

## BREEDING SEASON ECOLOGY AND BEHAVIOR OF RIDGWAY'S HAWK (*BUTEO RIDGWAYI*)

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**ABSTRACT.**—Ridgway's Hawk (*Buteo ridgwayi*) is endemic to Hispaniola and its satellites, where it occurs in a wide variety of habitats. We studied this hawk in the wet limestone karst forest of the Dominican Republic between January and June 1976.

The hawk is sexually dimorphic with females somewhat larger than males. Display flights of territorial pairs began in January and were observed most often between 10:00 and 12:00. Mean home range for three pairs was 57.8 ha. Nest building was first observed on 25 February. Construction was concentrated in the morning and males did most of the building. Incubation (two eggs) was underway at one nest on 22 March. Females performed all of the incubation except when males took over after food exchanges. Hatching at one nest occurred on 19 and 20 April. At another nest two chicks fledged during the 12th week after egg-laying. Both sexes defended nests against intra- and interspecific intruders.

Males captured 91% of prey brought to the nests. Lizards and snakes were the most numerous prey brought to nests while mammals formed the bulk of prey biomass. Birds were also brought to young. Ridgway's Hawks used four hunting techniques: (1) Still Hunting, (2) Hang-Searching (slow gliding flight), (3) Foot-Thrusting (thrusting foot into vegetation and cavities to flush prey), and (4) Direct Stoop from soaring.

The hawk has three basic vocalizations: (1) *Kleeah*, used in self-assertive and aggressive contexts; (2) *Weeup*, given in food exchanges and displays, and (3) the Whistle-Squeal, given during high-intensity interactions.

Our observations suggest that *B. ridgwayi* is closely related to *B. lineatus*.

Despite current interest in the biology of raptors, relatively little is known about those in the tropics. The habits of Ridgway's Hawk (*Buteo ridgwayi*), a species endemic to Hispaniola (Haiti and the Dominican Republic), are almost unknown, probably because few ornithologists have worked on that island.

Early records of Ridgway's Hawk in the Dominican Republic were concentrated in the northeastern part of the country (Fig. 1), where it was not uncommon, judging from the number of specimens collected there. Although Christy (1897) and Cherrie (1896) reported this hawk as common in some areas, Peters (1917) considered it rare, while Cory (1885) and Wetmore and Swales (1931) said it was nowhere abundant. In Haiti, Abbott (*in* Wetmore and Swales 1931) found it to be common on the Cayemite Islands as did Wetmore and Lincoln (1934) and Schwartz (*pers. comm.*) for Île à Vache.

Our main objectives in studying this hawk were (1) to determine its role as a predator of the Hispaniolan Parrot (*Ama-*

*zona ventralis*); (2) to compare this tropical woodland Buteo to temperate woodland species, particularly the Red-shouldered Hawk (*Buteo lineatus*), which we studied for many years in Florida and California; and (3) to gather basic ecological and behavioral data on this little-known raptor.

Here we report our observations on breeding activities, food and feeding habits, vocalizations, interspecific interactions, and relationship of Ridgway's Hawk.

### STUDY AREA

The study area was in the limestone karst hills (mogotes and dolines, or "cockpit country"; see Monroe 1966 for general description of geologic formation) in Los Haitises, a mountain range running more than 80 km southeast to northwest in the north-central part of the Dominican Republic (Fig. 1). Our study site, elevation ranging from 200 to 310 m, was approximately 20 km NE of Bayaguana, just west of the village of Pilancón. Bayaguana and Sabana de la Mar, the nearest weather stations to the study area, gave the mean annual rainfall as 1,811 mm and 2,088 mm, and mean annual temperatures as 24.5°C and 25.8°C, respectively. Our study site's rainfall and temperature figures probably fell between those given for the two stations.

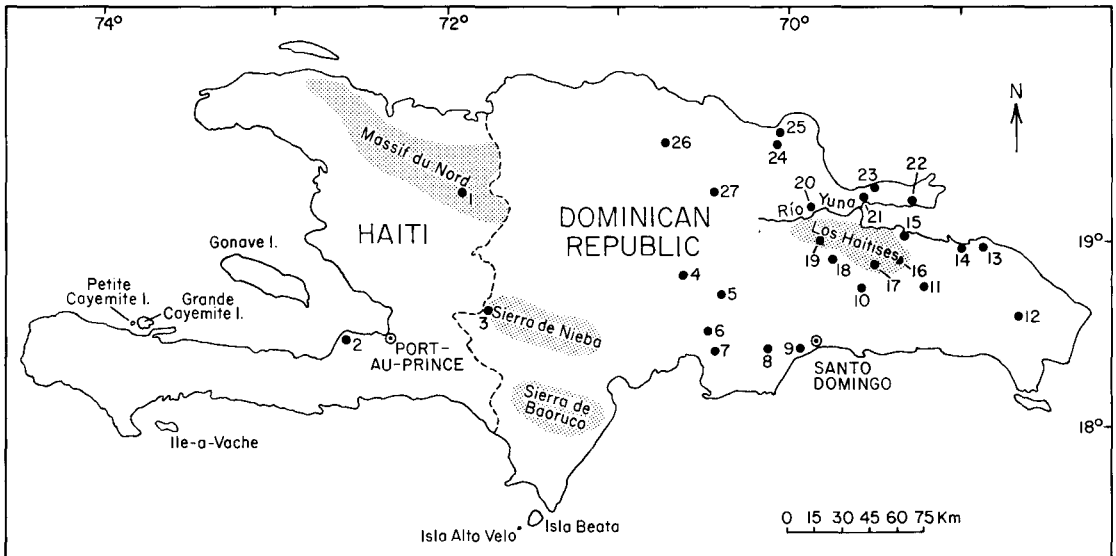


FIGURE 1. Map of Haiti and the Dominican Republic showing sites of Ridgway's Hawk occurrence. Numbers refer to the following localities: 1. Bois Laurence, E. Massif du Nord, 2. Geffard, 3. Angel Felix, 4. Valle Nuevo, 5. Rancho Arriba, 6. San José de Ocoa, 7. Rancho Francisco, 8. Cambita, 9. Haina, 10. Bayaguana, 11. Hato Mayor, 12. Higuey, 13. Guarabo (La Cuchoreta), 14. Miches, 15. Sabana de la Mar, 16. Arroyon, 17. Vereda and Pilancón, 18. Sabana Grande de Boyá (Zapoté), 19. Miranda, 20. Almercen (Villa Riva), 21. Sánchez (La Cañita), 22. Samaná, 23. Las Terrenas, 24. Laguna Flaca, 25. Los Cacaos, 26. Seibo, Magua, 27. La Vega.

Maximum rainfall occurs between May and October. The karst is quite permeable, and standing water is scarce.

The forest is classified as a Subtropical Wet Forest (Holdridge Classification; OAS Ecological Map, Washington, DC, 1967). Characteristic vegetation in the study area included cupey (*Clusia rosea*), granadillo (*Buchenavia capitata*), Dominican mahogany (*Swietenia mahagoni*), silk-cotton-tree (*Ceiba pentandra*), masa (*Tetragastris balsamifera*), American muskwood (*Guarea trichilioides*), and corcho bobo (*Pisonia albidia*). The study site consisted of virgin forest as well as active and abandoned small farms. Although the region was declared a national park (Parque Nacional Los Haitises) in 1976, clear-cutting and burning for farming continue at an alarming rate. Subsistence crops in the study area were mixtures of several fruits and vegetables. Abandoned farms were quickly invaded by higuillo (*Piper aduncum*) and matchwood (*Didymopanax morototoni*).

Between 24 January and 27 June 1976 we were in the study area for periods of one to six days at approximately two-week intervals; we spent a total of 685 h observing the hawks. We also spent two days in the study area in October 1974. Although we visited many places throughout the Dominican Republic, we did not attempt extensive observations of Ridgway's Hawks elsewhere.

## METHODS

We watched hawks from lookouts placed in tops of prominent canopy trees, from hilltops that offered overviews of hawk ranges, and from a blind placed 21 m from a nest ("#2"). The hawks were notably at ease with our movements, and our presence apparently did not disturb their behavior. We used binoculars and a spotting scope to make our observations. Full-day watches were made at the nests whenever possible although observations made during partial day watches are included here.

Vocalizations were recorded on a Uher 4000 IC Re-

port tape recorder with a parabolic reflector microphone and analyzed on a Kay audiospectrograph Model 6061-B. We weighed and measured chicks at irregular intervals, using vernier calipers and Pesola spring scales. Museum skins were measured with vernier calipers.

Biomass estimates of prey items brought to nests were based on weights of prey remains collected at the nests or of specimens we collected in the study area. We adjusted biomass estimates for amount of prey already consumed when delivered to the nest by the adults.

We watched three pairs of hawks in Los Haitises. We followed one pair ("#1") throughout the breeding season although most of our observations were made during the nest building period. The second nest ("#2") was watched from egg-laying through the nestling period. We observed the third pair ("#3") throughout the study, but particularly during the late nestling and fledgling stages.

Tree names follow Little et al. (1974). Specimens from the following institutions were examined: AMNH, American Museum of Natural History; ANSP, Academy of Natural Sciences of Philadelphia; AS-MDCC, Albert Schwartz-Miami Dade City College; CNHM FM, Chicago Natural History Museum; CM, Carnegie Museum; MCZ, Museum of Comparative Zoology; UMMZ, University of Michigan Museum of Zoology; USNM, United States National Museum; MNHNRD, Museo Nacional de Historia Natural de la República Dominicana.

## RESULTS

### SEXUAL DIMORPHISM

The sexes were easily distinguishable in the three pairs we watched in Los Haitises. The male was more gray overall, with bright rust shoulders, while the female was brown-er with drab, brown shoulders. Her breast

TABLE 1. Sexual size dimorphism in Ridgway's Hawk.

Measurement	Males			Females			Dimorphism index <sup>a</sup>
	Mean (mm)	Range (mm)	n	Mean	Range	n	
Culmen	18.3	16.9-19.5	17	19.9	18.5-21.0	10	8.38
Wing chord	228.1	215-139	18	244.9	235-251	10	7.10
Tarsus	66.2	58.0-70.9	12	70.3	61.0-76.2	9	6.01
Middle toe	30.3	29.0-31.0	4	32.6	29.0-35.4	3	7.31
Tail	148.9	135-166	8	160.5	150-166	4	7.50

Average dimorphism index—7.26

<sup>a</sup> Storer 1966.

was lighter with more barring, her belly gray with a reddish-pink tint instead of the neutral gray of the male, and her tail was more heavily barred. In general, these characters were useful in distinguishing between sexes of the museum skins we examined.

Females are larger than males. We found an average dimorphism index (Storer 1966) of 7.26 for a sample of 10 adult females and 18 adult males (Table 1).

#### BREEDING BIOLOGY

*Territorial and courtship display flights.* We observed 65 territorial and courtship display flights by known pairs. Of these 55.4% occurred between 10:00 and 12:00 (Fig. 2). Display flights between 10:00 and 13:00 were performed most frequently without the stimulation of territorial intruders, while at other times displays were usually instigated by intruders.

We often had difficulty determining whether we were watching courtship display flights or territorial flights. Sometimes an intruder may not have been visible to us, and we may have mistakenly categorized a territorial encounter as a courtship display. It is probable that most flights serve both to assert territorial ownership and to establish or reaffirm the pair bond.

