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An Account of Changes in the Earthworm Fauna of Illinois AND A Description of One New Species

BY

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AN ACCOUNT OF CHANGES IN THE EARTHWORM FAUNA OF ILLINOIS AND A DESCRIPTION OF ONE NEW SPECIES*

Frank Smith

The contents of this paper include additions to the list of species previously recorded from Illinois and also furnish evidence of obvious changes in the earthworm fauna of one locality which are probably similar to changes taking place in other parts of the state. The tendency is towards an increasing domination of European species and a corresponding decrease in the abundance of some indigenous forms. There are various records of similar modifications of the earthworm fauna in other parts of the world in which Europeans have settled and in which the European species of LUMBRICIDAE have to a greater or less extent replaced the indigenous species.

Recent additions to the former lists of European species found in the state include *Helodrilus veuctus hortensis* (Michaelsen), *H. chloroticus* (Savigny), *H. octaedrus* (Savigny), and *Lumbricus rubellus* Hoffmeister. Additions to the list of indigenous species include *Helodrilus beddardi* (Michaelsen) and *H. heimburgeri* n. sp.

During a period of over 30 years (1893-1927) the writer has been interested in Illinois earthworms and their distribution, partly because of their utilization in some of his instructional work and partly because of using them as objects of research leading to the publication of several papers on the subject. In connection with these activities numerous collecting and observation trips have been made in the vicinity of the University of Illinois in order to obtain specimens of the various kinds represented and, incidentally, to learn something of their relative numbers and the kinds of situations in which representatives of the various species are most abundant. A comparison of the results of such trips made in earlier years of that period and those near its close shows that some marked changes have occurred. Some kinds found infrequently or not at all in the earlier years have become abundant in some areas in which there has been a corresponding decrease in other species. Increasing irregularities of distribution have been apparent which are presumably due to increased numbers of introduced forms which have not as yet had time to become abundant except in restricted areas.

* Contributions from the Zoological Laboratory of the University of Illinois, No. 322.

UPLAND-SOIL SPECIES

The collecting and observation trips which involved ordinary upland-soil species have mostly been made immediately after rainfalls when large numbers of individuals of some species were crawling about on the surface or were sheltered under debris of various kinds and especially likely to be found on the sidewalks and along the curbing of paved streets. Actual digging for such forms has been restricted to small areas. The lack in the earlier years of a knowledge of the changes in the fauna which were to take place resulted in a failure to make records of dates and of many numerical data which, if available, would have been very useful in the preparation of the present paper.

The three species of LUMBRICIDAE, listed under other names by Garman (1888) as frequent or abundant in Champaign, Illinois, were *Helodrilus foetidus* (Savigny), *H. roseus* (Savigny) and *H. caliginosus trapezoides* (Dugès). They were found in similar abundance throughout the whole period of 1893-1927. *Octolasium lacteum* (Örley) was also of frequent occurrence throughout the same period, though not listed by Garman. *H. longicinctus* Smith and Gittins (1915) was found in limited numbers in a woodland of the vicinity of Urbana in 1901 and in considerable numbers in parkings and lawns of the city itself in 1910-1915, but has not been noticed since the latter date. The most interesting feature in the relations of the earthworms of the upland-soil localities that received attention, centered in the relations between *Diplocardia communis* Garman (1888) and *Lumbricus terrestris* Linnaeus, Müller. Garman's description of the former species was based on material from the Champaign-Urbana region, and he states: "Hundreds were seen this spring in this locality, migrating during showers of rain." The same statement has been equally applicable to this species during the period 1893-1927, with the exceptions noted in certain following statements.

The actual time of the first arrival of *Lumbricus terrestris* in Illinois is very uncertain. Garman (1888) and Michaelsen (1900) in their lists of North American OLIGOCHAETA refer to Eisen's (1874) record of its occurrence in "New England" but have no record farther west. The Mount Lebanon, New England, of Eisen's record was actually in the eastern part of New York. The first definite record for Illinois is that of the writer published in 1900 and based on specimens found still earlier. The exact date is not known, but it was certainly before 1898 and probably about 1896 that a few specimens were seen by the writer in a restricted locality in Champaign, crawling about during a rain storm. About the same date a workman engaged in digging a trench in an artificially forested area on the University campus (locally known as the Arboretum) found and gave to the writer a few specimens. These were the basis for the record mentioned above. During this period and for several years subsequently, it was necessary to send to dealers elsewhere for specimens needed for class work. Then came a time, not far from 1905, when specimens were sufficiently abundant in the Arboretum to meet some of the needs for material, but they had not spread in any appreciable num-

bers to other areas. Subsequently, the area within a few blocks of the campus became abundantly stocked with them, while specimens of *Diplocardia communis* became correspondingly infrequent.

