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Vol. XXIV, No. 1.—Bottom of p. 16: Vol. XXIII, No. 9, should read—Nipher, Francis E., Studies of Properties of Integral Numbers, 9 pp.; New Evidence of a Relation Between Gravitation and Electrical Action, and of Local Changes in the Electrical Potential of the Earth, 5 pp.

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ECOLOGICAL STUDIES OF THE ENTOMOSTRACA OF THE ST. LOUIS DISTRICT. PART I. DIAPTOMUS PSEUDOSANGUINEUS SP. NOV. AND A PRELIMINARY LIST OF THE COPEPODA AND CLADOCERA OF THE ST. LOUIS DISTRICT

C. H. Turner

Diaptomus Pseudosanguineus Sp. Nov.

The form is closely related to *Diaptomus sanguineus* Forbes and *Diaptomus conipedatus* Marsh, both of which it resembles in having a very rudimentary endopodite on the fifth foot of the male. If we ignore color, it is almost impossible to differentiate the females of this species from those of *Diaptomus sanguineus* Forbes. The males, however, are quite distinct. The fifth foot is quite different, as is also the armature of the male antenna. The fifth foot of the male of this species is similar to that of *Diaptomus conipedatus* Marsh but the antipenultimate joint of the right male antenna, in addition to a hook, similar to but somewhat longer than that of *Diaptomus conipedatus* Marsh, also bears a hyaline flange similar to that of *Diaptomus sanguineus* Forbes.

Description of the female. (*pl.* 1, *fig.* 1; *pl.* 2, *fig.* 1).—The female is about 2.00 mm. long and the widest portion of the thorax is about 0.54 mm. wide. The reflexed antennae extend to the distal extremity of the furcal setae. Viewed from the dorsal aspect, the cephalothorax widens gradually from the tip of the head to about the third thoracic somite, from which point it gradually tapers to the tip of the abdomen. Viewed from the lateral aspect the body slopes continuously upwards and backwards from the tip of the head to the third thoracic somite. Thence it extends almost horizontally to about the middle of the last thoracic somite, from there sloping abruptly to the abdomen. The cervical suture is distinct. Each latero-caudal margin of the thorax is produced outward and armed with two nipple-like tubercles (pl. 1, fig. 1c; pl. 3, fig. 4b). About the middle of the ventral surface of the first abdominal somite, and located nearer the sides than the middle line, there is a pair of long curved spines, somewhat larger than the tubercles (pl. 2, fig. 2f). The outed ramus of the fifth foot is two-jointed (pl. 3, fig. 5). The subrectangular first joint is twice as long as wide; for two-thirds its length the second joint is almost straight on its outer edge, the inner margin tapering gradually from its base to that point; there the foot abruptly turns inward at an angle of more than 45°, terminating in a blunt point. On its lower third it bears three spines. The inner one, which extends to the angle in the segment, is the longest; the next about half this long; and the outer one somewhat shorter than the intermediate one. The inner ramus of the fifth foot is straight and about five times as long as wide; at its tip are two setae which are about half as long as the ramus. The outer margin, on its distal third, is distinctly hairy. The specimens so far found are of a dirty white color.

Description of the male. (*pl.* 1, *fig.* 2).—The male is about four-fifths the size of the female; the tubercles on the laterocaudal margin of the thorax are absent or inconspicuous; there is no armature on the first abdominal somite. The first basal joint of the right fifth foot is short, about as long as broad (pl. 3, fig. 1); the second basal joint is about twice as long as wide and fully twice as long as the preceding joint. The inner ramus (endopodite) is missing; the outer (expodite) is composed of two joints of about equal length. The first of these joints is about the same length as the second basal segment but much more slender and bears at its outer distal margin a broad tooth-like expanse. The second joint is slightly curved inwards, its distal extremity somewhat wider than its proximal. Near the tip of its outer margin it bears a straight spine which is about two-thirds as long as the somite. At its tip is a stout curved claw which is about the same length as the segment. The first segment of the left fifth foot is about as long as the second and the whole appendage extends to a little beyond the tip of the first segment of the expodite of the right foot. The two segments of the outer ramus (exopodite) are of about the same length; the second bears at its tip one long and one short claw-like spine. The inner ramus (endopodite) is slender and about as long as the outer ramus; is unsegmented; its distal third pronouncedly hairy; and the inner margin of its intermediate third coarsely crenate. The antipenultimate segment of the right male antenna (pl. 1, fig. 2; pl. 2, fig. 3) bears a stout almost opaque curved process composed of the same material as the body of the antenna. This process is a little shorter than the next segment of the antenna. Intimately connected with this process and extending along the whole margin of the antipenultimate segment, is a hyaline flange similar to that of *Diaptomus sanguineus* Forbes.

Like the female, the male is of a dirty white or gray color. In the prime of life *Diaptomus sanguineus* Forbes, so far as my experience goes, is red in color, or marked with red or blue. However, it is not claimed that this color difference is of taxonomic value. In other localities the color scheme may be different for it is well known that color in Entomostraca sometimes varies with environment. Nevertheless, the color described is that of individuals in the prime of life, for numerous specimens were found in copulo (pl. 3, fig. 3) and many more with spermataphores attached (pl. 1, fig. 3j; pl. 2, fig. 2g).

Habitat.—The specimens were found in a spring-fed marsh where about two inches of water rested upon more than two feet of water-soaked silt. Originally this marsh was a reservoir which had been constructed on a shelf-like depression between two hills. In addition to receiving the wash from the surrounding hills, this pond was fed by a spring which furnished sufficient water to cause a continuous overflow through the spillway of the dam. The fine materials washed from the surrounding hills have gradually transformed this reservoir into a marsh but the water continues to flow out through the spillway. It was near this spillway that the specimens were found. A group of cattails, which has been gradually increasing in size since the day when it was surrounded by water many inches deep, still flourishes, and patches of duckweed are scattered over the surface of the marsh. At the time the specimens were found the temperature of the water was 25°C., the temperature of the surrounding atmosphere being over 32°C. The PH of the water was 7.6.

Associates.—The following Entomostracans were found associated with it: *Bosmina longirostris* (O. F. Mueller), *Ceriodaphnia rigaudi* Richards, *Cyclops leuckarti* Claus. In May *Cyclops albidus* Jurine var. *tenuicornis* was found in the same place; also *Cyclops viridis* Jurine. A species of Vorticellidae was found as a commensal, attached to the abdomen, among the eggs (pl. 2, fig. 1 e).

Preliminary List of Copepoda and Cladocera of St. Louis District

In this communication no attempt is made to give a complete list of synonyms; such lists will be found in the references mentioned. For easy reference, the genera and species are arranged in alphabetical order under each family.

COPEPODA

FAMILY CENTROPAGIDAE

GENUS DIAPTOMUS WESTWOOD

1. DIAPTOMUS ASHLANDI Marsh 1893.

Diaptomus ashlandi, Marsh, '93. p. 198. pl. 3, fig. 11-13.

Diaptomus ashlandi, Herrick & Turner, '95. p. 60. pl. 6, fig. 4-6.

Diaptomus ashlandi, Schacht, '97. pp. 167-169. pl. 32, fig. 1-4.

Common. Found in lakes, no-outlet ponds and marshes, through a temperature range of 15-35°C. Usually abundant.

2. DIAPTOMUS OREGONENSIS, Lilljeborg 1889.

Diaptomus oregonensis, Herrick & Turner, '95. pp. 72, 73. pl. 4, fig. 7-12; pl. 9, fig. 8.

Diaptomus oregonensis, Schacht, '97. pp. 151-154. pl. 29, fig. 1, 2.

Found three times in this district in no-outlet ponds; in one case collected from the midst of vegetation; in the other two cases the ponds contained no higher plants. The temperature of the water ranged from 15-20°C. The PH value ranged from 7.6 to 8.2. Abundant in each case.

3. DIAPTOMUS PALLIDUS Herrick 1879.

Diaptomus pallidus, Herrick & Turner, '95. pp. 73, 74. pl. 4, fig. 1-6; pl. 5, fig. 10; pl. 13, fig. 17.

Diaptomus pallidus, Schacht, '97. pp. 144-146. pl. 27, fig. 3.

Encountered in this region but once, in June, 1920, when it was abundant in a no-outlet pasture pond.

4. **DIAPTOMUS PSEUDOSANGUINEUS**, sp. nov. (pl. 1-3).

For description consult the first section of this paper.

5. DIAPTOMUS SANGUINEUS Forbes 1876.

Diaptomus sanguineus, Forbes, '76. pp. 15, 16, 23. fig. 24, 28-30.

Diaptomus sanguineus, Herrick & Turner, '95. p. 71. pl. 13, fig. 12.

Diaptomus sanguineus, Schacht, '97. pp. 133-137. pl. 23-26.

Collected but once in this district, in a no-outlet pond in 1909.

6. DIAPTOMUS SICILIS Forbes 1882.

Diaptomus sicilis, Herrick & Turner, '95. pp. 60, 61. pl. 5, fig. 1-7; pl. 13, fig. 18.

Diaptomus sicilis, Schacht, '97. pp. 122-124. pl. 21, fig. 1-3.

Found in April, 1909, in large numbers in the open waters of a large lake, the temperature of which was 11°C. The water was free from vegetation and there were practically no algae. The altitude of the lake is 440 feet. Not found since although frequent collections have been made in the same part of the lake.

7. DIAPTOMUS STAGNALIS Forbes 1882.

Diaptomus stagnalis, Forbes, '82. pp. 15, 16, 23. fig. 24, 28-30.

Diaptomus stagnalis, Herrick & Turner, '95. pp. 71, 72. pl. 13, fig. 8-10.

Diaptomus stagnalis, Schacht, '97. pp. 138-141. pl. 28, fig. 2.

Found in this district only once, in June, 1920, in a shallow, no-outlet pond free from vegetation.

FAMILY CYCLOPIDAE

GENUS CYCLOPS O. F. MUELLER

8. CYCLOPS ALBIDUS Jurine 1820, var. tenuicornis Sars 1863.

Cyclops signatus, var. *tenuicornis*, Herrick & Turner, '95. pp. 106, 107. pl. 15, fig. 5-7; pl. 20, fig. 1-7; pl. 33, fig. 1, 2.

Cyclops albidus, E. B. Forbes, '97. pp. 47-49. pl. 13.

A species widely distributed in this district, in marshes, small temporary ponds, small no-outlet ponds, and lakes. It is found where vegetation does and does not exist, occurring in water ranging from 10°-25°C. and having PH values ranging from 7.2 to 8.0. In some specimens the hyaline plate on the antenna is smooth, in others finely serrated. Found in both fetid water and in water having no perceptible odor. April, May and July.

9. CYCLOPS ALBIDUS Jurine 1820, var. CORONATUS.

Cyclops signatus, var. *coronatus*, Herrick & Turner, '95. p. 106. pl. 15, fig. 1-4.

Found only once in this district, among cattails in a shallow pond, the temperature of which was 21°C.

10. CYCLOPS BICUSPIDATUS Claus 1857.

Cyclops forbesi, Herrick & Turner, '95. p. 104.

Cyclops bicuspidatus, E. B. Forbes, '97. pp. 44-47. pl. 12, fig. 1-4.

Found in this district in four different no-outlet ponds free from vegetation, but once only in each place. In one pond the temperature was 17°C.; in another 19°; temperature of the others not recorded. The hydrogen ion content of one pond only was measured, the PH value being 7.2. April and October.

11. CYCLOPS FIMBRIATUS Fischer 1853.

Cyclops fimbriatus, Herrick & Turner, '95. pp. 121, 122. pl. 17, fig. 8, 9; pl. 21, fig. 11; pl. 25, fig. 9-14.

This form is rare here, it having been collected but once, June 1, 1921, when I obtained a few from a shallow temporary pond with a PH value of 8.2.

12. CYCLOPS FUSCA Jurine 1820.

Cyclops signatus, var. *coronatus*, Herrick & Turner, '95. p. 106. pl. 15.

I have always considered this a variety of *C. albidus* and have discussed it under that head.

13. CYCLOPS PHALERATUS Koch 1853.

Cyclops phaleratus, Herrick & Turner, '95. pp. 120, 121. pl. 17, fig. 1-7; pl. 18, fig. 2, 2d; pl. 19, fig. 1; pl. 21, fig. 6-10.

Cyclops phaleratus, E. B. Forbes, '97. pp. 59-63. pl. 20, fig. 3.

A few found on one occasion in a no-outlet pond, the temperature of which was 32°C. Also found in a weedy marsh with PH value of 8.2.

14. CYCLOPS LEUCKARTI, Claus 1857.

Cyclops leuckarti, Herrick & Turner, '95. pp. 96-98. pl. 16; pl. 18, fig. 1 a-j; pl. 24, fig. 2-6.

Cyclops edax, Forbes, '97. pp. 33-36. pl. 9, fig. 1-3.

Collected from three different localities in this district. Two were vegetationless no-outlet ponds, the other a weedy marsh. The temperature of the water and the hydrogen ion content were determined for only one locality, the temperature being 25°C. and the PH value 7.8. May, June and August.

15. CYCLOPS, SERRULATUS Fischer 1860

Cyclops serrulatus, Herrick & Turner, '95. pp. 111, 112. pl. 15, fig. 8-11.

Cyclops serrulatus, E. B. Forbes, '97. pp. 54-57.pl. 17; pl. 18. fig. 1-3.

One of the most widely distributed copepods in this district. Found throughout the season in all types of habitat, at all temperatures and in waters with hydrogen ion content varying from PH 7.00 to PH 8.2.

16. CYCLOPS VIRIDIS Jurine 1820, var. INSECTUS Forbes 1882.

Cyclops insectus, Forbes, '82. p. 649. pl. 9, fig. 6.

Cyclops viridis, var. *americanus*, Herrick & Turner, '95. pp. 91, 92. pl. 14, fig. 1-9.

Cyclops viridis var. *insectus*, E. B. Forbes, '97. pp. 41-44. pl. 11, fig. 3-6.

Perhaps the most common copepod in this district, occurring in all types of habitat, at all seasons and temperatures, and in waters with the hydrogen ion content ranging from PH 7.0 to PH 8.2. This and certain species of Vorticellidae and of one-celled green algae are often commensals.

Cladocera

FAMILY BOSMINIDAE

GENUS BOSMINA BAIRD 1845

1. BOSMINA LONGIROSTRIS (O. F. Mueller) 1785.

Bosmina longirostris, Birge, '18. p. 706. fig. 1096.

Common in this district, being abundant in many of the no-outlet ponds during the warm season. It has been found where vegetation does and does not exist. The hydrogen ion content of the water was determined for only three ponds, varying from PH 7.8 to 8.2.

FAMILY CHYDORIDAE

GENUS ALONA BAIRD 1850

2. ALONA COSTATA Sars 1862.

Alona costata, Herrick & Turner, '95. pp. 245, 246. pl. 60, fig. 8.

Collected in November, 1909, among pond lilies in a small no-outlet pond having a temperature of 18°C., the only time encountered in this district.

3. ALONA RECTANGULAR Sars 1861.

Alona pulchra, Herrick & Turner, '95. p. 245.

In May, 1921, this species was found in a marsh and in a large no-outlet pond. The hydrogen ion content in each case was PH 8.2. The temperature of the water was 27°C.

GENUS CHYDORUS LEACH 1843

4. CHYDORUS SPHAERICUS (O. F. Mueller) 1785.

Chydorus sphaericus, Birge, '78. pp. 23, 24.

Chydorus sphaericus, Herrick & Turner, '95. p. 261. pl. 64, fig. 4, 7, 8, 10.

This species is common in marshes and among the vegetation in certain no-outlet ponds of this district. The temperature of the water in which it was found varied from 18-31°C. The hydrogen ion content of the water was determined in only one instance, being 8.2. May to October.

GENUS KURZIA DYBOWSKI AND GROCHOWSKI 1894

5. KURZIA LATISSIMA (Kurz) 1874.

Kurzia latissima Birge, '18. p. 718. fig. 1120.

Alonopsis latissima, Herrick and Turner, '95. pp. 232, 233. pl. 61. fig. 8; pl. 68. fig. 1, 9.

Collected on two occasions in July, 1920, in large numbers among water plantain in a shallow lake.

GENUS LEYDIGIA KURZ 1874

6. LEYDIGIA QUADRANGULARIS (Leydig) 1860

Leydigia quadrangularis, Herrick & Turner, '95. p. 234. pl. 59, fig. 8; pl. 60, fig. 4.

Collected twice in this neighborhood, in April, 1910, among water lilies, in a shallow no-outlet pond, the temperature of which was 20°C.; and in August, 1921, in a shallow no-outlet pond, the temperature of which was 32°C. and the hydrogen ion content PH 7.4.

7. LEYDIGIA ACANTHROCERCOIDES (Fischer) 1854.

Leydigia acanthocercoides, Herrick & Turner, '95. p. 234.

A few specimens of this collected on June 25, 1910, in a no-outlet pond, the only time it has been encountered.

GENUS OXYURELLA DYBOWSKI AND GROCHOWSKI 1894.

8. OXYURELLA TENUICAUDIS (Sars) 1862.

Alona tenuicaudis, Herrick & Turner, '95. pp. 242, 243, pl. 62, fig. 11.

A few collected in June, 1921, in a shallow transitional pond having a temperature of 24°C.

GENUS PLEUROXUS BAIRD 1843.

9. PLEUROXUS DENTICULATUS, Birge, 1877.

Pleuroxus denticulatus, Birge, '76. pp. 20, 21. pl. 1, fig. 21.

Pleuroxus denticulatus, Herrick & Turner, '95. p. 256. pl. 45, fig. 8; pl. 63, fig. 10a, 12, 13.

Common in marshes and among vegetation, in no-outlet ponds and lakes of this district. Collected from water with temperature ranging from 18-31°C. The hydrogen ion content of the water was calculated only once, when it was found to be PH 8.2.

10. PLEUROXUS HAMULATUS Birge 1910.

Pleuroxus hamatus, Birge, '76. pp. 22, 23. pl. 2, fig. 13, 14.

Pleuroxus hamatus, Herrick & Turner, '95. p. 257. pl. 60, fig. 1.

This species which heretofore has not been found outside of New England and the Southern States, has been collected from three different no-outlet ponds of this district. In one case the pond was weedy and this species seemed to be dominant; in the other cases the water was free from any vegetation higher than algae. In two cases the water was comparatively fresh; in the third it had a disagreeable stench. The temperature and hydrogen ion content of the water were determined in only one case, the temperature being 32°C, the PH 7.4.

FAMILY DAPHNIDAE

GENUS CERIODAPHNIA DANA 1853

11. CERIODAPHNIA LACUSTRIS Birge 1893.

Ceriodaphnia lacustris, Birge, '18. p. 701. fig. 1083.

Found in this district in a large reservoir furnishing water for the Wabash railroad. The temperature of the water was 27°C., the hydrogen ion content PH 8.2.

12. CERIODAPHNIA LATICAUDATA P. E. Mueller 1867.

Ceriodaphnia laticaudata, Herrick & Turner, '95. p. 171. pl. 41, fig. 22.

Ceriodaphnia consors, Herrick & Turner, '95. pp. 171, 172. pl. 42, fig. 4; pl. 44, fig. 5, 6.

Collected twice in this district, each time from a temporary pond, once in June, 1910, when it was abundant, and again in June, 1920, when it was rare.

13. CERIODAPHNIA PULCHELLA Sars 1862.

Ceriodaphnia pulchella, Herrick & Turner, '95. p. 169. pl. 41, fig. 14, 19.

Collected in this district among water plantain in a lake.

14. CERIODAPHNIA RECTICULATA (Jurine) 1820.

Ceriodaphnia reticulata, Herrick & Turner, '95. p. 170. pl. 41, fig. 15, 21; pl. 42, fig. 3; pl. 43, fig. 3; pl. 44, fig. 3. 4.

This species was found in a no-outlet pond in March and in November, 1909.

15. CERIODAPHNIA RIGAUDI Richard 1894.

Ceriodaphnia riguadi, Birge, '18. p. 700, fig. 1078.

Collected July 21, 1921, from a no-outlet pond the temperature of which was 29°C. and the PH value 7.8. August 1, 1921, it was collected from a marsh having a temperature of 25°C. and a PH value of 7.8. On each occasion some of the females were carrying winter eggs. To the best of my knowledge this is the first time this species has been reported from this part of the country.

GENUS DAPHNIA O. F. MUELLER 1785

16. DAPHNIA LONGISPINA (O. F. Mueller) 1785.

Daphnia longispina, Herrick & Turner, '95. p. 199.

A form which seems to be the typical form of this species, found in a large reservoir having a temperature of 27°C. and a PH value of 8.2. Although it was May, some of the females were carrying winter eggs.

17. DAPHNIA LONGISPINA var. HYALINA Leydig, 1860.

Daphnia hyalina, Herrick & Turner, '95. pp. 195, 196. pl. 22, fig. 7, 8; pl. 27, fig. 6; pl. 35, fig. 16; pl. 49, fig. 3-5; pl. 53, fig. 1-4.

Found in spring and early summer in certain of the no-outlet ponds in this vicinity. Of the form *mendolatae.* In the latter part of May some of the females were carrying winter eggs.

18. DAPHNIA LONGISPINA var. LONGIREMIS Sars 1861.

Daphnia longiremis, Herrick & Turner, '95. p. 202.

Found in April, 1909, in great numbers in an ox-bow lake with a temperature of 15°C. Collected in May, 1920, from a small temporary pond the temperature of which was 18°C.

19. DAPHNIA PULEX (de Geer) 1778.

Daphnia pulex, Herrick & Turner, '95. pp. 193, 194.

The most common daphnid of this district. Frequently encountered in summer, even in water so fetid as to have a disagreeable stench. Occurs at temperature ranging from 19-35°C. and in water having a hydrogen ion content varying from PH 7.2 to 7.6. Winter eggs found in June and July.

20. DAPHNIA RETROCURVA Forbes 1882.

Daphnia kalbergenesis, Herrick & Turner, '95. pp. 203, 204. pl. 27, fig. 1-3; pl. 53, fig. 5-8.

Collected in spring and early summer from one of our lakes. The helmet on the head is small and rounded, probably enough so to warrant calling it var. *breviceps* Birge. The temperature of the water varied from 24-31°C. and the hydrogen ion content of the water was PH 8.0.

GENUS MOINA BAIRD 1850

21. MOINA BRACHIATA (Jurine) 1820.

Moina brachiata, Herrick & Turner, '95. pp. 162, 163. pl. 39, fig. 5-8; pl. 43, fig. 1, 2.

At times during the summer this species is abundant in some of the muddy ponds and marshes of this district. Found in water having a hydrogen ion content of PH 7.6-8.0. It frequently bears commensal Vorticellidae.

22. MOINA RECTIROSTRIS (Leydig) 1860.

Moina rectirostris, Herrick & Turner, '95. pp. 163, 164. pl. 39, fig 1-4; pl. 41, fig. 2, 5, 8, 10, 11.

Found in certain muddy temporary ponds of this district in May and June. The temperature of the water varied from 20-35°C., the hydrogen ion content from PH 7.0 to PH 7.6.

GENUS SCAPHOLEBERIS SCHOEDLER 1858

23. SCAPHOLEBERIS MUCRONATA (O. F. Mueller) 1785.

Scalpholeberis mucronata, Birge '78. pp. 6-9. pl. 2, fig. 8, 9.

Scapholeberis mucronata, Herrick & Turner, '95. pp. 174, 175. pl. 43, fig. 4-7; pl. 45, fig. 5.

Abundant in weedy marshes and certain ponds in this neighborhood. Collected in water ranging in temperature from 27-32°C. and having a hydrogen ion content between 7.6 and 8.2. The marshes dry up in summer and the ponds are temporary. April, May, June, and October.

GENUS SIMOCEPHALUS (O. F. MUELLER) 1776

24. SIMOCEPHALUS SERRULATUS (Koch) 1841.

Simocephalus americanus, Birge, '78. pp. 6-8. pl. 1, fig. 6.

Simocephalus serrulatus, Herrick & Turner, '95. pp. 179.

Simocephalus americanus, Herrick & Turner, '95. p. 179. pl. 45, fig. 9.

In this district frequently found in marshes and among vegetation in ponds and lakes from March to November, in water varying in temperature from 14-32°C. Sometimes so numerous in a certain pond as to be the dominant form and the following year failing to appear in that pond.

FAMILY MACROTHRICIDAE

GENUS ACANTHOLEBERIS LILLJEBORG 1853

25. ACANTHOLEBERIS CURVIROSTRIS (O. F. Mueller) 1776

Acantholeberis curvirostris, Herrick & Turner, '95. p. 218. pl. 49, fig. 1-4.

Rare or accidental in this district, a few having been found in a weedy pond on one occasion.

GENUS MACROTHRIX BAIRD 1843

26. MACROTHRIX LATICORNIS (Jurine) 1820

Macrothrix laticornis, Herrick & Turner, '95. p. 212. pl. 54, fig. 9-12; pl. 56, fig. 8, 9.

Found in four different localities in this district; in a marsh, among the water plants in a lake, in a no-outlet permanent pond, and in a transitional pond, the bottom of each being mud. The temperature range of the water was 14-31°C. The hydrogen ion content was determined for only three of the localities; for two it was PH 8.2 and for the third PH 7.2. In the marsh and lake only a few specimens were found; in the transitional pond it was abundant. April, May, June, and August.

FAMILY SIDIDAE

GENUS DIAPHANOSOMA FISCHER 1850

27. DIAPHANOSOMA BRACHYURUS (Lievin) 1848

Daphnella brachyura, Herrick & Turner, '95. pp. 148, 149. pl. 36, fig. 11-16.

In July, 1920, this was common in a transitional pond with muddy bottom, in a St. Louis park. The temperature of the water was 30°C.

28. DIAPHANOSOMA LEUCHTENBERGIANUM FISCHER 1850

Daphnella brandtiana, Herrick & Turner, '95. p. 149. pl. 37, fig. 3-6.

In June, 1920, this species was abundant in a temporary pond near Koch, Mo. The water was muddy and free from vegetation, with a temperature of 30°C.

GENUS LATONOPSIS SARS 1888

29. LATONOPSIS OCCIDENTALIS Birge 1891.

Latonopsis occidentalis, Birge, '91. pp. 383-388.

Latonopsis occidentalis, Herrick & Turner, '95. pp. 150-151. pl. 38

Collected in June, 1920, from a small permanent pond near Jefferson Barracks, Mo. The bottom was muddy and the pond held no vegetation. the water itself being clear.

GENUS PSEUDOSIDA HERRICK 1884

30. PSEUDOSIDA BIDENTATA Herrick 1884.

Pseudosida tridentata, Herrick & Turner, '95. pp. 147, 148. pl. 36, fig. 2-6; pl. 50, fig. 9.

In June, 1910, a few specimens were collected from a swamp near Union Avenue and Natural Bridge Road, St. Louis.

Succession of Life in a Transitional Pond

A transitional pond is one which is dry during part of the year, but which, during periods of high water, is connected to a permanent pond or lake.

It is not the purpose of this section to give an exhaustive treatment of the succession of entomostracan life in ponds and lakes but, by discussing the succession of cladoceran and copepodan life in one transitional pond for two successive years, it is hoped to demonstrate the futility of drawing conclusions as to the nature of and the reasons for the succession of life in inland waters without spending years in accumulating accurate data.

In one of the parks of St. Louis there is a lagoon-like pond that is several hundred yards long. About three-fourths of its length from one end is a strait-like constriction, the portion of the pond beyond this constriction being at times of high water much shallower than the remainder. During dry weather this portion gradually dries up. This shallow arm is the transitional pond that is to be discussed. During the high waters of early spring large areas of grass are submerged which die after a certain length of time. From that time until the pond dries up there is no vegetation higher than algae in the water. The depth of the water varies from a few inches to two feet, with mud bottom. The pond is exposed to the sun during most of the day, the temperature of the water ranging as high as 35°C and the hydrogen ion content varying from PH 7.2 to PH 8.2. The record presented is for the spring and summer of 1920 and the spring and summer of 1921.

Spring and summer 1920.—April 4. Water high; much grass submerged; temperature 15°C.; *Simocephalus serrulatus* Koch and *Cyclops viridis* (Jurine) *var. insectus* Forbes present in moderate numbers.

May 5. Water high; grass growing in water; temperature 16°C.; *Simocephalus serrulatus* Koch the dominant form; *Cyclops viridis* (Jurine) var. *insectus* Forbes present in large numbers.

May 20. Water high; grass abundant; temperature 22°C.; *Simocephalus serrulatus* Koch the dominant form; *Cyclops viridis* (Jurine) var. *insectus* Forbes and *Bosmina longirostris* (O. F. Mueller) present in large numbers.

May 22. Water high; grass dying; temperature 29°C.; *Simocephalus serrulatus* Kock the dominant form, *Bosmina longirostris* (O. F. Mueller) abundant, *Cyclops viridis* (Jurine) var. *insectus* Forbes and *Daphnia pulex* (de Geer) present in small numbers.

June 20. Water becoming shallow; no grass in pond; pond teeming with animal life; *Daphnia pulex* (de Geer) now the dominant form, *Cyclops viridis* (Jurine) var. *insectus* Forbes, *Bosmina longirostris* (O. F. Mueller) and *Ceriodaphnia laticaudata* P. E. Mueller abundant, *Simocephalus serrulatus* Koch and *Oxyurella tenuicaudis* (Sars) present in small numbers.

July 20. Pond drying up rapidly; no vegetation in the water; temperature 35°C.; animal life very scare, a few specimens of *Cyclops viridis* (Jurine) var. *insectus* Forbes and of *Diaphanosoma brachyurum* (Lievin) found.

August 17. Pond nearly dry and entomostracan life has almost disappeared, a few specimens of *Cyclops serrulatus* Fischer found.

Spring and summer 1921.—April 2. Pond moderately high; no vegetation in water; temperature 19°C.; hydrogen ion content PH 7.9; *Cyclops albidus* Jurine the dominant form; *Cyclops viridis* Jurine var. *insectus* Forbes abundant.

April 16. Pond moderately high; temperature 19°C.; hydrogen ion content PH 7.0 (a heavy rain having fallen the previous night); *Cyclops viridis* (Jurine) var. *insectus* Forbes and *Cyclops serrulatus* Fischer abundant, neither dominant, *Cyclops albidus* Jurine has almost entirely disappeared.

April 23. Water high owing to heavy rains; temperature 17°C.; hydorgen ion content Ph 7.4; *Cyclops viridis* (Jurine) var. *insectus* Forbes dominant, *Cyclops serrulatus* Fischer abundant.

April 30. Conditions about the same as on April 23; *Cyclops viridis* (Jurine) var. *insectus* Forbes the dominant form, *Cyclops serrulatus* Fischer abundant, *Bosmina longirostris* (O. F. Mueller) present in small numbers.

May 11. Water at greatest height; grass growing in water; temperature 22°C.; hydrogen ion content PH 7.4; distribution of life about the same as on April 30, although *Bosmina longirostris* (O. F. Mueller) Sars may be more abundant.

May 20. Physical features about as on May 11; *Cyclops viridis* (Jurine) var. *insectus* Forbes dominant, *Bosmina longirostris* (O. F. Mueller) abundant, *Cyclops serrulatus* Fischer has disappeared.

June 1. Water falling; hydrogen ion content PH 8.2; *Cyclops viridis* (Jurine) var. *insectus* Forbes dominant, *Bosmina longirostris* (O. F. Mueller abundant, *Cyclops fimbriatus* Fischer, *Macrothrix laticornis* (Jurine) and *Scapholeberis mucronata* O. F. Mueller present in small numbers.

July 5. Water lower, otherwise physical conditions same as on June 1; *Cyclops viridis* (Jurine) var. *insectus* Forbes dominant and present in enormous numbers, *Moina brachiata* (Jurine) abundant; no other cladocerans nor copepodans.

July 19. Water quite low, otherwise physical conditions same as on July 5; no perceptable change in life conditions.

July 27. Pond quite shallow; hydrogen ion content PH 7.2; literally thick with entomostracan life confined to the two species *Cyclops viridis* (Jurine) var. *insectus* Forbes and *Moina brachiata* (Jurine), the former dominant, all other cladocerans and copepodans absent or so scarce as to escape detection among the myriads of the two species mentioned; the Moinas bearing summer eggs but the

Cyclops not active sexually; of the countless millions of females practically none bearing eggs. When one remembers how prolific these creatures usually are this pronounced sexual impotence furnishes food for thought.

August 12. Pond almost dry, communicating with the permanent pond by a very shallow neck of water; the hydrogen ion content PH 8.0; water almost void of cladoceran and copepodan life; repeated hauls of the dredge discover a few specimens of each of *Cyclops serrulatus* Fischer, *Cyclops viridis* (Jurine) var. *insectus* Forbes, *Moina brachiata* (Jurine), all bearing eggs or young.

Two weeks ago this pond was literally teeming with life, today it is almost void of life. The explanation is as follows: A succession of life appears in the pond. *Cyclops viridis* (Jurine) var. *insectus* Forbes gradually becomes the dominant form. One by one the species associated with it die out until only *Moina brachiata* (Jurine) survives. *Cyclops viridus* (Jurine) continues to multiply until it is present in numbers unbelievably large, but they are sexually impotent. In a few more days that immense population disappears almost entirely. What is the cause? The deaths during the early and intermediate stages of the season may have been due to the elimination of the vegetation, or to the rise in temperature, or to the fluctuations in the hydrogen ion content of the water, but none of these factors accounts for the catastrophic destruction of this *Cyclops* in the early part of August. True the pond contained living grass at the beginning of the history and no vegetation at the close, but *Cyclops viridis* (Jurine) is as much at home in water free from vegetation as it is in the midst of water plants. The pond was quite shallow at the time of the climax but this copepod flourishes in the shallowest ponds as well as in the deeper lakes. The temperature of the water varied from 19°C to 17° and up to 35° but this species of *Cyclops* thrives throughout that entire range. The hydrogen ion content of the water descends from PH 7.9 to PH 7.0 and then ascends to PH 8.2 but this entomostracan has been found breeding throughout that entire range. When the pond contained multitudes of these minute crustaceans it must have been highly charged with the products of organic decay but this water did not have a disagreeable odor and this creature has been found flourishing in fetid water. Has not the marvelous prolificacy of this species, co-operating with the rapid evaporation of the water, caused the population to outgrow its food supply and thus to induce a famine which caused universal sexual impotency followed by death? The few individuals of *Cyclops serrulatus* Fischer which were found in the pond soon after the catastrophe were dwarfs of their kind. This is in harmony with the above conclusion, for excessive reduction of the food supply means underfed naupli, and underfed naupli develop into undersize adults.

As stated above, these seasonal life histories are recorded for the purpose of showing that a study of the succession of life in ponds and marshes, for only one or two seasons, does not furnish sufficient data to warrant the formation of scientific conclusions concerning the succession of life in inland waters. These two records have certain things in common. When winter gives place to spring there is very little life in the pond. Species after species appears, each to remain for a longer or shorter period of time. Some cladoceran or copepod becomes the dominant form. The living individuals contiuously become more and more numerous until the history culminates in a catastrophic elimination of almost the entire population. This is about all the two years have in common. In April, 1920, the first forms to become conspicuous are *Simocephalus serrulatus* (Koch) and *Cyclops viridis* (Jurine), neither of which is dominant; in April, 1921, the first to appear are *Cyclops albidus* (Jurine) and *Cyclops viridis* (Jurine), the former of which is dominant. In 1920 *Simocephalus serrulatus* (Koch) becomes dominant in the early part of May and retains the dominancy until the latter part of June, when it is succeeded by *Daphnia pulex* (de Greer); in 1921 *Cyclops viridis* (Jurine) achieves the dominancy about the middle of April and retains it until the elimination, and neither *Simocephalus serrulatus* (Koch) nor *Daphnia pulex* (de Geer) appears in that pond during the season, altho they do exist in other ponds of the district. *Simocephalus serrulatus* (Koch), *Daphnia pulex* (de Geer), *Ceriodaphnia lacticaudata* P. E. Mueller, *Oxyurella tenuicaudis* (Sars) and *Diaphanosoma brachyurum* (Lievin) are present during a part of 1920 but none of these appear in 1921. *Cyclops albidus* (Jurine), *Cyclops fimbriatus* Fischer, *Scapholeberis mucronata* Birge and *Moina brachiata* (Jurine) are in evidence during a part of 1921 but were not encountered at all during 1920.* Surely such contradictory data do not warrant reliable generalizations.

Commensalism and Symbiosis.—In the small ponds and marshes, *Cyclops viridis* (Jurine) almost invariably forms a symbiotic union with certain one-celled green algae.

This same species often bears certain Vorticellidae (*Pyxedium* sp.? and *Vorticella* sp.?) as commensals.

On several occasions *Daphnia pulex* (de Geer) has been noticed bearing a certain species of *Brachionidae* as a commensal. The union was not permanent. The rotifer attached itself by its toes and was free to leave when it became necessary. Whenever I have attempted to secure photographs, the attached commensal has always escaped.

Moina brachiata (Jurine) occasionally bears certain Vorticellidae as commensals (Pl. 4, Fif. 3).

A certain species of Vorticellidae has been seen as a commensal on *Diaptimus pseudosanguineus,* sp. n. (Pl. 2, Fig. 1e.)

*These forms may not have been entirely absent from the pond but, if they were present, they were so rare as to escape detection.

Commensal Vorticellidae (*Pyxedium* sp., etc.) have been discovered on *Scapholeberis mucronata* Birge.

Explanations of Tables.

The following tables epitomize the results of field observations. In the tables on seasonal distribution certain months are omitted, those being months in which no field work was done.

The tables on seasonal distribution, those on distribution according to temperature, and those on distribution according to habitat epitomize the work of four collecting seasons; the table giving the distribution according to the hydrogen ion content of the water is the result of only one year's work.

The centigrade scale is used for temperature; the hydrogen ion content is expressed in PH values.

The tables record the results of field observations, and contain neither inductions nor deductions.

Distribution of St. Louis Copepoda From April 1909 To June 1910

	1909							1910		
	Apr.	May	June	Aug.	Sept.	Oct.	Nov.	Apr.	May	June
1. Cyclops albidus	p	p	..	..	..	..	..	..	..	..
2. Cyclops bicuspidatus	..	p	..	..	..	p	..	..	..	..
3. Cyclops fusca	..	p	..	..	..	..	..	..	..	..
4. Cyclops phaleratus	..	..	p	..	..	..	..	..	..	..
5. Cyclops serrulatus	p	..	p	..	..	..	..	..	p	..
6. Cyclops viridis insecta	p	p	p	p	..	p	..	p	..	..
7. Diaptomus pallidus	..	..	p	..	..	..	..	..	p	..
8. Diaptomus sanguineus	..	..	..	..	p	..	..	..	..	..
9. Diaptomus sicilis	p	..	..	..	..	..	..	..	..	..

DISTRIBUTION OF ST. LOUIS CLADOCERA FROM MARCH 1909 TO JUNE 1910

	1909							1910		
	March	April	May	June	August	October	November	April	May	June
1. Alonaceostata							p			
2. Bosmina longirostris							p			
3. Ceriodaphnia laticaudata										p
4. Ceriodaphnia reticulata	p						p			
5. Chydorus sphaericus						p	p			
6. Daphnia longiremus		p				p				
7. Daphnia pulex		p								
8. Leydigia acanthocercoides										p
9. Leydigia quadrangularis								p		
10. Moina brachiata					p					
11. Moina rectirostris					p					
12. Pleuroxus denticulatus			p	p			p			
13. Pleuroxus hamulatus			p	p						
14. Pseudosida bidentata										p
15. Scapholeberis mucronata		p		p		p			p	
16. Simocephalus serrulatus	p		p	p	p	p	p	p	p	p

Distribution of St. Louis Cladocera From April 1920 To August 1921

	1920					1921				
	April	May	June	July	August	April	May	June	July	August
1. Alona rectangularis							p			
2. Bosmina longirostris		p	p			p	p	p	p	p
3. Ceriodaphnia lacustris							p			
4. Ceriodaphnia laticaudata			p	p						
5. Ceriodaphnia rigaudi									p	p
6. Chydorus sphaericus				p	p		p			
7. Daphnia longiremis hyalina		p								
8. Daphnia longiremis longispina							p	p		
9. Daphnia pulex		p	p			p	p	p	p	
10. Daphnia retrocurva		p	p				p			
11. Diaphanosoma brachyurum				p						
12. Diaphanosoma leuchtenbergianum			p							
13. Kurzia latissima				p						
14. Leydigia quadrangularis										p
15. Latonopsis occidentalis			p							
16. Macrothrix laticornis					p	p	p			
17. Moina brachiata				p					p	p
18. Moina rectirostris			p				p			
19. Oxyurella tenuicaudis			p							
20. Pleuroxus denticulatus			p	p			p			
21. Pleuroxus hamulatus			p							p
22. Scapholeberis mucronata		p	p				p	p		
23. Simocephalus serrulatus	p	p	p	p						

Distribution of St. Louis Copepoda From April 1920 To August 1921

	1920					1921				
	April	May	June	July	August	April	May	June	July	August
1. Cyclops albidus	p	p	p			p			p	
2. Cyclops bicuspidatus						p				
3. Cyclops fimbriatus								p		
6. Cyclops fusca							p			
7. Cyclops leuckarti								p		p
8. Cyclops phaleratus							p			
9. Cyclops serrulatus	p	p	p	p	p	p	p	p		p
10. Cyclops viridis insectus	p	p	p	p	p	p	p	p	p	p
11. Diaptomus ashlandi		p	p				p	p		
12. Diaptomus oregonensis			p				p		p	
13. Diaptomus pallidus			p							
14. Diaptomus pseudosanguineus										p
15. Diaptomus stagnalis			p							

Temperature Distribution of St. Louis Cladocera

	5°-9°	10°-14°	15°-19°	20°-24°	25°-29°	30°-35°
1. Alona costata	....	....	p	....	....	....
2. Alona rectangularis	....	....	....	....	p	....
3. Bosmina longirostris	....	....	....	p	p	....
4. Ceriodaphnia lacuustris	....	....	....	p	....	....
5. Ceriodaphnia laticaudata	....	....	....	p	....	....
6. Ceriodaphnia reticulata	....	....	p	....	....	....
7. Ceriodaphnia rigaudi	....	....	....	....	p	....
8. Chydorus sphaericus	....	....	p	....	....	p
9. Daphnia longiremis hyalina	....	....	p	....	....	....
10. Daphnia longiremis longispina	....	....	....	....	p	....
11. Daphnia pulex	....	p	p	p	p	p
12. Daphnia retrocurva	....	....	....	p	....	p
13. Diaphanosoma brachyurum	....	....	....	....	....	p
14. Diaphanosoma leuchtenbergianum	....	....	....	....	....	p
15. Kurzia latissima	....	....	....	....	....	p
16. Leydigia acanthoceroides	....	....	....	....	....	p
17. Leydigia quadrangularis	....	....	....	....	....	p
18. Macrothrix laticornis	....	....	p	....	....	p
19. Moina brachiata	....	....	....	p	p	p
20. Moina rectirostris	....	....	....	p	....	p
21. Oxyurella tenuicaudis	....	....	....	p	....	....
22. Pleuroxus denticulatus	....	p	p	....	....	p
23. Pleuroxus hamulatus	....	p	....	....	....	p
24. Pseudosida bidentata	....	....	....	p	....	....
25. Scapholeberis mucronata	....	p	....	....	....	p
26. Simocephalus serrulatus	....	p	p	p	p	p

Temperature Distribution of St. Louis Copepoda

	5°-9°	10°-14°	15°-19°	20°-24°	25°-29°	30°-35°
1. Cyclops albidus	....	p	p	p	....	....
2. Cyclops bicuspidatus	....	....	p	....	....	....
3. Cyclops fusca	....	....	....	p	....	....
4. Cyclops leuckarti	....	....	....	p	p	p
5. Cyclops phaleratus	....	....	....	....	p	p
6. Cyclops serrulatus	....	p	p	p	p	p
7. Cyclops viridis insectus	p	p	p	p	p	?p
8. Diaptomus ashlandi	....	....	p	p	....	p
9. Diaptomus oregonensis	....	....	p	p	....	p
10. Diaptomus pallidus	....	....	....	p	....	....
11. Diaptomus pseudosanguineus	....	....	....	....	p	....
12. Diaptomus sanguineus	....	....	p	p	....	....
13. Diaptomus sicilis	....	p	....	....	....	....
14. Diaptomus stagnalis	....	....	....	p	p	....

Distribution of St. Louis Copepoda and Cladoera According to the Hydrogen ion Content of the Water

CLADOCERA	7.0	7.2	7.4	7.6	7.8	8.0	8.2
1. Alona rectangularis	....	....	....	....	....	....	p
2. Bosmina longirostris	....	....	....	....	p	....	p
3. Ceriodaphnia lacustris	....	....	....	....	....	....	p
4. Ceriodaphnia rigaudi	....	....	....	....	p	....	....
5. Chydorus sphaericus	....	....	....	....	....	....	p
6. Daphnia longiremis hyalina	....	....	....	....	....	....	p
7. Daphnia longiremis longispina	....	....	....	....	....	....	p
8. Daphnia pulex	....	p	....	p	....	....	....
9. Daphnia retrocurva	....	....	....	....	....	p	....
10. Leydigia quadrangularis	....	....	p	....	....	....	....
11. Macrothrix laticornis	....	p	....	....	....	....	p
12. Moina brachiata	....	....	....	....	p	p	....
13. Moina rectirostris	p	....	....	....	....	....	....
14. Pleuroxus denticulatus	....	....	....	....	....	....	p
15. Pleuroxus hamulatus	....	....	p	....	....	....	p
16. Scapholeberis mucronata	....	....	....	....	....	p	p
COPEPODA							
1. Cyclops albidus	....	p	....	....	....	p	....
2. Cyclops bicuspidatus	....	p	....	....	....	....	....
3. Cyclops fimbriatus	....	....	....	....	....	....	p
4. Cyclops leuckarti	....	....	....	....	p	....	....
5. Cyclops serrulatus	p	p	p	....	....	p	p
6. Cyclops viridis insectus	p	p	p	p	p	p	p
7. Diaptomus ashlandi	....	....	....	....	....	p	....
8. Diaptomus oregonensis	....	....	....	p	....	....	....
9. Diaptomus pseudosanguineus	....	....	....	....	p	....	....

HABITAT DISTRIBUTION OF ST. LOUIS CLADOCERA

	Ditch	Marsh	Tem. Pond	Tran. Pond	N. O. Pond		O. Pond		Lake	
					Veg.	Open	Veg.	Open	Veg.	Open
1. Alona costata					p					
2. Alona rectangularis		p				p				
3. Bosmina longirostris		p		p	p	p				
4. Ceriodaphnia lacustris						p				
5. Ceriodaphnia laticaudata						p				
6. Ceriodaphnia pulchella									p	
7. Ceriodaphnia reticulata					p				p	
8. Ceriodaphnia rigaudi		p			p					
9. Chydorus sphaericus		p			p	p			p	
10. Daphnia longiremis hyalina						p				
11. Daphnia longiremis longispina			p			p		p		p
12. Daphnia pulex		p	p	p		p		p		
13. Daphnia retrocurva										p
14. Diaphanosoma brachuyrum			p	p		p				
15. Diaphanosoma leuchtenbergianum			p			p				
16. Kurzia latissima									p	
17. Latonopsis occidentalis						p				
18. Leydigia acanthoceroides					p	p				
19. Leydigia quadrangularis					p	p				
20. Macrothrix laticornis		p		p	p	p			p	
21. Moina brachiata	p	p	p	p		p				
22. Moina rectirostris	p		p			p				
23. Oxyurella tenuicaudis				p		p				
24. Pleuroxus denticulatus		p			p	p			p	
25. Pleuroxus hamulatus					p	p				
26. Pseudosida bidentata		p								
27. Scapholeberis mucronata		p		p	p	p	p		p	
28. Simocephalus serrulatus		p	p	p	p	p			p	

Habitat Distribution of St. Louis Copepoda

	Ditch	Marsh	Tem. Pond	Tran. Pond	N. O Pond		O. Pond		Lake	
					Veg.	Open	Veg.	Open	Veg.	Open
1. Cyclops albidus	..	p	p	..	p	p	..	..	..	p
2. Cyclops bicuspidatus	..	..	..	..	..	p	..	..	..	..
3. Cyclops fimbriatus	..	..	..	p	..	p	..	..	..	..
4. Cyclops fusca	..	..	..	..	p	..	..	..	..	..
5. Cyclops fimbriatus	..	..	..	p	..	p	..	..	..	..
6. Cyclops phaleratus	..	p	..	..	..	p	..	..	..	..
7. Cyclops leuckarti	..	p	..	..	..	p	..	..	..	..
8. Cyclops serrulatus	p	p	p	p	..	p	p	..	p	p
9. Cyclops viridis insectus	..	p	p	p	p	p	..	p	..	p
10. Diaptomus ashlandi	..	p	..	p	..	p	..	..	..	p
11. Diaptomus oregonensis	..	..	p	..	p	..	..	..	..	..
12. Diaptomus pallidus	..	p	..	..	..	p	p	..	..	..
13. Diaptomus pseudosanguineus	..	p	..	..	..	..	..	..	..	..
14. Diaptomus sanguineus	..	..	p	..	..	p	..	..	..	..
15. Diaptomus sicilis	..	..	..	..	..	..	..	..	..	p
16. Diaptomus stagnalis	..	..	p	..	..	p	..	..	..	..

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Explanation of Plates

PLATE I.

Fig. 1. *Diaptomus pseudosanguineous*, sp. nov., ventral view of female; c, tubercles on the distal margin of the thorax; d, strong curved spine on the lateroventral portion of the first segment of the abdomen.

Fig. 2. *Diaptomus pseudosanguineous*, sp. nov., lateral view of male.

Fig. 3 Lateral view of the female; j, spermatophore.

Fig. 4. Antenna of the female.

PLATE II.

Fig. 1. Lateral view of female illustrating a case of commensalism between this form and certain Vorticellidae; e, one of the commensal Vorticellidae. By examining that portion of the illustration labeled e with a magnifying glass the protozoan will be distinct. The use of the glass will also reveal retracted Vorticellidae among the eggs.

Fig. 2. Caudal extremity of the thorax and the first abdominal somite of a female (lateral view); f, stout curved spine; g, spermatophore.

Fig. 3. Antipenultimate segment of the male right antenna; h, terminal claw; i, hyaline flange.

PLATE III.

Fig. 1. Fifth foot of the male; a, endopodite of the left fifth foot.

Fig. 2. Antennae of the male.

Fig. 3. Pair in copulo.

Fig. 4. Enlarged view showing the tubercles on the caudal margin of the thorax; b, the tubercles.

Fig. 5. Fifth foot of the female. The terminal setae moved reflexly, while the photo was being taken, thus causing the appendage to appear to have several terminal setae. There are only two long setae at that place.

PLATE IV.

Fig. 1. *Ceriodaphnia rigaudi*, shell markings.

Fig. 2. *Ceriodaphnia rigaudi*, Female. b, antennae c, beak-like projection from head.

Fig. 3. *Moina brachiata*, female, showing commensalism; a, Vorticellidae.

Fig. 4. *Pleuroxus hamulatus*.

Fig. 5. *Ceriodaphnia laticaudata*.

Fig. 6. *Ceriodaphnia rigaudi*, female, showing the escape of a young specimen from the brood sac. By turning the page sidewise the details of this photo become more distinct.

