Introduction

Their bodies are covered in blue, yellow and numerous other colours, making them a popular ornamental fish in the aquarium trade. This fish is easily found in Singapore's canals. In fact, the older generations of Singaporeans would view this beautiful fish as a reminder of their childhoods since catching fishes in the canals was a favourite past time for the older generation.

Guppies are also popular fish for freshwater hobbyists, due to them being prolific breeders which can tolerate water conditions well. Many breeders had even successfully developed a wide variety of morphology in the domestic guppies, leading to exotic strains with snake skin patterns, and elaborate fin patterns which are not found in wild guppies. Hence, the domestic strains of guppies look remarkably different from the wild-type morph.

Where can you find guppies?

The guppy is native to parts of the Caribbean and northern South America, but it has been widely introduced throughout temperate and tropical regions originally for mosquito control, later as a popular species in the commercial aquarium trade. These live-bearers are native to fresh, brackish and salt water in the Americas. This fish can be found in Southern Lesser Antilles and and northern South America from western Venezuela to Guyana.
These fishes are also widely introduced elsewhere, and are either introduced deliberately or accidentally into their non-native habitats. Guppies are locally established in warm water sites in Hawaii, Idaho, New Mexico, and many other places. There are mainly two types of guppy populations in these areas, which are the introduced feral populations of guppies and the domesticated populations which have reverted to a feral state.

Local Distribution of the wild guppies

Guppies are introduced to Singapore since 1937 possibly for mosquito control. The guppy is common in many of Singapore’s waterways (Lim & Ng, 1990). It is also abundant in both Bukit Brown and Mount Pleasant streams.

Guppies are widely distributed in the freshwater and blackish water bodies of Singapore, such as canals. These fish tend to inhabit deteriorated micro-habitats in rivers where few species can occur. They tend to be found in Singapore's canals. Some sightings of this fish had been recorded in Bishan park, as well. Guppies are able to tolerate a wide range of aquatic environments and conditions as it is considered a rather hardy fish. Guppies are known for feeding on many different food sources, ranging from the algae to insect larva. It was found that the consumption rate of different prey types varied with the predator densities. Unfortunately, information regarding the positive and negative impacts of guppies on native species and ecosystems, when introduced, is extremely scarce.

History of the guppy in Singapore

This small but hardy freshwater fish was introduced into Singapore and other parts of Southeast Asia in the late 1930s to control mosquito breeding. Since this initial introduction, feral guppies managed to proliferate in both brackish and freshwater areas throughout Singapore but their exact local distributions were not documented. In the 1980s and 1990s, the habitats of these feral guppies shrank due to the rapid urbanization of Singapore. Consequently, the feral populations became fragmented and isolated.

The commercial culture of guppies started in the 1950s. Some farmers switched from growing vegetables and fruits to the more lucrative culture of ornamental and freshwater fishes. Since Singapore is ideal for rearing tropical fish due to the climate, temperature and rainfall, Singapore has been home to fishing communities and coastal fish farms for a very long time. In the 1960s, kelongs and traps were common, which then progressed to cage-nets. The wide variety in colour patterns, along with the large range of morphology in the shape and sizes of the domesticated guppy is the result of selective breeding and deliberate choosing of mutants with the desired traits from the feral guppies.

In the 21st century, the traditional fish farm had given away to a more high-tech business, with greater focus on automated processes to reduce manpower needs. For example, farms use automatic fish instead of feeding the fish by hand. The fish, including guppies, would then be sold around the world and even in our local fish hobby stores. The huge demand for guppies arises due to their small sizes, ease of maintenance, and their brightly coloured bodies. There are also private professional guppy breeders dedicated to breeding a particular strain of guppies, and they can breed guppies in the confines of their home aquariums as well. For example, a Singaporean guppy breeder specialized in rearing full-red albino guppies.
Biology

Sexual dimorphism

Male guppy (*Poecilia reticulata*)

Photo of male *Poecilia reticulata*

Referring to the image above, males have a slender body shape. Guppies from cultivated strains might have extrapolated and elaborate fins due to selective breeding. Males also have a gonopodium, a needle-like modified anal fin meant for transferring sperm into females. Male guppies generally have more colourful bodies than their female counterparts.

