

New Species of Parachute Gecko
(Squamata: Gekkonidae: Genus *Ptychozoon*)
from Northeastern Thailand and Central Vietnam

RAFE M. BROWN

I describe a new species of parachute gecko from localities in northeastern Thailand and the central highlands of Vietnam. The new species is known from intact climax rain forest and slightly disturbed clearings or secondary forest adjacent to intact rain forest. The new species differs from congeners by the combination of three (vs four) transverse bands in the axilla-groin region, 19-21 preanofemoral pore-bearing scales in a continuous series, 15-16 cutaneous denticulate lobes of the tail, lateral orientation of the caudal lobes, minimal reduction in total width of distal portions of the tail, absence of substantive lateral expansion of the straight-edged tail terminus beyond the nearest denticulate caudal lobe, minimal lobe fusion at the proximal border of the tail terminus, continuation of caudal tubercles distally on to the dorsal surface of tail terminus, absence of a predigital notch in the preantibrachial cutaneous expansion, and the presence (in a Thai specimen) of a single mid-vertebral row of flat dorsal tubercles (vertebral tubercle series absent in Vietnamese specimens).

THE enigmatic parachute geckos of the genus *Ptychozoon* inhabit climax tropical rain forest habitats from the southeast Asian countries as far north as Vietnam, Burma, and Thailand (Smith, 1930; Taylor, 1963; Bobrov, 1995; Fig. 1), through the Sunda Shelf Islands (Hamilton, 1979; Audley-Charles, 1981; Hall, 1996) of Indonesia (Smith, 1935; Wermuth, 1965; Manthey, 1985) and Malaysia (Dring, 1979; Manthey and Grossman, 1997), and as far east as the extra-Sundaic oceanic islands of Mindanao [the Philippines (Taylor, 1922; Brown et al., 1997)] and Sulawesi [Indonesia (Iskandar and Tjan, 1996)]. Currently the genus includes five rain forest species that, with the exception of *P. kuhli* (collected more often because it inhabits disturbed as well as forested habitats), are underrepresented in museum collections and virtually unstudied in their natural habitats. Both the paucity of preserved specimens and the occasional natural history observation (Taylor, 1922; Brown and Alcalá, 1978; Brown et al., 1997) suggest that most of the species are canopy obligates that are seldom encountered in the lower vegetation strata. Their ecological preferences and a presumed failure on the part of biologists to sample preferred habitat have, undoubtedly, contributed to the lack of understanding of much of the natural history of *Ptychozoon* species.

A recent taxonomic reevaluation of *Ptychozoon intermedium* (Brown et al., 1997) demonstrated the current need for a thorough taxonomic review of the genus and an application of a line-

age-based species concept (Frost and Hillis, 1990) to the problem of species boundaries. During the course of this effort (R. Brown, L. Reudas, and A. Russell, unpubl. data), I examined a substantial series of parachute geckos ($n = 25$; deposited at FMNH) from northeastern Thailand identified as *P. lionotum*. One unusual individual revealed a number of unique meristic and mensural aspects of the external phenotype, the combination of which precluded the assignment of this individual to any other described species of *Ptychozoon*. Due to the rarity of *Ptychozoon* specimens in museum collections, the conservation crisis in southeast Asian forests, and the low probability of obtaining more specimens (the original collection locality is now severely degraded; R. Inger, pers. comm.), I was prepared to describe the new species on the basis of the single specimen. However, recent biodiversity surveys in Vietnam have produced three more specimens (two juveniles and an adult) that uniquely share diagnostic character states with the Thai specimen, thus further bolstering my suspicion that at least one more undescribed species of *Ptychozoon* inhabits the rain forests of southeastern mainland Asia.

MATERIALS AND METHODS

I scored data from fluid-preserved specimens (Brown et al., 1997) deposited in museum collections (see Acknowledgments). Sex was determined by inspection of gonads when possible or by scoring of prominent secondary sexual characteristics (Brown et al., 1997) when dissec-

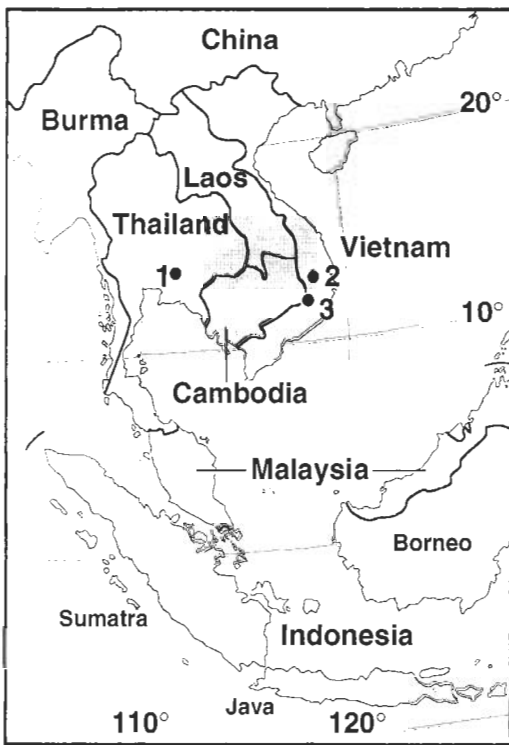


Fig. 1. Known distribution of *Ptychozoon trinotaterra* in Thailand and Vietnam. Shown is the type locality in Thailand (1: Sakaerat) and localities in Vietnam (2: Tram Lap; 3: Yok Don).

tion was not possible. Measurements (to the nearest 0.1 mm) were taken with Fowler digital calipers following character definitions by Ota and Crombie (1989), Brown et al. (1995), and Brown et al. (1997). Character abbreviations include the number of supralabials (SUL); infralabials (IFL); circumorbitals (CO); differentiated preanofemoral pore-bearing scales (PS); mid-body scales (MS); paravertebrals (PVS); denticulate tail lobes and associated whorls of tail annuli (TA); subcaudals (SC); transverse dorsal bands in the axilla-groin region; tubercles per tail annulation at the base of the tail (TTAB), at midtail (TTAM), and at the tip of the tail (TTAT); snout-to-vent length (SVL); tail length (TL); head length (HL); head width (HW); head depth (HD); snout length (SL); eye diameter, (ED); eye-narial distance (END); tympanic annulus diameter (TAD); inter-nasal distance (IND); interorbital distance (IOD); axilla-groin distance (AGD); femur length (FL); tibia length (TBL); toe I length (TIL); toe IV length (TIVL); tail width (TW); tail depth (TD); terminal tail flap width (TFW); terminal tail flap length (TFL).



