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DENDROBATID FROGS IN CAPTIVITY

BOB AND VAL DAVIES

5 Richards Road, Standish, Wigan, WN6 0QU, U.K.

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INTRODUCTION

The Dendrobatids inhabit the rainforest of South and Central America from Panama to Peru. One species (*Dendrobates auratus*) was introduced to Hawaii in the late 1920's and is now established there. They are commonly called Poison-Arrow frogs. This however is a misnomer because as far as it is known they were never used for tipping arrows but the skin toxins of three species were used for tipping blowpipe darts by the Choco Indians of Colombia. The Southern Choco used *Phyllobates terribilis*, the Northern Choco *P. bicolor* and *P. aurotaenia* which are some twenty times less toxic than *P. terribilis*. Indians who used poisoned arrows tipped them with vegetable poisons such as curare.

In a paper by Myers and Daly it is claimed that the skin of one adult wild-caught *P. terribilis* contains sufficient toxin to kill 20,000 mice. As far as is known no antidotes exist as yet. Recent research suggests that toxins from certain species may well have medicinal uses in the treatment of heart disease and arthritis, and at least one (epibatidine from *Epipedibates tricolor*), may be a painkiller more powerful than morphine but certain toxic elements need yet to be removed.

Most Dendrobatids have bright, warning (aposematic) colours but the degree of toxicity varies, some possessing little or none. As far as is known there is no information on the relative toxicities of different species - some may not even have been investigated. A recently discovered species *Aromobates nocturnus*, reported to be drab and non-toxic is named the Venezuelan Skunk Frog as it protects itself by emitting an evil-smelling secretion.

The bright colours of Dendrobatids have made them popular vivarium subjects and in recent years many species have been bred in captivity. The toxins of wild-caught specimens have been shown to reduce in captivity and captive-bred specimens do not possess toxins. In any case frogs should be handled as little as possible - apart from moving them to a different vivarium. Should the keeper have any qualms then disposable plastic gloves could be used. Obviously wild-caught specimens should be treated with respect unless known to be a non-toxic species. Escaped specimens tend to desiccate in a very short time so there is little chance of them terrorising the populace.

TAXONOMY

Taxonomy is in the usual state of flux with occasional revisions and disputes. Some species are known from only one specimen - no living specimens have been observed since. New species are occasionally discovered - *D. castaneoticus* from Brazil is a fairly recent discovery - no doubt others will be found and taxonomy revised. The generally accepted genera are as shown below:-

<i>Dendrobates</i>	approx 26 species
<i>Epipedibates</i>	25
<i>Minyobates</i>	8
<i>Phyllobates</i>	5
<i>Colostethus</i>	110
<i>Aromobates</i>	1

Other genera such as *Allobates*, *Phobobates* etc. have been proposed but have been disputed.

This article does not deal with the Rocket/Stream Frogs (*Coolesthus*) as very few species are kept in captivity. The more colourful species tend to be most popular but at the moment relatively few species exist in Britain, far more being kept in other European countries and in the U.S.A. The following is not necessarily the only way of keeping and breeding Dendrobatids but has proved to be extremely successful for the authors working with nine species.

CARE IN CAPTIVITY

The natural habitat is mainly warm rainforest where high humidity permits the terrestrial breeding habits of these frogs. Interestingly, a recently discovered species, *D. rufulus* (Venezuela), lives at 2100 m to 2600 m with a mean annual temperature of 14°C, the minimum air temperature dropping as low as 1°C. Commonly kept species need warmth (24°C - 28°C day, 18°C - 20°C night). A permanent maximum temperature is not advisable as the frogs' metabolism will be in 'top gear' with resultant exhaustion due to constant breeding. In winter the temperature can be lowered a degree or two and the photoperiod reduced from 14 hours to 10 hours.

THE VIVARIUM

Many keepers use normal all-glass aquaria with a ventilated lid and part cover-glass. The ventilation needs to be fine enough to prevent the escape of fruitflies, micro-crickets etc.. Too large a ventilation area will reduce the humidity necessitating frequent spraying. Purpose-built, front-opening vivaria are easier to furnish and service but the opening glass must be a good fit to avoid food items escaping. A 36" x 12" x 15" aquarium is adequate for 4 average-sized frogs such as *D. auratus*, but a slightly smaller one would house small species such as *E. tricolor* and *D. reticulatus*. Overcrowding must be avoided. A tall vivarium is preferable as it allows the plants to grow - small vivaria soon become overgrown as the plants will thrive in the humid atmosphere necessitating frequent pruning.

