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A NEW SPECIES OF *APPALACHIA* FROM MICHIGAN
(ORTHOPTERA, ACRIDIDAE, CYRTA-
CANTHACRINAE)

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THE handsome new species of *Appalachia* described below was first found by the writers in August, 1934, at Oscoda, Iosco County, Michigan. The species was immediately recognized as new, and subsequent study led us to place it as an aberrant member of the genus *Dendrotettix*. In 1936 Rehn and Rehn¹ revised this genus, and erected the genus *Appalachia* for the reception of a new species, *A. hebardii*, which they had discovered in the mountains of Pennsylvania and Virginia. The Michigan insect was evidently either identical with or very closely allied to *A. hebardii*.

Additional field work by F. M. Gaige, C. F. Walker, and the authors has resulted in the accumulation of specimens and data sufficient to show that the Michigan material is distinct from *Appalachia hebardii*. The entire type series of the latter was studied at Philadelphia and compared with a large part of our series from Michigan. It was found that while *arcana*

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¹ James A. G. Rehn and John W. H. Rehn, "On New or Redefined Genera of Nearctic Melanopli (Orthoptera, Acrididae)," *Amer. Ent. Soc., Trans.*, LXII (1936): 1-30, Pls. I-II.

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and *hebardei* differ in only minor morphological characters, these slight structural differences are accompanied by striking and constant color differences. The grounds for treating *arcana* as a distinct species, rather than as a race of *hebardei*, are stated below.

In the genera most nearly allied to *Appalachia*, i.e., *Dendrotettix*,² *Zubovskya*, *Podisma*, etc., the concealed male genitalia are more conservative and show much greater interspecific resemblance than in *Melanoplus*. In certain other genera of the Melanopli, such as *Hesperotettix* and *Aeoloplus*, these structures are so similar that they cannot be used for specific characters. It is, therefore, not surprising that the male genitalia of two such closely allied species as *Appalachia hebardei* and *A. arcana* should differ only in a few minor respects, nor should this be taken as proof of specific identity. So far as known the two populations are disjunct, separated by a distance of over four hundred miles in a direct line, and by a much greater extent of territory if one considers the geographic relations of the Alleghanian Biotic Province, to which *Appalachia* is apparently confined. In view of the low vagility of these brachypterous, thamnophilous insects, the discontinuous occurrence of their habitats over much of the intervening territory in New York and Ontario, the fact that no member of the genus has ever been found in either of those two much-collected regions, and the constancy of the color differences that characterize the two populations, we feel justified in according a specific rank to the Michigan form.

Appalachia arcana,³ n. sp.

(Plate I)

This species may be separated at a glance from *A. hebardei* by the coloration of the caudal femora, which ventrally and internally are a rich deep red instead of dull yellowish green.

² The male sex of *Dendrotettix zimmermanni*, hitherto unknown, is represented by two specimens from Allardt, Fentress County, Tennessee, in the University of Michigan Museum of Zoology.

³ *Arcanus*, secret, concealed; in allusion to the retiring habits of the species.

It is further distinguished by its more intensive and slightly different color pattern, and by minor differences in average proportions of head and pronotum, and in details of the male ultimate tergite and concealed genitalia. The two species are very similar; except as indicated below *arcana* agrees fully with the excellent generic diagnosis and specific description given by Rehn and Rehn for *hebarði*.

HOLOTYPE.—Male, taken 5.2 miles north of Oscoda, Iosco County, Michigan, August 29, 1934 (T. H. Hubbell). Allotype, a female with the same data. Both in the Museum of Zoology, University of Michigan.

DESCRIPTION OF MALE.—Size, form, and general appearance as in *hebarði*, except for differences in coloration and the fact that the body averages a trifle more robust, with the sides of the metazonal portion of the pronotum appreciably more flaring caudad. Head, pronotum, and tegmina varying as in *hebarði*, but showing the following average differences: genae a little fuller, eyes slightly less prominent, margins of fastigium a little more abruptly rounded, and the angle formed by the fastigium with the frontal costa slightly more pronounced; pale areas on lower portion of lateral lobes of pronotum normally impunctate (in *hebarði* often with a few punctations). Ultimate tergite (supra-anal plate) like that of *hebarði*, except lateral margins of basal third averaging much more strongly elevated in lateral aspect (Fig. 1*f* to *i*), as a whole, normally arcuate, but the margin frequently sinuate or emarginate, ridges (in two-thirds of series) either terminating distad in blunt and generally low angulations, or meeting elevated margin of distal portion of tergite end to end with scarcely any angulation, forming with it a continuous but strongly inbent, sinuous ridge. In *hebarði* (Fig. 1*e*) the angles are normally distinct and subacute, and margins proximal of them nearly straight and but little elevated. Concealed genital sclerites (Fig 1*a* and *b*) very similar to those of *hebarði* (Fig. 1*c* and *d*), differing only in having median point of endapophyseal arch truncate-emarginate at apex instead of angulate, and ventrocaudal rami ventrally angulate, appearing elbowed, instead of roundly curved as in *hebarði*. (Table I.)

