absence, may effect an animal's ability to successfully return to the riffle.

All of the recaptures on 26 May 1976 had increased dramatically in weight and 3 of 4 had grown more than one cm TL (Table 1). Therefore, some *C. alleganiensis* were capable of successfully reestablishing in riffles from which they were absent for more than seven months.

The release of captive animals or those reared in the laboratory should be done judiciously and with caution. In this study, animals were returned to the same populations and capture site. Occasionally, captured animals may be safely returned to the wild. These may be at a disadvantage when returned. The release of other genetic stocks or nonindigenous species has resulted in harmful introductions and competition with native forms (Bury and Luckenbach, 1976; King and Krakauer, 1966; Smith and Kohler, 1977).

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SPRINT VELOCITY OF TADPOLES (*BUFO BOREAS*) THROUGH METAMORPHOSIS.—Developmental stages 42 through 46 (Gosner, 1960) are key stages during the metamorphosis of an anuran tadpole. At stage 42 the forelimbs erupt; at stage 43 reabsorption of the tail begins; by stage 46 reabsorption is complete—the anuran has now transformed from a swimming, aquatic larva to a saltatory, terrestrial frog. These metamorphic transitions involve not only the locomotor apparatus, but also the respiratory system, hemoglobins, feeding appendages, digestive system and physiology, nervous integration and excretory physiology. Remarkably, this metamorphic "climax" is very rapid and may involve as little as 10% of the entire larval period (Wassersug and Sperry, 1977).

The rapidity of this transition may be related to the avoidance of hazards associated with metamorphosis (Szarski, 1957). Arnold and Wassersug (1978) demonstrated that garter snakes (*Thamnophis* spp.) in nature preyed nonrandomly on different developmental stages of toad (*Bufo boreas*) tadpoles; specifically, snakes

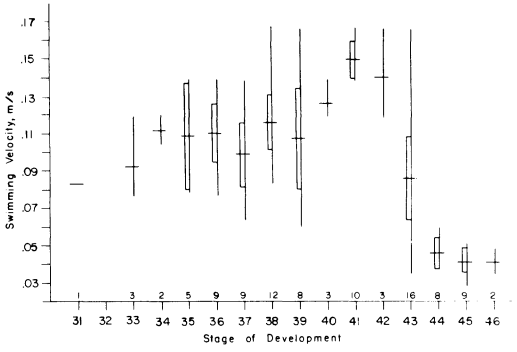

Fig. 1. Sprint velocity of *Bufo boreas* tadpoles at different developmental stages (Gosner, 1960). Vertical line = range, horizontal line = mean, box = 95% confidence limits. Sample size for each stage above abscissa.

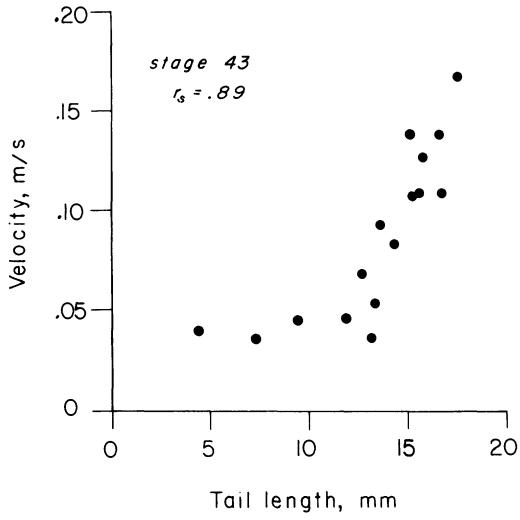

Fig. 2. Sprint velocity vs. tail length for stage 43 tadpoles.

preyed heavily on climax tadpoles. Prompted by these field observations, Wassersug and Sperry (1977) corroborated the predation results in a laboratory study with *Thamnophis sirtalis* and the frog *Pseudacris triseriata* and also quantitatively examined locomotor abilities of various developmental stages of this frog. Endurance of tadpoles in a flow tube was positively correlated with stage of development between stages 28 and 41. Endurance of stage 42 and 43 tadpoles was, however, dramatically reduced. Jumping ability (distance) was positively correlated with stage between stages 42 and 46+. Thus, in terms of locomotor performance, climax tadpoles are neither "good" tadpoles nor "good" frogs and are, therefore, probably especially vulnerable to predation. The rapidity of the final transformation might relate to extreme predation pressure on these stages (Wassersug and Sperry, 1977; Arnold and Wassersug, 1978).

