The Condor 87:246–251

PIRACY BEHAVIOR OF WINTERING BALD EAGLES

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ABSTRACT.—Inter- and intraspecific prey robbery (piracy) attempted by wintering Bald Eagles (*Haliaeetus leucocephalus*) was quantified during 1978–1979 and 1979–1980 near Lock and Dam 19, Mississippi River. Eagles robbed fish from conspecifics and seven other avian species. Interspecific piracy was successful in 55% of 65 attempts, whereas only 8.1% of 273 intraspecific piracy attempts were successful. I did not detect age-specific differences in the ability to rob or retain fish, but immature eagles made more attempts than adults. Eagles possessing large fish were more often attacked by pirates than birds with smaller fish; and large fish were more frequently relinquished. Immature eagles showed no preference for robbing a particular age class, but adults were more likely to rob other adults than immature birds. Opportunistic piracy appeared to be the optimal feeding method of immatures.

Most reports of inter- and intraspecific prey piracy involving Bald Eagles (*Haliaeetus leucocephalus*) are anecdotal (Bent 1937, Southern 1963, Erskine 1968, Grubb 1971). Few studies contain quantitative data about this behavior, and these deal only with intraspecific interactions. Craighead (1979) and Griffin (1981) quantified the occurrence of displacements and aerial pursuits among wintering eagles in Montana and Missouri, but only a portion were food-related. More recently, Stalmaster and Gessaman (1984) quantified intraspecific piracy among wintering eagles in Washington.

Some birds obtain a significant amount of food by piracy (summarized by Brockman and Barnard 1979). Most species that attempt piracy (including Bald Eagles) usually do so opportunistically. Optimal foraging theory predicts that when a bird has the opportunity to rob food, it will do so only if the net energy gained by this behavior exceeds or matches the net energy gained by ignoring the opportunity and feeding by other methods (Charnov 1976, Dunbrack 1979). Factors that might affect a bird's decision to attempt piracy include: (1) the energy content of the prey item, (2) the probability of success, and (3) the energetic cost of the attempt. Many investigators have studied the role of prey size or shape, but only Kushlan (1978) has measured and compared the energetic cost of piracy versus other feeding methods.

During the winters of 1978–1979 and 1979–1980, I investigated inter- and intraspecific piracy in a large population of wintering eagles in west-central Illinois. I examined three hypotheses concerning intraspecific piracy: (1) piracy is more often attempted by immature eagles than adults, (2) adult eagles are more successful than immature birds both at retaining prey when they are hosts and at robbing when they are pirates, and (3) piracy of larger prey is more likely to be attempted than piracy of smaller prey. The first two hypotheses are suggested by published qualitative observations of eagles (Southern 1963, Erskine 1968, Lish 1973, Stalmaster 1976). The last hypothesis has been confirmed in some larids (Hopkins and Wiley 1972, Fuchs 1977, Hulsman 1984). Another of my objectives was to describe behavioral responses of eagles to intraspecific piracy attempts. Lastly, using energetic values calculated by Stalmaster (1981), I compared the energetic cost of piracy versus that of aerial searching and swooping for prey, the foraging method used most often by eagles in my study area.

METHODS

I watched the behavior of Bald Eagles almost daily during December 1978–March 1979 and November 1979–March 1980 along a 10-km length of the Mississippi River immediately below Lock and Dam 19, near Keokuk, Lee County, Iowa, and Hamilton, Hancock County, Illinois. This study area was described by Jonen (1973) and Fischer (1982). I recorded the occurrence and outcome of piracy attempts during 0.5- to 1.0-h periods of observation (totaling 58 h) during which all of the eagles' feeding bouts along a designated segment of the river were recorded. A "piracy opportunity" was defined as any event in which a prey item was captured within 200 m of a foraging group of 10 or more eagles. A "piracy attempt" was defined as an aerial pursuit or attempted displacement of a bird that possessed prey. Intraspecific aerial chases frequently involved

