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Notes on *Microhyla inornata* Boulenger (Anura: Microhylidae) in Taiwan

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ABSTRACT.—Specimens of *Microhyla inornata* were collected at the southern tip of Taiwan. Descriptions of adults and tadpoles are presented. We show that the separation of different color morphs of the species into subspecies is probably inappropriate. Tadpoles of *M. inornata* can be distinguished from *M. ornata* in mouth morphology, tail shape, and pigmentation. Tadpoles of this species may eat macrophytic plant material in the water, regardless of their beakless mouthparts, in addition to filter feeding on microorganisms. *Microhyla inornata* breeds during and immediately after the heavy rain. Duration of development (from eggs to froglets) is less than three weeks. Thus, this species is considered an explosive breeder. Mating calls of *M. inornata* consist of three frequency bands at 4.4-5.7 (fundamental), 8.8-10.0, and 14.0-15.0 (two harmonics) kHz, respectively.

The occurrence of *Microhyla inornata* Boulenger in Taiwan was first documented when Boulenger (1909) described the new species *M. steinegeri* on the basis of five specimens collected by Mr. H. Sauter from Kanshirei, Formosa (=Taiwan; Fig. 1A). With reservation, Parker (1928, 1934) treated *M. steinegeri* as a synonym of *M. inornata*. Then Gressitt (1938) described a new species, *Rana gracilipes*, based on only one specimen from Kuraru (=Ken-ting Park), Formosa (=Taiwan) (Fig. 1C), but it was later considered a junior synonym of *M. inornata* (Matsui and Busack, 1985). Recently, Lue and Chen (1982) collected a specimen from Kanshirei. Kuramoto (pers. comm.) also collected two female specimens from Manchou, Pingtung (Fig. 1D). These nine specimens are, as far as known, representative of *M. inornata* from Taiwan. *Microhyla inornata* occurs in Burma, Thailand, peninsular Malaysia, Sumatra, Vietnam (Cochin China), and probably the Andamans (Parker, 1928, 1934; Taylor, 1962; Berry, 1975; Pillai, 1977).

Three additional species of *Microhyla* are found in Taiwan: *M. butleri*, *M. heymonsi*, and *M. ornata*. They also occur in the coastal provinces of China (e.g., Fukien, Kwangtung, and the island of Hainan). Taiwan was connected to mainland China by the Taiwan Strait in the Pleistocene (Kano, 1940). The range of *M. inornata*, on the other hand, is not continuous. Parker (1928) synonymized *M. steinegeri* with *M. inornata* with a question mark and suspected "the range of *inornata* is considerably greater than is at present known; further exploration

in S. China and Formosa alone can settle this point satisfactorily." Unfortunately, until now we can not find any evidence as to the occurrence of *M. inornata* on mainland China (Liu and Hu, 1961; and the references therein).

In August 1985, we found a breeding population of *M. inornata* at the southern tip of Taiwan (Fig. 1C), the same locality where Gressitt (1938) obtained the type of *R. gracilipes*. Our discovery not only confirms the occurrence of the species at that locality, but enable us to assess morphological variation within the population, describe its life history, and analyze mating calls. Our results are compared to those from populations outside of Taiwan.

MATERIALS AND METHODS

We collected 18 adult frogs and a series of eggs and tadpoles, now deposited in the Department of Zoology, National Taiwan University (NTUM) and the British Museum (Natural History) (BMNH). Among the adults, a pair (NTUM 1034-35) were from Ta-ping-ding (elev. 150 m) (Fig. 1B) and the others (NTUM 1036-49, BM1986.670-671) from Ken-ting Park (elev. 1-300 m) (Fig. 1C), Pingtung, Taiwan (Fig. 1). Average meteorologic data (1900-1970) of the area are: annual precipitation 2200 mm, with rainfall largely accumulating in summer (2030 mm from May through October); mean annual temperature 25.3°C (lowest 20.4°C in January, highest 27.8°C in July). Both Ken-ting Park and Ta-ping-ding consist of abundant uplifted coral reefs, but their vegetation are different. Ken-ting Park is a protected natural forest where *Ficus benjamina*, *Diospyros maritima*, *Bischofia javanica*, and *Drypetes littoralis* predominate (Miyawaki et al., 1981), whereas *Leucaena glauca* plantations and cultivated plants have replaced

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the natural vegetation at Ta-ping-ding. Amphiplexed pairs laid their eggs in portable aquaria. A few eggs were preserved for measurement, but most were allowed to hatch. Tadpoles were reared at ambient temperature (allowed to fluctuate with the environment) in the laboratory and fed boiled swamp cabbage (*Ipomoea aquatica*). Calling males were found in a gully between two uplifted coral reefs at Ken-ting Park and their calls were recorded with a cassette-tape recorder (Sanyo, M1780F) with a built-in microphone. Sounds were analyzed with a sonograph (Kay Elemetrics Co., Model 7800) to produce a frequency distribution spectrograph. The pulse rate and duration were counted on an oscilloscope (Nicolet Instrument Co., Model 201).

