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MORPHOLOGY AND LIFE HISTORY CHARACTERISTICS OF *PODISUS MUCRONATUS* (HETEROPTERA: PENTATOMIDAE)

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ABSTRACT

Podisus mucronatus Uhler is a generalist predator found in Florida and the islands of the Caribbean. Adult *P. mucronatus* were observed preying on larvae of the Australian weevil *Oxyops vitiosa* (Pascoe), a biological control agent of *Melaleuca quinquenervia* (Cav.) S.T. Blake. To facilitate field-based identification of this predator, we present descriptions of eggs, nymphal stages, and adults. Life history traits of *P. mucronatus* when held with no food or either of two prey species (*O. vitiosa* and *Tenebrio molitor* (L.) larvae) are also reported. The potential use of this species as a biological control agent of arthropods and its interference with weed biological control are discussed.

Key Words: *Podisus mucronatus*, Pentatomidae, developmental rates, predatory stinkbug, *Oxyops vitiosa*, *Melaleuca quinquenervia, Tenebrio molitor*

RESUMEN

Podisus mucronatus Uhler es un depredador generalista que se encuentra en Florida y en el Caribe. Se observaron adultos de *P. mucronatus* alimentándose de larvas de *Oxypos vitiosa* (Pascoe), un gorgojo australiano y un agente de control biológico de *Melaleuca quinquenervia* (Cav.) S. T. Blake. Se presentan descripciones morfológicas de los huevos, estadías ninfales 1-5, y los adultos, para facilitar la identificación de este depredador en el campo. Se reportan también características de la historia natural de *P. mucronatus* mantenidas sin alimento o sin las larvas de cualquier de las dos especies presa (*O. vitiosa* y *Tenebrio mollitor* (L.)). Se discute el uso potencial de esta especie como un agente de control biológico de artrópodos y su interferencia con el control biológico de malezas.

Species in the genus *Podisus* (Pentatomidae) are generalist predators, that attack primarily lepidopteran and coleopteran larvae (Aldrich et al. 1991). Because prey species include important pests in agroecosystems, some *Podisus* species have received attention as potential biological control agents for agricultural pests (Drummond et al. 1984, Stamopoulos & Chloridis 1994, De Clercq 2000). *Podisus maculiventris* (Say), for instance, has been the focus of various life history and comparative development studies as well as morphological descriptions of eggs, nymphs and adults (Aldrich 1986, Decoursey & Esselbaugh 1962, Legaspi & O'Neil 1993, Legaspi & O'Neil 1994). This attention is due, in part, to the use of *P. maculiventris* as a biological control agent of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Drummond et al. 1984, Stamopoulos & Chloridis 1994).

Only about 10% of the 300 known asopine species have been studied in detail (De Clercq 2000). For instance, the native Floridian and Caribbean species *Podisus mucronatus* Uhler has rarely been reported in the literature (J. Eger, pers. comm.). Occurrences of *P. mucronatus* attacking agricultural and horticultural pests were reported by Genung (1959) and Genung et al. (1964). Aldrich et al. (1991) described the attractant pheromone produced by male *Podisus* species, including that of *P. mucronatus*. Unfortunately, little else is known concerning this species.

We recently observed adult *P. mucronatus* preying on larvae of the weed biological control agent *Oxyops vitiosa* (Pascoe) (Coleoptera: Curculionidae) that feed on *Melaleuca quinquenervia* (Cav.) S. T. Blake in Lee Co., FL. We wished to quantify the population dynamics of both *O. vitiosa* and its newly acquired generalist predator, *P. mucronatus*. To date, no morphological descriptions of immature stages or life history traits exist for this predator, making accurate identification of eggs and nymphs difficult. To facilitate proper identification and future understanding of its ecological relationship with *O. vitiosa*, we describe herein the basic morphological characteristics and life history traits of *P. mucronatus.*

MATERIALS AND METHODS

Rearing and Maintenance of *P. mucronatus* Colonies

Podius mucronatus adults, found in association with *O. vitiosa*, were collected from coppicing

M. quinquenervia stumps at a site near Estero, Florida (N26°25.530' W81°48.620'). The biological control agent was originally released at this site in 1998 (Center et al. 2000). Adult *P. mucronatus* were maintained in 30 × 25 × 9 cm diameter plastic containers provisioned with paper towels lining the interior of the container. The paper towels were used to provide seclusion and oviposition sites. *Podisus mucronatus* colonies were sustained by feeding nymphs and adults mixed larval stages of *Tenebrio molitor* (L.) and *O. vitiosa*. Paper towels and dead prey were removed weekly. Adult colonies were examined every 12 h at which time newly deposited eggs were removed and placed into 10 × 1.5 cm diameter petri dishes. Aged cohorts were held separately. Eggs and first-instar nymphs were reared in 10 × 1.5 cm diameter petri dishes on filter paper with a small *M. quinquenervia* terminal vegetative bud (tip) for moisture. After the eggs hatched, decapitated *T. molitor* third and fourth-instar larvae were placed in the petri dish. *Tenebrio molitor* were decapitated to facilitate predation by *P. mucronatus* nymphs. Second and third-instar nymphs were then transferred into a 15 × 4 cm diameter plastic container with filter paper, several *M. quinquenervia* tips, and live larvae of *T. molitor.* Fourth and fifth-instar nymphs were reared in 18 × 8 cm diameter plastic containers and maintained in the same manner. Colonies were held under laboratory conditions at 25 (±5) °C, a photoperiod of 16:8 (L:D), and 70 (±10)% relative humidity. All stages were monitored every 12 h and exuvia were removed to accurately track life stages.

