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Target species for deep-sea studies in ecology, genetics, and physiology

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This paper describes *Tharyx luticastellus* sp. nov. (Polychaeta: Cirratulidae), an important structural component of the bathyal (approximately 1200 m) macrobenthic community in the San Diego Trough of the North Pacific Ocean. Its robust, distinctive, helically coiled tube permits ready identification and collection or manipulation in relatively un-traumatized condition.

Major problems in applying modern ecological, genetic, and physiological methods in the deep sea include the *in situ* or shipboard identification of species, the obtaining of sufficient specimens of any single species for adequate statistical treatment, and the manipulation or retrieval of animals without induction of severe trauma. This species satisfies all these criteria.

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INTRODUCTION

This paper describes a cirratulid polychaete (from the San Diego Trough of the North Pacific Ocean) which is sufficiently conspicuous, abundant, and robust to be routinely sampled by trawl, grab, or corer. It is sedentary (a coarse-grained species *sensu* Jumars, 1975a, b) and belongs to the bivalpate group of Cirratulidae, whose species numerically dominate the macrofaunas of many, if not most, deep-sea areas (e.g. many Gay Head-Bermuda transect stations: Hartman, 1965, and Hartman & Fauchald, 1971; abyssal North Pacific Ocean, Hessler & Jumars, 1974; two basins of the bathyal North Pacific Ocean, Jumars, 1974, 1975b; hadal Aleutian Trench, Jumars & Hessler, in prep.). The

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peculiar characteristics of this new species make it a good candidate for ecological and physiological, as well as genetic, study.

Several factors additional to the mechanics of sampling at great depths impede the biological study of single species in the deep sea. One obvious problem is the taxonomic one; much of the high diversity reported from the benthos of the deep sea (e.g. Hessler & Sanders, 1967; Hessler & Jumars, 1974) remains undescribed at the specific level. Even if this difficulty is overcome, the low density and cryptic nature of most deep-sea species hinders further ecological, genetic, and physiological studies.

One means of circumventing the problem of low density has been to take trawls over large areas of bottom. This procedure has succeeded in obtaining sufficient material for analysis of genetic variability in several species (e.g., Ayala & Valentine, 1974). Due to mesh-size considerations, however, trawls do not capture a representative collection of benthos, but rather concentrate large and/or encrusting organisms. Ironically, if genetic understanding of high deep-sea species diversity is sought, only species belonging to relatively depauperate taxa have been examined in detail. In addition, most of the species sampled adequately for genetic study have presumably large ambits (sensu Lloyd, 1967) and thus experience a relatively fine-grained environment (cf. Jumars, 1975a, b). Results for such species may not be characteristic of deep-sea species in general (cf. Selander & Kaufman, 1973).

Baited traps have been proposed as an alternative to trawling for obtaining many individuals of single species for physiological examination (e.g., Paul, 1973). Such traps have the decided advantage of producing less physical trauma than trawls. Again, however, although the data so obtained would be extremely valuable, baiting over short time intervals attracts only mobile animals which show low diversity in the deep sea (e.g., Shulenberger & Hessler, 1975).

DESCRIPTION

Tharyx luticastellus sp. nov.

"mudball cirratulid" Jumars 1975b: fig. 6

Material examined. Over 300 specimens from the Coronado Sea Fan region of the San Diego Trough (approx. 1200 m) were dissected from their tubes. The holotype (AHF Poly. 1134) and 16 paratypes (AHF Poly. 1135) are deposited at the Allan Hancock Foundation of the University of Southern California in Los Angeles, California. They were all taken from sample SIO R-16 (collected by Frank Rokop of Scripps Institution of Oceanography), an epibenthic sled trawl from 32° 26.8' N, 117° 28.8' W, to 32° 27.4' N, 117° 28.0' W, at depths of 1166 to 1222 m on 18 January 1971.