Adult *M. inornata* are compared to the same species from populations outside of Taiwan based on the description by other authors (Boulenger, 1890; Parker, 1928, 1934; Taylor, 1962; Berry, 1975). Tadpoles are compared only to those of *M. ornata* because both Smith (1930) and Parker (1934) had been unable to distinguish tadpoles of these two species; and because, in Taiwan, tadpoles of *M. butleri* and *M. heymonsii* can be distinguished easily from those of *M. ornata* and *M. inornata* (see Parker, 1934, pp. 126–127, for keys of *Microhyala* tadpoles).

RESULTS AND DISCUSSION

The external morphologies of adults and tadpoles of *M. inornata* have never been adequately illustrated and we provide that information here.

Description of Adults.—Head as wide or wider than long; snout obtuse, slightly longer than diameter of eye; nostrils large, round, moderately protuberant, directed anterolaterally, much nearer to tip of snout than to eye; canthus rostralis rounded; loreal region almost vertical; loreal distance shorter than eye diameter; interorbital distance about 1.5–2.2 times width of upper eyelid, much longer than internarial distance; tympanum hidden; choanae large, round, no ridge between them; tongue much longer than wide, its posterior border rounded, posterior two-thirds not adherent to floor of mouth; males with vocal slits near jaw angle and single subgular vocal sac; supernumerary palmer tubercles on hands large, several in number; subarticular tubercles strongly developed; no nuptial pad in males; fingers II < I < IV < III in order of length; tips of fingers blunt; heels overlapping when thighs are placed at right angle to body; tibio-tarsal joint reaches between shoulder and nostril; tibia shorter than foot; no tarsal fold; inner metatarsal tubercle prominent, rounded or elliptical; outer metatarsal tubercle indistinct; supernumerary tubercles of

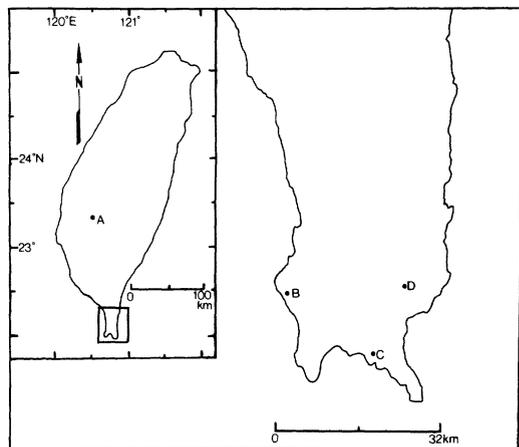


FIG. 1. The map of Taiwan (inset map) and the collecting localities of *Microhyala inornata* mentioned in the text. A, Kanshirei; B, Ta-ping-ding; C, Ken-ting Park; D, Manchou.

foot tiny, numerous; subarticular tubercles of toes strongly developed; toes with rudimentary webs; tips of toes blunt except that of fourth toe which is slightly swollen; toes I < II < V < III < IV in order of length. Dorsal surface with numerous small warts; throat and belly with numerous tiny granules; posterior side of thigh prominently granulated; feeble supratympanic fold present.

Comparing our sample of *M. inornata* from Taiwan with the original description (Boulenger, 1890) and the description of those from other regions (Taylor, 1962; Berry, 1975), we find that there are minor differences in external characters. In our Taiwan sample the ratio of interorbital distance to width of upper eyelid is about 1.5–2.2; there is a very slight rudiment of webbing between the toes, and the tips of toes are blunt, except for the fourth toe whose tip is swollen. Populations from Sumatra, Malay Peninsula, and Thailand have the following distinguishing features: the ratio of interorbital distance to the upper eyelid is about 1.33 (Parker, 1934); there is no web between the toes (Boulenger, 1890, 1912; Taylor, 1962; Berry, 1975) and the tips of toes are swollen (Boulenger, 1909, 1912; Parker, 1934; Taylor, 1962; Berry, 1975).

