deposits of the St. Johns II period, and date approximately A.D. 850-900. The presence of these species suggests that the climate was colder at that time.

I am indebted to Dr. Pierce Brodkorb for the use of his skeleton collection, and for checking my identification of these bones.—J. HILL HAMON, *Department of Biology, University of Florida, Gainesville, Florida.*

Effects of High Air Temperature on the Bill and Claw Keratin Structures of the Tree Sparrow.—During studies on the energy balance of Tree Sparrows (*Spizella arborea*), captive birds subjected to high air temperature developed abnormalities in the bill and middle claw.

Six birds, four males and two females, trapped on February 5, 1958, near Urbana, Illinois, were immediately confined in experimental cages measuring

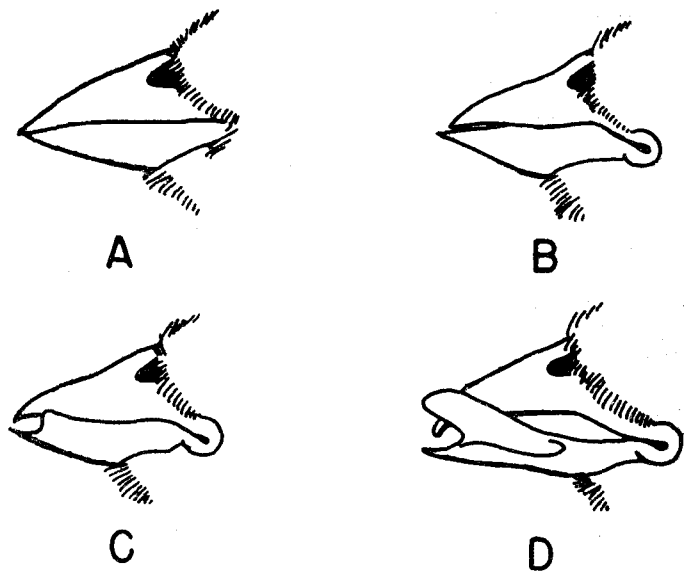

FIGURE 1. Stages in the development of bill deformities of Tree Sparrows at constant air temperatures above 35°C. A. Normal bill. B. After 27 days. C. After 37 days. D. After 44 days.

5 x 10 x 10 inches high, subjected to light at 10-hours photoperiod and air temperature of 10°C (50°F). On February 12, the temperature was raised to 30°C (86°F), on March 10 to 35°C (95°F), and on March 18 to 39°C (102.2°F). By March 21, one bird's lower mandible extended beyond the maxilla and small upward growths had appeared on each side of the mandible. All birds were then shifted back to 37°C (98.6°F), and the photoperiod was raised to 15 hours. On March 31, three of the six birds had mandibular growths. On April 2, all birds were placed at 39.5°C (103.1°F). By April 4, three had noticeable mandibular projections, two showed the elongated mandible, but the sixth did not develop a defect until April 7.

Stages in the development of this defect are shown in Fig. 1. The maximum growth, stage D, has two lateral mandibular projections that point forward and

curl slightly medially. The tip of the culmen is hooked. A fleshy bulb, about 1.5-2.0 mm in diameter, at the gape, appears in stage B and remains through stage D. The minimum time to gain stage B at 35°C or above was 27 days; to stage C, 37 days; and to stage D, 44 days. Birds previously exposed to 30°C, for 27 days showed no bill changes.

One bird was used in further experiments at lower temperatures. There was a gradual disappearance of the described growths, probably as a result of wear. On April 21, seven days after the last exposure to high temperature, the upper and lower jaws met evenly, the mandibular projections had decreased to a bump, similar to stage C, and the mandible height had decreased. By July 14, the bill did not differ from a normal bill and measurements corresponded with those of other caged birds.

