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Research Notes

Salinity Tolerance of *Cletocamptus deitersi* (Richard 1897) and its Presence in the Salton Sea

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The Salton Sea supports a limited diversity of aquatic invertebrates, and until recently only one copepod species, the cyclopoid *Apocyclops dengizicus*, had been reported from it (Dexter 1993). The presence of harpacticoid copepods has not been reported in the scientific literature, but at least two species have been found within the Salton Sea. In 1983 I. E. Bayly and S. H. Hurlbert collected a harpacticoid in shallow water (salinity 36–38 g/L) at the north end of the Salton Sea. This species was identified as *Nitocra dubia* by R. Hammond (in litt. to S. H. Hurlbert).

In 1990 I began salinity tolerance studies on *Apocyclops dengizicus*. Plankton tows collected in Oct. 1990 from Red Hill Marina, Salton Sea (salinity 43 g/L) in water approximately 1 m deep were used to establish cultures at various salinities (Dexter 1993). Within 60 days, in cultures maintained at 73 g/L a harpacticoid copepod became very abundant, while *A. dengizicus* became scarce. This harpacticoid was not present in cultures from the same source maintained at lower salinities. I hypothesize that at 73 g/L a few individuals avoided predation by *Apocyclops dengizicus*, and increased in density as the numbers of *A. dengizicus* declined through time at this high salinity.

This new harpacticoid was identified by R. H. Hammond as *Cletocamptus bicolor*, a species which has been synonymized by Yeatman (1963) with *C. deitersi*. Fleeger (personal communication) confirmed that the Salton Sea *Cletocamptus* is *C. deitersi*. *C. deitersi* is widely distributed throughout the world (Chandler and Fleeger 1987, Dussart and Defaye 1990, Fleeger 1980, Lang 1948, Yeatman 1963). It is reported from North America (Louisiana, Massachusetts, Texas), Central America (Guatemala, Nicaragua), the Caribbean (Bermuda, Cuba, Haiti), South America (Argentina, Ecuador, Uruguay), Hawaii, China, Australia, Ethiopia, and Israel. Habitats for this species include brackish coastal ponds, mangroves, estuaries, salt marshes, inland bays, saline lakes, freshwater lakes, and freshwater rivers. *C. deitersi* is characterized as an errant deposit feeder which grazes algae and detritus attached to sediment particles (Chandler and Fleeger 1987).

Water collected at the Salton Sea was evaporated outdoors until a salinity of 136 g/L was obtained. This water was filtered through a 35 μm mesh net and diluted with de-ionized water to obtain the desired salinities. Cultures of 0.5 g/L salinity were produced by combining Salton Sea water, de-ionized water, and filtered pond water (as source of phytoplankton). Salinity was determined with a Reichert-Jung refractometer, and final salinity determined using correction factors for Salton Sea ionic compositions.

Harpacticoid copepods collected during Oct. 1990 were separated from cyclo-

poids by maintenance at salinities between 68–73 g/L which killed the cyclopoids. Approximately 100 ml of concentrated harpacticoid culture was introduced into aerated plastic containers with 1.9 L of Salton Sea water adjusted to various salinities. Copepods were introduced without acclimation, and often without replication.

A series of culture experiments were run. A total of 18 salinities were used ranging from 0.5 to 119 g/L. Culture salinity and number of replications (in parentheses) were: 0.5 (4), 1 (2), 6 (1), 13 (1), 17 (1), 34 (1), 45 (1), 62 (1), 68 (1), 74 (1), 80 (1), 85 (4), 90 (1), 96(2), 102 (4), 107 (4), 113 (1) and 119 (2) g/L.

Salinities were monitored every 15 days and adjusted by addition of de-ionized water. Phytoplankton was present at all salinities and its growth was encouraged with approximately 0.2 grams biweekly of fish food pellets (Pet Co., Koi's Choice). At 30, 60, 90, and 120 days, each culture was gently filtered through a 35 μm mesh net, examined under a dissecting microscope for abundance and presence of life history stages, and returned to its respective container.

C. deitersi cultures at salinities from 0.5 to 80 g/L supported relatively high densities of individuals of all life history stages (nauplii, copepodites, males, females, and gravid females) throughout the duration of the 120 day experiment (Table 1). *C. deitersi* cultured at salinities between 85 to 96 g/L steadily declined in density, but some individuals were alive at the end of 120 days. Mating was observed at salinities from 0.5 to 107 g/L, but apparently was unsuccessful at salinities greater than 85 g/L. Copulating pairs remained attached for at least several hours. Reproduction was continuous during the 3 year period this species was maintained in laboratory cultures at salinities between 20 to 60 g/L.

Harpacticoids are considered an important food source for early stages of benthic fish and are often used in aquaculture systems to provide food for hatchery fish. The ease with which *C. deitersi* is cultured in the laboratory, at various salinities, without the presence of sediment, suggests it as a good candidate for this purpose.

The cosmopolitan distribution of this species suggests its ability to tolerate a wide variety of habitats, temperatures, and salinities. But such a distribution could also indicate that a number of morphologically indistinguishable sibling species are present. This study showed that the Salton Sea population of *C. deitersi* is very tolerant of a wide range of salinities in culture, from basically fresh water to high salinities. This favorable attribute may be of particular importance to this species, given that the salinity of the Salton Sea may reach 90 g/L by the year 2010 (Black 1983) if mandated water conservation programs are followed. The presence of this species within the Salton Sea is possibly a result of deliberate introduction of the seagrass *Diplanthera wighti* from Texas by California Fish and Game in 1957, although flora and fauna were also introduced from the Gulf of California and from the California coast (Linsley and Carpelan 1961).

A. dengizicus is the dominant copepod within the Salton Sea and normally there would be little interaction between this planktonic species and the benthic *C. deitersi*; the sediment habitat of the latter would limit or prevent predation. *A. dengizicus* is an effective predator of naupliar stages of *Artemia* in culture conditions (Hammer and Hurlbert 1992), and on *C. deitersi* in laboratory cultures without sediment. However, the upper limit of salinity tolerance differs in these species. Reproduction in *A. dengizicus* becomes limited at salinities exceeding 57

Table 1. Salinity tolerance of *Cletocamptus deitersi*.

Life history stage	Salinity g/liter	Abundance[1] at 30 days	60 days	90 days	120 days
Gravid females	0.5, 1, 6, 13, 17, 34, 45, 62, 68, 74, 80	+++	+++	+++	+++
	85, 90	+++	++	+	+
	96, 102, 107	+	0	0	0
	113, 119	0	0	0	0
Nauplii	0.5, 1, 6, 13, 17, 34, 45, 62, 68, 74, 80	+++	+++	+++	+++
	85, 90	++	+	+	0
	96, 102, 107	+	0	0	0
	113, 119	0	0	0	0
Copepodids	0.5, 1, 6, 13, 17, 34, 45, 62, 68, 74, 80	+++	+++	+++	+++
	85, 90	++	++	+	+
	96	++	+	+	+
	102, 107	+	+	+	0
	113	+	0	0	0
	119	0	0	0	0

[1] Abundance categories are denoted as follows: 0, not seen; +, 1–5/liter; ++, 6–20/liter; +++, >20/liter.

g/L (Dexter 1993), while *C. deitersi* appears unaffected in salinities up to 80 g/L. I predict that *C. deitersi* will become more abundant in the shallow water plankton and benthos as salinities increase at the Salton Sea.

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