Color and Its Variation.—The most remarkable variation of *M. inornata* is in its color. The color in life of our sample was: dorsal surface lustered with purple to orange brown or dark brown, a midline occasionally running from between two eyes to rump; four types of markings on dorsum were recognized; black stripes (type I), marbled with black (type II), irregular spots (type III), and sparsely freckled with black (type IV) (Fig. 2); a 1.5–2.0 mm wide black stripe from the tip of snout through eye, to groin, sometimes mar-

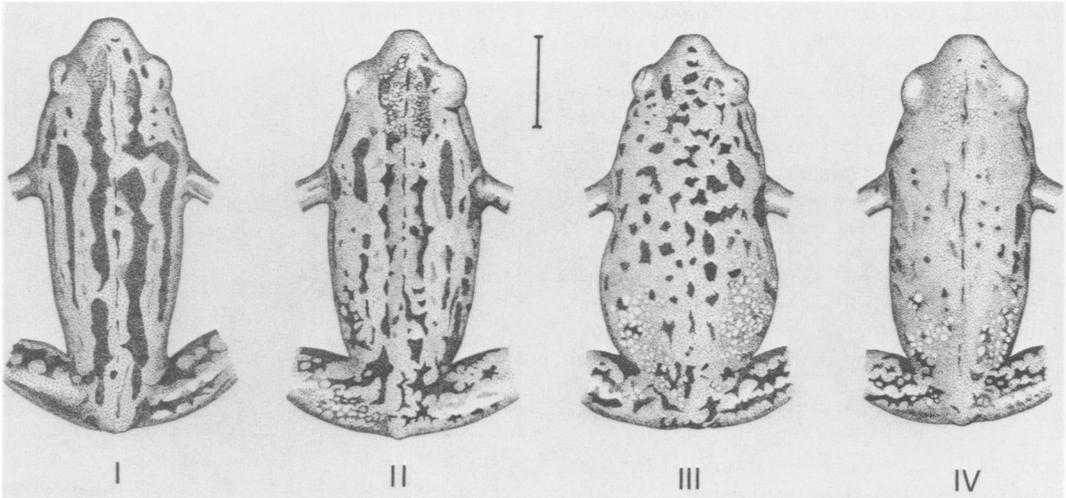


FIG. 2. Four types of dorsal markings of *Microhyla inornata*. Scale equals 5 mm. (Tubercles on back are not shown here.)

bled along flank; pupil black and rounded; iris golden; white spots on upper lip tend to form continuous irregular white line from mouth angle to front of the eye, but only white spots occur on lower lip; fawn or orange on dorsum of four limbs, with peppering of black; venter greyish white, marbled with black; throat of male black; ventral surface of four limbs white. Markings on the dorsum of *M. inornata*, reported in the literature are: Sumatra, "spotted or marbled with black" (Boulenger, 1890); Malay Peninsula, "spotted or marbled with black,

the spots sometimes forming longitudinal stripes" (Berry, 1975); Kanchirei, Taiwan, "spotted or freckled with black" (Boulenger, 1909) and a few light spots on the dorsum (Lue and Chen, 1982); in Thailand Taylor (1962) recognized two subspecies, according to the spotted or linear markings on dorsum, *M. i. inornata* and *M. i. lineata* from northern and southern part of Thailand, respectively. It seems to us that both correspond to one of the four types in our sample, and that the variation in color is present in a single population within the species.

TABLE 1. Comparison of measurements between two sexes of adult *Microhyla inornata* from southern tip (Ken-ting Park) of Taiwan (measurements in mm, mean \pm SD).

Characters	Male N = 13	Female N = 3	t-value
Snout-vent length	23.0 \pm 1.14	27.0 \pm 1.25	4.94**
Head length	7.4 \pm 0.39	8.0 \pm 0.35	2.74**
Head width	7.8 \pm 0.51	8.5 \pm 0.56	2.11
Snout-eye length	3.1 \pm 0.32	3.2 \pm 0.20	0.52
Internarial distance	1.9 \pm 0.21	1.9 \pm 0.10	0.74
Interorbital distance	3.0 \pm 0.15	3.2 \pm 0.10	2.32*
Snout-nostril length	1.1 \pm 0.13	1.2 \pm 0.15	1.76
Nostril-eye length	1.6 \pm 0.16	1.7 \pm 0.12	1.21
Upper eyelid width	1.6 \pm 0.20	1.7 \pm 0.15	0.12
Eye diameter	2.6 \pm 0.18	2.8 \pm 0.21	1.32
Distance between axillae	8.1 \pm 0.57	9.1 \pm 0.75	2.27*
Axilla-groin length	10.2 \pm 0.86	12.2 \pm 1.15	2.87*
Distance between groins	5.9 \pm 0.98	7.2 \pm 1.29	1.60
Forelimb length	16.7 \pm 2.00	18.9 \pm 1.10	3.07**
Hindlimb length	35.7 \pm 1.79	39.1 \pm 1.95	2.69*
Tibia length	10.8 \pm 0.69	11.7 \pm 0.10	4.31**
Tibia width	3.1 \pm 0.61	3.7 \pm 0.17	3.23**
Foot length	11.6 \pm 0.81	13.7 \pm 1.00	3.45**
Interorbital distance/ Upper eyelid width	1.9 \pm 0.27	1.9 \pm 0.24	0.48

* $P < 0.05$, ** $P < 0.01$.

