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A new *Euseius* species on citrus and wild lime, *Zanthoxylum fagara* (Rutaceae), in Florida and an updated key to *Euseius* species from the state

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Original research

ABSTRACT

A new *Euseius* Wainstein species, *Euseius ennsi* n. sp., is described from adult males and females collected from citrus and wild lime in an extensive survey conducted in 2009–2014 to evaluate the phytoseiid mites from citrus plants in dooryard, experimental and commercial plantations in Florida. An updated key is provided for the seven *Euseius* species reported so far from citrus in the state.

Keywords mites; Euseiini; predatory mites; general feeders

Zoobank <http://zoobank.org/986EFD99-3E90-498E-9002-2A40F6E9B8BC>

Introduction

In several crops, including citrus, mites in the family Phytoseiidae offer potential in suppressing below economic injury levels pest mite species of the families Diptilomiopidae, Eriophyidae, Tarsonemidae, Tenuipalpidae and Tetranychidae (Childers and Denmark 2011; Carrillo *et al.* 2012; Carrillo and Pena 2012; McMurtry *et al.* 2015). The phytoseiids are well represented on citrus and other plants in Florida, with numerous species identified (Muma 1975; Denmark and Evans 2011; Childers and Denmark 2011).

A major effort has been dedicated to update information about the phytoseiid fauna on Florida dooryard, experimental and commercial citrus plantations in the state, based on an extensive survey conducted in that state. During this survey, a new species in the genus *Euseius* Wainstein was found. This genus is presently composed of about 230 valid species, found in all continents, but predominantly in the tropics; altogether, six *Euseius* species have been reported from Florida (Muma *et al.* 1970; Demite *et al.* 2019). A large number of studies have been conducted about the biology and ecology of these mites, which have been classified as pollen feeding generalist predators, showing a preference for plants with glabrous leaves (such as citrus) as hosts (McMurtry *et al.* 2013). Different *Euseius* species are among the dominant phytoseiids on citrus in different countries, as for example *E. mesembrinus* (Dean) and *E. hibisci* (Chant) in North America (Denmark and Evans 2011), *Euseius concordis* (Chant) in Brazil, *Euseius scutalis* (Athias-Henriot) and *S. stipulatus* (Athias-Henriot) in the Mediterranean area (Ferragut *et al.* 2010), *E. victoriensis* in Australia (Schicha 1987) and *E. citri* (Van der Merwe and Ryke) in South Africa (Van der Merwe and Ryke 1964).

The objective of this publication is to describe the new *Euseius* species collected in Florida, and to present a key to separate the phytoseiid species so far reported from citrus in that state.

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The holotype and some paratypes will be deposited in the Acarology collections at the Florida Department of Agriculture & Consumer Services, Division of Plant Industry in Gainesville, Florida, USA and rest of paratypes at the National Collection of Arachnida, ARC-Plant Health and Protection (NCA-PPRI), Pretoria, South – Africa.

Material and Methods

A survey of dooryard, experimental and commercial plantations throughout Florida was conducted between 2009 and 2014 to determine the diversity of the family Phytoseiidae.

Samples of leaves, twigs and fruits were taken from the inner and outer areas of the tree canopy and washed in 80% ethanol, as described by Childers and Denmark (2011) and Childers *et al.* (2017). In this process, plant parts were vigorously agitated in the solution and then removed to extract the mites. All the material was collected by the third author. Identification of the citrus species was done according to Hodgson (1967).

The mites were slide-mounted in Hoyer's medium (Walter and Krantz 2009). The slides were dried at 45-50 °C for at least two weeks, and then examined under phase contrast microscope (Zeiss Axioskop™ Research). Line drawings were made with the aid of photographs of the specimens taken with a Zen Soft Imaging System. All illustrations were edited using Adobe Illustrator C5. Measurements were taken with a Zen Soft Im., and are given in micrometers as a range (paratype measurements) followed by the holotype measurements in square brackets.