Fig. 2. Paratype in life (male, ROM 31912, SVL = 71.3 mm) from Yok Don Province, Vietnam, in dorsal view. Photo: copyright A. Lathrop.

RESULTS

Ptychozoon trinotaterra, sp. nov.

Figures 2–7

Holotype.—FMNH 181825 (Field Catalog; R. F. Inger 1435), adult female; Thailand, Nakhon Ratchasima Province, Amphoe Pak Thong Chai, Sakaerat (Fig. 1), 14°30'N, 101°55'E; collected 1 May 1969 by R. Heyer.

Paratypes.—ROM 31912 (field no. 22135), adult male; Vietnam, Yok Don Prov., Yok Don National Park, S slope of Yok Don Mountain, adjacent to Dak Ken River (Fig. 1), 12°54'N, 108°42'E; collected 6 June, 1997 by A. Lathrop and R. Bain; ROM 31910 (field no. 7449) and 31911 (field no. 7450), Vietnam, Gia Lai Prov., 2 km N of Tram Lap, adjacent to Azum River (Fig. 1), 14°26'24"N, 108°32'59"E, 900 m above sea level;



Fig. 3. The holotype of *Ptychozoon trinotaterra* (female, FMNH 181825, SVL = 70.5) in dorsal aspect.

collected 18 June 1996 by N. Orlov and R. Murphy.

Diagnosis.—*Ptychozoon trinotaterra* differs from all known species of *Ptychozoon* except *P. intermedium* by the presence of three dark transverse bands in the axilla-groin region (vs four in remaining species). The new species differs from *P. intermedium* and further from *P. horsfieldii* by the presence of an enlarged (vs reduced) tail terminus, lateral (vs more caudal) orientation of the denticulate lobes of the tail, and the arrangement of preanofemoral pore-bearing scales in a continuous series (vs preanals and femorals separated). *Ptychozoon trinotaterra* differs from *P. lionotom* in having a smaller maximum body size (Table 1), 15–16 (vs 18–23) denticulate tail lobes, reduced lobe fusion at the proximal border of the straight-edged tail terminus (vs crenulate tail terminus composed of 3–9 denticulate lobes fused at the proximal border), and absence (vs presence) of a predigital notch in the preantibrachial cutaneous expansion. *Ptychozoon trinotaterra* differs from *P. kuhli* in having a smaller maximum body size (Table 1), limited terminal tail flap expansion (vs lateral expansion of the terminal flap well beyond the nearest denticulate lobe), and the absence (vs presence) of paravertebral tubercle rows. The new species is distinguished from *P. rhacophorus* by its larger body size, absence (vs presence) of highly spinose dorsal tubercles, presence (vs absence) of a terminal tail flap, presence (vs absence) of a lateral infraauricular cutaneous expansion, and presence (vs absence) of enlarged, imbricate membrane support scales on limb and midbody cutaneous expansions. Table 1 summarizes the distribution of di-

agnostic characters within the genus *Ptychozoon* and the Comparisons section provides more extensive comparisons between the new species and individual congeners.

Description of holotype.—Adult female in good condition with a large incision on the right side of the venter (Fig. 3); measurements are presented in Table 1 and the Appendix). Habitus strongly depressed; head at widest point nearly as wide (94%) as body at widest point; snout acutely tapered, rounded at tip; HW 83% of HL and 22% of SVL; SL 58% of HW and 48% of HL; auricular opening only slightly ovoid (longer axis horizontal); tympanum deeply sunken; eye large, pupil vertical, its margin wavy; TAD 35% of ED; entire anterior and posterior margins of forelimbs, entire posterior margins of rear limbs and distal half of anterior margins of rear limbs (along tibia) with wide cutaneous expansions; limb expansions with minute scales ventrally and enlarged, rectangular, strongly imbricate scales dorsally; preantibrachial cutaneous expansion continuous with digital fringe along medial surface of digit I of manus, also continuous with prebrachial expansion; postantibrachial expansion not continuous with postaxial cutaneous fringe of digit V but continuous with postbrachial expansion and joining axilla at posterior insertion of forelimb; pretibial expansion a single rounded lobe, from knee to 2 mm from base of pes; posthumeral expansion a wide lobe, joined at its constricted base to posttibial expansion; posttibial expansion continuous with postaxial digital fringe of digit V of pes; infraauricular cutaneous expansion a broad round flap with subimbricate hexagonal to round scales dorsally and minute scales ventral-

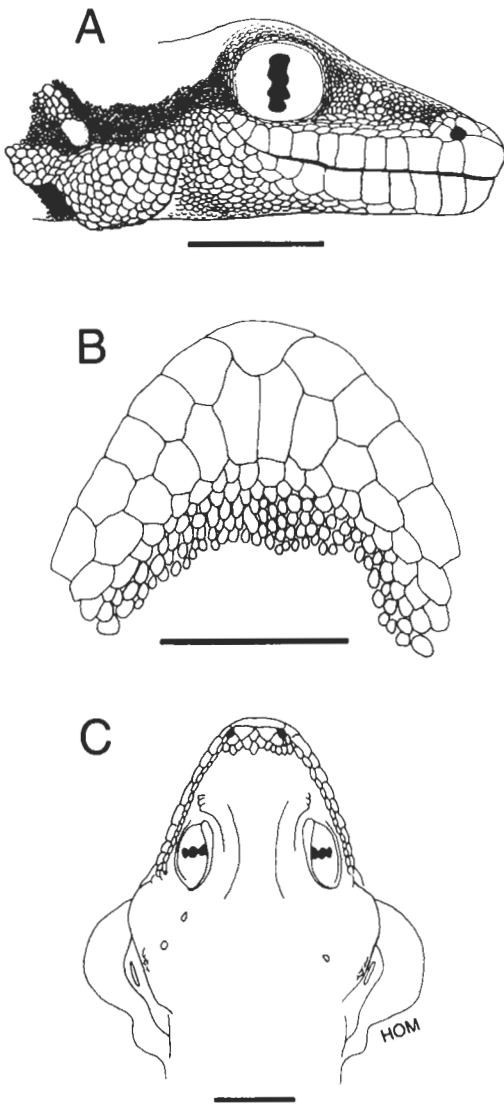


Fig. 4. The holotype of *Ptychozoon trinoterra* in (A) lateral view of head, (B) ventral view of chin, and (C) dorsal view of head. Scale bars = 3 mm.

ly; infraauricular flap extending from 2 mm caudal to angle of jaw, horizontally below auricular opening, and forming a second, smaller lobe, tapering into nuchal region (Fig. 4A); extensive laterally expanded, straight-edged midbody parachute with highly imbricate, elongated rectangular support scales dorsally ($n = 10\text{--}12$ across parachute) and minute scales ventrally; body width 44% of extended midbody parachute width.

