through "oiling" behavior, by lipids from the uropygial gland to insure that the feathers are properly lubricated. Dustbathing removes excess lipids and prevents the feathers from becoming matted.

This explanation for dustbathing requires a reassessment of the generally accepted thesis (Goodwin 1956; Simmons 1964; Stoddard 1931) that it serves primarily to remove ectoparasites. In both this and a previous study, the feathers of birds were observed microscopically and no ectoparasites were found. However, since the principal food of avian ectoparasites is lipid substances from the feathers (Dubinen, cited in Kelso and Nice 1963), dustbathing may secondarily remove ectoparasites by reducing their food supply, or perhaps by desiccating them or interfering with their respiration.

If dustbathing serves to remove excess lipids, then several predictions should be true. Removal of the uropygial gland should lead to a decrease in the frequency of dustbathing components, although the changes in dustbathing might be influenced by the bird's previous dustbathing experience. Application of artificial lipids to the plumage should increase the amount of dustbathing. Factors which might affect "oiling" behavior, such as rainy weather or indirect manipulation of the output of the uropygial gland (for instance by increasing or decreasing the fat content of the diet), should also influence dustbathing.

Another area for further research concerns the sex differences found for the frequencies of the head and side rub components of dustbathing (Borchelt 1972). Although no sex differences in the amount of feather lipid were found in the present study, this may have been due to the pooling of the greater amount of large feathers from the breast and back of each bird with the lesser amount of small feathers from the head and flanks. A difference in the chemical composition of feather lipid between small and large feathers from an unspecified species of duck has been reported (Bolliger and Varga 1961). It is clear that additional research involving both quantitative and qualitative analysis of the lipid from both the feathers and uropygial gland of one species of bird will be necessary to determine the relations between sex, uropygial and feather lipid, and dustbathing. Such analyses may also shed some light on the mechanisms underlying other behaviors associated with care of the body surface, such as waterbathing and "anting."

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NOTES ON THE FEEDING BEHAVIOR OF THE COMMON MERGANSER (*MERGUS MERGANSER*)

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The biology of the Common Merganser (*Mergus merganser*) has, until recently, been neglected. This species breeds in forested regions and uses large bodies of water during migration and in winter thus making it relatively inaccessible for study. Further, because of its low esteem as a game bird, it has not attracted the attention of game biologists other than with respect to its impact on game fish.

Erskine (1971, 1972) has studied the annual cycle in weights, reproductive organs, and molt, as well as nesting dispersion and postbreeding dispersal. Age and sex characteristics have been studied by Anderson and Timken (1971) and Erskine (1971). In the central United States, other studies have been made: food habits (Timken and Anderson 1969); and weights, age, and sex ratios (Anderson and Timken 1972). Our purpose in this report is to consider feeding activities during migration and winter and to report on observed posturing during feeding. This study was conducted along the Missouri River between Vermillion and Pickstown, at the Lake Andes National Wildlife Refuge in South Dakota, at Lake Hendricks and the Rock River in southwestern Min-

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nesota, and at the Salt Plains National Wildlife Refuge in northwestern Oklahoma. Some additional observations were made during summers in New York and Montana. We observed feeding behavior on 60 days from 1966 to 1968 in southeastern South Dakota and southwestern Minnesota, and on 83 days between 1969 and 1972 in northwestern Oklahoma.

Common Mergansers are abundant on rivers and lakes in the study region in late fall and early spring. At least a few individuals are likely to spend the winter anywhere open water and food are available, and in some such areas there may be thousands present. Common Mergansers are rare or absent as breeding birds in the study area (A.O.U. 1957). We observed one brood in the Pickstown, South Dakota area in June 1968.

METHODS

In the field we recorded feeding behavior by means of 8-mm motion picture films, photographs, and written accounts. Observations were made with binoculars and a 50× spotting scope from three or four vantage points (bluffs and an observation tower) overlooking the study areas. From these points we could observe all but a few of the mergansers in a local area. In South Dakota and Minnesota in spring and fall when mergansers were not confined to relatively small areas by ice, we could not follow them closely.

Climatological data were obtained from the U.S. Weather Bureau and the U.S. Army Corps of Engineers.

Data concerning the ratio of adult males to the other age and sex classes were collected by visual counts. Among the age and sex classes, only the white-winged, green-headed adult males could be accurately identified. Both females and immature males have brown heads and gray wings. Although immature males are noticeably larger than females, this difference was not consistently discernible during this study.