Formal description. Complete ovigerous specimens having 48-69 setigers measure from 15-30 mm long. A maximum width of about 2 mm is attained in the ovigerous segments of the largest specimens. The body is helically coiled as far as its midlength, where it is bent through 180°, and is again coiled parallel with the anterior half, so that the head and pygidium are juxtaposed. Preserved specimens retain this posture, and are withdrawn into the lower half of their robust, mucus-lined, mud tubes (Fig. 1). Both dextral and sinistral forms of the tube are found.

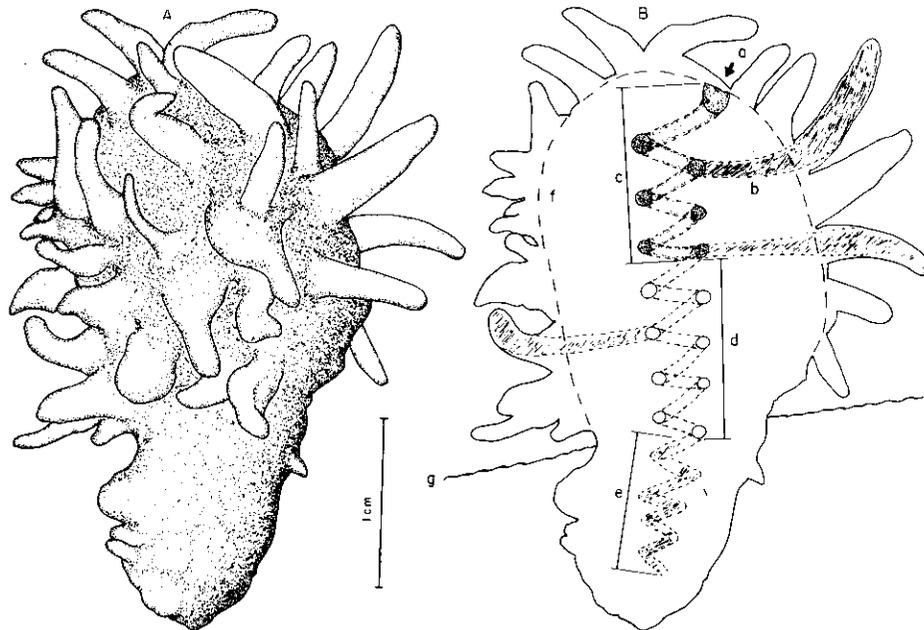


Figure 1. The mud tube of *Tharyx luticastellus*. A. External lateral view. B. Internal structure, highly diagrammatic: a, the single tube opening; b, presumed previous opening, now packed with sediment to form digitiform external protuberance; c, portion of tube occupied while feeding and defecating; d, portion of tube into which worm withdraws during fixation; e, disused portion (filled with sediment); f, dashed line showing approximate extent of solid "mudball;" g, *in situ* sediment surface.

The prostomium is short, bluntly conical, and weakly biannulate (Fig. 2A, B). When the lips are distended (Fig. 2B), the prostomium points dorsally, and the mouth is nearly terminal. The achaetous peristomium is longer than the following apparent segment, which is also achaetous. With the lips distended, the peristomium tightly seals the tube entrance. The upper lip is of a characteristic horseshoe shape (Fig. 2B), but the lower lip has from one to eleven or more lobes depending on its state of distension and the size of the individual.

Although they are peristomial in origin (cf. Day, 1967), the first setiger bears a pair of large, grooved palps crenulated along their margins and thinnest at their near-dorsomedian points of insertion on the anterior edge of the segment. The notopodial setal fascicles are directed dorsally, while the neuropodia are dorsolateral. Branchiae are inserted just above the notopodia. The next two setigers are identical, except that the branchial insertion shifts slightly backward. A ventral, muscular bulge extends through the first three setigers. In each of these segments, there is a dorsal region of very thin, transparent integument, which increases in coverage as the parapodia shift to a more lateral orientation in the fourth through the ninth setigers. The tenth setiger is abruptly moniliform, its dorsal portion greatly distended by ingested sediments or by developing ova (e.g., Fig. 2A). It also lacks the long branchiae of the first nine setigers. Branchiae are occasionally present on some ovigerous segments, but are short and are inserted near the posterior dorsal edge of the opaque ventral integument (e.g., setiger 12 of Fig. 2A). Ova appear generally limited to

