Journal of Freshwater Ecology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tjfe20

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Available online: 06 Jan 2011

To cite this article: Rick A. Hart, Mike Davis, James W. Grier & Andrew C. Miller (2001): Survival of Unionids Following Removal of Attached Zebra Mussels, Journal of Freshwater Ecology, 16:1, 29-33

To link to this article: http://dx.doi.org/10.1080/02705060.2001.9663784

Survival of Unionids Following Removal of Attached Zebra Mussels

Rick A. Hart[a, c], Mike Davis[b], James W. Grier[e], and Andrew C. Miller[d]

ABSTRACT

A mussel mark-recapture study was initiated in the upper Mississippi River, Wisconsin, to measure the survival of *Elliptio dilatata* colonized by *Dreissena polymorpha* in Lake Pepin, Mississippi River. In 1996, 240 adult *E. dilatata* were marked in Lake Pepin. At the time of marking we cleansed zebra mussels from 48 of the 240 *E. dilatata* to test if a one-time removal of *D. polymorpha* would be effective in improving survival of *E. dilatata*. In 1997, 1998, and 1999, marked mussels were recovered and identified; survival was determined; and live individuals were returned to the mussel bed. Mean annual survival of *E. dilatata* cleaned of *D. polymorpha* equaled 94 ± 3.0% and was not significantly different from those not cleaned (89 ± 1.7%) ($\chi^2_{df=1}$=2.31, p=0.13). The mean number of *D. polymorpha* colonized upon cleaned and uncleaned *E. dilatata* at the conclusion of this study in 1999 equaled 105.8 ± 12.9 and 94.6 ± 8.4 respectively (p>0.05). Since survival rates and the abundance of *D. polymorpha* on the two groups of *E. dilatata* were not significantly different following the years after initial cleaning, we suggest that a one time removal of *D. polymorpha* from native mussels is not a biologically effective management tool.

INTRODUCTION

Dreissena polymorpha (Pallas 1771) populations were first reported in the Great Lakes in the mid-1980s (Hebert et al. 1989) and have since spread into the Mississippi River basin (Ludyanskiy et al. 1993, Tucker et al. 1993). This exotic species, now found throughout the Mississippi River from St. Paul, Minnesota, to near New Orleans, Louisiana (Ram and McMahon 1996), was first reported in Lake Pepin, Upper Mississippi River, Minnesota and Wisconsin, in 1990; it is now found in some sections of the lake in excess of 20,000 mussels/m^2 (Hart 1999).

Recent research designed to measure the effects of *D. polymorpha* on native mussels has primarily been indirect in that mussel populations were monitored before and after infestations of *D. polymorpha*. When large changes in unionid densities have occurred in the presence of *D. polymorpha,* the population changes have been attributed to *D. polymorpha* colonization (Haag et al. 1993, Gillis and Mackie 1994, Schloesser et al. 1998). While this information is useful for identifying a correlation between native mussel declines and increasing densities of *D. polymorpha* (Ricciardi et al. 1995, 1998), this relationship does not directly measure causation. Unfortunately, there are few empirically derived results which would directly link *D. polymorpha* infestations to decreases in survival rates of unionid populations (Schloesser 1996, Hart 1999).

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It has been suggested that it may be possible to "enhance" the survival of unionids by the removal of *D. polymorpha* from the shells of the colonized native mussels (Schloesser 1996). This "management tool" could then be incorporated into conservation plans for freshwater mussels throughout the current *D. polymorpha* range in North America (Schloesser 1996). The recent arrival of *D. polymorpha* into Lake Pepin provided us the opportunity to empirically test the hypothesis that a one time cleaning of colonized *D. polymorpha* from freshwater mussels would enhance their survival.

METHODS AND MATERIALS

This study was initiated in 1996 and conducted in Lake Pepin, a natural widening of the Upper Mississippi River on the Minnesota-Wisconsin border. The only known mussel bed containing a high density of *Elliptio dilatata* (a species of special concern in Minnesota) in Lake Pepin was selected for the measurement of survival of this species and to test the efficacy of enhancing this survival by a one time removal of *D. polymorpha*.