Since many inferences concerning feeding behavior are based on the visual counts, the method of counting should be explained. Counts were made most often when birds were in flight. As mergansers flew toward a feeding or loafing area, one observer scanned the flock with binoculars and identified each bird as green-headed or brown-headed, calling out the identity of each bird. The second observer recorded the number of green-headed (adult male) and brown-headed (other) birds. In this manner the numbers in each of two categories could be tallied. Counts of mergansers on the water were less accurate for a variety of reasons; some individuals were diving, others were making short flights, birds were continually arriving and departing during feeding periods. High

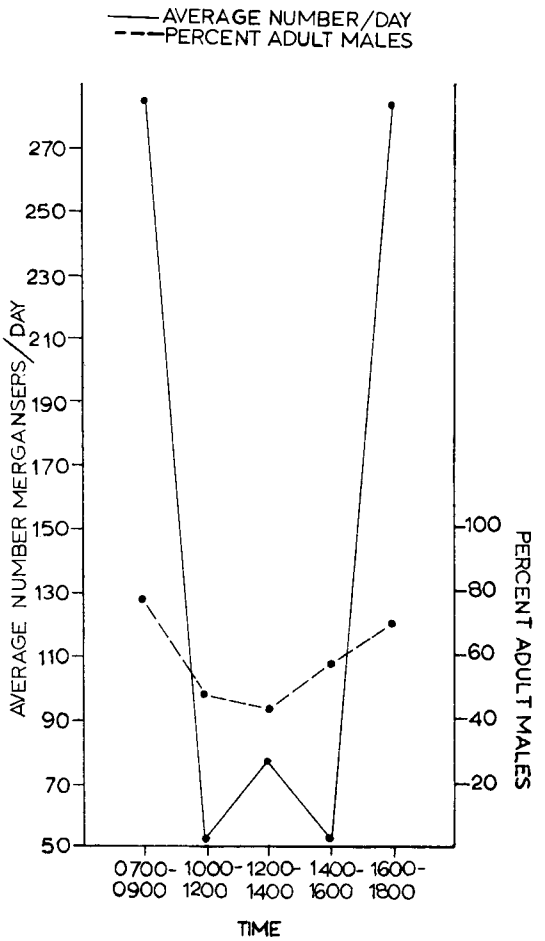

FIGURE 1. Percentages of adult males that were among the average numbers of mergansers which fed at various times of the day 13–31 December 1972.

TABLE 1. Age and sex ratios of feeding Common Mergansers at the Salt Plains Reservoir in Oklahoma on days when the reservoir was frozen and the mean temperature was near or below freezing. At such times the local population consisted of about 70% adult males and included a total population of 300 to 500 birds.

Date	Weather conditions	Mean daily temperature (°F)	Time	% feeding		No. feeding
				Adult males	Others	
1972						
Jan. 14	Winds 15–20 mph	−2	16:00–17:00	27[a]	73	301
			17:00–18:00	23[a]	77	165
Feb. 11	Overcast, heavy snow	20	14:45–16:00	67	33	354
			16:00–18:00	63	37	176
Dec. 14	Overcast, winds 15–20 mph, snow	9	10:00–12:00	33	67	153
			12:00–14:00	42	54	96
			14:00–16:00	49	51	112
Dec. 17	Winds 15–20 mph	23	12:00–16:00	62	38	65
			16:00–18:00	60	40	237
Dec. 24	Cloudy, winds 20–25 mph	34	10:00–14:00	62	38	65

[a] Total adult males in population on this date less than 30%.

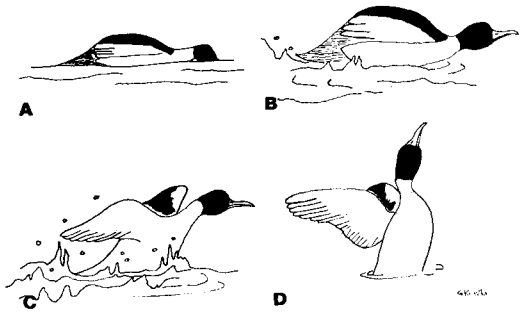

FIGURE 2. Postures of mergansers during feeding: A, looking for fish; B, running-on-water with wings folded; C, running-on-water with the aid of the wings; and D, wing-flapping after catching a fish.

waves often obscured observation on larger bodies of water.

