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Drinking, vigilance, and group size in White-tipped Doves and Common Ground-Doves in Costa Rica.—Animals are vigilant for predators because it reduces their chance of being preyed on, but vigilance is costly because it takes time away from other important activities (Bertram 1980, Krebs and Davies 1987, Cords 1990). Researchers have directed their attention primarily toward vigilance while potential prey are foraging (Page and Whitacre 1975, Caracao 1979, Hart and Lendrem 1984). Such vigilance decreases risk of predation (Lazarus 1978, 1979), kleptoparasitism (Thompson and Lendrem 1985), and human disturbance (Knight and Knight 1986). In general, vigilance of individuals decreases with group size (Lazarus 1979, Abramson 1979, Caracao 1979), indicating that this chore can be shared among group members.

Study area and methods.—I examined vigilance behavior of White-tipped Doves (*Leptotila verreauxi*) and Common (*Columbina passerina*) Ground-Doves at Palo Verde National Wildlife Refuge in Northwestern Costa Rica in March 1990. Palo Verde is a tropical lowland deciduous forest adjacent to marshes and the Tempisque River. All observations were made at an abandoned, concrete cattle trough with two large concrete tanks (3 × 8 m), an entering stream, and a wet area draining the troughs. The depth of the troughs was sufficient to ensure water throughout the year. While observing doves I remained quietly in a car or blind. Observations were made on individual doves from 06:00 to 20:00 h, although few doves were present after 15:00 or 16:00 h. I observed doves at the waterhole for 42 h. Whenever a flock of doves arrived, I selected the first dove to arrive and began observing it for its first two drinking bouts. I then switched to its nearest neighbor, repeating the process until I had observed one to three doves per flock. Because the flocks were changing rapidly and group size shifted frequently, I waited at least 10 min between recording data on flock members. Flock size was recorded when a flock first appeared and at 1 min intervals thereafter.

Data recorded on each dove included: date, time of day, species, group size, and lengths (in sec) for the first and second drinking bout. Drinking bout was defined as the time from when the dove first began drinking until it ceased drinking and raised its head to look around. Doves are capable of swallowing while drinking, and drinking bouts varied from one to 13 seconds.

I tested the null hypothesis that there are no differences in drinking bout length (and thus vigilance) as a function of species or flock size. I used Kruskal-Wallis χ^2 tests to distinguish species differences in the variables, and General Linear Models Procedure (SAS 1985) to determine the contribution of the independent variables to differences in length of drinking bouts (after log-transforming the data).

Results.—The waterhole was frequented by many raptors. For example I saw a Roadside Hawk (*Buteo magnirostris*) kill a Common Ground-Dove, and a Gray Hawk (*B. nitidus*) and a Collared Forest-Falcon (*Micrastur semitorquatus*) make passes at doves at the waterhole. The mammalian predators were a tayra (*Eira varma*) and coati (*Nasica nasua*).

I observed 293 White-tipped Doves and 93 Common Ground-Doves drinking at the waterhole. The best model (SAS Institute 1982) explained 49% of the variation in the length of initial drinking bouts ($F = 118$, df = 3,372) by group size ($F = 319$, $P < 0.0001$), species ($F = 24.2$, $P < 0.0001$), and time of day ($F = 11.2$, $P < 0.0009$). The number of the flock I observed did not enter the model, thus the behaviors of individuals observed within a flock were independent of each other. The smaller ground-doves drank when in smaller groups, but had longer uninterrupted initial drinking bouts than the White-tipped Doves (Table 1). The second drinking bout was significantly shorter in ground-doves compared to White-tipped Doves (Table 1).

TABLE 1
GROUP SIZE AND LENGTH OF DRINKING BOUTS IN DOVES IN COSTA RICA

	White-tipped Dove	Common Ground Dove	χ^2 (*P*)
Number of doves	293	93	
Mean time of day (h)[a]	0952 ± 12.6	1108 ± 12.4	39.1 (0.0001)
Group size[a]	5.9 ± 0.2	7.9 ± 0.4	22.6 (0.0001)
Time for initial drinking bout[a]	4.2 ± 0.1	5.4 ± 0.3	9.6 (0.001)
Time for second drinking bout[a]	4.2 ± 0.5	2.5 ± 0.5	8.7 (0.001)
Correlation of group size and initial drinking bout[b]	0.46 (0.001)	0.60 (0.0001)	
Correlation of time of day and initial drinking bout[b]	NS	0.24 (0.002)	

[a] Given are means ± SE.
[b] Given are Kendall tau correlation (level of significance, NS = not significant).

For both species there was a significant, positive correlation between group size and length of the first drinking bout (Table 1). Time of day was positively correlated with length of the initial drinking bout only for Common Ground-Doves. For both species the mean length of the initial drinking bout increased with group size (Table 2).

White-tipped Doves often drank in groups of 4–5 (max = 16), whereas ground-doves drank in groups of four or more (max = 18). No ground-doves came to the waterhole to drink solitarily.

Discussion.—In the dry deciduous forests of Costa Rica water with cover is limited to a few scattered waterholes. Birds and mammals concentrate near them, and come to drink throughout the day. Just as prey species concentrate near water, so also do predators who are drawn to the waterhole not only for the available prey but for water. Since the waterhole is within the forest, there is cover adjacent to and over the waterhole. The vegetation cover not only provides protection for drinking animals, but it provides hiding places for predators. The hawks I observed attacking doves all waited silently and quietly in the trees for several minutes after the arrival of a flock before making a pass at the doves.

Although the waterhole at Palo Verde provides necessary water for the doves, it also represents a clearly demonstrated, dangerous situation. Since the location of a waterhole is known, it provides a more dangerous threat than foraging because the doves cannot shift locations (as they can with feeding sites). Thus vigilance is crucial to their survival.

The doves at Palo Verde usually drank in groups; less than 4% of the doves drank solitarily, and these were all the larger White-tipped Doves. Given the size range of the raptor predators, the smaller Common Ground-Doves could be taken by any of the raptors, whereas the larger White-tipped Doves could easily fall prey only to the Collared Forest-Falcon (Brown and Amadon 1968).

The doves drink with their heads bowed, making them vulnerable while drinking. Drinking bout time increased with group size, suggesting that individual vigilance behavior decreased. Both species showed a dramatic increase in drinking bout length (decrease in vigilance) with group size. The data from Palo Verde indicate that predators are common and prey on the doves, and that the doves respond by being vigilant. Vigilance for individuals decreased with increasing group size.

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TABLE 2

MEAN TIME FOR INITIAL DRINKING BOUTS FOR DOVES IN COSTA RICA

Group size	White-tipped Dove			Common Ground-Dove		
	N (Flocks)	N (Individuals)	Time (Sec)	N (Flocks)	N (Individuals)	Time (Sec)
1	14	14	1.4 ± 0.1	0	0	—
2	15	23	2.1 ± 0.2	4	4	1.3 ± 0.2
3	26	35	2.6 ± 0.2	6	7	2.2 ± 0.2
4	34	43	3.2 ± 0.3	7	10	2.9 ± 0.2
5	41	59	4.2 ± 0.2	12	16	4.3 ± 0.3
6	26	42	4.6 ± 0.2	13	15	5.3 ± 0.4
7	18	24	4.9 ± 0.3	14	16	5.6 ± 0.3
>8	11	33	7.9 ± 0.5	16	26	8.4 ± 0.6

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