more than one pursuing eagle, and several distinct attacks (talon presentations) often occurred during a single chase. However, eagles also often approached birds possessing prey without presenting their talons or attempting a displacement, and these instances were not considered piracy attempts. Data recorded during each piracy attempt included species approached, number and age class of host and pirate eagles, size of prey sought, and the outcome (success) of the attempt. Eagles with mostly white heads were aged as adults; those with mostly dark heads were aged as immatures. I could accurately distinguish only two size classes of prey (fish): small (15 cm in length or less) and large (longer than 15 cm). A piracy attempt was considered successful if the pirate obtained and consumed most or all of the prey item sought. All observations were made with 9-power binoculars at distances of 50–1,000 m.

I examined the data with chi-square goodness of fit tests and standard contingency analysis. Age ratios obtained from 156 ground censuses were used to calculate the numbers of adult and immature eagles that would be expected to participate in piracy attempts.

RESULTS

POPULATIONS

Numbers of Bald Eagles at the study area fluctuated greatly. During the first winter (1978–1979), 8,263 eagles were sighted on 56 censuses, with a peak of 454 on 18 January. The number totaled 4,230 on 97 censuses in the second winter (1979–1980), with a peak of 127 on 18 February. The overall age ratio for the study was 2.28 adults to one immature (69.4% adults, 30.6% immatures). Details about changes in the size of these populations are given in Fischer (1982).

FEEDING BEHAVIOR

Eagles fed almost entirely on fish, especially gizzard shad (*Dorosoma cepedianum*), even though large numbers of waterfowl were sometimes present. Nearly all fish were captured with the feet after an aerial search and swooping glide to the surface of the river. Small fish were often transferred from talons to beak and swallowed in flight, whereas large fish were carried to eating perches. Foraging eagles were concentrated near open water. During the coldest weather, less than 1 km of river remained open immediately below the dam. Winter-killed or stressed shad appeared abundant during most of the study, and were eaten by large numbers of crows, gulls, and waterfowl in addition to eagles. Information on the eagles' foraging behavior is reported in Fischer (1982).

INTERSPECIFIC PIRACY

I observed piracy attempts involving eagles and other species of birds on 65 occasions. These included attacks on swimming birds (ducks and gulls, $n = 6$ attempts), birds perched on open ice (mainly crows, $n = 52$), and birds in flight carrying fish (two species of gulls and one species of hawk, $n = 7$). Species that were robbed were Common Goldeneye (*Bucephala clangula*), Canvasback (*Aythya valisineria*), Common Merganser (*Mergus merganser*), Red-tailed Hawk (*Buteo jamaicensis*), Herring Gull (*Larus argentatus*), Ring-billed Gull (*L. delawarensis*), and American Crow (*Corvus brachyrhynchos*). The single instance during which an adult Red-tailed Hawk was robbed of a fish is noteworthy because I never saw this species attempting to capture fish. Bald Eagles have previously been reported attempting to steal food from Common Mergansers, vultures (*Cathartes* sp.), Ospreys (*Pandion haliaetus*), Northern Harriers (*Circus cyaneus*), Peregrine Falcons (*Falco peregrinus*), Great Black-backed Gulls (*Larus marinus*), Ring-billed Gulls, Common Ravens (*Corvus corax*), American Crows, and sea otters (*Enhydra lutra*; Howell 1932, Bent 1937, Baldwin 1940, Kenyon 1961, Cooksey 1962, Erskine 1968, Grubb 1971, Jonen 1973, Sherrod et al. 1976).

Piracy was successful 56% of the time when eagles attacked birds standing on ice, 57% of the time when they attacked flying birds, and 50% of the time when they attacked swimming birds (differences not significant). I saw eagles swoop at ducks unsuccessfully on 25 other occasions, but could not determine if their attempts were directed at the ducks or at unseen food items in the ducks' possession.

