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FACTORS AFFECTING PIRACY IN HERRING GULLS AT A NEW JERSEY LANDFILL

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ABSTRACT.—We studied piracy among Herring Gulls (*Larus argentatus*) at a New Jersey landfill. We determined rates of attack with respect to species, age, and size of food item and rates of success with respect to species, age, size of food item, number of birds pursuing in each chase, and duration of chase. Rates of attack were affected only by size of the food item; birds carrying larger items were attacked more frequently than birds with smaller items. Rates of success were affected by size of the food item and the number of birds pursuing in each chase. Birds carrying larger items were attacked by more pirates than birds carrying smaller items. The probability that the host would drop the item increased with increasing numbers of pirates. Consequently, larger items were lost more frequently. *Received 26 June 1987, accepted 16 Feb. 1988.*

Piracy, an opportunistic foraging behavior that includes both interspecific and intraspecific food theft, has been noted in several orders of birds, most notably the Charadriiformes (Brockmann and Barnard 1979). The incidence of piracy is greater under high food and host densities (Dunn 1973, Hulsman 1984). The pirate spends less time searching for a host, and the host, if it loses its food item, can replenish itself relatively easily. Behavior by both pirate and host must balance the energetic value of the food item against costs of obtaining or retaining food items (Hulsman 1984). Some of the factors that have been noted as important to this balance are age and species of host and pirate (Moyle 1966; Verbeek 1977a, b; Burger and Gochfeld 1981), the size of the food item (Dunn 1973, Fuchs 1977, Hulsman 1984), number of pirates involved in a chase (Hatch 1975, Hulsman 1976, Verbeek 1977b), and duration of the chase (Hatch 1975). The present study examines costs and benefits of retaining or obtaining a food item for both host and pirate Herring Gulls (*Larus argentatus*). We tested the following null hypotheses: (1) There are no differences in rates of attack on a host as a function of the host's age, species, or the size of the food item carried. (2) There are no differences in rates of success for the host as a function of the host's age or species, the size of the food item carried, the number of pursuers in each chase, or the duration of the chase. (3) There are no differences in rates of success for the pirate as a function of the pirate's age or species, the size of the food item carried by the host, the number of pursuers in each chase, or the duration of the chase.

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METHODS

We observed gulls at the Edgeboro landfill in East Brunswick, New Jersey, from 16 October 1986 to 21 January 1987. Garbage was dumped at Edgeboro daily. Several ponds and fields within 500 m of the dumping surface provided areas for loafing and eating the items carried from the dump. We observed pirating behavior at both the loafing areas and at the dump. For each gull flying away from the dump with food, we recorded the following: date, time, age and species of the host, size of the food item, whether or not it was attacked, the number of attackers, the age and species of the attackers, the age and species of the successful pirate, the outcome of the chase, and the duration of the chase. The age of each gull was determined from the plumage. Young birds were those that had dark mottled coloration of the back and mantle. The head, neck, tail, and underparts had slightly lighter coloration but were thickly streaked with darker color. The tail had a dark terminal band or dark blotches. Subadult birds were those that were less mottled than young gulls. The head, neck, tail, and underparts were lighter than those of the young gulls but still had remnants of dark streaking. The tail band or blotches were smaller than in young gulls. Adult birds were those that had clear dark coloration of the back and mantle. The head and neck were white with hints of streaking. The tail and the underparts were entirely white (Dwight 1925).

The size of the food item was estimated in comparison with the length of the host's bill. The following are the bill length measurements used to normalize the size of the food item between different species: Greater Black-backed Gull (*L. marinus*), 6.3 cm; Herring Gull, 5.0 cm; Ring-billed Gull (*L. delawarensis*), 4.1 cm; and Laughing Gull (*L. atricilla*), 3.9 cm. Length measurements of the bill were taken from averages of measurements listed for male and female specimens of each species by Dwight (1925).

