population the following year. This series of events was essentially duplicated in 1936–1939. For the period covered by the report, a decline in owl population is suggested for one or more years following a southward migration. The difference in the size of the southward migrating Snowy Owl population is probably related to the somewhat spotty distribution of large populations of rodents which enable them to find their prey by migration from place to place within the tundra in years for which rodent declines are not quite general.

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OBSERVATIONS ON YOUNG TARSOMETATARSI OF THE FOSSIL TURKEY *PARAPAVO CALIFORNICUS* (MILLER)

BY HILDEGARDE HOWARD

Plate 25

THE abundance of turkeys [*Parapavo californicus* (Miller)] in the Pleistocene deposits of Rancho La Brea, California, has been frequently commented upon in previous publications, and the presence of large numbers of young turkey bones has led to the conclusion that the species must have bred in the region of the tar traps.

In the Rancho La Brea collections at the Los Angeles County Museum, the series of turkey tarsometatarsi, alone, numbers well over

a thousand bones, and represents more than 750 individual birds. These range in size from apparently newly hatched chicks, to full grown gobblers.

In about 205 of the represented birds, the tarsus had not yet fully united with the metatarsi. In another 75, the metatarsals, though completely united with the tarsal element, still show a roughness of texture indicating immaturity, and no sign of spur development is evident in the male (large) bones. In modern turkeys under domestication, the male bird shows the first sign of spur development in six to eight months after hatching, depending upon the breed. According to the U. S. Department of Agriculture, Bureau of Animal Industry, observations on wild birds raised in captivity indicate close similarity between wild and domestic forms in this respect. The fossil species presumably would not have varied greatly from the modern birds, and it may safely be said that at least 275 of the turkeys entrapped at Rancho La Brea were under a year old.

These young bones were distributed through ten or twelve different pits so do not indicate a mass entrapment of birds of a single flock. It is more reasonable to assume that the bones represent a random trapping such as might have been expected over a period of years in this area if a ground-dwelling bird nested and raised its young in proximity to the tar traps. That many young grew to adulthood in the region in spite of the tar is suggested by the presence of bones of close to 500 fully grown male and female turkeys.

Of the several considerations which present themselves as a result of the recovery of these young turkey bones, one of the most important is the study of the immature bones themselves. The excellent series of tarsometatarsi, in particular, affords a rare opportunity to observe growth stages in this composite element, and is of value not only because of the geologic age of the species, but as a means of contributing to the general knowledge of bone development.

The collection of tarsometatarsi falls, roughly, into nine groups according to stage of development, as follows:

GROUP I. (Plate 25, upper figure *a* and *b*)—22 specimens.[1] Bone porous with both ends very spongy. Shaft not straight as in adults, but flaring gradually both proximally and distally from a point slightly below center of bone.

GROUP II. (Plate 25, upper figure, *c*)—15 specimens. Bone still porous, but shaft straighter and relatively longer, so that proximal and distal ends flare more abruptly at either end of shaft.

[1] Number of specimens refers to complete bones only and does not include the many fragmentary specimens of each group which are available.

GROUP III. (Plate 25, upper figure, *d*)—29 specimens. Bone less porous. Facets of distal trochleae assuming recognizable contours. Shaft fairly straight between flared ends. Distal foramina still incomplete.

GROUP IV. (Plate 25, upper figure, *e*)—22 specimens. Distal end nearly completely formed except external foramen not entirely closed off. Proximal end still spongy.

GROUP V. (Plate 25, upper figure, *f*)—17 specimens. Proximal end less porous, and flattened for union with tarsus. Tarsal element not yet joined. Distal end fully ossified, with foramina complete.

GROUP VI. (Plate 25, upper figure, *g*)—30 specimens. Tarsus uniting with metatarsals, but union still incomplete.

GROUP VII. (Plate 25, upper figure, *h*)—56 specimens. Tarsus completely fused with metatarsals, but proximal part of metatarsals still porous, and tubercle for tibialis anticus roughly formed, or not yet present.

