

# Interaction Between The Mottled Waterhyacinth Weevil, *Neochetina eichhorniae* Warner, And The Waterhyacinth Mite, *Orthogalumna terebrantis* Wallwork

by  
Ernest S. Del Fosse<sup>1</sup>

## ABSTRACT

*Neochetina eichhorniae* Warner and *Orthogalumna terebrantis* Wallwork often occur sympatrically on waterhyacinth, *Eichhornia crassipes* (Mart) Solms-Laubach, providing several possible avenues of interaction. *O. terebrantis* will not feed upon eggs of *N. eichhorniae*. Weevils lay more eggs, and may feed more, in the presence of mites, possibly due to release of a kairomone from waterhyacinth tissue. This kairomone is apparently released by both mite and weevil feeding.

*O. terebrantis* is a better control agent than has been indicated in the past, due to a facultative interaction with the fungus *Acremonium* (= *Cephalosporium*) *zonatum* (Saw.) Gams., and a synergistic relationship with *N. eichhorniae*. Both organisms increase the indirect effect of the mite on waterhyacinth.

Combinations of *O. terebrantis* and *N. eichhorniae* reduce size and density of waterhyacinth significantly when compared to reduction due to either arthropod alone. No evidence of negative interaction was found between *N. eichhorniae* and *O. terebrantis*.

## INTRODUCTION

*Neochetina* spp. are specific to the Pontederiaceae (O'Brien 1975) with *N. eichhorniae* Warner (1970) and *N. bruchi* Hustache (1926) on waterhyacinth, and *N. affinis* Hustache (1926) on *Eichhornia azurea* (Swartz) Kunth. The host range of an insect can be precisely determined if the visual, tactile and chemical stimuli used for finding and accepting the host plant are known. If all these are characteristic of only one host plant, only that

will be attacked (Harris and Zwölfer 1968). Some Pontederiaceae fulfill these requirements for *Neochetina* spp., as some of these bagoine curculionids occur on both *Eichhornia* spp. and *Reussia* spp. in Guyana, Brazil, Uruguay and Argentina, and were found to be host specific in tests in Trinidad (Bennett 1968a).

*N. eichhorniae* has been reported from Argentina, Bolivia and Trinidad (Perkins 1974b). It is attacked by nematode, microsporidian and fungal parasites in South America (Andres and Bennett 1975) and apparently prefers warmer areas than *N. bruchi*. Eggs of *N. eichhorniae* hatch in ca. 7-14 days. The three larval instars require ca. 2 months for development. Final instar larvae create a cocoon out of cut waterhyacinth root hairs, through which an oxygen connection may be maintained to the plant. The pupal stage lasts ca. 14-20 days. Adults create 2-4mm diameter ovoid feeding spots, and can live 280 days in the laboratory. A 1:1 sex ratio occurs in the field. There is a positive thigmotrophic response to the crown of the plants and between the adults themselves. Females produce a maximum and average of 300 and 50 eggs, respectively, during their lifetime (Perkins, pers. comm.). Weevils often feign death after being disturbed. One adult produces 20 feeding spots/day, and 5 adults can kill a waterhyacinth plant in the laboratory in ca. 10 days (Perkins 1974b).

The waterhyacinth mite, *Orthogalumna terebrantis* Wallwork (1965) belongs to a small genus of oribatoid mites known mainly from Madagascar, southeastern North America and Central and South America (Balough 1960, Bennett 1968a,b, 1970 a,b). It may have been accidentally introduced into the United States with waterhyacinth over 90 years ago (Bennett 1972, Perkins 1973). *O. terebrantis* was originally thought to be in the genus *Leptogalumna* (Bennett 1968a, Bennett and Zwölfer 1968), but was placed in *Orthogalumna* by Wallwork (1965).

<sup>1</sup>Research Entomologist, Lee County Hyacinth Control District, Route One, Fort Myers, FL 33905.

