens were located in a closed-canopy primary rain forest. They preferred loamy slopes, but were also found on horizontal areas on the ground of small valleys (fig. 8). When calling they perched without exception on the surface of the ground where they stayed on bare humus or clay soil and on or between leaf litter. Loamy slopes between 600 and 700 m a.s.l. were most densely populated. Several hundreds of calling males were registered along an about 100 m wide and 4 km long strip.

At least some specimens sometimes eat ants, as two dissected specimens had ants in their stomachs. One of these stomachs contained 7 very small ants.

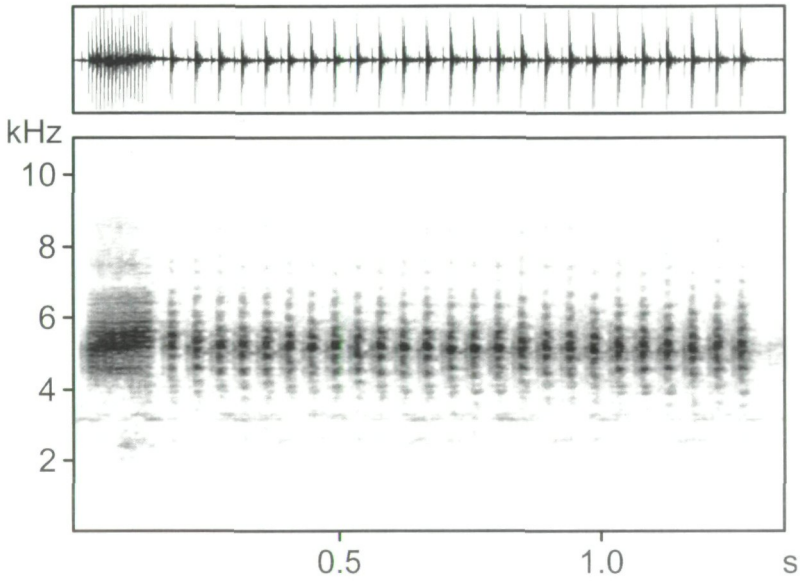


Fig. 9: Oscillogram (above) and audiospectrogram (below) of an advertisement call from *Cophixalus tridactylus* spec. nov. consisting of a long initial note followed by a series of 25 “double pulses”.

Abb. 9: Oszillogramm (oben) und Audiospektrogramm (unten) eines Anzeigerufes von *Cophixalus tridactylus* spec. nov., bestehend aus einer langen Anfangsilbe (note) der 25 „Doppelimpulse“ folgen.

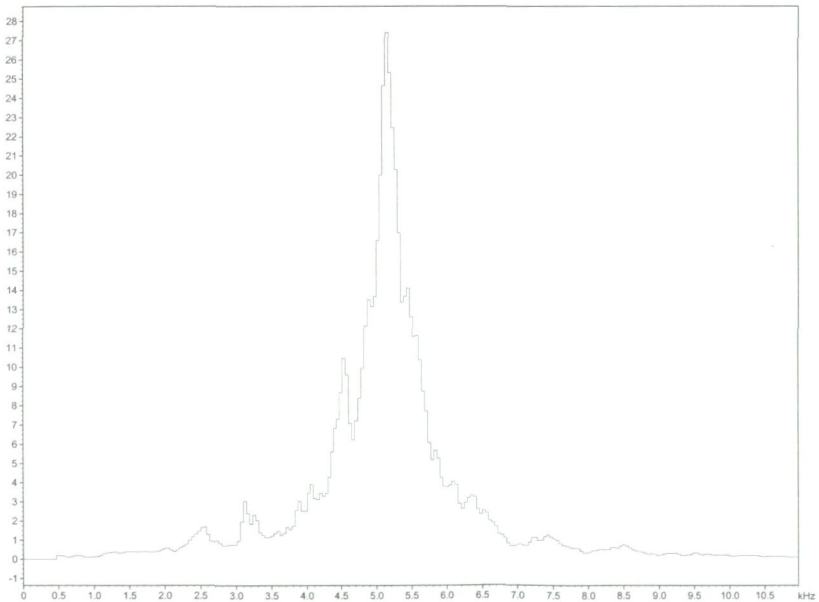


Fig. 10: Frequency spectrum of an advertisement call of *Cophixalus tridactylus* spec. nov.

Abb. 10: Frequenzspektrum eines Anzeigerufes von *Cophixalus tridactylus* spec. nov.