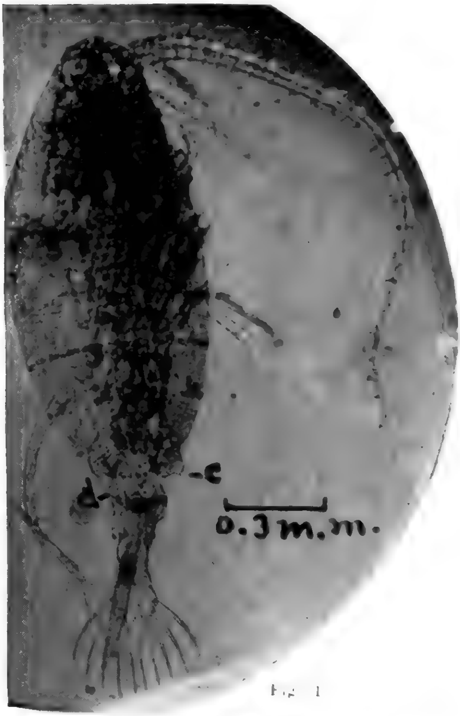


Fig. 1

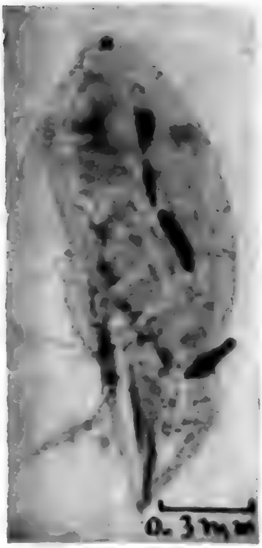


Fig. 2

Fig. 3

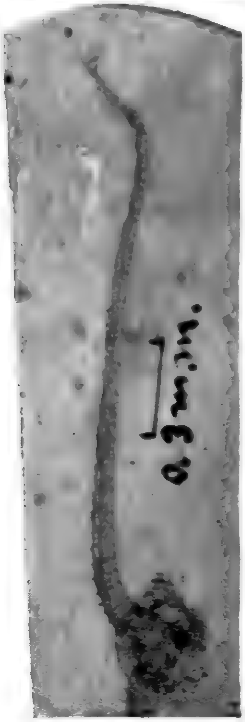


Fig. 4

Fig. 1

Fig. 2

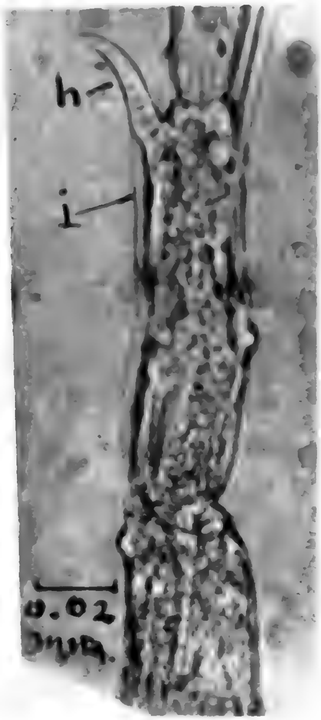


Fig. 3

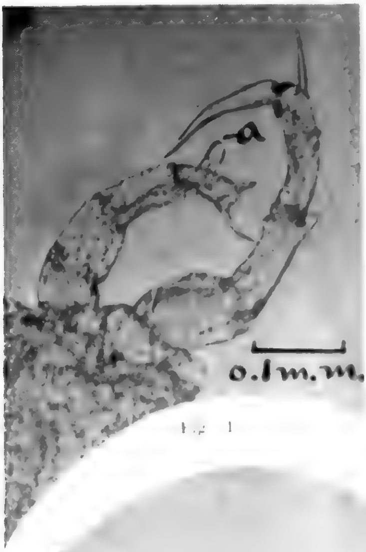


Fig. 1

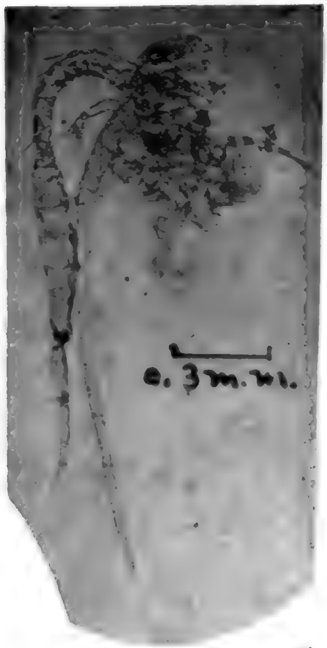


Fig. 2

Fig. 3

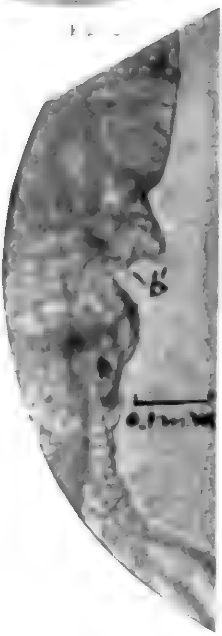


Fig. 4

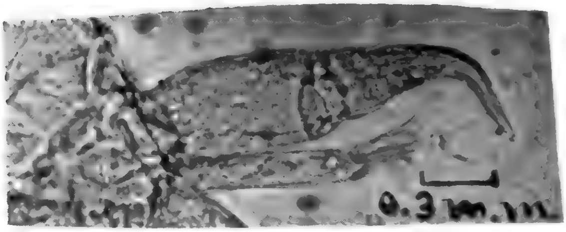


Fig. 5

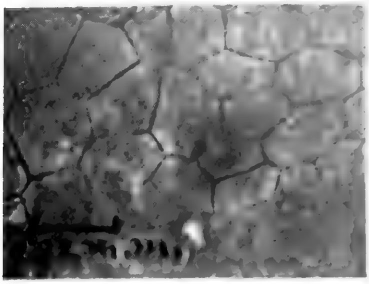
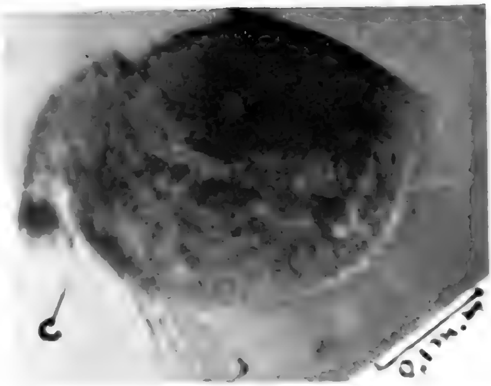
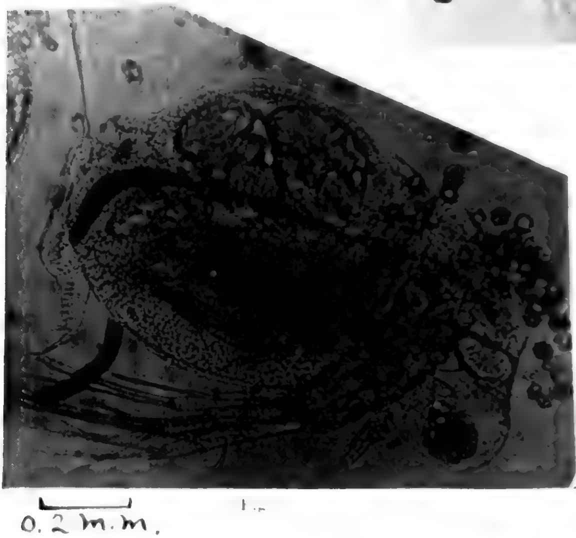
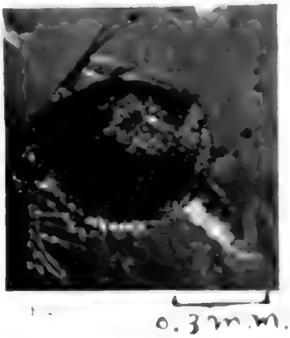


Fig. 1







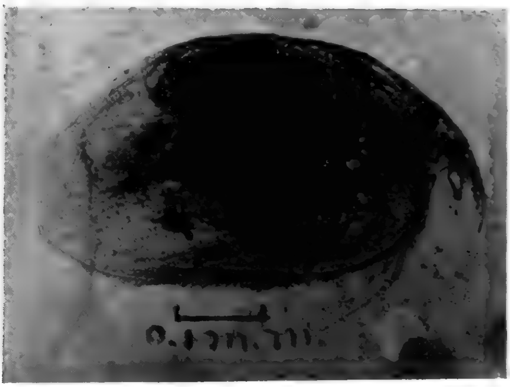
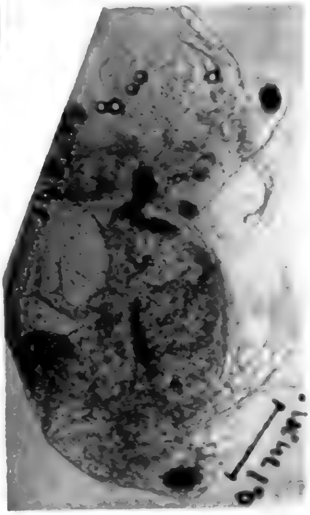


Fig. 4



BUFO FOWLERI PUTNAM IN MISSOURI

C. H. Danforth

At a meeting of the Boston Society of Natural History on August 2, 1843, Dr. Andrew Nichols exhibited a toad which had been captured by S. P. Fowler, Esq., of Danvers, Massachusetts, immediately after it had uttered its strange call. In a letter accompanying the specimen Dr. Nichols stated that he had long been familiar with the call of this toad, and from his account, which is summarized in the report of the meeting, there can be little doubt that the specimen was a representative of the form which has subsequently come to be known as *Bufo fowleri*. The short paragraph in which the incident is recorded[1] is probably the earliest reference to an individual of the species to be found anywhere in the literature. However, Dr. D. H. Storer, who was present at the meeting pronounced the specimen to be "the *Bufo lentiginosus*[2] of Shaw" and the species seems to have received no further notice from the Society for nearly forty years.

But Mr. Fowler apparently was not satisfied with the identification and continued his observations through many seasons, finally sending a collection of specimens and field notes to Professor F. W. Putnam who described the species, in manuscript, conferring upon it the name *fowleri* in honor of its first collector. Putnam apparently never published his description, but in 1875 Cope[3] listed "*Bufo lentiginosus fowleri*" and in 1882, Mary H. Hinkley[4] described the tadpoles of *Bufo americanus* Le Conte

1. Proc. Boston Soc. Nat. Hist., vol. 1, p. 136, 1844.
2. It may be recalled that the northern form, *B. americanus* Le Conte, was not recognized as different from the southern *B. lentiginosus* Shaw until some years later than this.
3. Checklist of North American Batrachians and Reptiles. Bull. U. S. Nat. Museum, No. 1, 1875. (Page 29)
4. Proc. Boston Soc. Nat. Hist., vol. 21.

and *Bufo fowleri* Putnam. In his "Batrachia of North America," published in 1889, Cope[5] gave considerable space to *Bufo lentiginosus fowleri*. In this publication he stated (page 279) that it "is so far known only as a native of a few ponds in northeastern Massachusetts near the town of Danvers," and further commented that "such a limited distribution of a land vertebrate is remarkable, as is also the fact of its having so long remained without an introduction to science."

Since the publication of Cope's checklist the range, or better the *recognition*, of *Bufo fowleri* has been considerably extended. Up to 1906 we find "*Bufo fowleri* reported only from Massachusetts, Rhode Island, and New York near the coast."[6]

About 1907 Miss Dickerson identified it as the most common form about Washington, D. C.,[7] and a year later Allard recorded it as abundant in northern Georgia[8]. In 1910 Miller and Chapin[9] reported it to be the only toad in southern and eastern New Jersey and on Staten Island, and also recorded its presence in the mountainous part of New York. Finally, in the summer of 1916, Dunn[10] found the species common in the mountains of North Carolina but not ascending to an elevation of more than 2700 feet.

It will be apparent from this brief review that by 1917 abundant evidence had accumulated to show that the range of *Bufo fowleri* includes a region reaching from southern New Hampshire to northern Georgia and extending westward at least as far as the Appalachian Mountains. It is interesting to find now that the range

5. Bull. U. S. Nat. Museum, No. 34.
6. Mary C. Dickerson: The Frog Book, 1906.
7. According to H. A. Allard: Science N. S. vol. XXVI, pp. 383-384, 1907.
8. H. A. Allard: *Bufo Fowleri* (Putnam) in Northern Georgia. Science, N. S. XXVIII, pp. 655-656, 1908.
9. W. De W. Miller and James Chapin: The Toads of the Northeastern United States. Science, N. S. vol. XXXII, pp. 315-316, 1910.
10. Emmett R. Dunn: Bull. Amer. Museum of Natural History, October 13, 1917.

is not limited by the mountains but continues far beyond them, reaching, in at least this one locality, the west side of the Mississippi.

The writer first found *Bufo fowleri* in St. Louis during May, 1920, when large numbers of these toads were heard singing in Forest Park. He had earlier had abundant opportunity in Maine and Massachusetts to become familiar with the habits and calls of typical *Bufo americanus* and *Bufo fowleri* but had not previously been aware of the latter species in Missouri. This is probably because no collection of toads had been made and also because of the din of automobiles in the St. Louis parks on warm evenings, the only time when *Bufo fowleri* calls. As soon as the notes were recognized a number of specimens were captured and found to be typical examples of *Bufo fowleri*. One of them was sent to the Agassiz Museum where it was submitted to Mr. Emmett Dunn, who verified the identification.

Since Hurter[11] mentions only *Bufo americanus*, the question arises as to whether he had never collected *Bufo fowleri* or had failed to differentiate it. Consequently a letter of inquiry was addressed to the National Museum, where the Hurter collection is deposited. In reply Dr. Stejneger stated that he had had the Missouri specimens examined and found that out of a total of thirty-five, thirty-three were *Bufo americanus*, but that one, #15871, had most of the characters of a typical *Bufo fowleri* while another, #57495, was intermediate. The latter specimens were both collected by Mr. Hurter at St. Louis. These data would seem to indicate that the species is confined in Missouri to the region of St. Louis, but since they also show that Mr. Hurter was not on the lookout for *Bufo fowleri*, the possibility remains that it may be more or less widely distributed in the state.

Since the literature relating to *Bufo fowleri* is

11. Julius Hurter, Sr.: Herpetology of Missouri. Transactions of the Academy of Science of St. Louis, vol. 10, No. 5, 1911.

rather scattered it may be worth while to review some of the outstanding characteristics of the species, contrasting it with *Bufo americanus.* It should be borne in mind that both species are quite variable and that almost any morphological characteristic of the one may occasionally be met in the other. There seems to be no definite evidence, however, that the two species hybridize or intergrade in the strictest sense.

Size. *Bufo fowleri* is of medium size, with very little difference between the sexes. A typical mated pair, from Forest Park, St. Louis, which produced a large number of fertile eggs when placed in an aquarium were measured from the tip of the snout to the tip of the urostyle. The length of the male was found to be 65 mm., that of the female 68 mm. *Bufo americanus* on the other hand is larger and shows a very marked difference in the size of the two sexes. A male selected as typical of a considerable collection of specimens from Norway, Maine (which appears to be beyond the northern limit of *Bufo fowleri*), had a length of 66 mm., while a female from the same source and selected in the same way measured 90 mm. in length. The weight of the female was more than twice that of the male. The contrast in size between the adult females of the two species is indicated in the accompany sketches which are drawn to scale.

Surface Anatomy. *Shape of the head.*—Viewed from above, the head of *B. fowleri* (fig. 3) appears rather narrow and pointed in front. The eyes generally form part of the outline. In *B. americanus* (fig 1) the head is very broad and slightly more rounded in front. The eyes, especially in adult females, do not enter into the outline of the head when seen in this position (Dunn). In profile (as pointed out by Deckert) the appearance of the two species is very different (figs. 2 and 4). The head of *B. fowleri* is short and thick with a very blunt snout, that of *B. americanus* is longer, not so thick, and with a tapering snout. This difference is quite as marked in males as in females.

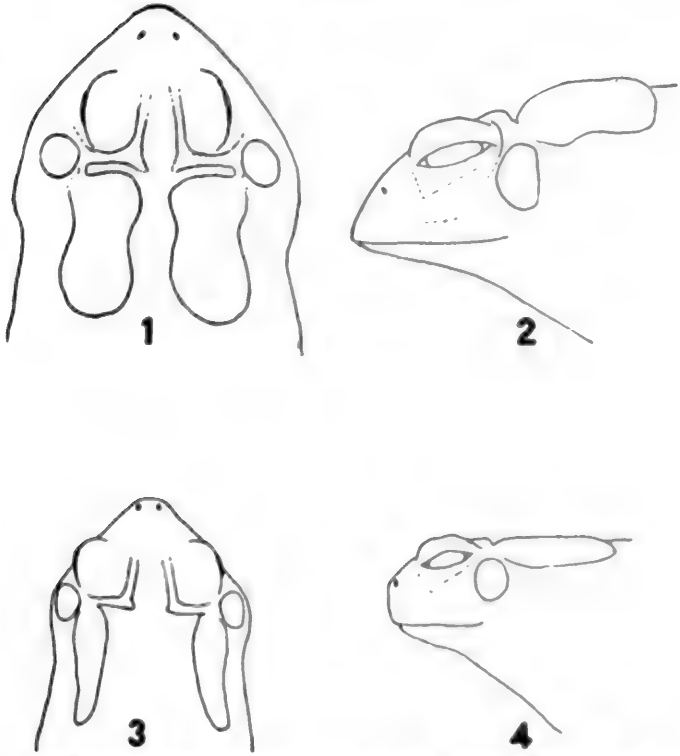


Fig. 1. Outline sketch of the head of an adult female *Bufo americanus* from Norway, Maine.
Fig. 2. Side view of the same specimen.
Figs. 3 and 4. Similar views of an adult female *Bufo fowleri* from St. Louis, Missouri.
These figures are all drawn to the same scale (approximately ×½).
The specimens from which the sketches were made, together with living specimens of both species, collected in the immediate vicinity, were exhibited at a meeting of the Academy on May 7, 1921.

Bony crests.—In *B. fowleri* the frontal crests are rather small and either slightly divergent behind or, more often, parallel, and even fused in the mid-line (Dickerson, Deckert[12]). In *B. americanus* the crests are more robust and often parallel, but not fused. In both species there is almost always a short medially or posteriorly directed prolongation of this crest beyond its union with the post ocular ridge which runs in a trans-

12. Deckert, Richard: Do the Fowler's Toad and the American Toad Interbreed? Science, N. S. vol. XLV. pp. 113-114, 1917.

verse direction (Figs. 1 and 3). In *B. americanus* the well developed postocular ridge ends laterally in a bifurcation, one branch running forward and downward between the eye and the tympanic membrane, the other, short but distinct, extending back to the parotid body. In *B. fowleri* the postocular ridge is less pronounced and the posterior prolongation is lacking.

Parotid bodies.—In *B. fowleri* the parotid bodies (fig. 3) are rather narrow elongated ovals adnate in front, at least laterally, to the postocular ridges. In *B. americanus* (fig. 1) they are short, generally more or less reniform in outline, and free from the postocular ridge proper, being united only to a prolongation from it.

Warts.—The warts of *B. fowleri* are relatively small and with only feeble spines or none at all, those of *B. americanus* are much larger and often tipped with strong spines. When comparing the males which are of about the same size in the two species the difference in the warts is very noticeable, but in the absence of representatives of both species it would often be difficult to identify a specimen on the basis of warts alone. In *B. fowleri* the under parts are finely granular, in *B. americanus* they are coarsely granular or even spiny.

Other structural characters.—*B. fowleri* is in general appearance more frog-like with a closer fitting skin and smaller, more slender feet than *B. americanus.* It is a "much more trim, dapper, active little fellow than its relative." (Allard.)

Color. Most specimens of *B. fowleri* show a grayish background with some greenish tints; only rarely is there a reddish brown cast. In *B. americanus* the background is most often more or less reddish. In *B. fowleri* the ground color may change from a light greenish gray to almost black in the course of a few hours. The dark dorsal spots are said (Dickerson) to be more constant in *B. fowleri* than in *B. americanus,* there usually being six pairs in the former. A mid dorsal longitudinal gray stripe is more distinct and more constant in *B. fowleri* than in *B. americanus.* The under parts of the former are generally unspotted, those of the latter usually are spotted.

Breeding Habits. *B. americanus* breeds relatively early, *B. fowleri* relatively late, the breeding season of the former having passed as a rule some time before that of the latter begins. The data for St. Louis are inadequate, but apparently during the past two years *B. americanus* has left the breeding sites before the middle of April, while in 1921 a careful watch for B. *fowleri* did not result in finding any specimens till April 23 and no active breeding until May. At St. Louis the breeding season extends into June. The egg strings of *B. fowleri* have the eggs arranged in several rows while those of *B. americanus* are in a single row.

The Call. The call, or song, of the two species is very different and when both have been heard they are not likely ever to be confused. The song of *B. fowleri* is a harsh unmusical call with a peculiar initial inflection —an "unmistakable, weird, wailing, scream" (Allard). "There is no sound in bog, pond, fen, forest or air, at all like it" (Nichols). The average duration of the call both at St. Louis and in Massachusetts is slightly over two seconds, rarely three seconds. The song of *B. americanus* on the other hand is a prolonged, uninflected trill of a rather pleasant droning quality. Its duration may be for as much as 30 seconds. It is heard only early in the season and may be uttered in relatively cold water. *B. fowleri* calls only when the temperature is comparatively high.

It is of interest to note that between these two species, which in some respects are very similar, characters that might be called fundamentally psychological—e.g. habits, notes,—are among the most distinctively differential. The writer has been impressed with a somewhat similar phenomenon among birds, where local differences in song or call notes are far more apparent than any physical differences. Perhaps the systematic value of these characters, and their evolutionary importance has been underestimated.

The range of *Bufo fowerli* is very likely more extended than recorded data would indicate. Since it has been found in the Carolinas and Georgia, and now in Missouri, it is probable that it occurs in the intermediate territory. In his "Notes on Illinois Reptiles and Amphibia" Garman[13] stated that *Bufo americanus* is the common form in Illinois, but described a call which he suggested might be that of *B. lentiginosus*. His description, however, fits the call of *B. fowleri,* and it would seem not improbable that this was the species which he really heard. Cope[14] remarked in 1889 that "a specimen of the var. *Americanus* from Nebraska approximates sufficiently close to the last specimen (*Fowleri*) to indicate that the *Fowleri* can not be regarded as under all circumstances separate, or be accorded full specific rank." When it is recalled that at the time this was written Cope believed *B. fowleri* to be confined to northeastern Massachusetts, it seems not improbable that he was misled in his diagnosis, and that his Nebraska specimen really was *B. fowleri*. In any event it is clear that much remains to be done before the exact range of this species can be stated with any certainty.

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13. Garman, H.: Bull. Ill. State Lab. of Nat. Hist., 1891, pp. 185-190.
14. Loc. Cit., p. 279.

CANCER, ITS COURSE AND ITS CAUSES

By

LEO LOEB

Cancer is a disease which differs very markedly in its character from all other diseases. It is common to man and to higher animals and in a few cases something analogous to it has been found also in invertebrates. In general, the character of the disease and its course are the same, wherever it appears, and in order to bring out this distinct character we are led to compare it with certain infectious diseases such as tuberculosis and diphtheria.

In tuberculosis a microscopic organism, the tubercle bacillus, enters the body usually through the respiratory tract or through the intestines. Wherever a few tubercle bacilli settle, they set up a certain reaction on the part of the host tissue. The cells nearest to the invaders undergo peculiar changes and a certain kind of leucocytes surround them with a wall. Sometimes a connective tissue capsule forms around it all and then the bacilli may become secluded, incarcerated so to speak, and innocuous temporarily or forever. Frequently, however, the tubercle bacilli multiply and produce poisons which kill the tissue around them; they spread in the neighboring tissue; they soften the tissue locally through killing it and may thus break into lymph and blood vessels and are carried to distant parts where they set up similar processes. They produce substances which are toxic and which disturb the general condition of the invaded organism, and the latter usually responds with the production of antagonistic substances which counteract to a certain extent the toxic substances of the bacteria and thus may cause either a certain degree of immunity against the bacillus and its products, or, on the contrary, hypersusceptibility. Such immunity reactions on the part of the host are quite common in bacterial infectious diseases. They may lead to the neutralization of the toxin produced as, for instance, in diphtheria, or they may be directed mainly against the invading organism as such, as for instance, in vaccinia, which is a very much mitigated, quite innocuous variety of smallpox.

If we compare with this process the changes which take place in cancer, we find a notable difference. In cancer certain constituents of the body and its component tissues, namely, the microscopic cells, multiply abnormally and invade the surrounding tissue; they penetrate farther and farther. They not only multiply, but very often actually move, migrate and push into the lymph channels and blood vessels. Once this is accomplished they are carried away by the blood or lymph stream to various parts of the body and there set up similar new growths by again multiplying and migrating into the neighboring tissue. These secondary growths are called metastases. They are composed of the same kind of cells which originally began to grow.

Usually cancer begins as a sharply localized growth and the multiplication and migration of cells is limited to one kind of cells. Any kind of tissue may thus become overactive, cancerous. It may be certain parts of the skin, mammary gland, stomach, tongue, cheek, intestine, liver, uterus. If it starts in the skin, skin-like formations are produced in excess, and in the most varied parts of the body where they do not occur normally. When the cancer starts in the mammary gland, breast tissue grows in excess and is found in internal organs as metastases. So it is with the stomach. In cancer of the stomach irregular stomach tissue may be found in the stomach itself, but a few cells may be carried to the liver and elsewhere and start the growth of stomach tissue there. In the ovary and testes, and occasionally elsewhere, not only single tissue may be found to grow, but through the simultaneous growth of various tissues very complex structures can develop which resemble disorganized embryos. And parts of this abnormal formation may again become invasive and set up secondary growths in other parts of the body.

We see then that in cancer parts of our body become overactive and grow and move in a somewhat hasty, disorganized way. This excessive growth of parts of our body is the essential disease, not, as in tuberculosis, the destruction and cell death caused by the toxins of bacteria.

In cancer no immunity is produced in the diseased organism such as is found in varying degrees in infectious diseases, because the essential invader and product of the disease is part of ourselves, our own body. Now, an organism defends itself only against something strange, which carries a chemical element into its economy quite different from that to which it is accustomed. A defense can therefore be set up against the strange bacteria and thus immunity develops; but no such chemical reaction occurs against the own cells of the body which are very familiar to all the surrounding cells and do not carry anything essentially new into the host. They produce nevertheless certain alterations in the metabolism of the body and may thus cause a certain loss of weight and other changes. But these are inconstant and of relatively minor importance. The injurious effect of cancer is essentially of a mechanical and locally destructive character. The cancer cells destroy important and necessary organs, or they interfere with their function; they may open the blood vessels and cause bleeding; they may break through the surface of the body and may give rise to putrefaction. However, there are great differences in the activity of different cancers. Some are relatively inert and may exist for many years without doing serious harm; but the majority of cancers are quite active and destructive in a relatively short time.

It is possible to remove cancer cells which develop in an animal from the original host and transplant them into other individuals of the same species. We may repeat reinoculation indefinitely, carrying the cells from animal to animal. This has been done in mice and rats. A swelling develops, which ordinarily is not painful, but merely weakens the animals. Now such transplanted cells, which grow in an individual, different from that in which they originated, are strange to the new organism, and thus defense processes may be set up and a certain immunity be produced against these grafted cancers. But this is an immunity against body cells of a strange individual and not an immunity against a microorganism, such as we find it in infectious diseases.

Cancer is then an abnormal growth process. It repeats in an exaggerated and irregular and endless way what may take place normally in a regular and self-limited manner during the embryonic development or in the repair of wounds in various organs, or after the grafting of tissues to different places. Under all those conditions we find an increased cell multiplication and we may even find an invasive growth. But under normal conditions all this is limited and comes to an end as soon as a certain stage in the process has been reached. It may, however, occur that processes of a typical embryonic development, or wound healing, which is kept up over a long period of time, change into the endless, continuous excess growth of cancer. We shall refer to that again later.

What are the causes of this excessive multiplication and invasiveness of a limited number of well defined cells of our body which in the end succeed in destroying themselves? As late as ten years ago the majority of physicians would probably have answered this question by stating that the causes of cancer are unknown to us; that the causes of tuberculosis and other infectious diseases, on the other hand, have been fully determined.

To-day it would come nearer the truth if we would acknowledge that while the external cause of tuberculosis is known, much has still to be learned about the cause of tuberculosis. That the external factor does not constitute the only cause of tuberculosis; that many individuals are equally exposed to or perhaps even invaded by the tubercle bacillus, but that the result differs very much in different cases. What part does the character and constitution of the exposed or invaded organism play in this infection? Does heredity play any part? Is the shape of the thorax, the condition of the lymphatic apparatus, of the circulatory organs of importance in determining the character of this disease? Does it assume an especially virulent course in certain populations, because they lack an acquired or perhaps inherited immunity? How does the toxin of the tubercle bacillus produce its specific effect on the organism? There are, then, multiple causes of tuberculosis and the analysis of the inner causes of tuberculosis still remains a large field for further investigation. In the case of cancer, conditions are somewhat analogous. We can speak very definitely about some of the principal causes of cancer, but as in the case of tuberculosis certain aspects of the problem need still further investigation.

In general, the causes of cancer in animals and man are the same. In many respects, however, animal cancer lends itself much more readily to an analysis than human cancer. One of the most completely analysed kinds of cancer is that of mice. The common variety in mice is cancer of the breast in female individuals. Mammary cancer in mice is essentially caused by two factors: 1) a disposition to cancer which is inherited in certain families and strains, and 2) a chemical stimulus which emanates from the ovary and causes the disposition inherent in the mammary gland in certain families to assert itself; thus cancer develops. The hereditary disposition to mammary cancer varies very greatly in different strains; in some families almost 100% of all females become cancerous; in other families almost none become diseased. This constitutional characteristic is transmitted by heredity from generation to generation, with only slight modifications. Even the age at which the cancer appears in mice is determined by heredity. In other kinds of animal cancer, heredity plays a similar role. And there is much evidence that the same holds good in the case of man. But in man conditions are much more complicated through continued interbreeding. This prevents the hereditarily transmitted constitutional factor from being as clearly recognizable as in the case of animal cancer where it can be followed in isolated families. But even in man indications are not lacking that heredity plays the same part as in animal cancer. This is especially clear whenever interbreeding has been less prominent; and the recent studies of C. C. Little, of the Eugenics Record Office of the Carnegie Institution for the Study of Evolution, show that an hereditary factor can be shown to exist in human cancer generally.

As we stated above, the heredity factor is usually accompanied by internal or external stimuli; and these stimuli must cooperate with the hereditary disposition which in certain cases seems to imply a tendency to a special kind of cancer, rather than a general tendency to cancer. These stimuli transform the potential hereditary disposition into an actual cancer. These stimuli may be chemical or mechanical. The effect exerted by the ovary, to which we referred above, is an example of a chemical stimulus. Certain parasitic worms in the body of the host may likewise stimulate some tissues to cancerous proliferation. This is probably also due to a chemical stimulus emanating from the parasite. Long continued irritation functions as a mechanical stimulus. Roentgen rays acting on unprotected skin through a long period of time may also cause a mechanical irritation.

Experimentally it has been possible to produce at will cancer in rats, mice and rabbits through the application of Roentgen rays, by infecting them with certain parasitic worms, or through the application of irritating substances like tar to their skin. In all of these cases the stimulus has to act over a relatively long period of time, and generally the appearance of fully developed cancer is preceded by increased growth activity of the stimulated areas which leads to the production of what is often called a precancerous condition. Such a stage often precedes cancer in man. Through the long continued stimulation the cells are kept in a continuous state of increased multiplication, such as we find in a wound healing during a short period of time; if this excessive multiplication continues sufficiently long, the cells change their character, they keep on multiplying in excess and invade neighboring tissues even after the direct stimulus has been removed. This effect of stimulation is very much promoted through the hereditary predisposition to a certain kind of cancer, but it seems that if the external stimulus is very strong and long continued, a deficiency in hereditary predisposition becomes less important; but an analysis of the quantitative relation between the strength of the predisposing hereditary factors and the external or internal stimulating factors has so far been attempted in only a few cases.

There are some cancers where at present we have no knowledge of stimulating factors, where, apparently merely on the basis of some error during the development of the embryo, cancer develops, or where ova undergo parthenogenetic development and lead to embryo-like tumors in the ovary or perhaps elsewhere. From these abnormal embryo-like structures cancer may develop. These kinds of cancer frequently appear relatively early in life, while usually cancer is more frequent in older individuals.

It seems also that in certain cases a cancer itself may stimulate neighboring tissues which had been normal to assume cancerous growth. In this case we have probably to deal with a chemical stimulus exerted by cancerous cells.

There still remains one kind of cancer to be considered which differs in some respects very markedly from all other kinds which have been so far investigated. There occurs in fowl a cancer of the connective tissue and cartilage which behaves in its course not unlike the typical cancer; it makes metastases, leads to the death of the animal and can be transplanted into other individuals of the same kind. It differs, however, very markedly from other kinds of cancer in three respects: 1) while in other kinds of cancers, notwithstanding many experiments in this direction, some of them carried out as early as twenty years ago, it has not been found possible to separate from the cells an agent which would cause the cancer when injected into suitable individuals, this attempt was successful in this particular cancer of fowl. By filtration through filters so fine that tumor cells cannot pass, the agent was separated from the cells. The same result was obtained through drying the tumor and similar devices which killed the tumor cells without causing a marked injury to the agent. As stated, the same means previously used in other kinds of tumors had led to the result that the inoculability of the tumor had been lost.

Here then exists an agent distinct from the tumor cells, which is presumably an ultramicroscopic microorganism. 2) It is possible to produce in birds an immune serum which protects fowl against the agent, as distinct from the tumor cells. This has never been possible in the case of the typical mammalian cancer. Here immunization is always directed against the cancer cells themselves and only succeeds in transplanted, not in spontaneous cancer. 3) Injection of the agent leads apparently not only to the production of the same kind of tumor, but also to other kinds of tumors; this is due to the fact that the agents can affect certain other kinds of cells.

In these respects then this particular kind of tumor differs from the typical mammalian cancer. We must assume that in this case the stimulus which calls forth the transformation of ordinary cells into cancer cells consists in the presence and continuous action of a microorganism which presumably acts through the medium of a chemical substance which it gives off.

To summarize then briefly what we know about the causes of cancer, we found an inherited predisposition, combined with the action of external or inner chemical or mechanical stimuli, to be responsible for the typical mammalian cancer. These factors have been analysed experimentally to such an extent that in certain cancers it is possible not only to predict, how many cases of cancer of a certain kind will originate in a given family or strain, but also to prevent the appearance of the cancer or to reduce its frequency at will. It has furthermore been possible to produce experimentally through the application of these stimuli various types of cancer. Conditions which favor cell growth in general favor the origin of cancer. Certain mechanical and chemical stimuli, an embryonic condition of tissues act in this way and the inherited factor in cancer acts presumably in a similar way. In a certain type of avian cancer a filterable virus causes the cancerous growth of cells. The same may apply to certain other kinds of atypical cancer. It is, however, not probable that microorganisms play a part in the typical mammalian cancer. But even if later it should be found that here, too, microorganisms are involved, the latter would have access equally to all individuals of a certain species; they would therefore not explain, why only certain individuals are affected by cancer. This would be explained through the difference in hereditary predisposition and the action of stimuli, and these will remain the important causes of the typical mammalian cancer independent of the possible, but not probable, action of microorganisms.

DO WE HEAR SOUND?

Augustus G. Pohlman

Almost every individual will admit without argument that we hear sound. He may also be inclined to arrive at the off-hand conclusion that the question properly belongs to the large category of scientific near-queries. The theoretically balanced ass between two equally attractive bales of hay and the hypothetical thunder storm on the theoretical desert island might be listed as representatives of this type; near-queries which make for much discussion but relatively little information. The question asked however does not belong to this group. While as has been said almost any individual will admit that we hear sound, no modern scientific theory of sound analysis grants this possibility. If the scientific conception of hearing is correct, then people in general are entitled to some explanation of the error in the popular notion of the problem. If, however, we are to make our answer an affirmative one, then some explanation must be made of how an error has crept into the theoretical considerations. Practically all of the information concerning things which lie outside of self are derived through the eye and ear. It should therefore be a matter of some little importance to know what it is we see and what it is we hear.

Lest someone may infer that our explanation may lead us farther than it really does, it may be well to bear in mind certain facts about the operation of the nervous system. We do not know how a nerve conveys an impulse neither do we know how the code message transmitted to our brain is resolved into terms of consciousness. We have not as yet discovered how a stimulus affects a nerve ending. This much, however, is fairly well understood. The activating agent which is to be transferred to the nerve ending in terms of impulse, must be applied directly to the nerve ending or to the cells which overlie the nerve ending. This statement holds for the sensations of touch, of pressure, of smell and of taste. We also recognize that heat is transmitted through various substances which may intervene between the source of the energy and the part which perceives the sensation. Therefore when the end organ is affected by the energy which arises from the object rather than by the object itself, we are dealing with distance rather than contact organs. The end organ resolves the energy, not the object, in terms of code message. We do not see heat; we feel it. We do not feel light rays; we see them. It would therefore follow as a matter of good logic, that we do not see or feel energy in the form of sound; we hear it.

Sound, next to heat, is the most difficult form of energy to deal with satisfactorily. From an experimental point of view it is the most difficult form of energy to analyze. The reason for this is easily grasped. In so far as sense organs are concerned, they are crude physical instruments when compared with the scales for measuring pressure, the thermometer for measuring temperature, or the photographic plate for measuring light. However when it comes to sound the reverse is true. All physical instruments for registering sound are extremely crude when compared with the human ear. In fact no instrument for measuring sound has yet been devised which does not have a human ear on one end of it. The phonodeik of Miller presents an instrument of great delicacy but with a limited range of registration.

We are likely to visualize the working of an ear much in the same manner as we visualize the operation of an eye by comparing it with some well-known physical apparatus. Bearing in mind the reservations in the previous paragraph, may the ear be compared with the familiar recording phonograph?

The general picture of the ear apparatus is well known. The drum membrane lies in the depth of the external auditory canal. The small ear ossicles, malleus, incus and stapes, are familiar to every high school student of physiology. Further we probably remember that the end organ of hearing, the organ of Corti, lies immersed in the liquid of the inner ear contained within a cavity of the temporal bone. The bony container has two openings in it which are related to the middle ear cavity. The footplate of the stapes occupies the oval window while the smaller round window is provided with a membranous diaphragm. The malleus is attached to the drum membrane and is brought into relation with the stapes through the intermediate incus. The drum membrane in this manner comes to have a definite connection to the liquid of the inner ear.

May the mechanics of hearing be likened to the familiar lateral-type recording phonograph? The diaphragm of the phonograph corresponds to the drum membrane; the hinged stylus may be likened to the hinged ossicles; the groove on the recording plate may be compared to the liquid of the inner ear. The sound pulses strike the phonograph membrane and cause it to swing in-and-out. The stylus membrane acts like a lever—the long arm from the center of the diaphragm to the fulcrum; the short arm resting a pointed tip in the wax. The excursion of the shorter arm is necessarily less than that of the longer arm and its power is thereby increased. We know that this record when placed on a reproducing phonograph will yield in a general way the cause—the voice or the instrument. Just so all modern theories of hearing assume that the sound pulses cause an in-and-out swing of the drum membrane. The lateral motions are transferred to the hinged ossicles; the long arm (malleus) attached to the drum membrane. The last of this chain of bones, the short arm of the lever system, the stapes, is not pointed like a phonograph needle but is broad and is applied to the liquid of the inner ear. The liquid material however obviously cannot respond after the manner of the wax and therefore it shivers as a mass. This mass shiver is not sound any more than is the lateral groove in the phonograph record, sound.

If we concede that the end organ embedded in the liquid is far more sensitive than any phonographic recording method, then the explanation why we do not hear sound is beautifully lucid. The answer to our question is correspondingly simple and let us repeat—according to all modern theories of hearing and their name is legion—"We do not hear sound". We hear a mass shiver in the liquid of the inner ear. It is also the writer's contention that this accepted description is not a true statement. The theory thus far presented, may be called the indirect activation theory. Briefly, what are the objections to it?

It is not a question whether the ear is built after the pattern of a phonograph. Some heating devices have been invented which also resemble the phonograph pattern of construction closely. The question is does the ear really record sound like a phonograph? Without going into unnecessary details it can be definitely shown that the drum membrane of the ear does not go in-and-out in response to sound vibrations of minimum or even optimum intensity. It can be definitely stated that a hinge operation of the ossicles is impossible under the mechanic conditions imposed. It can be shown that the amount of energy applied to the drum membrane under usual optimum conditions is insufficient to move the mass, disregarding all friction and attachments. It has been demonstrated that measurable variations of the drum membrane position have no effect on the liquid contents of the inner ear in the living animal. It is known as a subjective physiological fact that the ear picks up a dropped vibration in high frequencies up to 1/250th of a second. This eliminates any feature which includes the element of inertia. The phonograph and ear mechanism therefore become very dissimilar. If we are to agree that an ear cannot operate under the requirements of an indirect activation it is not unlikely that all theories based on this premise are also erroneous. This not only accounts for the variations in interpretation of the end-organ function but it also makes their discussion unnecessary.

The assumption that we do hear sound is much more satisfactory from a biological view point. It falls in line with the activating factors which operate other sense organs. One does not assume that the retinal cells are indirectly activated by a radiant heat reflected from the choroid merely because the choroid is black. One does not construct thermo-sensitive organs out of rods and cones to explain why they face what appears to be the wrong way and why they touch the pigment layer. One regards the eye-ball as a reasonably light-proof space except to the energies entering the pupil. One searches, as Parker has done, for an explanation of the inverted retina and finds it in the comparative anatomy. We may therefore assume that the inner ear occupies a reasonably sound-proof space except for the energies normally entering through the footplate. We may also search for the explanation of the refined histology of the end-organ in the pattern upon which it is developed rather than in terms of functional requirements.

Over a hundred years ago before the histology of the end-organ had been reported by Corti, men thought seriously on this problem. Carlisle in 1805 made far reaching deductions on the basis of comparative anatomy. Later in the forties the great anatomist and physiologist Johannes Mueller performed experiments which formulated the so-called molecular theory. The conception that the sound pulse itself activates the end-organ fell into disrepute as a result of the work of von Helmholtz among the physicists and the modern school of otologists headed by Politzer.

The mechanics of the direct activation theory has been gone into in no little detail by the writer. The physics is that of the string telephone and the recognition that sound pulses like light rays behave differently in various physical media. The drum membrane according to this theory affords a sort of catchment area for minute energies in the air. These energies within the membrane flow for the most part to the most tense area, the attachment of the ossicles. The ossicles behave like a solid rod transmitting the energies with longer wave length to the footplate area. This is widened to facilitate the discharge of the energy into the liquid of the inner ear and is insulated from transmitting the energy into the surrounding bone by an elastic annular ligament. In this manner a small amount of the energy from the drum membrane reaches the liquid of the inner ear as a sound pulse. The sound pulse in the inner ear liquid, apart from wave length, is identical with the sound pulse of the air of the external auditory canal. The shiver in the liquid is therefore dependent on the physical character of the liquid and not dependent on the elasticity of the bony container or the membrane of the round window. In other words no mass shifting of liquid occurs. The scheme does not involve the element of inertia and appears to fit the facts of the comparative anatomy.

The entire histological picture of the end-organ may be reinterpreted on the basis of the direct activation theory. The basilar membrane insulates the end-organ from sound pulses which might gain the sensitive epithelium through the bony container. The vestibular membrane limits the energy entering the cochlear duct through the Scala vestibuli. The membranes are, in other words, damping in effect—just as the iris and choroid are part of the light-proofing arrangement of the eyeball. We are at once in a position to argue according to this theory why individuals with ossicles gone may hear. We are also able to state why greater energies are required to hear low pitches than high pitches. We may explain the failure of the sound-proofing of the end-organ when sufficient energies of high pitch are applied to the surface of the individual.

It may be well therefore in our investigation of sound sources and of subjective sound registration to bear in mind that we do hear sound itself. We may come to regard the apparently crude apparatus of sound transmission as one of highly refined function. We may not be so likely to accept explanations, like the piano-tuners named in Dr. Wead's recent article in Science, merely because these explanations appear clear. If we do hear sound perhaps something may be done in time for certain conditions of deafness. One reason why fifty years of research has contributed nothing to treatment of the unfortunate who cannot hear, may be due to an erroneous conception of the mechanics involved. The writer desires to place himself on record on the side of the popular rather than the scientific explanation. We do hear sound!

DEVELOPMENT OF THE CHEMICAL INDUSTRY IN THE LAST HUNDRED YEARS

F. W. Frerichs

It was indeed a pleasure to me when I received from the Academy of Science an invitation to take part in a cycle of lectures which had been arranged for the purpose of discussing before its members the achievements of scientific research and the development of the condition of life, which we are witnessing in our period of time. It is only natural that chemistry should have a place in this discussion since this branch of knowledge has come forward in modern times to enter more than any other science into our daily life.

Chemistry was in its infancy at the beginning of the 19th century. It is true that at an early time men began to inquire the why and how of things about them, and to take them apart. It is true that from such analysis, particularly of inorganic things like rocks and ores, men began to learn the characteristics of the simple elements which go to make up our world and how they behave when brought together in compounds not occurring in nature. But the scope of chemical work done at that time was so small and the amount of chemicals produced was so insignificant that it hardly deserved mention among manufacturing industries.

Berzelius (1779 to 1848) did his experimenting in his kitchen, his cook his only assistant, and yet in this most primitive laboratory he discovered a number of elements and determined their atomic weights. He lived, as Woehler put it, in those happy days, when every rock he picked up contained a new element.

E. Mitscherlich (1794-1863), Heinrich Rose (1795-1864), Leopold Gmelin (1788-1853) and Robert v. Bunsen (1811-1899), worked steadily on the establishment of facts about the interaction of elements and tried to coordinate them into a system, while Gay Lussac (1778-1850), Berthollet (1748-1822), Aragadro (1776-1856), Proust (1754-1826), Stas (1813-1891) and many others were working on intermolecular relations between the elements.

While men like these were tirelessly experimenting to establish facts, there grew up a set of men who were destined to lead chemistry to its highest development. Woehler (1800-1882), Liebig (1803-1873) and Hofmann (1818-1892) were three men whose names for all time will be indelibly connected with the development of chemical science and chemical industry. I had the great privilege of being introduced into chemistry by Friederich Woehler, to be a student under him for three years, and to be assistant in his laboratory for a term of five and a half years, during all of which time I enjoyed daily intercourse with this illustrious man. When I entered the University of Göttingen in 1870 the course in chemistry was carried on quite differently from what it is now. During the time I was a student I heard one lecture course on inorganic chemistry by Woehler. The course, comprising one hundred and twenty hours, was spread over twenty weeks. I heard a lecture course of forty hours on organic chemistry by Huebner, and one course on physics by William Weber (who was one of the inventors of the telegraph) the course also comprising forty hours, spread over twenty weeks. These two hundred hours of lectures were all I heard during three years up to my graduation. But we worked in the laboratory daily from eight to twelve and from two to six, and work we did. During all these days our teachers were with us, going from student to student inspecting, exhorting and criticising our work. It was on these occasions that our teachers would speak to us individually and collectively, and so we heard by word of mouth many interesting facts about the early development of chemistry.

When Woehler was young, chemical research centered about inorganic bodies and Woehler occupied himself with the study of minerals and mineral substances. His first great discovery he made in the field of inorganic chemistry, when he in 1827 isolated aluminium by fusing aluminium chloride with sodium, obtaining a metal of silvery lustre but unusually light. His investigations of cyanogen compounds in 1828 led him to the greatest discovery of his life. In investigating the properties of cyanate of ammonium ($CNONH_4$) he studied its instability in aqueous solutions, effected its transformation into urea ($CO.NH_2 NH_2$) and recognized this body by its reactions and its properities. I well remember the cluster of urea-crystals, crystals several inches long, and of the thickness of a pencil, which were made at an early time, securely enclosed in a liter flask to serve as an exhibit in lecture courses for many years to come. In order to understand the importance of this discovery we must remember that at that time chemists were confining their efforts to the study of inorganic chemical compounds. They were also interested in organic things, meaning those resulting from growth of vegetation, or from living things, all of which contained carbon, but these bodies were found to be exceedingly complex and almost without number.

Methods of analysis had been developed by which the qualitative and quantitative composition of organic compounds could be ascertained, and it was known that in such compounds carbon was combined with other elements like nitrogen, oxygen and hydrogen in many proportions, but all chemists had failed to build up from the elements a single one of the many carbon compounds which occurred in nature. These compounds seemed to be exceedingly complex, and since all efforts had proven futile to produce any of them from the elements in the laboratory, it was generally believed that organic compounds could be produced only through the agency of "vital force".

Friederich Woehler, then a teacher at the Gewerbeschule in Berlin, broke down this barrier; the first time in the world's history a chemist had succeeded in making an organic material named Urea from inorganic substances, and *recognized the fact.* Since that time an almost inconceivable number of carbon compounds have been construed and manufactured, part of which were produced by nature in plants and organisms, and many more of equal importance, which are not found in nature but are made in chemical laboratories by men. From the preparation of artificial Urea the manufacture of organic chemical compounds has grown to enormous dimensions, culminating in the development of our present dyestuff industry and the manufacture of medicinal chemicals, of perfumes, flavors and scents.

But the study of organic compounds was taken up by other and younger men, among whom A. W. v. Hofmann (1818-1892) became famous as leader in the dyestuff industry. After splendid discoveries in the field of organic chemistry, Woehler drifted back to research in the inorganic field, where he had already been successful by discovering a way of making metallic aluminium in 1827, and in 1856 he discovered "Adamantine Boron" in cooperation with St. Claire Deville. Woehler's life work was in the field of inorganic chemistry, where he, through his many followers, exerted great influence up to the end of his life. Justus v. Liebig (1803-1873) was three years younger than Woehler, but they met in 1825 and became friends for life. The continuous interchange of experience was most fruitful, and is well known from their published correspondence. But about 1838 Liebig began to drift into chemistry of plant and animal life, and so we find about the middle of the 19th century Woehler, Hofmann, and Liebig as the great leaders in three fields; inorganic chemistry, organic chemistry, and agricultural chemistry. Under the guidance of these illustrious men and many of their colleagues, the three fields of chemistry have been developed by their many followers into chemical industry as we have it today. It is characteristic that none of the leaders ever actively engaged in the industries. They worked in their laboratories for the love of science, leaving the fruits of their work to be reaped by their followers. But owing to their methods of teaching, their students became their friends, remaining in contact with them in later life, and it seems this inter-relation between university and industry has been largely instrumental in the phenomenal development of our chemical inorganic and organic industries.

The first branch of chemical manufacture established on a large scale was an outgrowth of the French revolution and the Napoleonic wars, when the English blockaded the continent of Europe, and when the French could not obtain potash for making soap and glass. It was known that soda in many cases could be substituted for potash, and there was an abundance of salt. So the French Government offered a large reward for a chemical process to make soda from salt, and the LeBlanc soda process was the outcome of it. The LeBlanc soda process involved the manufacture of sulphuric acid and the chamber process was highly developed. As a by-product large quantities of hydrochloric acid were obtained, for which there was no immediate outlet, and the wasting of which poisoned the rivers, until it was learned that chlorine and bleaching powder could be made from it. Chlorine was made by the aid of manganese peroxide which was wasted, and the Weldon process was invented which regenerated this waste. Later hydrochloric acid was decomposed by the Deacon process, in which a catalyser was used for the first time on a large scale. The sulphur used in the process was lost and many efforts were made for its recovery, when the ammonia soda process superseded the LeBlanc process, putting an end to a beautiful combination of chemical processes. This most marvelously developed chemical structure, built up at the beginning of the 19th century, was superseded by a cheaper process at the end of the same century. The

LeBlanc soda process had become obsolete when the chemical industry began to develop in this country and therefore it has never reached this continent. Instead we make in this country soda ash by the ammonia soda process on the largest scale and the details of manufacture are worked out in the best research laboratories established by the soda factories themselves.

The process was particularly adapted to the requirements in the northern part of the United States, where enormous deposits of salt are underlying the surface near the Great Lakes. On account of the permeability of the soil to water these deposits could not be reached by mining operations, but we have learned to get hold of the salt by boring wells, letting water into the salt deposits, and pumping the brine. So abundant is the supply of salt, and so cheap its recovery, that it has become profitable to waste half of it in the process and to waste all of the chloride in order to save cost in the manufacture of soda ash. This is one of the few cases where it has been found that waste is economy.

The soda industry in the United States is most flourishing and repeatedly I have been asked to help in establishing the industry in China and Japan. Only recently an agent called to induce me to come to Bombay, India, for the purpose of establishing the art. In all instances I had to decline, knowing that in these countries there is no rock salt and that salt must be made from the ocean water by evaporation, the product containing much magnesium chloride and being expensive, costing eight dollars per ton for 85% pure salt, while here we pump the pure article for fifty cents. From recent reports, however, I have it that rock salt is found in Manchuria, which would make it possible to transplant the industry into that country for the purpose of covering their own requirements.

But even the ammonia soda process may be limited to the consumption of local industries. When our own civilization progresses westward and reaches the great natural deposits in the soda lakes in western States, then we may have soda for the digging of it.

