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Short communication

Palestine Saw-scaled Vipers hunt disadvantaged avian migrants

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ABSTRACT

The selection of an ambush-cum-foraging site and proper prey are indispensable for maintaining an adequate energy intake by sit-and-wait predators to optimize survival and future fitness. This is important for snakes, where an ambush site has suitable ambience. We studied the foraging strategy of the Palestine Saw-scaled Viper (*Echis coloratus*) at an avian migratory stopover site. Following initial observations, we hypothesized that vipers are able to discern the body mass of a perched bird and hunt accordingly. We implemented an experiment where vipers chose between four groups of migratory Blackcaps with different body mass. Prey choice by vipers of both age classes was not random and adults focused on Blackcaps with the lightest body mass. Juveniles displayed a variability of prey choice but selected mainly birds from the lightest categories. We concluded that Saw-scaled Vipers hunt prey based on thermal cues; juveniles practice on different prey groups prior to perfecting their foraging techniques i.e., hunting is a learned process; and that they prefer birds with the lowest body mass. The last because Blackcaps, when on migration, save energy by entering a state of deep torpor in which they sacrifice their vigilance capabilities.

1. Introduction

Ambush is one of the most common foraging strategies applied by predators, wherein the predator remains motionless in hiding and awaits the arrival of the potential prey within its' striking distance. Such a strategy requires special physiological adaptations like the reduction of one's metabolic rate to survive long periods without food, morphological adaptations to remain camouflaged in its immediate environment, but also behavioral adaptations which include the selection of a suitable ambush site that ensures its' survival. Such a model group of ambush predators are snakes which select sites that maximize benefit but also minimize costs (Shine and Sun, 2002). Further, the choice of ambush sites by snakes that remain for long periods is crucial because it may bear missed-opportunities costs and increases the risk of starvation if improperly chosen (Tsairi and Bouskila, 2004). Hence, for a snake to optimize its survival and future fitness, the selection of an ambush-cum-foraging site is important for maintaining an adequate energy intake.

Previous studies of ambush site selection by snakes indicate that they use prey olfactory cues to select odor rich patches for their ambush site (Reinert et al., 1984; Theodoratus and Chiszar, 2000). Moreover, it was suggested that Palestine Saw-scaled Viper (*Echis coloratus*) in the Judean Desert remained in microhabitats that provide cover, high probability for prey encounters, and possibly a physiologically convenient humid environment (Tsairi and Bouskila, 2004). Another study corroborated these findings for the species, based on individual markings on the vipers head, found that the same individuals remained at their ambush bushes for up to 6 months (Yosef et al., 2012). This sedentary behavioral characteristic of the vipers makes them model organisms in order to investigate the implications of ambush site selection and foraging tactics.

During 17 years of ecological studies at the Eilat Bird Sanctuary (EBS; e.g. Yosef and Tryjanowski, 2002; Yosef and Weinman, 2010; Yosef and Zduniak, 2011), we encountered Palestine Saw-scaled Vipers on a daily basis. Allowing that many of the migratory birds use the EBS as a stop-over site, and are regularly trapped and ringed, we can identify the avian prey to the individual level. However, the capability to distinguish between individuals in good condition compared to those in inferior physiological condition was highlighted during a study of torpor capabilities in migratory Blackcap (*Sylvia atricapilla*) at the EBS (Wojciechowski et al., 2005;

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Wojciechowski et al., 2014). Our observations led us to hypothesize that because avian migrants fresh off the flyway were in physiological stress, and able to overcome these by resorting to torpor (Wojciechowski et al., 2014), but also resulted in decreased vigilance capabilities and, hence, easier to capture.

Our aim was to characterize the preferred avian body mass of prey by the Saw-scaled Viper in the EBS and to compare them to those disregarded by the snake. We also wished to understand if this capacity is acquired through a learning process or innate. We considered a random search and a learning curve of what is best in juvenile snakes compared to the adults, to be proof of acquiring knowledge through experience.

2. Materials and methods

2.1. Study species

The Palestine Saw-scaled Viper is the most common venomous snake in rocky desert habitats in the Negev and the Judean Deserts (Mendelssohn, 1965). The diet of this species is not well studied and is based on sporadic observations (Mendelssohn, 1965; Gasperetti, 1988; Tsairi and Bouskila, 2004; Yosef et al., 2012).

2.2. Study site

The Eilat Bird Sanctuary (29°33′N, 34°57′E), is a critical migratory bird stopover and refueling site for hundreds of migratory species, especially during spring passage (Yosef and Tryjanowski, 2002; Yosef and Weinman, 2010; Yosef and Zduniak, 2011).

