SOME MARINE OLIGOCHÆTA OF NEW ENGLAND.

BY J. PERCY MOORE.

That the study of the littoral Oligochæta of the eastern United States has been much neglected becomes evident when it is mentioned that but four original references to the subject occur in the literature, and three of these are very brief diagnoses of species. The first is found in Prof. Leidy's *Contributions to the Marine Invertebrate Fauna of Rhode Island and New Jersey,* published in 1855, where *Lumbriculus tenuis* is described from specimens taken at Point Judith, Rhode Island. In 1863, Minor gave a quite recognizable description in the *American Journal of Arts and Sciences* of his *Enchytræus triventralopectinatus,* taken near high-water mark at New Haven, Connecticut. In 1873, in the *Report upon the Invertebrate Animals of Vineyard Sound,* Prof. Verrill describes as new *Clitellio irrorata* and *Halodrillus* (gen. nov.) *littoralis.* The first three of these have not since been reported by any other observers, but the last was carefully studied and its anatomy described in a *Bulletin of the Illinois State Laboratory of Natural History* for 1895 by Smith, who establishes its identity with a widely distributed species of *Enchytræus.* Michaelsen, in his *Monograph of the Oligochæta,* recognizes the close resemblance between Minor's species and the well-known *Paranais littoralis* of Europe. The remaining two species have been noticed repeatedly by monographers and systematic writers who have been unable to arrive at any satisfactory conclusions as to their status.

While engaged in studying *Polychæta,* chiefly in the region about Wood's Hole, Massachusetts, but also at other points on the New England coast, for several years past, the writer has collected a number of species of littoral *Oligochæta* which, besides permitting the identification of the previously recorded species with certainty, except in the case of *Lumbriculus tenuis,* embrace several interesting additions to our known fauna. Minor's *Enchytræus triventralopectinatus* proves to be *Paranais littoralis,* as supposed by Michaelsen; *Lumbriculus tenuis* Leidy is almost certainly *Clitellio arenarius* (Müller); *Halodrillus littoralis* Verrill is *Enchytræus albidus* Henle; and *Critellio irrorata* Verrill is a composite of *Tubifex irroratus* (Verrill), *Tubifex benedeni* Udekem and

Clitellio arenarius Müller. To the latter conclusion I have been much assisted by Prof. Verrill's great kindness in sending to me for study his entire collection of marine oligochætes, including many bottles labelled by him as *Clitellio irrorata*. Although this material was collected from 25 to 30 years ago, and had since been subjected to all of the vicissitudes of preservation in small vials of alcohol, it was possible to determine most of the specimens, and as a result to considerably extend the known range along our coasts of several species. For this privilege I am much indebted to Prof. Verrill.

In the present paper are noticed ten species representing three families, as follows: Naiidæ, *Paranais littoralis;* Tubificidæ, *Clitellio arenarius, Monopylephorus glaber, M. parvus, Tubifex irroratus, T. benedeni, T. hamatus* and *Limnodrilus subsalsus;* Enchytræidæ, *Enchytræus albidus* and *Lumbricillus agilis*. Of these *P. littoralis, C. arenarius, M. parvus, T. benedeni* and *E. albidus* are European species, but only the first and last have hitherto been recognized on our shores. *Tubifex irroratus* is the residuum of Verrill's *C. irrorata* and the remaining four are new, but have more or less closely related representatives in other parts of the world. It needs to be remarked that very few of these worms are really marine; they are more or less recent migrants from a rich limicoline or terrestrial oligochæte fauna. The naids and tubificids are derivatives of the former which have been carried down the streams into bays and estuaries and have spread through the brackish waters and along the littoral zone. In their new habitat they have undergone modifications that are sometimes considered to have generic value. A case of especial interest is that of the brackish water *Limnodrilrus subsalsus*, which is the only species of this large genus that has been recorded as occurring out of fresh water. As pointed out in the systematic part of the paper, especially under *Monopylephorus glaber*, some of the tubificids burrow in soil saturated with fresh water from springs, and are experimentally shown to take more kindly to pure fresh water than to salt water of sea density. The enchytræids are more particularly strand forms which inhabit the marine vegetation thrown by the waves upon the beach. They enter the littoral zone, but are often found in large numbers quite above the reach of the waves at high tide, particularly during rain storms. They are undoubtedly derived from terrestrial or amphibious forms that have found a favorable environment on the seashore. *Enchytræus albidus*, at least, is found in garden and wood soil also, but may have been introduced through the use of eel grass for fertilizer.

The species of Tubificidæ described in this paper, as well as some of

those described recently by other authors, tend to traverse some of the generic boundaries usually set up and to obscure their limits. *Tubifex* is here employed in a broad sense, and it will be noticed that *T. irroratus* approaches *Monopylephorus* in many respects and removes that genus from the isolated position that it has been considered to occupy. This species resembles *Monopylephorus* in its valvular and moniliform blood-vessels, the form of its nephridia and the short sperm ducts with diffuse prostate glands. On the other hand, the paired genital orifices, the well-developed penes and the capillary setæ in the dorsal bundles are characters of *Tubifex*. Ditlevsen has referred to *Monopylephorus* a species (*M. trichochætus*) having all of these characters except the penes. The supposed great gap between these genera is thus bridged by two species. On the other hand, *Tubifex hamatus*, which is in most respects a typical *Tubifex* of the *Psammoryctes* group, appears to lack capillary setæ altogether. Some of our forms here referred to European species exhibit slight departures from the published descriptions, and it is possible may prove to be distinct when actual comparison of specimens from both places comes to be made. Besides the species described in this paper my collections include several others represented only by immature specimens, from which the characters of the reproductive organs cannot be ascertained.

The following key will facilitate the determination of species noticed in this paper:

A.—Asexual reproduction by serial budding and fission.
B.—Spermathecæ in V; setæ all hooked and bifid, the dorsal bundles beginning on V; size very small, *Paranais littoralis.*
AA.—Reproduction normally by the sexual method only.
BB.—Spermathecæ in V; setæ all with simple (not bifid) tips and dorsal bundles beginning with the ventral on II; male pores on XII.
C.—Setæ *f*-shaped; blood yellowish; testes deeply lobulated, *Lumbricillus agilis.*
CC.—Setæ straight, with hooked internal ends; blood colorless; testes not subdivided, . *Enchytræus albidus.*
BBB.—Spermathecæ in X; setæ more or less distinctly bifid at the tips and of various forms, often associated in the dorsal bundles with capillary setæ; male genital pores on XI.
D.—Male genital pores and spermathecal pores paired; penes present.
E.—Atrium simple; no special prostate gland; spermathecæ reaching into XI when fully developed, ... *Clitellio arenarius.*

EE.—Atrium divided into penis sac and sperm reservoir, the latter with a special prostate gland; spermathecæ confined to X.

F.—Sperm ducts long and slender; prostate glands massive.

G.—Cuticle more or less completely covered with flattened papillæ; capillary setæ present or absent; no copulatory setæ, *Tubifex benedeni.*

GG.—Cuticle without papillæ; capillary setæ always(?) absent; posterior dorsal setæ enlarged and strongly hooked; copulatory setæ present on X, ... *Tubifex hamatus.*

GGG.—Neither cuticular papillæ, capillary setæ, nor copulatory setæ present; vas deferens very long and penis sac very complex, with spirally wound muscular coats and a trumpet-shaped chitinoid penis sheath, *Limnodrilus subsalsus.*

FF.—Sperm ducts short and wide; prostate glands diffuse.

H.—Penes present; genital pores paired; capillary setæ present, *Tubifex irroratus.*

DD.—No penes nor capillary setæ; spermiductal and spermathecal pores median or nearly so; sperm ducts short and wide; prostate glands diffuse.

I.—Spermathecæ paired; setæ all distinctly bifid at tips, *Monopylephorus glaber.*

II.—Spermatheca single; bifurcation of setæ often obsolete, *Monopylephorus parvus.*

Paranais littoralis (Oersted) Czerniavsky.

Nais littoralis Oersted, 1843.
Enchytræus triventralopectinatus Minor, 1863.
Paranais littoralis Czerniavsky, 1880.

This species was described under the name of *Enchytræus triventralopectinatus* as long ago as 1863, from New Haven, Connecticut, by Minor, but appears to have escaped subsequent notice in America. Michaelsen places Minor's species doubtfully among the synonyms of *P. littoralis.* Hitherto budding individuals only have been found, and until the characters of the mature reproductive organs of American examples are known the identity of the latter with the European species cannot be

considered as established. Nevertheless, so far as budding worms are concerned, no distinctions can be detected, unless the number of setæ averages somewhat less in American specimens. The prostomium is often slightly pigmented, but there are no eyes. The blood is pale greenish-yellow, and the chlorogogue cells pale brown. The first budding zone usually occurs at XX or between XIX and XX. A second may occur at XXXV, but usually only the first is conspicuously developed. Still attached zooids may possess as many as 28 or 30 segments before the appearance of a second budding zone. In buds nearly ready to become detached both dorsal and ventral setæ occur on all segments. All through July and August active budding continues under natural conditions, but worms kept throughout the autumn at Philadelphia failed to develop genital organs.