RESULTS AND DISCUSSION

Feeding during migration in South Dakota and Minnesota. Observations on feeding and movement indicated that fall migrants exhibited different feeding habits than overwintering mergansers or spring migrants. Fall migrants were usually seen singly or in flocks ranging from 2 to 30 individuals, with 3 to 9 being the usual number. They fed only occasionally. In a few instances small flocks were observed feeding actively on lakes and a few birds were seen feeding in the discharge areas of Missouri River Dams. In winter virtually all mergansers present fed twice daily.

Daily feeding patterns in winter. Between 19 and 29 December 1972, the Salt Plains Reservoir in Oklahoma was mostly ice-covered. We estimated the total merganser population to be 350–400 birds, including 70% adult males and 30% brown-headed birds. These birds congregated in patches of open water measuring about 100 × 50 yards. It is not likely that there were many fish in these small places (no feeding activity was noted). When the reservoir was ice-covered, most feeding was done below the dam, where large schools of Gizzard Shad (*Dorosoma cepedianum*) congregated. Feeding activity was typically most intense at sunrise and again at sunset (fig. 1) and the entire population probably fed at these times. This was also observed by Salyer and Lagler (1940) in Michigan, but they did not provide quantified data either with respect to feeding patterns of the age and sex classes or feeding behavior in relation to climatic conditions. Light feeding (by less than 20% of the population) did occur between 10:00 and 16:00 (fig. 1). The majority of birds feeding in mid-day was brown-headed. Brown-headed mergansers, being smaller and with relatively more surface area, probably have greater energy needs than adult males. Adult males did feed at mid-day on days characterized by strong winds, cloud cover, precipitation, and temperatures near or below freezing (table 1). Energy requirements may necessitate more frequent feeding even by adults under such conditions.

When the reservoir was free of ice, mergansers were more abundant, and seemed to prefer feeding in the relatively more secure confines of the large reservoir. The few which did feed below the dam included a larger proportion of brown-headed mergansers relative to the proportion of this group on the reservoir (table 2).

The mergansers almost always landed 100–150 yards downstream from the spillway area, but feeding was usually most intense immediately below the spillway. After landing, they appeared alert with head erect. As the number of birds increased, others seemed to land more readily and appeared less cautious than the first arrivals. If undisturbed, the birds began to swim upstream. As they approached the feeding site, many put their heads under the water (fig. 2A). We observed this behavior daily in December 1972 and on many occasions in other years. Sayler and Lagler (1940) also made reference to this behavior. We are convinced that they were looking for fish when doing this.

If other mergansers were already feeding, several of those swimming upstream ran on the water toward the feeding birds. This was accomplished with wings folded for short runs, but the wings were also used to propel them if the distance involved was more than a few feet (fig. 2B,C).

Upon reaching the feeding site, the mergansers dived repeatedly. All mergansers in the immediate vicinity rushed to the area in which fish were being caught. When a large school of shad was located, the birds became densely packed together. Frequently, only shallow dives were necessary to catch a fish on nearly every try. After surfacing with a fish, they typically raised up on the water, flapped their wings and stretched their necks (fig. 2D), lowered themselves, and shook their tails. Perhaps the neck-stretching and wing-flapping aid in swallowing.

Some merganser sexual displays are similar to postures seen during feeding. For example, the Upward-stretch and Wing-flapping displays are common sexual displays (Johnsgard 1965) and closely resemble the stretching and wing-flapping seen after catching a fish. Of course, these two movements are used in situations other than feeding, but the displays have almost certainly evolved from comfort and maintenance situations. The Sprint display of the Red-breasted Merganser (*Mergus serrator*) is very similar to the running-with-the-wings-closed performed by the Common Mergansers when feeding. No Sprint display has thus far been recorded for the Common Merganser (Johnsgard 1965), nor has a sexual dis-

TABLE 2. Age and sex ratios of feeding Common Mergansers above and below the dam at the Salt Plains Reservoir in Oklahoma on days when the reservoir was largely free of ice.

Date	Time	% below dam		No. feeding	% on reservoir		No. feeding
		Adult males	Others		Adult males	Others	
1972							
Jan. 21	16:00–18:00	43	57	179	68	32	2,175[a]
Feb. 4	16:00–18:00	39	61	679	60	40	1,103[a]

[a] Chi-square values 52.2 and 123.6; $P < 0.001$.

play been described which resembles the holding-of-the-head-under-water, which we observed in feeding situations.

After catching two to six fish each, the mergansers floated downstream and rested and preened while standing in shallow water, on ice, or on a mud flat. After resting about 10 min, they fed again or flew in the direction of the reservoir. Within a few minutes of leaving, flocks of similar size returned and began feeding. We suspect that these were frequently the birds which had just left.

