Frontal Muscle Scars of Trachyleberidinae and Hemicytherinae (Ostracoda)

Abstract. *One transverse and one mandibular muscle form the frontal scars on each valve in both the trachyleberines and hemicytherines. Bifurcation of the transverse muscle into anterior-posterior bundles (trachyleberine) and into dorsal-ventral bundles (hemicytherine) and mandibular muscle position account for the different frontal scar patterns observed.*

The term antennal scars has been used for the group of single, double, or triple muscle attachment scars located anterior to the centrally placed adductor muscle attachment scars on the interior of ostracod valves. The term frontal scars was proposed (*1*) to distinguish this scar group from the adductor muscle scars and to indicate their uncertain soft-part origin. Subsequent studies (*2, 3*) showed that in three species of modern freshwater cyprid ostracods the pair of frontal scars arranged in a dorsal-ventral alignment are formed by the termination of one mandibular muscle and one endoskeletal support muscle.

The trachyleberines and hemicytherines are two of the most important groups in the family Cytheridae, which comprises the majority of post-Paleozoic ostracods. Paleontologists working

with these groups consider differences in appendage morphology and carapace features sufficiently important to distinguish these groups as subfamilies (*1*) (as treated herein for general purposes) or as families (*4*). However, some contend that these characters have less systematic value than those used to distinguish other cytherid subfamilies (*5*).

Within the Trachyleberidinae and Hemicytherinae, valves are assigned to subfamily according to their patterns of adductor and frontal muscle scars. Genera with a vertical row of four undivided adductor muscle scars and an apparently single V-, J-, or U-shaped frontal scar are assigned to the subfamily Trachyleberidinae, whereas those with one or more of the four adductor scars divided, usually the second from the dorsalmost, and with two or three clearly separated frontal scars are assigned to the Hemicytherinae. Exceptions to this general rule and various interpretations result in taxonomic juggling within and between the two groups.

Freehand sections (*6*) of the trachyleberine *Actinocythereis vineyardensis* (Cushman, 1906) (*7*) and the hemicytherine *Muellerina lienenklausi* (Ulrich and Bassler, 1904) (*7*) as considered by Hazel (*4*) clearly indicate the origin and reason for the variation of the frontal scar pattern in these subfamilies. The frontal scars are formed on each of the paired valves by the termination of two

nonantennal muscles—a single major muscle, herein named transverse muscle, and a muscle extending from each of the paired mandibles to its adjacent valve (Figs. 1 and 2). As in the freshwater cyprid ostracods (*2, 3*), the mandibular muscles originate on the ventral interior surface of the mandibles.

The transverse muscle lies in the horizontal plane of the adductor muscles just behind the esophagus (Fig. 1). The fact that the central portion of the muscle is a band of nonstriated connective tissue indicates its strong structural similarity to the adductor muscles. No connection to the endoskeleton has been determined.

The rounded dorsal tip of the mandible lies between the frontal and adductor muscles and pivots against the lateral body wall, forming the commonly observed mandibular fulcral scar on the calcareous valves. As the mandible is operated by several large, powerful muscles terminating on the dorsal area of the valves, the mandibular tip exerts considerable pressure at the fulcral point on the body wall. Based on its position anterior to the mandible tip, its structural similarity to the adductor muscles, and its size, the transverse frontal muscle apparently functions as an auxiliary adductor muscle counterbalancing the lateral pressure exerted by the tip of the mandible.

