The Condor 90:942–945

EFFECTS OF BLOOD SAMPLING ON SHOREBIRDS: INJURIES, RETURN RATES, AND CLUTCH DESERTIONS[1]

MARK A. COLWELL, CHERI L. GRATTO, LEWIS W. ORING, AND ALBERT J. FIVIZZANI
Department of Biology, University of North Dakota, Grand Forks, ND 58202

Key words: Blood sampling; shorebirds; field endocrinology; injuries; return rates; clutch desertions.

Recent advances in endocrinology techniques (e.g., Follett et al. 1972; Wingfield and Farner 1975, 1976; McNeilly et al. 1978; Burke and Papkoff 1980; and others) have ushered in a new era in avian field endocrinology. With this technology it has become feasible to sample serially the levels of a variety of hormones in conjunction with annual behavioral and physiological cycles of individual wild birds (e.g., Harding and Follett 1979, Wingfield 1984, Oring et al. 1988, and others).

A requisite of many field studies is that behavior and survival of individuals not be affected by sampling (Frederick 1986). Although plasma samples necessary for hormone analysis can be obtained from most species of birds with relative ease, few studies have examined possible negative effects of sampling. In general, limited evidence suggests that sampling techniques have negligible effects on birds (see references in Oring et al. 1988).

This paper examines the effect of field sampling of blood on return rates, injuries, and breeding behavior of four species of North American shorebirds: Spotted Sandpiper (*Actitis macularia*), Semipalmated Sandpiper (*Calidris pusilla*), Red-necked Phalarope (*Phalaropus lobatus*), and Wilson's Phalarope (*P. tricolor*).

STUDY AREAS AND METHODS

Research was conducted at three sites: (1) Spotted Sandpipers were studied from 1973–1987 on Little Pelican Island, Leech Lake, Minnesota; (2) Semipalmated Sandpipers and Red-necked Phalaropes were studied from 1980–1987 in the delta of the Mast River, 40 km east of Churchill, Manitoba; and (3) Wilson's Phalaropes were studied from 1982–1987 at Last Mountain Lake National Wildlife Area, Saskatchewan. Details of study areas are presented elsewhere (Maxson and Oring 1980, Gratto et al. 1985, Colwell and Oring 1988).

Birds were captured using mist nests, walk-in traps, decoy traps, and nest traps. Each individual was banded with a unique combination of three colored leg bands and a metal band. We sampled blood by puncturing the brachial vein with a small (23–26 gauge) needle and collecting blood directly into heparinized microhematocrit capillary tubes (Oring et al. 1988). Pressure was applied to the wound if bleeding continued after sampling. For each sample, we recorded the method of capture, interval of time between trapping and completion of blood sampling (handling time), and obvious injuries to the bird. Total volume of plasma was recorded when samples were processed at field camps.

Reproductive histories of birds were recorded during regular daily observation periods, including behavior and fate of clutches. We noted especially whether or not a clutch was deserted following capture and/or blood sampling. Clutch desertion was characterized as immediate (within a day of capture) for Wilson's Phalarope, or eventual (any time following handling of a bird) for Semipalmated Sandpiper and Red-necked Phalarope. Differences among studies in the interpretation of desertion reflect the frequency and regularity with which observers checked nests, as well as differences in the biology of the species involved. Philopatry was calculated separately for bled and unbled birds. Here, a bird "returned" if it was seen at least once.

RESULTS

Field sampling techniques were similar among species (Table 1). Most birds were bled once a season, especially early in the descriptive stages of research (Fivizzani et al. 1986; Oring et al. 1986a, 1986b). Experimental phases, however, involved sequential sampling of individuals, sometimes three or four times over approximately 30 days (Oring et al., in press). Most serial samples of individuals were obtained at intervals greater than a week, but a few birds ($n = 4$) were sampled at 24-hr intervals with no detrimental effects. A small proportion (0–3%) of birds died or sustained debilitating injuries during blood sampling (Table 1).

