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Structural Organization of Muscular Elements of a Skin-Muscular Sac of Trematodes: Literature Survey

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ABSTRACT

The issue of structural organization of muscular elements of a trematodes' skin-muscular sac is considered in the study. Special attention is paid to an analysis of materials of preceding researches, study of foreign authors and also to additional literature reflecting peculiarities of structure of a trematodes' body muscular system. The stated issue is insufficiently studied and calls for further researches. A comparative analysis of places of trematodes' localization, taking into consideration disclosure of presence of special definite elements in them, impeding or weakening a function of a trematodes' body muscular system, is given. The purpose of the present study is a detailed analysis of the locomotor apparatus peculiarities of the trematodes of particular species. Typical peculiarities of a trematodes' body muscular system, separate organs and systems are picked out and described by this study. The study comes to a conclusion that the given theme remains unexplored, relevant and requires a detailed scrutiny of features of a body muscular system of definite trematodes' species.

Key words: Morphological researches, functional morphology, skin-muscular sac of trematodes, Fabricius bag, organ of localization

INTRODUCTION

Morphological researches constitute one of the traditional directions of biological science; its focus of interest covers all groups of living organisms and doesn't depend on a systematical position of an examined object. Morphological features typical for species or taxons of a higher rank were formed in the process of a long adaptive evolution for habitation in definite conditions. Vector of adaptive morphological transformations of organisms is aimed at a progressive use of opportunities provided by a habitat. Aforesaid is fair for all living organisms irrespective of their systematical position, existence manner or places of habitation.

Application of the research methods of functional morphology allows exploring and estimating the compliance of morphological features of a living organism to the conditions of its habitat. In the arsenal of a functional morphological method of study of adaptive signs of organs, tissues and smaller structures of living creatures there are modern techniques of researching organs, tissues, cellular structures and their functional destination along with classic descriptive means. In the number of techniques that allow appraising adaptations on a level of micro and ultra-subtle researches there are comparison methods of a light microscopy technique with electron microscopy technique. Means of histo and cyto-chemistry which allow specifying an adaptive reaction of subtle and ultra-subtle structures, are attracted to understand functions of nanostructures and mechanisms of their “work”.

LITERATURE REVIEW

Morphological researches of a skin-muscular sac of trematodes also include study of peculiarities of a muscular system of trematodes’ bodies which to date has been explored insufficiently. It is generally known that their muscular system has in its compound annular, longitudinal, diagonal layers and parenchymal muscles. However, at present time there aren’t any data about which from the enumerated details are typical for all trematodes and which are typical only for separate groups within this class. The stated questions are being explored by the scientists from all over the world, including the scientists from Russia and Kazakhstan. Akhmetov (2004), Galaktionov and Dobrovolskij (2003), Podvyaznaya (1999), Podvyaznaya and Dobrovolskij (2001), Threadgold (1963) and other belong to such scientists.

Certain studies by Malakhov (2007) mark the fact that functional morphological researches are obtaining their urgency again. In our opinion, there are several reasons for this, in nature it is possible to come across with phenotypes; adaptations of the phenotypes can be studied only by methods of functional morphology.

One of the interesting and insufficiently explored directions of the functional morphological researches is connected with examination of parasitic worms. The most archaic group of helminths included in compound of the type Platyhelminthes is represented by the class trematoda. The study of the structure and function of organs, tissues and smaller structures of the class trematoda reveals a number of specialized systems of their organism, as well as their constituent fabrics that ensure the functioning of multicellular organisms. Neural, excretory, complexly-organized sexual, transformed digestive systems and formation of a special type of the integumentary tissue refer to such systems.

In classic studies of Ginetsinkaya (1968), Shults and Gvozdev (1972), Dogel (1972), Shigin (1986), Galaktionov and Dobrovolskij (2003), Galaktionov *et al.* (2006), Hoglund (1991) and Moczon (1994, 1996a, b) a structural scheme of organization of the muscular system of trematodes’ bodies is adduced which consists of annular, longitudinal and diagonal layers, presence of separate dorsoventral muscles in bodies of adult trematodes is pointed at.