In the forenoon of March 19, 1927, following a rainy night, the writer traveled along the streets bordering an area of about one-half mile square adjacent to the east side of the campus in Urbana and found *Lumbricus terrestris* abundant in the streets bordering all of the 24 city blocks involved, while the total number of specimens of *Diplocardia communis* seen was but 19, or an average of less than one per block—a marked contrast to conditions existing in the same region in earlier times when *D. communis* was abundant throughout and *L. terrestris* was rarely seen. A trip on the following day through the area lying still farther east resulted in finding that *D. communis* was still abundant in a good deal of the territory covered and that *L. terrestris* was abundant in only a few detached areas. No noticeable difference was found in the relative numbers of smaller introduced European forms, such as *Octolasium lacteum*, *Helodrilus roseus* and *H. caliginosus trapezoides*, which were still abundant in both of the localities examined. The area in Champaign into which *L. terrestris* has extended its distribution has also greatly increased in recent years.

WOODLAND SPECIES

No observations have been made which would provide information concerning changes in relative abundance of the species that are more commonly represented in decaying tree trunks, under logs, and in masses of decaying leaves. *Helodrilus gieseleri hempeli* Smith (1915), *H. zeteki* Smith and Gittins (1915), and *H. tenuis* (Eisen) (1874) are such forms, and the writer is unaware of any notable changes having taken place during the past 30 years in their relative numbers, or of the appearance in such locations in recent years of introduced forms not previously found there.

STREAM-BANK SPECIES

The stream which has been most easily accessible and from which most of the collections of stream-bank species have been obtained, is locally known as the Boneyard Branch of Salt Fork. It is a small stream, but a few yards wide, which originates a short distance north of Champaign and flows south through the northern part of that city and then east through the eastern part and through the city of Urbana, which lies adjacent, and then joins the Salt Fork in the outskirts of the latter city. Its course extends across the University campus in the western part of Urbana. During the period 1893-1927 there have been extensive changes in the character of the water content and hence in the fauna contained. Increasing sewage contamination, due to increasing population and inadequate sewage disposal equipment in the two cities, of which it furnished the principal drainage outlet, gradually led to the elimination of all of its fauna except that which could exist under conditions similar to those of an open sewer. The earthworm fauna of the banks has necessarily been

influenced by these changes. Such conditions reached a maximum at about the time (1922-1923) that J. L. Hyatt, a graduate assistant, made an extensive series of collections of the earthworms inhabiting the soil in the banks of the stream in various parts of its course. Since that time the installation of a more adequate sewerage system and of a modern and efficient sewage-disposal plant has greatly altered the conditions, and resulting changes in the fauna are already in progress. During the time of Mr. Hyatt's collecting activities there was great diversity in the degree of sewage contamination in different parts of the course of the stream. In the part lying north of Champaign and in the northern outskirts there was but little. In progressing down stream an observer would find contamination from the few factories, the streets, and other sources becoming more and more evident, and the waters were already laden with foul material before the eastern limits of Champaign were reached. Still further additions were made in its course through the University campus and Urbana.

A study of the earthworms collected from the banks of the stream in various locations showed correlated changes in the relative abundance of the representatives of the different species of earthworms. Certain indigenous species and most of the species common in the upland-soil regions were found in much greater numbers in the places of least contamination, and certain other introduced species reached their maximum abundance where contamination was very pronounced. Most of the common upland species were represented in at least small numbers, and in addition about a half-dozen other species were represented which have not been found in the upland-soil locations. A very decided lack of uniformity was found in collections made from different localities even when the conditions and degrees of contamination seemed similar. Some species had a rather limited area of distribution, indicating a relatively recent introduction into the region.

The specimens collected were obtained by digging them from the soil of the banks of the stream, and they were then taken to the laboratory and fixed in a well-extended condition. The specimens were all preserved for the sake of greater certainty in identification and also with a view to their use in other ways, including a search for abnormal specimens, of which a considerable number were found. Collections were made from 11 different locations, distributed along some four miles of the course of the stream, from the northern outskirts of Champaign to its junction with Salt Fork east of Urbana. Five of these locations were in Champaign and six in Urbana. For convenience they will be designated by the letters *A* to *K*, which will be applied to the locations in the order of their occurrence along the stream, beginning with the one nearest the source in the northern Champaign region. The number of collections in each location varied from one at *A* to twelve at *F*, but in most of them three or more collections were made from each, and the times of making the collections were distributed over parts of two years, 1922 and 1923. Unfortunately, no similar extensive series of collections had been made

in earlier years; hence, definite comparisons of the fauna with that of earlier years could not be made, with the exception of locations *F* and *G*, where collections had been made at various times in preceding years.