DESCRIPTION OF FEMALE.—Similar to females of *hebardii* in all respects except as follows: on the average eyes slightly less prominent, genae a little more inflated, and dorsum of prozona

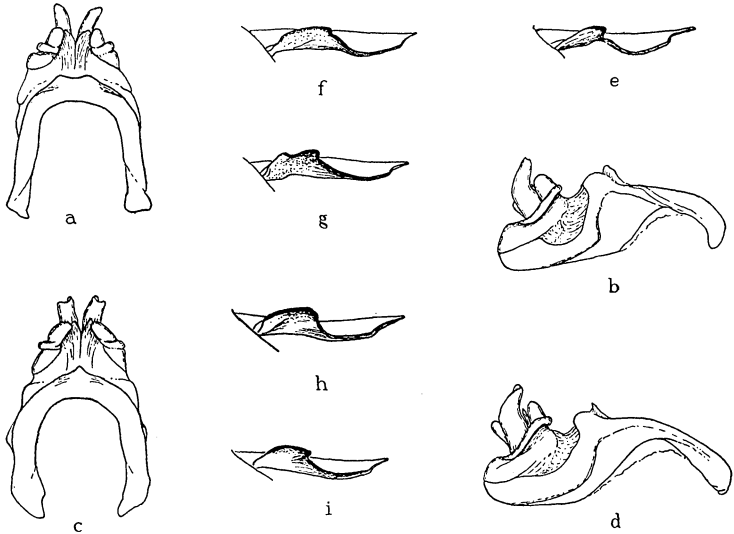


FIG. 1. Concealed male genital sclerites and male ultimate tergites (supra-anal plates) of *Appalachia hebardii* Rehn and Rehn and *A. arcana*, n. sp., drawn with camera lucida, $\times 22.5$.

a and *b*. *Appalachia arcana*, concealed male genital sclerites, dorsal and lateral aspects, endoparameres omitted. Paratypes, Oscoda, Ioseco County, Mich.

c and *d*. *Appalachia hebardii*, same structures as last. Paratype, Union County, Pa.

e. *Appalachia hebardii*, ultimate male tergite in lateral aspect. Paratype, Union County, Pa.

f-i. *Appalachia arcana*, ultimate male tergites in lateral aspect: (*f*) holotype, Oscoda, Ioseco County, Mich.; (*g*) paratype, Oscoda, Ioseco County, Mich.; (*h*) paratype, Crawford County, Mich.; (*i*) paratype, Leota, Clare County, Mich.

slightly less tumid and less smooth; sulci of prozona somewhat more deeply impressed, posterior sulcus almost always, anterior sulcus often plainly cutting the median carina.

STRUCTURAL VARIATION.—This species is very constant in most morphological characters, with less range of variation than occurs in *hebardii* according to Rehn and Rehn. In

TABLE I
MEASUREMENT OF *APPALACHIA* *ARCANA*, IN MILLIMETERS

MALES	LENGTH BODY	LENGTH PRO- NOTUM	CAUDAL BREADTH PRO- NOTUM	LENGTH TEG- MEN	BREADTH TEG- MEN	LENGTH CAUDAL FEMUR
Oscoda, Mich.*	17.4	3.8	2.9	3.0	1.4	9.4
Oscoda, Mich.	18.3	3.8	2.8	2.8	1.3	9.2
Oscoda, Mich.	16.3	4.1	2.8	3.1	1.3	9.7
Oscoda, Mich.	19.1	4.1	2.9	3.6	1.5	10.4
Crawford Co., Mich.	16.3	3.8	2.6	3.2	1.4	9.1
Crawford Co., Mich.	17.2	4.0	2.8	2.6	1.4	9.5
Lyons Manor, Mich.	17.9	3.8	2.9	2.6	1.3	9.6
Leota, Mich.	17.9	3.9	2.8	3.3	1.6	9.8
FEMALES						
Oscoda, Mich.*	26.6	5.4	4.2	4.0	2.9	12.6
Oscoda, Mich.	24.9	4.9	4.1	3.3	1.5	11.4
Oscoda, Mich.	29.5	5.8	4.8	4.1	1.9	12.9
Crawford Co., Mich.	26.2	4.9	4.0	3.8	1.9	11.3
Crawford Co., Mich.	28.0	4.7	3.9	3.7	1.8	11.4
Lyons Manor, Mich.	24.4	4.9	3.8	3.8	1.9	11.9
Lyons Manor, Mich.	29.5	5.4	4.3	4.8	2.2	12.1
Missaukee Co., Mich.	27.5	5.3	4.2	4.9	2.1	12.6

* Holotype and allotype. Additional measurements of these specimens are as follows, those of male given first; greatest vertical diameter of head 4.90, 6.07; breadth of head across genae 3.46, 4.48; breadth of head across eyes 3.60, 4.30; interocular distance 0.84, 1.21; greatest breadth of fastigium 1.54, 2.10; breadth across ocelli 1.40, 1.73; longest (vertical) diameter of eye 1.78, 2.01; shortest (horizontal) diameter of eye 1.59, 1.68; elevation of eye above base in cephalic aspect, looking squarely at front 0.93, 0.94; length of infraocular sulcus 1.45, 1.91; length of infraocular portion of genae 2.10, 2.85; length of antennae 10.7, 9.3; cephalic breadth of pronotal disk 2.20, 2.80; length of prozona of pronotum 2.34, 3.27; breadth of pronotal disk at principal sulcus 2.52, 3.51; dorsal length of lateral lobes of pronotum 3.55, 4.82; height of lateral lobes of pronotum to shoulders 2.34, 3.04; length of cercus 0.94, 0.75; proximal breadth of cercus 0.56, 0.56; length of ultimate tergite 1.82, 2.10; proximal breadth of ultimate tergite 1.47, 1.50; ventral length of ultimate sternite of male 1.50, length of free margins 1.73; maximum breadth of caudal femur 2.10, 2.45.

