Swimming against the current: the Brown Striped Marsh Frog *Limnodynastes peronii* success story

C. B. Schell[1] and Shelley Burgin[1,2]

[1]Centre for Integrated Catchment Management, University of Western Sydney, Richmond campus, Locked Bag 1797, South Penrith DC, 1797.

Corresponding Author:
[2]A/Professor Shelley Burgin
Centre for Integrated Catchment Management. University of Western Sydney, Richmond campus, Locked Bag 1797, South Penrith DC, 1797
Phone: (02) 4570 1209 Fax: (02) 4570 1621 E-mail: S.Burgin@uws.edu.au

ABSTRACT

Seven potential anuran breeding sites within Western Sydney were sampled between March and August 1997 to assess the effect of habitat disturbance upon species assemblages. The greatest species diversity and abundance was recorded in relatively less human impacted areas, than in more disturbed sites. Of the seven species recorded to chorus during cooler months, only *Limnodynastes peronii* successfully breed and only in disturbed sites. The species was also more abundant in such areas than more pristine habitat. Oviposition time influenced larval growth rate, although there was no defined trend over time. Intra-clutch variation in weight achieved (over 10 weeks) was greater than among clutches. Ability to take advantage of breeding habitat that is sub-optimal for other species, the ability to breed year around and larval growth plasticity have apparently pre-adapted this species to thrive in urban impacted habitat, in contrast to most local endemic species.

Key words: frogs, biodiversity, urban encroachment, habitat modification, reproductive characteristics.

Introduction

Anuran reproductive traits vary widely intra- and inter-species (Berven 1982; Cummings 1986). They may reflect the particular mode of life and the conditions under which eggs of individual females develop (Stebbins and Cohen 1995). In many cases, human induced alteration of the environment may be detrimental to frogs because of the constraints of reproductive physiology (Duellman and Trueb 1986; Tyler 1999). In other instances (eg. Ferraro and Burgin 1993; Hengl and Burgin 2002) species, such as the Brown Striped Marsh Frog *Limnodynastes peronii*, appear to take advantage of human modified environments.

Both temperature and photoperiod exert an influence on reproductive traits (Kaplan 1987; Alonso-Gomez *et al.* 1990; Pancharatna and Patil 1997) and seasonal changes in clutch parameters have been shown to occur (*e.g.* *Ranidella signifera*, cf. *Crinia signifera*, Williamson and Bull 1995a). In many cases these environmental parameters also serve to synchronise breeding (Barker *et al.* 1994). Most temperate frog species breed in warmer months (Kaplan 1987; Alonso-Gomez *et al.* 1990; Pancharatna and Patil 1997). However, some Australian species also breed during autumn and winter (*e.g.* *C. signifera*, Williamson and Bull 1995a; *L. peronii*, Hengl and Burgin 2002). This characteristic may result in pre-adaptation to changes in micro-habitat temperatures in the presence of human degradation (*e.g.* reduced vegetation cover and associated more extreme temperature fluctuations).

Ferraro and Burgin (1993) observed that *L. peronii* and *C. signifera* were abundant and formed a large part of the winter chorus in some waters of Western Sydney, however, *L. peronii* was more abundant in disturbed areas compared to those that were less disturbed. In this paper we investigated frog assemblages in north-western Sydney to assess the influence of 1) human impacts on species diversity and abundance, and 2) factors (clutch size and larval growth) that may impact on the success of *L. peronii* in human modified environments.

Methods

To investigate the influence of human disturbance, frog breeding sites were selected based on the data of Ferraro and Burgin (1993), and an additional extensive survey of local water bodies. Seven potentially suitable frog breeding habitats were selected in Western Sydney within a 25 km radius of the township of Richmond (UGR; 6280000N, 291000E; see Table 1). Sites 1-3 were relatively undisturbed areas of natural bushland containing large areas of aquatic and emergent native vegetation. Sites 4-7 were highly disturbed as a result of adjacent human activities, and received either urban or agricultural run-off. Exotic vegetation and the introduced Plague Minnow *Gambusia holbrooki* were characterisitic of disturbed areas. These areas also contained areas suitable for anuran oviposition (*ie.* herbaceous vegetation covering water with some aquatic vegetation).