Handling time averaged 8–11 min (Table 1). Plasma volume was negatively correlated with handling time in four of eight cases, suggesting that success in the initial stages of bleeding may reduce handling time. Average plasma volume was greatest for Wilson's Phalarope, the largest species. There were no sex differences in amount of plasma obtained (t-test: $P > 0.05$).

Bleeding had no effect on the return of birds of either sex the following year (Table 2). Wilson's Phalarope provides the best comparison of the effects of bleeding and capture, since virtually all individuals that were not bled were captured and banded.

The effect of bleeding on clutch desertion varied among species and depended on whether birds were captured during laying or incubation stages. The proportion of incubating male Wilson's Phalaropes that deserted following bleeding (19 of 207) did not differ

[1] Received 10 February 1988. Final acceptance 7 July 1988.

TABLE 1. Interspecific comparison of blood sampling and injuries sustained by shorebirds.

Species	Sex	Total bleedings	$\bar{x}$ yearly bleedings per bird (range)	$\bar{x}$ handling time (range)	$\bar{x} \pm$ SD plasma[a] volume	P[b]	% injured	Injury type
Spotted	M	161	1.4 (1–4)	9 (4–20)	184 ± 72	0.62	1	c, d
Sandpiper	F	46	1.5 (1–3)	9 (3–13)	184 ± 52	0.42	2	e
Semipalmated	M	207	1.2 (1–4)	10 (1–35)	167 ± 66	0.0001	0	
Sandpiper	F	136	1.2 (1–2)	10 (1–25)	179 ± 70	0.0001	1	f
Red-necked	M	92	1.5 (1–3)	8 (2–18)	186 ± 79	0.0001	3	g, h
Phalarope	F	39	1.2 (1–2)	8 (1–20)	175 ± 75	0.03	3	e
Wilson's	M	296	1.5 (1–4)	8 (2–40)	226 ± 74	0.05	0	
Phalarope	F	42	1.1 (1–2)	11 (5–25)	255 ± 94	0.77	2	e

[a] Whole blood volume was approximately twice plasma volume.
[b] Significance of Pearson's correlation between handling time and volume.
[c] Broken wing.
[d] Broken leg.
[e] Died during bleeding.
[f] Bird was flightless, with calloused brachial vein 30 days after bleeding.
[g] Birds (n = 2) were flightless, with calloused brachial veins 16 and 23 days after bleeding.
[h] Dislocated wing.

from males that were captured but not bled (1 of 11) (G-test, $P = 0.99$). Similarly, bled (7 of 33) and unbled males (6 of 23) captured during the laying stage did not differ in desertion rates (G-test, $P = 0.67$). Overall, however, male Wilson's Phalaropes were more likely to desert when captured during the laying stage (G-test, $P = 0.007$).

Clutch desertion by incubating male Red-necked Phalaropes was not related to whether a bird was bled (4 of 35) or not (1 of 15) (G-test, $P = 0.59$).

Incubating Semipalmated Sandpipers were more likely to desert a clutch if both adults were sampled (6 of 41) than when only one adult (2 of 53) (G-test, $P = 0.06$) or neither adult (2 of 56) (G-test, $P = 0.05$) was bled. The incidence of desertion did not differ between clutches where neither or one adult was bled (G-test, $P = 0.96$).

DISCUSSION

Sampling blood from wild birds appears to have few noticeable effects on individuals (Oring et al. 1988), although published accounts are few. For example, short-term survival of Eastern Bluebirds, *Sialia sialis* (Gowaty and Karlin 1984), and Canada Geese, *Branta canadensis* (Raveling 1970), was unaffected by bleeding. Recovery rates of Mourning Doves (*Zenaida macroura*) that were bled did not differ from recoveries of doves in studies where no blood sampling took place (Bigler et al. 1977).

Our blood sampling of shorebirds resulted in a low incidence of mortality and injury, some of which occurred when techniques were being refined by observers that were inexperienced in handling and bleeding birds. Similar return rates of bled and unbled birds suggest that blood sampling had no effect on long-term survival of individuals.

