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# Evaluation of a New Method for Measuring Salamanders

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# Evaluation of a New Method for Measuring Salamanders

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Collection of morphometric data is essential to many field studies of amphibian populations. One of the most common measurements obtained from salamanders is snout-to-vent length (SVL), a parameter useful in studies of sexual dimorphism (Bovero et al. 2003), demography (Semlitsch 1985), and systematics (Carlin 1997). Measuring salamander lengths in the field is challenging because of their small size, slimy texture, and propensity to maintain a nonlinear body position. Time expenditure is another concern, especially when researchers process large numbers of salamanders. Different measurement techniques vary in accuracy and precision, limiting the reliability of the data so that comparisons cannot be easily performed. We compare a new method of obtaining salamander SVL measurements to other commonly used methods.

To restrict salamander movement and maintain a linear body orientation, we constructed a device (the "Salamander Stick") using two equally sized polyvinyl chloride (PVC) pipes (40-cm long, with 2.5 cm outer diameter). We wrapped duct tape around both ends of one PVC piece such that a gap of 2 mm separated the two pieces when positioned parallel to each other. We then wrapped duct tape around both ends of the device, which secured the 2 mm gap. After assembly, we could pass a 23-cm wide plastic sandwich bag through the gap while prohibiting the passage of objects larger than 2 mm thick (Fig. 1a).

To obtain salamander SVL measurements, we placed a salamander into a plastic sandwich bag and fed the bag opening through the gap between the two PVC pipes. We pulled the bag through the gap until the salamander (at the bottom of the bag) reached the gap. We then manipulated the salamander through the walls of the bag to straighten it along the cranio-caudal axis and ensure that its ventral surface could be viewed. Once this was accomplished, SVL measurements were obtained with dial calipers (Fig. 1b).

We compared the precision and accuracy of the Salamander Stick to two other methods. In Method 1 (hereafter, "Freehand"; adopted from Phillips et al. 2002), a salamander was set on a table, straightened, and the SVL was measured with a plastic ruler. In Method 2 (hereafter, "Tube"; adopted from Mathis 1991), a salamander was placed into a clear plastic tube (inner diameter = 1.7 cm) and the SVL was measured by placing a ruler against the outside of the tube.

In March 2004, we captured 20 adult smallmouth salamanders (*Ambystoma texanum*) from a breeding pond in Coles County, Illinois, USA. During measurements, we housed all salamanders individually in 2 L plastic tubs in the laboratory. Salamanders were randomly selected and measured (SVL ± 1.0 mm) once with a

randomly chosen method. We repeated this process until each salamander was measured 4 times for each method. A plastic ruler was used to measure salamanders from the tip of the snout to the posterior margin of the vent. To reduce bias, one of us (LJW) measured all subjects. We determined the amount of time (± 0.1 sec.) required for each measurement to evaluate the efficiency of the three methods. We completed the measurements over a 5-day period and released salamanders at their capture site.

We determined measurement precision using the coefficient of variation (CV; Zar 1999). Salamanders have a tendency to contort their bodies when manipulated (Wise and Buchanan 1992), often reducing their body lengths. Because of this tendency, we assumed that the method providing the smallest mean SVL would be the least accurate representation of the "true" SVL. In contrast, the most accurate method should provide the greatest mean SVL. The precision and accuracy of each method were analyzed using one-way analyses of variance (ANOVA). All data conformed to assumptions of parametric statistics and analyses were conduced using SPSS 12.0 (SPSS, Inc. 2003).

There was a difference in the mean SVL ($F_{2,59} = 5.79$, $P = 0.005$) and CV ($F_{2,59} = 5.75$, $P = 0.005$) among the three measurement methods (Table 1). Bonferroni post-hoc tests indicated that measuring salamander SVL with the Salamander Stick was more accurate and precise than the Freehand and Tube methods. The Freehand and Tube methods did not differ in precision or accuracy. While our results obtained from the Tube and Freehand methods do not differ, neither method was more accurate or precise than the Salamander Stick. This is likely because the Tube and Freehand methods do not restrict salamander movement and straighten its vertebral column as well as the Salamander Stick. As another testament to its efficiency, we found that the Salamander Stick allowed measurements to be obtained with the least time expended (Table 1). Other techniques to obtain salamander measurements may not be as efficient as the Salamander Stick. For instance, using a plastic sandwich bag alone (without the stick) is another method used to immobilize salamanders and obtain morphometric measurements ("Baggie" method; Bury and Corn 1991). Although we did not compare the Baggie method and the Salamander Stick, we suspect that the PVC pipes decrease the time spent measuring individuals and the likelihood that a subject will contort its body as the measurement is taken.

TABLE 1. Accuracy (mean SVL ± 1 SE) and precision (CV ± 1 SE) for 20 Smallmouth Salamanders (*Ambystoma texanum*) measured by the three methods in March 2004. Measurement time (sec, mean ± 1 SE) is the amount elapsed between initially manipulating the salamander and the moment at which the measurement was obtained.

| Method | Mean SVL (mm) | CV% | Time (s) |
|---|---|---|---|
| Freehand | 76.7 ± 1.3 | 4.2 ± 0.4 | 56.5 ± 4.0 |
| Tube | 77.9 ± 1.5 | 4.4 ± 0.4 | 37.0 ± 1.3 |
| Salamander Stick | 82.7 ± 1.2 | 2.7 ± 0.3 | 34.7 ± 1.2 |


FIG. 1. The Salamander Stick, a device for obtaining precise and accurate measurements of salamander snout–vent length. A) The device shown with a plastic bag passing through the slit between the two polyvinyl chloride (PVC) pieces. B) The lateral view of an adult Smallmouth Salamander (*Ambystoma texanum*) immobilized in the device.

