Wilson Bull., 102(2), 1990, pp. 339–341

Wax-eating by African Common Bulbuls.—Recent evidence (Obst, Wilson Bull. 98:189–195, 1986; Roby, Place, and Ricklefs, J. Exp. Zool. 238:29–41, 1986) indicates that some and perhaps many seabirds depend upon a substantial amount of wax in their diet. Honeyguides (Indicatoridae) long have been known to eat wax regularly, using beeswax, or in some cases, the waxy exudate of scale insects as food (Friedmann, Bull. U.S. Nat. Mus. no. 208, 1955; Reyer and Isack, Science 243:1343–1346, 1989). There have been few investigations into the actual digestion of wax (Friedmann and Kern, Can. J. Microbiol. 2:515–517, 1956; Obst, Wilson Bull. 98:189–195, 1986; Diamond and Place, Ibis 130:558–561, 1988). It is known, however, that Greater Honeyguides (*Indicator indicator*) can live for three or more months exclusively on a diet of beeswax (H. A. Isack, pers. comm.).

Our Kenyan field studies of honeyguides rely upon a beeswax "feeding station," an old beehive cut out years ago by honey-hunting tribesman, having various crevices and wired trays into which we put wax. The beeswax is supplied ad libitum in more or less pure form (impure wax with particles of bees or dead bees and debris does not keep well under field conditions). Our studies are conducted on the Gallmann Memorial Foundation's Ol Ari Nyiro Ranch at 1800 m on the Laikipia Plateau, 25 km east of Lake Baringo in central Kenya.

While observing five to 38 individual honeyguides of up to four species (Short and Horne, Amer. Mus. Novitates no. 2825, 1985) feeding daily at the wax feeder, we have noted various other birds (and mammals such as squirrels, as well as skinks) that sporadically come to the feeder and eat bits of wax. Such birds are: Yellow-spotted Petronia (*Petronia pyrgita*), Chestnut Weaver (*Ploceus rubiginosus*), Red-cheeked Cordon-bleu (*Uraeginthus bengalus*), African Black-headed Oriole (*Oriolus larvatus*), and Common Bulbul (*Pycnonotus barbatus*). We have had five to 20 observations of each of these feeding on beeswax, except for the Common Bulbul which feeds on it much more frequently. In three August to November field seasons (1985 to 1987), at least one such bulbul briefly visited a hive feeder, poked into the wax, and took at least one piece about every second day. However, from July to October 1986 up to five Common Bulbuls sporadically, and then more regularly, visited and fed at the hive feeder; two became daily visitors. One of these individuals, which could be distinguished by heavy yellow pollen matted on the feathers of its forehead and front of its crest, developed a strong wax-eating habit. Bulbuls in the area were paired at the time, and no more than two visited the hive at once. Only the bulbul that became more persistent in its wax-feeding consistently had matted yellow pollen on its head (others showed a yellow spot or two occasionally), and it usually was accompanied at the hive by its presumed mate that lacked the yellow color. Although we could not identify with certainty all the bulbuls visiting the wax-feeder (we were reluctant to net them for fear of affecting the honeyguide research), we could distinguish the heavily pollen-marked individual and its mate from neighboring pairs of bulbuls. This particular pair actively defended a territory including the area within 10 m of the wax-feeder, driving off the other bulbuls. Thus, we were able to document the increase in attendance of the pollen-marked bulbul and its apparent mate at the wax-feeder (Table 1).

The presence or absence of honeyguides about the feeder, the presence or absence of different honeyguide species, and the dominants vs subordinate feeding honeyguides affected visits of the bulbuls to the feeder. When larger honeyguides, the Greater and Scaly-throated (*I. variegatus*), were present and interacting in numbers, the bulbuls approached but then flew off without going to the feeder. When only one or two larger honeyguides, and especially subordinate ones (to other conspecifics) were present, the bulbuls came in and often sup-

TABLE 1
SUMMARY OF COMMON BULBUL OBSERVATIONS AT WAX FEEDER IN 1986

Date	No. of individuals visiting[a]	Min of observation	Actual no. of visits	Min with bulbuls at hive
27 August	1 (?)	130	1	4
28 August	2 (2)	180	1	5
30 August	3 (2)	300	6	24
1 September	2 (2)	210	2	9
3 September	2 (2)	180	5	23
5 September	2 (2)	180	3	15
7 September	2 (?)	100	4	21
11 September	2 (2)	150	2	25
13 September	2 (2)	120	3	14
15 September	2 (2)	180	4	30
21 September	2 (2)	350	5	188
23 September	1 (1)	120	4	30
26 September	2 (2)	150	3	45
28 September	3 (2)	130	4	67[b]
30 September	2 (2)	180	4	30
2 October	2 (2)	210	7	118[b]
4 October	2 (2)	200	13	91[b]

[a] In parentheses we indicate the numbers of the pair including the chief feeding bulbul.
[b] Time spent greater than that of any honeyguide on that day.