Photo of female *Poecilia reticulata*

Females are typically dull-coloured with rounded bodies, although female guppies from cultivated domestic strains might have some speckles of coloration on their caudal fins. Mature females are also generally larger in size than mature males. The gravid spot in females consisted of black pigments or melanophores that covered the ovarian sac, which is seen as a dark spot located before the anal fin. Hence, only female guppies have gravid spots.

Reproduction

These fishes have an interesting mating system, known as polyandry, as females would mate with multiple males multiple times.

Although both genders benefit from multiple mating overall, males tend to benefit more from this system. As the reproductive success of male guppies is directly related to how often they mate, male guppies are thus inclined to mate multiple times. Additionally, the cost of multiple mating for males is very low anyways because they would not offer parental care to offspring nor gift resources to females.
Females’ mating choice

Female guppies have preferences for certain males, especially towards brightly coloured males. Female guppies are very attracted towards males with orange spots on the flanks. The orange spots might also resemble the orange fruits that guppies fed on in Trinidad. As the reflectance spectra of the orange fruit and the spots on the male guppies are similar, it is likely that female guppies are drawn towards males with more orange colouring due to this preexisting sensory bias. In fact, the carotenoid-containing orange spots of male guppies are also shown to be signals of foraging ability that females could use to choose high-quality mates. The chroma (colour saturation) of the orange spots increases with carotenoid levels in laboratory diets and females usually prefer males with larger orange spots and higher orange spot carotenoid concentration. Due to the advantage in mating, male guppies had evolved to have more ornamentation across generations in habitats with lower predation rates as the cost of being conspicuous is lower with lower predatory rates.

Male courtship

The rate and duration of courtship display of male guppies also play an important role in female guppies' mating choice. The courtship behaviour of male guppies is another indicator of fitness due to the physical strength involved in maintaining the courtship dances. The males would engage in sigmoid displays in which the males would flex their bodies into an S-shape and vibrate rapidly. The male guppies display gonopodial swinging behaviour to showcase their virility. The linked video would illustrate various types of courtship behaviour, including both sigmoid displays and gonopodium jerking. Males can also exhibit sneak mating attempts, but the amount of sperm deposited would be higher in consensual mating attempts. It can be noted that consensual mating could be easily differentiated from sneak attempts at mating.

Female guppies also seemed to be easily influenced by the mating choice of another female as well. In an experiment, female guppies watched two males, one solitary and the other actively courting another female, and were given a choice between the two. Most females spent a longer time staying next to the male that was courting than next to the solitary male. Hence, female guppies' preference for fit males allows their descendants to inherit better physical fitness and a better chance of survival.
Life cycle

*Poecilia reticulata* is also known as a prolific live-bearing fish species, capable of having two or three generations of guppies per year in the wild. In guppies, the brood size is extremely variable, yet some consistent differences exist among populations depending on the level of predation and other factors. For example, females tend to produce more numerous but smaller-sized offspring in high-predation conditions than in low-predation conditions. Upon birth, their fry would initially dive towards the bottom to seek out hiding places from larger guppies and other animals which would eat them. The young guppies are independent without further parental care by the time they are born.

Guppies mature rather fast, and are generally capable of mating after 2 months of age. Female guppies first produce offspring at 10–20 weeks of age, and they continue to reproduce until 20–34 months of age. Male guppies would mature in 7 weeks or less. The total lifespan of guppies in the wild would vary greatly, but it is typically around 2 years. As the guppies in different populations have many variations in their life histories, this meant that different environmental pressures can influence their life histories.

Species interactions

Interactions with prey

These fishes are opportunistic feeders, and are even known to be cannibalistic as they would feed on their own offspring. The wild guppies typically feed on algal remains, diatoms, invertebrates, plant fragments, mineral particles, aquatic insect larvae, but it is not limited to these sources. Algal remains constitute the biggest proportion of wild guppy diet in most cases. The diets of *Poecilia reticulata* would generally vary in composition, depending on the conditions such as food availability, in the habitat.

