LASTING EFFECTS OF WING TAGS ON RING-BILLED GULLS

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ABSTRACT.—Wing tags influenced Ring-billed Gulls (*Larus delawarensis*) unfavorably for up to four years after they were marked. Fewer tagged birds returned to the colony site, and birds that returned arrived approximately one week later, on average, than leg-banded birds. Although arrival dates and hatching dates were unrelated, the eggs of tagged birds hatched 2–5 days later than those of banded birds. Pair bonds of tagged birds were broken more often than those of banded birds. This may have contributed to delayed hatching. Most wing-tagged females (54–60%) that returned to the colony were unable to acquire mates. Birds whose tags were replaced with color bands resumed normal reproductive performance. Wing tags presumably interfered with Ring-billed Gull migration and had pronounced, long-term effects on behavior and reproduction. The potential impact of marking techniques must be evaluated carefully before or during any study of avian behavior. *Received 5 December 1988, accepted 4 May 1989.*

THE QUALITY of any investigation is dependent, among other things, upon choosing methods that do not produce spurious results. Previously (Bennett 1939, Goforth and Baskett 1965), the effects of artificial markings on bird behavior were noted, but the implications of such findings were largely ignored by ornithologists. Recently, investigators have come to recognize that a bird's behavior, survival, and ecology may be influenced by wing tags, leg bands, or radio transmitters (Burley et al. 1982, Burley 1985, Southern and Southern 1985, Szymczak and Ringelman 1986, Marks and Marks 1987, Ratcliffe and Boag 1987, Gessaman and Nagy 1988, Hagan and Reed 1988). The extent to which marking techniques are used without regard to potential effects seems to be decreasing. Yet, many ornithological studies still are conducted, supervised, reviewed, and published without even minimal examination of the possible influence of a marking technique. I report an example of lasting effects of wing tags on a bird species, and I point out some biases introduced by marking techniques.

Intermittently since the 1960s, Ring-billed Gulls (*Larus delawarensis*) at the Rogers City, Michigan, colony were marked with patagial tags (Southern 1971). Because many of these wing-marked birds returned to the colony site year after year and seemed, superficially, to breed normally, I originally had planned to use tagged birds as study subjects in long-term investigations. To be certain that tags did not affect the gulls adversely, I color-banded some birds in 1982 and compared the reproductive performance of this group with a wing-tagged group. In the year immediately after marking, fewer tagged birds returned to the colony site than expected, and tagged birds arrived later, bred later, and experienced pairing difficulties (Southern and Southern 1985). I ceased using wing markers in 1983 and color-banded birds for the following three years. To quantify the longer-term effects of tags, I compared the reproductive performance of tagged and color-banded birds.

STUDY AREA AND METHODS

Study area.—This study was conducted near Rogers City, Presque Isle County, Michigan (45°N, 83°W), where gulls nested on a manmade peninsula known as the Rogers City, or Calcite, colony site. An average of ca. 10,000 Ring-billed Gull pairs used the Rogers City site during the time of this study, and >13,000 pairs nested there in 1986. This colony was easily accessible by car, but unwanted human intrusions were prevented by a cyclone fence.

Capturing and marking birds.—Breeding Ring-billed Gulls were captured with a cannon-net during mid- to late-incubation when most were strongly attached to their nest and its contents. At the Rogers City colony, this technique was efficient and had minimal detrimental impact when performed properly (Southern and Southern 1983). Cannon-netting was conducted in and around three 10 × 20-m study plots.

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TABLE 1. Percentage of birds wing-tagged and color-banded in 1982 that were resighted in subsequent years at the Rogers City colony. For each year-specific Chi-square comparison of tagged and banded birds, $P < 0.001$. Sample sizes are in parentheses.

	1983	1984	1985	1986
Tagged birds				
Females (77)	64.9	22.1	22.1	3.9
Males (54)	79.6	37.0	29.6	14.8
All (150)[a]	62.0	24.7	23.3	7.3
All, corrected[b]	63.3	29.1	31.5	—
Banded birds				
Females (28)	92.9	85.7	82.1	71.4
Males (20)	100.0	70.0	55.0	50.0
All (53)[a]	90.6	76.5	68.6	60.8

[a] Includes birds of unknown sex.
[b] Corrected for tag loss, see text.