One surprising result of a study of the collections by Mr. Hyatt was the discovery of the presence of a considerable number of specimens of *Helodrilus veuctus hortensis*, a European species which had been previously recorded from North America only from California (Michaelsen, 1900). Thirty-one specimens were collected at one spot in location *F* on April 15, 1922, and a few had been found in neighboring locations in the preceding month. Still larger numbers were collected at location *G* in 1923. Since Mr. Hyatt had made collections at these two localities in 1921, and the writer also at various times in preceding years had made collections in the same places without finding any representatives of this species, it seems reasonable to assume that a recent introduction into this region has occurred.

Another unexpected result was the finding of large numbers of the species *H. chloroticus*. A single specimen had been found by Mr. Hyatt in October, 1921, which was the first record from the Boneyard Branch. It probably was taken at location *F* or *G*, where only eight specimens were found in the 16 collections made in 1922 and 1923. I know of no record of careful collections prior to 1921 from the banks of the stream at location *H* and below, where Mr. Hyatt found several hundred specimens of *H. chloroticus;* hence, the supposition of a relatively recent introduction of this species has less supporting evidence. The only record of the species being found in Illinois prior to 1921, which is known to the writer, is that of a dead specimen found September 12, 1918, by F. C. Baker while hunting mollusks in a shallow place in the Salt Folk about nine miles east of Urbana. The waters of the stream where the specimen was found were carrying much sewage contamination received from the Boneyard Branch at Urbana. An examination by the writer of the shores at a few points up stream from the place where the specimen was found, failed to disclose the presence of other specimens.

Another species of which specimens were found to be most abundant in badly contaminated localities is *H. subrubicundus* (Eisen). It has been abundantly represented since 1911 but was not found during the first few years of the period beginning with 1893.

The accompanying table shows the numbers and distribution of the specimens of the Hyatt collections and requires but little explanation. Locations *A*, *B*, and *C* were those which were most free from sewage contamination. The first vertical column of figures gives the total number of collections made at each of the locations, the next one shows the total number of specimens from each location, and the following columns show the total numbers of specimens of each of the species as found at each of the stations. The lower part of the table contains footings showing the total numbers of specimens of each of the species represented.

In addition to these collections which were all from the banks of one stream, other collections were made in rivulets or ditches tributary to the stream, or in adjacent fields. The more pertinent features of a few of these will be mentioned. In a field near location *A* a collection of 80 specimens included 77 *Helodrilus roseus*, one *Octolasium lacteum* and two *Diplocardia communis*. A collection of 367 specimens from near the margins of a ditch near location *C* contained 350 *D. singularis* (Ude), the others being common upland species. A collection of 209 specimens from a small tributary stream near location *D* had 18 *Helodrilus tetraedrus* (Savigny), two of the variety *H. t. hercynius* (Michaelsen), three of *H. tenuis*, and the others were common upland species. A collection of 21 specimens from the margin of Salt Fork above the entrance of Boneyard Branch, and where there was no sewage contamination, had 11 *Sparganophilus eiseni* Smith (1895), 8 *Helodrilus tetraedrus*, and two *H. caliginosus trapezoides*. *Sparganophilus eiseni* is widely distributed in the North Central States east of the Mississippi River and is abundant in the mud of the bottom and margins of many of their rivers and lakes, but does not appear to thrive in waters badly contaminated by sewage.

TABLE I

DISTRIBUTION OF BONEYARD BRANCH SPECIES OF EARTHWORMS

Locations	Collections	Total numbers, each location	*H. tetraedrus typ.*	*H. t. hercynius*	*H. veneta hortensis*	*H. foetidus*	*H. roseus*	*H. cal. trapezoides*	*H. chloroticus*	*H. subrubicundus*	*O. lacteum*	*L. terrestris*	*D. communis*	*D. singularis*
A	(1)	58	1				43	14						
B	(6)	830	666	22			45	63		6	28			
C	(3)	216	52					56		14	1	2		91
D	(3)	246	8	2	11	77		104	3	36		5		
E	(2)	161			31	9		84		29		8		
F	(12)	782	106	54	79	11	7	448	5	48	1	23		
G	(4)	917	4	4	204	36	4	402	3	248	2	10		
H	(2)	61	5		1	6		10	32	7				
I	(7)	1276	17	6	6	17	1	235	475	500	2	15		2
J	(3)	388	41	13		26	4	106	80	112		3	2	1
K	(3)	219	65	13		30	18	50	20	23				
Totals		5154	965	114	332	212	122	1572	618	1023	34	66	2	94

ADDITIONS TO THE LIST OF ILLINOIS EARTHWORMS

Helodrilus beddardi was not reported in the writer's list of Illinois species in 1915, but in a later paper (1917) dealing with the distribution of North American LUMBRICIDAE, Illinois was included among the "new localities" in the account of that species. The specimens on which the record was based had been collected in October, 1910, by Dr. P. S. Welch, then a graduate student, who found them in a field north of Urbana. They were not carefully studied until 1916. Several specimens have more recently been collected near Muncie, 20 miles east of Urbana. In both of these localities the specimens were found in damp places near standing water in pastures. The finding of *H. veneta hortensis* and *H. chloroticus* in Illinois was mentioned in a paper by the writer (1924) dealing with the calciferous glands of LUMBRICIDAE. Dr. Libbie Hyman of the University of Chicago collected specimens of *H. chloroticus* at Fox River Grove, Illinois, May 8, 1926.

