BIOINCRUSTATION CAUSED BY A HYDROID SPECIES IN THE TURBINE COOLING SYSTEM AT THE FUNIL HYDROELECTRIC POWER PLANT, ITATIAIA, RIO DE JANEIRO, BRAZIL

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ABSTRACT

Biofouling was found in the water-cooling system of generating units at the Funil Hydroelectric Plant, state of Rio de Janeiro, in May 2006, causing a perceptible decrease in the heat-exchanger efficiency and a consequent increase in the temperature of the bearings. The encrusting biological material was mainly composed by colonies of the euryhaline hydroid *Cordylophora caspia* (Pallas, 1771). According to reports of the technical team of the plant, under normal operating conditions of the electricitygenerating turbines, radiators were cleaned every six years and heat exchangers of the turbine guide bearing every 18 months. But, after fouling was discovered, clogging problems in heat exchangers usually began to occur four months after cleaning, with a consequent increase in temperature of the system. The situation is serious and has led to high maintenance costs and downtime, sometimes for extended periods, of equipment and generating units while the system is cleaned.

Key-words: *Cordylophora caspia*, fouling, Hydroelectric Power Plant, Rio de Janeiro, Brazil

Introduction

Bioincrustation, biological adherence, or "fouling" can be defined as the epibenthic biota that becomes established on submerged artificial structures constructed by humans. The organisms responsible occur also on natural substrates and are merely accidental as fouling assemblages (CAPITOLI 1988). In marine environments, where the fouling process has been better studied, succession begins with the formation of a more or less dense, delicate film over the substrate composed of bacteria, diatoms, and other microorganisms, with a component of adherent organic or inorganic detritus (MILLER *et al.* 1948). Though this film is not always a prerequisite for settlement of larvae of sessile and sedentary organisms, it probably facilitates their establishment. In the marine fouling succession process, hydroids are often among the first animal groups to become established (HUVÉ 1953, SENTZ-BRACONNOT 1966, CALDER & BREHMER 1967, BOERO 1984, SCHOENER 1984, ABSALÃO 1992, NASSAR 1994).

Problems caused by bioincrustation (fouling) in equipment using natural water sources to cool piping systems are common worldwide, and have been reported in factories, oil refineries, electric generating units, and nuclear power plants in Europe, North America, and elsewhere (STANCZAK 2004, FOLINO-ROREM & INDELICATO 2005, FULLER *et al.* 2006). Such episodes may cause serious problems especially where seawater is used. In this case, barnacles are not the only organisms responsible for fouling. Ascidians, bryozoans, and hydroids also contribute to obstruction of piping systems. But damage can also be significant in facilities using brackish or fresh water, as is the case of the Funil Hydroelectric Power Plant. Recent studies have shown that substrates colonized by the mesohaline-to-limnetic hydroid *Cordylophora caspia* support higher abundances of invertebrates than substrates not colonized by this hydroid, and this type of fouling may also have a negative economic impact (RUIZ *et al.* 1999, FULLER *et al.* 2006).

MATERIAL AND METHODS

The Funil Hydroelectric Power Plant (Furnas Centrais Elétricas) is located at Itatiaia, state of Rio de Janeiro, Brazil (Figure 1). Hydroid colonies removed from their piping systems were brought to the laboratory for identification. The material was fixed in 10% formalin, stained with Mayer's paracarmine, and mounted on slides for microscopic examination.

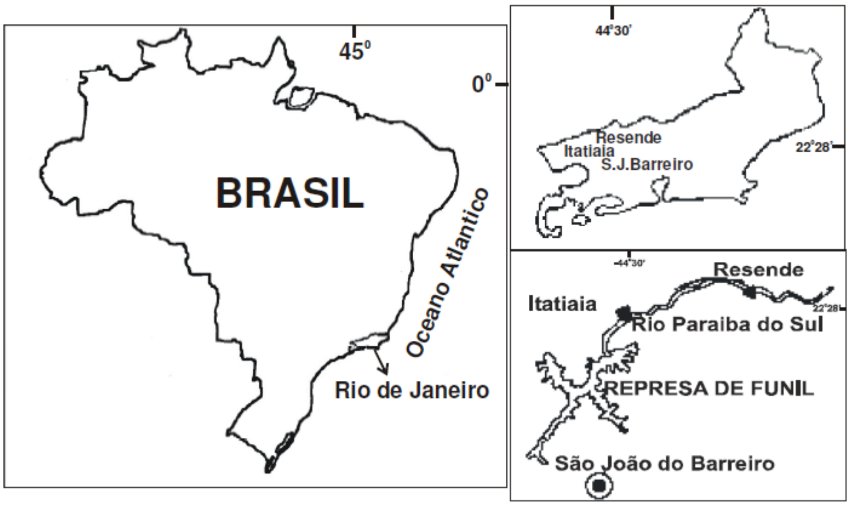

Figure 1- Map of Rio de Janeiro state showing the villages around the Funil Hydroelectric Power Plant

RESULTS

Material fouling the piping systems of the Funil Hydroelectric Power Plant mainly comprised the brackish-water anthoathecate hydroid *Cordylophora caspia* (Pallas, 1771). Colonies of this hydrozoan were fertile, facilitating the identification of the species.