certain features, however, *arcana* is apparently more variable than *hebarði*, and the extent of such variation necessitates revision of the generic diagnosis of *Appalachia*. Thus, the prosternal spine, described by Rehn and Rehn as blunt-acute in *Appalachia* (as contrasted with sharply acute in *Dendrotettix*) averages blunt-acute in *arcana*, but varies from very blunt to at least as acute as in most specimens of *Dendrotettix zimmermanni*. The size, form, and venation of the tegmina vary as in *hebarði*, but the venation ranges from a condition in which it appears simple, regular, and without definite humeral trunk grouping, to one in which such grouping is more distinct than in five of the seven individuals of *Dendrotettix zimmermanni* which we have examined. It never approaches, however, the condition characteristic of *Dendrotettix quercus*. Our series likewise shows that the apparently simple venation of *hebarði* and of many individuals of *arcana* results from more or less complete fusion of the two parallel veins that run from the humeral angle to the apex of the tegmen, which are so distinct in all brachypterous individuals of *D. quercus*.⁴ Depending upon the degree of fusion, the two veins in *arcana* may run parallel and approximate most of the distance to the apex (rare), may be fused at longer or shorter intervals along their course, giving rise to a series of oval loops or 8-shaped figures (the usual condition), or may be completely fused into a single vein (occasional). The degree to which the humeral trunk grouping is indicated appears to be of merely specific rather than of generic significance.⁵

In *A. hebarði* the elevated proximolateral margins of the

⁴ Cf. Rehn and Rehn., *op. cit.*, Pl. I, Fig. 8.

⁵ The form of the male cerci was also used by Rehn and Rehn to separate *Appalachia* and *Dendrotettix*. In *Appalachia* these are tapering and styli-form, in *Dendrotettix quercus* short, sublamellate, and distally twisted. Here again only specific differences are involved, since the male cerci of *D. zimmermanni* (hitherto unknown) prove very similar to those of *Appalachia*. The characters available for differentiating the two genera are reduced to those of the ultimate sternite of the male and female, and of the ovipositor of the female; but these are amply sufficient for generic distinction.

ultimate male tergite are stated by Rehn and Rehn⁶ to have “*pronounced* angulate raised points” at the proximal third (generic diagnosis); it is further stated⁷ that the “paired raised points at proximal third of lateral margins [are] due to an *angled emargination* of the latter, which are *straight and even* proximad of this point and thence distad [are] sharply cut away juxtacercally” (italics ours). Paratypic males of *hebardei* examined by us agree perfectly with this description (cf. Fig. 1e). In *arcana*, on the other hand, the degree of development of the points is quite variable (Fig. 1f-i), and in the great majority of individuals the form of the margin proximad of them is not “straight and even” but markedly convex-elevated, with the edge considerably arcuate to distinctly and unevenly sinuate or notched. In the entire series of 135 males of *arcana* only 23 per cent have the margin straight proximad of the locus of the points, it being more or less elevated and convex or sinuate in 77 per cent. Table II shows the number of individuals having straight or convex-sinuate margins, in combination with the degree of development of the points.

COLORATION

In our opinion *Appalachia arcana* is one of the most beautiful of North American Orthoptera. Even the best preserved specimens give only an imperfect idea of the appearance in life—the brilliant hues of the males, and the delicate and subdued coloration of the females, with the soft, mottled grays and browns that blend well with the background of bark or twigs against which they are normally seen. The following description, based primarily upon the holotype and allotype, was made just after they were killed. The figures on Plate I were drawn from the types by Miss Eager while the pattern and coloration were still nearly as in life.

COLORATION OF MALE.—General impression of dorsum brownish gray, sides with a pair of strongly contrasted black stripes extending from head nearly to apex of abdomen, pronotum

⁶ *Op. cit.*, p. 10.

⁷ *Ibid.*, p. 12.

TABLE II

VARIATION IN STRUCTURE OF PROXIMOLATERAL MARGINS OF ULTIMATE MALE
TERGITE (SUPRA-ANAL PLATE) IN *APPALACHIA ARCANA*

	NUMBER OF SPECIMENS					
	Iosco County	Roscommon County	Crawford County	Clare County	Total	Percentage of Entire Series
Proximolateral carinae low, straight						
Points subacute, promi- nent	8	1	9	6.7
Points bluntly rounded, not prominent	18	..	1	..	19	14.1
Points weak or absent, carinae continuous with distolateral mar- gins	3	3	2.2
Proximolateral carinae ele- vated, margins convex or sinuate						
Points subacute, promi- nent	12*	1	1	1§	15	11.1
Points bluntly rounded, not prominent	52†	..	4‡	..	56	41.5
Points weak or (usually) absent, carinae con- tinuous with disto- lateral margins	31	..	2	..	33	24.4
Totals	124	2	9	1	135	100.0

* See Fig. 1g.

† See Fig. 1f (holotype).

‡ See Fig. 1h.

§ See Fig. 1i.

with contrastingly pale areas bordering shoulders, and abdominal dorsum with a conspicuous, broad, median, pale stripe; legs greenish, more or less suffused with brown, caudal femur red beneath and internally.

