turned their eggs at approximately the same rate as the similarly-sized Mallard (*Anas platyrhynchos*) (Caldwell and Cornwell 1975). Thus, the nesting behavior of this species appears to conform to the general patterns established for waterfowl (Afton and Paulus 1992).

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Sleeping and vigilance in the White-faced Whistling-Duck.—Several hypotheses have been proposed to explain the function of sleep in birds (Amlaner and Ball 1983). Of particular interest is the trade-off between anti-predator vigilance and sleep. Short periods of eye opening, referred to as "peeks" (Lendrem 1983), regularly interrupt sleep in several species of birds. Birds have elevated arousal thresholds when peeking (Amlaner and McFarland 1981) and are able to move quickly if threatened by a predator (Lendrem 1983, 1984). Peeking behavior, therefore, has been considered to be an analogue to scanning behavior in active birds (Lendrem 1983). Like scanning, peeking has been reported to decrease with increasing group size of sleeping birds (Lendrem 1984). However, detailed field studies of sleeping-vigilance trade-off in birds are scarce. In this paper, we consider the effect of position in the group and time of day on vigilance during sleeping in the White-faced Whistling-Duck (*Dendrocygna viduata*).

The White-faced Whistling-Duck is a medium-sized duck found in West Africa and South America. Its feeding ecology and behavior were described by Roux et al. (1976), Douthwaite (1977) and Clark (1978). During the day, White-faced Whistling-Ducks devote most of their time to sleep, vigilance and comfort activities (Roux et al. 1976). Compared to other duck species wintering in West Africa, they appear to be particularly sensitive to disturbance by potential predators (Roux et al. 1978). Data were collected from 8:00 h to 17:00 h (local time) on two consecutive days of intensive observation at Goram in the Djoudj National Park, Senegal, West Africa, in April 1993. Vigilance rates were recorded for randomly selected individuals sleeping in a flock ranging from 300 to 496 (mean group size = 481). Sleeping birds that were floating on the water were observed with a 20× telescope. Two sleeping postures (Amlaner and Ball 1983) were used by White-faced Whistling-Ducks. In the sleep posture, the bill was pointed backwards under the scapulars. In the rest-sleep posture, the bird was floating with its head up and bill pointing forward. Focal birds were randomly selected. The observer (M.G.-C.) in a blind attempted to follow a focal bird for one minute, recording on a tape recorder the time of day, flock size, number of peeks, sleeping posture and position of the bird in the group. Males and females are alike and therefore were not distinguished in the wild. Ducks were considered central if they were part of the central 80% of the aggregation. Recording was sometimes interrupted when the bird awoke before the completion of the observation. We ran stepwise multiple regression analyses (Sokal and Rohlf 1981) to regress peeking rates (number of peeks per minute) on first to fourth degree terms of flock size and time of the day. A "predictor" equation was obtained by entering variables into the regression equation according to their *F*-to-enter values, provided they explained a significant portion of the observed variance in the dependent variable (peeking rate). We used an *F* statistic and a criterion of $P < 0.05$ in assessing the contribution of each independent variable to the total variance. The residuals of the multiple regression were used to study the effect of sleeping posture and position in the group on vigilance, using two-way ANOVAS (Sokal and Rohlf 1981).

The data set consisted of 72 focal observations. There was no relationship between peeking rate and the duration of a focal observation, i.e., observation time did not bias the results. Peeking rates of White-faced Whistling-Ducks were normally distributed (mean peeking rate: 18.4 ± 8.1 peeks/min). Peeking rates in White-faced Whistling-Ducks varied significantly according to time of day (Fig. 1). Only the linear term of time of day was retained in the multiple regression. There was no detectable effect of group size on peeking rates in the range of observed flock sizes. Sleeping posture did not influence peeking rate ($F_{1,68} = 0.516$, $P > 0.05$) nor did position within the group ($F_{1,68} = 0.072$, $P > 0.05$).

The observed high susceptibility of White-faced Whistling-Ducks towards predator disturbance (Roux et al. 1978) is here confirmed by the elevated peeking rates, compared to other duck species (Lendrem 1983; Cézilly et al., unpubl. data). The absence of a significant effect of group size on peeking rates may be due to the limited amount of variation in flock size within this study. Only large groups of White-faced Whistling-Ducks were observed, and it is likely that the decrease in vigilance levels between group sizes of 300 and 400 would be quite small, if any exists.

