

ogy (i.e., ambystomatid pattern-recognition software, Ravela and Gamble 2004; D. Church, pers. comm.) will automate the process of identifying individuals. Pattern recognition research is progressing in the field of facial recognition (Zhao et al. 2000), and this emerging body of literature (and associated products) can have practical applications for wildlife biology. Even with automated pattern recognition, a subset of computer-determined individuals may require validation using methods similar to the process we present (see also Whitehead 1990; whale fluke identification). Regardless of method, some assessment of bias is useful in evaluating whether a technique violates the assumptions of capture-recapture modeling (specifically 1) that marks are not lost during the period of study and 2) observers can recognize marked individuals, and do not designate marked individuals as new captures). Validation of data subsets can allow investigators to evaluate a marking approach, and thereby qualify the derived estimates of population size or trend.

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Further Observations of Oviposition in the Surinam Toad (*Pipa pipa*), with Comments on Biology, Misconceptions, and Husbandry

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Although the Surinam Toad (*Pipa pipa*) was originally described in 1758 (as *Rana pipa* by Linnaeus), published information on the biology of this species has been slow to accumulate. The limited information available has been derived largely from preserved materials and observations of a few captive specimens. This note reviews the biology of the species, details original observations on reproductive behavior in captivity, aims to dispel some persistent misconceptions, and offers recommendations for captive husbandry in the interest of stimulating further research.

The Surinam Toad occurs widely throughout northern South America and is certainly one of the strangest and most fascinating of all anurans. From its morphology to its reproductive mode, this species is strikingly different from what we think of as “typically anuran.” *Pipa pipa* is extremely depressed (dorso-ventrally flattened) and has a broad, triangular head with several fleshy sensory protuberances, a huge mouth, and tube-like nostrils. These traits combine to produce a bizarre appearance uncannily similar to that of the Mata Mata Turtle, as noted by Rabb (1969) and Armburst (1979). At 10–20 cm body length, their size is equally

impressive. Although the common name 'toad' suggests otherwise, pipids in general are primarily aquatic frogs that rarely venture out of water. However, they have been observed moving over land in the wild (Buchacher 1993; Deuchar 1974; Hewitt and Power 1913; Myers and Carvalho 1945; Pefaur and Cardoso 1992; Pough et al. 1998; Wager 1965; Zippel, pers. obs.) and will readily leave open-top aquaria.

Pipids tend to inhabit murky or swampy water where their vision is likely obscured and they rely on tactile cues delivered through the sensitive protuberances on their face and fingertips and through their lateral-line systems. Schüette and Ehrl (1987) discussed in detail the structure and function of the fingertips as tactile organs. The eyes of *Pipa pipa* are very small and antero-laterally placed (see misconception #7 below regarding their ability to see). Rabb (1969) offered that wild Surinam Toads are known to eat "crayfish and small spiny catfish;" Duellman (1978) found two relatively large fish—"an *Erythrinus erythrinus* (Erythrinidae) 30mm long and a somewhat smaller pimelodid catfish"—in the stomach of a wild 78 mm Surinam Toad. Captives will eat almost any appropriately-sized animal or piece thereof (see husbandry recommendations below). Their small forearms seem to move in a single plane, from in front of the face to the open mouth. They execute this movement repeatedly as they sift through benthic debris looking for food. The hind legs are large and powerful with heavily webbed feet and are used for propulsive swimming. The hind foot even has a spade, similar to that in *Scaphiopus*, which might be used for burrowing into loose benthic substrate.

Male Surinam Toads might be slightly smaller than females and have thicker forearms. Males have a pointed, down-turned cloaca; in females, the cloaca is thicker, rounder, and upturned (Schüette and Ehrl 1987). The female cloaca in swollen, reproductive condition is illustrated in Rabb and Snedigar (1960) and clearly photographed in Armburst (1979), Rabb (1961), Schüette and Ehrl (1987), and Shibuya (1968) (see misconception #3, below). Males call year-round, particularly at night, but with greater frequency and intensity in the breeding season, which might be annual (Palmer 1994) or semi-annual (Schüette and Ehrl 1987). The call is produced by the striking of two small bones in the larynx (Rabb 1960). Single clicks are thought to be a challenging territorial call, while the more rapid series of clicks is probably a mating call (Rabb and Rabb 1963a). Schüette and Ehrl (1987) provided sonogram and frequency data. Males can be extremely territorial, and male-male combat involves head butting, grappling, biting, snapping, swooping, and kicking (Rabb and Rabb 1963a).