Helodrilus octaedrus has recently been found in two different Illinois localities. In November, 1925, S. L. Neave, a chemist of the State Water Survey, found several specimens in a very restricted area near the new sewage-disposal plant in the outskirts of Urbana; and in November, 1926, J. F. Müller, a research assistant, found specimens at Starved Rock, Illinois, in moss in crevices of the rock and crawling about on stems of vegetation. *Lumbricus rubellus* was represented in a collection at LaSalle, Illinois, in the autumn of 1925, made by Dr. R. E. Greenfield of the Department of Chemistry at that time, who found them under debris on the banks of the Illinois River.

One specimen of a new form, together with specimens of other species, was collected by H. V. Heimburger, April 16, 1914, from the banks of a small stream flowing into the Sangamon River a few miles below White Heath, Illinois. The writer had sagittal sections made from one half of the anterior 17 somites, which showed that the specimen in some important characters resembles *H. palustris* Moore (1895). The specimen and sections were turned over to Mr. Heimburger, then a graduates student at the University of Illinois, and were part of the material used by him in the preparation of a thesis as a part of the requirements for a degree (A. M.). After an interval of several years the sections have been returned to the writer for examination and use in the description of the species, but the unsectioned part has not been available for study.

Helodrilus heimburgeri n. sp.

Length, 7.7 cm. Diameter, 0.25-0.3 cm. Color, very little pigmentation. Somites, 112. Setae, closely paired. Prostomium, epilobic. Clitellum, 25-32 and encroaching slightly on 33. First dorsal pore on 5/6. Male pores, paired on posterior part of 15, between seta lines *b* and *c*; surrounded by prominent glandular elevations. Oviducal pores, on 14 slightly dorsad of *b*. Septa 11/12, 12/13, and 13/14 somewhat and progressively thickened, the latter about two or three times as thick as septa anterior to 11. The calciferous gland has inconspicuous lateral

pouches in 10; has no conspicuous enlargements in 11 and 12; longitudinal chambers not much over 40 in number. Hearts, paired in 7-11. Spermaries, paired in 10 and 11. A pair of large chambers or atria in posterior part of 15, with large gland masses extending into 15 and 16, the latter one being smaller; sperm ducts extend dorsad on the anterior walls of atrial chambers and open into them at their summits. Sperm sacs, two pairs, in 11 and 12. Ovaries, paired in 13. Spermathecae lacking. Ovisacs, paired in 14 and open into the cavity of somite 13.

One specimen, collected near White Heath, Illinois, by H. V. Heimburger.

Holotype.—Sections of a part of the specimen in the collection of the writer.

But little attention was given by the writer to the external characters of the specimen when it was available, but a memorandum was made of the location of the clitellum. For certain other features the data of Mr. Heimburger have been utilized. The seemingly close relationship to the species described in 1895 by Dr. H. F. Moore under the genus name *Bimastos*, which species until the present time has been unique among the LUMBRICIDAE in the characters of the distal parts of the sperm ducts, has added to the interest felt in making a study of the new form. A comparative study has been facilitated by the use of three series of sections of *H. palustris* made from specimens kindly sent to the writer by Dr. Moore several years ago.

EXTERNAL CHARACTERS

Rather small in size and also similar to *H. palustris* in having a moderate number of somites, closely paired setae, and conspicuous glandular enlargements on 15, surrounding the external orifices of the spermiducal apparatus. The specimen was seemingly not in a state of sexual activity at the time of fixation, but apparently had passed through such a state previously and the gonads were of diminished size. The location of the clitellum on 25-32 very definitely distinguishes the new species from *H. palustris* in which the clitellum is on 23-28. The clitellum was stated by Mr. Heimburger to be nearly complete and to include the ventral setae. He also stated that no trace of tubercula pubertatis was found.