Cophixalus tridactylus shared its area of occurrence with species of the following frog genera (number of species in parentheses): *Litoria* (9), *Rana* (*Papurana*) (3), *Rana* (*Tylerana*) (1), *Rana* (*Limnonectes*) (1), *Platymantis* (3), *Lechriodus* (1), *Hylophorbus* (3), *Xenorhina* (2), *Asterophrys* (1), *Callulops* (3), *Austrochaperina* (2), *Copiula* (2), *Sphenophryne* (1), *Choerophryne* (1), *Albericus* (1) and *Oreophryne* (3).

Vocalisation: The advertisement calls of *C. tridactylus* are very conspicuous. They consist of fairly loud rattling (whirring) sounds that last about one second. The intervals between successive calls of the same male mostly last several minutes. Neighbouring males often stimulate one another to call and if there is a high population density, calling sounds may spread out in a wave. The main calling activities, especially "wave-like chorusing", were registered from 7:00 to 10:00 p.m. during wet weather conditions. Single calls could also be heard during dry weather and other night and dawn hours. No calls were heard during the day.

34 advertisement calls of 4 different males have an average length of 1.24 seconds (s), SD 0.19, range 0.86-1.46 s. The advertisement calls consist of series of notes, the initial note clearly differing from the other notes (fig. 9). The initial note starts with a low pulse followed by 10-20 fast and loud pulses. Mean duration of 32 initial notes of 4 different males was 193 milliseconds (ms), SD 24.8, range 150-240 ms. Pulse repetition rate of the initial note (n = 31) was on average 78 per second, SD 11.4, range 59-103 pulses/s. The "remainder" of the call is composed of series of "double pulses", each pair exhibits a low and a forte element. The latter consists of one to three pulses. 34 calls, excluding the initial note, of 4 different males lasted on average 1.06 s, SD 0.20, range 0.65-1.35 s. Mean note repetition rate, excluding the initial note, of 33 calls was 21.8/s, SD 1.11, range 19-24/s. Frequencies of the calls ranged mainly between 3 and 7 kHz with a dominant frequency clearly around 5.2 kHz (fig. 10). All notes exhibit the same frequency pattern without frequency modulation.

All calls were recorded at temperatures of 22-24 °C.

Etymology: The specific epithet refers to a very rare phenomenon in anuran amphibians which characterises the new species – possessing only three fingers. Tri is a Greek numeral meaning three and dactylus is the Latinised form of the Greek substantive dactylos meaning finger.

Comparisons with other species

Other tiny species of the genus *Cophixalus* from New Guinea are *C. ateles* (BOULENGER, 1898), *C. shellyi* ZWEIFEL, 1956 and *C. pipilans* ZWEIFEL, 1980. They seem to be closely related to *C. tridactylus* but differ from the latter by having obviously reduced, but clearly visible first fingers (thumbs). *C. sphagnicola*, of a similar small size, and obviously not in a nearer phylogenetic relationship to the new species, also has short thumbs, but moreover, no digital discs at all. *Cophixalus tridactylus* is very closely related to *C. bewaniensis* and differs from the other members of its genus in the same characteristics as pointed out by KRAUS & ALLISON (2000) for that species. What are the differences between the new species and *C. bewaniensis*? The best morphometric traits are the relative lengths of the tibiae, ratio TL/SUL is 0.52-0.53 in *C. bewaniensis* and 0.45-0.52 in *C. tridactylus*, and the ratio END/IND which is 0.74-0.75 in the former and 0.83-1.00 in the latter. Both known specimens of *C. bewaniensis* exhibit a solid dark brown blotch above and behind each forelimb. This blotch is also present in *C. tridactylus*, but is split into more or less numerous small spots in most specimens. Two dark brown flecks below the eye are broader and more intensively coloured in *C. bewaniensis* than in *C. tridactylus*. According to KRAUS & ALLISON (2000) the former species is rare, "perched in small shrubs one meter above the floor" and its calls are long series of peeps. In contrast, *C. tridactylus* is abundant, lives on the ground and utters rattling (whirring) advertisement calls.