Interactions with predators

In Singapore, guppies have a lot of natural predators. Colourful guppies tend to be preyed upon more than less colourful guppies. One natural predator of *P. reticulata* include bird predators such as kingfishers (e.g. *Chloroceryle americana*), herons (e.g. *Bulbucus ibis*) and flycatchers (e.g. *Pitan gus sulphuratus*). The Common Kingfisher would catch the fish by diving into the water and spearing it with its sharp bill, then proceeding to swallow the fish tail-first.

In defence, guppies often school together to avoid predation. Under high predation pressure, guppies tend to school together more. Next, male guppies that are brighter in colour have an advantage in mating as they attract more females in general, but they have a higher risk of being noticed by predators than duller males. Male guppies evolve to be more dull in colour and have fewer, smaller spots under intense predation both in wild and in laboratory settings. Even female guppies display differential mate preference according to the conditions they lived in. Female guppies in a high-predation environment also evolve to prefer brightly coloured males less, often rejecting them.

**Interactions with parasites**
Some examples of parasites found in guppies would be the parasitic nematode *Camallanus cotti*. Guppies display differences in their resistance towards parasites. For example, laboratory infections reveal that guppies under higher predation pressure have lower innate resistance to *Gyrodactylus*, which are parasitic flatworms, than guppies with lower predation pressure. Despite guppies from high predation populations likely being more resistant, *Gyrodactylus* prevalence was higher among them; this is most probably due to the increased transmission potential at these sites. Hence, it can be inferred that wild guppies suffer from a higher prevalence of parasitic infections than domestic strains, but they are more resistant to these infections and they do not die from them as much as the guppies from a domesticated guppy strain.

**Differences in morphology**

**Within domesticated strains**
Different variations in guppy tails

The wide diversity in the tail shapes of guppies would be attributed to genetics. In Singapore, the other tail forms like Double Sword, Swallow, Ribbon and Lyre Tail are very popular among aquarists. Besides their tail shapes, there are many other different variations in guppies, especially with regard to their colours and patterns. Many breeders selectively breed for a trait, resulting in the trait becoming more and more pronounced over generations. Despite this wide variety in morphology, they would still be identified as guppies and are capable of breeding with other guppy strains, even with feral wild guppies. As these strains are cultivated by hobbyists, wild guppies do not possess such a wide variety of tail shapes. These variations in tail shapes are only found in commercially bred guppies since wild guppies would be hindered by large flowing fins when trying to escape predators.

Take for example, the variations in the coloration of different guppy strains. What make them look so different?

Apparently, different combination of alleles would give rise to different colorations. For example, the two different colour strains green Snakeskin and Yellow Snakeskin, domestic guppies only differ by a single autosomal gene. The Green Snakeskin strain would have the wild-type background coloration caused by the dominant gene (B), whereas the Yellow Snakeskin is homozygous for the recessive blond allele (bb).

<table>
<thead>
<tr>
<th>Between domesticated guppy strains and feral guppies</th>
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<td>An example of feral guppies</td>
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</table>
In physical morphology, the domesticated guppy strains tend to have more elaborate fins, especially in males. Domesticated female guppies also have more colourful bodies and fins in comparison to their feral counterparts.

Individuals from the domesticated guppy strains are capable of breeding among themselves and even with feral guppies. The differences in physical morphology do not seem to hinder the breeding opportunities within guppies. This would be due to the fact that the domesticated strains are actually derived from wild guppies, so breeding both feral and domesticated guppy strains would be possible.

**Economic Value**
Examples of different guppy strains in Singapore

*Poecilia reticulata* has considerable economic value as an ornamental aquarium species, and it is widely cultured in commercial fish hatcheries. A number of highly ornamented aquarium strains, with elaborate fins and coloration, have been developed, and are extremely popular in the retail aquarium trade. Singapore is known internationally as a breeding centre for the guppy, *Poecilia reticulata*. There are many domesticated colour pattern and tail shape varieties reared in these farms, primarily for export. The guppy strains pictured are some of the breeds that are bred and sold in Singapore.