2.3. Field methods

The experiment was conducted in spring 2009. We trapped 38 Palestine Saw-scaled Viper (for individual identification see Yosef et al., 2012) and were tested and released within 24 h. We assumed that an individual with a snout–vent length of <20 cm as a juvenile ($N = 25$). Individuals with stocky bodies and snout–vent length >30 cm we considered adults ($N = 13$). The experiment was conducted during peak Blackcap migration (Yosef and Weinman, 2010; Wojciechowski et al., 2014) what allowed us to capture birds in the range of body masses required for the study – <11 g, 11–13 g, >13–15 g, >15 g. Although we did not control for body size, biometric data show that wing chord length and tail length ranged +1.0 mm from the average, such that we assumed that the birds included in the study were of similar size.

A special research arena in the form of a clearing without vegetation, sandy surface, 45 cm high plywood walls, opaque, and over which no other distractions (e.g., tree tops) could be seen by the snake placed in the enclosure. The Vipers were given a choice of four secure cages in which we kept 5 Blackcaps from each of the four body mass categories. Each cage was 80 cm off the ground and was placed 1 m from the side of the enclosure. Each snake was released in the middle of the study area, allowed 10 min to make a choice, and when the snake had settled under one of the cages and adopted a coiled ambush posture, we considered that to be its prey of choice. All snakes were allowed four repetitions by removing it from the arena, and returning it to the centre after the arena was raked, and during which the locations of the four cages were randomly changed. The arena for each of the individuals was the same but different for each individual. We reasoned that, if scent cues were used by the snakes then this would be evident in that the snake would always be at the site of first preference in spite of our having randomly rotated the bird cages. All animals were immediately released at site of capture upon completion of the experiment and no casualties occurred due to the experiment.

2.4. Statistical methods

To avoid pseudoreplication, for each of 38 snakes, we calculated the average probability of selection of each of the four body mass categories recorded during the four experimental trials. We treated the mean values for each snake as "dependent measurements" and compared using Friedman ANOVA. Analysis was performed separately for juvenile and adult vipers and the Bonferroni corrections were applied to adjust the alpha values for the increased probability of obtaining statistical significance from multiple testing.

3. Results

The choice of the Blackcap cages by the Palestine Saw-scaled Viper of both age classes was not random (Friedman ANOVA, adults: $\chi^2 = 39.00$, df = 3, $n = 13$, $P < 0.001$; juveniles: $\chi^2 = 15.84$, $df = 3$, $N = 25$, $P = 0.001$). Adult vipers exclusively focused on Blackcaps with the lightest body mass (Fig. 1). On the other hand, juveniles displayed a variability of prey choice but selected mainly birds from the two lightest categories (i.e. <11 g, 11–13 g; Fig. 1) among which there were no significant differences in choice (Wilcoxon matched-pairs test, $Z = 1.38$, $P = 0.168$).

4. Discussion

Ecological processes are influenced by the dietary decisions that define the trophic niche of an organism (Charnov, 1976). Animals feed selectively and develop abilities to discriminate between preys that are acceptable as food (Nakano et al., 1999; Shine and Sun, 2002). Snakes are known to hunt their prey based on a wide range of sensory capabilities which can include one or more of cues that are either chemosensory, visual, ground-borne vibrations, infrared, or thermal cues (Young and Morain, 2002; Krochmal and Bakken, 2003; Krochmal et al., 2004).

In order to understand how the vipers choose almost exclusively the birds with the lightest body mass we attempted an elimination process of the possible cues available. First, owing to the fact that *Echis* do not possess any defined infrared- sensitive receptors like facial pit organs or supranasal sacs (Safer and Grace, 2004), we assume that they do not posses infrared capabilities. Further, visual illumination is a largely ineffective cue at night, when residual temperature variations caused by solar heating are no longer associated with illumination cues (Krochmal and Bakken, 2003). In addition, since a roosting bird does not produce any ground vibrations, we also discounted this parameter as a possible method of detection. Neither could we think of a reasonable pathway in which a chemosensory or olfactory cue could help the vipers discern between body masses of perched individuals. However, all of these need to be tested (cf. Shine and Sun, 2002). That leaves us with the only other capability—that of thermal cues.

The behavioral evidence for thermal sensitivity in species lacking pit organs remains largely uninvestigated (e.g., Krochmal et al., 2004) and future studies of *Echis* spp. should check if they are capable of picking up temperature cues from small objects 80 cm away, and especially at night when ambient temperatures create greater temperature differentials between air and prey body-heat.

One of the factors that may influence the hunting strategy of snakes is the body size of potential prey (Shine and Sun, 2002). In Shedao Pit-vipers (*Gloydius shedaoensis*) the snakes body size influenced prey-size selectivity, with larger snakes not striking smaller prey (Shine and Sun, 2002). This is in contrast to our findings wherein *E. coloratus*, irrespective of age, showed a preference to birds with the lightest body mass. Taking into account that linear dimensions of birds included in the experiment were similar between compared categories, we assume that vipers preferred