The gulls I observed for this study were either wing-tagged (Southern 1971) in 1981 or 1982 (487 birds) or banded with colored Darvic leg bands (J. E. Warner, Durham, England) between 1982 and 1985 (162 birds). Wing tags were dumbbell-shaped, orange or yellow reinforced vinyl, 16 cm long by ca. 6 cm at the widest point, and weighed 2.5 g including an eyelet for attachment. These tags did not pierce the patagium but were wrapped around it instead. I also replaced wing tags with color bands on 18 birds recaptured in 1983 or 1985.

Observations.—Between 1982 and 1986, I spent 1,050 h conducting observations. Despite the long history of investigations at this colony, I chose methods that minimized human disturbance. To track the reproductive performance of marked birds, I watched them from an automobile which served as a blind. I entered plots only to census, cannon-net, describe nest sites, or maintain nest markers. During most years, I visited each plot for a total of only 1–3 h. When chicks reached a few days of age, I ceased all intrusions into the plots.

In 1983 and 1985, I arrived at the colony site during the first week of April and recorded the dates when marked birds were first seen. Initially, I searched the entire colony for marked individuals; these birds were seen always in or near the study plots. Thereafter, I perused the study plots and adjacent areas at various times of the day, and I occasionally examined other areas of the colony. Whenever possible, I identified mates of marked birds.

There was no indication that any color bands were lost during this study. Some wing tags, however, did not last the duration, and I estimated minimum tag loss as:

$$T_{\text{LOST 1-2}} = T_1(t_{\text{LOST 1-2}}/T_2 + t_{\text{LOST 1-2}}),$$

where T = number of tags, t = the number of birds known to have lost tags as determined by reading leg bands (mainly by spotting scope) on birds that were not carrying tags. First and second years in a 2-yr sequence are indicated by 1 and 2. I estimated tag loss between 1982 and 1983 at 2.1%, between 1982 and 1984 11.1%, and between 1982 and 1985 22.5%. Adequate data were unavailable on tag loss between 1982 and 1986. This method provides an estimate of minimum tag loss. The intensity and duration of observations, however, along with the strong site fidelity of Ring-billed Gulls assure that the vast majority of birds that lost tags were sighted.

Data analysis.—Most data analyses were performed with MYSTAT and SYSTAT (Northwestern University) on IBM-compatible personal computers. Zar (1984) was consulted for guidance on the proper application of statistical tests. Analysis of variance, Chi-square contingency, Chi-square goodness-of-fit, and regression analyses were among the tests used. Some analyses deal solely with birds that were marked in 1982; others consider gulls tagged in 1981 and 1982, or color-banded in 1982, 1983, and 1985.

RESULTS

Return to the colony site.—Subsequent sightings of birds tagged and banded in 1982 differed substantially (Table 1). Much higher proportions of color-banded birds, compared with tagged birds, were seen each year. This was true also when the resighting rate for tagged birds was corrected for tag loss (Table 1).

In general, more female birds color-banded in 1982 were resighted than males, whereas this gender difference was reversed in wing-marked birds (Table 1). The return rates of males and females were significantly different for tagged birds only in 1986 ($n = 131$, df = 1, $\chi^2 = 4.92$, $P = 0.03$) and for color-banded birds only in 1985 ($n = 48$, df = 1, $\chi^2 = 4.16$, $P = 0.04$). At the end of 4 yr, 96.1% ($n = 77$) of the tagged females and 85.2% ($n = 54$) of the males had disappeared (1986, $P = 0.03$). Among banded birds, 28.6% ($n = 28$) of the originally marked females and 50.0% ($n = 20$) of the banded males had disappeared 4 yr later ($n = 48$, df = 1, $\chi^2 = 2.29$, $P = 0.13$).

Date of return.—In April of 1983 and 1985, I recorded the dates when I first sighted marked individuals at the colony site. In both years, color-banded birds arrived about 1 week earlier, on average, than tagged birds of the same sex (Table 2). Females arrived earlier than males in 1985 ($P = 0.01$), but there was no significant difference in arrival dates between sexes in 1983 (Table 2).