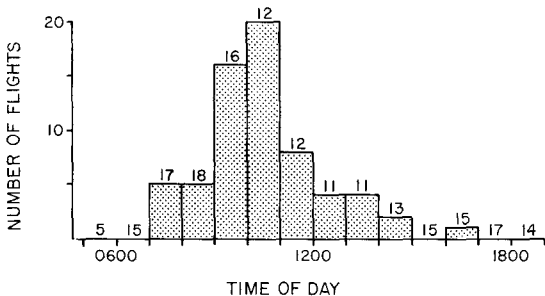


FIGURE 2. Time of courtship display and territorial flights of Ridgway's Hawks, Dominican Republic, from 191 h of observation during February and March 1976. Numbers on top of columns are number of hours of observation for that hour. Sunrise 06:40 to 06:50, sunset 18:25 to 18:35.

Courtship display flights appeared as less intricate and lower intensity versions of territorial flights. In 65% of our observations a display flight began with a male's circling up from his perch, with the female following shortly afterward (Table 2). The type of flight varied with the intensity of the display. In low-intensity flights the adults merely soared upward on fixed wings; in high-intensity displays they used rapid bursts of flapping flight alternating with soaring. In the beginning phase of the flight the hawks occasionally gave *Kleeah* calls, and less frequently *Weep* or *Whistle-Squeal* calls (Table 3; see Vocalizations section for description of calls).

While displaying, the adults soared close together, usually in the same direction. In all cases in which we could identify sex, the male soared above the female. Altitude attained in the flight varied directly with the duration of the display; i.e. longer flights were higher. Flights ranged from 30 to 250 m in altitude (mean 82 m). At the display apex the male occasionally performed a "dipping flight" ("Undulating Display" of Brown and Amadon 1968:95), which consisted of a series of two to nine shallow dives made near the female.

At the end of the display the birds dived into the forest, typically with the wrists of the wings held out from the body, head up, and tail down ("Parachuting"). They alternated this slowed descent-type flight with head-down, fast stoops. Stoop angles ranged from 10° to 90° (mean 39°). The female usually was the first of the pair to descend. Courtship display flights lasted 2 to 21 min (mean 6.6 min, n = 65).

Territorial flights were stimulated by the presence of intruders in the residents' territory and varied in intensity according to the species of the intruder and its proximity to the hawks' nest. Again, males were ordinarily the first sex to fly. Both sexes gave the *Kleeah* call, usually while climbing and sometimes throughout the entire display. *Weep* calls and *Whistle-Squeals* were given

TABLE 2. Courtship and territorial flight display characteristics of Ridgway's Hawk, Los Haitises, Dominican Republic, 1976.

Component of display	n <sup>a</sup>	Sex involved						Component presence <sup>b</sup>	
		Male		Female		Unknown		n	%
		n	%	n	%	n	%		
Only one member of pair in flight	65	12	18.5	7	10.8	—	—	19	29.2
First sex to fly	46	30	65.2	2	4.4	14	30.4		
Other Ridgway's Hawk involved in flight	65							17	26.2
Other species involved	65							32	49.2
Residents circle together	46							40	87.0
Residents circle in same direction	34							20	58.8
Sex above in flight	18	18	100.0						
Display dips	x <sup>c</sup>	8/42	19.1	2/32	6.3	2/7	28.6		
Legs hung during flight	x <sup>c</sup>	9/42	21.4	0/38	—	2/7	28.6		
Resident dives at intruder	x <sup>c</sup>	12/34	35.3	4/28	14.3	7/10	70.0		
Calls: <i>Kleeah</i>	x <sup>c</sup>	44/58	75.9	31/53	58.5	41/55	74.6		
<i>Weeup</i>	x <sup>c</sup>	30/58	51.7	18/53	34.0	26/55	47.3		
Whistle-squeal	x <sup>c</sup>	3/58	5.2	8/53	15.1	15/55	27.3		
Parachute to perch	x <sup>c</sup>	6/23	26.1	3/21	14.3	12/12	100.0		
Residents perch together after flight	46							10	21.7
Resident sex to land first	12	2	16.7	10	83.3				

<sup>a</sup> Number of observations differs for the components as not all classes of data were taken for each flight, some flights involved only one member of the pair, or members of the pair went out of sight during the flight.

<sup>b</sup> Number and percentage of total display flights in which behavioral activity is present relative to total number of flights in which we could have observed that activity.

<sup>c</sup> Numbers of observations are not given here, but are divided as to sex class or sex undetermined, as some components occurred in flights involving only males or only females, or were performed by only one sex in mutual flights.

TABLE 3. Context and sexual comparisons of Ridgway's Hawk vocalizations in Los Haitises, Dominican Republic, 1976.

Vocalization context	Sex of caller	Class of vocalization					
		<i>Kleeah</i>		<i>Weeup</i>		Whistle-squeal	
		n <sup>a</sup>	%	n	%	n	%
Territorial defense <sup>b</sup>	male	29/34	85.3	19/34	55.9	3/34	8.8
	female	24/40	60.0	14/40	35.0	6/40	15.0
	unknown	29/32	90.6	16/32	50.0	7/32	21.9
Display flight <sup>c</sup>	male	17/24	70.8	11/24	45.8	0/24	—
	female	7/13	53.9	4/13	30.8	2/13	15.4
	unknown	12/23	52.2	10/23	43.5	8/23	34.8
Food exchange	male	5/82	6.1	25/82	30.5	20/82	24.4
	female	3/82	3.7	32/82	39.0	82/82	100.0
	unknown	0/82	—	11/82	13.4	12/82	14.6
Nest building	male	3/35	8.6	4/35	11.4	3/35	8.6
	female	4/11	36.4	7/11	63.6	8/11	72.7
	unknown	0/15	—	4/15	26.7	4/15	26.7
Maintenance	male	0/45	—	1/45	2.2	0/45	—
	female	2/62	3.2	2/62	3.2	3/62	4.8
	unknown	2/13	15.4	2/13	15.4	0/13	—
Copulation	male	0/19	—	17/19	89.5	2/19	10.5
	female	0/19	—	4/19	21.1	19/19	100.0
	unknown	0/19	—	2/19	10.5	5/19	26.3
Handling prey	male	2/90	2.2	4/90	4.4	14/90	15.6
	female			1/90	1.1	87/90	96.7
	unknown					2/90	2.2
Incoming to nest	male	2/91	2.2	10/91	11.0	13/91	14.3
	female	12/121	9.9	6/121	5.0	4/121	3.3
	unknown	3/19	15.8	2/19	10.5	4/19	21.1
Female's response to:							
Male incoming		4/89	4.5	56/89	62.9	66/89	74.2
Male at nest without prey		0/9	—	2/9	22.2	9/9	100.0

<sup>a</sup> Number of times call was heard/number of times sex category was involved in the activity.

<sup>b</sup> Territory intruder observed.

<sup>c</sup> No territory intruder observed.

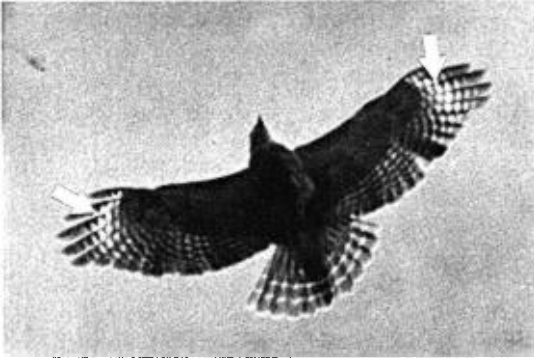


FIGURE 3. Soaring Ridgway's Hawk showing light "wing windows" (arrows).

en during high-intensity encounters. The residents soared to an altitude above the intruder(s) and then dived at it (them). These dives were very fast, head-down, closed-wings stoops. The resident(s) stooped at the intruder several times until the latter left the territory. Intensity of *Kleeah* calling increased during these stoops. Resident males were seen to dive at intruders in 35% of the

flights while females did so in only 14% of our observations.

During the soaring phase of the flights, males sometimes let their legs hang down (in 21% of our observations). Females were not seen to do this. "Wing Windows" (Fig. 3), similar to those of the Red-shouldered Hawk (Robbins et al. 1966), were very evident in these soaring flights. These light areas may serve as flash signals when the resident hawks throw open their wings after stooping on a territory intruder.

After the intruder had been evicted, the resident(s) soared for up to nine minutes, then descended in a slowed stoop or as a series of stoops alternating with leveling-out flights. In 22% of our observations the pair perched together after the flight, otherwise they hunted or preened in separate areas.

On 23 March 1976 we witnessed a severe territorial battle among all four members of the number 1 and number 2 pairs. This was a low altitude, tree-to-tree supplantation conflict which took place at the boundary of

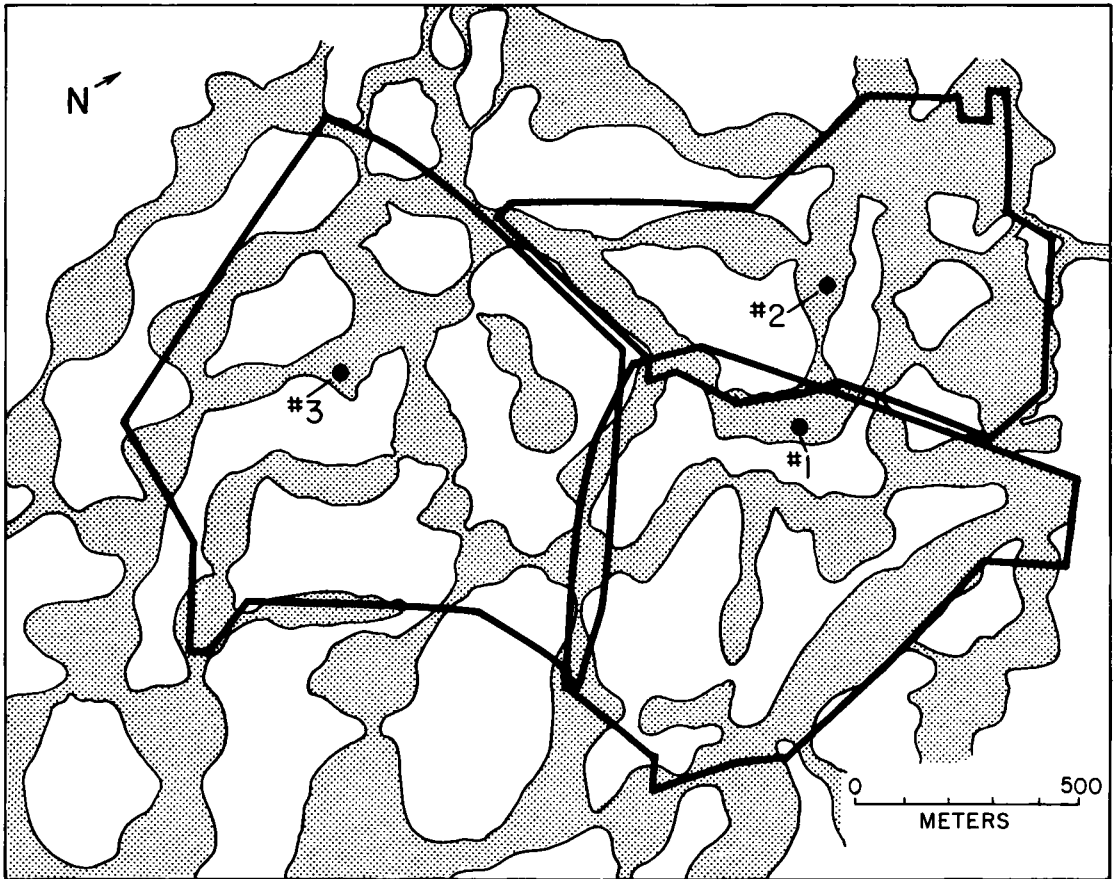


FIGURE 4. Diagram of home ranges of three Ridgway's Hawk pairs in Los Haitises, Dominican Republic, 1976. Hawk nests are marked with dot. Bold lines circumscribe hawk ranges. Shaded areas are steep limestone karst hills ("mogotes"), while unshaded areas are karst valleys or sinks.