With the replacement of the LeBlanc process by the ammonia soda process we lost the by-products of the former, which in time had become valuable and necessary for the purpose of making chlorine. But the electro-chemical decomposition of brine into sodium, chlorine, and hydrogen has met the emergency, and today we have large electro-chemical plants near Niagara Falls which make caustic soda and chlorine in quantities to satisfy our wants. And I have also heard of a process for making synthetic hydrochloric acid from chlorine and hydrogen, this reversing the former mode of manufacture. The chamber process for making sulphuric acid, which first was developed on a large scale in connection with the LeBlanc soda process, has experienced a similar transformation. The chamber process makes cheap sulphuric acid of moderate strength. If greater strength than 60° Be. or 75% acid was required, it was formerly necessary to concentrate the weak acid in platinum vessels at great expense, and fuming sulphuric acid was obtained by the distillation of sulphate of iron at great cost. Today we make sulphuric acid by the contact process and the mode of working is reversed. We make sulphuric acid anhydride first and dilute it with water to make the weaker grades. To make sulphuric acid we need sulphur as raw material. This we had to buy from Sicily, or we used pyrytes, a combination of sulphur with iron, which we imported from Spain. In most recent times Hermann Frasch showed us a way to recover sulphur which we knew to exist in Louisiana deep down in the earth. He built large steam plants, blew superheated steam through a double pipe down to the sulphur deposits, melted the sulphur, and forced the molten sulphur out through the other pipe to the surface of the earth. The supply seems to be inexhaustible, and we command the supply of the world. The sulphuric acid industry has often been referred to as a measure for the prosperity of the entire chemical industry, since sulphuric acid is used for many chemical processes. The following table gives the production of sulphuric acid in the United States in the last ten years.

SULPHURIC ACID 50° Be.*

Date	*Production in the U. S.* *Tons 50° B.*	*Value* *Dollars*
1911	2,700,000	17,369,872
1912	2,950,000	18,338,019
1913	3,575,000	22,684,526
1914	3,800,000	24,479,927
1915	4,120,000	32,657,151
1916	6,300,000	73,514,126
1917	7,200,000	87,541,181
1918	7,450,000	Not determined
1919	5,500,000 estimated	
1920	5,000,000 estimated	

*The Mineral Industry, 1920, G. A. Roush, Editor, McGraw-Hill N. Y., 1921.

For many centuries fine porcelain ware was made in China and Persia. Art collectors search eagerly for specimens of old manufacture, and praise them as products of a lost art which they represent as flourishing centuries ago, and small vessels and vases are sold for thousands of dollars. The fact is that kaolin of a certain composition was used in these goods. Kaolin comes in pockets and in isolated mines, and if the mine was exhausted, the art was lost. The chemist of today has analyzed kaolin and ascertained its composition. By properly mixing materials he has learned to reproduce the finest quality of porcelain at will.

We mine in Arkansas bauxite ($Al_2O_3\,2H_2O$), a mineral containing almost pure alumina. We ship it to St. Louis, where by the aid of cheap limestone and coal the impurities are removed in one of the largest manufacturing plants of the country, and pure alumina is made from it. This we carry to Niagara Falls to produce aluminium by an electrical process. The great discovery of producing aluminium, made by Woehler in 1827, has been improved by Hall, an American chemist. He isolates the metal by an electrical process, and a large part of the world's requirements takes its way through St. Louis and becomes a product of the United States.

We turn now to organic industry, particularly to dyestuffs, the development of which to a great extent is the work of A. W. v. Hofmann and his followers. Hofmann first studied law in Göttingen, but turned to chemistry, becoming a student and co-worker of Liebig. When in 1845 the School of Practical Chemistry was started in London, Hofmann, upon recommendation of Liebig and largely through the influence of the Prince Consort, became its director. For about twenty years he remained in this position, doing much work on coal-tar products, including aniline, and in 1856 Perkin, one of his assistants, discovered mauveine, the first aniline dyestuff. But the public support extended to the College of Chemistry was dwindling and Hofmann returned to Germany, first to Bonn in 1864, from where he was called to Berlin in 1865, to succeed E. Mitscherlich. There he spent the rest of his life working tirelessly and with great success on the development of coal-tar chemistry, on which he spent twenty of his best years in England, scoring little success for lack of support from the English government.

Fuchsin had been discovered in 1859 by Professor Verguin of Lyons, France, who made the dye but did not clear up its chemical compositions, which, many years later, was disclosed by Hofmann and his followers. And from the fundamental work of his school sprang success upon success. The most brilliant colors were found among the derivatives of aniline, but they generally lacked permanence under the influence of light. For many centuries beautifully colored rugs and tapestries had been made in the Orient. The colors were known to be permanent and almost indelible. They were derived from the madder and indigo plants, which were cultivated on a large scale. It was natural that attempts should be made to produce these dyestuffs in the laboratory, but they seemed to be complicated and their composition was difficult to establish. After many efforts Graebe and Liebermann in 1868 recognized that alizarine, which was then known to be a constituent of Turkey red, the madder dyestuff, was a derivative of anthracene and anthracene was found in coal-tar. In the same year Graebe and Liebermann succeeded in making artificial alizarine from anthracene, which was identical with Turkey red. The invention was quickly taken up by manufacturers and artificial alizarine superseded Turkey red, thus making unprofitable the cultivation of the madder plant. In 1875 I had the privilege of meeting Liebermann and also Hofmann on the occasion of the seventy-fifth anniversary of Woehler's birth. On that occasion Prof. Liebermann related to us how they had worked on the synthesis of alizarine. When success was assured they repeated the entire process in a single night, to make sure of results before publication. At that time there was no patent law in the North German Federation, and patents had to be secured in three dozen principalities. This made them of little value, and the inventors gave their work to the public, securing for themselves only the immortality of their names.

The process of making artificial indigo is largely credited to Adolph v. Bayer, who recognized its constitution. But many years of tedious work were required before the Bädische Aniline & Soda Fabrik succeeded in preparing artificial indigo at a price capable of competing with the natural article. Since 1897, however, artificial indigo has been sold and soon afterwards a process was worked out which made use of naphthalene as a raw material. Naphthalene was always available in great quantities and at a low price, and the naphthalene process made it possible to drive natural indigo out of the market. An interesting story is connected with the invention of the naphthalene process, the first step of which was to transform naphthalene into phthalic acid. Formerly phthalic acid was prepared by oxidation of Naphthalene with nitric acid or chromic acid at great cost. The yield by attempted oxidation of naphthalene by means of sulphuric acid was too small. It so happened that in one experiment the mercury thermometer broke, whereupon it was found that the reaction of the material became very animated, and the yield of phthalic acid by heating naphthalene with sulphuric acid in presence of mercury was almost theoretical. The accidental breaking of a mercury thermometer led to a very important discovery which became the basis of a cheap way of making indigo. These are only a few instances in which new chemical manufacturing plants have been established on a large scale on the basis of laboratory research. Many other industries followed, among which the manufacture of medicinal chemicals has become most important.

For the preservation and possible development of many industries which have sprung up during the war, when importations of chemicals were impossible, a liberal tariff and a wise patent law are most desirable and almost imperative. Particularly the dyestuff industry will have a hard fight for its existence. At a recent meeting of manufacturers in New York, a petition was formulated and sent to Congress asking for an embargo on the importation of dyestuffs, since manufacturers realized that nothing short of an embargo could save the industry, until a complete and liberal revision of our tariff law has been enacted. Of equal importance would seem to be a wise revision of our patent law. Many chemicals, particularly of the medicinal variety, are now manufactured abroad at a much lower price than in the United States.

The third branch of chemical research and manufacture, agricultural and biological chemistry, is represented by Justus v. Liebig and his school. Being a part of organic chemistry, it differs from it in that it does not attempt to make its products in the chemical laboratory, but is endeavoring to ascertain the conditions and requirements under which plants and animals will grow, then to provide these conditions and let nature do the rest. In this manner the greatest chemical industry was created, an industry which secures food for men for times to come, by regulating the cultivation of the soil. When as early as 1838 Liebig directed attention to the fact that all plants for their growth require carbon, nitrogen, and the elements of water, he also proved that certain mineral substances were necessary for plant life, among them potash and phosphorus. Carbon and nitrogen could come from the air; phosphorus and potash could come only from the soil, and when these were exhausted, vegetation necessarily would starve. This led Liebig to the statement that it was the decrease of soil fertility, and neither peace nor war, which was fundamental in bringing about the decay of nations. In Liebig's opinion old civilizations in Africa, Asia, and Europe were extinquished by sterilization of the soil, and undoubtedly the same will occur in America if no fertilizer is supplied to our fields. It is recognized that phosphates and other mineral fertilizers in some form must be added to the soil if its fertility is to be maintained. Nitrogen may be derived from the air by cultivation of clover in a rotation of crops. The early Roman writers on agriculture knew the value of leguminous crops as restoratives of soil fertility. But the fact that legumes assimilate nitrogen from the air by a biological process has only become known within the last fifty years. If an uninterrupted succession of large crops is desired, it becomes imperative to supply nitrogeneous fertilizer in a more concentrated form, such as Chilean nitre of ammonium salts. Dr. Lipman, Director of the New Jersey Agricultural Experiment Station, was quoted in the hearings before the Senate Committee on Agriculture and Forestry (Senate Document 3390) as having estimated that the total annual loss of nitrogen from all land under cultivation in the United States, after allowance for all returns to the soil, was between three and four million tons. Considering only the lower figure of three million tons, manure, ammonium salts from coke ovens, and Chilean nitrate will replace less than ten per cent. The remaining ninety per cent—two million, seven hundred thousand tons—would have to come from nitrogen fixation plants, similar to the one our government attempted to put up at Muscle Shoals during the war, where one million horse power could be developed, as J. W. Worthington of the Tennessee River Improvement Association has testified.

It has been stated that one half of one pound of fixed nitrogen can be made per horsepower hour by the Haber process. One million horsepower would make over two million tons fixed nitrogen per year, which is a large part of the amount which the United States may require. The cyanamid process is said to require eight times as much power, and one million horsepower would only make two hundred and fifty thousand tons. The Claude process, which is similar to the Haber process, but is working under high pressure, requires less power and makes more fixed nitrogen per horsepower than the Haber process.

Only the cyanamid plant was in operation at Muscle Shoals at the time of the armistice, and was reported as running at the rate of forty thousand tons per year,—sixty to seventy such plants would be necessary to supply the nitrogen which is necessary to keep up the fertility of the soil in the United States. A large part of this can be made in Muscle Shoals, provided the water power is developed as Henry Ford proposes to do if he can lease the plant. His proposition is before Congress and it would seem desirable for the good of the country that the plant be utilized for making fertilizing material. The people of the United States have invested over one hundred million dollars as a war measure in this enterprise and it is expected that additional thirty million to fifty million dollars be spent on the second and third dam across the river to develop the water power. The first expenditure was made so that we might be independent of Chilean nitre in case we should be cut off from South America. Nitrates are necessary for making explosives and are therefore necessary for our national defense. For this reason it would seem desirable that the plant be completed. But it is only fair, that in time of peace the large investment should be utilized. Mr. Ford is guaranteeing, according to the first proposition, to pay the United States government about one million, five hundred thousand dollars a year for a long lease. He also agrees to keep the Muscle Shoals plant in operation as a fertilizer plant and ready for the Government in time of war. His investment in the plant is expected to be relatively small, which cuts his overhead expenses down to almost nothing on a plant which cost over one hundred million dollars. Therefore he could put out fertilizer at low cost. If in this way the American farmer could obtain materials which are necessary to uphold the fertility of our soil, the entire enterprise in time might become a profitable investment and the entire American people would be benefited by it. Mr. Ford is recognized as a great organizer and a daring business man. He is no doubt also a fine engineer, and the work before him is a great engineering problem. But the best engineer cannot design a plant if he is not told how the plant is to accomplish its purpose. To design the process in detail is the work of a chemist, and Mr. Ford must succeed in associating with himself chemists who are fitted for this special work.

The Haber plant at Muscle Shoals has never worked. It was erected under the direction of holders of American patents, and these people were naturally desirous of using their patented process. However, processes on similar lines have been tried in Germany and abandoned for cheaper ones. Had the war lasted longer, the Haber plant at Muscle Shoals might have proven just as great a failure as the manufacture of airplanes.

In the Treaty of Versailles the Allies stipulated that a commission of allied engineers be admitted to the German nitrate plants for the purpose of learning the process. The commission went there, was shown the plants at Oppau and Merseburg, were given every information they asked for, were given large quantities of the catalyser used by the Germans, and returning to Muscle Shoals, failed in setting the plant to work. Under these conditions the War Department acceded to the request of The American Institute of Chemical Engineers that a paper be submitted describing the German and United States synthetic ammonia process, hoping that the Muscle Shoals plant could be put into operation by outside assistance. The paper was presented and read at the Detroit meeting in June, and was authorized for publication by the War Department. Shortly after, the permission to publish was withdrawn upon demand of the American patentees, and the paper was never published. Meanwhile the Muscle Shoals plant is at rest, waiting for the man who is to blow life into it and make it run. If Mr. Ford obtains the lease it is sincerely to be hoped that he will associate himself with chemists who will show him the way. The farming population of our country is most fortunate in having in the Department of Agriculture of the United States a splendid research laboratory to guide its work.

It is a well-known fact that the unprecedented development of chemical industry in Germany was largely due to its research laboratories and to their relation to the universities. At German universities the leading professors are not overburdened with work and can devote a large part of their time to solving questions of general interest. In the United States the conditions are different. Professors of universities are overworked and the men who are best prepared for research are overburdened with routine work. The consequence is that a great many manufacturers are operating in the dark, wasting money and time in their operations.

Professor W. D. Bancroft in a recent article calls particular attention to the fact that, as far as can be learned, in the ceramics, rubber, paint, varnish, leather, dyeing and printing, cellulose, cellulose nitrates and acetates, photographic and other industries, the operators of plants have a vast amount of empirical information as to what happens and know practically nothing about why it happens. The silicate industries are avowedly empirical and so is the dyeing industry. The rubber industry knows practically nothing about the theory of vulcanization. People in the cellulose industries do not seem to know how many cellulose nitrates there are. The photographic industry has only empirical knowledge in regard to emulsions and has no adequate theory in regard to photographic development Nearly all the tanneries in the country run on an empirical basis. All these industries will eventually be put on a sound and scientific basis, and this work will have to be done by chemists. Conditions as they are described by Professor Bancroft were recognized many years ago by The American Institute of Chemical Engineers. This body of men devotes not a small part of its activities to developing courses for students in Chemistry at our universities which ensure efficient preparation for industrial work. Its Committee on Education, Dr. A. D. Little of Boston, Chairman, has recently secured with much labor and at great expense very complete information from many American universities, and a comprehensive report will be circulated shortly among the interested institutions. Columbia University of New York, The Institute of Technology in Boston, The Polytechnic Institute in Brooklyn, N. Y., and Cornell University, are co-operating. A number of universities have already remodeled their courses in chemical engineering, and it is hoped that others will follow, for the benefit of our chemists and of our chemical industry.

ECOLOGICAL AND BEHAVIOR NOTES ON MISSOURI INSECTS.

Phil Rau.

The notes on the ecology and behavior of Missouri insects, spiders and myriapods here presented were made in the vicinity of St. Louis during the past few years. The region comprises an area of about forty miles west and thirty miles south of St. Louis. There are two exceptions, however; some dozen notes bear the locality of Wesco, Mo., which is one hundred miles south-west of St. Louis, and a few are from Lake View, Kansas. Wherever no location is mentioned, the observation was made at St. Louis or its immediate environs.

The order in which the species are generally arranged is as follows: Hymenoptera, according to Hymenoptera of Conneticut.* Coleoptera, according to Blatchley, Coleoptera of Indiana, 1910. In the orders of Diptera, Orthoptera, Lepidoptera, etc., the species observed are so few that no taxonomic arrangement is followed.

All of the material has been indentified by expert entomologists whose names appear in brackets along with the specific name of the insect. I wish here to extend to these gentlemen my thanks for their kindness in naming the material.

Wasps

Scolia bicincta Fab. [S. A. Rohwer]. This wasp was seen at Wickes, Mo., feeding on the flowers of smartweed and buck-brush in late August, and on goldenrod on September 15.

Scolia dubia Say. We record in Wasp Studies Afield having found Scolia dubia for two successive seasons, flying about the manure heaps near a barn, and really conspicuous by their absence elsewhere in the large field

*State Geol. and Nat. Hist. Surv. Bull. 22, 1916.

surrounding this barn. On September 1 of the third year they appeared without the slightest change in habit or habitat. The vegetation surrounding the manure-heaps had meanwhile been supplanted by cinders and the wasps had no foliage upon which to rest; hence many paused to rest on the manure-piles. Long and careful watching, however, revealed none of these entering the manure for prey or hosts. A few smartweeds in blossom nearby afforded them food. By seven o'clock, all had disappeared, and efforts to locate their sleeping abode were futile. In this the third year also their dissemination over the field was nil. A visit to the area on October 6 showed that they were not to be found so late in the season.

Scolia nobilitata Fabr. [S. A. Rohwer]. Taken on the flowers of buck-brush at Wesco, August 1, 1920.

Elis atriventris Gahan. [S. A. Rohwer]. A dead specimen of this wasp was lying on the hot sand at Lake View, Kansas, July 29.

Elis quinquecincta Fabr. [S. A. Rohwer]. While I have made observations on the gregarious sleeping habits of the males,* I have found nothing on the habits of the females excepting on one occasion in a dirt road, where one made three attempts to get under some clods of dirt, and under the last one she remained hidden for some time. Since this species is supposed to sting and oviposit in the larva of may-beetles, this may indicate that she was searching for prey. This species was seen feeding upon the flowers of Melilotus alba. On another occasion, on July 26, a group of a dozen males and one female was found sipping the nectar of these flowers.

Elis interrupta Say. [S. A. Rohwer]. This species was also on the buck-brush flowers at Wesco, August 1, 1920.

Tiphia vulgaris Rob. [S. A. Rohwer]. This medium-sized wasp was taken from the mouth of a robber-fly, *Proctacanthus milberti* Macq. [F. Knab] on August 18.

*Ann. Ent. Soc. Amer. 9:227-274, 1916.

Tiphia inornata Say. [S. A. Rohwer]. Taken on the sidewalk in the city on September 12.

Bruesia sparsiformis Ckll. and Roh. [S. A. Rohwer]. A pair was discovered just at the conclusion of copulation on a clay bank at Jerseydale, Mo., July 31.

Bruesia bexar Blake [S. A. Rohwer].

Dasymutilla zella Rohwer [S. A. Rohwer].

Dasymutilla mutata Blake [S. A. Rohwer].

Can it be that wasps, like the rest of us, may sometimes be gravely misjudged because of the company they keep? The part of a stubble field bordering the woodlands contained a large number of burrows occupied by *Cicindela* larvae, and about this particular area an abundance of the three above-named species of velvet-ants lurked. The abundance of both larvae and wasps seemed to indicate that there might be some relation between the two, especially since it is known that certain species of Mutillids are parasitic upon *Cicindela* larvae. We spent a good many hours in the field on many days watching the parasites move about in the vicinity of the beetle burrows, in the hope of catching them redhanded at something or other, but all that they did was to slowly walk about doing nothing that we wanted or expected them to do.

Thinking that in confinement some results would be obtained, several jelly-glasses were filled with soil and a *Cicindela* larva and a Mutillid introduced into each. The larvae immediately made their burrows, and the Mutillids dug deep into the soil. The way these Mutillids bury themselves is quite interesting, and since they are often seen in the open fields with particles of earth clinging to their velvety bodies one is led to believe that this behavior is for some reason necessary. The head is the simple implement which these insects use in digging their way sometimes for several inches into the soil. They thrust the head under the earth and pry it up, by manipulating the head and thorax in a lever like fashion. With this exertion they make a great deal of stridulating noise, similar to the sharp squeak which they emit when they are held up squirming in the forceps. These Mutillids in the jelly-glasses seldom came to the top. After four days had elasped an examination was made; both wasps and larvae seemed healthy, but there was no evidence of any parasitism. The beetle larvae were fed on insects, but nothing was placed in the cages for the Mutillids, yet at this time they looked none the worse for lack of food. Since propinquity did not affect them, the experiments were abandoned.

A dozen or so other Mutillids were kept for later study in a fish-globe. There was no soil in this glass jar, but a few grape-leaves were strewen on the bottom for the comfort of the insects, and in one corner was a cloth kept moist with sweetened water. During the first two days they were out and active, and at night they would creep in between the folds of the leaves for sleep, but later when they were in a weakened condition they seldom came from their hiding places. They lived only a week; just why they were so short-lived I do not understand, since without food the others lived nearly as long. It may be that they were more comfortable in the damp cool earth of the jelly-glasses, or perhaps they found something of a nutritive nature in the soil. I have spoken only of the females so far, because in several visits to this area in early July, no males had been discovered.

Some twelve days later, July 24-25, a thorough search was made in this same area and then only males were abundant and only the species *Bruesia bexar* Blake [S. A. Rohwer]. They were constantly on the wing in a zigzag flight from two to four inches above the ground. Their stops were few and far between, and they paused only for toilet-making. I suppose they were seeking the females. The priority of the emergence of one sex seems here to be reversed, at least in so far as this one species is concerned. Wishing not to judge hastily, I made a thorough search for three hours in this area; several hundreds of males were found, all in the same behavior, but the only female discovered was one *Dasymutilla zella.* It is possible that the females of *B. bexar* taken early may have been unfertilized,—hence the lack of any positive results in the experiments with the *Cicindela* larvae.

The female *D. zella* and about a dozen males of *B. bexar* were placed in a large glass jar with earth in the bottom. As soon as the thirteen were thrown together, many of the males showed great eagerness to mate with this female, even though she was of a different species. She eventually escaped by climbing a tall stalk of grass placed in the jar, and later burrowed in the soil.

The males, like the females, often had bits of earth adhering to the thorax and abdomen when they were captured, which indicates that they had recently been in the ground. The above insects were placed in the jar with earth at twilight, and before it was fully dark, three had dug themselves in for the night, and before nine o'clock all had disappeared under the earth, which was moderately hard-packed. One is suprised that the winged males can do this without injury to their delicate wings, which are not heavily chitinized like those of other earth inhabiting insects. The next morning at six o'clock one was already up, and within a half hour all were out. This is in all probability their sleeping behavior in nature; the performance was repeated exactly night after night.

Honey was placed on small pieces of paper, and on an aster flower with a six-inch stem. They often ate ravenously, climbing up to the flower to feed, or eating from the edge of the drop of honey on the papers; only one male was so awkward as to walk into it.

On August 11 the same region was searched; a half-dozen females of *Dasymutilla zella* were taken there, and an enormous number of males of that species were out at that time. The larvae of *Cicindela* were again abundant, but I could see *D. zella* do naught but walk or fly about the low stubble.

Pseudomethoca canadinses Blke. [S. A. Rohwer.] This pair of mutillids was found in copulo on June 28. They were walking slowly along the clayey margin of a clover field, the male riding the female. He, being much smaller, covered only the rear half of her body. The body of the female, at a point where the abdomen joins the thorax, is narrowly contracted. At this point the male grasped her firmly with his jaws in order to hold his position. The real union lasted for only a very few seconds. This momentary mating was repeated so many times that I concluded that this was the normal method. Many of them were to be seen among the new wheat stubble in a field skirting the woods, where also *Cicindela* holes were abundant.

Dasymutilla acrobinata. [S. A. Rohwer]. One female was taken July 3, on a path in the forest.

Dasymutilla allardi Roh. [S. A. Rohwer]. This cow-killer was seen on August 29, on a hard-packed baseball diamond in a city lot. It was prowling about in the immediate vicinity of several burrows of aculeate Hymenoptera.

Dasymutilla blawana Roh. [S. A. Rowher]. At Lake View, Kansas, two females were found walking about in a sandy area by the roadside, and lurking about a hole. When we inserted a probe into this hole, one of these wasps jumped out, but upon opening the burrow we found nothing but a colony of red ants. At Creve Coeur Lake, Mo., one specimen was taken on a sandy area where bees and some Pompilid wasps were at work and where *Cicindela* beetles abounded.

Dasymutilla ferrugata Fabr. [S. A. Rohwer]. Some half-dozen of these cow-killers were observed on the sandy beach of the Kaw River at Lake View, Kansas, on August 16. One female was feasting upon the remains of a watermelon left on the river bank by some picnicers. One specimen was taken on the bald field of the baseball diamond in a city lot on September 17.

Dasymutilla occidentalis Linn. [S. A. Rohwer]. These Mutillids were becoming quite abundant on the stubble field at Wickes by September 4. They occupied the same area as *Bruesia bexar* and *D. zella,* and spent their time in walking slowly about and entering holes and crevices indiscriminately. At Wesco, Mo., about the first of August, I saw on two separate mornings, a dozen or so males flying about one certain hawthorn shrub which was less than two feet high. These shrubs were plentiful thereabouts, but no others attracted these insects. I suspected at once that this was a courtship flight, and that the wingless females were lurking somewhere unseen, but careful and continued watching led me to conclude that this was only play. Or we might borrow a suggestion from the ways of some other species of wasps, and suspect that these males had emerged prior to the females, and that they were here around the burrow of a female, which they could by some sense incomprehensible to us detect, awaiting her emergence.

Timulla hexagona Say. [S. A. Rohwer]. This velvet ant was found walking about on the short grass surrounding the baseball diamond in the city in early August.

Sphaerophthalma pennsylvanica Lep. [S. A. Rohwer]. On June 15 a female was taken, after having been observed for some time poking its head under loose lumps of earth and tufts of grass on a broken area.

Sphaerophthalma scaeva Blake. [S. A. Rohwer]. We have never caught *S. scaeva* in the field busy with any significant occupation. We have seen them only in the autumn; on September 12 a male was walking about on the top of a high bluff at Falling Springs, Ill., and on September 23 and October 7 they were flying slowly about over the vegetation near Creve Coeur Lake and near the Meramec River at Moselle. One male specimen of *S. scaeva* emerged from a cocoon of *Sceliphron caementarium* on June 15. It was placed in a vial where, in a few days, it broke up with its jaws much of the cork stopper. It was then placed in a cage with sugar-water and fruit, where it lived for twenty-five days.

Priocnemis nebulosus Dahl. [S. A. Rohwer]. In a road sparsely covered with grass, this Pompilid was actively chasing a spider, but the wasp in her chase encountered a spider's web in the grass; she paused in her quest and spent several seconds searching it, and thus lost her quarry.

Priocnemis nothus Cres. [S. A. Rohwer]. One specimen was taken on the sunny baseball field on September 17.

Priocnemis nigripes Cres. [S. A. Rohwer]. We have twice found this wasp out walking about on the ground, once in an open field in St. Louis and again on the sandy ground near the river front in Kansas. They moved nervously, and were poking their heads enquiringly into every crevice and under sticks and leaves. From this conduct we judged they were foraging.

Priocnemis pompilus Cress. [S. A. Rohwer]. Two individuals were seen foraging on a clay bank in St. Louis on June 20, 1918. They were eagerly scrambling under clods and nervously tumbling into crevices. After many such adventures, one brought a small spider out of a crevice. She carried it a short distance, explored about the region for a few minutes, then returned to the spider. This performance she repeated three times, then she carried the spider into one of the crevices. Three quarters of an hour elapsed and she did not reappear.

Cryptocheilus unifasciatus Say. [S. A. Rohwer]. On August 31, at Wickes, Mo., this wasp was seen dragging a large spider by the mandibles across a rough road and over a grassy area, traveling with ease and rapidity. The spider was limp and apparently dead.

Cryptocheilus magnus Cress. [S. A. Rohwer]. One male taken in sweeping an oats field July 9, 1917.

Cryptocheilus fulvicornis Cress. [S. A. Rohwer]. This wasp made its appearance on the baseball field after the rain on July 23, 1918.

Episyron biguttatus Fab. [S. A. Rohwer]. The wasp with her prey clasped under her body was seen to enter her hole in the sand; when she emerged, she was captured for identification. The burrow was three inches deep, one quarter inch in diameter, and went down at an angle of 45°. There was no pocket, but at the terminus lay a spider with an egg fastened to it laterally. On this occasion the mother remained in the burrow for five minutes, presumably adjusting the spider and depositing the egg. The spider was not entirely lifeless, but the legs could not move. After seven days it still showed slight traces of life.

A second member of this species was seen the next day, digging. It would enter its hole head first, and throw the sand out of the burrow literally in a spurting stream. With rapid movements of her forefeet she would brush the sand under the body and out of the hole. Sometimes she cleaned out in the same manner the sand that accumulated in her doorway, and every so often she would come out and work in the same way cleaning the sand from the area surrounding the hole. At 5:15 p. m. she left, evidently in quest of prey; up to 6:15 she had not returned. The next day at 10 o'clock I found the hole closed, but the friable condition of the sand rendered futile all attempts to explore the completed nest.

In the sunshine in the dooryard another of these wasps was spied covering her nest. I could not then watch her, but after the nest had been filled and she once more returned to the spot, I took her. For more than fifteen minutes of this time, a parasitic fly was hovering persistently about this spot. The nest was dug up, but the tunnel could not be traced. The pocket with the spider, *Epeira prompta* [J. H. Emerton] was only three-fourths inch under the surface of the ground. The wasp's egg was on its back, but evidently the Dipteron had also been successful in its quest, for three maggots were around the egg. The spider was not dead, and for four days thereafter responded freely to stimuli.

This wasp was also seen feeding on the flowers of buckbrush at Wesco on August 1.

Episyron quinquenotatus Say. [S. A. Rohwer]. Several were seen on the sandy beach at Creve Coeur Lake when it grew warm between one and three o'clock on October 13.

Episyron maneei Bks. [S. A. Rohwer]. This wasp walked across the road and into the dense woods, walking backwards and dragging a spider, *Cylosa conica* [Emerton] at about 6 p. m. on July 7. The spider, when taken away, seemed dead, but three days later it showed signs of life, reacting abundantly to stimulus, and by July 18 it had wholly recovered. May it be that with certain Pompilids the process is reversed—that instead of the sting causing slight injury and slow death, the sting here causes immediate total paralysis and slow recovery?

Pompiloides americanus Beauv. [S. A. Rohwer]. Several of these were seen in the wheat stubble in early September, and on October 3 one was carrying away a spider, *Pardosa nigripalpis* Emerton [N. Banks].

I also saw this red-banded Pompilid walking about the sand at Wickes, Mo., on October 3, 1917. Without preliminary warning it plunged into a crevice and soon came up again with a medium-sized spider, later identified as *Pardosa nigripalpis* [Emerton]. This is one of the vagabond hunting spiders, some of which, according to Warburton*, burrow in the loose sand. The wasp, with its jaws inserted in the ventral portion of the spider's ab-

*Cambridge Nat. Hist. 4, p. 417.

domen, walked backwards for twenty feet and deposited its prey under a loose piece of clay. After walking about for five minutes, probably looking for a desirable hole, she returned to the spider, grabbed it in the same way, dropped it for a few seconds while again she looked about, then returned, picked it up and removed it to a spot under another clod. There she left it again while she investigated an opening under another lump of clay only an inch distant. This at last seemed satisfactory, for the wasp then fetched the spider, dragged it under this lump of earth and remained there for fifteen minutes. Losing patience at last, I lifted the clod and found the spider in a very neat depression, but I could not tell if the hole was natural or a wasp-made one. Both spider and wasp were then taken.

This wasp also seems to abound until late in the season. At Herculaneum, Mo., on October 18, on the shore of the Mississippi river, about a dozen were seen in the half-hour from 10 to 10:30 a. m. One in particular was atop a spider, *Philodromus sp.* [J. H. Emerton]. Approaching too near we frightened her away, and she never returned for her prey. The spider was probably more frightened than injured, for after a few minutes it seemed to recover its faculties and walked away.

Pompiloides marginatus Say. This wasp was carrying off a spider, an immature *Xysticus sp.* [J. H. Emerton], on October 19 at Hematite, Mo.

Pompiloides subviolaceus Cress. [S. A. Rohwer]. This beautiful wasp was taken while she was foraging about a lot of piled logs at Creve Coeur Lake on August 30, 1916. She was also seen carrying away an immature *Xysticus* [J. H. Emerton] at Hematite on October 19.

Psammochares (*Lophopompilus*) *aethiops* Cress. [S. A. Rohwer]. Several individuals of this species were seen flying about the bluffs at Clifton Terrace, Ill., on October 28, 1916. The days were then warm, but the nights were so cold that I marveled that they could survive. They were also seen on a mid-September day at Hematite, Mo. The day was dull and gloomy; despite the fact that wasps of this genus are supposed to be sun-loving creatures, more than a dozen of these were seen on the sandy patches along Joachim creek, apparently foraging, walking nervously about and exploring all small holes and crevices. They were also out here on October 19.

Arachnophoctonus ferrugineus Say. [S. A. Rohwer]. Two specimens of this Pompilid wasp were taken at Wicks, Mo., on July 17, and one at Moselle, Mo., on September 23. On July 3, 1921, Mr. Ernst Schwarz and I watched one of these wasps carry an enormous Lycosid spider, *Dolmedes idoneus* [J. H. Emerton] crossing the road amid many passing automobiles. The wasp grasped the spider's palpi in its mandibles and was walking backwards, dragging the spider thus; this was no easy task, and she was obliged frequently to tug and strain when the spider became lodged against some obstruction. She was compelled repeatedly to leave her property by the passing machines, but each time she left it she took an elaborate flight of orientation, just as we have seen other individuals of this species do when leaving their prey when homeward bound to examine the nest. Each time she returned to it readily, excepting one time when for its safety we moved it two feet to place it out of the track of the passing automobiles; as we expected, she returned to the exact spot where she had left it, and after a prolonged search stumbled upon it as if by accident.

Anoplius hyacinthinus [S. A. Rohwer] was found feeding on the flowers of a wild pea, August 17.

Anoplius luctuosus Cress. [S. A. Rohwer] flew in at the laboratory window on July 9.

Pepsis elegans Lep. [S. A. Rohwer] was observed feeding on the flowers of a composite on July 17, and on the blossoms of the Madeira vine on August 11. On August

4, 1917, they were rather abundant in open spaces, roadsides, etc., bordering on the forest.

Planiceps niger Cress. [S. A. Rohwer]. At Meramec Highlands, Mo., this wasp was walking about on a clay bank, probably foraging. In the course of its travels it walked over a heavy spider-web; when in the center, it bit a hole through the web with its mandibles, and dropped through it to the ground below.

Notiochares philadelphicus Lep. [S. A. Rohwer]. This wasp was taken at Cedar Bluff, Mo., on July 9, 1916, and on a mud embankment at Jerseydale, Mo., on October 19. On August 13, one was seen in the dusty road carrying a spider, *Lycosa scutulata* [Emerton]. This prey, when taken from the wasp, was limp and made only slight response to stimulus. Sixteen days later the response was still slight, and shortly after that date the spider seemed dead.

Our first real acquaintance with this wasp was when we discovered four holes in a bald and hard-packed area near the old log smoke-house, and three of these black wasps (beautiful blue in the sunshine) were loitering about the area. They walked slowly about, or flew languidly to near-by plants; they casually nosed about any holes or irregularities in the surface. The four holes mentioned had been recently dug, for the fresh earth still lay in front of each. For about two hours these wasps lingered about these holes (Pl. VI, fig. 5), but did nothing constructive that we could see. In their slow walks over the area, their antennae and wings moved nervously, but they paid each other no heed. One hole was dug out; it was seven-sixteenths inch diameter at the mouth, very crooked, and went down at an irregular slope for two and one-half inches. It was empty. A second one was found to be of about the same size and irregular direction, but it contained a large spider, *Lycosa scutulata* [Emerton], with its abdomen almost eaten away by a large larva.

My opinion of the wasp's listlessness was at once changed when one discovered a spider. This spider was on her large, spreading web at the base of the smoke-house wall. I was attracted by the amazing rapidity with which the wasp traveled over this web without becoming ensnared. By a fine trick, like a hare before the hounds, the spider suddenly ceased the race and stood stock still in the center of the web, while the wasp in full pursuit dashed right past her and did not discover the error, it seemed, until she had reached the edge of the web. Then she betrayed her agitation, by quivering wings and antennae, but for some time appeared either rather stupid or near-sighted in again locating her quarry. The spider, meanwhile, remained motionless until it was again discovered, whereupon it dodged for a time, then leaped to the wall and escaped. Two days later the burrows had not been closed; they were dug up, and all were like the first.

A little later in the season, in early September, this species was frequently seen along the roadside on the hills near Wickes; they were evidently foraging or feeding. One was even seen so late as October 19, feeding on the last smart-weed blossoms.

On August 14, at Manchester, Mo., we were attracted by a commotion at the foot of a sunny clay bank. A wasp was in a hole, with her face flush with the surface, and four others were in a fussy wrangle over it. Our first thoughts were that the ones on top were helping another in distress, since their manner did not denote anger or enmity. After five minutes more of this turmoil, the one below emerged; and then did the excitement break into perfect furore among them. The new one emerging was a large, handsome female; the other four were males. One of these took possession of her at once, while two others clung to her and struggled to crowd him away. The fourth, outwitted, walked away and was captured in a vial. The mating lasted for about a minute, when the female also was placed in the same vial, where the mating was repeated.

Agenoideus humulis Cress. [S. A. Rohwer]. This was found at Creve Coeur Lake, September 30, in possession of a spider, *Epeira globosa* Keys [N. Banks]. The spider was so helpless that only with a magnifying glass could its pulsations be detected, and five days later it was quite dead.

Ancistrocerus capra Sauss. [S. A. Rohwer]. This was feeding on goldenrod down by the river at Wicks, September 16, 1919, and one specimen was captured at Hematite, Mo., on October 19.

Ancistrocerus campestris Sauss. [S. A. Rohwer]. A specimen of this species was taken on October 27, 1916, at Clifton Terrace, Ill., feeding on the nectar of the few remaining flowers of white aster. This wasp has been found nidificating in discarded mud nests of *Sceliphron caementarium.*

Eumenes fraternus Say. [S. A. Rohwer]. We have no records of the building of the nest of this wasp, but this note will give one phase of the work. On August 13, at 4 p. m. we found a nest at the edge of the field, attached to the stem of an aster plant, about four feet from the ground. The nest when we found it was complete, but uncovered, and the tail of the last caterpillar protruded. This was taken and identified by Mr. S. B. Fracker as *Omphalocera dentosa.* The completion of the provisioning took some time, for on the next morning and also the day following, nothing more was done to it, but on the third day at 5 p. m. we found the little pot had been filled and sealed. (See Plate V fig. 1.)

A five-potted nest was found in St. Louis in 1917; four pots were on the upper side of a petiole of a leaf and one on the under side. The occupants had already emerged. I believe that these delicate little clay receptacles of the potter wasps cannot withstand the rigors of the winter, but that they disintegrate under the severe weather.

Their thin walls would certainly offer little protection from the elements. The five mentioned above all fell when I tried ever so gently to move the twig to photograph them. This cluster also suggests that one mother may be capable of building that number, although of course we have not absolute proof that they are the work of one parent. These facts, as well as the fact that these wasps have been seen late in the autumn, lead me to suspect that these wasps hibernate as adults.

Monobia quadridens. This wasp was bringing in caterpillars at intervals of thirty minutes, at 6 a. m. on June 28. Five days later the nest was examined; the caterpillars were still alive, although much shrunken. They were very dissimilar, and represented probably two species of the Gelechidae. This wasp uses the old galleries of carpenter bees and one such nest with mud partitions is shown in Pl. VII, fig 10; all three young were parasitized by cuckoo bees. The first of these to emerge was the lowermost one, the first egg deposited. This made a hole in its cocoon and a neat hole in the mud plug above, entered the cell above, crept past its younger brother and bit a neat round hole in the second plug also. It was in the antechamber when I discovered and removed it.

Ancistrocerus near *tigris* Sauss. [S. A. Rohwer]. This was seen to enter and leave an old beetle burrow in a fence-post. The hole contained no nest; the purpose of the visit was not ascertained. In earlier studies we have learned that this species inhabits the old nests of mud-daubers, *Sceliphron caementarium.* Five of these wasps emerged from sumac stems taken in St. Louis, between April 3 and 7, 1919.

Stenodynerus quadrisectus Say. [S. A. Rohwer]. This was captured on the window of a log chicken-house, September 12, 1917.

Stenodynerus zendaloides Robt. [S. A. Rohwer]. This wasp hatched early in May, 1918 from a sumac twig brought from Wickes, Mo.

Zethus spinipes Say. [S. A. Rohwer]. Found feeding on the flowers of *Melilotus alba* July 15.

Nortonia symmorphy Sauss. [S. A. Rohwer]. Swept from the low grass at twilight, July 30, 1917.

Odynerus geminus Cress. A turret built by this species and many fresh pellets of mud were found on the baseball diamond October 9, 1919. This is two weeks later than the latest date heretofore recorded.

Odynerus dorsalis Fab. The empty compartment which regularly occurs in the top of the burrow of *O. dorsalis* (see Wasp Studies Afield, pages 312-331) has been puzzling in so far as utility is concerned. I called it the air-chamber, because the only use that I could think of for its presence was to prevent the extremes of temperature from affecting the immature organism which spends the winter in a shallow burrow. Another logical hypothesis for explaining this must be accredited to the sincere interest of a small boy. Since the parent wasp is not equipped with jaws sufficiently powerful to dig out the hard earth, but must carry water to first change it into soft mud, we cannot expect the young emerging insect to cut its way out through a solid plug of hard earth when it can get no water; in fact, under a heavy plug they would practically be hopelessly entombed. Iseley records two species of caterpillars used for prey by this wasp in Kansas. We have recorded, from three distinct times and localities, only the caterpillars of *Pholisora cattulus* used by the St. Louis *O. dorsalis.* We here add another record of twelve cells taken September 2, 1918, containing an aggregate of 51 caterpillars, all of which were of the one species.

Odynerus foraminatus Sauss. [S. A Rohwer]. An elder twig, taken at Hematite, Mo., on October 18, 1918, gave forth this adult Eumenid on April 30, 1919. This twig was hollow, and the lower four inches were filled up with finely bitten up pith. This indicates that the twig had probably been used previously by a *Crabro* wasp. Four inches below the top of the remaining cavity, this Eumenid mother had laid a mud floor and inserted a mud ceiling one-half inch above this, thus making only one large cell in the twig. In lieu of making a cocoon, the larva had varnished the walls of the room with some substance which had hardened into a very thin, onion-skin-like, white tissue. Nothing remained to indicate what the food supply had been. Another individual made its nest in the interstices of a corrugated cardboard box in the laboratory. Others were seen on the flowers of buck-brush on August 1, 1920.

Odynerus (*Ancistrocerus*) *tigris* Sauss. [S.A.Rohwer]. Found on the screen door, carrying a caterpillar, at Wickes, May 29, 1920.

Odynerus (*Ancistrocerus*) *capra* Sauss. var. [S. A. Rohwer]. Taken from blackberry blossoms, May 29, 1920.

Odynerus (*Stenodynerus*) *anormis* Say. [S. A. Rohwer.] On flowers of buck-brush, August 1, 1920.

Odynerus (*Stenodynerus*) *pedestris* Sauss. [S. A. Rohwer]. On buck-brush blossoms, Wesco, August 1, 1920.

Alyson melleus Say. [S. A. Rohwer]. This was seen on June 13, 1918, entering a hole in a bank. It was one among many bee holes, so it might have been the wasp's own burrow or that of a bee.

Nysson (*Hyponysson*) *raui* [S. A. Rohwer].* One was seen on August 5 to enter the bee burrow of *Calliopsis nebrascensis* Cfd. [J. C. Crawford].

Nysson sp. [S. A. Rohwer]. The freshly-cut stems of roadside weeds and bushes, including sumac, afforded attractive places for the building of stem-dwellers. In less than two hours after the weeds were cut, two wasps of this species had already dug deep tunnels in the soft pith.

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*Described by S. A. Rohwer, Proc. U. S. Nat. Mus. 53:176, 1917.

Nysson (*Zanysson*) *texanus* Cress. [S. A. Rohwer]. Taken at Lake View, Kansas, July 29, 1916. This is described in Proc. U. S. Nat. Mus. 59:406, 1921 and through an error the locality given as St. Louis, Mo.

Paramellinus bipunctatus Say. [S. A. Rohwer]. One spicemen of this wasp was found dead in a shallow hole in the sand at Creve Coeur Lake, Mo., October 13, 1916. It had probably sought shelter here and had been overcome by the cold.

Hoplisoides costalis Cress. [S. A. Rohwer]. This wasp had its hole in the ground under a small piece of loose bark. This was evidently her nest, as she entered it carrying something green. There was much loose earth about the hole. In pushing her way in, she left the burrow open, and when she left the hole she kicked over enough dirt to cover it. The burrow and its contents could not be traced out on account of the looseness of the soil. Another individual of this species was captured on a windowpane in a chicken-house. This was an old log house, and the logs and the mortar in the crevices contained many burrows of insects; hence we were always curious regarding the business of any insects captured there.

Mimesa cressoni Pack. [S. A. Rohwer] was found on the baseball field in St. Louis, October 13, 1918.

Oxybelus sp. near *striatus* [S. A. Rohwer]. A hole, one-eighth inch in diameter, was found in the sand at Moselle, Mo., July 2, with a neat pile of loose sand about it. This wasp entered the hole and soon emerged, when it was taken. The burrow was lost in digging.

Solenius interruptes Say. [S. A. Rohwer]. Found dead on window at St. Louis, June 30, 1920.

Solenius bellus Cress. [S. A. Rohwer]. Several of these were found snugly secure in burrows in the upright posts of a pagoda at Creve Coeur Lake, June 13, 1918. They sat with their heads in their doorways, calmly looking into the sunshiny world outside, but would drop back into their holes most tantalizingly upon our approach. These holes proved to be the old burrows of beetles, tightly packed with sawdust. The wasps were evidently enlarging their quarters by removing this packing.

Hypocrabro texanus Cress. [S. A. Rohwer]. This wasp was found in a hollow stem, together with some larvae and three pellets of bee-bread. It is probable that this was really the bee's home, and the wasp had merely sought shelter here for the night.

Hypocrabro stirpicolus Pack. [S. A. Rohwer]. The live wasp was found in a tunnel in an ailanthus twig taken in the Missouri Botanical Garden. It had evidently only taken temporary refuge there, since there was no evidence of its nest; the cells below it were filled with caterpillars, while this species rears its young on flies. Another stem with soft pith, taken at Wicks, Mo., contained a tunnel which ocillated from side to side of the pith area. One cell in this burrow was full of flies and a wasp larva; another cell contained only the debris of flies, and a partition of pith one-half inch thick separated the two. Early in May this young wasp emerged a full-grown *H. stirpicolus.* Their prey in one nest was *Viviania calosomae* Burgess [J. M. Aldrich]. A third nest was found in a cottonwood sprout, which had been chopped off exposing the pith. The tunnel was newly completed, nine inches long and three-sixteenths inch wide, and the first cell was being stocked when I interrupted the worker. The mother was caught in the burrow with three flies, all dead: *Oxycera maculata* Oliv. [C. T. Greene], *Phorbia fuscipes* Zett. [C.T.Greene] and *Rivellia pallida* Lve. [C. T. Greene]. In still another nest we took flies of two other species: *Chiromeyia sp.* [J. F. Aldrich] and *Agromyza parvicornis* Loew. [J. F. Aldrich]. All this prey is an addition to the list already published in Wasp Studies Afield. Another cocoon of this wasp, taken from a sumac twig, was found to contain not the rightful owner but the parasite, *Diamorus zabriskiei* Cress. [R. A. Cushman], which was fully developed and occupied the entire space.

Cerceris clypeata Dahlb. [S. A. Rohwer]. Taken at Kimmswick, Mo., by sweeping the low grass at 5 p. m. on July 17.

Cerceris raui Roh. [S. A.Rohwer]. A male was found feeding on buck-brush blossoms at Wesco, about a hundred miles from the point from which it was described.

Philanthus politus Say. [S. A. Rohwer]. Taken on July 2, in an area of white sand at Silica, Mo., in company with several other Hymenoptera.

Philanthus punctatus Say. [S. A. Rohwer]. Taken at Hematite, Mo., as late in autumn as October 19, 1918.

Crossocerus scutellatus Say. [S. A. Rohwer]. One individual of this species was seen to enter three holes in a clay bank at Lake View, Kansas, July 27, 1916; then it returned to the first one where it was captured. Another was twice seen doing "the Higland fling" before its hole in the bank; it would poise before the hole in humming-bird fashion for many seconds and sometimes move from side to side, and eventually dart away. I did not ascertain if it was foraging in these holes or actually nesting there.

Crossocerus incavus Fox. [S. A. Rohwer]. This wasp was found in the same clay bank as the above species. One entered a hole in the bank, and despite the fact that the tunnel went in for several inches it remained near the entrance kicking out loose dirt, until it was captured.

Xylocelia ater Mickel. [S. A. Rohwer]. At Lake View, Kansas, on July 27 and 30, two were seen to enter crevices in the dirt bank.

Xylocelia spiniferus Mickel. [S. A. Rohwer]. Taken at Creve Coeur Lake, Mo., October 7, 1916.

Diodontus corusanigrens Roh. [S. A. Rohwer].* On

*This is a new species described from this material in Proc. U. S. Nat. Mus. 57:270, 1920.

July 6, 1918, an elder stem was taken with this adult wasp within; in 1919 five wasps emerged between March 31 and April 14. This indicates but one generation a year.

Didineis texanus Cress. [S. A. Rohwer]. On October 6, 1916, about a dozen of these were seen walking about on the loose soil at the base of a clay bank, apparently killing time.

Trypoxylon rubrocinctum Pack. [S. A. Rohwer]. An elder twig contained a gallery three inches long and one-eighth inch in diameter. The lowermost cell of this was one-half inch long and contained the black cocoon from which this wasp emerged during the middle of July. A very thin partition of mud separated this from the next cell, which was one and three-fourths inches in length. Next was another partition of mud, and beyond this was the old case of a cuckoo-bee, *Chrysis* (*trichrysis*) *parvula* Fab. [S. A. Rohwer]. No explanation has been found for the enormous size of the second cell.

Trypoxylon johnsoni Fox. [S. A. Rohwer]. This red-bodied *Trypoxylon* was this time found occupying a hole in a mass of soil which was clinging to the roots of an upturned tree. The burrow was only an inch deep and wide enough to accommodate only the wasp's body. We have previously found it in twigs.

Trypoxylon frigidum Sm. [S. A. Rohwer]. A dead male found in the stem of a sumac.

Trypoxylon clavatum Sm. [S. A. Rohwer]. This emerged in June 1920 from a *Polistes* paper nest with mud plugs taken at Meramec Highlands October 6, 1919.

Chlorion ichneumoneum Linn. Feeding upon flowers of *Aster multiflora,* October 6, 1919, and on buck-brush blossoms at Wesco, July 30, 1920.

Chlorion cyaneum Dahl. Found on August 14, 1919, carrying a cricket, *Gryllus assimilis* Fab. [A. N. Caudell]. The cricket, at first quite helpless, slowly regained the ability, after several hours, to respond slightly to stimulus, but died the next day.

Priononyx bifoveolatum Tachenberg. [S. A. Rohwer]. We arrived upon the scene, a mud bank with sparse vegetation, just in time to see the wasp riding her hopper, *Melanoplus scudderi* Uhler [A. N. Caudell] to her door. She trundled it along in the regulation manner, riding atop and grasping the hopper's antennae in her jaws. She left it, as her sisters *P. atratum* and *P. thomae* usually do, beside the mouth of the burrow while she went in for a final inspection of the interior, poked her head out the door and dragged it in, and half a minute later she emerged and began packing in the soil. The burrow was only a small, sloping pocket in the earth, similar to that of *P. atratum* but somewhat smaller. The hopper gave only a slight response to stimulus, and died the next day. The wasp's egg was attached exactly in the place where *P. atratum* and *P. thomae* habitually fasten theirs, on the right side of the body at the base of the hind leg.

Priononyx atratum Lep. [S. A. Rohwer]. A grasshopper, *Melanoplus femoratus*, which was taken from this wasp lived for four days, August 1 to 5, 1920. Other wasps of this species were taken on flowers of buck-brush at Wesco, July 30, and on *Aster multiflora* as late as October 19, 1918.

Ammobia pennsylvanica Linn. [S. A. Rohwer]. Captured in the kitchen at Wickes, Mo., September 4, 1917.