Piracy typically occurred when a foraging eagle spotted another bird carrying or eating a fish. The eagle first flew slowly toward its victim, then swooped rapidly at it with talons lowered and open. Interspecific piracy usually appeared to be an irregular, opportunistic way of supplementing food obtained by other methods. During one period, however, the behavior appeared to be intentional. During three weeks of January, 1980, 10–15 eagles (30% of the population in the study area at the time) fed daily on fish stolen from crows at a small cove near Warsaw, Hancock County, Illinois. For unknown reasons, many fish had died in the cove. On 16 January, I estimated the density of carcasses visible beneath the ice in the middle of the cove to be one fish per 2 m^2. Crows pecked through the ice and extracted the carcasses floating underneath. Meanwhile, eagles perched in trees along a peninsula separating the cove from the main channel of the river. They normally faced the river, but dur-

TABLE 1. Outcome of intraspecific piracy attempts according to the age of the host bird and the size of the prey item.

Age of host	Length of prey (cm)	n (chases)	Fate of prey (% of total prey)			
			Retained by host	Stolen and eaten	Stolen and lost[1]	Dropped, but not retrieved by a pirate
Adult	>15	70	55.7	15.7	12.9	15.7
Adult	≤15	41	75.6	17.1	0.0	7.3
Immature	>15	24	50.0	12.5	12.5	25.0
Immature	≤15	19	84.2	5.3	5.3	5.3
Total		154	63.6	14.3	8.4	13.6

[1] Prey successfully stolen, but then lost to another eagle in a subsequent piracy attempt.

ing this period most of them faced the cove. When crows pulled up a fish too large to be carried off or eaten quickly, eagles swooped and robbed them. On two occasions I watched groups of 2–4 crows work for more than 20 min to free a fish only to have it stolen by an eagle seconds after it was pulled up onto the ice. By late January, the ice layer on the cove thickened and this source of food became unavailable.

INTRASPECIFIC PIRACY

All intraspecific piracy attempts recorded during my observation periods were rapid aerial pursuits of eagles carrying fish over distances of 0.1–1.5 km. (I occasionally saw perch displacements involving food at other times, but did not count them.)

Eagles were considerably less successful when attempting to rob each other rather than other species. Only 11 (7.7%) of 142 intraspecific attempts made by adult eagles and 11 (8.4%) of 131 attempts made by immatures were successful. During 154 aerial chases, a fish was taken by a pirate only 22.7% of the time and was consumed by the original pirate only 14.3% of the time (Table 1). In 63.6% of the cases, the host eagle retained the fish. Large fish were more likely to be dropped than small ones ($\chi^2 = 10.48$, df = 1, $P < 0.01$). I found no age-specific differences in the ability of eagles to retain fish ($\chi^2 = 0.05$, df = 1, $P \gg 0.05$) or steal them ($\chi^2 = 0.04$, df = 1, $P \gg 0.05$). Although more adults than immatures attempted piracy, immatures comprised a significantly greater proportion of the pirate group (48.0%) than they did the population as a whole (30.6%; $\chi^2 = 38.9$, df = 1, $P < 0.01$).

TABLE 2. Number of adult and immature Bald Eagles attempting piracy per 100 opportunities according to the host's age and the size of the prey sought.

Age of host	Length of prey (cm)	Piracy opportunities n	Eagles attempting piracy (no./100 opportunities)	
			Adults[1]	Immatures
Adult	>15	126	69.8*	46.8
Adult	≤15	293	8.9	11.9
Immature	>15	46	30.4*	47.8
Immature	≤15	107	13.1	14.0

[1] Values followed by asterisks differ significantly ($\chi^2 = 15.49$, df = 1, $P < 0.01$).

The size of the fish that was carried appeared to be the key factor eliciting intraspecific chases. Hosts were chased on 154 of 572 occasions when they captured fish, for an average of one chase per 3.7 fish captured. One of every 1.8 eagles capturing a large fish was pursued, whereas only one of every 6.9 eagles capturing a small fish was pursued. This difference occurred during both years of the study.