Head. Front, genae, clypeus, labrum, and exposed surfaces

of mandibles Pale Olive Gray,⁸ when seen under microscope whitish, closely mottled with Deep Grayish Olive except for pale areas bordering eyes ventrad and mesad; vertex fuscous, slightly mottled with paler, and with darker blotch between eyes, and on occipital region a triangular blackish marking having its apex directed forward and its base as broad as median dark stripe of pronotum, these darker areas but little contrasted with remainder of vertex; eyes bronzy black, their mesocephalic margins whitish, becoming lavender toward edge of dark portions; antennae with base of proximal segment pale (whitish laterad, yellowish mesad), distal part of segment reddish brown, second segment reddish brown, next nine segments narrowly margined mesad and laterad with yellow, leaving a narrow median reddish brown line on dorsal and ventral faces, the yellowish lateral borders fading out on distal half of antennae, the distal thirteen segments unicolorous, segments 12 to 19 reddish brown (Cameo Brown), segments 20 to 24 darker brown (Light Seal Brown); postocular bar intensely black, with straight, horizontal dorsal margin bordered by a narrow pale line, ventral margin strongly declivent caudad and indistinctly and narrowly margined with yellowish; this black postocular bar continuous with dark bars on upper portions of lateral lobes of pronotum.

Pronotum. Disk with broad median stripe of same color as vertex, on metazona becoming dilute and fading out laterad; lateral margins of disk bordered by conspicuous white stripes faintly tinged with gray-green, these stripes interrupted between the two anterior sulci, their anterior portions narrowly triangular, caudal portions broader and on metazona punctate with small blackish dots; postocular dark bands broad, dorsally expanding on disk between first two sulci and there fusing with median dark stripe, and ventrally sending a broad projection to lower margin of lateral lobes along and cephalad of second sulcus, intensely black and polished cephalad of principal sulcus, on metazona broadening and becoming

⁸ Capitalized color names refer to Robert Ridgway, *Color Standards and Color Nomenclature* (Washington: Published by the author, 1912), 44 pp., 53 pls.

duller, deeply black only along margins, the area enclosed by the darker margins dull Grape Green weakly suffused toward its center with reddish brown; ventrocaudal angles of pronotum broadly and conspicuously marked with polished, callous-like areas of Ivory White, a small irregular patch of same above ventrocephalic angle.

Tegmina. As a whole appears Light Seal Brown, under microscope veins dark brown and cells Pale Olive Brown.

Thorax. Venter of thorax and base of abdomen Strontian Yellow, shading to Citrine Drab on last two sternites.

Abdomen. Dorsal stripe pale Olive Gray to eye, under microscope grayish white mottled (especially toward mid-line) with dilute brownish gray, mesocaudal bosses of tergites Ivory White. Lateral dark stripe extends caudad to base of penultimate (ninth) tergite, deep black throughout, its dorsal margin regularly scalloped (on each tergite dorsally convex), its ventral margin strongly serrate due to prolongation of infuscation ventrad along caudal margin of each tergite. Ultimate tergite (supra-anal plate) pale mesoproximad, its lateral margins blackened from apex almost to base, and distal half somewhat suffused. Cerci reddish brown at base, deepening to black at apex.

Legs. Cephalic and middle legs pale greenish (Chromium Green), femora mottled on dorsal and cephalic faces with dilute reddish brown; tarsi bluish green (Jade Green). Caudal femora dark reddish brown above, with three pale transverse bands that extend across dorsal surface and down external face, subproximal band broadest, middle one narrow, distal one slightly broader and forming a complete annulus, the others terminating at ventrolateral sulcus; ventrolateral and ventral sulci and lower two-thirds of internal face deep red (Coral Red proximad, deepening to Corinthian Red distad). Caudal tibiae with ventral face yellowish green (Olive Yellow), becoming bluish green distad (Jade Green), sides and dorsal face the same, except washed with dilute brownish in distal fourth and just distad of proximal pale annulus; tarsi Jade Green.

COLORATION OF FEMALE.—General impression of dorsum mottled olivaceous gray, closely resembling jack-pine bark; without conspicuous, contrasted light markings such as are prominent in the male.

Head. As in male, except pale blotches beneath eyes more extensive.

Pronotum. As in male, except as follows: dorsum without pale marginal stripes; postocular band very narrowly and inconspicuously bordered on disk of metazona with yellowish; light area enclosed in metazonal portion of postocular band Light Grayish Olive, scarcely paler than dorsum of metazona; ventral margins of lateral lobes broadly pale-bordered, the light areas pale Smoky Gray, much less conspicuous than those of male, not broadly interrupted by ventral projection of dark postocular infuscation as in male, but with narrow dark line along second sulcus and narrow, short bar extending horizontally above ventrocephalic angle.

Abdomen. Lacking contrasted pale dorsal stripe and lateral black bands, dorsum finely gray mottled on a paler ground, mottlings more extensive in area than lighter parts, but enclosed by them; each tergite with two pairs (dorsolateral and lateral) of narrow, oblique, caudally divergent bars of darker gray or blackish, the two sets outlining position occupied by lateral dark bands of male, dorsal bars sinuate, ending caudad in darker blotches near caudal margins of tergites, lateral bars hookshaped, especially on proximal tergites; venter dark Olive Buff, becoming suffused with grayish laterad and changing to Buffy Brown on distal sternites.

Tegmina and legs. As in male, except caudal tibiae Olive Ocher ventrad.

