EASTERN TARSIERS IN CAPTIVITY, PART II: A PRELIMINARY ASSESSMENT OF DIET

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ABSTRACT

Five Eastern tarsiers were kept in cages, three males in one cage and a mated pair (a pregnant female) in the other cage. We classify these animals as *Tarsius tarsier, T. sp* ("Selayar Form"), and *T. lariang* ("Palu Form"). The tarsiers were offered and consumed a variety of 22 species of commercially available and wild-caught insects and lizards. On average, 15.4 g of food were consumed per tarsier per day. Four species accounted for over 95% of the diet: commercial crickets, commercial mealworms, the large-bodied nocturnal grasshopper *Caedicia major*, and house geckos. The tarsiers' favored food items in order of preference were: crickets, house geckos, grasshoppers, and mealworms. They appeared to have a negative preference for mealworms and the large-bodied diurnal grasshopper, *Austricris guttulosa*. The tarsiers' preference for specific items may be inversely proportional to that item's scarcity in the tarsiers' diet.

Keywords: *Tarsius tarsier, T. spectrum, T. lariang*, Diet, Body Weight.

INTRODUCTION

We use the term Eastern tarsier for tarsiers from Sulawesi and surrounding islands. Until recently, these tarsiers were classified as two taxa, *Tarsius spectrum* and *T. pumilus* (Niemitz 1984a, Musser and Dagosto 1987). Groves *et al* (this volume) argued that *T. tarsier* is a senior synonym of *T. spectrum*, and has a type locality of Makassar (=Ujung Pandang), South Sulawesi (see Shekelle 2003, Brandon Jones et al. 2004). Several authors have offered evidence that Eastern Tarsiers are actually a constellation of related taxa (e.g. MacKinnon and MacKinnon 1980, Niemitz *et al*. 1991) including: *T. sangirensis* from Sangihe Island (Feiler 1990, Shekelle *et al*. 1997, Groves 1998), *T. pelengensis* from Peleng Island (Groves 2001), and *T. dianae* from areas of Central Sulawesi that flank the southern rim of Tomini Bay (Niemitz *et al*. 1991, Shekelle 2003, Brandon Jones *et al*. 2004).

Our colony, which was founded in October 2001, has a mated pair of tarsiers from Pattanuang, near Maros, South Sulawesi, about 40 km northeast of Makassar, that are classified as *T. tarsier*. The colony also has two tarsiers (one adult male, one subadult male at time of capture) from Selayar Island southeast of Makassar that are classified as *T. sp1* "Selayar form" (see Groves 1998, Nietsch and Babo 2001). There is also a single subadult male from Gimpu (Central Sulawesi) that is classified as *T. lariang*, see MacKinnon and MacKinnon 1980, Niemitz 1984b, Shekelle 2003, Merker and Groves 2006), this animal having arrived in November 2001. The mated pair is housed in one enclosure, and the remaining tarsiers are housed in a second enclosure (Severn *et al*. this volume for more on enclosure design)

Wild Eastern tarsiers are obligate faunivores, as are all other known tarsiers (Sussman 1999, Gursky 2002). The diet consists principally of insects, but is supplemented with virtually any wild prey item that the tarsier can catch and eat, including snakes, birds, bats, and others. Food preference has not been studied systematically in the wild.

Fitch-Snyder (2003) records 10 Eastern tarsiers having been kept in captivity outside of Indonesia, six of which date from the 1990's at the Night Safari in Singapore. The other four are

insufficiently documented, and it is uncertain whether they were in fact Eastern tarsiers. Prior to Hill (1955), *T. spectrum* was most often used for tarsiers other than Eastern tarsiers, and Eastern tarsiers were usually referred to something other than *T. spectrum* (e.g. *T. fuscus*). Thus, any reference to *T. spectrum* prior to 1955, for example, Clark (1924) and presumably Woollard (1925), typically referred to something other than an Eastern tarsier. In any event, we are unaware of any published data from any of the 10 animals mentioned by Fitch-Snyder. Both Philippine and Western tarsiers have been kept in captivity in North America and Europe (Fitch-Snyder 2003), but it is unclear whether dietary data from Philippine and Western Tarsiers would be for Eastern tarsiers. Both Musser and Dagosto (1987) and Groves (1998) view Philippine and Western tarsiers as forming a clade relative to Eastern Tarsiers. Groves (1998) went so far as to suggest that Eastern Tarsiers should be generically separated from the Philippine and Western tarsiers.

