

RESEARCH NOTE

THE EFFECTS OF REPRODUCTIVE STATUS ON SPRINT SPEED IN THE SOLIFUGE, *EREMOBATES MARATHONI* (SOLIFUGAE, EREMOBATIDAE)

Costs associated with reproduction are delineated by trade-offs between the current reproductive capacity of an animal and the probability of its future survival and reproductive success (Williams 1966). The successful analysis of life history parameters depends on our ability to identify proximate mechanisms by which such costs are mediated. Documented costs associated with reproduction include decreased survivorship resulting from physiological or behavioral changes that accompany reproduction (Hirshfield & Tinkle 1975; Bell 1980). For example, if escape from a predator depends on the speed or endurance of a potential prey organism, then any reduction in the locomotor performance of gravid females could increase the risk of predation. Locomotor performance has been correlated with survivorship in many species of vertebrates (Shine 1980; Punzo 1982; Huey et al. 1984; Svensson 1988; Brodie 1989; Jayne & Bennett 1990; Plummer 1993) but little information exists for arthropods in general (Winfield & Townsend 1983; Crowl & Alexander 1989; Punzo 1989) or for arachnids specifically (Moffett & Doell 1980; Shaffer & Formanowicz 1996).

Solifuges are common representatives of the arachnid fauna in desert regions worldwide (Turner 1916; Muma 1967; Cloudsley-Thompson 1977; Wharton 1987). These predators may forage over a considerable area actively searching for prey (Muma 1966; Wharton 1987; Punzo 1994b, 1995a), and rely on speed to escape from encounters with aggressive conspecifics or potential predators (Cloudsley-Thompson 1977; Wharton 1987; Punzo 1995b, 1997). In the present study, I compared the sprint speeds of gravid and non-

gravid females of the solifuge *Eremobates marathoni* Muma 1970. To my knowledge, no previous data on sprint speed or the relationship between sprint speed and reproductive status exist for the Solifugae.

Eremobates marathoni is a common inhabitant of the Big Bend region of Trans Pecos Texas (Punzo 1997), which lies within the northern confines of the Chihuahuan Desert. I collected gravid (G) and nongravid (NG) females by hand at night with the aid of a head lamp as they wandered over the surface of the ground, or through the use of pitfall traps as described previously (Punzo 1994a). All solifuges were collected within a 3 km radius of Marathon, Texas (Brewster County) during July 1996. A detailed description of the geology and dominant vegetation of this area is given by Tinkam (1948).

Solifuges were transported back to the laboratory, housed individually in plastic containers (30 × 15 × 10 cm), and fed on a diet of crickets and mealworm larvae as described by Punzo (1997b). Gravid females were identified by the presence of embryos visible through the ventral body wall. I recorded the following measurements for each G and NG female: body length (BL) in mm; width of propeltidium (WP) in mm, and body weight (BW) in grams. Adult solifuges, as well as eggs, were maintained at 25–27 °C and 70–72% relative humidity in a Percival Model 816 environmental chambers (Boone, Iowa). Adult females were removed from these chambers only when subjected to sprint speed analyses. Voucher specimens have been deposited in the Invertebrate Collection at the University of Tampa.

I measured the sprint speed of 20 solifuges

Table 1.—Measurements for body length (BL) and width of propeltidium (WP) in millimeters, body weight in grams, and sprint speed (cm/sec) for females of *Eremobates marathoni*. Data represent means (\pm SD) for 20 females for each of the following groups: nongravid females; gravid females while carrying embryos and 24 hours post-oviposition.

	Nongravid	Gravid	Post-oviposition
Body length	23.8 (2.1)	22.7 (1.5)	23.1 (2.7)
Propeltidium width	5.71 (0.4)	6.14 (0.6)	5.84 (0.2)
Body weight	3.49 (0.2)	4.62 (0.1)	3.71 (0.3)
Sprint speed (cm/sec)	23.6 (2.4)	14.5 (1.3)	21.7 (1.9)

in a linear race track (length = 90 cm; width = 6 cm). The floor of the track was constructed of wood and covered with coarse plastic carpet material. The floor was marked at 10 cm intervals with black tape. I attached a piece of clear acrylic tubing (5 cm diameter) that was cut in half lengthwise to the bottom of the floor. This prevented the solifuges from climbing or escaping while running and also eliminated shadows. One end of the track was closed by a plastic panel and designated as the start chamber (10 cm in length) where the solifuge was restrained from entering the runway (80 cm) by a hemispherical cardboard gate positioned between slits in the tube. The plastic panel was fitted with an intake valve through which a gentle stream of compressed air could be introduced in order to initiate running (Punzo 1989). The track was placed under a 50 W fluorescent lamp. Animals were deprived of food for 48 h prior to testing.

