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**Arthropod feeding by two Dominican hummingbird species.**—Hummingbirds are predominantly floral nectar feeders (Montgomerie and Redsell 1980) and are thought to be closely tied to flowers through most or all of their life cycle (Wolf 1970). Although hummingbirds forage extensively on insects and other arthropods (Wagner 1946; Stiles and Wolf 1970, 1979; Feinsinger and Colwell 1978; Montgomerie and Redsell 1980), arthropods as food are not well known in comparison with nectar (Remsen et al. 1986). Because nectar is high in calories and because hummingbirds have great energy requirements, detailed studies of hummingbirds have assumed that energy is the most important variable determining their behavior. Arthropods may not be a crucial or limiting resource for hummingbirds (Feinsinger 1976, Wolf et al. 1976, Feinsinger and Colwell 1978) and may represent only a limited energetic component of diets (Wolf and Hainsworth 1971). Hainsworth (1977), however, suggests that an equal time flycatching by hummingbirds, even with low efficiency rates of 40%, can provide more energy than nectar feeding.

Detailed foraging studies (reviewed in Gass and Montgomerie 1980) report foraging for insects by hummingbirds as generally less than 15% of feeding time (Wolf and Hainsworth 1971, 1977; Hainsworth 1977), however, other studies report searching for arthropods as the bulk of foraging effort (Young 1971) or, at times, the only food taken (Kuban and Neill 1980). Several studies of hummingbirds show that under field conditions some humming-

birds feed exclusively on arthropods for short periods of time (Wagner 1946, Kuban and Neill 1980, Montgomerie and Redsell 1980). A recent study (Remsen et al. 1986) shows an unexpectedly high frequency of arthropods in hummingbird diets from Bolivia, Peru, Costa Rica, Venezuela, and Panama. It was found that 79% (1279 of 1629) of examined hummingbird stomachs and crops contained arthropod remains. It appears that insect feeding by hummingbirds is not incidental or opportunistic but probably occurs regularly in many species (Remsen et al. 1986). Foraging for arthropods by hummingbirds may be in response to abundant insects or may be a necessary alternative during nectar shortages (Wagner 1946, Young 1971). Whatever the reason for arthropod foraging by hummingbirds it appears more widely spread than previously considered.

Here we report observations made on the insect feeding of the Purple-throated Carib (*Eulampis jugularis*) and Green-throated Carib (*E. holosericeus*) in the tropical dry forest of Dominica, West Indies. The diet of these species contained high percentages of arthropods captured by gleaning on leaves and flowers or by flycatching. The Purple-throated Carib is known to forage on insects (Wolf and Hainsworth 1971, Lack 1973) but in Dominica is reported spending less than 1% of total foraging time searching for insects. The Green-throated Carib's diet is not well documented but it probably also consumes insects (Lack 1973).

The Purple-throated and Green-throated caribs are distributed throughout the Lesser Antilles in the West Indies. The Green-throated Carib occurs in all islands of the Lesser Antilles and Puerto Rico (Bond 1985). It seems to prefer forest clearings and inhabits primarily lowland areas (Lack 1973, Bond 1985). The Purple-throated Carib occurs in all the mountainous islands of the Lesser Antilles except Grenada (Lack 1973). This species is found both in the forest (Lack 1973) and clearings (Bond 1985) from sea level to 1200 m (Wolf and Hainsworth 1971). In Dominica both species are common and were observed regularly throughout the island.

*Methods.*—We studied hummingbirds on the Archbold Tropical Research Center, Springfield Field Station, located on the western side of the island at an elevation of 380 m. The vegetation here is lowland rainforest (Bullock and Evans 1990) or deciduous forest (Nicolson 1991). The deciduous rainforest is considered a transitional community between the lower dry scrub woodland and the higher evergreen rainforest. The area studied contains patches of typical primary forest, secondary forest, and areas of cultivation (banana, coffee, and citrus) either in use or overgrown with vines and other secondary invaders. We observed foraging by hummingbirds at three different sites in the forest for periods of 1 to 2 h between 08:00 and 11:00 h EST or 12:00 and 17:00 h EST between 27 May and 14 June 1991. The three sites were undisturbed primary forest, a forest gap, and an old abandoned field. We observed hummingbird foraging activity for 31 h. At each feeding attempt observed, we recorded the food item (nectar or arthropod) taken by each individual and the substrate from which it was taken (19 h of observation). The other 12 h of observation were divided into three, 2-h observation periods conducted on each of two territorial Purple-throated Caribs to determine time activity budget in relation to foraging. The two territorial caribs were in two contrasting sites. One territory was in a landscaped garden composed mainly of torch plants (*Alpinia purpurata*), with scattered heliconias (*Heliconia* spp.) located near the entrance to the station headquarters. The second territory was located in primary forest, in a ravine with the ground strata dominated by heliconia plants with a few scattered torch plants.

All sites where caribs were observed foraging had flowers of one or more species present, although the number of flowering plants was low. The species observed flowering during the study period include *Heliconia caribea, Psittacanthus martinicensis, Inga ingoides, Passiflora* spp., *Lantana* spp., and *Musa* spp. Despite the many flowering species present, during

the season in which our observations were made, few flowering plants, except heliconias, were observed in significant numbers throughout the forest.