Both adults and immatures pursued eagles carrying large fish more often than eagles carrying small fish. Nevertheless, immatures showed no preference for a particular host age class ($\chi^2 = 0.08$, df = 1, $P \gg 0.05$), whereas adults were more likely to attack another adult than an immature bird ($\chi^2 = 10.28$, df = 1, $P < 0.01$; Table 2). This suggests that adults ignored opportunities to steal prey from immatures.

Eagles searching from the air and then swooping to capture fish were successful nearly 70% (61% for immatures, 74% for adults) of the time and required on average less than 5 min (5.5 min for immatures, 4.4 min for adults) of foraging time per fish obtained (Fischer 1982). Although attempts at piracy rarely exceeded 1 min, the energetic cost of intraspecific piracy was probably much greater than that required for aerial searching and swooping for prey. Stalmaster (1981) estimated the cost of flapping flight (which would be used during piracy attempts) to be 12.5 × a bird's basal metabolic rate (*BMR*), and that of gliding flight to be 3.5 × *BMR*. Since aerial searches consisted of roughly equal amounts of flapping and gliding, I estimate that the cost of aerial searching is 8 × *BMR*. I did not record the durations of intraspecific pirating chases, but I estimate that an average chase lasted 0.5 min. Eagles successfully robbed conspecifics of 22 fish in 136.5 min, an average of 6.3 min (6.5 min for adults, 6.0 min for immatures) of pursuit time per fish obtained. Hence, it took on

average 1.5 times longer (6.5 min vs. 4.4 min) for adults and 1.1 times longer (6.0 min vs. 5.5 min) for immatures to steal a fish than to capture it by aerial searching and swooping. However, since the cost of piracy flights is about 1.6 times that of aerial searching and swooping (12.5 *BMR* vs. 8 *BMR*), piracy should be 2.4 times more expensive for adults and 1.7 times more expensive for immatures than using the aerial search-and-swoop method.

Nonetheless, opportunistic intraspecific piracy may still be a useful foraging method if the net energy (E_{net}/min) that eagles obtain from piracy exceeds that from the search-and-swoop method (Charnov 1976, Pyke et al. 1977). An eagle's expected net energy gain (in kcal/min) = benefit obtained − cost. For adults that search and swoop for prey, E_{net}/min = (X/4.4 min) − 8(0.2078 kcal/min), where X is the energy content or gram-weight of the average fish obtained and 0.2078 kcal/min is Stalmaster's (1981) estimate of *BMR*. For adults attempting piracy, E_{net}/min = (0.077 Y/0.5 min) − 12.5(0.2078 kcal/min), where 0.077 is the probability of success (7.7% for adults, 8.4% for immatures) and Y is the average energy content or gram-weight of the fish sought. For immature eagles that search and swoop for prey, E_{net}/min = (X/5.5 min) − 8(0.2078 kcal/min), and for pirating immatures, E_{net}/min = (0.084 Y/0.5 min) − 12.5(0.2078 kcal/min). If the average fish obtained by aerial searching (X) were a 15-cm, 50-g shad, piracy would be worthwhile when fish sought (Y) were larger than 80 g for adults and 60 g for immatures. Seventy percent of the fish obtained by aerial searching and swooping were ≤15 cm in length, whereas 64% of fish obtained by piracy were >15 cm in length. Most large shad appeared to be 20–25 cm in length, or about 90–140 g (Carlander 1969:82). Hence, if the estimates used above are accurate, immature eagles, and possibly adults, increased their net energy intake by using piracy as a foraging behavior.

ANTI-PIRATE BEHAVIOR

I identified nine tactics that eagles appeared to use to avoid being robbed: (1) feed away from other eagles, (2) feed when few eagles were present, (3) select small prey items, (4) conceal prey that had been caught, (5) continue to act as if they were searching after they obtained prey, (6) select protected eating sites, (7) use aerial maneuvers to elude pirates, (8) exhibit threat displays, and (9) use mantling behavior. I observed some of these tactics on numerous occasions (4, 6, 7); some rarely (5, 8, 9); and I have only circumstantial evidence that some were used at all (1, 2, 3). A quantitative study of these behavioral patterns is needed.