HEATING

Methods of heating depend on the situation. In a warm room the fluorescent tube may provide sufficient extra heat but cannot be thermostatically controlled. Other heating methods employed are heater mats, soil cables and spotlamps beamed down through the cover glass, all controlled by a thermostat - the 'dimmer type' being best with spotlamps to avoid alternating light and dark periods. In a tall vivarium temperatures in the upper and lower parts must be checked.

LIGHTING

There is some debate over the necessity for ultraviolet light with Dendrobatids, one view being that sufficient Vitamin D3 for calcium metabolism can be provided by dietary means alone, but the authors have produced large numbers of healthy young frogs by using Tru-lite ® tubes inside the vivarium. Moisture-proof aquarium type leads are used because of the humidity and the control unit placed outside the vivarium for safety. (Dusted food is also supplied). In one experiment, half the froglets from one clutch were retained in Wisconsin and raised under Tru-lite and the other half were raised without Tru-lite in Hawaii. After twelve months the Wisconsin frogs were larger and had brighter colours, showing less black in their coloration.

FURNISHING

Furnishing is a matter of individual taste, for aesthetic reasons a variety of plants is better. Cork bark, bogwood etc. also adds to the effect. The system outlined here has been used successfully in many vivaria, including one for 15 years although it has never contained more than four frogs (*D. auratus*). One wild-caught specimen survived in it for 13 years, others for slightly less periods.

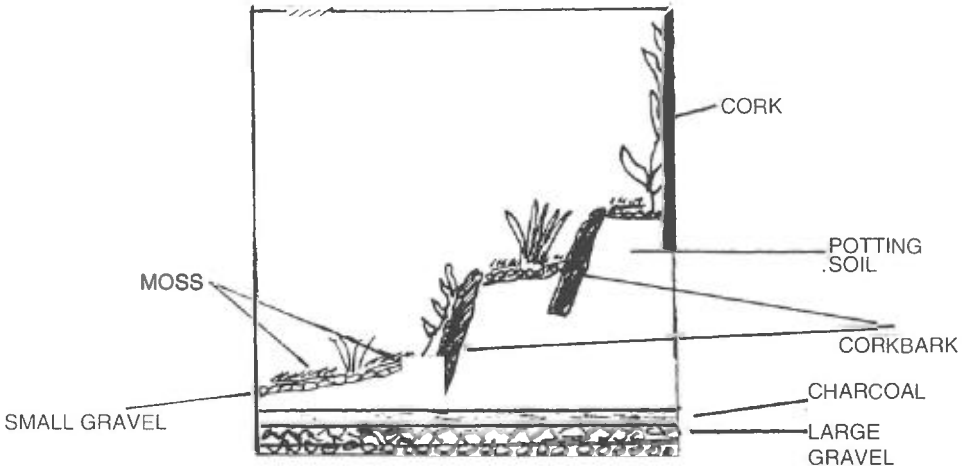


Fig 1. A basic vivarium for Dendrobatids.

The theory behind this system is that with regular spraying the waste is gradually washed into the substrate and is converted by soil organisms into nitrates which are taken up by the plants. The potting compost is loam (soil) based. Planting is best done before adding the final layer of gravel and moss. Tall/climbing plants are planted at the rear as in aquaria. The moss used is the short, encrusting type found on stones. Moss will often die off at first, possibly because the light or new substrate may be unsuitable, occasionally it will then start to grow again, but planting new moss on the dead one is often successful. Some writers proscribe the use of gravel claiming that it injures the frogs' tender skin but the authors use well-rounded, small aquarium gravel and have experienced no problems whatsoever. It is even used in the metamorphosis containers - the froglets climb out on to a shelving gravel bank (see breeding).