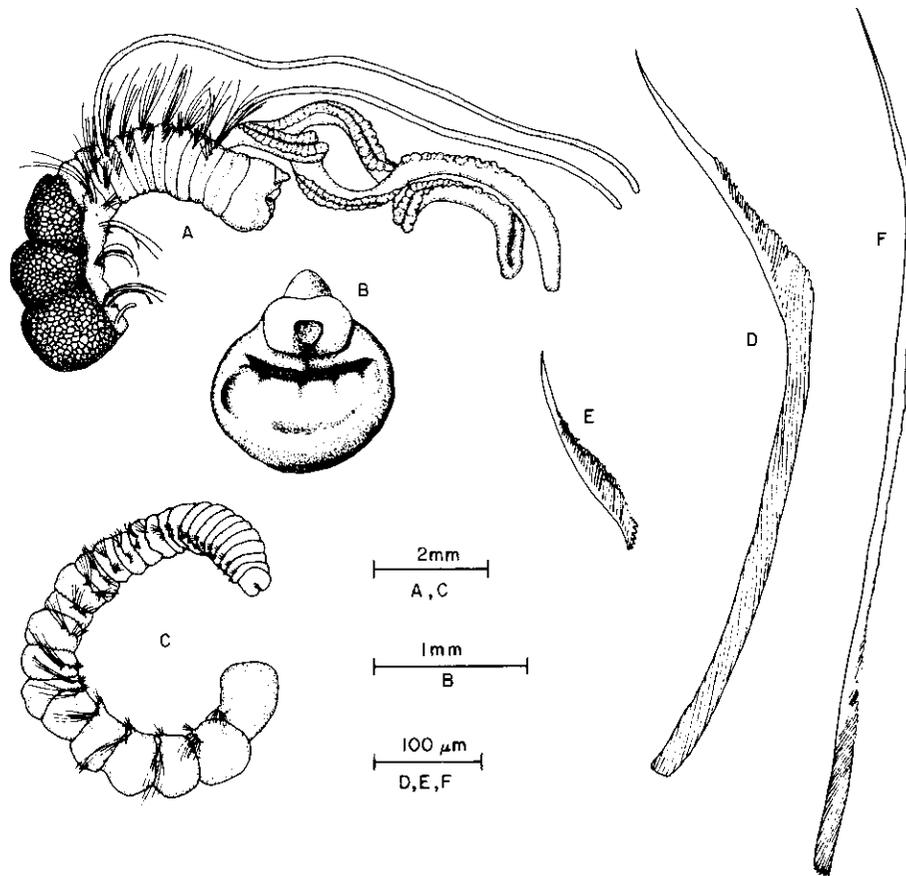


Figure 2. *Tharyx luticastellus* paratypes. A. Anterior end in lateral view, most branchiae removed, ova developing in setigers 10-12. B. Anterior view, lips distended. C. Posterior end in oblique view. D. Modified neuroseta from setiger 10, lateral view. E. Tip of modified seta, oblique view showing irregular rows of fibrils. F. Distal portion of neuroseta from setiger 40.

setigers 10 through 22, although they are occasionally scattered among a few more posterior segments.

The nine or ten immediately pre-pygidial setigers are somewhat crowded, but not inflated (Fig. 2C). The anus is terminal or slightly displaced dorsally by distension of a ventral papilla in some specimens (not in Fig. 2C). Both notopodia and neuropodia are low, semicircular lobes in the posterior region, where they attain maximal development (Fig. 2C).