For comparative purposes, measurements were taken on two groups of birds: a) fourteen Tree Sparrow skins collected in the field during the winter of 1956-1957; and b) eight captive birds, trapped on or before February 5, 1958, caged and fed the same as the birds at high temperatures, and maintained at a photoperiod of 10 hours, but at temperatures from 4°C (39.2°F) to −29°C (−20.2°F). All birds were taken from the same area, four miles north-east of Urbana, Illinois. Statistical analyses of eleven measurements of the bill (Baldwin, Oberholser and Worley, Sci. Publ. Cleveland Mus. Nat. Hist., 2: ix + 165, 1931) and one of the middle claw showed that the described growths represent significant changes in keratin structure (Table 1).

Results of the comparisons showed that the birds kept at high temperatures had a significant reduction in the length of the culmen, probably due in part to the decurving of the tip. Specimens collected in the field had lower bill heights and lower mandible heights, probably due to shrinkage. Birds kept at high temperatures had significantly higher mandibles than those kept at low temperatures. The length of the mandibular projection from base of notch and the height of the mandibular projection, measured from the notch to the occlusal surface of the mandible, were measurable only in the high temperature birds. No significant differences were found in the length of the mandible from gape, the greatest height of the maxilla, the greatest width of the maxilla, nor in the greatest width of the mandible.

The maxilla of collected specimens and of birds kept at low temperatures extended beyond the mandible, while the mandible of high temperature birds extended beyond the maxilla. All birds kept in cages had significantly longer middle claws than those shot in the field (probably because of less wear), but birds maintained at high temperatures showed a significant increase in claw length over those at low temperatures. The fleshy bulb was present only in the birds kept at high temperature. Dissection revealed no changes in the maxillary, premaxillary or mandibular bones.

Keratin structures are constantly growing; their normal size is maintained through wear, which may not be sufficient under certain captive conditions. Although no activity recordings were made, it was not observed that the birds at high temperature were less active than those at lower temperatures. It is doubtful that a slight decrease in activity would be sufficient to allow the described excessive growths to occur.

The abnormalities observed in the present study, although persisting at a photoperiod of 15 hours, started to develop at a 10-hour photoperiod. Ten hours

TABLE 1

COMPARISON OF BILL AND MIDDLE CLAW MEASUREMENTS OF TREE SPARROW STUDY SKINS AND CAGED TREE SPARROWS AT HIGH AND LOW TEMPERATURES.

Measurement	*Study skins* $n = 14$		*Caged at low temperature* $n = 8$		*Caged at high temperature* $n = 6$	
	Range (mm)	*Mean ± S.E.*	*Range (mm)*	*Mean ± S.E.*	*Range (mm)*	*Mean ± S.E.*
Length of total culmen	11.1–11.6	11.31 ± 0.04	11.2–12.1	11.66 ± 0.13	10.0 – 11.1	10.48 ± 0.19
Length of maxilla from gape	9.7–11.3	10.46 ± 0.12	10.0–11.8	10.84 ± 0.23	8.9 – 11.4	10.28 ± 0.35
Length of mandible from gape	9.0–11.2	9.99 ± 0.64	9.5–11.6	10.40 ± 0.22	10.0 – 12.6	10.90 ± 0.42
Height of bill at base	5.6– 6.2	5.84 ± 0.05	6.2– 6.7	6.31 ± 0.06	6.2 – 6.8	6.60 ± 0.11
Greatest height of maxilla	3.8– 4.7	4.07 ± 0.07	4.0– 4.7	4.29 ± 0.08	4.0 – 4.6	4.28 ± 0.08
Greatest height of mandible	2.7– 3.1	2.81 ± 0.04	3.2– 3.9	3.55 ± 0.10	4.0 – 4.6	4.23 ± 0.10
Greatest width of maxilla	5.2– 5.9	5.55 ± 0.05	5.4– 5.9	5.69 ± 0.06	5.4 – 5.8	5.60 ± 0.06
Greatest width of mandible	4.9– 5.8	5.34 ± 0.07	5.1– 5.8	5.54 ± 0.07	5.4 – 5.7	5.55 ± 0.05
Length of mandibular projection from notch	—	—	—	—	0 – 1.8	0.48 ± 0.32
Height of mandibular projection at notch	—	—	—	—	0.1 – 1.7	0.87 ± 0.29
Extent of maxilla beyond mandible	0 – 1.1	0.47 ± 0.09	0.2– 0.6	0.44 ± 0.05	0 – –1.6	–0.60 ± 0.25
Length of middle claw	5.0– 6.2	5.56 ± 0.09	6.3– 7.8	6.78 ± 0.21	8.7 – 10.4	9.78 ± 0.25

