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Got It Clipped? The Effect of Tail Clipping on Tail Gripping Performance in Chameleons

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Abstract.—Toe and tail clipping are commonly used methods for permanent marking of animals and for obtaining tissue samples for genetic analyses. Although it has been tested whether toe clipping affects locomotor performance (and thus potentially the fitness of an individual), little is known about the effect of tail clipping. Tails are important organs in many amphibians and reptiles and are used for balance or stability during locomotion or as prehensile organs. Effects of tail autotomy or the removal of large parts of the tail have previously been demonstrated. Here, we test whether the removal of a small part (<5 mm) of the distal tail in chameleons affects their ability to cling to branches of different diameters by measuring gripping strength using of a force platform. Our data show no significant or directional effect of tail clipping on the maximal forces that can be generated by the tail and, thus, suggest that tail clipping can be used as a method for tissue collection.

Toe and tail clipping are commonly used methods for permanent marking of animals and to obtain tissue samples for genetic analyses (Ferner, 1979; Gosner and Collura, 1996). In lizards, tail clipping is predominantly used to obtain tissue for genetic analysis. Toe clipping is, in addition, used to permanently mark individuals. Given the possibility of clipping several toes on each foot, this gives the researcher access to a nearly unlimited number of individual codes. Despite being minimally invasive, previous studies have documented how toe clipping can affect locomotor performance, especially in pad-bearing lizards (Bloch and Irschick, 2004; but see Paulissen and Meyer, 2000). For example, the clinging ability of *Anolis* lizards decreased by 40% when one finger was removed on each hand. Sprint speed, however, does not appear to be affected by the clipping of toes in terrestrial lizards (Huey et al., 1990; Dodd, 1993).

However, little is known about the effect of tail clipping. Yet, tails are important organs in many amphibians and reptiles and used for balance or stability during locomotion (e.g., Ballinger et al., 1979; Jusufi et al., 2008; Boistel et al., 2010) or as prehensile organs (Zippel et al., 1999). The effects of tail autotomy or the removal of large parts of the tail have been investigated and involve the loss of dynamic stability during jumping (Gillis et al., 2009), a decrease in sprint speed (Brown et al., 1995; Chapple et al., 2004), and a negative effect on mating success and social status (Fox and Rostker, 1982; Martin and Salvador, 1993) in some lizards. However, the effect of the removal of a small part of the tail (as is typically done when taking tissues for genetic analysis) on ecologically relevant performance traits has not been investigated.

Here, we test whether the removal of a small part (<5 mm, approximately 5–7% of tail length) of the distal tail in chameleons affects their ability to hold onto branches of different diameters. Chameleons are particularly relevant in this context, as many chameleons use their tails as a prehensile organ, providing balance during arboreal acrobatic maneuvers such as gap bridging or moving through dense vegetation (Tolley and Burger, 2007; Tolley et al., 2010). Moreover, the tail is often used as a balancing organ during prey capture and intra-specific interactions (Tolley and Burger, 2007). Here, we study the effect of tail clipping on the maximal force that can be exerted by the tail in the Cape Dwarf Chameleon (*Bradypodion pumilum*). Because Cape Dwarf Chameleons exhibit two morphotypes (closed and open habitat morphs; see Measey et al., 2009), we decided to study the closed habitat morph, which has longer tails and for which tail use is likely critically important while moving about in its natural habitat consisting of dense cover (typically large bushes and trees).

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Fig. 1. Picture illustrating the set-up used to measure tail-gripping performance for *Bradypodion pumilum*. The chameleon is allowed to wrap its tail around the dowel mounted onto the force plate and is then pulled dorsally.

Materials and Methods

Animals.—Ten *B. pumilum* were caught by hand during nighttime surveys along a river in Stellenbosch, South Africa. Animals were brought back to the lab, measured and tested for tail-gripping performance. Next, a small piece (3–5 mm) was cut from the distal tail tip and stored in 100% ethanol for genetic analysis. Animals were allowed to rest overnight and retested the next day.