Table 1: Brief description of sites where frogs were found calling in north-western Sydney, surveyed for frogs between March and August 1997.

Site	Closest settlement	Universal Grid Reference	Notes on site
1	Windsor Downs	6273500N, 295000E	Billabong, catchment dry sclerophyll forest. Abundant aquatic and terrestrial understorey vegetation.
2	Richmond	6276583N, 292333E	Ephemeral swamp, catchment *Melaleuca* forest. Abundant aquatic vegetation.
3	Richmond	6278375N, 288375E	Ephemeral swamp, catchment *Melaleuca* forest. Abundant aquatic vegetation.
4	Richmond	6278833N, 29241E	Constructed wetlands (established >20 years) used in the treatment of wastewater, catchment farmland. No upper storey canopy, many exotic weeds.
5	Richmond	6278500N, 29137E	Large Dam, receives treated sewage effluent, catchment farmland. No upper storey or mid-storey canopy.
6	Richmond	6277250N, 29170E	Shallow body of water, catchment farmland. Receives agricultural run-off during flood. Upper and mid-storey canopy present, ground cover mainly grasses and endemic herbs.
7	Blacktown	6260500N, 306562E	Urban creek, catchment housing estates and road run-off, no upper or mid-storey canopy, mostly exotic aquatic plants.

Egg collection occurred between March and August 1997, following rain (>0.1mm). An assessment of the frog chorus was also undertaken at dawn and dusk between May and August. On each visit to each site, approximately one hour was spent recording frog calls and searching for eggs around the margins of water bodies, attached to aquatic plants, or on the water's surface. In addition, sweep-netting was undertaken to identify the presence of tadpoles and, if present, tooth row morphology (Tyler 1999) was used to determine species.

All egg masses located were collected and placed in individual plastic bags, together with approximately one litre of water from the site. They were then transported to the laboratory. On arrival, the contents of each plastic bag were placed into a 4000 mL glass beaker. The eggs were then left to develop at ambient laboratory temperature (19-25°C). For each egg mass, the number of hatched tadpoles, non-hatched eggs and larvae that died in the first week after hatching were recorded.

To assess the hypothesis that there was no difference in larval growth as a result of environmental factors during vitellogensis and oviposition, three *L. peronii* egg masses (the only species observed to oviposit) were randomly selected from each of three collection times (May 8, May 30 and June 3, 1999) from the total population of egg masses collected. Sixty stage 21 tadpoles (*cf.* Gosner 1960) from each egg mass were segregated into three groups of twenty individuals. Each group of twenty individuals was then placed into a separate 4000 mL plastic bucket, with two litres of aged tap water. Each fortnight, all tadpoles were removed from the water, blotted dry and individually weighed to four decimal places using an analytical balance. A complete water change was provided at this time. Over the 10 weeks of the trials tadpoles were fed *ad libitum* on Wardley tropical fish food flakes™. Growth was

monitored for ten weeks and then tadpoles were released at their point of capture, after appropriate rain.

Egg data were analysed using a One Way Analysis of Variance (ANOVA), while growth trial data were analysed using a Nested Three Way ANOVA. Homogeneity of variances was tested using Cochran's test. Both log and square root transformations failed to reduce the heterogenous variances, therefore, where heterogeneity was identified, significant differences were accepted only at the 1% level. The Sequential Bonferroni Test (Rice 1989) was used to reduce the risk of Type 1 error associated with repeated analysis of the same sample units. Ryan's Q-test was also performed on data with homogeneous variances to identify specific significant differences.

Results

Frogs called after rain, at least intermittently, throughout late autumn and winter (see Table 2). Abundance and diversity varied among sites from relatively few (Site 5) to many hundreds of individuals (Site 1) and seven species (Site 2).

Although heard to chorus less frequently and in substantially smaller numbers than *C. signifera*, *L. peronii* was the only species that bred, and it bred only at one site. Larvae were observed at two sites (Site 6, 7) but eggs were only observed at Site 7. Reproduction occurred throughout winter: 16 egg masses were found between early May and August 1997. No eggs, or tadpoles, were observed at less disturbed sites (1-3) and no tadpoles of other species were found.

