

## = Poison dart frog =

Poison dart frog ( also known as dart @-@ poison frog , poison frog or formerly known as poison arrow frog ) is the common name of a group of frogs in the family Dendrobatidae which are native to tropical Central and South America . These species are diurnal and often have brightly colored bodies . This bright coloration is correlated with the toxicity of the brightly colored species , making these species aposematic . Some species of the Dendrobatidae family exhibit extremely bright coloration along with high toxicity , while others have cryptic coloration with minimal to no amount of observed toxicity . The species that have great toxicity , derive this from their diet of ants , mites and termites . Other species however , that exhibit cryptic coloration and low to no amounts of toxicity , eat a much larger variety of prey . Many species of this family are threatened due to human infrastructure encroaching the places they inhabit .

These amphibians are often called " dart frogs " due to the Amerindians ' indigenous use of their toxic secretions to poison the tips of blowdarts . However , of over 170 species , only four have been documented as being used for this purpose ( curare plants are more commonly used ) , all of which come from the genus *Phylllobates* , which is characterized by the relatively large size and high levels of toxicity of its members .

## = = Characteristics = =

Most species of poison dart frogs are small , sometimes less than 1 @.@ 5 cm ( 0 @.@ 59 in ) in adult length , although a few grow up to 6 cm ( 2 @.@ 4 in ) in length . They weigh 1 oz. on average . Most poison dart frogs are brightly colored , displaying aposematic patterns to warn potential predators . Their bright coloration is associated with their toxicity and levels of alkaloids . For example , frogs of the genus *Dendrobates* have high levels of alkaloids , whereas *Colostethus* species are cryptically colored and are not toxic .

Poison dart frogs are an example of an aposematic organism . Their bright coloration advertises unpalatability to potential predators . Aposematism is currently thought to have originated at least four times within the poison dart family according to phylogenetic trees , and dendrobatid frogs have since undergone dramatic divergences ? both interspecific and intraspecific ? in their aposematic coloration . This is surprising given the frequency @-@ dependent nature of this type of defense mechanism .

Adult frogs lay their eggs in moist places , including on leaves , in plants , among exposed roots , and elsewhere . Once the eggs hatch , the adult piggybacks the tadpoles , one at a time , to suitable water , either a pool , or the water gathered in the throat of bromeliads or other plants . The tadpoles remain there until they metamorphose , fed by unfertilized eggs laid at regular intervals by the mother .

## = = Habitat = =

Poison dart frogs are endemic to humid , tropical environments of Central and South America . These frogs are generally found in tropical rainforests , including in Bolivia , Costa Rica , Brazil , Colombia , Ecuador , Venezuela , Suriname , French Guiana , Peru , Panama , Guyana , Nicaragua , and Hawaii ( introduced ) .

Natural habitats include subtropical and tropical , moist , lowland forests , subtropical or tropical high @-@ altitude shrubland , subtropical or tropical , moist , montanes and rivers , freshwater marshes , intermittent freshwater marshes , lakes and swamps . Other species can be found in seasonally wet or flooded lowland grassland , arable land , pastureland , rural gardens , plantations , moist savanna and heavily degraded former forest . Premontane forests and rocky areas have also been known to hold frogs . Dendrobatids tend to live on or close to the ground , but also in trees as much as 10 m ( 33 ft ) from the ground .

## = = Reproduction = =

Many species of poison dart frogs are dedicated parents . Many poison dart frogs in the genera *Oophaga* and *Ranitomeya* carry their newly hatched tadpoles into the canopy ; the tadpoles stick to the mucus on the backs of their parents . Once in the upper reaches of the rainforest trees , the parents deposit their young in the pools of water that accumulate in epiphytic plants , such as bromeliads . The tadpoles feed on invertebrates in their nursery , and their mother will even supplement their diet by depositing eggs into the water . Other poison frogs lay their eggs on the forest floor , hidden beneath the leaf litter . Poison frogs fertilize their eggs externally ; the female lays a cluster of eggs and a male fertilizes them afterward , in the same manner as most fish . Poison frogs can often be observed clutching each other , similar to the manner most frogs copulate . However , these demonstrations are actually territorial wrestling matches . Both males and females frequently engage in disputes over territory . A male will fight for the most prominent roosts from which to broadcast his mating call ; females fight over desirable nests , and even invade the nests of other females to devour competitor 's eggs .