To our knowledge there are no publications regarding the diet of captive Eastern tarsiers. We report our results regarding the diet of captive Eastern tarsiers after more than eight months in captivity.

METHODS

The tarsiers are housed at the Center for Biological Research—Division of Zoology of the Indonesian Institute of Science at Cibinong, West Java, Republic of Indonesia (the same administration that runs the *Museum Zoologicum Bogoriense*). Systematic data on diet were collected from March 11, 2002 until May 31, 2002. Systematic data on body weight were collected from the time of capture until control of the colony passed from that of MS to a LIPI staff scientist, Wirdateti in August 2004.

For body weight we used an electronic scale with a one kilogram capacity measured in 1 gram increments ("Thinner" Measurement Specialties Electronic Chrome Kitchen Scale, Model MS-6845). Each enclosure is equipped with two feeding dishes. A converted ashtray used specifically for mealworms (10 cm X 10 cm X 4.5 cm) and a larger tray (45 cm X 23 cm X 8 cm) used both for feeding as well as weighing the tarsiers. Food items were placed in the tray. During weekly weighing, the tray was placed on top of the scale and zeroed after food items had been added. Cellophane tape was used on the inner walls of the tray to create a slick surface that inhibited insects from climbing out. Nevertheless, many food items were able to escape, but tarsiers are skilled hunters and the large majority of these were caught and eaten by the tarsiers. Observations suggested that the tarsiers first caught and ate those food items that could most easily escape, leaving the other food items in the tray to be eaten later.

A grasshopper enclosure was used to store wild-caught grasshoppers for up to 24 hours (dimensions 17 cm x 13.5 cm x 18 cm). Following capture, grasshoppers were placed in the enclosure, identified and separated by species, and weighed before being offered to the tarsiers.

The following food items were offered to the tarsiers: commercial crickets (*Gyllus sp.*), commercial mealworms (*Tenebrio molitor*), a commercially available bamboo worm (possibly *Synochycha grandis*), wild-caught house geckos (*Gekko hemidactylus frenatus, Gekko hemidactylus turcicus*), and many types of wild-caught grasshoppers including Tettigoniidae (*Caedicia major, Zaprochilus australis, Conocephalus sp., Yorkiella picta, Phasmodes renatriformis*), Acrididae (*Austracris guttulosa, Bermiella acuta, Coryphistes ruricola, Acrida coneca*), Gryllacrididae (*Hadrogrylacres magnifica*), Eumastacidae (*Biroela sp., Keyacris scurra, Waramunga desertorum*), Pyrgomorphidae (*Atractomorpha crenaticeps, Desmoptera truncatipennis, Psednura sp.*), and Mantidae (*Creoboter spp.*). No other nutritional supplements were provided.

The total weight of all food items was measured in the feeding dish before it was re-zeroed. Unconsumed items, if any, were then weighed again to estimate the amount of food that was actually consumed. The overall weight of food items offered per day was adjusted *ad hoc* to minimize leftovers. Food was offered twice per day. The first feeding was at about 18:30 and the second feeding was at about 23:00.

RESULTS

In the 82 day measurement period, the tarsiers consumed 6329 g of food. This yielded an average intake of 77.2 g per day for five tarsiers, or 15.4 g of food per tarsier per day. Of the total food consumed, the breakdown by food type by weight was: 48.4% crickets, 23.9% meal worms, 19% grasshoppers (*Caedicia major*), 4.2% house geckos, 2% grasshoppers (*Austracris guttulosa*), 0.4% grasshoppers (*Bermeiella acuta*), and 2.1% other grasshoppers.

Table 1. Weekly change in body weight prior to and during the feeding study. **Bold italic** = capture weight. *Italic* = first weighing after arrival at MZB. Asterisk (*) = not weighed. ET-105 and ET-106 lost appreciable body weight (26 g and 22 g, respectively) in the time between capture and transport.