the pairs' territories (home range boundaries were the same as territory boundaries in this section of the pairs' ranges, Fig. 4). The activity centered about a large *Clusia rosea* tree 150 m from the number 1 nest tree. The number 2 pair appeared to be the aggressor. In the latter part of the battle, the hawks (particularly the #1 pair) flew in tight circles low over a valley. They alternated soaring with rapid flapping. Then the number 2 pair closed in and the two pairs repeatedly struck one another for two minutes. During the conflict all birds called with great excitement. Calling began with *Kleeahs* and increased in intensity to *Weeups* and Whistle-Squeals. The number 2 pair seemed to fare better but soon returned to its own nest (with eggs). The number 1 pair remained in the immediate area. The male followed the female closely and once, when she perched, landed on her back and called with Whistle-Squeals. Copulation was not attempted.

Perched intruders were attacked with a supplantation flight. Typically the intruder fled immediately, but occasionally it did not leave after the first attack, and the resident then performed a series of low amplitude stoops on the perched bird. When the intruder finally flew, it was chased from the resident's territory.

Although most of our observations were made during the breeding season, we believe that this species maintains a territory year-round. When we first visited the Haitises study area in October 1974, we observed Ridgway's Hawks in territorial display flights and chasing Red-tailed Hawks (*Buteo jamaicensis*) and White-necked Crows (*Corvus leucognaphalus*) from defended areas.

*Home range size and distance between nests.* We plotted hawk sightings in the study area and considered the circumscribed areas shown in Figure 4 as the home ranges of the pairs. They measured 53.7 ha (#1), 47.4 ha (#2), and 72.2 ha (#3), with a mean of 57.8 ha. Distances between the three nests averaged 727 m (#1 to #2—300 m, #1 to #3—880 m, #2 to #3—1000 m).

*Copulation.* During 363 h of observation in March and April we saw 19 copulations, mostly ( $n = 14$ ) in the morning (07:00–12:00). Copulation frequencies were distributed as follows: 07:00 (beginning of hour)—4, 08:00—2, 09:00—4, 10:00—2, 11:00—2, 13:00—1, 14:00—1, 18:00—1, 19:00—1. No copulations were observed during the hours beginning at 06:00 and 12:00, or between 15:00 and 18:00. Copu-

lations ranged in duration from 4.0 to 14.5 s (mean 8.8 s). Mean daily duration of copulation in the number 1 pair increased until 8 April, then declined somewhat.

In all copulation sequences the male flew to the perched female. Occasionally he landed on her back at the end of a fast, twisting stoop. Copulation was preceded by a display flight in only 2 of the 19 cases (10.5%) and followed by a display flight only once (5.3%). Copulation activity was interspersed with hunting, nest building, and loafing.

A typical copulation sequence began with the female calling with *Weeups*, which increased in intensity to Whistle-Squeals, and the incoming male usually giving *Weeups*. As he approached, the perched female anticipated his arrival by posturing with her head down, body and tail held horizontal, and legs spread. When the male landed on her back, either directly or after first landing on the perch beside her, the female braced herself further by leaning against the perch with the leading edges of her wings. She bent her head lower with her rectrices tightly compressed and held up, while he supported himself on his tarsi and flapped his wings to maintain his balance on her back. He then pushed her tail to one side with his own tail and made vent contact. After coition the male stepped off the female's back onto the branch next to her, and the pair would either perch together silently for up to several minutes, or the male would fly off.

The birds uttered *Weeup* and Whistle-Squeal vocalizations through the entire copulation sequence. The male gave only *Weeups*, but the initial *Weeups* of the female increased in intensity to Whistle-Squeal vocalizations. His calling was louder and more rapid than hers.

*Nest building.* Nearly all nest building took place in the early morning; 80.4% of all trips to the nest with material were observed between 07:00 and 10:00 ( $n = 61$ ). The male did most of the building; he was seen making 76% of the trips with material to the nest ( $n = 46$  trips where sex was identified). Females appeared to become more active in the later stages of nest building.

Nest material was collected at a mean distance of 25 m (range 0.8–90 m) from the nest site. The bird broke or plucked twigs from trees by grasping the material in its feet or bill, leaning back, and flapping its wings. The hawk pulled with its neck and back and used sideways twisting movements of its head to break off difficult pieces. In our ob-

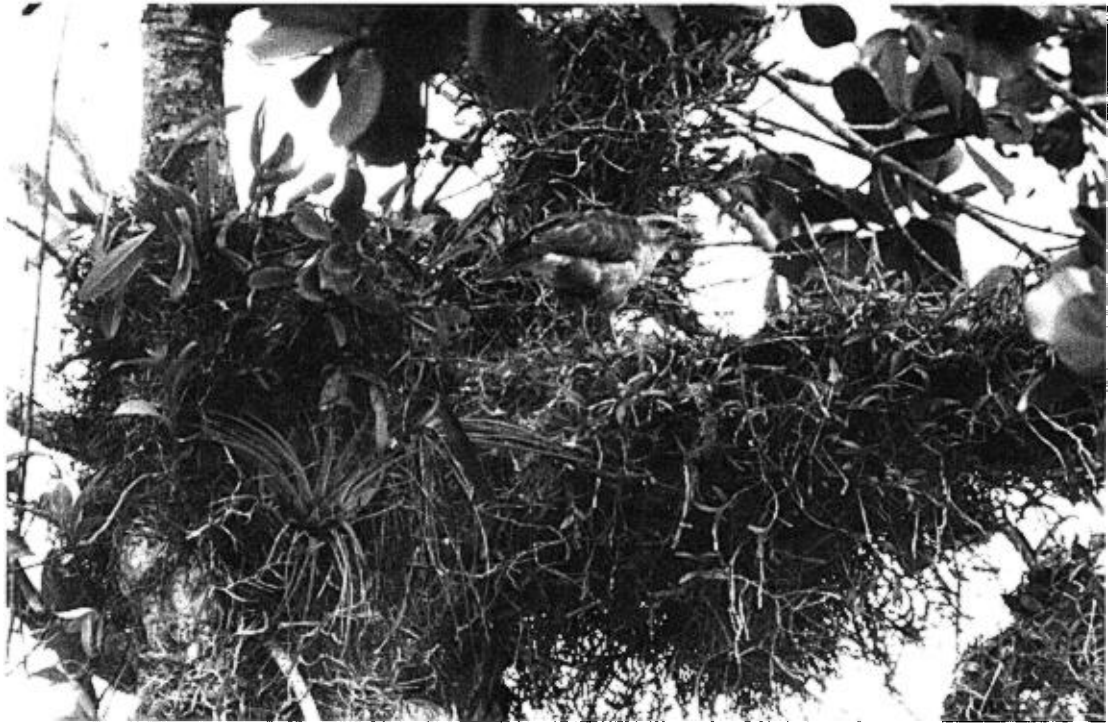


FIGURE 5. Female Ridgway's Hawk on nest number two. Nest was built on a horizontal branch and was partially supported by orchids and bromeliads growing on the branch.

servations, 51.6% of the nest material was transported in the feet and 48.4% in the bill. In half of their delivery trips males carried the twigs and lining in their feet. Females used their feet in only 11.1% of their trips.

The number 1 nest fell in a wind storm before eggs were laid. The adults continued to deliver lining material to the old nest tree stump and other nearby trees for four weeks. No replacement nest was completed, and no eggs were laid. Birds were observed gathering nest material near the number 1 territory as late as 26 June, but we were unable to determine if they were the resident hawks.

*Nest tree and nest.* We measured three nests in the study area. The nests were on hillsides at 255 m (#1), 305 m (#2), and 275 m (#3) elevation. Nests number 1 and number 2 overlooked cultivated valleys and the hillsides had been cut-over and burned for farming, leaving many dead trees standing. The number 3 nest was in the virgin forest. The number 2 nest was in a living tree; while number 1 and number 3 were in dead trees. The number 2 and number 3 nest trees were partially engulfed by living *Clusia rosea* trees.

Nest 1 was 6.1 m high at the top of a *Buchenavia capitata*. Nest 2 was on a horizontal branch near the junction of the trunk

at 23.3 m in the 26-m tree. The third nest was balanced 7.8 m from the tree trunk on a bare horizontal branch that projected over a cliff on the steep side of the "haystack hill." Nest height from the tree base was 17.7 m, while plumb-line distance to the ground under the nest was 36.6 m.

When we located the number 1 nest on 11 March 1976 it was being built upon by a pair of hawks and a colony of Palm Chats (*Dulus dominicus*). Apparently the hawks had built their nest on the already partially constructed chat nest, judging from the size of the twigs used in the foundation of the structure. The number 2 nest was almost completely obscured by surrounding bromeliads and orchids (Fig. 5). The orchid (*Epidendrum rigidum*, *Encyclia ottonis*, *Pleurothalus gelida*) bed was used as part of the nest structure and gave it additional support.

Dimensions for the number 2 nest were: 45.7 cm wide, 50.8 cm long, and 11.4 cm deep, with the bowl 15.2 cm across by 5.1 cm deep. When we inspected the number 3 nest in May it was trampled completely flat and had a diameter of 48.8 cm. The number 2 nest was composed of 55 twigs averaging 5.2 mm in diameter ( $n = 41$ ; range 3–7 mm) for the main structure and 1.6 mm ( $n = 14$ ; range 1–2 mm) for bowl lining

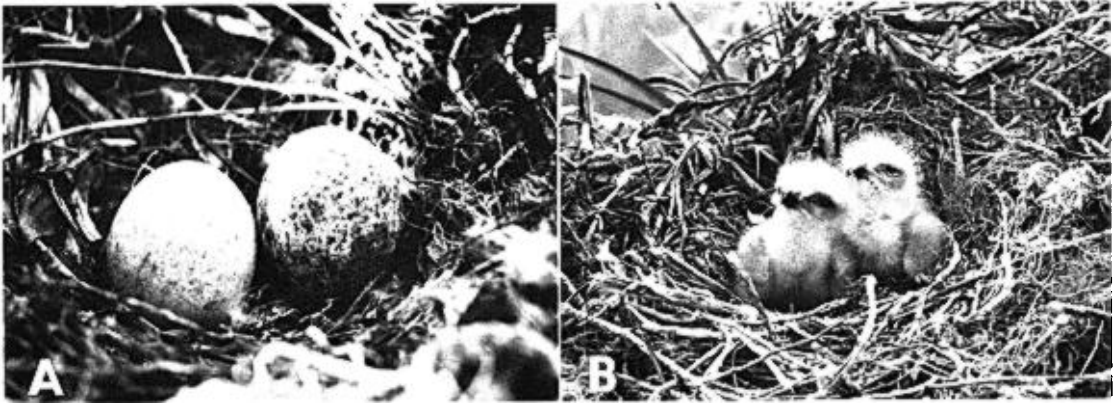


FIGURE 6. A: Eggs of Ridgway's Hawk from the number two nest. Egg on the right was much more heavily pigmented than the other. Nest lining of *Usnea* and banana leaves is visible. B: Ridgway's Hawk chicks at nest number two. Chick on the left is one day old, the nestling on the right hatched earlier in the day. *Usnea* lining of nest is visible.

twigs. Nest number 3 was constructed of 63 twigs averaging 8.3 mm in diameter (range 6–13 mm).