In general, mergansers also fed intensively at sunrise and sunset in South Dakota in the winter. On mild days, when ice broke up on the Missouri River, mergansers dispersed from the area immediately below the dams. On cold days, when there was little open water on the river, feeding intensity was much greater below the dam. On very cold days (temperatures near 0°F) feeding activity was minimal. On these days mergansers were observed loafing on sandbars. Apparently, it is metabolically more economical to utilize fat reserves on very cold days than to utilize energy required in the search for food. Mergansers in areas where temperatures may on some days be near 0°F all day average 300 g heavier than relatively fat-free mergansers (Anderson and Timken 1972).

In South Dakota the mergansers loafed and spent nights on ice and sand bars down river from the dam at Pickstown. As feeding time approached, they flew upstream and landed immediately below the discharge area where dead and crippled fish, which had gone through the turbines, were on or immediately below the surface of the water. Here, when all of the turbines were in operation, 30,000–40,000 ft^3 of water per second were released; mergansers had considerable difficulty in maintaining their position in such a strong current. Perhaps for this reason and because the water was 60 ft or more deep, we rarely observed them putting their heads under the water. This posture probably occurs most frequently in shallow water with little current.

Reactions to disturbances. Merganser feeding activities were frequently interrupted by Ring-billed and Herring Gulls (*Larus delawarensis* and *L. argentatus*), Bald Eagles (*Haliaeetus leucocephalus*), and by the approach of man. The gulls often congregated when mergansers began to feed. They hovered over, swooped at, and even landed on the backs of mergansers. The mergansers reacted to this in one of three ways: by diving again; by rapid swallowing movements; or by regurgitating one or more fish. It was our impression that Brown-headed Mergansers were bothered by the gulls more than the adult males. On occasion, we observed Bald Eagles harassing mergansers, but this was comparatively rare even though eagles were abundant in Oklahoma and South Dakota.

Feeding behavior of broods. Several broods of Common Mergansers were observed feeding in southwestern New York. These broods numbered 8–14 birds, all in brown-headed plumage. In some broods the individuals were flightless, while in others they could fly. We watched birds feeding in clear, shallow rivers. Initially, all birds in a brood would dive simultaneously at the upstream edge of a deep hole and swim as a unit through it, thus driving fish into the shallow lower end of the hole. Once the fish were in shallow water, the mergansers would surface, dive, and capture fish until the water became too murky to see or the fish had escaped. This procedure was repeated in several holes until they had finished feeding.

Habituation. During the years 1962–73, we observed that Common Mergansers were wary at all seasons of the year. They seemed to be the last waterfowl species to habituate under conditions warranting habituation. In the Pickstown, South Dakota area, we observed Mallards (*Anas platyrhynchos*), Canada Geese (*Branta canadensis*), and Common Goldeneyes (*Bucephala clangula*) during and after the hunting season. During the hunting season all species were wary, but soon after its close the Mallards and Canada Geese were not as wary and one could easily approach within 75 yards in an automobile. Common Mergansers and Common Goldeneyes remained wary and did not habituate. This was also true on federal and state refuges where little disturbance ever occurred. One exception to this pattern was noted at Gavin's Point Dam, Yankton, South Dakota, where Common Mergansers had become habituated to intensive sport fishing activities (Timken and Anderson 1969). Ten to 20 mergansers would fly to the discharge areas and proceed to feed among the fishing boats. Most of these birds were brown-headed; only a few adult males were observed feeding under these conditions.

SUMMARY

Feeding behavior of Common Mergansers was observed in South Dakota, Minnesota, Oklahoma, New York, and Montana. In South Dakota and Minnesota fall migrants were rarely observed to feed, even though they were abundant. Mergansers in winter in South Dakota and Oklahoma usually fed intensively near sunrise and sunset, with little feeding activity during mid-day. Birds which did feed at this time were primarily adult females and immatures. Various climatic conditions, including cold weather, wind, cloud cover, and precipitation, led to an increase in the mid-day feeding activities of mergansers. When the Salt Plains Reservoir in Oklahoma was covered with ice, the entire population fed below the dam, but when the reservoir was free of ice only a relatively small number of mergansers fed there. Some of the postures of feeding mergansers are similar to ritualized sexual displays. Feeding mergansers were regularly harassed and their catch sometimes was pirated by Ring-billed and Herring Gulls. Feeding behavior of juvenile mergansers in broods was described. Mergansers rarely habituate to man, one exception being habituation to fishermen at a South Dakota dam.

