Ecology and reproduction of the endangered Fijian Ground Frog *Platymantis vitianus* - Fiji Islands

Edward Narayan[1*], Ketan Christi[1] and Craig Morley[2]
[1]*Division of Biology (SBCES), Faculty of Science and Technology*
The University of the South Pacific, Suva, Fiji
[2]*Department of Conservation – New Zealand*
[*] *Corresponding author, email: edward_nryn@yahoo.com*

ABSTRACT
This paper reports on the terrestrial nesting behaviour and biometrics of eggs and froglets of the Fijian ground frog, Platymantis vitianus *observed on Viwa Island (900m east of the mainland Vitilevu, Fiji Islands), including day-time choices of micro-habitats and variations in capture rates in the sex-age classes of adults and metamorphs with respect to in-situ rainfall conditions. More adult males and gravid females were captured during the wet months of November until January. Metamorphs were more common subsequent to these months. Furthermore, egg masses of* P. vitianus *were discovered on Viwa Island for the first time, two nests were located underneath rotten logs during high rainfall month of December, 2007. It is highly probable that the reproductive cycle of* P. vitianus *is continuous while courtship and nesting events are influenced by the variable and higher rainfall months on Viwa Island.*
Keywords: *Conservation, Endangered, Frog,* Platymantis vitianus*, Fiji Islands, Reproduction, Ecology*

1 INTRODUCTION

Two species of terrestrial frogs of the genus *Platymantis* (Family Ranidae, subfamily Platymantines) survives in Fiji Islands, while a third species *P. megabotoniviti* is extinct. The two recognized extant endemic frog species are the Fijian ground frog (*Platymantis vitianus*) and the Fijian Tree Frog (*Platymantis vitiensis*). The extinct Fiji frog, *P. megabotoniviti* is believed to have been hunted down to extinction by the first Fiji inhabitants and rats (*Rattus rattus and R. praetor*) that had come with them in the late Holocene (Worthy 2001). Also found in the Fiji archipelago is the introduced cane toad, *Chaunus (Bufo) marinus*, which was introduced into Fiji in 1936 to control the insect pests in Fiji's sugar cane fields (Ryan 2000). *Platymantis vitiensis* is listed as near threatened (NT) by the International Union for Conservation of Nature (IUCN) while *P. vitianus* is listed as endangered (EN B1 + 2C) [Anon 2006]. *P. vitiensis* is restricted to four of the largest islands (Orsborne 2006): Viti Levu, Vanua Levu, Taveuni, and Ovalau. While *P. vitianus* is present only on one small site (Waisali forest reserve) on Vanua Levu (Morrison *et al.* 2004) and four other islands in the mid-parts of Fiji; Viwa Island in Tailevu; Ovalau and Gau in Lomaiviti group; and Taveuni (Morrison 2003). These islands are all free of invasive Small Asian Mongoose (*Herpestes javanicus*).

Over the past decade, research gaps were identified mainly in the knowledge of geographic distributions of native Fijian frogs because of incomplete surveys of several natural habitat areas (Morrison, 2005). Therefore, more targeted herpetological surveys were undertaken by local scientists (Morrison *et al.* 2004; Kuruyawa *et al.* 2004; Osborne 2006; Thomas 2007) in order to completely evaluate the distribution of amphibian fauna of Fiji Islands. Kuruyawa *et al.* (2004) confirmed that the range in distribution of *P. vitianus* has decreased considerably because of invasive predators. There is no evidence that the abundance of frogs has decreased where they still occur. Thomas (2007) conducted recent surveys on Viwa Island and compared the spatial distributions and nocturnal micro-habitat choices of *P. vitianus* and *C. (Bufo) marinus*. Considerable numbers of frog surveys have been conducted and now we need more concerted conservation actions for *P. vitianus*.

The current paper presents results of a separate and more specific field survey conducted on Viwa Island as it provides report on the reproduction of *P. vitianus* and it also provides information on their day-time micro-habitat choices. Furthermore, it discusses the observed reproductive pattern in the wild with the reproductive activity of frogs maintained in captivity. Ultimately this paper aims to provide information that can guide and inform future conservation programmes for *P. vitianus* both in captivity and in the wild.