The two species show marked similarity in the locations of the first dorsal pores; the external openings of the spermiducal organs on the posterior part of 15 and a little dorsad of seta line *b;* the oviducal pores on 14 slightly dorsad and posteriad of *b;* and of the nephridiopores, in the anterior part of the somites with some of them opening a little dorsad of seta line *b*, and others approximately midway between seta line *d* and the mid-dorsal line. Moore in his description of the nephridia of *H palustris* states: "The external opening is near the ventral couple of setae." An examination of the sections from three of his specimens reveals a variability in the positions of the openings similar to that of the new species. Like variability has been noted by certain other writers and myself in the location of these pores in other species of LUMBRICIDAE. (Langdon, 1895, p. 215) (Smith, 1915 and 1925)

INTERNAL CHARACTERS

The septa connecting the alimentary tract with the body wall are mostly without much thickening. Septa 11/12, 12 13, and 13 14 are somewhat thickened with the thickness gradually increasing from anterior to posterior; 13/14 being most thickened, but not very strongly. *H. palustris* differs in having none of the septa with increased thickness. The deeply staining glandular bodies attached to the wall of the pharynx and anterior esophagus in somites 4-6 in *H. palustris* are represented in only 4 and 5 in the new species; the space in 6 being largely filled by a mass of cells of different type and but lightly stained. The calciferous gland is similar to that of *H. palustris* (Smith, 1924) with approximately uniform diameter in 10-12, with paired esophageal pouches in 10, and but few more than 40 longitudinal chambers posterior to 10. Communications of the chambers of the gland with the pouches in 10 were found in both species and none were found elsewhere. No especial differences have been noticed between the two species in the location and relations of the crop and gizzard, respectively, the former in 15 and 16 and the latter in 17 and 18.

Circulatory system.—This has not been studied in detail otherwise than to determine the relations of the hearts and lateral-longitudinal vessels to the other vessels of the vascular system and to the calciferous gland. Five pairs of hearts are present in 7-11 and have the usual relations to the dorsal and ventral vessels. The hearts of 11 are similar in size to the others. An examination of the three series of sections of *H. palustris* resulted in finding similar conditions in them except that in two of them the hearts of 11 were much smaller than the others. In no instance was there any indication of any of the hearts passing into the wall of the alimentary tract in a part of their course, as described by Moore (1895, p. 489) in some of the specimens examined by him. The lateral-longitudinal vessel of one side of the specimen of the new species, which was included in the sections studied, extends through the space between the anterior pairs of hearts and the esophageal wall to the posterior part of 9, and then dorsad and mesad along the anterior surface of septum 9 10 until near the dorsal side of the esophagus where with a turn posteriad it extends through the septum and presumably joins the dorsal vessel about midway of the length of somite 10. Since the sections do not include much of the dorsal vessel and the last ones are imperfect, a more positive statement cannot be made. In his description of *H. palustris*, Moore states: "A pair of esophageal vessels arise from the sub-intestinal trunk in somite X and pass laterally forward to supply the tissues surrounding the anterior portion of the alimentary canal." Elsewhere on the same page he says, "The vascular system has not been investigated, except in a very general way." The writer has not found among the LUMBRICIDAE studied by him any species in which the lateral-longitudinal vessels arise from the ventral vessel, and but few in which they do not have their posterior union with the dorsal vessel in 12. The three series of sections of *H. palustris* available for comparison include a transverse,

a sagittal, and a frontal series. All of them have been utilized but have not always been equally helpful for each particular problem. In all three specimens the course of the lateral-longitudinal vessels has been similar to that found in the new species. They extend to the posterior part of 9, then dorsad and mesad anterior to septum 9/10, then through the septum into 10, where they join the dorsal vessel. The junction with the dorsal vessel is clearly shown in two of the series and nearly as certainly in the third one.

Reproductive organs.—There is marked similarity between the two species in respect to the reproductive organs. There is agreement in the number and location of the gonads in 10, 11, and 13, and of the sperm sacs in 11 and 12. Spermathecae are lacking in both. No essential differences have been noted in the characteristics of the oviducal organs. The characteristics of the spermiducal organs are of especial importance in determining the relationship of this species to others, and it would be highly desirable to have specimens more nearly at the height of sexual activity than is the only one of the new species now available. In this specimen the maximum height of the atrial chamber including the thick glandular wall, as seen in sagittal sections, is but little more than half of the dorso-ventral diameter of the worm. The apex of the atrial cavity, which is the place where the slender cylindrical lumen of the sperm duct opens into that cavity, is about one-third of the diameter of the worm from the ventral margin, as seen in section. In the specimens of *H. palustris* the chamber and cavity are more nearly cylindrical and extend nearly to the dorsal wall of the body cavity. In the new species, as in the other, the course of the sperm duct after reaching somite 15 is dorsad along the anterior wall of the chamber, going deeper and deeper into the glandular wall tissue, until finally reaching the uppermost part of the chamber, or atrial cavity, where the lumen of the duct is continuous with the cavity. No modified setae with related glands in 13 and 16 comparable with those of *H. palustris* have been found in the new form, but perhaps such setae may be present at the time of sexual activity. Large masses of gland cells associated with the wall of the atrial chamber and extending into the body cavities of 15 and 16 are present in the new species and resemble those of *H. palustris* in general appearance, but no careful study of their histological characters has been made. Nothing is known concerning the presence or absence of spermatophores in the new species at the time of sexual activity.

