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Comparative demography and diet breadth of Brazilian and African populations of the predatory mite *Neoseiulus baraki*, a candidate for biological control of coconut mite

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Abstract

Neoseiulus baraki Athias-Henriot (Phytoseiidae) is one of the few predators associated with the coconut mite *Aceria guerreronis* Keifer (Eriophyidae), the most damaging pest of coconut fruits in the Americas, Africa and more recently in Oman, Sri Lanka and parts of India. As Brazil is presently considered the putative origin of *A. guerreronis*, a large effort is presently underway to develop a classical biological control strategy for this pest in Africa and Asia. In this study, we investigated the life history of a Brazilian (NbBr) and a Beninese (NbBe) population of *N. baraki* on prey and non-prey diets under laboratory conditions (25 ± 1 °C 70–90% RH and 12:12 h L:D). Both populations were able to complete juvenile development and reproduce when feeding on *A. guerreronis*, *Tetranychus urticae* Koch eggs—a prey commonly used in the maintenance of phytoseiid mite colonies—and maize pollen. The two predators developed faster on *A. guerreronis* than on any other diet. The longest developmental time was recorded for NbBe on castor bean pollen (12.3 days), which also was not suitable at all for the development of NbBr. The longest developmental time of NbBr was 8.94 days on *T. urticae* eggs, whereas NbBe needed only 5.86 days to develop from eggs to adult stage on the same diet. For both populations, oviposition rate and longevity as well as demographic parameters were most favorable on *A. guerreronis*, the target prey. Intrinsic rate of natural increase (r_m) and net reproductive rate (R_o) were significantly higher for NbBr (0.19 and 24.9) than for NbBe (0.16 and 18.0). Taken together, the life history data from this study predict that NbBr is a more specialized and efficient predator of *A. guerreronis* compared with NbBe. The ability of the latter to utilize alternative food types, however, predicts that it would be able to persist longer in coconut habitat in the absence of its primary prey *A. guerreronis*. Implications for the implementation of a sustainable control strategy against *A. guerreronis* are discussed.

Keywords: *Cocos nucifera*; *Aceria guerreronis*; Eriophyidae; Phytoseiidae; Life history; Classical biological control

1. Introduction

Phytoseiid mites are well studied plant-inhabiting predators because of their established usefulness in the biological control of a wide range of phytophagous arthropods on agricultural crops (e.g., Helle and Sabelis, 1985; McMurtry and Croft, 1997). Among other traits, the diet breadth of a phytoseiid predator is considered an important factor determining its suitability and efficacy in the control of a given pest and in its ability to persist in a crop when the primary prey pest is scarce (McMurtry, 1982; McMurtry and Croft, 1997).

Two phytoseiid mites, *Neoseiulus baraki* Athias-Henriot and *Neoseiulus paspalivorus* DeLeon, were recently found associated with the coconut mite *Aceria guerreronis* Keifer (Acari: Eriophyidae) during surveys conducted in Sri

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Lanka, Brazil, Benin, and Tanzania (Fernando et al., 2002; de Moraes et al., 2004; Lawson-Balagbo et al., 2007a,b; Negloh et al., unpublished). The two species were the most abundant predatory mites found in association with *A. guerreronis*; preliminary observations showed that both readily feed and reproduce on *A. guerreronis*. They were therefore suggested as possible natural enemies in a classical or augmentative biological control program for *A. guerreronis* (Sabelis, 1996; de Moraes and Zacarias, 2002). This approach has recently gained support due to the finding that *A. guerreronis* might be native to Brazil (or elsewhere in South America) and is definitely invasive in Africa and Asia (Navia et al., 2005).

Aceria guerreronis was first recorded from coconut in the 1960s in the state of Guerrero, Mexico, and was subsequently found in Central America and the Caribbean, as well as in Brazil and several other countries in South America (Cartujano, 1963 cited by Mariau, 1986) and Africa (Mariau, 1969). This species recently invaded Sri Lanka and India, two major coconut production countries (Fernando et al., 2002; Ramaraju et al., 2002) and is likely to continue its devastating expansion into south Asia and the Pacific where coconut palm is native and where much of the world's coconut is produced.