2 METHODOLOGY

2.1 FIELD SITES

The field surveys were conducted with the help of three field assistants (local villagers) on selected natural habitat sites of *P. vitianus* on Viwa Island. Surveys were conducted every month (av. 15 days per month) from January 2006 until December 2007. The accessibility to mainland and easy terrain makes Viwa Island one of the best natural locations for herpetological surveys. The surveys were conducted mainly within the forested landscape. The details of the potential habitat areas of *P. vitianus* on Viwa Islands have been provided by Thomas (2007). The amount of rainfall in the field was recorded (mm per day) by the help of a rain gauge.

2.2 SAMPLING DESIGN

Field sampling was conducted using visual encounter surveys (VES). The VES technique was formalized in 1982 by Campbell and Christman and in 1990 by Corn and Bury, both using time as the constraint (Crump and Scott 1994). VES were used to document the presence of frogs in three sex-age classes (adult males, adult females and metamorphs) within the survey site. The advantage of using VES method for herpetological surveys is that they are effective in most habitats and for most species that breed in

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lentic (non-flowing) water. 10 x 10 m quadrants (n = 3) were established using tags within the survey area.

2.3 DAYTIME SEARCHES

These were conducted over four hours between dawn, noon and dusk. Since the frogs remain under cover by day, searches involved lifting substrates such as coconut husks, logs and other debris on the ground. The types of the micro-habitat in which the frogs occurred and the number within each of the three sex-age classes observed were noted. Substrates were also inspected for the presence of any eggs of *P. vitianus*.

2.4 NIGHTTIME SEARCHES

These were conducted along 50 m transects (n = 3) over four hours per night starting from 2000 h. At night, *P. vitianus* that had emerged from cover were located mostly by eye shine (due to reflection of the torch light in the tapetum of the eye). Frogs were generally caught by hand capture upon sighting. All frogs were examined and their colour, weights (wt), snout-vent length (SVL), and gender was recorded. Capture rates per hour of frog collection were calculated. There were a total of 15 night surveys per month.

2.5 FROG BIOMETRICS

The weights of the frogs were recorded using a hand held Pesola balance and SVL was recorded using a Vernier calliper. Initially, Thomas (2007) had provided the cut off values for the sizes of the frogs. The SVL of adult male should be > 25 mm to 49.2 mm while the SVL of adult female should be between 48.8 mm to 105 mm. There was an obvious overlap of SVL between males and females in the range of 48.8 mm to 49.2 mm. Furthermore, it was difficult to distinguish between non-gravid females and small males of similar sizes since *P. vitianus* does not generally express sexually dimorphorphic characters. However, gravid females (i.e. those with developing eggs) were easily identified by a rapid method of visual inspection performed in a dark area, under a bright light source from a hand-held torch, for creamy, round egg clutches visible through their semi-transparent underbelly skin. Non-gravid females were those frogs that did not show presence of developing eggs.

An alternative method was developed to assist with sexing similar sized frogs. The stress "alert" calls were used whereby, upon handling (gentle rubbing of the underbelly), a female frog produced laud "dog-barking" call while in a similar handling position, a male frog generally produced a softer "bird chipping" call. This method seemed to have worked well with both larger (> 50 mm) gravid and non-gravid females as well.

2.6 STATISTICAL ANALYSIS

Comparison of day-time micro-habitat preferences (forested landscape), capture rates (dry and wet nights; light and heavy rainfall nights) were done using Mann Whitney *U* test, $p < 0.05$. Combination of a linear graph (for average monthly rainfall) and bar graphs (average monthly captures of gravid and non-gravid females) was used to find out the reproductive trends. All statistical analysis was performed using SPSS version 12.0 statistical programme.

3 RESULTS

3.1 DAYTIME RETREAT SITES

By day most of the frogs were found within the forested landscape micro-habitats, frogs were found underneath piles of coconut husks, rotting logs and leaf litter. Frogs were usually observed in a water conserving posture such as pressed flat. On average, per hourly intervals, more frogs were collected underneath rotting logs (n = 5 per hour) in comparison to coconut husks (n = 3 per hour) and leaf litter (n = 2 per hour) in the forested landscape ($\chi^2 = 5.41$, $p < 0.01$).

3.2 BREEDING

Egg masses (n = 2; average 50 fertile eggs per egg mass) of *P. vitianus* were discovered, these were found underneath rotting logs (Figure 1 and Figure 2) within the forested landscape on 22nd of December, 2007. The average diameter of eggs was 9 mm. It was easier to locate the metamorphs underneath rotting logs and sometimes they were found in crevices within the logs. The average SVL of adult males were 40.4-59.7 mm, adult females were 60.3-110 mm and metamorphs were < 40 mm over the survey.

