

## TRANSMITTER LOADS DO NOT AFFECT THE DAILY ENERGY EXPENDITURE OF NESTING COMMON TERNS

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Abstract.—Using the doubly-labeled-water method, daily energy expenditure of free-living, nesting Common Terns (*Sterna hirundo*) was measured in five birds equipped with an 8-g dummy transmitter glued to the skin between the wings. No difference in daily energy expenditure and in mass change between capture and recapture was detected between the radio-marked and five control birds.

### **PESO DEL TRANSMISOR NO AFECTA EL GASTO DE ENERGÍA DIARIO DE INDIVIDUOS DE STERNA HIRUNDO DURANTE EL PERÍODO DE ANIDAMIENTO**

Sinopsis.—Durante el período de anidamiento, se midió el gasto energético diario de cinco individuos silvestre de *Sterna hirundo* los cuales tenían pegado a la piel en la region interescapular entre sus alas, un falso transmisor de 8 g. Utilizando recapturas, no se encontró diferencias entre el gasto energético diario y el peso de las cinco aves experimentales al ser comparadas con cinco individuos controles.

Equipping free-living animals with telemetric devices can enhance our knowledge of their ecology. Both package size and the method of attachment, however, can cause abnormal behavior as well as increases in energy demand (Cochran 1980, Kenward 1987). Recent attention has focused on attachment methods. Backpack-harnesses have resulted in feather wear, inflammation of the skin, behavior changes, weight loss and higher flight costs (Cochran 1980, Gessaman and Nagy 1988, Obrecht et al. 1988, Perry 1981). Fixing transmitters to feathers on the back or tail, preferably close to the center of gravity, has become popular for a number of species due to less influence on behavior, reproductive success, and body mass (Becker et al. 1991, Giroux et al. 1990, Hill and Talent 1990).

In any radiotelemetry study, it is important to understand the energetic costs of equipping a subject with a transmitter as well as any behavioral effects caused by the attachment method. We studied the effects of transmitter attachment on the daily energy expenditure of Common Terns (*Sterna hirundo*). By using the doubly-labeled-water technique (Lifson and McClintock 1966, Nagy 1980), we were able to measure energy expenditure of free-ranging animals.

## METHODS

We studied Common Terns on the Wadden sea island Minsener Oldeoog (53°45'N, 08°20'E, see Becker and Finck [1986] for a detailed description), on the southern coast of the North Sea, Germany. Between 15 and 30 Jun. 1989, after at least 10 d of incubation, 25 adult birds were caught on the nest by wire drop-traps and weighed to the nearest gram. All birds had two or three eggs, one bird had one egg and a newly hatched chick (Control # 4, Table 1). In six birds, blood samples taken from the bracheal wing vein were flame-sealed in glass micro capillary tubes (per individual, on average,  $5 \times 15 \mu\text{l}$  blood). Samples were taken to be analyzed for the natural  $\text{O}^{18}$  (oxygen 18) and D (deuterium) enrichments in the blood. In the remaining 19 birds, "background" enrichments of  $\text{O}^{18}$  and D were increased by injecting a mixture of 0.30 ml 90.1%  $\text{H}_2\text{O}^{18}$  and 0.15 ml 99.8%  $\text{D}_2\text{O}^{16}$  into the abdominal cavity. After injection, 10 of these birds (hereafter called transmitter birds) were each equipped with a dummy radio-transmitter. These were made from Castin resin, weighing 8 g and measuring  $18 \times 16 \times 13$  mm with two antennas, one pointing to the tail (23.8 cm long), the other one ascending in an angle of  $90^\circ$  from the back (13.8 cm). Dummy transmitters had the same properties as the original transmitters used in our Common Tern studies (TW-2 with mercury switch, Biotrack, U.K.; see Becker *et al.* 1991). The transmitter was glued to the skin at the interscapular area between the wings. For a detailed description of the attachment methods see Becker *et al.* (1991). The remaining nine terns were also injected but not equipped with a dummy transmitter (control birds). From both transmitter- and control-birds, the initial blood samples were taken 1.5 h after injection. Between injection and initial blood sampling, the birds were not handled and were kept in a dark box.

We tried to recatch the birds 1–4 d after releasing them. As a result of the birds' trap shyness, we used electric or mechanical spring traps. In this way, we retrapped seven control and six transmitter birds, and took the final blood samples following procedures used for the background and initial blood samples.

All blood samples were stored at 5 C until later analysis at the Center for Isotope physics in Groningen, The Netherlands. Using the  $\text{O}^{18}$  and D enrichment changes between initial and final blood samples,  $\text{CO}_2$  production was calculated for each bird according to Eq. 21 from Lifson and McClintock (1966), adjusting for physical fractionation effects and accounting for the background enrichments of the blood. The body water volume needed to calculate carbon dioxide production was assumed to be 60% of the body mass (Mahoney and Jehl 1984). We calculated energy expenditure from the carbon dioxide production using 25 kJ/l  $\text{CO}_2$ .

