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A new forest-dwelling gecko from Phuket Island, Southern Thailand, related to *Cyrtodactylus macrotuberculatus* (Squamata: Gekkonidae)

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Abstract

We describe a new sylvicolous *Cyrtodactylus* Gray from Phuket Island, southwestern peninsular Thailand, having a banded pattern, precloacal groove, continuous series of enlarged pore-bearing femoro-precloacal scales, and strongly developed tuberculation—characters that distinguish it from all congeneric taxa except *C. macrotuberculatus* Grismer & Ahmad, 2008 from Peninsular Malaysia, from which it can be separated mainly by having three instead of four dark bands between the limb insertions and a precloacal groove in females.

Key words: Thai-Malay Peninsula, Khao Phra Thaeo Non-hunting Area, insular endemism, *Cyrtodactylus phuketensis* **sp. nov.**

Introduction

Within the framework of our ongoing taxonomic and zoogeographical review of the herpetofauna of peninsular Thailand (see Grismer *et al.* 2010; Pauwels *et al.* 2004; Sumontha *et al.* 2011; Grismer *et al.* in prep.), we visited the forested areas of Phuket Island, one of the most popular tourist destinations of Thailand. Although most of the forested areas of the island have suffered much from anthropogenic disturbance and have been replaced by human settlements, tourism infrastructure, and agricultural plantations, some patches of primary and mature secondary forest remain, especially in the center of the island from where two presumably endemic squamate species were recently described (Das & Leong 2004; Sumontha *et al*. 2011). Although the snake fauna of the island benefitted from some dedicated surveys in the 1970s (Frith 1977, 1978), the lizard fauna has received little attention thus far (Pauwels & Bauer 2001; Leong *et al.* 2003), and we hence made efforts here to contribute to the inventory of the island's lizard fauna. In the Khao Phra Thaeo Non-hunting Area and its direct surroundings, we collected a series of *Cyrtodactylus* which, by their banded pattern, their possession of a precloacal groove and their very strong tuberculation, show obvious affinities with *C. macrotuberculatus* Grismer & Ahmad, 2008, originally described from the Peninsular Malaysian island of Langkawi but which has since been found in several localities in northwestern mainland Peninsular Malaysia from Perlis and Kedah states (Grismer 2011). We thoroughly investigated possible morphological differences between them and found that, while morphologically closely related, they are clearly distinguishable.

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Material and methods

Measurements and meristic counts follow Grismer & Ahmad (2008), and the sections of the morphological description follow those in their description of *Cyrtodactylus macrotuberculatus* to facilitate comparisons. Numbers of supralabial and infralabial scales are counted from the largest scale immediately posterior to the dorsal inflection of the posterior portion of the upper jaw to the rostral and mental scales, respectively. The number of paravertebral tubercles was counted in a straight line immediately left of the vertebral column, between the limb insertions. The number of longitudinal rows of body tubercles was counted transversely across the center of the dorsum from one ventrolateral skin fold to the other. The number of rows of ventral scales was counted transversely across the center of the abdomen from one ventrolateral skin fold to the other. The number of the subdigital lamellae beneath the 4th toe was counted from the base of the first phalanx to the claw. The total number of precloacal and femoral pores was combined as a single meristic referred to as the femoro-precloacal pores number. Measurements were taken with a Senator digital caliper to the nearest 0.1 mm. Morphological abbreviations: AG = axilla to groin length, taken from the posterior margin of the forelimb at its insertion point on the body to the anterior margin of the hind limb at its insertion point on the body; ED = eye diameter, the greatest horizontal diameter of the eye-ball; EE = eye to ear distance, from the anterior edge of the ear opening to the posterior edge of the eye-ball; EL = ear length, the greatest horizontal distance of the ear opening; EN = eye to nostril distance, from the anterior margin of the eye-ball to the posterior margin of the external nares; ES = eye to snout distance, from the anteriormost margin of the eye-ball to the tip of snout; FL = forearm length, taken on the dorsal surface from the posterior margin of the elbow while flexed 90° to the inflection of the flexed wrist; HD = head depth, the maximum height of head from the occiput to the throat; HL = head length, from the posterior margin of the retroarticular process of the lower jaw to the tip of the snout; HW = head width, measured at the angle of the jaws; IN = internarial distance, measured between the nares across the rostrum; IO = interorbital distance, measured between the anterior edges of the orbit; SVL = snout-vent length, taken from the tip of snout to the vent; TBL = tibia length, taken on the ventral surface from the posterior surface of the knee while flexed 90° to the base of the heel; TL = tail length, taken from the vent to the tip of the tail, original or regenerated; TW = tail width, taken at the base of the tail immediately posterior to the postcloacal swelling. Institutional acronyms: Chulalongkorn University Museum of Zoology, Herpetological Section, Bangkok (CUMZ R); La Sierra University Herpetological Collection, La Sierra University, Riverside, California (LSUHC) (LSUDPC refers to the Digital Photo Collection of LSU); Prince of Songkhla University Zoological Collection, Reptile Section, Songkhla (PSUZC-RT); Natural History Museum, National Science Museum, Technopolis, Pathum Thani (THNHM); and Zoological Research Collection of the Raffles Museum of Biodiversity, National University of Singapore (ZRC).