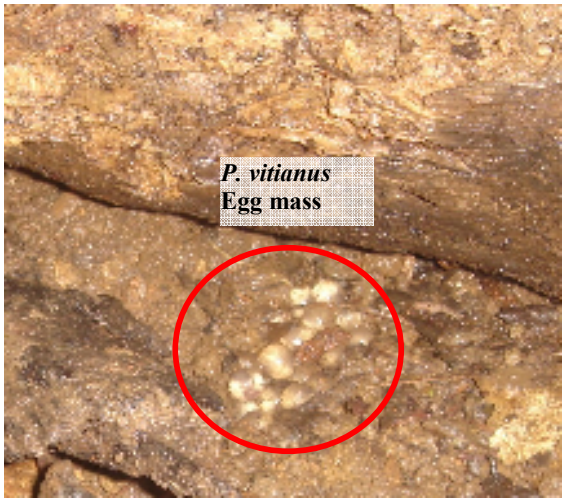

Figure 1 showing the fertile eggs (n = 50) of *P. vitianus* discovered in a nest created underneath rotting log on Viwa Island.

Figure 2 showing developing *P. vitianus* embryo within eggs found on Viwa. These eggs were removed from the egg mass for closer view of developing embryo.

3.3 NOCTURNAL ACTIVITIES

Total number of frogs caught was highest in December (n = 79), followed by November (n = 47) and August (n = 15). The capture rate (per hour) for each sex caught during monthly surveys has been provided in the Figure 3.0.

Capture rates of adult frogs were significantly different between the dry and wet nights ($\chi^2 = 6.51$, $p < 0.01$), more frogs were caught on the latter. Generally more adult frogs were found during the wetter months of November to December in comparison to the drier months (Mann Whitney *U* test, $p < 0.01$). Mean capture rates were significantly different between light rain and heavy rain (Mann Whitney *U* test, $p < 0.01$), more adult frogs being caught after light shower.

It was observed that the frogs had a tendency to climb higher up in the available vegetation, frogs (usually females) being found up to 3 m high on sloping trunks of *Inocarpus fagifer* trees even on nights with light rain (Figure 4).

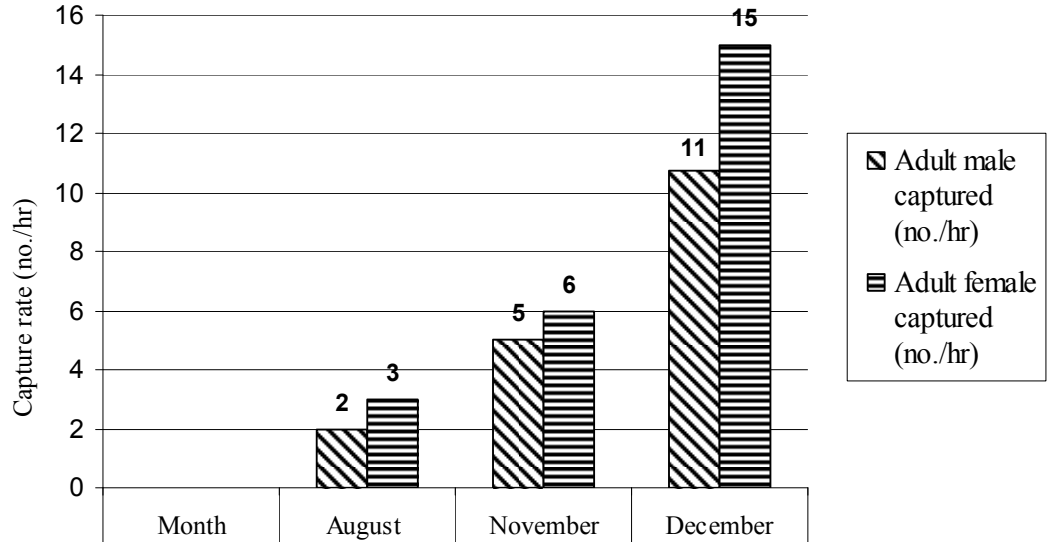

Figure 3 showing the comparison of mean capture rates (no. /hr) of *P. vitianus* in relation to rainfall on Viwa Island.