*Results.*—During the 19 h of observations, 18 Purple-throated Caribs and 13 Green-throated Caribs were observed feeding. The majority (94.4%, N = 42) of Purple-throated Carib feeding attempts were directed at arthropod prey. Most arthropod prey items (61%) were gleaned from plant substrates, such as flowers, leaves, and branches and also by flycatching (33.3%). Most insects (63.1%) taken from substrates were gleaned from *Heliconia* inflorescences. A difference between nectar and insect feeding was readily apparent when observing caribs feeding on flowers. When taking insects from flowers the caribs gleaned (Remsen and Robinson 1990) rapidly from the outside of the flower corolla, while when taking nectar the birds probed (Remsen and Robinson 1990) between the petals. Green-throated Caribs were observed feeding on arthropods 100% (N = 31) of the time. Most prey (92.3%) was taken from the air by flycatching or sally-hovering while 7.6% of observations were of Green-throated Caribs gleaning insects from branches.

The time spent foraging by the two territorial Purple-throated Caribs was similar. The carib in the torch plant site spent 21% of time foraging while the carib in the forest territory spent 23% of time foraging. Foraging for insects differed greatly between the two caribs. At the torch plant site the carib spent 20% of foraging time feeding on insects and 80% of time feeding on nectar. By contrast, in the forest territory the carib spent 92% of time feeding on arthropods and only 8% feeding on nectar.

*Discussion.*—All female Caribs and Antillean Crested Hummingbirds (*Orthorhyncus cristatus*) captured during other phases of field work during the study period possessed a brood patch. The presence of the brood patch in examined birds, in addition to four nests that we found (2 Purple-throated Carib, 2 Antillean Crested Hummingbird) in early stages of construction (2 nests) or with eggs (2 nests), suggest our observations occurred during the reproductive period of these species. The high protein costs associated with egg production in birds may stress a female's daily energy balance (Ricklefs 1976, Walsberg 1983). Whether arthropods are used as a source of proteins by female hummingbirds during the reproductive period is not known. Some frugivorous and granivorous passerine birds make use of insects during parts of the breeding season, particularly to feed young during the early stages of nestling development (Morton 1978). In frugivorous birds, insects are considered to be more important than fruit availability in determining breeding cycles of birds in Costa Rica (Levey 1988). Concerning hummingbirds Montgomerie and Redsell (1980) made observations of a nesting female and report that it fed exclusively on arthropods over a two week period. Information regarding hummingbird use or importance of arthropods previous to egg laying or during the rearing of young is needed.

The high percentage of arthropod food items taken by the caribs studied here may be a response to a low availability of nectar due to decreased density of flowers during the dry season. During this season insects may serve as an alternate food resource. A second alternative is that the caribs are not undergoing a shortage of floral nectar but are making use of arthropods because they are present in abundance throughout the habitat and are easily captured. Remsen et al. (1986) have proposed that most hummingbirds feed on arthropods routinely, perhaps on a daily basis, and probably at regular intervals throughout the day. Our observations tend to support this idea, since all studied caribs were observed consuming arthropods. Even the Purple-throated Carib in the torch plant territory, in which nectar producing flowers were present in great numbers, spent 20% of foraging time feeding on arthropods.

Hummingbirds in areas with distinct wet and dry seasons, as in Dominica, may utilize distinct foraging strategies during the different seasons. Wagner (1946) found that, in areas of Mexico with a pronounced dry season, hummingbirds live chiefly on insects. Wolf (1970)

discovered that in Costa Rica during the early part of the dry season hummingbirds take mostly insects while taking large amounts of nectar during portions of the rainy season. Because of the hummingbird's small size and limited capacity to store energy, it is of vital importance that it adjust rapidly to changing food resources (Stiles and Wolf 1970). It is necessary to study the foraging behavior of the Dominican caribs during both the wet and dry season to determine if they are simply adjusting to changing food resources, using arthropods only seasonally during the breeding period, or if they feed regularly on arthropods throughout the year.

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**Behavior of polygynous and monogamous Loggerhead Shrikes and a comparison with Northern Shrikes.**—Reports of polygyny in *Laniinae* are rare (Verner and Wilson 1969). To date, polygyny has been recorded only once in Loggerhead Shrikes (*Lanius ludovicianus*) (Verner and Wilson 1969) and in one study in Northern Shrikes (*L. excubitor*) (Yosef and Pinshow 1988). Additional records will allow us to understand prevailing conditions, strategies adopted, and the costs and benefits of being polygynous.

*Methods.*—Two polygynous and 23 monogamous Loggerhead Shrikes were studied at the MacArthur Agro-ecology Research Center, Archbold Biological Station, Lake Placid, Florida. This 4120-ha cattle ranch consists primarily of improved pasture, with scattered cabbage palm (*Sabal palmetto*) hammocks, native wetlands, and live oak (*Quercus virginianus*) uplands.

Time-budgets were constructed for all pairs included in the study. The birds' diurnal behavior was divided into (1) perching, (2) flying (to or from collecting prey, chasing conspecifics or heterospecifics, or changing lookout points), (3) handling prey (recorded from the instant the shrike landed on or near the prey and attacked it until the prey had been impaled or consumed), and (4) preening.

Males were captured with either a bal-chatri noose trap or treadle trap and color banded. Territories were mapped by plotting points of shrike activity and by observing their reaction to taped songs of other males, and to a mounted specimen. Data are presented as mean ± SD.

*Results and discussion.*—Monogamous males captured 7.2 prey per hour as compared to 9.3 in polygynous males. Monogamous males captured mainly insects, the rest being reptiles. Although polygynous males also captured mostly insects, they also caught amphibians and reptiles. Territories of polygynous males did not differ in area from those of 23 monogamous males ($U_{2,23} = 39$, $P < 0.1$), although the total number of nestings attempted per territory