Sprint speed trials were conducted on 20 NG females and 20 G females. All of the NG females were tested once. Each of the G females was also tested once at each of two reproductive states: gravid, but prior to oviposition (G), and within 24 h after oviposition (post-oviposition, PO). The amount of time between the initial testing of gravid females and oviposition ranged from 8–14 days. The first trial for all animals occurred within 4–7 days after being brought to the laboratory. The second trial for PO females occurred two days after oviposition. Each female was weighed immediately following the running trials on a Mettler electronic analytical balance and returned to its holding cage.

At the start of each trial, a solifuge was placed in the start chamber with its head facing the runway and allowed to habituate for 2 min prior to running. Following this period, the cardboard gate was lifted manually and a

gentle stream of compressed air was introduced through the intake valve. In response to the air flow, the solifuge would immediately begin to run out of the start chamber and into the runway. Since preliminary observations had indicated that solifuge sprint speed was fastest over the first 40 cm, I used the data for locomotor performance over this distance for all statistical analyses. I used a stopwatch to record the amount of time required for a solifuge to cross the 40 cm mark on the runway. Data on sprint speeds were expressed in cm/sec.

All statistical analyses used in this study follow procedures described by Sokal & Rohlf (1981) and Wilkinson (1984). They were conducted using Stat View (Abacus Concepts, Inc., Berkeley, California) and SYSTAT (SYSTAT, Inc., Evanston, Illinois).

Gravid (G) females ran at a significantly slower speed than nongravid (NG) females (Table 1; $t = 7.14$, $P < 0.01$). Following oviposition, post-oviposition (PO) females ran significantly faster than they did while carrying embryos (Wilcoxon matched pairs test; $z = 3.27$, $P < 0.01$). There was no significant difference between the sprint speeds of NG and PO females.

There were no significant differences in body length (BL) ($t = 0.53$, $P > 0.50$), and width of propeltidium (WP) ($t = 0.65$, $P > 0.35$) between G and NG solifuges used in this study. The mean body weight (BW) of G females was 38.5% higher than that of NG females due to the weight of the embryos and associated body fluids. The number of eggs oviposited per G female ranged from 19–46 with a mean of 26.6 ± 3.8 SD. The number of nymphs per female that successfully completed embryonic development and hatched ranged from 9–32 with a mean of 17.7 ± 2.9 SD.

The results of this study, the first reported for a solifuge, indicate that pregnancy results in a significant reduction in locomotor performance. This has important ecological implications because a decrease in sprint speed may increase the risk of predation in a significant way. Solifuges frequently utilize their locomotor capacities to escape predation. (Predators include scorpions, theraphosid spiders, other solifuges, centipedes, road runners, and badgers (pers. obs.)). Similar results have been reported for the striped scorpion, *Centruroides vittatus* (Say 1887) by Shaffer & Formanowicz (1996). In this study, sprint speed was determined for each female at each of three reproductive states (pregnant, while carrying young on her back, and after neonates had dispersed from her back). Sprint speed for pregnant scorpions averaged 84% of post-dispersal speeds. Sixty five percent of the scorpions carrying young on their backs did not run at all when disturbed and assumed a defensive posture while standing their ground. Sprint speeds for the remaining 35% that did run with young on their backs averaged only 61% of their post-dispersal speeds.

ACKNOWLEDGEMENTS

I wish to thank J. Bottrell and B. Trivett for assistance in collecting solifuges in the field, T. Punzo for assistance in maintaining solifuges in the laboratory and construction of the runway, B. Garman and A. Zenjarli for consultation on statistical analyses, J. Smith, P. Sierwald, J. Berry, D. Formanowicz and anonymous reviewers for comments on an earlier draft of the manuscript, and the University of Tampa for a Faculty Development Grant which made much of this work possible.

