

DETERMINING SEX RATIOS FROM COLLECTED SPECIMENS

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Ornithologists have recently shown considerable interest in determining the sex ratios of birds, particularly on the breeding grounds. Field counts are possible only for sexually dimorphic species. Investigators working on monomorphic species have therefore turned to the data accompanying museum specimens. The method of collecting these specimens is usually unknown, and may bias the sex ratio, as I will show.

In 1971 I collected a number of Franklin's Gulls (*Larus pipixcan*) in the vicinity of Agassiz National Wildlife Refuge, Marshall County, Minnesota. The gulls were collected during May and June at or within 8 km of a breeding colony of 10,000–15,000 pairs of gulls (see Burger, Anim. Behav. 22:521–567, 1974). Birds were collected by three methods; nest-trapping (Burger, Bird-Banding 42:123–124, 1971), shooting, and netting birds that were feeding behind a plow. I used all three methods only to increase my sample of specimens. I nest-trapped between 09:00 and 11:00 throughout the incubation period. Shooting and netting were done on the same days and in the same two fields where 200–500 gulls were feeding. A local farmer

TABLE 1. Sex ratios of Franklin's Gulls collected by different methods. Shown are the number of each sex collected by each method.

	Males	Females	Total
Shot	29	6	35
Nest-trapped	22	20	42
Netted behind plow	6	22	28
Total	57	48	105

DIVING DEPTHS OF THE GENTOO PENGUIN (*PYGOSCELIS PAPUA*)

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At Marion Island in the southwestern Indian Ocean (46°52'S, 37°51'E), the Gentoo Penguin (*Pygoscelis papua*) breeds sympatrically with Macaroni (*Eudyptes chrysolophus*), Rockhopper (*E. chrysocome*) and King (*Aptenodytes patagonicus*) penguins. Duration of foraging trips and chick feeding rates suggest that, in contrast to the other species, the Gentoo Penguin is primarily an inshore feeder (Croxaall and Prince 1980a, Williams 1980, 1981). Consequently, Gentoo Penguins may need to dive for food less

caught birds following his plow with the use of a long-handled fish net, reaching out from the tractor seat and catching gulls as they flew close by. The birds that were shot were also feeding on invertebrates in the same fields, although only six were shot directly behind the plow.

The three methods yielded different sex ratios ($\chi^2 = 23.2$, $df = 2$, $P < 0.001$). Gulls collected by shooting were mostly males (83%), those netted were mostly females (79%), and those nest-trapped had an equal sex ratio (Table 1). Characteristically, once a bird was shot, other gulls approached, circled over it, and were themselves shot. If this behavior is related to the greater aggressiveness of males, it might explain their greater vulnerability. Or, males may simply have remained in the area longer. Females may have been less wary, hence more likely to come closer to the plow and so be netted. Since birds were collected by both methods in the same field, it is apparent that one or both samples gave biased estimates of sex ratios (Table 1).

I assume that the sex ratio of Franklin's Gulls was nearly equal in the area because no birds were loafing near the colony (Franklin's Gulls loaf near their nests), and no males on territories lacked females. There were no areas where birds loafed within 40 km of the refuge. I had enlisted the aid of local farmers in reporting any gull flocks. Although I received many reports of foraging gulls, there were no reports of any sizeable loafing flocks. Furthermore, this was the only breeding colony of Franklin's Gulls in Minnesota; consequently, there was no influx of gulls into the area around the Agassiz colony during the breeding season.

My results indicate that the method of collecting can influence the sex ratio of the specimens obtained. Thus, the sex ratio of this sample may be a misleading indicator of the population's sex ratio. The danger in using museum specimens to gauge sex ratios is greater if the exact method of collecting is unknown, if the direction of the biases have not been examined for that species, and if sample sizes are small.

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deeply than the more pelagic species. We report here on our measurements of the diving depths of Gentoo Penguins at Marion Island.

We conducted our study during November and December 1981. Twenty-five Gentoo Penguins were fitted with depth gauges attached to leather harnesses and released. Harnesses were recaptured upon their return to the island to spend the night ashore or to feed chicks.

The harnesses consisted of a contoured collar (placed above the flippers) joined to a thoracic band below the flippers by four narrow leather straps. The depth gauge was fitted to the thoracic band and lay flush with the penguin's back. The harness is described more fully in Wilson and Bain (in press). The depth gauges were a capillary type, coated on the inside with a water-soluble powder. Water entering the open end of the capillary tube compressed the volume of air trapped in the tube, and compression varied with depth as described by Boyle's Law. Because the relationship is non-linear, however, shallower depths were recorded more precisely than deeper

depths. The maximum depth attained by the diving penguin was indicated by the boundary between the dissolved and undissolved powder. A similar device has been used to measure diving depths in seals (Kooyman 1965) and Emperor Penguins (*Aptenodytes forsteri*; Kooyman et al. 1971).

Penguins were recaptured one to eight days after release. Nineteen of the recaptured birds showed depth traces. Four others had not been to sea in the interval between release and recapture, and two others lost their harnesses. Maximum diving depths recorded ranged from 3.5 m to more than 70.0 m, the median depth being 9.0 m. The diving depths were non-randomly distributed ($\chi^2 = 22.3$, $P < 0.005$, $n = 19$) with 16 dives reaching less than 20.0 m; two more attained 40.0 m, and only one dive exceeded 70 m. The maximum diving depths attained by the penguins were not significantly correlated with the time interval between release and recapture ($r = -0.291$, $P > 0.1$).

Penguins swim at three levels in the water: on the surface, at the travelling depth (two meters or less in the Jackass Penguin [*Spheniscus demersus*]; R. Wilson, pers. comm.), and at the foraging depth, the latter being the most variable and, generally, the deepest. Their ability to dive to great depths is well established. A depth of 130 m has been recorded for the Jackass Penguin (R. Wilson, pers. comm.), more than 240 m for the King Penguin, and 265 m for the Emperor Penguin (Kooyman et al. 1971). Circumstantial evidence indicates that Gentoo Penguins may dive to 100 m (Conroy and Twelves 1972). Dive duration for Emperor Penguins may exceed 18 min but the longest dive recorded for Gentoo Penguins, observed feeding at shallow depths, was 2 min (Kooyman 1975). The mean dive duration of the Jackass Penguin, slightly smaller than the Gentoo, was 2.5 min (R. Wilson, pers. comm.). Assuming that an appreciable proportion of a dive is spent hunting and pursuing prey, the time available for descent and ascent is limited. The dive duration of the Gentoo Penguin suggests that the modal depths of 3.5–20.0 m recorded in our study probably represent the normal foraging depths, dives to 40.0 m or more being unusual. This is supported by the finding that birds recaptured up to eight days after release still had not dived deeper than 20.0 m, despite the opportunity to make several foraging trips and, consequently, many dives.

Both major kinds of prey of Gentoo Penguins, known from other localities, fish and krill, occur within the recorded diving range of these birds at Marion Island. The size classes of notothenid fish taken at South Georgia are known to frequent offshore kelp beds that are less than 30 m deep (Croxall and Prince 1980b), while large concentrations of krill are known to occur at depths of less than 100 m, even during the day (Volkman et al. 1980).

The depth gauge/soluble powder technique is inexpensive and the harnesses are easy to manufacture. On the other hand, the technique is limited because the device can measure only the maximum depth attained during any one, or a series, of foraging trips. More detailed information on diving depths and dive profiles is required in

order to validate the biological significance of maximum diving depths. Such studies will require more expensive and sophisticated devices, such as the autoradiographic devices of Wilson and Bain (in press) or the electronic recorders of Kooyman et al. (1982).

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