The operational sex ratio in the poison dart frog family is mostly female biased . This leads to a few characteristic behaviors and traits found in organisms with an uneven sex ratio . In general , females have a choice of mate . In turn , males show brighter coloration , are territorial , and are aggressive toward other males . Females select mates based on coloration ( mainly dorsal ) , calling perch location , and territory .

= = Taxonomy = =

Dart frogs are the focus of major phylogenetic studies , and undergo taxonomic changes frequently . The family Dendrobatidae was revised taxonomically in 2006 and contains 13 genera , with about 170 species .

= = = Color morphs = = =

Some poison dart frogs species include a number of conspecific color morphs that emerged as recently as 6 @, @ 000 years ago . Therefore , species such as *Dendrobates tinctorius* , *Oophaga pumilio* , and *Oophaga granulifera* can include color pattern morphs that can be interbred ( colors are under polygenic control , while the actual patterns are probably controlled by a single locus ) . Differing coloration has historically misidentified single species as separate , and there is still controversy among taxonomists over classification .

Variation in predation regimens may have influenced the evolution of polymorphism in *Oophaga granulifera* , while sexual selection appears to have contributed to differentiation among the Bocas del Toro populations of *Oophaga pumilio* .

= = Toxicity and medicine = =

Many poison dart frogs secrete lipophilic alkaloid toxins such as allopumiliotoxin 267A , batrachotoxin , epibatidine , histrionicotoxin , and pumiliotoxin 251D through their skin . Alkaloids in the skin glands of poison frogs serve as a chemical defense against predation , and they are therefore able to be active alongside potential predators during the day . About 28 structural classes of alkaloids are known in poison frogs . The most toxic of poison dart frog species is *Phylllobates terribilis* . It is argued that dart frogs do not synthesize their poisons , but sequester the chemicals from arthropod prey items , such as ants , centipedes and mites ? the diet @-@ toxicity hypothesis . Because of this , captive @-@ bred animals do not possess significant levels of toxins as they are reared on diets that do not contain the alkaloids sequestered by wild populations . In fact , new studies suggest that the maternal frogs of some species lay unfertilized eggs , which are laced with trace amounts of alkaloids , to feed the tadpoles . This behavior shows that the poisons are introduced from a very young age . Nonetheless , the captive @-@ bred frogs retain the ability to accumulate alkaloids when they are once again provided an alkaloid @-@ containing diet . Despite

the toxins used by some poison dart frogs, some predators have developed the ability to withstand them. One is the snake *Leimadophis epinephelus*, which has developed immunity to the poison.

Chemicals extracted from the skin of *Epipedobates tricolor* may be shown to have medicinal value. Scientists use this poison to make a painkiller. One such chemical is a painkiller 200 times as potent as morphine, called epibatidine; however, the therapeutic dose is very close to the fatal dose. A derivative ABT 594 developed by Abbott Laboratories, called Tebanicline got as far as Phase II trials in humans, but was dropped from further development due to unacceptable incidence of gastrointestinal side effects. Secretions from dendrobatids are also showing promise as muscle relaxants, heart stimulants and appetite suppressants. The most poisonous of these frogs, the golden poison frog (*Phyllobates terribilis*), has enough toxin on average to kill ten to twenty men or about ten thousand mice. Most other dendrobatids, while colorful and toxic enough to discourage predation, pose far less risk to humans or other large animals.

= = Evolution of skin coloration and toxicity = =

An early study by Summers and Clough (2000) on the evolution of skin coloration and toxicity in the family Dendrobatidae indicated that evolution of skin toxicity correlated significantly with the evolution of bright coloration. Adding to this research, a study by Santos and Cannatella (2011) went on to explain that conspicuous coloration correlated with diet specialization, body mass, aerobic capacity, and chemical defense in poison frogs. Santos and Cannatella (2011) offer two evolutionary scenarios that explain these correlations. One possibility is that aposematism and aerobic capacity preceded greater resource gathering, making it easier for frogs to go out and gather the ants and mites required for diet specialization. This is counter to classical aposematic theory, which assumes toxicity from diet arises before signaling. Their second hypothesis suggests that diet specialization preceded higher aerobic capacity and that aposematism evolved in order to allow dendrobatids to gather resources without predation.

