(1982) found that the percentage of successful pecks in flocks of birds was greater than for solitary birds; however, our results showed that solitary birds were more efficient than those in larger groups. This effect could be caused by direct interference in larger groups, or by a change in prey behavior with increases in the number of predators (K. Bildstein, pers. comm.).

Acknowledgments.—The senior author wishes to express his warmest appreciation for the opportunity to work at the Tour du Valat. The director, Dr. Luc Hoffman, his family, and the staff at the Station made the experience most rewarding in many ways. We also appreciate the support of all the valuable Earthwatch project participants. J. Wallace and R. Lansdown provided field assistance, logistical support, and identified the prey organisms throughout the project. K. Bildstein, S. Gregory, H. Ohlendorf, J. Rodgers, D. White, and an anonymous reviewer provided constructive comments on an earlier draft. C. Bunck and B. Dowell assisted in statistical analyses and K. Hall typed the manuscript.—R. MICHAEL ERWIN, *U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708*; HEINZ HAFNER AND PATRICK DUGAN, *Station Biologique de la Tour du Valat, le Sambuc, 13200 Arles, France.* (Present address of PD: *International Union for the Conservation of Nature, CH-1196 Gland, Switzerland*). *Accepted 14 May 1985.*

Wilson Bull., 97(4), 1985, pp. 538–541

Interactions between Great Blue Herons and gulls.—Previous reports of interactions between Great Blue Herons (*Ardea herodias*) or Gray Herons (*A. cinerea*) and gulls (*Larus* spp.) have been largely anecdotal, and they indicate that the interactions are generally immediately selfish. For instance, interactions have included food piracy (Lowe, The Heron, Collins, London, England, 1954; Dummigan, Br. Birds 70:117, 1977; Willard, Condor 79: 462–470, 1977; Quinney et al., Can. Field-Nat. 95:205–206, 1981), mutual cueing to each other's feeding flocks (Marshall, Br. Birds 54:202, 1961), or gulls mobbing predatory Gray Herons in gull colonies (Axell, Br. Birds 49:193–212, 1956). There have, however, also been several accounts of gulls attacking Great Blue Herons (Imhof, Wilson Bull. 62:210, 1950) or Gray Herons (Lowe 1954:109–110; Birkhead, Br. Birds 66:147–156, 1973), where an immediate purpose was not evident.

Here, I examine the interactions of Great Blue Herons and various gulls, describe interaction types, determine interaction frequencies, and ascertain if all interactions are immediately purposeful.

Study area and methods.—All observations were at the 15.8 km^2 Yaquina Estuary (approximately 44°38′N, 124°03′W), on the midcoast of Oregon. From 1973 through 1981, I recorded over 1000 h of observations (including 745 60-min watches) of herons in intertidal areas as they foraged in the 3-h interval before and after low tide. Only interactions during 60-min watches were used to determine relative interaction frequencies, but notes from supplementary observations were used for other analyses. Sample sizes differ for various aspects of interactions because all characteristics of each interaction were not always recorded. All statistical tests are two-tailed.

Because of the frenzied activity generally accompanying interactions between herons and gulls, and because of the subtle plumage differences between Western Gulls (*L. occidentalis*), Glaucous-winged Gulls (*L. glaucescens*), Western × Glaucous-winged Gull hybrids (see Hoffman et al., Auk 95:441–458, 1978), Herring Gulls (*L. argentatus*), and Thayer's Gulls (*L. thayeri*), I was unable to distinguish among these species of gulls. My impression, however, was that 90% or more of these "large" gulls were Western Gulls or hybrids. Other

TABLE 1
TYPES OF INTERACTIONS OBSERVED DURING 60-MIN OBSERVATIONS

Gull taxon	Heron approaches gull				Gull approaches heron		
	N	% Cueing[a]	% Piracy attempt	% No food involved	N	% Piracy attempt	% No food involved
Large gull[b]	103	7	48	45	73	41	59
Ring-billed and California gulls	4	25	0	75	8	38	62
Mew Gull	5	20	20	60	2	100	0
Bonaparte's Gull	2	50	0	50	7	0	100
Total	114	9	45	46	90	39	61

[a] Cueing involves herons flying to a flock of feeding gulls; gulls did not cue to flocks of herons.
[b] Large gulls included mainly Western Gulls, Glaucous-winged Gulls, and Western × Glaucous-winged hybrids; some Thayer's Gulls and Herring Gulls may have also been included.

gulls that interacted with herons included Bonaparte's Gulls (*L. philadelphia*), Mew Gulls (*L. canus*), Ring-billed Gulls (*L. delawarensis*), and California Gulls (*L. californicus*).