Rostral scale large, rectangular, twice as broad as high, with slight depression in dorso-caudal edge but without dorsomedian groove; nostril

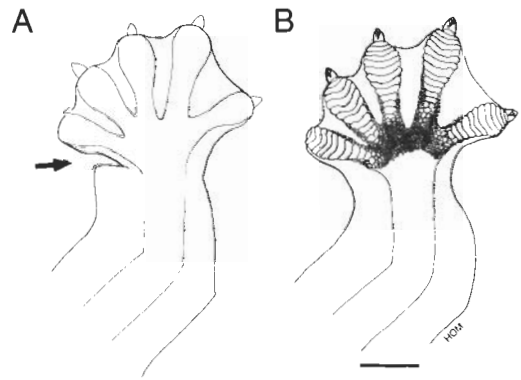


Fig. 5. Palmar aspect of left manus of (A) *Ptychozoon lionotum* (FMNH 181825; arrow indicates predigital notch in preantibrachial cutaneous expansion) and (B) left manus and subdigital lamellae of *P. trinoterra* [composite of Holotype (FMNH 181825) and Paratype (ROM 31912); note absence of predigital notch in preantibrachial cutaneous expansion]. Scale bar = 5 mm.

surrounded by rostral, labial, and enlarged triangular supranasal (supranasals contact slightly between nostrils; Fig. 4A) a single enlarged postnasal scale on right and two smaller postnasals on left (Fig. 4A–B); azygous internasal vaguely rhomboidal or diamond shaped (slightly damaged); two slightly enlarged cycloid scales follow postnasals along lateral margins of internasal; supralabials 11/11 (L/R; 7 through 11 subocular), bordered dorsally by one row of slightly differentiated snout scales; infralabials 9/11, bordered ventrally by a single row of slightly differentiated chin scales; several short rows of enlarged, imbricate subtricals immediately below last infralabials (Fig. 4A); mental scale triangular, followed by two highly elongated postmentals, first in series bordering infralabials (Fig. 4C); remainder of undifferentiated throat scales very small, round, nonimbricate; dorsal cephalic scales round to oval, nonimbricate, strongly granular; frontal, prefrontal, and loreal regions strongly concave; undifferentiated head scales irregularly convex, reducing in size posteriorly by interorbital region and becoming smaller and less granular in the temporal and parietal regions; palpebrals larger than scales in adjacent frontal region; nuchals granular, weakly to strongly convex, continuously grading into enlarged dorsals; small throat and chin scales increasing greatly in size, becoming strongly imbricate in posterior gular region and pectoral region, and continuing to increase in size through ventral abdomen; ornamental cephalic scalation including a small cluster of 11–16 supraauricular tubercles (enlarged scales from

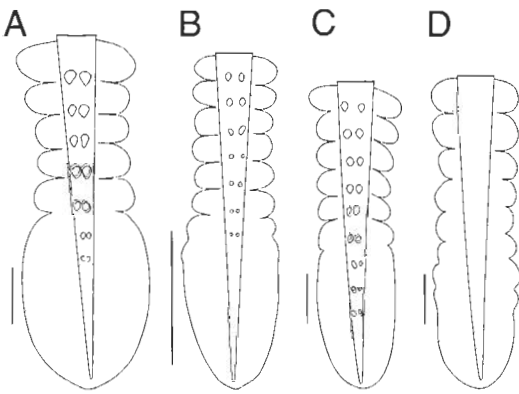


Fig. 6. Dorsal views of terminal tail flaps in selected *Ptychozoon* species (see also Brown et al., 1997: fig. 6): (A) *Ptychozoon kuhli* (MCZ 166251); (B) *P. trinotaterra* juvenile paratype (ROM 31911); (C) *P. trinotaterra* adult holotype (FMNH 181825); (D) *P. lionotum* (FMNH 181828). Note continuation of whorl series tubercles to the dorsal surfaces of tail termini in *P. kuhli* and *P. trinotaterra* but not in *P. lionotum*. Scale bars = 5 mm.

convex to spinose), several enlarged scales in the temporal region on both sides of the head, and slightly enlarged, conical and pointed spicular scales in preocular region (Fig. 4A); 48/44 circumorbitals, undifferentiated except for slight dorsolateral transverse elongation and dorsocaudal modification of some circumorbitals into slight points, projecting into orbit, with slightly pointed, fringed appearance; 29 interorbital scales.

AGD 49% of SVL; TBL 17% of SVL; undifferentiated dorsal body scales round to hexagonal, nonimbricate, varying in size (smaller laterally); each dorsal with 6–8 minute surrounding interstitial granules; 76 transverse midbody dorsals (above the midbody parachute) and 70 midbody ventrals (below parachute); a conspicuous single row of 14 circular tubercles (enlarged flat scales) along vertebral column with 3–6 undifferentiated midvertebrals between each (Fig. 7); supraantibrachials and suprabrachials greatly enlarged, strongly imbricate, rectangular (closer to anterior surfaces and on dorsal surfaces of cutaneous expansions) to subcircular (posteriorly), reducing sharply in size at insertion of the limb; infraantibrachials and infrabrachials small, circular to oval, slightly to nonimbricate; suprahumeral and supratibials only slightly larger than dorsal body scales, with scattered irregularly enlarged intermixed scales; prehumeral greatly enlarged, flat and strongly imbricate, grading smoothly into similarly enlarged scales on the pretibial cutaneous expansion; infrahumeral and infratibials greatly en-

