

The Husbandry of Poison-Dart Frogs (Family Dendrobatidae)

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INTRODUCTION

The striking appearance, complex behavior, and toxic secretions of many species of dendrobatid frogs (Family Dendrobatidae) have long held the fascination of amateur and professional herpetoculturists. These characteristics, combined with a diurnal life style, make dendrobatids a popular frog to maintain and breed in captivity. Not surprisingly, there are a number of published works on dendrobatid husbandry (Cover *et al.* 1994; Cover and Wisnieski 1989; Heselhaus 1988; Schulte 1980; Walls 1994; Weygoldt 1980, 1984; Zimmermann 1986, 1989; Zimmermann and Zimmermann 1981, 1984, 1994).

There are nearly 170 described species of dendrobatid frogs. These are divided into at least eight genera, including *Allobates*, *Aromobates*, *Colostethus*, *Dendrobates*, *Epipedobates*, *Mannophryne*, *Minyobates*, and *Phyllobates* (see Duellman 1993 for a review). Dendrobatids are small frogs, varying in snout-vent length from little more than 1 cm (*Minyobates minutus*) to about 6 cm (*Aromobates nocturnus*).

Dendrobatids are found in the wet tropical areas of Central and South America, occupying a diversity of micro-habitats, including aquatic (one species), terrestrial, riparian, semi-arboreal, and arboreal, depending on the species.

The present paper summarizes the techniques currently used at the National Aquarium in Baltimore (NAIB) to maintain and breed dendrobatid frogs. Over the past fifteen years, NAIB has successfully bred 24 of the 26 species of dendrobatids kept in the collection. This reproductive success has enabled the Aquarium to send hundreds of captive-bred frogs to other zoological institutions and universities in Europe and throughout North America. Currently, NAIB maintains a collection of more than 1000 dendrobatids, in addition to several hundred specimens representing other families of Neotropical frogs.

Housing

Cover and Wisnieski (1989) provide a detailed description of basic caging for dendrobatid frogs at NAIB (updated in Cover *et al.* (1994)). A more detailed discussion of housing and enrichment applicable to dendrobatids is provided by Barnett *et al.* (in press).

The basic enclosure used at NAIB is a 38 L (10 gal) glass aquarium with a floor drain located beneath a false floor. The false floor, made from plastic egg-crate grating, rests on biofilter-ring pilings (sections of PVC pipe may be substituted). The floor is covered with a layer of fiberglass window screening, overlaid by several centimeters (about 1 in) of pea gravel, and covered with a layer of moist sheet moss. There may be a depressed area in the gravel to provide a small, shallow

pond (dendrobatids are not strong swimmers and may drown in deep water). Golden pothos (*Epipremnum aureum*) and cordatum philodendron (*Philodendron oxycardium*), "planted" in their pots, are used to provide cover, perching sites, and in the case of some frog species, oviposition sites. In addition, the plants help to increase humidity in the enclosure and absorb waste products. Pieces of curved cork bark provide cover and serve as feeding platforms. The dark plastic reinforcement cups on the bottom of two-liter soda bottles are fashioned into "privacy huts". They provide retreats and are the preferred oviposition sites for some species of dendrobatids (see Cover *et al.* 1994). Care is taken to intersperse relatively open areas among well-planted ones in the frog enclosures, so that the frogs can easily hunt their insect prey.

The cage is covered with a hinged, vinyl framed lid (aluminum window framing may be substituted) inset with fiberglass window screening. Metal screening can be abrasive on delicate amphibian skin, and is not recommended.

These enriched enclosures are used to house new (quarantined) animals, as well as the permanent collection. Frogs are temporarily transferred to plain enclosures with a wet paper towel substrate and plastic hut only when necessary to collect fresh fecal samples. In our experience, these spartan enclosures are stressful for many dendrobatids. It is also difficult to feed tiny insects to frogs on a wet paper towel; the insects tend to stick to the toweling and get trampled by the frogs or they drown in the water film.

Lighting

The lighting requirements of amphibians are poorly known. A conservative approach, and the one followed by NAIB, is to provide artificial light that mimics, as closely as possible, the spectral characteristics, intensity, and diurnal cycle of light found in the dendrobatid's natural habitat.

At NAIB, dendrobatid cages are illuminated with two, 120 cm (4 ft) "Instant Sun" (Verilux, Inc., Stamford, CT) full-spectrum fluorescent lights. The lights are located approximately 8 cm above the screened tops of the frog enclosures. They are controlled by timers, with a 12 hr on/off cycle, similar in duration to the day/night cycle in the tropics.

Temperature

Optimal temperatures for keeping and breeding lowland species of dendrobatids is 25-27 °C (78-80 °F). At NAIB, post-larval frogs have been successfully maintained at temperatures as low as 23 °C (73 °F). However, their eggs and tadpoles experience high levels of mortality and deformity at this low temperature.

NAIB maintains mountain species of dendrobatids in an air conditioned room kept at 23 °C (73 °F). However, with the exception of several highland/mid-elevation species of dendrobatids (*Dendrobates speciosus*, *Epipedobates espinosai*, *E. tricolor*), all frog eggs are incubated and the resultant larvae are raised at temperatures appropriate for lowland species. In our experience, some species of dendrobatids which thrive as adults in a cool environment (*Dendrobates fantasticus*, *D. imitator*) fail to hatch or have exceedingly prolonged development time and high mortality rates when incubated at 23 °C.

Temperatures above 32 °C (90 °F), for even short periods, may be lethal to dendrobatid frogs.