There are various tiny species of *Cophixalus* on the Cape York Peninsula of Australia which have toe discs wider than finger discs and a reduced first finger and first toe (ZWEIFEL 1985). All but one have clearly different advertisement calls from *C.*

tridactylus. This one, *C. crepitans* ZWEIFEL, 1985, has only very vestigial first fingers, small and discless first toes and its calls consist, similar to those of *C. tridactylus*, of sequences of double pulses (ZWEIFEL 1985). The structure of these double pulses and a missing initial note clearly differ from the calls of *C. tridactylus*. Moreover, some

morphometric traits as well as the colouration differ between these species. Further studies are needed to show whether the overall similarities between the tiny Australian and New Guinean species are a result of a close phylogenetic relationship or of convergent evolution.

Cophixalus humicola spec. nov.

Holotype: ZMB 69705 (FN 7494), adult male, collected by R. GÜNTHER and M. KAPISA on the Waira Mountain, 15 km linear distance NE of Serui, altitude 670 m a.s.l., 1°47'S and 136°20'E, Yapen Island, Papua Province of Indonesia, 11 April 2002.

Paratypes: ZMB 69704 (FN 7492), ZMB 69706 (FN 7505) and ZMB 69707 (FN 7797). ZMB 69704 and ZMB 69706 were collected within a radius of 50 m around the locus typicus by the same collectors on 12 April 2002. ZMB 69707 was collected on a ridge of the Amoman Mountain, about 17 km linear distance NE of Serui, 1100 m a.s.l., Yapen Island, Papua Province of Indonesia, collector H. HASSER. All three paratypes are adult males.

Diagnosis: Obviously a sibling species of the above described *C. tridactylus*. There are no biometric traits which distinguish between them. The distinction mainly results from differences in advertisement calls and in base sequences of the mitochondrial 12S rRNA gene. Calls of *C. humicola* are longer than those of *C. tridactylus* (means 1.61 s vs 1.24 s), and pulse repetition rate is higher (means 172/s in the initial note and 28.5/s in the main note vs 78/s and 21.8/s). Differences in base pairs amount to more than 10 % in a sequence of about 600 bp of the mitochondrial 12S rRNA gene. Moreover, the large blackish blotch on the anterior flanks is largely solid as in *C. bewaniensis* and not split as in *C. tridactylus*. From *C. bewaniensis* the new species differs mainly by rattling (whirring) not peeping advertisement calls and a terrestrial rather than an arboreal life style. Moreover, *C. humicola* has thumb residues in form of small tips, most *C. tridactylus* do not show such residues.

Description of the holotype (fig. 11): The holotype has the following measurements (in mm) and body ratios: SUL 15.7, TL 7.6, TaL 5.1, T4D 0.6, F3D 0.3, HL 5.2, HW 5.5, SL 2.2, END 1.5, IND 1.8, ED 1.9, TyD 0.7, OCD 4.4; TL/SUL 0.48, TaL/SUL 0.32, T4D/SUL 0.038, T4D/F3D 2.0, HL/SUL 0.33, HL/HW 0.95, END/IND 0.83, ED/SUL 0.121, TyD/ED 0.37, SL/SUL 0.140 and OCD/SUL 0.28. Snout subelliptical in dorsal view and rounded in profile, canthus rostralis strongly rounded, loreal region oblique, no clearly discernible vocal slits present, tympanum and supratympanic ridge scarcely visible, pupil horizontally elliptic, dorsal and ventral surfaces smooth except two larger tubercles in the shoulder region and various very small tubercles in the "neck" region. Legs moderately long, no webs. First fingers reduced to very small rudiments, their relative length III>IV>II>I, no clearly demarcated subarticular or palmar tubercles, discs of fingers II-IV rather small and with grooves. First toe also reduced, its terminal disc scarcely broader than penultimate phalanx and with faint grooves, terminal discs on other toes broader than that of fingers and with better developed grooves. Relative length of toes IV>III>V>II>I, no clearly developed subarticular, plantar or metatarsal tubercles. Dorsal ground colour in preservative beige, anterior of the scapular spots brownish, snout light grey. Dark brown spots in the scapular region, between eye and insertion of forelimb, below eye and progressing on lower jaw, from tip of snout through nostril to eye, on lower arm, on anterior flank and the region of knee. Weaker expressed darkish spots or bands around vent, on posterior tarsus and tibia



Fig. 11: Holotype of *Cophixalus humicola* spec. nov.: a – lateral view of the head and anterior flanks; b – dorsal surfaces; c – ventral surfaces; d – ventral view of hands; e – ventral view of feet and tarsi.

Abb. 11: Holotypus von *Cophixalus humicola* spec. nov.: a – Seitenansicht von Kopf und Vorderkörper; b – Dorsalansicht; c – Ventralansicht; d – Ventralansicht der Hände; e – Ventralansicht der Füße und Tarsen.