There was a tendency for individual birds color-banded in 1982 to arrive earlier in 1985

TABLE 2. Dates ($\bar{x} \pm$ SD) in April when marked birds were first seen at the Rogers City colony. Sample sizes are in parentheses; *P*-values reflect ANOVA results.

Year/sex	Wing-tagged	Color-banded	*P*	
			Marking	Sex
1983				
Females (138)	17.6 ± 10.4	9.4 ± 5.2	<0.001	0.51
Males (112)	18.0 ± 11.4	9.8 ± 4.7		
1985				
Females (77)	13.1 ± 6.2	6.5 ± 3.6	<0.001	0.01
Males (72)	15.9 ± 8.3	8.3 ± 4.2		

than they had in 1983. This applied to 69.6% of females and 72.7% of males ($n = 35$). Conversely, for birds wing-tagged in 1981 or 1982, smaller proportions of both females (50.0%) and males (44.8%) arrived earlier in 1985 than they had in 1983 ($n = 59$). The difference between proportions of tagged and banded birds that arrived earlier in 1985 was significant ($n = 94$, $\chi^2 = 5.63$, df = 1, $P = 0.02$).

Five of six birds that wore tags in 1983 but carried only bands in 1985 arrived at the colony earlier in 1985 than they had in 1983 (mean difference = −5.0 days ± 8.1 [SD]).

Date of hatching.—Over a 5-yr period, birds tagged in 1981 or 1982 always hatched their eggs 2–5 days later than birds color-banded between 1982 and 1985 (Table 3). Pairs in which one member was tagged and the other was banded were excluded from this analysis.

Among birds marked in 1982, hatching dates of color-banded individuals tended to get progressively earlier between 1982 and 1986, but it was not clear whether tagged individuals showed a similar tendency (Table 4).

I examined the possibility that hatching dates of tagged birds might have been affected by their later arrival dates by regressing hatching date on arrival date. One of the three data sets for tagged birds showed a slight but significant effect ($P = 0.04$); however, only 9% of the variance in hatching date was accounted for in this instance (Table 5). For both tagged and banded birds, there tended to be no relation between arrival date and hatching date (Table 5).

TABLE 3. Hatching dates ($\bar{x} \pm$ SD) for color-banded and wing-tagged birds; May 1 = day 1, June 1 = day 32, etc. Sample sizes are in parentheses (tags, bands); differences were tested with ANOVA.

Year	Hatching date		*P*
	Wing-tagged	Color-banded	
1982 (143, 23)	32.3 ± 4.0	29.9 ± 2.5	<0.01
1983 (72, 77)	35.1 ± 6.3	30.4 ± 5.0	<0.01
1984 (33, 58)	29.8 ± 3.7	24.7 ± 3.1	<0.01
1985 (33, 118)	24.7 ± 3.6	22.5 ± 3.6	<0.01
1986 (12, 118)	25.5 ± 4.3	22.4 ± 3.9	<0.01

Of 13 birds whose tags were replaced with color bands, 12 hatched eggs earlier in the year after their tag was removed than in the previous year (mean difference = −5.5 days ± 4.5 [SD]). The 3 females in this sample hatched their eggs 6, 7, and 15 days earlier during the year after their tags were removed and replaced with bands.

Reproductive performance.—Wing-tagged females had greater marker-associated problems related to reproduction than did wing-tagged males (Table 6). The primary problem that tagged females encountered was rejection by potential mates; 59.5, 58.3, and 53.8% of returning tagged females did not acquire mates in 1983, 1984, and 1985, respectively. This represented a substantial difference between tagged and color-banded females for each year (Table 6; 1983: $n = 56$, df = 1, $\chi^2 = 15.24$, $P < 0.001$; 1984: $n = 33$, df = 1, $\chi^2 = 9.17$, $P < 0.01$; 1985: $n = 31$, df = 1, $\chi^2 = 5.90$, $P = 0.02$). Once a tagged female had acquired a mate, she was just as likely as a banded bird to complete the reproductive cycle (see below).

Marked male failures at most stages of the breeding cycle, especially for banded birds, were extremely rare. It appeared that similar, high proportions of tagged and banded males proceeded through various stages of the nesting cycle successfully (Table 6).

