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Poison Dart Frogs

The Poison Dart Frog, of the family Dendrobatidae, is a frog native to Brazil and Bolivia. The frogs are distinguished by their bright coloration. Their skin color ranges from yellow, gold, copper, red, blue, green, and black. The Poison Dart Frog has adaptations that allow them to survive in their environments(Dutfield, 2021).

The color of their skin warns predators not to eat them. This aposematic coloration warns predators of their extremely toxic excretions. The skin of the Poison Dart Frog demonstrates a morphological adaptation since it's a structural change that scares off predators before they consume the frog's deadly poison. The bright coloration of their skin is caused by and dependent on alkaloid toxins present in their skin which is a result of their diet of ants and other insects. Bright colors serve as a warning of toxicity for predators(Maxmen, 2013).

The tongue of Poison dart frogs is adapted to enhance their survival by facilitating the process of catching food. Their tongues can stretch out up to 1.5 times the length of the frog's themselves. The elasticity of the tongue makes it easier to catch prey farther away. The tongue of the frog contains a protrusion called a papilla which is lined with mucus. The sticky mucus further helps the frog to capture prey. The frog's tongue demonstrates a morphological adaptation since it relates to the tongue physically. The fitness of the frog to survive is enhanced by the tongue since food is essential to survival. The range of food that the frog can obtain is increased by the tongue's capacity to catch prey(Orta, 2022).

The tongue of the frog demonstrates a structure-function relationship. The tongue's elasticity and ability to stretch out far allow the frog to capture a range of insects. The stickiness of the papilla ensures that once prey is caught, it can't escape. The adaptation of the tongue's structure allows the frog to capture food which is essential for survival.

The toxicity of the Poison dart frog's skin allows them to survive in their environment. The bright skin coloration of the frog serves as a warning to their extremely toxic skin(Dutfield, 2021). Glands in the skin of the frogs secrete alkaloid toxins which can kill predators. Alkaloid toxins are nitrogen-containing organic compounds. The alkaloid toxin produced by poison dart frogs includes batrachotoxin which blocks voltage-gated sodium ion channels in the cells of predators. Poison dart frogs also produce pumiliotoxin which blocks nerve impulses, causing paralysis. The strength of the toxins that they produce makes the Poison dart frog one of the most toxic animals in the world and they are loaded up with enough toxins to kill more than 20,000 mice. The fitness of the frog is enhanced by this adaptation as if attacked, the toxicity of the skin can paralyze or kill predators that take a bite. The toxins that the frog produces are entirely dependent on the frog's diet. Frogs that consume ants and termites tend to be able to synthesize poisons and produce alkaloids. The toxicity of the frog's skin is an example of a physiological adaptation since the king's toxicity relates to its chemical composition(Greshko, 2017).

An example of emergent properties is the Poison dart frog's resistance to the toxins they produce. An amino acid swap allows the Poison Dart frog to be unharmed by their poison. Production of a neurotoxin called epibatidine attaches to cell membrane proteins which protects them from poison. The poison dart frogs evolved to undergo amino acid replacements which reduce epibatidine sensitivity which allows them to resist their toxins and maintain neurotransmitter functionality(Tarvin & Zakon, 2017).

The superkingdom of all animals, including the Poison Dart Frog, is Eukarya. The Kingdom of the Poison Dart Frog is Animalia, the Phylum is Chordata, the Class is Amphibia, the Order is Anura, and the Family is Dendrobatidae. The genus and species of the Poison Dart Frogs can differ and examples of the genus include Adelphobates, Colostethus, and Epipedobates(Dendrobatidae, n.d.).

An adaptation of the Poison Dart Frog is aposematic, meaning that their bright coloration serves as a warning to predators to not eat them. Members of the family Dendrobatidae are aposematic which

implies that the frog's bright coloration evolved in parallel. Researchers carried out a comparative method of analysis for Phyllobates, Dendrobates, Epipedobates, and Minyobates. Toxicity data from previous literature and comparative analysis showed that the genera were significantly correlated. This research is into the evolutionary relationship between different frog genera. The constant relationship between the genus which is still widely varied all exhibit aposematic features(Dendrobatidae, n.d.). This evolutionary relationship is an example of the Unity of Life. The four genera of frogs exhibit similar evolutionary branching and have a constant relationship of being aposematic though they branched out into separate genera of frogs.

The phylogenetic tree studies the rapid color evolution in the poison dart frogs which are an aposematic species. This phylogeographic approach to understanding the evolution of color polymorphism outlines the evolutionary relationships between different Poison Dart Frog colors. It was found that changes in coloration are due to independent events which suggests a history of evolution and color changes.

