

**NEPENTHIPHILOUS LARVAE AND BREEDING HABITS  
OF THE STICKY FROG, *KALOPHRYNUS PLEUROSTIGMA*  
TSCHUDI (AMPHIBIA: MICROHYLIDAE)**

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**ABSTRACT.** - Tadpoles of the microhylid *Kalophrynus pleurostigma pleurostigma* Tschudi, 1838 were collected from cups of the pitcher plant *Nepenthes ampullaria* Jack from a forest reserve in Singapore. *Kalophrynus pleurostigma* is known to be a phytotelm breeder, but its use of pitcher plant cups is novel. This is the second record of nepenthiphily in this family. The larvae of this species is apparently non-feeding, relying on fat deposits in its gut.

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**INTRODUCTION**

The first known record of anuran larvae inhabiting the cups of the carnivorous pitcher plants (*Nepenthes* spp.) in Southeast Asia was by Dover (1928: 13) who found tadpoles in the cups of *Nepenthes ampullaria* at the "Kalang Reservoir" [present Lower Peirce Reservoir], Singapore, in 1926. He however failed to rear these tadpoles to a stage permitting identification. He commented that "... they almost certainly belong to the Bufonidae, possibly to *Bufo melanostictus* Schneider, a very common local toad ..." (p. 13). He had the tadpoles sent to Dr. Malcolm Smith who indicated that "... they belong to a *Bufo*" (p. 13). Dover speculated that "... these larvae only spend their earlier stages in the pitchers, and that when they grow to a size when the small pitchers of *N. ampullaria* are unable to accommodate them comfortably they transfer themselves to water near by" (p. 13).

In Peninsular Malaysia, the eggs of a rhacophorid, possibly *Philautus aurifasciatus* (Schlegel, 1837) were collected from dried cups of *Nepenthes sanguinea* on Genting Highlands, Pahang, Peninsular Malaysia in 1988 (Yong *et al.*, 1988: 4). All the larval stages were found to be completed within the eggs, i.e. direct development. In Borneo, Parker (1934) reported that the larvae of *Microhyla borneensis* Parker, 1926 were obtained from a *Nepenthes* in Sarawak; while Philipps & Lamb (1988: 12) have found adult *Philautus mjobergii* Smith in *Nepenthes villosa*, but did not record any larval stages.

A documentary film by the Singapore Broadcasting Corporation in 1990 - "Nature in Singapore : Rhythm of the Forest", showed anuran tadpoles dwelling in the cups of *Nepenthes*

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*ampullaria* in Bukit Timah Nature Reserve. Through the assistance of the chief ranger, examples of these tadpoles dwelling in *Nepenthes* cups were eventually obtained among secondary forest (Belukar) vegetation near the Catchment Contour Hut, Bukit Timah Nature Reserve.

The tadpoles were successfully reared to metamorphosis and were identified as *Kalophrynus pleurostigma pleurostigma* Tschudi, 1838 (Family Microhylidae). This is the second record of a member of this family breeding in pitcher plant cups, the first being *Microhyla borneensis* (fide Parker, 1934). A subsequent collection obtained a cup with about half a dozen gelatinous eggs attached to the side of the cup near the aperture. The present note is intended to document and discuss this peculiar and interesting habit.

Specimens are deposited in the Zoological Reference Collection (ZRC), Department of Zoology, National University of Singapore; and the Field Museum of Natural History (FMNH), Chicago, Illinois, U.S.A.

### MATERIALS AND METHODS

Cups of *Nepenthes ampullaria* were collected within a three square metre area of the forest. About twenty of the larger cups were plucked at random and a tear made near the base to allow the contents to flow into a plastic vial. Not all tadpole-containing cups were immediately discernible as the tadpoles tend to dive into the debris when disturbed. Only two cups were observed with tadpoles and these were separated. The contents of the other cups were pooled.

A total of 71 tadpoles were obtained. Some of the tadpoles were immediately preserved in 10% formalin, and the rest were left to metamorphose in plastic vials containing *Nepenthes* cup fluid as well as within the pitcher plant cups. No attempts were made to feed the tadpoles. A total of 46 larvae and newly metamorphosed frogs are preserved in the ZRC (Nos. 1.2938-2983). Samples have also been deposited in the FMNH.

### RESULTS AND DISCUSSION

The tadpoles and newly metamorphosed frogs agree very well with the descriptions of *Kalophrynus pleurostigma pleurostigma* Tschudi, 1838 (Microhylidae) given by Inger (1966: 135). *Kalophrynus pleurostigma* is a forest litter dweller which can be found far away from any large water body. In Singapore, the species is, so far, known only from Bukit Timah Nature Reserve. Although it is believed to be largely a primary forest taxon (see Inger, 1966: 135; Berry, 1975: 113), the area where the tadpoles are found would indicate that it is also adaptable to Belukar vegetation (secondary forest), provided there is plenty of leaf-litter on the substrate.