Nothing but its small size and mode of occurrence has caused this species to be overlooked for so many years as it is extremely abundant and widely distributed. More than any other species it withstands a wide range of density in the water, being almost equally at home in the rain-soaked eel-grass above high tide, on the shores of brackish ponds and under stones near low-water mark on the exposed shores of Vineyard Sound. Its movements are characterized by frequent quick, nervous turnings and contractions.

Clitellio arenarius (Müller) Savigny.

Lumbricus arenarius Müller, 1776.
Clitellio arenarius Savigny, 1820.
?*Lumbriculus tenuis* Leidy, 1855.
Clitellio irrorata Verrill (in part), 1873.

Of the ten species noticed in this paper the present one is the largest, full-grown examples exceeding two inches in length and a millimeter in diameter at the clitellum. Preserved specimens usually have the mouths of the spermathecæ and the penes protruding in the form of prominent papillæ, as Prof. Verrill has noted in his description. Sexually mature worms are abundant, enabling one to secure cocoons in numbers and to study the anatomy of the genital organs with ease. There is little doubt of the identity of the American and European worms, the only noticeable differences being a slightly greater average number of setæ in ours and an apparently somewhat shorter spermathecal duct than is figured by European authors. No entirely satisfactory figures of the setæ of the European worm have been found, and it is possible that there may be a difference in their form also. The spermathecæ are often filled with large vermiform spermatophores.

The distribution of this form is equally extensive on the European and American sides of the Atlantic. It is excessively abundant in

Casco Bay and northward in Maine, where it occurs under stones and among grass roots up to high-water mark on muddy and gravelly shores. While apparently less plentiful south of Cape Cod, it is common at many suitable points on the shores of Vineyard Sound, Buzzard's Bay, Narragansett Bay and Long Island Sound.

Without being able to decide the matter definitely, it seems extremely probable that this is the species described by Leidy. Although the characters given in the brief description of *L. tenuis* are not diagnostic, they are sufficient to eliminate every other species described in this paper except the brackish water *Limnodrilus subsalsus*, while they all and the character of the habitat, as well, apply to *C. arenarius*. Vaillant, indeed, has already referred *Lumbriculus tenuis* doubtfully to *Clitellio*. Later writers have been more cautious.

In Prof. Verrill's collections this species occurs far more frequently than any other and usually under the name of *Clitellio irrorata*, thus giving the best of authority for the inclusion of the latter in the synonymy. It is this species that is figured under the name of *C. irrorata* in *Trans. Conn. Acad.*, 1881, Pl. VIII, figs. 3 and 3*a*. The localities represented cover a wide extent of coast and, named from north southward, are as follows: Nova Scotia, Bay of Fundy, Casco Bay, Cape Ann, Gloucester, Massachusetts; Salem, Massachusetts; Cape Cod, Vineyard Sound, Wood's Hole and New Haven.

Monopylephorus glaber sp. nov. Plate XXXII, figs. 1–6.

This species is relatively short and stout for a tubificid, the largest examples not exceeding 40 mm., and the usual length of living mature worms being about 25–30 mm., with a diameter of .8 mm. Young examples are relatively much more slender. In mature worms there are from 67–74 segments, and generally they are 4-ringed, bearing the setæ on the third and consequently well behind the middle. The greatest diameter is at the clitellum and genital region, from which the body tapers rapidly to the small pointed prostomium and very gently to the anal somite. The clitellum occupies part of X, all of XI and XII, and sometimes extends on to XIII. Except for the sensory hairs belonging to a zone of cutaneous organs encircling the middle of each somite, the skin is devoid of cuticular pilosities and perfectly smooth. Owing in part to the presence of grayish-brown pigment granules, and in part to the remarkably high peritoneal layer of cells, the body walls are decidedly opaque. The external opening of the genital bursa is a conspicuous median, transversely elongated aperture in the setæ zone on the venter of XI. The female pores are paired in the furrow

$\frac{XI}{XII}$, and the spermathecæ open close together in a common depression just behind furrow $\frac{IX}{X}$.

The general color varies from pinkish in young worms to brown or purple in fully grown ones, in which the color is due to a combination of the rose of the blood with the brown of the chlorogogue cells, the opaque white of the cœlomic corpuscles, the dark contents of the intestine and the pigment of the skin. Anteriorly the color remains pink or, through the accumulation of cœlomic corpuscles, becomes opaque white. When, as in certain individuals, the latter are very numerous, they impart a characteristic whiteness and opacity to the entire worm.

The setæ are all of the usual short, bifid, hooked form (fig. 4), with a deeply cleft tip and the terminal process somewhat longer and more slender than the widely divergent basal one. The portion of the seta external to the body wall is peculiarly thickened, but otherwise presents no characteristic features. In each bundle the inner setæ are somewhat the longer and those of ventral bundles slightly exceed the dorsal, but no marked differences are anywhere noticeable. As usual, the ventral bundles of XI are wanting. From II to XI 4 or 5 is the prevalent number in each bundle, the last being most usual in the ventral bundles, though they occasionally contain 6. Behind the clitellum 3 is usual in the ventral, 2 in dorsal bundles, and both may become reduced to one toward the posterior end.

Owing to the opacity of the body walls and the profusion of cœlomic corpuscles in mature worms the internal anatomy is difficult to work out upon living subjects, though practically all of the results of the study of sections have been confirmed upon living material and dissections. The spherical cœlomic corpuscles (fig. 5) are from .009 mm. to .0125 mm. in diameter, and filled with a comparatively small number of spherical granules measuring .0025 in diameter, and whose opacity and whiteness gives to the corpuscles their characteristic aspect. Among these corpuscles are seen a few filled with very much smaller granules which appear to be budded from the high peritoneal cells.

No unusual features are presented by the alimentary canal. The pharyngeal region is very small, though its glands extend diffusely to V or VI; the simple intestine is regularly and prominently sacculated, especially behind the intestine, and except in the genital region, where they are slightly developed, and in somites IV and V, in which they make their appearance, is thickly enveloped in chlorogogue cells, which largely conceal the dorsal vessel also.

As in all members of the genus hitherto described, the vascular system presents a well-developed integumental plexus on the lateral

arches and a remarkable system of unicellular valves. The ventral vessel is free from the intestine, without sacculations and without valves. It bifurcates in III, but is usually reunited in II by an asymmetrical commissural vessel, from which a small azygous vessel arises. The dorsal vessel is contractile, sacculated and provided with a set of valves at each constriction throughout its entire length as far forward as somite III. Although its anterior end is largely free from the intestine, it retains a covering of chlorogogue cells as far as somite IV and bifurcates only on reaching II. A pair of small lateral arches without valves arises in I, and after dividing each joins the here double ventral vessel. Beginning with III, the arches spring from the dorsal trunk at the posterior ends of the somites just anterior to the valvular constrictions. They reach to the body walls, which they enter and then divide into a complex integumental network emptying into the ventral vessel by two trunks in each somite, while the plexuses of contiguous somites are united by a longitudinal connecting vessel. The network is similar to that of *M. pilosus*, but appears to be somewhat more open. The lateral contractile trunks increase in size to X, one of which loops into the sperm sac, while one in XI forms a rich plexus within the ovisac. Behind XI they become much smaller, but continue to form integumental plexuses which join the ventral vessel by two trunks. The arches from III to XI are moniliform and provided with valves at each constriction. That in III contains one set of valves, IV 2 sets, V 2 or 3 sets, VI and VII 3 or 4 sets, and in VIII to XI 5 or 6 sets—numbers which, while occasionally varying, are remarkably constant. In the larger arches the two primary branches also may each contain a set of valves.

The brain (fig. 3) has a peculiarly lobulated surface and is broad and very deeply incised anteriorly, somewhat narrower and scarcely emarginated posteriorly, where the muscular sheath is produced into a pair of contractile strands, between which the dorsal vessel passes. Ordinarily the brain is about ¼ longer than broad, but the proportions vary greatly with the state of contraction and extension of the worm.