COMPARISON OF COLORATION WITH THAT OF *A. HEBARDI*.—The coloration of *A. arcana* is quite constant, the above description applying equally well to material from all localities. Besides differing strikingly from *hebardii* in the coloration of the caudal femora, *arcana* averages considerably more intensive and more constant in general coloration than that species, and differs in details of pattern. Males of *hebardii* are said by

Rehn and Rehn to have the black lateral stripe extending to the base of the antepenultimate (eighth) abdominal tergite; paratypic males examined agree with this description, and also have the lower margin of the stripe nearly even, and its distal portion narrowed and somewhat dilute, with indistinct boundaries. In males of *arcana* the stripe invariably extends at least as far as the base of the ninth tergite, and, in slightly dilute form, often spreads to or beyond the dividing sulcus of this tergite. Furthermore it is as broad and intense at its caudal terminus as at mid-length of the abdomen, and a narrow prolongation extends ventrad along the caudal margin of each tergite, making the ventral margin of the stripe as a whole conspicuously serratiform.

The male cerci in *hebardii* are described as blackish fuscous in their distal sections; this description fits one-third of the males of *arcana*, but the remainder have the cerci entirely black or fuscous, except for a small yellowish spot at the base of the dorsal margin. The furcula and apices of the raised lateral points of the male ultimate tergite are fuscous in *hebardii*; in *arcana* the furcula vary from wholly pale, through a condition in which their inner borders are blackened, to wholly fuscous. The furcula in 57 per cent of the series of *arcana* are wholly or prevailingly pale, in only 43 per cent wholly or prevailingly fuscous. The margins of the ultimate male tergite are more extensively blackened in *arcana* than in *hebardii*, the entire distal border is darkened in most individuals, and the infuscation generally extends proximad of the locus of the lateral points half or two-thirds of the distance to the base.

In life the general coloration of the females varies from bluish gray to reddish brown, the majority of individuals being some shade of brownish gray. A considerable proportion of the individuals of both sexes have the mesal faces of the two proximal antennal segments deeply infuscated in a manner not recorded for *hebardii* nor shown by the specimens of that species before us. The yellow margining of the proximal part of the antennae is pronounced in most of both sexes.

MATERIAL EXAMINED.—224 specimens: 135 males, 67 females (holotype, allotype, and paratypes), 15 immature individuals, 2 exuviae, 5 egg masses, all from Michigan, as follows:

Iosco County, State Game Refuge, near Oscoda, August 26–29, 1934 (T. H. Hubbell and I. J. Cantrall), 58 males, 11 females (including holotype and allotype); July 21, 1935 (A. L. Olson and L. K. Gloyd), 1 male; September 3, 1935 (F. M. Gaige and C. F. Walker), 12 males, 3 females; August 1–8, 1937 (F. M. Gaige, T. H. Hubbell, and I. J. Cantrall), 14 males, 10 females; September 11–12, 1937 (I. J. and D. L. Cantrall), 39 males, 29 females. Van Etten Lake, near Oscoda, August 2–17, 1937 (J. A. Oliver), 2 females.

Crawford County, seven miles south of Military Reservation, July 14, 1937 (Hubbell), 8 males, 5 females, 4 juvenile males, and 6 juvenile females in instar preceding maturity, 1 juvenile in antepenultimate instar;⁹ north end of Higgins Lake, August 16 (Geo. Kelker), 1 female.

Roscommon County, Lyons Manor, west shore of Higgins Lake, July 13, 1937 (Hubbell), 2 males, 3 females, 2 juvenile males and 2 juvenile females in instar preceding maturity.

Missaukee County, 5 miles northwest of Lyons Manor, July 14, 1937 (Hubbell), 1 female.

Clare County, Leota, July 15, 1937 (Hubbell), 1 male.

Holotype, allotype, and most of paratypes in the Museum of Zoology, University of Michigan; additional paratypes in the Museum of Comparative Zoology, Academy of Natural Sciences of Philadelphia, United States National Museum, and Ohio State Museum.

DISTRIBUTION.—It is of interest that both *Appalachia hebarði* and *A. arcana* are members of the Alleghanian fauna, though their ranges are very widely separated. The Alleghanian Biotic Province forms a belt running east from Michigan through central Ontario and southern Quebec into New England and New York, and southward along the moun-

⁹ Some of these specimens were kept alive, caged in the laboratory, until August 10, 1937; one male nymph was killed by emergence of mermithids July 29, one male and one female died in cage August 6. The five egg masses listed above were deposited by the caged females.

tains in New York, Pennsylvania, and Virginia at increasingly high altitudes. In Michigan¹⁰ this province occupies the northern part of the Lower Peninsula and all of the Upper Peninsula. It is the region of the pine forests and is chiefly characterized by the extensive development of the pines (*Pinus strobus*, *P. resinosa*, and *P. banksiana*), which form very important successional stages, sometimes long maintained, and perhaps in some situations never followed by hardwood forest. As in the Ohioan province, the Alleghanian climax forest is hardwood, dominated by hard maple, with which are associated beech, hemlock, yellow birch, basswood, and elm.¹¹

South of the Alleghanian lies the Ohioan Biotic Province, characterized by its deciduous forests. Hard maple and beech dominate the climax association of this province, with oak-hickory forming an important successional stage of long duration on the sandy and gravelly soils. The dividing line between the Alleghanian and the Ohioan provinces is probably the most significant faunal boundary in the state. The distribution of Orthoptera in Michigan is far more strongly affected by the presence and position of this boundary than by the water barrier at the Straits of Mackinac. Although the line separating the two provinces is somewhat indefinite, it can be approximately located along the southern boundaries of Mason, Newago, Montcalm, Gratiot, Saginaw, Tuscola, and Huron counties.