Tactics 1–3 were used before a host bird caught a prey item. Although 70% of the fish captured by eagles were ≤15 cm in length, I cannot say that eagles selected small fish preferentially (tactic 3) because I have no information about the availability of prey of different sizes.

Tactics 4–6 were used after a host eagle captured a fish. Eagles concealed fish (tactic 4) by holding them close to the undersurface of the tail. Even large fish carried in this manner were barely detectable by observers with binoculars. Eagles used tactic 5 as soon as they regained height after swooping to the water's surface and procuring a large fish. They intermittently flapped and glided 10–15 m above the river with the head pointed downward. Minutes later, such birds drifted to the edge of the foraging area and flew off quickly to an eating site. This behavior was only noted when 20 or more eagles were foraging simultaneously over the same pool, and was in marked contrast to the more typical behavior in which an eagle flew directly to a perch after capturing a large fish. I believe that the behavior was intended to prevent other eagles from detecting the fish that it had caught. Sherrod (1983) described a similar aerial behavior pattern among young Peregrine Falcons. Protected eating perches (tactic 6) were those surrounded by dense vegetation. They were often located in the interior of riparian woods, away from more heavily used perches along the shore. The dense vegetation at these sites hindered potential pirates from approaching the host eagle.

Tactics 7–9 were used to fend off the attacks of potential robbers. Most commonly, hosts tried to stay above their pursuers, to out distance them, or to twist and turn suddenly when pirates presented their talons. Threat postures were well described by Jonen (1973). Mantling, in which prey is concealed under outstretched wings, is a specialized form of the threat display (Brown 1976) and was not used often; but every time I saw it, the host eagle retained its prey.

DISCUSSION

Because they are much larger and more powerful than the other birds, it is not surprising that eagles had more success when robbing other birds than when stealing from conspecifics. Kushlan (1978) showed that robbing success among five species of wading birds depends on relative differences in size of host and pirate, with larger species able to steal from smaller species, but not vice-versa. When an eagle attempts to rob a smaller bird, the host itself is potential prey and may relinquish its food in order to escape predation. Such hosts

probably drop their food sooner and offer less resistance than would another eagle. Conceivably, fights between eagles may be dangerous for the participants, and, therefore, a host eagle also risks injury if it does not relinquish its prey. However, I did not see (nor find evidence in the literature) an eagle injured during such encounters.

My data support hypotheses that (1) intraspecific piracy is more often attempted by immature birds than adults, and (2) piracy is more likely to be attempted on larger prey than smaller prey. However, they do not support the hypothesis that adults are more successful than immature birds, either as hosts or as pirates.

Griffin (1981) found that adult Bald Eagles interacted aggressively with other adults more often than with immature birds; he also reported that immatures avoided interactions with adults and concluded that adults dominated younger birds. Stalmaster and Gessaman (1984) have presented convincing data to support this conclusion. On the other hand, neither I nor Sherrod et al. (1976) found evidence of this. Griffin (1981) found no age-specific difference in the initiation of displacement attempts, but reported that significantly more aerial pursuits and talon presentations were initiated by immatures than adult eagles. However, Stalmaster and Gessaman (1984) reported that adults initiated more intraspecific piracy attempts and were more successful than immatures when doing so. They concluded that (1) adult eagles tend to parasitize immatures to obtain food (through piracy), whereas (2) immature eagles tend to parasitize adults to learn about the location of food by following them from communal roosts to feeding areas (also see Knight and Knight 1983). Although my results are inconsistent with their first conclusion, my observation that lone eagles feeding away (2+ km) from the main foraging areas were nearly always adults supports the second conclusion. I rarely saw immature birds feeding away from adults.