Nephridia (fig. 2) begin in VII with their nephrostomes opening into VI; none is present in X and XI, though a pair communicating with the latter is frequently developed in XII. In young worms, in which the transparent body wall permits the nephridia to be readily studied, they are absent from many somites and developed on one side only of others, but in full-grown worms few segments, except at the posterior region, lack them. The funnel is small, with the prolonged lip or tongue more slender and elongated than in *M. pilosus*. It passes into a short

neck, which penetrates the septum and joins an irregular massive region in which the canal is much folded, with granular coalesced walls and irregular lumen in the anterior part, while in the posterior part the lumen becomes more regular and provided at intervals with ciliated ampullæ. From this portion an elongated lobe passes caudally and medially along the ventral blood-vessel. In this lobe are four canals arranged in two loops, the proximal one of which contains ciliated ampullæ, while the distal one lacks cilia and, after returning to the massive region, passes into a large thick-walled efferent canal, the lumen of which exhibits a few irregular lateral diverticula, and which finally opens to the exterior by a pore situated a short distance anterior to the ventral setæ bundles.

The reproductive organs agree closely with what is known of other members of the genus. A pair of testes suspended from the posterior surface of the septum $\frac{IX}{X}$ fill not only the cœlome of X, but large anterior and posterior sperm sacs. The former is a short, wide, nearly spherical diverticulum from the septum $\frac{IX}{X}$ which arises dorsal to the intestine and projects forward when fully developed to the septum $\frac{VIII}{XI}$. The posterior sac is much longer and, arising from the septum $\frac{X}{XI}$ above the intestine, accompanies, but usually does not enter, the ovisac to about somite XIII or XIV. In young worms there are two, but later one disappears. Before maturity the cavity of the functional one is closed by a transverse diaphragm which prevents the vascular arch from entering more than a short distance.

The large sperm funnels rest on the floor of X against the posterior septum, which is perforated on each side of the nerve cord by the short vasa deferentia, which then bend laterally and each expands into a slightly enlarged region covered completely by a continuous layer of rather small prostate gland cells. This region—the sperm reservoir—bends upward around the intestine, and at the highest point passes into a short ductus ejaculatorius free from glands and opening into the summit of the fusiform penis sac. The latter is provided with a very deep epithelium thrown into rugous folds and relatively thin muscular layers; but there is no trace of a penis. The atria of the two sides open into the lateral portions of the summit of an eversible median bursa, which probably acts to some extent as a substitute for the penis (fig. 1).

Ovaries occupy a position in XI relatively similar to that of the testes in X, and are provided with a median dorsal ovisac which, arising from the septum $\frac{XI}{XII}$ above the intestine, reaches to XVI or beyond. In addition to the ova it receives a vascular network, usually from the

left arch of the pair in XI, and sometimes the posterior sperm sac in addition.

Spermathecæ (fig. 6) are nearly always conspicuous even in young worms. They open either very close together or by a common median pore just behind the furrow $\frac{IX}{X}$, and consequently are well forward in the latter somite. They have short, thick, muscular ducts without glands, and ovoid or sometimes nearly spherical ampullæ which when fully distended may reach nearly the length of the somite. When fully distended the lining epithelium is thin and flat and the muscular layer thin, but when nearly empty the former becomes thick and folded, often in a spiral or annular fashion, a condition which usually prevails near the entrance to the duct, where the circular muscular layer is much thickened. The spermatozoa are never fashioned into spermatophores, but fill the ampulla in compact masses and bundles.

This species is closely related to *Monopylephorus rubronivens* Levinsen, to which Ditlevsen has recently referred *Vermiculus pilosus* Goodrich. From this species, as elaborately described by Goodrich, *M. glaber* differs in the entire absence of villous processes on the cuticle, the greater number of setæ, the form of the nephridia and some minor characters of the vascular system, brain, etc.

Another closely related species is *M. fluviatilis* (Ferronnière), but if the sperm ducts are correctly figured for the latter the position of the prostate glands is quite different.

Both Goodrich and Ditlevsen have attached much importance to the form of the nephridia, which they consider to approach the enchytræid type. In *M. glaber* this resemblance is entirely superficial and the arrangement of the tubules is nearly typically tubiciform, their analysis into glandular region, large and small tubule loops being easy.

In suitable localities this species is very abundant about the shores of Vineyard Sound and Buzzard's Bay. It prefers regions overlaid by a layer of fine organic mud in places where there is an accumulation of decaying eel grass or other vegetable matter, and especially where the salt water is diluted by springs or streams of fresh water. In such places it occurs in enormous numbers beneath stones or a short distance below the surface, while in nearby spots, where the water is of much greater density but the conditions otherwise similar, few or none will be found. Nowhere in this region have these worms been found in greater numbers or of such large size (mostly exceeding 40 mm. in length and 1 mm. in diameter) as along the gravelly and muddy banks of the Wareham river, a small stream emptying into the head of Buzzard's Bay. Here under stones near high water-mark, at a point where

saltness of the water is just barely discernible to the taste, enormous numbers occur quite unmixed with other species. If placed in pure salt water of the density found in Vineyard Sound these worms die much sooner than if placed in fresh water, but may be acclimatized to either by gradual changes. In brackish water they have lived and bred in confinement in Philadelphia for seven months, and are now, after this lapse of time, as vigorous as ever. That they are partial to low rather than high densities is shown by the observation that those living on the shores of the Eel Pond at Wood's Hole, at a point where fresh water oozes from the ground below high-water mark, burrow deeper toward the source of the spring when the tide rises and covers their habitation, and come to the surface when it falls. Other favored localities are certain shallow and nearly closed coves where great quantities of eel grass and algæ accumulate and decay in water diluted by rains. Here under small stones below half-tide mark the species associates with *Tubifex irroratus* and *Lumbricillus agilis*, though the latter is far more plentiful in the decaying eel grass at a higher station on the shore, and the former prefers the roots of salt grasses growing on more gravelly shores. Though not active in their movements, they are less sluggish than the *T. irroratus* and far more hardy than that species. From the latter part of July, at least, onward this species breeds, and some specimens brought to Philadelphia continued sexually active throughout the fall and into winter. When breeding they are especially active and congregate in such numbers beneath stones that they impart a quite red color to the surface of the soil when exposed by turning over the stones.

Monopylephorus parvus Ditlevsen. Pl. XXXIII, figs. 29–34.

A second small species of *Monopylephorus* is referred to the above species, with which it agrees closely in nearly all of the characters recorded in the original brief diagnosis. Further information may necessitate a separation.

In size and form this species closely resembles *Lumbricillus agilis*, but its distinctly pink color and the opacity due to cœlomic corpuscles, as well as its more sluggish movements, are a ready means of separation. Fixed specimens can be distinguished in many cases only after a careful study, especially as sexually mature individuals are infrequent.

The length is from 8 to 15 mm., the diameter about .4 mm. and the number of segments from 38 to 43. The prostomium is much more slender and pointed than in *M. glaber*, but the somites are similarly quadri-annulate. The number of setæ in each ventral bundle is 3 or 4 anterior to the genital region and 2 posteriorly; in the dorsal bundles

usually 5 anteriorly and 2 to 4 posteriorly. The setæ are all small and of the usual form, except that their tips are curiously variable (fig. 29). As the setæ were studied only under the rather unfavorable conditions presented by alcoholic material, it is uncertain how far this may be due to wear. Many of the setæ are undoubtedly broken, but those figured appear to be intact. In some the tips are deeply bifid and the points long and acute; others, especially in the posterior dorsal bundles, have the upper or distal point more or less reduced, and still others have a mere apical notch or are apparently entire.

The cœlomic corpuscles are very numerous and about .012 mm. in diameter, with opaque white granules smaller and more numerous than those of *M. glaber*.

In internal anatomy this species closely resembles *M. glaber*, from which, however, it is easily distinguished by the single spermatheca (fig. 34) which opens in the median line of the furrow $\frac{IX}{X}$, and is usually folded on itself transversely. The atria (figs. 32, 33) also differ in that they join in the middle line before opening into the bursa by a single small pore raised on the summit of a papilla. It will thus be noticed that the primitively strictly paired character of the reproductive organs has been departed from more widely in this than the other species. The prostate and other regions of the male ducts are otherwise as usual. An anterior sperm sac extends through IX, a posterior through XII and XIII, and an ovisac to XVI. The vascular system presents the characteristic valvular and chambered vessels and integumental plexus. The brain (fig. 31) is slender and the anterior lobes much elongated. Nephridia are of the character belonging to the genus, but are slender and elongated and the nephrostomial lip especially narrow and prolonged.

This species has not been found abundantly anywhere. Occasional examples occur with the larger tubificids and with *Lumbricillus*, but it appears to prefer more gravelly shores and the neighborhood of beach grass, among the roots of which it may be found. In a few cases larger numbers were found living gregariously beneath stones at half-tide on the south shore of Naushon. It is quite probable that it has often been mistaken for the young of *M. glaber* or even of *Lumbricillus*.