It is almost certain that *Appalachia arcana* will be found throughout the northern part of the Lower Peninsula of Michigan, but not south of the limits of the Alleghanian Bi-

¹⁰ The biotic provinces of Michigan are discussed and mapped by Lee R. Dice, in "A Preliminary Classification of the Major Terrestrial Ecologic Communities of Michigan, exclusive of Isle Royale," *Papers Mich. Acad. Sci., Arts, and Letters*, XVI (1932): 217-39, 1 map. In this paper the Ohioan Biotic Province is characterized and distinguished from the Carolinian Biotic District, and the Lake Forest Province of Weaver and Clements (*Plant Ecology* [New York: McGraw-Hill Co., 1929], p. 440) is treated as a variant of the Alleghanian Biotic Province.

¹¹ Dice, *op. cit.*, p. 225.

otic Province. While it may also occur in the Upper Peninsula, or in the Alleghanian districts of Ontario, if it does so it is surprising that the amount of collecting already done in those regions has not revealed its presence.

HABITAT

The situation in which *Appalachia arcana* was found in greatest numbers is an extensive and typical boreal bog situated 5.2 miles north of Oscoda, Iosco County, Michigan. This bog consists of a dense growth of leatherleaf (*Chamaedaphne calyculata*) knee to waist-high, underlain by deep, hummocky sphagnum, and with labrador tea (*Ledum groenlandicum*) appearing in some quantity in the areas less dominated by leatherleaf. The bog is surrounded, on slightly higher ground, by a pure stand of jack pine (*Pinus banksiana*), and clumps and strands of these trees, with an occasional tamarack, invade the margins of the bog and divide it into roomlike openings varying in size from a fraction of an acre to many acres. In this bog the species was taken in greatest numbers on the trunks and foliage of isolated clumps of jack pine and tamarack, but specimens were also found scattered throughout the bog in the leatherleaf.

Although *A. arcana* was most abundant and readily found in the large bog, the species was also taken in a variety of other habitats in the vicinity of Oscoda. At a point west of the town (in Sec. 11, Twp. 24 N., R. 9 E.), several individuals were found in an open woods composed of large-toothed aspen (*Populus grandidentata*), red oak (*Quercus rubra*), white pine (*Pinus strobus*), and jack pine, with undergrowth made up largely of bracken fern (*Pteridium latiusculum*) and sweet fern (*Myrica asplenifolia*). These specimens were taken on the trunks of the aspens and on sweet fern and bracken. Five and one-half miles northwest of Oscoda, two males were found in the shrubby margin of a small dried-up marsh surrounded by jack pine forest. They were taken by trampling down the vegetation of bracken fern, leatherleaf, and blueberry. In a shallow swale seven miles west of Oscoda a male and female

were collected. Here sweet fern was the most abundant plant of the undergrowth, accompanied by scattered low-bush blueberry (*Vaccinium angustifolium*), goldenrod (*Solidago altissima*), Indian hemp (*Apocynum cannabinum*), dwarf willow, and blackberry; trees—jack pine, poplar, and paper birch (*Betula alba*, var. *papyrifera*)—are widely scattered, and the habitat is open and sunny. Several individuals were also taken three miles west of Oscoda in an open woods of jack pine and scrub oak. The soil is sandy here, with a sparse cover of mosses and lichens, and with beard grass (*Andropogon scoparius* and *A. furcatus*), sand cherry (*Prunus pumila*), frostweed (*Helianthemum canadense*), bearberry (*Arctostaphylos uva-ursi*), low-bush blueberry, and bush honeysuckle (*Diervilla lonicera*) scattered about in small isolated clumps.

In Roscommon County *A. arcana* was found in an open grove of aspen (*Populus tremuloides*), jack pine, Norway pine (*Pinus resinosa*), and an occasional white pine, with scanty undergrowth where the trees are most dense, but heavy undergrowth composed of bracken fern and sweet fern occurs in the more open parts. In Crawford County the species was located in an open forest of aspen, pine, and white oak (*Quercus alba*) with dense undergrowth of bracken fern, sweet fern, wild strawberry, and other herbs. A single male was found in Clare County in the edge of an open grove of black oak, willow, and aspen, with dense herbaceous undergrowth in which bracken fern, sweet fern, clumps of dwarf willow, wild strawberry, low-bush blueberry, and grass are conspicuous; the soil in this habitat is black, moist, and mucky.

As indicated below, *Appalachia arcana* may feed on a wide variety of plants, so that its food habits probably have little bearing on its choice of habitat. Our field observations indicate that the species may be found in almost any habitat occurring within its range that is shrubby in character and sufficiently open to be exposed to full sunlight for a considerable part of the day. In terms of Dice's¹² classification of the major habitats of the Alleghanian Biotic Province in Michigan, *Appa-*

¹² *Op. cit.*, pp. 225-30.

lachiea arcana may be listed as occurring in the leatherleaf and the black spruce-tamarack communities of the bog succession, the jack pine community of the sand succession, and, in the fire and clearing succession, the pine barren and aspen-paper birch communities, as well as the earlier shrub-thicket stages of the second-growth hardwood forest community. In which of these it is most frequent and abundant has not yet been determined.