Overt interactions included pursuit flights (i.e., one bird flying behind another flying bird), supplanting (i.e., an attacking bird flew, walked, waded, or ran towards a nonflying bird), "Swoop-and-soar" displays by gulls (see Tinbergen, The Animal in its World, Harvard Univ. Press, Cambridge, Massachusetts, 1972), or "Full forward" displays by herons (see Bayer, Colonial Waterbirds 7:45–54, 1984). If multiple attacks occurred within a min of each other, they were all classed as one interaction. An attack was considered to involve food piracy if one bird approached another bird that had food.

Frequency of interactions.—A total of 317 interactions between herons and gulls was recorded. The majority (86%) of interactions during 60-min watches involved large gulls (Table 1). The average frequency of interactions during 60-min watches of herons was 0.11/heron-h (SD = 0.41, N = 745 h), with territorial herons having an insignificantly higher frequency than nonterritorial herons. The infrequency of interactions was not due to a scarcity of either herons or gulls; both were present throughout the year, typically numbering over 100 individuals of each (unpubl. data). Most (54%) heron assaults involved gulls with food, while only 39% of gull attacks were on herons with food (Table 1).

Interactions involving food.—Gulls never joined heron feeding flocks. Herons rarely cued to (i.e., oriented to, approached, or joined) gull feeding flocks (Table 1); when they did, as many as 22 herons joined them. Most flocks of gulls were in water deeper than one m where herons could not feed.

Piracy attempts occurred when a heron or gull did not swallow food quickly (e.g., large prey with handling times > about 15 sec); then another bird had a chance to fly near the bird and attempt to steal its food. When a heron or gull with a large food item was approached, it often flew with the item held crosswise in its bill. Such birds seemed particularly susceptible to piracy because of their reduced maneuverability.

Piracy attempts by herons.—Although heron piracy attempts were usually infrequent (0.03/heron-h ± 0.13 [SD], N = 745 h), some territorial herons had rates as high as 4/h. Ninety-seven percent of 115 heron attacks were on large gulls; the remainder were on Mew Gulls and Ring-billed Gulls. Although 3–9 gulls were attacked in 29% of the attacks on large gulls, 54% of the attacks were on solitary gulls.

Only one heron at a time attempted to steal food from a large gull. In 84% of 81 attempts,

the gull flew away. A heron flight-pursued a large gull during a piracy attempt an average of 1.1 times (range = 1–3, N = 85). The average duration for each heron pursuit ranged from 3.0 to 80.0 sec with the mean duration for successful pursuits (19.4 sec ± 27.6, N = 6 attacks) not significantly different from unsuccessful ones (22.9 sec ± 20.5, N = 23) (t = 0.35, df = 27, $P > 0.10$).

Large gulls retained their food in 65% of 99 heron attacks, and herons ate stolen food after only 18% of these attempts. In 8% of these forays the food was lost to both the heron and the gull(s), and in 9% of the raids, herons obtained food but abandoned it. Territorial herons that attempted piracy twice or more per hour were successful in only 11% of 37 attempts, which was not significantly different from herons with lower attack frequencies ($\chi^2 = 3.02$, df = 1, $P > 0.10$). Herons assaulting solitary gulls were successful in 16% of 56 forays, which was not significantly different than for herons attacking groups of gulls (26% of 43 forays) ($\chi^2 = 2.02$, df = 1, $P > 0.10$).

Pirated food abandoned by herons included clams, large (i.e., >8 cm wide) starfish (*Pisaster* sp.), large pieces of carrion, and large crabs (*Cancer* sp.). These food items were probably too wide for a heron to swallow. Herons attacked gulls with such inappropriate prey in 29% of 72 attempts. In these instances, herons usually dropped the item and moved away, allowing the gull to reclaim the food; but two different territorial herons that had tried unsuccessfully to swallow robbed food defended it until encroaching gulls left, after which they moved away.

Piracy attempts by gulls.—Gull attempts at pirating herons were rare in Oregon (0.02/heron-h ± 0.11, N = 745 h) (this study), as well as in Nova Scotia (mean = 0.06/heron-h, N = 80 h) (Quinney et al. 1981). In Oregon, 85% of 34 piracy attempts were by large gulls, and the rest were by Mew, Ring-billed, or California gulls. Large gulls attempting to steal from a heron walked or flew toward the bird and tried to seize the item from the heron's bill. Usually, only one large gull attacked a heron, but as many as 4 gulls were sometimes involved. In 17% of 29 attempts by large gulls, the gulls were joined by a second heron that also attempted to steal the fish from the first heron.

