FIJI AMPHIBIA.

by P.A. RYAN.

To many people there appears to be only one amphibian in Fiji, the Cane Toad, **Bufo marinus**, often erroneously called a frog. While **Bufo** has done very well in Fiji, and is present in millions, it is not a native species. It was introduced from Hawaii in 1936 to keep down pests of sugar cane (Simmonds, 1937). Whether it has done so is a moot point, but it is now found on all the main islands, where it ranges from the coast up into the rainforest.

There are reasons for this phenomenal success, which, incidentally, is reflected in Queensland, New Guinea, Tuvalu and the Solomon Islands in the South Pacific (not to mention as many islands elsewhere). Perhaps the most important is its ability to withstand dessication by virtue of its thick warty skin, but poison glands on either side of its neck must also play a part. If sufficiently disturbed the toad inflates these sacs and a milky yellow or white discharge appears. If a predator tries to eat the toad this discharge causes intense irritation to its mouth lining, usually discouraging further investigation. But occasionally an over-enthusiastic puppy eats the toad regardless and dies for its trouble. From a biological viewpoint this is unfortunate. Most animals possessing a defensive venom or a poison do not kill their attacker but benefit from the previous experience of the predator. A dog which has attempted to eat a toad never tries again. A toad eaten by a predator which then dies from the poison is just as dead as its attacker! For this reason many unpalatable animals sport bright warning colouration, a fact sometimes cashed in on by harmless mimics, but that is a study in itself. The Cane Toad does not rely on such a mechanism, possibly because it possesses an 'Achilles heel', and bright colouration would attract predators able to circumvent its defenses. I have found dead Cane Toads with their legs and lower belly eaten but with the head left intact. I assumed that these were mongoose victims, a supposition much strengthened by the observations of Dr W. Kenchington, who saw a mongoose catch and kill a toad by biting it round the upper thighs. The toad was not eaten, perhaps because the mongoose was disturbed before it had a chance to feed? I hope more mongooses become proficient at eating toads, as this may reduce

pressure on many native birds and lizards.

Unpalatability is not restricted to adult toads. The eggs, which are laid in their thousands in long spiralling strands of jelly, frequently in still pools, are also mildly poisonous. This ensures that fish, usually efficient amphibian egg predators, leave them alone. The tadpoles are reputedly unpalatable, but this did not stop a 15 month old baby of my acquaintance from sitting in 5 cm of water in the Sabeto river, swallowing large tadpoles as fast as her pudgy hands could catch them. She suffered no ill-effects so I conclude that the tadpoles are not poisonous!

The mating cry of the male Cane Toad is well known. It echoes through the night and attracts females in breeding condition. A willing female is mounted by a male and as she releases eggs, he releases sperm. This takes place in shallow water. I have often seen female toads carrying two males, the uppermost male clasping the one underneath it as if it were a female. Most toads and many frogs have a release call which tells the prospective mate that the female is unreceptive, or that the apparent female is another male! Presumably this mechanism breaks down during amplexus (as frog and toad mating is termed). The release call is poorly named, as in many species it consists of a particular vibration brought about by the abdominal and back muscles. To be pedantic, it should more properly be called a release cue.

Hatching and tadpole development is rapid. Initially tadpoles are herbivorous with the long coiled gut so characteristic of herbivores, but as metamorphosis approaches they become more and more carnivorous. When they finally leave the water, perhaps with a remnant of the tadpole tail, they are almost completely carnivorous. However, unlike the vast majority of other amphibia, Cane Toads will eat fruit and household scraps, and even eat from dog bowls! This may be another reason for their success. Normally they eat any moving animal small enough to ingest (Hinkley,1962).

Our Cane Toads exhibit an interesting phenomenon; they are very much smaller now than when first introduced. The reasons are obscure. They could be genetic, very large toads somehow being selected against here, or could be more directly environmental. There may be diseases or specialised predators in the Cane Toad's natural habitat in Central and South America that keep the population density low, thereby reducing intraspecific competition and indirectly encouraging maximal growth rates. These may be lacking in Fiji and without any severe selection pressures, apart from the occasional mongoose and being flattened by vehicles, intraspecific competition may be

intense, ensuring that most toads have difficulty in finding enough food. This would keep the size of the average animal small. Perhaps it is significant that the largest **Bufo marinus** I have found in Fiji were from rainforest, where toads are not common. This suggests that Cane Toads in Fiji have not lost the genetic ability to grow large.

GROUND FROG.