Idiosomal setal notation used in this paper is that of Lindquist and Evans (1965), as applied to the phytoseiids by Rowell *et al.* (1978) and Chant and Yoshida-Shaul (1989) for the dorsal surface, and by Chant and Yoshida-Shaul (1991) for the ventral surface. Macrosetal notation (*Sge*, genual macroseta; *Sti*, tibial macroseta; *St*, tarsal macroseta) are that of Muma *et al.* (1970). The system of classification follows that of Chant and McMurtry (2007). Pore (= solenostome) and poroid (= lyrifissure) notation are that of Athias-Henriot (1975).

Results and Discussion

Subfamily Amblyseiinae Muma

Tribe Euseiini Chant and McMurtry

Genus *Euseius* Wainstein

Euseius ennsi sp. n. (Figs. 1–4)

Zoobank: 7C513FDB-9D08-4D6A-967F-6157DF355BD7

Type material — Holotype female, 3 paratype females and 2 paratype males, on *Citrus aurantium* L., 5620 SW 3rd Place, Margate, 26.22660°N, 80.20377°W, 18 June 2012; 3 paratype females on *C. reticulata* x *C. paradise*, 2817 NE 20 Court, Fort Lauderdale, 26.15238°N, 80.11113°W, 18 June 2012; one paratype female on *Citrus sinensis* (L.), 2756 18th Street NE, Fort Lauderdale, 26.14980°N, 80.11139°W, 18 June 2012; one female on wild lime, *Zanthoxylum fagara* (L.) Sarg., Secret Woods Park, Fort Lauderdale, 26.08839°N, 80.18028°W, 25 January 2012; one paratype female on *C. sinensis*, 600 SW 9th Street, Cape Coral, 26.63397°N, 81.9869°W; 17 June 2013; one paratype female and one paratype male, on *Citrus tangelo* J.W. Ingram & H.E. Moore, 401 SE 1st Terr, Pompano Beach, 26.22495°N, 80.12369°W, 18 June 2018; one paratype female, on *Citrus limon* (L.) Burm. Fil., 617 NW 13th Terr, Cape Coral, 26.67776°N, 81.98931°W, 12 June 2013; 2 paratype females, on *C. tangelo*, 11773 85th Avenue N, Seminole, 27.85024°N, 82.80457°W, 19 June 2013; one paratype female, on *Citrus paradise* Macfad, 1288 Olympic Circle, Green Acres, 26.65660°N, 80.15261°W, 20 June 2012; ; one paratype female on *C. sinensis*, 14642 168 Avenue, Indiantown, 27.02817°N, 80.48491°W, 15 June 2012; one paratype female on *Citrus limon*, 507 Warwick Drive, Venice,