Systematics

***Cyrtodactylus phuketensis* sp. nov.**
(Figs 1–4)

Holotype. Adult male PSUZC-RT 2010.58 (formerly Montri Sumontha field number MS 510) from Ban Bangrong (coordinates UTM UPS ca. 47 p0433130 0888891 = 08º02.465N, 98º23.588E; altitude ca. 41 m asl), Thalang District, Phuket Island, Phuket Province, southwestern Thailand. Collected by Kirati Kunya on 2 June 2008.

Paratypes. Adult male THNHM 15378 (formerly MS 509) and adult female QSMI 1170 (formerly MS 508). Locality, collecting date, and collector are the same as the holotype.

Diagnosis. *Cyrtodactylus phuketensis* is distinguished from all other Sunda Shelf *Cyrtodactylus* by having the unique combination of a maximum SVL of 114.7 mm; very large, trihedral, keeled, tubercles on body, limbs and tail; tubercles present on occiput and top of head and on gular region and throat; no granular scales (only large tubercles) on dorsal surfaces of limbs; 22–24 ventral scale rows; transversely enlarged, median, subcaudal plates; proximal subdigital lamellae square; 19 subdigital lamellae on 4th toe; abrupt transition between posterior and ventral femoral scales; enlarged femoral and precloacal scales in a continuous series bearing 33–36 pores; precloacal groove present in males and females; precloacal depression absent; no white reticulum on head; three dark bands between limbs insertions; no bands on fore- and hind limbs.

FIGURE 1. Preserved type series of *Cyrtodactylus phuketensis* **sp. nov.** Photo. by M. Sumontha.

Description of holotype. SVL 102.6 mm. Head large, moderate in length (HL/SVL 0.29) and wide (HW/HL 0.69), somewhat flattened (HD/HL 0.40), distinct from neck, and triangular in dorsal profile; lores concave; frontal and prefrontal regions deeply concave; canthus rostralis rounded; snout elongate (ES/HL 0.40), rounded in dorsal profile. Eye large (ED/HL 0.34). Ear opening elliptical, relatively large (EL/HL 0.29), obliquely oriented. Eye to ear distance shorter than diameter of eye. Rostral rectangular, deeply divided dorsally, bordered posteriorly by left and right supranasals and internasal, bordered laterally by first supralabials. Nares bordered anteriorly by rostral, dorsally by two supranasals, posteriorly by granular scales, ventrally by first supralabial; 12 (left) / 13 (right) rectangular supralabials extending to just beyond upturn of labial margins tapering abruptly below midpoint of eye; 1st supralabial tallest, 2nd largest; 10 (left & right) infralabials; scales of rostrum and lores raised, larger than granular scales on top of head and occiput, those on canthus rostralis largest; occipital scales intermixed with enlarged tubercles; large, boney frontal ridges bordering orbit confluent with boney, transverse, parietal ridge. Dorsal supraciliaries elongate, smooth, V-shaped. Mental triangular, bordered laterally by infralabials I and posteriorly by left and right, rectangular postmentals which contact medially for about 50% of their length; one row of slightly enlarged, elongate sublabials extending to 6th infralabial; small, granular, gular scales intermixed with numerous large, conical tubercles grading posteriorly into larger, conical tubercles on throat which abruptly transition into large, flat, smooth, imbricate, pectoral and ventral scales.

