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RAPTOR ROAD SURVEYS IN SOUTH AMERICA

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Abstract.—Twenty-six (23 traveling and three point) raptor roadside surveys were conducted during a 29,000 km expedition through nine nations of South America. During roadside surveys, we tallied 41 of the 87 (47%) diurnal raptor species (including vultures) that occur in South America. The number of species observed per route varied from 17 in the wet savanna of Venezuela to only two species recorded in the harsh Atacama Desert and the dry montane grasslands of Chile and Peru. Raptor density (non-vultures) varied from 1 per 67 km in the Atacama Desert to more than 1 per km in agricultural areas where caracaras and other species that utilize disturbed habitats were common. Responses of raptor communities to deforestation and other habitat disturbances are discussed. While certain habitat modifications potentially increase raptor abundance and diversity, the alteration of primary forest has the opposite effect, at least on diversity.

Indagaciones sobre aves raptoras, hechas en carreteras de América del Sur

Extracto.—26 (23 viajando y 3 estacionarias) ispecciones de aves raptoras, a lo largo de una carretera, fueron realizadas durante una expedición de 29,000 km a través de 9 naciones de América del Sur. Durante las inspecciones de carretera hemos contado 41 de las 87 (47%) especies raptoras diurnas (incluyendo buitres) que se encuentran en América del Sur. El número de las especies observadas en cada ruta varió de 17 en las praderas lluviosas de Venezuela, hasta solo 2 especies registradas en el desierto de Atacama y las secas lomas de Chile y Perú. La densidad de aves raptoras (no buitres) varió desde 1 por 67 km en el desierto de Atacama, hasta más de 1 por km en áreas agrícolas, donde eran comunes las caracaras y otras especies que utilizan habitats alterados. Se discuten los resultados de la deforestación y otras alteraciones del habitat en las comunidades de aves raptoras. Mientras que ciertas modificaciones del habitat potencialmente aumentan la abundancia y diversidad de aves raptoras, la alteración de florestas naturales tiene el efecto opuesto, a lo menos en la diversidad.

[Traducción de Eudoxio Paredes-Ruiz]

Raptor survey methods have been reviewed by Fuller and Mosher (1981, 1987). Although the limitations and biases inherent in the road counts are well known (Verner 1985, Millsap and LeFranc 1988), road surveys unfortunately are the only practical means now available for rapidly assessing raptor distribution and, to a degree, abundance over large areas. Roadside surveys have been used to determine species composition and to estimate relative abundance for diurnal raptor communities in Africa (Rowan 1964, Cade 1969), Europe (Meyburg 1973, Saurola 1976), North America (Nice 1934, Craighead and Craighead 1954, Enderson 1965, Johnson and Enderson 1972, Woffinden and Murphy 1977, and many others), and, to a very limited degree, in Latin America (Reichholf 1974, Ellis et al. 1983, Albuquerque et al. 1986, Wotzkow and Wiley 1988).

Using road counts and point counts, we surveyed diurnal raptors in nine South American nations and related both species composition and relative abundance to gross features of the habitats.

Methods

The expedition was conducted from 12 January through 23 April 1979. During this time, we established 23 roadside survey routes and two point count locations (Fig. 1). Abbreviated descriptions of survey locations, habitat types, and other salient features are presented in Table 1. Descriptions of the physical and biotic characteristics of the survey routes and photographs of survey route boundaries are available from the senior author.

To facilitate relocating each route in future surveys,

Table 1. Descriptions of South American raptor counts in 1979.

No.[a]	Nation: Zone	Length (km)	Date Day/Mo.	Time Start	Habitat Type[b]	Disturbance[c]
1	Venezuela: NC	90	26.01	0645	VDFor (montane), OFor (coastal swamp), AgC	Low–Medium
2	Venezuela: NC	81	29.01	1615	DSav, OSav	Low
3	Venezuela: NC	113	30.01	0910	DSav, OSav, AgP	Medium
4	Venezuela: NE	80	31.01	1355	OFor, VDFor (montane), VDFor (lowland)	Medium
5	Venezuela: E	96	01.02	1130	DFor (montane)	Low–Medium
6	Brazil: N	119	03.02	0835	VDFor & SecG (road swath)	Low–Medium
7	Brazil: N	119	05.02	0722	VDFor & SecG (road swath)	Medium
8	Brazil: WC	144	13.02	0840	D-VDFor & AgC (road swath)	Medium
9	Brazil: SC	124	24.02	1240	OSav & Wd, AgC & AgP	Medium
10	Brazil: S	131	28.02	0825	Wd, AgC	Medium–High
11	Paraguay: S	111	01.03	1050	Wd, AgC	High
12	Argentina: NE	76	03.03	0805	OSav & RGFor	Low
13	Argentina: SE	150	07.03	0945	AgC & AgP, DScrub	High
14	Argentina: S	178	08.03	0920	DScrub	Low
15	Argentina: S	162	12.03	0745	DFor, DScrub	Low
16	Argentina: S	77	12.03	1445	DScrub	Low
17	Argentina: SE	169	16.03	1000	DScrub	Low
18	Chile: C	84	21.03	1100	AgC & AgP	High
19	Chile: NC	134	23.03	1000	SDes	Low
20	Peru: S	202	31.03	0715	MScrub, SDes	Low
21	Ecuador: N	70	07.04	0655	MScrub, OFor, RGFor, AgC	Medium
22	Venezuela: W	79	13.04	1035	DSav, RGFor, AgP, OSav	Medium
23	Venezuela: N	116	15.04	0655	OSav, AgP	Medium
A	Venezuela: NC	N.A.	28.01	1050–1150	VDFor (montane), same location as C	Low
B	Venezuela: NC	N.A.	31.01	1535–1805	OSav (formerly DSav)	Medium–High
C	Venezuela: NC	N.A.	19.04	0835–0935	VDFor (montane), same location as A	Low