The effect of blood sampling on the behavior of breeding individuals is less well documented, but also appears to be minimal. Frederick (1986) showed that blood sampling caused no clutch desertions among adult White Ibises (*Eudocimus albus*), and that feeding and brooding behaviors continued normally. Furthermore, subsequent observations of individuals on wintering grounds suggested that bleeding does not compromise ability to migrate. Similarly, reproductive behavior of White-crowned Sparrows (*Zonotrichia leucophrys*) was not adversely affected by blood sampling and laparotomy (Wingfield and Farner 1976). All sparrows remained on their territory following bleeding and these birds did not differ from normal sectors of the population with regard to timing of breeding or number of chicks fledged.

Our data on shorebirds indicate that blood sampling had no detectable effect on some features of breeding behavior. Compared to the stress of activities associated with capture of an individual, bleeding did not increase levels of clutch desertion. However, the timing of capture in an individual's reproductive cycle may be critical in determining whether or not a clutch is deserted. Male Wilson's Phalaropes were significantly more likely to desert a clutch if they were captured during the laying stage.

Interspecific differences in clutch desertion following capture or bleeding may be related to a species' mating system. Desertion by biparental Semipalmated Sandpipers was more likely when blood was sampled from both incubating adults than when one or neither parent was sampled. By contrast, desertion was lower for uniparental phalaropes captured during incubation.

Given blood samples of similar volume, the effect of blood sampling on a bird may vary with the size and blood volume of a species. Similar-sized blood samples constitute an increasing proportion of total blood volume as the mass of a bird decreases. On average, blood contributes 8% to total body weight of an individual (Sturkie 1976). If plasma comprises approximately 50% of blood sampled, then our samples from shorebirds averaged 9–17% of total blood volume. Percent total blood volume sampled from Canada Geese averaged less than 1% for adults and under 2% for young (Raveling 1970); samples from Mourning Doves comprised about 6–10% of total blood volume (Bigler et al. 1977); and blood samples from White-

TABLE 2. Comparison of return rates for bled and unbled shorebirds, expressed as percent of birds that returned the next year. Bled and unbled birds did not differ in return rates (G-test, $P > 0.05$).

Species	Year	% return (n)			
		Males		Females	
		Bled	Not bled	Bled	Not bled
Spotted	1983	48 (23)	56 (9)	75 (4)	36 (11)
Sandpiper	1984	27 (30)	29 (7)	40 (5)	73 (11)
	1985	31 (29)	50 (6)	35 (23)	67 (3)
	1986	56 (16)	17 (6)	0 (1)	57 (14)
Semipalmated	1985	71 (45)	69 (29)	48 (40)	52 (27)
Sandpiper	1986	58 (26)	70 (10)	52 (21)	75 (8)
Red-necked	1985	52 (29)	50 (14)	54 (11)	46 (13)
Phalarope	1986	37 (19)	15 (13)	50 (12)	44 (9)
Wilson's	1984	32 (28)	25 (8)	6 (17)	0 (14)
Phalarope	1985	13 (68)	17 (12)	13 (16)	0 (7)
	1986	18 (33)	5 (20)	—	0 (18)

crowned Sparrows constituted 23–37% of total blood volume (Wingfield and Farner 1976). Clearly, birds can tolerate the loss of considerable blood volume without severe consequences and often maintain normal breeding behavior. One incubating male Wilson's Phalarope inadvertently provided us with approximately 40% of his blood volume 5 days into incubation. This male continued to incubate for 21 additional days and was sampled twice more at 10-day intervals.

Although blood sampling resulted in mortality and injury to a few individuals, we failed to detect other noticeable effects of bleeding. Our study, however, was not designed to test for such effects, and as a result, we may have overlooked instances of stress caused by capture. Specifically, capture myopathy, an immediate complication of capture and handling of birds, has been reported for a number of avian species (e.g., Wobeser 1981, Chalmers and Barret 1982). The severity of myopathy may vary with capture technique and handling time (G. Wobeser, pers. comm.); longer, stressful handling of birds results in greater myopathy. Handling time and capture methods of shorebirds varied and may have resulted in differing susceptibility of individuals to capture myopathy.