Breeding Behavior.—Certainly one of the more interesting and scrutinized aspects of *Pipa* biology is the bizarre behavior involved in reproduction. Amplexus is inguinal and can last for several days before oviposition. In all seven species of *Pipa*, the maneuvers involved in amplexus result in the eggs being deposited on the dorsum of the female. Here they are engulfed by the hypertrophying, tumescent integument and are incubated for periods of weeks to nearly half a year, depending on the species. In *P. carvalhoi* (Brazil), *P. myersi* (eastern Panama), and *P. parva* (northeastern Colombia and northwestern Venezuela), the eggs develop into tadpoles, which are released into the water after 3–4 weeks and filter feed until they metamorphose into aquatic froglets 2–3 months later. In *P. arrabali* (Guyana, Surinam, eastern Venezuela, and northern and central Brazil), *P. aspera* (Surinam), *P. pipa* (Colom-

bia, Venezuela, Guyana, Surinam, French Guiana, Ecuador, Peru, Bolivia, Brazil), and *P. snethlageae* (Brazil), the eggs develop directly into froglets before being released into the water after gestation of two to nearly five months (Table 1).

That the eggs are brooded within the dorsum of female Surinam Toad has been known since 1705 (Merian, *vide* Schüette and Ehrl 1987); however, it was not until a series of captive breedings at the Brookfield Zoo in the late 1950s and early 1960s that it was revealed how the eggs got there (Rabb 1961; Rabb and Rabb 1960, 1963a; Rabb and Snedigar 1960). Although this species has been bred at other zoos and by private individuals, observations and data are rarely published. Several other institutions or individuals, in Germany (Armburst 1979; Jahn 1982; Schüette and Ehrl 1987), Japan (Iwasawa 1979; Iwasawa and Tanaka 1980, 1993, 1994; Shibuya 1978), England (Bartlett 1896; Sclater 1895) and the US (Drewes 1977; Tenny 2002), have published articles regarding reproduction in *Pipa pipa*. Summaries of oviposition and gestation data (Table 1) and growth and development data (Table 2) are provided herein.

I was fortunate enough to observe a single successful breeding event, which is herein compared to the three documented breeding events (all involving a single female, two with the same male) at the Brookfield Zoo. All reproductive behaviors occurred as documented by Rabb and colleagues with one exception: the amplexant pair observed by me used a modified form of the ovipositional "turnover." According to Rabb and Rabb (1960, 1963a), the ovipositional turnover consists of two distinct rotations, one about the longitudinal axis (an ascending sideways half-roll) resulting in an inverted or upside-down position *near the water surface*, followed by one about the transverse axis (a descending head-first half-roll) returning the pair to an upright position on the substrate (Fig. 1A). Note: It is not a simple, circular somersault (see misconception #1 below). By my observations, the turnover sequence began with the amplexant pair at rest on the tank floor. As previously documented, the female pushed off sideways with a hind foot to begin the rotation about the longitudinal axis. However, the pair immediately flipped into the upside down position about 10 cm from the bottom, not near the water surface. From here, they swam backwards using jerky motions of the hind limbs and moved upwards into a vertical head-down position; it was during this movement that the eggs were released and rolled forward on the dorsum of the female. From the vertical position, the turnover was completed normally, and concluded with the typical tilted, resting position (Fig. 2).

The significance of this modification is unclear. It is not a function of water depth, i.e., that this pair had less vertical water space than the animals at Brookfield, and the initial longitudinal rotation left them too near the substrate to complete the transverse rotation. The Brookfield enclosure was actually shallower (see comments below in misconception #2 regarding water depth required for breeding). The frogs observed by me had 40 cm of vertical water available, but utilized only the lower 20 cm. Alternatively, this modified behavior pattern might represent variation among females: all three breedings at Brookfield forming the basis of the original descriptions involved the same female, two with the same male (Rabb and Rabb 1963a). In other documented breedings where turnover behavior was actually observed, variations similar to what I observed have been depicted or described. Ac-

TABLE 1. A summary of oviposition and gestation data in Surinam Toads (*Pipa pipa*).

| # Eggs oviposited | Yolk diameter (mm) | # Eggs implanted ¹ | # Froglets emerging | Gestation ² (d) | Reference |
|-------------------|--------------------|-------------------------------|---------------------|-----------------------------|--------------------------|
| | 6.35 | 40–114 (N = 6) | | | Wyman 1854 |
| | | 80–90 (N = 1) | 0 | at 21°C | Sclater 1895 |
| | | | 80 50–60 | | Deckert 1917 |
| 96 | 6 | 76 | 20 | 77–136 at 21–27°C | Rabb and Snedigar 1960 |
| 66 | | 55 | | | Rabb and Rabb 1960 |
| 105 | | 103 | 0 | at 25–27°C | Rabb and Rabb 1963a |
| 78 | | 62 | | | |
| | | 190 | 25 | ≤ 62 at 24°C | Drewes 1977 |
| 273 | 6 | 184 | | | Shibuya 1978 |
| 208 | | 208 | 0 | | Armburst 1979 |
| 250 | | 192 | 52 | 105–139 | Schüette and Ehrh 1987 |
| 250 | | 193 | 24 | 129–145 both at 26 ± 2°C | |
| 73 | 5 | 68 | 0 | | Iwasawa and Tanaka 1994 |
| 128 | | 115 | 0 | | |
| 130 | | 130 | 0 | | |
| 138 | | 106 | 0 | | |
| 167 | | 163 | 0 | | |
| 183 | | 173 | 5 | 75 at 24 ± 2°C | |
| 230 | | 159 | 0 | | |
| 283 | | 184 | 0 | | |
| | | ~70 | | 90 at 21 ± 3°C | Palmer 1994 |
| 60–64 | | 59 | 57 | 70–88 at 29°C | R. Haeffner, pers. comm. |
| | | | 14 ³ | 72–77 at 25–26°C | B. Johnson, pers. comm. |
| | | | 27 | 83–100 at 24–27°C | K.C. Zippel, pers. obs. |

¹ - the difference between # eggs oviposited and # implanted represents the lost infertile eggs and a few lost fertile eggs; infertile eggs might become attached prior to falling off, but are not implanted as are most fertile eggs.