It is specific to the Pontederiaceae, mainly feeding on waterhyacinth, but occasionally on *E. azurea*, or pickerelweed, *Pontederia* sp. (Gordon and Coulson 1971, Perkins 1974a, Cordo and DeLoach 1975, Perkins, pers. comm.) and overwinters in Argentina, apparently feeding on algae, on waterlettuce, *Pistia stratioties* L., and *Salvinia* sp. (Cordo and DeLoach 1976).

*O. terebrantis* is one of very few phytophagous oribatoids (Cordo and DeLoach 1975). It damages waterhyacinth in South America (Bennett 1970b, Bennett and Zwölfer 1968, Coulson 1971, Perkins 1973), the United States<sup>6,7</sup> (Bennett 1968b, 1970a, Del Fosse *et al.* 1975), and has been introduced and established in Zambia and Rhodesia (Bennett 1974). Del Fosse *et al.* (1975)<sup>6</sup> and Perkins (1973) found that adult mites could enter pseudolaminae to feed, whereas Cordo and DeLoach (1975) did not. Strain differences and experimental technique may have produced these conflicting results. Cordo and DeLoach (1976) later found that tritonymphs of *O. terebrantis* could enter waterhyacinth tissue directly.

Perkins thought that waterhyacinth mite populations were related to high humidity and moderately warm temperature (Perkins, pers. comm.), and that it may be worthwhile to bring the Argentine strain into the U.S. (Perkins 1972). Cordo and DeLoach (1975) however, found that differences between U.S. and Argentine strains of *O. terebrantis* did not warrant introduction of the Argentine strain into the U.S. Later, Cordo and DeLoach (1976, p. 249) thought that introduction of the Argentine into the U. S. "might have an advantageous effect on the vigor and effectiveness of the mite" by "probably [increasing the U.S.] gene pool of the waterhyacinth mite."

Because of the high degree of host specificity and damage displayed by *O. terebrantis*, this galumnid is considered one of the 4-5 most promising biological control agents of waterhyacinth (Bennett 1968a,b, Coulson 1971, Perkins 1973, Cordo and DeLoach 1975).

*N. eichhorniae* and *O. terebrantis* are native to the area of origin of waterhyacinth, South America, and apparently evolved their host specific behavior sympatrically. Since both are essentially specific to waterhyacinth, and during their life cycles occupy some of the same areas on a particular waterhyacinth plant, possibilities for interactions are good.

## ARTHROPOD INTERACTIONS

Eggs.—*O. terebrantis* will starve in the presence of eggs of *N. eichhorniae* as their only source of food. In tests run at four different temperature and humidity regimes, mites did not feed, or attempt to feed on weevil eggs, as evidenced by microscopic examination.

Waterhyacinth mites oviposit, and immatures (larvae, proto-, deuto-, and tritonymphs) develop in waterhyacinth pseudolaminae. This is also the area where *Neochetina* spp. oviposit. These studies indicate that *O. terebrantis* would not consume eggs of *Neochetina* spp. if encountered during mite feeding.

The reverse is probably not true; mite eggs are so small (0.10 x 0.14mm) (Cordo and DeLoach 1976) that either adult or larval weevils would probably consume or damage waterhyacinth mite eggs during their feeding. No evidence exists, however, to indicate that *Neochetina* spp. would seek out eggs of *O. terebrantis*. Destruction of waterhyacinth mite eggs by *Neochetina* spp. would probably be accidental and unavoidable, and, as evidenced by large populations of mites present when large weevil populations are present (Cordo and DeLoach 1975, 1976, Perkins 1974), is apparently an insignificant stress upon waterhyacinth mite populations.