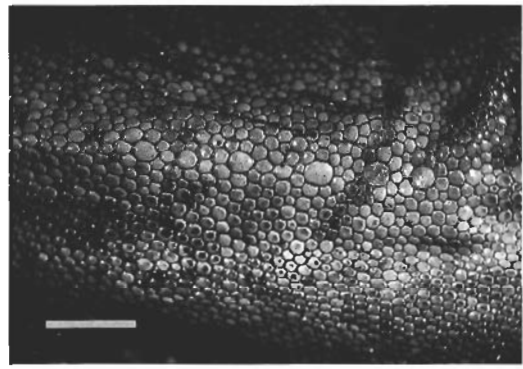


Fig. 7. Midvertebral series of enlarged flat tubercles in the holotype of *Ptychozoon trinotaterra* (FMNH 181825). Scale bar = 2 mm.

larged, flat and strongly imbricate; scales on dorsal surfaces of manus and pes (on both digits and interdigital webbing) at most slightly more enlarged than adjacent scales on dorsal surfaces of limbs; scales on palmar surface of manus not distinctly different in size with respect to infraantibrachials; scales on plantar surface of pes strongly reduced in comparison to adjacent infratibials; ventral body scales strongly imbricate, with rounded caudal edge, conspicuously larger than nonimbricate dorsals, uniform in size along anterior-posterior body axis until nuchal region where they sharply reduce to nonimbricate minute chin scales; imbricate ventrals also reduce laterally to minute before insertion of midbody parachute.

A pair of cloacal gland openings each followed by a caudolaterally oriented slanted series of four increasingly enlarged scales, ending in a single protuberant cloacal spur on each side of ventral tail base; 20 continuous dimpled scales in the preanofemoral pore-bearing series, arranged in a slightly bowed, inverted obtuse V-formation; preanofemorals preceded by one and followed by four rows of similarly enlarged but nondimpled scales; postcloacal swellings only slightly distinct; subcutaneous endolymphatic sacs not evident.

Tail 87% of SVL; TD (not including basal denticulate lobes) 76% of TW; tail depressed, subcylindrical, ventrally flattened; fifteen pairs of lateral denticulate tail lobes along each side of the tail, one pair per annulation (the first bilobed with smaller sublobe anteriorly); dorsal caudal scales slightly convex, slightly imbricate, round to hexagonal, with ovoid and round, flat to slightly spurred (raised, pointed tips facing caudally) tubercles arranged at caudal margin of each clearly evident fracture plane/autotomy groove (= whorls or annulations); medianmost

TABLE 1. SUMMARY OF SELECTED QUALITATIVE AND QUANTITATIVE MORPHOLOGICAL CHARACTERISTICS (+ PRESENT, — ABSENT) OF *Psychozoon trinotalera* AND OTHER SPECIES OF *Psychozoon*. Sexes combined in table for simplicity of presentation; sample size is presented in parentheses with species name. Mensural data are presented in mm. See Brown et al. (1997) for more extensive comparisons of all species exclusive of *P. trinotalera*.

Character	<i>P. trinotalera</i> (4)	<i>P. kuhlii</i> (31)	<i>P. lionotum</i> (20)	<i>P. horyfoddii</i> (7)	<i>P. intermedium</i> (19)	<i>P. rhacophorus</i> (2)
SVL ^a	70.5–71.3	64.6–107.8	70.1–98.6	56.8–73.9	68.6–98.8	58.8–64.5
Disposition of dorsal tubercles	single paravertebral series or absent	2–6 straight rows	absent	absent	0–10 irregular rows	scattered
Tubercle shape	flat, —	convex or spiculate	—	—	flat or convex	spiculate to highly spinose
Separated femorals	—	late	—	—	—	—
Prenals	19–21	14–32	15–26	8–11	12–19	—
Caudal tubercles continue to tail terminus	+	+	—	10–11	8–12	12–18
Number lobes fused before straight flap	1–2	1–3	3–9	2–3	2–4	—
Tail terminus length	17.8	21.4–30.0	7.8–21.4	5.0–7.0	3.2–8.0	—
Bands in axilla-groin region	3	4	4	4	3	—
Supranasals contact	+	+, —	—	—	+, —	—
Caudal lobe angling	slight	slight	slight	extreme	extreme	extreme
Tail + lobes width reduction distally	minimal	minimal	minimal	extensive	extensive	extensive
Scales across widest portion of tail terminus	26	42–51	24–31	9–21	14–18	—
Predigital notch in preantibrachial expansion	—	—	+	—	—	—
Intraauricular cutaneous expansion	+	+	+	+	+	—
Imbricate parachute support scales	+	+	+	+	+	—

^a Sexually mature adults only.

tubercle pair the most strongly spinose, flanked on each side by flatter, rounder tubercles; tubercles most strongly and irregularly congregated at tail base; tubercle pairs decrease in size distally, continuing on to tail terminus before becoming indistinguishable among undifferentiated dorsal caudals; tail terminus widened, at most only slightly beyond nearest lobe (Fig. 6B–C), straight-edged, with only a single lobe fusion evident anteriorly; ventral tail scales flat, irregularly rectangular, arranged into 76 differentiated subcaudal rows of pairs and triplets (usually four rows per annulation); subcaudal series continuing onto tail terminus to its rounded tip.

Digits widely dilated (Fig. 5B), webbed in proximal four-fifths to five-sixths (to point of widest digital expansion) of dilated hyperextensible portions; subdigital lamellae occupying distal one-half of toe IV; subdigital lamellae undivided, strongly curved, manus: 10/11, 12/11, 13/13, 13/15, and 10/12 on left-right digits I–V respectively; pes: 11/12, 12/12, 13/13, 14/12, and 12/12 on left/right digits I–V respectively; all digits but I (inner) clawed; unclawed first digit with cycloid convex scale; terminal claw-bearing phalanges compressed, very large, rising free at distal end, extending only slightly beyond dilated portion of digit.