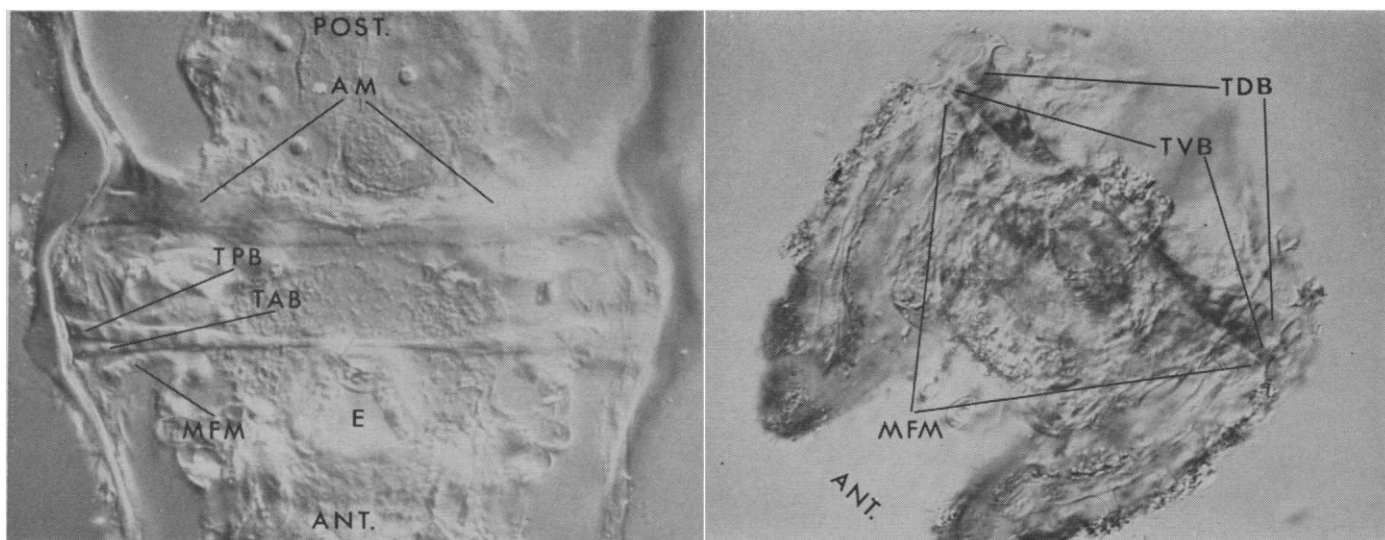Ostracod muscles are attached to the

Fig. 1 (Left). *Actinocythereis vineyardensis.* Decalcified specimen transversely sectioned in horizontal plane at level of adductor and frontal muscles. Large adductor muscles (*AM*) are posterior to smaller frontal muscles. Left side of specimen is in focus. The esophagus (*E*) is anterior to frontal muscles. The transverse frontal muscle is bifurcated into anterior (*TAB*) and posterior (*TPB*) bundles, and the mandibular frontal muscle (*MFM*) is anterior to transverse muscle and slightly dislocated by sectioning (× 350). Fig. 2 (right). *Muellerina lienenklausi.* Anterodorsal view of anterior portion of transversely sectioned decalcified specimen rotated to enhance muscle interference contrast. The transverse frontal muscle is bifurcated into dorsal (*TDB*) and ventral (*TVB*) bundles. The mandibular frontal muscle (*MFM*) attachment is adjacent and anterior to transverse ventral bundle (*TVB*) and extends at an angle toward the ventral interior surface of the mandible (× 240).

calcareous layer of the valve by a terminal, thin, flattened chitinous boss (3). The boss has a greater cross-sectional area than the muscle and is inset into the calcareous layer. Muscles are attached to the boss by interlacing of muscle myofibrils and boss tonofibrils. The bosses form the muscle scars on the valves, and coalescing of adjacent bosses form the so-called "sutured" muscle scars. In Fig. 1, the adductor muscle in the focal plane is the second from the dorsalmost. The muscle is terminally bifurcated, but the two bosses coalesce to form an apparently single boss at the point of attachment on the valve. Under high magnification ($\times$ 600 to $\times$ 800) the "suture" between the coalesced bosses is readily apparent.

In the two species studied, the basic difference between the trachyleberine "single" V-, J-, or U-shaped frontal scar and the hemicytherine frontal scars arranged in a more or less dorsal-ventral alignment of two or three elements is due to the nature of the transverse muscle termination and the position of the mandibular muscle. In the trachyleberine species *Actinocythereis vineyardensis*, each end of the transverse muscle bifurcates terminally into an anterior and a slightly larger posterior bundle (Fig. 1). Coalescing of the terminal attachment bosses of the bundles forms a V- or U-shaped frontal scar on the calcareous valves. The small mandibular muscle terminates in a contiguous dorsal position to the anterior bundle of the transverse muscle thus forming a small portion of the anterior side of the V- or U-shaped scar. Any minor variation in the attachment position of either the transverse or mandibular muscle accounts for the V-, J-, or U-shaped frontal scar found on the calcareous valves.