Few Fijians and still fewer people of other races are aware that there are two species of endemic frog here. This is not surprising. Neither the Ground Frog, **Platymantis vitianus**, nor the Tree Frog, **Platymantis vitiensis**, are vocal, nor do they live in cities and towns. In addition, both are totally nocturnal, unlike the Cane Toad, which is occasionally seen in daylight.

The larger of the species is the Ground Frog; at up to 106 mm snout-vent length, with muscular thighs, it is a big frog by world standards. It is usually grey-brown dorsally, but red-brown or cream-grey individuals do occur. Nearly all have a characteristic white blotch just behind the large external eardrum.

Rarely, they possess a thin white or cream mid-dorsal line which continues on the thighs and calves. The Ground Frog, also known as **dreli** or **botoniviti** in Fijian, used to be eaten quite regularly. Some Fijians today deny this, perhaps feeling it denigrates their ancestors in some way. In view of the popularity of frog's legs in 'haute cuisine' restaurants, perhaps they were just a little ahead of their time.

P. vitianus is found on Vitilevu, Vanualevu, Taveuni, Viwa, Beqa, Ovalau and recently has been recorded from Gau. I expect it is also on Koro. Except for Viwa, these are all high volcanic islands with good rainfall and some intact rainforest. **P. vitianus** is usually considered to be associated with streams (Gorham, 1968; Pernetta & Goldman, 1976) but more recent observations by Zug (1983) and myself suggest this may not always be the case. Zug collected specimens at least 100 m from the nearest permanent stream, and John Gibbons and I collected others from the beach on Viwa, which has no permanent streams! One of these, a large female, 90 mm snout-vent length, produced a faecal pellet containing the remains of a sizeable crab!

Ground Frogs are hard to find as they blend in with their background and rarely move. Our first specimen came when an enthusiastic guide trod on it! This did the frog no harm, but precipitated a

A Fijian Ground Frog, **Platymantis vitianus.** Photograph: P.A. Ryan.

loud cry and rapid escape response in the guide. Since the first visit to Viwa I have caught, measured, weighed, toe-clipped and released 22 specimens. Work there is still in progress.

Captive Ground Frogs have proved catholic in their taste, feeding on almost any moving object. Their very big mouth enables them to cope with large prey. A frog of 70 mm snout-vent length swallowed a hawk moth with a wingspan of 65 mm. The same frog attacked and partially ingested a 50 mm snout-vent length immature Ground Frog, which, although rescued, died soon afterwards. Small prey are caught by flicking out the front mounted, sticky tongue. Large prey are leaped at with the mouth open and stuffed into the mouth with the aid of the front legs. Cannibalism is probably common in the wild.

In captivity, Tree Frogs have also been eaten.

I used to believe that the Ground Frog is voiceless, but one of the 31 I have handled gave a long series of typical 'frog croaks', which continued while I held it, but stopped upon release.

Like the Tree Frog, the Ground Frog lays large, direct development eggs. The embryo does not go through a tadpole stage, but develops directly into a small frog, which, on leaving the egg is capable of a full terrestrial existence. The eggs are laid under rotting logs or in leaf litter and do not need free water for their development. Very few Ground Frog eggs have been found, but their development is presumably similar to that of the Tree Frog.

TREE FROG.

The Fijian Tree Frog, **Platymantis vitiensis**, is considerably smaller than the Ground Frog. A large female will reach just over 50 mm snout-vent length, with a weight of around 10 gs, compared with 100 gs in a big female Ground Frog. The large adhesive discs on the toes of the Tree Frog also separate the two species. Despite being classified in the same genus, I do not think they are closely related. The Tree Frog used to be called **Cornufer vitiensis** but was placed into **Platymantis** when the generic name **Cornufer** became no longer available.

Colour pattern of the Tree Frog is immensely variable, something for which I have no satisfactory explaination. I have identified 22 different, regularly occurring morphs (frequency of each more than 1% of the 500 frogs examined) with another 17 rare or unique patterns (frequency of each less than 1%). Background colour may be yellow, orange, grey, brown or tan, and patterns include vase-shaped dark areas, white speckles, and mid-dorsal lines. These mid-dorsal lines may be narrow and white or, occasionally, wide and yellow. Some individuals, which I have nick-named 'headlight' frogs, sport yellow flashes on the forearms and below the nostrils. Suprisingly all these morphs appear to be genuine, as there are few intermediates and those patterns occurring in very low frequency bear little resemblance to the most common patterns. To confuse things even more, belly colour is variable and is apparently not correlated with dorsal colour pattern.