Coloration in preservative.—Dorsum background light gray with five black dorsal M-shaped transverse wavy black bands (1 mm in width; Figs. 2–3): a small and incomplete band in nuchal region, one caudal to insertion of forelimbs, one at midbody, one anterior to insertion of rear limbs, and one above base of tail (= three bands in the axilla-groin region); dorsum light gray between each thin transverse band, with brown blotches and faint black specks laterally above insertion of midbody parachute; small amount of black mottling interrupts the interband fade on either side of the vertebral body axis; fore- and hind limbs with two or three dark bands, interspersed with brown and gray as above; barring immediately before and after ulnar region giving the impression of a light circle, bordered by black, on point of elbow; light gray nuchal region switches abruptly to dark brown anterior to auricular opening; a prominent postorbital brown bar continuing to and fading in nuchal region; cephalic dark brown interrupted with black and gray mottling, frontal region distinctly lighter gray than lateral (more brown) regions of head; darker, thin interorbital bar present; darker, thin, inverted V-shaped marking present on snout (point facing anteriorly); infraauricular cutaneous expansion white with a few brown markings; labials and

internasal scales yellowish gray with dense aggregation of melanophores associated with labial sutures; venter and undersides of limbs pale creamy yellowish white with occasional brown and gray spots; tail with five dorsal black transverse bands on gray (and more brown caudally) background; venter of tail with five alternating light (dirty yellowish white) and darker (gray and dark brown mixture) regions; a distinctive distal white tip on dorsal and ventral sides of tail; dorsal midbody and limb cutaneous expansions white and light gray with medium brown and black marbled markings; ventral midbody expansion yellowish gray with dark gray and black radiations; palmar regions of manus and pes yellowish gray with darker gray-brown markings; subdigital lamellae dark gray. Coloration in life unrecorded. My experience with live *P. kuhli* and *P. intermedium* specimens (Brown et al., 1997) suggests that coloration in those species fades very little with preservation and I expect the same is true for *P. trinotaterra*.

Variation.—Variation in meristic and mensural characters in *P. trinotaterra* is presented in the Appendix. The sample consists of a sexually mature male, a sexually mature female, and two juvenile males. In general, the Thai and Vietnamese specimens share the same color pattern, but the specimens from Vietnam are more distinctly marked in contrasting lighter and darker extremes (Fig. 2). The holotype (from Thailand) has dense congregations of melanophores along the sutures between adjacent labials and a white chin with a few distinct black markings while the Vietnamese specimens exhibit more scattered and irregularly blotched melanic coloration on the labials and a gray chin with scattered melanophores. The thin dark interorbital bar is more distinct and straight in the Thai specimen and transverse dorsal bands are thicker and bolder in the Vietnamese specimens. In life, nighttime coloration in the Vietnamese specimens was darker than that observed during the day, with more contrast between the light dorsum and thick darker transverse bands (Fig. 2). During daylight hours, dark dorsal bands became thinner and less distinct, rendering the animal more cryptic on the gray bark background of tree trunks (Brown et al., 1997:fig. 9; A. Lathrop, pers. comm.).

The dorsal surface of the infraauricular flap is white in the Thai specimen and gray in the adult specimen from Vietnam. Additionally, circumorbitals in the Vietnamese specimens are distinctly barred in alternating black and white

sections of three to five scales per section (Fig. 2).

The adult male paratype from Vietnam possesses 19 large round yellowish preanofemoral pores, a lateral swelling of the ventral tail base, and a greatly enlarged, strongly convex pair of cloacal spurs on either side of the vent. This specimen also differs from the female holotype in having smaller scales on the dorsal surface of the rostrum and slightly less convex scales on the lateral surfaces of the rostrum. The adult paratype also exhibits fewer and smaller ornamental scales in the nuchal and temporal regions and has fewer scales in the supraauricular cluster. The juvenile paratypes differ from the adult paratype by the presence of more numerous differentiated nuchal and temporal region tubercles. The adult paratype shows only slight enlargement of only a few vertebral scales (not arranged in a straight vertebral series as evident in the Thai holotype; Fig. 7). The specimens from Vietnam also show a marked reduction in the dorsal caudal tubercles of the posterior margins of the tail annulations. In the Thai specimen, there are four tubercles along the proximal caudal margins of each tail annulation; the most medial pair are consistently more spinose, with their caudal border rising free of adjacent scales to a prominently spinose point. Reduction to a medial pair of weakly convex tubercles occurs at midtail. In the Vietnamese specimens, dorsal caudal tubercles are weakly differentiated, flat to weakly convex, and reduced to a single median pair (none of which are spinose) throughout the length of the tail.

Tail autotomy (in the adult paratype) is followed by nondenticulate regrowth of the lateral cutaneous caudal expansions. One juvenile (ROM 31911) has a terminal tail flap laterally expanded slightly beyond the nearest denticulate lobe, suggesting that some geographic and/or ontogenetic variation in this character may naturally occur. The tail regrowth in the adult *P. trinotaterra* paratype is narrow (more like *P. lionotum*) and unlike the wider, slightly expanded regrowth in *P. kuhli* (Barbour, 1912; pers. obs.).

The juvenile paratypes have dark grayish brown venters and ventral portions of limbs. These specimens also exhibit prominent white subgular endolymphatic sacs and especially distinct and bright color patterns.

If future collections from Vietnam result in adult specimens with laterally expanded tail termini, this fact plus the more extensive disposition of caudal tubercles and the presence of vertebral tubercles in the Thai specimen will require broadening of the diagnosis of *P. trinota-*

terra or, possibly, taxonomic recognition of the Vietnamese populations. At present, the most conservative position is to recognize the Thai and Vietnamese specimens as conspecific.

Etymology.—The specific epithet is a noun in apposition, derived from the Latin *tri* (three), *nota* (band, streak), and *terra* (mainland), in reference to the fact that *P. trinotaterra* is the only known *Ptychozoon* from the Asian mainland with three transverse dark bands in the axilla-groin region.

Comparisons with individual congeners.—Extensive comparisons of meristic characters (and a list of specimens examined) among other *Ptychozoon* species are provided elsewhere (Brown et al., 1997). Table 1 summarizes selected diagnostic characteristics that distinguish *P. trinotaterra* from its congeners.

Ptychozoon trinotaterra differs from *P. kuhli* (*P. homalocephala* Crevelde 1809; see Stejneger, 1902; recorded from Java, Sumatra, peninsular Malaysia, southern Thailand, Borneo, Sulawesi, and possibly Burma) by presence or absence of flat dorsal tubercles (vs consistently present and invariably strongly convex to raised and spinose); the disposition of tubercles in a single vertebral row in the Thai specimen or the complete absence of dorsal tubercles in Vietnamese specimens (vs dorsal tubercles arranged in 2–6 parallel paravertebral rows); a narrower (8.0 mm; Fig. 6B–C) terminal tail flap [vs wide lateral expansion beyond nearest denticulate lobe and 8.9–18.9 mm ($\bar{x} = 13.5 \pm 2.3$ SD, $n = 22$); Fig. 5A] width; a shorter tail terminus length (17.8 vs 21.4–30.0; $\bar{x} = 24.5 \pm 2.5$; $n = 21$); three (vs normally four; five in one specimen) transverse wavy bands in the axilla-groin region; a markedly lower maximum number of preanofemoral pore-bearing scales (21 vs 32); fewer scales (26) across the widest point of the tail terminus (vs 42–51); 19–21 (vs 12–17) denticulate tail lobes and associated annulations; and a smaller apparent maximum body size (71.3 mm vs 107.8 mm in *P. kuhli*).

