

### Belly-soaking as a Thermoregulatory Mechanism in Nesting Killdeers

BETTE J. SHARDIEN AND JEROME A. JACKSON  
*Department of Biological Sciences, Mississippi State University,  
Mississippi State, Mississippi 39762 USA*

Killdeers (*Charadrius vociferus*) typically select open areas for nest sites. As a result, Killdeers in hot climates must protect their eggs from direct sunlight. They rarely "incubate" their eggs during the daylight hours but instead crouch over them with wings slightly extended shading them from the sun. The birds are reluctant to leave the nest during the heat of the day.

On 29 June 1978 while banding Killdeers at a nest, we captured both pair members within about 5 min of one another. While banding the first bird, we noticed its belly feathers were very matted and dirty. In retrospect, this Killdeer was probably near the end of its attentive period. The second bird entered the trap while we were still processing its mate. Its belly feathers were saturated with water. This was the first instance in which we had observed wet breast feathers despite observations and handling of many nesting birds earlier in the season.

Five other Killdeer nests were subsequently studied in 1978. At three of these, belly-soaking was observed in both pair members. One pair of these birds had been previously captured on 10 April, at which time neither had wet or matted breast feathers. All four nests where belly-soaking was observed were in open areas and had a gravel or mixed gravel and asphalt substrate. Both pairs not exhibiting belly-soaking nested in grassy areas. One of these nests was located near a magnolia tree (*Magnolia grandiflora*), which shaded the nest during part of the day. The "off-duty" pair member often rested in the shade of this tree. The other pair not exhibiting belly-soaking nested under a dense hedge, which protected the eggs from direct sunlight throughout the day. Despite a lack of belly-soaking, this pair had a nearer supply of water (a small pond about 50 m from the nest site) than any other Killdeer pair under observation. One Killdeer pair continued to exhibit belly-soaking after two of their chicks hatched (Fig.



Fig. 1. Killdeer with wet belly feathers at its nest in Starkville, Mississippi.

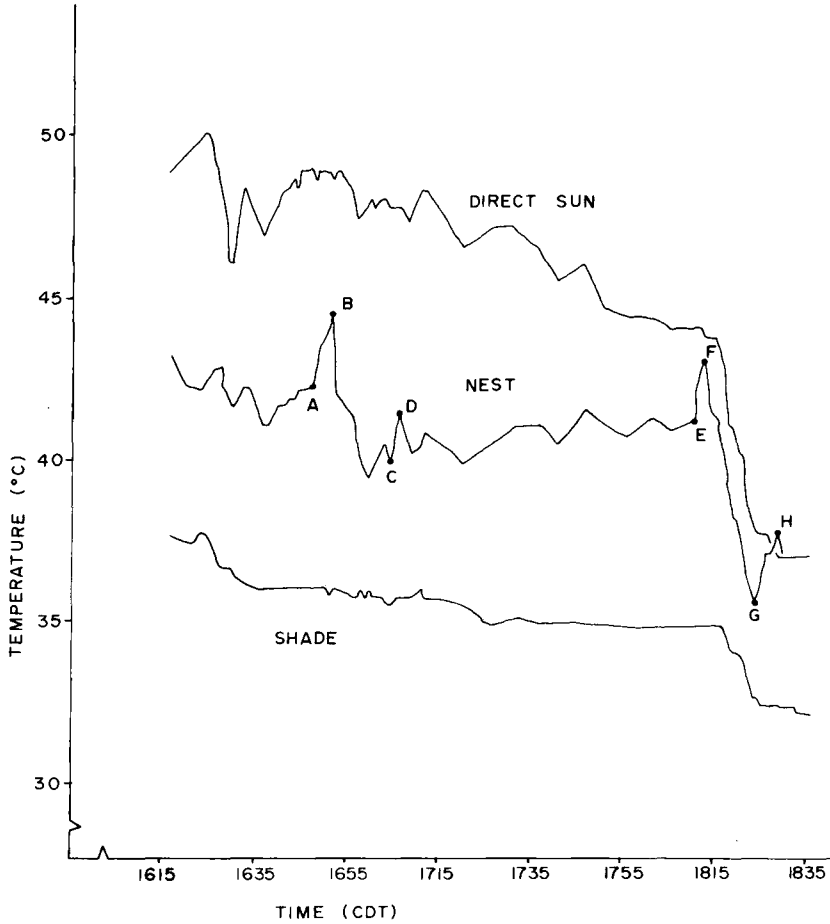


Fig. 2. Temperatures recorded at a Killdeer nest where both pair members exhibited belly-soaking. The decline in temperature at 1815 was caused by the sudden approach of a storm front. See text for an explanation of lettered points.

1). We did not have the opportunity to observe brooding in any of the above pairs after all their chicks hatched.