	ET-105 female adult	**ET-106** male adult	**ET-108** male subadult	**ET-109** male adult	**ET-113** male subadult
18-Sep	***113 g***	***133 g***	*	*	*
28-Sep	*	*	***75 g***	***103 g***	*
2-Oct	*87 g*	*111 g*	*	*	*
3-Nov	116 g	128 g	*98 g*	*108 g*	*
10-Nov	116 g	128 g	98 g	108 g	*
12-Nov	*	*	*	*	***85 g***
19-Nov	116 g	129 g	98 g	110 g	*102 g*
25-Nov	118 g	129 g	100 g	110 g	102 g
1-Dec	121 g	131 g	105 g	113 g	*
8-Dec	122 g	132 g	107 g	115 g	100 g
15-Dec	124 g	134 g	107 g	117 g	103 g
22-Dec	125 g	134 g	107 g	*	104 g
29-Dec	127 g	135 g	108 g	119 g	106 g
5-Jan	127 g	134 g	109 g	120 g	106 g
12-Jan	128 g	135 g	111 g	121 g	108 g
19-Jan	131 g	136 g	113 g	122 g	111 g
26-Jan	131 g	136 g	113 g	121 g	112 g
9-Mar	134 g	137 g	*	122 g	*
17-Mar	136 g	138 g	*	119 g	*
24-Mar	138 g	138 g	*	124 g	*
30-Mar	141 g	139 g	*	126 g	114 g
8-Apr	140 g	139 g	*	124 g	*
15-Apr	143 g	138 g	112 g	123 g	117 g
23-Apr	142 g	138 g	113 g	128 g	121 g
29-Apr	142 g	139 g	*	128 g	*
8-May	143 g	139 g	117 g	131 g	*
21-May	146 g	136 g	114 g	*	117 g
30-May	148 g	136 g	*	*	*

Of the tarsiers in this study, ET-105 was a pregnant female that gave birth on June 29th. With a gestation period of approximately six months, ET-105 predictably gained weight throughout the study, starting at 134 g shortly before the study began and increasing to 148 g at the time the study concluded (Table 1). ET-106 was the adult male that was mated with ET-105. His weight stayed fairly constant throughout the study, fluctuating between 136 and 139 g. ET-108 was a subadult at the time of capture. This was the most difficult animal to weigh and often would not come down to the feeding dish. Prior to the study, ET-108 had been weighed at 113 g. Near the end of the conclusion of this study, he weighed 114 g. ET-109, an adult male, increased in body weight throughout the study, from 122 g to 131 g. ET-113 was a subadult male at the time of capture. This animal was also difficult to weigh. Body weight for this animal increased slightly from 112 g prior to the study to 117 g.

DISCUSSION

Nearly three-quarters of the tarsiers' diet (72.3%) consisted of commercial crickets and mealworms. The rest was composed almost entirely of wild-caught food items. Of these, *Caedicia major* and house geckos accounted for 23.2% of the total diet. Therefore, these four food items accounted for over 95% of the diet. Sixteen different species of wild-caught food items plus commercially available insects known locally as *ulat bambu* (=bamboo worm) accounted for the remaining 4.5%.

The data on diet cannot be broken down to amounts consumed by individual tarsiers because they were caged together. Body weight data from the tarsiers in this study are consistent with what we would expect from healthy, wild Eastern tarsiers (e.g. see Shekelle 2003 for a table of over 100 wild-caught Eastern tarsier body weights). Indeed, after nearly three years in captivity, four of the tarsiers in this study are still healthy, and the mated pair have an offspring born July 25th, 2004. Male ET-113 died on January 18th 2003, three days after showing signs of having been in a violent fight, either with another tarsier in his cage, or with a predator that had entered his cage.

Total daily consumption was probably affected by the fact that the adult female was pregnant during the study period. She gave birth on the 29th of June, 2002. The gestation period of all tarsiers for which these data are known is similar, around six months (reviewed in Sussman 1999). Gursky (1997) estimated the gestation period of Eastern tarsiers from Tangkoko (North Sulawesi) to be 190 days. This means that the tarsiers possibly conceived on December 21st, 2001, and the female tarsier was about 80 days pregnant when the study began and about 161 days pregnant when the study concluded.