Ptychozoon trinotaterra differs from *P. lionotum* Annandale 1905 (recorded from Thailand, Burma, and peninsular Malaysia) by the presence (vs absence) in the Thai specimen of dorsal tubercles; supranasal contact (vs widely separated); three (vs four) transverse bands in the axilla-groin region; a straight-edged terminal tail flap (vs tail flap edge wavy; Fig. 6D); limited fusion of 1–2 lobes at the proximal border of the tail terminus (vs extensive fusion of 3–9 denticulate lobes); a smaller maximum known body size (71.3 vs 98.6 mm); by the extension of cau-

dal whorl tubercles distally to the tail terminus (vs tubercles reduced or absent by midtail); 15–16 (vs 18–23) denticulate tail lobes and associated annulations; and the absence (vs presence; Fig. 5A) of a predigital notch in the preantebrachial cutaneous expansion of the forelimb.

Ptychozoon trinotaterra differs from *P. horsfieldii* (Gray 1827; reported from Thailand, peninsular Malaysia, Borneo, Sumatra, Java, and Burma) by the presence (in Thai specimen) of dorsal tubercles (consistently absent in *P. horsfieldii*); supranasal contact (vs widely separate); nonreduction in degree of lateral expansion of distal tail lobes (vs caudal lobe size reduction gradually to tail terminus); more lateral orientation of the denticulate tail lobes (vs tail lobes more caudally angled; Stejneger, 1907; Brown et al., 1997); the presence of a continuous series of preanofemoral pore-bearing scales (vs preanal pore-bearing scales separated from a distinct femoral pore-bearing series); extension of caudal whorl tubercles distally to the tail terminus (vs tubercles reduced or absent by midtail); a wide (8.0 mm) vs narrow (2.2–3.2; $\bar{x} = 2.6 \pm 0.5$ SD; $n = 7$) and elongate (12.3 mm) vs truncate (5.0–7.0; $\bar{x} = 6.2 \pm 1.1$ SD; $n = 7$) terminal tail flap (Stejneger, 1907:fig. 164; Brown et al., 1997:fig. 6); three (vs four) transverse bands in the axilla-groin region; the absence (vs presence) of distinct, dark, circular nuchal spots; and 15–16 (vs 21–22) denticulate tail lobes and associated annulations.

Ptychozoon trinotaterra differs from *P. intermedium* Taylor 1915 (from Mindanao and associated landbridge islands; Brown et al., 1997) by the presence (in the holotype) of a single vertebral row of dorsal tubercles and by the absence of dorsal tubercles in Vietnamese specimens (vs convex dorsal tubercles arranged in normally 4–6 irregular longitudinal rows); lack of reduction in the degree of lateral expansion of distal tail lobes (vs caudal lobe size reduced gradually to tail terminus); more lateral orientation of the denticulate tail lobes (vs tail lobes more caudally angled); a continuous series of preanofemoral pore-bearing scales (vs preanal pore-bearing scales separated from a distinct femoral pore-bearing series); a wide (8.0 mm) vs narrow (2.9–5.0; $\bar{x} = 3.9 \pm 0.6$ SD; $n = 15$) and elongate (12.3 mm) vs usually more truncate (3.2–8.0; $\bar{x} = 5.5 \pm 1.3$ SD; $n = 5$) terminal tail flap (Brown et al., 1997); an apparently smaller maximum body size (71.3 mm vs 99.8 in *P. intermedium*); and 15–16 (vs 22–27) denticulate tail lobes and associated annulations.

Ptychozoon trinotaterra differs from *P. rhacophorus* (Boulenger 1899; recorded from northern Borneo) by the constant presence of dorsal

transverse bands (vs solid dark coloration or dark mottling dorsally in *P. rhacophorus*; banded in recent photographs of live specimens; Manthey and Grossman, 1997:fig. 179); supranasal contact (vs supranasals widely separate); the occasional presence of flat, parallel vertebral tubercles [vs tubercles widely scattered, sharply spinose, or thorny (Brown et al., 1997)]; smooth-edged cutaneous midbody expansions (vs jagged and irregularly lobed); a much greater extent of digital webbing; wider (vs narrow or reduced) cutaneous expansions of the limbs; the presence (vs absence) of an infraauricular cutaneous expansion; the presence (vs absence) of a terminal tail flap; and the presence (vs absence) of strongly imbricate scales on the dorsal surfaces of midbody parachute and cutaneous expansions of the limbs (Brown et al., 1997).

Natural history.—The holotype was captured with a large series of *P. lionotum*, taken in Sakarat, Nakhon Ratchasima Province, northeast Thailand between April and June 1969. Field notes (by R. Heyer and R. Inger, deposited at FMNH) state that FMNH 181825 was taken 3 m high on a tree trunk (17 cm in diameter), bordering a large clearing surrounded by dry evergreen forest. All other specimens in the series (*P. lionotum*) were taken within a nearby dry evergreen forest, and no *P. lionotum* were taken from within a nearby deciduous forest. These differences in circumstances of collection may indicate differences in habitat preferences for these two sympatric (but possibly not syntopic) species. Inger and Colwell (1977) reported that the climate of the selectively logged clearings in the evergreen forest was similar to a nearby deciduous forest (more sunlight reaching the forest floor, more air movement, less humidity, higher temperatures, and higher, more variable total evaporation). The nearby evergreen forest was composed of two strata (Inger and Colwell, 1977) with dense undergrowth present (lianas abundant). The canopy at this site was estimated to be between 20 and 35 m in height, and tree diameter at breast height (dbh) ranged from 30 to 140 cm. The deciduous forest exhibited a single layered canopy, with thin, scattered undergrowth of grasses, seedlings, and shrub-layer vegetation (burned annually). The canopy was estimated to be between 15 and 25 m, with a maximum trunk dbh of 95 cm. Annual precipitation at this site was estimated to be 1500 mm, and the specimen was collected at the beginning of the rainy season. Other geckos collected sympatrically in the nearby evergreen forest include (presence or absence of species in deciduous forest also noted in parentheses): *Pty-*

Chazoon bimotum (absent), *Cosymbotus platyurus* (present), *Cyrtodactylus angularis* (present), *C. intermedius* (absent), *Gekko gekko* (present), *Hemidactylus garnotii* (absent), *Hemiphyllodactylus yunnanensis* (absent), *Gehyra lacerata* (present), *G. mutilata* (present), and *Dixonius siamensis* (present). For a thorough description of the habitat and communities of sympatric amphibians and reptiles, see Inger and Colwell (1977).