Tubifex irroratus (Verrill). Pl. XXXII, figs. 7–11.

Clitellio irrorata Verrill (in part), 1873.

The length of this slender species seldom exceeds 30 mm., but the number of somites may equal 90. Most of the examples found in the vicinity of Wood's Hole are not fully mature, and are from 15 to 17 mm. long, with about 70 somites. The prostomium is more acute than

in *Monopylephorus*, and the somites are more elongated but similarly ringed. In mature examples the clitellum is developed on X, XI, XII and for a short distance on XIII. A pair of spermathecal pores occurs far forward on X just behind the furrow $\frac{IX}{X}$, and in line with the ventral setæ, the male pores occupy the place of the ventral setæ or a little behind on XI, and the ovipores are minute slits in the furrow $\frac{XI}{XII}$.

In young worms the color is pinkish, but in larger ones becomes deep brownish or purplish-red, often very dark, and in mature worms always very much darker than in *Monopylephorus glaber*, a difference which is probably due chiefly to the fact that the deep color of the chlorogogue cells is untempered by the whiteness imparted by great numbers of peritoneal corpuscles.

The setæ are of two forms, one kind being hooked and bifid and the other capillary and of very characteristic form. Both occur in the dorsal bundles. In preclitellar somites there are usually 2 or 3 or rarely even 4 of the former, with 1 or 2 or occasionally 3 of the latter alternating with, or 1 on the ventral side of each of, the hooked ones. Bundles of the middle region contain 2 hooked and 1 capillary seta, and those of the posterior region 1 of each. Normally every dorsal bundle except a few at the posterior end contains capillary setæ, but they are easily detached, and in some specimens fully formed ones are absent from as many as one-half or more of the bundles. When more than one is present they are usually of unequal lengths, the longest much exceeding the diameter of the body. They are very slender and taper regularly to the end, toward which they exhibit 2 or 3 very slight but distinct spiral turns (fig. 11). Possibly this region may be slightly flattened, though this appearance may be due to the lights and shadows caused by the spiral turns. The short hooked setæ (fig. 9) are always bifid, with the distal process decidedly longer unless worn or broken, which is seldom the case. Ventral bundles contain hooked setæ only which are quite similar in form to those of the dorsal bundles but somewhat larger; those of anterior bundles of both rows are larger than the posterior. Anteriorly the ventral bundles usually contain 3, in the middle region 2, and posteriorly 1. As usual the ventral bundles are wanting on XI, but those of X are not modified as copulatory setæ.

The vascular system of this species is remarkably like that of *Monopylephorus glaber*, presenting a similar valvular dorsal vessel, chambered and valvular lateral trunks, complex integumental plexus, and similar mode of branching. As distinctive characters it presents a finer and more numerously branched integumental plexus, with a more conspicuous longitudinal intersegmented trunk, and a greater number of sets

of valves in the lateral arches. Usually the arches in III and IV have 1 set, V 1 or 2 sets ,VI 3 or 4, VII 4, VIII 4 or 5, IX and X 6 or 7, and XI 6. The right arch in X sends a loop into the sperm sac as far as the diaphragm present in the immature worm, while that of XI enters the ovisac and breaks up into a rich plexus. The intestinal plexus reaches as far forward as VII.

Owing chiefly to the height of the cœlomic endothelium the body walls are thick and opaque. Peritoneal corpuscles (fig. 10) are of two forms, about 90 per cent. of them being spherical and filled with rounded opaque granules having nearly the color of the vertebrate red blood corpuscle. The corpuscles measure .01 to .015 mm., and the granules .0012 mm. in diameter. The corpuscles are much less abundant than those of *Monopylephorus glaber*, and are easily distinguished by their smaller and more numerous granules. With the spherical corpuscles are associated a number of nearly homogeneous, colorless, flattened, fusiform corpuscles and a few leucocytes.

The brain is about as broad as long, very massive and with a slight median emargination posteriorly, and prolonged anteriorly into a pair of relatively slender lobes separated by a deep cleft.

Like so many other organs the nephridia have much in common with those of *Monopylephorus glaber*. The funnels are provided with a tongue which, however, is short and broad, and the remainder of the funnel is much lobulated. Nearly sessile on the septum, it passes into a short and narrow postseptal neck which, in turn, enters a large tubule with a very wide irregular lumen and highly granular walls which is doubled on itself and forms, with the first section of the tubule loops, the so-called glandular portion of the nephridium. The tubule loops have ciliated ampullæ and are in general arranged as in *M. glaber*, but their folds are much more open and in the posterior nephridia reach through two somites. The efferent canal springs from the glandular mass and opens to the exterior in front of the ventral setæ. Altogether the nephridium is of the true tubificid type. They are frequently developed on one side only or altogether absent from many somites.

The spermathecæ (fig. 8) are large, with prominent simple ellipsoidal ampullæ, varying much in size and shape with the degree of distension, but usually filling a large part of the cœlome of X, and reaching to the dorsal level of the intestine and the septum $\frac{X}{XI}$. There is always a well differentiated muscular duct without glands, short in distended spermathecæ, but relatively long in empty ones. There are no spermatophores, the spermatozoa being free and loose.

The male organs (fig. 7) are remarkable as combining the short sperm

duct and diffuse prostate gland of *Monopylephorus* with the soft penis having a thin cuticular sheath of a typical *Tubifex*. Large funnels open into X on each side near the body floor and, after perforating the septum in line with the ventral setæ, pass into short wide vasa deferentia which bend laterally and gradually expand into the long sperm reservoirs constituting at least one-half of the entire duct. Near the posterior end of the somite they bend abruptly upward to a point above the intestine, and, by a short constricted region, pass into the summit of the penis sac, which is nearly vertical but curves forward to the external pores. The penis sac is cylindrical and has a thick muscular coat; the free penis begins at about its middle, but is usually considerably folded within the lower part of its cavity. There is a distinct but thin cuticular lining reflected on to the penis. The prostate gland is a thick layer of cells, especially enlarged on the dorsal side, uniformly covering the entire sperm reservoir.

The sperm sacs and ova sacs are quite similar to those of *Monopylephorus glaber*. When fully developed the anterior sperm sac reaches through IX, the posterior to XV and the ova sac to XXII. The posterior sperm sacs are originally paired and in immature worms may be seen to be swept back and forth, alternately reversing and righting themselves, with the movements of the cœlomic fluid.

It is certain that this is one of the species included by Prof. Verrill in his *Clitellio irrorata*, and a few specimens are included among those so labelled. As no type is indicated, it seems perfectly proper to preserve the name by applying it to this, rather than to permit it to lapse as a synonym of one of the species already named, even though the latter chiefly influenced the original description.

Like *M. glaber* this is a brackish water species, and the two are frequently found associated about the outlets of littoral springs where an accumulation of organic mud makes the conditions otherwise favorable. The remarks under *M. glaber* concerning acclimatization to fresh and salt water apply equally to this species, which is, however, much less resistant to unfavorable circumstances than that species. Perhaps this fact accounts for its much less abundance, though its habit of burrowing more deeply into the soil among the roots of beach grass, in the smaller rootlets of which its peculiar capillary setæ become twisted, make it much more difficult to find. Sexually mature individuals constitute a much smaller per cent. of those found than in *M. glaber*. So far as now known this species occurs only south of Cape Cod.

Tubifex benedeni Udekem.

Tubifex benedii Udekem, 1855.
Clitellio ater Claparède, 1862.
Clitellio irrorata Verrill (in part), 1873.
Hemitubifex benedii Beddard, 1889.
Psammoryctes benedeni Michaelsen, 1900.

In its usual form this interesting species is at once distinguished from any others of our marine oligochætes by the nearly black or deep gray color, resulting from the remarkable flattened papillæ filled with greenish-gray granules with which the cuticle is thickly studded. These papillæ are arranged in irregular transverse rows in all regions except the prostomium, peristomium and clitellum, but they differ greatly in size and consequently in conspicuousness in different regions, being largest on the segments following the clitellum, and thence gradually decreasing in size toward the posterior end, where they are small and widely separated. There is also much individual variation in respect to the number and size of these papillæ, and it seems probable that they may be shed and developed periodically, though my opportunities for observing this species over a period of time have been very limited. Certain it is that small individuals with nearly or quite smooth cuticle are frequently found living with fully papillated mature ones, from which they appear to be otherwise indistinguishable. Fully grown worms with the papillæ scarcely developed also occur, and some of these are among the material collected by Prof. Verrill at Savin Rock, near New Haven, Connecticut, which is one of the type localities for *Clitellio irrorata*. It is quite evident, from a careful study of Prof. Verrill's description, that his account of the setæ is derived largely from specimens of this species in which, as is frequently the case, some of these organs were broken or abraded, and the others exhibited the normally great variability in the length of the distal process. When as slightly developed as in the specimens mentioned, the papillæ might be readily overlooked as unimportant. In my experience the capillary setæ are more often absent than present. That the European worm also is variable in these respects is shown by discrepancies in the several descriptions, and by the numerous names that have been applied to the species and listed by Michaelsen. So far as studied the internal anatomy of American examples agrees fully with the accounts given by Claparède, Beddard, etc. The spermatophores are very large, but less slender than in *Clitellio arenarius*.