² - gestation values include only animals that survived, omitting premature births.

³ - nine of these died within the first month.

ording to the photographs in Shibuya (1978), the pair made their initial rotation about the longitudinal axis immediately, as did the animals I observed, such that they were upside down just above the substrate, not at or near the water surface. Armburst (1979) used the words “Salti rückwärts” or backward somersault to describe the maneuver, suggesting a backward-moving component to the ovipositional turnover. Translated from German: “A backwards somersault brought the animals into a nearly vertical position, head down.” He also offered that the eggs were always released when the pair was in the vertical head-down position. His

Figure 3 clearly shows the animals in a head down position perpendicular to the substrate and the legend reiterates that this is when oviposition occurs. As with my observations, there is a backward moving component to the maneuver, and eggs were laid during the vertical head-down component. Iwasawa and Tanaka (1994) also observed that oviposition occurred after the pair rotated transversely “when they reached mid-water rather than near the water surface ...” Sughrue (1969) showed a pair from the Brookfield breedings inverted just over the substrate, a position that likely would not allow a transverse roll without first some backward or

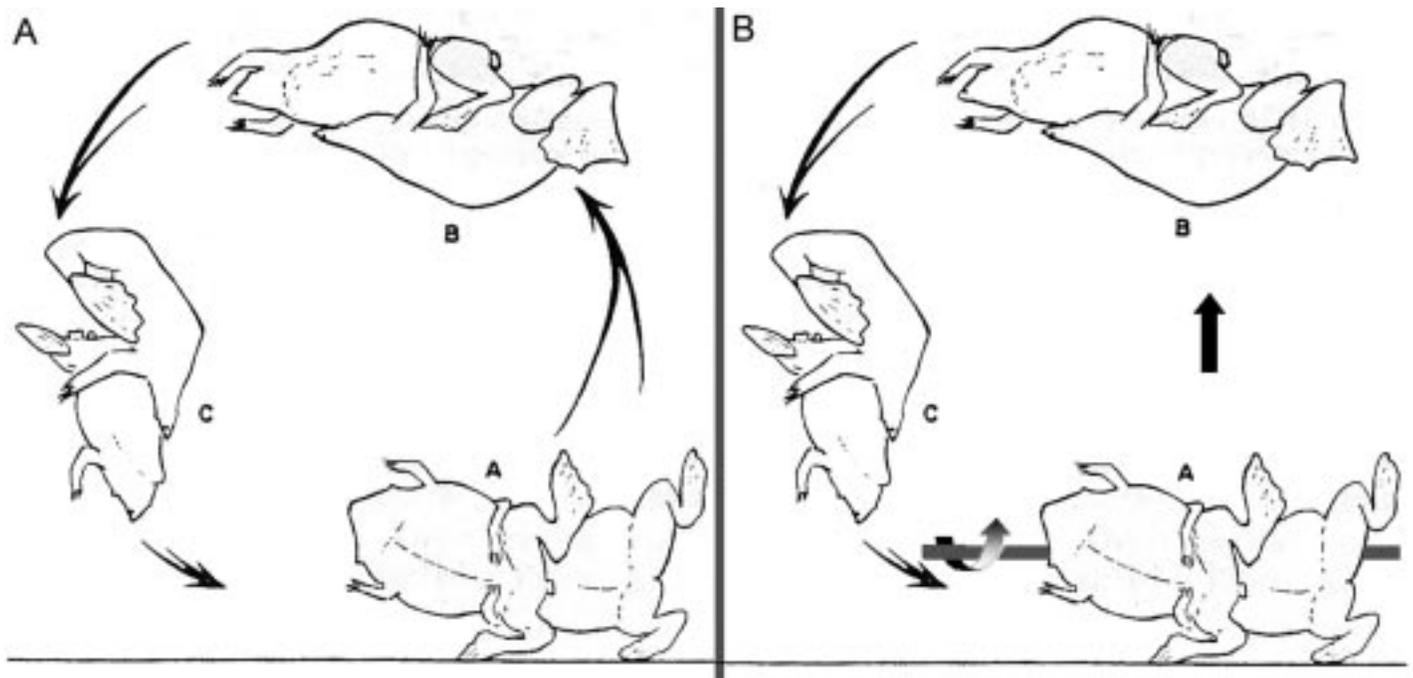


FIG. 1. The ovipositional turnover of *Pipa pipa* as observed by Rabb and colleagues. **A.** The original figure (Fig. 2) from Rabb and Rabb (1960), which might be misleading in its use of arrows connecting the different phases of the turnover using a circular format. **B.** My re-interpretation of the original: Position A has been moved directly under Position B and a straight vertical arrow connects the two. Note also the gray horizontal bar, which represents the longitudinal axis of the amplexant pair, the axis around which the first rotation occurs.

upward-moving movement. Eventually, Rabb (1973) changed his language, describing the location of the upside-down position and oviposition as “mid-water” without further explanation.