Body relatively short (AG/SVL 0.48) with well-defined, tuberculate, ventrolateral folds. Dorsal scales small, granular, interspersed with very large, trihedral, regularly arranged, keeled tubercles separated by no more than three granules at their base (Fig. 2); tubercles extend from occiput to anterior part of tail. Tubercles on occiput and nape relatively small, those on body largest; approximately 23 rows of tubercles at midbody; approximately 40 paravertebral tubercles; 22 flat, imbricate, large, ventral scale rows between ventrolateral body folds; ventral scales much larger than dorsal scales. Precloacal scales large, smooth. Distinct precloacal groove (Fig. 3).

FIGURE 2. Dorsal view of the preserved holotype of *Cyrtodactylus phuketensis* **sp. nov.** showing the large tubercles. Photo. by M. Sumontha.

FIGURE 3. Ventral view of hind limbs of the preserved holotype of *Cyrtodactylus phuketensis* **sp. nov.** Photo by M. Sumontha.

Forelimbs moderately robust, relatively short (FL/SVL 0.16). No granular scales on dorsal surface of forelimbs, only large, trihedral, keeled tubercles. Palmar scales rounded. Digits well-developed, inflected at basal, interphalangeal joints. Subdigital lamellae nearly square proximal to joint inflection, only slightly expanded distal to inflection. Digits more narrow distal to joints. Claws well-developed, sheathed by a dorsal and ventral scale.

Hind limbs more robust than forelimbs, moderate in length (TBL/SVL 0.20). No granular scales on dorsal surfaces of hind limbs, only large, trihedral, keeled tubercles. Ventral scales of thigh flat, imbricate, same size as dorsals; ventral, tibial scales flat, imbricate, slightly keeled. Two rows of enlarged, flat, imbricate femoral scales extend from knee to knee through precloacal region where they are continuous with enlarged, precloacal scales. Posterior row of enlarged femoral scales composed of 33 contiguous, pore-bearing scales extending from knee to knee forming a V bordering the precloacal groove; 8 pores bordering groove; postfemoral scales immediately posterior to the pore-bearing scale row conical. Plantar scales low, slightly rounded. Digits well-developed, inflected at basal, interphalangeal joints; subdigital lamellae proximal to joint inflection nearly square, only slightly expanded distal to inflection. Digits more narrow distal to joints. Claws well-developed, sheathed by a dorsal and ventral scale; 19 (left & right) subdigital lamellae on 4th toe.

Tail original, 133.9 mm in length, 9.6 mm width at base, tapering to a point. All postcloacal scales flat, large, imbricate. Median row of transversely enlarged, subcaudal scales. Three well-developed lateral postcloacal spurs at the base of tail on hemipenial swelling.

Coloration in life. Dorsal ground color of head, body, limbs and tail tan. Wide dark brown nuchal band edged with thin, white lines extends from posterior margin of one eye to posterior margin of the other eye. One similar dorsal band extends across forelimb insertions, two bands on dorsum between limbs insertions, one additional band at base of tail; these bands do not extend below the level of the ventrolateral skin fold. Tail has seven dark bands, not edged with white lines, and forming complete rings around the tail. Ventral surfaces of head, limbs and base of tail uniformly light brown; ventral surface of abdomen uniformly beige.

Variation. The paratypes (see Figs. 1, 4, 6) match the holotype in most respects. Meristic and morphometric characters are presented in Table 1. The postmentals of the female paratype contact medially for more than 30% of their length. The female paratype has a precloacal groove that is less marked than that in males, and she has three minute postcloacal spurs. This specimen also has an incomplete, discontinuous fourth band, above the hind limb insertions. Nine additional individuals not part of the type series (Figs. 7a–h) also have three dark bands between limb insertions.

FIGURE 4. Ventral view of hind limbs of preserved female paratype *Cyrtodactylus phuketensis* **sp. nov.** (QSMI 1170). Photo by M. Sumontha.

TABLE 1. Meristic and morphometric (in mm) data for the type series of *Cyrtodactylus phuketensis* **sp. nov.** Paired meristic characters are given left/right.