The two juvenile paratypes from Vietnam (ROM 31910 and 31911) were collected at 2100 h on a burnt tree stump (4 m high), surrounded by a large slash-and-burn clearing, 20 m from the bank of the Azum River of Trap Lam. The adult paratype (ROM 31912) was captured near the Dak Ken River at Yok Don in a mist net set for bats and was taken from the net at 2030 h. The position of the specimen in the net was approximately 3 m from the ground and ≥ 3 m from the closest tree trunk, indicating that it was gliding or parachuting when caught. Another *Ptychozoon* specimen (presumably conspecific) was observed in a head-down position 3.5 m from the ground on a large dipterocarp tree (≥ 2 m in diameter), but eluded capture. No other *Ptychozoon* species were recorded at the site, but other sympatric geckos included *Cosymbotus platyurus*, *Cyrtodactylus irregularis*, and *Gekko gekko*. Habitat at this site included large (1–3 m in diameter) dipterocarp trees, qualitatively characterized as evenly spaced, approximately 5 m apart. Upper canopy height was estimated to be between 15–20 m and the canopy was characterized as open (consisting of breaks between adjacent crowns). Lower strata of the forest were open, with the lowest branches above 8 m from the ground; the shrub and herb layer consisted of mixed grass species, from 30 cm to 1 m in height, with very little scrub vegetation. Climate was characterized as 33–34°C, no wind, very humid at the approximate beginning of the rainy season.

DISCUSSION

The description of *P. trinotaterra* brings the total number of *Ptychozoon* species to six. The distribution of shared character states (Table 1) associated with the terminal tail flap (Fig. 6), lateral width reduction and angling of denticulate tail lobes (Brown et al., 1997:fig. 6), and disposition of preanofemorals into a continuous versus interrupted series suggests two major lineages within the genus, one composed of *P. kuhli*, *P. lionotum*, and *P. trinotaterra* and the other consisting of *P. intermedium*, *P. horsfieldii*, and possibly *P. rhacophorus*. Discussion of species relationships and the systematic affinities of the genus

Ptychozoon must await a phylogenetic analysis in progress (R. Brown, L. Ruedas, and A. Russell, unpubl. data).

ACKNOWLEDGMENTS

For the loans of specimens or assistance while visiting museum collections, I thank the following individuals and their respective institutions (museum abbreviations, with the exception of the Cincinnati Museum of Natural History, CMNH) follow Leviton et al. (1985): J. Vindum, J. Slowinski, A. Leviton, and R. Drewes (CAS); K. de Queiroz, R. Crombie, G. Zug, and T. Hartsell (USNM); J. Rosado and J. Cadle (MCZ); A. Resetar, R. Inger, C. Redhead, and H. Voris (FMNH); J. Ferner and R. Kennedy (CMNH); H. Ota and T. Hikida (KUZ); R. MacCulloch and R. Murphy (ROM); G. Hess (DMNH); G. Schneider (UMMZ); D. Cannatella (TNHC); R. Sison (PNM); K. Vaughan (TCWC). Financial support for a visit to CAS was provided by the C. Stearns Fellowship of the California Academy of Sciences. In particular, I thank R. Inger and R. Murphy for access to specimens in their care and A. Lathrop, R. Bain, and R. Murphy for use of photographs and field notes. I also thank J. C. Loucek III for providing access to live comparative material.

Fieldwork in Vietnam (by R. Murphy and colleagues) was supported by grants from the Royal Ontario Museum Foundation and the Natural Sciences and Engineering Research Council (NSERC) of Canada (grant A3148). R. Murphy thanks Cathay Pacific Airlines, Magnalight, Coleman, Johnsons, Waco, Huffy, Endurables, and Benjamin Film Laboratories. Support for R. Inger's and R. Hever's fieldwork in Thailand is acknowledged in Inger and Colwell (1977). I thank T. LaDuc, A. Gluesenkamp, D. Cannatella, and two anonymous reviewers for comments on previous drafts of the manuscript.

LITERATURE CITED

- AUDLEY-CHARLES, M. G. 1981. Geological history of the region of Wallace's Line, p. 25–35. *In*: Wallace's line and plate tectonics, T. C. Whitmore (ed.), Clarendon Press, Oxford.
- BARBOUR, T. 1912. A contribution to the zoogeography of the East Indian Islands. Mem. Mus. Comp. Zool. 44:1–203.
- BOBROV, V. V. 1995. Checklist and bibliography of the lizards of Vietnam. Smiths. Herpetol. Info. Serv. 105:1–28.
- BROWN, R. M., J. W. FERNER, AND R. V. SISON. 1995. Rediscovery and redescription of *Sphenomorphus beyeri* (Reptilia: Lacertilia: Scincidae) from the Zam-