Clutch size varied between 158-2037 (Figure 1). However, fecundity (F = 1.789; d.f. = 8; P = 0.203), egg viability (F = 1.174; d.f. = 8; P = 0.360) and the proportion of larvae dead within one week of hatching (F = 2.032; d.f. = 8; P = 0.163) did not differ significantly between oviposition events.

Table 2: Frogs observed in chorus at seven sites (1–3, relatively undisturbed; 4–7 modified) in north-western Sydney between March and August 1997.

Site	Species	May 8	May 13	May 21	May 30	Jun 3	Jun 17	Jun 30	Jul 2	Jul 7	Aug 7	Aug 8
1	*Crinia signifera*	>50	3	>100	>50	1	1	1	>100	>100	>20	3
	Litoria nasuta	4	0	3	1	0	0	0	0	0	0	0
	Crinia signifera	4	3	2	2	2	1	2	>20	4	2	6
	Litoria fallax	12	1	0	2	0	0	0	0	0	0	0
	Litoria dentata	2	1	1	1	0	0	0	0	0	0	0
	Litoria peronii	1	1	0	1	0	0	0	0	0	0	0
	Lim. dumerilii	1	0	0	0	0	0	0	0	0	0	0
	Lim. peronii	1	0	0	0	1	0	0	0	0	0	0
	Litoria nasuta	0	0	0	0	0	0	0	0	1	0	0
3	*Crinia signifera*	2	1	2	4	1	2	1	2	6	0	0
	Litoria peronii	0	2	1	0	0	0	0	0	0	0	0
	Litoria dentata	0	1	1	1	0	0	0	0	0	0	0
4	*Lim. tasmaniensis*	6	4	0	3	0	0	0	1	0	0	0
	Lim.dumerilii	1	1	0	0	0	0	0	0	0	0	0
	Litoria fallax	4	4	0	2	2	0	0	0	0	0	0
5	*Litoria peronii*	0	1	1	0	0	0	0	0	0	0	0
6	*Crinia signifera*	8	5	8	5	1	1	1	3	0	1	8
	Lim. peronii	3	1	2	0	1	0	0	0	0	0	0
7	*Lim. peronii*	4	1	5	2	0	0	0	0	0	0	0

Collection time significantly influenced weight attained ($F = 13.326$; d.f.$=2$; $P=0.0062$). Tadpoles from eggs collected in late autumn (May 30) achieved the highest mean weight, although those from eggs collected earlier in the month (May 8) attained the lowest mean weight at 10 weeks (Figure 2).

Differences in weight attained within clutches (replicates) were significantly different ($F=2.221$; d.f.$=18$; $P=0.0028$), although there were no significant differences among clutches ($F=1.640$; d.f.$=6$; $P=0.1935$). There was, therefore, generally greater variation in weight achieved within clutches than among them.
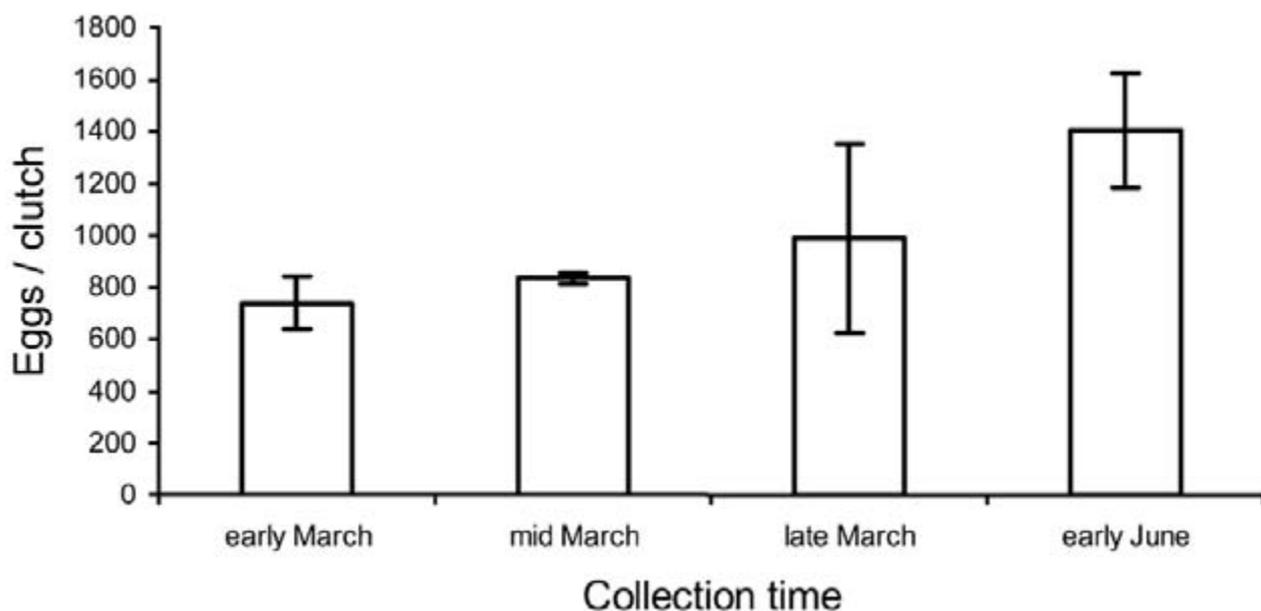