The bowls of all three nests were also lined with pieces of banana leaves, rootlets, *Usnea* moss, and bromeliad bracts. Hawks trampled moss and bromeliad leaf lining into place with their feet. At the time of egg laying the nests were heavily dotted with down from the adult hawk. Down continued to accumulate on the nest through the early nestling stage.

*Eggs and nesting chronology.* We first noted the number 3 pair carrying nest material on 25 February and the number 1 pair building a nest on 11 March. Although the nest tree of the number 2 pair was not climbed when discovered on 22 March, the birds' behavior suggested that they were incubating. When the nest was inspected on 4 April, it held two eggs. They measured  $50.0 \times 39.3$  mm and  $50.9 \times 40.3$  mm, and weighed 40 and 41 g, respectively. Both eggs had chalky-cream backgrounds, but one was much more heavily marked (Fig. 6A). It had burnt sienna dots somewhat evenly distributed over its surface, but with some of the flecks aggregated into small blotches and streaks. Reddish-brown markings were heavily concentrated at the large end. The other egg was sparsely but evenly speckled light gray-brown. The eggs were short oval in shape (see Harrison 1975).

At the number 2 nest the first chick hatched the morning of 19 April and the second during the early morning of 20 April, giving a minimum incubation period of 28–29 days. Only one chick survived beyond the second week after hatching. It was last seen on the nest on 27 May (day 37 after hatching) and, at that time, was not moving

more than 0.5 m from the nest. It is probable that the young did not depart from the nest until a few days later.

The two number 3 chicks left the nest during the twelfth week after egg laying. They were dependent on the adults at least through week 13. We observed both fledglings in the number 3 nest area during week 16 although we could not determine if they were still being fed by the adults.

*Incubation and nest exchange behavior.* During the incubation period the male regularly replaced the female at the nest while she fed, hunted, and groomed herself. For the first week after the chicks hatched he covered them when she was off the nest but thereafter did not do so if she fed or perched nearby. With older nestlings, the male frequently perched in the nest tree or close to it for the time the female fed away from the nest.

Nest exchanges were smooth with no aggression displayed by either adult. The exchanges typically began with the male entering and perching in the nest area with prey. The female watched him with interest, then flew to him calling with Whistle-Squeals (Table 3). She gently took the prey from the male and fed in his presence. Within two minutes the male flew to the nest and immediately covered the eggs. After eating the prey, the female flew directly to the nest where she stood beside her mate and waited for him to move. When he stepped off the nest, she proceeded onto it, covered the eggs, and he flew off quickly.

Usually the male remained on the nest until the female relieved him although once he left it to perch beside her 150 m away, and she flew directly to the nest. Sometimes the male was slow to leave the nest after the



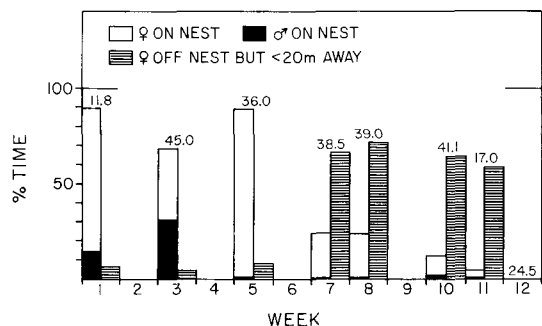


FIGURE 7. Ridgway's Hawk nest attendance by week at two nests in Los Haitises, Dominican Republic, 1976. Numbers above columns are hours of observation at the nests/week.

female returned and she would Whistle-Squeal loudly as she perched on the nest edge. Twice the female came to relieve the male, but he refused to leave. Both times she reacted by standing at the nest for a few minutes, then flying off about 35 m and preening for several minutes before returning.

*Nest attentiveness.* The number 2 adults were most attentive between weeks one and five (Fig. 7). During weeks one and three the male covered the eggs whenever the female left the nest. The eggs were covered 100% of the time during week 1 and 99% during week 3.

Male attendance had dropped off greatly by the week of hatching (week 5), when the nest was left uncovered 14% of the time observed. After the sixth week, the nestlings apparently did not need much brooding. By then, the male's visits to the nest were limited to delivering food, and the female was on the nest only 24% of the time. Her attendance continued to decline until the chick fledged (or was lost) in week 11. The female's visits were increasingly restricted to feeding the chick(s) and shielding the young from rain showers, although she still covered the chick(s) overnight at least until the eleventh week. During week 12 at nest number 3, the female did not cover the chicks overnight but roosted within 40 m of the nest.

Whereas adult attendance at the nest steadily declined after hatching, the amount of time the adults spent in the nest vicinity (i.e. within 20 m of the nest, but usually in the nest tree top) rose sharply after week 5. Even after the nest number 2 chick fledged, or was lost, during week 11 the female continued to guard the nest and was within 30 m of it 58% of the time we observed the pair. Presumably she stayed near the nest

TABLE 4. Growth of chicks at a Ridgway's Hawk nest (#2) at Los Haitises, Dominican Republic, 1976.

Measurement	Age after hatching (days)			
	0	1	16	23
Weight (g): chick #1	34	37	251	353
chick #2	33			
Culmen (mm)			14.0	16.4
"Forearm"			64.0	82.6
Tarsus			54.4	70.4
Span of foot			52.6	79.2
Middle toe			33.2	33.1
Hallux			14.1	18.6
Primary no. 3:				
Length outside of follicle			20.5	56.4
Out of sheath			5.5	17.0
Primary no. 8:				
Length outside of follicle			16.0	49.3
Out of sheath			5.0	17.5
Rectrices, outer:				
Length outside of follicle				27.0
Out of sheath				7.4

in order to prevent loss of the chicks to White-necked Crows or Red-tailed Hawks.

*Nest sanitation.* Adults essentially ceased nest building once the eggs were laid. Thereafter we did not observe males bringing material to the nest, although at about the time of hatching, females began delivering additional greenery (*Usnea*, bromeliad bracts, orchid leaves, other leaves). During weeks one and three (56.8 h of observation), females twice delivered greenery. During the week of hatching (week 5; 36.5 h observation) female number 2 made nine trips with greenery. Delivery rates declined thereafter: week 7 (38.5 h of observation)—4 trips with greenery; week 8 (39.0 h)—3 trips; week 10 (fledging; 41.1 h)—5 trips. She persisted in bringing greenery at least until 26 June, about a month after the chick left the nest.

Periodically throughout the day the adult female bent over, grabbed bowl material with her bill, and shook it with an up-and-down movement. We observed this activity more often toward the later part of the nesting season.

*Growth and development.* On the day of hatching for nest number 2, chick number one weighed 34 g (19 April) and chick number two, 33 g (20 April; both chicks had one-quarter-full crops) (Table 4). They were covered with dingy, gray down (Fig. 6B) and could feebly hold their heads up on day one (after hatching). Their eyes were partially

open. Neither called nor moved much for the first two days.

On day two, the chicks were able to hold their heads up steadily and called with sibilant squeaks. They appeared to fight between themselves on days one and two, lunging at one another with their bills. The older chick was clearly stronger in these sibling interactions. By day two the larger chick was using its bill to pick at prey in the nest.

On 22 April we noted that the younger chick (age 2 days) was not taking much food, even though the adults offered such in abundance to both nestlings. On 4 May only the first-hatched nestling (15 days old) was present in the nest. We found no trace of the younger bird. When J. Wiley climbed to the nest, the surviving chick remained motionless and low. It gave a high, squeaky *Kleeah* call at the intruder and grabbed his hand when he reached to handle the bird. At this age the nestling showed considerable interest in its surroundings and pulled at orchids and other vegetation in the nest. When a Turkey Vulture (*Cathartes aura*) flew low over the unattended chick, the young bird watched it and gave a soft *Kleeah* call. It occasionally stretched and flapped its wings.

On 5 May the 16-day old chick had cinnamon to light brown primary tips just breaking out of their sheaths. The bird was otherwise covered with grayish down which was particularly dark on the upper wings; no other pin feathers were present. The cere was lemon yellow while the legs and feet were orange-yellow. The egg-tooth had been lost. The chick could sit up in the nest and occasionally moved to the nest edge to shoot its excreta over the rim.

The 21-day old chick (10 May) was able to stand and walk about. The following day it attempted to tear up a lizard it had snatched from the adult. The chick wagged its tail stump after excreting or exercising. Like other raptors with barred tails we have observed, Ridgway's Hawk rapidly "wags" its tail upon landing. The tail is jerked to one side, held there momentarily, then jerked to the other side, held, and the cycle repeated. The tail "wagging" becomes increasingly deliberate and slower with each cycle.

On 12 May (day 23) the chick excreted over the nest edge, hopped back to the nest bowl, flapped its wings vigorously and wagged its tail. It weighed 353 g with an empty crop. Its iris was deep brown with a dark charcoal pupil. Its culmen was char-

coal and lores greenish-yellow. Plumage characteristics were as follows: scapular tract erupting; breast feathers erupting at the sides; no feathers on the thighs or underwings; the rectrices emerging from their sheaths; primaries approximately one-third out of the sheaths with some hunger streaks ("fault marks") present. The rest of the body was covered with the dingy, gray down.

The 36-day old chick (25 May) was covered with dark brown feathers on its back and head, slightly rufous feathers on its chest, and beige feathers marked with dark brown on its belly. Its thigh and white-tipped, dark brown tail feathers were well out. The chick could balance on one leg while stretching a wing and the opposite leg.

#### INTERSPECIFIC BEHAVIOR

We often observed aggressive interactions between Ridgway's Hawks and other species. We saw five species attacking these hawks: White-necked Crow—10 observations, Hispaniolan Parrot—1, Gray Kingbird (*Tyrannus dominicensis*)—2, Antillean Mango (*Anthracothorax dominicus*)—1, American Kestrel (*Falco sparverius*)—2. Our observations of non-predatory interactions of Ridgway's Hawks attacking other species included: Turkey Vulture—18 observations, White-necked Crow—7, Red-tailed Hawk—7, Hispaniolan Parrot—5, Plain Pigeon (*Columba inornata*)—1, and Palm Chat—1.

Turkey Vultures were common in the study area and were attacked whenever they entered the hawks' territories. Red-tailed Hawks were also vigorously attacked by the residents. No Red-tailed Hawks nested in our study area in 1976 although we found nests from former years there.