Gulls carrying items could fly to the ponds or to the loafing area adjacent to the dumping face or could be chased in the air. Piracy attempts in the air were recognized by the closely associated flying patterns of two or more birds. Piracy attempts on the ground were noted when one or more birds ran, with wings spread, towards the host. Data were recorded on both air and ground attempts. The result of the attacks were recorded with respect to the pursuers. Results of piracy included: an unsuccessful attempt = host retained the item; a lost attempt = pirates caused host to drop the item which was not recovered by any of the pursuers; and a successful attempt = one of the pirates (subsequently designated the successful pirate) obtained the food item.

The duration of a piracy attempt was measured by stopwatch from the tapes of the observations. Observations began when birds attacked the host. Observations for a chase ended when the item was eaten by the host, lost, or the pirates dispersed leaving the host with the item. Any secondary attack on the host was discarded to eliminate the complication of the previous outcome on the ensuing chase. Some data obtained from Greater Black-backed, Ring-billed, and Laughing gulls were included in this study for the sake of completeness. However, sample sizes were often too small for statistical analysis.

Data were analyzed using Kruskal-Wallis χ^2 tests to distinguish differences among means. Pearson correlations were used to examine relationships between variables.

RESULTS

Types of piracy.—Gulls carried food items that ranged in size from 5 cm^3 to 100 cm^3 ($\bar{x}$ = 19.65 ± 0.62 cm^3 [SE], N = 401). Pirates tried to obtain a food item by grabbing it from the bill of the host or by grabbing the wings or the back of the host, causing the host to drop the item. Piracy attempts in the air varied from simple plunges at the host lasting only 1

TABLE 1
PERCENTAGE ATTRIBUTED TO EACH SPECIES OF PIRATE FOR EACH SPECIES OF HOST

	L. marinus	*L. argentatus*	*L. delawarensis*	*L. atricilla*
L. marinus	55.9%	29.4%	14.7%	0%
L. argentatus	24.1%	69.4%	6.5%	0%
L. delawarensis	15.4%	15.4%	69.2%	0%
L. atricilla	0%	10.3%	0%	89.7%

sec. to more complex chases that could last for up to 100 sec. ($\bar{x}$ = 11.79 ± 0.89 sec [SE] N = 254). During ground attempts, a lunge from a neighbor was sometimes enough to displace the host, and at other times a tug-of-war over the food item ensued between the host and a pirate. The number of birds involved in both air and ground chases varied from 1 to 15 ($\bar{x}$ = 2.14 ± 0.12, N = 254). All host species were chased by conspecifics more often than by other species (Table 1). Chases were usually accompanied by vocalizations of the birds involved.

Rates of attack on the host.—Different species carried different sized food items from the dump (χ^2 = 12.26, df = 3, $P < 0.006$, N = 401). Greater Black-backed Gulls carried larger food items than Herring Gulls (χ^2 = 2.04, df = 1, $P < 0.04$, N = 376) or Ring-billed Gulls (χ^2 = 3.34, df = 1, $P < 0.0008$, N = 44) but there was no difference between the sizes of items carried by Greater Black-backed and Laughing gulls (χ^2 = 1.90, df = 1, $P < 0.06$, N = 39). Herring Gulls carried larger items than Ring-billed Gulls (χ^2 = 2.57, df = 1, $P < 0.01$, N = 362). There was no difference in the size of items carried by Herring and Laughing gulls (χ^2 = 0.86, df = 1, $P < 0.39$, N = 357) or by Laughing and Ring-billed gulls (χ^2 = 1.28, df = 1, $P < 0.2$, N = 25). There were also no differences in the size of items carried by different age groups among Herring Gulls (χ^2 = 2.03, df = 2, $P < 0.3$, N = 347).