This black worm is widely distributed on the seashores of Europe down to a depth of 7 fathoms. On our coasts it has not hitherto been identified. It is common between tides on muddy shores strewn with

stones in Casco Bay, Maine. Here it occurs nearly up to high-water mark in association with *Clitellio arenarius*, though the latter is far more abundant. In similar situations in Narragansett Bay also both species occur, and Prof. Verrill has taken them near New Haven. The writer has found *T. benedeni* only sparingly in the neighborhood of Wood's Hole, and in water both fully salt and brackish. My brother, Dr. H. F. Moore, has collected it along with *Clitellio arenarius* at Campobello, New Brunswick.

Tubifex hamatus sp. nov. Pl. XXXII, figs. 12–18.

Length up to 35 or 40 mm.; greatest diameter about .8 mm. at the genital region; number of somites 85–110. In preserved specimens the prostomium is short and bluntly rounded, the peristomium about as long as the prostomium and divided into two rings, the first of which is papillated and evidently retractile. Succeeding somites increase in size, and the next five or six are biannulate, with the smaller annulus anterior. No further annulation is evident. The greatest diameter is at XI, behind which the segments become much narrower, but undergo no diminution in length for half the length of the body. Many of the specimens have somite VIII and often part of IX or even X strongly wrinkled or furrowed transversely. None has the clitellum distinctly developed. The cuticle is thick and everywhere perfectly smooth.

Setæ are absent from the peristomium, the ventral bundle of XI and the anal somite. Elsewhere from one to four occur in each bundle. Anterior to the clitellum four is the normal number both dorsally and ventrally on somites V to VIII, and usually two or three on the remaining somites. Postclitellar somites bear almost invariably two in the ventral and a single large one in the dorsal bundles. In no case have capillary setæ been detected in the dorsal bundles, the setæ being, therefore, exclusively of the hooked and bifid type. It is, of course, possible that further acquaintance with the species, now known from but one locality, may disclose the occasional or periodical presence of capillary setæ in the dorsal bundle. The anterior setæ (fig. 14) exhibit no noteworthy peculiarities, and are but little larger in the dorsal than in the ventral bundles. They are slightly sigmoid, with a small nodulus at the junction of the inner and outer limbs, the distal process of the slightly hooked tip longer and more slender and the proximal one shorter and stouter. Behind the clitellum they undergo little change for several segments, but at about the 20th to 28th somite in different individuals the dorsal and ventral setæ become strongly differentiated. The latter (fig. 13) gradually diminish in size and the two divisions of the tip become equal in length, the proximal one, how-

ever, remaining the stouter. Probably as a result merely of their being less worn, the points are usually longer and sharper than on more anterior setæ. At the point indicated the dorsal bundles become abruptly reduced to a single seta of very characteristic form (fig. 15). These are very large and stout, especially in the outer limb, which joins the inner one in an abrupt elbow marked by a prominent enlargement. The tip remains bifid, but is formed almost entirely by the stout, strongly hooked proximal division, which bears the small, slender distal division as an accessory process on its convexity. In intact individuals such large setæ continue nearly or quite to the caudal extremity, but in those which are regenerating the dorsal as well as the ventral bundles contain unmodified setæ, which are consequently here probably provisional.

The ventral setæ of X, which lie just anterior to the orifice of the spermathecæ, are much modified as copulatory setæ (fig. 17). Usually each fasciculus is reduced to one functional and one developing seta. The former is about one-third longer than the ordinary setæ, with a very long slender outer limb curved in the same direction as the inner limb and deeply cleft into two delicate, very slightly diverging prongs, which are, however, united by a thin curved plate to form a groove. The setæ sacs are also enlarged and their outer thirds form eversible sheaths or pockets for the setæ, and their closed ends receive the secretion of two or three small groups of gland cells.

The preservation of the specimens is unsatisfactory, so that histological details are avoided in the following description of the internal anatomy. The digestive tract consists of a short eversible buccal chamber in I and II, a pharynx with a conspicuous spheroidal and glandular dorsal diverticulum in III, a short œsophagus extending through IV and V, and an intestine with its chlorogogue covering from VI onward. The septa $\frac{III}{IV}$, $\frac{IV}{V}$, $\frac{V}{VI}$ and $\frac{VI}{VII}$ are thickened, muscular, and carried back to the alimentary canal in the form of funnels. The last is especially muscular.

While a true integumental plexus appears to be absent, the vascular system is conspicuous from the great development of the anterior lateral vessels, which are very long and arranged in a series of loops and folds beside the alimentary canal as far back as the genital somites (X and XI), those in the latter especially being enlarged, somewhat moniliform and extending into the sperm sac and ovisacs respectively. The lateral vessels of VIII are also of large size, but whether they form contractile hearts is uncertain. A highly developed gridiron plexus of blood-vessels exists in the walls of the intestine, especially in the

somites VIII to XII, where it resembles the condition figured by Stolc for *Bothrioneuron*.

None of the specimens is mature, so that the reproductive organs are not fully developed, and further study may require some modification of the following account, especially in what relates to the penis sheath, prostate glands and extent of the sperm sac and ovisacs. The testes have the usual location in X, but remain small in all of the specimens sectioned. A single sperm sac (which may be double anteriorly) reaches from the septum $\frac{X}{XI}$ as far as XIII or XIV, but probably much farther in fully mature worms. It includes long loops of the lateral blood-vessels of X, and is itself enclosed in the ovisac which arises from the succeeding septum.

The male efferent apparatus is shown semi-diagrammatically in fig. 16. The large, few-celled sperm funnel is so distorted by pressure from the intestines, blood-vessels, sperm sac and the septum $\frac{X}{XI}$ that no accurate drawing could be made. After penetrating the septum $\frac{X}{XI}$ the vas deferens forms several close loops between the sperm sac and the intestine, and then, after curving round the former, takes a more open course in the posterior part of the segment before opening into the atrium. The entire atrium is about one-fourth the length of the vas, consists of a small fusiform sperm reservoir receiving the vas at one end and the rather small prostate gland on one side. At the other end it passes into a scarcely distinct ductus ejaculatorius of about equal length, which in turn passes into the summit of the simple erect penis sac. The latter is about as long as the preceding two parts of the atrium combined, is of nearly cylindrical form, has no special nor well-developed muscle sheath and contains the soft filiform penis, which in these specimens lacks any chitinous sheath. The free end of the retracted penis is received into a small bursa which is provided with a circle of small glands and opens at the position of the missing ventral setæ of XI. The ovaries are in XI, but the oviducts have not been detected. As mentioned above, an ovisac arises from $\frac{XI}{XII}$ and, receiving the sperm sac and a pair of vascular loops, extends to about XV or XVI.

The spermathecæ (fig. 18) open just behind the ventral or copulatory setæ of X. They are probably not fully developed in any of the specimens. In those of largest size they have a length about equal to one-half the diameter of the body, are more or less club-shaped with a simple duct forming about one-half the length, and a more or less distinct pouch, which may be elongated or spherical and pass gradually into the duct or be sharply defined. No distinct spermatophores are

present, though several of the spermathecæ contained small elongated aggregations of spermatozoa.

Nephridia are present on the left side only of most, if not of all, segments. In sections they are very conspicuous owing to the large size especially of the middle tubule loop, but they are not sufficiently well preserved to permit a detailed description of their structure. The terminal vesicles are likewise large and the external pores, which are situated well mediad and a little cephalad of the ventral setæ, are very conspicuous in entire mounts, in which their asymmetry is very striking.

The brain (fig. 12) is somewhat broader than long, slightly cleft anteriorly and deeply cleft posteriorly.

This species has been found only under stones between tides on the shores of the Acushnet river, above New Bedford, Massachusetts. At this point the water is brackish.

Limnodrilus subsalsus sp. nov. Pl. XXXIII, figs. 19-22.

Length up to 40 mm., but most examples are less than this; greatest diameter (at XII) .6 mm.; number of segments up to 120.

