

## LIFE HISTORY EFFECTS OF PREY CHOICE BY COPEPODS: IMPLICATIONS FOR BIOCONTROL OF VECTOR MOSQUITOES

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**ABSTRACT.** *Macrocyclops distinctus*, *Megacyclops viridis*, and *Mesocyclops pehpeiensis*, which are common in rice fields during the summer season in Nagasaki, Japan, showed variable potentialities as biological control agents of larval *Aedes albopictus*, *Culex tritaeniorhynchus*, and *Anopheles minimus* in the laboratory. *Macrocyclops distinctus* and *M. viridis*, the largest copepod species, had fewer eggs within an egg clutch in nature than the smallest species, *M. pehpeiensis*, which also had a lower developmental time for sexual maturation (based on the appearance of the 1st clutch). Longevity as well as fecundity were influenced by nutritional conditions and varied significantly between the species. All species had shorter life spans when starved, but resistance to starvation was more pronounced in the larger species. All the species had lower clutch production when starved. Also, although the frequency of clutch production was high in *M. pehpeiensis* (*M. pehpeiensis* produced a clutch every 2 days, whereas *M. distinctus* and *M. viridis* took on average almost 3 days), total clutch production was far higher in the larger species. The copepods fed readily on mosquito larvae, with *M. distinctus* and *M. viridis* killing fewer *Ae. albopictus* than *M. pehpeiensis*, which, however, killed fewer *An. minimus*. These copepods exhibited a similar and limited predation against *Cx. tritaeniorhynchus*. Results of our study support the contention that these copepods have the potential to be used as biological control agents of immature mosquitoes. Also, our results give useful information on colony maintenance and field introduction. In particular, releasing copepods with *Paramecium* as food could increase their survival in the habitat of the targeted pest.

**KEY WORDS** Mosquito, immature, copepod, predation, reproduction

### INTRODUCTION

Cyclopoid copepods are distributed almost universally in aquatic habitats and may occur at high densities in areas that produce mosquito larvae (Nasci et al. 1987, Brown et al. 1991). Although their interactions with mosquito larvae still are not fully understood, they have been demonstrated to serve as obligate hosts for fungi (Whistler et al. 1974, Frederici 1980) and microsporidia (Andreadis et al. 1985, Sweeney et al. 1985, Vossbrinck et al. 1998) to which mosquitoes are vulnerable. In addition, copepods have become a focus of large number of studies focused on their use for biocontrol (Riviere and Thirel 1981, Marten 1984, Nasci et al. 1987, Marten 1990, Marten et al. 1994, Zhen et al. 1994, Schreiber et al. 1996). Copepods have been shown to be very useful in controlling mosquitoes (*Aedes* sp.) in large containers (Nam et al. 2000, Kay et al. 2002) and in subterranean habitats (Russell et al. 1996, Kay et al. 2002). Presently, copepods are one of the most promising biological control agents.

Consideration of predatory efficiency, reproductive potential, ease of mass production, and survival is the 1st step of evaluating a candidate biocontrol agent. However, most of the evaluations of copepods as candidates for mosquito control have considered only their predatory efficiency on 1st-stage larvae. No evaluation has taken into account the

reproductive biology of the candidate copepods, which is clearly directly related to their survival and ease of mass production in field applications. It has been reported that habitat desiccation (Zhen et al. 1994) and loss (Marten et al. 1994) have been reported to influence the populations of most species, including copepods. Disappearance of habitat was particularly noted when ecologically different species were mixed to improve control efficiency (Marten et al. 1994). Indeed, population loss is the most important factor limiting their use. Recently, Kay et al. (2002) reported desiccation resistance of eggs in the genus *Mesocyclops*. Therefore, a population ecological approach, especially one that includes the study of reproductive biology, should be involved in evaluating copepods as biological control agents.

In cyclopoid copepods, female reproduction is always sexual (Wyngaard and Chinnapa 1982, Gilbert and Williamson 1983) and ovigerous females carry their eggs in 2 sacs attached ventrolaterally to the genital segment of the urosome. When mature, the sacs drop and subsequently hatch within the medium (Gilbert and Williamson 1983). Females have 4 recognizable reproductive phases: ovigerous, bearing egg sacs; gravid, oviducts full of visible darkened matured oocytes; both ovigerous and gravid; and neither ovigerous nor gravid (Williams and Butler 1987). Females are able to store sperm, which enables the fertilization of many oocytes from 1 insemination (Hill and Cooker 1930, Williams and Butler 1987, Maier 1992). These alternative reproductive states depend largely on environmental factors, that is, food in particular (Williams and Butler 1987). Thus, diagnosis of the reproductive state is useful during a field trial.

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