Sphex (*Ammophila*) *pictipennis* Walsh. At St. Louis, in 1918, several of these wasps were seen out on October 12; one was even earnestly trundling a caterpillar home. This was not the latest date of their appearance, however, for one was taken at Hematite, Mo. on October 19. Others were taken in summer from the flowers of sweet clover and buck-brush. We took possession of a caterpillar, *Leucania unipuncta* [S. B. Fracker] which one was taking home at Wesco, August 1; it lived six days.

Sphex (*Ammophila*) *abbreviata* Fab. [S. A. Rohwer]. Two of these were seen in copulo at Wickes, Mo., on September 4, 1917. They alighted on a leaf nearby, remained for perhaps three minutes and resumed their flight high in the air without separating. Another pair was seen likewise, the male atop his mate, on August 13. They flitted about with ease and rested frequently on the vegetation. On July 17, a female was seen carrying a green caterpillar belonging to the Hesperiidae [S. B. Fracker]. It was not dead.

Sphex (*Ammophila*) *procera*. These were seen at Wickes at the end of June, and on July 2, one was starting to dig her well at Silica. She seemed hard to satisfy, and abandoned her first two attempts after making a good beginning. Her method of digging was to stand, head downward, with her body straight up in the air, bite out a chunk of earth and fly with it a short distance before dropping it.

Sphex (*Ammophila*)*argentatus* Hort. [S. A. Rohwer]. When first I saw this wasp at work, I thought it was *Sphex pictipennis*, on account of the similarity of its coloring and size, but upon seeing it at work, I at once saw that its method of proceeding was slightly different from the fixed habits of *S. pictipennis*. The difference in the behavior of the two species lies chiefly in the method of carrying out the soil when excavating the nest. *S. pictipennis* always walks from the burrow and carries the dirt to a pile at a point about four inches distant. The two individuals of *S. argentata* observed at work on a sandy area in St. Louis on September 1, 1918, would always, when leaving the burrow with a load of dirt, fly into the air and drop the sand while they were on the wing.

At first it appeared, as just stated, that these two females were at work in a sandy area, but upon excavating the burrows I found that the sand was only a thin layer which had been dumped on top of the hard yellow clay. The nest of *S. pictipennis* is clearly and invariably "L" shaped, but in these two cases the nests looked more like those of *Priononyx atratum*. The bottom chamber was three-quarters of an inch below the surface of the ground; the length was 1¼ inches, and the diameter was 3/16 inch. I could not ascertain whether *S. argentatus* always makes this type of nest, or whether these two mothers, when they dug into the sand and struck the hard clay, sidled along horizontally and made the nest such as we describe, instead of abandoning the attempt or working through the tough clay to make an "L" shaped burrow. Besides *S. pictipennis*, we know that *S. procera* make nests of that conventional form. Both of these nests contained a caterpillar each of the same species of Geometridae [Fracker], and each caterpillar had a wasp egg on the left side of the body a little below the center. Both caterpillars were dead, but these were dug up four days after the nests had been sealed.

These wasps were out late in the season. On October 18, 1918, about half a dozen of them were seen at Herculaneum, Mo., and the next day three more were observed along the roadside to Hematite, one of which was trundling her caterpillar home at that unusual date. The method of carrying the caterpillar is of some interest, since in Wasp Studies Afield we have stated that the method of certain *Sphex* (*Ammophila*) in carrying the caterpillar with the dorsal surface toward the ground was no mere accident, but was a very effectual improved method. In this specimen of *S. argentatus* it was clearly demonstrated to be a fact.

On three separate occasions, when the wasp left her caterpillar because of my too close proximity, and the caterpillar in curling up its body rolled on its side, in each instance she mounted it, marched on with it for a time with its side to the ground. After pulling it along in this difficult position for a foot or so, she each time stopped and deliberately turned it on her back with her feet and resumed her march with it with more ease and speed. The facts that the stops were deliberate, and that the caterpillar was righted with her feet on all three occasions before she traveled on, show that this is not merely instinctive or tropismic behavior, but actual use of judgment or experience to gain her own convenience; she tried to move it in the position in which she found it, but after a short pull she found a better way and stopped to put it into practice. Of course it is clear to anyone how much more smoothly the rounded dorsal surface will slide over the ground than any other part of the prey's anatomy.

The caterpillar was injured only slightly, wriggled actively when I took it up, and responded to stimulus for five days thereafter. Since this wasp was found nidifying so late in the autumn, one wonders if it does not hibernate as an adult.

Notogonidea argentata Bve. This wasp was seen to fly into a hole in a clay bank, with its prey under the abdomen; she was captured as she emerged, and the burrow opened. This proved to be only a spider's hole, one-half inch across and six inches deep, but at the bottom was a cricket, *Nemobius fasciatus* De Geer [A. N. Caudell]. The cricket was very much alive but its powers of locomotion were dead; however it could cling tightly to my hand by its tarsi. Anothr wasp was caught in a trap set for burying-beetles as early as June 12, 1917, while others were out as late as October 20.

Tachytes peptictus Say. [S. A. Rohwer]. In July, 1918, I noticed a species of green-eyed wasp performing a sun-dance. These were astonishingly fleet of wing, and could not be captured without a net; so, for lack of identification, no record was made of this occurrence. The earth at that place was somewhat sandy and almost bare of vegetation for an area about six feet square under the spreading branches of an old cotton-wood tree.

Two years later, July 2, 1920, I revisited the same spot and was gratified to find the same performance going on in precisely the same way. The wasps had evidently emerged from the ground at that place and were in high spirits in the dance. They were a riotously noisy lot, emitting almost constantly a bee-like buzz when in flight, and the greater part of them were in flight all the time. They danced and cavorted to and fro, in and out, up and down, over this sparsely-covered spot. Occasionally a few would rest for a time on the grey earth or on a green leaf, or on the trunk of the tree. Most of the flight occurred within six inches of the ground; occasionally one would dash off for a moment to a higher altitude, but the swarm in general kept pretty steadily to about that level, and they never ventured more than a few inches above that. When in flight, small groups of from two to four were seen waltzing about one another in circles; often one chased another for a short distance with great swiftness. Sometimes a pair would tumble to the ground, struggle and separate, but I have so far failed to see if this was actual copulation. There were about fifty wasps present in this area, and all were participating in the dance. It appeared that they had recently emerged here; no evidence of their digging could then be detected. The dance was observed for about an hour, which was as long as I could remain at high noon. This species was later seen on the buck-brush flowers at Wesco, Mo., on August 1.

Tachytes obscurus Cress. [S. A. Rohwer]. Several were seen on the sandbar at Wickes, Mo., sometimes entering crevices.

Tachytes mergus Fox. [S. A. Rohwer]. These wasps were on the river sandbar on September 6, 1919, actively running about and often entering holes which appeared to be those of *Microbembix monodonta*.

Tachytes obductus Fox. [S. A. Rohwer]. Seen entering holes in the sand at Wesco, August 1.

Bicyrtes fodiens Hdl. [S. A. Rohwer]. Three were seen to enter holes in the sandy clay by the roadside at Lake View, Kansas. The burrows were evidently in course of construction, and went down diagonally for about four inches. A fourth one entered an abandoned burrow of *Bembix sp.,* from which it kicked out some dirt.

Bicyrtes quadrifasciata Say. [S. A. Rohwer]. One was seen to dig in the soil of Chestley Island on September 16, 1919. It commenced burrows in a dozen places, and often entered ready-made burrows in the sand, which probably belonged to its kin, *Microbembix monodonta.* The latter species, as well as *Bembix spinolae,* was plentiful at this spot, as were likewise the diptera, *Chaetoplagia atripennis* Coq. [J. M. Aldrich], which probably were parasitic on all three species of wasps.

Miscophus americanus Fox [S. A. Rohwer]. A number of wasp cocoons were dug out of the soft sand in the bluff at Silica, Mo., on July 2, 1920. Some of them later brought forth this wasp.

Specius speciosus Say. On two mornings I saw perhaps a half dozen of these formidable wasps flying about a small clump of hawthorn bushes. Some white faces showed that a part of the number were males. The wasps in their flight to and fro often met in collisions in a manner and frequency that certainly made it appear far from accidental; hence we concluded that the whole performance was a flight of courtship of some sort. However, several hours' vigil discovered no cases of actual mating.

On another occasion a day or so later a big cicada-killer flew wildly in circles near where I was busy. Suddenly she flew high in a willow tree fifty feet away and I gave her no further thought. Fifteen minutes later, down she flew swiftly in a straight, diagonal line and without stopping flew directly into a rodent's burrow at my feet. Hence it seems that her circling flight was to make sure of her burrow, perhaps so there would be no search for it when she had her prey. I had known that they often climb trees with their prey in order to be able better to launch on wing with their heavy burden, but I had not suspected that they first select a burrow, or that they may use burrows made by others. She did not reappear, and an attempt to dig up the rodent's burrow proved unsuccessful.

Microbembix monodonta Say. [S. A. Rohwer]. On a large, bald area of white sand on a hilltop at Silica, many of these little wasps were active. They were neither digging nor dancing; but they flew aimlessly about, dropped to the ground and rested, whereupon a second would often bump against the first. Although I watched for about two hours, I could see no actual mating or nest digging; hence I suspected that these were probably the males just emerging. They flew near to the ground, and it was with difficulty that the net could be manipulated to effect their capture. This was on July 2, 1920.

Bembix spinolae. While on September 1 *B. nubilipennis* had entirely disappeared, we saw a female of *B. spinolae* on September 16 just commencing her burrow. In consideration of the fact that it would take her several weeks to feed her young to maturity, this seemed surprisingly poor physical economy. The site was a small sandy area on a vacant city lot. On this spot the wasp scratched some sand out at about eight different places before she found one satisfactory. She scratched and kicked the sand under her in much the same manner as *B. nubilipennis.* She would go down and push the loose soil up from below until the channel was full, then push her way out through it, turn about with her head just inside the channel and rapidly kick out the sand as she retreated, (Plate VI fig. 8) repeat this several times, and then go in again and work up more soil from the bottom.

Bembix nubilipennis. From June 15 we watched daily for the 1919 population of this species, but they did not come out until June 29; on the 30, they were there in goodly numbers, and by July 1 they were at the height of their abundance. From that date on, their numbers did not increase, but with the disappearance of the males a decrease was soon apparent. The appearance of the same colony has been previously recorded for June 16 in 1914 and July 4 in 1915 and June 27 in 1918. In 1920 they emerged on July 2, in even greater numbers than in previous years, and the increased numbers made the dance seem even more riotous than usual. This celebration was confined strictly to the morning hours, 9 to 11. We were long in doubt whether the young wasps emerged from their cells deep underground by following the old channels made by the mother and refilled, or by cutting new ones straight to the surface above them. More recent investigation has shown that some follow one route, some the other, and we have so far been unable to find any factors which would determine their choice in this matter.

While these *Bembix* generally choose their own site for a new burrow when the time arrives for them to give serious attention to nidification, yet we have seen several instances of the newly-emerged insect turning around and utilizing the old slanting channel of its emergence, which in turn was the channel dug by its mother and filled in the previous season.

While this species feed Dipterous insects to her young, the mothers have been seen a number of times feeding on the nectar of the iron-weed flowers.

Cerceris fumipennis. Wickes, Mo., July 17, 1918. Roaming at twilight down a little frequented road I chanced to find in the middle of the path a pretty mound of soil with an entrance in the center. The burrow was uncovered. The nest was excavated; a wasp of the above species was found half way down the burrow, and another at the very bottom. No prey nor pocket was found; hence we concluded that the burrow was evidently in course of construction. Likewise it seemed improbable that two females were nidificating in the same hole; rather it would seem more likely that a second one had merely come in to spend the night. The discovery at this late hour of the day proves conclusively that these wasps do not go elsewhere to spend the night.

The burrrow was about eight inches in depth and of the contour illustrated. (Plate VIII fig. 12, half natural size). The width varied from about three-eights to one-half inch. The form of this nest differed considerably from that of the one described in Wasp Studies Afield, p. 127.

Cerceris flavofasciata H. S. Sm. [S. A. Rohwer]. Taken on buck-brush flowers at Wesco, August 1, 1920.

Omalus iridescens Norton. [S. A. Rohwer]. A sumac twig was taken at Meramec Highlands on July 6, 1918. Early in August a cuckoo-bee emerged. The following April a second individual of this species emerged, showing an astonishingly wide difference in the time of maturity, or at least of emerging. The remains of chewed-up pith in this twig pointed to *Ceratina calcarata* as the host.

Chrysis (Tetrachrysis) venusta Cress. [S. A. Rohwer]. A dead specimen was found in an elder stem, October 15, 1918.

BEES

Halictus lerouxii Lep. [J. C. Crawford]. A male was found feeding on the flowers of sweet clover on July 19, 1918, and on buck-brush on August 1, 1920.

Halictus lignatus Say. [J. C. Crawford]. For half an hour I watched one individual which was sitting motionless within its burrow looking out, with its face flush with the surface of the ground, and fitting the hole like a plug. When finally it was routed and the burrow explored, a second one was found within. This was on July 25, 1915.

Halictus parallelus Say. [S. A. Rohwer]. A number of these bees were seen on the flowers of wild aster near the river at Wickes as late as October 13, 1920. Others were on buck-brush blossoms and sweet-clover in July and August.

Halictus tegularis Robt. [J. C. Crawford]. A female was seen going into its burrow in the sand at Lake View, Kansas, July 26, 1916.

Halictus zephyrus Sm. [J. C. Crawford]. A colony of these bees was seen at Creve Coeur Lake on June 13, 1918. The entrance of each burrow was blocked by the head of the male occupant. This great number of bright eyes peering out their dark doorways was quaintly suggestive of a neighborhood of curious gossips. The females were coming in from time to time laden with pollen. The orifices of the tunnels were small enough to admit no intruder when the head of the male closed the opening, but beyond that point the tunnels were much wider. They went into the bank horizontally for several inches.

Augochlora similis Robt. [J. C. Crawford]. A cluster of seven cells (See Plate VI, fig. 6) was taken from under the bark of a log at Wickes on August 10, 1917. These were made of coarsely chewed bits of wood, and held together by some unknown substance. Adults of this species emerged from these later. This species also nests earlier, for on May 10, 1915 at Meramec Highlands, a similar collection of cells was taken from a like situation; the occupants were in the larval stage and were feeding on the pellets of bee-bread provided for them.

Augochlora confusa Robt. [J. C. Crawford]. A female heavily laden with pollen had fallen prey to a spider, *Phidippus audax* Htz. [J. H. Emerton]. The pair was found on the window-sill at Wickes, July 18, 1917.

Augochlora pura Say. [S. A. Rohwer]. This bee, a male, was feeding on the wild flowers at Cliff Cave, April 21, 1920.

Augochlora prunus Say. [S. A. Rohwer]. Dozens of these bees were seen during the day, April 23, 1920, when the old bark was peeled from fallen trees. They evidently declined to come out into the drear cold weather; perhaps they even nidificated under the sheltering bark.

Augochlora persimilis Vier. [S. A. Rohwer]. This golden bee was very beautiful on the black-berry blossoms at Wickes, May 29, 1920.

Paralictus cephalicus Robt. [J. C. Crawford]. These bees and their burrows were seen in a clay embankment along the roadside at Falling Springs, Ill., September 11, 1916. The tunnels went in horizontally at first and then became tortuous; they could be followed only a few inches. The width of the tunnel was quite ample, but the opening was just small enough to be snugly closed by the head of the watcher. The males sat quietly for long hours at their doorways. That intruders were effectually kept out was evidenced by the fact that a persistent *Halictus* made six attempts in the course of half an hour to enter one of the burrows, and was always repelled by the guard.

Calliopsis nebraskensis Cfd. [J. C. Crawford]. For several summers, a number of large colonies were seen on a baseball diamond on a city lot. The openings of the burrows were completely covered by mounds of fine dust. One nest which was dug up had two entrances covered by separate mounds of dust about two inches apart. These nests were abundantly visited by parasitic bees *Sphecodes sp.* [S. A. Rohwer], which spent much of their time nosing about the hills, poking their heads into the loose dirt and entering the tunnels below, often scuttling out again head first a moment later.

Calliopsis andreniformis Sm. [J. C. Crawford]. One specimen taken from the same area as *C. nebraskensis*, July 15, 1915.

Sphecodes ronunculi Robt. [J. C. Crawford]. One specimen was taken on a window sill in a log house, where it was evidently parasitic on some of the inhabitants of the burrows in the logs.

Andrena crataegi Robt. [J. C. Crawford]. This bee was dug out of its burrow at Cliff Cave, Mo., on April 7, 1915. The aperture of the burrow was open and surrounded by a very pretty hill of pellets resembling an ant hill. It went down three inches; it was evidently in course of construction.

Andrena claytoniae Robt. [J. C. Crawford]. This bee was found in its tunnel a few inches below the surface of the ground at Castlewood, Mo., on April 28, 1915.

Nomada luteoloides Roh. [S. A. Rohwer]. One feeding on sunflower, August 30, 1914.

Melissodes confusa Cres. [S. A. Rohwer]. Many of these bees were gathering pollen from iron-weed at Wesco, August 1, 1920.

Melissodes agilis Cr. [J. C. Crawford]. A hill of loose soil with the opening in the center was found on the baseball diamond July 24, 1915. The burrow was in course of construction, and the female bee was at the bottom. The hole was five inches deep, and went downward quite precipitously. A second bee was taken near to the above on August 22, 1915. This mother had made a horizontal burrow in the face of a clay bank.

Melissodes bimaculata Lep. [J. C. Crawford]. One female taken from a head of red clover July 30, 1917.

Melissodes obliqua Say. [J. C. Crawford]. One specimen taken from the flowers of white snakeroot at Lake View, Kansas on August 30, 1914, and at St. Louis on August 22, 1919. A female was seen to begin digging her burrow in the moist clayey soil. On another occasion a specimen of *M. obliqua* was taken from the grasp of a spider, *Runcinia aleatoria* Htz. [C. R. Shoemaker], to which it had fallen a victim.

Xenoglossa pruinosa Say. [J. C. Crawford]. A male specimen was taken from the flower heads of white snakeroot on August 1, 1917, at Wickes, Mo., and on September 4, at the same place, a second male was removed from the grasp of the spider, *Runcinia aleatoria* Htz. [C. R. Shoemaker]. This yellow flower-spider was hidden in the yellow corolla of a pumpkin blossom where its high degree of protective coloration made it invisible to me; I captured the bee with the forceps, and was surprised to pull out the spider clinging to it.

Anthophora abrupta Say. [J. C. Crawford]. A number of mud cells containing larvae of this species were unearthed at the base of a tree at Creve Coeur Lake on Jan. 15, 1910. A number of these were parasitized by the Chalcid wasp, *Monodontomerus montivagus* [J. C. Crawford] which emerged between the 10th and 15th of the following May. The great preponderance of female parasites that emerged led me to tabulate the count of ten cells. The figures showed a large predominance of females in every cell; out of the 218 insects in the ten cells, the males numbered 31 and the females 187. The number of these parasites supported by a single bee varied from 13 to 29. Some of these lived up to 22 days in confinement, probably feeding on the sugar water in their cage. In another lot of cells, taken from Cliff Cave during the winter of 1915-16, the adult bees emerged between May 8th and 12th. None of these were parasitized by the Chalcids, but by about a dozen specimens of a Dipterous insect, *Mycophaga sp.* (identified by C. H. T. Townsend, who writes that "this genus has not been recorded for America.")

These burrowing, turret-building bees were at work in the disintegrating mortar of an old stone chimney at Manchester, Mo. None of the turrets of the last year's group had survived the winter weather, but I kept close and frequent watch on the chimney because of other insects which I was studying there. The chimney was examined on June 3, 1919, and no *A. abrupta* were there. The next visit, June 7, revealed an abundance of these bees, and since their numbers never increased I concluded that the entire population emerged simultaneously. By July 5 they had so decreased in numbers that only about a half dozen were at work, and by July 15 all had disappeared. This is a water-carrying bee. They came to a puddle in a wagon-rut about a hundred feet away for water; when this dried up they readily filled their crops from a dish of water placed on the ground with floating sticks in it for them to alight on.

On the first of May 1921 a lot of cells containing maturing *Anthophora abrupta* bees were brought into the laboratory, and the sex and date of emergence noted. The males emerged over a period of sixteen days, May 10 to May 25, and the females over a period of only three days, May 23 to 25, or the time coincident with the last three days of male emergence. With one male emerging on May 10, the number on each day following was 1, 2, 4, 1 ,2, 4, 5, 9, 84, 54, 30, 64, 8, 3 and 1, totaling 273 males. The females first appeared thirteen days later than the first males, but 28 strong; 53 emerged on the next day, and 20 on the last, or 101 in all. Hence the priority of male emergence is here quite unmistakable. This fact is frequently met in the insect world; it seems to be an ingenious device of nature to eliminate a waste of the time of the busy females when every summer day is precious.

In Saturniids a similar condition exists. In recording the sex of nearly 3600 giant silk-worm moths as they emerged from their cocoons, we found the ratio of the sexes to be 111 males to 100 females, and the mean date of emergence of the males was from one to five days earlier than that of the females.

Prosopis pyganeus Cress. [S. A. Rohwer]. Found in a sumac twig in the park, in winter of 1919.

Prosopis sayi Robt. [J. C. Crawford]. Two males taken from a tunnel in a sumac stem at 7:30 p. m. on July 4, 1918. The burrow was only one-half inch deep, and the insect had evidently crept in there to sleep.

Prosopis cressoni [J. C. Crawford]. An elder twig taken at Wickes, Mo., on June 28, gave forth three adults of this species about the middle of July. The interior of this twig gave every evidence of being, or at one time having been, the property of a *Ceratina* bee, but I could not discover whether or not *P. cressoni* was a parasite on *Ceratina*, or merely an occupant of her abandoned dwelling.

Colletes compactus Cress. [J. C. Crawford]. We have described the courtship and mating habits of this species* on a bright September afternoon. I was so fortunate as again to meet this species, on September 17 and October 3, 1917, on a sandbar in the Mississippi River at Wickes. They were abundant on both of these occasions. Identification by Mr. J. C. Crawford showed that the first lot collected contained some males of *Colletes willistonii*. Associated with the bees in great numbers was the beetle, *Cicindela rapanda* De Jean [E. A. Schwarz]. The courtship behavior witnessed on October 3 was just as exciting as the sun-dance observed a few years ago, despite the fact that the weather was dark and gloomy. Hence it seems that the courtship is not influenced by the sunlight, since a more sunless and dreary day could hardly be imagined than the last. Furthermore, the sandy area upon which their activities occurred was thoroughly moist. Hundreds came from their mysterious hiding-places to dance over an area about three feet in diameter. All were in a great state of excitement, weaving in and out in the air, in the limited space and never higher than two or three inches from the ground. When one of them stopped to rest, others were soon on top of it. All appeared from their size to be males, and there was no sign of mating. Once a drowsy *Polistes annularis* happened to alight in their midst; at once several male *Colletes* alighted on her back, and one actually attempted to mate. The *Cicindela* beetles which were watchers on the outskirts of the dance area often slowly crept into the ring

*Journ. Animal Behavior 6:367-370, 1916.

and very often appropriated a bee for a meal, but more often the male bees would alight upon their backs with antics which were very suggestive of attempts at mating. Strange, that they should fall upon every larger intruder or stranger which came among them, and even crowded about one of their own number, when it stopped to rest. The excitement ran high, but all of the foregoing activity was as naught when a female *Colletes,* heavily laden with pollen, alighted in their midst. (When I saw this creature, I was sure that all the others were males). A half dozen males alighted on her back at one time, and after much tumbling and rolling about one male accomplished the mating which lasted for fully two minutes, while the others showered her with attentions. So many attempted mating after the successful suitor had left that she was soon so weakened that she could not fly, and even as she slowly walked out of the crowd her very appearance so excited the others that they made life so miserable for her that I interfered. These bees had undoubtedly come from a distance to this area, for all summer up to a short time previously, the sandbar had been completely under water.

Colletes inaequalis [J. C. Crawford]. A female of this species was taken out of her burrow at Cliff Cave on April 7, 1915. The hole went straight down into the ground for seven inches; its diameter was about one-fourth inch, and it had a neat mound of earth around its entrance. The mother was found alone at the bottom of the burrow.

Megachile generosa Cress. [J. C. Crawford]. A female was seen at Moselle on June 30, 1916, carrying bits of green leaves under a loose clod of earth in a recently cultivated field. After she had been watched for several trips, she was captured and the clod removed. A neatly formed cup, made of bits of leaves cut with her madibles, (Pl. V, fig. 2) was disclosed. Since the leaf-cutter bees are known to build in hollow twigs, an occurrence of this sort shows that their behavior is not bound by iron-clad instincts. On August 21, 1916, I found a number of these bees going through a sort of courtship dance on a sandbar in Fox Creek, near Allenton, Mo. All of the specimens taken were males.

Megachile mendica Cress. [J. C. Crawford]. A nest of ten cups made of bits of green leaves was dug out of a rotten log at Creve Coeur Lake. Eight adults emerged between July 1 and 5, 1916. An adult was taken on a black-eyed susan flower at Cliff Cave, October 19, 1920.

Megachile sp. In an old stem was found the dainty two-celled nest of an unknown species of *Megachile*. The cells were made of discs cut from the leaves and yellow petals of wild mimosa. On April 10, 1919, the parasite *Coelioxys* near *sayi* and *octerentati* [T. D. A. Cockerell] emerged.

Megachile brevis Say. [S. A. Rohwer]. In a sumac stem taken at Cliff Cave on April 21, 1920, a beautiful nest of this little bee was found. The tunnel was about two inches deep, and this was completely filled with the nest made of yellow petals. During the last week of May, five perfect adults emerged. Pl. V fig. 4, shows the nests or cells made from portions of leaves in hollow stems by *Megachile* bees.

Osmia near *pumila* Cress. [T. D. A. Cockerell]. Several bees were found dead in their cocoons which were cut out of a sumac twig on November 11, 1919.

Heriades carinatus Cress. [J. C. Crawford]. Three individuals of this species emerged from sumac twigs on August 4 and 5, 1916. These twigs had been taken at Eureka, Mo., on July 12. Two emerged on August 11 and 25 from twigs taken at Meramec Highlands, and a dead specimen was taken from a hollow twig on July 6, 1918. The tunnel in that case was three-sixteenths inch in diameter and four inches long, and in the bottom was a half-pellet of bee-bread. It would be interesting to know whether or not the nest and provisions were her own handiwork.

Ceratina dupla Say. [S. A. Rohwer]. Two of these bees were on the wild flowers at Cliff Cave on April 21, 1920. They carried no pollen.

Bombus impatiens Harris. [J. C. Crawford]. These bees are frequently met in the fields. In midsummer several of them were visiting the potato-blossoms, and in September they were abundant on the goldenrod. In July they were on the flowers of the buck-brush, even early in the morning on dark, cloudy days, and on the *Aster multiflora* in October.

Bombus americanorum Fab. (Frank.) [S. A. Rohwer] A robber-fly, *Proctacanthus milberti* Marq. was seen at rest on a plant inbibing the juices of this bumblebee on August 14, 1919. These bees have often been seen on the goldenrod flowers.

Bombus auricomus Robt. [S. A. Rohwer]. On September 1, 1920, two pairs of these bees were seen in mating down by the river; one pair was on a leaf, the other on the wet ground. The great difference in the size of the sexes made the feat rather difficult for the little male. After two minutes he flew swiftly away and paid her no more heed. The day was dark, with occasional showers, but this did not hinder their activity.

Bombus pennsylvanicus De Geer (Franklin). [J. C. Crawford]. While bumble-bees normally make nests in the ground, occasionally they leave the beaten paths of habit and build in novel situations. One such novelty was discovered at Eureka, Mo., on July 12, 1916. An old paint bucket was hanging, seven feet from the floor, on a barn wall. This bucket, after the paint had dried up, had been used by wrens for a nesting-place the previous summer, and this year the bucketful of sticks and straws was occupied by a thriving swarm of bees. The second odd nest was discovered in a sack filled with straw, lying on the floor of an abandoned club-house at Wickes on August 31, 1918. Bees heavily laden with pollen flew in by the doorway and entered their nest through a rent in the sack. The colony was very strong—at least in the estimation of the small son who complacently sat down upon the sack. Bees of this species were seen visiting the few remaining flower heads of sweet clover on August 24, 1916.

Apis mellifera Linn. A white flower spider, *Mesumena vatea* Clerck. [C. R. Shoemaker] was inconspicuously at rest among the flower-heads where it was sucking the life-blood of a honey-bee. I could not see the spider at first, but was attracted to the motionless honeybee among hundreds of active ones, and soon discovered the reason for the condition.

ANTS

Crematogaster lineolata Say. [W. M. Wheeler]. In the fall, solitary queens of this species are found in tunnels made by the *Ceratina* bee and *Hypocrabro* wasp in sumac and crimson rambler stems. Often the queen makes for herself a little crypt, and uses bits of pith from the sides to plug up the opening. A dead queen was found in such a stem on March 9, 1919; it had probably died of the cold despite the fact that she had made for herself a cozy little room by building a partition or plug of tightly packed pith. During the summer the colonies become quite large. One such colony was taken in the stem of a crimson rambler rose on August 14, 1917.

Camponotus herculeanus L. subsp. *pennsylvanicus* De G. [M. W. Wheeler]. Several females of this species were flying about the lights in the house in the evening of June 18, 1918. Some were smaller than others, and were probably males. One female flew under the lampshade containing a sixty-watt lamp, came out fluttering the wings and fell dead. On June 28, 1918, a worker of this species was taken from the jaws of a cincindela beetle.

Eciton schmitti Emery. [W. M. Wheeler]. A long file of workers of these driver ants was seen at Wickes on

September 10, 1918. They were first seen at twilight, and they continued their travels after dark. Of this species Dr. Wheeler writes: "The northermost point at which this species has been taken in the west is Doniphan, Mo. In the eastern states I have not seen the genus *Eciton,* which is nearly neotropical and runs to Argentine, further north than North Carolina." This shows that the species is gradually working its way northward.

PARASITIC AND OTHER HYMENOPTERA

Pteronidea quercus Marl. [S. A. Rohwer]. Found alive and mature inside a hollow sumac stem at Wickes, April 23, 1920

Tromatobia rufopectus Cr. [R. A. Cushman]. One egg-sac of the common green orb-weaving garden spider gave forth during the summer of 1920 fifteen adults of this parasite. Of the fifteen specimens, thirteen were females. None of the spider's eggs hatched. The parasites each had a separate cocoon, and these were closely massed together within the spider's sac but surrounding her eggs, but whether the parasites themselves spun the material for their cocoons or merely wrapped themselves snugly in the fluffy spider's silk already at hand, I could not tell.

Epistenia osmiae Ash. [J. C. Crawford]. This Chalcid parasite emerged from an elder twig on May, 21, 1918. The twig had been taken at Meramec Highlands just the week before. The tunnel had probably been originally dug by *Ceratina* or *Hypocrabro.*

Grotea anguina Cress. [S. A. Rohwer]. This parasite was in a number of sumac twigs gathered for *Ceratina* and *Hypocrabro* specimens, and is probably parasitic upon one of these two species. The twigs were gathered at Wickes in October, 1917. The silky white, transparent cocoons of this parasite measured twenty mm. in length, and were at the bottom of burrows, about four inches deep, in the twigs. The adults emerged early in the following May. Another cocoon, which was identical with the above, was found in a sumac stem taken at Meramec Highlands on October 4, 1919. This specimen gave evidence of having been parasitic upon *Ceratina calcarata;* pellets of bee-bread, identical with those made by this bee, were found in the chamber. Hyper-parasites which could not be identified emerged from the cocoon, and the only evidence that the original parasite was *G. anguina* was the striking similarity of the cocoon. One other specimen, identified as *G. anguina* by Mr. R. A. Cushman, gave conclusive proof that the host is *Ceratina calcarata.* A sumac stem containing a nest of *C. calcarata* was brought home from Meramec Highlands on July 6, 1918. The bottom cell contained the cocoon of this parasite, and above this were eight cells with pellets of bee-bread and larvae of various sizes. It was not until the first day of May of the following year that the adult of *Grotea anguina* emerged, making a period in the immature stages of at least ten months.

Gasteruption tarsatornis Say. [S. A. Rohwer]. One specimen was obtained from an elder twig taken at Meramec Highlands on May 20, 1918. The date of emergence was not ascertained. The other twigs in the same lot contained *Hypocrabro stirpicolus;* probably this wasp was its host. These parasites, in an immature condition, were found in a broken twig on the ground at Cliff Cave on April 21, 1920. During the last week of May, three adults emerged.

Ophion bilineatus Say. [S. A. Rohwer]. Several adult specimens were entrapped at the light on May 19, 1915.

Psilomastox vulpinus Grovenhorst. [R. A. Cushman]. On the vegetation at Wickes, May 28, 1920.

Amblyteles malacus Say. [S. A. Rohwer]. One specimen taken in the city on July 25, 1918.

Amblyteles sp. [S. A. Rohwer]. One adult emerged from a lepidopterous pupa clinging to a horse-weed stem.

Ptinobius magnificus Ash. [S. A. Rohwer]. A twig containing a channel three and one-half inches deep was taken at Wesco, August 2, 1920. The lower portion contained four cells. The plug and partitions were made of chewed up vegetation, which indicates an *Alcidaema* bee as host The host larvae all died, but the parasite emerged as an adult May 18, 1921.

Parasierola sp. [S. A. Rohwer]. A sumac twig taken at Wickes, Mo. on June 30, 1918 gave forth this adult parasite on the same day. Upon opening the stem, I found a second and empty cocoon of the same species; the pith partitions, some pellets of bee-bread and a dried larvae indicated that the host of this parasite was *Ceratina calcarata.*

Parisierola cellularis Say. [S. A. Rohwer]. One was found alive inside a hollow sumac stem at Wickes, April 23, 1920, and during the last week in May, a half-dozen emerged from stems collected on that same day.

Axima zabriskei How. [J. C. Crawford]. The host of this parasite is unknown to me. Three larvae were found in a hollow blackberry stem on August 14, and on May 1, two adults emerged.

Allocota thyridopterygis Riley. [S. A. Rohwer]. These parasites emerged from cocoons of the bag-worm, *Thyridopteryx ephemeraeformis* between September 11 and 23, 1911. These were kept in confinement, fed on molasses and water, and their length of life noted. Four males lived three days, twelve females lived three days, and the remaining fourteen varied in longevity from four to twenty-four days.

Beetles

Cicindela punctulata Oliv. [E. A. Schwarz] was seen on June 28, feeding upon a large black ant.

Panagaeus fasciatus Say. [E. A. Schwarz]. These beetles were often found walking in the barren road at Wickes, Mo., during the first half of July, 1917. Their coloration and behavior were so similar to those of the

Mutillids as to lead one at a casual glance to mistake the beetles for wasps.

Pterostichus lucublandus Say. [E. A. Schwarz] was abundant in the roads in the lowlands near the river during the middle of August. Two of them were feeding upon a dead moth, *Estigmene acraea* Dru. [H. G. Dyer].

Brachynus intermedius (?) [E. A. Schwarz]. A specimen of this "bombardier beetle" was observed in May, 1914, when it was a party to a little drama enacted with a hop-toad. At about eight o'clock one evening the toad was at the lights getting his dinner. I observed him snap at an insect and just as quickly spit it out, whereupon the prey rapidly ran away. I picked it up to ascertain what this distasteful one might be. It exploded three times in rapid succession while in my fingers. This caused a slight burning sensation of the skin of the parts touched.

Brachynus minutus Harr. [E. A. Schwarz] and *Braychynus cyanipennis*. Several of these were taken under stones by the roadside near Falling Springs, Ill., April 1, 1916.

Selenophorus pedicularius Dej. [H. S. Barber]. In a vacant lot in St. Louis, July 14, 1915, this beetle had its burrow. The hole was just wide enough that the occupant's head blocked the entrance neatly. The resident beetle was kept busy keeping out a little beetle, *Saprinus posthumus* Mars. [E. A. Schwarz] which was making a very persistent effort to get into the hole. Whenever the large beetle would retire to the bottom of the hole, the little one would enter. The former had no trouble in routing it out, since the hole was too narrow for two, and the owner at the bottom of the hole had the advantage of being able to push out the intruder. During the half hour when I watched them, the little one made about twenty attempts to enter. Then with the forceps I pulled the larger beetle out and permitted the little one to enter, then released the larger one and let it reenter. It remained in only a little while, however, came out; went in once more and soon came out, and then seemed to give up, as if disappointed at being unable to rout the smaller one. I dug out the hole, and found it six inches deep, without nest or provisions.

Geopinus incrassatus Dejean. [E. A. Schwarz]. In a stretch of gravelly bottom along Joachim creek at Hematite, Mo., were a number of small sandy areas. On three of these places the sand was heaped up, apprising us of the burrows beneath. The sand had been pushed out in plugs, as is usual with beetles. The holes were about eight inches deep, and sheltered this beetle at the bottom.

Harpalus caliginosus Fab. [E. A. Schwarz]. This beetle was found on a sunflower head which was almost completely withered. The beetle had extracted a seed and was diligently chewing it. It was placed in a vial with an *Epeolus* bee; later it was discovered that the beetle had completely chewed away the abdomen of the bee. Another individual was found in the top of a small rag-weed, munching at the seeds. Thus this ground beetle, essentially carnivorous, sometimes takes the trouble to climb plants for seeds.

Harpalus erraticus Say. [E. A. Schwarz]. The presence of the burrow of this beetle was indicated on the surface of the ground by several piles of loose earth which still retained slightly the plug-shaped or sausage-like form in which it had been pushed out. I followed this burrow, about one-fourth inch in diameter, to a depth of about thirty-six inches, and was rewarded by nothing more than to find this beetle sitting complacently at the bottom. This was on September 12, 1917.

Harpalus pennsylvanicus Dej. [E .A. Schwarz]. Hundreds of these beetles were seen about the roads and stubble fields, and about a dozen pairs in mating on September 17, 1917.

Dineutes assimilis Aube. [H. S. Barber]. This records the fact that this large whirligig beetle was seen in company with large numbers of the small variety, *Gyrinus aeneolus* Lec. [E. A. Schwarz]. In the Meramec river near Moselle, Mo., on September 23, 1916, an oval area about 12 by 36 inches was so closely studded with *Gyrinus* that a pencil could not be inserted between them without disturbing them. This congregation was in the water by the side of a fallen log, and looked like an artifically made piece of bead-work, the whole set off as with studied carelessness with about a dozen of the large ones, *D. assimilis.* A disturbance of the water would cause them to whirligig away, but one by one they would glide back, and so the group would become again intact, and all would be quiet again. The next day they were in the same place and at 6 p. m., when it was nearly dark, they were likewise there. I suspect that it is their habit quietly to spend the night in the water, for I returned early the next morning and found no change in their position or behavior. The mass remained intact until noon that day, when I had to leave. This is the only time I have seen the intimate association of the two species, and I wonder if it is an accidental or occasional occurrence, or if there is any mutual benefit to be derived from the association.

Silpha interrupta Fab. [E. A. Schwarz].

Aleochara lata Groh. [E. A. Schwarz]. These two species were shaken out of the head of a dead robin at Cliff Cave, Mo., in May 1916.

Creophilus villosus [E. A. Schwarz]. About twenty of these beetles, together with other species, were discovered under the body of a dead and decaying chicken. They all buried themselves immediately in the loose earth under the hen, the moment the body was lifted up. In digging them up with the trowel I found them always in pairs, although not in actual copulo; it appeared as though they might have just separated. A few minutes after placing them in a glass jar, I found three pairs in mating. They in the mated condition would walk about, back to back sometimes accomplishing surprising feats of climbing. The others were burrowing in the ground and perhaps mating underground, for in two instances I saw insects that were above ground attempting to mate with others which were fast disappearing underground and had the tips of the abdomens barely protruding. Food was later let down to them on a piece of twine and the twine tied about the lid. The beetles would often climb this twine and sometimes, with difficulty, accomplish mating even there, but soon both would fall.

They were kept for some time in a deep glass jar half filled with earth, and were fed on cooked and raw meat. Often they would crawl on top of the provender but seemed very wary; a slight lifting of the lid would cause them to scamper under cover. When a tiny pool of juice had accumulated on the side of the dead mouse which we had served to them, the beetles were seen to actually drink this up. A small dead garter snake was at another time inserted. At a bruised spot on the side, five of these beetles soon gnawed out a hole three-fourths of an inch in length, and another place twice as large in the middle of the snake. Cooked beef was only sparingly nibbled at, but when no raw food was given they ate enough of the cooked meat to sustain life. They lived thus from April 24 to about May 18. Whether their death then was natural, or due to their artificial environment, I know not.

The beetles themselves had no distinctive odor, but always when picked up with the forceps (and I suppose always when defence is needed), a drop of thick brownish-gray fluid was emitted from the anus. This had a sharp and offensive odor. I made experiments sufficient to prove to my own mind that it was the drop and not the insect which exhaled the smell; both insect and container remained odorless until the animal was teased.

However they could not constantly or continually perform this act, and if the teasing occurred at short intervals they were incapable of giving off this fluid, but instead they would go through abdominal contortions and squeeze out a drop of clear, odorless liquid. They seemed to try to aim directly to strike their persecutor with the substance; when one attempted to pick up a *C. villosus,* it would grasp the forceps with the mandibles and curve the abdomen around ventrally until it touched the forceps, and spread the offensive material on that enemy. If at that moment they were suddenly released, or if they merely missed their aim, they would spread it on their own faces. They required several hours of rest to regenerate this substance in its full strength. While this feat appeared to be a mode of defence, it is possible that it was only a function to facilitate mating.

Staphylinus maculosus [E. A. Schwarz]. This large beetle was discovered accidentally while I was digging out a burrow of a small beetle, *Aphodius fimetarius* Linn. [E. A. Schwarz]. I suspected that this Staphilid feeds on these dung-beetles, and this theory was confirmed five days later, May 3, when it fed on one in my presence. It grabbed the victim in its mandibles, attacked the ventral part of the abdomen and ate headwards.

Hippodamia convergens Guer. [E. A. Schwarz]. Many were to be seen on a vacant lot in St. Louis during July and by the latter part of the month a number were seen in copulo on the grass and milk-weeds.

Tritoma plaincollis Lacordaire. [E. A. Schwarz]. Several of these beetles were feeding on a fungus on the sunny side of a tree and six or eight feet above the ground at Wickes, Mo., on June 11, 1917.

Antherophagus hecate Panz. [E. A. Schwarz]. Shaken out of the head of a dead bird, May 1916.

Hester abbreviatus Fab. [E. A. Schwarz]. Taken from cow dung April 15, 1915.

Saprinus lungens Erickson. [E. A. Schwarz].

Saprinus assimilis Payk. [E. A. Schwarz.] Shaken out of head of dead robin, in company with several other beetles, in May 1916.

Chalcolepidius viridipilis Say. [E. A. Schwarz].

Alaus oculatus Lem. [E. A. Schwarz]. These two chick-beetles were taken at St. Louis the first of July, 1915.

Limonius agonus Say. [E. A. Schwarz]. Found on top of a plant, nestling among the leaves as though asleep, on June 6, 1915.

Photinus pryalis. [H. S. Barber]. This lightning bug was being devoured at night by a spider, *Lycosa rabida* Wlck. [N. Banks], and all the while she was lighting up the gruesome spectacle.

Clerus lunatus Spinola. [E. A. Schwarz]. In the afternoon of July 22 1917, I saw this beetle walking about on a leaf of an oak shrub. Its appearance and movements were so Mutillid-like that I at first really thought that it was a female Mutillid which had wandered from its usual place.

Thanasimus dubius Fabr. [E. A. Schwarz]. Larva was found in stem of a sumac; the adult beetle emerged May 21.

Lucanus dama Thunb. This stag-beetle was taken at Moselle, Mo., the female under rotten bark, on July 1, and the male on the wing at the lights on July 2. Later, in confinement, they ate of grape leaves and strawberry.

Passalus cornutus Fab. Three of these, kept in confinement and fed on disintegrating white oak wood, lived from March 1 to June 4. Three others taken on April 7 died the middle of August.

Canthon chalcites Hald. [E. A. Schwarz]. Thousands of these dung-rollers were seen about Wesco about August 1, busying themselves in every available variety of dung, crowding each other for choice bits and trundling their balls down the rocky roads. There were surely more than three hundred of these and their sister species, *Canthon laevis,* in one eager group in the road. These bearing the purplish tint predominated in number.

Choeridium histeroides Web. [E. A. Schwartz]. Taken near St. Louis, in human dung, May 10, 1915.

Copris minuta Drury. [H. S. Barber]. This horned dung-beetle was found in horse manure at Clifton, Ill., October 27, 1916.

Copris anaglypticus Say. [E. A. Schwarz]. This beetle was taken at St. Louis in cow-dung, May 15, 1915. Later, at Wickes, on June 6, 1917, I dug up in a garden three balls and a beetle of this species from a depth of twelve inches. The balls were at first spherical, with only a small prominence on one side making them slightly pear-shaped. Later, by June 11, I found that on one of the balls the bump had been much enlarged, having been pushed out from the inside, leaving cracks in the crust at that point. I refrained from opening the balls, in the hope that the occupants would in time emerge, but in that I was disappointed, for they slowly dried up. The beetle lived an uneventful life in a can of earth with a little manure until August 18.

Onthophagus hecate Panzer. [E. A. Schwarz]. This dung-beetle was found in St. Louis, burrowing under both human and cow manure.

Ataenius abditus Hald. [E. A. Schwarz]. Taken in cow dung at St. Louis, April 15, 1915.

Aphodius fimetarius Linn. [E. A. Schwarz]. Literally thousands of these dung-beetles were to be seen burrowing in the sand immediately beneath human excrement at a camp at Castlewood, near St. Louis, on April 28, 1915.

Aphodius granarius Linn. [E. A. Schwarz]. Taken in cow manure at St. Louis, April 15, 1915.

Aphodius inquinatus Herbst. [H. S. Barber]. Very abundant in and under horse manure October 27, 1916.

Bolboceros farctus Fabr. [E. A. Schwarz]. At Meramec Highlands, Mo., in a space sheltered by a half dozen pine trees growing close together were about a dozen holes in the earth. They were about the size of a lead-pencil, and each had a neat mound of earth around it. Thinking perhaps they were bee burrows, I attempted to dig them out, but failed on account of the entanglement of roots. One, however, went straight downward for six inches, and at the terminus was this little yellow and black beetle. Whether his presence there was rightful or accidental remains to be determined.

Geotrupes blackburnii Fab. [E. A. Schwarz]. These were taken a number of times in the vicinity of St. Louis, both on the wing at the lights at night, and in the dung-piles or in their burrows beneath. These holes were vertical, and usually had a depth of three or four inches when found. They were found several times in March and April, and were again found to be plentiful on October 27, 1916.

Trox suberosus Fab. [E. A. Schwarz]. At Cliff Cave, Mo., on May 20, 1916, I opened up a short burrow, only one inch deep, in the side of a clay bank, and found this grey beetle within. I do not know whether this was its temporary or permanent abode.

Cotalpa lanigera Linn. [E. A. Schwarz]. While digging into a sandy soil at Wickes, Mo., September 11, 1917, I came upon this insect thirty-six inches below the surface, fully developed but still encased in a light cocoon.

Euphoria inda Linn. [E. A. Schwarz]. On a westward slope at Cliff Cave, in early April, hundreds of these beetles were seen flying low over the ground, often suddenly dropping into the dry leaves beneath. Presently we learned that a number were mating in this seclusion. When disturbed or picked up, they feigned death.

Chion cinctus Drury. [E. A. Schwarz]. This long-horned beetle was taken in the city near a lumber pile. It ate of rotten wood which was offered it, but lived only ten days in confinement.

Romaleum simplicicalle Handl. [J. F. Abbott]. A specimen of this large longicorn was taken at the lights on August 11, 1910. It was kept in confinement for some time, and fed on soft peach and apple, often being found with its head buried in these fruits. It lived for 20 days.

Elaphidion villosum Fabr. [H. S. Barber]. While opening up some sumac stems in quest of wasps on February 12, 1919, I found an adult beetle in the stem, still moist and soft, and a fresh shedding-skin near by; this condition indicated that emergence had just taken place. The most interesting feature was that a plug was just above the chamber and about two inches from the aperture at the top of the stalk. This plug was about one-fourth inch in length, and was made not of the pith of the sumac, but of the tough, woody threads, tightly curled and matted together, making a very compact plug.

Liopus alpha Say. [E. A. Schwarz]. Taken alive in a hollow elder stem, May 15, 1918, and emerged from a sumac twig on May 31, 1920.

Liopus variegatus Hald. [H. S. Barber]. The pupa of this beetle was taken from under the bark of a dead tree at Meramec Highlands on May 11, 1916. On May 17 it became adult, and lived in the jar, containing dead bark, for twelve days.

Saperda tridentata Oliv. [H. S. Barber]. Several larvae and pupae and a few adults of this beetle were found under the loose bark of rotting logs on May 7 and 11, 1916.

Gastroidea cyanea Melsh. [E. A. Schwarz]x *Coccinella 9-notata* [E. A. Schwarz]. A ♀ of *C. 9-notata* and a ♂ *G. cyanea* were in actual copulo when kept in confinement on April 29, 1914. This same condition had been noted in the open field a few days previously.

Melasoma scriptum Fab. [E. A. Schwarz]x *Melasoma interruptum* Fab. [E. A. Schwarz]. These two distinct species of *Chrysilomeda* were actually seen in copulo on May 5, 1915 on a willow. Later the female laid eggs in confinement which hatched.

Babia quadriguttata Oliv. [E. A. Schwarz]. About a dozen of these beetles were seen on a sumac, some in copulo, on June 22, 1916.

Gastroidea cyanea Melsh. [E. A. Schwarz]. A large number of plants of sour-dock, *Rumax,* had, on April 4, 1914, a large number of adults of these blue beetles. On April 14, none were to be seen, and careful scrutiny proved that the adults had entirely disappeared. On April 20, both adults and eggs were present again in abundance. This was probably a new generation. On that date, many dead adults were found on the ground, showing that they were even then on the decline. On April 29, the adult beetles were very scarce indeed, and the eggs were fewer, but on the thousand or more dock plants, all seemed infested—fairly alive—with larvae, in various stages ranging from very small to half-grown. Most of them were feeding on the under side of the leaves, leaving the foilage dotted with transparent spots. While one does not want to call the larvae gregarious, the fact is that they actually did live in clusters or masses, but this was probably due to the simple fact that their food supply was so close at hand that they had little occasion to wander from the place where they hatched from the clusters of eggs. With very few exceptions, the eggs as well as the larvae were on the under side of the leaf. The largest groups of larvae were on the apex of the plant, where the tender young shoots were being devoured. I did not ascertain whether the larvae had migrated to the top, or whether the eggs had been deposited there.

The following year, 1915, I was on the ground earlier, and gathered more data on the life cycle of this beetle. On March 27, with the weather quite cool and the sprouting dock just raising its head above the ground, there were no beetles on the dock in the open field. In a sheltered spot under a large piece of building-paper which had been thrown in the field, a few dock shoots were about one inch high. On these, about thirty adult beetles were found feeding, one pair in copulo. They had probably just emerged from the ground. On April 15, the population of adult beetles seemed to be at its height, and egg-laying was prolific. No larvae were on the leaves, and by digging in the soil under the plants we unearthed no pupae. Hence at this date we got the eggs produced by the first generation. On April 25, the adults had nearly all disappeared, and eggs were rare, but thousands of small and medium-sized larvae were defoliating the plants. By May 13, no eggs, no larvae and no adults were to be seen, but an inch or so beneath the surface of the soil were found hundreds of pupae. A hundred of these were removed from the earth under one plant. They were taken into the larboratory, and on May 16 the yellow pupae transformed into blue beetles. On May 15, just the day before the insects in the laboratory matured, the field was examined and only one adult beetle could be seen. The date of emergence of the population must have been determined by its controlling factors with most wonderful precision, for on May 16, at 3 p. m., enormous numbers of fresh adults were at work on the dock. None were yet copulating or ovipositing, nor were any females with distended bodies in evidence. They all looked alike in regard to size, and I could not tell at a glance if all were males (due to priority of male emergence), or if the females had not yet had time to become distended. In the ground beneath, yellow pupae were scarce.

The field could not be visited for a month. On June 27, we found the blue adults abundant once more. The many dock plants were almost defoliated. I have observed this field for a number of years, but this was the first year that the beetles had wrought such destruction. Plate V, figure 3 shows a dock plant—the upright midribs—all that was left of a thriving clump. This was a typical plant from the field, and not at all a selected exception. With the dock thus gone, the beetles had migrated to the nearby pig-weed, milk-weed and pepper-grass, but many still clung tenaceously to the mid-ribs of their favorite, the dock.