Similar, but more spectacular colour pattern variability is found in a number of South American frogs, but most are virulently poisonous and their colours warn that they are unpalatable. The Tree Frog seems to be edible, so the variability cannot be so easily explained

A Fijian Tree Frog, **Platymantis vitiensis.** Photograph: P.A. Ryan.

(even the suggestion that the bright colours of the South American frogs act as a warning raises more questions than it answers).

If the Tree Frog was widely distributed in small, isolated pockets, then it might be expected that each population would evolve a characteristic pattern, indeed this sort of situation occurs with many frogs. But the answer is not so simple, for in the three populations I have examined (Wailoku, Coloisuva and Monasavu) each population carried a full range of patterns. This leaves us with the suggestion that there is no selective advantage to any particular colour pattern or that there is no serious selective disadvantage to any specific morph (If there were it would presumably be removed from the population). A truly neutral character of this sort is rare in nature.

A Fijian Tree Frog. Note the difference in colouration between this frog and the one pictured opposite. Photograph: P.A. Ryan.

The only factor in common between reproductively mature varieties is the possession of a distinctive yellow/orange groin, thigh and calf flash. This bright colour is usually hidden when the frogs sit, but is revealed when they move. If the colour **per se** is of significance then the all yellow morph could constitute a 'super-normal' stimulus and might be expected to have great breeding success. On the other hand, if the lack of contrast with the rest of the animal mitigated against it, the yellow morph would not occur quite so frequently!

Predation usually offers a clue to the reason for the existence of polymorphic species, but there appears to be little help from this avenue with the Tree Frog. So far as I can gather the major predator appears to be the Pacific Boa, **Candoia bibroni**, which is an olfactory rather than a visual hunter. No morph would possess a selective advantage against predation from this source.

Both Ground and Tree Frogs possess colour change ability. Although the basic pattern remains the same, both are capable of lightening or darkening their background colour. The Tree Frog is very adept at this and at night individuals present a much more uniform colour than they do during the day, when individual patterns are particularly striking.

The Tree Frog used to be considered rare, but I now believe that it is locally common on the islands on which it has been located - Vitilevu, Vanualevu, Taveuni and Ovalau. In lowland forest it is usually found during the day in the leaf axils of **Pandanus vitiensis**, but at night it will range over other plant species. The Wailoku frogs are frequently found on **Syzygium corynocarpum**, but are sometimes seen on most other plants growing on the stream bank. In Monasavu they live high up canopy trees in an epiphytic lily, **Collospermum montanum.** The Tree Frog seems to be a very adaptable species and has taken advantage of the lack of competition to occupy many of the tree frog niches that in a richer fauna than ours would be divided amongst several different species.

Platymantis vitiensis eats any small arthropods which are within its capabilities to subdue. It feeds in the same manner as the Ground Frog, but does not use its front legs to the same extent.

Breeding takes place primarily from December to March with a peak in late February, early March. Analysis of monthly size data, however, suggests that some breeding may take place at any time of the year. Eggs are large when laid, approximately 7-8 mm in diameter, and may increase to as much as 12 mm shortly before hatching. Mean

clutch size based on 13 clutches was 18.1, with a range of 13-29. Nests are usually found in the leaf axils of pandanus.

Contrary to limited observations by Gibbons and Guinea (1983), the embryos do not remain dorsal to the yolk for the whole of the incubation period. At about day 10 they roll over and lie below the yolk, but by day 22 they may re-rotate and remain dorsal until hatching, which takes place around day 27. Emergence is fast, presumably facilitated by an enzyme which breaks down the egg membrane. After hatching, the uniformly dark froglets retain considerable quantities of yolk and do not need to feed for at least a week after emergence.

Even at this stage their colour pattern is visible and does not appear to change as they grow. At this small size, 9-12 mm snout-vent length, they must be vulnerable to many predators, including spiders and centipedes. Their dark colour, however, camouflages them amongst the predominantly black, moist leaf litter. By the time they start sitting openly on leaves, presumably after several weeks, they have lightened considerably.

Defence Mechanisms.

Tree Frogs are easy to capture when perched on leaves, but if they leap to the ground they are hard to find. Characteristically they twist in the air, hit the ground and jump once, often at right angles to their initial leap. The colour pattern which looked so bright on the feeding perch merges wonderfully amongst leaf litter, so most evade capture.

