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SHORT NOTE

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Social behaviour in the context of a limited resource in juvenile tortoises (*Manouria emys*)

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Social structures and dominance hierarchies are well documented in various species of tortoises, typically in sexually mature adults. We used artificial shelters to assess the effect of social setting and other factors that might affect dominance in juvenile Burmese mountain tortoises (*Manouria emys*). We found that the presence of other tortoises significantly increased the occupancy in our shelters, and larger tortoises occupied the shelters significantly more than did the smaller tortoises. Our results indicate clear existence of social structure in juvenile tortoises and suggest that the value of resources, such as shelters, may change under differing social conditions.

Key words: dominance, *Manouria emys*, shelter use, social behaviour

Tortoises worldwide and particularly in southern Asia face a number of dangers from humans, including the destruction of habitat, the harvesting for use in traditional medicine or for use as food (Rhodin et al., 2011). The Burmese mountain tortoise (*Manouria emys*) is among species facing these threats. It is one of the most basal species in Testudinidae (Crumly, 1984; Le et al., 2006) and is the largest terrestrial turtle in Asia. It is listed as Endangered on the IUCN Red List, and such species often are maintained in captive survival assurance colonies (e.g., www.turtlesurvivalalliance.org), so studies of their social behaviour in captivity becomes relevant to their possible conservation and can provide potential insights into their behaviour in the wild. Generally these tortoises are difficult to observe under natural conditions, so captive breeding programs allow for unique opportunities to study this species and others in similar peril (McKeown et al., 1982).

Tortoises exhibit a variety of social behaviours, including dominance behaviours (Brattstrom, 1974; Auffenberg, 1977). Niblick et al. (1994) showed that in male-male interactions in *Gopherus agassizii*, the larger tortoise was more dominant, and generally garnered more mates and occupied burrows more frequently. Niblick et al. (1994) also observed differential dominance between individual male tortoises of equivalent sizes, indicating that factors other than sheer size come to play in determining social rank. Burrows and shelters of various sorts are important for some species of tortoises, serving as nesting sites, safety from predators and refuges offering appropriate levels of temperature and humidity (e.g., McGinnis & Voigt, 1971; Hazard & Morafka, 2004). So, despite a lack of solid natural history data for the species, it follows that *Manouria emys* also likely uses shelters and refuges for similar purposes, although the species does not construct burrows (D.P. Lawson, pers. comm.; Schaffer & Morgan, 2000). Social information on the occupancy status of shelters may be communicated between individual tortoises using chemical cues, and female tortoises have been shown to avoid burrows that have been marked with the secretions of other females (Bulova, 1997).

The majority of studies of social behaviour and dominance have focused on adult individuals where reproductive success is likely to be a primary driving factor of dominance rank. The quality of a home range and its available burrows and shelters is a key aspect of reproductive success. In this study, we manipulated the social context, in the form of group size, and shelter availability of juvenile *Manouria emys* in order to assess if social structures exist in juveniles in the context of limited shelter availability.

All trials were conducted in the animal facility in the Department of Herpetology at Zoo Atlanta; the tortoises were maintained in the same temperature and humidity controlled room. We manipulated a group of 42 juvenile *Manouria emys* that were paternal half-siblings and hatched between July and September, 2011. Our study was conducted between February and April 2012. Tortoises were individually marked with nail polish divided into three size classes based upon initial mass: small (59–85, $\bar{x}$=76 g), medium (86–99, $\bar{x}$=94 g), and large (100–123, $\bar{x}$=111 g). The classes contained an equal number of tortoises. The tortoises were then randomly assigned to treatments where one of each size class was represented in each three-tortoise treatment. Assignments were made such that all social combinations

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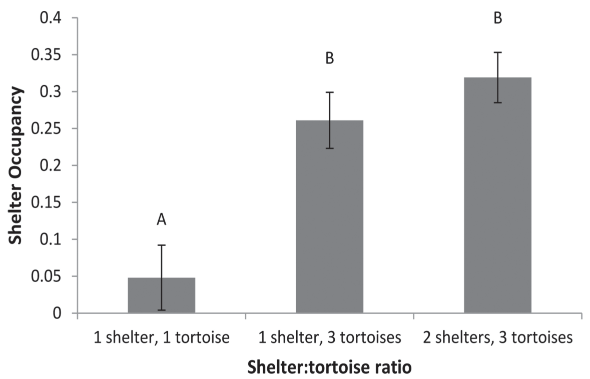

Fig. 1. The least square means for shelter occupancy ± SE. The letters represent treatments that are significantly different from each other.

included in the study were novel for each tortoise, to avoid any possible pre-established dominance and social structures from prior housing conditions.

There were three treatments with six replicates: A) one shelter and one tortoise (1:1), B) one shelter and three tortoises (1:3), and 3) two shelters and three tortoises (2:3). The shelters were prepared from 32oz. round plastic food containers. Black spray paint was applied to the outside of the containers to create a darkened environment within, and an entrance was cut on one side of the container. We created a "porthole" in the top of the containers to enable rapid and unobtrusive observation of inhabitants without dislodging the shelters from the enclosure substrate. The shelters were only large enough to contain a single tortoise. In a few instances, it was observed that a second tortoise had forced its way into the shelter by dislodging the shelter from the substrate. In our estimation, the second tortoise was not actually covered by the shelter and was situated on top of the original occupier. So, the individual on the bottom was scored as the occupying individual.