[a] Count type: Road Count (1–23), Point Count (A–C).

[b] Habitat type abbreviations and overstory canopy cover (oscc) classes: Desert (Des), Semi-Desert (SDes), Desert Scrub (DScrub), and Montane Scrub (MScrub) 0–5% oscc; Open Savanna (OSav) 5–20% oscc; Dense Savanna (DSav) 20–50% oscc; Open Forest (OFor) 50–70% oscc, Dense Forest (DFor) 70–90% oscc; Very Dense Forest (VDFor) 90–100% oscc; Second Growth (SecG), Woodlots (Wd), Agricultural Pastures (AgP), Agricultural Croplands (AgC), Riparian Gallery Forest (RGFor).

[c] A gross evaluation of the degree of alteration of habitat from pristine form.

where practical, we chose distinctive topographic features and road junctions to define beginning and ending points of survey routes. We located routes in one habitat type, or in a uniform interspersion of two habitat types. The imposition of these parameters resulted in transects of varying lengths. We also attempted to limit surveys to morning hours (five exceptions) during fair, calm weather. Driving speeds were 70–80 km/hr on paved roads and 50 km/hr or less on dirt roads, although road conditions were occasionally too variable to permit a uniform driving speed.

Roadside counts (a form of Verner's 1985 line transects without distance estimates) were conducted by two experienced observers; a driver and a record keeper, both in the front seat of a Toyota Land Cruiser. A third person acted as a recorder for some of the routes. We identified and tallied most raptors while we were in transit. Occasionally, we stopped to confirm identification of an individual bird; raptors detected during these stops were not tallied unless, in our judgment, they would have been noted during uninterrupted travel. Although the new world vultures (family Cathartidae) are not now considered members of Order Falconiformes (Rea 1983), we included them in our counts. Along many survey routes, however, vultures were so abundant that to count them all would have diverted our attention inordinately from our search for true raptors. Therefore, only the first 20 individuals of the common vulture species were counted. Only rarely did we identify and tally raptors further than 1 km from the road.

Three point counts (a form of Verner's 1985 point counts

Table 2. Raptor count summary, South America, 1979.

	Road Count												
Species	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13
Cathartes aura	>20	>20	>20	>20	11	>20	3	1	5			3	
Cathartes burrovianus												2	
Cathartes melambrotus								12					
Cathartes b. or *m.*								13					
Cathartes sp.				2	3			>20	7		2	21	
Coragyps atratus	75	>20	>20	4		>20		>20	>20	>20	>20	>100	
Sarcoramphus papa	1					1			1				
Vultur gryphus													
Pandion haliaetus						1							
Chondrohierax uncinatus													
Elanoides forficatus						3	1	2		1			
Gampsonyx swainsonii						1			1				
Elanus caeruleus (leucurus)		7										1	
Rostrhamus sociabilis												6	
Ictinia plumbea	1				6	8		3					
Geranospiza caerulescens		1										1	
Circus cinereus													1
Circus sp.													1
Accipiter sp.					1		1						
Leucopternis albicollis							1						
Buteogallus anthracinus	5												
Buteogallus urubitinga	1		1			3	4					1	
Heterospizias meridionalis		1	1	2		1			3	1		14	
Busarellus nigricollis								1				1	
Geranoaetus melanoleucus													

Table 2. Continued.