The prostomium is conical with the apex rounded, one and one-half times to twice as long as broad. The first two or three segments are very short, not exceeding the prostomium; succeeding somites rapidly increase in length to X, which, with those following, is five or six times that length. The greatest diameter is at XI and XII, from which point it decreases to the very slender posterior third. Usually the peristomium is simple, but occasionally is faintly biannulate; II, III and IV are very distinctly biannulate, with a small, sharply defined annulus split off anterior to the setæ, which are borne on the prominent middle portion of the larger annulus; V is triannulate with the setæ posterior to the middle of the largest, middle annulus; VI has a second narrow annulus splitting off anterior to the setigerous one and a single one behind; VII is more distinctly quadriannulate, and VIII has four narrow annuli before and two behind the large setigerous one. The next few annuli present an irregular multiannulate condition, there being in most cases 5 presetal and 2 postsetal rings, which are nearly or quite equal to the setigerous one. Postclitellar somites are only very obscurely or not at all annulated.

Setæ are absent from the prostomium, the ventral bundles of XI and 2 or 3 caudal somites. Preclitellar bundles contain 4 to 6, usually 5 setæ; behind the clitellum are found at first 4, then 3, and toward the posterior end 2. Smaller numbers are very likely to occur in the dorsal bundles, though there is no constancy in this respect. There are no

copulatory setæ and none in any way much modified or enlarged. Throughout the entire length they have essentially the form shown in figs. 19 and 20, the ventral ones averaging somewhat longer and stouter. The two divisions of the tip are nearly equal in length, especially in posterior setæ, but the distal is usually longer and the proximal stouter.

The simple digestive tract has the pharyngeal diverticulum divided into two lobes by a median fissure in II and III; the chlorogogue investment begins in V or even IV, and the posterior region of the intestine is very strongly beaded. The anterior margin of the brain, near which the connectives arise, is nearly truncate, but has two pairs of small ganglionic projections; the posterior is about one-half as wide and produced into a pair of prominent lobes separated by a narrow sinus, through which the dorsal vessel passes. Nephridia are of the usual type, symmetrical, and open immediately in front of the ventral setæ.

The chief characteristic of the species is found in the reproductive organs, especially in the abruptly bent atrium. The testes are in X, the ovaries in XI, the latter filling a large part of the cavity of that somite, but apparently unprovided with an ovisac. The former produce spermatogonia very copiously and fill not only the cavity of X, but a prominent median sperm sac which reaches to about XXI. The male genital ducts (fig. 21) present the structure and complexity of Eisen's genus *Camptodrilus*. The large discoid sperm funnel is in contact with anterior face of the septum $\frac{X}{XI}$, on the posterior side of which the vas deferens has contracted to a diameter of one-eighth to one-tenth its diameter. From this point the vas deferens forms many and varied coils and loops (not accurately represented in the figure) and has a total length to the point of entrance into the sperm reservoir of about three and one-half times the entire atrium. The sperm reservoir (*ss.*) is stoutly fusiform, constitutes nearly one-fourth of the entire length of the atrium and receives the massive prostate gland (*p.*) near the middle of the ventral side. A ductus ejaculatorius about as long as and one-fourth to one-fifth the diameter of the reservoir unites the latter with the penis sac. Sometimes this ductus is folded as in the figure, and has a posterior connection with the sperm reservoir; in other examples it stretches forward beside the penis sac, and the ends of the reservoir are reversed. The penial apparatus is bent sharply at the summit of the bursa at nearly a right angle and extends thence caudad, sometimes horizontally, sometimes obliquely upward, carrying with it the septum $\frac{XI}{XII}$ to a point opposite the setæ zone of XII. The penis is the direct continuation of the vas deferens, and is slightly bulbous at the distal

and gently enlarged toward the proximal end. Surrounding it is the cuticular penis sheath, which is 12 or 13 times as long as its proximal diameter and closely envelopes the penis except at the distal end, where it expands broadly like the mouth of a trumpet. The epithelial penis sheath (*es.*) expands distally into a bursa divided by a horizontal, diaphragm-like partition into a larger dorsal chamber (*dc.*) which receives the free end of the penis and its cuticular sheath and a very shallow ventral chamber (*vc.*) lined by enlarged cells. From this lower chamber a narrow passage leads to the exterior. The entire penial apparatus is ensheathed in muscle, for the most part arranged in two layers, wound spirally in opposite directions and united at the proximal end in a loose coil around the lower end of the vas deferens. Distally these muscles partly unwind and form a sheet enveloping the bursa and binding the entire organ to the body floor.

Spermathecæ (fig. 22) open as usual in line with the ventral setæ of X. They are usually bent into a coil and have a large spherical pouch and a duct about twice as long, the proximal half of which is narrow and the distal half expanded into a somewhat fusiform enlargement with thick walls.

This species occurs in considerable numbers along with *Tubifex hamatus* under stones at half-tide on the Acushnet river, above New Bedford, Massachusetts. At flood-tide the water is here strongly brackish, and this species is of interest as the first of its genus to be recorded as occurring under such conditions, all other species being inhabitants of fresh water strictly.

Enchytræus albidus Henle.

Enchytræus albidus Henle, 1837.
Halodrillus littoralis Verrill, 1873.
Enchytræus humicultor Vejdovsky, 1879.
Enchytræus littoralis (Verrill) Smith, 1895.

This, the best known and most generally distributed of our littoral Oligochæta, was redescribed and identified with *E. humicultor* Vejd. by Smith. Michaelsen, to whose monograph reference is made for the complete synonymy, considers the latter to be part of *E. albidus* Henle. It is an abundant species from Casco Bay, Maine, to Sea Isle City, New Jersey, at least, and, while found more or less everywhere in the upper littoral zone, is especially abundant in the windrow of eel grass which traces the line of high-water along the beach. Wherever the eel grass is kept moist by brackish water and retains a thick coating of diatoms to serve as food, these worms become large and stout, attaining an inch in length and a millimeter in diameter. Elsewhere they are smaller. The same species, but of smaller size, is found in

moist spots on farm lands on Martha's Vineyard, where it could readily be introduced in the large quantities of eel grass that are annually spread for fertilizer. About Wood's Hole it also lives in damp, sandy woods and on the shores of fresh-water ponds, especially of one that formerly was connected with the Sound. Whether this particular species originated on the strand and migrated landwards or *vice versa* is not apparent. Its wide distribution along the shore, however, may be accounted for by the ease with which it could be transported in masses of eel grass attached to floating logs, or by clinging to the feet of migrating shore birds. The same influences would affect *Lumbricillus*, but not the various species of tubificids, which burrow in the mud or conceal themselves beneath stones. As a consequence many of the latter appear to occur quite locally.

Enchytræus albidus may be easily recognized among our littoral species by its milk-white color and nearly straight, internally hooked setæ.

Lumbricillus agilis sp. nov. Pl. XXXIII, figs. 23–28.

The length of fully extended mature worms is about 16 mm. or less, the greatest diameter is .4 mm., and, owing to the relatively stout anterior and slender, tapering posterior parts, the general form is distinctly clavate, particularly in fixed examples. Considerable variation in the number of segments has been observed, ranging from 30 to 48, 47 being a very frequent number in breeding examples. The prostomium is short, blunt and verrucose, and possesses a distinct cephalic pore a little behind the apex on the dorsal side. The spermathecal pores are inconspicuous slits facing laterally in the furrow $\frac{IV}{V}$, and the spermaducal pores are rather conspicuous simple or usually trifid slits in the position of the absent ventral setæ of XII. In preserved worms they are usually on the apex of the everted male bursa. The female genital pores are visible only in sections. When fully developed the clitellum is thick and conspicuous and extends completely around somites XI and XII. Anteriorly the somites increase in diameter and length to the genital region, but are always short; posteriorly they taper rapidly, and are slender and divided into 3 annuli, of which the middle one bears the setæ, and each of which may be further divided into 2 or 3.

As usual in the genus, the setæ are of a gently sigmoid form with rather acute, slightly hooked tips and a slight thickening at the junction of inner and outer limbs. Those of the ventral fascicles (fig. 23*a*) are decidedly larger than the dorsal ones (fig. 23). Ventral bundles contain from 5 to 8, usually 6, anterior to the clitellum, and from 4 to 6, usually 5, posteriorly; dorsal bundles usually 5 anteriorly and 3 or 4

posteriorly. On somite XII there are no ventral and only 1 to 3 dorsal setæ.

Anteriorly the color is a delicate pink which resides in the ovaries, testes and œsophagus; this is purest as far back as the setæ of somite VI and again in XI and XII, but is elsewhere obscured by the brown color of the chlorogogue cells. In the youngest worms the blood is colorless, in larger ones sulphur yellow, and in still larger ones reddish-yellow. At all ages these worms are transparent and especially so when young, rendering the anatomical study of living ones an easy matter.