**Social Value**
Guppies in an aquarium

Guppies thrive in a hard-water aquarium with a temperature between 25.5 and 27.8 °C and they also prefer salt levels equivalent to one tablespoon per 19 l (5 US gal). They can also withstand levels of salinity up to 150% that of normal seawater, which has led to them being occasionally included in marine tropical community tanks, as well as in freshwater tropical tanks. Guppies are considered peaceful fish, though nipping behaviour is sometimes exhibited between male guppies or towards other top swimmers like members of the genus Xiphophorus (platies and swordtails), and occasionally other fish with prominent fins, such as angelfish. Guppies, as they tend to school together and live in huge groups in the wild, should not be kept as a single fish in an aquarium. Poecilia reticulata is one of the most popular aquarium fishes, and has been in the ornamental fish hobby since the early 1900s. It has high recreational and aesthetic value in captivity, but has limited social benefit in its feral state. Many beginner aquarists would view guppies as a good beginner fish for sprucing up the households, allowing people to enjoy the sight of these colourful fishes swimming and displaying their beautiful colours. Guppies are also prolific breeders, so it is also possible for novice fish keepers to breed for certain looks as well.

Conservation status

The guppy is unlisted in the IUCN red list, but it is generally considered as being of the least concern. This fish is an invasive species in Asia, Australasia-Pacific, Europe, North America, and South America. As an invasive species, its populations are monitored. The guppy is considered a threat to many native cyprinids and killifishes. The invasive guppy had adversely affected the White River springfish, Crenichthys baileyi, in a Nevada spring.

In Singapore, Poecilia reticulata are not wiping out the native aquatic species in Singapore. They seemed to have integrated into Singapore’s ecosystems rather well. This suggests that the guppies are able to occupy an ecological niche in Singapore and they are not displacing local fish species.

Risk and impacts
Guppies are known as an invasive species in Singapore as there had been numerous introduction of this species in our waterways. As they are highly adaptable to different environments, and are considered as a habitat generalists, these guppies are known to occupy disturbed areas, and are capable of securing and ingesting a wide variety of food. These fishes are also fast growing, which means that they are able to occupy foreign habitats quickly, especially with their naturally high reproductive potential. A single female can even store the sperm from previous mates for subsequent fertilization of her eggs over a lifetime, leading to an easy spread of these fishes in the introduced habitats. In Singapore, as there is a large demand for a wide variety of artificially coloured guppies, they are widely bred. This would mean that there would be a large amount of unwanted guppies, released into the streams and drains all around Singapore due to the Asian concept of gaining “good Karma” from releasing an organism back into the wild. Guppies could lead to a reduced native biodiversity, as they pose threats to the native species, especially for endangered species.

Prevention and Control

Prevention

While further intentional introductions by government bodies are unlikely in Singapore and in most countries, accidental and illegal releases of guppies by are likely to continue. In order to prevent such releases, Singapore in particular improved public awareness programs to remind the public not to release pets into the wild in general.

Animals are usually released at reservoirs and parks as a symbolic gesture of compassion on Vesak Day. Hence, during Vesak day, there are volunteers participating in outreach programs dedicated to remind the public not to release animals, like guppies, into the waterways. Prevention strategies must therefore be carried out by both government and public groups, and empower individuals to contribute to solutions at the regional level.

Eradication

Eradication of the established guppy populations is difficult and may only be successful in small enclosed pools. In Singapore, this approach is difficult as there are many other species in the same area as well and eradication of a feral guppy population in one area would threaten the other species living in that area as well.

Containment

Due to their small size and ability to move freely through water bodies by swimming, containment of P. reticulata within a particular section of a river or stream is too difficult to maintain. Transmission between water bodies can be prevented by eliminating human-assisted movement of fish through accidental or intentional release.

Biological control
The introduction of larger predatory species is possible in small, contained water bodies, but this opens the possibility of introducing further problem species. One measure taken by enthusiast groups overseas to eradicate *Gambusia holbrooki* (a poeciliid species with broadly similar biology to *P. reticulata*) has been to introduce tropical predatory fish in the summer months, which then die off during the winter and leave the water body devoid of the invasive species. Unfortunately, this measure would not be feasible in Singapore since Singapore is a tropical island with limited seasonal changes. The introduced predatory fishes might pose as a problem in itself since they would be able to thrive and proliferate in Singapore due to our rather constant climate.

**Control by utilisation**

Although the collection of wild and feral stock for the aquarium trade may occur in Singapore, it is unlikely to occur at any level that would control or reduce the established populations of *P. reticulata* in the wild.