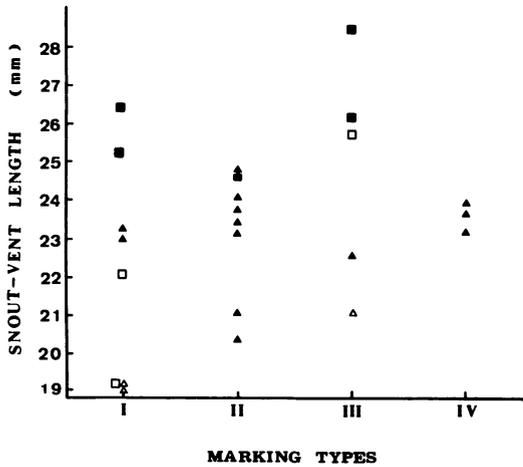


FIG. 3. Plots of snout-vent length of male (triangle) and female (square) *Microhyla inornata* from Kenting Park, Taiwan (black) and from Thailand* (white) (*data adopted from Taylor, 1962). I, II, III, and IV are four markings types in Fig. 2.

Measurements.—Females are significantly larger than males in 10 measurements; snout-vent length, head length, interorbital distances, distance between axillae, axilla-groin length, forelimb length, hindlimb length, tibia length, tibia width, and foot length (Table 1). Larger size in females is usually positively correlated with increased clutch size. Taylor (1962) noted that the spotted type of *M. inornata* was larger in size than the linear type in Thailand. The frogs of each marking type in our sample do not differ much (Fig. 3). However, the population from Taiwan seems to be larger in size than that from Thailand (Fig. 3).

Description of Tadpoles (at Stage 31–36).—Head-body elliptical and depressed; snout broadly round; nostril dorsal, little nearer to tip of snout than to eye; naso-orbital groove distinct, slightly curved, almost transversely across head, extending from nostril to anterior end of eye; eye lateral, little nearer to tip of snout than to base of hindlimb; interorbital distance about 7 times internarial distance; spiracle open on median line of ventral surface of body near anus; anus median, anal tube short, anal flap absent; tail height/body height ratio 0.7–1.3; tail length/tail height ratio 2.3–3.2; tail height/musculature height ratio 2.6–3.2 (tail height and musculature height are measured at the highest place of tail fin and at the vent region, respectively); anterior half of tail nearly equal in height, then acutely narrowed to posterior third to form filamentous rest of tail, tip of tail pointed; dorsal fin narrower than ventral fin.

Mouth dorso-terminal, jaw and horny teeth absent; horizontal dorsal lip narrow, clearly defined from head behind by a narrow groove,

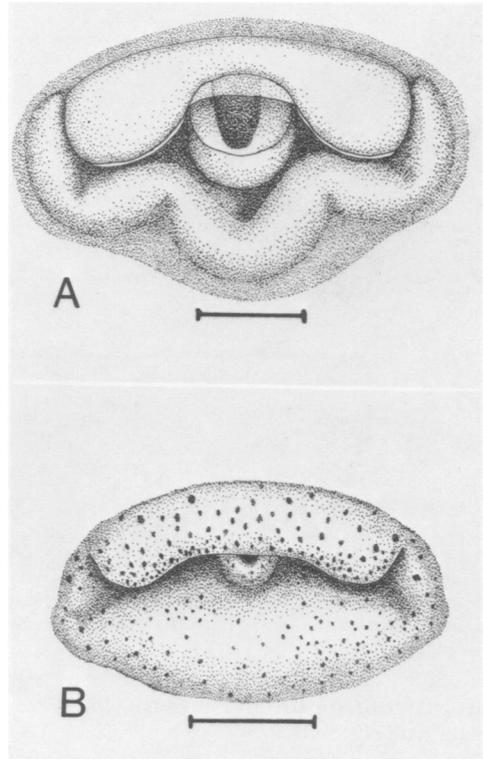


FIG. 4. Anterior view of the mouthparts of the tadpoles of *Microhyla inornata* (A) and *M. ornata* (B). Not drawn to the same scale. Each scale equals 1 mm.

concave in front, posterior half of concavity replaced by transparent membrane, its lateral border free but continuous to ventral lip below; ventral lip vertical, its median part protruded anteriorly in a U-shaped appearance, its anterior end broadly rounded and slightly extruded anteriorly beyond upper lip.