Time of day can influence vigilance in several ways. Lima (1988) showed that vigilance in Dark-eyed Juncos (*Junco hyemalis*) is high in the early morning because of the increased risk of predation when foraging in dim light. McNamara and Houston (1986) have suggested that vigilance rates may vary according to the time of day in relation to energetic requirements. Temperature is likely to correlate with time of the day, and variation in temperature has been shown to affect the use of sleeping postures in Black-billed Magpies (*Pica pica,* Reebs 1986). However, daily temperature showed little variation at the time of data collection in the present study. White-faced Whistling-Ducks forage mainly two hours after dawn

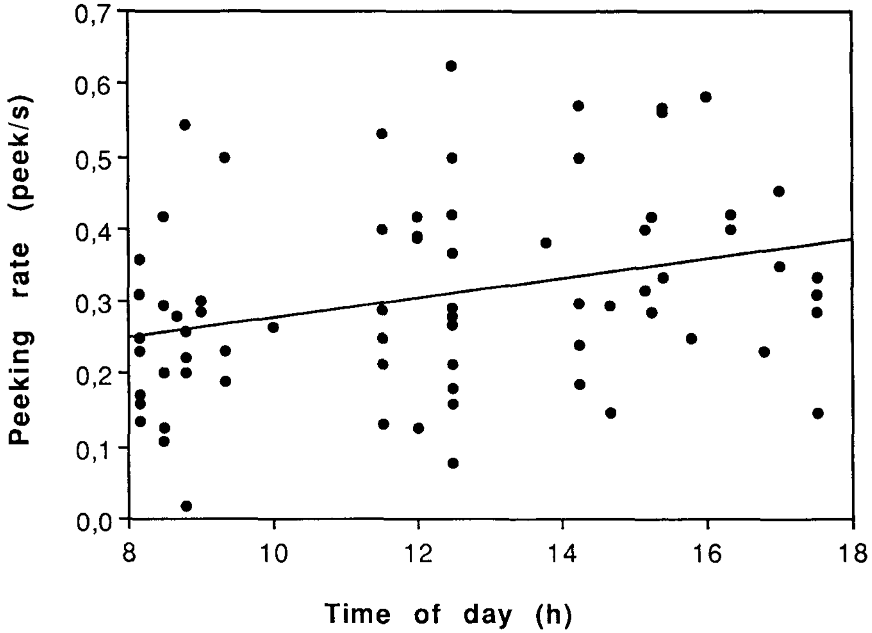

FIG. 1. Variation in the peeking rate of White-faced Whistling-Ducks according to time of day ($r = 0.31$, $N = 72$, $P < 0.05$).

and before dusk (Brown et al. 1982). The observed slight, yet significant, increase in peeking rate from early morning to late afternoon might therefore reflect a progress in the level of arousal between two peaks of activity.

Various postures can be used by birds while sleeping (Amlaner and Ball 1983). It is however not clear whether different postures represent different arousal thresholds (Amlaner and McFarland 1981). Observations of Herring Gulls (*Larus argentatus*) (Amlaner and McFarland 1981) showed that peeking was less frequent during the sleep posture than during the rest-sleep posture. This was not the case in the White-faced Whistling-Ducks where the two postures appeared to be used equally. Among 72 randomly selected individuals 32 birds were in the sleep posture and 40 in the rest-sleep posture (binomial test, $z = 0.83$, $P = 0.203$).

Birds on peripheries of foraging flocks have been previously shown to spend more time scanning the environment as compared to other group members (Jennings and Evans 1980, Inglis and Lazarus 1981, Petit and Bildstein 1987). This was not the case in White-faced Whistling-Ducks. Westcott and Cockburn (1988) also found that position in the flock did not influence scanning rate or total time spent scanning in the Red-rumped Parrot (*Psephotus haematonotus*). They interpreted this result in relation to foraging constraints and the need to monitor the behavior of conspecifics. In the case of the White-faced Whistling-Duck, the absence of edge effect may be explained in relation to the type of predator attack. Individuals in the periphery of flocks would be particularly exposed to predation in the case of a ground predator. In the case of an aerial predator, however, it is less clear that birds in the center of flocks would experience higher safety.

Sleeping-vigilance trade-off in birds is likely to be affected by a variety of environmental and social factors (Elgar 1989). The present study suggests that its relationship with other components of circadian activity deserves further attention.

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