GROUP VIII. 27 male specimens. Bone apparently fully ossified except shaft which shows slight graininess of texture. Spur core not yet formed. Thirty-six bones of females which show similar graininess of texture are placed in this group also.

GROUP IX. Fully grown adult bones. Males with spur core.

Bones of males and females are readily distinguished in the adult stage by the presence of the spur core in the male, as well as by generally smaller size in the female. Within the younger groups, it is possible to separate the sexes on the basis of size of the bones within a given developmental group. Although male bones at one stage of growth may overlap in length those of the females of the next succeeding group, the stage of development, as well as generally greater sturdiness in the male bones, serves to distinguish between them.

In the first group, variation in size appears to be entirely due to age rather than to sex. In the second group, sex variation is not marked but strongly suggested; there are a few bones which are slightly shorter and noticeably more slender than the rest. These are regarded as females, the rest males. In Group III, the proportions of male and female bones are more clearly indicated.

The age of the birds represented in these groups can be only roughly estimated. In Group I, the youngest birds were probably no more than a week old; the larger bones may represent birds of 4 or 5 weeks. Studies by Jaap, Penquite, and Thompson (Poultry Sci., 22: 11–19, 1943), as well as Harshaw, Titus and Fritz (Jour. Agric. Res., 48: 997–1008, 1934), on bone development in chickens, indicate that size

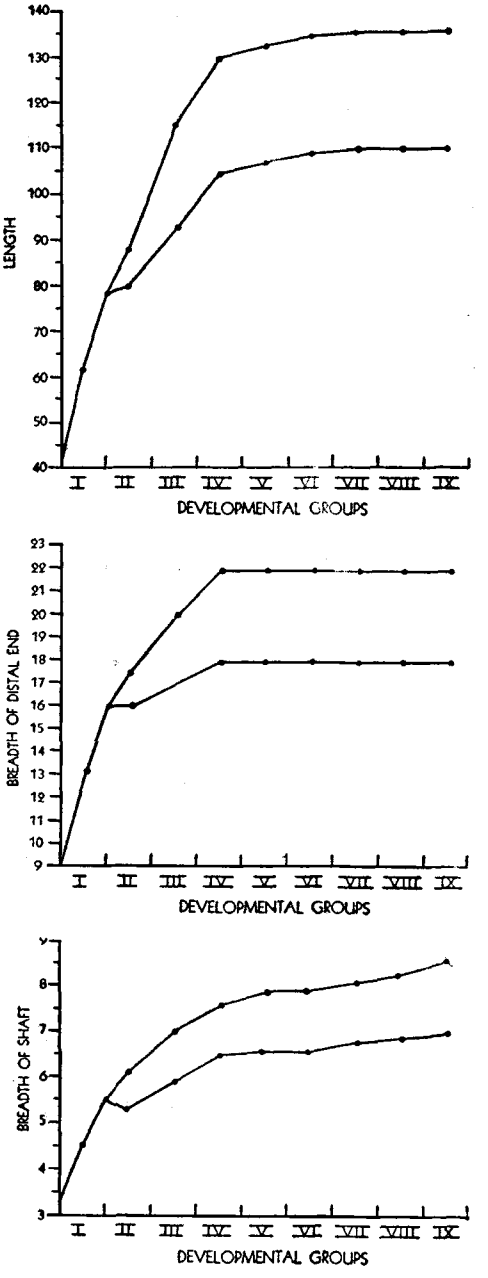
distinction of sexes in these birds occurs from the 4th to the 6th week depending on the breed. The time should not be markedly different in the turkey, possibly a little later. The age of individuals in Group II might, therefore, be estimated at from 5 to 7 or 8 weeks.