	Holotype PSUZC-RT 2010.58	Paratype THNHM 15378	Paratype QSMI 1170
Sex	Male	Male	Female
Supralabials	12/13	13/12	12/11
Infralabials	10/10	9/9	9/9
Strong tuberculation	Yes	Yes	Yes
Tubercles on forelimbs	Yes	Yes	Yes
Tubercles on hind limbs	Yes	Yes	Yes
Tubercles on head and occiput	Yes	Yes	Yes
Tubercles on gular region	Yes	Yes	Yes
Tubercles on at least anterior third of tail	Yes	Yes	Yes
No. of paravertebral tubercles	40	43	41
No. of longitudinal rows of tubercles	23	24	24
No. of ventral scale rows	22	24	22
Enlarged median subcaudals	Yes	Yes	Yes
Proximal subdigital lamellae square	Yes	Yes	Yes
No. of subdigital lamellae on 4th toe	19 (9 + 10)	19 (8 + 11)	19 (8 + 11)
Contact of posterior thigh scales abrupt	Yes	Yes	Yes
Enlarged femoral and precloacal scales present	Yes	Yes	Yes
No. of femoro-precloacal pores (males) / shallow pits (female)	33 (13 + 8 + 12)	36 (13 + 9 + 14)	36 (14 + 8 + 14)
Precloacal groove present	Yes	Yes	Yes
Precloacal depression present	No	No	No
Enlarged precloacal scales present	Yes	Yes	Yes
SVL	102.6	94.3	114.7
TL	133.9	124.1	124.0 (partly regenerated)
TW	9.6	8.8	8.4
FL	16.5	13.1	16.1
TBL	20.1	17.1	21.0
AG	49.2	43.4	52.7
HL	29.5	27.0	30.4
HW	20.5	17.8	21.3
HD	11.8	10.0	12.5
ED	9.9	7.5	10.7
EE	8.7	6.2	7.9
ES	11.9	10.6	12.7
EN	9.0	8.0	9.5
IO	5.3	4.0	5.5
EL	3.0	2.5	3.7
IN	4.1	3.9	4.3

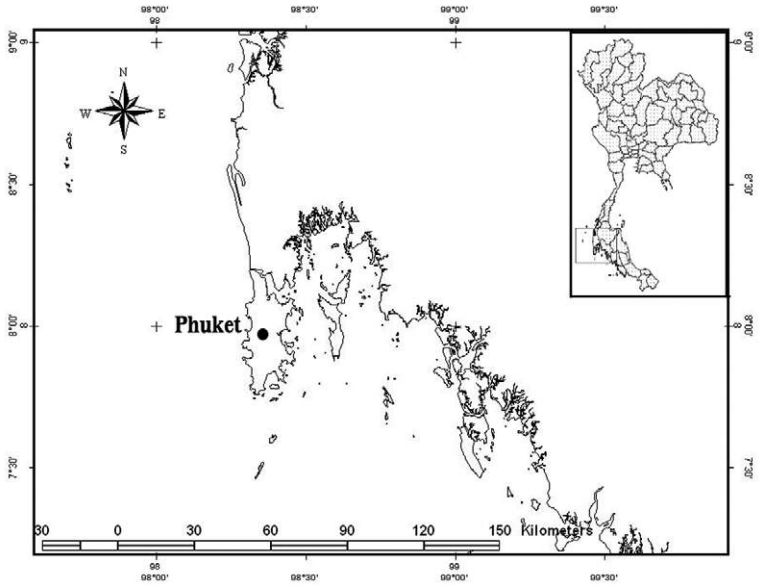

FIGURE 5. Map of Thailand showing the type locality of *Cyrtodactylus phuketensis* **sp. nov.** (black dot). Map by W. Sodob.

FIGURE 6. Live male paratype of *Cyrtodactylus phuketensis* **sp. nov.** (THNHM 15378). Photo by M. Sumontha.

Distribution. This species only has been recorded from the type locality and nearby in Khao Phra Thaeo Non-hunting Area (Figs. 5, 8), but probably occurs in other remaining forested areas of the island and possibly forested areas from the adjacent peninsula near Phuket Island. Extensive field work in forested areas in Phang-Nga Province did not reveal any *Cyrtodactylus phuketensis* sp. nov., although a related species, also belonging to the *C. pulchellus* Gray complex (Grismer *et al.* in press), was found (Pauwels *et al.* 2000, 2002).