It should be noted that, until now, the scientists have not studied the features of development of the muscular system of the skin and muscle bag in the process of individual development of a living organism, as well as the sequential morphological, physiological and biochemical changes occurring in the trematodes of hermaphrodites. Such data exist only for free-living Turbellaria (Baguna and Romero, 1981; Rieger *et al.*, 1994, 1995).

Thus, at Macrostomum and Dugesia multiplication of quantity of the muscular cells, including cells in the side of body (Romer and Parsons, 1992; Baguna and Romero, 1981) is registered, according to the growth of worms in the course of postembryonal development at Macrostomum growth of the muscular fibers is noted.

Muscles of the skin and muscular sac of adult Cercariae serve as a starting point in development of the hypodermic muscular system. At *D. chromatophorum* (*D. pseudospathaceum*) they are presented by three layers-annular, longitudinal and diagonal muscular fibrae, exact topography of which is described in study of Czubaj and Niewiadomska (1997) in detail. Using this circumstance, we confine ourselves only to the analysis of separate morphological peculiarities of the hypodermic muscles of Cercariae *D. chromatophorum* which, in our opinion, have significant meaning for understanding a course of successive transformations of the muscular system in the process of metamorphosis of separate species of trematodes.

It is generally known that the trematodes' integumentary tissue is a part of a special complex named as the skin-muscular sac. Structure of the complex includes the integumentary tissue proper which covers the helminth's body and consists of a special type of an epithelium histologically presented by the submerged epithelium and the muscular system. Since, times of electronic microscope researches (Threadgold, 1963) the submerged epithelium has been called as the tegument (integument). Its basic morphological and functional signs have been determined to date. There are a lot of literature data (Chubrik, 1982; Akhmetov, 2002) concerning the fact that conditions in organs of localization exert conclusive influence on a subtle structure of all layers of the trematodes' tegument. Being a significant contact area of a host and a parasite, the tegument provides functioning of protective mechanisms of liable layers from all types of influence of the localization organ, tegument nourishment which is ascertained for trematodes and in a row of cases the tegument participates in fixation to a surface of the host's organ (Erasmus, 1967; Bjorkman and Thorsell, 1964; Wittrock, 1978). Naturally, muscles of the trematodes' specialized organs and the muscular system as a whole play important role in providing fixation. Specialized organs include first of all suckers, herewith the overwhelming majority of taxonomic groups of trematodes have the abdominal sucker-the only function of which is providing fixation and holding a helminth; besides they have the oral sucker which participates not only in the parasite's nourishment but also in fixation, providing locomotor functions of the fluke. In the process of an evolution special fixation organs, as ventral furrows (*Gastrothylax crumenifer*) or a specialized multifunctional brands organ at representatives of the suborder Strigidae, were developed at numerous systematic groups of trematodes. The issues of participation of the whole skin-muscular sac in providing the fixation act (Feizullaev, 1980; Akhmetov, 2002, 2004) are also being discussed in the literature. In the last case an external layer of the tegument and the muscular system participate in fixation.

In all cases participation of the muscular system and its elements in structure of separate organs provides fixation of a helminth on the surface of the localization organ. Cavities of organs of vertebrates from different classes serve as places of localization for adult trematodes. Enumerating them, we will characterize only separate types of mechanic factors having influence upon trematodes.

In cavities of digestion organs of vertebrate animals mechanic influences are connected with food grinding and mechanic loads in the oral cavity (representatives of the phylum Cyclocoelidae), a continuous peristalsis of the intestine (representatives of the Paramphistomatidae, the Echinostomatidae and other phyla), movement of food masses at different stages of digestion; in glandular organs bound with the digestive tract usually cavities of ducts (the bile-ducts (representatives of the phylum Fasciolidae)) serve as places of localization. Movement of secretion fluids is present in the last case, although their speed is rather low, high enzymatic aggressiveness against the helminth is typical for them (Aleksandrova, 1975).