Roberts and Kohn (1993) reported that *T. bancanus borneanus* in their study self-selected a diet that was composed almost entirely of crickets. They reported the following average numbers of crickets consumed per day: adult male = 33.6, non-lactating females = 25.3, lactating females = 34, and juveniles (measured as <110 g in their study) = 33.2. Using their value for average cricket weight equals 0.368 g, we calculate the following average intakes in grams: adult male = 12.4, non-lactating females = 9.3, lactating females = 12.5, and juveniles (measured as <110 g in their study) = 12.2. Therefore, we calculate that had their colony had the same composition as ours, i.e. four adult males and one non-lactating female (by this study's start date, March 11, 2002, all of our male tarsiers would have been considered as adult in the Roberts and Kohn study), they would have consumed 58.9 g of food per day [(12.4 x 4) + 9.3 = 58.9)], or 11.8 g per individual per day, on average. Compared with the value we found, 15.4 g, the tarsiers in Roberts and Kohn consumed only about 76.6% by weight the amount of food as the tarsiers in our study. This difference could be due to a several factors, e.g., metabolic differences among species. Western tarsiers are described as much less active than either Philippine or Eastern tarsiers, when they are caged side-by-side (Wright *et al*. 1989, MS personal observation).

Izard *et al*. (1985) found that food intake, in grams, did not differ between non-pregnant animals and tarsiers during the first two trimesters of pregnancy. In the third trimester, food intake doubled.

They cited Niemitz (1979) as estimating a daily intake of 10-12 g, a value they felt was consistent with the tarsiers they observed. In fact, Niemitz cited both Fulton (1939) and Ulmer (1963) who both estimated that tarsiers consume about 10% of their body weigh each day. What Niemitz wrote was, "in the present study it was not possible to determine exactly how much *T. bancanus* eat in grams per night, but the figure is probably approximately correct for this species in captivity as well" (Niemitz 1979). Wright *et al.* (1987) stated that each tarsier pair in their colony was offered approximately 12 oz. (~340 g) per day. This amount must include substantial excess and waste, since it exceeds 100% of the tarsiers' body weight per day.

The data on percentage of diet by food item cannot necessarily be construed as food preference, as diet composition was based largely upon availability. We can make some inferences about preference, however, based upon food items that were not consumed and the rank order of food item consumption. Crickets and mealworms made up most of the diet because they were commercially available and could be offered to the tarsiers in large quantities. Anecdotal observations indicate preference in this order: crickets, house geckos, grasshoppers, mealworms.

Of the wild-caught grasshoppers, *Caedicia major* formed a much larger percentage of the tarsiers' diet than the others, probably due to their much larger body size than most of the others and not because tarsiers necessarily prefer *Caedicia major*. Another large-bodied grasshopper, however, *Austricris guttulosa*, was frequently left unconsumed, and we infer a negative preference for this food item. It may be coincidence, but our observations indicate that *A. guttulosa* has a diurnal activity pattern, whereas tarsiers and most other food items offered to them were nocturnal. It was rare for any of the other wild-caught species to be left unconsumed by the tarsiers. Finally, it appeared to us that if any food items were given to the tarsiers routinely, to the exclusion of the other food items, their interest in the common item went down and interest in the other items went up. For this reason, we infer that tarsiers in our study may prefer to vary their diet. That is, although they typically prefer crickets, if fed crickets exclusively for long enough, and then exposed to a different food, such as grasshoppers, in addition to crickets, their preference is for the new food item (i.e. in this example, grasshoppers). Therefore, it may be that among the items they commonly received, preference varied in inverse proportion to availability.

Wright *et al.* (1987, 1989) fed *T. bancanus borneanus* and *T. syrichta* a similar diet of crickets and *Anolis* lizards (similar to the house geckos in our study) and remarked that the lizards were "relished primarily by *T. syrichta*, although occasionally *T. bancanus* will eat them" (Wright *et al.* 1987). They also offered mealworms and found that "only a few individuals" ate them. As in our study, their tarsiers' diet was supplemented by opportunistically captured wild insects. For Wright *et al.*'s tarsiers, these supplements consisted of grasshoppers, dragonflies, cicadas, praying mantis, and scarabid beetles (Wright *et al.* 1987), as well as katydids (Wright *et al.* 1989). Similar to our study, Wright *et al.* (1989) commented that tarsiers were more enthusiastic about hunting and eating these rare items, which had only a "limited role" in the tarsiers' diet (Wright *et al.* 1987).