In 1996, 240 adult *E. dilatata* were randomly collected for marking. Collected mussels were held in mesh bags at the substrate-water interface while awaiting processing. Mussels being processed in the boat were held in a 20-liter pail of water. Water in the pails was exchanged after every 10 mussels were processed to minimize stress.

Collected mussels were measured for shell length and height, and marked with a unique number etched into the right valve of the shell with a battery-operated hand-held grinder. *Dreissena polymorpha* attached to the marked native mussels were counted. We removed *D. polymorpha* from the shells of 48 randomly selected marked *E. dilatata*.

Marked mussels were placed in 20 low, open corrals constructed from 10 cm (high) x 60 cm (diameter) plastic cylinders attached to a wooden frame. These corrals were then anchored to the river bed with concrete blocks. Twelve marked *E. dilatata* were hand placed in each of the cylinders. Corrals were primarily designed to assist divers in relocating marked mussels, while still allowing for movement of unionids within their individual cylinders. Corral locations were recorded with a global positioning system.

At the mussel bed during the summers of 1997, 1998, and 1999, marked mussels were recovered by divers, returned to the boat, and identified by their unique numbers; shell length and height were measured; attached *D. polymorpha* were counted. All live E. dilatata were returned to the corrals.

Survival rates for marked mussels were calculated using the software program MARK (White and Burnham 1999). We used the Burnham model contained in MARK which uses information from both live and dead encounters of marked animals (White and Burnham 1999) as well as from missing individuals. This method estimates the fidelity (i.e., the probability that the animal remains in the area available for recapture; White and Burnham 1999). Therefore, this model is able to estimate actual survival probability, and not apparent survival, as is the case when using only live recapture data (White and Burnham 1999). Survival rates of cleaned versus uncleaned *E. dilatata* were compared using the statistical techniques presented in Sauer and Williams (1989). Differences in colonizations of *D. polymorpha* upon *E. dilatata* both within and between groups and years were analyzed with an ANOVA and Tukey's multiple comparison tests (Zar 1984).

RESULTS AND DISCUSSION

The one time removal of *D. polymorpha* from colonized *E. dilatata* did not appreciably increase its survival when compared to the uncleaned controls. Survival rates of *E. dilatata* that had *D. polymorpha* removed (94 ± 3.0%) versus those which retained *D. polymorpha* (89 ± 1.6%) were not significantly different ($\chi^2_{df=1}$=2.31, p=0.13) (Fig. 1).

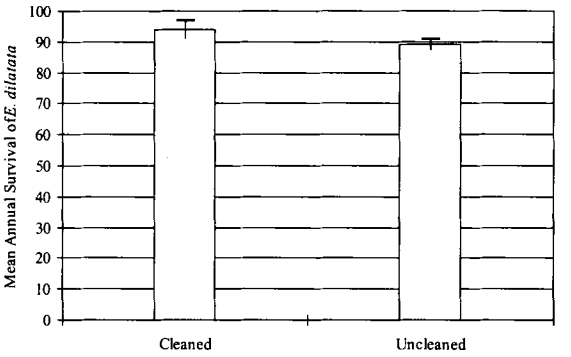

Figure 1. Mean annual survival of *Elliptio dilatata* ± 1 standard error. Means are not significantly different ($\chi^2_{df=1}$=2.31, p=0.13).

The survival of *E. dilatata* reported in this study for both those groups cleaned and not cleaned of zebra mussels was relatively high compared to other populations of mussel species colonized by *D. polymorpha*. Hart (1999) measured survival of *Amblema plicata* in Lake Pepin and reported mean annual survival rates equal to 71 ± 2.6% for a population colonized by similar levels of *D. polymorpha*. Previously, Schloesser (1996) measured the effectiveness of periodic cleaning of *D. polymorpha* from unionids in Lake Erie and found survival of uncleaned mussels was greatly reduced by colonizing *D. polymorpha*. While we only cleaned mussels of *D. polymorpha* on one occasion over the course of four years, Schloesser (1996) cleaned native mussels eight times and reported the combined survival rates of 10 species of mussels. Schloesser (1996) reported 0% survival for uncleaned specimens compared to 42% for cleaned specimens over the one year of his observations.