Figure 1: Fecundity of *Limnodynastes peronii* during Autumn/Winter breeding (March – August, 1997). Standard error bars are indicated (n = 4 for each collection time).
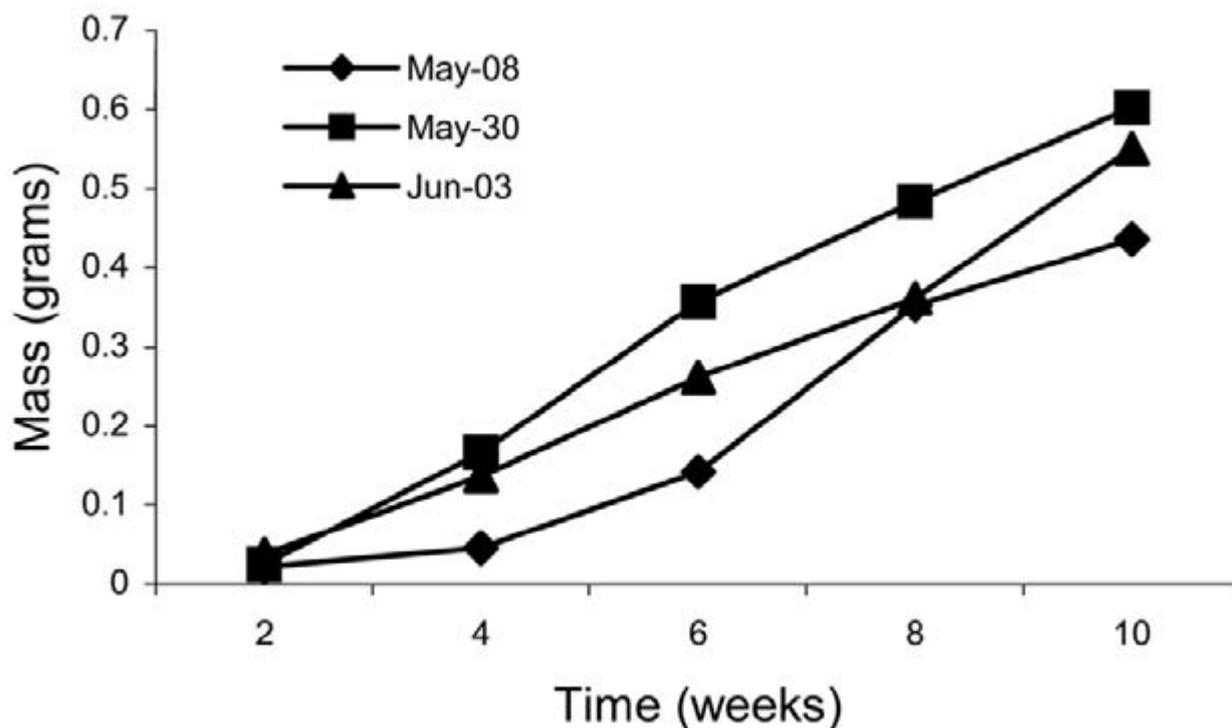
Figure 2: Mean growth mass of *Limnodynastes peronii* tadpoles collected during Autumn/Winter (March–August, 1997).

