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Orange-tufted Sunbirds do not Feed Nectar to their Chicks

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In most bird species, parents eat the same types of food that they deliver to their nestlings (Ydenberg 1994). Many frugivorous and granivorous species supplement chick diets with arthropod prey that contains essential nutrients such as proteins (Gill 1990), but parents may also eat this food themselves. Several studies have shown that single-prey-loading parents selectively transport large prey to their nestlings and eat smaller prey themselves (Carlson 1985, Krebs and Avery 1985, Sonerud 1989). This may lead to different ranges of prey types being consumed by parents and chicks, but rarely does it lead to exclusive food types for parents versus chicks.

Adult Orange-tufted Sunbirds (*Nectarinia osea*; body mass 6 to 7 g) feed on flower nectar and arthropods, but all observed cases of parental provisioning appear to involve only arthropod prey (Markman et al. 1995, 1996). Therefore, we hypothesized that adult Orange-tufted Sunbirds would feed on flower nectar but would not feed it to their chicks. If so, this would provide us with an experimental tool to manipulate parental self feeding independent of chick feeding and enable us to address questions pertaining to the evolution of parental-care strategies (e.g. Kacelnik and Cuthill 1990, Martins and Wright 1993, Ydenberg 1994). We tested our hypothesis using free-living sunbirds at Sede Boqer in the Negev Desert, Israel, by placing artificial nectar sources in the territories of breeding pairs and using a food dye marker to see whether the young received this nectar from their parents.

Methods and results.—In the first experiment, we addressed the question of whether parent sunbirds feed sugar solution to their chicks. We used feeders filled with a 0.25-mol sucrose solution colored red with 0.004 g of food coloring (Maimon Spices™) per g of water. In a pilot study, we found this to be the highest dye concentration that the parent birds would accept and drink in the same quantities as a clear sugar solution.

In order to encourage unbiased use, feeders were covered with brown paper bags, a red artificial flower was stuck in the feeder opening, and a perch was provided in front of each feeder. Each feeder was suspended from a tree 5 m from the nest to enable an observer to watch the nest and the feeder simultaneously. By suspending paper sheets beneath the feeders, the observer could discern the color of parental feces. The color of chick fecal sacs was clearly visible during their removal from the nest by the parents.

Feeders were placed in occupied sunbird territories in April 1996 three days before the chicks hatched. In all, we used five sunbird pairs, two that had three chicks, two with two chicks, and one with one chick. Each pair was observed for 90 min per day. The order of observation was changed each day, which ensured that each pair was observed at all daylight hours at different times during the 17-day chick-rearing phase. All pairs regularly used the feeders, and during 24 of the 85 observation sessions both parents fed exclusively on sugar solution from the feeders (Table 1), despite the fact that flowers were locally abundant and used at other times.

During this experiment, we consistently observed that parental feces were colored following feeder use, but on no occasion did we observe colored fecal sacs being removed from a nest. As part of an additional experiment, during the remainder of the 1996 breeding season (May to September) we offered colored sugar solutions in a range of concentrations (0.25, 0.75, 1.25 mol) to 36 pairs that were rearing natural brood sizes of two or three chicks. Again, we observed no evidence of colored dye in any of the chick fecal sacs removed by parents or in those collected by us while handling the chicks for body measurements.

The fact that we observed no colored fecal sacs does not unequivocally prove that the dyed sugar solution was never fed to the chicks. It is possible that, unlike their parents, the chicks somehow digested the food dye. It is also possible that the parents fed their chicks sufficient clear flower nectar and other prey items to dilute the dye enough for it not to be detected by human observers. In a pilot study, we found that we could easily detect food dye in adult feces when fed as little as 5 mL of the dyed sugar solution (i.e. the amount of nectar typically found in just one flower) administered to each of five captive adult sunbirds (four males and one female), although the birds were fed *ad libitum* immediately afterwards with clear sugar solution and fruit flies.

In light of this finding, we conducted a second experiment to assess whether a single small dose of dyed sugar solution, diluted by other foods, would

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TABLE 1. Summary of 90-min observation sessions (n = 85) of parent sunbirds. Those labeled + are where both parents fed exclusively from artificial feeders placed in their territories and not on flower nectar.

Nest ID	Brood size	Chick age (days)															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	3	+		+			+			+					+		+	+
2	3		+			+			+						+	+		
3	2	+		+				+				+	+				+	
4	2		+	+					+							+		
5	1	+																+

also show up in the feces of sunbird chicks. For this purpose, five newly hatched broods (two broods of three chicks, two of two chicks, one of one chick) were fed a dyed sugar solution with a 5-mL capillary tube. Each day, from hatching until day 5, the chicks received a single dose of 3 mL; from day 6 until day 11 they received 4 mL; and from day 12 until day 16 they received 5 mL. After feeding, we immediately returned the chicks to the nest where the parents resumed provisioning their chicks at a normal rate within a few minutes. These nests were then observed for 90 min, during which time the parents first removed clear fecal sacs, and then always at least one colored fecal sac for each chick in the nest. These results suggest that even if parents fed their chicks only a single small portion of the dyed solution and then continued to provision the chicks normally (i.e. with arthropod prey) for the rest of the feedings, we would have detected the food dye during our observations of chick fecal sacs.