I examined the breeding performance of 18 birds in years when they were tagged, and after

TABLE 4. Number of days ($\bar{x} \pm$ SD) between hatching dates for individual birds marked in 1982. Sample sizes are in parentheses. Negative values reflect progression toward earlier nesting.

	Tagged		Banded	
	Females	Males	Females	Males
1982–1983 (29)	0.3 ± 1.3	4.1 ± 2.8	0.8 ± 1.5	0.5 ± 1.7
1982–1984 (25)	2.0 ± 3.7	−1.6 ± 2.1	−4.0 ± 1.0	−4.6 ± 1.3
1982–1985 (20)	−2.0[a]	−7.4 ± 1.4	−6.6 ± 0.9	−7.0 ± 1.6
1982–1986 (16)	−14.0[a]	−1.0[a]	−4.2 ± 1.5	−7.2 ± 2.7

[a] $n = 1$.

their tags were removed and replaced with color bands. When data for both sexes were combined, there was a tendency (not statistically significant) for individuals to fledge more chicks after tags had been removed ($n = 55$, $\chi^2 = 1.71$, df = 1, $P = 0.19$). Males fledged chicks in 89.7% of 29 instances when they wore bands, and 75.0% of 16 cases when they carried tags. Similarly, females fledged young 83.3% of the time ($n = 6$) when banded, and 75.0% of the time ($n = 4$) when tagged.

Pair bond.—When at least one member of a pair was wing-marked, there was a greatly increased chance that the bond would break between breeding seasons ($n = 226$, df = 1, $\chi^2 = 5.83$, $P = 0.02$). Among pairs with a banded (but not tagged) member, bonds were broken 28.9% of the time ($n = 90$). Among pairs with a tagged (and not banded) member, bonds were broken in 44.8% of 136 cases.

Birds that changed mates tended to avoid a tagged bird as a new mate (Table 7; $n = 83$, df = 3, $\chi^2 = 45.6$, $P < 0.001$). For this analysis, I calculated expected values based on the availability of tagged and untagged birds. The avoidance of tagged birds as new mates appeared to hold true for both banded and tagged individuals (Table 7), but sample sizes were small for some color-banded categories, and these groups were combined for the goodness-of-fit analysis.

There was no relationship between pair-bond status and prior fledging success for tagged birds ($n = 98$, df = 1, $\chi^2 = 0.18$, $P = 0.67$). This was similarly true for color-banded birds (Kinkel 1988). For tagged birds also, there was no relationship between mate fidelity and reproductive success in the following year ($n = 89$, df = 1, $\chi^2 = 0.004$, $P = 0.95$). This contrasts with color-banded birds, which were less likely to raise young in the year immediately following a mate change (Kinkel 1988).

Body mass.—Some birds that were cannon-netted in 1983 and 1985 had been marked previously, and they had worn a tag or band for ≥1 yr. Because there was a strong correlation between bill length and body mass ($r = 0.48$, P

TABLE 5. Relationship between arrival date and hatching date of marked gulls. Sample sizes are in parentheses.

	Slope of regression (b)	r^2	P
Tagged birds			
1982 (61)	−0.03	0.01	0.58
1983 (49)	0.19	0.09	0.04
1985 (26)	0.07	0.00	0.46
Banded birds			
1983 (32)	−0.07	0.03	0.31
1985 (60)	−0.14	0.02	0.15

TABLE 6. Proportions of returning 1982-marked birds that successfully reached various stages of the reproductive cycle in subsequent years. Sample sizes are in parentheses.

	Females		Males	
Year/stage[a]	Tagged	Banded	Tagged	Banded
1983	(36)	(26)	(34)	(19)
Mate	40.5	92.3	94.6	100
Eggs	38.9	92.3	85.7	100
Chicks	21.1	82.6	64.7	88.2
Fledglings	10.5	58.3	40.6	68.8
1984	(12)	(23)	(15)	(12)
Mate	41.7	91.3	100	100
Eggs	33.3	91.3	100	100
Chicks	33.3	90.5	100	100
Fledglings	U[b]	U	U	U
1985	(13)	(23)	(10)	(11)
Mate	46.2	82.6	100	100
Eggs	33.3	78.3	100	100
Chicks	25.0	72.7	100	100
Fledglings	18.2	60.0	83.3	90.0

[a] Mate = mate acquired; eggs = eggs laid; chicks = eggs hatched; fledglings = young raised to 21 days of age.
[b] U = unknown.