planted them. When Lesser Honeyguides (*I. minor*), much smaller than the bulbuls, were present singly or in any numbers, the bulbuls went directly to the feeder and drove them off. In fact, the frequently visiting pair of bulbuls gradually became very aggressive to Lesser Honeyguides (juveniles of which, despite their small size, ordinarily were dominant to the larger honeyguides). More and more the activity of the bulbul pair centered about the feeder, and by October the chief wax-eating bulbul frequently perched for long periods near the feeder, and vigorously chased away every incoming Lesser Honeyguide. On 4 October 1986, we collected this wax-eating bulbul after it had been feeding uninterruptedly on wax for 35 min (in addition to feeding on wax earlier in the day). It proved to be a male with slightly enlarged testes. Its stomach was crammed with soft, "milky" wax like that found in the stomachs of honeyguides, although slightly more solid in form and perhaps less digested. No other food items were detected in its stomach. Since our removal of this individual, no other bulbul subsequently has taken up this unusual habit, although bulbuls frequently pass about the hive, perch on it, or even occasionally peck once or twice at the wax, eating some.

We used various forms of beeswax, including "pure" wax on many days, but found no indication that the bulbuls were selecting conspicuous non-wax items such as parts of bee larvae. We conclude that the chief wax-feeding bulbul was eating wax. As B.S. Obst had noted to us (in litt.), beeswax, even in pure form, contains wax esters, complex hydrocarbons and other organic compounds, so the "wax" contains sources of energy stored in wax-ester and non-wax form. What elements of the beeswax were being utilized by the bulbul, and how it was able to digest them are unknown. What is certain is that this particular bulbul was selecting and feeding extensively on beeswax, and even was defending the wax source against other birds. These observations imply that it was indeed securing nutrients from the wax. The long period over which the bulbul fed on wax suggests that it encountered no problems in using a food item undigestible to most animals. The honeyguide-bulbul interactions also suggest the obstacles presented by honeyguides in the possible evolution of beeswax-eating habits by other birds in the range (Asia, Africa) of honeyguides.

When bulbuls came to the feeder after honeyguides had been feeding we noted that the bulbuls usually went directly to the particular site that the honeyguides had vacated. Possibly the bulbuls could have acquired some capability to digest wax from wax pieces that had been "mouthed" by, or disgorged by honeyguides, if digestion of wax esters occurs by microbial fermentation, as suggested by Friedmann and Kern (1956; but see Roby et al. 1986, who discuss wax digestion by enzymatic hydrolysis).

Our observations suggest that landbirds other than honeyguides have, or can develop, the ability to utilize beeswax, and we agree with Diamond and Place that many birds may have the capacity to digest wax.

Acknowledgments.—We are grateful to the Gallmann Memorial Foundation and to R. Leakey and C. M. Gichuki for their assistance, and to the L. C. Sanford Fund of the American Museum of Natural History and Mrs. M. Collins for financial support. We thank K. L. Bildstein, F. B. Gill, B. S. Obst, and L. Wolf for comments benefiting the manuscript.

JENNIFER F. M. HORNE, *Nat. Mus. Kenya, P.O. Box 40658, Nairobi, Kenya;* AND LESTER L. SHORT, *Amer. Mus. Nat. Hist., New York, New York 10024-5192.* *Received 3 May 1989, accepted 8 Oct. 1989.*

Wilson Bull., 102(2), 1990, pp. 341–343

The effect of observer variability on the MacArthur foliage density estimate.—Scientists have used the technique developed by MacArthur and MacArthur (1961) for many years to estimate shrub and tree foliage density during studies of avian-habitat relationships (MacArthur et al. 1966, Recher 1969, Willson and Moriarty 1976, Dickson and Segelquist 1979, Conner et al. 1983). Conner and O'Halloran (1986) compared the accuracy of estimates made using the MacArthur technique with actual leaf surface area and biomass. They determined that the MacArthur and MacArthur (1961) technique provided an excellent relative estimate of the surface area and biomass of foliage and supported its use to measure foliage in avian-habitat studies. Although Conner and O'Halloran (1986) suggested correction factors to adjust the technique to provide more exact estimates of leaf surface area, they did not examine an important potential bias of the technique. Because the technique requires an observer to estimate when 50 percent of a black-and-white checkered board is obscured by foliage, the comparability of studies by different researchers is in question. The experience of an observer in estimating how much the density board is obscured also has the potential to affect variability and accuracy of foliage estimates.

Observer differences can affect foliage density estimates in two major ways. First, the basic accuracy of the estimation is at question; how close is the observer's estimate to the desired 50 percent obscurity of the black-and-white checkered density board? Second, how consistent is the observer in making estimations?

Methods.—A basic problem with comparing the accuracy and abilities of different observers is damage to the vegetation because of repeated measurements made at each test location. To avoid this problem a series of photographs (100) was taken of a black-and-white checkered density board. Each photograph (12.7 × 17.7 cm) was taken at a different location with varying proportions of the density board obscured by foliage. Thirteen of the