Setae are simple, with the neurosetae generally less than half the length of the notosetae except in more posterior segments. All setigers possess two fan-like, interdigitating fascicles per parapodial ramus, the setae of each ramus forming an irregular row upon emergence from the epidermis. All notosetae are apparently smooth capillaries, but faint striae can be resolved along one edge under $\times 1500$ magnification. The neuropodia of setigers 1-7 possess similar, though shorter, setae. A few modified setae appear in the inferiormost position in the eighth setiger. In the ninth neuropodium, more than half the setae are of the modified type, and, in the tenth, all neurosetae are modified. These setae

are thick, geniculate, striated at the base, and have two to three irregular rows of spines along their distal margins beneath the smooth, tapering tip (Fig. 2D, E). Modified setae continue through the neuropodia of setiger 22 (ovigerous region), after which they gradually change in character by the extension of the smooth tip and the straightening of the shaft until, in far posterior setigers, they are again nearly straight (Fig. 2F). Anterior notopodia bear 13-17 setae, and anterior neuropodia carry 19-24 setae. These numbers diminish after the first nine setigers to approximately 8 and 12, respectively, until the pre-pygidial setigers, where a further reduction occurs.

The mid-body region is greenish in life, while the anterior and posterior (including palps and branchiae) show a dark brown pigment in addition to the greenish hue. The green color fades entirely from alcohol-preserved specimens, leaving a pale, flesh-colored midregion and dark-brown extremities.

Distribution. *T. luticastellus* is known through positive identifications only from the San Diego Trough at depths of roughly 1200 m, although photographs (Neil Marshall, Scripps Institution of Oceanography, unpubl.) reveal its likely presence at reduced densities in the deeper (to 2100 m) San Clemente Basin to the southwest. It is conspicuously absent from samples and photographs taken in the Santa Catalina Basin (e.g., Jumars, 1974) to the north at approximately the same depths at which it dominates in the San Diego Trough.

Remarks. The extreme prostomial-peristomial modification, limited branchial region, helical posture and tube, and modified midregion neurosetae (even in individuals of only 20 setigers, the smallest thus far recovered), clearly distinguish *T. luticastellus* from other *Tharyx* species. The tube with the worm retracted and the peristomium distended is so impervious to formalin that the "mudball" must be injected with fixative or the tube must be perforated to obtain satisfactory fixation. Otherwise, only the prostomium and peristomium are preserved.

Separate generic status might be warranted for *T. luticastellus* by its unusual tagmosis associated with tube dwelling and a doubled helical posture. However, numerous already-collected deep-sea cirratulid species, which may elucidate the taxonomic position of *T. luticastellus*, remain to be described (Jumars, in prep.), and in these circumstances monotypic generic status seems premature, particularly in the light of the strong resemblance between *T. luticastellus* and *T. tessellata* Hartman, 1960.

The limitation of branchiae to a few anterior setigers and the tube-dwelling habit of *T. luticastellus* is reminiscent of *Dodecaceria* (e.g., Knox, 1971: fig. 7). The lack of a prostomial hood and the spoon-shaped hooks characteristic of *Dodecaceria* suggests that the branchial limitation is convergently associated with the tube-dwelling habit.

T. luticastellus is named by compounding the Latin *luteus*, "made of mud," and *castellum*, diminutive of "castle."

DISCUSSION

The importance of *T. luticastellus* to the community structure of the benthos in the region of 32° 28.2'N, 117° 29.8'W, of the Coronado Sea Fan can hardly be questioned. Among all the macrofauna it is second in abundance only