We collected temperature data at the nest of one pair of Killdeer exhibiting belly-soaking using a YSI model 44TD tele-thermometer. Three probes were used: one in the nest, one on the gravel 1 m from the nest in full sun, and one under a car which provided the only accessible shade. We recorded the temperatures for the three locations (Fig. 2). The bird designated as Magenta was on the nest when we began monitoring temperatures. Red, its mate, flew to the vicinity of the nest (within 10 m) at 1631 and remained in the area until 1640. Its belly feathers were dripping water when it first arrived. Magenta, however, remained on the nest until 1649 (Fig. 2, point A) when it left the nest, calling as it did so. At 1650 (Fig. 2, point B) Red came to the nest, stood over it briefly, and then lowered its wet belly feathers onto the eggs. During this changeover, a temperature of 44.4°C was reached. This was the highest nest temperature we recorded. Internal egg temperatures were probably lower. Whittow (1976) gives 42.2–47.8°C, depending on the age, as the lethal temperature for chicken embryos. At 1653, Magenta returned to the nest vicinity (within 5 m) with wet belly feathers and remained there until 1657 when it flew out of sight. Red continued to cover the eggs, stepped away briefly at 1705 (Fig. 2, point C) when a dog and its owner passed by, but quickly returned (Fig. 2, point D). Red then remained on the nest until 1710 (Fig. 2, point E) when it flew directly from the nest and out of sight. Red returned at 1712 (Fig. 2, point F) with freshly soaked belly feathers and resumed attending the nest. A combination of the cooling effect

of the water and a drop in ambient temperature caused the nest temperature to drop to 35.8°C (Fig. 2, point G), at which time the bird apparently began to apply heat to the eggs, as the nest temperature increased to 37.7°C (Fig. 2, point H) and then dropped to 37.2°C, which corresponded to the temperature of the surrounding gravel. Drent (1973) reports that normal egg temperatures during incubation vary from about 33°C to 38°C for several bird species. Throughout their attentive periods, both birds kept the eggs shaded, usually lowering their wet belly feathers directly onto the eggs early in the attentive period, but often standing over the eggs with their matted feathers barely touching the eggs (Fig. 1). The adults stood over the eggs with feathers fluffed, mouth open, and gular area vibrating.

Belly-soaking has been recorded in seven families of Charadriiformes (Maclean 1975 and references therein). Within the family Charadriidae, belly-soaking has been reported in the genera *Charadrius* (*C. dubius*, *C. pecuarius*, *C. alexandrinus*, *C. melanops*, *C. marginatus*, and *C. vociferus*) and *Vanellus* (*V. albiceps*, *V. spinosus*, *V. indicus*, *V. malabaricus*, *V. senegallus*, and *V. leucurus*) (Maclean 1975 and references therein, Begg and Maclean 1976, Roberts 1977). The majority of records on belly-soaking have occurred in areas with hot climates. These include Nigeria (9°N), India (20°–26°N), and Zambia (15°–18°S) (Maclean 1975). An exception to this is an observation of belly-soaking in *C. dubius* near Plochingen, West Germany (49°N) (Gatter 1971). There, belly-soaking was observed when the ambient temperature was 29°C. In North America belly-soaking has been reported for the Least Tern (*Sterna albifrons*) (Tompkins 1942) and for Killdeer (Boyd 1972, Kull 1977). Belly-soaking has not been reported in several studies conducted in the more northern portions of the Killdeer's range (e.g. Bunni 1959, Lenington and Mace 1972, Mace 1971).

Belly-soaking appears to be an important thermoregulatory mechanism in Killdeers nesting in Mississippi. It apparently becomes more common late in the season with higher temperatures and in pairs selecting nesting substrates that readily conduct heat.

We appreciate helpful comments made by C. Dwight Cooley and two anonymous referees. A grant to Schardien from the Eastern Bird Banding Association facilitated work on this study.

#### LITERATURE CITED

- BEGG, G. W., & G. L. MACLEAN. 1976. Belly-soaking in the White-crowned Plover. *Ostrich* 47: 65.
- BOYD, R. L. 1972. Breeding biology of the Snowy Plover at Cheyenne Bottoms Waterfowl Management Area, Barton County, Kansas. Unpublished M.S. thesis, Emporia, Kansas, Kansas State Teachers College.
- BUNNI, M. K. 1959. The Killdeer in the breeding season. Unpublished Ph.D. dissertation, Ann Arbor, Univ. Michigan.
- DRENT, R. H. 1973. The natural history of incubation. Pp. 262–311 in *Breeding biology of birds* (D. S. Farner, Ed.). Washington, D. C., Natl. Acad. Sci.
- GATTER, W. 1971. Wassertransport beim Flussregenpfeifer (*Charadrius dubius*). *Vogelwelt* 92: 100–103.
- KULL, R. C., JR. 1977. Color selection of nesting material by Killdeer. *Auk* 94: 602–604.
- LENINGTON, S. & T. MACE. 1975. Mate fidelity and nest site tenacity in the Killdeer. *Auk* 92: 149–151.
- MACE, T. 1971. Nest dispersion and productivity of Killdeers (*Charadrius vociferus*). Unpublished M.S. thesis, St. Paul, Univ. Minnesota.
- MACLEAN, G. L. 1975. Belly-soaking in the Charadriiformes. *J. Bombay Nat. Hist. Soc.* 72: 74–82.
- ROBERTS, M. G. 1977. Belly-soaking in the White-fronted Plover. *Ostrich* 48: 111–112.
- TOMPKINS, R. L. 1942. Least Tern watering eggs: Gideon Mabbett's query. *Auk* 59: 308.
- WHITTOW, G. C. 1976. Regulation of body temperature. Pp. 146–173 in *Avian physiology* (P.D. Sturkie, Ed.). New York, Springer Verlag, Inc.

Received 5 February 1979, accepted 9 April 1979.

#### Helpers at the Nest in Passerines from Buenos Aires Province, Argentina

ROSENDO M. FRAGA

Guido 1698, 16 B., 1016 Buenos Aires, Argentina

Breeding systems that involve the presence of additional helping individuals are now considered to be relatively widespread among birds of tropical regions and southern continents. Cooperative breeding is