Comparison of the Tadpoles of *M. inornata* and *M. ornata*.—Smith (1930) and Parker (1934) suggested that tadpoles of *M. inornata* were indistinguishable from those of *M. ornata* from the Malay peninsula. Heyer (1971b) found that, in both the natural environment and in preserved specimens, tadpoles of *M. inornata* were darker than those of *M. ornata*. We compare tadpoles of both species from the southern tip of Taiwan and find that they differ conspicuously in mouth morphology, tail shape, and pigmentation. The dorsal lip of *M. inornata* is concave medially, with a transparent membrane in the concavity, while that of *M. ornata* is slightly convex and lacks the transparent membrane (Fig. 4). The anterior half of the tail is equal in height, then abruptly narrows with rest of the tail filamentum in *M. inornata*, whereas in *M. ornata* the tail is highest near its base, gradually narrows to

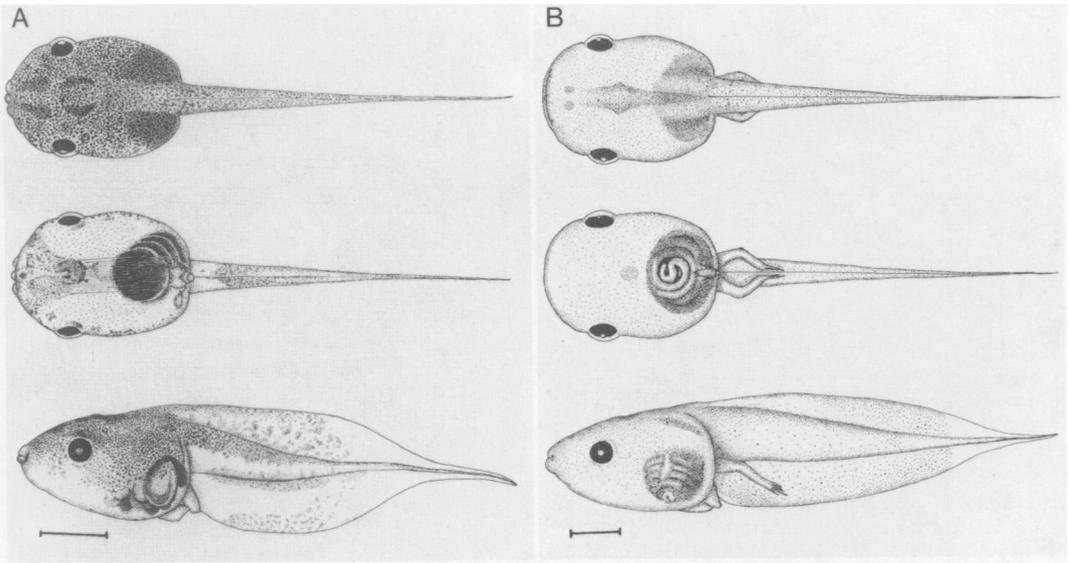


FIG. 5. Dorsal (upper), ventral (middle) and lateral (lower) view of the tadpoles of *Microhyla inornata* (stage 25) (A) and *M. ornata* (stage 36) (B). Not drawn to the same scale. Each scale equals 2 mm.

the posterior fourth and then sharpens to its distal tip (Fig. 5).

Comparing the tail length/tail height ratio (2.8 in *M. inornata*, 3.8 in *M. ornata*) and tail height/tail musculature height ratio (2.8 in *M. inornata*, 2.0 in *M. ornata*), it is apparent that *M. inornata* has a broader fin than *M. ornata* (Table 2). The dorsal surface of the body and the non-filamentous portion of the tail, except the narrow areas beside the muscular tail, are dark brown in *M. inornata*, but are only sparsely pigmented with black in *M. ornata*.

Food and Feeding of the Tadpoles.—All tadpoles of the *Microhyla* species are beakless. They are

reported as midwater filter feeders (*M. ornata* and *M. butleri*) or surface film feeder (*M. heymonsii*) (Heyer, 1973). So when we first observed *M. inornata* tadpoles nibbling on the boiled *Ipomoea aquatica*, we thought they were collecting microorganisms that grew on the surface of the macerated leaves. But then we found that: a) leaves after being "scraped" by the tadpoles apparent faded in green color. In fact, spots of leaves which had been extensively explored by the tadpoles were devoid of pigments and the underlying veins were exposed; b) feces of tadpoles that accumulated on the bottom of the aquarium were apparently green in color; and c) the transparent coiled guts of living tadpoles showed shades of green.

Even though the gut contents of the tadpoles were not analyzed, we are quite certain, based on the above observations, that *M. inornata* tadpoles can use macrophytic plant material as a food source. In fact, our tadpoles reared in the laboratory metamorphosed into froglets with the boiled vegetable as the only food. However, Li and Lin (1935) and Savage (1952) thought microhylid tadpoles are specialized for microphagy. Heyer (1973) found diatoms and filamentous algae in the guts of *M. ornata* tadpoles and none of the *Microhyla* tadpoles swam near underwater plants or fed on them. In natural environments tadpoles of *M. inornata* may feed on floating microorganisms. But whether this "scraping" feeding behavior in the laboratory is due to the crowding and the shortage of algae in the water still need further observation.