In a cavity of the thorax trematodes localize on the bronchi (representatives of the phylum Paragonimidae), at birds they localize in cavities of the auriferous bags (representatives of the phylum Cyclocoelidae) and directly in tissues of the lungs (representatives of the phylum Plagiorchiidae), herewith trematodes are influenced by movement of the air breathed in and out. Sometimes such streams are notable for their large speed, for example, in case of localization in the auriferous bags of birds. Representatives of some taxonomic group of flukes parasitize on the hosts' urinary bladder (representatives of the phylum Pleurogenidae), the infraorbital area of an eye (representatives of the phylum Phyllophostomidae) and there is a necessity of fixation on sides of these cases. Organs of a circulatory system, the sanguiferous channel are places of trematodes' localization; representatives of the phylum Schisthosomatidae are well-known in this meaning, herewith active movement of blood is present in the sanguiferous channel. In addition to this, trematodes can localize in temporary organs, for example, in a juvenile organ of birds-the Fabricius bag. The Fabricius bag is a bag-shaped organ that refers to immune system of young birds. This organ is assimilated by adult trematodes (the phylum Prosthogonimidae).

Muscles of the suckers together with separate groups of the muscular system of a body participate in providing fixation of trematodes in the localization organ. In spite of function of fixation, the muscular system of flukes provides locomotor acts of the helminth at change of place of fixation, resistance to natural physiological movements of sides of the localization organ or resistance to physiological streams existing in the organ regardless of affiliation to definite systems of the host's organism.

Morphological organization of muscles of the oral or the abdominal suckers of adult trematodes, apparently, is more or less realized on the same type, although different variations are possible bound with sizes of the suckers relative to sizes of the body, development of the suckers or degree of their reduction. Separate taxonomic groups don't have suckers.

Structural organization of the skin-muscular sac of trematodes' intestinal forms is accepted to consider as primary by a row of authors and therefore exactly this type of structure of the muscular system turns out to be initial and typical. In their opinion, acknowledgment is connected with the fact that all its constitutive elements are clearly expressed (Chubrik, 1982). Such thought about primacy of morphological organization of the trematodes' intestinal forms was earlier stated in study of Aleksandrova (1975) but at this he regards the form of a body as the determinative factor. In researcher's opinion, the unique form of a body in particular allowed trematodes to irradiate at assimilation with new host's organs as new places of localization. Supporting this idea of the evolutionary significance of the body form of adult flukes, it is possible to tell that the form of trematodes' body is amorphous in itself, on basis of which the adaptive process had been occurring. As an indirect evidence studies in the literature considers reservation of an initial scheme of organization of the muscular elements at a row of forms examined by him.

DISCUSSION

Taking into consideration the fact that it is assumed by the above-mentioned studies to regard the morphofunctional organization of muscular system of body of trematodes' intestinal forms as initial, we will analyze literature data on the peculiarities of the structural organization of the muscular system of representatives of different taxonomic groups of trematodes. Particularly, numerous authors mark that the peculiarity of the structural organization of the trematodes' muscular elements lies in fact that the most developed group of muscles is the longitudinal muscular system, for example, this was ascertained by Chubrik (1982) at trematoda (*Hirudinella marina*) trematoda from the stomach of a large tuna, *Botulus alepidosauri* from the end gut of a luminescent anchovy, *Paramphistomum cervi* from the paunch of cattle.

Trematodes whose localization is connected with definite parts of the digestive system of birds with the oral cavity specifically, are notable for development of the annular and longitudinal muscular systems. This is marked by the Akhmetov (2004), at that he notes that these layers aren't situated compactly and on one level from a surface of the trematodes' body and Smirnova *et al.*

(2010) characterize structural allocation of the annual and longitudinal muscles in the body of the helminth as "the multi-storeyness". At the same time the last author considers that such form of allocation gives the both layers definite strength that is necessary at localization in the mechanically aggressive area.