It is clear that the ovipositional acrobatics of *Pipa pipa* are more variable than is commonly assumed and are not clearly understood. Repeated observations, under captive conditions or preferably in the species’ natural habitat, are required to determine the “normal” sequence.

Misconceptions.—In addition to my observations suggesting an element of variety in *Pipa pipa* ovipositional behavior, there are seven misconceptions that I wish to dispel. Although several of these have been previously addressed throughout a disparate set of literature, some authors continue to miss them. These clarifications are herein summarized in one document, in the hope that the myths are not perpetuated in future works.

1. According to Rabb and Rabb (1960, 1963a), the ovipositional turnover consists of two distinct rotations: one about the longitudinal axis (a sideways ascending half-roll) leading to momentary pause in an inverted or upside-down position near the water surface, followed by one about the transverse axis (a descending head-first half-roll) returning the pair to an upright position on the substrate (Fig. 1). It can also sometimes include a backwards-swimming component during oviposition whereby the pair remains near the substrate (see discussion above, and Fig. 2). *In either case, it is not a simple, circular somersault.* This complex maneuver is photographed in Rabb (1961, unfortunately plates are printed in reverse order, per Rabb and Rabb 1963a,b), Shibuya (1978), and Sughrue (1969). However, it is still often described and illustrated as a circular somersault, both in the hobbyist/popular (Drewes 1977; Jahn 1982; Mattison 1991; Staniszewski 1995; Walls 1995;

Zimmerman 1995) and academic secondary (Halliday and Adler 2002; Stebbins and Cohen 1995; Zug 1993) literature. This might be the result of misinterpretation of the Fig. 2 illustration in Rabb and Rabb (1960), recreated here in Figure 1A, which uses a circular format to show the different phases of the maneuver connected by arrows, thereby giving the misleading impression of a complete circular motion. I believe Rabb himself must have realized the confusion created; a later publication of this figure (1973) replaced the semi-circular arrow between A and B with a wavy arrow more vertical in orientation. I believe these figures would be

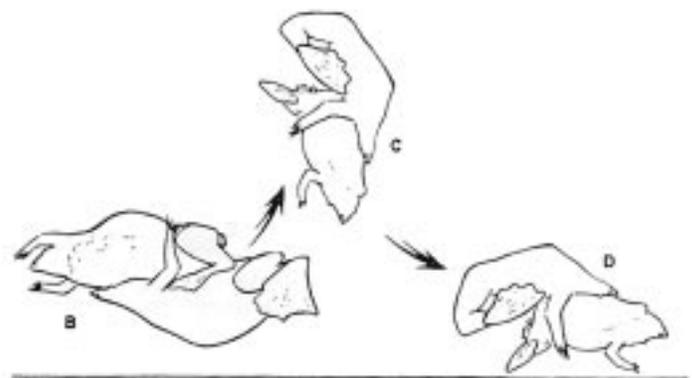


FIG. 2. The ovipositional turnover as observed by KCZ. Note that Position A has been omitted from this figure as it occurs largely in the same space as, and would be obscured by, Position B. That Position A occurs is assumed in this case; it would appear exactly as it does in Fig. 1. Oviposition occurs during the jerky backward movements transitioning Position B to C.

TABLE 2. A summary of growth and development data in captive Surinam Toads (*Pipa pipa*).

| Time post emergence | Temp. (°C) | Length (mm) | Weight (g) | Sexual maturity | Reference |
|---------------------|------------|------------------------|-----------------------------------|-----------------------------|--------------------------|
| 0 | 21–27 | | 0.31–0.41 (mean = 0.36, N = 6) | | Rabb and Snedigar 1960 |
| 0 | 24 ± 2 | mean = 15.6 (N = 5) | mean = 0.41 (N = 5) | | Iwasawa and Tanaka 1994 |
| 0 | 24 | 17 | | | Drewes 1977 |
| 0 | 26 ± 2 | 18 | | | Schüette and Ehrl 1987 |
| 0 | 23 ± 1 | 13–19 | | | Palmer 1994 |
| 0 | 26–27 | 11–18 | | | R. Haeffner, pers. comm. |
| 70 days | 26–27 | 57 | | | R. Haeffner, pers. comm. |
| 4 months | 26–27 | 110 | | near adult size | R. Haeffner, pers. comm. |
| 5 months | 24 ± 2 | 81 | 57 | spermatogenesis | Iwasawa and Tanaka 1994 |
| 6–8 months | 26 ± 2 | 40–70 | | | Schüette and Ehrl 1987 |
| 8 months | 24 ± 2 | 90 | 62 | | Iwasawa and Tanaka 1994 |
| 1 year | 26 ± 2 | 52–110 (mean = 75) | | | Schüette and Ehrl 1987 |
| 1 year | | | | cloacal dimorphism | Schüette and Ehrl 1987 |
| 1 year | 23 ± 1 | 50 | | | Palmer 1994 |
| 1 year | 24–27 | | | males calling | K.C. Zippel, pers. obs. |
| 15 months | | | | males calling | Schüette and Ehrl 1987 |
| 2 years | | 77–210 (mean = 131) | | oviposition | Schüette and Ehrl 1987 |
| 3+ years | | | | males “capable of breeding” | Palmer 1994 |
| 6+ years | | | | “maturity” | Rabb 1969 |