Figure 1 suggests that Dendrobates and Phyllobates are most closely evolutionary related. Phyllobates also exhibit toxicity and bright colors that warn predators of their extreme toxicity which explains the two species' proximity and shared branches on the phylogenetic tree. Dendrobates are least closely related to Colostethus. Separation can be due to Dendrobate's high alkaloid levels while Colostethus's cryptic coloration while not being toxic(Evolution in Family, n.d.). Figure 2 shows the evolution of the Strawberry Poison Dart Frog's aposematism. The phylogenetic tree explores cryptic coloration evolutionary change in the Strawberry Poison Dart Frogs. Divergences in color are caused by nucleotide variation within the species. On the phylogenetic tree, Tortuguero and Colon are the most distant, exhibiting greater evolutionary divergence(Wang, n.d.).

To form phylogenetic trees, the physical features of organisms can be observed. Sydying physical information such as bone structure and carcasses can give scientists information about the evolutionary relationships between organisms. Additionally, homologous DNA and protein sequences

can be used to determine evolutionary relationships. Aligning DNA sequences and forming a tree based on the overlapping of specific DNA sequences can give insight into interconnects of species(Biological Principles, n.d.). Paleontology, comparative atamy, comparative embryology, and molecular genetics all give information to determine phylogenetic tree relationships. Phylogenetic trees support evolutionary evidence that all life stemmed from a common ancestor and that evolutionary divergences map commonality across organisms(Biological Principles, n.d.).

The phylogenetic trees give an evolutionary history of the Poison Dart Frogs. Ultimately, all eukaryotes evolved from a shared common ancestor. The poison dart frogs are most closely related to other frogs on a phylogenetic tree encompassing all organisms. While all organisms share a common ancestor, factors that cause evolution such as mutation, genetic drift, gene flow, noin-random mating, and natural selection, caused evolutionary divergences on the phylogenetic tree. Different organisms adapted different traits to increase their fitness to survive in their given habitat. For example, aposematic Poison Dart Frogs evolved their unique color based on their environments and independent events.