Roberts and Kohn (1993) reported that the *T. bancanus borneanus* in their study were fed a variety of live and prepared food, but their diet consisted almost entirely of crickets. Live *Anolis* lizards were seldom eaten. The same was true for Haitian cockroaches. Infant mice, both live and dead were completely ignored, as were mealworms. This observation may imply that the tarsiers in their study showed the reverse of the pattern seen in this study and that of Wright *et al.* (i.e. tarsiers studied by Roberts and Kohn preferred crickets exclusively and did not have a preference for rare food items). The lack of enthusiasm for lizards does not seem to agree with Izard *et al.* (1985), who studied gestation length in *T. bancanus borneanus* from the same location as the animals in Roberts and Kohn, and who described that large weight gain seen in the third trimester of pregnant females was due mainly to an increased consumption of lizards.

Wright *et al.* (1987) and Roberts and Kohn (1993) both reported on the problems of a diet based

too heavily on crickets because of the low levels of some minerals, notably calcium, in crickets. To overcome this deficiency, Wright *et al*. (1987) purchased commercial crickets and then fed them a diet of "apples, crushed high protein monkey chow, Zeigler Brothers' cricket diet and fresh water" before offering them to the tarsiers. Roberts and Kohn (1993) reported feeding their crickets "Cricket Diet 53-9000-00" from Zeigler Brothers, a granulated alfalfa pellet enriched with calcium, phosphorus, trace minerals, and Vitamin D, which was placed in the crickets' holding bin as well as in the tarsier enclosure. Crickets raised on the mineral-supplemented diet as well as "presupplemented" crickets were placed in the tarsiers' enclosures at the rate of about 6000 crickets per week.

Wright *et al*. (1987) and Roberts and Kohn (1993) also commented on the problem that crickets tended to congregate on the floor, but that the tarsiers did not hunt animals on the floor, except for *T. syrichta* and then 'only to retrieve a highly desirable prey item like a praying mantis" (Wright *et al*. 1987). Both reports described techniques to get the tarsiers' prey items off of the floor and onto the various supports that filled the enclosures. In the wild, tarsiers commonly hunt prey on the forest floor, ambushing them from vertical perches about 0.5-1.0 m high. Our tarsiers have shown no such tendency to avoid the floor. There are potential sources of error in our study for example , some food items might have escaped the enclosure , but these would have been recorded as consumed. Similarly, since the enclosures are outdoors, the tarsiers might supplement their diet with wild prey that wander into the enclosure, and such supplements not have been recorded. Neither event was commonly witnessed, but each remains a potential source of error. Given that food intake was averaged over an 82 day period, we suspect the effects of these potential sources of error to be small.

In summary, mean intake of food was 15.4 g per tarsier per day. Body weight data and observations of health status indicate that this diet was healthy and sufficient. Four food items accounted for over 95% of dietary intake: commercial crickets (48.4%), commercial mealworms (23.9%), the large-bodied nocturnal grasshopper *Caedicia major* (19.0%), and house geckos (4.2%). Unconsumed food items were rare with the exception of commercially available mealworms and wild-caught grasshoppers of the species *Austricris guttulosa*. In general, these Eastern Tarsiers prefer food items in the following order: crickets, house geckos, grasshoppers, mealworms. However, preference for a food item tended to increase when availability of that item was reduced.

ACKNOWLEDGEMENTS

This material is based on work supported by the National Science Foundation under Grant No. INT 0107277 to MS and grants from the Margot Marsh Biodiversity Foundation and the Gibbon Foundation to MS. Sponsorship for MS in Indonesia was provided by the Center for Biodiversity and Conservation Studies, University of Indonesia (CBCS-UI) and by the Indonesian Institute for Science (LIPI). Facilities for the tarsiers were provided by the Indonesian Institute for Science, Center for Biological Research—Division of Zoology (host institution of the *Museum Zoologicum Bogoriense*, or MZB). special thanks Dr. SN. Prijono for permits for conducting research in conservation areas, for trapping tarsiers, transferring live tarsiers among provinces, and maintaining tarsiers in captivity were provided by the Indonesian Department of Forestry. Donatus Dahang's participation was courtesy of a collaboration with *Universitas Satria*, Makassar. Helpful criticism came from Jim Sackett and Helena Fitch-Snyder who reviewed this manuscript.

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