Data on shorebirds suggest that some measures of behavior were not adversely affected by blood sampling techniques; thus, blood sampling may be compatible with other studies of avian reproductive biology. Compared to normal handling of birds during banding operations, bleeding had a minimal effect on birds. However, the response of individuals to capture varied across reproductive stages and among mating systems. Future studies of the effect of blood sampling on behavior should incorporate a rigorous experimental approach that quantifies behavioral changes in individuals.

We thank the many individuals who assisted in the field; the Canadian Wildlife Service (CWS), Churchill Northern Studies Centre, Huddle's Resort, University of Minnesota Forestry and Biological Station, Clint Jorgenson, Judge Miles Lord, Kay Oring, and Phil Taylor for logistical support; and the Arctic Institute of North America, CWS, Eastern Bird Banding Association, E. Alexander Bergstrom Memorial Research Fund, National Geographic Society, National Science Foundation grants PCM-8315758 and DCB-8608162 to LWO and AJF, Natural Sciences and Engineering Council of Canada, and the Northern Training Grants Program of the Canadian Department of Indian and Northern Affairs for funding.

LITERATURE CITED

BIGLER, W. J., G. L. HOFF, AND L. A. SCRIBNER. 1977. Survival of Mourning Doves unaffected by withdrawing blood samples. Bird-Banding 48:168.

BURKE, W. H., AND H. PAPKOFF. 1980. Purification of turkey prolactin and the development of a homologous radioimmunoassay for its measurement. Gen. Comp. Endocrinol. 40:297–307.

CHALMERS, G. A., AND M. W. BARRETT. 1982. Capture myopathy, p. 84–94. *In* G. L. Hoff and J. W. Davis [eds.], Noninfectious diseases of wildlife. Iowa State Univ. Press, Ames.

COLWELL, M. A., AND L. W. ORING. 1988. Sex ratios and intrasexual competition for mates in a sex-role reversed shorebird, Wilson's phalarope (*Phalaropus tricolor*). Behav. Ecol. Sociobiol. 22:165–173.

FIVIZZANI, A. J., M. A. COLWELL, AND L. W. ORING. 1986. Plasma steroid hormone levels in free-living Wilson's phalaropes, *Phalaropus tricolor*. Gen. Comp. Endocrinol. 62:137–144.

FOLLETT, B. K., C. G. SCANES, AND F. J. CUNNINGHAM. 1972. A radioimmunoassay for avian luteinizing hormone. J. Endocrinol. 52:359–378.

FREDERICK, P. C. 1986. Parental desertion of nestling by White Ibises (*Eudocimus albus*) in response to muscle biopsy. J. Field Ornithol. 57:168–169.

GOWATY, P. A., AND A. A. KARLIN. 1984. Multiple maternity and paternity in single broods of apparently monogamous Eastern Bluebirds (*Sialia sialis*). Behav. Ecol. Sociobiol. 15:91–95.

GRATTO, C. L., R. I. G. MORRISON, AND F. COOKE. 1985. Philopatry, site tenacity, and mate fidelity in the Semipalmated Sandpiper. Auk 102:16–24.

HARDING, C. F., AND B. K. FOLLETT. 1979. Hormone

changes triggered by aggression in a natural population of blackbirds. Science 203:918–920.

MAXSON, S. J., AND L. W. ORING. 1980. Breeding season time and energy budgets of the polyandrous Spotted Sandpiper. Behaviour 74:200–263.

MCNEILLY, A. S., R. J. ETCHES, AND H. G. FRIESEN. 1978. A heterologous radioimmunoassay for avian prolactin: application to the measurement of prolactin in the turkey. Acta Endocrinol. 89:60–69.

ORING, L. W., K. P. ABLE, D. W. ANDERSON, L. F. BAPTISTA, J. C. BARLOW, A. S. GAUNT, F. B. GILL, AND J. C. WINGFIELD. 1988. Guidelines for use of wild birds in research. Auk (Supplement) 104: 1A–44A.