- bales Mountains, Luzon, Philippines. *Proc. Biol. Soc. Wash.* 108:6–17.
- , ———, AND A. C. DIEMOS. 1997. Definition of the Philippine parachute gecko, *Ptychozoon intermedium* Taylor 1915 (Reptilia: Squamata: Gekkonidae): redescription, designation of a neotype, and comparisons with related species. *Herpetologica* 53:357–373.
- BROWN, W. C., AND A. C. ALCALA. 1978. Philippine lizards of the family Gekkonidae. Silliman Univ. Nat. Sci. Monogr. Ser. 1:1–146.
- DRING, J. C. M. 1979. Amphibians and reptiles from northern Trengganu, Malaysia, with descriptions of two new geckos: *Cnemaspis* and *Cytodactylus*. *Bull. Brit. Mus. (Nat. Hist.) Zool. Ser.* 34:181–241.
- FROST, D. R., AND D. M. HILLIS. 1990. Species in concept and practice: herpetological applications. *Herpetologica* 46:87–104.
- HALL, R. 1996. Reconstructing Cenozoic southeast Asia, p. 153–184. *In: Tectonic evolution of Southeast Asia*. R. Hall and D. Blundell (eds.) Geological Society, London.
- HAMILTON, W. 1979. Tectonics of the Indonesian region. U.S. Dept. Interior, Geol. Sur. Professional Pap. 1078:1–335.
- INGER, R. F., AND R. K. COLWELL. 1977. Organization of contiguous communities of amphibians and reptiles in Thailand. *Ecol. Monogr.* 47:229–253.
- ISKANDAR, D. T., AND K. N. TJAN. 1996. The amphibians and reptiles of Sulawesi, with notes on the distribution and chromosomal number of frogs, p. 39–46. *In: Proceedings of the first international conference on eastern-Australian vertebrate fauna*. D. J. Kitchener and A. Suyanto (eds.) Western Australian Museum for Lembaga Ilmu Pengetahuan Indonesia, Perth, Australia.
- LEVITON, A. E., R. H. GIBBS JR., E. HEAL, AND C. E. DAWSON. 1985. Standards in herpetology and ichthyology. Part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. *Copeia* 1985:802–821.
- MANTHEY, U. 1985. Die Gattung *Ptychozoon* Kuhl, 1822 (Faltengecko) Teil I mit einem Bestimmungsschlüssel für die fünf Arten. *Sauria*, Berlin 4: 5–12.
- , AND W. GROSSMAN. 1997. Amphibien und Reptilien sudostasiens. Natur und Tier-Verlag, Berlin.
- OTA, H., AND R. I. CROMBIE. 1989. A new lizard of the genus *Lepidodactylus* (Reptilia: Gekkonidae) from Batan Island, Philippines. *Proc. Biol. Soc. Wash.* 102:559–567.
- SMITH, M. A. 1930. The Reptilia and amphibia of the Malay Peninsula. *Bull. Raffles Mus.* 3:1–149.
- . 1935. The fauna of British India, including Ceylon and Burma. Reptilia and amphibia. II. Sauria. Taylor and Francis, London.
- STEJNEGER, L. H. 1902. *Ptychozoon kuhli*, a new name for *P. homocephalum*. *Proc. Biol. Soc. Wash.* 15:37.
- . 1907. Herpetology of Japan and adjacent territory. *Bull. U.S. Natl. Mus.* 58:1–577.
- TAYLOR, E. H. 1922. The lizards of the Philippine Islands. Philippine Bureau of Science, Manila.
- . 1963. The lizards of Thailand. *Univ. Kans. Sci. Bull.* 44:687–1077.
- WERMUTH, H. 1965. Gekkonidae, Pygopodidae, Xantusidae, p. 154–155. *In: Das Tierreich*. Vol. 80. R. Mertens, W. Hennig, and H. Wermuth (eds.) Walter de Gruyter and Co., Berlin.

(RMB) SECTION OF INTEGRATIVE BIOLOGY AND TEXAS MEMORIAL MUSEUM, UNIVERSITY OF TEXAS, AUSTIN, TEXAS 78712-1064. E-mail: rafe@mail.utexas.edu. Submitted: 7 Dec. 1998. Accepted: 17 March 1999. Section editor: A. H. Price.

APPENDIX. VARIATION IN MERISTIC AND MENSURAL CHARACTERS OF THE TYPE SERIES OF *Ptychozoon trinotaterra*.
See text for character abbreviations.

	FMNH 181825 holotype	ROM 31912	ROM 31910 paratypes	ROM 31911	Mean ^a	SD
SVL	70.5	71.3	30.6	31.2	70.9	0.6
TL	61.1	56.6	24.9	28.0	58.9	3.2
AGD	34.3	36.8	12.9	13.6	35.6	1.8
TW	5.6	5.8	2.2	2.4	5.7	0.1
TD	1.3	1.2	2.1	2.0	1.3	0.1
TAD	1.7	1.6	0.7	0.8	1.7	0.1
HL	19.1	18.6	9.2	9.6	18.9	0.4
HW	15.7	14.9	7.4	7.4	15.3	0.6
SL	9.2	8.6	3.5	3.9	8.9	0.4
HD	8.1	7.8	4.4	3.8	8.0	0.2
IND	3.3	3.2	1.5	1.7	3.3	0.1
IOD	8.0	8.0	4.5	4.1	8.0	0.0
ED	4.7	4.9	2.5	2.5	4.8	0.1
END	6.2	6.0	3.3	3.2	6.1	0.1
Toe I	6.6	6.3	2.1	1.9	6.5	0.2
Toe IV	7.9	8.5	3.7	3.6	8.2	0.4
FL	13.0	12.4	4.7	5.1	12.7	0.4
TBL	12.3	11.4	5.1	5.4	11.9	0.6
TFW	8.0	— ^b	3.6	2.8	—	—
TFL	17.8	— ^b	7.1	6.5	—	—
CO	48/44	46/49	45/48	44/50	46.8	2.3
PS	20	19	20	21	20.0	0.8
TA	15	9 ^b	16	16	—	—
SC	81	34 ^b	82	90	—	—
PVS	201	208	220	211	210.0	7.9
MS	146	132	151	161	147.5	12.1
TTAB	4	2	2	4	2.5	1.0
TTAM	4	2	2	2	2.5	1.0
TTAT	2	2	2	2	2.0	0.0
SUL	11/11	12/12	12/13	12/13	12.0	0.8
IFL	9/11	11/12	10/12	11/11	10.9	1.0
Subdigital lamellae of (L/R):						
Finger I	10/11	11/10	11/11	11/12	10.9	0.6
Finger II	12/11	10/11	12/12	12/13	11.6	0.9
Finger III	13/13	13/13	13/13	13/13	13.0	0.0
Finger IV	13/15	14/13	13/13	13/13	13.4	0.7
Finger V	10/12	11/11	11/12	11/12	11.3	0.7
Toe I	11/12	10/11	10/10	11/10	10.7	0.7
Toe II	12/12	11/11	11/13	12/13	11.9	0.8
Toe III	13/13	14/13	14/13	15/13	13.5	0.8
Toe IV	14/12	14/14	14/12	15/14	13.6	1.1
Toe V	12/12	12/12	13/13	13/12	12.4	0.5

^a Only adult specimens (n = 2) are included in statistical summaries of mensural characters; statistics for meristic characters include juveniles (n = 4); statistics for bilaterally present characters (e.g., supralabials) include counts from both sides of the animals (n = 8).

^b Tail autotomized with regrowth, scales distal to tail break not counted.