For stages represented by Groups III to VI, there is no available information on living birds which would indicate age. Group VII, however, the stage at which full length of the tarsometatarsus is apparently attained, can be estimated on the basis of studies on domestic fowl. Jaap (Proc. World's Poultry Congr. and Expos., 1939: 68–70) and Milby (unpublished measurements) have shown that full length of the tarsometatarsus is attained by female domestic turkeys at 22 to 24 weeks, by males at 26 to 28 weeks. In chickens the time of maximum growth of the element is less. There appears to be some correlation between ultimate size and age at which this size is attained; that is, the longer the bone, the longer time is required for complete growth. The length of the tarsometatarsus in *Parapavo* is about 90 per cent of that of wild *Meleagris gallopavo* and of still less proportion to the large domestic breeds with which Jaap and Milby are working. It is probable, therefore, that the tarsometatarsus of *Parapavo* reached its maximum length slightly earlier than is the case in the domestic turkey, and that the age of the individuals in Group VII ranges from about 21 to 26 or 27 weeks. The male bones of Group VIII, which represent a stage betweeen the time of attaining full linear growth and the time of appearance of the spur core, possibly include ages from 27–28 weeks up to 32–34 weeks, if spur development is comparable in the fossil and modern turkeys. The bones of females assigned to this group may be younger.

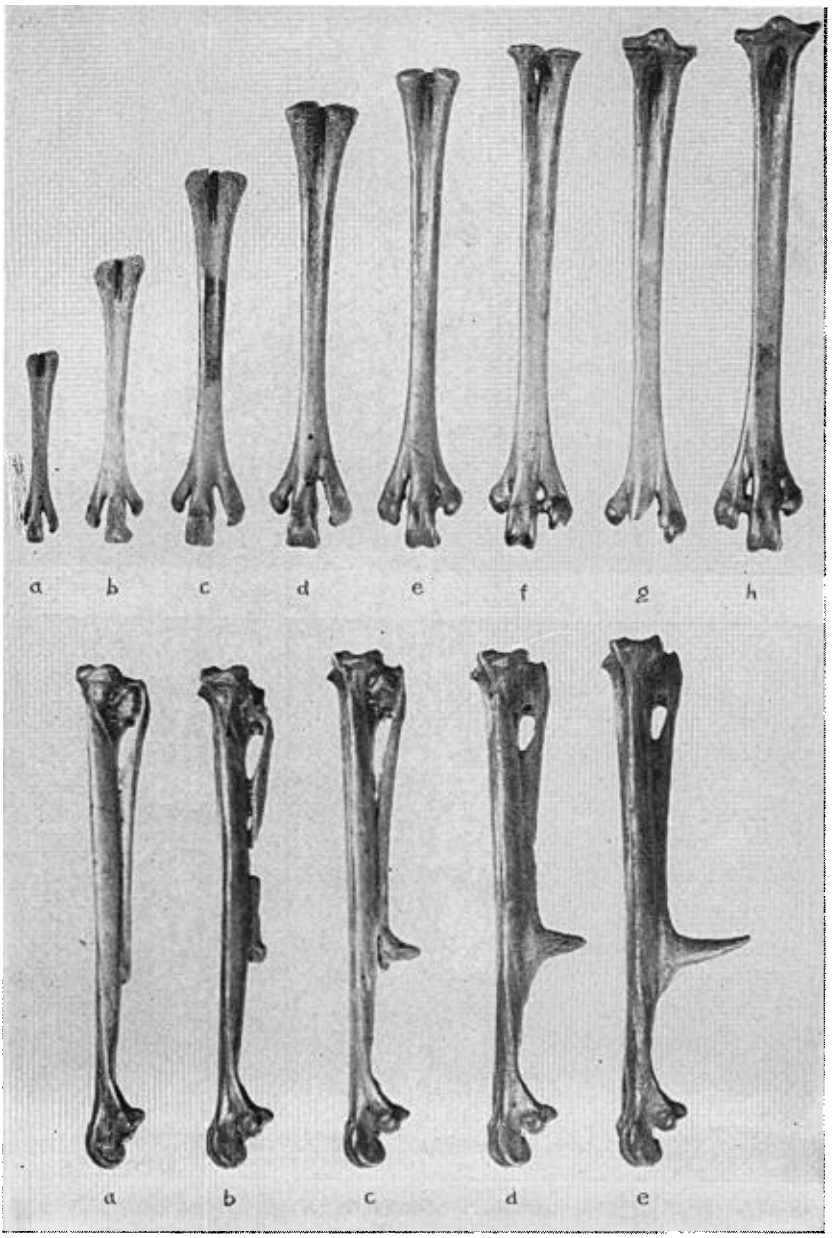
Measurements of length, breadth of distal end, and least breadth of shaft have been made on most of the specimens in the eight groups of subadult individuals, and on a representative series of adult bones. Measurement of proximal breadth was useless owing to the extreme porosity of this portion in the young bones, and the number of specimens in which the proximal end is badly worn.