ORING, L. W., A. J. FIVIZZANI, AND M. E. EL HALAWANI. 1986a. Changes in plasma prolactin associated with laying and hatch in the Spotted Sandpiper. Auk 103:820–822.

ORING, L. W., A. J. FIVIZZANI, M. E. EL HALAWANI, AND A. GOLDSMITH. 1986b. Seasonal changes in prolactin and luteinizing hormone in the polyandrous spotted sandpiper, *Actitis macularia*. Gen. Comp. Endocrinol. 62:394–403.

ORING, L. W., A. J. FIVIZZANI, M. A. COLWELL, AND M. EL HALAWANI. In press. Hormonal changes associated with natural and manipulated incubation in the sex-role reversed Wilson's phalarope. Gen. Comp. Endocrinol.

RAVELING, D. G. 1970. Survival of Canada Geese unaffected by withdrawing blood samples. J. Wildl. Manage. 34:941–943.

STURKIE, P. D. 1976. Avian physiology. Cornell Univ. Press, Ithaca, NY.

WINGFIELD, J. C. 1984. Androgens and mating systems: testosterone induced polygyny in normally monogamous birds. Auk 101:665–670.

WINGFIELD, J. C., AND D. S. FARNER. 1975. The determination of five steroids in avian plasma by radioimmunoassay and competitive protein-binding. Steroids 26:311–327.

WINGFIELD, J. C., AND D. S. FARNER. 1976. Avian endocrinology—field investigations and methods. Condor 78:570–573.

WOBESER, G. 1981. Diseases of wild waterfowl. Plenum Press, New York.

The Condor 90:945–947

ADVERSE EFFECTS OF RADIO TRANSMITTERS ON THE BEHAVIOR OF NESTING LEAST TERNS[1]

BARBARA W. MASSEY, KATHLEEN KEANE, AND CONSTANCE BOARDMAN
California State University Department of Biology, Long Beach, CA 90840

Key words: Least Tern; radiotelemetry; foraging; nest desertion; behavior.

Radiotelemetry was used on California Least Terns (*Sterna antillarum browni*) in 1986 and 1987 in an effort to learn more about foraging behavior. This technique has been used successfully to obtain information on movements and activities of several species of seabirds (Morris and Black 1980, Croll et al. 1986, Trivelpiece et al. 1986), and appeared to be the method of choice for following wide-ranging, ocean-foraging birds such as terns. Previous foraging studies on terns have been based on counts of fishing birds made from fixed stations (Erwin 1975, Atwood and Minsky 1983), a method that shows the comparative use of selected areas under observation. Radiotelemetry offered a means of following individuals through their daily foraging routines. We knew from many years of experience with California Least Terns that they were not amenable to more than minimal handling, and intrusive techniques such as patagial tags have caused high desertion rates (Brubeck et al. 1981). Common (*S. hirundo*) and Roseate terns (*S. dougallii*) are more tolerant of handling but have also deserted their nests (although temporarily) if trapped when the eggs were pipping (Nisbet 1981, Spendelow 1982). Thus we took all care to minimize the trauma that might be associated with the technique.

In 1986 a preliminary study was done at the Terminal Island nesting colony in the Port of Los Angeles to test the method. Our trapping experience had shown that males were less trap-shy than females, and older birds less likely to desert nests than 2- or 3-year-olds breeding for the first time. Desertion was also minimized by trapping in the third and final week of incubation (Massey and Atwood 1981). At the Terminal Island colony there were many individually color-banded birds with nesting histories of several years, and we were able to select four males aged 6 years or older for telemetry. At two of the nests both birds were banded, and had been paired for several years. To establish normal incubation behavior, we observed the nests from a blind the day before trapping.

The study was initiated within 5 days of the expected hatching date. A wire-mesh trap was propped over the nest; the birds walked onto their eggs immediately and were easily caught. After a bird was weighed we glued a transmitter to the skin of the dorsum between the

[1] Received 29 January 1988. Final acceptance 28 May 1988.