Moore created the genus *Bimastos* for the species *palustris*, in part because of the striking difference from other LUMBRICIDAE in the character of the terminal organs of the spermiducal apparatus, to which he applied the terms prostates and atrial chambers. Later writers have used the name with corrected spelling (Bimastus) as a name for a sub-genus to include Moore's species and others that resemble it in having no spermathecae and regardless of the presence or absence of atrial chambers. To the writer, the existence of this latter character in two species that are also closely related in other ways seems to be a sufficient basis for the restric-

tion of the use of the name Bimastus to these two species and others that may later be discovered having similar characteristics including the paired atrial chambers. There may perhaps be as much justification for recognizing a genus Bimastus as there is for the genus Octolasium. If more were known about the details of the relations of the lateral-longitudinal blood vessels in the various species of Lumbricidae, it might aid in the determination of a more correct classification. The similarity between *H. palustris* and the new species in the course of the lateral-longitudinal vessels seems to be a matter of considerable significance. The only other species in which the writer has found a similar course in these vessels is *H. octaedrus* (Savigny), but in this species there are several important characters in which it differs materially from the Bimastus group.

The lateral-longitudinal vessels of the three last-named species seem noticeably smaller and less conspicuous than those of other species in which these vessels join the dorsal vessel in 12.

DISTINGUISHING CHARACTERS OF ILLINOIS SPECIES

A list of species, together with statements of the important characters which serve as the basis for determining their systematic relationships, can be presented in a convenient and compact manner in tabular form (Table II), as was done in an earlier paper on the species of the State (Smith, 1915). Before presenting this list, reasons will be given for changes in the statements of some of the characters of certain species from those given in the former list or from those commonly found in the literature dealing with such species.

In the former paper the sperm sacs of *H. tetraedrus* and of its variety *hercynius* were listed as being contained in somites 9-12, in conformity with statements commonly made by writers on the group. Since the majority of the specimens examined by the writer lack sperm sacs in 10, though small ones are present in that somite in occasional specimens, they are listed as in 9, 11, 12. A change has also been made in the location given for the spermathecal pores of the same forms. Instead of 8 9 and 9 10 as stated by earlier writers and in the former paper, the location of these pores in most specimens has been found by the writer to be in 9 10 and 10 11, and this location has also been found by Cognetti (1905) to be the normal one in European specimens (Smith, 1917, p. 162).

Specimens apparently related to *H. tetraedrus*, but having spermiducal pores on other somites than 13 or 15, have been found by investigators in Europe, and certain species, varieties, or forma have been named on the basis of such specimens. *Tetragonurus pupa* Eisen with spermiducal pores on 12 was described from specimens collected in North America near Niagara Falls, and one specimen considered by Eisen as the type and presented to the United States National Museum was later studied by the writer and found to be in all probability an abnormal representative of *H. t. hercynius* (Smith 1917, p. 163). Many abnormal specimens belonging to several different species were found by Mr. Hyatt in his collections from the banks of the Boneyard Branch, and among