a more accurate reflection of Rabb’s text if they used a truly vertical arrow to transition from Position A (on the substrate) to Position B (inverted) and had Position B directly above Position A. Thus, the movements include a longitudinal rotation during a direct vertical ascent, and a transverse rotation during a semicircular descent (Fig. 1B). Such a non-circular ovipositional maneuver occurs in other species of *Pipa* (Plunk 1996; Weygoldt 1976) and in some, but not all, non-pipine pipids (Rabb 1973; Salthe and Mecham 1974).

2. As a result of the circular somersault misconception, some authors have suggested that Surinam Toads require deep water for breeding to complete the “full circle” (e.g., Armburst 1979; Palmer 1994, Tenny 2002). Tenny recommended nearly 1 m of vertical water depth to allow for the ovipositional maneuvers; Palmer (1994) offered that anything less than 107 cm would result in failure of fertilization and implantation. This notion of required depth is also not uncommon in the zoo community. However, few of the successful breedings have had such depth available; in fact, most took place in surprisingly shallow water, not even twice the SVL of the adults. The original Brookfield breedings took place in a

70-liter tank (comparable to the industry-standard 20-gallon) (Rabb and Rabb 1960) and 28 cm of water depth (Rabb and Snedigar 1960). Drewes (1977) used a standard 15-gallon aquarium. The Toronto Zoo used a 150-liter tank with 25-cm deep water (B. Johnson, pers. com). Iwasawa and Tanaka (1993, 1994) offered 35 cm of vertical water. Armburst (1979), Schüette and Ehrl (1987), and the Denver Zoo (R. Haeffner, pers. com.) provided access to as much as 50 cm, while Palmer (1994) apparently offered ~120 cm. However, no other author described how much of the water column was actually utilized by the amplexant pair during breeding. I presented them 40 cm of water, of which they utilized only the lower 20 for their nuptial acrobatics. Palmer (1994) claimed annual success for 12 continuous years as a direct result of offering deeper water. He claimed that each ovipositional ‘backflip’ in deep water is accompanied by a close second backflip solely for fertilization, something which did not occur for him in shallow water. However, he offers no real data for comparison. This second fertilization maneuver has not been noted by anyone else working with *P. pipa*, other species of pipines (Plunk 1996; Weygoldt 1976), or other non-pipine pipids with nuptial acrobat-

TABLE 3. A summary of food items consumed by captive Surinam Toads (*Pipa pipa*). All whole-animal food items live unless otherwise noted.

| Adults | Frogllets | Reference |
|--|---|-------------------------------|
| worms, fish | | Sclater 1895 |
| “frogs” ¹ | | Deckert 1917 |
| strips of beef muscle and liver, guppies | tubifex, cyclops | Rabb and Snedigar 1960 |
| goldfish, frozen smelt and whitebait | brine shrimp, tubifex | Drewes 1977 |
| live and dead fish, earthworms, beef heart strips | | Armburst 1979 |
| earthworms, fish, fish fillets, rodent pups, freshwater shrimp | tubifex, daphnia, mosquito larvae, guppies | Schüette and Ehrl 1987 |
| strips of pig liver, goldfish | tubifex | Iwasawa and Tanaka 1993, 1994 |
| large nightcrawlers, live goldfish | small sections of redworms, guppies, slivers of liver | Palmer 1994 |
| | blackworms, small guppies | Tenny 2002 |
| goldfish, nightcrawlers | tubifex, daphnia; small goldfish and chopped nightcrawlers by 28 days | R. Haeffner pers. com. |
| worms, centrarchids and cyprinids ≤ 5 cm total length | blackworms, aquatic field sweepings | K.C. Zippel pers. obs. |

¹ - the author was relating this information from a colleague maintaining the *Pipa* in the field in Trinidad and speculated that these were *Leptodactylus* sp., further stating that fish were offered but refused.

ics (Rabb 1973; Salthe and Mecham 1974).