The Salamander Stick is an accurate, precise, and time-efficient method for obtaining standardized salamander measurements. The device is simple in design, durable, and easily transported and used in the field. It can be used to measure salamander SVL as well as total length, and the width of the device is easily modified to accommodate salamanders of different sizes including large larvae (> 3 mm girth) or neotenic species. It is inexpensive, costing less than US $6.00 to manufacture. The plastic sandwich bags used in measurements can be replaced after wear and can be easily cleaned. We have used this device in the field to measure breeding adult *A. texanum* in the spring of 2004 (N = 986), without any injury to the study organisms. Similarly, we witnessed no ill effects of repeated use of this device on the salamanders measured in this study.

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# HERPETOLOGICAL HUSBANDRY

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## Husbandry and Captive Reproduction in *Carlia ailanpalai* (Scincidae)

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The skink *Carlia ailanpalai* is introduced (Zug 2004) on the southernmost islands of the Mariana archipelago (Guam, Rota, Tinian, and Saipan) and reaches dense populations on Guam (mean population estimate of 9150 *Carlia*/ha for certain areas; Campbell 1996). It is likely that the species was introduced in the late 1950's to early 1960's (McCoid 1993, 1999). On Guam, the species is medium-sized and exhibits a negligible sexual dimorphism in size (males reach at least 63 mm and females 62 mm SVL) and in coloration (both sexes have a uniform light brown dorsum with cream venter grading to a slight peach on the ventral aspect of the tail). It has been suggested that C. *ailanpalai* might negatively impact native scincids (McCoid 1995, 1997). The biology of *C. ailanpalai* has not yet been reported.

We are unaware of information on long-term captive maintenance of small Australasian scincids. Available information on captive maintenance of small scincids comes from short-term studies on behavior (Done and Heatwole 1977; Perrill 1980; Torr and Shine 1994; Whittier 1993; Whittier and Martin 1992; Zwickel and Allison 1986).

As part of a larger study on the colonization biology and interactions of two western Pacific skink species (*C. ailanpalai* and *Emoia caeruleocauda*), we established a colony of these species in Kingsville, Texas. We maintained this colony for approximately 20 months until we voluntarily ceased observations. On 30 June 1995 we received 14 adult *C. ailanpalai* (6 male: 8 female; 45–55 mm SVL) and 10 subadult to adult *E. caeruleocauda* (5 male: 5 female; 35–45 mm SVL*)* from Guam, Mariana Islands. Observations on captive maintenance of *E. caeruleocauda* are presented elsewhere (McCoid et al. 1997). Size at maturity was determined by the presence of secondary yolking follicles revealed by dissection of preserved material (McCoid 1997). Sexes can be easily distinguished as adult males have a markedly swollen tail base. Initially, all *C. ailanpalai* were housed in a single 75 L (20 gal) aquarium. This aquarium had a sand substrate with three flat rocks for basking and cover. A shallow water dish was placed in the tank along with a small potted ivy plant (*Pothos* sp.). The aquarium was kept in a curtained, secluded room and supplied with fluorescent lighting set in an aquarium reflector. The room was air-conditioned and daily air temperatures in the aquarium ranged between 20 and 32.2˚C while daily humidity ranged between 60 and 90%. Crickets were fed twice weekly and we maintained the *C. ailanpalai* under these conditions for approximately nine months. There was no mortality during this period.

Beginning in Apri1 1996, for the next seven months of this study, we divided the 14 lizards into four 75 L (20 gal) screen-covered aquaria. Two females were placed in each tank and two males in two of the tanks. The remaining two tanks each received a single male. A 50:50 mixture of potting soil and sand was provided as a substrate and a potted ivy plant was placed in each tank. Several small flat rocks were placed in each tank as cover and basking sites. A small shallow tray in each tank was kept filled with distilled water and tanks were hand-misted twice daily. Approximately once a week, about 0.5 L of distilled water was poured into the substrate. A 300 ml dirt-filled rectangular Tupperware, container with a hole cut in the top was supplied as an egg-laying chamber. We replaced the 48-inch fluorescent lamp with a full-spectrum Vita-Lite fluorescent lamp (Duro-Test Corp.) set in a reflector and installed an additional 50 W basking-lite heat lamp (Duro-Test Corp.). The heat lamp was suspended within the aquarium ca. 20 cm above the substrate and over a basking rock. Heat lamps and fluorescent lamps were turned on at 0700 h. At 1000 h, heat lamps were turned off. At approximately 1800 h heat lamps were turned on again and left on until 1900 h when all illumination was discontinued for the evening. Daily temperatures ranged between 20 and 32.2˚C with the basking spot under the heat lamp reaching 55˚C.

Throughout the study period, the photo regime was kept at 12L: 12D to approximate conditions on Guam (which vary seasonally between 13L: 11D and 12L: 12D*)*. Lizards were fed *ad libitum* with crickets every other day. Two feeding regimens were attempted. Initially, for the first week, crickets were dusted with Tetra, Reptical calcium/vitamin powder but all lizards refused 'white' crickets. In order to provide the lizards with a vitamin supplement, for the remainder of the study, we then fed the crickets powdered (prepared with a coffee grinder) T-Rex, Calcium Plus cricket food, essentially 'gut-loading' crickets with nutrients and calcium. Crickets also were fed dry oatmeal and given water *ad libitum.* The 14 *C. ailanpalai* would consume ca. 1000 two- to