FIGURE 7A–H. Nine individuals of *Cyrtodactylus phuketensis* **sp. nov.** (not collected) *in situ* in Khao Phra Thaeo Non-hunting Area. Photo by P. Samphanthamit and N. Panitvong.

Natural history. The three individuals of the type series were found active at night on large trees in mature secondary forest, approximately one meter above the ground. When disturbed, they tried to escape by running to the tree roots. Two individuals (see Fig. 7a) were observed during the day on walls inside the headquarters of the Gibbon Rehabilitation Project in Khao Phra Thaeo Non-hunting Area. Four more individuals were observed at night on trees of large and medium diameter in primary forest in Khao Phra Thaeo Non-hunting Area, where they were found in direct proximity to the agamids *Acanthosaura* cf. *crucigera* Boulenger and *Calotes emma* Gray; the gekkonids *Cnemaspis phuketensis* Das & Leong 2004, *C. vandeventeri* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya 2010, *Cyrtodactylus brevipalmatus* (Smith), *C. oldhami* (Theobald), *Gekko gecko* Linnaeus, *Hemidactylus frenatus* Duméril & Bibron, *H. platyurus* (Schneider), and *Ptychozoon lionotum* Annandale; the colubrid *Ahaetulla prasina* (Boie); the pareatid *Pareas carinatus* Wagler; the pythonid *Python brongersmai* Stull; and the viperids *Trimeresurus* (*Popeia*) *phuketensis* Sumontha, Kunya, Pauwels, Nitikul & Punnadee, 2011 and *Tropidolaemus wagleri* Wagler. When handled, all individuals defended themselves by biting. This nocturnal species seems mostly restricted to primary and mature secondary forest and is probably threatened by forest alteration. The type specimens were briefly kept in captivity and fed on ground crickets, cave crickets (Orthoptera) and meal worms (Coleoptera, Tenebrionidae). The female paratype laid two eggs in captivity a few days after it was captured, but they failed to hatch.

Etymology. The specific epithet *phuketensis* refers to Phuket Island, on which the type locality is situated. Suggested common names: *Took-kai Phuket* (Thai), Phuket bent-toed gecko (English), *Cyrtodactyle de Phuket* (French); *Phuketkromvingergekko* (Dutch).

FIGURE 8. Biotope of *Cyrtodactylus phuketensis* sp. nov. in Khao Phra Thaeo Non-hunting Area. Photo by O.S.G. Pauwels.

Discussion

Among the *Cyrtodactylus* species occurring on the Sunda Shelf in Thailand, Peninsular Malaysia, Borneo, Java and Sumatra, only seven possess a precloacal groove: *C. aurensis* Grismer from Pulau Aur, Malaysia, *C. cavernicolus* Inger & King from Borneo, *C. macrotuberculatus* (males only), *C. marmoratus* Gray from Java, *C. pulchellus* which occurs in Thailand and Peninsular Malaysia, *C. semenanjungensis* Grismer & Leong from Peninsular Malaysia, and *C. stresemanni* Rösler & Glaw from Peninsular Malaysia. From *C. aurensis*, *C. cavernicolus*, *C. semenanjungensis* and *C. stresemanni*, *C. phuketensis* sp. nov. can be readily distinguished by the presence of femoral pores. From *C. marmoratus* it is readily distinguished by the possession of enlarged median subcaudals. From *C. pulchellus*, it can be easily separated by its lower number of ventral scales (22–24 versus 33–35 cf. Table 1 in Grismer & Ahmad 2008), its continuous series of femoro-precloacal pores. From all of the above species it is readily distinguished by its strong tuberculation. It is morphologically similar to *C. macrotuberculatus*, with which it shares numerous diagnostic characters besides the large tubercles (see Table 2 for the morphological comparison between populations of *C. macrotuberculatus* and *C. phuketensis* sp. nov.). While the holotype and the four paratypes of *C. macrotuberculatus*, as well as all specimens listed in the Appendix and another individual from Pulau Langkawi illustrated by Chan-ard *et al.* (1999: 113, under *C. pulchellus*) have four dark dorsal bands between limb insertions (n = 32), all *C. phuketensis* sp. nov. known so far, i.e., the holotype, the male paratype THNHM 15378, the nine individuals shown on Fig. 7 plus four additional individuals observed by us *in situ* but not photographed and a specimen illustrated in the Visitor Center of Khao Phra Thaeo Non-hunting Area (n = 16), have three dark bands between limb insertions. The only known exception is the female paratype QSMI 1170, which shows an irregular pattern, made of three bands plus part of an incomplete fourth band between limb insertions. Other differences between *C. macrotuberculatus* and *C. phuketensis* sp. nov. are the possession by the female paratype of *C. phuketensis* sp. nov. of a precloacal groove, while the groove is absent from all known female *C. macrotuberculatus* (Grismer & Ahmad 2008), and the lower number of subdigital lamellae under the 4th toe in *C. phuketensis* sp. nov. (19 vs. 21–23, see Table 2).