The tiny wormlike *A. guerreronis* exclusively lives beneath the perianth of the coconut fruits where it feeds on the tender meristematic tissues resulting in physical injuries that develop into necrotic and suberized scars on the fruit surface from the perianth down to the bottom part of the fruit. The space beneath the perianth provides a shelter for *A. guerreronis*, protecting it from environmental hazards and natural enemies and therefore interferes with natural, biological and chemical control (Hernandez, 1977; Mariau, 1977; Julia and Mariau, 1979; Aratchige et al., 2007; Lawson-Balagbo et al., 2007a,b). The species is responsible for considerable coconut yield losses worldwide (Hernandez, 1977; Julia and Mariau, 1979; Moore et al., 1989).

To determine the potential of *N. baraki* and *N. paplivorus* as biological control agents of *A. guerreronis*, studies are required to provide insight into the relationships of the predators to the target pest in term of their ability to feed and multiply on *A. guerreronis* and other food sources available in coconut habitat. The ability of phytoseiid mites to feed and survive on various food sources is well documented (e.g., Klein, 1990; Bruce-Oliver et al., 1996; Toko et al., 1994; Gnanvossou et al., 2003, 2005), and life history studies of a Brazilian population of *N. paspalivorus* have been recently completed on various food types (Lawson-Balagbo et al., 2007b); but to our knowledge studies on life history and diet breadth of *N. baraki* are non-existent.

In the present study, we investigated under laboratory conditions the life history of two populations of *N. baraki*—from Benin and Brazil—on diets of all life stages of *A. guerreronis*, eggs and larvae of *Tetranychus urticae* (Koch), pollens of maize (*Zea mays* L.), coconut (*Cocos nucifera* L.) and castor bean (*Ricinus communis* L.). Pollens were included to determine if they can be used by the predator as food source in the absence of mite prey. *T. urticae* was included to determine its potential as alternative food for mass-rearing of *N. baraki* populations, and as proxy for other tetranychid species found in the coconut habitat. *T. urticae* has been shown to be a suitable diet for the maintenance of several phytoseiid mite species worldwide (see Helle and Sabelis, 1985 for review).

2. Materials and methods

2.1. Origin and colony maintenance of predatory mites

The Beninese population of *N. baraki* was collected from coconut fruits in the village of Gbéhoué (06°21′73 N; 01°55′08 E) in southern Benin, while the Brazilian population originated from Itamaraca (07°46′S, 34°52′W) in northeastern Brazil. Both populations were maintained in the laboratory on a diet of eggs and mobile juveniles of *T. urticae* for at least one year prior to the start of the experiments. Each rearing unit consisted of a Petri dish (14.5 cm diameter and 1 cm high) filled with water-saturated cotton wool. A foam pad (4 cm × 4 cm × 1 cm) carrying a black PVC tile (4 cm × 4 cm × 0.1 cm) rested on top of the cotton. The edges of the tile were covered with moist tissue paper reaching down into the water-saturated cotton to prevent the mites from escaping. A tuft of hydrophobic cotton wool covered by a piece of transparent plastic was placed in the center of each rearing arena and served as oviposition site for the predators.

2.2. Experimental procedures

One hundred to 150 gravid *N. baraki* females of each population were placed on separate arenas and fed eggs and larvae of *T. urticae* for 24 h. Eggs of each population, 70 and 100, respectively, for NbBr and NbBe for each treatment, were collected and placed singly on arenas of 2 cm dia, constructed as described above. Experimental units were placed in a large plastic tray and kept in an incubator at 25 ± 1 °C, 70–90% RH and 12:12 h L:D photoperiod.

Life history experiments consisted of the following food type treatments: (1) All stages of *A. guerreronis* collected from meristematic tissue and bracts of coconut fruits, (2) eggs of *T. urticae* obtained using a method described by Megevand et al. (1993), (3) coconut pollen, (4) castor bean pollen, and (5) maize pollen. All pollens were collected just prior to their use from plants present in the IITA-Benin campus. Each food type was provided in surplus quantities and replenished every 48 h.

Mite development was monitored at 12-h intervals until all individuals reached adult stage; and subsequently at 24-h intervals until the last individual died. One adult male of the respective population was added to each arena soon after the protonymph molt. Males were removed immediately after the initiation of oviposition. Males that died before