Cordylophora caspia (Pallas, 1771)
(Figure 2)

Synonym *Cordylophora lacustris* Allman
Phylum Cnidaria
Subphylum Medusozoa
Superclass Hydrozoa
Class Leptolida
Subclass Anthoathecatae
Order Filifera
Family Clavidae

Description of the species (according to NUTTING, 1901):

Trophosome - colonies regularly branched, attaining a height of about three-fourths inch. Main stem not fascicled, straight, giving off alternate branches, which in turn often give off alternate branchlets and pedicels; branches and pedicels annulated at their origins. Hydrants with fusiform bodies and 16 to 20 scattered filiform tentacles.

Gonosome – gonophores ovate invested in a gonangium-like extension of perisarc, borne on the branches and hydranth pedicels near their bases.Pedicels of gonophores very short and annulated.

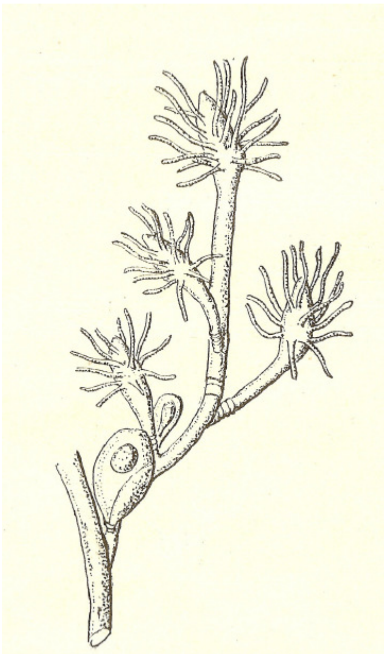

Figure 2- *Cordylophora caspia* (Pallas, 1771) according to Nutting, 1901

For details of the description and/or the ecology of the species, see HUMMELINCK (1936), HAND & GWILLIAM (1951) and DAVIS (1957).

DISCUSSION

The brackish-water hydroid *Cordylophora caspia* has been considered a species in the 'process of evolution of migration to fresh water' (DAVIS 1957). According to that author, the species can be abundant in estuarine areas, but can also be found in bodies of fresh water. It is a euryhaline species and tolerant of low salinities. Also according to DAVIS (1957), *C. caspia* invaded the limnetic environment in the United States on hulls of ships or on the feet of birds. The oldest record of this species in fresh water, dating from 1870, was made by Joseph Leidy observing material collected in a river at Fairmount, Philadelphia, Pennsylvania. More recently, studies have suggested that the species was introduced into the North American continent, at several locations, via ballast water (RUIZ & HINES 1997).

There are some recent reports suggesting that *C. caspia* may be a complex of species, because of the high degree of its morphological plasticity (D'AUSILIO & FOLINO-ROREM 2005). These authors stated that at least *C. caspia* and *C. lacustris* are synonyms, but suggested applying both molecular and morphological analyses to clarify the question.

Cordylophora caspia was recently confirmed in Brazil for the first time by two different research groups, one in São Paulo (SILVEIRA & BOSCOLO 1996) and the other in Paraná (HADDAD & NAKATANI 1996). SILVEIRA & BOSCOLO (1996) found the species in mesohaline waters of the Rio Escuro estuary in Ubatuba, São Paulo, along a shore area where the bivalve *Brachidontes solisianus* had settled. In their material, male and female colonies were fertile, and bore elliptical sporosacs sprouting from hydranth pedicels. HADDAD & NAKATANI (1996) collected *C. caspia* in plankton samples from the Rio Paraná, 4 km downstream from the Itaipu Dam in the municipality of Foz do Iguaçu. Their specimens were simple hydrocauli, but male and female gonophores were present in large numbers. They noted that the species had previously been observed in South America from tributaries of the Rio de la Plata, at Buenos Aires, Argentina (GAGGERO 1923, ***in*** HADDAD & NAKATANI 1996) and in Montevideo, Uruguay (CORDERO 1941). These observations support an early 20th century report (ROCH 1924) of *C. caspia* from Brazil (Rio de Janeiro), a record that SILVEIRA & BOSCOLO (1996) considered doubtful.

According to information furnished by the technical team responsible for functioning of turbines at the Funil Hydroelectric Power Plant, generator radiators were cleaned every six years and heat exchangers of bearings linked to the generator (above/on the turbine well-head) and the exchangers of the turbine guide bearings were cleaned every 18 months. Residue removed from the equipment usually consisted of mud (which occasionally passes through the filters) and tubercles resulting from bacterial corrosion of the metal parts. The recent discovery of biological fouling caused by *C. caspia* in the cooling-system piping of the Funil Hydroelectric Power Plant indicated that this new problem merits greater attention in Brazil.

To eliminate hydroids from several varieties of tubing in which they are apt to settle, recent reports suggest the use of biocides (e.g., chlorine), physical methods (e.g., using high temperatures in the affected system) (CRISTIANI 2005, FOLINO-ROREM & INDELICATO 2005) or even biological processes, e.g., introducing a predator (MILLS & SOMMER ***in*** FULLER *et al.* 2006). Another option, perhaps less complicated, would be the use of an antifouling coating in the pipes (PEREIRA *et al.* 1997).

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