TABLE II
KEY TO THE ILLINOIS EARTHWORMS

Clitellum	Tubercula pubertatis	Prost. pores	Sp'd. pores	Spermathecal pores	Setae	Sperm sacs	Last hearts	Somites	Length cm.	Species
13-18 sad.		18, 20	19	7/8, 8/9	wide	9, 12	13	136-157	20-25	*Diplocardia riparia* Smith
13-18 sad.		18, 20	19	6/7-8/9	wide	9, 12	12	123-165	20-30	*D. communis* Garman
13-18 cing.		18, 20	19	6/7-8/9	wide	9, 12	12	95-115	5-10	*D. singularis* (Ude)
13-18 cing.		18, 20	19	6/7-8/9	wide	9, 12	12	100-120	6-10	*D. s. fluviatilis* Smith
13-18 sad.		19, 21	20	8, 9	wide	9, 12	12	100-125	7-15	*D. verrucosa* Ude
15-25		23-26	19	6/7-8/9	close	11, 12	11	165-220	15-20	*Sparganophilus eiseni* Smith
22, 23-26, 27	23-25, 26		13	9/10, 10/11 dors.	close	9, 11, 12	11	70- 90	3- 6	*Helodrilus tetraedrus* (Savigny)
22, 23-27	23-25, 26		15	9/10, 10/11 dors.	close	9, 11, 12	11	70- 90	3- 6	*H. t. hercynius* (Michaelsen)
24, 25, 26-32	28-30, 31		15	9/10, 10/11 dors.	close	9-12	11	80-110	6-13	*H. foetidus* (Savigny)
25, 26-32	29-31		15	9/10, 10/11 dors.	close	9-12	11	120-150	3- 8	*H. roseus* (Savigny)
26, 27-32, 33	30-31		15	9/10, 10/11 dors.	wide	9, 11, 12	11	80-120	4-10	*H. venetus hortensis* (Michaelsen)
27-34	31-33		15	9/10, 10/11 *cd*	close	9-12	11	105-240	6-17	*H. caliginosus trapezoides* (Dugès)
29-37	31, 33, 35		15	8/9-10/11 *cd*	close	9-12	11	80-125	5- 7	*H. chloroticus* (Savigny)
28, 29-33	31-33		15	9/10-11/12 *d*	sep.	9, 11, 12	9 or 10	80- 95	2.5-4	*H. octaedrus* (Savigny)
26-31	28-30		15	9/10, 10/11 *c*	wide	9, 11, 12	11	60-110	4-7.5	*H. subrubicundus* (Eisen)
26-31	29-30*		15	usually none	wide	11, 12	11	90-105	4-8	*H. tenuis* (Eisen)
24-31, 32	24, 25-30*		15	none	close	11, 12	11	66-100	2-6.5	*H. beddardi* (Michaelsen)
23, 24-32, 33	none		15	none	close	11, 12	11	98-122	6-9	*H. longicinctus* Smith & Gittins
27-37	none		15	none	close	11, 12	11	100-142	10-14	*H. zeteki* Smith & Gittins
22-29	none		15	none	close	11, 12	11	105-115	5-8	*H. gieseleri hempeli* Smith
25-32	?	Atrial po. 15		none	close	11, 12	11	112	7.7	*H. heimburgeri* n. sp.
30-35	31-34		15	9/10, 10/11 *c* or *d*	wide	9-12	11	100-165	5-16	*Octolasium lacteum* (Örley)
26, 27-32	28-31		15	9/10, 10/11 *cd*	close	9, 11, 12	11	95-150	7-15	*Lumbricus rubellus* Hoffmeister
32-37	33-36		15	9/10, 10/11 *cd*	close	9, 11, 12	11	110-180	10-30	*L. terrestris* Linnaeus, Müller

* Indistinct.

As the above table may sometimes be utilized by persons not familiar with the various symbols and terms in common use in systematic papers dealing with earthworms, it seems desirable that some of these be explained.

Arabic numerals are conveniently used to designate the number of a somite, counting from the anterior end. In the first two columns of the table, a comma separating two numbers is equivalent to the word *or*. Elsewhere in the table, a comma is equivalent to the word *and*. Externally, the limits of somites are ordinarily indicated by transverse (intersegmental) grooves; while, internally, the septa serve this purpose. Not infrequently, especially in the anterior part of the worm, there is a considerable lack of correspondence in the external and internal boundaries of somites thus indicated. Septa and intersegmental grooves for any two adjacent somites are represented by the same formula (for example, 5/6), the context showing which is meant.

In all Illinois earthworm species except a few chiefly limited to greenhouses and which are not included in the list, there are but eight setae per somite and these are more commonly arranged in pairs. It is customary to indicate the setae of either side by the use of the letters *a*, *b*, *c*, and *d*; the ventralmost one being designated by *a*, the next by *b*, the next by *c*, and the dorsalmost one by *d*. If the distances *ab* and *cd* are less than one third of the distance between *b* and *c*, the setae are said to be closely paired; and if otherwise, they are widely paired; or they may be unpaired, or separate (sep.).

The clitellum may be incomplete ventrally (saddle) or, in some species of Diplocardia, it may be nearly as thick on the ventral surface as elsewhere (cingulum). Tubercula pubertatis are glandular ridges closely associated with the ventral edges of the clitellum on some of its somites.

The spermathecae are pouches which open to the exterior and receive sperm cells from another individual. They are the same as the seminal receptacles mentioned in many text-books. The sperm sacs open into the cavity of 10 or 11 and store temporarily the sperm cells produced in those somites. Each sperm sac lies in a somite adjacent to the one into which it opens. These organs are often called seminal vesicles in the text-books. The prostate glands are not found in the LUMBRICIDAE and, hence, are not ordinarily mentioned in the text-books. They are large glands more or less closely associated with the external openings of the sperm ducts (sp'd. pores), and in indigenous Illinois species open separately from them on neighboring somites (prostate pores).

Spermathecal pores (sp'th. pores), when present, are located in the intersegmental grooves or very near them. *Diplocardia verrucosa* is the only exception among the species listed in the table. In some species they lie between seta line *d* and the mid-dorsal line (dors.), and in others they are in line with the dorsal pairs of setae (*cd*), or with the single lines of setae as *c* or *d*. In *Octolasium lacteum* some of the spermathecal pores are in seta line *c* and others in seta line *d*.

Diplocardia riparia Smith, *D. singularis fluviatilis* Smith, and *D. verrucosa* Ude have been found in the Illinois River region but have not yet been reported in the vicinity of Urbana and Champaign.