SPECIES	ROAD COUNT												
	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13
Parabuteo unicinctus		3											
Buteo nitidus (Asturina nitida)					1	1		7					
Buteo magnirostris	2	3	2			15		3	2	1		20	
Buteo platypterus	1												
Buteo brachyurus										1			
Buteo albicaudatus			1	3								1	
Buteo polyosoma													14
Buteo sp.				1			1						
Spizaetus tyrannus													
Daptrius ater						3	2	4					
Daptrius americanus					6			2					
Polyborus plancus		9	26	3						4		20	2
Milvago chimango												5	15
Milvago chimachima	7	11	7			1			5	1	3	6	
Polyborinae sp.	1											1	
Herpetotheres cachinnans		1				1			1				
Falco sparverius			1	1					17	29	27	8	26
Falco rufigularis					1	7	2	19				1	
Falco femoralis									1				
Falco peregrinus													
Falconiformes sp.		1	4					2					
Total Species (non-vult. only)	9 (6)	10 (8)	9 (7)	6 (4)	6 (5)	15 (12)	8 (7)	11 (8)	10 (7)	8 (7)	4 (2)	16 (13)	5 (5)
Total Indiv.: non-vultures	18	37	43	10	15	45	12	43	30	38	30	86	59
Diversity: non-vultures	0.699	0.789	0.570	0.654	0.554	0.874	0.778	0.766	0.596	0.400	0.141	0.910	0.566
Abundance: km/bird, non-vult.	5.0	2.19	2.63	8.0	6.4	2.64	9.92	3.35	4.13	3.45	3.70	0.88	2.54

Table 2. Continued.

Species	Road Count										Point Count		
	RC14	RC15	RC16	RC17	RC18	RC19	RC20	RC21	RC22	RC23	PCA	PCB	PCC
Cathartes aura						1			>20	10	>20		4
Cathartes burrovianus									1	2			
Cathartes melambrotus													
Cathartes b. or *m.*													
Cathartes sp.										16			
Coragyps atratus								9	>20	>20	>20		3
Sarcoramphus papa									3		2		
Vultur gryphus							1						
Pandion haliaetus									3	3			
Chondrohierax uncinatus													1
Elanoides forficatus													
Gampsonyx swainsonii									3	4			
Elanus caeruleus (leucurus)										2			
Rostrhamus sociabilis										9			
Ictinia plumbea									6				
Geranospiza caerulescens													
Circus cinereus		1	1	1									
Circus sp.													
Accipiter sp.													
Leucopternis albicollis													1
Buteogallus anthracinus													
Buteogallus urubitinga													1
Heterospizias meridionalis									8	3		14	
Busarellus nigricollis									2				
Geranoaetus melanoleucus		7		24									

Table 2. Continued.

SPECIES	ROAD COUNT										POINT COUNT		
	RC14	RC15	RC16	RC17	RC18	RC19	RC20	RC21	RC22	RC23	PCA	PCB	PCC
Parabuteo unicinctus													
Buteo nitidus (Asturina nitida)									5				
Buteo magnirostris									11	4			3
Buteo platypterus													
Buteo brachyurus													1
Buteo albicaudatus										3		3	
Buteo polyosoma	15	1	2	7									
Buteo sp.													
Spizaetus tyrannus											2		1
Daptrius ater									3				
Daptrius americanus													
Polyborus plancus		131		6					2	8		14	
Milvago chimango	19	36		129	113								
Milvago chimachima									9	9		2	
Polyborinae sp.		3											
Herpetotheres cachinnans									1			2	
Falco sparverius	9	13	1	27	16	8	3	5	8	2		1	
Falco rufigularis												2	
Falco femoralis		2		1					1	1		5	
Falco peregrinus			1										
Falconiformes sp.										1			2
Total Species (non-vult. only)	3 (3)	7 (7)	4 (4)	7 (7)	2 (2)	2 (1)	2 (1)	2 (1)	17 (13)	14 (11)	4 (1)	8 (8)	8 (6)
Total Indiv.: non-vultures	43	194	5	195	129	8	3	5	62	49	2	43	10
Diversity: non-vultures	0.458	0.454	0.579	0.471	0.163	0	0	0	1.020	0.982	0	0.731	0.797
Abundance: km/bird, non-vult.	4.14	0.84	15.40	0.87	0.65	16.75	67.33	14.00	1.27	2.37	—	—	—

Figure 1. South America, showing count locations and route of travel.

without distance estimation) were conducted to evaluate use of a stationary watch in finding and counting raptors and also for comparison with traveling counts. For two of these point counts, an elevated ridge was chosen to afford maximum visual advantage. The point counts were conducted in fair, calm weather. Two observers equipped with 7 × 50 binoculars and a 20× spotting scope counted all raptors seen during at least a 60-min observation period.