HABITS AND LIFE HISTORY

Living individuals of *Appalachia arcana* were brought to Ann Arbor from Roscommon and Crawford counties, and caged in the laboratory for observation. On August 13, 1937, two males and two females of this group, with ten males and nine females from the type locality at Oscoda, all adult, were released in a large cage on the Edwin S. George Reserve, four and one-half miles west of Pinckney in Livingston County, Michigan. The cage was placed in the margin of a small leatherleaf bog; it enclosed ninety-six square feet of a moderately heavy growth of leatherleaf. The sphagnum moss substratum was at all times sufficiently moist to provide a continuous water supply for the insects. The activities of the captive individuals were frequently watched through glass windows in the sides of the cage. The insects appeared to behave normally; feeding and mating were observed, but not oviposition. Some of the individuals placed in the cage August 13 were still alive on November 12. The cage was left undisturbed through the winter and spring of 1937-38; no nymphs had been seen in it up to mid-July, 1938. The following account is based in part on field observations and in part on notes made on the caged individuals.

SEASONAL OCCURRENCE.—On July 13 in Crawford and Roscommon counties, last and next to the last preadult instars outnumbered adults, and many of the latter were teneral. On August 6 and September 11 adults were numerous in the bog at the type locality near Oscoda, and no immatures were observed. As noted above, several of the adults introduced into the large cage on August 13 were seen alive on November 12,

indicating a minimum duration of adult life of about three months under favorable circumstances.

FOOD.—Specimens caged in the laboratory ate with avidity the foliage of sweet fern, wild plum (*Prunus* sp.), and willow (*Salix* sp.). That of American elm, wild cherry, hawthorne, and the ornamental shrubs *Evonymus*, privet (*Ligustrum vulgare*), and Russian olive (*Eleagnus angustifolius*) was also eaten, with apparently somewhat less relish; wild grape (*Vitis* sp.) and basswood (*Tilia americana*) were hardly touched. In most instances a choice of food plants was available when these observations were made. Foliage of an undertermined species of pine was also eaten, but as it was the only food in the cage at the time, the insects may have been forced to accept a relatively unpalatable diet. Individuals caged in the bog on the George Reserve were seen to eat the leatherleaf on many occasions, and some of them, at least, survived for three months with this as almost their sole available food. It is probable that the species has certain preferred food plants (sweet fern appears to be one of these), but it is evidently not in any way restricted to them,¹³ and probably feeds upon a wide variety of shrubs in nature.

PARASITES.—Two adult females and one last-stage male nymph of *Appalachia arcana* from Crawford County were noted to be in lethargic condition shortly after being caged.

¹³ There are many undoubted instances of Acridid species being restricted to a single species or genus of food plants (*Melanoplus davisi*, *quercicola*), and others confined to oaks (*Schistocerca ceratiola* to *Ceratiola ericoides*, etc.), but such instances are probably less numerous than is sometimes assumed. Field observations, upon the basis of which some particular plant species is identified as "the food-plant" of a species of Orthoptera, are often misleading, since they may merely record choice of a preferred food plant where several are available, or limitation of choice due to absence of equally acceptable alternatives from the particular habitat where the observations are made. Thus, in the sand scrub region of Marion County, Florida, *Hesperotettix osceola* is almost invariably found only on the woody herb *Garberia fruticosa*, which, were observations confined to this area, would doubtless be recorded as the essential food plant. *H. osceola*, however, also occurs in other habitats, such as high pine-turkey oak, where *Garberia* is not found; in such situations it feeds on dog fennel (*Eupatorium capillifolium*) and other herbs.

They were placed in a dish of warm water, and within a few minutes several mermithid worms emerged. These have been determined as *Mermis subnigrescens* Cobb by Dr. G. Steiner of the United States Department of Agriculture, Bureau of Animal Industry.

BEHAVIOR AND ACTIVITIES.—This thamnophilous species is very secretive and extremely difficult to find except where it is unusually abundant. The cryptic coloration of the insects and their habit of remaining immobile for long periods enable them to escape all but the closest scrutiny of the shrubs and trees in which they usually rest.

In the leatherleaf bogs and in thickets of shrubbery the males generally climb up to within a few inches of the tips of the branches, and there sit and sun themselves for long intervals. When they wander about their movements are peculiarly jerky and nervous, with frequent pauses; the slightest movement of the observer causes them to relapse into immobility. If they encounter a tree in their wanderings they move up its trunk for a few inches, pause and look around, move up a little farther, and continue this progress until they reach a height of from one to ten feet; there they sit motionless in the sunlight, or move out to the tip of a branch where the sun's rays can reach them. Females are far more secretive than the males, and although they also climb up into trees and shrubs, they generally remain lower down and well hidden; in a leatherleaf bog it is necessary to trample the bushes to find them, except where they have crawled up on the bases of tree trunks.

During the day *Appalachia arcana* seems to spend most of its time sunning itself. As the sun moves the insects shift with it, so that in the morning they are for the most part to be found on the east side of shrubs and tree trunks, in the evening on the west side. When the sun goes down those in peripheral positions move to the undersides of twigs and branches, and remain in this inverted position through the night; those on tree trunks are generally found at night resting head upward.