A few batches of eggs laid in the laboratory hatched in six days. The pupae transformed in the earth 1½ inches below the surface, in a little smoothly-lined burrow without an opening.

Trirhabda canadensis Kirby. [E. A. Schwarz]. These beetles were abundant on the resin-weeds at Wickes, June 16, 1917. The fact that portions had been eaten from the weeds in so many places led us to suspect that the adults fed on this plant.

Diabrotica 12-*punctata* x *D. vittata.* Between September 4 and 14, 1912, seven cases of mating between the two species were observed in the pumpkin-blossoms. In every case, the male was the striped beetle, *D. vittata,* and the female the spotted variety, *D.* 12-*punctata.* One pair was observed in copulo for one-half hour continuously; they were then disturbed when being placed in the bottle, but later in the day they re-united for another hour and a quarter.

Haltica bimarginata Say. [E. A. Schwarz]. Feeding on the leaves of a willow sprout October 3, 1917.

Blepharida rhois Frost. [H. S. Barber]. This beetle was found dead in a sumac stem in January. From the position it was evident that it had crept into the hole for shelter and died.

Synchroa punctata Newm. [H. S. Barber]. These pupae were taken from under the bark of a rotten log on May 11. The adults emerged the next day.

Nacerdes inclanura Linn. [E. A. Schwarz]. Many were seen in St. Louis in the first week of June, 1915.

Nemognatha lutea. [E. A. Schwarz]. These were abundant in July on the blossoms of the sunflower, and seldom flew from plant to plant. They could easily be picked up from the flower; they practiced no dropping reaction, but feigned death, stretching out the legs stiff and exuding from the joints of the legs a yellowish liquid. They often spent the night in the heart of the flower.

Orthoptera

Ischnoptera deropeltiformis Brunn. [A. N. Caudell]. On May 10, these were taken during the day from under the bark of a fallen tree. On June 26, at 4 a. m., one was found on a leaf of a roadside plant four feet above the ground.

Ischnoptera pennsylvanica De G. [A. N. Caudell]. Observed frequently at Wickes in June 1917.

Ischnoptera uhleriana Sauss. [A. N. Caudell]. More than a dozen of these brown roaches, all males, were seen on top of leaves of oak bushes by the roadside at 8 p. m. on June 10.

Periplaneta americana Linn. [A. N. Caudell]. This southern roach is now thoroughly established in a north St. Louis planing-mill, having probably been introduced with lumber shipped from Florida.

Parcoblatta pennsylvanica De G. [A. N. Caudell]. During the first part of June 1919, at Manchester, Mo., the males of this species were abundant at early twilight, flying about the outside of an old log house, evidently in search of females. Ten or twenty of these could be seen almost any evening, but only once during the season did I note a female. She was occupied with the most amorous attention to the nearest male. She dashed about him with commotion sufficient to attract the attention of the most naive. Again and again he would turn indifferently aside as she thrust herself squarely in front of him with her demonstrations, but each time, undaunted, she wheeled about and planted herself directly before him with her "tail" toward him, lifted the posterior part of the body and her wings high in the air by stretching and spreading the legs, and nervously vibrated the wings, as though inviting him to approach. Since he did not respond, she abandoned allurement, and in the same manner blocked his path and precipitously backed up under him until the union could be formed. After a moment he escaped and ran away, rather indifferently, but was recaptured by precisely the same method.

Melanoplus femur-rubrum. A number of times recently I have seen the English sparrow pursuing or eating insects, frequently this grasshopper or butterflies. May it be that the disappearance of many horses on the streets is seriously reducing their food supply, and that thus the automobiles may be a factor in changing the diet of the English sparrow from vegetable matter to insects?

Schistocerca damnifica Sauss. ♂ [A. N. Caudell]. This full-grown hopper was found jumping about among the dead leaves at the surprising date of April 7, 1915. Whether he had hibernated or migrated remained a mystery. His coat was all clean and unscarred.

Gryllus pennsylvanicus Burm. [A. N. Caudell]. Crickets in confinement prove themselves practically omnivorous. They eat almost any vegetable material offered them—crackers, clover leaves, potatoes, etc., and in case of extremity, they readily devour the dead bodies of their companions.

Ceuthophilus uhleri (?) Scud. ♀. [A. N. Caudell]. A large quantity of soil had been thrown out of a hole in the side of a little knoll in the road. This earth was in the form of large chips, and their size and form showed that they had been bitten out by some large-jawed insect. The hole was three-fourths inch in diameter, and went in horizontally, quite irregularly, for a distance of 16 inches. It terminated in a pocket 1¼ inches long and 1 inch in diameter, which was 5 inches beneath the surface. The pocket was empty. Midway in the gallery, the above cricket met me. It seems hardly possible that a creature no larger than a grasshopper could have made so large an excavation. The above burrow was found on July 17. On June 16, the following year while excavating a wasp burrow, I accidentally uncovered another containing this cricket. This burrow was very different from the above in all but diameter; it sloped downward into the earth only two inches to the pocket, which was two inches long.

Gryllus domesticus Linn. [A. N. Caudell]. Two specimens, evidently the entire population, captured in a house; one was adult and the other one third grown, although the date was December 1.

Camptonotus carolinensis Gest. [A. N. Caudell]. At twilight I plucked from a shrub a leaf which was curled up and spun together. Snug within was this female cricket. I offer no explanation of its presence.

Hapithus agitator Uhler. [A. N. Caudell]. This cricket was being devoured by a young spider, *Phidippus tripunctatus* [J. H. Emerton].

Paratettix cucullatus Burm. [A. N. Caudell]. This hopper was abundant on the sandy shore at Wickes, September 6, 1919; many in copulo.

Ceresa bubalus Fabr. [E. H. Gibson]. This tree-hopper was evidently a satisfying morsel for an unidentified spider.

Ormenes venusta Melch. [E. H. Gibson]. Being devoured by a spider, *Phidippus audax* Htz. [J. H. Emerton].

Publicia fulginosa Oliv. [E. H. Gibson]. In early September this tree-hopper was abundant on the stems of horse-weed and rag-weed. One was being devoured by a wheel-bug, *Arilus cristatus* Linn.

Acanalonica conica Say. [W. L. McAtee]. This protectively colored tree-hopper was being carried off by a spider. It is of interest because the spider found this protectively colored creature, and furthermore, because it carried its prey to a distance before devouring it. The spider escaped unidentified, but was one of the jumping kind, small and dark, such as are usually found on the ground in low places.

Bugs

Tibicina septendecim [W. L. McAtee]. This cicada can make an astonishing amount of commotion when it is being carried off alive by a bird. Even so large a bird as a robin has to pause frequently and pound it on the ground with its beak to bring it to submission, the cicada screeching frantically all the while. In early summer, the latter part of May, when the adults are newly emerged and the chitin still soft, they often fall prey to birds. By the middle of June, the population is usually at its height, but hundreds of dead ones are to be seen by the roadside and at the edge of the woods; many of these bodies give evidence of a death by violence.

Phymata erosa Linn. [E. H. Gibson]. This "ambush-bug" was snugly hidden in the flowers of the goldenrod while it devoured a fly, *Ennyommopsus nigrifrons* T. [C. H. T. Townsend]. Had not the black fly been so conspicuous in the yellow flower, I should never have noticed the episode. Another such bug was caught devouring a honey-bee in a sweet-clover blossom.

Alydus eurinus Say. [W. L. McAtee]. This bug was mistaken for a wasp, *Pompilus sp.,* and even picked up for such as it ran about on a barren area, June 22, 1916. Not only did its color in the sunshine strongly resemble that of the wasp, but its manner of walking and of opening and closing its wings were strangely deceiving. One cannot understand this in looking at a dead, pinned specimen.

Lygus pratensis [W. L. McAtee]. On February 10, 1919 a twig was brought indoors, with this adult bug in the tunnel. It was very lively, despite the time of year, and flew about the lamp for an hour before it was captured.

Trichopepla semivittata Say. [W. L. McAtee]. A pair taken in copulo at St. Louis, July 26, 1915.

Gerris remigis Say. [W. L. McAtee]. A few years ago in April I took a water-strider of this species preying upon a green caterpillar. The caterpillar had evidently fallen into the water from a tree above; the strider had its beak inserted into its victim for more than a half hour before I took it.

Rasahus biguttatus Say. [E. H. Gibson]. Taken among twigs and leaves at Wickes, June 12, 1917.

Podisus sp. [O. Heideman]. On June 25, 1915, at Cliff Cave, Mo., a nymph of this Hemipteron was found preying upon an adult, *Reduvius personatus* Linn. [O. Heideman]. It had its proboscis inserted in the ventral side of the victim's abdomen, and held it free in the air. Even when picked up it did not release its grip, but continued for half an hour to drain the life-blood of its prey. It lived in confinement for thirty hours after this feat.

Melanolestes picipes (?) [H. S. Barber]. Our notes from various times and places contain half a dozen records of having taken this "kissing bug" in various houses, by the evening lamp. One made known its presence on the back of my neck by inflicting a momentary pain which was so sharp that, in a most unscientific manner, I slapped it without even trying to observe its ways.

Anasa tristis De G. On Aug. 12, 1912, I made notes on the clusters of eggs laid by this insect. The great majority of them had been deposited on the under or shaded side of the leaf. Out of 58 lots observed, 49 were on the under side of the leaves, 2 were on the top of the leaf, 2 were on the stem and 5 were on the board fence nearby. Although most of the groups contain, as Howard says, from 20 to 40 eggs, we found many batches comprising fewer. On September 30, a large number of adults were found under the loose bark of a dead tree where they were probably preparing for hibernation.

Podisus (*Apeteticus*) *maculiventris* Say. [O. Heideman]. At 5:30 one August afternoon this Hemipteron was observed holding by its legs to the fluffy flower of the white snake-root, while it held far out in the air, on its dainty proboscis, a small caterpillar from which it was sucking the juices.

Sinea diadema Fabr. [E. H. Gibson]. Feeding on small beetle, June 22, 1916.

Apiomerus crassipes Fabr. [E. H. Gibson]. Walked sidewise when uncovered under loose board, June 22, 1916.

Alydus eurinus Say. var. *A. ater* Dall. [O. Heideman]. In flight and in manner of walking they closely resemble wasps, October 27, 1916.

Diptera

Morellia micans Macq. [J. M. Aldrich]. Three of these Diptera were found huddled together under the bark of a dead tree, on November 26, 1916. They appeared dead or frozen, but soon revived in the warmth of my pocket, and became quite active.

Trichiopodo radiata Loew. [C. H. T. Townsend]. Pair in copulo at Wickes, Mo., on sumac, June 28, 1918.

Pyrgota undata Weid. [F. Knab]. Taken at lights 10 p. m. May 26, 1917.

Tephritis aequalis Loew. [F. Knab]. Some wasp, as yet undiscovered, had used this species of fly exclusively in provisioning her nest in the hollow of a sumac stem. The two lower cells, less than an inch in length, contained each six flies, while the topmost cell was evidently just being filled by the wasp-mother, and contained only one fly. No wasp egg was found.

Toxophora pellucida Coq. [C. T. Greene]. This Dipteron emerged from a bramble where it had evidently been parasitic on wasps, since between the mud partitions were dead and shrunken Lepidopterous larvae, the provisions stored by the Eumenid wasps for their young.

Tipula sp. [J. M. Aldrich]. Crane fly devoured by an English sparrow, May 15, 1915.

Proctacanthus milberti Macq. [F. Knab.] On several occasions we have noticed the carnivorous habits of this robber-fly. Once it was seen devouring a grasshopper, *Melanoplus sp.* [A. N. Caudell] nymph; again one was flying from plant to plant as we pursued it, carrying lightly a large sulphur butterfly, *Colias philodice,* upon which it was dining—a pretty sight. Another had subdued and was devouring so formidable an adversary as *Bombus sp.* [S. A. Rohwer].

Archytas aterrima R. D. [F. Knab]. In a curled up leaf, which was spun together with silk threads, were a Lepidopterous pupa and the puparium which gave forth this Dipteron, side by side.

Archytas analis Fabr. [C. T. Greene]. Thousands were seen feeding on the flowers of *Melilotus alba* at Silica, July 2, 1920.

Chrysophila velutina Loew. Four of these were found dead in a tiny streamlet at Wickes, July 12, 1917. Two of these were parasitized by a tiny red mite.

Helicobia halicis T. [C. H. T. Townsend]. An ant, *Formica pallidifulva* Latr. [W. M. Wheeler] female was seen going off at a galloping pace carrying this fly. The fly was fresh and limp, but I do not know whether it was newly killed or had been found dead.

Syrphus americanus Wied. [C. T. Greene]. This fly had fallen prey to a spider, *Morptusa sp.* [Emerton].

Erax rufibarbis Macq. [C. T. Greene]. Numerous on the white sand flats at Silica, Mo., July 2, 1920.

Calabata antennipes Say. [C. T. Greene]. Two specimens seen on cottonwood tree where the bark was decayed, July 21, 1920.

Conops brachyrhynchus Mocq. [C. T. Greene]. This dipteron resembling a wasp was abundant at Silica, July 2, 1920.

Slichopogon trifasciatus Say. [C. T. Greene]. These, in intimate company with *Microbembix monodonta* and *Philanthus politus* Say, behaved and appeared in flight so like *M. monodonta* as to deceive even an experienced eye.

Spilomyia quadrifasciata Say. [C. T. Greene]. This wasp-like fly was taken while at rest in the crevice of a tree at Wickes, October 13, 1920. It looks so much like *Odynerus foraminatus* that one would at once suggest protective mimicry, excepting for the fact that in all probability the two species do not appear at the same time in the season.

Chironomus tentans F. [J. M. Aldrich]. At twilight at Creve Coeur Lake, many hundreds of these flies were seen flying from the lake toward the shore. Earlier in the afternoon a beetle, *Cicindela repanda* [H. S. Barber]. was found preying upon this fly.

Chironomus sp. [C. T. Greene]. Over a little stream in Tower Grove Park, three groups of these mosquito-like flies were seen dancing at dusk, on March 20, 1921. One swarm was near a foot-bridge, two feet above the water, and the other two groups were about eight feet above the ground. Each group comprised a hundred or more insects. They hovered or poised in the air without changing their positions, with their heads all pointing southward for many minutes at a time; then for a time they would change to another form of maneuvering, dancing in and out, up and down, facing in various directions. In a short time, however, they always resumed the former behavior. Out of the group a mated couple would occasionally dash away and escape, but darkness was falling so fast that I failed to ascertain from which type of dance the mating occurred.

The gnats and midges of this family bear great general resemblence to the Culicidae. Sharp says,* "They occur in enormous numbers, and frequently form dancing swarms in the neighborhood of the waters they live in."

Tabanus lineola Fabr. [F. Knab]. Found dead in the

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*Insects, Pt. II, p. 468.

laboratory window at Wickes, June 12, 1917.

Hylemyia cilicrura Rdi. [J. M. Aldrich]. This was taken from a milkweed blossom where it was being devoured by a flower spider, *Misumena.*

Cachliomyia macellaria Fab. [C. H. T. Townsend]. Being devoured by a young spider, *Phidippus sp.* [J. H. Emerton].

Phormia regina Meigen [C. H. T. Townsend]. Many of these flies were in the head of a dead robin, perhaps ovipositing, May 20, 1916.

Psorophora ciliata Fab. [J. M. Aldrich]. This fly's method of alighting on one's flesh is very similar to that of the mosquito, but its bite on August 30, seemed more painful.

Actina viridis Say. [J. M. Aldrich]. Two living specimens were taken in April, and in September a number of their puparia were found in manure.

Empis sp. [F. Knab].* At 4 p. m. on a September day, about a hundred of these were doing a sun dance for several hours in a small sunny spot in a shady road. They hovered constantly in one spot, about three feet from the ground. No others were to be seen that day, but at 10 o'clock the next morning a similar group was performing in the same manner further down the road, this time in a shady spot.

Copecrypta ruficauda Wulp. [C.H.T.Townsend]. This fly was abundant on Fox Creek, at Allenton, August 21.

Ogcodes eugonatus Loew. [F. Knab]. This fly had been used for provisions by an unknown wasp. One compartment in the elder stem contained four flies, and the cell on the other side of the sawdust partition contained only one and was evidently unfinished.

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*Later identified by J. M. Aldrich as Empis clausa, Loew.

Termites

Reticulitermes virginicus Bks. [T. E. Snyder]. On April 25, 1915, my attention fell upon a number of winged Termites on the wing. They were easily traced to a tiny hole in the wall of a house, from which they were issuing, single file, and flew away. Sentinels or soldiers were standing guard just outside and also inside the hole as the line filed out. This exodus continued in a practically unbroken stream for a half hour. The place was watched occasinoally for the next two days, but no further emergence was seen. The swarm of sparrows which soon assembled was enough to attract the attention of the neighbors, and they continued their merry feast and noisy chatter as long as the insects come out in the air. A similar exodus was observed from other houses, on May 7, 1920 and May 21, 1920. Some of them which were captured lived less than fifteen hours in vials.

Lepidoptera

Tortricidia pallida H. S. [H. G. Dyar]. Being devoured by spider, *Pardosa nigropalpis* ♀. [J.H.Emerton].

Pieris protodice was preyed upon by the devil's-horse, *Stagmomantis carolina.*

Plagodis alcoolaria Guen. [H. G. Dyar]. This moth was found helplessly impaled and dead on a last year's cockel-bur on April 24.

Hemerocampa leucostigma S. & A. [H. G. Dyar]. This moth was found depositing its eggs in a cleft in a maple tree trunk, October 10, 1917.

Thecla sp. [A. Busck]. Hundreds of these butterflies were clustered in little independent groups frisking about in the sun on a country road, frequently resting with vertical wings on the grey earth. I could see no occasion for courtship, and suspected that the gregariousness was only for play. This was on September 8.

Arctia sp. A sparrow, on May 11, was eating a butterfly, and left us only a wing for identification.

Papilio phylenor Linn. [Ernst Schwarz]. Actually feeding on human excrement by the roadside, September 9, 1916.

Thyridopteryx ephemaeformis. During the past few years, bag-worm cocoons have been taken from the following vegetation: maple, wild sunflower, white snake-root (*Erigeron canadensis*), horse-weed, elm tree, rag-weed, sour-dock, pokeberry, iron-weed, elderberry, pepper-grass, cultivated rose-bush, wisteria vine, rose of Sharon, tamarack, hop vine, iris, sycamore, willow, peach and sweet clover. While they are for the most part found on trees, yet the list shows that they feel at home on almost any plant. In a region where the bag-worms were plentiful, only three were found on a group of eight cedar trees. It is easy to suspect that cedar is distasteful to them. Notes were kept on the longevity of 20 males which emerged in confinement: 18 lived 24 hours; 1 lived 14 and 1 only 12 hours. On October 14, a jumping spider was found devouring the ♂ bagworm while he was fertilizing the ♀ within the bag.

One occasionally finds these bags nicely decorated with seeds (as in Pl. VII fig. 11) instead of the usual bits of twig and leaves.

Pyrgus tesselata Scud. [H. C. Dyar]. A day on the highroad showed this butterfly in only one spot; about a dozen were fluttering around some fresh horse-dung, evidently refreshing themselves upon it. This was on October 19, 1920.

Myriapods

Scutigera forceps. [J. M. Aldrich]. Frequent observations have led me to conclude that this house centipede is carnivorous and feeds chiefly at night. One night in July one was seen clinging to the screen door devouring a small moth. Another was surprised on the stone wall of the cellar where it was eating a young spider, *Zelotes* *sp.* [N. Banks]. On the night of September 9, a moth, *Acronycta sp.* [Heinrich] was also taken from a centipede's mouth. Again, on May 26, one was enjoying a moth, *Diacrisia virginica* Fab. [H. G. Dyar] which it had captured in the darkness. An incision had been made in the victim's body wall, at the side, and the soft abdominal contents devoured. They are even canibalistic. I once placed two of them in a jar; the next morning, there was only one, the larger, and a few scraps of legs and skin of the other.

Polydesmus serratus Say [R. V. Chamberlin]. Under the bark of a rotten log May 20, 1916 we found the neat mud nest and eggs of this species, with the mother's body coiled carefully around them.

Parajulus venustrus Wood. [R. V. Chamberlin]. This milliped was found feeding on the flower cluster of some white-flowered composite by the roadside, October 7, 1916.

Spiders

Theridium tepidariorum Koch. [N. Banks]. A large spider, *Phidippus audax* Htz. [N. Banks] became entangled in the web of the little spider above. The small spider quickly threw a web about the larger one and easily made him his victim—a veritable game of David and Golioth.

Misumena (*Runcinia*) *oleatoria* ♀. [J. H. Emerton]. Feeding on grasshopper, (Pl. VI fig. 7, p=prey) September 10, 1918.

Runcinia aleatoria Htz. [C. R. Shoemaker]. A little Hymenopteron seemed to be asleep on the flowers of a goldenrod. When I picked it up, I was surprised to find that it was held fast by this yellow spider, whose color afforded him such good protection in his hunting-ground, the flower, that even my practiced eye did not notice him.

Misumena asperata. [J. H. Emerton]. One often finds, in the fields or by the railroad-track, sumac twigs, with the tops cut away by the mower, the pith removed and the tunnels plastered with mud. In one large collection which I made of these sealed twigs, about a dozen were found upon closer examination to have the tunnel closed not with mud, but with this little gray spider, motionlessly keeping guard at the top of the tunnel. There is doubtless purpose in this; he probably gets many a meal through this disguise. Even though the bushes are leafless, the *Ceratina* bees come to nest in the cut stalks, and a certain Chrysomelid beetle is frequently found among them. This spider was seen at Wickes, June 18, 1920, devouring a fly, *Ptilodexia sp.* [J. M. Aldrich].

Dolomedes idoneus. [J. H. Emerton]. Two of these females were observed for a time in confinement. The first, after having spent a week in the glass jar with earth-covered bottom, made a packet of eggs and carried it beneath her body. During my absence of three days her egg-case disappeared; I fear that some beetles or a cricket, which I had placed there for food, had dispatched it. The most interesting point is that this one seemed never to eat during the time she carried her egg-case, although all the while choice viands were before her, and she became thinner and thinner until her death on July 14, while her contemporary without an egg-case, in the cage beside her, ate freely and looked well. The other, after a few days, was found manipulating a bunch of wet, yellow, fresh eggs. They were in three heaps, but she seemed to try to get them together while she stood high on tiptoe and spun a web around them, but in the artifical surroundings the work was too imperfectly done for the details to be normal. She, too, died before the eggs hatched. These two, while imprisoned, refused to eat honey-bees, *Lucanus dania,* Carolina locust, cuckoo bee, ensign fly, larvae of potato beetle, *Bercaea haemorrhoidales* Fab., and another bug, *Acrostrernum hilaris* Say. [E. H. Gibson], but gladly accepted daddy-long-legs, spiders, black crickets, meal-bug adults, flies, a half-grown katy-did, and a large brown twig-mimicking caterpillar.

Lycosa rabida Walck. In following a suspicious-looking hole I soon uncovered a chamber, two inches below the surface of the ground; this contained this large spider with a small wasp larva attached to it which shows that this spider is the prey of a digger wasp.

Lycosa kochi Kyserling [J. H. Emerton]. This spider was found in a rubbish pile on May 15, carrying her egg-case. This she lost while being transferred to the vial, but she soon regained it and adjusted it as before, and carried it constantly. A week later I suddenly found that her body was completely covered with myriads of little ones. After three days, they disbanded. The mother was then very very weak and thin and walked slowly, and died after two more days.

Phidippus tripunctata [J. H. Emerton]. These spiders' nests were abundant about the sheds June 13 to 19, 1920. One unique nest had two openings; when disturbed, the spider would use either extremity which at the time seemed the safer.

Plate V

Fig. 1. Nest of the potter wasp, *Eumenes fraternus*. (Photo by Dr. C. H. Turner.)

Fig. 2. Bits of vegetation from which *Megachile generosa* makes her cup-shaped cells.

Fig. 3. A sample of the work of defoliation on sour-dock, done by *Gastroidea cyanea*.

Fig. 4. Nests of Megachile bees in hollow twigs.

Plate VI

Fig. 5. Opening to the burrow of *Notiochares philadelphicus*.

Fig. 6. Cells from which *Augochlora similis* emerged.

Fig. 7. *Misumena oleatoria* feeding upon (p) grasshopper.

Fig. 8. *Bembix spinolae* digging her burrow.

Plate VII

Fig. 9. The cells of the burrowing bee, *Anthophora abrupta*.

Fig. 10. Wood burrow of carpenter bee, *Xylocopa virginica*, reused by wasp, *Monobia quadridens*, which made the mud partitions.

Fig. 11. An unusual decoration of seeds on bag of *Thyridopteryx ephemaeformis*.

Plate VIII

Fig. 12. Burrow of *Cerceris fumipennis*.

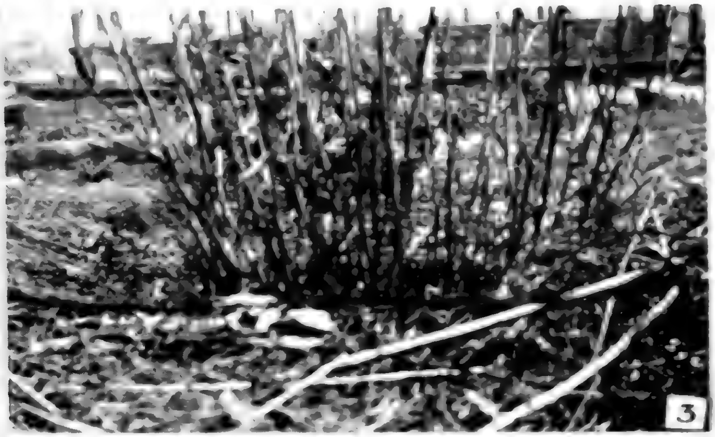

PLATE V


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PLATE VI

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PLATE VII

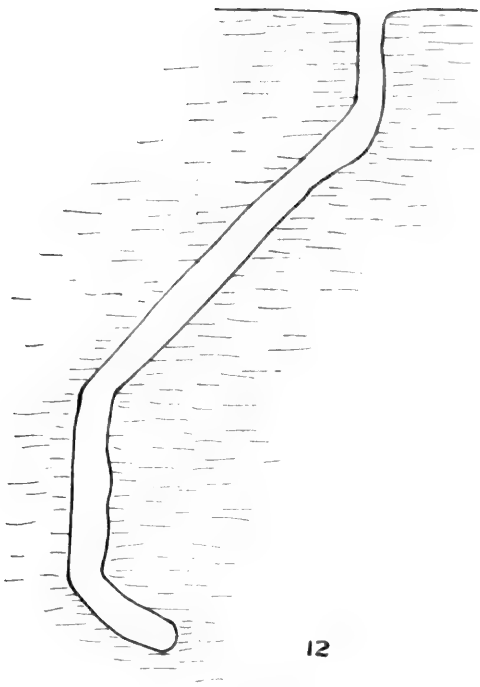

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PLATE VIII

EXTRACTS FROM THE DIARY OF OTTO WIDMANN

NESTING HABITS OF THE PURPLE MARTIN

Old Orchard, Mo., January 24, 1890.

There is certainly more to be said about birds than merely to describe the nests and eggs, and it is a real fact that the habits of our birds, even the commonest, are not too well known. For instance, do we not find in some of our best works that the Martin raises two broods in a season, or "that it is said to raise even two or three broods in the southern states"? With a better knowledge of the habits of the bird such statements would not be possible, considering that the Martin does not commence nesting in Louisiana before April, although the first arrives in February. The time required for a successful rearing of a brood of Martins does not vary much from ten weeks, of which about two weeks are occupied by nidification and oviposition; two weeks are necessary for incubation; four weeks are passed in feeding the nestlings, and the remainder is spent in feeding, leading and teaching the fledglings. Here in this vicinity the Martins begin to arrive in the latter part of March, but of a record of eleven years the earliest date on which young Martins have left the Martinbox is June 25.

The following list gives the earliest and latest dates of young Martins leaving the box, *i. e.,* able to fly:

1878	July 16-July 22	1883	July 14-July 31
1879	July 6-July 12	1884	July 1-July 25
1880	June 25-July 21	1885	July 3-Aug. 4
1881	June 25-July 13	1886	July 1-Aug. 8
1882	July 24-Aug. 7	1887	July 3-July 27
1888	June 30-July 27		

Whole number of eggs laid during the season of 1888 was 220. Pairs building, 43; pairs laying one set, 33;

two sets, 6; no eggs, 4; sets laid, 45; sets hatched, 33; eggs hatched, 128; young brought up to be able to leave the box, 110. Fifty boxes had been erected. Seven were not occupied.

The very early and really untimely return of the old Martin in spring can only be explained by a strong desire to take possession of a suitable nesting site before others arrive. He knows that without a desirable home his chances for getting a spouse are slim. He knows that on her frail heart his glossy coat makes no impression, if it is not backed by a comfortable home. His melodious and rapturous carols will attract her, but before she makes up her mind to stay she satisfies herself that the house which he offers suits her ideas of a home and nursery.

That the same individuals return to the same place has seldom been doubted, but a good proof of it may not be out of place. A few years ago, when Progne appeared on the scene a little earlier than I expected and before I had put up the boxes which were taken down every winter, I had the satisfaction of seeing an old Martin hovering in the air at exactly the same spot and at the very same height above the ground where a box used to stand. This shows that a bird's memory is much better than it is generally known.

In possession of a box of his choice the old Martin sticks to it and awaits the arrival of the females. Sometimes he has to wait for weeks, but whenever the weather is propitious his eyes scan the firmament, and as soon as he discovers the coveted object his voice is raised in ecstacy. A female thus attracted soon alights and the whole colony is in the greatest excitement, every male doing his best to invite the sweet newcomer into his house. After a little rest and meditation she settles daintily at the side of one of the noisy wooers, whose entreaties become now still more boisterous. He persuades her into his house, but she only looks attentively into it at first. She may or she may not enter it. She reflects, is undecided, and goes off into the air, accompanied by an excited outcry from the whole colony. Immediately all males are at her side, and drawing beautiful circles around her bewitching form beseech her in the most passionate terms. Soon she returns, goes from one box to the other, comes back again and sits on neutral ground to reconsider the situation. The whole manoeuver may not take more than half an hour and the choice is made. The rejected suitors content themselves immediately and fights are rare among old people who respect each other's domain, but after the arrival of birds of the second year, when both females and vacant bird boxes become scarcer, quarrels are more numerous. Occupation of a box and mating do not mean nest-building yet. A pair may have possession of a box for weeks before it begins to build, which is generally not before the middle of April and which is even then sometimes interrupted by cold spells, when food is scarce for several days. On fine, warm spring days nest-building is done with great zeal all day, not only in the morning, as before. The female is the one that does most of the work, but the male accompanies her on the collecting trips, and his presence is really of value as he stands guard while she alights on the ground to pick up twigs, weed-stalks, straws, pieces of string or rags.

These rough materials are laid down, not very artistically, but with a good deal of method to make the structure fit for its use. The rough material is kept in place by bits of half-dried cow manure and the wall facing the door is plastered with mud. In rainy seasons more mud is used and some boxes facing west have been found to contain regular walls of mud between the entrance and the nest, the mud-wall itself weighing as much as eight ounces.

When the construction of the nest is nearing completion the happy couple visits the apple tree to line the nest with green leaves. The nest is now ready for the reception of eggs and oviposition begins. In strong contrast to the doings of the European House Sparrow, which continually offends the eyesight by his endless attempts, the copulations of the Martin are performed at such an early hour of the morning that they are seldom seen by human eyes. At this period, when in the dawn of the morning he greets the approaching day with sweet music from the door of his home, the voice of the male Martin has a peculiar softness, and his utterances on these occasions are entirely different from what he says at other times.

Before nest-building has made much progress the Martins do not watch their boxes all day, and especially in cool, dry weather the procuring of food necessitates their absence from home for hours at a time, and often when they return in the evening they find their homes invaded by the European House Sparrow. In such cases, particularly when the Sparrow has already begun to fill up the box with his rubbish, the chances for a recapture of the box by the Martin are poor, unless a friendly hand comes to his help.

After the nests are finished the watch is kept close and often the precaution is taken to cover the newly-laid eggs with a fresh supply of green leaves.

Besides concealing the eggs from the eyes of intruders it also serves to keep them cool. But in starvation times nest and eggs are left alone long enough to give the Sparrow time to enter the house. The Sparrows, however, are not the only ones that play havoc with the hidden treasures; the House Wren also has been seen to intrude and to throw the eggs out of the Martin's box. The Bluejay, the Grackle, the Robin and the Catbird have been seen to inspect the inside of the bird-houses, and it is a question whether such visits are not dangerous in the absence of the owner. It is therefore not at all surprising to find that from eggs deposited in early May none, or few, are hatched. The eggs laid in the last week of May and first of June prove to have the best chance for a successful ultimate result. The outcome of later broods is uncertain for the reason that the mortality among nestlings increases with the advancement of the season. Soon after the first of July the heated, dry period sets in and with its progress insect food adapted for nestlings becomes scarcer and scarcer, while the terrible scourge of the poor bird, its parasites, increases at an enormous rate. The excessive heat in the bird-houses, the parasites and the want of succulent food combine to produce a restlessness among the helpless creatures which early leads to destruction by their falling out of the lofty cradle. The number of eggs is generally five; one nest out of five contains six eggs. Four eggs are laid when a second set is deposited after the first has been destroyed, or it is the result of some mishap, of which a not unusual one is the accidental brushing out by the bird herself in leaving the nest. When incubation is under way the male's business is to watch while she does the sitting, but several times during the day he is seen to enter the box with something in his bill, and a moment later the lady of the house comes out of the door, stretches her wings and goes off. She stays away only fifteen to twenty minutes, but when she returns she has hardly passed the threshold when the male is already on the start and generally leaves in great haste. His presence seems to be hardly more than a watch, and when she stays away long he is likely to come out on the porch, look up to the sky, and even to go off in search of her.

The time which elapses from the dropping of the last eggs to the appearance of the young varies considerably, namely, between thirteen and twenty days. The ordinary time seems to be fifteen or sixteen days. Early broods take longer, late broods a shorter time, so that the weather, directly or indirectly, seems to be the cause of these irregularities.

From the appearance of the first young to the hatching of the last egg in the same nest a difference of two, three or even four days is rather the rule than the exception, and this tends to show that incubation may have set in before the last egg was laid, and it may be the effect of the high temperature in the boxes during day time, while the female covers the eggs at night and in the morning. Oviposition takes place in the morning. The remarkably large number of addled eggs, reaching as high as 20 to 25 per cent, may possibly be accounted for by this spontaneous incubation and subsequent cooling.

When the young Martin is six days old its eyes begin to open, and when it is twelve days old it has already strength enough to crawl out of the nest and take position under the door. Here all the inmates, numbering often four to six, are seen, closely packed, stretching their necks and greeting every approaching object with mouths wide open. At this period the parents are kept busy in appeasing their hunger, and large numbers of dragon flies, soft grasshoppers and other substantial morsels disappear in the capacious throats. Sometimes, however, the insect proves to be too large for one swallow, when the parent bites it in two, but otherwise no dressing of wings or legs is done. In order to facilitate the work of digestion, possibly also for the sake of their chemical constituents, small snail shells which they gather on the sandbars are fed along with the insects, and some knowing mothers descend into the chicken yard to pick up egg shells for an extra dish. Pieces of broken china, found in the stomachs of young Martins, were probably fed by mistake. But the busy old ones not only carry food to their brood, they also remove all their alvine discharges. By the time the young folk appears under the door it is already educated to cleanliness, and a peculiar touch and motion of the parent has the effect that the thus accosted member of the household turns around and offers a white little pellet, which the attending parent seizes cleverly and carefully and carries it off to a distance. Few young Martins die during the first two weeks of their life, but the mortality is enormous during the following two or three weeks, when in a hot, dry season fully one-half were seen to perish. Exposed to a merciless July sun, tormented by innumerable parasites, half dead with the sting of an empty stomach, desperation seizes the poor bird, when it is seen to lose its hold and half falls, half flutters to the ground below. Once down it is lost. If not killed outright by the fall, it is soon found by an animal or, crawling under some sheltering object, starves to death. The parents were never seen to feed one on the ground. They content themselves with a short endeavor to make it fly up, but seeing that this is impossible they give it up as lost. The assistance which man can give in this case is to restore it to its nest, but the probability is that it will fall out again. The best prevention of such disasters is the free and often repeated application of insect powder, scattered over young and nest. When four weeks old the pinions are far enough advanced to carry the young bird a short distance in the air and the parents decide that the time has come when the offspring should leave the nursery. This is the most critical moment in the life of young Progne and bad judgment on the part of the parents has cost many a child's life. Some young fellows, unconscious of danger, follow the leading parent without any trouble, but others, afraid of trusting the untried wings, must be pushed off the platform and, when in the air, instead of following the parent flutter aimlessly about until exhaustion lets them drop where danger lurks. The Martins themselves know well the importance of this step, and a young bird's first appearance on wing never fails to create general commotion in the colony. Some of them, taking delight in the chase, follow the fledgling, and in their endeavor to drive it to a safe place often harass the poor thing until its strength gives out and it falls a prey to the ever-present bad boy, who puts it in a cage and stuffs bread crumbs down its throat until death comes to the rescue.

After the second day out this danger is over, but the parents have to feed it for some time yet, and good parents bring their offspring home before an approaching storm and in the evening to have them under shelter during the night, since camping in the treetop on a stormy night would result fatally. Some have been seen to bring them home, all of them, for ten consecutive nights, but such instances are rare. The rule is to bring them a few nights only and not all of them, either. About one-half are never seen again after leaving the box. This home-bringing is a very noisy and amusing affair, since the parents have a good deal of trouble to collect all the members of a family into one box and to keep them there.

The peculiar call note, one which is only used by parents to command their children, comes here to perfection, and the arrival of every individual is signalized by a general uproar. Having at last succeeded in getting all their children into one box it is necessary to watch and feed them there, lest they be off again. One of the old birds remains until dusk, when it suddenly disappears in the direction of the common roost, leaving the young alone until dawn next morning.

HOW YOUNG BIRDS ARE FED.*

St. Louis, Mo., July 17, 1884.

It may be interesting to you to know more about the family cares of our birds. In order to find out how often young Martins are fed by their parents, and at what time the principal meals are served, I watched my sixteen feeding pairs during an entire day, June 24, from 4:00 A. M. till 8:00 P. M., marking every visit of the feeding parents, males and females separately.

The Martins began hunting at 4:15, but no food was brought until 4:30.

The accompanying table shows that our young Martins had to put up with a light breakfast, but the visits became more and more frequent as the sun and mercury climbed up, and reached their liveliest time between 9 and 10 A. M., *i. e.*, lunch time. After that a lull was noticeable, broken only by an approaching storm, which brought new life into the feeding business, but for a short time only, and to be reduced to a minimum during the light rain, 1:25 to 2:46. Even after the rain had ceased little feeding was done until the sky began to clear up and the sun reappeared.

From that moment the number of visits swelled with great rapidity, and kept me hard at work for over an hour. It was the most substantial meal of the day, and the young Martins may well call it their dinner.

After this the parents took a well-deserved rest, but when the sun neared the horizon they were all off again preparing for supper, which was not so hearty as one might expect.

As a rule the older the birds in the nest the oftener they are fed, and from the size of the insect which the parents bring the age of the young may be judged.

The youngest birds are fed at longer intervals with

*Reprinted from Forest and Stream, Vol. XXII, p. 484, 1884.

crushed insects, mostly small beetles, from the craw. About a fortnight old they are fed from the bill with soft insects of the size of large flies, but insects with stings, such as bees and wasps, are never brought. When four weeks old, large dragonflies, grasshoppers and butterflies make the principal food.

The young Martins do not leave their box until they are six weeks old.

The table needs no further explanation except that the occupants of the sixteen boxes were of all ages, from one week old in No. 6 to five weeks in Nos. 12, 16, 17.

The number of hungry mouths has something to do with the frequency of the visits. No. 7, which heads the list, has four young ones (four weeks old), while most of the other boxes have three. No. 16 has only two.

WEATHER CONDITIONS.	Time.	No. 7	No. 12	No. 17	No. 5	No. 11	No. 10	No. 24	No. 25	No. 22	No. 16	No. 36	No. 1	No. 14	No. 26	No. 19	No. 6	T'l.
75°, calm, clear	4 to 5 A.M.	11	1	9	4	4	10	7	5	6	2	6	6	6	4	3	1	85
74°	5 to 6 "	12	5	9	9	12	12	8	7	4	5	8	6	6	6	4	5	118
77° to 84°, wind light, S.	6 to 7 "	19	4	16	15	9	22	12	10	7	7	8	9	12	11	6	4	171
84° to 85°	7 to 8 "	22	17	22	18	14	17	9	11	7	14	14	8	8	10	6	5	202
85° to 86°	8 to 9 "	26	18	16	19	18	21	9	14	13	13	19	9	7	10	11	9	232
86° to 87°	9 to 10 "	28	25	22	27	25	17	15	15	20	22	12	14	11	7	6	10	276
87° to 89°, wind increasing S	10 to 11 "	27	32	20	20	27	20	12	9	13	17	17	13	6	10	5	7	255
89°	11 to 12 "	17	18	23	14	24	10	16	14	18	18	12	10	8	4	6	5	217
92°, storm approaching, wind shifting to W.	12 to 1 P.M.	28	27	22	22	17	23	15	13	20	14	13	10	11	4	6	5	250
83°, rain commencing at 1:25	1 to 2 "	16	17	13	12	9	7	5	7	7	8	8	6	7	3	5	2	132
78°, rain ceases at 2:45	2 to 3 "	7	5	8	7	9	4	12	10	11	7	7	2	9	12	3	6	119
80°, clearing, calm	3 to 4 "	41	38	35	45	31	38	35	40	32	24	22	23	18	15	14	8	459
79°	4 to 5 "	25	32	20	22	14	17	14	13	13	6	11	5	8	11	8	5	224
79° to 82°, wind S.W.	5 to 6 "	7	20	11	15	12	12	9	14	12	11	7	10	10	3	7	6	166
82° to 81°, calm, clear.	6 to 7 "	11	14	23	15	12	15	24	11	10	14	12	8	4	9	7	5	195
81° to 80°, calm, clear.	7 to 8 "	15	11	11	11	17	4	15	10	10	10	9	10	16	15	6	7	177
		312	284	280	275	254	249	217	203	203	192	185	149	147	134	103	90	3277
Number of visits by male		119	164	140	128	127	92	83	119	98	61	73	39	63	58	57	33	1454
Number of visits by female		193	120	140	147	127	157	134	84	105	131	112	110	84	76	46	57	1823

WHERE THE MARTINS ROOST.*

St. Louis, Mo., September 19, 1884.

It is generally known that Martins spend the night in their boxes only during the breeding season. At all other times they sleep in the open air. By taking possession of the box in the early spring the Martin shows its intention to become *pater familias.* All old males take boxes on arriving, as soon as they can find any to suit them. Young males, although several weeks behind in arriving, do not show so much eagerness to own their own box, and even young pairs prefer camping out until nest-building has begun. Bachelors sleep in the open air all summer, but visit the colony of their brothers and sisters regularly in the morning and evening, meddling sometimes with their domestic affairs, playing tricks, and doing real mischief by annoying the young ones. During the breeding season both parents sleep in their box until the young ones have left the box. The first few nights the young Martins are often brought home by their parents. The weather has much to do with it; rainy, windy weather brings home most of them, but as a rule the best parents, those which feed them most regularly and diligently, bring them home safest and longest, even to a whole fortnight. This home-bringing is attended by much noise-making, and great excitement prevails until the young are safely lodged. The parents do not enter the boxes, but one of them watches the entrance until quite dark, when it hurries off in the direction of the common roost.

Where is the roost? This is not so easily found out. When Audubon saw a high old tree covered with Martins after sunset and again the next morning before sunrise, he thought he would make no mistake by imagining that the Martins sleep on those dead trees all night. But they do not. Those trees are only the meeting place for the

* Reprinted from Forest and Stream, Vol. XXIII, pp. 183-184. 1884.

Martins of a certain district, from whence they start for the distant roost in the willow thicket, which they do not enter until it is quite dark, and which they leave with the first dawn, from ten to fifteen minutes before the swift leaves its chimney.

The young join the parents as soon as they are able to fly the distance, or, as here, to cross the Mississippi. From that moment the boxes are never entered again, but their roofs are used for social gathering in the morning hours during the next few weeks. The regularity of these visits does not last long; pauses occur; in dry, hot weather the visits are short, in cool spells they are cut off entirely, but a sultry, rainy term brings them back again to spend a few hours in animated chattering around the old home. In the evening they only pass without stopping, but they visit often their old hunting grounds in the neighborhood. During the day they are seldom seen after the first of August. After this date they appear late in the evening, but their number increase rapidly. They collect on treetops, church steeples and other points of prominence and loftiness, around which they swarm like bees for about half an hour, when the air for a mile around is filled with Martins, which now form a whirling body of many thousand, rolling up and down at first above the bluffs, then above the Mississippi, going and returning in wide circles, but all this time drawing surreptitiously toward the willows on the other side of the river. It has now become dusk and the descent cannot be seen from this shore, but the moment can be known by a sudden outcry of alarmed Crows and Blackbirds which had retired into the same willows long before.

Such vast numbers of Martins cannot be sent forth from one city nor from a few counties. The Martins of half of the states of Missouri and Illinois must flock together to form such an army. But it is not yet migration; it is only the prelude to it. Such common roosts are the starting points for those thousands, and are the resting stations for many more thousands which pass through in the last week of August and in September.

Our birds became peculiarly excited and mysteriously restless after August 12. After an interval of several weeks, the old birds began at this day to visit their boxes again, hung around them for half hours, not with merry carols as in early summer, but for the purpose of giving a last look at the scenes of former happiness.

August 20 and 21 were stormy, followed by a north wind period with several cool nights. The tactics of the great army were now changed. Migration began. After the 24th the gatherings on this side of the river ceased, our St. Louis Martins had left, and to the St. Louis man the Martins had become very scarce. Not so to the initiated, and if you come along with me across the Mississippi, I will show you more Martins than one can otherwise see in a lifetime.

It is August 24, 6 P. M. Only a few Martins are seen on this side of the river going east. We take a skiff and follow them. After ten minutes' rowing we approach the opposite shore. What is that? Hundreds and hundreds of birds sailing low, above the water, hundreds of silvery splashes flashing up from the now dark waters of the great river. What a strange sight! The Martins are taking their bath. Now we are on the sandbar of the Illinois side, opposite the southern part of St. Louis, just north of Arsenal Island. It is a large tract of fine river sand, newly formed, almost quite dry and free from vegetation, except a strip along the willow thickets which border it on the east. It is 6:30. Since we have arrived the air all around us has filled up with Martins, pouring in from all directions, high up and low above the water, all going toward the one place—the outer rim of the sandbar, where on a few acres of sand ten thousand Martins are sitting already in solemn silence, probably in secret session. Ten thousand Martins sitting close together on a few acres of sandbar is a sight not often met with, and we must look at them very sharply. They are not very shy, many alight a few yards from us and we can watch every movement. The only movement we can see is a picking motion as if taking up a grain of sand, but this is only play work, because we see them also pick at straw protruding from the sand. They did not come to eat sand, their only purpose is to meet here and decide if to go on with their journey southward or to take a rest in the neighboring roost. It is now 6:45 and getting dusk. The smoke of the city, driven by a northeast wind, has enveloped the western horizon and all will be dark in a few minutes. Do they sleep on that sand? They have been sitting here now for half an hour. Look here, four birds coming toward the willows; they are scouts! Is this not a strange call, a call never heard around their breeding boxes? They are now all four above us, circling over the willows and returning to the sand. Presently the ranks of the Martins thin out, and in less than a minute all have left the sand, flying out on the river, down toward the island, rising above the willows, and in a few minutes all is quiet, dark. The Martins have gone to rest, and we will not disturb them. It would be difficult work to penetrate these willow thickets at night.

The willows are about twenty feet high and stand very close together. The ground is swampy in some places and it is covered all over with debris left by last year's inundation. We shall try to see them leave the willows tomorrow morning.

It is 5 A. M., the stars have disappeared, with the exception of a few bright ones. We are on the bluffs opposite the sandbar. The first break of day stands in the eastern horizon, but night still reigns west of us. This is the moment when the Martin leaves its roost. They are already coming over the river; a few voices only, then more and more, and now the whole air is filled with the short calls of Progne. They seem to be all around us, below and above, but we may strain our eyes in all directions, not a single bird can be discovered; it is too dark and the birds are too high above us. A few minutes later the bulk has passed, but it is getting lighter and we are able to see a few loiterers, mere dots passing the zenith, following the others in a northwesterly or westerly direction. A few minutes more the last will be gone and no Martin will be seen at this place before 5 P. M.

After migration has thus begun it will be good for us to visit the scene of rendezvous every day. The Martins begin to arrive at 5 P. M.; they arrive mostly low above the water, comparatively few are coming at some height. As soon as a few hundred are together they begin to sit down on the sand. In the beginning they are pretty restless, changing their places every few minutes, sometimes flying up in a cloud to settle down at or near the same spot again. If we are watching them now from a place south of the bar we notice that not all settle down again. After swinging a few circles, part of the flock detaches itself from the rest, and, heading south, soon disappears in that direction. Although the number remains about the same for two weeks, we soon find that a change has been going on from the beginning. As early as September 1 we become aware that we have almost entirely to do with birds of the year. The old birds, the old males, at least, have mostly left.

The most imposing sight may be had by disturbing the army at the moment when all have settled on the sand. The whole mass goes up in a body, turning right and left, forms two mighty streams which unite above the water in a great whirlpool, rushes up and down, sweeping along the river to a distant point, then coming back again like a huge cloud, which moves hither and thither until the neutral tint of night allows the safe retreat. On September 7 and 8 the number of Martins present was still as large, or larger, than ever. After the sultry, stormy weather of September 9 and 10 a cold northwest wind reduced the temperature to 66 degrees on the 11th, and on this evening the Martins assembled on the sandbar for the last time. The number was much smaller than usual, and when the cloud rose from the bank at 6 P. M. comparatively few returned. On the 12th no Martin was sitting on the bar, but about a hundred flocked together low above the water near the bar and disappeared soon, moving slowly in a southerly direction. The same took place on all the following days. Small flocks began to collect at 5:30 and disappeared after staying about the neighborhood until a little after 6 P. M. The last were seen on the 18th, but only a few, and none today.

THE CROWS' WINTER ROOST AT ST. LOUIS.*

St. Louis has many sights worth seeing, all more or less known and appreciated, but one of its greatest natural curiosities, the big roost of wintering Crows on Arsenal Island, where thousands and perhaps a hundred thousand Crows congregate, is never mentioned.

The Crow is a common summer resident in this part of the country. Every grove has its pair nesting, and around their favorite feeding grounds a dozen Crows may be seen together any day during the breeding season. To these places the young resort when able to fly, and parties of thirty or so are nothing unusual in summer, oftener or sooner heard than seen, especially when the presence of a Hawk excites their hatred.

In the neighborhood of their winter roost they are not seen in any unusual numbers before the middle of September. The river front of St. Louis is sixteen miles long. The center of the city with the courthouse is about half way of this long line. Four miles south of the courthouse, down the river, is the head of an island called Arsenal Island (formerly Smallpox Island, because during the Civil War the smallpox hospital was situated on this island).

At that time the head of the island was opposite the St. Louis Arsenal, and for that reason the name Arsenal Island was given. At the present day the island begins one mile south of the Arsenal, having been washed off continually at its head until about five years ago, when it was fixed by strong embankments erected by the government. At the same time, in order to force the current to the Missouri side, the island was connected with the Illinois shore by a dam which obstructed the flow of water so much that the old channel east of the island is nearly dry now in summer, and willows begin to grow

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in many places. The island is therefore steadily growing; it is two miles long, one-fourth mile wide, mostly grown up with willows and cottonwoods, from twenty-five years old at its present head, where the flora is already more varied by admixture of shrubs and climbers, to one year old and entirely new growth at its recent additions. The foot of the island is a sandbank, changeable in size according to the stage of water, at the present low water about half a mile long, and reaching to the Illinois shore in the vicinity of the Bessemer Steel Works.