Table 2: Body ratios of 4 males of the type series of *Cophixalus humicola* spec. nov. SD = standard deviation, explanation of other abbreviations in paragraph "Materials and methods".

Tab. 2: Körperproportionen von 4 Männchen der Typenserie von *Cophixalus humicola* spec. nov. SD = Standardabweichung, Erklärung der übrigen Abkürzungen im Abschnitt "Materials and methods".

Ratio / Verhältnis	Mean / Mittelwert	SD	Range / Spannweite
TL/SUL	0.49	0.015	0.48-0.51
TaL/SUL	0.33	0.0005	0.32-0.33
T4D/SUL	0.051	0.011	0.041-0.063
T4D/F3D	1.77	0.29	1.40-2.00
HL/SUL	0.33	n = 1	n = 1
HL/HW	0.95	n = 1	n = 1
OCD/SUL	0.29	0.018	0.27-0.31
END/IND	0.86	0.032	0.83-0.89
ED/SUL	0.130	0.0007	0.121-0.137
TyD/ED	0.37	n = 1	n = 1
SL/SUL	0.142	0.0007	0.136-0.152

and in the sacral region continuing on femur and tibia. Ventral surfaces cream coloured with irregular brownish marks.

Morphological variation in the paratypes: Snout-urostyle-length of the three paratypes varied from 14.5 – 16.2 mm. Means and ranges of various measurements and body ratios of all four types are listed in table 1. Overall colouration of the preserved paratype ZMB 69704 is nearly identical to that of the holotype. Ground colour of dorsal surfaces of ZMB 69706 is dusky grey-brown. Its dark spots and stripes are on the same places as on the holotype, but, because of the dark overall colour, are far less conspicuous. Ground colour of its ventral surfaces is grey, much more densely spotted with irregular brownish flecks than in the holotype. Ground colour of ZMB 69707 is reddish-brown, dark sacral spots and stripes as well as stripes on hind legs are reduced to small spots, ventral surfaces exhibit a similarly strong flecking as in ZMB 69706. Ground colour in life varied from light brown to darker brown always with a reddish hue, the dark spots on various body parts were blackish (fig. 12).

Distribution: Collected and/or heard on the Waira and Amoman Mountains NE of Serui (Yapen Island, Cenderawasih Bay) at altitudes from 500 m to 1150 m a.s.l. Moreover, I recorded advertisement calls at 54 km along the road Nabire-Mapia (750 m a.s.l.; 3°29.517'S, 135°43.913'E) that resemble that of the specimens from Yapen and Steve RICHARDS sent a photograph of a specimen and a recording of an advertise-

ment call from the Foya Mountains (02°36'S 139°05'E) which indicate that *C. humicola* also occurs in that region.

Habitat and habits: All frogs were encountered on the ground of primary and secondary rainforests where they perched on bare humus soil and on, or between, leaf litter. Calls were heard at rather great intervals (several minutes) and at great distances (more than 10 m) from one another. I never heard a wave-like spread of the calling sounds as in the previous species. That means *C. humicola* is obviously less abundant than *C. tridactylus*.

Vocalisation: Sound and structure of the advertisement calls of *C. humicola* are similar to those of *C. tridactylus*. There is an initial note consisting of a low pulse followed by a longer pulsed part and a long series of notes with "double pulses". The first pulse of such a "double pulse" is always low and singular while the corresponding loud part consists in most cases of three or more oscillations ("pulses"). There is a tendency that notes at the beginning of a call have more pulses than later ones (fig. 13). 26 calls stemming from three different males have a mean duration of 1.6 s, SD 0.19, range 1.16-1.87 s. 15 initial notes last on average 77 ms, SD 6.4, range 62-87 ms. 17 calls, excluding the initial note; have a mean duration of 1.53 s, SD 0.18, range 1.07-1.79 s. Mean pulse repetition rate in 11 initial notes is 172/s, SD 17.3, range 150-200 pulses/s. Mean note repetition rate in 22 calls, excluding the initial note, is 28.5/s, SD 2.5, range 26-35/s. Frequencies are mainly