The septa $\frac{IV}{V}$, $\frac{V}{VI}$ and $\frac{VI}{VII}$ are thickened and $\frac{III}{IV}$ only less so. The three most anterior bear large, clear septal or pharyngeal glands, the third being more granular than the others. The brain (fig. 24) is slightly longer than broad, straight or slightly truncate anteriorly, with the prostomial nerves and circumœsophageal connectives arising from the antero-lateral angles; just behind these is the narrowest part, from which the width gradually increases to the two quadrate posterior lobes, which are separated by a moderate cleft and give rise to a pair of muscle strands. Copulatory supra-neural glands are well developed, especially in somites III, IV and V. They are slender and elongated, not closely united with the ventral nerve, and open on each side nearly at the ventral setæ bundles.

The blood vascular system presents the usual simple structure found in species of this genus. There is a well-developed periintestinal sinus terminating anteriorly at VII. The dorsal vessel is conspicuous and contractile for most of its length, becomes free from the intestine in XIII, and terminates without bifurcating at the anterior margin of the brain, where it joins the pair of vessels arising from the two loops into which the ventral trunk splits in III. Cœlomic corpuscles (fig. 25) are of two kinds, much the most numerous being elongated, irregular, flattened, colorless and finely granular ones measuring about .025 mm. long and .008 mm. wide. The other and less numerous being flattened, irregularly circular disks, with large granules and a pale grayish-green color, which are .015 mm. in diameter.

Nephridia of the form shown in fig. 26 occur regularly in pairs in every somite, except XI, XII and XIII, from VII caudally. They have very small funnels and massive tapering postseptal regions, from the postero-ventral angle of which the large efferent duct, which is shorter than the massive portion, arises and passes to the external pore.

When fully developed the testes, which occupy the usual position in

XI, are divided into from 10 to 20 slender, pyriform lobes which fill a large part of the somite. Sperm sacs are either altogether absent or very small. The sperm funnels occupy a great part of XI, are slender, about 6 to 8 times as long as thick, nearly cylindrical, more or less folded when *in situ*, and slightly contracted near the mouth, the margins of which are provided with a ciliated roll or lip. The vas deferens is about three times as long as the funnel, closely but very variously folded in XII, and has the terminal part somewhat enlarged and ciliated. It opens into the small, depressed, spheroidal, glandular and opaque atrium, which itself opens on the medial side of a small bursa in the position of the ventral setæ. The bursa can be everted as a conical penis (fig. 27).

Somewhat like the testes, the ovaries are subdivided into about 20 ellipsoidal bodies, each with a cross division, on one side of which is one or several large ova, and on the other a number of small ones. A small ovisac pushes back from septum $\frac{XII}{XIII}$, but is never extensively developed. The spermathecæ (fig. 28) are small, pinkish, pyriform tubes without diverticula or distinct ducts, which communicate with the lumen of the œsophagus in V and with the exterior in the furrow $\frac{IV}{V}$, near which they bear a circle of glands chiefly aggregated into an anterior and a posterior group.

This is an exceedingly pretty and active little worm which crawls rapidly and clings closely to surfaces. It is extremely abundant among the eel grass thrown on shore near high-water mark, and which accumulates in great quantities in sheltered coves. Its special habitat is a certain stratum in the bedded masses where the plant is neither soaked in water and much decayed, nor dried by the sun and air as in the uppermost layer, but where it remains moist and coated with a layer of diatoms on which the worm feeds. If sexually active worms be removed from such conditions and placed in clean salt water without diatoms the genital organs quickly shrink, but if kept in even a small quantity of moist eel grass exposed to moderate light they continue to reproduce. These worms are much parasitized by a monocystid gregarine. The species is known from Casco Bay, Maine, to Vineyard Sound, Massachusetts.

Bibliography.

Beddard, F. E. On Certain Points in the Structure of *Clitellio*. *Proc. Zool. Soc. London*, 1888, 485–495, Pl. XXIII.

Bourne, A. G. Notes on the Naidiform Oligochæta. *Quar. Jour. Micr. Sci.*, XXXII (1891), pp. 349–356, Pls. XXVI and XXVII.

Claparède, E. Études Anatomiques sur les Annélides, etc. *Mém. Soc. Phys. Genève*, XVI (1861), pp. 101–110, Pls. III and IV.

Claparède, E. Recherches Anatomiques sur les Oligochètes. *Id.*, XVI (1862), pp. 217–291, Pls. I–IV.
Ditlevsen, A. Studien an Oligochäten. *Zeit. f. Wiss. Zool.*, LXXVII (1904), pp. 398–480, Pls. XVI–XVIII.
Ferrionnière, G. Contribution à l'étude de la faune de la Loire-Inferieure. Annélides oligochètes. *Bull. Soc. Sci. nat. Ouest*, IX (1899), pp. 242–4, 246–9, 294, Pl. XIX.
Goodrich, E. S. On the Structure of *Vermiculus limosus*. *Quar. Jour. Micr. Sci.*, XXXVII (1895), 253–267, Pls. XXVI–XXVIII.
Leidy, J. Marine Invertebrate Fauna of Rhode Island and New Jersey. *Jour. Acad. Nat. Sci. Phila.*, III (1855), p. 148, Pl. XI, fig. 64.
Michaelsen, W. Oligochæta. Berlin, 1900.
Minor, W. C. Natural and Artificial Section in Some Chætopod Annelids. *American Journal of Science and Arts*, XXXV (1863), p. 36.
Smith, F. Notes on Species of North American Oligochæta. *Bull. Ill. State Lab. Nat. Hist.*, IV (1895), pp. 289–292.
Vaillant, L. Histoire des Annelés. Paris, 1890, III, 2, pp. 421, 422.
Verrill, A. E. Report upon the Invertebrate Animals of Vineyard Sound and Adjacent Waters. *Rep. U. S. Fish Comm.*, 1873, pp. 622–624, 324.
Verrill, A. E. New England Annelida. *Trans. Conn. Acad.*, IV (1881), Pl. VIII, fig. 3.

Explanation of Plates XXXII and XXXIII.

Plate XXXII.—*Monopylephorus glaber*, figs. 1 to 6.

Fig. 1.—Male genital duct entire, dissected. ×180. The histology is semi-diagrammatic.
Fig. 2.—Outline of a living nephridium *in situ*, seen from below. ×180. *v*, ventral blood vessel.
Fig. 3.—Outline of brain, from above. ×180.
Fig. 4.—A ventral seta from VIII. ×335.
Fig. 5.—Three cœlomic corpuscles of different sizes. ×280.
Fig. 6.—A pair of spermathecæ. ×55.

Tubifex irroratus, figs. 7 to 11.

Fig. 7.—Side view of entire male genital duct, the penis sac partly concealed behind the sperm reservoir; from a dissection and sections. ×180.
Fig. 8.—Two spermathecæ from different worms; *a*, much and *b*, little distended with sperm. ×55.
Fig. 9.—Ventral setæ, *a*, from somite IV; *b*, from somite XL, and *c*, from the posterior end. ×335.
Fig. 10.—Cœlomic corpuscles, *a*, of the ordinary form; *b*, the homogeneous, colorless form. ×280.
Fig. 11.—Terminal portion of a dorsal capillary seta. ×560.

Tubifex hamatus, figs. 12 to 18.

Fig. 12.—Outline of brain, from above. ×180.
Fig. 13.—A posterior dorsal seta. ×280.
Fig. 14.—A dorsal seta from VIII, and *a*, tip of a ventral seta from the same. ×280.
Fig. 15.—Two of the hooked dorsal setæ from the middle region. ×280.
Fig. 16.—Outline of the male genital duct, with a portion only of the vas deferens represented. ×180. Funnel diagrammatic.
Fig. 17.—A copulatory seta retracted within its sac. ×280.
Fig. 18.—Outline of a nearly empty spermatheca. The line *a–a* shows the form of the same partly distended. ×180.

Plate XXXIII.—*Limnodrilus subsalsus*, figs. 19 to 22.