Oviposition and Development.—*N. eichhorniae* lays more (P 0.05) eggs/female in the presence of *O. terebrantis* than alone. This may be due to the release of a kairomone (*sensu* Nordlund and Lewis [1976] from waterhyacinth tissue. This kairomone may also contain an oviposition stimulant and/or phagostimulant for weevils and mites. In addition, *N. eichhorniae* laid twice as many eggs at a temperature regime of 15-35°C as compared to 10-30°C. Larval *Neochetina* spp. develop best at ca. 20-35°C in the field (DeLoach and Cordo 1976a). This corresponds to best population development as measured in the laboratory.

*O. terebrantis* laid more eggs at 20-40°C than at 10-30, 15-35 or 20-40°C, although there was no statistical difference in mite oviposition at these temperature regimes. A temperature regime of 5-25°C was most unfavorable for mite oviposition with significantly fewer eggs/female laid.

In addition, the greatest development of immature waterhyacinth mites occurred at 10-30 and 15-35°C (i.e. the largest number of immature mites developed to adults at these temperatures rather than the extreme regimes).

These data indicate that the oviposition and development of both species of arthropods is not mutually exclusive, and in fact, sympatric presence of both species can lead to higher levels of each species.

Feeding.—*O. terebrantis* is often found in fresh *Neochetina* feeding spots (Perkins 1973, Del Fosse *et al.* 1975, Cordo and DeLoach 1975). Presumably, mites obtain nutrients from these spots. Perkins (1973) and Del Fosse *et al.* (1975), unlike Cordo and DeLoach (1975), found that adult waterhyacinth mites could penetrate uninjured waterhyacinth tissue to feed. Cordo and DeLoach (1975) however, used a different strain of mites and experimental technique, and later (Cordo and DeLoach 1976, P. 246) found that “. . . tritonymphs . . . penetrated the epidermis, and began a new gallery in a young leaf without a previous break in the epidermis”. Thus, an injury, such as that caused by *N. eichhorniae* feeding, is not necessary for survival of this mite.

*N. eichhorniae* and *N. bruchi* are also attracted to the kairomone contained in waterhyacinth tissue. The chemical(s) released from injured plants by both weevil and mite feeding may attract concentrations of weevils and mites around attached plants. This system apparently functions to concentrate weevils in small areas when populations are low. This concentration has been noted by several authors (DeLoach and Cordo 1976b, Perkins *et al.* 1976). This concentration leads to a higher level of feeding, mating and oviposition by both species on a small number of host plants. This, in turn, leads to high concentration populations of both species, and greater chance of mating success, resulting in higher populations when other conditions are proper. Such population peaks were demonstrated by Cordo and DeLoach (1976) with *O. terebrantis* and DeLoach and Cordo (1976b) with *N. eichhorniae*. Peaks in adult populations of both species occurred during favorable weather in the second generation (both species are trivoltine in Argentina) each year from a small concentrated overwintering population.

Mortality.—Temperature optima for both *N. eichhorniae* and *O. terebrantis* were determined in the laboratory. Weevile mortality was 100% at 5-25°C and 79% at 20-40°C and 50 and 41% at 10-30 and 15-35°C, respectively, and mite mortality was 100% at both 5-25° and 10-40°C and negligible at 10-30 and 15-35°C. These data generally support field data gathered by DeLoach and Cordo 1976a, b) and Cordo and DeLoach (1976) for weevils and mites, respectively.