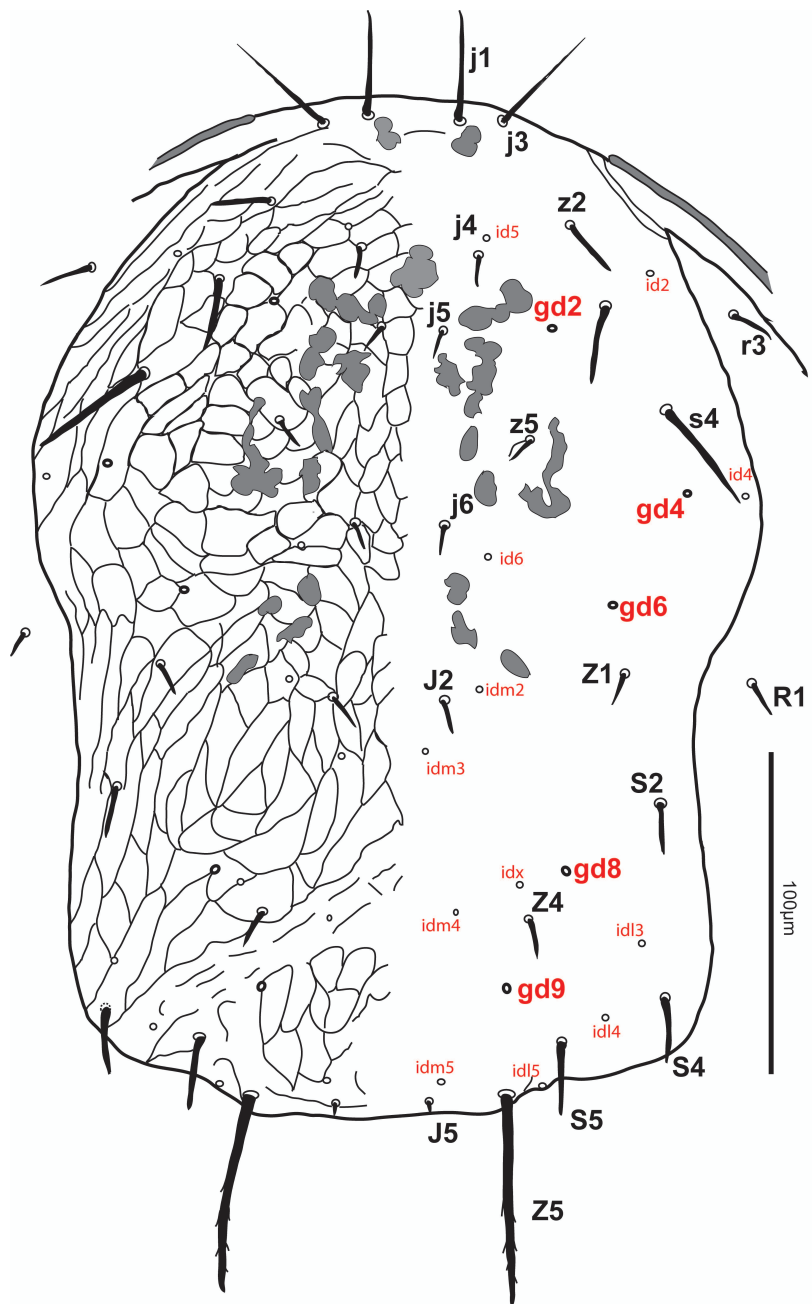


Figure 1 *Euseius ennsi* n. sp., female. Dorsal view.

27.06157°N, 82.36867°W, 17 June 2013; one paratype female on *Citrus limon*, 27595 Tarpon Way, Bonita Springs, 26.33568°N, 81.82864°W, 11 June 2013.

Female (n = 8)

Dorsum — Shield strongly reticulated. Length of shield (305-329) [310], width (214-233) [217]. Setae *j1* (28-33) [30], *j3* (32-41) [31], *j4* (9-14) [11], *j5* (9-12) [11], *j6* (8-12) [10], *J2* (10-12) [12], *J5* (4-6) [5], *z2* (17-25) [19], *z4* (23-34) [25], *z5* (8-11) [10], *Z1* (9-13) [13], *Z4* (9-13) [13], *Z5* (61-73) [64], *s4* (36-52) [36], *S2* (13-24) [17], *S4* (17-26) [21], *S5* (20-30) [24], *r3* (12-17) [15], *R1* (9-13) [11]. All dorsal setae smooth except for *Z5*, which are slightly serrate. Dorsal shield with 5 pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8*, *gd9*) and 11 pairs of