The island is not inhabited except by a single old man, who keeps a few cows in summer and tries to raise a little crop of corn for their feed. He does not molest any of its feathered visitors, but the island is a much frequented shooting ground for boy hunters, who make it very unsafe on Sundays.

This island has been chosen by the Crows for their winter roost, and during the fifteen years in which I lived in the neighborhood, I have seen them regularly every winter.

The reason why the Crows selected this island seems to be the convenient position in regard to food supply coupled with comparative safety from nightly raids.

The food supply is twofold: On the land, the environs of a large city surrounded by gardens and dairies and pastures, etc.

On the water, the rich harvest provided by the dumping places of the city, which throws its garbage into the river to carry it off.

The Crow is the typical scavenger, and the choice of its winter roost proves it. If it could live on corn and mice, it would spend the winter hawk-fashion in solitude near some out-of-the-way cornfield, but it is no mice destroyer. Neither is it a grain eater. I have examined thousands of pellets (the indigestible parts of food thrown up), which are lying under the trees where they roost and on the sand where they gather. These pellets show that very few mice enter the bill of fare of the Crow. But they also prove that the Crow has no stomach for grain. Large pieces of maize and entire kernels of oats and wheat are thrown out undigested, and even the acorn, which must often appease their hunger, is found intact in the pellets.

The Crow eats anything and everything, when pressed by hunger, but it prefers animal matter, and it makes no difference whether it is fresh or old. It turns over the old droppings of cattle to see if there is anything eatable underneath. It devours a rotten apple for a change of diet, and eats the chicken without asking how long it has been dead or with what disease it died.

When they are so lucky as to find the dead body of a horse, they return to it every day until the bones are perfectly clean. I have even heard of the remarkable sight, when the cadaver of a man was seen driving down on an ice field, surrounded and torn to pieces by hordes of Crows.

The Crows like our climate, because we have, as a rule, very little snow. The snow which precedes our cold spells comes with a high wind and is, therefore, drifted. Snow which falls heavily later in the season does not stay long. After a fresh snowfall, or during a sudden cold snap, the Crow's resource is the river. For miles and miles along its shores Crows abound, watching at the water's edge, visiting the sandbars and hovering over the river, fishing from its surface choice morsels with which they make hastily for a safe place to eat in peace.

The most animated picture is to be had in times when the river is full of floating ice. At such times it is fairly alive with Crows all day. Sitting on the edge of floating ice fields, they drift down for miles, watching the agitated waves until they bring to light the eagerly sought for dainty in the shape of a rosy lung or similar succulency. When such an article has been found, it is accompanied for many miles by troops of hungry Crows, and the crowning event takes place when the Bald Eagle joins the revelers and gets the lion's share.

In former years, Herring Gulls were not uncommon at such feasts, but of late they seem to be quite scarce around here.

In very hard winters, when the river remains solidly frozen for some time, the Crows are very much less numerous, but as soon as the snow begins to go they return, and when the ice breaks up they are back in full force.

From the middle of September, when they first appear at the roost, until the middle of October, the increase is slow. The last decade of October and the first of November is the time when the bulk of Crows arrive at the roost.

Cool, still days, with gloomy skies and misty air, bring them from the North in loose, straggling flights, from different directions, but falling into line north of the city, they pass around its western bounds near Shaw's Garden, and thence in a straight line towards the foot of the Island, where they arrive in a regular stream which pours in some days from 1 or 2 p. m. until dark.

On arriving above the river the Crow ceases beating the air and, instead of flapping heavily along as usual, it spreads its wings and floats down majestically towards the island, where it first goes for water and then for a perch in the trees. This perch is often changed before the final selection is made. Cottonwoods and willows, twenty to thirty feet high are chosen, and a dozen or more find a place in a single tree.

When the November sun has set, the trees on the lower part of the Island are black with Crows, and the noise they make and which they keep up until quite dark is heard for miles around. Before the sun is up in the morning the Crows leave the roost, but the noise may be heard long before daybreak, and does not cease until they have left. In open weather in fall, hardly a Crow is seen at the roost all the forenoon. The place looks deserted. The Crows have gone, and the first rays of the sun find them scattered over hundreds of square miles. We may go out any direction within twenty miles of St. Louis, but we see Crows winging their way to some distant feeding ground, scattering as they proceed, spreading over fields and woods, but enlivening the scenery wherever they appear.

They seem to do most of their feeding in the morning. In the early afternoon they begin to collect into flocks, and large congregations may be seen in many places, passing the time playfully until ready to go home, when flock joins flock, trying to keep track if wind and weather permit. On clear, still days they fly at great heights. A gale throws them far out of their beaten path and they fly as low as possible, seeking shelter from the wind behind woods and buildings, and following as much as possible the lowest depressions of the ground.

They first appear at the roost soon after midday, but the majority arrive within an hour before sunset; comparatively few come later.

It is not unusual to see them carry food in their bills to the roost, and different kinds of nuts and acorns, pieces of meat and even bones may be found on the sandbank.

As long as the weather remains mild the Crow sleeps in the trees, but when the sharp north wind strips the trees of their leaves the trees lose much of their attraction for the Crows, and they begin to spend the nights on the sand which girdles the island.

In November comparatively few Crows resort to the sand, but when in December zero weather sweeps over the island, most of them remain on the ground, covering the vast sandbar at the foot of the island with innumerable black dots, and as many more again stay on the large ice field which stretches now along the shallow eastern shore like a continuation of the sandbar.

Here they are on the bare ice from 4 p. m. till 7 a. m., fifteen long hours, with temperature near zero, exposed to the fierce wind without any shelter at all. How they can stand it is more than I know, and although I have found frozen Crows, and Crows with stumped toes as reminiscences of former experiences, I still believe, as a rule, they stand the rigors of our winter quite well. The first sunny mild day, and immediately after the coldest spells, the Crow thinks of courting, and shows all signs of an amorous Crow whose love is not by our temperatures refrigerated.

This courting is done openly, in broad daylight, socially, gracefully. The Crows gather on a sunny hillside or some similarly favorable place, and talk to each other in the softest crow language; one flies straight up into the air, soars for a moment, floats gracefully down, cheered by the rest, amidst which he alights to see others do what he did.

As soon as the weather becomes mild and the ground free from snow and ice, the Crows begin to disperse. This is generally not before February, and sometimes quite late in that month, but by the middle of March their ranks are thinned out very much, and few are left after the first of April. Generally, their departure is not particularly noticed, it being a continuation of their daily flight, failing to return to the roost in the evening.

But sometimes I have seen two birds flying together in a northerly direction, even in the afternoon, and right against the incoming stream of Crows. These I take for absconders, ready to dispense with sociability, the two being enough company by themselves. With the beginning of the breeding season the history of the common roost ends. We do not now follow them into the sylvan retreats where they raise a big family. Let us hope that all will return to us in the fall, bringing with themselves a great army of jolly young Crows. Interesting would it be to learn if other cities on the lower Missouri River and Mississippi have similar roosts. Omaha, Kansas City, Cairo, Louisville, Memphis are probably like favored.

OUR BIRDS IN WINTER.

Illustrated by Life-Size Colored Pictures.

(St. Louis Naturalists' Club, February 28, 1920.)

Forty members of the St. Louis Bird Club counted twenty-seven species of birds in taking a Christmas census for "Bird Lore," covering four square miles in the vicinity of Creve Coeur Lake on December 27, 1919. The same number of species was reported by the St. Louis Bird Club on December 22, 1918, but Dent Jokerst and Paul Dent, by making twelve miles on foot in seven hours on the same day, enumerated forty-four species. This is all one party can be expected to see in one day, but if a few days of observation could have been added and different localities visited, the number might have been increased to fifty-six, as has been done once by me. And even this number is possible of a farther increase by some of the casual species that may be met with only by a rare chance and of which there are about ten.

The three Audubon Charts, though made in Massachusetts, can be used to advantage for our purpose, since the bird fauna of the United States east of the 100th meridian, or about the middle of Kansas, is practically the same. The only drawback is that they do not contain all the species mentioned.

Beginning at the upper left corner of Chart No. 3, the Northern Shrike or Butcherbird, *Lanius borealis,* comes to us in November and leaves us in March. It breeds in Canada and Alaska and winters in the northern United States and as far to the south as North Carolina, Kentucky, Arkansas, Texas and Central California. It is a larger bird than the Shrike which is with us in the summer, formerly called Loggerhead, now Migrant Shrike, one of the several subspecies of the Loggerhead. The typical Loggerhead, at home only in the southern states, differs from the Migrant in having the wings slightly shorter and the general coloration darker. In western

Missouri the Migrant intergrades into the paler subspecies, the White-rumped Shrike, with much more white in its dress. All the different subspecies of the Loggerhead are much smaller than the Northern Shrike, the difference amounting to one and one-third inch in total length, and are of less robust build. The general coloration is the same in both species. One of the characteristic, distinguishing markings, the white under eyelid, has escaped the painter of the charts, but the difference in the black stripe through the eye is plainly visible, for in the Loggerhead the black extends over the forehead. Another character is the wavy, darkish lines on the underparts of the Northern Shrike in distinction from the plain white of the Loggerhead. While in the United States in the winter the Northern Shrikes live mostly on mice, but lacking this favorite food they kill small birds and are said to play havoc in some places with the English Sparrows. They are courageous birds; one has been seen to attack a Hairy Woodpecker, a bird as large and strong as the Shrike itself. I myself have witnessed the attack by one of our Migrant Shrikes upon a Downy Woodpecker, which he held on the ground and would have killed if I had not been attracted to the scene by the pitiful cries of the Downy.

There are numerous species of Shrikes, inhabiting most parts of the world. All have the habit of impaling their prey on thorns or barbed wire, or fixing the mice or small birds in forks of twigs in order to get at them more easily, or to preserve them for the future, if they have captured more than they can dispose of at once. In Germany, where there are four species, they are, for this reason, called Neuntöter or Dorndreher. Our summer Shrikes spend the winter in the southern states, but return to us very early and are among the first birds to build nests, often having fully fledged young in May. Young ones taken out of the nest and reared by hand make interesting, charming pets, for the Shrikes are intelligent birds with a comparatively large brain. However, they are quarrelsome and envious, and when two are kept in one cage it will not be long before one of them is killed by the other. Shrikes require much food, and it is for this reason that they are not sociable, prefer a solitary life and drive intruders from their chosen domain. Although belonging to the Oscine Passerine birds, Shrikes are generally not classed among singing birds, but they have a melodious song, though not loud and only given when they believe themselves not heard by man. It was only when I was entirely out of his sight that my pet indulged in his vocal practices, soft and really pleasing performances. Much can be learned from birds kept in confinement.

One grand dominating impulse of migration in spring is breeding, to insure the perpetuation of the species. Migratory birds come north to breed, to rear their young in a climate where the temperature is best suited to their requirements. Another physiological process tells them when to leave their summer homes. The failure of food supply is undoubtedly the most important impulse, but this southern flight has been performed so often and so regularly that the impulse has become hereditary as is demonstrated by many facts. My pet Shrike was in a dark room where no noise such as the calls of migrants passing over could reach him, the room was warm and the food plentiful, but when October came along every evening about nine o'clock he began to flutter in his cage and thrust himself against the wires until quite exhausted. This migratory instinct forces most birds to leave their breeding grounds long before real want of food is felt, often at a time when nothing indicates the approach of winter. Many insect-eating birds leave in August and September when insects are most abundant; seed and fruit eaters depart when there is still an abundance of food for them. Few insectivorous birds winter in the United States, but many species go deep into South America to Brazil and Peru. Some nesting in the northern United States winter in the Gulf States, and many Canadian birds find our climate not too severe for their winter quarters. Birds that have the longest journey to travel start earliest. Some birds born in high altitudes arrive in the United States as early as July. Nineteen species of shore birds breed north of the Arctic Circle, and everyone of them visits South America in winter; six of them go to Patagonia, a route of 3,000 miles. But the Arctic Tern beats them all; it nests as far north as the bird can find land to make its nest. When the young are grown the family leaves the Arctic and a few months later they are found skirting the edge of the Antarctic Continent, 11,000 miles away. Of land birds the Nighthawk has the largest route, 7,000 miles from Yukon to Argentina.

While it has been proved that regular migrants, the real birds of passage, have their fixed winter quarters, to which they return every year, there is another kind of migration which we may call nomadic migration. This is most prevalent in cold regions, but is found over most of North America. To this class of migrants with no settled or definite winter home belong the Pine Grosbeaks, the Crossbills, Redpolls, Snow Buntings, Shore Larks and many others.

As the nomad wanders to and fro, pitching his camp here one day, miles away the next, so do these vagrant birds pass the non-breeding season in quest of food. All of these species are gregarious, are fond of each other's company, some wandering in troops, others in large flocks. It is this sociability which forces them to move constantly from one place to another to find all the food they need. So long as food can be obtained in sufficient quantity some species show a reluctance to leave their home, unmindful of temperature. Even in the Arctic regions some birds may be found all winter, where food can be had, species whose food consists of buds, twigs, seeds, berries, or of carrion or refuse; or those that prey upon other birds. Ptarmigans, Ravens, Gyrfalcons and Owls belong to this class.

Of avian nomads several are shown on the chart. The Purple Finches, the Pine Siskins, the Gold Finches may be called nomads, for their stay in any place is of short duration. Few birds are more erratic than the Waxwings, the Cedar Waxwing of the United States, and the Bohemian Waxwing of the Boreal Zone of both hemispheres.

Many of the nomadic wanderers have a circumpolar distribution. Either the species themselves or nearly related species or subspecies occur in Boreal regions of America and Eurasia. One hundred and twenty-eight genera of birds are found in both hemispheres, and of the 31 boreal genera of the North American mammals 25 are common to Boreal America and Eurasia. As similar facts exist in reference to insects, reptiles and plants, faunal geographers have combined the Palaearctic and Nearctic regions into one grand division under the name of Holarctic Realm.

A fine example of a bird with circumpolar distribution and nomadic habit is the Pine Grosbeak. In summer it lives in the forests of the Boreal region. In winter it wanders in flocks far and wide, according to circumstances, extending its movements irregularly into the northern United States, exceptionally as far south as Missouri, where it has been recorded once from La Grange by Susan Johnson, December 3, 1903. Other southern records are Kentucky and District of Columbia. They live on the seeds of trees, coniferous and deciduous, their buds, and are particularly fond of the berries of the Red Cedar and of the seeds of the

White Ash. The males have a pleasing song and are favorite cage birds in the north of Europe, where the bird is common.

The Crossbills are of circumpolar distribution, inhabiting in nearly related species the coniferous belt of both hemispheres. The White-winged Crossbill is purely American, breeding chiefly in the Northwest, but occurs often in the company of the Common Crossbill, with which it shares the same habits.

Crossbills are peculiar in structure; the head is large, the jaw stout, the bill long and compressed, the tips of the mandibles abruptly bent, so that their sharp points cross each other at an angle. This curious tool is a special adaptation to its food and the manner of securing it. The sharply pointed curves serve as the most convenient hooks for getting the seeds of the pines, spruces and hemlocks out of the cones. The bill is also used as a tool for climbing after the manner of the parrots. Crossbills are true nomads. They have not even fixed places nor regular times for nesting. They may occur by thousands some years and be quite absent during others. Nests have been found from February to October. They seem to breed only in places where they are sure of enough of their favorite food trees, spruces and balsams, loaded with ripening cones. They rove widely in search of food and their wanderings in winter extend irregularly southward, exceptionally as far as South Carolina and Louisiana.

When feeding in trees no sound escapes their throats, and they would easily be overlooked if it were not for the noise made by the falling scales detached from the cones by the birds in securing the seed. When disturbed in their work they all start at once with a peculiar note, and fly far, but may be back again after a short time. On the wing they look like female Cowbirds or overgrown House Sparrows, especially the young birds and females in their dusky dress.

A great wanderer is the Snow Bunting. It makes its nest in the Arctic and Subarctic Region, and is the first passerine bird to penetrate into those regions with the return of spring, before the snow is melted. In winter they come south, usually in large flocks, to the northern United States, sometimes as far south as Indiana, Missouri, Kansas, Colorado and Oregon. They are decidedly gregarious and delight to fly in the stormiest weather. Their appearances is often considered the harbinger of snow, and they return northward with the disappearance of snow. All are gone from the United States by the end of April. They are said to be much less numerous than formerly in the regions which they visit regularly in winter. One of the reasons for the decrease is that they have been slaughtered by hundreds for food and for millinery purposes, the beauty of the bird in its spring plumage of black, white and brown rendering it particularly attractive as a "hat bird." It is also said that thousands of heads of Snow Buntings were palmed off on county clerks as those of English Sparrows, when bounties were paid on them. It may be said that bounty laws under the best conditions are expensive and unsatisfactory, and as far as the English Sparrow is concerned have proved to be extremely unwise and ineffective, as many of our valuable birds have been destroyed and bounties illegally paid.

Better acquainted than with the Snow Bunting are we Missourians with its cousin, the Lapland Longspur, because we have it as a regular winter visitant, appearing from the north in November and remaining till March, exceptionally as in the cold spring of 1907 till the middle of April. They are similar in general appearance to the Snow Bunting, but with a large black patch on the breast and a chestnut collar on the back of the neck. In early winter the black is obscured by white tips of the feathers. It breeds in the northern part of both hemispheres and comes south to the United States, chiefly the middle states, abundantly to Kansas and Colorado. Near St. Louis we meet with it in most unlikely places, on windswept hillsides, often in company of Horned Larks, feeding on grass seeds, probably also on grasshopper eggs and dead grasshoppers. It is a great sight to watch a flock of a few hundred hungry Longspurs alight on a tract of untilled land. They do not scatter over it promiscuously as some other birds would do, but start all together at one end of the tract and go at once to work picking up whatever there is for them to eat, advancing like an army in one direction. After a very short time those in the rear of the advancing column fly low over the heads of the flock and alight at the head of the army, but are at the head only a few moments when another party leaves the rear and goes to the head. This goes on until the whole tract has been gone over, and is certainly a good way of gathering everything desirable with the least possible loss. When disturbed the whole flock goes up to a great height and is soon lost out of sight, for they are great flyers and are among the longest-winged members of the Sparrow family.

A rover, but a 100 per cent American rover, not a hyphenated intruder from the Old World, is the Evening Grosbeak. He is at home in the mountainous West from Canada to Guatemala, but visits with irregular frequency, sometimes in large flocks, as far east as New York and New England. The species has repeatedly been encountered in Missouri and may be looked for at any time between October 1 and April 1.

I had the pleasure of making its acquaintance in Stratton Park, near Colorado Springs, June 6, 1903, where a male and female were hopping unconcernedly on the walks of that very much frequented pleasure resort. It is a bird of distinguished appearance and not easily overlooked or forgotten. It would be something to be thankful for if the species would become more plentiful and would extend its breeding range into the middle states.

There is no reason why it should not find food in cultivated, settled regions, as it does not live mainly on the seeds of conifers, but eats all kinds of seeds, high and low, and feeds its young on insects like its congener, the Hawfinch of the Old World. This bird, the Kirschkernbeisser of Germany, is an ornament to any landscape, admired by the nature lover, but less popular with the grower of cherries, which the bird likes more for the kernel than for its meat.

When speaking of the avian rovers likely to be met with by St. Louisans in their winter walks, it would be amiss to omit the Waxwings, of which there are two well-defined species, one a rare winter visitant, the other a common resident. The rare guest, the larger of the two species, is the renowned Bohemian Waxwing, citizen of two worlds, equally well known in the Old World and in the New, because of circumpolar distribution. The smaller species is the Cedar or Cherrybird, a 100 per cent American with no brothers or sisters in the Old World. For the larger part of the year the Bohemian deserves its name, for it leads the life of a gypsy, a man without a country. In breeding time it retires to parts of Alaska and the Canadian Northwest, but, wishing to live in company and feeding chiefly on wild berries, it has taken to a habit of wandering, which carries it far away from its nests in search of sufficient food. They may appear in a particular locality one winter and not be seen again at the same place for many years. It is probable that they come to Missouri much oftener than we are aware of, for it is by mere chance that we come across a troop of birds of such erratic behavior. They must not be confounded with our Cedarbird, which they resemble very much in color, shape and habit, but which are about an inch smaller, have no white on the wings, and white instead of chestnut under tail feathers.

Although a troop of Cedarbirds may be met with on our walks in any month of the year, as a rule the bulk of the species spends the coldest time south of our state, when they feed largely on the berries of the Red Cedar, Haw, Sumac, Bittersweet, Chokeberry, Black Alder *(Ilex verticillata)*, Smilax and Hackberry. Restless fruit eaters, like these Cedarbirds, are nature's best agents in the distribution of the seeds of many trees and shrubs. I may state here that I had the good fortune last summer of watching a pair of these birds at their nest. This is considered a rare chance, not only because the birds themselves are uncommon in summer, but because they are the most secretive of breeders. The nest was fifty feet from the ground in the top of an Elm tree, and luck willed it that one of the owners slipped into it at the very second when my glass was fixed upon it. Unlike most other birds the Cedarbirds are very seldom seen in the vicinity of their nest, but arriving from a distance alight directly at the nest and disappear within. When leaving they take wing immediately at the nest and fly over the tree tops, disappearing in the distance. As soon as the young are able to fly the family joins others and is never seen at the breeding stand again.

One of the best treats we can have in the bird line is when our winter walk leads us upon a troop of Redpoll Linnets, as the Redpolls are often called. These beautiful, sprightly little birdies with a red crown and pink breast belong to the rovers, who restlessly go from place to place in flocks containing from 6 or 8 to more than a hundred birds each. Like Crossbills and other rovers they are irregular in respect to their visits in the United States. Sometimes absent in a locality for several years, they may again appear in small numbers or perhaps only late in winter. In Missouri the earliest ever reported was on November 4 and the latest April 8. Redpolls have one of the greatest ranges of passerine birds, and the very same species is found in Europe and Asia from England to Japan and in America from Alaska to Labrador.

Their near relationship to the Goldfinches and Siskins is at once noticed in their behavior, the same affectionate and confiding disposition, allowing a near approach when occupied in feeding on the seeds of herbs and grasses, in the pursuit of which they come into our towns and suburbs.

One of the best-known birds with a circumpolar distribution is the Horned or Shore Lark. It is known in Europe and Asia, in northern South America, northern Africa, and received its specific name Alpestris because found as a breeder in the Alps.

The type species, the one upon which the genus has been based, breeds in northeastern North America and in Europe and comes to the United States only in winter, occasionally as far south as Missouri. At least it appears that flocks of Horned Larks seen on the sandbars in the Mississippi River opposite St. Louis belonged to this subspecies, a geographic race that may be distinguished from our resident subspecies *praticola* by its large size, darker color and yellow instead of white head-and-throat markings. As the difference in size amounts to half an inch it is quite obvious to a practiced eye, but the fact that our Prairie Horned Lark is not known to frequent sandbars at any season, but that the type species habitually prefers large flat tracts along the seacoast or inland waters in the winter wanderings, seems to confirm our identification. It is, however, true that in cases of subspecies real proof is desirable and scientists are not to be blamed for rejecting reports of unusual occurrences not attested by specimens. As the West and Northwest of North America are inhabited by other subspecies, there is a probability or possibility that some of our winter visitants belong to one of those. The study of Horned Larks is made still more complex because our breeding subspecies is largely a resident bird and does not leave us until driven away by deep snow. Even snow has no horror for some of them who know where to find sustenance in pastures and farmyards or follow roads into towns in quest of a favorite bird food, horse droppings. With the replacement of horses by the auto this supply has greatly diminished, a circumstance which our House Sparrows have especial reason to deplore.

The Larks, though having a general resemblance to many members of the Sparrow family, have anatomical characters that separate them into a family of their own. It has its center of distribution in the Old World, where about one hundred species are recognized, among them the celebrated Sky Lark, while America has only one species, but this is so well scattered over the whole continent that the last edition of the A. O. U. Check List enumerates fourteen subspecies. While the song of the Horned Lark cannot be compared to that of the Sky Lark, it still has some merit, and is so much more interesting because given by the bird while on wing high in air.

When speaking of the birds of a circumpolar distribution, we must not forget to mention the Snowy Owl. Everybody has seen mounted specimens of it, for it is a favorite object of the curio shops, especially those at Niagara, a region in which the bird sometimes appears in large flights. Old males are nearly pure white, younger birds and females are more or less barred by transverse spots of brownish. In its summer home the Snowy Owl lives mostly on lemmings, and it is not every winter that it leaves its boreal home, but in some years large flights have reached the United States, when as many as 500 have been reported from New England alone. Exceptional wanderings have carried some of them into central and even southern states to South Carolina and Louisiana, and flights have been observed far out at sea. The species is more diurnal than nocturnal, and when away from home takes what food can be obtained, chiefly mammals, but also birds, fish and even offal. The breeding range extends from the limit of trees north to the Arctic Ocean. The flesh of the bird is said to resemble that of chicken in appearance and is very much relished by the Eskimos. The bird is capable of rapid flight and is able to catch ducks and pigeons on the wing, striking them down after the manner of the Duck Hawk.

Siskins, as we generally call them, although the name belongs to a different species of the Old World, are counted among the winter residents of Missouri, but we better call them winter visitants, for they are, like the Purple Finches, highly erratic. They may stay a few days at a place, but when gone may not be seen for a whole year. They breed in the northern coniferous forests and in the western mountains down to the Mexican border, but are great wanderers for one-half of the year. In appearance they resemble much our Goldfinches in their winter dress, but are easily known by the spotted underparts and yellow areas on wings and tail. Having the feeding habits of the Goldfinches, the two species are often found together on their feeding grounds and at the water pools, but when disturbed the Siskins go off their own way, keeping together in troops, which sometimes amount to real flocks. Before their departure in spring the males become very musical, but their song is not as melodious as that of the Goldfinches or that of the Purple Finches.

The latter are great musicians, in fact they are one of our best songsters, their song resembling that of the Warbling Vireo, undisputedly an artist among songsters. Purple Finches are more regular in their visits to us and might be classed among our winter residents if they would only remain longer in one place, but they like to rove from one feeding ground to another in search of favorite food, the seeds of trees, shrubs, weeds and grasses. Like other birds they have sometimes a hard task to get at their food. During one of those dreaded periods, when everything was covered by snow and frozen rain, when boys were skating in the streets of St. Louis, I came upon a troop of Purple Finches in a sinkhole near Carondelet.

They were feeding on the berries of the Coral Berry, Indian Currant or Buck Vine, as the shrub is variously called. They had probably been feeding there all day, for the frozen ground was covered with the pulp of the berries, discarded by the birds in the attempt to get at the kernels, which served them as food for the time being.

Most of the Purple Finches seen in winter are in the brown dress of the female or young male, but there are always a few more or less crimson colored old males among them. Brown birds seen in the act of singing are probably all young males, though it is possible that females try to sing, as we know that female Cardinals and female Pine Grosbeaks are doing.

The Yellow-rumped Warbler or Myrtle Bird is not really a winter resident with us. When we see it late in December, as we see it often, we can label it a delayed transient, rather than winter resident, because records of their occurrence in January and February to the middle of March are rare. Some observers insist on calling all birds seen in the month of December winter residents. This is a mistake. A bird may be kept back by an abundance of its favorite food, as, for instance, in this case the drupes of Poison Ivy or Red Cedar berries, but when these are all gone the birds will leave and not return until spring migration sets in. In the Atlantic states it is the Myrtle Berry or Bay Berry, the fruit of *Myrica Carolinensis,* which grows in large numbers along the coast, that keeps the bird lingering through a part of winter and has given it the name of Myrtle Bird. To us Yellow-rump seems to be a more appropriate name. Late in fall as well as in early spring Chipping Sparrows and Bluebirds are often their companions. Bluebirds may also be mentioned among our winter birds, for though the real winter home of the species is south of the Ozarks, there are always a few remaining with us in sheltered bottoms and are liable to appear at their breeding stands any warm day, even in January. This year the first were seen at Webster Groves on February 2, when a sudden warm spell induced them to visit their old haunts, not to stay, but simply to see how matters stand. On such inspection tours they remain only a short time, announce their presence by a few carols and retire to their feeding grounds in the creek or river bottom. It is hard tc explain how they find nourishment enough to bridge them over the snowy and icy periods, since their main sustenance must be taken from the insect world, but for warm quarters to spend the nights old woodpeckers' holes serve them well, and I have myself witnessed how three or four entered the same hole, certainly a good way to keep warm. All birds accumulate a layer of fat in autumn, and it may be taken for granted that this store is drawn upon in times of want.

The Missouri River, flowing from west to east and cutting our state into two parts, North Missouri and South Missouri, forms in winter the dividing line of two faunal zones for many species of birds, absent or rare in North Missouri, but becoming more and more regular or numerous as we proceed from the river southward.

As belonging to this class we may name the Migrant Shrikes, Mockingbirds, Bewicks and Winter Wrens, Meadowlarks, Doves, Prairie Horned Larks, Rusty Blackbirds, Cowbirds, Grackles, Sapsuckers, Flickers, Turkey Vultures, several kinds of Sparrows, Purple and Goldfinches, Siskins, Kinglets, Kingfishers, several kinds of Hawks and Ducks, Robins and Bluebirds.

The Robin is no stranger to our winter fauna. We meet him in flocks in the heavy timber in Christmas time, hear even his song and cheerful call when we least expect him. I have seen him as early as the first day of February in Shaw's Garden, but ordinarily it is a month later when he mounts his favorite perch at his summer home for his first song within the city of St. Louis.

At Old Orchard I have seen one once when the mercury was below zero, but the intelligent bird was not freezing to death, for he was hugging a pile of fresh stable manure that kept him warm and may have fed him at the same time.

Birds which do not breed with us but come to us regularly to spend the winter we call winter residents, distinguishing them from winter visitants, those species that appear only for a short time and are more or less irregular in their visits to the same locality.

Of our true winter residents we have to name at first the Junco or Snowbird, as it is commonly called. Ours and the adjoining states are the winter homes of millions of these lovely, sprightly creatures, to whom no cold seems to be too severe as long as they find something to eat. In former times they found food and shelter in the virgin forests with their fallen trees and impenetrable brush, but since these have given way to farm land, the Junco resorts to the pasture and farmyard for its food supply. With the first awaking of spring the Junco becomes restless and excited and gathers into flocks to begin the flight toward its summer home, which is chiefly north of the United States and extends to the Arctic Coast. Subspecies inhabit the western mountains, one the Alleghanies.

The Canada Tree Sparrow occurs through the greater portion of British America in summer and winters from the northern United States southward to Virginia, Tennessee and Oklahoma. In general appearance it reminds us of the Chipping Sparrow, which is with us in the summer, but leaves us at the time when its northern cousin comes. Besides being a little larger, the Tree Sparrow differs from the Chippy by having broad white wing bands and a dark spot on the breast. It always occurs in troops, sometimes in large flocks, and is provided throughout the winter with an unfailing supply of seeds from the dried flower clusters of goldenrod and other withered weeds that reach above the snow. The number of wild plants and trees which keep their seed through the winter is greater than the casual observer would believe. Many of them are widespread species well suited to form winter staples for granivorous birds. Like most visitors from the north the Tree Sparrows are very active, lively birds. Even when feeding they utter a low note with a musical sound, and given by many individuals at the same time produce a conversational chirping, so pleasantly modulated as to sound like the expression of contented companionship. This habit is so much like that of the European Tree Sparrow that it caused the early European settlers to give the bird the name of Tree Sparrow, otherwise a misnomer, since the bird from Canada does not frequent trees at all, but seeks the thickets for a retreat and protection from weather and enemies and makes its nest on or near the ground. To the winter residents of the vicinity of St. Louis we must add several more members of the Sparrow family, though they occur in much smaller numbers than the Tree Sparrows and Juncos. The more common of them is the Song Sparrow, to be found chiefly along the "wet weather branches" running through fields and pastures and usually bearing a fringe of tangled weeds and grasses, thus forming an excellent retreat and feeding ground in all kinds of weather. Among them are sometimes a few Swamp Sparrows, but their true winter home is from southern Missouri to the Gulf. A particular pleasure is derived from a meeting with a party of Fox Sparrows in the bottoms of the rivers. They are likely to greet you with a few musical notes even in January, and you will see the musician on top of a low tree only a short distance away. They are usually in company of other Sparrows, among which they appear like big brothers.

White-throated Sparrows are not rare, but they stick to their seclusion in the heavy underbrush of the forest, while the White-crowned Sparrow is to be looked for along the hedges in the fields or with other sparrows at the border of forests.

Other Sparrows, but belonging to the class of "permanent" residents, because here in winter and summer, are the Cardinal and the Towhee. Like the other Ground Sparrows, with which they are often associated, the Towhees are great hiders, and when keeping silent, as it is their habit in winter, it is not easy to get a sight of them, although they may be present in the same locality all winter. Even the Cardinals of striking coloration and large size know how to keep out of view in the heavy shrubbery, but it is a fine sight to see one of the beautiful birds emerge from its seclusion and, if the sun shines brightly, give you one of its cheering songs even in the depth of winter. In sheltered places where corn is shocked or left standing on the stalk in the field we may have the good luck of coming upon a whole flock of them when other food is scarce.

On such an occasion we may discover that Nuthatches don't starve when corn is to be had and we may be astonished to see them extract the nucleus only, the sweetheart of the kernel and reject the rest. Nuthatches, of which we have four good species with seven subspecies in North America, belong to a family which is like the nearly related Creepers and Titmice of circumpolar distribution. In Missouri two species are of regular occurrence and a third of local range in the pine region of the Ozarks. Of the two commonly found around St. Louis one is a permanent resident, the other a transient and occasional winter visitant. The first is the White-breasted or Carolina Nuthatch, the other the Red-breasted or Canadian Nuthatch. Both have the same habit of hopping up and down the trunks and branches of trees in a manner which distinguishes them easily from other birds. While other woodland birds like the Wood Thrush and Pewee have learned to accommodate themselves to the new conditions connected with civilization and are building their nests near human habitations, the Nuthatches stick to the woods and avoid man as much as they can in nesting time. But in winter they lose this shyness, join roving troops of Titmice and come to our fruit trees in the orchard and to our shade trees around the dwellings, doing much good as insect destroyers.

Chickadees and Tufted Tits belong to that small coterie of permanent residents who try and mostly succeed in braving our winters. That they sometimes succumb to the cold, I have seen myself. After a cold night a Chickadee fell lifeless from a tree in front of me and a Nuthatch was found frozen stiff in the spout of a gutter on our house in Old Orchard. The poor bird had crawled in it, taking it for a safe place, not knowing that metal is a good conductor of heat, becoming very cold at night and taking off the warmth of the little body. But as a rule we may assume that birds which take refuge in tree holes can withstand very low temperatures and our Chickadees and Titmice are happy and frolicking even in the cold weather. Their food supply is always accessible, insects and seeds serving them equally well for nourishment. In search of these they wander in little troops, never alone, but often accompanied by other birds, usually Downies and Nuthatches, sometimes Creepers or Kinglets, a lively assemblage, welcome wherever they go, be it forest or park, farm or city, never doing any harm, but always lots of good. The Downy and the Hairy Woodpecker are permanent residents, often seen in pairs in winter and therefore believed to remain mated the whole year. It stands to reason that many other species could furnish examples of permanent mates, but it is not easy to prove in species where male and female are not as easily distinguished as in most of the Woodpeckers. Redbirds, the sexes of which are easily told, are also found keeping together in winter, as if mated for another year.

While our Woodpeckers are very quiet in winter, they are among the first to feel the impulse of love and are with their companions, the Tufted Tits and Chickadees, the most prominent wooers in early spring, announcing their intentions in no mistakable manner, and notifying others of their kind by drumming to keep out of their chosen domain.

An unique visitor of our wintry woods is the Brown Creeper. It is invariably found hugging the trunks of trees and easily overlooked, because of its colors of various shades of brown and white. It is the busiest little body in the woods, always on the move, diligently following its useful occupation of gleaning insects and their eggs from cracks in the bark, holding to its support by its sharp claws and rigid tail feathers. On seeing an observer it goes to the opposite side of the tree, but by waiting and watching we may get a glimpse of it again higher up on the tree. It starts usually near the base of a tree and ascends by little jerks in a spiral way, uttering an occasional soft chirp, leaving the tree before ascending very high in order to begin the ascent at the base of another tree. It is a conscientious worker, but its labor becomes monotonous, because it is an endless repetition without variation. When you have watched it a few minutes you have seen it a year, and seeing one is seeing a thousand. To us the species is of particular interest, because Missouri is the only state in which it has been found breeding south of the coniferous forests of the North, except in mountainous regions. Nests have been found in the Bald Cypress swamps of the Southeast and on dead elm trees in the Duckpond in St. Louis County. The nests are usually built behind the loose bark of decaying trees, but with the disappearance of these opportunities for nesting sites our Creepers will be forced to do as the Old World cousins have been doing for a long time and put up with any kinds of holes in trees and even crevices on buildings in the woods.

One of the birds most difficult to find is the Winter Wren. It has to be looked for chiefly along creeks in the woods, where it loves to hide under the exposed roots of trees. In migration it has visited wood piles and brush heaps in populated places, but as a rule it seeks the retirement of the forest.

The Bewick's Wren, whose summer home is chiefly south of the Missouri River, while that of the Winter Wren is in the north, is sometimes found in winter in the suburbs of St. Louis. The Carolina Wren used to be one of our conspicuous birds in winter. Its loud whistle was one of the first sounds we heard on entering its haunts. The species was known as a most faithful permanent resident, being found at its breeding stand all the year round. It is only since the unusually severe winter of 1917-18 that Carolina Wrens have become scarce, and in fact in most places where it was known to occur for many years it is totally absent since then.

A really dainty little bird to be met with in our woods in winter is the Golden-crested Kinglet. It is a hardier species than its cousin, the Ruby-crowned Kinglet, which is with us in spring and fall. The Golden-crested has two black stripes on the head enclosing a yellow stripe, which in the old male has a scarlet center. It is not always easy to get a good view of these markings, as the little fellow is in almost perpetual motion. In migration they occur in small troops by themselves, but in winter we find them usually in company of Titmice. Their soft "see, see, see" and sprightly actions show they are always in the best of spirits. Their summer home is mainly north of the United States, but we find them breeding in the mountains of the Atlantic States and in the West. In Europe, which has nothing like our Hummingbird, two species of Kinglets are the smallest birds known.

Bluejays are not as plentiful in winter in our neighborhood as some seem to think. They are rather few in number, but by many people oftener seen in winter than in summer, because they come into our very yards in the city to gather food from the garbage pail and chicken coop. They have found out that the immediate vicinity of dwellings is not only the best place for finding food, but also the safest from their winged enemies, the Hawks and Owls. Very few Bluejays remain in our woods in winter; even such places as cemeteries are forsaken, though these are favorites in nesting time. It is the omnivorous nature of the Jays and Crows that helps them over the hardest times. Crows were formerly the most conspicuous birds in winter in the city of St. Louis, when all the garbage collected in the city was dumped into the river. In the eighties they had an immense roost on Arsenal Island, opposite Carondelet, and later on Gabaret Island, opposite North St. Louis. In going to and coming from their feeding grounds in the county they had to fly over the city. While the flight from the roost in the early morning was but little noticed, the flight to the roost in the afternoon was a grand spectacle. As early as four o'clock, in cloudy weather even much earlier, troops of Crows began to come from the west, flying at great heights in clear, calm weather, but low over the roofs of houses on windy or cloudy days, crossing the city at certain points, troop following troop until the passage became a continuous stream of birds, denser and denser, until the sun had sunk down in the west. From points of vantage one could follow the birds to the island and see them alight on the sandbar that separated the willow-covered interior from the water. There the thousands and thousands of Crows alighted, went to the water's edge to get a drink and took a good long rest before flying up to find a perch in the willows, which were then forming an almost impenetrable thicket, 15 to 30 feet high. On these willows they spent the long winter nights, poorly sheltered from the cold northerly and westerly winds blowing over the river.

A crow can withstand severe cold much better when the feet, the most tender spot, are protected, and when too cold for them in the willows they remained all night on the sand, and when snow was on the ground, on the snow. After they had left in the morning one could see every spot where a Crow had spent the night; a round depression of about six inches in diameter, flanked on the lee side by a few droppings of excreta and on the wind side by a few holes in the snow made by the bird's bill. When Illinois began paying a bounty for Crows their number dwindled down rapidly, and in the past ten years there were no crows flying over the city and one has to go to the Missouri River region to see flocks of crows in winter.

The most interesting winter roost in the vicinity of St. Louis is that of the Red-winged Blackbird, a place where thousands of them come together every evening to spend the night in company, while they scatter far and wide in search of food during the day. The roost is on sandy land between the Creve Coeur Lake and St. Charles bridge. The place is overgrown with scouring rushes, *Equisetum hiemale,* which during the summer reaches a height of two to three feet. In the fall the stems break, and in leaning over in all directions form a matted mass under which small animals find the best possible resting place in winter. The ground being sandy absorbs rain quickly, snow remains mostly on the matted mass and a freezing rain makes the shelter even more secure.

Under these rushes the Redwings spend the coldest, windiest nights in perfect comfort, and it is only lack of food that reduces their number when deep snow covers their feeding grounds, fields and pastures, where animals are kept or cornfields where corn is left in shocks or on the stem. During the day not a bird is seen about this roost, the birds crossing over the river to spread over St. Charles and neighboring counties, but in the evening before sunset they come in long streams, pouring into the adjoining timber before going to the rushes, which is done only when dusk is settling over the region. Most of these Redwings belong to that subspecies or geographic race that breeds in the United States, but in the depth of winter they are joined by a northern, larger subspecies which comes down from Canada to spend the coldest time with us.

When we watch the incoming flocks closely, as they fly over or alight in trees to rest, we see sometimes a troop of Bronzed Grackles in their company, and once in a while we meet with a few Rusty Blackbirds or a Cowbird on our rambles through the county in winter, but as a rule these species are less hardy than the Redwings, especially the males. We may assume that the Redwings we have here in winter, though of the same subspecies as the ones that breed here, are from the northern United States, and some of them seem to be intermediates between ours and the Canada subspecies, *ostralegus*, which is nearly an inch larger than ours.

There are always a few of our Flickers and Redheads left behind when the great army of their kind has gone to more genial winter homes. These abandoned individuals lead a recluse life and are therefore easily overlooked. The Red-bellied Woodpecker is of a decided sedentary habit and we count it among our true permanent residents. Another truly permanent resident is our Bobwhite. It can stand well our ordinary winters, can go without food a few days, but extraordinarily cold and snowy winters have proved destructive and have decimated their numbers badly.

The Grouse, Partridge or Pheasant, as the Ruffed Grouse is called by different people, is still found, though rarely, in our state. Old settlers claim the species was once plentiful, but this must have been before the state became settled by the white man with his shotgun and hunting dogs. There are several theories trying to explain the deplorable scarcity of this valuable game bird. One is that a disease killed them; another that the spread of the jigger was destructive to the young or sitting hen; one said the extension of the range of the Red Fox into Missouri was the cause, the Red Fox being much more dangerous to birds than the Grey Fox, but I think it is mainly the farmer's hog that prevents the rearing of all kinds of birds nesting on the ground in the timber. Towhees, Ovenbirds and several other species nesting on the ground are exterminated in woodlands where hogs are kept, and most of our Missouri woods are overrun by hogs. They are as destructive to eggs as to young birds, and where no young are reared the species must soon disappear.

Besides the birds already mentioned there are several kinds of Hawks and Owls to be found here in winter. The Screech, Barred and Great Horned Owls are true permanent residents, while the Short-eared, Long-eared and Saw-whet Owls may be counted among the winter visitants. The Sparrowhawk is a real permanent resident in St. Louis, but has only become so since the English Sparrow has multiplied so wonderfully, affording the Hawk a never-failing provision at all times. Of the large Mouse-hawks, the Red-tailed is with us all the year, the Red-shouldered being a less hardy bird, while the Marsh Hawk and Rough-legged Hawk are regular winter visitants.

CHAETURA PELAGICA (Linnaeus) CHIMNEY SWIFT.

(St. Louis Naturalists' Club, Feb. 26, 1921.)

The great Linnaeus took our Chimney Swift for a Swallow and called it *Hirundo Pelagica* in his *Systema Naturae* of 1758, and changed the orthography of the specific name in a later edition in 1766 to *Pelasgia.* It is not clear why he employed these words, since the meaning of *pelagic* relates to the high seas, like marine; it can only be understood that he took it figuratively to mean nomadic, migratory, in allusion to the nomadic *Pelasgi,* an ancient, prehistoric race of the Mediterranean region. Even Wilson described it in his *American Ornithology* in 1812 as *Hirundo Pelasgia,* Chimney Swallow. Bonaparte in his *Synopsis, Birds of the United States,* 1828, took it from the Swallows and placed it in the same genus with the European Swifts and called it *Cypselus Pelasgius.* He was followed by Nuttall in his *Manual* in 1832, and by Audubon in his *Ornithological Biography* in 1834, but in Audubon's *Synopsis* of 1839 and in his *"Birds of America"* in 1840 the bird appears under its new name, *Chaetura Pelasgia,* which was corrected by Baird in 1858 to *Pelagica,* on account of its priority, being used by Linnaeus in 1758.

The genus name *Chaetura* has been bestowed on the bird by Stephens in Shaw's *General Zoology* in 1826. The word is made from the Greek χαὶτλ, a bristle, and ευδα, tail, in allusion to the spines, which project from the ends of the tailfeathers. Although Swifts have much in common with the Swallows in appearance and habits and were formerly counted among them, not only by the people generally, but, as we have seen, also by systematists, they are now widely separated from them in classification.

While the Swallows belong to the Suborder *Oscines* of the Order *Passeres,* the Swifts form together with the Nighthawks and Hummingbirds the Order *Macrochires,* from *macro,* long, and *chir,* hand, established by Nitzsch in 1829, an order well defined by anatomical characters. It is remarkable that, though so much like Swallows in many respects externally, the Swifts have scarcely any part of the structure which is not formed on a different plan. The Swallow family is a good member of the *Oscines* or Song Birds, a suborder of the order *Passeres* or Perching Birds. There is only one other suborder of the *Passeres,* the *Clamatores* or Songless Perching Birds, to which belong in North America only the Flycatcher family, *Tyrannidae,* while the *Oscines* comprise all the rest of the small land birds with the exception of the Woodpeckers, Cuckoos and Kingfishers, which form orders by themselves. The order *Passeres* exceeds by far all other orders in number of species, of which there are over 9,000, as many as of all other orders put together.

The *Macrochires* of the United States are divided into three suborders: *Caprimulgi,* Goatsuckers; *Cypseli,* Swifts, and *Trochili,* Hummingbirds; the first two are *fissirostral* or birds with deeply cleft gapes, and the latter *tennirostral* or birds with slender bill. *Cypseli* is taken from the Greek word κυψεηος, Swift, from their rapidity of flight. The suborder *Cypseli* is again divided into families and subfamilies. Our Chimney Swift belongs to the subfamily *Chaeturinae* or Spine-tailed Swifts of the family *Micropodidae,* also called *Cypselidae,* of which there are nine genera and seventy-eight species. The four species of Swifts of the United States belong to three genera, two of which are only found in the western United States, the Black Swift and the White-throated Swift; the third genus, to which our Swift belongs, is represented on the Pacific Coast by the Vaux's Swift, a much smaller bird, but of similar habits.

The Swifts are found all over the globe and are well represented in America, but some genera are exclusively East Indian and Polynesian. All have the salivary glands developed to secrete a mucus which serves to glue together the material to build the nest. Species of the Old World *Collocalia* make the edible bird's nests, so much sought after in China and Japan. There are many interesting peculiarities connected with the nidification of Swifts. A *Panyptila,* a cousin of our White-throated Swift, living in Guatemala, attaches a tube a foot or more in length to the underside of an overhanging rock, constructed of the pappus of plants, caught flying in the air. Entrance is from below and the eggs are laid on a shelf near the top. A near relative of our Swift in Brazil makes a similar tube nest out of seeds of a certain plant, suspends it to a horizontal branch and covers the outside with feathers of various colors. As there is no shelf to receive the eggs, it is believed that these are cemented against the sides of the tube and brooded on by the bird while in an upright position. A *Dendrochelidon,* a Swift of Java, builds, on a horizontal branch, a narrow platform of feathers and moss, cemented together, and lays in it a single egg. The nest is so small that the bird sits on the branch and covers the egg with the end of her belly.

When this country was first settled Swifts were breeding and roosting in hollow trunks of forest trees, but the change from trees to chimneys must have been early, for the first writers on birds connect them with their habit of using chimneys for nesting and roosting. At present the change is nearly complete, as comparatively few cases become known where hollow trees are used for nesting. In Missouri it is mainly the water tupelo, *Nyssa uniflora,* which may still offer them retreats, because apparently healthy trees are entirely hollow, resembling flues and affording entrance by broken-off branches. We found a nest with eggs in such a tupelo in the St. Francis River in Dunklin Co., fastened to the wall of the shaft only two feet above the water in which the tree was standing. As the opening was fifteen feet from the water, the nest was in the safest place possible, no enemy being able to reach it and it was hard work for an axe to get at it from the skiff in which we were.

It is a remarkable coincidence in their domestic affairs that in spite of the great difference in anatomical structure and therefore distant relationship, the Chimney Swift has one important trait with the Swallows and that is the readiness with which it modifies its way of nesting according to circumstances. Of the seven species of Swallows which we have in North America six have almost completely changed their modes of nidification, breeding now in convenient places offered by buildings, or in houses expressly provided for their use. It may be presumed that in consequence of this change of nidification Swallows have increased in numbers of individuals with the settlement of the country or civilization, as we are pleased to call it, but it is a positively known and easily explained fact that the Swifts have not only become much more numerous in all populous parts of the Eastern United States, but have extended and are still extending their breeding range into the treeless regions of the West, following the building of human habitations on the Great Plains which formerly had to be avoided for want of nesting sites. The present distribution of the Chimney Swifts is a large one; it breeds in all the Eastern United States, from the Atlantic to the Great Plains and from about 50° latitude in the southern provinces of Canada to southern Florida and southeastern Texas. Reports of its occurrence in this large area are so evenly and thickly spread that we cannot help to assume that in numbers of individuals the Swift surpasses the six species of Swallows of the Eastern United States put together, but, strange to say, its winter home is not known. A few Chimney Swifts have been taken in migration at Vera Cruz and in Yucatan (Cozumel Island), but it is a known fact that when the last Swift has left the United States at the end of October the species has entirely vanished until the first ones reappear in the Southern States in March, five months after their disappearance. This is such an unique occurrence in birddom, for we know by this time the winter habitat of nearly all North American birds, that it is not strange to find people who think the Swifts must hibernate in some unknown, inaccessible retreats in Central or South America, spending the five months in a lethargic or torpid state like the bats and many reptiles and batrachians. About half a dozen species of *Chaetura*, resembling our Chimney Swift, have been found in different parts of Central and South America and the Antilles, but no one has ever told us where the millions and millions of Chimney Swifts of the United States spend the winter. That such enormous numbers of birds of one species could escape the vigilance of scores of collectors working for generations in all parts of the Western Continent is really mysterious. If the species had a restricted distribution and were therefore little numerous, as, for instance, the Kirtland Warbler, which is breeding in only three counties in central Michigan, it would not astonish anybody to be told that its winter quarters are not known. But in the search by ornithologists the winter home of even this rare Warbler has been found in the Bahama Islands.

This chapter of possible hibernation of a bird is so interesting that I cannot refrain from reading to you what Dr. E. Coues, the most talented writer in bird literature and one of the most distinguished promoters of American ornithology had to say on the subject.*

The Chimney Swift is a wonderful bird. Besides its mysterious disappearance in fall there are three features in the economy of its life which stand out prominently: Its marvelous powers of flight, its peculiar nest building, and its unique roosting. Few birds spend such a large part of their life on the wing as the Swift does; it never

*Birds of the Colorado Valley, by Dr. Elliott Coues, pages 372-378.

perches on trees or wires as Swallows do; it alights only on perpendicular walls in holes. On account of its almost incredible rapidity of flight a Swift is of all land birds the most difficult to procure. There is little doubt that a Swift flies usually at the rate of a mile a minute, and since it is on the wing, when with us in summer, at least ten hours, it covers daily a distance of 600 miles, equal to a straight line from St. Louis to New Orleans or to Duluth. Since the distance from New Orleans to Yucatan is only 600 miles, a Swift could cross the Gulf of Mexico in one night, from 7 p. m. to 5 a. m.