I examined whether the general results for *Pseudacris* swimming apply to *Bufo* tadpoles. Rather than examining endurance, however, I chose to examine sprint velocity. Most predation attempts by garter snakes take seconds, not minutes (S. J. Arnold, pers. comm.): velocity or acceleration might, therefore, more closely index potential escape ability than does endurance (Elliott et al., 1977).

Tadpoles (*B. boreas*) were collected in July 1978 from a pond created by an overflow from Muck Creek, 8 km ENE of Roy, King Co., Washington—one of the ponds used in field studies on predation on tadpoles by Arnold and Wassersug (1978). Specimens were acclimated to 24 C for at least one week before testing. Food (Purina rabbit chow in gelatin matrix) was provided ad libitum.

Sprint velocity was measured by racing 100 tadpoles at 24 C in a 75 × 8 × 3 cm swimming tank. Tadpoles were stimulated to apparent maximum velocity by tapping their tails. The time to cover 0.5 m from a swimming start was recorded with a hand stopwatch and converted to velocity (m/s). Some transforming and transformed individuals would not swim the full 0.5 m continuously, and velocities of these were based on shorter distances. A number of transforming and transformed toads failed to swim properly or frequently bumped the sides of the tank. Data on these were not recorded. An individual was raced only once and preserved immediately. Stage (Gosner, 1960) and tail length (to 0.1 mm, distance between posterior insertion of hind leg and tail tip) were subsequently scored.

Average swimming velocity of *Bufo boreas* tadpoles increased with developmental stage (Fig. 1, $r = 0.51$, $P < 0.001$) throughout premetamorphosis (stage 31 to 41). Velocity began to decrease during early climax metamorphosis (stage 42, 43); and by late climax metamorphosis (44 to 46), velocity was very slow (⅓ that of stage 41 tadpoles).

Tail length also increased with stage of development for premetamorphic tadpoles (r =

0.50, $P < 0.001$), and velocity was positively correlated with tail length during this period (0.63, <0.001). Partial correlation analysis demonstrates that velocity during premetamorphosis was more closely associated with tail length (0.46, <0.001) than with stage (0.16, > 0.1).

Rapid decreases in velocity and in tail length occur during climax metamorphosis. At stage 42, tails began to be reabsorbed; and reabsorption was most dramatic during stage 43. By stage 44, tadpoles had short tails and swam poorly. Partial correlation analysis demonstrates that velocity during climax metamorphosis (42 to 45) was more closely associated with length ($r = 0.66$, $P < 0.001$) than with stage (0.23, >0.1).

The transition in velocity from fast to slow occurred primarily at stage 43 (Fig. 1). Variance in velocity was very high, and individuals ranged from very fast to very slow. Variance in tail length was also great at this stage (15.1 vs. 0.2 to 4.8 for all other stages). Not surprisingly, stage 43 tadpoles with long tails swam quickly, whereas those with shorter tails were much slower ($r_s = 0.89$, $P < 0.001$, Fig. 2).

Wassersug (pers. comm.) has also found positive correlations between apparent maximum velocity in a flow current and total length for *Bufo americanus* and *Rana "pipiens"* tadpoles. Endurance of *Pseudacris* tadpoles showed a similar relationship to length and stage (Wassersug and Sperry, 1977). Endurance dropped at stage 42, however, rather than at stage 43. In *Pseudacris,* eruption of the forelimbs (stage 42) apparently increases drag (Wassersug and Sperry, 1977). Whether tail reabsorption occurs primarily at stage 42, rather than at stage 43 as in *Bufo,* is not known. For both species tail length is correlated with swimming ability, because thrust generated by swimming animals is in part a function of length (Wu, 1977). However, ineptitude of climax tadpoles in swimming and jumping (Wassersug and Sperry, 1977) is probably not only a function of tail size and locomotor drag, but also of the metamorphic reorganization of the entire animal.

The high frequency of climax tadpoles (*Bufo*) in the guts of *Thamnophis* (Arnold and Wassersug, 1978), coupled with these laboratory data on sprint velocity, suggest that risk of predation of *Bufo* tadpoles is indeed directly related to locomotor abilities. Moreover, because morphological shifts during metamorphosis are stereotyped among frogs (Gosner, 1969), high predation rates on climax tadpoles should be expected for many frogs. [This pattern also raises the interesting possibility that cannabilistic tadpoles (e.g., *Scaphiopus*) might be able to capture and eat individuals older as well as younger (but less swift) than themselves]. A study of the sprint velocity of aquatic frogs (e.g., *Xenopus*) would be of interest.