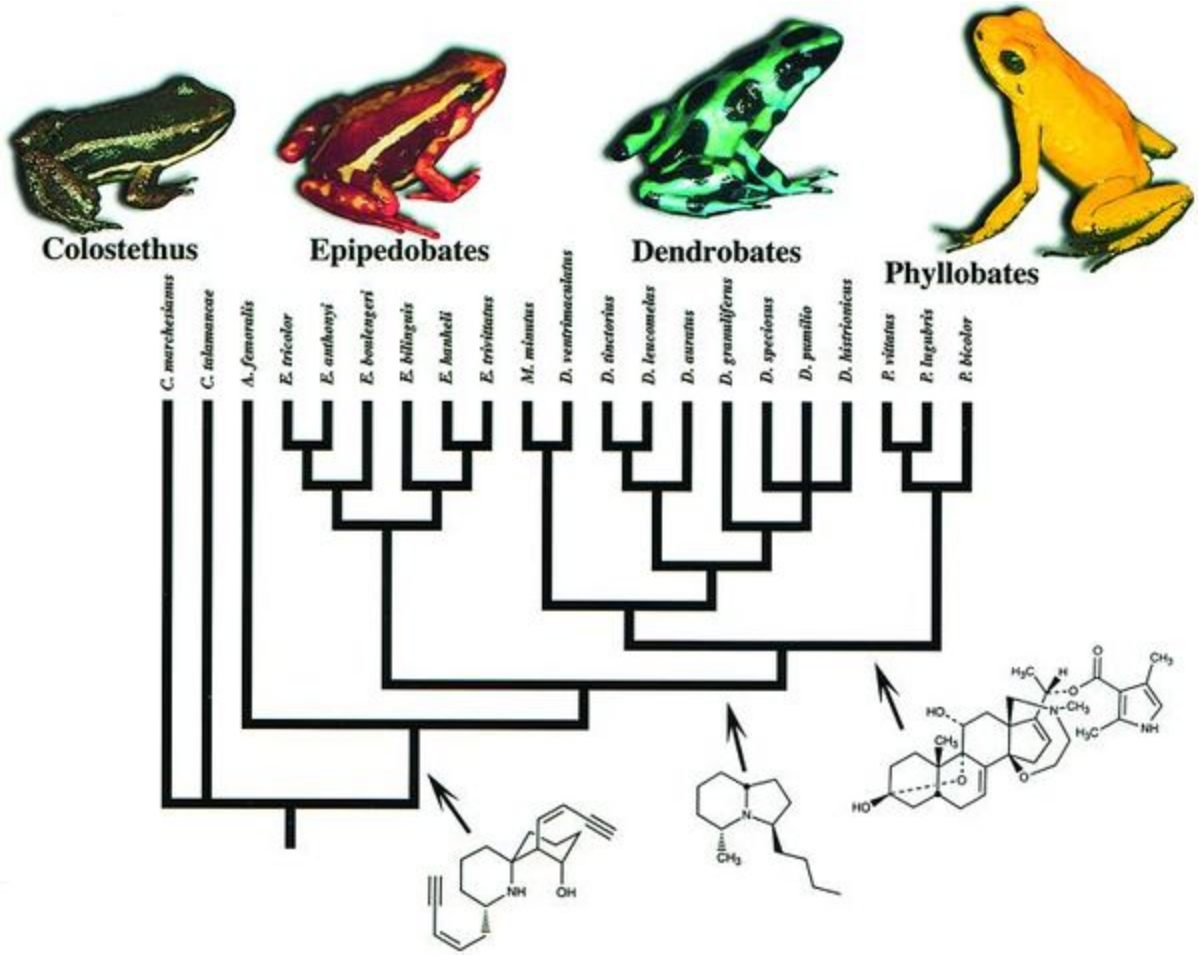

Figure 1: The image above shows the phylogenetic tree of four genera of Dendrobatidae (Evolution in Family, n.d.).