The existing housing bins were divided into two parts with a piece of plywood to create experimental habitats that were approximately 61 x 40 cm. Each bin was washed and disinfected (Quatricide PV), and fresh mulch (coconut husk) and leaf litter were added to each habitat to prevent any chemical cues remaining from prior occupancy. The location of each tortoise was recorded every three days at approximately midday, for a total of 14 observation-days. The tortoises were not fed on the days of observation to ensure that food availability did not influence their location in the bins.

We used a generalized linear model (PROC GENMOD, SAS, Inc., Cary, NC) to compare shelter occupancy in the different treatments. We also tested for possible effects of non-social factors such as location of the bin in the rack unit (left versus right side=column), or the partitioned section of the bin (front versus back=area). While both habitats in a bin received identical illumination from above, the front habitat had a clear plexiglass wall such that the tortoises could see into the room, whereas the back habitat was opaque on all four vertical surfaces. We also tested for the repeated measure of date on shelter occupancy. We determined that the pairing of two habitats per larger bin had no apparent effect on occupancy, allowing us to eliminate this variable from future analyses (PROC STEPWISE). Finally we used the occupancy data for the 1:3 and 2:3 treatments in a generalized linear model with habitat as a repeated subject to determine if physical factors, such as gender and mass, might have affected occupancy rate of a tortoise. In this model we counted the total number of times that tortoises occupied a shelter to give each tortoise an overall occupancy rate.

Shelter occupancy was higher when three tortoises were present (genmod, χ^2=9.31, *p*=0.009, Fig. 1). The habitat location in the bin and the rack unit were also significant (Table 1). There was no effect of time on shelter occupancy. An individual tortoise's occupancy rate increased with mass while gender had no effect (genmod, mass χ^2=4.38, *p*=0.037, Table 1).

Our study suggested the presence of social structure among juvenile *Manouria emys.* In the control treatment (1:1), tortoises were rarely found within the shelters. However, when three tortoises were present, the animals frequently used the shelters. This suggests that the perceived value of the shelter resource changed based on the social context of the group of individuals. In this initial study, we are not able to identify the particular reasons why tortoises favour shelters when in groups. We hypothesize that the tortoises may be using the shelters as a refuge from others, or they may be attempting to claim the resource when its availability is threatened by the presence of other tortoises. It is also possible that shelters may present unique thermoregulatory opportunities, and these are more valued when an individual is also interacting with other tortoises. We noted a few occasions where a second tortoise had attempted to enter an occupied shelter, and this may have been an attempt to dislocate the occupant or co-occupy the burrow. Burrow usurpation has been previously recorded (Diemer, 1992) in tortoises and co-occupancy has also been documented in juveniles (Pike & Antworth, 2005).

Social hierarchy in tortoises can be dependent on mass (Niblick et al., 1994), with the larger individual gaining greater access to mates, shelter and food. In our study, the heavier tortoises occupied the shelters more frequently. Tortoises that occupy shelters more frequently are considered dominant (Niblick et al.,

Table 1. Generalized linear model results of shelter occupancy and tortoise occupancy rate.

Factor	*p*	df
Shelter Occupancy		
Shelter: Group size ratio	0.009	2
Date	>0.05	13
Left or right column	0.004	1
Front or back of bin	0.0149	1
Tortoise occupancy rate in 1:3 or 2:3 treatments		
Gender	>0.05	1
Mass	0.036	35

1994) and aggressive behaviours associated with burrow occupancy are known (Ruby et al., 1997), so we conclude that we identified socially dominant tortoises among our study group of juvenile individuals. Interestingly, there was no indication that gender had an effect on occupancy of the shelter; perhaps gender effects develop coincident with reproductive maturity. In other studies, females appeared to compete for burrows while males competed for territories and/or mates (e.g., Bulova, 1994; Milinkovitch et al., 2004).

We found that there was some variation in shelter occupancy based on two factors: the left or right column in the rack unit, and front versus back half of bin. In the experimental set-up, there were only two columns and the treatments were randomly distributed between the two. The low number of columns or the low number of treatments may have created this statistical effect. It is also possible that there existed some unintended temperature or humidity differential between the columns. The effect of whether the treatment was in the front or back of the bin resulted in lower occupancy in the front habitat. The front habitat had a plexiglass wall which may have allowed the tortoises to be affected by movement in the experimental room of animal care personnel. Despite this effect, our results indicate distinct increase in shelter occupancy when group size was increased.

While social structure and dominance hierarchies are well known in chelonians, our documentation of such in juveniles may have important implications for maintenance of juveniles in captive breeding programs and in studying wild populations occurring in very restricted spaces or very high densities. Inasmuch as social conflicts and dominance hierarchies can result in stress and affect survivorship (Boice et al., 1974), this research may be important for high-risk situations that are common in critically endangered species. For captive management of chelonians, these results indicate that competition for shelters may occur in situations where individuals are housed in groups. Whereas this study involved fewer shelters than tortoises, future work could explore the provision of multiple shelters (in excess of the number of tortoises) and how this may decrease social conflicts.

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