The number 1 pair built their nest within 40 m of an active White-necked Crow nest and interactions between the two species were frequent. However, the crows were much more aggressive toward non-resident hawks than toward the territory-holding hawks. Early in the breeding season (early nest building) a juvenile hawk was associating with the number 1 pair. The crows consistently forced the juvenile from their nesting area, while the adult hawks continued building in relative harmony with the crows. We observed hawks striking crows and crows striking hawks during interactions. After the number 1 nest failed, the crows became increasingly dominant over the hawks around the crow nest and, in most

cases, quickly drove them away with supplantation flights.

During incubation and early nestling stages, the attending hawk did not often leave the nest to drive away intruders. The non-attending adult chased the trespasser while the bird on the nest remained alert and called. By the mid-nestling period (after week 2) the female frequently assisted in pursuing intruders.

We watched an interesting situation involving the number 1 pair and a colony (minimum of 7 birds) of Palm Chats. On the day we found the nest (11 March) birds of both species were working on it. The chats and hawks continued building until the supporting branch broke and the nest fell during the night of 13 March. The two species worked at different times, the hawks generally between 07:00 and 10:00, and the chats usually after the hawks had finished (09:00–18:30). When we examined the fallen nest, we found three broken chat eggs. After the first nest was destroyed, the chats began constructing a new one in a crotch 5 m from the original site, although this nest was soon abandoned.

Although we did not see Ridgway's Hawks attacking Palm Chats, these passerines gave distress vocalizations whenever the hawks flew by them, even if the hawks were obviously of no threat (e.g., hawk carrying nest material). The same calls were given if the chats were near a Still-Hunting hawk when it dropped to the ground in pursuit of other prey. They also gave distress calls when attacked by American Kestrels, which we often saw feeding on them. Palm Chats could also produce calls which sounded like a subdued Ridgway's Hawk *Kleeah* (they likewise mimicked the calls of the Hispaniolan Parrot and the kestrel).

Both male and female adult hawks attacked humans at the nest. Females were more aggressive than males. As we climbed the nest tree, they circled above it and called with *Kleeahs*. When we were at the nest the hawks dived at us, although only the female struck us. Unsuccessful at driving us away, the adults would land 3–5 m above us and call loudly. On a few occasions the female left the area. After the chick disappeared from the number 2 nest, the female alone defended. During her defense, the male perched in a tree 200 m from the nest.

The hawk chick at the number 2 nest was parasitized by warble fly (*Philornis pici*) larvae. On 5 May the nestling had 4 maggots on its head, 1 on its right leg, and 1 on the

left leg. The larvae had left the chick to pupate by 12 May.

#### FEEDING BEHAVIOR

The hawks used four basic hunting techniques: (1) Still-Hunting, (2) Hang-Searching, (3) Foot-Thrusting, and (4) Direct Stoop from soaring. Of the 29 observations we made on hunting techniques, Still-Hunting was the most common (13 observations; 44.8%). We observed two types of Still-Hunting techniques. In both, the hawk searched the surrounding area from its perch. The method we most often observed ( $n = 11$ ; 37.9%) involved the hawk attacking a potential prey using either a stoop or flapping flight depending on the angle of flight to the prey (rats—3, snakes—3, lizards—5). In another form of Still-Hunting, the prey (lizards) was run down along its branch perch ( $n = 2$ ; 6.9%).

The Hang-Search flight began with the hawk leaving its perch in a very slow flight; the wings were flapped just a few times, and then the birds changed to a broad-winged glide at almost stalling speed. At this slow speed it appeared to hunt the area below it, particularly the tree branches. Sighting prey, the hawk would suddenly dive, cleanly snatching it from the substrate in mid-flight. Frequently the hawk would turn a complete backward somersault in grabbing the animal from the underside of a branch. *Anolis* lizards ( $n = 5$ ), vine snakes (2), and a bird were taken in this manner. The Hang-Search technique was the second most common hunting method observed ( $n = 8$ ; 27.6% of hunting observations).

In the Foot-Thrust mode of hunting, the hawk plunged its foot into bromeliads or orchids in an apparent attempt to flush prey ( $n = 7$ ; 24.1% of our observations). The bird first peered into the vegetation, then thrust its foot into the plant, and, sometimes, finally tore it apart with feet and bill. We saw the hawk capture *Anolis* lizards ( $n = 6$ ) and an insect this way. Twice we saw a hawk thrusting its foot into tree cavities, perhaps searching for roosting bats.

Only once (3.4% of our 29 observations of hunting behavior) did we see a hawk stoop from a soaring flight in a prey capture attempt. It dived at an angle of 35° into a large *Clusia* tree where a family of Hispaniolan Parrots was feeding. The hawk caught one parrot, which apparently was taken completely by surprise. The hawk killed the parrot outright.

Figure 8 depicts the time of prey delivery (and presumably the time of hunting activ-

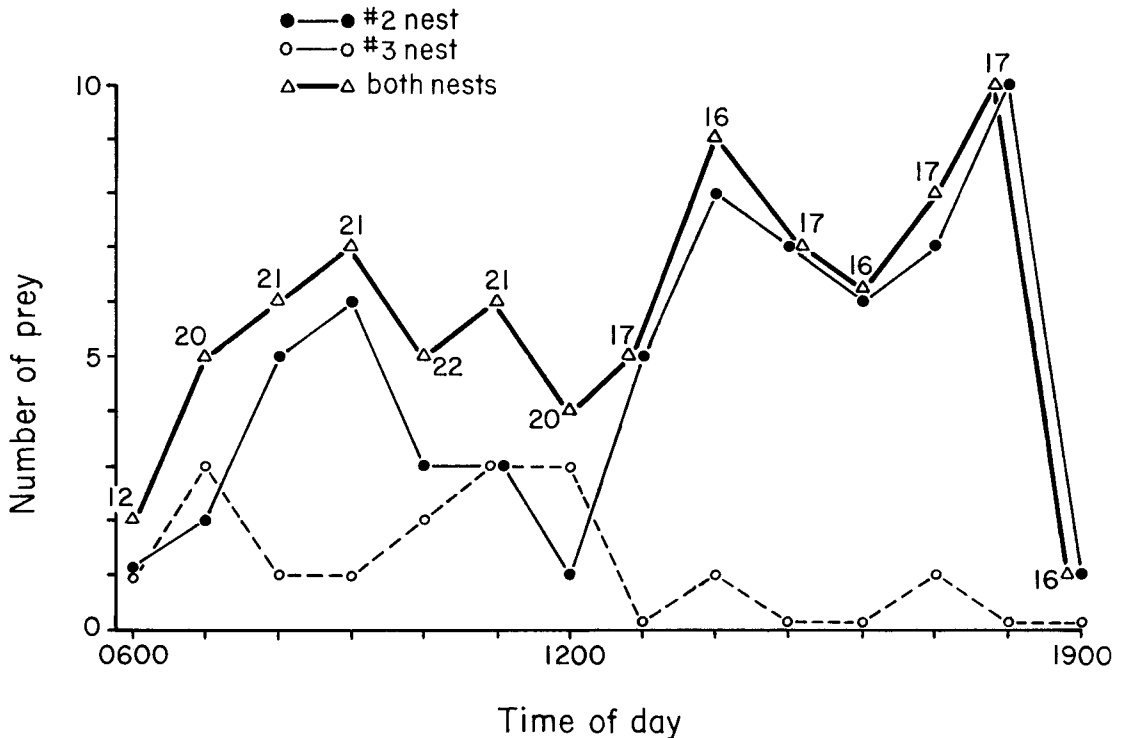


FIGURE 8. Times when prey was brought to two Ridgway's Hawk nests, Los Haitises, Dominican Republic, 1976. Numbers above triangles are number of hours of observation. Sunrise ranged from 06:10 to 06:45, and sunset from 18:35 to 19:05 during the study period.

ity) at the two hawk nests we watched during incubation and nestling stages. We could trace sex of captor to 63 of the 81 prey items delivered to the nests. Males captured 90% of these. On 6 (10%) of the items were taken by the females. We observed no prey captures made by females before week eight; at that time a female brought two prey items. During week 12, the number 3 female was providing at least 25% of the fledglings' food.

Ridgway's Hawk prey recorded in the literature or given on museum specimen labels include: mammals—rats (*Rattus* sp.)—2, mouse—1; birds—Red-legged Thrush (*Turdus plumbeus*)—1, Common Ground-Dove (*Columbina passerina*)—1, "columbid"—1; lizards—*Leiocephalus* sp.—2, *Leiocephalus melanochlorus*—3, *Ameiva taeniura*—2, *Anolis* sp.—2, and "lizard"—1.

Of the prey we observed delivered to hawk nests, lizards and snakes were the most numerous, each numerically making up 28% of the total items (Table 5). Mammals (rats and bats) made up 19.5%, and birds 8.5%. Although frogs were abundant in the area, we saw only one brought to a nest. Biomass estimates showed mammals (48.1%) to be the most important prey with regard to the amount of food brought to the

nest, with lizards (20.7%) and snakes (17.6%) next (Table 5). We also found the following prey remains in the nests: mammals (*Rattus rattus*)—3, bird (Stripe-headed Tanager, *Spindalis zena*)—1, snakes (*Uromacer oxyrhynchus*, *Epicrates fordi*)—5, lizards (*Anolis baleatus*)—5. These were not included in biomass or feeding rate calculations as prey remains tend to give biased evaluations on hawk food habits (see Snyder and Wiley 1976:1).

Table 6 presents data on feeding rates at the numbers 2 and 3 nests. The low feeding rates during incubation at the number 2 nest suggested that the female probably was hunting for herself during this time as well as being fed by the male. After the chicks hatched, feeding rates increased until the eighth week when they leveled out. The single chick at number 2 disappeared after a thunderstorm during week 11, but the male continued to bring food to the nest and feed the female. At the number 3 nest, feeding rates in the 12th week dropped somewhat below those we had observed for number 2 during week 10. The number of grams delivered per hour was considerably less at the number 3 nest compared with the number 2 nest, although the number 3 pair was feeding two chicks and the number 2 pair

TABLE 5. Prey observed brought to two nests of Ridgway's Hawk in Los Haitises, Dominican Republic, 1976.

Prey species	Number of items	Percent of total	Biomass	
			Grams	Percent of total
Amphibian	1	1.2	15	0.4
<i>Eleutherodactylus inoptatus</i>	1	1.2		
Snakes	23	28.0	609	17.6
<i>Uromacer oxyrhynchus</i>	13	15.9		
<i>Antillophis parvifrons</i>	3	3.7		
<i>Ialtris dorsalis</i>	2	2.4		
<i>Tropidophis haetianus</i>	2	2.4		
Unidentified snakes	3	3.7		
Lizards	23	28.0	716	20.7
<i>Anolis baleatus</i>	12	14.6		
<i>Anolis chlorocyanus</i>	4	4.9		
<i>Anolis</i> spp.	5	6.1		
<i>Mabuya mabouya</i>	1	1.2		
Unidentified lizard	1	1.2		
Birds	7	8.5	133	3.9
<i>Coereba flaveola</i>	2	2.4		
<i>Phaenicophilus palmarum</i>	1	1.2		
Unidentified birds	4	4.9		
Mammals	16	19.5	1,660	48.1
<i>Rattus rattus</i>	11	13.4		
<i>Artibeus jamaicensis</i>	5	6.1		
Unidentified prey	12	14.6	321	9.3
Totals	82	99.8	3,454	100.0

only one. The chick at nest 2 often did not eat all of the prey items even during the 10th week, which indicated an excess of food (for one chick) was being delivered to the nest. Some of the uneaten food was cached 40 to 200 m from the nest, although most remains were left on the nest. Both males and females cached uneaten food.