As for one transmitter and two control birds the final blood samples had an  $\text{O}^{18}$  enrichment too low (less than 4‰ of the background value) for accurate calculation of energy expenditure. For these cases, the 95% confidence interval for the mean, calculated by multiple analyses of the blood samples (at least two for each sample, yielding at least  $2 \times 2 = 4$

TABLE 1. Comparison between the Common Terns carrying a transmitter dummy and the control birds. No significant differences between the two groups were found. Number of eggs and chicks as well as mass (without transmitter) refer to the first capture of the birds. Duration = time between capture and recapture; night/day ratio = proportion of night time (6 h of night per day); mass change = between capture and recapture.

Common Tern	# eggs	# chicks	Mass (g)	Duration (d)	Night/day ratio	Mass change (g/d)	Energy expenditure (kJ/d)
Control							
4	1	1 <sup>2</sup>	139	1.56	0.32	-14.7	313
7	2	0 <sup>1</sup>	125	1.46	0.17	-5.5	365
8	2	0	117	2.13	0.23	-0.9	294
14	3	0	119	3.77	0.27	-0.5	
15	3	0	123	3.67	0.27	-0.8	
18	3	0	116	2.11	0.24	+0.5	372
22	3	0 <sup>1</sup>	148	1.96	0.25	-3.1	372
mean			127	2.38	0.25	-3.6	343
SD			12	0.95	0.05	5.3	37
Transmitter							
6	3	0	120	2.94	0.25	-1.0	339
9	2	0	122	2.40	0.21	-2.5	418
16	3	0	140	1.64	0.31	-1.8	281
17	3	0	130	2.07	0.24	-1.0	419
20	3	0	144	1.95	0.26	-10.8	383
21	3	0	115	2.58	0.29	+1.9	
mean			129	2.26	0.26	-2.5	368
SD			12	0.47	0.04	4.3	58

<sup>1</sup> At recapture, one egg had hatched.

<sup>2</sup> At recapture, the chick had disappeared and the egg had hatched.

estimates), would be up to  $\pm 30\%$  of the mean. For the remaining energy expenditure values (presented in Table 1), the 95% confidence interval was within  $\pm 10\%$  of the mean.

We compared the results of the two experimental groups using analysis of variance (ANOVA) with regard to the variables body mass (mass at first capture, without transmitter), experiment duration (time between capture and recapture), night/day ratio (proportion of night-time, 6 h of night/d), body mass change between capture and recapture, and daily energy expenditure. For the last two variables, number of eggs or young, experiment duration, night/day ratio and body mass were entered into the ANOVA both as discrete variables or as covariates.

## RESULTS

We found no significant difference in body mass ( $F_{1,11} = 0.073$ ,  $P = 0.793$ ), experimental duration ( $F_{1,11} = 0.075$ ,  $P = 0.789$ ) and the night/day ratio ( $F_{1,11} = 0.151$ ,  $P = 0.705$ ) between the two experimental groups. Daily energy expenditures of transmitter birds were on average slightly

higher than those of control birds (7.3%, Table 1), but did not differ significantly between the two groups ( $F_{1,8} = 0.632$ ,  $P = 0.450$ ). Body mass changes were likewise indistinguishable between the two groups ( $F_{1,11} = 0.152$ ,  $P = 0.704$ ). The number of eggs and young, experiment duration, night/day ratio and body mass, in addition to transmitter bearing, did not contribute to the variation in energy expenditure or change in body mass. Also, interactions of variables did not significantly explain the variance. Only the proportion of night-time hours tended to influence the energy expenditure negatively ( $r = -0.546$ ,  $P = 0.103$ ) as could be expected as the Common Tern is mainly active during the day.

#### DISCUSSION

We observed no significant differences in energy expenditure, body mass change (this study), or in behavior and breeding success between control and transmitter birds (Becker et al. 1991, unpubl. data). A slightly higher daily energy expenditure in transmitter birds is expected according to the aerodynamic flight-cost models of Caccamise and Hedin (1985) and Pennycuik (1989). Taking the changes in mass and drag into account, and using a total daily flight duration of 5.9 h (see below), these models predict an increase in daily energy expenditure of only 2–3% for transmitter-equipped Common Terns. It should be noted that our transmitters weighed only half of the mean body mass increase after feeding (13.2–15.8 g, Frank and Becker 1992; 18% of the maximum recorded mass gain of 45 g).