Discussion

Factors influencing success - winter breeding

Numbers of individuals calling did not reflect reproductive success during the cooler months of this study. Despite recording seven species in chorus, one (*C. signifera*) in relatively large numbers, only *L. peronii* reproduced across this period that is generally considered sub-optimal for temperate frog reproduction (Pancharatna and Patil 1997; Tyler 1999). No eggs or tadpoles of other species were observed although some species (*e.g. C. signifera*, Lemckert and Shine 1993; Williamson and Bull 1995b; Lemckert 2001) are known to be winter breeders. These data indicated that under unusually dry conditions, *L. peronii* was unique in its ability to opportunistically take advantage of rainfall for breeding in cooler months.

Factors influencing success – coping with anthropogenic impacts

Sites where *L. peronii* bred were highly disturbed, with low species diversity. Hengl and Burgin (2002) also observed that this species bred in highly modified situations (*e.g.* ornamental garden pools within north-western Sydney). This species is, therefore, able to take advantage of conditions that are presumably sub-optimal for other endemic taxa. They may persist in, or re-colonise, areas that no longer support a broader range of endemics. They also appear to be able to invade recently developed wetlands. Qualitative evidence has indicated that *L. peronii* is expanding its range, coincidently with the range of other species retracting (Tyler 1999). The observation that *L. peronii* were uncommon in 'pristine' areas and relatively more abundant in degraded waterbodies (Ferraro and

Burgin 1993) indicates that they may be poor competitors under natural conditions but pre-adapted for disturbed environments, such as those modified by humans.

Influences on larval success

Viability was not diminished by fecundity, despite variation in clutch size, which was generally higher than those previously reported (Moore 1961; Littlejohn 1982; Anstis 2002). Despite typical winter temperatures (0 – 20ºC), egg masses collected in early June contained in excess of 1000 eggs (1042-2037) and, therefore, were larger than previously recorded. Since warm temperatures often result in increased egg number (Pancharatna and Patil 1997), the local population may be particularly fecund, compared to those previously investigated. Alternatively they may naturally produce large clutches during cooler months.

Variation in growth was not a seasonal adaptation to enhance pre-metamorphic survival. However, it is probable that variability was a response to local climatic factors experienced during vitellogenesis and/ or tadpole phenotypic plasticity. Since variation was greater within clutches than between, it is likely that phenotypic plasticity was the dominant factor, despite uniform housing condition. Such variability may reduce competition between individuals and thus enhance pre-metamorphic survival and fitness.

Pre-adaptation for success in human affected habitats

The data presented here as well as previous studies (*e.g.* Ferraro and Burgin 1993; Hengl and Burgin 2002) indicate that *L. peronii* is pre-adapted to allow it to exploit human modified environments: These characteristics include:

- taking advantage of habitat that is apparently hostile for congeners, for example, it has the ability to breeding in a wide range of waterbodies including degraded wetlands (Ferraro and Burgin 1993; Hengl and Burgin 2002) and even ornamental garden ponds (Hengl and Burgin 2002);

- ability to breed opportunistically during cooler months;

- production of large clutches with larvae that have variable growth rates; and

- other adaptations, such as a dynamic foam nest that provides a variety of advantages (*e.g.* insulation, buoyancy properties; Tyler 1999).

Recent urban expansion has resulted in greater encroachment on natural areas and modification of many natural wetlands. This has serious ramificati on for most endemic frogs (White and Burgin in press). In contrast to the general trend, *L. peronii* could be considered to benefit from just such an eventuality. It is able to utilise these degraded areas that are apparently unacceptable to many other endemic species.

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