is not a sufficient photoperiod to cause gonadal recrudescence in the Tree Sparrow (personal observation). Moreover, such a photoperiod did not greatly differ from the natural photoperiod at this time of year. At Urbana, Illinois, the time between sunrise and sunset on February 1 is 10:07 hours and increases to 12:36 hours by March 31, with an average photoperiod of 10:41 hours in February and 11:56 in March. The environmental conditions, to which the birds would normally be exposed locally, differed greatly from the experimental conditions in temperature. The mean local outdoor temperature during February 1958 was −4.9°C (23.1°F); over all recorded years the average is −0.3°C (31.5°F). February 1958 temperatures ranged from −21°C (−6°F) to 17.2°C (63°F). During March 1958, the temperature average 2.3°C (36.2°F); over all recorded years the average is 4.5°C (40.1°F). March 1958 temperatures ranged from −4.4°C (24°F) to 14.4°C (58°F).

The fact that the keratin structures of the birds kept at high temperatures differs significantly in many respects from those of either wild birds or those maintained under identical conditions at lower temperatures suggests strongly that high air temperature is the causative agent. One possible explanation for the excess keratin production is that extreme high air temperature, approaching body temperature, increases the metabolic rate of the keratin producing cells. The increased growth would be the result of a faster mitotic rate of cells in the exposed epidermal stratum germinativum.—GEORGE C. WEST, *Department of Zoology, University of Illinois, Vivarium Building, Champaign, Illinois.*

The Function of the Depressor Mandibulae Muscle in Certain Passerine Birds.—The function usually ascribed to the depressor mandibulae muscle of birds is that of depressing the lower jaw. This action is accomplished by an upward pull on the lower mandible posterior to its articulation with the quadrate such that the mandible pivots downward anterior to this articulation. It has long been known, however, that in some non-passerine species this muscle has a second function—namely that of raising the upper jaw (see Hérissant, Mém. Acad. Sci. Paris 1748, 1752: 345–386). The only muscle of passerines commonly thought to have this function is M. protractor quadrati, which pulls the distal end of the quadrate forward, thereby moving the palatal and jugal struts forward and rotating the upper mandible dorsally around the frontonasal hinge. (See Beecher, Auk, **68**, 1951: 412–416, for a more complete discussion of jaw mechanics.) I believe that in certain passerine birds the depressor mandibulae serves in part to raise the upper jaw, thus complementing the action of the protractor quadrati.

The dual function of the depressor mandibulae may be explained in terms of its angle of pull to the long axis of the quadrate. If the muscle pulls parallel to the body of the quadrate, its sole action is depression of the lower jaw. On the other hand, if the muscle pulls forward with respect to the quadrate its forward component will be transmitted to the distal end of the quadrate through the lower jaw, swinging the quadrate anteriorly and raising the upper jaw. Furthermore, if there is resistance to depression at the tip of the lower jaw, the point of resistance then acts as the fulcrum of a second class lever and the force of the muscle is increased at the level of the quadrate. The forward component acting on the quadrate is therefore also increased.

Beecher has described the adaptations for feeding by "gaping" in certain species of Icteridae. Meadowlarks (*Sturnella magna*) "drive the closed bill into the ground and open it powerfully against the resistance of the earth" (*op. cit.*, p. 422). In