Another peculiarity of organization of the muscle elements of the trematodes' body inhabiting the oral cavity and possibly, in other organs with active movements as of their sides, as of their contents is bound with development of the dorsoventral muscles. Particularly by Akhmetov (2004) at trematoda (*Typhlocoelium cucumerinum*) trematoda from the oral cavity of a mallard and by Yastrebov (1997) at trematoda (*Clinostomum foliforme*) from the oral cavity of a Caspian tern dorsoventral muscles in area of the ventral socket are ascertained which fulfill function analogous to functions of the radial muscles of the suckers.

At trematodes from a thin part of the intestine, at trematoda (*Bolbophorus conphusus*) (Yastrebov, 1997) and trematoda (*Hypoderaeum conoideum*) (Akhmetov, 2004) in particular, it is ascertained that the annular muscular system is developed less than the muscles of the longitudinal layer. By the study this situation was explained by adaptation to resistance to the strong expulsive unilateral stream of chime and the peristalsis of the intestinal sides. Naturally, more detailed examination of all layers of the muscular system of the mentioned helminths can provide more adequate explanation for the whole adaptation system of the stated organisms to localization in the thin part of the host's digestive tract.

At trematodes remarkable for small sizes and localizing among the villi of the host's intestine, at trematoda (*Leucohloridium macrostomum*) (Yastrebov, 1998) and trematoda (*Microphallus montanus*) (Akhmetov, 2004) particularly, the most developed muscle elements are the muscles participating in creation of the sucking effect which are the dorsoventral villi at the given helminths.

Podvyaznaya and Dobrovolskij (2001) assert that similar processes adduced in the ontogenesis occur also at development of the Metacercariae *D. chromatophorum*. At the same time they are far from exhausting complicated dynamics of development of the hypodermic muscular system of the examined parasites.

Data of certain studies (Podvyaznaya, 1999) demonstrate that development of muscles of side of body at Metacercariae *D. chromatophorum* is closely connected with transformations of their integumentary epithelium. Thus, at initial stage of development of Metacercariae while their teguments preserves basic features of Cercaria organization, also muscular system of the skin-muscular sac of a free-swimming larva is retained. At the same time on ultra structural level obvious signs of degeneration of the composing muscular cells are traced which are most vividly expressed in contractile outgrowths.

Data on a subtle structure of myocytes of sides of body of Cercariae and Metacercariae on concluding stage of their development on the whole adjust with ultra structural descriptions of the nonstriated muscular system of the skin-muscular sac of other species of trematodes (Burton, 1966; Lumsden and Foor, 1968; Silk and Spence, 1969; Koie, 1971; Rees, 1974).

Suppositions of Lumsden and Byram III (1967), according to which appearance of micro tubes in muscular cells, is dated to a definite period of their development.

Analyzed data reflect nature of occurring processes but it is not possible to succeed in authentic tracing transformations of the muscular system of the skin-muscular sac on a level of its anatomic structure. There is no doubt that further researches by means of fluorescent microscopy on total specimens are necessary to complete the picture of development of the skin-muscular sac of certain species of trematodes.

CONCLUSION

A brief excursus to the literature on problems of the structural organization of the muscles of trematodes' body provides the evidence of primary development of the elements providing holding helminths in the organs of localization and resistance to the basic mechanical factors in the organs of localization.

For the adaptive apparatuses of sufficiently large trematodes of the phylum Prosthogonimus such as at trematoda (*Schisthogonimus rarus*) and trematoda (*Prosthogonimus ovatus*) habiting the Fabricius bag of birds, where streams and special streams of physiological fluids aren't present, Akhmetov (2004) provides an explanation by creation of the sucking effect to the side of the organ. Thus, certain analogy is observed between small intestinal trematodes and large trematodes of organs. We regard that the analogy of morphological nature can be explained by participation of the surface structures of the skin-muscular sac ("papilloma-shaped structures", "offshoots" and etc.) in fixation. True trematodes, evidently, have poorly developed locomotor functions.