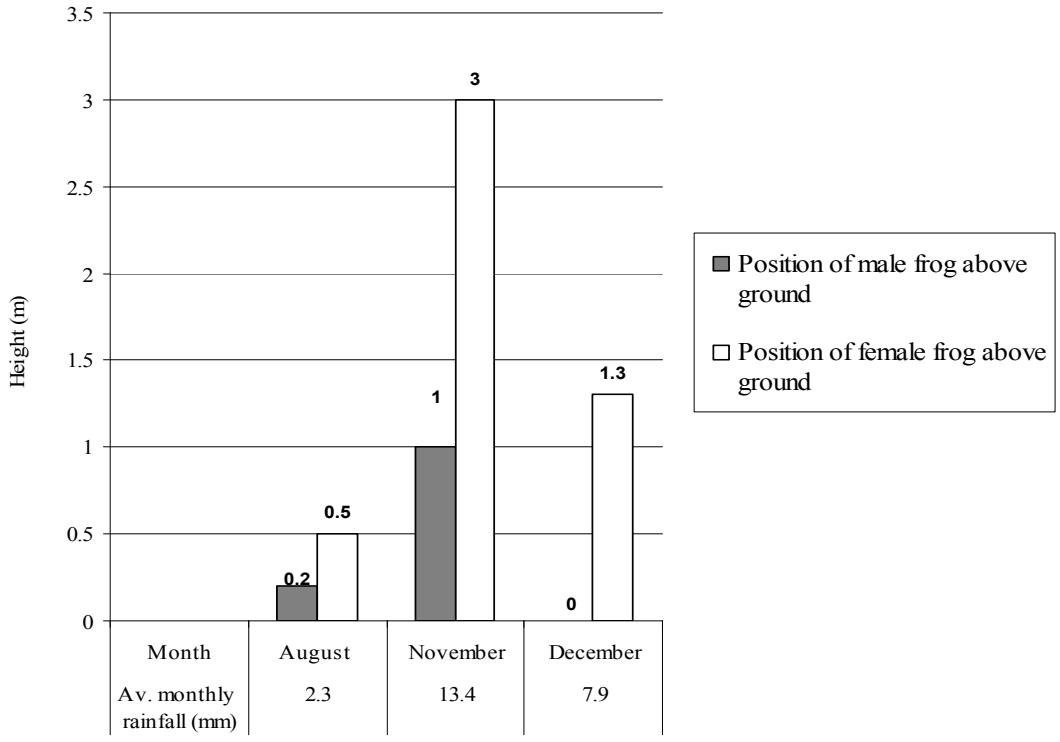

Figure 4 showing the comparison of mean height (m) of *P. vitianus* above ground in relation to rainfall on Viwa Island.

Average monthly rainfall data is provided (Figure 5) in comparison with average monthly number of adult gravid and non-gravid females captured. Metamorphs (av. SVL < 25 mm) were generally observed throughout the survey period. More froglets (av. SVL < 11 mm) were captured towards the end of the year i.e. completion of the high rainfall months.