TABLE 2. Comparison of measurements in tadpoles of *Microhyla inornata* (stage 31–36) and tadpoles of *M. ornata* (stage 37) from Ken-ting Park, Taiwan (in mm, mean \pm SD).

Characters	<i>M. inornata</i> N = 17	<i>M. ornata</i> N = 8
Total length	16.0 \pm 0.89	23.1 \pm 1.07
Body length	5.7 \pm 0.28	7.5 \pm 0.20
Body height	3.5 \pm 0.13	4.1 \pm 0.24
Interorbital distance	2.7 \pm 0.13	3.7 \pm 0.20
Tip of snout to eye	2.2 \pm 0.13	3.0 \pm 0.13
Eye to base of hindlimb	3.8 \pm 0.17	4.5 \pm 0.14
Tail length	10.3 \pm 0.72	15.6 \pm 1.07
Tail height	3.8 \pm 0.39	4.2 \pm 0.34
Tail musculature height	1.3 \pm 0.05	2.1 \pm 0.15
Tail length/tail height	2.8 \pm 0.25	3.8 \pm 0.31
Tail height/tail muscul. height	2.8 \pm 0.34	2.0 \pm 0.14

Breeding and Development.—We observed *M. inornata* breeding at Ken-ting Park and at Ta-ping-ding between 17–23 August 1985. Beginning on 15 August, there were five days of incessant rainfall (more than 300 mm recorded). At Ken-ting Park, males called day and night in a temporary pond as well as in the grass surrounding the pond. Females were only found during the nights swimming toward the calling males. At Ta-ping-ding, two amplexing pairs were swimming in the water, and another four males were in the water pit. When the rain stopped, the frogs stopped breeding and disappeared. Only tadpoles were found on 20 August.

The eggs were deposited as a single layer film, floating at the pond's surface, with the jelly coats sticking to one another. The egg film was attached to grasses and rocks in water. Three clutches contained 242, 334, and 304 eggs. The ova had a single jelly coat and distinctly pigmented animal hemisphere. In preservative, 28 ova at or prior to the four-celled stage averaged $2.1 \pm (\text{SD}) 0.11$ mm in diameter. The eggs hatched within 24 hr. In the first week, tadpoles were less pigmented and somewhat transparent and then turned much darker as more pigments appeared. Forelimbs erupt and the tadpoles metamorphose into froglets as early as 17–20 days. The mean snout-vent length of six froglets with a spot-like vestigial tail was $6.5 \pm (\text{SD}) 0.31$ mm.

The detailed breeding habits of *M. inornata* have never been reported. The copious rainfall made possible the suitable oviposition sites, and the tadpoles grew to metamorphosis before the rain water drained. *Microhyla inornata* is sympatric with *M. ornata* and *M. heymonsi* which also breed in ponds or rain pools (Smith, 1917; Pope, 1931; Chang and Boring, 1939; Liu, 1940; Dring, 1979). However, we did not find them or any other species sharing the breeding sites with *M. inornata* in Ken-ting Park. In Wushan-tou Dam, Tainan (southern Taiwan; about 40 km SW of Kanshirei), males of the three *Microhyla* species were calling at the same time during the rain from 21 to 23 August 1987. Male *M. inornata* called in the pond and in the grass only during the rain, while male *M. ornata* and *M. heymonsi* frogs called continuously during and after the rain. Only *M. inornata* were found in amplexus during the rain, while no females of the other two species were present at the pond during the two-day period (S.-H. Wu, pers. obs.). Male *M. heymonsi* is known to call all year in Singapore (Berry, 1964). And in Taiwan, calls of *M. ornata* can also be heard in the nights throughout the year (Lue et al., 1985). In Taiwan, *M. ornata* and *M. heymonsi* usually breed in open habitats (small ponds in the grasslands)

and will call from beneath the vegetation (usually grass) in the night or during and after rain (H.-T. Yu, pers. obs.). Similar patterns are found in the three species of North American microhylid frogs (Wells, 1977). *Gastrophryne olivacea* and *Hypopachus variolosus* breed days after summer rains while *G. carolinensis* breeds in late spring and summer. Males of the two former species call in groups and will actively search for females when in dense groups; the latter call from concealed isolated sites. The habitats in the Ken-ting area where breeding *M. inornata* was found is usually forest, and in no case did we find any *M. inornata* in open areas. The very short period of development of *M. inornata* (less than three weeks), as well as their sudden appearance for breeding after the heavy rains may suggest that this species is an explosive breeding type (Wells, 1977). The weather at the southern tip of Taiwan certainly provided a suitable environment for *M. inornata* to breed: 90% annual precipitation occurred in summer, due mostly to several typhoons and thunderstorms.