In the present survey issues concerning functional morphological approach as a classic way of studying living organisms in ontogenesis are touched on.

REFERENCES

Akhmetov, K.K., 2002. Micromorhological and functional peculiarities of trematoda *Codonocephalus urnigerus*. Bull. Tyumen State Univ., 4: 93-98.

Akhmetov, K.K., 2004. Functional morphology of the skin-muscular sac and the digestive system of trematodes of different taxonomic and biological groups. Ph.D. Thesis, Faculty of Chemical Technology and Natural Science, Almaty University, Almaty, Kazakhstan.

Aleksandrova, O.V., 1975. Morphological adaptations of non-intestinal echinostomatid flukes to places of localization. Issues Parasitol., 1: 11-12.

Baguna, J. and R. Romero, 1981. Quantitative analysis of cell types during growth, degrowth and regeneration in the planarians *Dugesia mediterranea* and *Dugesia tigrina*. Proceedings of the 3rd International Symposium on Biology of the Turbellaria, August 11-15, 1980, Diepenbeek, Belgium, pp: 181-194.

Bjorkman, N. and W. Thorsell, 1964. On the fine structure and resorptive function of the cuticle of the liver fluke, *Fasciola hepatica* L. Exp. Cell Res., 33: 319-329.

Burton, P.R., 1966. The ultrastructure of the integument of the frog bladder fluke, *Gorgoderina* sp. J. Parasitol., 52: 926-934.

Chubrik, G.K., 1982. Morphofunctional adaptation to the parasitic lifestyle at adult generation of trematodes. Parasitology, 16: 53-61.

Czubaj, A. and K. Niewiadomska, 1997. The muscular system of the cercaria of *Diplostomum pseudos-pathaceum* Niew., 1984 (Digenea): A phalloidin-rhodamine fluorescence and TEM study. Acta Parasitologica, 42: 199-218.

Dogel, V.A., 1962. General Parasitology. University of Leningrad Press, Leningrad, Pages: 464.

Erasmus, D.A., 1967. The hast-parasite interface of *Cyathocotyle buschiensis* Khan, 1962 (trematoda Strygeoidea): Electron microscope studies of the tegument. J. Parasitol., 53: 703-714.

Feizullaev, N.A., 1980. [Trematodes of the Superfamily Cyclocoeloidea. (Morphology, Biology, Phylogeny and Systematics)]. ELM Publishing House, Baku, Russia, Pages: 212, (In Russian).

Galaktionov, K.V. and A. Dobrovolskij, 2003. The Biology and Evolution of Trematodes: An Essay on the Biology, Morphology, Life Cycles, Transmissions and Evolution of Digenetic Trematodes. Springer Science and Business Media, Dordrecht, Netherlands, ISBN-13: 9781402016349, Pages: 592.

Galaktionov, K.V., S.W.B. Irwin and D.H. Saville, 2006. One of the most complex life-cycles among trematodes: A description of *Parvatrema margaritense* (Ching, 1982) n. Comb. (Gymnophallidae) possessing parthenogenetic metacercariae. Parasitology, 132: 733-746.

Ginetsinkaya, T.A., 1968. [Trematodes, their Life Cycles, Biology and Evolution]. Nauka Publishers, Leningrad, Russia, Pages: 411, (In Russian).

Hoglund, J., 1991. Ultrastructural observations and radiometric assay on cercarial penetration and migration of the digenean *Diplostomum spathaceum* in the rainbow trout *Oncorhynchus mykiss*. Parasitol. Res., 77: 283-289.

Koie, M., 1971. On the histochemistry and ultrastructure of the tegument and associated structures of the cercaria of *Zoogonoides viviparus* in the first intermediate host. Ophelia, 9: 165-206.

Lumsden, R.D. and J. Byram III, 1967. The ultrastructure of cestode muscle. J. Parasitol., 53: 326-342.