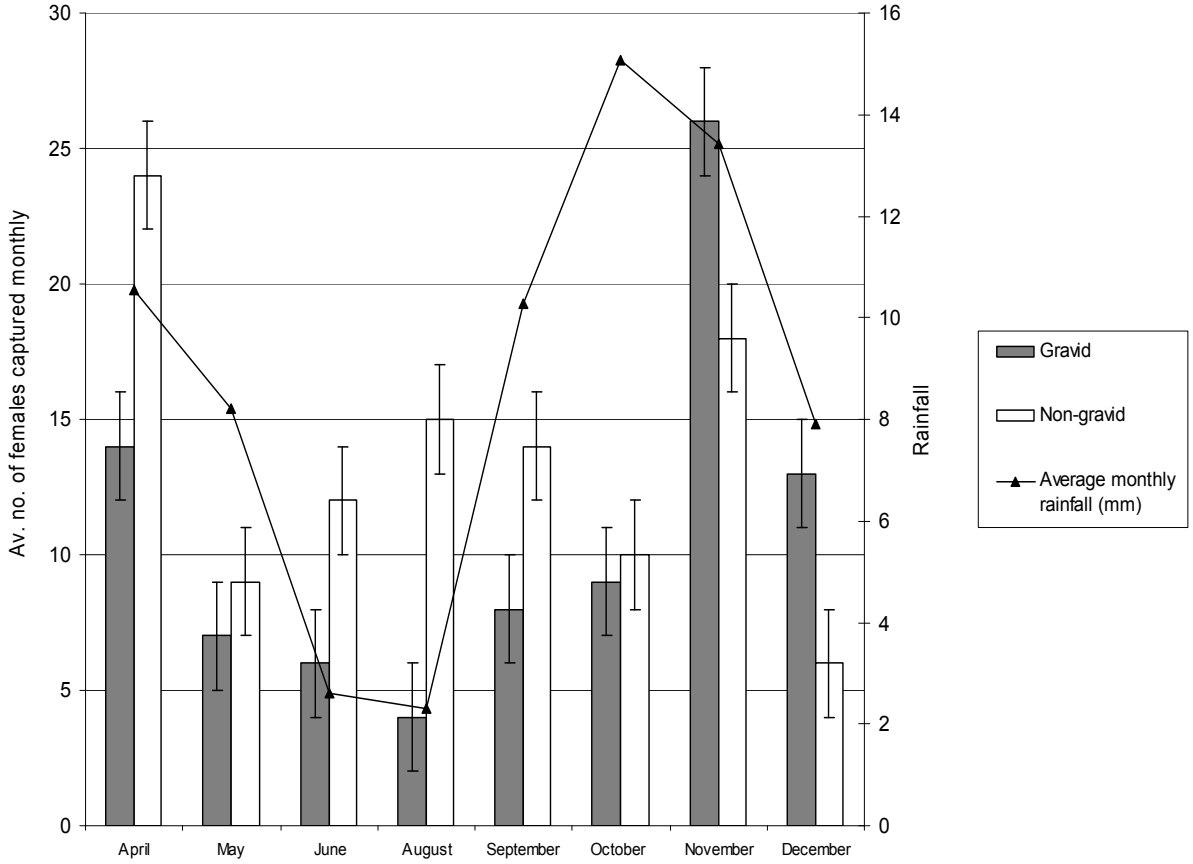

Figure 5 showing the comparison of adult gravid and non-gravid female captures in relation to rainfall on Viwa Island. Data for July month was unavailable.

4 DISCUSSION

The visual encounter survey technique was selected for the field surveys because of effectiveness in easily identifiable habitats such as uniform habitats with good visibility. However, the night time surveys were mainly affected by poor visibility during periods of heavy rainfall. Similar indication were given by Thomas (2007) during night time surveys on Viwa Island for *P. vitianus* and Bell (1978) during night time field surveys of *Leiopelma* species in New Zealand. Furthermore, the unpredictable rainfall conditions on Viwa Island could have also modified the situation, for example, in general frogs were more readily located after period of heavy rain than during dry periods. More frogs were mainly captured during periods of light rainfall rather than during dry period or heavy rainfall. Similar observation was reported by Thomas (2007) and Osborne (2006), who studied phenology of *P. vitiensis* along two permanent transects along Vago Creek, Savura. Low numbers of frogs were encounted at day-time because they remained hidden within the natural substrates.

The encounter of gravid females throughout the year indicates that reproduction is more likely continuous rather than annual. The observation of more metamorphs, froglets and findings of egg masses towards the end of the year indicates that although reproduction is a continuous event, the frequency of courtship and mating events were higher towards the end of the year, which also coincided with high rainfall months on Viwa Island.

Duellman and Trueb (1994) have stated that among anurans, two basic reproductive patterns are evident. Most tropical and subtropical species are capable of reproduction throughout the year; rainfall seems to be the primary extrinsic factor controlling the timing of reproductive activity. On the other hand, in most temperate species, reproductive activity is cyclic and dependant on a combination of temperature and rainfall. The climatic pattern on Viwa is more seasonal than many of the major islands because it is a low-lying small island (Mueller-Dombois and Fosberg 1998). Therefore, the high variability in rainfall months might restrict their reproductive activity temporarily, which could provide reason for fewer gravid females being encountered during lower rainfall months.

Furthermore, the availability of appropriate breeding sites (terrestrial nesting areas) may also limit the continuity of reproduction in *P. vitianus*. Sufficient rainfall is

normally required to provide oviposition sites (Duellman and Trueb 1994). In captivity, it was found that rainfall created favorable micro-climate conditions required for mating and nesting by *P. vitianus*, it also decreased predatory sources such as invertebrates including invasive ant species *Pheidole megacephala* that could harm any eggs and froglets and it also provides abundant food supply for gravid females and any future hatched froglets (Narayan *et al.* 2007). Further investigations are required for longitudinal monitoring of reproductive activity of females in the wild, possibility by using mark recapture techniques.

In conclusion, the information presented in this paper provides new information on the ecology and especially the reproductive biology of this poorly researched amphibian species. Therefore, this paper provides an avenue for concerted conservation strategies for *P. vitianus*.

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