To further test whether intensive feeding on flower nectar may have diluted a single dose of the dyed solution, we fed five hatchlings with similar amounts of the above-described dyed sugar solution each day until they fledged. For 30 min afterwards, we fed them 6 mL (from hatching until day 5; body mass 0.8 to 3 g), 8 mL (day 6 until 11; mass 3.1 to 5 g), or 10 mL (day 12 to 16; mass 5.1 to 7 g) of clear sugar solution at the average rate that parents usually fed chicks at each age (Markman et al. 1995, 1996). We then returned the chicks to their nests and observed their parents for another hour. Although we fed the chicks mostly clear sugar solution, we always observed the parents removing at least one colored fecal sac per chick per nest. Additionally, in all of these tests no long-term presence of the food dye was apparent in chick fecal matter. The effect on fecal color lasted less than an hour after its first appearance in the excreta.

It is possible that owing to taste or physical properties of the dyed solution, parent sunbirds may have deliberately avoided feeding it to their chicks while still feeding flower nectar to them. This seems unlikely, because pairs often used our feeders exclusively in preference to flower nectar that was abundant and readily available (Table 1).

We used six newly hatched broods (two of three chicks, two of two chicks, two of one chick) to directly test whether parents were feeding flower nectar to their nestlings. Each day at a different hour, we took fluid samples from the lower esophagus of each chick (sunbirds have no well-defined crop; Downs 1997) by using an elastic polyethylene tube (1.09 mm diameter). We also collected fecal sacs from each chick. Using a temperature-compensated refractometer (Atago ATC-1E, 0 to 32%), we tested for the remains of sugar in esophageal and fecal fluids. We found no evidence of sugar in any of these samples despite the presence of nectar-producing flowers in all territories. We did the same test on 31 chicks during the remainder of the breeding season (May to September 1996) while providing their parents with dyed sugar solution in feeders. Again, we found no sugar in the samples.

We collected nectar from flowers on which parent sunbirds usually fed (measured nectar sugar concentration 11 to 32%) and fed it to five chicks, each from a different nest, at different ages from hatching to fledging. We then sampled their subsequent fecal sacs with the refractometer until we measured a consistent 2 to 3% sucrose equivalent in these excreta irrespective of the initial sugar concentration. These results confirm that we were able to make sufficiently accurate measurements of fecal sugar contents, and that our failure to find similar evidence of sugar in normal sunbird chick feces supports our contention that parents do not feed nectar to their chicks.

Discussion.—The purpose of using a soluble marker, such as food dye, was so that we could easily determine whether parent sunbirds fed their chicks with our sugar solution from a large number of feeders placed on many different territories during a single breeding season. We therefore avoided an extensive chick-sampling program, which would have involved considerable time and effort, and disturbance to the birds. Additionally, by supplementing sugar solutions in feeders we made nectar superabundant, thereby excluding the possibility that nectar was a limiting factor in our study area.

Recently, Downs (1997) used red food coloring in a similar manner to determine gut-passage times in two species of South African sunbirds (*Nectarinia fa-*

mosa and *N. amethystina*). She found that, as in our study, the quantification of transit time of the solution could be observed by "simply examining the color of the excreta, which was clear and then showed red with time."

That we always clearly detected a small dose of dyed sugar solution in the color of feces of hand-fed chicks, and that we failed to detect any color changes in chick fecal sacs during our feeder presentation, suggest that parent sunbirds feed none or only negligible amounts of feeder sugar solution to their chicks. Moreover, no detectable amounts of sugar occurred in nestling esophagi or excreta fluid samples, despite the fact that we could simulate such a measurable effect through hand-feeding chicks with nectar. Therefore, we conclude that nectar is an exclusively parental food type in Orange-tufted Sunbirds. It has been suggested that hummingbirds feed nectar to their chicks (Hainsworth 1977). To our knowledge, however, no one has documented this empirically. Therefore, we suggest that our methodology can be used to determine whether adult hummingbirds feed nectar to their nestlings.

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Video Identification of Predators at Songbird Nests in Old Fields

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Nest predation is an important factor in the ecology of passerines (Martin 1988, 1993; Sherry and Holmes 1992) and has received much recent attention owing to concern about population declines (Peterjohn et al. 1995) and high levels of nest predation in Neotropical migrants (Donovan et al. 1995, Robinson et al. 1995). Studies that use artificial nests have attempted to identify predators with various methods, including photography, track samplers, imprint-receptive eggs, and poisoned eggs (see Major and Kendal 1996). Conclusions about real nests drawn from artificial nests may be misleading, however, because parental activity (Skutch 1949), nestling noise (Haskell 1994), or other characteristics of occupied nests may be important cues for predators. Attempts to use motion-sensitive cameras at real bird nests are problematic because frequent parental

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