The utilisation of *Nepenthes* cups for spawning constitutes a new record for the species, and probably the second for the family Microhylidae. The only other anurans known reliably to breed or occur in pitcher cups (cf. Yong *et al.*, 1988; Philipps & Lamb, 1988) are rhacophorids. Inger (1966: 135) who described the tadpoles from Borneo collected his larval series from "... very shallow water in a log in primary rain forest". The nepenthiphilous habits of *K. pleurostigmata* thus appear to be an extension of the phytotelmic breeding preferences of the species.

This species has been reported to breed in shallow temporary pools of rain water, rain-filled road ruts and water-filled holes in logs (Inger, 1954, 1956, 1966). The larval features and developmental stages have been described in detail by Inger (1956). The development of the present specimens, most of which were obtained with the hind limb buds visible lasted only four days. All morphological features of the tadpoles agreed with Inger's report. Parker (1934) also mentioned that the species has a short developmental series from specimens reared by Hewitt in Sarawak. Like Inger (1956), he recorded the loss of gills on the fifth day. The front legs erupted on the third day, and tail resorption began on the fourth. The eggs obtained in the present study were not found in the water but stuck to the inside of the pitcher cup near the aperture. The half a dozen eggs measured about 0.5 mm in diameter (including gelatinous mass). They were not firmly attached and slid down into the cup if gently nudged.

Inger (1966: 135) observed that the larvae of the Bornean *K. pleurostigma* do not feed. He noted that the tadpoles possess weakly-developed mouths, rapid development (about 16 days from early gastrulation to resorption of tail), and an apparently yolk-filled gut. Dissections of the various tadpole stages confirm Inger's suspicions. Tadpoles with the hind limb buds developing possess a short, clear gut, the walls of which contain extensive oil or fat deposits. As the hind legs develop and the front limb buds become visible, the deposits become less. Simultaneously, the foregut and oesophagus of some specimens become filled with detritus. As all the limbs become discernible and the tail begins to shorten, the fat/oil deposits disappear completely and most of the gut gets filled with detritus. The mouth also gradually becomes more developed and by the time all the legs are visible, the tongue is already developed. Indications are that the later tadpole stages might derive some nutrition from the detritus within the cup. We have not observed the tadpoles grazing, feeding on fresh insect matter or on the many insect larvae and other invertebrates in the cup. The nepenthophilous larvae of *Microhyla borneensis* have also been reported to have yolk-filled intestines (fide Parker, 1934).

The air-filled lungs are prominent even in the preserved earlier tadpole stages (hind limb buds) and account for their spending most of their time hovering in midwater, or just under the water surface, inclined at an angle, with head towards the water surface. When disturbed, they dive rapidly into the sediment at the bottom of the cup or rearing vial.

The two cups in which tadpoles were observed contained about six specimens each. This agrees well with the six eggs obtained from another cup, and suggests that the number of eggs laid per batch is approximately this number. We are however, uncertain as to how many batches are laid per female.

The newly metamorphosed frogs are excellent jumpers, and it is probably through this mechanism which they exit via the large aperture of the *N. ampullaria* cup. They have been observed to cover a distance of at least 60 cm in one leap. We have observed that they were unable to crawl up the sides of the cups due to the waxy smooth interior surface. In any event, the lip of the aperture is curved inwards in such a way as to prevent easy exit via climbing.

The identity of Dover's (1928) tadpoles remain unresolved as he did not indicate if any specimens were preserved. The authors however, have some doubts as to whether they were bufonids, especially *B. melanostictus*. The breeding habits of *B. melanostictus* (and most *Bufo*) strongly argue against this. During amplexus and spawning, the toads (due to their relatively large size) would probably damage or even destroy the relatively small and frail cups of *N.*