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**Taxonomic**

**Diagnosis**

This species is characterized by viviparity, having live birth, and also having marked sexual dimorphism. While wild-type females are grey in body color, males have splashes, spots, or stripes that can be any of a wide variety of colors. This species has morphological traits that are very distinct from their wild-type morphs.

**Taxonomic classification**

Binomial: *Poecilia reticulata* Peters, 1859

**Synonyms**

1) *Acanthocephalus guppii* (Günther, 1866)  
2) *Acanthophacelus reticulatus* (W. Peters, 1859)  
3) *Girardinus guppii* (Günther, 1866)  
4) *Girardinus reticulatus* (W. Peters, 1859)  
5) *Lebistes poecilioides* (De Filippi, 1861)  
6) *Lebistes reticulatus* (W. Peters, 1859)  
7) *Poecilioides reticulatus* (W. Peters, 1859)

**Vernacular names**

English: Guppy  
Korean: (guppy)  
português: Arú, Guppy, Bobó  
svenska: Guppy  
Chinese:

**Etymology**
The guppy, *Poecilia reticulata*, collected from Venezuela, was first described and named by the German ichthyologist Wilhelm Peters in 1859. Two years later, the Spanish zoologist, De Filippi, obtained some fishes from Barbados which he considered a new genus and species, and named them *Le bistes poeciloides*. In 1866, Robert J. Lachmere Guppy, who resided in Trinidad, sent some fishes to ichthyologist Albert Günther who named it as a new species, *Girardinus guppii*. However, Rosen and Bailey showed that the correct name for this species is *P. reticulata*. The common name guppy was used in the 19th century in honor of R.J.L. Guppy, a clergyman in Trinidad who first presented specimens to the British Museum.

**Type information**

Type specimen of *Poecilia reticulata*[^50]

Name: *Poecilia reticulata* (Peters, 1859)

This specimen is located in the Natural History Museum in Berlin. The type specimen is notably a female guppy. A female guppy is probably chosen as the type specimen since female guppies are larger than males, and this would aid in easier identification of this species.

The type specimen had also been catalogued in the catalogue of fish types stored at the Zoological Museum of the Humboldt University of Berlin.[^51]
Original description

Original species description of the guppy, *Poecilia reticulata*.

English translation: *Poecilia reticulata* is greenish yellow with a black network, whose meshes are parallel to the edges of the scales, on the abdomen. They have scales in 7 longitudinal and 27 transverse rows; although some of them appear pierced, there is no clear side line. The whole body length is 39 mm, height is 9 mm, and the length of the head is 7 mm.

Classifications

<table>
<thead>
<tr>
<th>Domain</th>
<th>Eukaryota</th>
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<td>Kingdom</td>
<td>Metazoa</td>
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<tr>
<td>Order</td>
<td>Cyprinodontiformes</td>
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<td>Poeciliida</td>
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<td>Genus</td>
<td>Poecilia</td>
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<tr>
<td>Species</td>
<td><em>Poecilia reticulata</em></td>
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Barcode:

The genetic barcode of *Poecilia reticulata* can be found [here](#).

Taxonomic Confusion

While juvenile and female *Poecilia reticulata* appear similar to many other poeciliid species, particularly *Gambusia holbrooki*, male *P. reticulata* are easily distinguished by their elaborate colour patterns. *Gambusia holbrooki*, also known as mosquito fish are also introduced in Singapore along with guppies.

<table>
<thead>
<tr>
<th>Species</th>
<th>Image</th>
<th>Traits</th>
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<tr>
<td><strong>Guppy</strong></td>
<td></td>
<td>Female colouring: The caudal peduncle area is opaque.</td>
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<tr>
<td><em>Poecilia reticulata</em></td>
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<td>The gravid spot is also larger in guppies and goes farther up the flanks.</td>
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<td></td>
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<td><strong>Size:</strong> Females can grow to 2.5 inches</td>
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<td><strong>Brood Size:</strong> Female guppies of the same size have broods of</td>
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| **Guppy**  
*Poecilia reticulata*  
(Male) | **Accent colours:** Males can have blue, red, green, gold and many other colours. But most of these colours are matte, not metallic.  
**Size:** Males can reach almost 1.5 inches.  
**Gonopodium shape:** It is thick with several hooks, a rounded end and a large, thick palp. |
|---|---|
| **Mosquito fish**  
*Gambusia holbrooki*  
(Female) | **Features:**  
1) The females usually have a black stripe near their eye area, unlike guppies.  
2) Spots on the dorsal (along the midline of the back) and caudal (on the hindmost part of the body) fins.  
3) **Size:** Females reach 2.5 in (6.4 cm). |
| **Mosquito fish** | **Features:**  
1) The male may have a blue shimmer on the sides. |
Gambusia holbrooki (Male)