When disturbed the males usually attempt to escape by executing two or three powerful, zigzag leaps in rapid succes-

sion, and then dropping to a lower position or to the ground; if sufficiently alarmed they will burrow into the sphagnum or ground debris. Females ordinarily merely drop to the ground when alarmed, immediately burrow into sphagnum or debris, and remain motionless. When an individual of either sex has attained the security of this concealment, even close approach of the hand will not cause it to move; to find such a hidden specimen it is usually necessary to tear up most of the vegetation about the spot where it was last seen and then to sift the ground debris in handfuls.

MATING BEHAVIOR.—When in proximity to females the unattached males are rather restless; they seem to peer about and shift the body from side to side by swinging movements of the legs whenever another individual moves in the vicinity. When an unmated female is spied, often at a distance of as much as two and one-half feet, the male crawls and jumps quickly toward her, and upon reaching her immediately jumps upon her back. If the female is receptive the male assumes the copulatory position, forefeet generally grasping the lower edge of the female's pronotum, middle feet grasping the angle back of the hind leg of the female, or a little higher up on the side, and hind feet resting on the dorsum of the female's abdomen. The hind legs are then stretched out upward and backward at an angle of about 45° to the axis of the male's body, tibiae extended, and are twitched back and forth in small but abrupt and opposite movements. The tip of the abdomen is worked about, and sometimes defecation takes place before attachment. The male then bends his abdomen down beside that of the female, the apices are brought into apposition, and a mass of soft, green, membranous tissue¹⁴ appears at each side of the male genital cavity as attachment is made. The abdomen of

¹⁴ Unmated females frequently make yawning movements of the ovipositor valves. On one occasion careful observation showed that as the valves closed a mass of soft, green, membranous tissue momentarily appeared as a small bulb between the bases of the two lower valves of ovipositor and the margin of the ultimate sternite; as the valves opened the mass was withdrawn. The significance of this action is not known; it is possible that attractant odors are thus diffused.

the male may lie to the right or the left of that of the female; most copulations observed were from the left, but one female which lacked the right hind leg was always seen with the male copulating on the side of the missing leg.

The average duration of copulation is not known, but is certainly long. Pairs have been seen in continuous coitus for more than twelve hours in daylight. It is probable that most connections made in the late afternoon are continued at least until the following morning, since pairs found as late as midnight in the Oscoda bog were so lethargic from the low temperature that they could be picked up with the fingers without making an attempt to separate or escape. During the day a copulating pair may remain motionless for long periods, or the female may walk slowly about nibbling the vegetation. If another male comes near, the copulating male raises his hind legs and jerks them in stiff alternating movements; the movements increase in amplitude and rate as the interloping male comes closer. The unattached male almost invariably seems to recognize the warning, and moves away. At intervals the hind legs of the copulating male quiver and twitch as if galvanized.

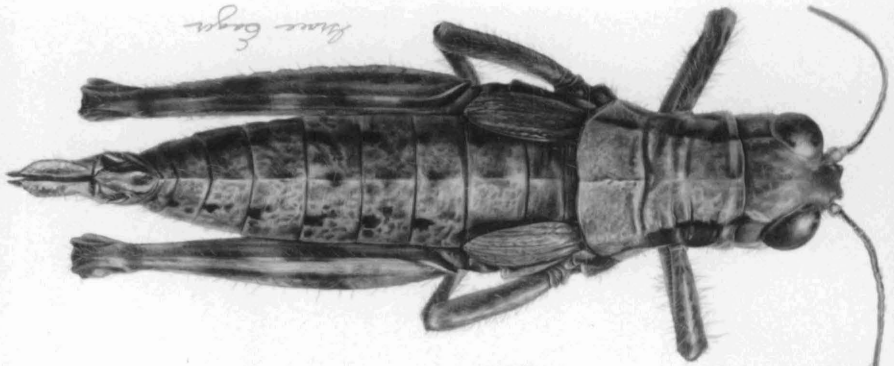
If a female approached by a male is unreceptive she will leap away, or if the male suddenly jumps upon her she removes him with a deft thrust of the hind tibia. Unattached males often leap upon one another, but after a short tussle they separate and go their own ways. At times individuals of both sexes merely approach one another, cross antennae, and then leap apart.

OVIPosition.—*Appalachia arcana* has not been observed ovipositing in the field or in the large cage on the George Reserve. In cages in the laboratory females were seen to deposit frothy egg masses upon twigs and cage walls. Trays of soil were then made available, but were not used; egg masses continued to be placed on the twigs. Upon hardening, the egg masses thus formed were roughly globose, light brown in color, and from eight to twelve millimeters in greatest diameter. They are probably not indicative of the normal oviposition

habits of the species, since some were imperfectly formed, and none of the contained eggs hatched. One other egg mass was deposited in sphagnum by a female in transit to the laboratory; it was spherical and eight millimeters in diameter. No egg masses were found in the sphagnum at one end of the large cage, in spite of very careful search. It seems probable that the species oviposits in soil rather than in the sphagnum of the bogs, and that the young stages migrate into the bogs from the margins. Eggs removed from the egg masses are pale straw color, with average dimensions of 4.2 by 2.0 mm.; the entire surface is closely and minutely punctate.

PLATE I

Lateral and dorsal views of *Appalachia arcana*, new species. Holotype and allotype. Oscoda, Ioseo County, Michigan.



Miss Gwyn