Although apparently defenceless, the Tree Frog has a number of defence behaviours. The first, changing direction in the air, has already been mentioned. To lighten themselves to jump further they usually void bladder water. If threatened head on by a predator (I used a Pacific Boa) they puff themselves up with air, bow their head and front legs, and fully extend the hind legs. They then sway from side to side by alternating the extension of their hind legs. This display, reminiscent of that of **Bufo bufo** when confronted by a predator, makes the frog look larger than it actually is. I have occasionally detected a low hissing, but whether this is deliberate or the result of the exertion of keeping the body fully inflated I do not know. This inflation produces a significant internal pressure.

Boas apparently have difficulty in coping with an inflated frog. The remarkably tight, slippery skin, prevents a boa from obtaining

good purchase with its jaws anywhere on the body. I fed five **P. vitiensis** to a tame boa and in no case was the snake successful in keeping its grip. Although the teeth may have penetrated the skin and lungs, they must be self-sealing, as the frog maintained pressure. Only frogs struck on a hind or front leg could be manipulated into the constricting coils. This is only true of frogs which had seen the snake and had time to inflate. One frog, caught completely unawares, was hit mid-body by the strike and died before inflation occurred. Another, caught by a front leg, produced a loud and penetrating scream, the first record, as far as I know, of a voice in **P. vitiensis.** Some specimens in the wild show scarring which may be the result of escape from boa attack.

Ground Frog defensive behaviour includes voiding of bladder water and puffing up with air, but I have not yet confronted a captive specimen with a boa.

Arrival in Fiji.

Opinions as to how our frogs got to Fiji vary. It is possible that they were introduced by man either as a food source (Pernetta & Watling, 1978) or by accident. There is no doubt that the eggs of either species could have reached here from the northwest in organic material around root crops. Frogs are believed to evolve quite slowly and both our species are endemic, which implies they have been here quite some time. In my view they almost certainly pre-date man, particularly as the earliest date we have for human habitation is 1590 BC (F. Clunie, **pers comm**). If this is the case, then they must have arrived by rafting, probably during the wet season, when the southeast trades tend to fail, giving mats of floating vegetation a better chance of reaching the Group. Although the Fijian frogs and the nearest **Platymantis** species in the Solomon Islands are separated by large expanses of water, this may not always have been the case. Sealevel fluctuations caused by ice-ages and island-building (and destruction) by undersea volcanoes could have provided a series of stepping stones whereby shorter voyages would suffice to bring either eggs or adults to Fiji.

For any journey requiring exposure to a hypertonic medium and dessication, the smallest possible surface area to volume ratio is desirable. This suggests that the largest individuals of any Fiji frog ancestor would be the best-equipped to make the journey, and significantly, these would also be close to sexual maturity.

Eggs have a small surface area to volume ratio and it is true that direct development eggs are better adapted to such journeys

than those of most other frogs. However, as soon as they hatch, the surface area to volume ratio becomes totally unfavourable. I also find it difficult to believe that eggs or minute newly hatched frogs could survive a journey across the reef and onto out beaches, run the gamut of predators over the beach, and move from there into suitable habitat. Far more likely, surely, that adult frogs made the crossing? Arguments against this include such straw men as the fact that all our lizards (with one exception) lay eggs. A colleague has argued that this suggests that these species rafted here as eggs, ignoring the fact that in the Solomon Islands, potentially a source of many of our species, all geckoes and all **Emoia** skinks (our commonest skink species) are egg-layers. To me this just shows that the source material for our fauna consisted almost entirely of egg-layers, not that the eggs themselves made the journey. It is quite possible that eggs of many of our lizards did raft here, but it is not acceptable to then extrapolate to our frogs.

Conservation.

The Fiji frogs are not as rare as has previously been considered, but this is no reason for smugness. As long as rainforest is heavily logged and secondary rainforest is modified, the Tree Frog must be endangered. The Ground Frog situation is problematical. They are so difficult to find and have been reported from so many islands that they may not be endangered at all. Until we know more about them it is prudent to assume the worst. I would like to see Viwa set up as Fiji's first frog reserve, and for it to be made illegal to capture or harm these animals without a special permit. The people of Viwa are quite proud of their frogs and I am sure that they would like to see the population preserved. It would not be impossible to destroy the vast majority of Cane Toads on the island. There are very few areas of water available for the toads to breed in and a toad 'egg patrol' would reduce their numbers significantly. This could prove an excellent project for the National Trust if the Viwa people agreed to it.

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