3. In several hobbyist articles and books, authors have referred to an ‘extensible ovipositor’ in the female (e.g., Staniszewski 1995). The source of this falsehood comes from the 1896 paper by Bartlett, in which he unknowingly describes a pathologic condition of prolapse in one ovipositing female that died shortly after breeding. Although female *Pipa* spp. in breeding condition do show a distinct swelling of the cloacal lips, to 4 cm diameter (Schüette and Ehrl 1987), there is no cloacal tube with which the male maneuvers the eggs onto the dorsum of the female. Rabb and Snedigar (1960) made this point offering an illustration of a normal swollen female cloaca, and Rabb and Rabb (1960) and Schüette and Ehrl (1987) reaffirmed it, yet the misinformation continues to persist.

4. The eggs are not received *into* a honeycomb-like structure on the back of the female, as is sometimes reported in the hobbyist literature (e.g., Staniszewski 1995). Rather, they roll between the venter of the male and the slightly swollen dorsum of the female, where they adhere beginning near the vent and advancing anteriorly. The skin then swells up around the eggs and they sink into it, *forming* the individual chambers. This process can take as few as two (Iwasawa and Tanaka 1994) or as many as 10 days (Rabb 1961).

5. The stroking behavior of the amplexant male has been the subject of some speculation. Rabb and Rabb (1960) observed this behavior 11 times near the end of oviposition, both before a turnover and after a trip to the surface for air. The male was reported to swing his hind leg forward alongside the female’s back, as far forward as the back of her head, and this movement was interpreted as stretching or a mechanical stimulus for inducing ovipo-

sition. It was observed again late in a subsequent breeding, after the female had gone into a swimming frenzy when frightened by a camera flash, and re-interpreted as an expression of dissatisfaction on the part of the male (Rabb and Rabb 1963a). In Sughrue (1969), it was called “a stimulating gesture.” It was later shown in male *P. carvalhoi* that the stroking movements of the male’s hind feet facilitate egg adpression (Mattison 1993; Weygoldt 1976; Zimmerman 1995). Eventually, this behavior was clearly observed in *P. pipa* as well: Jahn (1982) observed and provided photographs of “sweeping movements” of the hind legs of an amplexant male, movements which served to direct the eggs to “the right place” and “firm them down.” [One otherwise reputable book reports that it is the hindlimbs of the female that distribute the eggs across her own back (Stebbins and Cohen 1995).] My observations of *P. pipa* agree with those of Jahn (1982): the amplexant male clearly used his hind feet to reach forward and adpress those eggs that fell onto the anterior portion of the female’s dorsum. Rabb (1961) and Rabb and Rabb (1960) had previously attributed implantation of the eggs to the male’s clasp and adpressed head, which is undoubtedly the case for the more posteriorly deposited eggs. However, as amplexus is inguinal, the anterior portion of the female’s dorsum is not reached by the male’s overlapping venter and chin. Indeed, Rabb and coworkers observed only two eggs deposited anterior to the midbody region, and thus this potential function of the stroke was not apparent them. This stroking behavior would be especially useful in pipines, and is in fact most frequently seen, late in the ovipositional period when eggs are being deposited furthest from the male’s head, or before and after movements where egg loss is likely, such as those involved in breathing, turnovers, or

fright. Of course, the stroke might be multifunctional, also serving to stimulate or manipulate the female, as Rabb suggested. Indeed, the stroke is also seen in several non-pipine pipids (Rabb and Rabb 1963b) for which egg adpression is not a concern. The occurrence of the behavior in several genera in the small family suggests it might be a shared characteristic, perhaps for female stimulation or manipulation. However, for pipines, it would appear to be an exaptation that now assists with egg adpression.

6. Embryos do not receive sustenance from the female (e.g., Jahn 1982; Halliday and Adler 2002). Although froglets weigh more than eggs (Rabb and Snedigar 1960; Wyman 1854), their dry weights are the same (Rabb 1961). However, the embryos do appear to be receiving some essential substance or hormone from the brood pouch, as fertile eggs that fail to attach develop for approximately two days, to the same stage as eggs becoming enveloped at that time (Iwasawa and Tanaka 1994). In addition to not providing significant nutrition, the pouch might not be particularly well vascularized, as previously reported (Rabb and Snedigar 1960 and therein). Rather, it is lined with a hypertrophied epidermis (Iwasawa and Tanaka 1994), so the embryos might not even be exchanging respiratory gases with the female. Wyman (1854) observed in preserved specimens how the larvae tend to sit on top of the yolk, where they are nearest to the water and in an ideal location for external gas exchange. Iwasawa and Tanaka (1994) described how embryos sometimes protrude their highly vascularized transparent "tails" from the pouches late in gestation, possibly using the structure as a gill analogue. Rabb (1961) first described the highly vascularized tail and speculated on its possible role as a respiratory organ prior to its resorption three weeks before emergence. Rabb and Snedigar (1960) observed a similar structure in late abortions and early births, but were clear to state that this is not a tail, rather it is a vascularized sac protruding from the cloaca. However, Rabb (1969) no longer made the distinction and wrote "Respiration may be helped by a thin membranous out-pocketing from the cloaca, which possibly represents the remains of the tadpole tail."