All species were attacked at similar rates (χ^2 = 6.25, df = 3, $P < 0.1$, N = 233). All Herring Gull age groups were attacked at similar rates (χ^2 = 1.17, df = 3, $P < 0.5$, N = 209). Sample size was too small for analysis of the other species. In general, gulls carrying larger food items were attacked more often than gulls carrying smaller food items (χ^2 = 50.38, df = 1, $P < 0.0001$, N = 401, Table 2). Specifically, this was true for Greater Black-backed Gulls (χ^2 = 6.08, df = 1, $P < 0.01$, N = 29) and Herring Gulls (χ^2 = 46.29, df = 1, $P < 0.0001$, N = 348), but not for Ring-billed Gulls (χ^2 = 0.73, df = 1, $P < 0.4$, N = 15). Laughing Gulls were always attacked.

TABLE 2

RANGES AND MEANS OF ITEM SIZES ATTACKED AND NOT ATTACKED FOR DIFFERENT SPECIES AND ITEM SIZE TO BILL LENGTH RATIO

		N	Range (cm^3)	Mean (cm^3)	±SE	Bill length (cm)	Size/ length ratio
L. marinus	(not attacked)	11	10–25	16.36	0.65	6.3	2.5
	(attacked)	18	10–100	31.67	5.03		5.0
L. argentatus	(not attacked)	138	5–45	14.42	0.71	5.0	2.9
	(attacked)	209	5–70	22.99	0.87		4.6
L. delawarensis	(not attacked)	6	5–15	10.00	1.29	4.1	2.4
	(attacked)	9	5–20	13.33	2.36		3.2
L. atricilla	(not attacked)	—	—	—	—	3.9	—
	(attacked)	10	5–25	15.50	2.03		4.0

Rates of success for the host.—There were no differences in the percentage of items retained and eaten by different host species when attacked ($\chi^2 = 2.44$, df = 3, $P < 0.5$, N = 261). There were also no differences in the percentage of items retained and eaten by different age groups among Herring Gulls when attacked ($\chi^2 = 2.45$, df = 2, $P < 0.3$, N = 207). All of the species and all of the age groups among Herring Gulls kept food items more than 50% of the time when attacked.

Herring Gull hosts lost large items more frequently than small items ($\chi^2 = 26.49$, df = 7, $P < 0.01$, N = 207). Sample size was too small for analysis of other species. Herring Gull hosts were also more likely to lose their food item when chased by increasing numbers of pirates ($\chi^2 = 26.02$, df = 4, $P < 0.001$, N = 212). The success of the host was not related to the duration of the chase ($\chi^2 = 1.79$, df = 2, $P < 0.4$, N = 233). Sample size was again too small for analysis of other species.

Rates of success for the pirate.—There were no differences in the frequency that each species was a successful pirate ($\chi^2 = 3.02$, df = 3, $P < 0.5$, N = 479) or in the frequency that each age group among Herring Gulls was a successful pirate ($\chi^2 = 0.047$, df = 2, $P < 0.9$, N = 292). Once a pirate attacked, the size of the food item was not related to the success of the pirate ($\chi^2 = 3.58$, df = 2, $P < 0.2$, N = 254). Nor was the duration of the chase related to the success of the pirate ($\chi^2 = 1.79$, df = 2, $P < 0.4$, N = 233). The number of pursuers for each chase, however, was related to the success of the pirate ($\chi^2 = 22.71$, df = 2, $P < 0.0001$, N = 254). More birds were involved in successful chases and chases in which the food item was lost to both the pirate and the host than in chases

in which the host retained the food item. There was also a positive correlation between the size of the food item carried by Herring Gulls and the number of birds pursuing in each chase ($r = 0.236$, $P < 0.001$, N = 207).

DISCUSSION

Hypothesis 1 is supported with respect to the host's species and age groups among Herring Gulls, but not with respect to item size. Hypothesis 2 is supported with respect to species, age, and duration of the chase, but not with respect to item size and number of birds chasing for each chase. Hypothesis 3 is supported with respect to the pirate's species, age, the food item size, and the duration of the chase, but not with respect to the number of birds pursuing in each chase.