Prey exchanges were made either at the nest or at one of several regularly-used ex-

change perches 10 to 250 m from the nest. In 45% of the food exchanges the male flew directly to the nest with prey, usually with a flapping flight. Occasionally, however, the male soared up above the nest then dropped to it with the food. He carried prey to an unattended nest in 65% of our observations. In 55% of the exchanges the male flew into the area and the female left the nest to meet him on exchange perches.

The mode of carrying prey while in flight differed significantly ( $P < 0.05$ ). Larger items (mean weight 54.8 g) were carried to the nest or exchange perches in the feet, with smaller items (mean 18.0 g) carried in the bill.

In most prey exchanges we observed, the male quickly passed the food from his bill to the female. These exchanges were characteristically without aggression. However, in one instance the male retained the prey in his talons and mantled it by turning his back to the female and shielding the item with his wings. The female shouldered her way under his wing and grabbed the prey. He made no attempt to reclaim it. On another occasion the male dropped the prey as the female landed next to him on the exchange perch. Both birds immediately dived to the ground to recover it.

We determined sex of caller in 167 call series given during food exchanges. The fe-

TABLE 6. Feeding rates at two Ridgway's Hawk nests, Los Haitises, Dominican Republic, 1976.

Week	Total grams delivered	Total hours of observation <sup>a</sup>	Numbers of chicks	Grams per hour	Grams per hour per chick
1 <sup>b</sup>	40	11.8	0	3.4	
2					
3	114	45.0	0	2.5	
4					
5	356	36.5	2	9.8	4.9
6					
7	651	38.5	1	16.9	16.9
8	905	39.0	1	23.2	23.2
9					
10	900	41.0	1	22.0	22.0
11 <sup>c</sup>	105	17.0	0	6.2	
12 <sup>d</sup>	383	24.5	2	15.6	7.8
Total	3,454				

<sup>a</sup> Data do not include hours of observation made before birds became active in morning or after they had gone to roost in evening.

<sup>b</sup> Week 1 through 11 are represented by nest number 2.

<sup>c</sup> Chick disappeared.

<sup>d</sup> Data for week 12 are from nest number 3.

male typically was more vocal than the male during these exchanges. Her calling usually began with low-intensity *Weeup* vocalizations while she was on the nest. These increased in fervor to high-intensity Whistle-Squeals as she flew to the male or as he approached the nest. The female called with *Weeups* about as often as the male. He gave the Whistle-Squeal vocalization during only 25% of the exchanges while the female gave it during all of them. The *Kleeah* call was not often given during food exchanges. Those few times we did hear it in this context the adults were distant and out of sight of one another.

#### VOCALIZATIONS

Calls in their usual behavioral contexts have been discussed in sections dealing with those activities and are presented in Tables 2 and 3. Here we will describe the calls.

*Kleeah*. This call (Fig. 9A, B) is relatively loud and is commonly used in self-assertive and aggressive activities. The *Kleeah* is prefaced by a short (0.01 s) "click" ranging from 2,270 to 3,780 Hz (means of 16 calls from three birds). The fundamental element appears at 2,650 Hz, rises quickly to an inflection point, then on to 4,200 Hz. It then drops to 3,000 Hz where it continues for 0.07 s before falling sharply to 1,820 Hz. This syllable is closely followed by a blurred tone of initial intensity (0.03 s) drawn out to form a languishing tail of between 0.17 and 0.34 s at 3,000 Hz. The two-syllable sequence (less "click" preface) lasts a total of about 0.35 s. An underlying tone (2,100 Hz) and several overtones (6,000 Hz, 8,300 Hz, 10,100 Hz, 11,900 Hz, 13,800 Hz, and 15,900 Hz) parallel the fundamental elements. *Kleeah* syllables are separated by about 0.7 s from the end of the main element to the start of the new syllable. Several calls may be repeated in series.

*Weeup*. These calls range from lower intensity *Weeos* (Fig. 9H) and *Weeps* to more intense *Wee-up* or *Wee-ep* calls (Fig. 9I, J). The less intense calls are drawn out compared to the high-intensity vocalizations which are sharp and short.

In the high-intensity *Weeup* call the main element starts at about 2,400 Hz and rises quickly for 0.03 s, with one minor hesitation, to 3,450 Hz. This tone lasts 0.03 s before a sharp, ill-defined inflection of 0.05 s drops it to 3,350 Hz. There is then another sharp rise to 3,530 Hz, and a drop to 2,780 Hz where the tone ends. Total duration of the syllable is 0.2 s. Following the funda-

mental element is a fading tail of about 0.4 s.

The lower intensity *Weeo* call has the fundamental element prefaced by two short, soft elements, one rising for 0.08 s from 1,200 Hz to 1,550 Hz, and the other lasting 0.03 s at a steady 2,400 Hz. The fundamental element, continuing about 0.2 s at 2,100 Hz, is followed for about 0.5 s by several short tones of decreasing strength. Approximately 0.3 s after the beginning of the main element, a short element at 2,900 Hz, ending in a sharp spike, is given, succeeded by then another short one at 2,560 Hz. Both of these short elements have overtones and diminishing tails.

*Whistle-Squeal*. The Whistle-Squeal (Fig. 9L) is nasal in quality. Its elements are spaced according to the intensity of the situation in which the call is used: during high excitement the Whistle-Squeals are given at close intervals; during low-intensity interactions the elements are widely spaced. The call has a short element (0.03 s) at 2,560 Hz, then a more emphatic note of 0.06 s duration at 3,080 Hz, followed by a languishing tone of about 0.2 s. These calls are separated by 0.2 to 0.5 s depending on the intensity of the bird's calling.

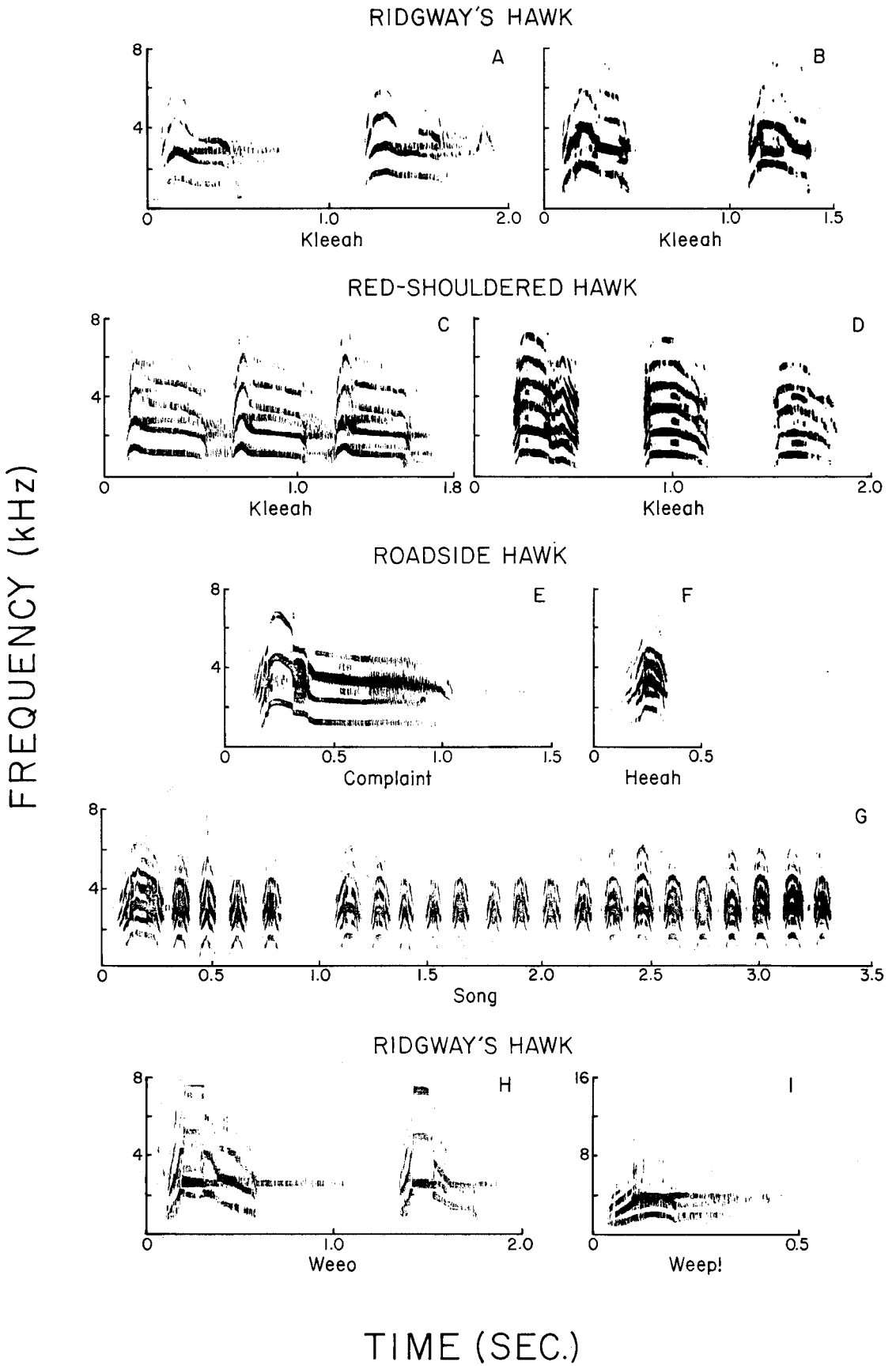
*Soft calls*. Adults gave "peeping" calls in anticipation of flight and when performing some solo activities, such as arranging nest bowl material or preening. Nestlings produced sibilant squeaks in response to several situations, including our handling them, feeding by the adults, and movements of the adults on the nest.

## DISCUSSION

### HABITAT AND STATUS

Our observations support Bond (1956) who felt that Ridgway's Hawk was locally common. We often saw this species in the virgin forests and forest edges of Los Haitises, but encountered it infrequently in other habitats we searched. We occasionally saw this hawk in the largest tracts of the degraded wet forest above Miches on the northern coast of the Dominican Republic, but failed to find it in the largely destroyed forests of the Samaná Peninsula where apparently it was once common. The species has been reported from most of Hispaniola's satellites and at least until recently (1962), was evidently still common on Île à Vache, as Schwartz (pers. comm.) found it conspicuous and tame there.