The vivarium is lined inside with 1 inch thick granulated cork slabs. This is ideal for climbing plants such as Creeping Fig (*Ficus pumila*), Devil's Ivy (*Scindapsis aureus*), Sweetheart Vine (*Philodendron scandens*) etc.. Various other houseplants can be tried, especially species recommended for bottle gardens as well as certain aquarium plants which will grow immersed e.g. Amazon Sword, *Anubias nana* etc.. The success of the plants is determined by the light levels and sometimes by their position in the vivarium i.e. some are more successful in the higher, better drained areas. Trial and error may be necessary. Bromeliads are only necessary if the 'Egg-feeders' are kept (see below). Constructing terraces increases the floor area, provides drained areas and spawning sites and gives the frogs climbing facilities.

Dendrobatids do not need deep water. A small pool is provided by creating a depression in the top gravel layer and keeping the water level in the substrate at an appropriate depth (about $\frac{1}{2}$ " is adequate). If preferred a small dish can be sunk in the substrate, the water in it being changed when necessary. The water level in the vivarium can be controlled by siphoning off surplus. The frogs are often seen sitting in the water before and after spawning. An open area is left for feeding at the front of the vivarium. Other refinements, depending on the keeper's financial state, include ultrasonic misters, rain chambers, waterfalls, drainage taps etc..

This is not the only possible system. Vivaria with a partial or complete undergravel filter powered by a small pump (with optional waterfall) have been successful. Planted islands were provided using seed trays. Small cobbles, partially buried in the gravel provided extra 'land' areas. Whatever system is used it must not be overcrowded - it can only cope with a certain amount of waste.

FOOD

Dendrobatids have a relatively small mouth so food must be of the appropriate size, the usual food being wingless *Drosophila*. The larger, winged, flightless *Drosophila* can be used for most Dendrobatids but some smaller species such as *D. reticulatus* may not be able to consume them. Crickets of suitable size can also be supplied. Winged and wingless green aphids are extremely nutritious but as with 'sweeping' there is always the risk of pesticides. Small waxmoth larvae will be eaten but should not constitute too large a part of the diet. They need to be supplied on a shallow lid as they soon die when in contact with the moist substrate. Springtails can be temperamental to culture but are eagerly devoured and are especially useful for the young of small species. They may even breed in the vivarium. A small piece of fruit placed on a lid in the open area will help to concentrate the *Drosophila*. Crickets and *Drosophila* are dusted with a fine multivitamin powder at least three times a week, but some products are too coarse to adhere to small insects. Aphids and Springtails are not dusted. The frogs are fed on a daily basis.

CAPTIVE BREEDING

Dendrobatids are notable for their breeding behaviour, especially brood care. As far as captive-breeding is concerned they can be divided into two main groups with an intermediate group. Captive breeding behaviour may not always exactly replicate that in the wild.



Plate 1. *Phyllobates terribilis* - Colombia - described as the 'most toxic animal in the world'.



Plate 2. *Dendrobates auratus* - Costa Rica, Nicaragua, Panama - green and black form. One of the commonest in captivity - regularly bred.



Plate 3. *Dendrobates tinctorius* - French Guyana - another common, 'easy' species.



Plate 4. *Dendrobates pumilio* - Costa Rica, Nicaragua, Panama - an oophage - typical colour form but numerous variations occur especially in Panama.

SEXING

Sexing is not always easy but generally speaking mature females tend to be larger in length and girth. In *Dendrobates* at least, the males have wider 'plates' on the toes of the front feet (although there are exceptions). Finally in some species with a pale underside it may be possible to see a wrinkled or darkish throat patch on the male. The surest way of sexing is to observe behaviour and to see the male's throat expand as in some cases isolating a suspected male in a small container and spraying him may stimulate calling. Calls may be a low 'buzz' which is barely audible or pleasant trill. Certain species (e.g. *D. lehmanni*) can be difficult to sex visually.

SEX RATIOS

Some species have bred with a 1:1 ratio but we have achieved better results with 2:1, 3:1, and in one case 4:1. In the confines of a vivarium, having more than one female frequently results in eggs being eaten. Occasionally dominant females will press another female to prevent her mating. The pressed female remains prone for a short time as the other moves off to mate. This behaviour can be seen when a male starts to call. An exception to using these sex ratios is *D. ventrimaculatus* (formerly *quinquevittatus*), which can be kept in larger groups. Communal spawning may be triggered by one male starting to call.