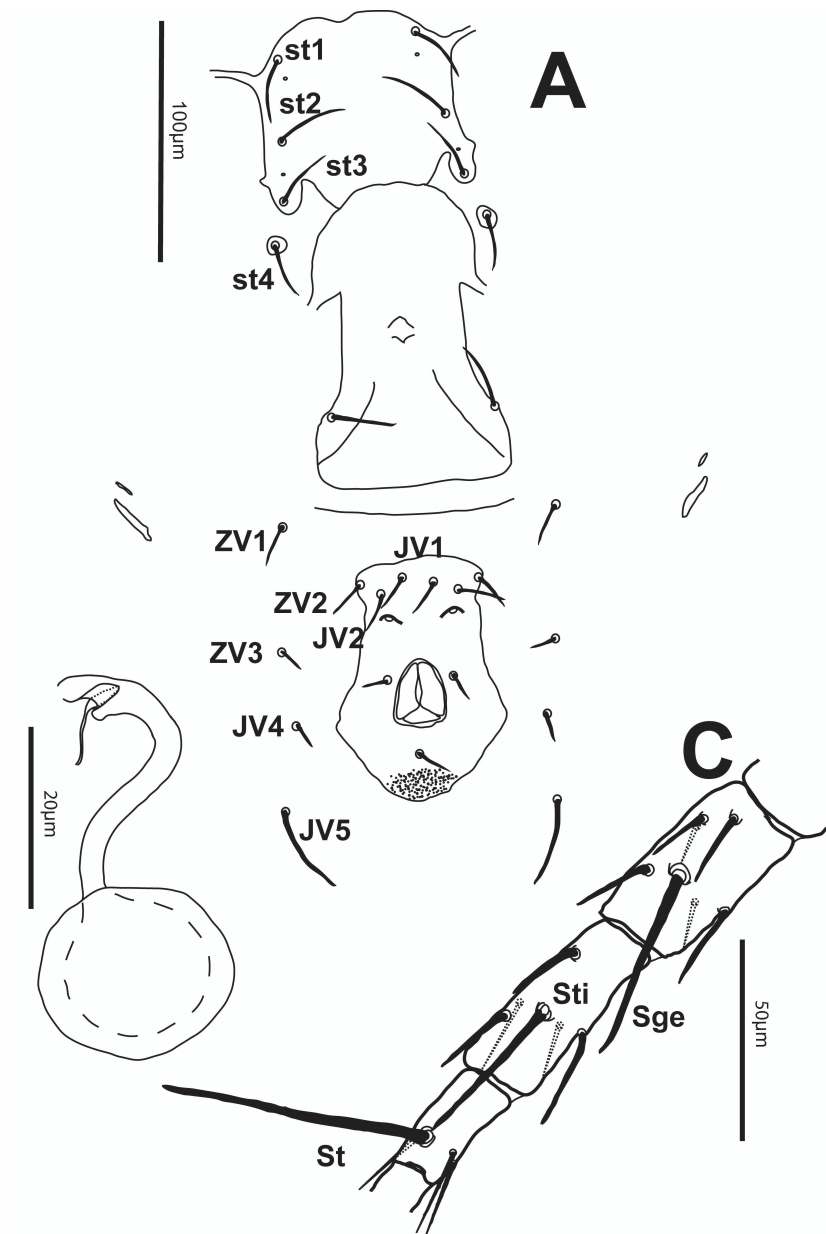


Figure 2 *Euseius ennsi* n. sp., female. A – Ventral shields; B – Spermatheca; C – Leg IV.

poroids. Sigilla present on prodorsum. Peritreme reaching to or just beyond setae *z*2 (130-153) [153] long (Fig. 1).

Venter — All ventral shields smooth. Distances between *St*1-*St*3 (58-65) [56], *St*2-*St*2 (65-72) [67], *St*5-*St*5 (64-72) [68]. Sternal shield with 3 pairs of setae and 2 pairs of pores. Posterior margin of sternal shield lobed. Two pairs of metapodal shields present, primary shield (16-21) [20] long and secondary shield (9-120 [9] long. Ventrianal shield (95-105) [98] long, width at level of setae *ZV*2 (46-56) [49], width at level of anal opening (66-74) [69]. With 3 pairs of preanal setae almost transversely aligned and 2 pores. Setae *JV*5 smooth, (34-42) [37] (Fig. 2A).