Host and pirate frequency.—It seemed likely that smaller species would be hosts more frequently than larger species and pirates less frequently than larger species, based on the greater strength (i.e., ability to carry larger food items) of the larger species. However, we did not find this to be true; all species exhibited similar frequencies as a host and as a successful pirate. This disagrees with the findings of Verbeek (1977b) who found species-related differences in the use of piracy and of Burger and Gochfeld (1981) who found both species-related differences and age-related differences in the use of piracy. The similar frequencies in our study might be attributed to smaller species being more agile flyers, capable of outmaneuvering larger species, making it more difficult for the larger species to harrass the smaller species (Burger and Gochfeld 1981). Another possibility is that smaller species do not carry large enough items to warrant attack by larger species. Indeed, we found that smaller species carried smaller food items. Conversely, smaller species might have difficulty obtaining a food item from a larger species, even though the smaller species were capable of harassment, because of the greater strength of the larger species. Yet another possible explanation may be related to our finding that hosts were chased primarily by conspecifics. This preference by the pirate may have been more important in host selection than the size of the host. Stealing from conspecifics may be preferable because of equal strength, maneuverability, and energy needs.

It also seemed likely that the young, less experienced birds would be hosts more frequently and be pirates less frequently than older birds. We did not find this to be true. All age groups among Herring Gulls exhibited similar frequencies as a host and as a successful pirate. Adults may have been less likely to steal food from young birds because of the feeding relationship that existed between young and adult birds during the fledging period. Similarly, adult birds may tolerate piracy by young birds for the

same reasons. Moyle (1966) found that young Glaucous-winged Gulls (*L. glaucescens*) did not react, while subadult gulls did, to adult threat displays. Furthermore, adults were usually found in the company of younger gulls while they avoided the company of other adults.

Effects of item size.—In general, larger species carried larger food items away from the dump than those carried by smaller species, presumably because larger species are more aerodynamically capable of carrying larger food items and have greater energy requirements than smaller species. Birds carrying larger items were also attacked more often than those with smaller items. Similar results were found in studies of Arctic (*Sterna paradisae*) and Common terns (*S. hirundo*) (Hopkins and Wiley 1972). This preference is beneficial because of the greater energy gained from larger food items, and may be explained by greater visibility of larger items. A pirate must first find a host before attacking, and a large food item is more conspicuous than a small one.

Herring Gulls lost large food items more frequently to pirates than smaller items. It is more difficult for a host to hold a larger item than a smaller one. Larger items have a larger surface area and might be more easily grabbed whole or torn into pieces by a pirate (Burger and Gochfeld 1981). The greater loss of larger food items may also be attributed to the greater number of pirates in each chase involving larger items. This was found to be true for Arctic and Common terns (Hatch 1975), Lesser Black-backed (*L. fuscus*) and Herring gulls (Verbeek 1977b). A host evading one pirate has many directions in which to flee, but a host being chased by many pirates has far fewer choices. The more birds involved in the chase, the more intense the harassment of the host, causing it to drop food more frequently.

Costs and benefits to the host and to the pirate.—Larger food items contain more energy but are also more likely to elicit attack. One might expect hosts to carry food items at the best benefit/cost ratio between energy gained and vulnerability to attack. A very small item may never elicit attack but may also be too small to recoup the energy necessary for the trip to the dump. Conversely, a very large item may be worthwhile energetically but is more likely to be lost to a pirate. The optimal item size should be represented by the mean size of items successfully carried away from the dump, roughly 2.6 times the length of the host's bill (Table 2, last column).

Pirates have a similar dilemma. Large items are energetically preferable, but usually elicit attacks from more than one bird. Theoretically, pirates should attack the host carrying the item size that is large enough energetically to balance the cost of competition among multiple pirates. This size should be greater than the mean size carried by the host because

larger items would be more worthwhile energetically. The mean size of items attacked was, indeed, larger than the mean size of items carried for both Herring Gulls and Greater Black-backed gulls (Table 2).

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