The hemicytherine species *Muellerina lienenklausi* bears three frontal scars with the lower two occasionally fused (4). In contrast to the anterior-posterior bifurcation of the transverse muscle in the trachyleberine species, the hemicytherine transverse muscle bifurcates into dorsal-ventral bundles approximately halfway between the body center and the body wall (Fig. 2). The mandibular muscle terminates adjacent and anterior to the ventral transverse muscle bundle (Fig. 2). Minor variation of the attachment of either the ventral transverse muscle bundle or mandibular muscle accounts for the fusion of the two lowermost scars or the distinct separation into three frontal scars.

Therefore, as similar muscles form the frontal scars of the trachyleberines and the hemicytherines, the nature of the bifurcation of the transverse muscle and the position of mandibular muscle attachment determines the frontal muscle scar patterns.

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Sexuality in Chodatella

Abstract. *The unicellular green alga* Chodatella longiseta Lemm. *is described as reproducing solely by the production of autospores; however, it is also capable of oogamous sexual reproduction. Division of a single cell produces 8, 16, or 32 sperms which, upon release, attach to nonmotile cells. Fusion takes place, and a thick-walled resistant zygospore develops.*

Sexual reproduction has not been previously reported in *Chodatella*, a unicellular planktonic freshwater genus in the order Chlorococcales of the green algae. For this reason, as well as because of its unicellular condition, the mode of asexual reproduction (autospores), and the lack of any sort of motile cells, the genus has been considered a member of the Oocystaceae. Reconsideration of the classification of this organism is now imperative in view of the observation of sexual reproduction involving biflagellate gametes.

Unialgal cultures of *Chodatella longiseta* Lemm. were grown in soil-water medium (*1*) at room temperature under a bank of fluorescent lights. Such cultures produce biflagellate cells, each containing a chloroplast and lacking an obvious cell wall. The motile cells serve as sperm. Cells forming these sperm can usually be distinguished from those reproducing asexually. They first appear in a culture 4 or 5 days after inoculation and are generally smaller than cells forming autospores. As the chloroplast in such cells divides repeatedly, it usually becomes a very pale green and the pyrenoid becomes indistinct. After the sperms are complete, they are crowded toward the center of the cell, and the wall swells at the equatorial region. The sperms then break out of the cell wall and thin vesicle in which they have been enclosed during development. A single cell may form 8, 16, or 32 sperms.

The biflagellate swarmers attach to cells indistinguishable from typical asexual *Chodatella* cells (Fig. 1), generally at the equatorial region, but sometimes at the poles. These same cultures also contain thick-walled cells, singly within spiny *Chodatella* cell walls (Fig. 2), which are later free in the culture medium. These thick-walled cells are assumed to be zygospores. Though not yet observed, actual fusion of the small biflagellate cells with the larger nonmotile cells can be concluded for two reasons. (i) In many instances the thick-walled cell has a small protuberance on one side (Fig. 2) in the usual position of attachment of the flagellated cells, as if the membrane surrounding the swarmer were incompletely incorporated into the nonmotile
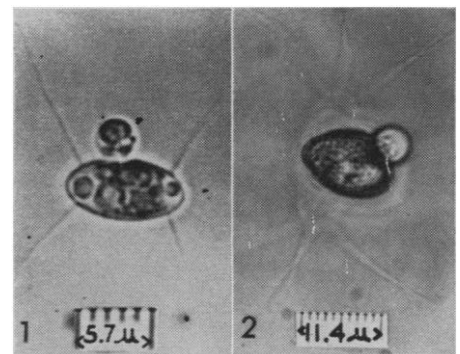

Fig. 1. Typical *Chodatella* cell with sperm attached at the equatorial region.   Fig. 2. Single zygospore still within the spiny parental cell wall. The protruding portion of the zygospore wall indicates where the sperm was attached.