Chelicera — The position of the chelicerae renders an illustration impossible. Fixed digit (20-26) [24], with apparently 4 small teeth and a pilus dentilis; movable digit (20-25) [24], with

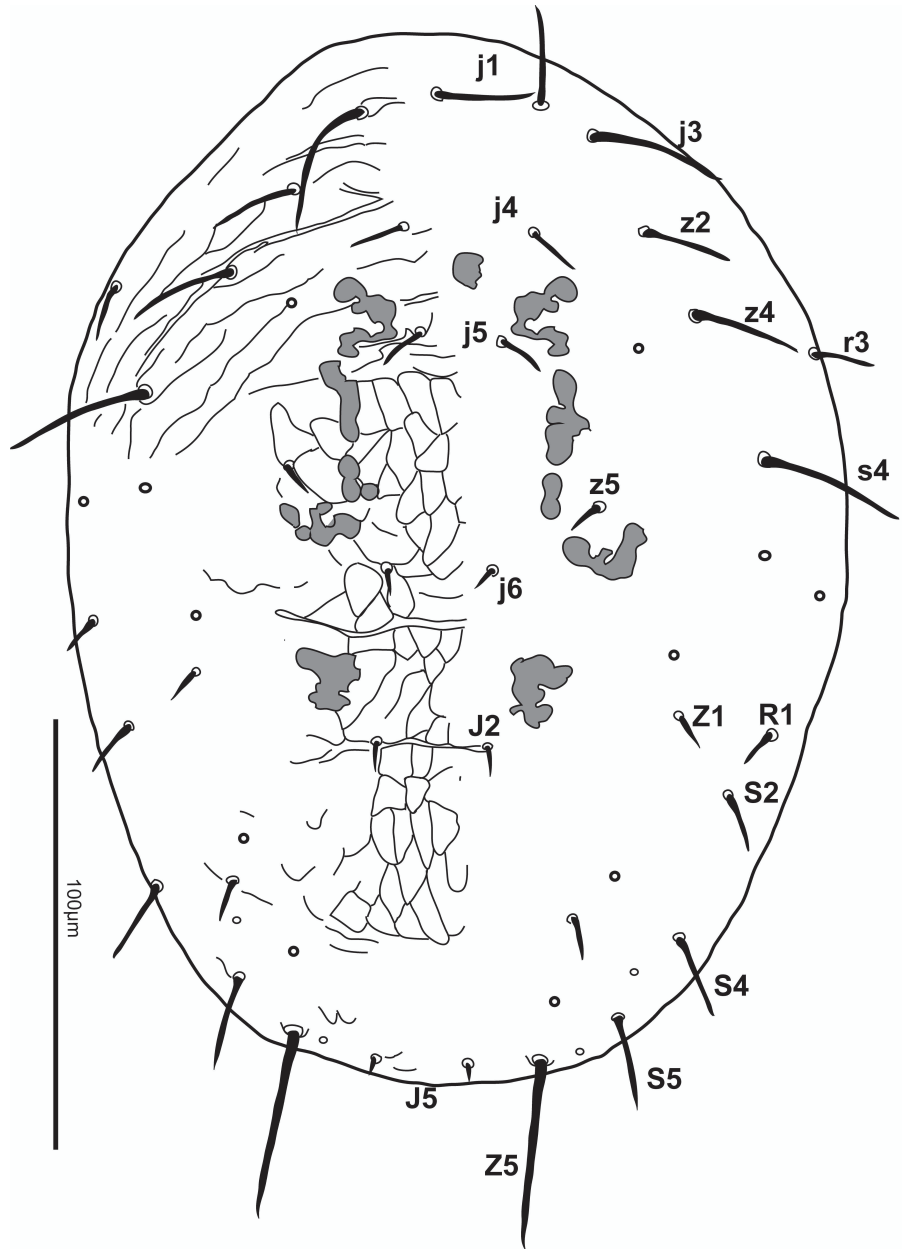


Figure 3 *Euseius ennsi* n. sp., male. Dorsal view.

only one tooth.