The stage of emergence of climax tadpoles onto land may partially reflect an interaction between swimming and jumping ability. The rapid decrease in sprint velocity at stage 43 suggests that ponds suddenly become less safe environments for tadpoles. The land is not necessarily a safer environment, of course. Physiological stress from heat and dehydration (Tracy, 1976) may be extreme for a toadlet weighing a fraction of a gram. Also, jumping ability of *Pseudacris* (distance), which might affect risk of predation on land, is much lower at stage 43 than at stage 46+ (Wassersug and Sperry, 1977). It is interesting to note, however, that the earliest tadpole stage that emerged onto rocks in aquaria during the present experiments was stage 44 and that the earliest stage of emergence observed in field collections of *Bufo* was also stage 44 (Arnold and Wassersug, 1978). Emergence at this stage is certainly unrelated to exploiting a food resource on land, because tadpoles have insufficiently developed mouthparts. Emergence might be related to problems of acquiring oxygen (Wassersug and Seibert, 1975); or simply that ineptness at swimming makes the ponds unsafe beginning at stage 43, whereas the land becomes relatively safe only at stage 44 or 45 when tadpoles are beginning to jump effectively.

Wassersug and Sperry (1977) demonstrated that climax metamorphosis, despite involving profound morphological, physiological and behavioral changes, occupies a surprisingly small part of a tadpole's life. They argued that high mortality from predation may have been a strong selector for rapid metamorphosis. These present data on sprint velocity of *Bufo* tadpoles plus the field study on predation (Arnold and Wassersug, 1978) are consistent with this proposal.

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THE KARYOTYPE AND CHROMOSOMAL BANDING PATTERNS OF THE GREEN TURTLE (*CHELONIA MYDAS*).—The karyotype of *Chelonia mydas* was first reported by Makino (1952) and was said to possess a diploid number of 56 in males and 55 in females. A subsequent study (Waddell and Sigel, 1956) confirmed the diploid number of 56 in an unreported number of individuals of unreported sex. Karyological data, both nondifferentially stained and banded preparations, from 5 specimens representing at least 3 and probably 4 distinct breeding aggregations are presented. The banding patterns are compared between sexes and breeding aggregations of *C. mydas*, as well as to the banded karyotype of another cryptodiran turtle, to determine any possible differences.

Materials and methods.—Tissue cultures were initiated from heart muscle excised from animals either in the field or in the lab. Cell cultures were grown in Medium 199 fortified with 20% fetal calf serum and chromosome preparations were made as described previously (Sites et al., 1979b). The G-band and C-band methods of Seabright (1971) and Sumner (1972) were used as described by Sites et al. (1979b).

The following specimens were studied: *Chelonia mydas*, Aves Island, Venezuela (15°40′N, 63°36′W), 2♂♂, Florida State Museum (UF) 42372, 42373; Philippine Islands, 1♀, UF 43674; Miskito Cays, Nicaragua, 1♂; Baboen Santi, Surinam (5°48′N, 53°57′W), 1 hatchling (sex unknown); *Chinemys reevesi*, 1♀, Texas Cooperative Wildlife Colllection No. 56736. The Aves Island, Surinam and Philippine Islands specimens are hatchlings from breeding aggregations at those sites. The exact locality for the Philippine specimen is unknown. The Miskito Cays specimen is from an immature animal captured by fishermen; no voucher specimen exists. Tag returns from breeding females indicate that this animal is a member of the Tortuguero, Costa Rica breeding aggregation; however, the possibility remains that it is derived from another site, such as Aves Island. No voucher specimen is available for the Surinam specimen but a series of hatchlings collected at the same time have been preserved and will be deposited in the Museum of Vertebrate Zoology, University of California, Berkeley.

Results.—*Chelonia mydas* has a diploid number of 56. The karyotypes of a ♂ and ♀ are presented in Fig. 1 and the chromosomes are arranged according to Bickham (1975). There are 7 pairs of group A (metacentric or submetacentric) macrochromosomes; 5 pairs of group B (telocentric or subtelocentric) macrochromosomes; and 16 pairs of group C microchromosomes. There are no heteromorphic sex chromosomes and all animals examined are karyotypically identical.

Fig. 2 is a comparison of the G- and C-banded macrochromosomes of *C. mydas* and a bata-