The table includes all but two of the described species of earthworms of which specimens are known to have been collected in Illinois. *Pheretima heterochaeta* (Michaelsen) and *P. hawayana* (Rosa) have been found in greenhouses, but their identification is complicated because of the very large number of species in the genus Pheretima. *Helodrilus longus* (Ude) has been found in Indiana by Heimburger (1915), and *H. parvus* in Michigan by the writer; hence, their occurrence in Illinois seems probable. It is also probable that still other species of Diplocardia will be found in the State as a result of further study and collection.

them were 16 specimens belonging to *H. tetraedrus* and two to the variety *hercynius*. In eight of these specimens asymmetry is found, and in ten specimens the spermiducal pores are paired on somites other than 13 or 15. Sections were made of parts of these ten specimens and studied with the following results. In one specimen with spermiducal pores on 14, the clitellum, tubercula pubertatis, oviducal pores, spermathecal pores, gonads, sperm sacs, hearts, and calciferous gland were all found one somite anterior to the location normal in the variety *hercynius*. In each of three specimens with spermiducal pores on 12, the various parts named above are located one somite anterior to the positions normal in *H. tetraedrus typicus*. In four specimens with the spermiducal pores on 11, the other organs named are two somites anterior to the positions normal for specimens of that species. In one specimen with spermiducal pores on 10, the various other organs named, in so far as they are present, are three somites anterior to the normal positions. Only the three posterior pairs of hearts were recognized. In this specimen there are four spermathecae in 4-7 on one side and three in 5-7 on the other side. The general appearance of a few anterior somites suggests strongly their having been regenerated. One specimen that at first glance with a lens showed spermiducal pores on 9 was found on more careful study to have lost some anterior somites (probably four) and had just begun regeneration for their replacement. Thus far the writer has not made a sufficiently careful study of the specimens with spermiducal pores on 11 or on 12 to provide a basis for a satisfactory conclusion concerning the probable cause of such departures from the normal numerical relations—whether it may be due to injury and subsequent incomplete regeneration or to some other cause.

H. venetus hortensis is given in the table as having a length of 4-10 cm. instead of the 3.5-5 cm. found in an earlier paper (Smith, 1917) and based on the statements of European writers. Specimens in the collections studied by the writer included several that were 7-10 cm. in length. They had been anesthetized before fixation and were in a well-extended condition.

Specimens of *H. octaedrus* from Norway, Colorado, and Illinois have been sectioned, and in them the writer has found hearts in 7-9 only. In specimens from Virginia no hearts have been found posterior to 10. In the other species of LUMBRICIDAE listed the posterior pair of hearts is in 11.

Specimens of *H. tenuis* are usually without spermathecae, but the writer (1917, p. 177) has reported specimens from Michigan and Indiana with spermathecae imperfectly developed or in reduced numbers (less than four), and more recently has found three specimens from Homer Park, Illinois, which also have spermathecae in reduced numbers or imperfectly developed.

GENERIC NAMES OF LUMBRICIDAE

There has been much confusion in the present century in the use of generic names for LUMBRICIDAE. In 1845, Hoffmeister created a genus *Helodrilus* for a species *oculatus* which he erroneously believed to differ from related forms in the absence of a clitellum in all stages of the life history. The related species were left in the genus Lumbricus. In 1874, Eisen separated the species of Lumbricus into four groups, leaving but few species in Lumbricus and creating three new genera: Allurus, Dendrobaena, and Allolobophora. Michaelsen, in a monographic paper (1900a) on OLIGOCHAETA, replaced the name Allurus Eisen, which was preoccupied, by the new name Eiseniella Michaelsen. He also substituted the genus name Helodrilus Hoffmeister for Allolobophora Eisen, using the latter name for a subgenus of Helodrilus. He felt that a strict adherence to certain rules of nomenclature, which he was obligated to follow, required such substitution. In this procedure he was followed by the majority of writers of systematic papers dealing with LUMBRICIDAE. During the past few years there has been a rather general tendency among various writers, including Michaelsen, to restore the genus Allolobophora and discard Helodrilus. Five groups—Eiseniella, Eisenia, Dedrobaena, Bimastus, and Eophila—are variously treated as distinct genera, or as subgenera of Helodrilus or of Allolobophora, depending on which of the latter happens to be recognized as a valid genus. Such diversities of terminology cause little inconvenience to the specialist familiar with the situation, but are naturally confusing to others. In the present paper the writer has preferred to follow the precedent set in his earlier paper (1917) based on Michaelsen's paper of 1910. The real need for a satisfactory system of nomenclature carefully followed is obvious.

LITERATURE CITED

The following list includes the papers to which direct references are made in the text. More extensive lists of the literature on OLIGOCHAETA will be found in the bibliographic lists in some of the papers here listed, especially in those of Beddard (1895), Michaelsen (1900a and 1910), and of Smith (1917 and 1924).

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