Table I lists average measurements and ratios of breadth to length, showing progressive steps in development of proportions in the different groups. The youngest bones are seen to be the shortest and narrowest, but are relatively broadest when ratio of breadth to length is taken.

Text-figure 1 depicts graphically the increasing dimensions of the element through the several groups. In all bones of Groups VI to VIII, as well as those of the adult series, an adjustment has been made for the addition of the tarsus. As the tarsal cap is found to



TEXT-FIGURE 1.—Graphs depicting measurements (in millimeters) of tarsometatarsi of *Parapavo* in each of the nine groups. In all except Group I only the average measurement is given for each sex. In Group I, where sex difference in size is not discernible, and variation is due to age, minimum and maximum measurements are given as well as the average. X = Stage at which maximum growth is reached.


a
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c
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TABLE I

AVERAGE MEASUREMENTS AND RATIOS

	Group I	*Group II*	*Group III*	*Group IV*	*Group V*	*Group VI**	*Group VII**	*Group VIII**	*Group IX**
Length (mm.)									
Male	62†	88	115	130	133	135	136	136	136
Female		80	92	105	107	109	110	110	110
Breadth (mm.) distal end									
Male	13†	17.5	20	22	22	22	22	22	22
Female		16	17	18	18	18	18	18	18
Breadth (mm.) shaft									
Male	4.5†	6.1	7.0	7.6	7.9	7.9	8.1	8.3	8.6
Female		5.3	5.9	6.5	6.6	6.6	6.8	6.9	7.0
Ratio (%) breadth distal end to length	20.5	19.5	18.0	16.9	16.6	16.4	16.3	16.3	16.3
Ratio (%) breadth shaft to length	7.5	6.9	6.1	6.0	6.0	6.0	6.0	6.1	6.3

*Length and ratios adjusted to younger groups by subtraction of 5 mm. (height of tarsal cap) from measurement of length in each specimen in this group.

†Both sexes.

average 5 mm. in height, this amount has been subtracted from the total linear measurement in each specimen of the groups noted. This makes possible a comparison of growth and development throughout the entire series.

From the table and graphs, it appears that the distal dimension is first to attain full size (Group IV), though, relatively, the distal end is progressively smaller up to Group VII, at which stage the maximum length of the bone is reached. The shaft continues to broaden up to adulthood; however, as linear growth proceeds more rapidly than transverse development in the earliest stages, the shaft is relatively narrower through successive groups to Group IV. Growth of shaft and length are then apparently proportional until after linear growth ceases, when the continued enlargement of the shaft results in a proportionately greater transverse dimension.

CONCLUSIONS

The following observations have resulted from study of the series of turkey tarsometatarsi just described.

Though the very youngest chicks have a semblance of the general shape of the adult bone, contours are undeveloped, and the bone is extremely porous.

The shaft straightens as the contours of the distal end begin to take shape (Groups II and III). A slight indication of size difference due to sex becomes apparent in Group II and is more clearly discernible in Group III.

Full breadth of distal end is apparently reached by the time the internal foramen is completely outlined, although the external foramen is still open (Group IV).

The indefinitely rounded proximal tips of the metatarsals flatten out and become less porous before uniting with the tarsal cap (Group V). Formation of the distal foramina is completed by this stage.

Separate tarsal elements have not been discovered in the Rancho La Brea material. As observed at the time of beginning of union with the metatarsals (Group VI), they are fully formed, though porous at the edge of contact with the metatarsals. At this time the tarsal section is in one piece which forms the proximal cap bearing the articular cotylae of the tarsometatarsus, and posteriorly fits over the middle metatarsal to form the hypotarsus, through and over which pass the tendons of the flexor muscles of the foot.