< 0.001), I performed analyses of covariance, with mass as the dependent variable, marking type as the independent variable, and bill length as a covariate. This was an attempt to establish if marking affected mass independent of size (as indicated by bill length). Weight was unaffected by marking type for both females ($n = 53$, df = 1, $F = 1.06$, $P = 0.31$) and males ($n = 83$, df = 1, $F = 1.38$, $P = 0.24$).

TABLE 7. Mates chosen by banded and tagged birds whose pair bonds were broken. Values are number of instances; Chi-square goodness-of-fit $P < 0.001$.

		Bird changing mate	
Prior mate	New mate	Color-banded	Wing-tagged
Tagged	Tagged	3	11
	Untagged	10	30
Untagged	Tagged	2	9
	Untagged	10	8

DISCUSSION

For four years after they were marked, wing-tagged Ring-billed Gulls returned to the colony site in lower proportions than color-banded birds. I am confident that I sighted all marked birds present at the colony each year; nest censuses and investigations elsewhere in the colony never revealed marked birds away from the study plots. The return rates I observed in the first year postmarking corresponded well with those previously reported by Southern (1977). Southern noted that ca. 90% of banded birds and 60% of tagged birds were resighted at the colony. In my data, the difference in return rates was substantial even when corrected for tag loss.

Low return rates of wing-tagged birds have several possible explanations. First, there may be an increased tendency for tagged birds to change colony sites. Second, tagged birds may experience greater mortality between breeding seasons. Third, tags may interfere with physiological processes or behavior, or both, associated with migration, such that spring migration was not attempted or completed.

Reports of tagged birds at other colony sites have been exceedingly rare (4 of ca. 2,500, pers. obs.), and birds color-banded at Rogers City have never been seen at other colonies. Although resighting efforts at other colonies have varied, adult Ring-billed Gulls (Kinkel 1988) and other larids (Coulson and Wooller 1976) show strong site fidelity. It is unlikely that the lower return rate of tagged birds was attributable to birds changing colony sites.

Wing tags almost certainly affect Ring-billed Gull mortality rates. No birds color-banded at Rogers City ever have been seen at any other Great Lakes colonies. Each year, the entire Rogers City colony was searched for marked birds. None was ever found more than a few meters from the study plots. Birds that failed to return to the colony site in any year were never seen again. It is reasonable to assume that they had died. For the color-banded sample, mortality (nonresighted) rates are comparable to related species (Coulson and Thomas 1985, Coulson and Butterfield 1986). The relationship of tags to increased mortality requires further investigation.

It appears that wing tags might also interfere with migration or the timing of migration. Howe (1980) suggested that wing tags prevented Willets (*Catoptrophorus semipalmatus*) from completing their round-trip migration. He proposed that increased drag or abnormal feather replacement caused by tags could leave birds more susceptible to predation or nutritional stress. This may hold for Ring-billed Gulls as well.

Over a 4-yr period, color-banded individuals generally hatched eggs progressively earlier, a tendency characteristic of seabirds as they age (Ryder 1980). Tagged males showed a similar trend, perhaps indicating that tags did not interfere with an age-related tendency to hatch eggs earlier each year. Because hatching date is probably determined largely by the female, it is somewhat surprising that pairs in which males were wing-tagged hatched their eggs later than those in which males were color-banded. Possibly tags interfered with or delayed courtship behavior. Tagged birds also broke their pair bonds ca. 45% of the time, and newly formed pairs tended to hatch eggs slightly later than established pairs (Kinkel 1988).

Among banded birds, established pairs were more likely to raise young. The lack of such a relationship among the tagged group implies that tags interfered with reproduction in some way and could not be overridden by familiarity and cooperation between mates. Possibly tags affected a bird's ability to brood its chicks or to forage efficiently.