COURTSHIP AND SPAWNING

Group 1 - 'Detritus Feeders'

In the first group the tadpoles would normally be transported (usually by the male) to small pools where they would feed on detritus or whatever happened to be in the pool. Their captive breeding is as follows:

Generally speaking there is no amplexus although in a few species cephalic amplexus occurs (e.g. *E. tricolor*). Males are usually territorial - courtship starts with one calling which will attract others. Pressing down is attempted but is usually resisted and results in a 'wrestling contest'. A defeated male runs off into the plants frequently pursued by the victor. A responsive female approaches a calling male and paws or strokes his back sometimes accompanied by a butting movement. Courtship may last for several days or an hour or two. Eventually the male leads the female to the selected spawning site.

Spawning Sites

The clutch is usually laid in a secluded spot. For this we provide two or three laboratory watch glasses (concaves) which have a piece of green plastic on them. These are covered with a piece of coconut shell with a small entrance cut in one side. These sites are usually utilised but occasionally a clutch may be deposited on a leaf or even on the substrate. If laid on a leaf they may be kicked off as the male fertilises them. Instead of a watch glass a shallow plastic lid will suffice - some keepers use petri dishes.

The number of eggs varies according to species and also would seem to be dependent on frequency of breeding, but most species produce small clutches (4-8 eggs in many cases but *P. vittatus* regularly produced 15-17 eggs). *D. ventrimaculatus* tends to stick eggs in a variety of locations rather than using a spawning site.

Care of Eggs

The plastic (with eggs) is removed to a petri dish and 2-3 mm of water (vivarium temperature) added - just sufficient to touch the base of the eggs. The eggs must not be covered with water. After 10 to 14 days (according to species and temperature) the eggs hatch and the tadpoles (after one or two days) are removed to individual tubs (margarine/butter etc.) containing 1.5 cm of water which has been allowed to stand for 24 hours. The tadpoles are separated to prevent cannibalism - but some species (*D. auratus*, *truncatus*) can be raised communally in an adequate sized container provided they are well fed. Using tubs the water is changed daily (dechlorinated which has stood for 24 hours) and food added. Food is made up as follows:

- 3 parts tropical fish flake food
- 1 part Tetra ® condition food
- 2 'pinches' powdered cuttlefish bone
- 1 'pinch' multivitamin powder

The ingredients are ground together to produce a fine powder. The tadpoles will not feed for a day or two but a very small amount of food can be added, gradually increasing as the tadpole starts to grow. Adding too much food must be avoided and it is advisable to stir the food slightly to make it sink. Feeding usually occurs at night.

When the tadpoles have all four legs and the tail has almost disappeared they are removed to a small aquarium with facilities for climbing out of the water - usually a small covered aquarium with a shelving area of small aquarium gravel and 2.5 cm of water. On the gravel is a clump of moss. Once the tail has disappeared the froglets are removed to small ventilated containers (glass food storage jars) containing wet moss and provided with wingless *Drosophila*. They do not feed for 2 or 3 days until the mouth is fully adjusted to the new diet. Once they are known to be feeding they can be transferred to a simple nursery vivarium with Tru-lite ®.

Group 2 - Egg Feeders

This group contains species such as *D. lehmanni*, *D. histrionicus*, *D. pumilio* etc.. They are not as easy to breed as the 'Detritus Feeders'. Males are very territorial and a large vivarium is advisable. There are reports of tadpoles being reared on powdered egg yolk suspension and proprietary fish fry foods but some keepers report failure with these methods. It is probably better to let them breed normally as outlined below.

Breeding

Courtship and spawning is similar to that above but tadpoles are removed by the female to bromeliads and placed singly in a water-filled axil. Several bromeliads are needed, the eggs being normally laid on the leaf of these or other plants. As stated brood care is normally done by the females but we have observed a *D. pumilio* (Panama form) male guarding and moistening eggs and also transporting larvae - even calling when he was carrying the tadpole. Once the tadpoles have been deposited in the bromeliad the female will regularly visit them and deposit infertile eggs on which they will feed. In both groups larval transport is accomplished by the adult placing its posterior near the hatching larvae which will then wriggle on to the dorsal surface. In Group 1 several may be carried at one time - in Group 2 it is usually done singly although *D. pumilio* and *D. reticulatus* have been observed carrying 2 larvae. The larvae can survive in surprisingly



Plate 5. A set-up for oophages - contains bromeliads for tadpoles.