Raptor abundance for each survey route was calculated as the number of km per observed individual (excluding vultures). A gross measure of raptor diversity was obtained using the Shannon diversity index (Zar 1974). Because various species of raptors differ in observability in some habitat types and a single species is often more detectable in more open habitats than in forest, these indices should be used with caution.

RESULTS AND DISCUSSION

Raptor diversity and abundance varied greatly among survey routes. The greatest variety (17 species) and the highest species diversity index ($H' = 1.020$) were found in a region of mixed riparian gallery forests, savanna, and pastures in western Venezuela. By contrast, only two species (present in low densities) were found in the Atacama Desert and the high elevation montane scrub habitats of Peru and Ecuador. In other, less harsh environments, raptor density typically varied inversely with raptor diversity. Raptors were most abundant in modified or open habitats and in association with human activities such as animal husbandry. In such areas, vultures and Crested Caracaras (*Polyborus plancus*) predominated. For example, a Chilean survey route (No. 18, Table 2) through cropland and pasture habitat had the greatest concentration of raptors observed (0.65 km per individual), but only two species were represented (diversity index $H' = 0.163$). Similarly, certain raptors were observed in dense concentrations in agricultural habitats in Venezuela, Paraguay, Brazil, and Peru. Surveys with high raptor variety and abundance were typically in mixed habitat, ranging from highly stratified dense forest to relatively open savannas or second growth forest.

Results of the three point counts also varied greatly. Eight species were recorded on point counts B and C, but only two species on point count A, although A and C were both in dense montane forests. Three problems were encountered for point counts. First, we found it difficult to identify raptors readily observed at distances greater than 1 km. Second, we could not accurately tally the total number of individuals because birds often repeatedly soared through the observation zone. Finally, it proved impractical to observe birds in dense forest. Because of these difficulties, we de-emphasized point counts in favor of road surveys.

Roadside raptor surveys proved efficient in detecting and counting common raptors in non-forested habitats. For all counts combined, we recorded 41 (47%) of the 87 diurnal raptor species that occur in South America. This included all of the Cathartid vultures and most other species that soar regularly.

Raptors of the deep forest are much more difficult to observe and our roadside counts in forest habitats certainly underestimate both diversity and abundance of raptor communities. Most of the raptors counted on routes through rainforest habitats in Venezuela and Brazil (RC 5–8) also normally occur in secondary forest habitat and were probably seen because of their association with the secondary growth forest of the roadside swath. By contrast, many species of obligate forest raptors (e.g., *Harpia, Morphnus, Micrastur*) were never recorded during counts nor seen while traveling between survey locations. We suggest that occurrence and abundance estimates for these will ultimately come from species-specific counting techniques such as listening to early morning calls or mark and recapture methods used for forest falcons (*Micrastur*; Klein and Bierregaard 1988). Other species will require mist nets, radiotelemetry, systematic searches, and other more time-consuming methods (Fuller and Mosher 1981, 1987, Thiollay 1989, Vannini 1989).

As primary forests are converted to open agricultural areas, forest-dwelling raptors, especially the large eagles, disappear while migrants and savanna-dwelling species increase (Harris 1984). In southern Brazil, Reichholf (1974) found that as forests were cut and replaced by agricultural and grazing lands, the diversity of highly rapacious species decreased while scavengers (i.e., vultures and caracaras) increased. Thiollay (1985) reported similar changes in raptor diversity and abundance in a survey of seven habitat classes in the southern Ivory Coast of Africa and four habitat classes in the neotropics. By contrast, in arid regions, the introduction of irrigation may benefit some raptors. Fields and croplands provide foraging areas; trees provide nesting and roosting habitat. Sheep and cattle ranching can also result in local concentrations of caracaras and other scavengers that forage on carcasses and offal (e.g., road counts RC3, RC15, and RC17–18, Table 2).

CONCLUSIONS AND SUMMARY

Our survey work, and the studies of Reichholf (1974) and others, demonstrate the feasibility of roadside counts in estimating relative abundance and determining species composition of diurnal raptor communities in relatively open neotropical habitats. The efficiency of roadside surveys is, however, extremely limited for owls (we detected only one species) and for other raptors that live primarily beneath the forest canopy.

Our results suggest that total raptor diversity and relative abundance were frequently inversely correlated. The most diverse raptor species assemblages observed during roadside counts were in mixed savanna and dense forest habitats. By contrast, the greatest number of scavengers were found in association with agricultural fields and rangelands. In addition, while diversity of forest raptor communities often decreases as natural habitats are modified, agricultural development in arid environments tends to increase primary productivity, biotic diversity, and food supply. These changes, in turn, result in local increases in raptor abundance and diversity. Such localized increases, however, fail to compensate for the loss of raptor diversity that is the direct result of widespread neotropical deforestation.

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