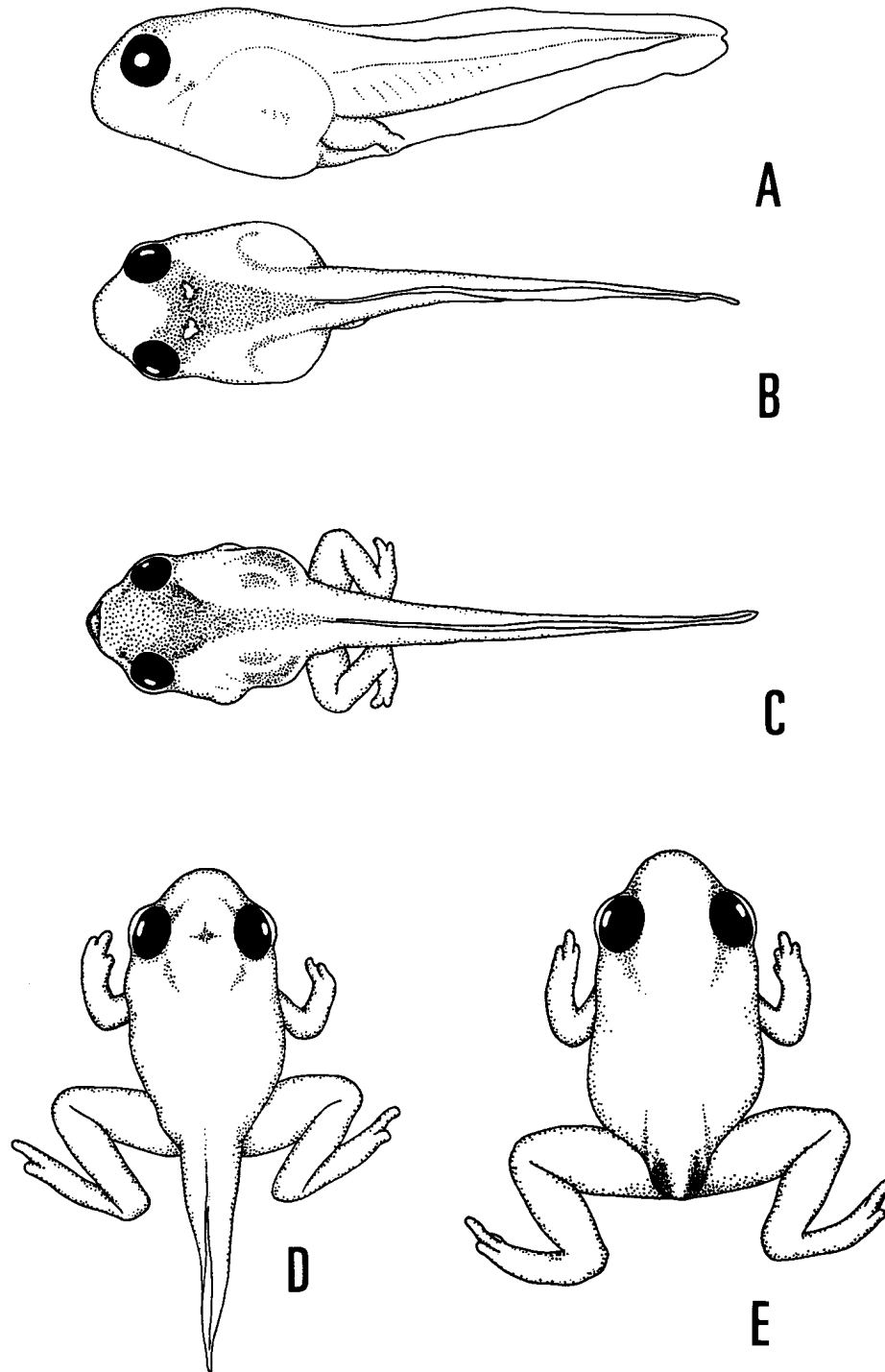


Fig. 1. A-E. Nepenthiphilous larvae of *Kalophrynus pleurostigma*. A, lateral view; B, dorsal view of tadpole with hind limb buds (8 mm total length); C, dorsal view of tadpole with developed hind limbs (9.5 mm total length); D, tadpole with developed fore and hind limbs (6 mm total length); E, newly metamorphosed frog (4.5 mm snout-vent length).

*ampullaria*. Moreover, *Bufo melanostictus* spawns and lays long gelatinous strings with large numbers of eggs in the water. The cups are also unable to accommodate the amplexing pair. Only the smaller bufonids, e.g. the known phytotelm breeder *Pelophyrne brevipes* (Peters, 1867) would be capable of doing so (see Inger, 1960).

The choice of *N. ampullaria* as a breeding site is reasonable. Of the three *Nepenthes* species known from Singapore (see Tan *et al.*, 1983), the cups of *N. ampullaria* are frequently found growing flushed with the forest floor among the leaf litter in moist and well-shaded areas. The cups of *N. ampullaria* are also proportionately shorter, rounder and the aperture wider than the other two species. Its lid is also very small and narrow, and directed backwards, not covering the aperture at all. Although some cups of the other common species *N. gracilis* Korth are sometimes found on the ground, its cups are more cylindrical, the aperture narrower and the lid covers the entire aperture. Egg laying for any anuran would be extremely difficult. The ground pitchers of *N. rafflesiana* Jack are possible breeding sites, but this species is generally less common. Despite many surveys on pitcher plant cup communities of these three species in Singapore and Penang (e.g. Thienemann, 1932, 1934; Llyod, 1942; Beaver, 1979a, b; Fish & Beaver, 1979; Tan *et al.*, 1983; Ng & Lim, 1987; Ng, 1990), no tadpoles since 1926 have been reported until now.

Laessle (1961) and Zahl (1973, 1975) reported that some Central American tree frogs (e.g. Hylidae) take refuge in bromeliads; a well studied phytotelm. The pitcher plant cup phytotelm is potentially more "hostile" than other similar habitats. The cups are known to secrete a variety of digestive enzymes and other chemicals to help digest the arthropod matter which falls in. How the tadpoles manage to survive nevertheless remains puzzling (see Juniper *et al.*, 1989).

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