The most dramatic influence of wing tags was the rejection of tagged females by males with

whom they tried to pair. Males were resistant despite persistent approaches and solicitations by tagged females. Wing tags were sometimes, but not always, visible when marked females tried to approach potential mates. Although tags often were not conspicuous (to me), the gulls may have been aware of a physical difference. Alternatively, the behavior of tagged females may have been responsible for males' reactions. Although I lack quantitative data, tagged females were very subordinate, and often in sleeked-upright posture. Perhaps this submissive behavior, along with the signal the females carried, made it unlikely that a male would choose a tagged female as a mate. Each male had other unmarked females among which to choose (because of a female surplus; Kinkel 1988), and wing-tagged birds apparently were regarded as low-quality mates. Colored leg bands affect other species but not the Ring-billed Gull. Apparently, leg color is not important during courtship activities for this species.

The presence of wing markers on Ring-billed Gulls virtually ensured that the fitness of most wing-tagged individuals would be severely lowered. The potential for introducing bias into a study by a marking technique is one which investigators and reviewers ought to consider. The effects of marking techniques on study subjects and on results should be carefully assessed before, during, and after any investigation of animal behavior.

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LITERATURE CITED

BENNETT, M. A. 1939. The social hierarchy in ring doves. Ecology 20: 337–357.

BURLEY, N. 1985. Leg-band color and mortality patterns in captive breeding populations of Zebra Finches. Auk 102: 647–651.

———, G. KRANTZBERG, & P. RADMAN. 1982. Influence of colour-banding on the conspecific preferences of Zebra Finches. Anim. Behav. 30: 444–455.

COULSON, J. C., & J. BUTTERFIELD. 1986. Studies on a colony of colour-ringed Herring Gulls *Larus argentatus*: I. Adult survival rates. Bird Study 33: 51–54.

———, & C. S. Thomas. 1985. Changes in the biology of the kittiwake *Rissa tridactyla*: a 31-year study of a breeding colony. J. Anim. Ecol. 54: 9–26.

———, & R. D. WOOLLER. 1976. Differential survival rates among breeding kittiwake gulls *Rissa tridactyla*. Ibis 100: 40–51.

GESSAMAN, J. A., & K. A. NAGY. 1988. Transmitter loads affect the flight speed and metabolism of homing pigeons. Condor 90: 662–668.

GOFORTH, W. R., & T. S. BASKETT. 1965. Effects of experimental color marking on pairing of captive Mourning Doves. J. Wildl. Manage. 29: 543–553.

HAGAN, J. M., & J. M. REED. 1988. Red color bands reduce fledging success in Red-cockaded Woodpeckers. Auk 105: 498–503.

HOWE, M. 1980. Problems with wing tags: evidence of harm to Willets. J. Field Ornithol. 51: 72–73.

KINKEL, L. K. 1988. Nest site fidelity in the Ring-billed Gull (*Larus delawarensis*). Ph.D. dissertation. DeKalb, Northern Illinois Univ.

MARKS, J. S., & V. S. MARKS. 1987. Influence of radio collars on survival of Sharp-tailed Grouse. J. Wildl. Manage. 51: 468–471.

RATCLIFFE, L. M., & P. T. BOAG. 1987. Effects of colour bands on male competition and sexual attractiveness in Zebra Finches (*Poephila guttata*). Can. J. Zool. 65: 333–338.

RYDER, J. P. 1980. The influence of age on breeding ecology of colonially nesting seabirds. Pp. 153–168 *in* Behavior of marine animals, vol. 4: marine birds. (J. Burger, B. L. Olla, and H. E. Winn, Eds.). New York, Plenum Press.

SOUTHERN, L. K., & W. E. SOUTHERN. 1983. Responses of Ring-billed Gulls to cannon-netting and wing-tagging. J. Wildl. Manage. 47: 234–237.

———, & ———. 1985. Some effects of wing tags on breeding Ring-billed Gulls. Auk 102: 38–42.

SOUTHERN, W. E. 1971. Evaluation of a plastic wing marker for gull studies. Bird-Banding 42: 88–91.

———. 1977. Colony selection and colony site tenacity in Ring-billed Gulls at a stable colony. Auk 94: 469–478.

SZYMCZAK, M. R., & J. K. RINGELMAN. 1986. Differential habitat use of patagial-tagged female Mallards. J. Field Ornithol. 57: 230–232.

ZAR, J. H. 1984. Biostatistical analysis. 2nd ed. Englewood Cliffs, New Jersey, Prentice-Hall, Inc.