Plate 6. Tadpole rearing system (non-oophages).



Plate 7. *Dendrobates reticulatus* female depositing tadpole in bromeliad.



Plate 8. *Dendrobates auratus* froglet showing spindly-leg syndrome.

small amounts of water. *D. granuliferous* (Costa Rica) tadpoles were found living in less than half a teaspoon of water in a bromeliad. Another amazing feature is the females' ability to remember where the tadpoles have been deposited.

Group 3 - Intermediate

There are some frogs which in captivity will raise their tadpoles in bromeliads, feeding them infertile eggs, or the tadpoles can be removed and raised as in Group 1. Both methods have been used by the authors to breed *D. reticulatus* and *D. ventrimaculatus*. In artificial rearing the resultant froglets were larger and took less time to metamorphose. On occasion some Group 1 frogs have deposited eggs in inaccessible corners and later transported the tadpoles to a small pool in the vivarium. Probably due to lack of food they were also smaller at metamorphosis than those reared artificially although they eventually attained normal size.

PROBLEMS

Obtaining stock from a reputable source and quarantining for several weeks in a simple set-up will help to avoid many problems. If a diseased frog is introduced to the main vivarium then it may become contaminated and will probably lead to later introductions becoming infected. Emptying and sterilising a furnished vivarium is a major undertaking. Complete 'wipe-outs' have been known to occur when wild-caught *Mantella* have been introduced to captive-bred Dendrobatids and disease has been passed on via plant cuttings given by one keeper to another. There would seem to be less available information on frog diseases than on reptile diseases and among keepers treatment tends to be limited to the topical application of antibiotics and wormers. This is carried out by dribbling the medication onto the frog's dorsal surface in the hope that sufficient will be absorbed by the permeable skin. Such treatment for external (skin) disease is probably more effective than for internal conditions. Oral administration of drugs is difficult with such small creatures and expert help would be needed.

Antibiotics etc. can only be obtained from vets - a number of which are now expanding the treatment of exotic animals and it is worthwhile trying to find one when starting to keep reptiles and amphibians.

A common problem is 'spindly-leg syndrome' in newly metamorphosed froglets - the forelegs are very thin and practically useless. They may also be curved inwards or even wrongly positioned. It can usually be detected in the tadpole before metamorphosis. The 'body' may be over-large and flabby looking, often with a 'figure-eight' shape. The envelope of skin over the forelegs has a rectangular rather than triangular shape and the legs cannot break out of it properly. The condition is irreversible. The cause is not fully understood but evidence would seem to point to some nutritional deficiency in the adult female, and could be aggravated by intensive breeding. Various preventive measures have been suggested - vitaminising the adults every feed, full spectrum lighting over the tadpoles and feeding adults with rice flour beetle larvae. A varied nutritious diet combined with a reduction in breeding would seem to be the best bet. In the authors' collection spindly-leg appeared a few years ago in one group towards the end of a fairly intensive breeding season. The adult frogs were separated and kept at slightly lower temperatures and the vivarium allowed to dry a little. Food items were dusted and offered four times a week and as much variety as possible provided. After six months they were allowed to breed again which they did, although not as intensively as before, and no problems were experienced with spindly-leg again.

CONCLUSION

Using the above methods, the authors have been successful in breeding substantial numbers of certain species. Given the right conditions and adequate care Dendrobatids are not difficult to keep and can be surprisingly long-lived e.g. wild caught *D. auratus* 13 years, captive-bred *D. auratus* 10 years and various reports of others upto 17 years (*D. azureus*). They are attractive, fascinating creatures and there remains much scope for observation and investigation.

We would however make a plea to potential keepers to avoid inbreeding and hybridisation. Inbreeding leads to numerous problems such as infertility and can only be detrimental. Hybridisation - since there are relatively few Dendrobatids in the U.K., it would be a tragedy if the pure forms were lost in a sea of hybrids.