Vocalization.—*Microhyla inornata* called from banks adjacent to water or from a floating posture in water. At Ta-ping-ding, we saw an amplexed male calling in water. Mating calls sounded more like a cricket than a frog and this is also true for the population from Thailand (Heyer, 1971a). The mating call of *M. inornata* recorded at an air temperature of 25°C contained a single long note which consisted of many fine pulses repeated rapidly. The analysis of 10 calls on an oscilloscope revealed the following characteristics (mean \pm SD): duration 1.39 ± 0.27 sec, pulse/call 82.6 ± 1.5 , and pulse/sec 59.4 ± 2.5 (Table 3). There were three frequency bands on the sonogram (see Fig. 6): the fundamental or dominant was 4.4–5.7 kHz; the second and third harmonic were apparent at 8.8–10.0 and 14.0–15.0 kHz, respectively. Modulation of frequencies is lacking. The dominant and the second harmonic were slightly lower at the very beginning. The third harmonic was weak in the proximal two thirds and strengthened in the terminal third, but was too weak to be detected in some calls.

The vocal characteristics of *M. inornata* from Taiwan deviate little from those from Thailand (Table 3), except that Heyer (1971a) analyzed only the 80–8000 Hz frequency range so the comparisons of the second and third harmonics are not possible. It is well known that temperature affects the vocal structure of anurans. Kuramoto (1977) reported the clear harmonics of *M. ornata* found at lower temperatures could not be detected at higher temperatures. Temperature was not reported for Heyer's recording calls of *M. inornata* in Thailand. We can not ascertain whether the possible difference in

TABLE 3. Comparison of characteristics of mating calls of *Microhyla inornata* from Taiwan and from Thailand (mean \pm SD shown in parentheses).

Locality	N	Duration (sec)	Pulse/call	Pulse/sec	Dominant frequency (kHz)	Harmonic interval (kHz)
Taiwan	10	1.11-1.92 (1.39 \pm 0.27)	67-113 (82.6 \pm 15.0)	56-65 (59.4 \pm 2.5)	4.4-5.7	8.8-10.0 14.0-15.0
Thailand*	4	0.79-2.02	66	66	4.4-6.5	absent

* Data from Heyer, 1971a.

harmonics were caused by temperature or reflect a genetic distinction between these populations.

The almost identical vocal characteristics between these two populations, except for the third harmonic, further verified the occurrence of *M. inornata* in Taiwan. But it also raises another question: why does the species not occur in the coastal provinces in mainland China? Another species, *M. pulchra*, is only found in China but not in Taiwan. Is it competition between *M. pulchra* and *M. inornata* that has caused the local extinction of *M. inornata* in China or is it only the result of insufficient collection? Still another possibility is that *M. inornata* has arrived in Taiwan from some other land connections with the Asia continent. A more in depth comparison of the fauna composition between Taiwan and other geological provinces of interest may shed light on this question.

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T. Clarke of the British Museum (Natural History) confirmed our identification of the *M. inornata* specimens. Mitsuru Kuramoto critically reviewed the manuscript and gave us information on his *M. inornata* specimens. Richard J. Wassersug also gave us many valuable suggestions. The manuscript was greatly improved by comments from Arnold G. Kluge and Mark Wilkinson. The field trip was supported by the Headquarters of Ken-ting National Park, R.O.C. Finally, we wish to thank Chen-Meng Kuo for his continuous encouragement and support.

LITERATURE CITED

- BERRY, P. Y. 1964. The breeding patterns of seven species of Singapore anura. *J. Anim. Ecol.* 33:227-243.
- . 1975. The amphibian fauna of Peninsular Malaysia. Tropical Press, Kuala Lumpur. 130 pp.
- BOULENGER, G. A. 1890. Reptiles and Batrachia. *In* The fauna of British India, including Ceylon and Burma. London. 541 pp.
- . 1909. Descriptions of four new frogs and a new snake discovered by Mr. H. Sauter in Formosa. *Ann. Mag. Nat. Hist.* 8:492-495.
- . 1912. A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore including the adjacent islands. Taylor and Francis, London. 294 pp.
- CHANG, T. K., AND A. M. BORING. 1939. Notes on some amphibians and reptiles from Kwangsi. *Bull. Fan. Mem. Inst. Biol. (Zoo.)* 6:233-238.
- DRING, J. C. M. 1979. Amphibians and reptiles from northern Trengganu, Malaysia, with descriptions