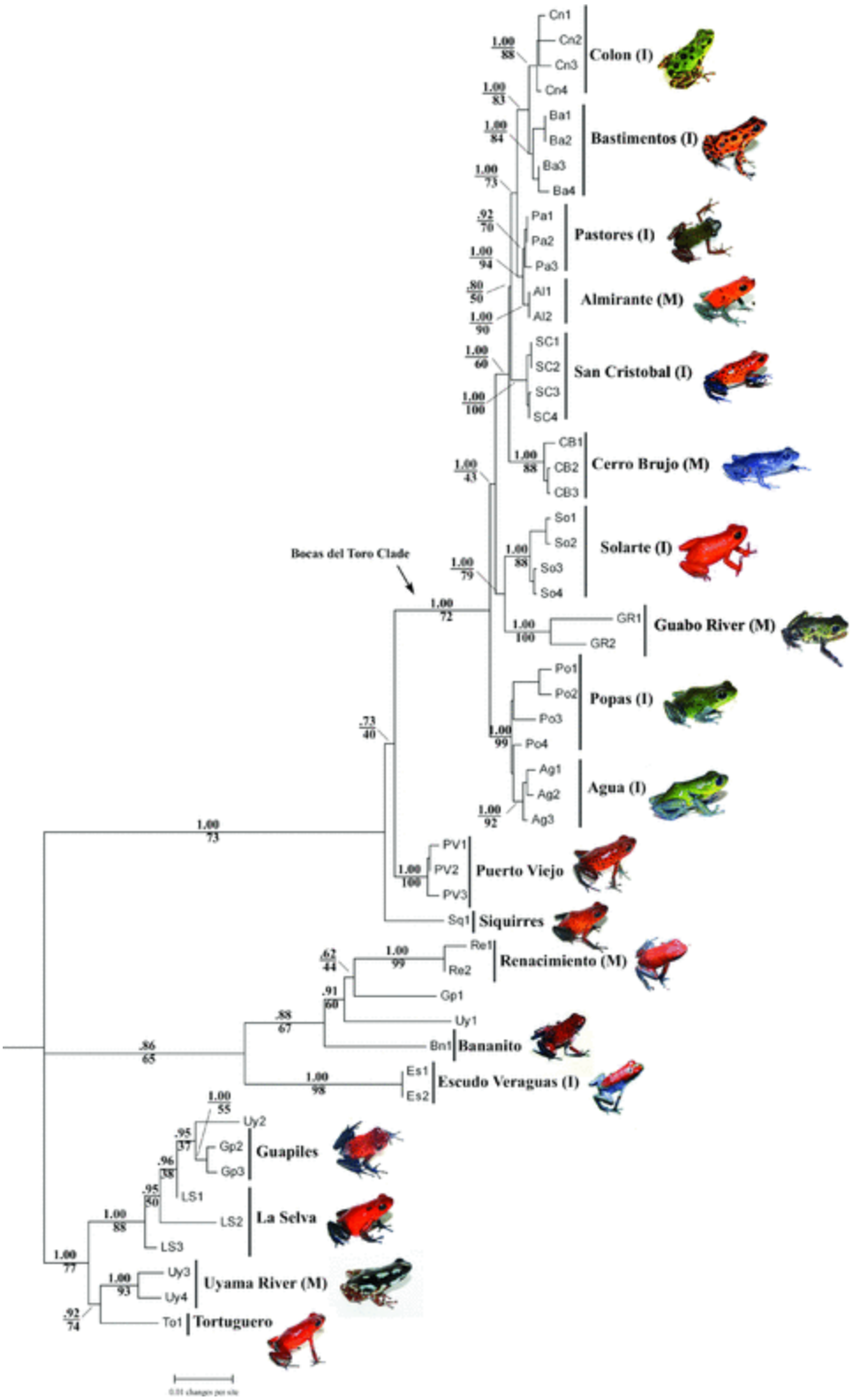

Figure 2: The figure above shows a Maximum-liklihood phylogenetic tree for *Dendrobates pumilio* color morphs. Data is baked on 3051 bp of mtDNA sequencing of the frogs.

(Wang, n.d.).

Adaptations the frogs employ help them to survive in their environment. Poison Dart frogs are iteroparous organisms since they typically sexually reproduce several times throughout their lives. Male and female poison dart frogs care for tadpoles together until they reach maturity. After the tadpoles metamorphose into frogs, they leave their parents. Reproduction in Poison Dart Frogs generally occurs when they are between 1 and 2 years old. Fecundity, or capacity for the production of offspring, is an average of 5-10 eggs at a time(Blue Poison, n.d.). Tadpoles hatch 14-18 days after eggs are laid and it takes 10-12 weeks to become adult frogs after metamorphosis. Eggs are laid in moist areas for males and females to care for eggs. Male and female dart frogs give excellent care to eggs. In most frogs, parental care ends after eggs are laid. In Poison Dart frogs, males guard eggs right after they are laid(Yellow Banded, n.d.). Dendrobatidae carry tadpoles on their backs. Adult frogs carry the tadpoles to streams and other bodies of water(Poison Frogs, n.d.).

Poison Dart frogs are considered K-strategists with high parental care and relatively low reproductive rates. Female frogs generally lay 5-10 offspring at a time and those offspring are cared for by their parents until they metamorphize. Poison Dart frogs live up to 10-15 years in the case of smoke species. The frogs invest in a small number of offspring and give them abundant care, increasing their chances of survival. To contrast, an R-strategist would produce abundant offspring, have little care for offspring, and some offspring might die off. Poison dart frogs face threats during their early stages including environmental threats, predation, and disease. Therefore, a lot of tadpoles don't survive into adulthood. Those that do survive into adulthood have a low risk of mortality in the wild, displaying a Type III survivorship curve.

As K-strategists with high parental care and low reproductive rates, Poison Dart Frogs produce a lower number of offspring. Since Poison Dart Frogs are relatively vulnerable to disease, predation, and

environmental stressors in their early stages, younger Poison Dart Frogs have a higher mortality rate than adult frogs. A cost of higher levels of parental care to increase chances of survival is producing a lower number of offspring. A lower number of offspring would potentially decrease the number of offspring that can reproduce in future generations.

Poison Dart Frogs are native to tropical rainforests in South America with three abiotic factors that determine their niche temperature, humidity, and rainfall. Poison Dart frogs reproduce in warm and humid environments to keep eggs moist and warm to increase the chances of hatching. Temperature affects the frog's health and metabolism. Humidity increases the chances of the frogs being hydrated and moist skin calls for oxygen absorption and release of CO2. Rainfall season is when most Poison Dart Frogs reproduce since eggs must stay moist and tadpoles need water bodies for development into adults(Poisonous Dart, n.d.).

A commensalism relationship is where one organism is benefited but the other does not benefit and is not harmed. Bromeliads are plants whose leaves serve as a habitat for different plants and animals. bromeliad form a "tank" through their tough leaves. Poison Dart Frogs utilize this tiny habitat to protect eggs and tadpoles from threatening environmental factors such as predation. Adult frogs additionally use bromeliad to gain moisture and for protection(Philip A. Silverstone, 1973). The bromeliad isn't benefitted or harmed from this relationship but the frogs are benefited.

Poison Dart frogs are considered to be secondary consumers in the food chain. The frogs eat small insects such as ants and spiders, which give them their toxic secretions. The frogs are eaten by various predators such as snakes and birds. Competition for food, water, and items to care for offspring helps to determine where the Poison Dart Frogs live. Adaptations such as their bright coloration, skin secretions, and long tongues with papilla help reduce competition with other organisms to occupy a certain niche. These adaptations help increase fitness to fight for a certain niche to ensure the survival of the species and to assert dominance over the limited resources, connecting to natural selection and "survival of the fittest."

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