7. *Pipa pipa* has incredibly small eyes. However, they are not blind or particularly visually impaired, as some authors suggest (e.g., Palmer 1994; Staniszewski 1995; see also comments in Armburst 1979). In fact they see quite well and respond to keepers peering into their enclosures without the vibrational cue of foot movement (pers. obs.). They will also come up to the surface to beg for food when they see a keeper and can readily learn to hand feed, gaping to receive their rations (Armburst 1979; Deckert 1917).

Husbandry Recommendations.—Breeding *Pipa pipa* in captivity has proven challenging. Given the right conditions, newly imported animals will readily engage in amplexus, but rarely oviposit. Unfortunately, most ovipositions that do occur end with all the eggs falling from the female's back. After a decade of working with the species, Brookfield only managed to produce offspring in two of eight breedings (Sughrue 1969). Toronto Zoo produced five offspring from a single fertile clutch, despite over a dozen breeding attempts by the frogs (B. Johnson, pers. comm.). Iwasawa and Tanaka (1994) managed success in only one of eight breedings. Even in full-term pregnancies, perfectly formed froglets sometimes die in or shortly after exiting the maternal chambers (Schüette and Ehrl 1987; pers. obs.). Rabb and Snedigar (1960) and Iwasawa

and Tanaka (1993) tried using hormones to induce and maintain breeding condition, but met with negligible success. In the interest of promoting better husbandry to provide more opportunities for studying breeding behavior, I offer the following husbandry advice:

—Re-create a neotropical swamp. These large frogs need a lot of room to move around, and the more volume offered, the easier it will be to maintain water quality. A standard 55-gallon aquarium is minimal for a pair or maybe two if the filtration system is robust and sized to meet their biological filtration needs (see below). Cattle tanks or even small swimming pools are ideal for groups. Water depth is not so important (see misconception #2, above). Water should be warm (24–27°C), soft, acidic (pH = 6.5–6.9 using sphagnum or peat moss, tea bags, and/or oak leaves, which also beneficially stains the water with tannins), and murky (direct light limited). Excellent substrata include Java moss, sphagnum moss (slow to break down, but monitor pH), and leaf litter. The latter two take some time to waterlog, but provide excellent cover (psychological well being) for the frogs. Avoid putting heaters in the tank with the animals, as they might wedge themselves behind the tube and get burned when it activates. I have observed this in *P. parva* on more than one occasion. To avoid this risk, place the heater in a sump.

—Monitor water quality. pH can change, and biological wastes accumulate rapidly, especially in smaller tanks. Pipids generate copious amounts of ammonia (Cragg et al. 1961), which must be removed with manual water changes (can become a daily requirement) or with robust biological filtration. Aeration is not so important for pipids, which rely heavily on pulmonary respiration, but it is important to maintain adequate bacterial colonies in the biological filters (see Zippel 2001). A high dissolved oxygen might also be required for the embryos (see below).

—Provide good food in abundance. Avoid strips of meat or organs and rodent pups (see Table 3), which seem unnatural. Feed live fish of the appropriate size, but avoid the exclusive use of goldfish, which are fatty and possibly cause hypervitaminosis D (Frye 1992). Also feed earthworms or nightcrawlers from clean sources (some are reported to be toxic [Schüette and Ehrl 1987]), and when they are available, one can supplement with freshwater shrimp, other crustaceans, and tadpoles.

—Odor is a very important breeding stimulus for *P. pipa* (Rabb and Rabb 1963a) and other pipids (Rabb 1963b). Try to maintain males in tanks isolated from the females and isolated from each other. This way, when animals are finally introduced, the encounters are novel and elicit the genuine responses that are gradually lost during the acclimation of cohabitation (pers. obs.). Isolated animals should be fed well, and kept in relatively shallow warm water. See Palmer (1994) regarding the use of cooler maintenance temperatures, although this paper offered so few data that it is difficult to gauge success relative to warmer temperatures. When they are to be introduced, put them into a deeper (preferably several feet, but 45 cm will suffice), cooler (to 21°C) tank to simulate conditions of flooding from the onset of the cool, rainy season. Schüette and Ehrl (1987) successfully used a similar temperature change regime, as did Rabb and Rabb (1963a), unintentionally. The Denver Zoo actually raised temperature (water level same) from 26 to 29°C to stimulate breeding.

—Light quality and duration have been shown to have a signifi-

cant effect on induction of spawning in two species of African pipids. Savage (1965) showed that *Xenopus laevis* spawns more readily in the presence of light vs. complete darkness. Rabb and Rabb (1963b) induced spawning in an inactive group of *Hymenochirus boettgeri* by moving them from under indoor artificial lighting to outdoor natural lighting. The effect of light, however, might occur indirectly via an increase in the concentration of an algal metabolite (Savage 1965). Commercial *Xenopus* breeders keep their isolated males under intense light to simulate the dry season insolation. Palmer (1994) claimed photoperiod decline is important to stimulate breeding in *P. pipa* but did not state how or to what extent it was manipulated.