to another much more cryptic (undescribed) *Tharyx* species, showing mean densities of approximately 138 and 142 per m² (Jumars, 1974: appendix). Its tube is a source of environmental heterogeneity recognized by sympatric polychaetes of the family Paraonidae (Jumars, 1975b: fig. 7). When still occupied, the external surface of the tube occasionally provides a substrate for attachment of some foraminiferal species, and the basal portion sometimes is invaded by a sipunculid species. Once the tube is vacated many more species are associated with it. The external surface is fouled by Foraminifera and a colonial calcareous ectoproct, and the inner chambers are occupied in varying degrees by other Foraminifera, Sipunculida, the isopod *Gnathia coronadoensis* (males and females), a neotanoid species, various Nematoda, and the polychaetes *Exogone* sp., *Fauveliopsis glabra*, and *Notomastus* sp. All these associations were observed in samples totaling only 1.25 m²; many more species probably utilize the tube. It provides a degree of structural diversity (MacArthur and MacArthur, 1961; Thistle, Scripps Institution of Oceanography, in prep.) which is otherwise lacking from the community.

T. luticastellus is an ideal target species for further ecological study. Casual observations reveal bits of man-made detritus occasionally incorporated into the "mudball," suggesting that this structurally important species may be amenable to a life-table analysis of population dynamics. Exotic mineral grains could be introduced into the environment of *T. luticastellus* on one or more pre-sampling occasions, as Edmondson (1945) has done so successfully with Rotifera. This method could provide the time-markers absent or obscure in most deep-sea populations due to their apparently continuous reproduction and recruitment (Rokop, 1974). Poelchau (Scripps Institution of Oceanography, unpubl.), in a study of sediment bioturbation, has established the feasibility of dispersal and subsequent recovery of such sediments using an unmanned submersible system (RUM-ORB of the Marine Physical Laboratory, Scripps Institution of Oceanography). While other tube-building species may be examined in the same manner, *T. luticastellus* is a logical first choice due to its abundance and seeming lack of locomotor ability as an adult. Tube switching (e.g., Day, 1967: 753) would only complicate the life-table analysis.

Manipulative experiments, which have provided numerous insights into community structure elsewhere (e.g., Dayton *et al.*, 1974), meet many practical difficulties in soft substrates. Woodin (1974), shows the profit to be gained by overcoming these difficulties, but few deep-sea species are known which can be recognized and manipulated *in situ*. *T. luticastellus*, by virtue of its conspicuous, robust tube, is an obvious candidate for an experimental approach to such questions as whether deep-sea mortality rates are density dependent (Van Valen, 1974).

Allozyme analysis in *T. luticastellus* could provide a valuable genetic datum point as well: the degree of genetic heterogeneity in an abundant, presumably coarse-grained (cf. Jumars, 1975b) member of a speciose group (Cirratulidae) in the deep sea. This species is also amenable to the analysis of allozyme frequencies in the center versus the periphery of a species range (e.g., Prakash *et al.*, 1969). The mudball is distinctive in bottom photographs (e.g., Jumars, 1975b: fig. 6), and hence this species' range could be far more easily determined than that of most others.

T. luticastellus is an attractive possibility for physiological study as well. The

robust tube resists destruction even in otter trawl samples, but the species is sufficiently abundant that it may regularly be recovered from gently taken cores as small as 0.01 m². Thiel (unpubl. and Thiel & Hessler, 1974) maintained sediment samples at ambient temperature (3.5°C), but only one atmosphere of pressure, in which I several times noted *T. luticastellus* to protrude its branchiae, palps, and pygidium. The casual observation that this species preserves poorly, coupled with the disproportionate size of the gut in the midregion of non-ovigerous specimens, hints that this species may harbor an active microflora and/or active lysozymes. Of the roughly 150 polychaete species so far observed in the Coronado Sea Fan benthos, only two others, *Laetmonice pellucida* (bearing gut diverticula) and *Sternaspis* cf. *fossor* (long, coiled gut), show gross morphological modifications which might be interpreted as potential adaptations to deep-sea life (Allen & Sanders, 1966; Grassle & Sanders, 1973). Neither of these species, however, can be recovered regularly from cores or grabs due to their relatively low abundances, and the required trawling and screening for their reliable recovery can be expected to produce considerable trauma.

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