Linear growth continues until the tarsus and metatarsals are completely united (Group VII). At this time the length apparently becomes fixed, even though the texture of the bone is still slightly rough.

As the tarsal cap appears to have completed its proximal ossification before union with the metatarsals, the transverse dimension of the proximal end should be fixed at this time. It could be slightly altered, however, by the growth of the small muscle attachment on the outer side which, in many specimens, is found to merge with the lip of the external cotyla. Although many of the subadult specimens, in which the tarsus has united with the metatarsals, are considerably worn just below the lip of the cotyla, a comparison of those which can be accurately measured, with adult specimens, justifies this assumption.

The bony lamina which extends downward from the internal process of the hypotarsus becomes well developed before the appearance of the spur core (Plate 25, lower figure, *a*). It appears to remain loosely attached to the main shaft of the metatarsals, however, until after the spur core has begun to form. The shaft, itself, maintains a roughness and porosity in its mid-posterior section which would suggest that the core originates and grows from the metatarsals. This idea is refuted, however, by specimens in which the core is undergoing development (Plate 25, lower figure, *b* and *c*) which show the core fully attached to the bony lamina, but both lamina and core separated from the metatarsal shaft. The growth of the core appears to be entirely from the

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EXPLANATION OF PLATE XX

Parapavo californicus.—(*Upper figure*) Series of young metatarsi, illustrating growth stages in the first seven groups: *a*, one of the youngest available specimens, Group I; *b*, a larger (presumably older) specimen from Group I; *c*, Group II; *d*, Group III; *e*, Group IV; *f*, Group V; *g*, Group VI; *h*, Group VII. About 0.30 ×.

(*Lower figure*) Series of tarsometatarsi, showing development of spur core. Conditions illustrated: *a*, complete lamina with slight proliferation of cells present at its distal tip; *b*, nubbin of spur core; *c*, more advanced nubbin; *d*, core well united with shaft; *e*, full-grown spur core. About 0.32 ×.

internal side of the lamina, the external surface of which remains smooth. In one specimen, the lamina appears to be made up of two separate, thin layers, only the inner of which takes part in core development. With the continued growth of the core, core and lamina attach to the metatarsal shaft, evidently aided by a proliferation of cells from the rough area on the shaft of the metatarsals (Plate 25, lower figure, *d* and *e*).

Although the breadth of the shaft in the adult bones may be partially affected by this activity in the area of the developing spur core, the shaft as a whole maintains a slight porosity in both male and female bones until the ridges and grooves formed by the tendons are fully etched on its surface. As long, therefore, as roughness or graininess in texture of bone exists, slight increase in breadth of shaft may be expected, though the linear dimension is apparently not altered once the tarsal and metatarsal elements are well united.

This concept of the proportions of the bones of immature individuals is of importance in paleontological studies. Lacking true epiphyses, the time of cessation of growth in avian specimens is not clearly marked as in mammalian bones. It appears, however, that in the tarsometatarsus, in which the tarsal element acts as an epiphysis, it is safe to consider linear measurements on a par with those of adult individuals when the fusion of the two parts is complete, though the proportion of breadth of shaft would be unreliable as long as roughness exists.

Los Angeles County Museum
May 1, 1945

BEHAVIOR OF BIRDS DURING A FLORIDA HURRICANE

BY GEORGE MIKSCH SUTTON

ON October 19, 1944, a much publicized hurricane, which moved northward from Cuba by way of Tampa, struck the vicinity of Orlando, Orange County, Florida. Hundreds of large trees were blown down in Orlando and in the neighboring town of Winter Park, just to the north, but destruction of houses was not great on the whole; damage to the citrus crop appeared to many eye-witnesses to be considerably overstated in the newspapers, and very few lives were lost. At the 'New Area' of the Army Air Forces Tactical Center, at which base I was stationed at the time, scores of large pine trees were broken off or uprooted, several wooden barracks were shoved from their cement-block foundations, and roofing paper, tin chimneys, and wooden ventilators were blown off right and left.