The bird is only five and one-half inches long, but has a wing spread of twelve and one-half inches. Its color is a sooty brown, darkest on the head and back; the throat is pale. In flight the tail is folded to a point until a change is made in the direction of the flight, when the ten tail feathers are spread far apart to check the force of motion. In spite of the general resemblance the flight is more steady and free from jerks than that of a Swallow, the wings are used with extremely fast fluttering motion, alternating with only short moments of soaring, and all movements are performed with an abruptness, distinguished from the easy, elegant evolutions of the Swallow. It is astonishing to see two creatures so little related as Swift and Swallow resemble each other so much, and it shows "how nature attains the same end in different ways, furnishing similitudes in diversity no less easily than she produces a wealth of diversity from essential unity."

A bird student can soon tell a Swift from a Swallow in flight at any distance, as he can learn to identify other birds on the wing. This study is interesting and gives much amusement, for we see how different birds move in different ways through the air. Hawks and Vultures spread out their broad wings and sail gracefully and apparently without any effort in straight lines as well as in beautiful gyrations. Most other birds have to keep their wings in constant motion, some with long, measured wing-strokes, others beating the air as fast as they can. The members of whole families are easily recognized by their flight, as, for instance, the Woodpeckers, which alternately close and open their wings and thereby fall and rise at intervals. The flight of the Bluejay seems to cost the bird much effort and the bird knows he is not a fast flier; when going great distances as in migration he keeps as much as possible over tree tops in order to take ready refuge in case of danger. The Robin is a swift flyer, more rapid than the Blackbirds, from which it is easily distinguished when they are flying together to a common roost. The Song Sparrow can easily be known from other ground Sparrows in its flight from one thicket to another, as can the Goldfinch be recognized by its undulatory flight accompanied by a sweet note with every bound through the air.

Good flyers have the advantage of being able to indulge in the pleasure of aggregating in large masses, impossible to their lesser agile fellow creatures. Thousands of Swifts, Swallows, Robins, Blackbirds, Crows and others of equal flying power can spend the nights together and find sufficient food the next day by spreading over hundreds of square miles, if necessary. All birds have the social instinct well developed, even Hawks and Owls flock in migration and roost together, but the comparatively feebly winged Sparrows and Warblers may hold together only a few dozens of their kind without endangering their food supply.

When not in the air the Swift is found clinging to the wall of a hollow tree, a chimney flue or a rough board in the attic of a house, in a barn or shed or deserted building, and we must admire the courage of the little bird in risking its life by entering and descending into dark places to depths to which no other bird, not even an Owl, would dare to penetrate.

While the high keel of the Swift's breastbone, able to support large pectoral muscles, corresponds to the untiring power of flight, the long tibiae, short tarsi and strong claws are most ably adapted to the purpose of which they are intended, that of clinging in upright position to perpendicular surfaces, in which the stiff, bristly tail feathers serve as a brace. It is in these places that the Swift not only finds rest and spends its nights, but also builds its nest, a semi-circular, half-saucer-shaped basket, a curious and unique structure of short bits of twigs glued together by the saliva of the bird. Male and female are both provided with glands situated below the tongue producing this glutinous substance, but only during the time of nest building and in small daily quantities. It is a colorless liquid, which soon hardens to a yellowish varnish, a strong cement in a dry place, but soluble in water. As this glue is the only means by which the nest is fastened to the wall, long spells of rain loosen its hold, causing the destruction of its contents. If this happens early in the season, a second attempt is made, and this explains why late broods are found, giving rise to the mistaken belief that two successful broods are reared. By actual observation it has been established that to raise a brood of Swifts takes much longer than formerly supposed. It takes the Swift longer to build a nest than other birds, because the glue put down one day has to harden before a new layer can be added. While it dries in one day of warm, dry weather, it takes longer in wet and cool weather. Starting the construction of a nest a good layer of glue is smeared against the wall and a few short bits of twigs are stuck to it while yet wet. These twigs are broken from dry branches of trees by the bird flying repeatedly against them and taken hold of and carried to the nest with their feet. The whole process of nest building, egg laying and raising of young to the state when they can feed themselves is a slow one and requires fully two months. As the Swifts live entirely on small winged insects and have to catch them on the wing, weather conditions influence all their functions, not only the building of their nests, but even the deposition of their eggs, of which 4 to 6 are laid. Like most eggs deposited in dark places their color is white, but while a Canary hatches its eggs in 13 days, it takes the Swift 17 to 19 days. Both parents not only help in nest building, but also in incubating and feeding the young. The incubating parent spreads its breast protectingly over the base of the nest and, when necessary, spreads its wings over its contents. The young ones, too, lie with heads to the base and the anal region protruding over the rim to keep the nest clean. Several nests may be found in one chimney, but never one below the other. The young make a strong hissing noise when the feeding parent appears, and when three weeks old fly with the same hiss against the face of an intruder of their home. They are at least four weeks old when able to try their wings for a first flight, but are brought back to and fed in the chimney for some time afterward. When nest building is completed, the salivary glands beneath the tongue shrink and when feeding young this space is used as a pouch to store the insects for the young. In feeding the parent thrusts its head deep into the wide open mouth of the young, ejecting the contents of its pouches with jerky motions. That these consist partly of living insects is seen when the parent's head is retracted and minute insects appear trying to escape from its bill. This explains the peculiar cleaning of the bill after feeding. That the Swift, like most other birds, returns to its former home to breed has again been demonstrated by Mr. Baynes who banded one in 1911 and caught the banded bird the following year when it came again down into the same room.

Swifts are very devoted to their young and instances are known when they have risked and sacrificed their lives in the attempt to reach them in burning buildings.

In some cases they give offense by making noise in the early morning or by the shrill twitter of the young when being fed and cause people to close their chimneys against these lovable birds, whose services in the destruction of disagreeable and obnoxious insects are so very beneficial to mankind. Fortunately there are many chimneys not used in summer to be found in populous districts, and where all other suitable places such as garrets, barns, etc., are absent, instances have been reported where the daring bird has built its nest several feet below the ground to the side of deserted wells.

The occasion of the first flight of young Swifts is made a holiday affair for all the Swifts of the neighborhood and is attended by much merry noise-making.

After the young are strong on the wing the whole family betakes itself in the evening to the community roost and these places are used for rest until migration from the north sets in, when all resort to the great roost where hundreds and thousands can spend the nights together. These are the places that cause so much comment and admiration, because they offer a spectacle which even the most unobserving and disinterested passer-by cannot overlook. The first settlers of the country were struck with the novelty of seeing a cloud of small birds revolving above an old hollow tree and at last disappearing within it. They called these trees "Swallow trees," because they took the birds for Swallows, though England has a bird which is called Swift, a cousin of ours, but of another genus, a Cypselus, a spineless Swift of similar appearance, but different habits.

Swallow trees may still exist in remote regions, but all over their United States range Swifts are now known to occupy large chimneys for this purpose and, if not disturbed, return to them year after year in ever-increasing numbers.

We St. Louisans have always had excellent opportunity for watching such Swift chimneys. From the southern part of Carondelet to the Chain of Rocks, and in the suburbs, there have been and still are a number of chimneys used for the purpose, some harboring hundreds, some thousands of transients in their passage through the state. To the student of bird migration the visit to such chimneys is of great interest, for it is the only place where he can get early dates for the appearance of the first Swift in spring and for the very last, present in fall. It was thus possible for me to get dates much in advance of others in spring and the latest in fall as long ago as in the year 1885, the report of which has been published by the Department of Agriculture in "Bird Migration in the Mississippi." The whole record of the movements of the species in that spring from March 31 to May 16, and in fall from August 17 to October 17 is given in dry figures, but the exquisite pleasure these visits and observations gave me and my family who helped me has not been told and cannot be adequately told, one has to witness the sight one's self.

Many times since then have I watched Swift chimneys in different parts of the city, but the grand spectacle has never ceased to imbue me with the same feeling of wonder and admiration as it did on the first day. It was last fall that we had the good luck of discovering the roost which in size and accessibility and ease of observation surpasses all others, the chimney of the greenhouse in Tower Grove Park. It was in the late afternoon of September 17 that we noticed an unusually large number of Swifts hunting over Shaw's Garden, and following them to the park we came just in time to see the first individual of an enormous mass of highly excited, twittering birds, revolving in a large circle over the greenhouse, drop into the mouth of the chimney. After a few more had followed a continuous stream poured into the chimney for the next ten minutes without the least interruption. Since each bird balances itself with highly elevated wings and a side to side movement to prevent a too rapid descent, we are permitted to judge the number of birds by counting how many enter in one second and multiplying this with the number of minutes. In this manner we arrived at the prodigious number of 3,000. One of our surprises was to see that after the birds had poured in for five minutes the number of wheeling, rushing, twittering birds was the same as at the beginning, their ranks being constantly filled by new arrivals and there was no let-up in the rate of the influx until the last had dropped out of sight at 6:25 and darkness had fallen over the park.

The chimney was built of brick in 1885, and according to employes of the park has been used by the birds for twenty years. It is 60 feet high, square and tapering from six feet at the bottom to five feet at the top. Immense as this structure is, it is sometimes not sufficiently spacious to accommodate all the Swifts that come to roost, and for such occasions an overflow roost has been established in the chimney of the florist opposite the park on Magnolia Avenue. Between 500 and 600 entered this roost on October 14, but it had been given up on October 17. Between September 17 and October 15 we paid several visits to the roost and found little change in behavior and numbers except that on October 15 the first entered at 5:46, half an hour earlier than on September 17.

October 15 was a fine day, partly cloudy with a temperature of 73° and very light wind. When we arrived at the roost at 4:35 only about 50 Swifts were dotting the sky above the park disappearing for short times, appearing again, but without any increase for an hour, and we feared the bulk of the species had left us for good. But during all this time the sight of a most beautiful illumination of the evening sky was enjoyed with utmost gratification. As the clouds drifted slowly from west to east they were colored by the setting sun, producing the most delicate tints of rose upon the bluish gray and blackish gray background, deepening to fiery red from 5:20 to 5:25, fading rapidly. At 5:40 an increase in the number of Swifts was noticeable, and at 5:45 two separate bodies had formed, one over the florist's, the other over the park chimneys. At 5:46 the first entered the park chimney and it was now evident that the wild, whirling flock of excited, twittering birds was thickening fast, but the descent was slow compared with former entries for the next five minutes, though continuous. At 5:51 an enormous crowd of birds was in the air and the crowd above the florist's went over in a body to the main army, which now poured in a thick stream for over five minutes, while new flocks arrived and circled in clouds hardly visible on account of the darkness which had set in. Only sharp eyes could see them enter and I had to use my fieldglass to see the large numbers lately arrived go in during the last four minutes, until at 6 p. m. the last disappeared. October 15 had always been considered a late date for Swifts, but there were fully as many birds present as before; it took them fourteen minutes instead of eight to enter and the descent commenced when almost dark, the birds arriving later than usual and in real flocks. In many years October 14 to 19 were the dates for the very last Swift on my records, but the extraordinary beauty of last autumn retained our Swift long enough to break all records for the state of Missouri, namely October 26, the previous latest being October 24. Though the weather after the 15th continued with maximum temperatures above 80° until October 23, the number of roosting Swifts became smaller and irregular; only 800 were counted on rainy, dark October 18th, 1,200 on the 19th, and 600 on the 21st. When cooler weather set in on October 23rd we thought migration would be over and were astonished to see, on October 24th, that the roost was not entirely deserted, as two birds came when almost dark and went directly into the chimney without any preliminary ostentation.

Mr. Christie visited the roost in a drizzling rain on October 26 and reported that within 18 minutes, from

5:05 to 5:23, forty-four Swifts went in. They arrived in troops of ten, four, five, twenty-one and four. The cold weather of October 27, with snow flurries on the 28th, made farther visits unnecessary.

Mr. Frank Rand, the gentleman who saved our Kingfishers in Forest Park from destruction, gave me the result of a visit to the roost to see the Swifts leave the chimney in the early morning. He arrived before six o'clock on the morning of October 21, when it was still dark. At 6:12 the Swifts began to come out, one or two at a time, but continuously following each other for thirteen minutes until 6:25, when the last appeared and left. At the rate of one in a second, he thought 780 left the roost. After flying a few times around the greenhouse they disappeared, mostly southward.

The exit in the morning is not such a spectacular affair as the entry in the evening, but it is worth mentioning that I have seen the Swifts go back into their chimney, when after flying around a short time they found the weather cold, with a misty rain and no prospect of a breakfast for the moment. I have also repeatedly seen them go into the chimney and remain there during the hottest hours of the day, an observation which explains their sudden commonness toward evening where few or none were seen in the afternoon.

If the weather be ordinarily favorable we may expect to welcome our first Swift about the first of April, but whether this will be at the Tower Grove Park greenhouse or not will depend on the condition of the furnace. As many fires are still burning under their favorite autumn retreats, the early Swifts have to look for unused chimneys elsewhere or go directly to the nesting chimneys for rest and shelter.

While the first Swift arrives at New Orleans between March 18 and 25 (earliest date March 13), the earliest for southern Missouri is March 28 and for St. Louis March 31, 1885. Let us hope that with an unusually early spring we can beat this date in 1921.

BIRDS OF THE OZARKS.

(St. Louis Naturalists' Club, February, 1906.)

For the bird lover a trip through the Ozarks is one of real delight. A great variety of his feathered friends greet him from all sides, on the high ridges as well as on the hillsides, on the rich flood plains of the valleys and in the picturesque ravines. He has the pleasure of not only finding the different kinds of birds common to the rest of the state, but also some southern species which have in the Ozarks the northern limit of their breeding range. Others are so numerous in comparison with adjacent regions of their occurrence that we may regard the Ozarks as the center of their geographic distribution.

The best known among the latter is the Bewick's or Long-tailed Wren, which in the Ozark region entirely replaces the ordinary House Wren of northern Missouri and the Eastern States generally. The Bewick's Wren, a name given the bird of Audubon in honor of one of his friends in Edinburgh and adopted by all ornithologists, differs from the House Wren in color, size and shape, but it is mainly its long tail and entirely different song by which it is easily distinguished. While the House Wren has only a monotonous, though sprightly, ditty, the Bewick's Wren has a real, modulated song that reminds one very much of the well-known song of the Song Sparrow, but is superior to it in harmony and strength. Anyone who hears the song for the first time stops to listen to the loud, melodious notes, uttered generally from a post or the roof of a building. When hopping about in search of food it holds the long tail up almost perpendicularly, but when singing it throws its head backward, pointing its bill straight up and drooping its tail in a pendent position. It likes the proximity of man; we seldom find it far away from human habitation. In the Ozarks, if not driven away, every farm has its pair; they are familiar objects about the barn, stable and wood sheds, frequent the wood pile and brush heaps and may be approached within a few steps. But it is not only the farms which enjoy this familiarity—in the village and even in the large towns are they at home, and there are probably very few houses in the Ozarks from which their song cannot be heard during a large part of the year.

Most of them leave Missouri in the fall and spend the coldest months in the more southern states, but some are permanent residents, remaining with us all the year round, spending the cold winter nights in some sheltered nook about the outhouses and seeking their insect food among the piles of wood, the crannies in the walls and trees wherever insects hide themselves or their eggs. It is one of the most useful birds on a farm, working nearly the whole year in the interest of the farmer, since those that winter farther south return to us early in March. Like the common House Wren our Bewick's Wren makes its nest in holes, selecting any cavity out of reach of the house cat for a nesting site. Being a welcome visitor everywhere it often builds in some nook about the house or stable and, where such are provided for them, in bird boxes. Where suitable sites are not to be had it selects sometimes queer places such as the pocket of a coat hanging on the wall, the board over a door, shelves in rooms, or in any kind of vessel accessible to them. It is now very seldom that it goes back to its original nesting sites, the natural cavity of a tree or old woodpeckers' holes. For ordinary use it has a soft, low call note, but when surprised or on the approach of an enemy it utters angry scolding notes and defends its young by bold swoops upon the intruder. Two broods are usually made, but if one should come to naught they try it for a third time. While feeding their broods of five or six young they destroy an enormous number of noxious insects in the garden and orchard, thereby becoming great benefactors to the horticulturist.

Another bird characteristic of the Ozarks, having there its center of distribution, is the Prairie Warbler. This name was given the bird by Wilson in the early part of the last century and was given on very slight acquaintance. The bird is hardly ever seen on the prairie. A more appropriate name would be Hillside Warbler; the hillside is its real home, where its song is heard from the time of its arrival about the middle of April through May to the end of June. It has a peculiar song, strangely resembling the notes of a young Quail when calling for its mother. It consists of five notes, begins low and grows louder with a strongly rising intonation. Its peculiarity is such that it never fails to attract the attention of everyone who has an ear for the voices of nature.

Though not loud, the song has a far-reaching quality and it is often not easy to detect the source of the sprightly strain even if the singer is not concealed, generally being perched on some eminence as the top of a low tree or the highest branch of a shrub. Its home is not in the forest, not among high trees, but in those stretches of scrub oaks, so common in the Ozarks. It is a neighbor of the Cardinal Redbird, the Yellow breasted Chat, the Indigobird and Field Sparrow. It makes only one brood in a year and places its neat little nest in a bush or sapling, generally between two and five feet from the ground. It leaves us in the latter part of September and winters from southern Florida and the Bahamas through the West Indies to Honduras. Above yellowish green with a patch of chestnut in the middle of the back, it might be called the Chestnut-backed Warbler. The color of the lower parts, most often seen when singing, is bright yellow with dark streaks along the sides of the neck and body. Male and female differ but little, the yellow of the female being paler and the markings generally duller.

Another bird of special interest to the bird lover who visits the Ozarks is the Blue Grosbeak, a southern bird which finds its northern-most habitat in southern Missouri, where it takes the place of the Rose-breasted Grosbeak so common in the central and northern portions of the state. As large as a female Cowbird, the male Blue Grosbeak looks like an overgrown Indigobird, being deep blue except parts of the wings, which are brown. The female is light brown with very little blue, and that only on the tail. It is not a woodland bird, being rather found along the edge of the woods, and preferring cultivated land. It is a common resident of the orchard, where it likes to make its nest. This is sometimes found in close proximity to occupied houses, where the bird is a great favorite, since its song is one of the sweetest we hear throughout the southern and western Ozark region. It is oftenest heard in the early morning and toward evening and reminds one rather of the song of the Purple Finch than of that of its nearest relative, the Rose-breasted Grosbeak. Although a bird of more northern distribution in the breeding time the Rose-breasted Grosbeak, this beautiful and gifted songster, is by no means a total stranger in the Ozarks, as it is fairly well represented along the northern slope and in the border region, *i. e.,* the region which joins the Ozarks with the western and northern prairie region of the state.

There is hardly any one of our feathered songsters of a more general distribution through the Ozarks than the Orchard Oriole. Somewhat smaller and of less striking coloration than its cousin, the Baltimore Oriole, it is a much more voluble singer. No orchard, no cluster of shade trees is without a pair and their remarkably lively song is heard all the day long through May and June. They prefer cultivated land to unsettled regions and come into the larger towns where their wonderful grass-woven semi-pendulous nests are built in shade trees of the most frequented streets. While with us their diet consists chiefly in the obnoxious insects which infest our shrubs, and in doing so pay fully for the little fruit which they take from our trees. Like ourselves, birds need some fruit for a change of diet, especially on hot summer days, and there was formerly no lack of wild fruit in our woods, but by cutting down these trees we deprived the wild creatures of their possessions and ought therefore be willing to share with them what grows in our orchard, or else plant some of their favorite fruit trees, such as Red Mulberry and Wild Cherry for their exclusive use. The georgeous Baltimore Oriole, such a common denizen of central and northern Missouri, is much less common than its congener, but not entirely unknown in the bottoms of the larger streams as a summer sojourner from May till August.

Still another bird which finds in the Ozarks its center of distribution is the Summer Tanager, also called Summer Redbird, a true woodland bird which is nowhere so much at home as on our Ozark hills. The bird is a beauty, bright vermilion all over, no black wings like its northern relative, the Scarlet Tanager, and its song is one of the best bird songs we have, and that means much. Its notes are a clear whistle somewhat in the style of the Robins, but much more fluent and melodious. It is given with great constancy all through summer, often in the heat of noonday when most other songsters are resting. Much oftener heard than seen because hidden by the dense foliage of our forest trees, the bird is nevertheless not shy, visits frequently our gardens and orchards and builds its nest often by the roadside, sometimes so low in branches hanging over the road that their contents can be inspected by simply standing on the seat of the wagon passing under it. It is not easy to decide which one of our two Tanagers is the more beautiful, the southern Summer Tanager or the more northern Scarlet Tanager with its deep black wings and tail in sharp contrast with its scarlet body. In song the former is decidedly superior to its cousin, for in spite of a general resemblance the mellowness of the one distinguishes it at once from the other, but both are true woodland songs, charming wherever they are heard. While the domain of the Summer Tanager comprises the hills and higher elevations, the Scarlet Tanager sticks to the rich and varied sylva which follows the streams high up into the valleys and ravines, affording us thereby the opportunity to hear both species sing at the same time.

Many people have noticed that in Missouri, from Perry County southwestward along the southern slope of the Ozarks, we have two kinds of Whippoorwill. They have heard, alone or together with the well-known common call, another different call, but given under similar conditions at night after dark and again in the early morning before daybreak. Very few know that the originator of the strange doleful notes is the Chuck-wills-widow, a larger southern relative of the more northern and better known Whippoorwill. In general habits they resemble each other very much, are never seen in daytime except when accidentally driven from their nests or hiding places in the shady retreats of the forest, preferably on hillsides overgrown with much underbrush. Their call, which has given rise to its queer name is uttered in rapid succession for several minutes and often resumed again for hours after short breathing spells. They are loudest and most excited during the mating and nesting time in May and June and are occasionally heard throughout summer. Though they are with us from latter part of April to the end of September, very few people, in the region where they are plentiful, get a chance to see one, so well do they understand to evade detection by remaining in their hiding places among the dry leaves and logs or rocks on the ground until almost trodden upon.

Such is the abundance of bird life in the Ozarks that the trained observer may with little effort identify sixty to seventy species during the nesting time in any one of its valleys.

We may yet mention a few other species frequently met with in the southern slope of the Ozarks, but not at all, or rarely, seen along the northern slope, namely the Black Vulture and Mississippi Kite. The former is a cousin of the better known Turkey Buzzard, sharing the same tastes and living the same lazy kind of life, but easily distinguished by its different shape and black head and neck. The contour of the bird on wing soaring above us, often in company of its cousins, is especially marked by broader wings with whitish stripes and a stumpy tail. Its flight differs from that of the Turkey Buzzard by much less soaring and by often repeated flapping of the wings. While a common bird in the southern states, its first acquaintance is a remarkable incident to the visitor from the northern states and contributes to the joy of the newness of experiences. Another surprise to most of us is the Mississippi Kite. It is not unknown along the northern slope of the Ozarks and was even a breeder in the woods of the city of St. Louis thirty-five years ago, but its real home is farther south. It is a great delight to see the handsome bird draw its circles high over our heads when we stand on one of the prominent look-out points so common in the Ozarks with the view of the rows upon rows of long-stretched hills, so characteristic of the region.

REMINISCENCES OF A VISIT TO BRANSON AND WHITE RIVER IN TANEY COUNTY, MO., IN THE SPRING OF 1906.

When the naturalist visits a new locality he is full of eagerness to learn what is in store for him in general and in his favorite hobby in particular.

It was therefore with great expectations that Mrs. Widmann and I began our ornithological reconnaissance of Branson, the new town so happily situated where the new branch of the Iron Mountain Railroad, the so-called White River Division, crosses the White River on a long and high bridge. To call Branson a new place would not be correct, since the post office Branson has been on the map for perhaps fifty years, but what we saw of the town in 1906 was all new and everything built on a large scale, the hotels, drug stores, general and furniture stores, livery, barns, post office building and a bright new bank. There seemed to be no doubt that Branson would in course of time become an important place for the distribution of everything people need for comfort and luxury. But this push and boom is not what the nature lover admires most; it is the surroundings of the town, especially the magnificent curves of the beautiful White River walled in by steep cliffs and high bluffs.

A short walk over an excellent road through a forest leads to Branson Height and Table Rock, points commanding extensive views up and down the river for several miles from the new railroad bridge on the left to far beyond the new Maine Club House on the right. The foreground comprised the newly plowed fields in the bottom land on the opposite side of the curve with men and teams still working, and 200 feet below us the swift stream carrying at this moment a long raft of cedar poles guided by two men to its destination, the loading incline at the foot of the bridge, where a truck and wire rope were busy lifting the poles from the water onto the cars. A little stream with the promising name Turkey Creek opens its romantic valley just opposite Branson, and on our way to the clubhouse we followed it for a short distance. For the convenience of the members the railroad station Hollister has been erected a mile south of Branson on the opposite side of the river, doing away with the trouble and delay of crossing the river on a ferry, and thereby greatly facilitating access to the clubhouse at all seasons.

While the view over the White River Valley from the Branson side was grand, that from the cliff in front of the clubhouse was more imposing and surprisingly picturesque. The sides of the bluff being almost perpendicular, a point projecting beyond the rest seemed wonderfully adapted for the erection of an observation tower, standing out like a bastion 288 feet above the water of the swift stream which describes here a wide semicircle, with nothing to obstruct the view over many miles of the river's course and over the bluffs and cliffs on both sides. Flanked and backed by rows of wooded hills as far as the eye can reach, the sight is so grand that it is not easily forgotten.

It was near noon of May 7 when my wife and I stepped from the train at Branson under the finest Ozark sky imaginable, bright and clear, with a light refreshing breeze which kept the temperature at a lovely point all afternoon and enabled us to identify fifty-two species of birds before nightfall and without going beyond the confines of the town.

The next two days were spent in the environs of the town, varied by a drive to the Maine Clubhouse on the afternoon of the 9th, and before we boarded the car again on the 10th our list of birds had swelled to the number of eighty-four, only fourteen of which were transients, seventy being recognized regular summer sojourners and breeders in the locality.

As the water in the river was pretty high and rapid, few waders could be expected in our search for bird specimens, and we saw only a Green Heron and a few

Spotted Sandpipers frequenting the pebbly islands. Of gallinaceous birds the Bobwhite was repeatedly flushed, but being already paired they were rather quiet. The Doves were much more in evidence, and often seen and heard. One of the common sights were the Turkey Buzzards, several of which were drawing their circles over distant hills all day long. A rare sight, because seldom met with so far north as Missouri, was the appearance of two Black Vultures, or Carrion Crows, among a party of Turkey Buzzards on the afternoon of the 9th at the clubhouse. Of Hawks only two species were noticed, the harmless red-shouldered Hawk, which lives chiefly on snakes and frogs, and the Sparrow Hawk, a pair of which had their home in a stump by the river. The Owl family was represented only by the Screech Owl, whose soft notes were heard at dusk down by the ferry at the edge of the town. The weatherwise Cuckoo, or Raincrow, was one of the birds often heard, but its wisdom did not prove true. At the White River at the foot of town a Kingfisher had its home.

Of the Woodpeckers five species were observed, the ubiquitous downy, the gaudy redhead, the red-bellied and the Flicker, all rather quiet because occupied with family cares. Strange enough, a belated Sapsucker, who spends the winter here, but whose summer home is in the northern states, gave us a surprise, because not expected here so late in the season.

The true Whippoorwill, being a more northern summer sojourner, was not heard, but the Chuck-wills-widow, the southern representative of the family, extends its range into Southern Missouri, and several could be heard every evening, coming even into town under cover of night. About sunset the Nighthawks began to go in search of food, gnats, mosquitoes and similar quarry, which they sometimes find at great heights, at others over fields or river. The Chimney Swifts, omnipresent companions of civilization, had their noisy time of love and happiness chasing in pairs wildly through unmeasured space, or sailing with wings held aloft in close proximity, and with such harmony that it is plain to see two little souls are animated by one thought. Humming birds were repeatedly seen visiting the flowers, and seem to be quite numerous along the bluffs, the home of many a wild flower seldom or never seen in other localities.

The Flycatcher family was well represented by six members, the Kingbird on open ground, the Great-crested everywhere in the woods, the Phoebe, whose nest with eggs was on the veranda of the clubhouse, the Pewee and Acadian Flycatcher, common inhabitants of the forest, and as a rare guest on its way from Central America to the northern states the least Flycatcher, or Chebec. Blue Jays were much in evidence all the time, the home birds having nests were rather quiet, but there were yet small troops of transients present, and these were noisily flying about, headed northward.

Crows were rather rare in Taney and neighboring counties, for the reason, as we were told, that farmers lay poison for them in the fields which they visit, believing to thereby increase the product of their farms, while the result will be quite the other way by giving many pests a better chance to propagate.

The Cowbird, the faithful companion of the cattle, was present wherever animals were grazing, but of other Blackbirds none were noticed, though they may locally occur in small numbers.

The Meadow Lark also distinguished itself through absence. So much more conspicuous was the Orchard Oriole, then in its full song period, mating, courting, and nest building. It seems to thrive best in the immediate vicinity of human habitation and frequents the shade trees of the town. The Baltimore being a more northern breeder but not entirely missing in the valleys of the Ozarks was represented by only a few which had apparently come to stay in addition to a troop of 6-8 transients, which showed by their action that they were only on a short visit, probably checked in progress by the preceding cold spell of May 5-6-7 when the frost nipped many a tender young oakleaf on the Ozark hills without doing any appreciable damage to fruit trees which can stand well a little frost after the blooming season is passed.

Of the Sparrow family ten species were noted, six breeding and four transient. The summer resident species were the Goldfinch, the Larkfinch, the Chippy, Field Sparrow, Cardinal and Indigo Bird. The transients, present in small numbers, were the white-crowned, white-throated and Lincoln's Sparrows, and the rose-breasted Grosbeak, the latter possibly staying in small numbers. The Tanagers were both there, the summer Tanager being heard in the forest everywhere, and the scarlet Tanager, a fine old male, met but once. More gregarious than any others were the members of the Swallow family. All our eastern species, six in number, were well represented and played a prominent part in the enlivening of the valley. Whole droves of them, composed of three, four or more species, were constantly flying up and down the river in search of food, which in cold weather they find over water easier than elsewhere.

Martins, Rough Wings, Barns, Bank and Eave Swallows were probably all at home in the vicinity, but the number of Tree Swallows seemed too large for summer residents, the species being rather rare in summer in southern Missouri, and must therefore be regarded as in part transient. Four species of Vireos were prominent among the musicians in the great concert performed every morning and, belonging to our most industrious and persevering singers, were often heard during the day when most other birds are silent. The red-eyed, the warbling, the yellow-throated and the white-eyed Vireos were all more or less common in their favorite haunts. The splendid prothonotary Warbler was at home on the willow-covered islands, and the modest blue-winged yellow Warbler in the scrubby growth of the hillside. Its cousin, the Tennessee Warbler, one of the latest of northern migrants, an indefatigable musician, though of low ability, betrayed its loitering in the tree tops many times every day. The Parula Warbler, though probably not rare in the trees of the river bottoms, escaped notice with the exception of one singing male. The Yellow Warbler is by far the most common of its tribe and, being in the height of its mating period, was one of the birds oftenest seen and heard during these days. Lingering far behind its brothers and sisters, the majority of whom had by this time reached their northern breeding ground, was a solitary Yellow-rumped or Myrtle Warbler. Cerulean Warblers, rightful citizens of all southern woodlands, were rather common, and not sparing with their sprightly musical efforts, therefore much oftener heard than seen. The Black-poll Warbler is of all its relatives the last to leave the state on its vernal travel from South America to the coniferous wood of the North and quite a few were detected among the Tennessee and other Warblers populating the lately verdured oaks and hickories with which these hills are mostly covered.

Down in the elms and sycamores along the banks of the river rang out from time to time the clear and peculiar songs of the Sycamore Warbler, indicating where the pair had settled for the summer. An entirely different locality is chosen for that purpose by the Prairie Warbler, which betakes itself to the second growth of the hillside. The ringing song of the Oven Bird is one of the ordinary sounds of the region, while the small-billed Waterthrush, repeatedly startled from the water's edge, must be classed among the guests, present only for a short term of rest and shelter from a winter home in South America to breeding grounds in Canada.

Small differences in size and coloration distinguish the northern small-billed, from the Louisiana Waterthrush, but their songs differ widely, and it was a great satisfaction to enjoy the opportunity to listen to both songs at the same time. But while the northern species was yet hundreds of miles from its nesting grounds, the Louisiana Waterthrush was quietly feeding half-grown young in their cozy nook under roots protruding from the banks of a creek. While the Kentucky Warbler seems to prefer the lower levels of a valley or ravine, the Maryland Yellow-throat, its congener, finds a home wherever there is a thicket to its taste, and is therefore much more often heard along the hills than the other, but both are plentiful.

One of the most common sights and sounds met with on our strolls, high and low, was the "Chat" and its almost human whistle. Being in the height of the love season the execution of its flight song was a more common occurrence. Wilson's Black Cap, a small, easily overlooked, transient, but by no means rare in migration, was several times the object of attention. Numerically strong and generally distributed, was the Redstart, a breeder in the region, but probably reinforced by the transient individuals northward bound. Catbirds were not common, the Carolina Wren was noticed a few times, and Bewick's Wren several times in town and about farms, never away from human habitation. As true and not uncommon denizens of the woods, we have to mention the Carolina Nuthatch, the Tufted Tit, and Carolina Chickadee. Rather unexpected, because late in the season, was the appearance of a Ruby-crowned Kinglet, travelling leisurely in company of our late Warblers, the Black-cap and Tennessee.

One of the most interesting woodland birds is the Gnatcatcher, or *Polioptila*; though nowhere common, it is so well distributed through the state that we find its curious nest in a bald cypress over the water of the St. Francis, as likely as in a post oak on a ridge of the Ozarks. Though already with family cares, and not at leisure to sing, their tiny forms were detected in a few places in the deep forest.

The Thrush family was represented by three species: The Wood Thrush in full song near the Table Rock; the Alice's and Swainson's Thrushes, transients on their way to far northern breeding grounds, were well scattered and met with every day. The absence of the Robin can be explained by the nearness of Branson to the southern limit of its breeding range, Robins being very rare in summer south of Missouri. One pair of Bluebirds was all that was met with, though the species is not rare in summer in Southern Missouri.

CHARLES HENRY TURNER.

CHARLES HENRY TURNER.

Charles Henry Turner, Ph.D., Professor of Biology at Sumner Teachers College, Saint Louis, died at Chicago, February 14, 1923.

Dr. Turner was born at Cincinnati, Ohio, on February 3, 1867. From the Cincinnati University he received the degrees of B. S. and M. S. in 1891 and 1892. In 1907 the University of Chicago conferred upon him the degree of Doctor of Philosophy, *magna cum laude*.

While Dr. Turner held various teaching positions, such as the Chair of Biology, Clark University, 1892-1905; Principal of High School, Cleveland, Tenn., 1905-1906; Chair of Biology, Haynes Normal School, 1907-1908; Teacher of Biology and Psychology, Sumner Teachers College, 1908 until his death, yet he is best known among scientists for his research work.

CORRECTIONS.

Vol. XXIV, No. 1.—Bottom of p. 16: Vol. XXIII, No. 9, should read—Nipher, Francis E., Studies of Properties of Integral Numbers, 9 pp.; New Evidence of a Relation Between Gravitation and Electrical Action, and of Local Changes in the Electrical Potential of the Earth, 5 pp.

CHARLES HENRY TURNER*

AN APPRECIATION.

It has been said that the size of a man may be measured in terms of his influence for good and for the betterment of his fellow man. But just as the striving to attain is more important to us than the desired thing itself, so we tend to look abroad for a truly great man when, forsooth, he walks in our very midst. We are very likely to think of the great man as one who has acquired a vast amount of money; as one who has achieved a political distinction; as one who has gained a social prominence; as one whose opinion on public questions is eagerly sought. Many people mistake notoriety for fame; confuse the word politician and statesman; take for granted that well-known is the equivalent of great. Were not the historians so overcome with the pomp and the splendor of a Pilate that they quite forgot to mention the humble Carpenter of Nazareth? It may be well to consider some of the features which go to make up the truly great man, that those of us who have sought afar shall recognize a brother who perhaps at this moment is touching elbows with us.

The first essential in the great man is a devotion to work. Some of us envy the well-known man who toils but little and therein we cater to our own ambitions of lassitude. But no man is great unless he rises above the petty inconveniences of his surroundings. No man is strong unless he meets the competition about him. Devotion to work means exactly what it says. It does not

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*Read at the memorial to Dr. Charles H. Turner, at Sumner High School, May 25, 1923.

mean devotion to methods. It does not imply a certain number of hours a day. It does not suggest a contentment with the doing of a daily stint in a manner which calls for neither commendation nor criticism. Devotion to work means work because one must work, and, faced by such a spirit, seemingly insurmountable obstacles are swept away along with other trivial factors of birth and race and station.

But work itself is not enough. The second ingredient in our strength of character is unselfishness: the desire to share the joys and the sorrows of life with others; the accomplishment of the friendly act for its own sake; the appreciation of a bond of proper sympathy of man for man. The man who works with an unselfish devotion ever searches for that which shall bring his neighbor to a higher level of doing and thinking and living. A great man must indeed be unselfish and take a pride in the merit which his talent may lend to others.

And in the search for truth, even in the little things of life, our great man interprets that which he finds and is ever threading the beads of fact into some pattern of a worldly philosophy. Faithfulness to truth is after all but a faithfulness to the little things and our great man achieves merit in his respect for that which is known and that which is unknown. Because of his consciousness of his own limitations and because of his respect for truth, the great man is humble.

We have been misinformed in our ideas of great men. We have been misled into looking for magnificence and for vain-glorious trappings in which our fancy would clothe an important person. Indeed the humble simplicity of the truly great man disarms us quite completely and we crane the neck to overlook exactly that which we seek.

It is for you who knew Doctor Turner to satisfy yourselves that here indeed was a great man. It is for you to determine in your own hearts if this man possessed the strength of character, the devotion to work, the faithfulness to ideals, the respect for truth, and the unselfishness in sharing that which he possessed. Was he indeed the humble man of science who might well be taken into the fold of the most highly esteemed?

You have answered this question yourselves. It will not be given to many of us that men and women and little children shall gather together after we are gone to pay tribute to our memory. It is a privilege to appear before you as a representative of the Academy of Science, an organization of which Doctor Turner was not only a member, but also a councillor. Let each one of you cherish the memory of Doctor Turner who left behind him the priceless heritage of devoted service that those who knew him and worked with him cannot help but have been the better and the stronger through this contact.

Permit me, in the name of the Academy of Science, to pay our respect not only to Turner the Scientist, but also to Turner the Man.

A. G. POHLMAN.

THE SCIENTIFIC WORK OF DR. CHARLES HENRY TURNER*

During his lifetime, Dr. Turner published about fifty treatises on Neurology, Invertebrate Ecology, and Animal Behavior. In addition to these, he wrote, for a number of years, reviews of the literature on Comparative Psychology in the Psychological Bulletin and in The Journal of Animal Behavior. This alone is an index of the esteem in which scientists in his own line regarded his work.

His first work was published in 1892 in the Journal of Comparative Neurology. A few years later an important volume on The Entomostrica of Minnesota was published jointly with Herrick. In this 500-page treatise, with eighty-one plates, many new species were described and much attention was paid to the ecology of these creatures.

Then, suddenly, his attention was turned from the microtome, and he produced a most interesting series of experimental investigations on the behavior of insects. His researches on homing, on reaction to light, on death-feigning, on tropisms, have cleared up some of the most perplexing problems of comparative psychology and have thrown new light on the subjects of the interrelations of tropisms, instinct, and what may, to a certain extent, be called intelligence.

But most interesting of all was his technique of experimenting. Dr. Turner spent much thought on his method of work before he ever went into the field, and there with ingenious devices, some simple, some intricate, he solved

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*Paper read at the memorial to Dr. Charles H. Turner, at Sumner High School, May 25, 1923.

some of the big problems of animal behavior. For instance, he discovered, by ingenious experiments, that ants are not guided home by odors, but that light-rays as landmarks are a larger factor than has heretofore been supposed in their orientation. Again, by adjusting the window shades on three windows in the room where mud-daubers were nesting, thereby alternating the light and darkness, Dr. Turner proved that wasps find their way home, not by some mysterious sense, but by means of landmarks.

In his work on the homing of the burrowing bees, he devoted from five to ten hours a day during the month of August to studying the insects in the field. He found that any change made in the topography is sure to confuse the insect upon its return, in finding the entrance to its home. Many other details were brought to light which militate against the old idea of a "homing instinct" and against Bethe's contention that bees are guided home by an unknown force which acts reflexly. He concludes from his work that the burrowing bees are guided by memory in finding the way home, and that they examine carefully the neighborhood of the nest for the purpose of forming memory pictures of the topographical environment of the burrow.

Whether insects can or cannot distinguish colors is a matter of much theoretical importance, for the correct interpretation of the relation of insects to flowers depends upon this answer. Most students of natural selection believed at one time that forms and colors of flowers were adaptations to attract insect visitors. Dr. Turner solved this problem in 1910 by experiments carried on in O'Fallon Park. By his ever ingenious methods he contrived tests with certain colored disks of paper and certain colored boxes which were filled with honey. After long weeks of experimenting he discovered and has conclusively shown that odors alone do not lead bees to flowers, but that bees do respond to colors, and not only that, but also that they are capable of recognizing them at a distance.

Not content with discovering that bees are capable of recognizing colors, a year later he carried out in great detail a series of experiments which proved that bees can distinguish between patterns. Here, too, he used ingeniously devised paper boxes with various color markings. His method was to permit a few bees to learn that they could collect honey more easily from artifacts of a certain color pattern, than they could from flowers, and after they had thoroughly learned this, to see if these bees could select artifacts of this particular color pattern from a number of different color patterns. The result of this investigation was the discovery that bees can distinguish color patterns, and there is much in their behavior to indicate that in their ability to distinguish details they are near-sighted. This ability is of value to them in recognizing plants that yield honey; and since insects can distinguish colors and the fine details of color patterns, there remains nothing in the visual powers of bees to militate against the theory that the colors and markings of flowers are adaptations which attract insect visitors.

In a work on the behavior of that marvel of the insect world, the pit-making ant-lion (larva), Dr. Turner describes in detail its method of excavating the pit, which, when completed, is a trap for insect prey. He explains the method of the creature in capturing prey, which it sucks dry with its hollow jaws; he tells of its various reactions, which are probably tropisms; how it is impossible for the insect to move forward, but in its backward movements it can move in straight lines or curves, and can scale vertical surfaces. He tells us further the details of its cocoon, and then with painstaking experiments he works out the details of the insect's ability to "play possum." Here he concludes that death-feigning poses are not death attitudes, and that death feigning is not instinctive, but an exaggerated prolongation of the pause made by most animals when they are startled, and he endorses James when he says, "It is really no feigning of death at all, and requires no self command. It is simply terror paralysis which has become so useful as to become hereditary."

In 1922 Dr. Turner published a paper entitled "A Week With a Mining Eumenid." He tells how the water-carrying mining wasp digs her nest, paralyzes the caterpillars for her young, attaches her egg to the roof of the chamber by a silken thread; how she is guided to and from the nest by visual landmarks, and how, when he made slight changes about the nests, the wasps returning home with caterpillars had great difficulty in finding their nests.

Important work was also done on the common roach. In a paper entitled "Behavior of the Common Roach on an Open Maze," he finds that a roach may be taught within a day to run the maze. It learns by trial and error method, yet in so doing it utilizes sense stimuli. At times the insect acts as though experiencing the emotion psychologists call will; in its toilet-making activities the roach very much resembles the cat, and in their behavior on the maze, roaches display marked individuality. In another roach paper entitled "An Experimental Investigation of an Apparent Reversal of the Responses to Light in the Roach," he takes roaches, which are nocturnal animals and habitually shun the light, and trains them to reverse their lifelong habit, and avoid the dark instead. This he does by teaching them to avoid certain dark places because of disagreeable experiences associated with them. The disagreeable experiences were slight electric shocks from an instrument contrived by him. By means of this precise apparatus, he finds that male roaches learn more quickly than the females, and the young ones are more apt than adults.

Up to a short time ago, most naturalists believed that insects can hear, not because it has been experimentally demonstrated, but for morphological reasons, and because many kinds of insects can produce sounds; they believed that insects would not be endowed with the power of producing sounds unless other members of the species could hear them. In a joint paper by Dr. Turner and Mr. Ernst Schwarz, it was experimentally proven that the Catocalas not only hear sounds, but that they can hear sounds of certain pitch, as the authors demonstrated by use of an organ pipe and Galton whistle. Moreover, it was discovered that a species which responds only to a high pitch on the Galton whistle can be taught to respond to low tones also when low tones are of life significance, or in the popular language, when they mean danger.

And so on throughout his work, such alluring titles appear as "Behavior of a Parasitic Bee," "Do Ants Form Practical Judgment?" "Psychological Notes on the Gallery Spider," "Habits of Mound-Building Ants," "Hunting Habits of an American Ammophila," "An Orphan Colony of *Polistes pallipes,*" "The Reactions of the Mason Wasp," through a list of fifty-odd titles that came from his pen.

Nature lovers and scientists cannot but feel grateful for Dr. Turner's admirable contributions. In making his studies he did not venture on lengthy and costly voyages to far-away countries teeming with fascinating allurements. In his scientific work, as in his other interests, he had the ability to take the material that was near at hand and make the most of it.

Among Dr. Turner's notes were three completed papers of a less technical nature, which will be published by The Academy of Science of St. Louis. The titles are: "Tropisms in Insect Behavior," "The Homing of the Hymenoptera," and "The Psychology of 'Playing 'Possum'." Another paper, "The Hydrotropism of Marine Invertebrates," was accepted for publication in the Biological Bulletin just before his death.

Dr. Turner's works have been very favorably quoted both here in America and in Europe. Dozens of quotations from his treatises are to be found in such works as Wheeler's Ant Book, Washburn's The Animal Mind, Smith's Mind in Animals, Holmes' Evolution of Animal Intelligence, and Bouvier's The Psychic Life of Insects. In fact, in the behavior literature of France, they have named a certain type of orientation after this discoverer. This is best described in Bouvier's book, The Psychic Life of Insects, translated from the French by Dr. L. O. Howard, where it is "called *Turner's circling,* using the name of the learned American who best studied this phenomenon."

Dr. Turner's interests were not solely scientific. Often his time and strength were severely taxed by his faithful devotion to various sociological works among his people. Among his unfinished papers were found several chapters of a novel, a number of chapters of a book of nature stories for children, and the manuscript of a book of thirty-two poems. Not alone has science lost one of its most thorough students, but also the colored race has lost one of its most efficient workers for race betterment, in its various and intricate phases.

The handicaps under which Dr. Turner's work was accomplished were many, and were modestly and bravely met. Only one of these was the limitations of a small salary, out of which he was compelled to purchase his own tools and library for research, since he did not enjoy the access to laboratories and institutions where equipment is supplied.

And when at last one considers the quantity and the quality of his scientific research work, accomplished under handicaps, and in addition to a full life of other activities and unusual efficiency in the class-room, one can only say—well done!

PHIL RAU.

A LIST OF PAPERS PUBLISHED BY C. H. TURNER

1892 Psychological notes on the gallery spider. Journal of Comparative Neurology, pp. 95-110. 1892.

1893 Preliminary note on the nervous system of the genus Cypris. Journ. Comp. Neurol. 3:35-40, pls. 3, 4.

1894 Notes on the Cladocera of Georgia, Bull. Sci. Lab., Denison Univ., 8:22-25. pl. 7.

1895 Synopsis of the Entomostraca of Minnesota. (With C. L. Herrick). Geol. and Nat. Hist. Surv. Minn. 1895, p. 552, 81 pl.

1896 Morphology of the nervous system of Cypris. Journ. Comp. Neurol. 6:20-44. 8 pl.

1899 Notes on the mushroom bodies of the invertebrates. Zool. Bull., 2:155-166. 6 fig.

1899 Synopses of North American invertebrates. Amer. Nat., pp. 877-888. 1899.

1901 The mushroom bodies of the crayfish and their histological environment. Journ. Comp. Neurol. 11:321-368. pls. 21-24.

1906 A preliminary note on ant behavior. Biol. Bull., 12:31-36.

1907 The homing of ants. Journ. Comp. Neurol. and Psychol., 17:367-434. 3 pls.

1907 Do ants form practical judgments? Biol. Bull. 13:333-343.

1908 The homing of the mud-dauber. Biol. Bull., 15:215-225.

1908 The homing of the burrowing bees. Biol. Bull., 15:247-258.

1908 The workers of *Vespa corolina* Dr. resemble in coloration the moles. Psyche., 1908. 1-3.

1909 The mound of *Pogonomyrmex badius* and its relation to the breeding habits of the species. Biol. Bull., 17:161-169.

1910 Ecological notes on the Cladocera and Copepoda of Augusta, Ga., with descriptions of little known species. Trans. Acad. Sci., St. Louis, 19:151-176. pls. 36-38.

1910 Experiments on color-vision of the honey bee. Biol. Bull., 19:257-279.

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1911 Recent literature on the behavior of the higher invertebrates. Psycholog. Bull., 8:277-286.

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1911 Literature for 1910 on the behavior of spiders and insects. Journ. Animal Behavior, 1:401-412.

1911 Notes on the behavior of a parasitic bee of the family Stelidae. Journ. Animal Behavior, 1:374-392.

1912 An experimental investigation of an apparent reversal of the responses to light of the roach (Periplaneta orientales L.). Biol. Bull., 23:371-386.

1912 An orphan colony of Polistes pallipes. Psyche, 19:184-190.

1912 The copulation of Ammophila abbreviata. Psyche, 19:137.

1912 Reactions of the mason wasp, Trypoxylon albatarsus, to light. Journ. Animal Behavior, 2:253-362.

1912 Sphex overcoming obstacles. Psyche, 19:100-102.

1912 Recent literature on the behavior of the higher vertebrates. Psychological Bulletin, 9:290-300.

1912 Literature from 1911 on the behavior of spiders and insects. Journ. Animal Behavior, 2:380-397.
1913 Behavior of the common roach, Periplaneta orientales on an open maze. Biol. Bull., 25:348-365.
1913 Recent literature on the behavior of the higher invertebrates. Psychological Bulletin, 10:307-317.
1913 Literature for 1912 on the behavior of spiders and insects. Journ. Animal Behavior, 3:401-428.
1914 Auditory powers of the Catocala moth; an experimental field study. (With Ernst Schwarz.) Biol. Bull., 27:275-293.
1914 An experimental study of the auditory powers of the giant silk worm moths, Saturniidae. Biol. Bull., 27:325-332.
1914 Recent literature on tropisms and instrinctive activities. Psychological Bulletin, 11:278-285.
1914 Literature for 1913 on the behavior of spiders and insects. Journ. Animal Behavior, 4:394-413.
1915 Notes on the behavior of the ant-lion with emphasis on the feeding activities and letisimulation. Biol. Bull., 29:277-307.
1915 Literature for 1914 on the behavior of spiders and insects. Journ. Animal Behavior, 5:415-445.
1915 The mating of Lasius niger, L. Journ. Animal Behavior, 5:337-340.
1916 Literature for 1915 on the behavior of spiders and insects. Journ. Animal Behavior, 6:383-399.
1916 Notes on the feeding behavior and oviposition of a captive false spider. Journ. Animal Behavior, 6:160-168.
1917 Literature for 1916 on the behavior of spiders and insects. Journ. Animal Behavior, 7:405-419.
1918 The locomotion of surface-feeding caterpillars are not tropisms. Biol. Bull., 34:137-148.
1921 Ecological studies of Entomostraca of the St. Louis district. Trans. Acad. Sci., St. Louis, 24:1-25. pls. 1-4.
1922 A week with a mining Eumenid; an ecologico-behavior study of the nesting habits of Odynerus dorsalis. Biol. Bull., 42:153-172.
1923 The hydrotropism of marine invertebrates. (To appear later.)

TROPISMS IN INSECT BEHAVIOR

By C. H. TURNER

Dr. Jacques Loeb's experiments demonstrating that certain invertebrates exhibit a form of activity identical with what students of plant life call tropisms gave a new impetus to the study of animal behavior and stimulated numerous investigators to add a large amount of material to our scientific literature. Unfortunately some of this material will not stand critical analysis. So elated were some of these men over the discovery of what seemed a simple mechanical interpretation of animal behavior, so certain were they of its universal application, that almost any simple kind of behavior was called a tropism. No wonder Claperade exclaimed: "A physiologist of another world, knowing nothing of our language, coming here might well, on noticing the numerous points of attraction which, in the shape of taverns, draw the human crowd, invent ethylotropism, which would certainly be one of the most universal after heliotropism. He might ascribe, also, a negative heliotropism among bakers, actresses and other persons who turn day into night, a nostropism for physicians, a necrotropism for undertakers, a phytotropism for gardeners, a geotropism for field laborers." This is humorous and, at first blush, may sound ridiculous; but, is it not warranted by the loose manner in which the word tropism is used?