## ARTHROPOD-PLANT INTERACTIONS

Arthropod-fungus Relationships.—Several authors have commented on the use of *Acremonium* (= *Cephalosporium*) *zonatum* (Saw.) Gams. and other pathogens against waterhyacinth (Zettler and Freeman 1972, Freeman *et al.* 1974, Charudattan (1975a,b) mentioned that *A. zonatum* is sometimes more severe when *N. eichhorniae* and *O. terebrantis* are present, and suggested integrated control using pathogens and these arthropods. It has been assumed that adult feeding damage by both weevils and mites contributed to development of *A. zonatum* (viz. Charudattan [1975b, p.11] “*A. zonatum* is the most virulent of pathogens found on waterhyacinth damaged by [*N. eichhorniae* and *O. terebrantis*]”). However, in the examination of thousands of waterhyacinth pseudolaminae heavily damaged by both *N. eichhorniae* and *O. terebrantis* in the field from 1973-1976, Del Fosse<sup>6</sup> did not find a single instance where *A. zonatum* developed in feeding spots of *N. eichhorniae*. More recently, Perkins (see paper, these Proceedings) found a few lesions of *A. zonatum* apparently developing around feeding spots of *N. eichhorniae*. This occurred under highly unusual circumstances of sustained high humidity in the field, and is not typical of attack of this pathogen. In addition, Charudattan *et al.* (1976) found that *A. zonatum* could be induced to develop in the laboratory in weevil feeding spots. Very high humidity (nearly 100%) created under these artificial conditions was needed to cause this development. All fungal lesions of this pathogen developed in tunnels of *O. terebrantis* after the adult mite had created its emergence hole. The adult mite (which often crawls back into adult tunnels) apparently picks up fungal spores and carries them back into the tunnel. Spores could also be carried to tunnels by wind, other arthropods, etc. High humidity and temperature inside the tunnels are apparently conducive to development of *A. zonatum*, for a mite tunnel from which an adult has emerged is often the focus of development of this pathogen in the field.

In addition, Del Fosse (unpublished data) has found extensive damage to waterhyacinth mite-infested pickerelweed, *P. cordata* L., by *A. zonatum* in southwest Florida. As is normally the case with waterhyacinth, all *A. zonatum* fungal lesions in pickerelweed were coincident with adult mite tunnels.

Arthropod-Waterhyacinth Relationships. — Large summer populations of waterhyacinth mites (plus associated fungal diseases and saprophytes) can cause large areas of waterhyacinth destruction

(Cordo and DeLoach 1975, 1976, Perkins 1974a), as can populations of *N. eichhorniae* (Andres and Bennett 1975, DeLoach 1975, 1976, Perkins and Maddox 1976, Perkins 1973, 1974a,b). When these species are used together for biological control of waterhyacinth, their combined action produced a stress on the plants, resulting in greater reduction than the additive effects of each species used individually i.e. biological synergism occurred.

Reduction occurs both in size of plants (e.g. a 30+ cm reduction in petiole length after 50-weeks) and density (e.g. nearly a 50% reduction in density after 50-weeks). Addition of *N. bruchi* (already released in Florida) and *Sameodes* (= *Epipagis*) *albiguttalis* (Warren) (if and when cleared for U.S. release) to mats of waterhyacinth already containing *O. terebrantis* and *N. eichhorniae* may stress waterhyacinth further, and in turn, achieve greater control of the plant.

### CONCLUSIONS

Generally, the waterhyacinth mite has been underestimated with respect to its stress potential against waterhyacinth. De Loach (1975), using a numerical rating system developed by Harris (1973), rated *Acigona* sp., *Sameodes* (= *Epipagis*) sp., *N. bruchi*, *N. eichhorniae* and *Cornops* sp., in that order, ahead of *O. terebrantis*. However, at that time it was not known that tunnels of *O. terebrantis* are conducive to development of *A. zonatum*, that presence of high populations of *O. terebrantis* cause *N. eichhorniae* to oviposit and feed at greater rates, or that a biological synergism occurs when *O. terebrantis* and *N. eichhorniae* are present together on waterhyacinth. These new factors raise DeLoach's (1975) rating of *O. terebrantis* from 18 to at least 25 points, thus increasing its rating beyond that of at least *Cornops*. This system is, of course, artificial, and both Harris (1973) and DeLoach (1975) have recognized its limitations. It is a rough scale only, and was not meant to be used as the sole determinant for release of exotic organisms.

All data indicate that there are no negative interactions between *O. terebrantis* and *N. eichhorniae* that affect the utility of both species released together in control programs of waterhyacinth.

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