Lumsden, R.D. and W.E. Foor, 1968. Electron microscopy of schistosome cercarial muscle. J. Parasitol., 54: 780-794.

Malakhov, V.V., 2007. Evolutional morphology in Russia revives. Nature, 8: 74-78.

Moczon, T., 1994. Histochemistry of proteinases in the cercariae of *Diplostomum pseudospathaceum* (Trematoda, Diplostomatidae). Parasitol. Res., 80: 684-686.

Moczon, T., 1996a. A serine proteinase in the penetration glands of the cercariae of *Plagiorchis elegans* (Trematoda, Plagiorchiidae). Parasitol. Res., 82: 72-76.

Moczon, T., 1996b. A serine proteinase in the penetration glands of the hexacanths of *Hymenolepis diminuta* (Cestoda, Cyclophyllidea). Parasitol. Res., 82: 67-71.

Podvyaznaya, I.M., 1999. Subtle structure of integuments of the cercariae and the metacercariae *Diplostomum chromatophorum* (Trematoda: Diplostomidae). Parasitology, 33: 507-519.

Podvyaznaya, I.M. and A.A. Dobrovolskij, 2001. Development of muscular elements of the skin-muscular sac of the metacercariae *Diplostomum chromatophorum* (Trematoda: Diplostomidae). Parasitology, 35: 531-539.

Rees, G., 1974. The ultrastructure of the body wall and associated structures of the cercaria of *Cryptocotyle lingua* (Creplin) (Digenea: Heterophyidae) from *Littorina littorea* (L.). Zeitschrift Parasitenkunde, 44: 239-265.

Rieger, R.M., W. Salvenmoser, A. Legniti and S. Tyler, 1994. Phalloidin-rhodamine preparations of *Macrostomum hystricinum marinum* (Plathelminthes): Morphology and postembryonic development of the musculature. Zoomorphology, 114: 133-147.

Rieger, R.M., W. Salvenmoser, D. Reiter and B.C. Boyer, 1995. Differentiation of the body wall musculature in *Macrostomum* and *Hoploplana* (Turbellaria, Platyhelminthes). Hydrobiologia, 305: 225-225.

Romer, A. and T. Parsons, 1992. [Anatomy of Vertebrates]. Mir Publishers, Moscow, Russia, Pages: 406, (In Russian).

Shigin, A.A., 1986. [Trematode Fauna of the USSR: The Genus *Diplostomum*]. Nauka Publisher, Moscow, Russia, Pages: 253, (In Russian).

Shults, R.S. and E.V. Gvozdev, 1972. [Fundamentals of General Helminthology, Volume 2: The Biology of Helminths]. Íàóêà Publisher, Moscow, Russia, Pages: 515, (In Russian).

Silk, M.H. and I.M. Spence, 1969. Ultrastructural studies of the blood fluke: *Schistosoma mansoni*. II. The musculature. South Afr. J. Med. Sci., 34: 11-20.

Smirnova, D.I., M.V. Yastrebov and I.V. Yastrebova, 2010. Muscular system of *Clinostomum filiforme* (Trematoda Clinostomida): Works of center of parasitology of institute of issues of ecology and evolution named after severtsov. Biodivers. Ecol. Parasites, 5: 257-269.

Threadgold, L.T., 1963. The ultrastructure of the cuticle of *Fasciola hepatica*. Exp. Cell Res., 30: 238-242.

Wittrock, D., 1978. Ultrastructure of the ventral pappile of *Qinqeserialis qinqeserialis* (Trematoda Notocotylidae). Z. Parasitenk, 57: 145-154.

Yastrebov, M.V., 1997. Muscular system of certain trematodes and fixation of phases in the evolution of a sucking function. Zool. J., 6: 645-656.

Yastrebov, M.V., 1998. Locomotor apparatuses of separate Trematoda (Plathelminthes) with undifferentiated body. Zool. J., 77: 627-636.