Tail-Grip Strength.—One of two dowels (broad: 10 mm, and narrow: 5 mm) was mounted on a piezo-electric force platform (Kistler Squirrel force plate, ± 0.1 N). The force platform was positioned on a custom-designed metal base (Fig. 1) and connected to a charge amplifier (Kistler Charge Amplifier type 9865). Forces (N) were recorded during a 60-sec recording session at 1,000 Hz. During that interval, chameleons were allowed to repeatedly grip a dowel with their tail and then pulled away from the dowel. A recording session typically

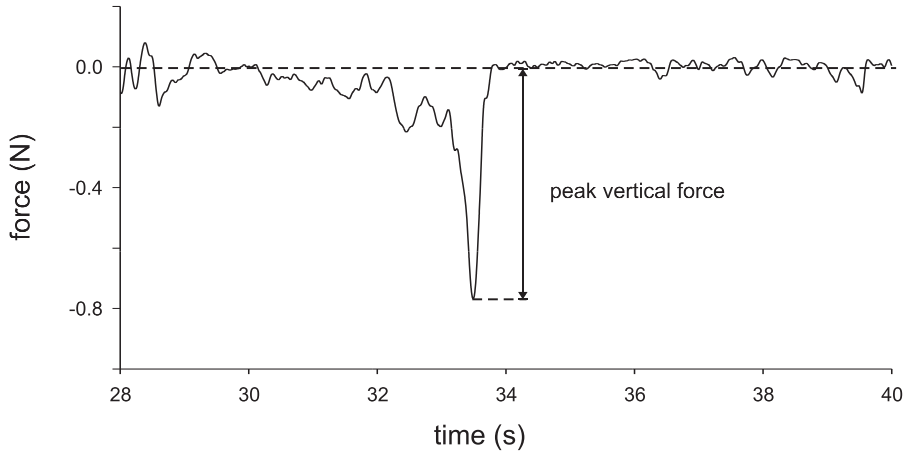

FIG. 2. Representative force profile illustrating the increase in vertical force while the chameleon grips a dowel with its tail. Negative forces indicate tensile forces (i.e., the chameleon pulling with its tail on the branch).

included 3–4 tail-grip trials (Fig. 2). As animals were pulled from the dowel in the vertical direction, we extracted peak *Z*-forces only using the Bioware software (Kistler). Each chameleon was tested three times (i.e., three recording sessions) on each dowel with at least a 30-min rest between trials and a one-hour rest between recording sessions with dowels of different sizes. Trials before and after tail clipping were run on subsequent days. The highest tail-grip force for each individual on each dowel before and after tail clipping was retained for analysis (for a rationale on the use of maximal performance, see Losos et al., 2002).

Analyses.—All data were $\log_{10}$-transformed before analysis to fulfill assumptions of normality and homoscedascity. Next we ran a repeated-measures analysis of variance (ANOVA) to test for effects of tail clipping on maximal tail-grip strength on both narrow and broad dowels. All analyses were performed using SPSS V. 15.0.

RESULTS

Bradypodion pumilum was able to exert 1.60 ± 0.78 N on average while gripping a narrow and 1.76 ± 0.83 N on average while gripping a broad dowel with its tail. After tail clipping, chameleons were able to exert 1.23 ± 0.20 N and 1.46 ± 0.56 N on narrow and broad dowels, respectively. A repeated-measures ANOVA showed no effect of tail clipping on either narrow ($F_{1,9} = 1.47$, $P = 0.26$) or broad ($F_{1,9} = 0.14$, $P = 0.72$) dowels. Moreover, no consistent directional effect of tail clipping on maximal grip force was observed. Indeed in 12 of 20 cases were forces higher before tail clipping, in the other eight cases forces were higher after tail clipping.

DISCUSSION

Our data show that Cape Dwarf Chameleons have very strong tails able to exert up to 32 times their own body mass in grip force on a narrow dowel and up to 35 times their body mass on a broad dowel. Thus, the tail can play a crucial role in securing the animal to the substrate while capturing prey, moving from branch to branch or fighting with an opponent. The high forces chameleons are able to exert suggest the ecological and functional importance of their tails. Thus, an understanding of whether or not tail clipping affects the performance of the tail during gripping appears crucial. Our data show no significant or consistent effect of tail clipping on the peak forces that can be exerted. These results suggest that clipping a small piece (<5 mm) from the tail likely does not affect the ability of chameleons to effectively use their tails. However, potential fitness effects remain to be tested.

Interestingly, our data suggest that closed habitat morphs of the Cape Dwarf Chameleon can exert higher forces on broad compared to narrow dowels. This suggests that the longer tails in this morph may be better suited for gripping relatively larger branches compared to the open habitat morph, which has shorter tails and lives on narrower substrates (Hopkins and Tolley, 2011). However, a more comprehensive sample of chameleons of both morphs is needed to test for the adaptive nature of the difference in tail length.

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