Spermatheca — Calyx tubular with atrium bifid, (25-32) [27] long (Fig. 2B).

Legs — Macrosetae acute distally: *Sge* II (20-26) [24], *Sge* III (20-32) [28], *St* IV (66-76) [68], *Sti* IV (37-44) [38], *Sge* IV (47-55) [49]. Genu I 2-2/1-2/1-2, genu II 2-2/0-2/0-1, genu III 1-2/1-2/1-0, genu IV 1-2/1-2/1-0 (Fig. 2C).

Male (n = 2)

Dorsum — Similar to that of female, except for setae *r3* and *R1* which are on the dorsal shield (Fig 3). Length of shield 248-261, width 178-182. Setae *j1* 20-23, *j3* 28-32, *j4* 7-11, *j5* 8-10, *j6* 8-10, *J2* 10-11, *J5* 5-7, *z2* 19-22, *z4* 25, *z5* 7-10, *Z1* 9-10, *Z4* 11-12, *Z5* 52-53, *s4* 34-35, *S2* 15-16, *S4* 19-22, *S5* 17-26, *r3* 14-16, *R1* 9-10. All dorsal setae smooth except for setae *Z5* which are slightly serrate. Peritreme reaching level of setae *z4*.

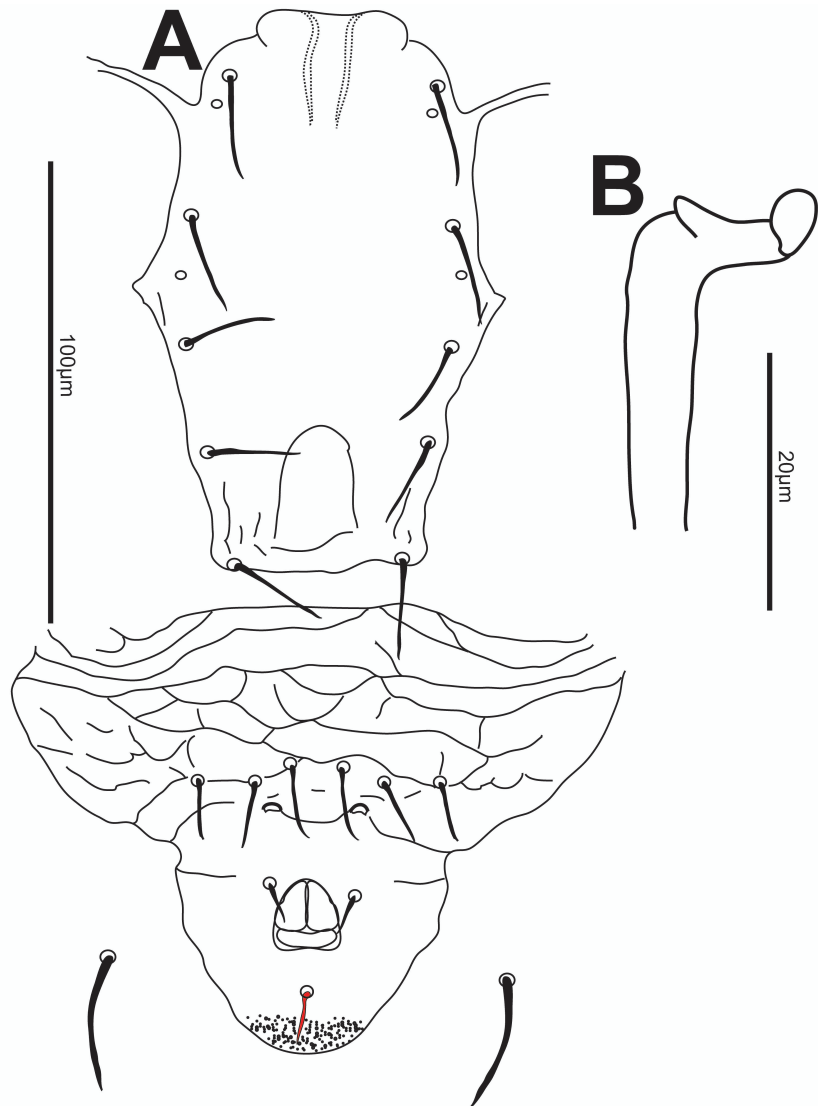


Figure 4 *Euseius ennsi* n. sp., male. A – Ventrianal shield; B – Spermatodactyl.

Venter — Sternogenital shield smooth, 123-134 long and 84-87 wide at level between setae st2 and st3 with 5 pairs of setae and 2 pairs of poroids. Ventrianal shield reticulate-striate, 104-105 long, width at level of anterior margin 143-149, with 3 pairs of transversely aligned preanal setae and 2 pores. Setae *JV*5 smooth, 22-23 (Fig. 4A).

Chelicera — Spermatodactyl L-shaped and 26-27 long (Fig. 4B). Fixed digit, with 2 teeth and a pilus dentilis; movable digit with only one tooth.

Legs — Macrosetae acute distally: *Sge* II 21, *Sge* III 22-23, *St* IV 53-54, *Sti* IV 29-31, *Sge* IV 36-38. Genu I 2-2/1-2/1-2, genu II 2-2/0-2/0-1, genu III 1-2/1-2/1-0, genu IV A 1-2/1-2/1-0.

Etymology

This species is named after the late Dr Wilbur R. Enns in recognition of his roles as teacher and advisor in the Department of Entomology, University Missouri-Columbia.

Remarks

This species closely resembles *Euseius quetzali* McMurtry *et al.*, 1985, a species described from Guatemala and also reported from Mexico and California (Demite *et al.*, 2019). Congdon