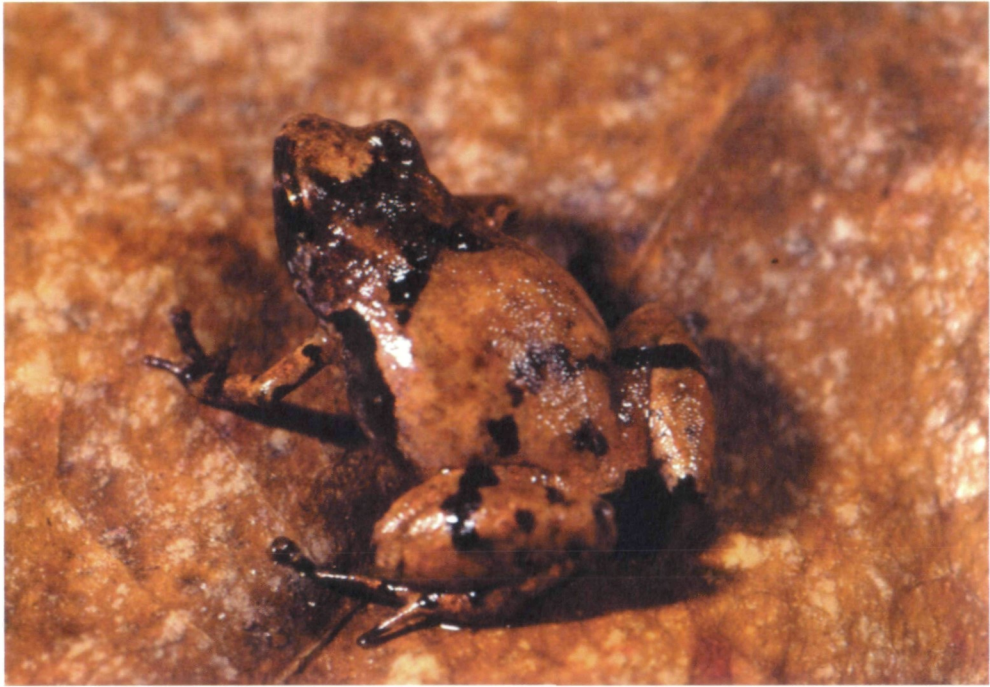


Fig. 12: Paratype of *Cophixalus humicola* spec. nov. (ZMB 69704); characteristic dark blotch on anterior flank and below eye is clearly visible.

Abb. 12: Paratypus von *Cophixalus humicola* spec. nov. (ZMB 69704); die charakteristischen dunklen Flecken an der vorderen Flanke und unter dem Auge sind gut zu erkennen.

distributed between 4.0 and 5.5 kHz with a dominant frequency at 4.9 kHz (fig. 14).

Calls were recorded at temperatures between 19 °C and 22 °C.

Etymology: The specific epithet *humicola* is derived from the Latin substantive *humus* (soil) and the Latin verb *colere* (to inhabit) and refers to the terrestrial mode of life of the new species. Most species of the genus *Cophixalus* live on vegetation.

Comparisons with other species

From the above text follows that *C. humicola* clearly differs in morphology and behaviour from all other species of the genus except *C. tridactylus* and *C. bewaniensis*. Differences between *C. humicola* and *C. tridactylus* are a solid blackish blotch on anterior flanks and broad blackish spots below the eye in the former and multiple dark spots on the anterior flanks and small

blackish spots below the eye in the latter. *C. humicola* has small vestiges of the first fingers, in most *C. tridactylus* such vestiges are missing. *C. tridactylus* has shorter advertisement calls (means 1.24 s vs 1.61 s; $t = 7.5$, $p = 4 \cdot 10^{-7}$) and a slower pulse repetition rate in the initial note (mean 78.4 vs 171.6; $t = 20.2$, $p = 0.0$) as well as a slower repetition rate of the “double pulses” (mean 21.8 vs 28.5; $t = 13.8$, $p = 3 \cdot 10^{-12}$). Moreover, the second pulse in each “double pulse” is much stronger and generates more oscillations in the calls of *C. humicola* than in that of *C. tridactylus*. There are also biochemical differences between both taxa. R. KNOP (pers. comm.) investigated homologous base sequences of the mitochondrial 12S rRNA gene of two *C. tridactylus* and three *C. humicola*. The method was the same as specified by GÜNTHER & KNOP (2006, in press). Comparisons of more than 600 base pairs yielded differences of less than 0.9 % within