TABLE 2. Morphological comparison between *Cyrtodactylus macrotuberculatus* and *C. phuketensis* **sp. nov.** (data for *C. macrotuberculatus* from Grismer & Ahmad 2008, Grismer 2011 and comparative material listed in the Appendix).

	Cyrtodactylus macrotuberculatus	*Cyrtodactylus phuketensis* sp. nov.
Maximal known SVL	120.1	114.7
Strong tuberculation	Yes	Yes
Tubercles on forelimbs	Yes	Yes
Tubercles on hind limbs	Yes	Yes
Tubercles on head and occiput	Yes	Yes
Tubercles on at least 1st third of tail	Yes	Yes
No. of paravertebral tubercles	40–47	40–43
No. of longitudinal rows of tubercles	22–26	23–24
No. of ventral scales	19–22	22–24
Enlarged median subcaudals	Yes	Yes
No. of subdigital lamellae on 4th toe	21–23	19
No. of femoro-precloacal pores	35–37	33–36
Reticulate pattern on head	No	No
Precloacal groove present in both sexes	No (only in males)	Yes
Number of dark bands between limbs insertions	4 (n = 32)	3 (3.5 in one individual) (n = 10)
No. of dark rings on original tail	9–10	8

Another recently discovered insular species, *Cyrtodactylus surin* Chan-ard & Makchai, 2011 also from southwestern Thailand (Surin Islands, Phang-Nga Province), was compared to *C. macrotuberculatus* because of its

strong dorsal tuberculation, which characterizes *C. phuketensis* sp. nov. However, *C. surin* lacks a precloacal groove, femoral pores and large tubercles in the gular region and throat, and is smaller (maximum SVL 80.4 mm) than *C. phuketensis* sp. nov.

Cyrtodactylus phuketensis sp. nov. is the third species of *Cyrtodactylus* recorded from Phuket Island, after *C. brevipalmatus* and *C. oldhami* (Leong *et al*. 2003). It is the third squamate species believed to be endemic to Phuket Island, along with *Cnemaspis phuketensis* and *Trimeresurus* (*Popeia*) *phuketensis*. *Cyrtodactylus phuketensis* sp. nov. and *Trimeresurus* (*Popeia*) *phuketensis* share the same type locality and were found less than a meter from each other.

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APPENDIX. Comparative material examined

Cyrtodactylus pulchellus: Malaysia—Penang: Pulau Pinang; Empangan Air Itam LSUHC 6668, Moongate Trail LSUHC 6726–29, 6785, Air Terjun Titi Kerawang LSUHC 9967–68, 10022, Penang Hill ZRC 2.117, 2.5197, 2.4854, 2.5857.

Cyrtodactylus macrotuberculatus (in addition to type series listed in Grismer & Ahmad 2008): Malaysia—Kedah: Gunung Raya LSUHC 7532, 9428–29, 9432, Gunung Machinchang LSUHC 7560, 9133, 9448–50, Hutan Lipur Sungai Tupah LSUHC 9671–73, 9690, 9693, Bukit Wang 10329–30, Ulu Muda LSUDPC 6323. Perlis: Perlis State Park LSUHC 9214, 9980–81, 10067, ZRC 2.4869, Bukit Chabang LSUHC 9686, 10037–38, Chuping ZRC 2.1919.