So varied are the ways in which the term is used that the standard dictionary defines a tropism as "The inherent tendency of living matter to respond definitely to an external stimulus." Any reflex action is a definite response to an external stimulus and is an inherent tendency of living matter. If a tropism is not something different from reflex action, differential sensibility, trial and error, practical judgment, etc., then the term is superfluous. When Dr. Loeb first used the term he had in mind a characteristic type of behavior. He asserted, unequivocally, that it was identical with what the botanists call tropisms. The best way to avoid misunderstandings is to use the word as Dr. Leob intended and in no other way. The following is thought to epitomise that conception: Tropism is a form of externally induced behavior in which the organism automatically so adjusts itself as to have morphologically symmetrical portions equally stimulated. After orientation it may advance, retreat, or remain stationary. In the light of this definition let us critically examine examples of what appear to be typical tropisms.

On first noticing foraging ants one is almost certain to conclude that they are guided by tropisms. There is the long sinuous double line of ants; one file going toward the nest and the other in the opposite direction. Draw your finger across the line. Almost immediately the ants on each side of the finger-print rush to and fro along its edges. Is not that a case of chemotropism? Are not the two sides of each ant equally stimulated by the odor trail and is not the confusion caused by the obliteration of that trail? By means of a simple experiment let us analyze that behavior.[1]

About a foot or more from the ground arrange a platform eight to twelve inches square. To its left edge attach a cardboard incline leading from it to territory that is familiar to the ants. On the platform place some ants with their larvae and eggs. In a short time the ants will be carrying the larvae and eggs down the incline to their nest. After the procession is well established,

[1] Turner, C. H.; The Homing of Ants. *Journ. of Comp. Neur. and Psy.*, 1907, Vol. XVII, pp. 367-435, Pl. II-IV.

attach to the right edge of the platform an incline leading to territory that is unfamiliar to the ants. This will cause no change in the behavior. Allow a few moments to be certain that the manipulation has not influenced the actions of the ants and then interchange the two inclines. On the right you now have an incline that is well scented with the odor of ants; on the left one that is entirely free from such odors. If the behavior of the ants is a chemotropism, the substitution of an unscented for the scented trail should disturb the movements and make it necessary for them to relearn the way home. Such will not be the result. Without a moment's hesitation the ants will continue down and up the incline, although there is no ant odor on it. Evidently that behavior is not a chemotropism.

Moreover, a careful study of ants shows that in most, if not all, cases the path by which ants leave a nest is not identical with the one by which they return. This is especially true of those ants that have eyes.[2]

In that case the trails are often widely separated. It is not intended to ignore the fact that certain species of blind ants deliberately deposit an odor trail which assists in guiding them home.[3] In that case it is next to impossible to determine the exact width of the odor trail; but, even then, the incoming and outgoing ants travel along parallel rather than identical trails. It seems highly probable that the scented pathway was to one side of the ant that led the others back to the nest. If that is so then the odor trail must function as a reference point and not as an inducer of tropisms.

Enter a dark cellar at night. Turn on the electric

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2 Turner, C. H. Op. cit. Cornetz, V.; Trajet de Fourmis et Retours du Nid. *Inst. Gen. Psychologique*, Mem. No. 2, 1910, pp. 1-167.

3 Santschi, F.; Comment s'Orientent des Fourmis. *Revue Suisse de Zoologie*, Vol. XXI, 1913, pp. 349-426.

light. A keen eye will detect roaches rushing in all directions to the cracks and crannies. Undoubtedly they are rushing away from the light. Is that behavior a negative phototropism? Let us analyze it experimentally. Arrange a floorless rectangular glass pen. Have the walls and ceiling of one-half of this enclosure opaque and of the other transparent. Place this pen on an opaque floor so constructed that, on the touching of a key, an electric shock may be given to any creature standing on it. Thus we have a run-way, one-half of which is in darkness and the floor of which is an electric shocking board. Place a roach in the lighted portion of the run-way. Immediately it rushes into the darkness. Turn on the current. It dashes into the light. Turn off the current and it will soon re-enter the darkened portion of the run. Every time it enters the darkness switch on the current; as soon as it leaves the darkened portion turn the current off. Shortly it will approach the entrance to the darkened run-way very cautiously; later it will halt at the dividing line and refuse to enter the darkness and will often retreat to the other end of the run-way.[4] Perhaps you think we have simply reversed the tropism; what was a negative phototropism has become a positive heliotropism. Let us examine this behavior a little more. As soon as the roach has thoroughly formed the habit of refusing to enter the darkness, remove the run-way from the shocking board and place it in a piece of ordinary board or cardboard. Place the roach in the runway. Immediately it enters the darkened portion. Restore the run to the shocking board and place the roach therein. It now refuses to enter the darkness. Evi-

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[4] Turner, C. H.; An Experimental Investigation of an apparent Reversal of the Responses to Light of the Roach *(Periplaneta orientalis)*. *Biol. Bull.*, 1912, Vol. XXIII, pp. 371-386.

dently it was not darkness as such that it refused to enter, but darkness associated with a peculiar kind of floor. It was responding to a darkness that had acquired a meaning; it was responding to darkness, not as a controller of tropism, but to darkness as a perception. If you have any doubts as to the soundness of your analysis place the roach on an open maze so arranged that to fall from the runways means a plunge into cold water. In a reasonably short time the roach will learn to run the maze, although in doing so it crosses the rays of light at several different angles.[5]

Several kinds of insects—bees, wasps, ants, flies—have the habit of hovering in great swarms and performing what looks like a sun dance. In the case of certain flies, at least, all seem to be facing the wind and the behavior has been interpreted as an anaemotropism. Examine the hovering swarm carefully—be it composed of bees, wasps, ants or flies—and you will find that the participants are males. Occasionally a female corkscrews through the group or approaches its outskirts. Immediately a few males dart in pursuit and the rest go on with the dance.[6] Evidently this is a prenuptial dance and is probably no more of an anaemotropism than is the soaring of a vulture. When we remember that the hovering of some flies consists in hovering before a wall or other opaque body this point of view is strengthened because such a fly cannot be facing the wind, since the wind

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[5] Turner, C. H.; Behavior of the Common Roach *(Periplaneta orientalis)* on an Open Maze. *Biol. Bull.*, Vol. XXV, 1913, pp. 348-365.

[6] Turner, C. H.; The Sun-Dance of Mellissodes, Psyche, 1909.

Turner, C. H.; The Mating of Lasius. *Jour. of Animal Behavior*, Vol. V, 1915, pp. 337-340.

Rau, Phil and Nellie; Wasp Studies Afield, 1918, pp. 9-17.

Pérez, J.—Sur Quelques Particularités Curieuses du Rapproachement des Sexes chez Certains Deptéres. *Bull. Scientifique de la France et la Belgique,* 1911, 7th series, T. XLV, pp. 1-14.

always moves parallel to a wall and not at right angles to it.

Watch the behavior of tent caterpillars. They move upward and outward, feeding when they find the proper materials. Later, satiated, they return to the tent. "Negative geotropism when hungry, positive geotropism when satiated", some say. Or, take the recessional caterpillars. They move along in a procession with the head of one in contact with the larva just in front of it. Lead them to the rim of a bucket and start the procession around the rim. When the circuit has been completed, knock aside the superfluous caterpillars and permit the head of the leader to come in contact with the tip of the abdomen of the last member of the procession. They will continue to march around the rim hour after hour.[7] "Positive thigmotropism", you say. Let us analyze the behavior of such caterpillars. Arrange a vertical maze consisting of an upright about one-inch in diameter to which are attached a number of jointed arms. Let the arms be so articulated that they can be bent in a variety of ways. Such a maze contains no succulent buds nor tender leaves for the larvae to nibble; hence there can be no reversal of tropism due to satiety. A caterpillar, when placed at the foot of such a maze will explore it. It may continue up to the center support to the top or it may explore one or more of the arms. After a time it is almost certain to descend the maze to the ground. This behavior may be repeated several times. The apparatus may be so manipulated that the caterpillar crosses the light at several different angles, so that it moves toward the wind, from the wind, and at angles to it, and so that it moves at times toward the earth and at other times away

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[7] Fabre, J. H.; The Life of the Caterpillar, Translated by Alexander Teixeira de Mattos. Dodd, Mead & Co., 1916, pp. 58-88.

from it; but the manipulation will have no appreciable effect upon the behavior of the insect.[8] The above behavior will be true of practically any species of surface-feeding caterpillar provided the larva has not just hatched from the egg or just emerged from hibernating, or is about to pupate or to hibernate. If a horizontal maze is substituted for the vertical one the behavior will be essentially the same. Since these caterpillars cross the rays of light, the wind and the vertical line at every possible angle, the behavior is neither a phototropism nor an anaemotropism nor a geotropism.

Secure a piece of glass tubing large enough to allow free movements but too narrow to permit the larva to turn around in it. By such a device it is possible to introduce the caterpillar to the maze with its head pointing in any desired direction. Under such conditions the caterpillar, when introduced to the maze, always starts off in the direction in which its head happens to be turned at the time. Irrespective of the direction of either the light or of the wind or of the pull of gravitation, it continues in that direction until some new stimulus is reached. There is no automatic adjusting of the body so as to have symmetrical portions equally stimulated. Evidently, except perhaps just after emerging from the egg or a state of hibernation, or immediately before pupating or hibernating, there is nothing about the behavior of surface-feeding caterpillars to warrant the assumption that these locomotions are tropisms. The movements made in locomotion are identical with those executed by animals that learn by the trial and error method. Instinctively the caterpillars are physiologically attuned to a certain environment. Outside that environment there

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[8] Turner, C. H.; The Locomotions of Surface-Feeding Caterpillars are not Tropisms. *Biological Bulletin*, Vol. XXXIV, 1918, pp. 137-148.

is physiological unrest. To escape the unpleasantness of this environment, the creature makes random movements. There is no automatic adjusting the body so as to have it symmetrically stimulated by the excitant. Some internal stimulus causes forward movement until some sensation factor induces it to change its course. If physiological satisfaction is not obtained, it continues its rambling until fatigue causes it to rest.

For the purposes of this paper, several cases of what appear to be typical tropisms have been selected and it has been shown how experimental analyses demonstrate that none of these are tropisms. It is thought that these results constitute an unanswerable argument against the careless manner in which the word tropism is now used. It is not contended that there are no such things as insect tropisms. In the light of our present knowledge, that would be claiming too much, for the scientific literature contains records of a few cases of what appear to be real tropisms.[9] It may be that at certain critical periods in the life of the insect, such as birth, emergence from hibernation, just before pupation or hibernation, etc.—the insect may be more or less under the control of tropisms, but the behavior of normal insects under ordinary conditions cannot be called tropisms. That is the message of this paper. It insists that the term tropism be so defined as to make it an easily recognized type of behavior, and that nothing be called a tropism that does not stand the test of critical experimental analysis.

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9 Loeb, Jacques; Studies in General Physiology, 1905, pp. 24-37.

THE HOMING OF THE HYMENOPTERA

By C. H. TURNER

INTRODUCTION

Hymenoptera is the name of a group of insects which includes ants, wasps, bees and their near kin. With the exception of those forms which in their babyhood are parasites, all construct homes to be occupied by their young. These homes may be subterranean, terrestrial or aerial; solitary or communal; constructed of clay, wood or paper; but, in all cases, in order to supply the young with food, the adults make frequent visits to these nurseries. By some species all of the food is stored in the nest before the eggs hatch; by others a portion is deposited before birth and the remainder is added as the young need it; yet others, which store no food before the larvae appear, are kept busy supplying the daily bread of their offspring. Their numerous periodic visits to the home make the adults excellent subjects for investigations of the methods by which insects find their way home. At first blush it may seem that the subject would have been exhausted long before now; but, by coining new psychological concepts and by insisting upon more exacting methods of experimentation, this age has stimulated a number of scholars to reinvestigate the subject.

The creeping ant leaves its burrow, meanders to its distant foraging ground and returns, without error, to its nest. Likewise the wasp and the bee repeatedly fly away to their hunting grounds and return. From time to time, four different factors have been proposed to account for this behavior; a homing instinct, tropisms, muscular memory and recognition of landmarks.

The advocates of the homing instinct claim that there is a peculiar inner power which guides insects home by the shortest route. Recognition and memory play no part whatsoever in this form of behavior. The insect leaves home and forages here and there. When ready to return, it instinctively knows in which direction and how far to go.

According to believers in the tropism theory, there is some external stimulus or stimuli which forces an insect homeward in the same manner that iron filings are impelled to orient themselves and move toward a strong magnet. This process is purely mechanical; it differs from the above in the stimulus being external instead of internal.

The advocates of muscular memory insist that all the time an insect is wandering away from home the movements of the muscles and the stresses and strains of the tendons are inducing in the nervous system a certain form of tension. When the insect is ready to return home, this tension is gradually released and induces the insect to right-about-face and retrace its steps.

Those who contend that there is a recognition of landmarks insist that insects and men find the way home in essentially the same manner; namely, by an associative memory enabling the possessor to recognize landmarks. This hypothesis differs from all the others in predicating an intellectual factor. It presupposes that insects are capable of learning by experience and profiting therefrom.

ANTS

Have you ever watched long lines of ants move to and fro between foraging grounds and nest? Have you ever wondered what enables them to find their way? Have you ever speculated upon the psychology of their behavior? Not many years ago, it was almost universally believed that there is a mysterious impulse which guides insects and other animals. Even today there are a few who believe in this homing instinct. Watson's recent experiments[1] which seem to demonstrate that terns are guided by a homing instinct will, no doubt, cause some to feel that this same interpretation may be made of the homing of insects. This is not the place to discuss the validity of Watson's experiments but birds and insects are morphologically so unlike that what is true in one case is not necessarily so in the other.

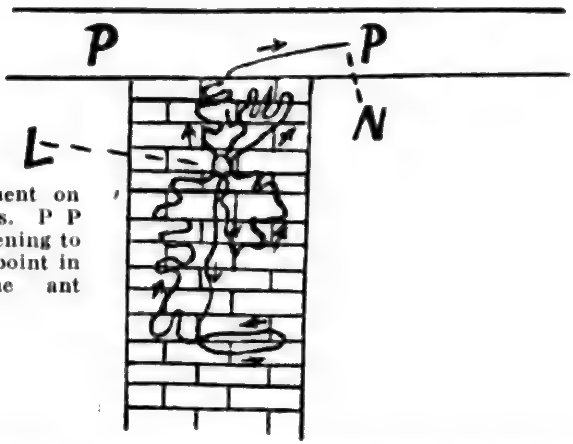

Fig. 1. Experiment on the homing of ants. P P porch, L leaf, N opening to nest. The arrows point in the direction the ant moved.

In the south many frame houses are supported on narrow brick pillars. Within the base-board of the porch of such a building a species of wood-boring ant had established its home. The entrance of this nest was within a foot of one of those supporting pillars. To the ants that brick pillar was an unexplored territory; weeks of watchful waiting failed to detect a single ant upon it.[2]

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[1] Watson, John B. The Behavior of the Noddy and Sooty Terns. *Publication 103, Carnegie Institution of Washington;* pp. 187-225.

[2] Turner, C. H. The Homing of Ants. *Jour. of Comp. Neur. and Psychology,* 1907, pp. 381-382.

The porch was shaded with vines that furnished pasturage to innumerable herds of "ant cows". At almost any hour of the day ants could be seen milking aphids, or moving to and from the pasture. Much patient waiting and careful searching finally revealed a leaf upon which a single ant was sipping food from plant lice. This leaf was gently removed and inserted in a hole previously made in the brick pillar (Fig. 1). This was accomplished without interrupting the ant's meal. Presently the ant finished its dinner and was ready to go home. Being within two feet of its nest, if in possession of a homing instinct, it should have gone directly home. What really happened is as illuminating as it was unexpected. In a meandering line it descended the pillar until almost to the ground, then turned and zigzaged slowly upward until it had reached the leaf. After exploring the leaf it twice more meandered over the pillar and back, each time in a different direction. On its fourth sinuous journey, it reached the base-board of the porch and then rushed directly to the nest. Evidently, transporting the leaf had caused the ant to become lost.

It is an easy matter to cause ants to lose their way. After a hard rain, if a number of ants are transported a few yards from a nest and deposited on the ground, almost none of them will be able to find the way home. After numerous profitless random movements, they will usually take refuge under stones or chips. Unless discovered by workers from the nest, they are apt to remain in such situations a long time. Would it be possible to do this if ants were in possession of a homing instinct?

You may think Miss Fielde[3] entirely wrong when she claims to have demonstrated that each joint of the anten-

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[3] Fielde, A. M. *Proc. Acad. Sci. Philadelphia,* 1903.

na is the organ of a special kind of odor; you may not be able to decide whether to agree with those who claim that the sense of smell is located in the antenna or with those who claim that it is located elsewhere[4]: but in the light of the following experiments, there is no escaping the conviction that ants possess a well developed sense akin to the olfactory sense of man.

Paint a narrow odoriferous band across the pathway of homegoing ants, or even draw your finger across the trail of certain species; immediately the procession halts and those nearest the offending streak move hither and thither as though lost. The confusion will not be permanent. Presently the procession will move along as before.

As a rule ants will attack any strange worker ant that attempts to enter the nest but members of the household will be received with open arms even after an absence of several days. Take some ants from a nest, wash the nest odor from their bodies, bathe them in the blood of an alien colony of ants and then return them to their own nest. They will be attacked, as least temporarily, as strangers. On the other hand, take some ants from a nest, wash the nest odor from their bodies, bathe them in the blood of ants of an alien colony and then place them in that colony and they will be welcomed, at least temporarily, as members of the household.

However, the admission that ants have a well developed olfactory or topochemical sense is no justification for the conclusion that odors, by arousing chemotropisms, guide them home. There are a few species of ants that do seem

[4] Forel, August. The Senses of Insects. Translated by Macleod Yearsley. *Methuen & Co., London,* 1908, pp. 73-100.

McIndoo, N. E. The Olfactory Sense of Insects. *Smith. Misc. Col.,* 63, number 9, pp. 1-63. 1914.

———— The Olfactory Sense of the Hymenoptera. *Proc. Acad. Sci., Philadelphia,* 1914, pp. 294-341.

to rely almost entirely upon odors for guidance; ants which on their outward journey deposit odors on the trail to make it more conspicuous. This, however, is not true of the majority of ants for it is now well known that the individuals of many species do not return home along the identical trail by which they departed.[5] The two pathways are near together and roughly parallel but not coincident. Then, too, the following easily repeated experiments militate against such a conclusion:

By means of a pin through its center, attach a rectangular piece of cardboard, eight inches square to the cork of a bottle six or more inches high. By means of a narrow cardboard inclined plane, connect this stage with the runway of a nest of ants with well developed eyes. On the cardboard platform place a number of ants with their eggs and pupae. At first the ants will rush about at random as though lost. After a number of fruitless efforts, they will finally find the way to the nest. Soon there will be a procession of ants moving to and fro between the nest and the stage. When the trail has been well established, replace the inclined plane with a new one and attach it to the opposite side of the platform. If ants are guided home solely by odors stimulating tropisms, those ants should act as though confused and spend much time learning the way home. Such will not be the case. Without a moments hesitation the ants will journey homeward along the unscented pathway.[6]

Arrange the card-board stage as above with the inclined plane upon the right. Near to the right and to the left sides of the stage and separated from it by heat fil-

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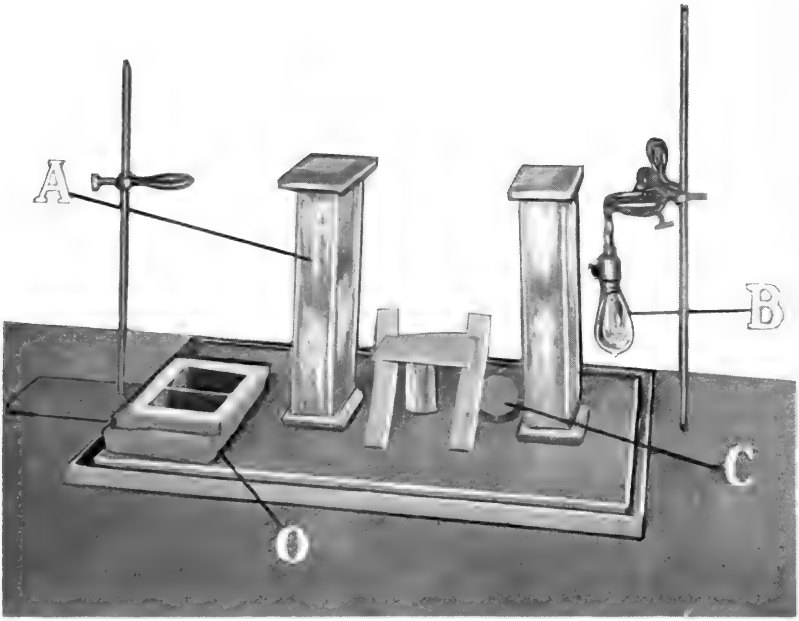
[5] Turner, C. H. The Homing of Ants. *Jour. of Comp. Neur. and Psy.*, Vol. 17, pp. 370-378.

Cornetz, Victor. Trajets de Fourmis et Retours au Nid. *Institut Général Psychologique, Mémoires*, No. 2, pp. 1-167.

[6] Turner, C. H. Homing of Ants, ibid. pp. 399-401.



Apparatus used to demonstrate that certain species of ants use light as a landmark. In the series represented by this photograph the light was shifted from side to side. Later lights were placed permanently on both sides; but these were so connected that when one was lighted the other was automatically extinguished. A, heat filter. B, electric light. C, mirror for viewing the lower side of the inclined plane. O, Janet nest.

ters, arrange electric lights so connected that when the light on one side is burning the other is automatically extinguished (Pl. X). Place a number of ants with their eggs, larvae and pupae upon the stage, and switch on the light on the right side of the stage. Soon there will be a continuous procession of busy ants passing to and fro between the nest and the stage. When the procession is so thoroughly established that no ants are straggling about on the stage, attach a second incline plane to the left side of the platform. You will now have one incline on the side where the light is shining and another on the opposite side. You may watch for hours and the ants will continue to travel along the pathway on the right. Switch off the light on the right; turn on the light on the left. Immediately a remarkable change occurs. The ants act as though they were in a panic. As you watch them darting to and fro there is no escaping the conviction that they are lost. Presently order will be re-established and the procession will be moving to and fro between the nest and the stage, but not along the inclined plane on the right. The approach on the left is now the means by which the ants enter and leave the stage! Evidently light is a factor in guiding those ants home. Since, on their homeward journey, the ants moved toward the light, across the light, and away from the light, it was light as a landmark and not as an inducer of phototropisms that guided those ants.

Or, as Sancti[7] has done, select a place in the open where there is a nest of ants with well developed eyes, and choose a time of day when the home-going ants are facing the sun. By means of a mirror flash the sunlight upon a

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[7] Sancti, F. Observations et Remarques Critiques sur le Mécanisme de l'Orientation chez les Formis. *Revue Suisse de Zoologie,* Vol 19, pp. 316-332.

home-going ant. Immediately it will depart from the trail and move toward the mirror. Could that happen if the insect were slavishly following the odor trail?

To jump to the conclusion that light is the sole factor guiding these ants would be as great a fallacy as that made by those who claim that odors are. It is well known that ants sometimes pass under shelters and out on the other side, that they traverse shadows and that they often forage after sundown. Admitting that the high sensitivity of ants to the ultra violet rays indicates that they are stimulated by light in situations where we can detect only darkness, yet, recalling that there is experimental evidence that ants are affected by the olfactory and tactile peculiarities of their trails, one is forced to conclude that light is not the only factor which influences the homing of ants.

Any serious student of the behavior of ants is sure to be impressed with the fact that they have an awareness of distance in both a horizontal and a vertical direction, and that this awareness is something which has been acquired by the ant on its outward journey. Just after a rain, if some ants are taken from a nest and transported to a distance, they will wander about without finding the way home. Even a casual observer would know that they were lost. Let those same ants make that journey on foot and each would easily find the way home. The following experiment, which was first performed by Pieron,[8] has convinced some students that this awareness of distance is a function of the muscular sense.

Select a place where the surface of the ground around the nest is practically uniform. Watch for a home-com-

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[8] Pieron, M. Du Role du Sens Musculaire dans l'Orientation de Quelques Especes de Fourmis. *Bull. Inst. Gen. Psych., Paris,* Vol. IV, 168-187.

ing ant. In its path place a flat piece of cardboard. When the ant has mounted this, in as gentle a manner as possible, transport the whole to the ground on the opposite side of the nest. The ant will leave the cardboard and continue on in the direction it was going until it has gone as far as the distance from the nest to the original position of the card-board. There it will describe that series of short complex curves, frequently made by ants when in the vicinity of the nest, which Cornetz has called "tournoiement de Turner." As stated above, Pieron thinks that the movements of the muscles of the ant on its outward journey induced a certain tension in the nervous system. As a result of this tension the home-going ant is automatically warned when it has gone far enough.

Without passing judgement upon Pieron's theory as to how ants determine distance, it is the contention of this article that the awareness of direction is a function of the perceptual peculiarities of the environment of the outgoing ant. In other words, on its outward journey the ant notices certain characteristics of its surroundings; on its return trip it recognizes these and uses them as landmarks. The use of the expression perceptual peculiarities implies that that which guides the ants is a fusion-product of more than one sense. In those ants with poorly developed eyes, the olfactory (topochemical) sense is basal; where the visual organs are well developed, sight is the sense about the recepts of which the contributions of the other senses are fused. The contention of some that we should seek a simpler explanation is offset by the fact that there is experimental evidence that ants possess associative memory.

It is thought that the following description of how an ant was taught to use an elevator on going to and from a stage a few inches high is proof that ants possess associative memory. Two marked worker ants, A and B, were being experimented upon at the same time. "The one I have called A readily learned the way down and up the incline; but to B this was an insoluble problem.[9] It continued for a long time to move at random over the stage, reaching down over first one edge and then over another as though it was reaching for a support that was not to be found, but nothing prompted it to pass down the incline. Prompted by another thought, I shoved the section lifter under the ant and transferred it to the island. The ant then stepped off and carried the pupa to the nest. As soon as B returned to the island, I shoved the section-lifter under it and transferred it to the stage. B stepped off and picked up another pupa. With the section-lifter I again transferred it to the island. After this was repeated several times, the moment I presented the section-lifter, whether on the island or on the stage, the ant immediately mounted it and rested quietly thereon until it had been removed to the stage or to the island; then it stepped off and picked up a pupa or else went into the nest. I usually held the section-lifter from two to four millimeters above the surface of the island or stage. In this manner the industrious creature passed to and from the stage about fifty times in something less than two hours."

At least two other investigators[10] have succeeded in teaching ants to do unexpected things. Since ants possess associative memory and since they are easily disconcerted by changes made in the environment, it is not

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[9] Turner, C. H. The Homing of Ants, pp. 386-387.

[10] Ernst, C. Einige Beobachtungen and künstlichen Ameisennestern *Biol. Centrlb.*, vol 25, pp. 47-51; vol. 26, pp. 210-220.

Wasmann. Die psychischen Fahigkeiten der Ameisen. *Zoologica*, vol. 26.

claiming too much to insist that they are guided by landmarks.

WASPS AND BEES

Tarry upon a busy corner of either a small town or a metropolitan city. Stop each pedestrian and inquire how wasps and bees find the way home. Nine out of ten will say they are guided, in a straight line, by some mysterious inner force. This is so ingrained in the folk-consciousness that the expression "bee line" is used to designate the most direct route. Some scientists must be included in that number; for Bethe[11] insists that up to three kilometers bees are guided home by a mysterious power. He bases his conclusions upon such experiments as the following:

If a hive is removed a short distance the returning bees at first fail to find it.

Bees were taken into the town of Strasburg, a place which Bethe claims the bees did not visit, and turned loose in the streets. They went home directly. Bethe claims that the majority of them started in the right direction before they reached the housetops.

A yellow hive was placed on a table. Near the hive was placed a folding screen. On the screen were hung colored handkerchiefs. The table and hive were covered with green branches and blue paper was glued to the yellow face of the hive. The bees on returning hesitated a moment, forming a slight swarm. Thereafter, they flew without hesitation to the door of the hive.

Bethe cites several other experiments but none are more conclusive than these. Bethe's preconceived notions caused him to ignore those facts in his experiments that do not serve his purpose. His experiments show

[11] Bethe, A. Die Heimkerh fähigkeit der Ameisen und Bienen zum Theil nach neuen Versuchen. *Biol. Centrlb.*, Bd. 22, s. 193-215, 234-238.

conclusively that when the position of the entrance of the hive is gradually changed, either in a straight line or in a circle, the bees are not disconcerted. In Strasburg, according to Forel, the streets are narrow and straight. In narrow straight streets, how would it be possible for bees to start directly toward the hive, before reaching the house-tops, unless the experimenter had selected streets that pointed in the right direction? In his hive experiment he counts as insignificant the hesitation of the bees mentioned above. He noticed that flashing light by means of mirrors and placing fresh paper around hives caused bees to hesitate and accumulate in swarms before entering, but he attributed the disturbance to the keen sense of smell of bees.

One of Bethe's own experiments militates against his contention. He conveyed a hive a long distance from home and turned the bees out. The old bees returned to the place from which the hive had been removed but the young bees re-entered the hive in its new location. When we remember that old bees on leaving a hive depart immediately and that young bees describe circles of orientation, does not this indicate that the old bees followed well-known landmarks to their former home and that the young bees, being unfamiliar with such landmarks, were guided back to the hive by newly acquired data? Then, too, how can Bethe harmonize his view with the fact that bees caught afield after dark remain out all night? The weakness of Bethe's contention becomes even more apparent when we consider the experimental work of those whose conclusions are unlike his.

In a school building in the city of Augusta, Georgia, there was a schoolroom with windows on three sides. On the north there were four adjacent windows, with a space of about eight inches between each two.[12] Each window was provided with two shades, one extending from the top to the middle, and one covering the lower sash. On the west there were two widely separated windows. One of these was kept open night and day. For convenience, the windows on the north were numbered three, four, five and six. They were kept closed at all times but the shades were manipulated in a variety of ways. At the beginning of the experiment all shades were down except the top shade of window four, which was raised to the fullest extent. A mud-dauber wasp began a nest a little to the west of the upper left-hand corner of window four. After one cell had been about completed, while the wasp was afield, the upper shade of window four was lowered and the corresponding shade of window five raised. This shifted a broad beam of white light one window to the east. No other change was made in the surroundings. If wasps are guided home by the mysterious force for which Bethe contends, no change should have been made in the behavior of this wasp. Presently the insect returned and flew directly, not to the nest, but a little to the west of the upper left-hand corner of window five. She searched and searched, but on that trip did not find the nest until the shades were restored to their former position. To make a long story short, for several days, the shades were manipulated in a variety of ways. Each time a change was made the wasp acted as though it was confused. Evidently that Hymenopteron was using landmarks, of which the beam of light was one.

"Several of the walks of the Haines Normal School, Augusta, Georgia, are separated from the adjacent flower

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[12] Turner, C. H. The Homing of the Mud-Dauber. *Biol. Bull.*, vol. 15, pp. 215-225.

beds by bricks inclined in such a manner as to form a serrated border of wedges of bricks, each wedge being about two inches high and something over four inches wide at the base.[13] One of these flower beds, which was quite sandy, contained in its center a patch of nasturtiums. * * * In a barren spot in this bed, adjacent to an inverted tin cap of a Coca-Cola bottle, and within an inch of the northern face of one of the bricks that formed the serrated border, a burrowing-bee excavated a burrow. The nest was discovered at nine a. m., August 8, 1908. The sun was shining brightly at the time but the nest, which was situated a little to the west of the southern wall of a large three-story brick building, was in the shadow. A gentle breeze was blowing from the south. At the time mentioned, the bee was busy collecting pollen and storing it in its burrow. The flowers from which it obtained its supply must have been quite remote, for it required about thirty minutes to make the trip.

"For convenience, the brick before which the burrow was located was designated zero and bricks to the west of it W_1, W_2, W_3, etc., in regular succession. Likewise the bricks to the east were named E_1, E_2, E_3, etc.

"The field from which the bee obtained its pollen was situated to the south of the school, and the burrow of the bee was located to the north of the brick border. On arriving from its forage, the bee would reach the brick border at or near brick W_{10}. It then would turn about so as to face the northern surface of the brick border. Then hovering at about an inch and a half from the ground and at about the same distance from the bricks, the bee would sidle along. Usually its movement was toward the east but occasionally it would retrograde

[13] Turner, C. H. The Homing of Burrowing Bees. *Biol. Bulletin*, vol. 15, pp. 247-258.

westward a short distance and then resume its eastward progress. On reaching the brick before which the nest was located, it would drop immediately into the burrow. After remaining in the burrow a few minutes, the bee would depart, without stopping to explore the surroundings. Several trips were observed carefully and, in each case, the behavior was essentially the same. In its flight, neither the orientation of its body, nor the direction of its movements, bore any constant relation either to the direction of the wind or to the rays of the sun."

While the bee was afield a hole of the same diameter as the burrow was made in front of bricks W_1 and E_1; and the bottle top was placed adjacent to the hole made before brick W_1. Presently the bee returned and after the usual preliminary movements, dropped quickly into the hole before brick W_1. Discovering her error, she backed out and searched about for her home until it was found. By making additional holes and by altering the conditions around the original burrow, the bee was caused to make numerous errors.

These and experiments similar in results but unlike in detail, which have been described by several investigators[14], warrant the conclusion that wasps and bees are guided home by utilizing landmarks.

It is evident that the behavior exhibited in the above experiments cannot be classed as either an anemotropism or as a phototropism, for neither the orientation of the

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[14] Buttel-Reepen. Sind die Bienen Reflexmaschinen? *Leipzig*, 1900.
——— Die Sinne der Biene. 1914.
Forel, Auguste. The Senses of Insects. Trans. by Macleod Yearsley. *London*, 1908.
Lubbock, Sir John. Ants, Bees and Wasps. 1881.
——— On the Senses, Instincts and Intelligence of Animals. *London*, 1888.
Peckham, G. W. Some Observations on the Special Senses of Wasps. *Proc. of the Nat. Hist. Soc. of Wisconsin*, April, 1887.
Peckham, Geo. W. and Elizabeth G. On the Instincts and Habits of the Solitary Wasps. *Madison, Wis.*, 1898.

body nor the direction of flight bore any constant relation either to the direction of the wind or the rays of the sun. It would be erroneous to claim that these wasps and bees find their way home by the method of "trial and error," for there is no gradual "stamping in" of the appropriate response. When the returning insect finds the environment markedly changed, it searches until the opening to its nest is found. On its next departure a careful examination of the vicinity of the nest is made. On its next return, unless the environment has been changed in the meanwhile, the wasp or bee flies directly to its burrow in the minimum amount of time; there is none of that blundering into solution which the method of "trial and error" demands.

The contention that wasps and bees use landmarks to guide them home predicates to them the ability to recognize things by sight. This predication is justified by the following experiments which demonstrate that these insects possess both color-vision and pattern-vision.

A large number of cardboard artifacts were made.[15] Some were circular discs, some pill-boxes and others cornucopias. Each cornucopia had a semi-circular flange projecting beyond its mouth. The bottom of the outer case of each pill-box projected a short distance beyond the front, and the drawer of each box was shorter than the case and contained an opening in its front end. Some of these artifacts were colored red, some blue, some marked with alternating red and green longitudinal stripes, some with alternating red and green transverse stripes; some marked with alternating black and white longitudinal stripes, some with alternating

[15] Turner, C. H. Experiments on Color-Vision of the Honey Bee. *Biol. Bull.*, vol. 19, 257-279.

——— Experiments on the Pattern Vision of the Honey Bee. *Biol. Bull.*, vol. 21, pp. 249-264.

black and white transverse stripes; and some speckled with red and green. These colors were not optically pure, but were such as could be procured in the market.

The place selected for the experiments was a large field of white, sweet clover, which was visited by countless numbers of bees. The experiments occupied a part of two summers. The bees were trained to visit an artifact of a certain color by placing honey on or in an artifact of that color and leaving the others empty. The first season they were trained to visit a plain artifact; the second, to visit a striped one. Much time and patience was required to induce a single bee to visit one of these artifacts. Soon after one of the bees had discovered the richness of these artifacts in honey, a large number of bees began to make regular visits to them. After the bees had been foraging upon these artifacts for several days and had practically neglected the melilot for them, new artifacts were constructed and the following examination was held:

The tests covered a number of days and were arranged in series. In one series no honey was placed in any of the artifacts; in another, honey was placed in some of the artifacts, but none in those of the color and pattern from which the bees had been trained to expect honey; in a third series honey was placed in some of the artifacts of each color pattern used. The number of varieties of color patterns used at one time varied from two to seven and the total number of artifacts used at one time varied from two to twenty. Almost invariably the bees flew into the artifacts of the color and pattern from which they had been trained to collect honey; but paid no attention to artifacts of any other color and pattern. The manner in which the bees passed by most artifacts, even when they contained honey, and the eagerness with which they rushed into the empty artifacts of the color and pattern from which they had been trained to expect honey would have convinced any unbiased spectator that to those bees certain artifacts had acquired a meaning and that those insects were exercising the faculty of recognition.

Less than two per cent of mistakes were made, and in the light of subsequent experiments, these were instructive. Two consisted in selecting a box mottled red and green for one painted with alternating red and green longitudinal stripes; two in selecting a box with black and white longitudinal stripes for one with red and green longitudinal stripes; the other six consisted in selecting a box marked with alternating red and green transverse stripes for one marked with red and green longitudinal stripes. Remembering that these colors were not optically pure, and recalling the experiments by which Frisch[16] claims to have demonstrated that bees are red-green color blind, these are just the kind of mistakes we would expect bees to make if they are guided by landmarks.

Further experimental confirmation that recognition is one of the mental traits of bees and wasps may be found in the published works of Foreel (l. c.), Lubbock (l. c.), the Peckhams (l. c.), Lovell[17], and others.[18]

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[16] Frisch, Karl v. Ueber den Farbensinn der Bienen und die Blumenfarben. *Muenchener medizinischen Wochenschrift*, 1913, pp. 1-10.

[17] Lovell, John H. The Color Sense of the Honey Bee. *The Amer. Nat.*, vol. 46, pp. 83-107.

——————— The Color Sense of the Honey Bee: Can Bees Distinguish Colors? *Amer. Nat.*, vol. 44, pp. 673-692.

[18] In a series of papers extending over a decade ["Comment les fleurs attirent les insects." "Un filet empeche-t-il le passage des insectes." "Nouvelles recherches sur les rapports entre les insectes et les fleurs." "Recherches experimentales sur la vision chez les arthropodes," etc.] Platean describes a number of experiments which he thinks demonstrate that these insects do not make visual discriminations. Forel and Lovell have pointed out so conclusively the defects of his experiments and the fallacies of his conclusions that it was not thought necessary to discuss them in the body of this article.

CONCLUSION

After studying the subject from all possible angles, the conviction has been reached that neither the creeping ant, nor the flying bee, nor the hunting wasp is guided home either by a mysterious homing instinct, or a combination of tropisms, or solely by muscular memory, but by something which each acquires by experience. As these insects journey outward, one or more senses contribute recepts which, functioning as percepts, enable the homebound insects to recognize certain landmarks and be guided by them.

THE PSYCHOLOGY OF "PLAYING 'POSSUM"

By C. H. TURNER

Playing 'possum, feigning death, letisimulation—to use in succession the language of the southerner, the Bostonian and the behaviorist—are terms for a form of behavior which is as widespread as it is remarkable. Any one who has hunted opossums in the south has observed an interesting exhibition of it. When an opossum is attacked, usually it falls to the ground, draws back its lips and looks as though dead. You may toss it about, kick it, pinch it, do what you may, but not a sign of life will you get. Individual specimens have been known to remain as though dead for hours. This peculiar method of protecting itself from danger is found throughout the animal kingdom. Not all animals, nor yet all species, practice it, but from the protozoa upward, almost all groups of active invertebrates contain certain species that practice it, and among the vertebrates some members of all groups letisimulate. So widespread is this phenomenon that Weir, in his Dawn of Reason, thought it wise to coin a scientific name for it. He called it letisimulation (from *letum,* death, and *simulare,* to feign).

All students of one-celled animals have noticed Vorticella fold in its cilia, coil its flexible stalk and retreat against a support when approached by a larger invertebrate. Weir noticed that the approach of certain water fleas caused a species of rhizopods to drop to the bottom and to remain quiet until the larger creatures had disappeared.

There is an annelid worm about one-eighth of an inch long, which swims gracefully. As soon as a water beetle appears, it hangs in the water as limp as a cotton thread.

Most students of vertebrate behavior are familiar with the behavior of the black viper, which Weir considers the greatest letisimulator of all animals. When it is threatened and a mode of escape is not apparent, the snake writhes and twists in apparent agony, then turns over on its back and seems to be in *rigor mortis.* You seem to see the reptile pass through its death throes and expire. Turn your back a few moments and the snake disappears.

The opossum and the black viper seem to have made a lasting impression on Weir, for, while citing examples from the protozoa, worms, insects, reptiles, birds and mammals, he leaves the impression that the most remarkable examples of death-feigning are to be found in the reptiles and certain mammals. Since that time much attention has been given to the study of the letisimulation of insects. Barret (Porto Rico Agri. Exp. Sta. Bull., 1902) has studied it in the mole-cricket; Gee and Lathrop (Ann. Ent. Soc. of Amer., 1912, Vol. V., pp. 391-399) and Johnson and Girault (Circ., Bull. of Entom., U. S. Dept. of Agri.), in the plum cuculio; Girault (Entom. News, 1913, Vol. XXIV, pp. 338-344), in trox; Holmes (Jour. of Comp. Neur. & Psy., 1906, Vol. XV, pp. 305-349), in the water scorpions; Newell (Jour. of Ec. Ent., 1913, Vol. VI, pp. 55-61), and Weiss (Canad. Entom., 1913, Vol. XLV, pp. 135-137) in the rice weevil; Riley (Ann. Ent. Soc. of Amer., 1912, Vol. V, pp. 273-292) in dragon fly nymphs; the Severins (Jour. N. Y. Entom. Soc., 1911, Vol. XIX, pp. 99-108), in the giant water bugs, and Wodsedalek (Ann. Entom. Soc. of Amer., 1912, Vol V, pp. 31-40, 367-381), in May-fly nymphs and dermestid larvae. In the light of the remarkable traits revealed by these investigators, were he writing his article today, Weir, no doubt, would agree with Holmes that "it is among the insects that the death-feigning instinct reaches its highest development, occurring, in a greater or less extent, in most of the orders. It is especially common in beetles and not unusual among bugs, but it is quite rare in the highest orders such as the Diptera, or flies, and the Hymenoptera, or ants, bees and their allies. It occurs in a few cases among the butterflies and moths, both in the imago as well as the larval state. The instinct is exhibited in different species in all stages of development from a momentary feint to the condition of intense rigor lasting for over an hour. "Some insects may be severely mutilated," according to De Geer, "even roasted over a fire before they cease feigning."

At the planning of this paper it was intended to give an epitome of the researches of all recent investigators of letisimulating insects; but later it was decided to limit this part of the paper to recent investigations of mine upon our common ant-lion. Although the ant-lion is considered such a marvel that all popular treatments of insects and practically all textbooks on entomology discuss it, hitherto almost no attention has been paid to its death feigning. Emerton (Amer. Nat., 1871, Vol. IV, pp. 705-708) and MacLachlan (Ent. Mag., 1865, Vol. II, pp. 73-75) are the only ones that mention it and each devotes only a short sentence to the matter.

One hundred ant-lions, isolated in numbered jelly glasses of suitable soil formed the subjects of these investigations. These were kept in an out-of-doors insectary, the whole north wall of which is exposed to the weather. Although any kind of rough treatment will cause an ant-lion to letisimulate, in these experiments letisimulation was induced either by roughly turning the creature upon its back, or else by dropping it from a slight elevation.

Several investigators have thought it important to determine if the poses assumed by letisimulating individuals are death attitudes. Darwin was convinced death-feigning attitudes are not identical with those caused by death. Based on consideration of seventeen species of invertebrates, Holmes (Pop. Sci. Monthly, 1908, Vol. LXXII, pp. 179-185) concludes that the poses assumed were usually quite different from death attitudes, although there were some species in which they were always identical. I find that the ant-lion has not one, but several, death attitudes; likewise it possesses a number of death-feigning postures, some of which resemble death poses and some of which do not. The insect becomes rigidly immobile in whatever attitude it may be when it receives the shock. Absolute immobility is the character that is common to all cases. When the feint follows a long period of fasting, this inactivity often simulates death. The rigidity, however, is not so great as that described for certain insects. In some species of insects the rigidity of parts during a death feint is so great that the insect may be picked up by the tarsus and held out at right angles without the leg bending in the least. That is not the case with the ant-lion. When an attempt is made to lift it by a tarsus, the leg bends and the insect awakes from its feint.

With a pair of sharp scissors one may cut off the legs and the tips of the mandibles of a letisimulating ant-lion without arousing the slightest response. Attempt to cut the legs with a pair of dull scissors and the insect awakes at once.

The duration of the death feint varies. Fabre, in his study of a certain beetle (Souvenirs Entomologiques, 7th series, pp. 14-27), found that the duration of the feints gradually increased from the first to the fifth feint. To test this matter, I selected one hundred ant-lions and, by proper manipulations, made it possible for each to have an opportunity to make twenty successive letisimulations. These experiments revealed marked individual variations. The longest feint occurred anywhere from the first to the sixteenth feint; although it usually occurred near the beginning of the series. This irregularity in the location of the longest feint is in accord with the work of the Severins (Jour. N. Y. Entom. Soc., 1911, Vol. XIX, pp. 99-108) and of Gee and Lathrop (Ann. Ent. Soc. of Amer., 1912, Vol. V, pp. 391-399) on the giant water bugs and the plum cuculio.

To see if the duration and location of the maximum feint and the total time consumed in the series of letisimulations mentioned were factors of external stimuli, experiments were devised to test the effects of temperature, strength of the inducing stimulus and hunger. There did not seem to be any relation between these stimuli and the results. These phenomena seem to depend upon the individuality of the ant-lion; *i. e.,* upon internal physiological states which vary in different individuals and in the same individual at different times.

It seems to me that even a layman cannot listen to a recital of such peculiar behavior as that mentioned above without asking, "What does it indicate as to the psychological status of the individuals?" Weir (Dawn of Reason, 1889, p. 202) considers the letisimulation of animals "one of the greatest evidences of intellectual action on their part." Hamilton (Canad. Entom., 1888, p. 179), Webster (Canad. Entom., 1888, Vol. XX, p. 199) and a few others feel that the creatures consciously fear death and take this means of avoiding it. Dr. Lindsley, in "Mind in Animals," thinks "this must require great command in those that practice it." However, the majority of modern students of the subject look upon it as merely a remarkable instinct.

Surely no one who is acquainted with how slowly the ant-lion recovers from injuries could, for a moment, consider anything intellectual which induces it to passively submit to portions of its legs and of its mandibles being amputated. Its letisimulation may be an emotional response, but it certainly is not intellectual. The tonic contraction of the muscles and the diminished reflex irritability suggest hypnotic phenomena and lead one to agree with Holmes (Pop. Sci. Mon., 1908, Vol. LXXII, pp. 179-185) that "the instinct of feigning death is doubtless connected with much of what has been called hypnotism in the lower animals." It is well known that most animals pause momentarily when confronted with an unexpected or violent stimulus. The letisimulation of the ant-lion seems such a pause prolonged and exaggerated. The more I ponder over the results of my experiments with death-feigning ant-lions, the more I am inclined to exclaim with James: "It really is no feigning of death at all and requires no self command. It is simply terror paralysis which has been so useful as to become hereditary."

I am fully convinced that a careful examination of the writings of recent experimenters upon letisimulating insects will convince any unbiased person that the above explanation is valid for all members of that group. Can this same interpretation be given to the numerous apparently authentic anecdotes about death-feigning mammals? Let us consider three typical ones selected from Romanes "Mental Evolution in Animals":

"It so happened that, while puss was reclining at ease, seemingly inattentive to all the world around her, a weasel came unexpected up, was seized in a moment, and dangling from her teeth as if dead, was carried to the house at no great distance. The door being shut, puss, deceived by its apparent lifelessness, laid her victim on the step while she gave her usual mewing cry for admittance. By this time the active little creature had recovered its recollection and in a moment struck its teeth into its enemy's nose."

Listen to the description of a death feigning Brahmin bull which Surgeon Bidie describes as follows: "Some years ago, while living in Western Mysore, I occupied a house surrounded by several acres of fine pasture land. The superior grass in this preserve was a great temptation to the village cattle, and whenever the gates were open trespass was common. My servants did their best to drive off intruders, but one day they came to me rather troubled, stating that a Brahmin bull, which they had beaten, had fallen down dead. It may be remarked that these bulls are sacred and privileged animals, being allowed to roam at large and eat whatever they may fancy in the open shops of the bazaar men. On hearing that the trespasser was dead, I immediately went to view the body, and there sure enough it was lying exactly as if life were extinct. Being rather vexed about the occurrence in case of getting into trouble with the natives, I did not stay to make any minute examination, but at once returned to the house with the view of reporting the affair to the district authorities. I had only just gone for a short time, when a man with joy in his face came running to tell me that the bull was high on his legs again and quietly grazing. Suffice to say the brute had acquired the trick of feigning death which practically rendered its expulsion impossible, when it found itself in a desirable situation. The ruse was practiced frequently with the object of enjoying our excellent grass, and although for a time amusing, it at length became troublesome, and resolving to get rid of it the sooner, I, one day, when he had fallen down, sent to the kitchen for a supply of hot coals which we placed on his rump. At first he did not seem to mind this much, but as the application waxed hot he gradually raised his head, took a steady look at the site of the cinders, and finally getting on his legs went off at a racing pace and took the fence like a deer. This was the last occasion on which we were favored with a visit from our friend."

Foxes, when surprised in a hen house, have acted as though dead and permitted themselves to be carried out of the house without displaying any sign of life. As soon, however, as they have been thrown upon the dump heap they have scampered away at great speed.

At first blush these examples seem to be on a higher plane than the death-feigning of insects but, until the letisimulation of mammals has been investigated by means of carefully controlled experiments, it is best to suspend judgment.

Ingersoll's discussion of the origin of the death-feigning instinct of the opossum is illuminating. He mentions the well-known fact that the same stimulus does not always cause an opossum to letisimulate. When threatened, sometimes it fights, some times it attempts to run away, at others it feigns death. As far as keen investigators have been able to determine, the external stimulus is identical. He also calls attention to his belief that, at the present day, the death-feigning behavior of the opossum is baneful rather than beneficial. To illustrate, in Texas there is a species of buzzard that threatens the opossum by flapping its wings; then, as soon as the animal letisimulates, proceeds to pluck out its eyes and to gouge chunks of flesh out of its body. Since this instinct is now detrimental to the opossum, Ingersol thinks it a survival of a time when it was of value. He reminds us that the opossums rank among the most primitive mammals, and that when they appeared none of the higher mammals had been evolved. The reptiles were then the monarch of land, air and water. Many of them were gigantic beings but, judging from the size of their skulls, they must have been of a very low order of intelligence, probably lower than our present alligators. The indications are that these ancient reptiles fed exclusively upon live prey. Small objects would not have attracted the attention of such stupid creatures unless they moved. It is easy to see how this death-feigning behavior would be of value to an opossum under those conditions. Ingersoll thinks that the instinct appeared and was perpetuated at that time. When one recalls the gigantic size of many of those reptiles and the small size of the opossum, although Ingersoll does not say so, the death-feigning of these marsupials might have arisen as a case of terror paralysis.

If Ingersoll's interpretation of the origin of the letisimulation of the opossum is correct, we seem justified in saying that in both the opossum and in insects death-feigning is but an exaggerated prolongation of the pause made by most animals when startled. Although, until other experiments are forthcoming, we must suspend judgment about the nature of the letisimulation of many of the higher mammals, so far as the insects and the opossum are concerned, we can exclaim with James: "It really is no feigning of death at all and requires no self-command. It is simply terror paralysis which has been so useful as to become hereditary."