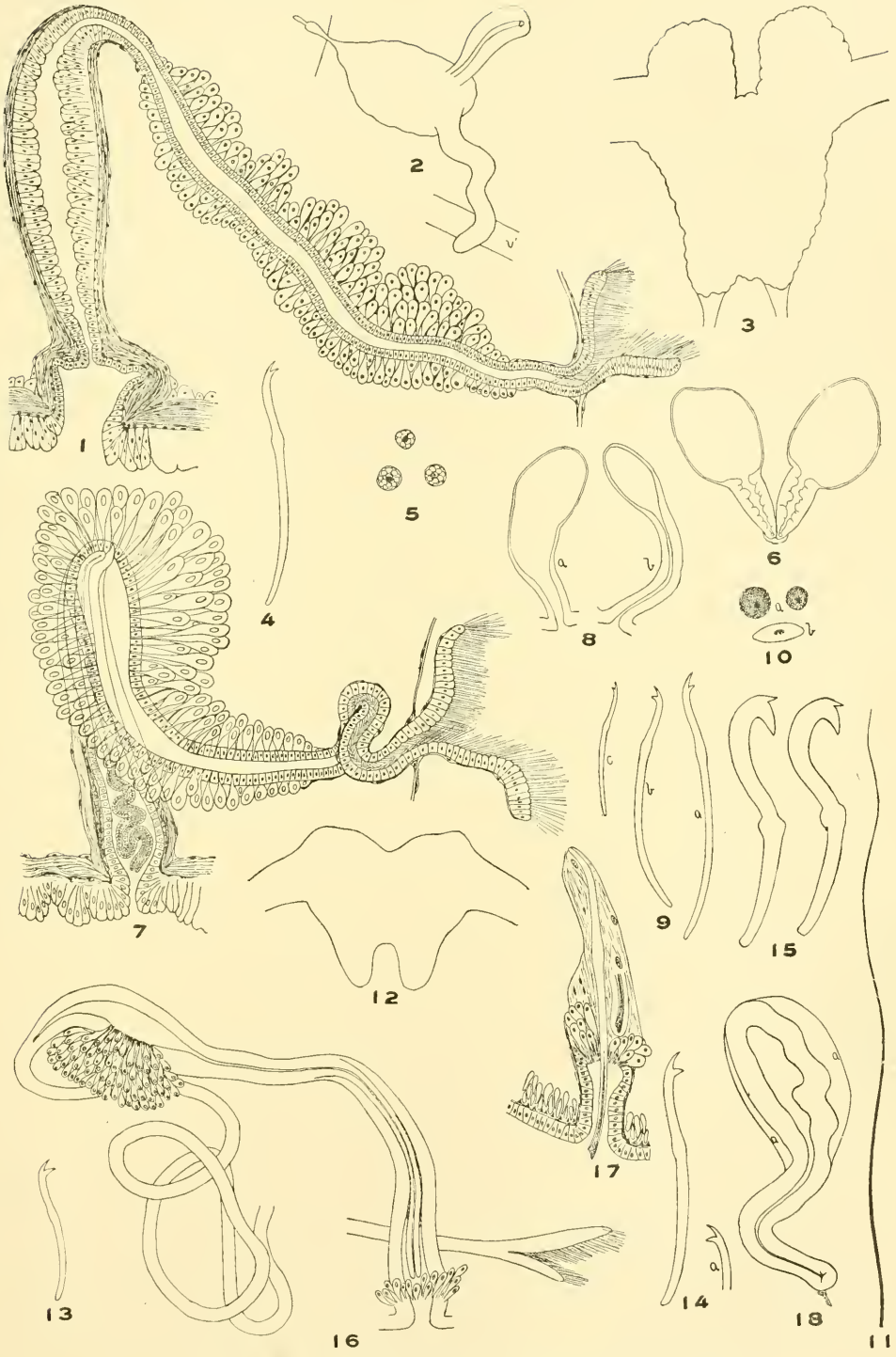
Figs. 19 and 20.—Ventral and dorsal setæ, respectively, from somite VI. ×280.
Fig. 21.—Side view of the entire male genital duct, combined from several dissections. × about 100.
Fig. 22.—A spermatheca shown in outline. × about 100.

Lumbricillus agilis, figs. 23 to 28.

Fig. 23.—Three dorsal and *a*, one ventral setæ. ×335.
Fig. 24.—Outline of brain, from above. ×150.
Fig. 25.—The two forms of cœlomic corpuscles. ×335.
Fig. 26.—A nephridium from life. ×225.
Fig. 27.—Dorsal view of one of the male genital ducts. Drawn from a living worm. ×55.
Fig. 28.—A spermatheca showing communication with œsophagus above and external opening below. ×110.

Monopylephorus parvus, figs. 29 to 34.

Fig. 29.—A strongly bifid seta from the ventral bundle of VI; *a*, a slightly forked one from a dorsal bundle; *b*, tips of three from the posterior region. ×280.
Fig. 30.—Two cœlomic corpuscles. ×280.
Fig. 31.—Outline of the brain, from above. ×180.
Fig. 32.—Outline of both male genital ducts *in situ*, as seen from the ventral surface of the body. ×180.
Fig. 33.—A transverse section passing through the male pore. ×180. *at*, atria; *b*, genital bursa; *dv*, dorsal blood-vessel; *in*, intestine; *n*, nerve cord; *p*, prostate gland; *ss*, sperm sac; ♂, common orifice of male ducts.
Fig. 34.—Outline of spermatheca. ×280.



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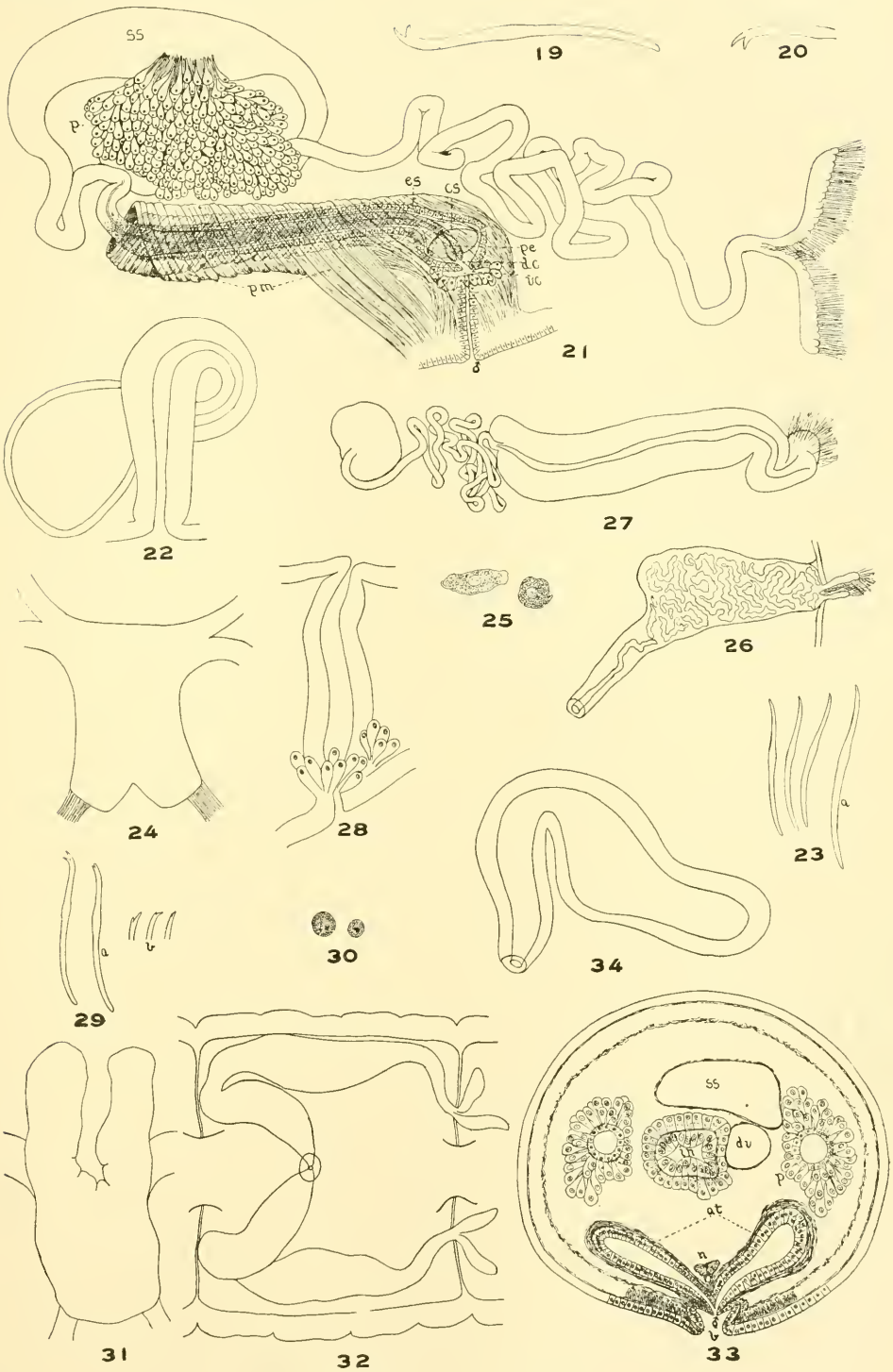

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