Surface topography of the branchiuran *Argulus appendiculosus* Wilson, 1907 as revealed by scanning electron microscopy

Daniel R. Sutherland\(^1\) and Darwin D. Wittrock\(^2\)

\(^1\) Department of Veterinary Sciences, University of Wisconsin-Madison, Madison, WI 53706, USA
\(^2\) Department of Biology, University of Wisconsin-Eau Claire, Eau Claire, WI 54701, USA

Abstract. The body surface of adult *Argulus appendiculosus* is characterized by a carapace which dorsally is devoid of surface ornamentation except for the presence of a series of grooves and sutures which are similarly arranged in all specimens. The ventral surface of the carapace is bounded laterally by spines and medially by unadorned respiratory areas. Sucking discs possess circumferential flanges with marginal papillae and supporting rods composed of two elements. Sexual dimorphism is particularly evident in the structure of the natatory lobes of the fourth swimming legs and in the presence of accessory copulatory structures on second, third and fourth swimming legs of males. A previously undescribed pocket on the coxa of the third swimming appendage of males may function together with the peg and socket apparatus in the clasping of males and females during copulation. Ventral surfaces of the thorax and maxillae are covered with posteriorly directed scales which have distal ends bearing comb-like teeth. Presumed sensory structures on the body surface are of at least two types: (1) recurved spinous projections which often arise from cuticular blebs, and (2) small circular pits containing papillae which do not project beyond the rim of the pit. Many *A. appendiculosus* had attached peritrichous ciliates on the lateral and ventral body surfaces.

Introduction

Members of the family Argulidae are highly modified crustaceans which have become specialized as external parasites of fish. The varied morphological adaptations by argulids for a parasitic existence are of considerable taxonomic significance. Such characters have been used in a number of regional keys to argulids parasitizing fish of North America (Cressey 1972, 1978), India (Thomas and Devaraj 1977), China (Wang 1961), and Africa.

*Reprint requests to:* Daniel R. Sutherland
Significant monographs on the morphology of North American argulids include those of Wilson (1902, 1944) and Meehan (1940). Argulus appendiculosus was described by Wilson (1907), and Argulus biramosus Bere 1931 was placed as a junior synonym of A. appendiculosus by Meehan (1940). Wilson (1944) challenged Meehan's synonymization; yet, Cressey (1972, 1978) does not mention A. biramosus and apparently does not recognize Bere's taxon.

No studies have been made of the surface of argulids using scanning electron microscopy (SEM). The present work details the surface morphology of A. appendiculosus from carp (Cyprinus carpio).

Materials and methods

Argulus appendiculosus were recovered from body surfaces of carp (Cyprinus carpio L.) collected from the Little Sioux River, Dickinson Co., Iowa, USA. Live branchiurans were washed for approximately 1 h in several changes of filtered lake water to remove mucus. Argulids where then fixed in 10% neutral buffered formalin, dehydrated through ethanol to amyl acetate and critical point dried with CO2. Specimens were mounted on stubs with silver paint, sputter coated with pure gold and examined with an ISI Super I SEM operating at 10 kV and a JEOL JSM-U3 SEM operating at 20 kV. Swimming appendages were dissected from some adult specimens prior to dehydration. Each dissected appendage was oriented on a stub to allow observation of its dorsal or lateral aspect. Additional specimens were dehydrated, cleared in either glycerin or methyl salicylate and mounted unstained for observation with Nomarski or phase contrast optics.

Results

The external morphology of A. appendiculosus is essentially as described by Wilson (1907), Bere (1931) and Meehan (1940) (Figs. 1–3). Several features differ from earlier descriptions and additional structures are apparent when A. appendiculosus from Iowa carp were examined with SEM.

Dorsally, the carapace and abdomen are devoid of surface ornamentation except for the presence of a series of grooves on the carapace which are distributed in a similar manner for all specimens examined (Fig. 2). A horseshoe-shaped suture ('Seitenlinie' of Stammer 1959) separates the cephalic area from the rest of the carapace. This suture extends anterolaterally and ends in distinct sinuses at the margin of the carapace. A pair of secondary sutures extends posteriorly on either side of the horseshoe-shaped suture parallel to the outer margin of the lateral lobes of the carapace. A pair of transverse sutures extends laterally from either side of the horseshoe-shaped suture. Each transverse suture bisects a secondary suture at a level approximately one-quarter to one-third the total length of the secondary suture from its origin on the horseshoe-shaped suture. The transverse sutures extend short distances beyond the intersections with the secondary sutures.

The dorsal ridges of Meehan (1940) ('Chitinleisten' of Stammer 1959) are not readily apparent when A. appendiculosus is viewed with SEM. The dorsal ridge configuration for A. appendiculosus from Iowa carp is as figured by Wilson (1907) except that each ridge branches at the anterior end near