Bond (1971) described the general habitat of Ridgway's Hawk as woods and fairly



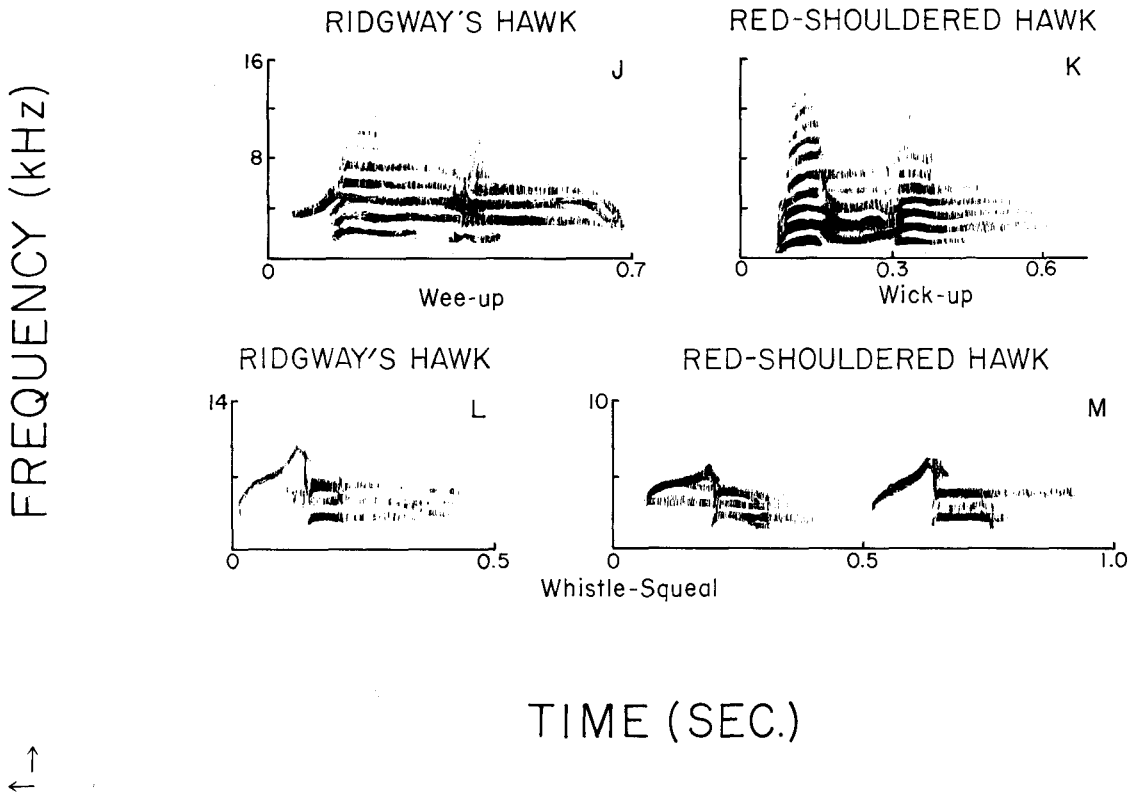


FIGURE 9. Wide band vocalization sonograms for three species of woodland buteos: A. Ridgway's Hawk—*Kleeah*, B. Ridgway's Hawk—more intense *Kleeah*, C. Red-shouldered Hawk—*Kleeah* of excited adult, D. Red-shouldered Hawk—*Kleeah* series as adult flies off, E. Roadside Hawk—complaint or bother, F. Roadside Hawk—*Heeah*, G. Roadside Hawk—*Heeah*, then fast chattering "song," H. Ridgway's Hawk—*Weeo*, I. Ridgway's Hawk—*Weep!*; sharp and emphatic, J. Ridgway's Hawk—*Wee-up*, K. Red-shouldered Hawk—*Wick-up*, L. Ridgway's Hawk—Whistle-Squeal, M. Red-shouldered Hawk—Whistle-Squeal. A through H: 80–8,000 Hz; I through M: 160–16,000 Hz. Ridgway's Hawk vocalizations from Los Haitises, Dominican Republic, 1976; Red-shouldered Hawk—Everglades National Park, Florida, 1972; Roadside Hawk—Tikal, Guatemala, 1975 (G. B. Reynard).

open country. The species has been recorded from a wide variety of habitat types (Holdridge Classification: OAS Ecological Maps—Dominican Republic, 1967; Haiti, 1972, Washington, D.C.): (1) Subtropical Dry Forest—lowland scrub (Wetmore and Lincoln 1934; J. A. Ottenwalder, pers. comm.). (2) Subtropical Moist Forest—a) pine forest (Bond 1928, pers. comm.); b) lowland scrub (Wetmore 1932; Schwartz, pers. comm.); c) lowland/littoral woodland (Tristram 1889, Peters 1917, Wetmore and Swales 1931); d) lower montane hardwood forest (Verrill and Verrill 1909; Danforth 1929; A. Dod, pers. comm.); e) lower montane pasture and agricultural land (A. Dod, pers. comm.); f) lower montane cut-over pine/hardwood (A. Dod, pers. comm.); g) lowland riparian woods/marsh (Wetmore and Swales 1931). (3) Subtropical Wet Forest—a) lower montane limestone karst forest (A. Dod, pers. comm.; pers. observ.); b) rain forest (Christy 1897, Wetmore and Lin-

coln 1934; pers. observ.). Elevational distribution is also broad, with the hawk found from sea level (e.g. Gonave Island, Danforth 1929) to 1,800 m (Valle Nuevo, pers. observ.). Ridgway's Hawk apparently has a wide tolerance for habitat types and for that reason its survival probably is not presently threatened rangewide. However, with the widespread and extensive loss of forested habitat (particularly wet forests) in the Dominican Republic and especially Haiti, there is cause for concern for the species' future.

#### SEXUAL DIMORPHISM

Friedmann (1950) and Cory (1883) described the male's plumage as similar to the female's, with the exception of the upper parts which had a more slate-like cast and much less rufous, and the thighs which were a somewhat brighter rufous. We found these characters useful in distinguishing the sexes in the field.



Friedmann (1950) noted sexual differences in juvenal plumages based on one specimen of each sex. The female's upperparts were darker, fuscous-blackish while the male's were lighter fuscous or reddish-brown. He also noted sexual differences in thigh plumage color patterns. We examined two immature males and one immature female, but found these differences inconsistent.

Ridgway's Hawk has moderate sexual size dimorphism (average Dimorphism Index 7.26), as would be expected in a species feeding mainly on mammals and reptiles (Snyder and Wiley 1976). This hawk's sexual size dimorphism is comparable to that of most other small-to-medium sized New World buteos (e.g., Red-shouldered Hawk, *B. lineatus*—7.1; Broad-winged Hawk, *B. platypterus*—7.7; Roadside Hawk, *B. mag-nirostris*—6.2; Hawaiian Hawk, *B. solitar-ius*—9.1; Gray Hawk, *B. nitidus*—10.3; mean = 8.08; data from Friedmann 1950, Snyder and Wiley 1976). Our average Dimorphism Index (18 specimens) was somewhat greater than that derived from Friedmann's data which yields an Index of 6.08 for 13 specimens. This discrepancy is perhaps due to the difference in sample sizes.

#### NESTING BEHAVIOR AND ECOLOGY

Our observed Ridgway's Hawk home ranges were small compared with *Buteo* ranges reported in some other studies (e.g., Craighead and Craighead 1956, Tubbs 1974). However, if the cockpit country terrain (i.e., close-set hills separated by deep valleys) of the Ridgway's Hawk ranges is considered, the actual acreage used by the birds increases greatly above the two dimensional projection we have presented. Also, Ridgway's Hawk may require a range in proportion to its relatively small body size (Craighead and Craighead 1956, Newton 1979).

Bond (1928, pers. comm.) found two Ridgway's Hawk nests, each with downy young, at Boise Laurence, Haiti, on 2 May 1928. They were 7.6 and 12.2 m from the ground. Dod (1978) watched a pair building a nest and copulating near Sabana Grande de Boyá, Dominican Republic, on 15 February 1974. The nest was 15 m high and, as in the three nests we watched, was in a prominent tree. On Île à Vache, Wetmore (Wetmore and Lincoln 1934) found a partially completed nest 10 m from the ground in the top of a royalpalm (*Roystonea regia*) on 28 April 1931. Breeding activity at that nest was late compared to that of the three pairs we

watched in Los Haitises, which had finished nest building by the end of March. The stages of nests reported by Bond and Dod were in close synchrony with the nests we observed.

We saw hawks delivering greenery to each of the three nests. As Snyder (1975) suggested, use of greenery may function to keep the chicks above the excreta and food remains that are dropped in the nest bowl. The "excavating" movements of the adult female, wherein she shook nest materials with up-and-down movements of her head, may function in sifting excreta, food wastes, and scavenging arthropods down through the nest structure.

The feeding rates we observed at the number 2 nest, if the amount of food brought to the nest was distributed between two chicks, were similar to those we observed for the somewhat larger Red-shouldered Hawk for comparable brood size (Snyder and Wiley 1976). Apparently the loss of the younger chick was not due to insufficient food coming into the nest as, even with two chicks, uneaten food remained. Perhaps the chick's loss was related to the persistent attacks by the older sibling which may have so weakened the younger chick that it was unable to adequately beg for food from the adults. Such sibling conflicts in medium-sized buteos have been reported to occur only at times of great hunger, and are unknown in smaller buteos (Newton 1979). The adults at the number 2 nest evidently failed to adjust their feeding rates after the loss of the younger chick as uneaten food accumulated on the nest or was cached and later eaten by the adults. Snyder and Snyder (1973) have experimentally shown that Cooper's Hawks (*Accipiter cooperii*) show no clear adjustment of feeding rates with artificial changes in brood size. The number 2 Ridgway's Hawk female did little hunting during most of the nesting period and showed high nest attendance rates, perhaps as a result of the male's high feeding rates.

#### ECOLOGICAL RELATIONSHIPS WITH OTHER RAPTORS

Six other raptor species were present in our study area: Turkey Vulture, Sharpshinned Hawk (*Accipiter striatus*), Red-tailed Hawk, American Kestrel, Barn Owl (*Tyto alba*), and Stygian Owl (*Asio stygius*). Red-tailed Hawks hunted and nested in the areas surrounding the virgin forests of Los Haitises, apparently preferring the forest edge of burned and cut-over farmlands. We

occasionally saw them hunting over the virgin forest. Prey of the Red-tailed Hawk overlapped moderately with that of Ridgway's Hawk, as it consisted mostly of rats. Red-tailed Hawks ate a large number of medium-sized birds (e.g. Red-necked Pigeon, *Columba squamosa*, Plain Pigeon), which we did not observe Ridgway's Hawk taking. Infrequently we found *Anolis baleatus*, a lizard also taken by Ridgway's Hawk, in Red-tailed Hawk nests.

American Kestrels were common in the active and deserted farm areas in our study area but avoided the virgin forest. They fed primarily on insects, small lizards, and small birds. Sharp-shinned Hawks appeared to be feeding exclusively on small birds and they kept to the virgin forest areas. No niche overlap among the owls and Ridgway's Hawk was noted.

Although the Broad-winged Hawk occurs in Cuba and Puerto Rico, it has been recorded in Hispaniola only once (Wetmore and Swales 1931), and this was probably a migrant straggler. Johnson and Peeters (1963) suggested that this species and Ridgway's Hawk may not co-exist because of their similar size. We found that the two species have similar habitat use and feeding behavior in the Greater Antilles. In Puerto Rico the Broad-winged Hawk is found in rain forest (Luquillo Forest) and wet limestone karst forest (Río Abajo), which is comparable to the Haitian habitat. Observations at two Broad-winged Hawk nests in Puerto Rico revealed that the birds fed on some of the same sorts of prey (lizards, small mammals, birds) taken by Ridgway's Hawk (Wiley and Snyder, unpubl. data). Ridgway's Hawk may have excluded the Broad-winged Hawk from Hispaniola by being the superior competitor for the two species' common food and nesting habitat niches. If the level of differentiation is any indication, Ridgway's Hawk was probably in the West Indies before any resident Broad-winged Hawks and may have "locked out" the more recent arrival (Diamond 1980).