—The role of auditory cues in inducing reproductive readiness has yet to be fully explored. Rabb (Rabb 1973; Sughrue 1969) was able to induce oviposition in isolated female *Xenopus laevis* and *Pipa parva* simply by playing back the calls of males. Most keepers realize that a metallic tap on the tank can induce calls from the males. Drewes (1977) commented on the role of a nearby garbage compactor in initiating amplexus in his animals. I have heard my males call vigorously in response to a nearby air conditioner, and especially in response to the low, rumbling frequencies of an electric bass guitar.

—The inclusion of certain snails, specifically Indian Tower Snails (*Melanoides tuberculata*), is not recommended, as these animals tend to attack the eggs before they can sink into the dorsum (Schüette and Ehrl 1987).

—Late-term deaths of froglets still in the pouches are not uncommon (e.g., Schüette and Ehrl 1987, pers. obs.). Drewes (1977) had eight such 'stillborns' out of 33 full term young. Schüette and Ehrl (1987) experienced some full-term deaths and even had fungus attack the female's dorsum. The froglets are moving around within the pouch at this stage, and will even feed on live prey (Rabb and Snedigar 1960). They are presumably relying on cutaneous respiration at this stage, so dissolved oxygen levels might be an important factor. Dead froglets should be manually removed from the maternal pouches to prevent infection of neighboring pouches and of the female systemically.

—Once froglets are free-swimming, they are very easy to raise. Feed them heavily on live food items (see Table 3) and watch water quality closely.

—The tadpole-bearing species will readily consume their own young (pers. obs.), while the froglet-bearers do not (Rabb 1961; Rabb and Snedigar 1960; Schüette and Ehrl 1987; pers. obs.). In *P. parva*, hungry cagemates will sometimes also eat newly deposited eggs off the back of a 'gravid' female (pers. obs.); feed heavily and isolate accordingly.

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Electronic submission of manuscripts is requested (as Microsoft Word or Rich Text format [rtf] files, as e-mail attachments). Authors without the ability to send manuscripts electronically may supply hard copy instead. Figures can be submitted electronically as JPG files, although higher resolution TIFF or PDF files will be requested for publication. If figures cannot be provided in this format, you may send them to the section editor for scanning. Additional information concerning preparation and submission of graphics files is available on the SSAR web site at: <http://www.ssarherps.org/HRinfo.html>. Manuscripts should be sent to the appropriate section editor: **Marc P. Hayes** (amphisbaenids, crocodylians, lizards, and *Sphenodon*; mhayesrana@aol.com); **Charles W. Painter** (amphibians; cpainter@state.nm.us); **Andrew T. Holycross** (snakes; holycross@asu.edu); and **James Harding** (turtles; hardingj@pilot.msu.edu).

Standard format for this section is as follows: SCIENTIFIC NAME, COMMON NAME (for the United States and Canada as it appears in Crother [2000. *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding*. *Herpetol. Circ.* 29:1–82; available online at <<http://herplit.com/SSAR/circulars/HC29/Crother.html>>]; for Mexico as it appears in Liner [1994. *Scientific and Common Names for the Amphibians and Reptiles of Mexico in English and Spanish*. *Herpetol. Circ.* 23:1–113]), KEYWORD. DATA on the animal. Place of deposition or intended deposition of specimen(s), and catalog number(s). Then skip a line and close with SUBMITTED BY (give name and address in full—spell out state names—no abbreviations). (NCN) should be used for common name where none is recognized. References may be briefly cited in text (refer to this issue for citation format).

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CAUDATA

AMBYSTOMA T. TIGRINUM (Eastern Tiger Salamander). **PAE-DOMORPHIC POPULATION**. Examples of paedomorphism can be observed in all caudate families (Duellman and Trueb 1986. *Biology of Amphibians*. Johns Hopkins University Press, Baltimore. 670 pp.). Paedomorphic individuals have been reported in several species of the genus *Ambystoma*, however paedomorphic *A. t. tigrinum* populations have only been reported in Michigan (Hensley 1964. *Herpetologica* 20:203–204). This subspecies occurs in bottomlands, open fields, and deciduous and coniferous forests in most of the mid-western and southeastern states (Petranka 1998. *Salamanders of the United States and Canada*. Smithsonian Institution Press, Washington. 587 pp.), although records in East Texas are sparse (Dixon 2000. *Amphibians and Reptiles of Texas*. Texas A&M Univ. Press, College Station, 421 pp.). This is the first report of a population of paedomorphic *A. t. tigrinum* in Texas.

From 23 Nov to 8 Jan 2005, four paedomorphic *Ambystoma t. tigrinum* were captured in minnow traps placed in a permanent farm pond at Camp Tyler ca. 5 km N of Whitehouse, Smith County, Texas (32° 15.267'N, 095° 11.645'W). The pond is located in a horse pasture and is ca. 150 m from the closest forest edge. Of the individuals captured, two males were identified by the presence of swollen cloacal vents. The other captures were presumed to be