Other evidence suggests conspicuousness and toxicity may be inversely related. A recently published study by Wang and Shaffer (2011) supports this idea. This study found that polymorphic poison dart frogs that are less conspicuous are more toxic in comparison to the brightest and most conspicuous species. Energetic costs of producing toxins and bright color pigments lead to potential trade offs between toxicity and bright coloration. Prey with strong secondary defenses (like the toxic frogs in the Wang and Shaffer 2011 study) have less to gain from costly signaling. Therefore, prey populations that are more toxic are predicted to manifest less bright signals. This theory challenges the tenet that increased conspicuousness always evolves with increased toxicity.

Prey mobility could also explain the initial development of aposematic signaling. If prey have characteristics that make them more exposed to predators, such as size or habitat, then they have ample reason to develop aposematism. An example of this is the shift from nocturnal behavior to diurnal behavior in some dendrobatids. After the switch to diurnal behavior, the frogs had greater ecological opportunities and as a result dietary specialization arose. Thus, aposematism is not merely a signaling system, but a way for organisms to gain greater access to resources and increase their reproductive success.

Marples et al., however, showed that dietary conservatism (long term neophobia) in predators could facilitate the evolution of warning coloration if predators avoid novel morphs for a long enough period of time. Another rarely acknowledged avenue of the evolution of aposematism is the gradual change hypothesis. Lindström et al. found that the gradual change hypothesis did not provide an easy solution to the beginnings of aposematism, but that cost-free stepwise mutations over the range of weak signals could accumulate under neutral selection to produce effective strong signals.

Many studies have suggested that sexual selection plays a role in the diversification of skin color and pattern in poison frogs. With female preferences in play, the coloration of males would change more rapidly. Sexual selection is influenced by many things. The parental investment may shed some light on the evolution of coloration in relation to female choice. In the species *Oophaga*

pumilio parental investment is not equal . The female makes the eggs and provides care for the offspring for several weeks whereas the males makes the sperm ( less energy ) and only provides care for a few days . This differential in parental investment indicates that there will be a strong female preference . Sexual selection makes the phenotypic variation in a species increase drastically . Tazzyman and Iwasa ( 2010 ) found that there were populations of *O. pumilio* that participated in sexual selection and populations that did not . In the populations that did use sexual selection , the phenotypic polymorphism was evident .

The lack of sexual dimorphism in some dendrobatid populations suggests that sexual selection is not a valid hypothesis of the changing coloration . This could be because the main protective measure in aposematic frog populations is their ability to warn predators of their toxicity . Rudh et al . ( 2011 ) predicted that female preference for brighter males would increase the coloration in both sexes and thus increase the fitness of both of the sexes . If there were a sexual dimorphism between males and females within an aposematic population there would be a difference in the predation of males and females that would cause an imbalance in the number of males and females , which would affect mating strategies and ultimately change the mating behavior of the species .

= = Captive care = =

All species of poison dart frogs are neotropical in origin . Wild @-@ caught specimens can maintain toxicity for some time ( this can be obtained through a form of bio accumulation ) , so appropriate care should be taken when handling such animals . While scientific study on the lifespan of poison dart frogs is scant , retagging frequencies indicate it can range from one to three years in the wild . However , these frogs typically live for much longer than that in captivity , having been reported to live as long as 25 years . These claims also seem to be questionable , since many of the larger species take a year or more to mature , and *Phyllobates* species can take more than two years . In captivity , most species thrive where the humidity is kept constant at 80 to 100 % and where the temperature is around 72 ° F ( 22 ° C ) to 80 ° F ( 27 ° C ) during the day and no lower than 60 ° F ( 16 ° C ) to 65 ° F ( 18 ° C ) at night . Some species tolerate lower temperatures better than others .

= = Conservation status = =

Many species of poison dart frogs have recently experienced habitat loss , chytrid diseases , and collection for the pet trade . Some are listed as threatened or endangered as a result . Zoos have tried to counteract this disease by treating captive frogs with an antifungal agent that is used to cure athlete 's foot in humans .

= = = Media = = =

Dendrobatidae at CalPhotos  
Terrarium.tv