If bearing a transmitter increases energy expenditure, then transmitter birds may compensate behaviorally when off the nest. But effects of the transmitters on the terns off the nest were not measured. The duration of single feeding flights, however, as well as the total time spent feeding per day, seem to be within the range known for the Common Tern ( $5.9 \pm 1.4$  [SD] h per day,  $n = 3$  transmitter birds of pairs studied for 3–6 d each in 1989 on Oldeog, P.H. Becker, unpubl. data; cf. Frank and Becker 1992; the untagged mates of these birds, however, spent more time feeding owing to more flights:  $9.7 \pm 1.3$  [SD] h per day). Mass gain per feeding flight also was alike in radiotagged terns and untagged mates (P. H. Becker, unpubl. data). It seems unlikely that the terns have energetically cheaper foraging alternatives without a concomitant decrease in foraging success. In both experimental groups (Table 1) the mass change between first capture and recapture was in the range of the mean body mass fluctuations as a result of feeding in Common Terns (Frank and Becker 1992, on average 13.2–15.8 g).

We could not sex our terns. Could our results be biased by distinct parental roles? This seems unlikely as we restricted our investigation to the incubation period, when male and female spend similar time incubating their clutch and attending their territory (Wiggins and Morris 1987, pers. obs.). The male primarily feeds the chicks, whereas the female spends significantly more time attending the chicks (Wiggins and Morris 1987). Thus transmitter effects would be measurable in the male when

more and shorter foraging flights are required and energy costs are increasing. In situations of high stress, the possibility of the couple compensating behaviorally for the wearing of a transmitter by one of the two might be limited, if it exists at all. Terns in our study already had high energy expenditure; the mean was 105% of the expected parental daily energy expenditure for a bird of the same size (Daan et al. 1990).

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#### LITERATURE CITED

- BECKER, P. H., AND P. FINCK. 1986. Die Bedeutung von Nestdichte und Neststandort für den Bruterfolg der Flußseeschwalbe (*Sterna hirundo*) in Kolonien einer Wattenerinsel. *Vogelwarte* 33:192–207.
- , D. FRANK, S. R. SUDMANN, AND M. WAGENER. 1991. Funkpeilung von Flußseeschwalben (*Sterna hirundo*) im Wattenmeer. *Seevögel* 12:52–61.
- CACCAMISE, D. F., AND R. S. HEDIN. 1985. An aerodynamic basis for selecting transmitter loads in birds. *Wilson Bull.* 97:306–318.
- COCHRAN, W. W. 1980. Wildlife telemetry. Pp. 57–520, in S. D. Schemnitz, ed. *Wildlife management techniques manual*. The Wildlife Society, Washington, D.C.
- DAAN, S., D. MASMAN, AND A. GROENEWOLD. 1990. Avian basal metabolic rates: their association with body composition and energy expenditure in nature. *Am. J. Physiol.* 259:R333–R340.
- FRANK, D., AND P. H. BECKER. 1992. Common Terns' (*Sterna hirundo*) body mass and incubation shifts related to different feeding conditions in the Wadden Sea. *Ardea*, in press.
- GESSAMAN, J. A., AND K. A. NAGY. 1988. Transmitter loads affect the flight speed and metabolism of homing pigeons. *Condor* 90:662–668.
- GIROUX, J.-F., D. V. BELL, S. PERCIVAL, AND R. W. SUMMERS. 1990. Tail-mounted radio transmitters for waterfowl. *J. Field Ornithol.* 61:303–309.
- HILL, L. A., AND L. G. TALENT. 1990. Effects of capture, handling, banding, and radio-marking on breeding least terns and snowy plovers. *J. Field Ornithol.* 61:310–319.
- KENWARD, R. 1987. *Wildlife radio tracking*. Academic Press, London, United Kingdom. 222 pp.
- LIFSON, N., AND R. M. MCCLINTOCK. 1966. Theory of use of the turnover rates of body water for measuring energy and material balance. *J. Theor. Biol.* 12:46–74.
- MAHONEY, S. A., AND J. R. JEHL, JR. 1984. Body water content in marine birds. *Condor* 86:208–209.
- NAGY, K. A. 1980. CO<sub>2</sub> production in animals: an analysis of potential errors in the doubly-labeled-water method. *Am. J. Physiol.* 238:R466–R473.
- OBRECHT, H. H., C. J. PENNYCUICK, AND M. R. FULLER. 1988. Wind tunnel experiments to assess the effect of back-mounted radio transmitters on bird body drag. *J. Exp. Biol.* 135:265–273.
- PENNYCUICK, C. J. 1989. *Bird flight performance*. Oxford University Press, Oxford, United Kingdom. 153 pp.
- PERRY, M. C. 1981. Abnormal behavior of canvasbacks equipped with radio transmitters. *J. Wildl. Manage.* 45:786–789.
- WIGGINS, D. A., AND R. D. MORRIS. 1987. Parental care of the Common Tern *Sterna hirundo*. *Ibis* 129:533–540.

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