Rapid temperature changes and extreme temperatures should be avoided when transporting dendrobatids by putting their carrier (e.g. deli cup with moist paper toweling) in a closed Styrofoam box or other insulated container cushioned with shredded newspaper.

Water quality and hydration

Although post-larval dendrobatids are tolerant of chlorine levels typically found in municipal water supplies, eggs and larvae are extremely sensitive. In addition, all stages are very sensitive to chloramines, which may form when chlorine and ammonia are both present. It is recommended, therefore, that tap water used with dendrobatids be run through an activated charcoal filter or aged for at least 24 hrs in an open container to remove the chlorine. Water conditioners sold for use with tropical fish may be used to remove chloramines, as well as several other potentially dangerous contaminants, if these are present. An excellent review of specific water quality standards applicable to amphibians is provided by the National Research Council (1974).

At NAIB, frog enclosures are misted twice daily to keep the environment moist and relative humidity above 70 %. Misting stimulates the frogs to become active and move around their cage, so feedings are always done in concert with one of the waterings. The frogs are misted using a fine FOG-IT spray nozzle (Fog-It Nozzle Co., San Francisco, CA) on a garden hose. The water, drawn from the municipal supply is tempered to 23 °C (73 °F) and dechlorinated by passing the water through a series of activated charcoal filters.

Food and feeding

Stomach-content analyses of wild-caught dendrobatids indicate that they feed on a wide variety of small invertebrates, especially ants (Donnelly 1991; Silverstone 1975, 1976). At NAIB, adult dendrobatids are fed every other day on a diet that alternates between newly hatched to 1 week old crickets (*Acheta domestica*) and flightless fruit flies (*Drosophila melanogaster* and *D. hydei*). Immature dendrobatids, and adults housed in large groups, are fed daily, with the diet alternating between crickets and fruit flies.

Very small dendrobatid froglets (approximately 10 mm snout-vent) have difficulty eating even newly hatched crickets. We successfully maintain them on several species of sprigtail (Order Collembola). We culture these minute leaf litter insects in moist African violet potting mix and feed them commercial flake fish food.

At NAIB crickets are cultured in-house as well as purchased from a commercial supplier. The crickets are fed Ziegler's Cricket Meal (Ziegler Brothers, Inc., Gardners, PA) for at least 48 hr prior to being fed to the frogs. This insures that the insects have an adequate calcium content and positive calcium to phosphorus ratio (Allen and Oftedal 1989).

The fruit flies are reared on *Drosophila* Medium, Formulae 4-24 (Carolina Biological Supply Co, Burlington, NC). Recipes for making culture media are readily available (Flagg 1988; Frye 1992).

Crickets and fruit flies are lightly dusted, just prior to being fed to the frogs, with multiple vitamin and mineral supplements (Nekton-Rep and Nekton-MSA, Nekton-USA, Inc., Clearwater, FL).

Larval dendrobatids, except for obligate oophagous species, are fed Aquarian Vitamin and Mineral Flake Fish Food (Thomas's, Batley, England). Larvae of obligate oophagous species (*Dendrobates granuliferus*, *D. histrionicus*, *D. lehmani*, *D. pumilio*, *D. speciosus*) are raised by their mother in a

bromeliad kept in the home cage. The mother periodically produces unfertilized eggs that she deposits in the bromeliad cup for her young to eat (Weygoldt 1980, Zimmermann and Zimmermann 1981; Brust 1993). To date, no satisfactory substitute diet has been devised, although some success has occurred using the eggs of *Dendrobates auratus* as food for *D. pumilio* larvae (Hiler, pers. comm.). Zimmermann and Zimmermann (1981) successfully used chicken egg yolks to feed *D. histrionicus* and *D. lehmani* larvae, but NAIB has been unable to repeat their results.

The lack of appropriate elements in the captive diet may explain why captive-born dendrobatids of toxin-bearing species do not produce the toxins characteristic of their wild counterparts (Daly *et al.* 1994). Wild-caught specimens do not produce new toxins once captured (presumably also due to a lack of appropriate dietary elements), and in fact they lose some of the toxicity they acquired in the wild, albeit very slowly over a period of years (Daly, pers. comm.).

Reproduction/Social grouping

Sex determination is essential in creating successful breeding units, as well as in assembling non-breeding groups that minimize stress. Cover and Wisniewski (1989) describe sex identification in dendrobatid frogs. Captive propagation techniques, including larval rearing protocols, employed at NAIB are described by Cover *et al.* (1994).

In our experience, dendrobatid frogs usually breed better when maintained in pairs rather than in groups. In the latter case, reproduction is often hindered by preoccupation with territorial defense and egg cannibalism by cage-mates.

To minimize social stress, conspecific cagemates should be about the same size; large specimens can intimidate smaller ones, causing the latter to go off feed, and become ill. Although different species of dendrobatids may be safely mixed in a terrarium, care must be given in selecting animals that have compatible temperaments and life styles.

Wild-caught dendrobatids of different species may be safely housed together as well as with captive-born specimens. However, NAIB does not ship wild-caught dendrobatids in contact with heterospecifics (*Colostethus* excepted). In shipping containers, frogs are likely to be exposed to a much higher level of heterospecific toxins than they would experience in normal living conditions in captivity.

By following the guidelines described above, it is possible to successfully maintain, and in many instances breed, dendrobatid frogs in captivity. Such success will ultimately reduce the demand for wild-caught specimens, and thereby contribute to their conservation in their natural habitat.

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