& McMurtry (1986) compared the morphology of populations from California and Guatemala identified as *E. quetzali*. They were very similar, except for the larger ratios $j1/j3$ and $z4/z2$, and shorter peritreme in the Californian population; these characteristics of the Californian population are comparable with those of the specimens collected in this study. Results of crossing experiments conducted by Congdon & McMurtry (1986) led them to conclude that the Californian population belonged to the same species as populations they collected in Mexico and Guatemala. In the first part of that study, no offspring were obtained when crossing Californian *E. quetzali* and Mexican *Euseius hibisci* (Chant), indicating that they belonged to different species. However, the results obtained when crossing Californian populations of those species were not considerably different from the results obtained when crossing Californian and Guatemalan populations of *E. quetzali*. In both cases, females were never produced in the crossings. In the first case, males and females were produced only by *E. hibisci* females, while in the second case, males and females were produced by females from both areas. Hence, we consider that their decision about the identity of the species was based on the lack of sufficient evidence that they belonged to different species rather on the availability of evidence showing that they belonged to the same species. Phytoseiids are known to reproduce mainly by a process designated as pseudoarrhenotoky (Hoy, 2011), in which offspring are only produced after mating and fertilization of the eggs.

According to our examination of paratypes of *E. quetzali*, from data provided in the original description of the species (McMurtry *et al.*, 1985) and in the redescription by Congdon & McMurtry (1986), this new species differs from *E. quetzali* by the ornamentation of the dorsal shield (smooth in the central area of the podonotal region of the dorsal shield in *E. quetzali*), and by the much shorter $j4-j6$, $J2$, $z5$, $Z1$ and $Z4$, which appear to be the shortest dorsal shield setae of the new species but also shorter than that of *E. quetzali*. In our examination of the paratype females, the peritreme extends only up to $z2$, instead of up to $j3$ as shown in the illustration of the original description.