In our study, *D. polymorpha* immediately re-infested those individuals of *E. dilatata* that were cleaned in 1996. Numbers of *D. polymorpha* on cleaned *E. dilatata* were not significantly different from those *E. dilatata* that had not been cleaned of *D. polymorpha* (Fig. 2). While there were significant differences between years in the number of *D. polymorpha* colonized on the *E. dilatata* within the groups(i.e., cleaned or uncleaned; $F=70.435_{df=3}$, p<0.00001), there were no significant differences in the number of *D. polymorpha* between the groups within years ($F=0.810_{df=3}$, p=0.489). The mean number of *D. polymorpha* colonized upon cleaned and uncleaned *E. dilatata* at the conclusion of this study in 1999 equaled 105.8 ± 12.9 and 94.6 ± 8.4 respectively (p>0.05).

Ricciardi et al. (1995) predicted severe mortality (>90%) when densities of *D. polymorpha* reach about 6000 mussels/m^2 and 100 *D. polymorpha*/unionid. While the colonization rates that we measured equaled those levels predicted by

Ricciardi et al. (1995) to cause severe mortality, we did not measure mortality this high. Yet, this Mississippi River population of *E. dilatata* only has been exposed to these high levels of *D. polymorpha* for the past two to three years. Therefore it seems likely that in the next few years if the trend of increasing densities of *D. polymorpha* (Hart 1999) and, hence, greater colonizations of unionids in Lake Pepin continues, lowered unionid survival may become increasingly evident within this mussel bed.

In this study, survival rates of cleaned vs. uncleaned mussels were not significantly different, and individual *E. dilatata* cleaned of *D. polymorpha* were colonized to levels equal to their uncleaned counterparts by 1999, three years after the one-time cleaning. These results suggest that the cleaning unionids of *D. polymorpha* does not increase the long-term probability of native mussel survival and is not an effective management tool for the conservation of freshwater mussels.

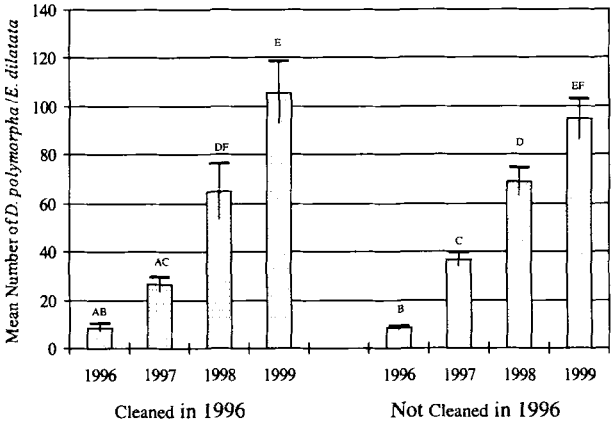

Figure 2. Mean number of *Dreissena polymorpha* ± 1 SE colonized upon *Elliptio dilatata*. Means with a common letter are not significantly different ($p>0.05$), ANOVA using Tukey's multiple comparison tests.

ACKNOWLEDGMENTS

We thank W. Popp, T. Schlagenhaft, D. Sogla, B. Knudsen, and others from the MNDNR Lake City field office for their assistance. G. White, D. Johnson, D. R. Anderson, and K. Burnham provided useful discussion of survival estimation procedures. Thanks to R. Cullen, D. Kelner, S. Miller, J. Mitchell, and M. Wipf for the collection of field data.

This study was supported by the North Dakota State University Department of Zoology; U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi; Minnesota Department of Natural Resources, Ecological Services Section, Lake City office; Minnesota Non-game Wildlife Tax Check-off; and the Reinvest in Minnesota Program through the Minnesota DNR, Section of Wildlife, Natural Heritage and Non-game Research Program.

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Received: 10 May 2000 Accepted: 5 July 2000