#### HUNTING METHODS

The Hang-Search hunting method of Ridgway's Hawk seemed particularly well suited to the dense canopy of the virgin forest. We have seen similar techniques effectively used by Red-tailed Hawks hunting *Anolis* lizards in the Luquillo Forest of Puerto Rico. Because of the dense nature of the virgin forest, the Direct Stoop from a soaring flight probably was not a useful hunting method there. Even though the hawks also

foraged over the old farm areas where Red-tailed Hawks used this technique effectively, we did not see Ridgway's Hawk using the Direct Stoop in that habitat either. Rather, the hawks employed a Still Hunting method in edge and open habitat, the method they also used successfully sub-canopy in the virgin forest.

The Foot-Thrust hunting method is unusual for a *Buteo*, but is known for *Geraospiza* and *Polyboroides* (Brown and Amadon 1968). It perhaps represents a behavioral adaptation to take advantage of a food resource (e.g., roosting bats) unexploited by other predators in that habitat. We observed two individuals using this technique and found evidence (prey remains and pellets) that at least one other hawk was taking bats.

#### TAXONOMIC RELATIONSHIPS

Considerable controversy has existed over the relationship of *B. ridgwayi*. Several investigators (including Ridgway 1925, Wetmore and Swales 1931, Bond 1957) considered this species as most closely related to *B. magnirostris*, the Roadside Hawk of Central and South America, while others believed it closer to *B. lineatus* (Peters 1931, Hellmayr and Conover 1949, Friedmann 1950, Bond 1978). Johnson and Peeters (1963) suggested that within the genus *Buteo* the "woodland" species *magnirostris*, *ridgwayi*, *lineatus*, and *platypterus* should be put in sequence to indicate a probable relationship. They found that *B. lineatus* and *B. ridgwayi* have essentially the same patterning of juvenal and adult plumages in addition to similar wing-tarsus and wing-tail ratios, and therefore are closely related. Johnson and Peeters believed *magnirostris* stands apart from *lineatus* and *ridgwayi*. More recently, Mayr and Cottrell (1979) have indicated relationship between *ridgwayi* and *lineatus* by placing the former between *lineatus* and *B. leucorhous*, the little-known Rufous-thighed Hawk of South America.

Based on our observations on behavior and vocalizations we believe that *B. ridgwayi* and *B. lineatus* are closely related. Both species have a very similar repertoire of calls: *Kleeah* (Fig. 9A–D), *Wick-up* (similar to *Weeup*; Fig. 9J, K), and Whistle-Squeal (Fig. 9L, M). Many *buteos* have calls comparable to the Whistle-Squeal, which are used in high-excitement interactions, but the other two call classes are different enough from vocalizations of other species to serve as criteria of relationship. Contexts of the *Kleeah* and *Wick-up/Weeup* calls were also analo-

gous between the two species (J. Wiley, unpubl. data).

Additional similarities between the two species are the pale "wing windows" and the consistent use of down on nests during incubation and early nestling periods. Other species add down to their nests but *B. lineatus* and *B. ridgwayi* practice this habit to a notable degree. Our examinations of adult and juvenal plumage characteristics support Johnson and Peeters (1963) in the similarities between the two species.

While *B. magnirostris* has some vocal elements (Fig. 9E through G) which closely resemble those of *B. ridgwayi*, the two species are not closely related on the basis of vocalizations. Neither *B. ridgwayi* nor *B. lineatus* has the chattering "song" (Fig. 9G) of *magnirostris*, although the initial element (*Heeah*) of the song is similar to the *Kleeah* of both *lineatus* and *ridgwayi*. Behavioral similarities between *ridgwayi* and *magnirostris* (or *leucorrhous*) may exist, but the behavior of the Roadside Hawk needs to be studied before that can be determined.

## RESUMEN

Durante enero a junio de 1976 estudiamos tres parejas de gavilanes (*Buteo ridgwayi*), una especie endémica a la Española y pequeñas isolates cercanos. El estudio se llevó a cabo en el bosque muy húmedo de la zona cársica al noreste de República Dominicana.

Las hembras son más grandes que los machos, con un grado de dimorfismo en tamaño comparable con otros halcones similares del mismo género. Las parejas defendieron sus territorios con despliegues y desplazamientos. El tamaño promedio de los "home ranges" fue de 57.8 ha. Observamos la construcción del primer nido el 25 de febrero. La incubación en un nido comenzó alrededor del 22 de marzo y los polluelos salieron de los huevos el 19 y 20 de abril (2 polluelos) dando como resultado un periodo de incubación de 28–29 días. En otro nido dos pichones volaron por primera vez durante la octava semana después de empollar. Las hembras ejecutaron toda la incubación, excepto cuando los machos incubaron durante los cambios para alimentarse.

Los machos capturaron casi todas las presas traídas a los nidos, aunque las hembras aparentemente cazaron un poco durante la época de incubación y aumentando durante el último periodo de los pichones. Los lagartos y culebras fueron las presas más nu-

merosas dadas a los pichones, mientras que los mamíferos formaron la mayoría de la biomasa. Algunas aves fueron traídas a los juveniles también. Los halcones usaron los siguientes cuatro métodos de caza: (1) cazar desde una posición fija, (2) volar bajo sobre el dosel del bosque y atrapar la presa, (3) buscando con las patas y el pico en la vegetación y en cavidades, y (4) vuelo en picada.

Este halcón tiene tres vocalizaciones básicas: (1) *Kliia*, usado en el contexto agresivo y asertivo o afirmativo, (2) *Wiiop*, usado en los despliegues y cambios para alimentarse, y (3) Silbato-chillón, dado durante acción recíproca intensa.

Nuestras observaciones sugieren que *B. ridgwayi* está estrechamente relacionado con *B. lineatus*.

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## LITERATURE CITED

- BOND, J. 1928. The distribution and habits of the birds of the Republic of Haiti. Proc. Acad. Nat. Sci. Phila. 80:483–521.
- BOND, J. 1956. Check-list of birds of the West Indies. Academy of Natural Sciences, Philadelphia.
- BOND, J. 1957. Second supplement to the Check-list of birds of the West Indies (1956). Academy of Natural Sciences, Philadelphia.
- BOND, J. 1971. Birds of the West Indies. Second ed. Houghton Mifflin, Boston.
- BOND, J. 1978. Derivations and continental affinities of Antillean birds, p. 119–128. In Gill, F. B. [ed.], Zoogeography in the Caribbean. Acad. Nat. Sci. Phila. Spec. Publ. No. 13.
- BROWN, L., AND D. AMADON. 1968. Eagles, hawks and falcons of the world. Vol. 1. McGraw-Hill, New York.
- CHERRIE, G. K. 1896. Contribution to the ornithology of San Domingo. Field Col. Mus. Ornithol. Ser., Vol. 1:1–26.
- CHRISTY, C. 1897. Field-notes on the birds of the island of San Domingo. Ibis 3:317–343.
- CORY, C. B. 1883. Descriptions of three new species of birds from Santo Domingo. Q. J. Boston Zool. Soc. 2:45–46.

- CORY, C. B. 1885. The birds of Haiti and San Domingo. Estes and Lauriat, Boston.
- CRAIGHEAD, J. J., AND F. C. CRAIGHEAD, JR. 1956. Hawks, owls, and wildlife. Stackpole, Harrisburg, PA.
- DANFORTH, S. T. 1929. Notes on the birds of Hispaniola. *Auk* 46:358-375.
- DIAMOND, J. M. 1980. Patchy distributions of tropical birds, p. 57-74. In Soulé, M. E., and B. A. Wilcox [eds.], *Conservation biology: an evolutionary-ecological perspective*. Sinauer Assoc., Sunderland, MA.
- DOD, A. S. DE. 1978. Aves de la República Dominicana. Museo Nacional Historia Natural, Santo Domingo.
- FRIEDMANN, H. 1950. The birds of North and Middle America. Part XI. U.S. Natl. Mus. Bull. 50.
- HARRISON, H. H. 1975. A field guide to birds' nests. Houghton Mifflin, Boston.
- HELLMAYR, C. E., AND B. CONOVER. 1949. Catalogue of birds of the Americas and the adjacent islands. Part 1, no. 4. *Field Mus. Nat. Hist., Zool. Ser.* 13:1-358.
- JOHNSON, N. K., AND H. J. PEETERS. 1963. The systematic position of certain hawks in the genus *Buteo*. *Auk* 80:417-446.
- LITTLE, E. L., R. O. WOODBURY, AND F. H. WADSWORTH. 1974. Trees of Puerto Rico and the Virgin Islands, Vol. 2. U.S. Dep. Agric., Agric. Handbook No. 449.
- MAYR, E., AND G. W. COTTRELL [EDS.] 1979. Check-list of birds of the world. Vol. 1, second ed. Museum of Comparative Zoology, Cambridge, MA.
- MONROE, W. H. 1966. Formation of tropical karst topography by limestone solution and reprecipitation. *Caribb. J. Sci.* 6:1-7.
- NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.
- PETERS, J. L. 1917. Birds from the northern coast of the Dominican Republic. *Bull. Mus. Comp. Zool.* 61:391-426.
- PETERS, J. L. 1931. Check-list of birds of the world. Vol. 1. Harvard Univ. Press, Cambridge, MA.
- RIDGWAY, R. 1925. Diagnosis of a new genus of Buteonine hawk (*Coryornis* gen. nov.). *Auk* 42:585.
- ROBBINS, C. S., B. BRUUN, AND H. S. ZIM. 1966. Birds of North America. Western Publ. Co., Racine, WI.
- SNYDER, N. F. R. 1975. Breeding biology of Swallow-tailed Kites in Florida. *Living Bird* 13:73-97.
- SNYDER, N. F. R., AND H. A. SNYDER. 1973. Experimental study of feeding rates of nestling Cooper's Hawks. *Condor* 75:461-463.
- SNYDER, N. F. R., AND J. W. WILEY. 1976. Sexual size dimorphism in hawks and owls of North America. A.O.U. Ornithol. Monogr. No. 20.
- STORER, R. W. 1966. Sexual dimorphism and food habits in three North American accipiters. *Auk* 83:423-436.
- TRISTRAM, H. B. 1889. Catalogue of a collection of birds belonging to H. B. Tristram, D.D., LL.D., F.R.S. Privately Printed.
- TUBBS, C. R. 1974. The buzzard. David and Charles, North Pomfret, VT.
- VERRILL, A. E., AND A. H. VERRILL. 1909. Notes on the birds of San Domingo, with a list of the species, including a new hawk. *Proc. Acad. Nat. Sci. Phila.* 61:352-366.
- WETMORE, A. 1932. Birds collected in Cuba and Haiti by the Parish-Smithsonian Expedition of 1930. *Proc. U.S. Natl. Mus.* 81:1-40.
- WETMORE, A., AND F. C. LINCOLN. 1934. Additional notes on the birds of Haiti and the Dominican Republic. *Proc. U.S. Natl. Mus.* 82:1-68.
- WETMORE, A., AND B. H. SWALES. 1931. The birds of Haiti and the Dominican Republic. U.S. Natl. Mus. Bull. 155.

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