LITERATURE CITED

- Bell, G. 1980. The costs of reproduction and their consequences. *American Nat.*, 116:45–76.
- Brodie, E.D. 1989. Behavioral modification as a means of reducing the costs of reproduction. *American Nat.*, 134:225–238.
- Cloudsley-Thompson, J.L. 1977. Adaptational biology of Solifugae. *Bull. British Arachnol. Soc.*, 4:61–71.
- Crowl, T.A. & J.E. Alexander. 1989. Parental care and foraging ability in male water bugs (*Belostomatia flumineum*). *Canadian J. Zool.*, 67:513–515.
- Hirshfield, M.F. & D. Tinkle. 1975. Natural selection and the evolution of reproductive effort. *Proc. Nat. Acad. Sci., USA*, 72:2227–2231.
- Huey, R.B., A.F. Bennett, H. John-Alder & K.A. Nagy. 1984. Locomotor capacity and foraging behavior of Kalahari lacertid lizards. *Anim. Behav.*, 32:41–50.
- Jayne, B.C. & A.F. Bennett. 1990. Selection on locomotor performance capacity in a natural population of garter snakes. *Evolution*, 44:1204–1229.
- Moffett, S. & G.S. Doell. 1980. Alteration of locomotor behavior in wolf spiders carrying normal and weighted cocoons. *J. Exp. Zool.*, 213: 219–226.
- Muma, M.H. 1966. Feeding behavior of North American Solpugida. *Florida Entomol.*, 49:199–216.
- Muma, M.H. 1967. Basic behavior of North American Solpugida. *Florida Entomol.*, 50:115–123.
- Plummer, M.V. 1993. Thermal ecology of arboreal green snakes, *Opheodrys aestivus*. *J. Herpetol.*, 27:254–260.
- Punzo, F. 1982. Tail autotomy and running speed in the lizards *Cophosaurus texanus* and *Uma notata*. *J. Herpetol.*, 16:329–331.
- Punzo, F. 1989. Effects of hunger on prey capture and ingestion in *Dugesia echina* Chamberlin (Orthognatha, Theraphosidae). *Bull. British Arachnol. Soc.*, 8:72–79.
- Punzo, F. 1994a. Trophic and temporal niche interactions in sympatric populations of *Eremobates palpisetulosus* Fichter and *E. mormonus* (Roewer) (Solpugida: Eremobatidae). *Psyche*, 101:187–194.
- Punzo, F. 1994b. An analysis of feeding and optimal foraging behavior in the solpugid, *Eremobates mormonus* (Roewer) (Solpugida, Eremobatidae). *Bull. British Arachnol. Soc.*, 9:293–298.
- Punzo, F. 1995a. Feeding and prey preparation in the solpugid, *Eremorhax magnus* (Solpugida: Eremobatidae). *Pan Pacific Entomol.*, 71:13–17.
- Punzo, F. 1995b. Intraspecific variation in life history traits between sympatric populations of *Eremobates palpisetulosus* Fichter and *Eremobates mormonus* (Roewer) (Solpugida, Eremobatidae). *Bull. British Arachnol. Soc.*, 10:109–113.
- Punzo, F. 1997. Dispersion, temporal patterns of activity, and the phenology of feeding and mating behavior in *Eremobates palpisetulosus* Fichter (Solifugae, Eremobatidae). *Bull. British Arachnol. Soc.*, 10(8):303–307.
- Shaffer, L.R. & D.R. Formanowicz. 1996. A cost of viviparity and parental care in scorpions: Reduced sprint speed and behavioral compensation. *Anim. Behav.*, 51:1017–1024.
- Shine, R. 1980. "Costs" of reproduction in reptiles. *Oecologia*, 46:92–100.

- Sokal, R.R. & F.J. Rohlf. 1981. *Biometry*. 2nd ed. W.H. Freeman, San Francisco.
- Svensson, I. 1988. Reproduction costs in two sex-role reversed pipefish species (Syngnathidae). *J. Anim. Ecol.*, 57:929–942.
- Tinkam, E.R. 1948. Faunistic and ecological studies on the Orthoptera of the Big Bend Region of Trans Pecos Texas. *American Midl. Nat.*, 40: 521–583.
- Turner, C.H. 1916. Notes on the feeding behavior and oviposition of a captive American false-spider (*Eremobates fornicaria* Koch). *J. Anim. Behav.*, 6:160–168.
- Wharton, R.A. 1987. Biology of the diurnal *Metasolpuga picta* (Kraepelin) (Solifugae, Solpugidae) compared with that of nocturnal species. *J. Arachnol.*, 14:363–383.
- Wilkinson, L. 1984. SYSTAT: The system for statistics. Systat Inc., Evanston, Illinois.
- Williams, G.C. 1966. *Adaptation and natural selection*. Princeton Univ. Press, Princeton, New Jersey.
- Winfield, I.J. & C.R. Townsend. 1983. The cost of copepod reproduction : Increased susceptibility to fish predation. *Oecologia*, 60:406–411.
- Fred Punzo:** Department of Biology, Box 5F, University of Tampa, 401 W. Kennedy Blvd., Tampa, Florida 33606 USA
- Manuscript received 13 March 1997, accepted 27 May 1997.*