Herons lost food during 13% of 30 gull piracy attempts; but because several gulls sometimes attacked a heron, the percentage of success per gull was only 8%. Only single large gulls were successful. The four successes included (1) an instance in which a gull waited until a heron abandoned a starry flounder (*Platichthys stellatus*) that was too large for the heron, (2) a gull eating young perch that were being born as a heron mandibulated a female live-bearing perch (family Embiotocidae), and (3) two instances of gulls quickly stealing fish that a heron had dropped on the mud to stab with its bill.

Attacks on gulls without food.— Seventy-three percent of 91 attacks by herons (all by solitary herons) were on large gulls, and the remainder were on Bonaparte's, Mew, Ring-billed, and California gulls. A solitary gull was assaulted in 63% of these attacks, but sometimes as many as 50 roosting gulls were involved.

Forty percent of the attacks occurred when a heron acquired a perching or foraging site. Herons were always successful in obtaining such sites from gulls. Although interspecific ardeid attacks in the tropics resulted in herons acquiring demonstrably better foraging sites (Caldwell 1980), Oregon herons did not catch significantly more prey in the 15-min period after an attack for a foraging site than they had before the attack (paired $t = 0.75$, N = 16, $P > 0.10$).

In 22% of these attacks, herons attacked gulls fighting among themselves. As fighting gulls vocalized similarly whether or not they had food, these attacks may have been mistaken piracy attempts.

Only 4% of these interactions could be classed as heron territorial defense. These were cases where a heron's pursuit ended when the gull passed the border of the heron's territory.

Such territorial defense was rare, as all gulls usually roamed over a heron's territory without assault, and some large gulls maintained feeding territories within that of a heron.

The purpose of the remaining 34% of heron assaults was not obvious, but seemed to be harrassment. These included three attacks by one heron on a pair of large gulls that were involved in courtship behavior (e.g., "Choking," and "Head-tossing," see Tinbergen 1972).

Attacks on herons without food.—Ninety-one percent of 47 gull attacks were by large gulls; the remainder were by Bonaparte's, Ring-billed, and California gulls. Gulls usually used the "Swoop-and-soar" display in attacking either flying or standing herons. Herons that were standing did not fly away but stayed and often directed "Full forward" displays at the attacking gull.

Gull attacks on herons were usually difficult to classify because no obvious purpose was apparent; however, in two interactions, herons that had initially disturbed gulls were outmaneuvered and subsequently pursued by a gull. In five gull attacks, a large gull could have been defending its nest against an approaching heron. Heron attacks on gull chicks were never observed, and gull chicks were not found as food given to heron young (unpubl. data). Herons have rarely been reported to prey on larid chicks (Chapman and Forbes, J. Field Ornithol. 55:251–252, 1984). The threat to gull chicks, however, may not have been as much predation as disturbance, which may cause chicks to wander from the nest, fall into the water, and drown (see Bayer, Murrelet 64:87–91, 1983).

The purpose of the remaining gull assaults seemed to be harrassment of flying herons. These included instances where large gulls, Ring-billed Gulls, and Bonaparte's Gulls forced a flying heron to change direction, to land in deep water (where the heron swam), or to find a nearby perch. Although gulls have been reported to prey on or kill other birds that they force into the water (Colston et al., Br. Birds 52:312–313, 1959; Boshoff, Cormorant 8:15–16, 1980), the attacked herons I watched seemed unharmed.

Conclusions.—Overt interactions were probably uncommon because they were not directly important for survival; only 48% of the interactions involved food (Table 1). Interactions did not result in greatly increased food availability, nor was either species a predator of the other. Gulls and herons did not forage similarly, so their interactions can not be ascribed to direct competition as have some interactions between other species (Roth, Wilson Bull. 90:450–451, 1978; Tye, Ibis 126:95–101, 1984).

Acknowledgments.—I am grateful to M. Guin and L. Murray of the Oregon State Univ. Marine Science Center Library for their assistance in locating reference materials. The constructive comments of D. W. Mock and an anonymous reviewer on an earlier draft of this manuscript are appreciated.—RANGE D. BAYER, *P.O. Box 1467, Newport, Oregon 97365.* *Accepted 14 May 1985.*

Wilson Bull., 97(4), 1985, pp. 541–543

Circumstantial evidence of foraging interference between two species of dabbling ducks.—In a recent article on competition in bird communities, Maurer (Wilson Bull. 96:380–395, 1984) presents a verbal model that predicts the types of competition that can occur in different ecological settings. Maurer also calls attention to passive interference, a type of interspecific competition that may be important, but difficult to detect, in many bird communities. In this type of competition, direct aggression is rare, but interference occurs as resources are temporarily depressed by the activity of foraging individuals. In general, conclusive documentation of any competitive interaction in natural communities is difficult to achieve. Among the strongest evidence that empirical data can provide for competition