2) Their gonopodium is longer proportionately to their bodies than male guppies.

3) Size: Males reach 1.5 in (3.8 cm)

Phylogeny

The guppy (*Poecilia reticulata*) belongs to the superfamily known as Poeciliidae. This superfamily have three subfamilies: *Aplocheilichthyinae, Procatopodinae* and *Poeciliinae*. The subfamily Poeciliinae is a cyprinodontiform group widely distributed throughout the Americas. Poeciliinae is also the sister group of the Procatopodinae, a group composed of the South-American *Fluviphylax* Whitley and the African procatopodines. The clade Poeciliinae plus Procatopodinae is the sister group of the Aplocheilichthyinae. These three subfamilies compose the family Poeciliidae. The Poeciliinae embraces approximately two hundred twenty species currently allocated in approximately twenty-eight genera. The fishes in this genus are characterized by the uniquely derived possession of a gonopodium formed by the modified male anal-fin rays 3, 4, and 5.
The taxonomic and the implied phylogenetic tree of the *Poeciliinae* according to the systematic hypothesis of Rosen and Bailey (1963) and Rosen (1979).

From this tree, it can be observed that the tribe *Poeciliini* contains 4 genera: Alfaro, *Poecilia*, *Priapella* and *Xiphophorus*. Phylogenetic analyses were conducted based on both molecular and morphological data, leading to this proposed phylogenetic hypothesis of the *Poeciliinae* family. The genus *Poecilia* currently contains 40 recognized fish species, including *Poecilia reticulata*. The placement of the guppy in this family of *Poeciliinae* is well-supported in its classification. Despite having a robust placement in this superfamily, there had been debates over the tribe *Poeciliini* and the genus *Poecilia*. In 1997, the tribe *Poeciliini* was redefined as comprehending the genera *Poeciliini* *Alfaro*, *Priapella*, *Xiphophorus*, *Poecilia*, *Limia* and *Pamphorichthys*. Ptaceck & Breden (1998) also proposed a molecular phylogeny for *Poecilia*, focusing on the species of the subgenus *Molliesesia*. Poese (2003) also carried out a taxonomic revision of *Poecilia* and proposed a phylogenetic hypothesis for this genus.

With high bootstrap support for both ML and MP tree, *Poecilia reticulata* is hence confirmed to be the sister taxon of the endler, *Poecilia wingeii*. The mean Bayesian posterior probabilities (BPPs) based on two independent runs and ML bootstrap support percentages (BSPs) are also highly supportive of the relationship between *Poecilia reticulata* and *Poecilia wingeii*. This relationship is also supported with morphological evidence between the females of both species, along with high breeding success between these two species. This tree also shows mean Bayesian posterior probabilities (BPP) based on two independent runs above the branches, and ML Bootstrap Support Percentages (BSPs) below the branches for analyses with 11 partitions. All of the topological relationships in this tree are supported with Bayesian analyses of the combined data set with four or eight partitions.
ML phylogram (ln likelihood = 27849.8817) obtained with RAxML for the combined data set with 11 partitions. Mean Bayesian posterior probabilities (BPPs) based on two independent runs and ML bootstrap support percentages (BSPs) are shown above and below branches, respectively.

References


2. Deacon, A. E., Ramnarine, I. W., & Magurran, A. E. (2011, September 19). Global distribution and origins of Poecilia reticulata including (A) their native distribution compared with (B) their distribution as a result of introductions and (C) reported reasons behind introductions. [Distribution of Poecilia reticulata]. Retrieved November 5, 2018, from https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0024416