Immature eagles are less efficient than adults at obtaining food independently (Jonen 1973, Shea 1973, Stalmaster 1981, Fischer 1982), so they might partially compensate for this by robbing (Griffin 1981). Such a situation occurs in Herring Gulls (Verbeek 1977) and appeared to be the case in the eagle population that I studied.

My data indicate that immature eagles are as likely to steal from adults as from other immatures, but that adult eagles are more likely to steal from other adults than from immatures. This suggests that adults preferentially rob other adults. It is difficult to explain how such an apparently altruistic tendency could have evolved. One possibility is that immatures are more food-stressed than are adults, and therefore offer more resistance than adults when attacked. Stalmaster (1981:130) found that immature eagles did not consume enough food to meet their daily energy requirements, even though food was generally abundant. In contrast, adults in the same wintering population were not food-stressed. Under these circumstances, adults may be more likely than immature birds to drop their prey quickly and not retaliate when attacked. Consequently, adults may have learned to rob other adults preferentially, whereas immatures, lacking experience, have not. However, my data only weakly support the premise that adults retaliate less than immature eagles when attacked. Of 111 adult hosts, 41 (37%) dropped their prey; of 43 immature hosts, 15 (35%) dropped prey (proportions not significantly different; $\chi^2 = 0.06$, df = 1, $P \gg 0.05$). Eighteen (or 44%) of the 41 prey items dropped by these adults were taken and eaten by attacking eagles; 4 (or 27%) of the 15 prey items dropped by immatures were taken and eaten by the eagle that caused the drop (Proportions not significantly different; $\chi^2 = 1.58$, df = 1, $P \gg 0.05$).

The best foraging behavior of immature eagles appeared to be to search independently for prey, but to attempt piracy when an opportunity arose. This may have been true for adults as well, but cannot be shown without more precise data. For either age class, the net energy obtained via piracy increases as robbery attempts become shorter and as larger fish are taken. Hence, selection should favor individuals that only attack hosts with large prey and break off aerial pursuits quickly if the probability of success is low.

Although my results are consistent with the hypothesis that eagles attempt piracy because doing so maximizes their net energy gain, other explanations are also possible. Kushlan (1978) argued that robbing may be the optimal method of feeding for Great Egrets (*Casmerodius albus*) only during the brief periods when food is scarce, but that, because selection pressures are strongest at these times, piracy is attempted readily at other times as well. Stalmaster and Gessaman (1984) used this reasoning to explain why Bald Eagles in Washington stole food even though it appeared to be energetically more expensive than other methods of feeding. Caldwell (1980) suggested that the mo important consequence of piracy attacks be veen egrets is not the gain or loss of a prey item, but the acquisition of a better foraging site. This may also be true of supplanting attacks among eagles: those birds that are repeatedly robbed

or displaced at feeding areas may be forced to leave, thus reducing competition for food among those birds that remain.

Alternatively, the selection value of intraspecific piracy may be at least partially unrelated to food acquisition. Aerial pursuits could be a means of establishing individual dominance and overall fitness. Such behavior may be important as a prelude to courtship and mate selection, activities which begin on the wintering grounds. Lish (1973) suggested that social dominance hierarchies exist among wintering groups of eagles. If so, piracy could be a means of establishing and reinforcing social rank. This possibility cannot be discounted, but it is unlikely that a complex social system existed among eagles in my study, because most individuals were present for only brief periods.

ACKNOWLEDGMENTS

I thank the Institute for Environmental Management, Western Illinois University, and the Iowa Department of Transportation for funding portions of this study. Access to restricted areas was granted by the Union Electric Power Company, Illinois Chapter of The Nature Conservancy, U.S. Coast Guard, and Western Illinois University. I also thank D. Osterfeld, J. Grubaugh, V. Anderson, T. Howe, G. Kruse and J. Wescott for assistance in the field; T. C. Dunstan who served as my advisor and was instrumental in securing funding; and C. M. White, H. D. Smith, K. L. Bildstein, M. V. Stalmaster, and S. K. Sherrod who commented on earlier drafts of the paper.

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