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BODY TEMPERATURE OF THE NESTING RED-FOOTED BOOBY (*SULA SULA*)

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The Red-footed Booby (*Sula sula*) nests in low bushes and trees in the Hawaiian Islands. The environmental conditions at the nesting site are extremely demanding (Howell and Bartholomew, Condor 64:6, 1962). There is no shade; the air temperature is quite high; there are both intense solar radiation and a great deal of radiant heat from the surroundings. Moreover, the air movement at the nest may be quite low and there is no fresh water available to replace water lost by evaporative cooling. In spite of this, an individual booby may sit on the nest from sunrise to sunset, conspicuously gular fluttering during the warmer parts of the day. Howell and Bartholomew (op. cit.) removed birds from the nest and quickly inserted a thermister probe into the stomach in order to measure their deep-body temperatures. Although the temperature recorded in this way was higher during the day than at night, the deep-body temperature did not exceed 42°C in any of the birds.

The purpose of the experiments described in this communication is to obtain continuous records of deep-body temperature in nesting boobies, using a telemetry technique which obviated the necessity to handle the birds, and in particular, to correlate changes in body temperature with behavior and indices of physiological thermoregulation such as gular fluttering.

MATERIALS AND METHODS

Two adult, female Red-footed Boobies were studied in the nesting colony established at Sea Life Park on the Island of Oahu. One of the birds was tested on two separate occasions. The deep-body temperature of the birds was recorded by feeding a "radio-pill" (Fox et al., J. Physiol. London 160:22, 1962) to the bird, in a fish. The radio pills were able to detect changes in temperature of 0.1°C, but the highest temperature that the pill was able to record varied in different pills. Its signal was detected by an antenna concealed near the nest, and a receiver (Rigel Instrument Co. Ltd.) approximately 25 ft away from the nest. Air temperature varied between a maximum of 30°C during the day and a minimum of 21.6°C at night. The amount of radiant heat impinging on the bird was estimated by means of black globe thermometer readings. Gular flutter rates were counted with the aid of a stopwatch.

RESULTS

Two separate experiments on one of the birds, a female, are illustrated in figure 1. On the first occasion, the telemetry capsule was fed to the bird while it was on the nest, at 10:15. Temperature readings were obtained until the bird left the nest at 19:45. The booby returned the next morning at 05:30, but the transmitter had been passed, presumably while the bird was feeding at sea. While the transmitter was in the bird, the booby was able to keep its body temperature below 40°C, although it was exposed to direct sunlight. During this time, the bird was observed to gular flutter at a rate of approximately 450/min. During the latter part of the afternoon, when the sun was obscured by cloud, the body temperature diminished and gular flutter did not occur at body temperatures below 39.3°C. The bird displayed a number of the behavioral thermoregulatory responses described by Bartholomew (Condor 68:523, 1966) for the Masked Booby during the course of the day. Its wings were held away from the body, the scapular feathers were elevated, and the bird tended to orientate its body so that the bill pointed away from the sun. In addition, the bird sometimes adopted a characteristic posture in which the body was tilted, head down, so that the entire head was in the shade of the bird's body. This was also observed in other boobies that were perched on adjoining branches of the tree or on rocks (fig. 2). In this posture, the bird appeared to be asleep and it did not gular flutter.

In the second test on the same booby, the radio pill was fed to the bird in the evening at 20:40, shortly after the female had returned to the nest after an absence of at least 12 hr. Unfortunately, the bird's temperature was beyond the range of the radio pill used on this occasion. Approximately 2 hr after the bird had returned to the nest, it was held gently and its rectal temperature taken by insertion of a mercury thermometer. The rectal temperature was 40°C. Forty-five minutes later, the bird's temperature could be detected by the radio pill (fig. 1). In spite of its relatively high deep-body temperatures, the booby did not display any indication that it was heat stressed. Gular flutter was absent and so also were the behavioral manifestations of heat stress observed in the previous test. The body temperature of the booby diminished while the bird was asleep (fig. 1). At 05:45, the booby awoke and exchanged positions on the nest with the male bird. It appeared to shiver at this time and the deep-body temperature increased (fig. 1). At the end of the test, shivering was again observed, but on this occasion it was prompted by the feeding of 10 cold fish (fig. 1). During the day, the body temperature of the bird increased to a maxi-