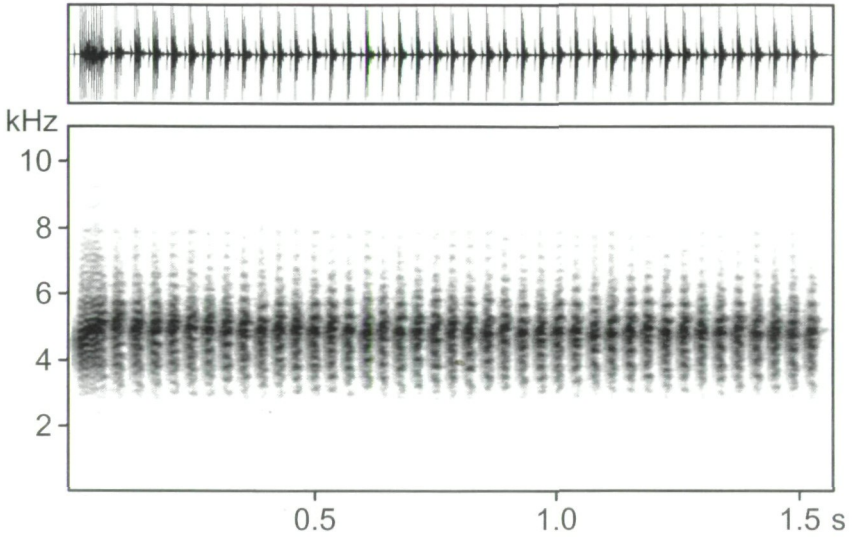


Fig. 13: Oscillogram (above) and audiospectrogram (below) of an advertisement call from *Cophixalus humicola* spec. nov. composed of a longer initial note and 40 shorter notes consisting of “double pulses”.

Abb. 13: Oszillogramm (oben) und Audiospektrogramm (unten) eines Anzeigerufes von *Cophixalus humicola* spec. nov. bestehend aus einer längeren Anfangssilbe und 40 darauf folgenden kürzeren “Doppelimpulsen”.

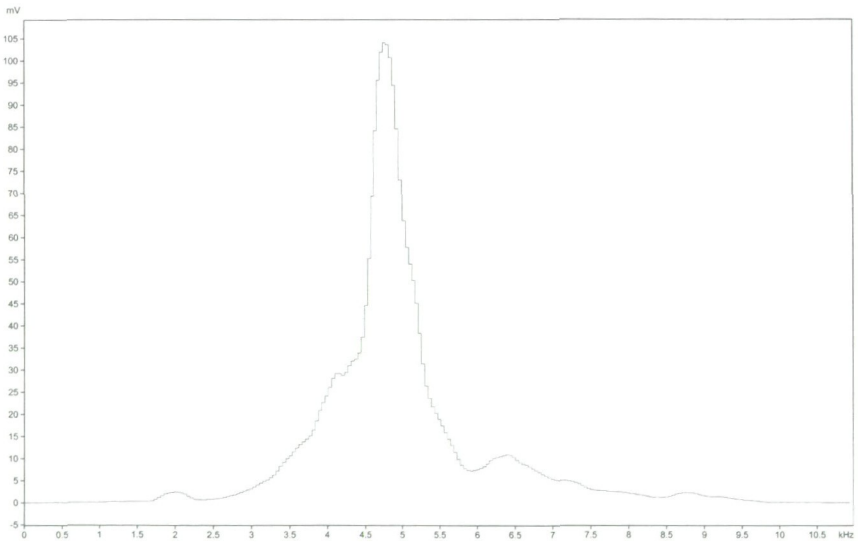


Fig. 14: Frequency spectrogram of an advertisement call of *Cophixalus humicola* spec. nov.

Abb. 14: Frequenzspektrum eines Anzeigerufes von *Cophixalus humicola* spec. nov.

each taxon but of 13 % or 12.6 % between the two taxa. These findings together with the morphological and bioacoustic results support the notion that *C. tridactylus* and *C. humicola* are different species.

Cophixalus humicola differs from *C. bewaniensis* in having a higher snout in profile, the relative length of tibiae (TL/SUL is 0.48-0.51 in the former and 0.52-0.53 in the

latter), the ratio END/IND (0.83-0.89 in the former and 0.74-0.75 in the latter), the ratio SL/SUL (0.136-0.152 in the former and 0.155-0.160 in the latter) and especially in the advertisement calls (rattling in *C. humicola* and peeping in *C. bewaniensis*) and the life style (terrestrial in the former and climbing in the vegetation in the latter). Colouration is much the same in both species.

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