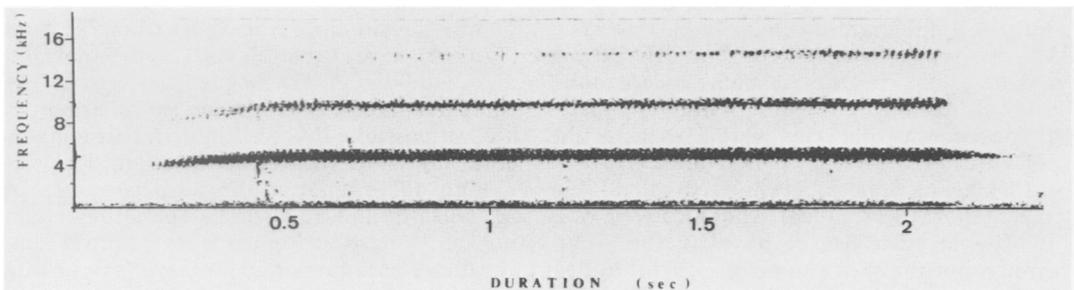


FIG. 6. Sonogram of mating calls of *Microhyla inornata* from Keng-ting Park, Taiwan.

- of two new geckos: *Cnemaspis* and *Cyrtodactylus*. Bull. Brit. Mus. (Nat. Hist.), Zool. 34:184-241.
- GRESSITT, J. L. 1938. Some amphibians from Formosa and the Ryu Kyu Islands, with description of a new species. Proc. Biol. Soc. Washington 51:159-164.
- HEYER, W. R. 1971a. Mating calls of some frogs from Thailand. Fieldiana (Zool.) 58:61-82.
- . 1971b. Descriptions of some tadpoles from Thailand. Fieldiana (Zool.) 58:83-91.
- . 1973. Ecological interactions of frog larvae at a seasonal tropical location in Thailand. J. Herpetol. 7:337-361.
- KANO, T. 1940. Zoogeographical studies of the Tsugitaka Mountains of Formosa. Shibusawa Inst. for Ethnographical Researches. Tokyo. 145 pp.
- KURAMOTO, M. 1977. Mating calls of the frog, *Microhyla ornata*, from the Ryukyu Islands. Bull. Fukuoka Univ. Education 26(pt. III):91-93.
- LI, J. C., AND C. S. LIN. 1935. Studies of the rain frog, *Kaloula borealis* II. The food and feeding of the embryos and adults. Peking Nat. Hist. Bull. 10:45-53.
- LIU, C. C. 1940. Tadpoles of West China Salientia. J. West China Border Research Soc. Ser. B, 12:7-62.
- , AND S. C. HU. 1961. Tailless Salientia in China. Scientific Press, Beijing. 364 pp. (In Chinese.)
- LUE, G. Y., AND S. H. CHEN. 1982. Amphibians of Taiwan. Zhang Zheng Xiong, Taipei. (In Chinese.)
- , M. C. DO, S. H. CHEN, S. Y. LUE, AND G. S. JUAN. 1985. The limnology and the survey of the herpetofauna of the freshwater area in Nan-Jen Shan. Dept. of Biology, Nat'l Taiwan Normal Univ. and the Headquarters of Ken-Ting Nat'l Park, R.O.C. 55 pp. (In Chinese.)
- MATSUI, M., AND S. D. BUSACK. 1985. A reassessment of the taxonomic status of *Rana gracilipes* Gressitt, 1938 from Taiwan. Herpetologica 41:159-160.
- MIYAWAKI, A., K. SUZUKI, T. C. HUANG, AND C. M. KUO. 1981. Pflanzensoziologische Untersuchungen in Taiwan (Republic of China), Erste Bericht: Kunsten-Vegetation und immergrüne Laubwälder auf dem Berg Nan-Fong-San. Hikobia Suppl. 1:221-223.
- PARKER, H. W. 1928. The brevipitid frogs of the genus *Microhyla*. Ann. Mag. Nat. Hist. 10:473-499.
- . 1934. A monograph of the frogs of the family Microhylidae. British Mus. (Nat. Hist.). 208 pp.
- PILLAI, R. S. 1977. On two frogs of the family Microhylidae from Andamans including a new species. Proc. Indian Acad. Sci. 86(B), No. 2:135-138.
- POPE, C. H. 1931. Notes on amphibians from Fukien, Hainan, and other parts of China. Bull. Am. Mus. Nat. Hist. 61:397-611.
- SAVAGE, R. M. 1952. Ecological, physiological and anatomical observations on some species of anuran tadpoles. Proc. Zool. Soc. London 122:467-514.
- SMITH, M. A. 1917. A list of the batrachians at present known to inhabit Siam. J. Nat. Hist. Soc. Siam 6: 226-231.
- . 1930. The Reptilia and Amphibia of the Malay Peninsula. Bull. Raffles Mus. 3:1-149.
- TAYLOR, E. H. 1962. The amphibian fauna of Thailand. Univ. Kansas Sci. Bull. 43:265-599.
- WELLS, K. D. 1977. The social behaviour of anuran amphibians. Anim. Behav. 25:666-693.

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