Euseius ennsi n. sp. is also similar to *E. obispoensis* Aponte & McMurtry, 1997 especially for the strong reticulation of the dorsal shield. The latter differs for: having $r3$ always and $R1$ occasionally on dorsal shield; most dorsal shield setae as long as to up to 20% longer except $z4$ and $s4$, about 20% shorter; and ventrianal shield strongly reticulate in preanal region and light reticulation in anal region. The new species also resembles *E. citri* van der Merwe & Ryke, 1964 and *E. citrifolius* Denmark & Muma, 1970; however, *E. citri* has calyx of spermatheca slightly bulged near atrium and flaring near vesicle, whereas *E. citrifolius* has dorsal shield only lightly reticulate and macroseta of basitarsus IV distinctly bent. As the latter species, *E. relictus* Chaudhri, Akbar & Rasool differs from the new species by having macroseta of basitarsus IV (as well as macrosetae of genu and tibia IV) distally bent. *Euseius vulgaris* Liang & Ke, 1983 differs from the new species for having peritreme longer (reaching midway between insertions of $j3$ and $z2$, and ventrianal shield almost twice as wide at anus level than at level of $Zv2$).

This new species is also very closely related to *E. vivax* (Chant & Baker) and *E. fructicolus* (Gonzalez & Schuster) but differs from both in that the dorsal shield is completely reticulated and not smooth as in *E. fructicolus* and lightly reticulated as in *E. vivax*. They also differ from the new species in the shape of the tubelike calyx of the spermatheca, which is almost straight in the former two but bent or coiled in the new species. The macrosetae on leg IV of *E. fructicolus* are blunt distally but acute in the new species. Setae $Z5$ are serrated in the new species but smooth in both *E. vivax* and *E. fructicolus*. In the new species setae $Z5$ is about six times as long as $j6$ and $J2$ but about five times or less in *E. vivax* and *E. fructicolus*, respectively (Lopes *et al.*, 2015).

Key to the *Euseius* species from citrus reported from Florida, USA

Euseius ho De Leon and *E. brazilli* (El-Banhawy) were synonymized with *E. mesembrinus* (Dean) (Lopes, *et al.*, 2015). Additional information about the *Euseius* species from Florida can be found in Muma *et al.* (1970), Childers & Denmark (2011) and Denmark & Evans (2011).

One of the species included in the key (*E. ovalis* (Evans, 1953)) represents a new record for Florida, collected on citrus trees in Fort Myers, Jupiter, Naples, Palm City and West Palm Beach between June 2012 and June 2013.

1. Setae *r*3 and *R*1 on dorsal shield; macrosetae only present on leg IV *Euseius sibelius* (De Leon 1962)
— Setae *r*3 and *R*1 off dorsal shield (if on dorsal shield, with macrosetae on legs I–IV); macrosetae present at least on legs III and IV 2
2. Setae *r*3 and *R*1 on dorsal shield; calyx of spermatheca short-tubular, less than three times as long as its largest diameter *E. urceus* (De Leon 1962)
— Setae *r*3 and *R*1 off dorsal shield; calyx of spermatheca distinctly more than three times as long as its largest diameter 3
3. Seta *j*3 less than half as long as *j*1; dorsal shield smooth over most of its extent, except anterolaterally (reticulate) *E. ovalis* (Evans 1953)
— Seta *j*3 distinctly more than half as long as *j*1; ornamentation of dorsal shield variable 4
4. Dorsal shield strongly reticulated; macrosetae of leg IV acute distally *E. ennsi* n. sp.
— Dorsal shield not strongly reticulated; macrosetae of leg IV variable 5
5. Macrosetae of leg IV acute distally *E. hibisci* (Chant 1959)
— Macrosetae of leg IV blunt to spatulate 6
6. Seta *Z*v1 well anterior of *J*v1 *E. victoriensis* (Womersley 1954)
— Seta *Z*v1 about in transverse line with *J*v1 *E. mesembrinus* (Dean 1957)

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