Morphological Descriptions and Measurements

Each nymphal and adult stage was examined using a Nikon® dissecting microscope (10-50×). Descriptions were based on live individuals whereas measurements were based on specimens preserved in ethyl alcohol. The number of individuals measured ranged from 11-35, depending on the number available from each respective cohort. Size and number of micropylar processes were measured on 44 eggs. Length of each nymph and adult was measured from the tip of the tylus to the tip of the abdomen. The width of the head was measured from the outer margins of the compound eyes. The pronotal width of adults was measured between the humeral spines. Lengths of the metathoracic leg and femur were also measured.

Life History Parameters

Life history parameters were assessed in experimental arenas that consisted of 10 × 1.5 cm plastic petri dishes, provisioned with a slightly moistened filter paper. Newly hatched (<10 h old) *P. mucronatus* first-instar nymphs were collected from colonies and transferred using a camel's hair brush to individual arenas. Twenty randomly selected first-instar nymphs were assigned to each of 4 diets: 1) moistened filter paper only, 2) diet 1 plus the addition of a *M. quinquenervia* tip, 3) diet 2 plus a single *O. vitiosa* larva (second-third instar) or 4) diet 2 plus a single *T. molitor* larva (second-fourth instar). *Melaleuca quinquenervia* tips consisted of the terminal 4 cm of a newly developed, succulent shoot. All petri dishes were stacked with an additional dish at the top, which contained only a moistened filter paper. Stacks of petri dishes were placed in an environmental chamber at 25 (±1) °C, a photoperiod of 16:8 (L:D), and 65 (±10)% relative humidity. Developmental stages and survivorship were assessed every 24 h. The presence of exuvia was used to assess molting between stages. *Melaleuca quinquenervia* tips were replaced every 48 h. *Oxyops vitiosa* survivorship was assessed daily by probing each larva with a camel's hair brush, those not responding were considered dead and were replaced. *Tenebrio molitor* larvae were replaced every 48 h.

Results

Nymph and Adult measurements are presented in Table 1.

Eggs (Fig. 1A)

Egg shape elliptical, height 0.91 mm (±0.08; mean (SD), and width 0.80 mm (±0.05), laid in clusters. Color opaque initially then silver or maroon with a shiny surface before eclosion. An average of 8.25 (±0.90) micropylar processes occurring circularly around the operculum, generally curving outward. Micropylar processes white terminating with a spherical structure, ranging from white to black.

First-Instar Nymph

Shape oval, convex, widest at second or third abdominal segment. Head convex dorsally, widest basally, narrowing to tip of tylus. Head brown and eyes red with a metallic appearance. Antennae 4-segmented, segments brown with white annuli. Antennae covered with increasingly more setae towards apex. Rostrum 4-segmented and brown, apex extending slightly beyond metacoxae.

Thorax narrowest anteriorly, width increasing posteriorly. Length of pro-, meso-, and metathorax medially equal. Dorsal sutures well defined. Dorsal color brown. Thoracic median line visibly lighter in color. Coxa, femur, and tibia also brown with tarsi and tarsal claws gray. As stadium proceeds, first two tarsal segments turn brown and tarsal claws elongate. Leg segments setose. Brown scent glands present on pro-epimeron and meta-epimeron, becoming obscured after sclerotization.

Abdominal sutures between segments distinct. Lateral margins of abdominal segments I and II

TABLE 1. MORPHOLOGICAL MEASUREMENTS OF *PODISUS MUCRONATUS* NYMPHAL AND ADULT STAGES.

Morphological characteristic	Nymphal stage						
	First	Second	Third	Fourth	Fifth	Adult male	Adult female
Body length[a]	1.24 (0.23)[d]	2.00 (0.22)	4.01 (0.92)	4.77 (0.35)	8.46 (0.80)	10.13 (0.88)	11.46 (0.94)
Pronotal width[b]	0.91 (0.16)	1.22 (0.17)	2.34 (0.34)	2.73 (0.26)	4.91 (0.35)	6.51 (0.47)	7.05 (0.47)
Head width[c]	0.56 (0.13)	0.73 (0.11)	1.33 (0.23)	1.34 (0.14)	2.16 (0.13)	2.22 (0.12)	2.28 (0.14)
Antennal segment							
1	0.07 (0.01)	0.08 (0.03)	0.15 (0.03)	0.12 (0.04)	0.21 (0.05)	0.27 (0.11)	0.20 (0.00)
2	0.20 (0.08)	0.38 (0.08)	0.83 (0.18)	1.02 (0.12)	1.69 (0.24)	1.20 (0.19)	1.27 (0.20)
3	0.18 (0.06)	0.30 (0.07)	0.62 (0.12)	0.71 (0.08)	1.14 (0.14)	0.97 (0.25)	0.99 (0.16)
4	0.28 (0.06)	0.38 (0.05)	0.64 (0.08)	0.67 (0.06)	0.95 (0.12)	1.14 (0.29)	1.19 (0.17)
5	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.95 (0.21)	1.00 (0.12)
Total length	0.74 (0.19)	1.13 (0.18)	2.25 (0.37)	2.48 (0.19)	3.94 (0.40)	4.51 (0.80)	4.46 (0.43)
Rostrum segment							
1	0.19 (0.03)	0.30 (0.03)	0.44 (0.09)	0.51 (0.05)	1.07 (0.12)	1.03 (0.16)	1.19 (0.14)
2	0.18 (0.06)	0.35 (0.07)	0.64 (0.09)	0.66 (0.11)	1.13 (0.17)	1.22 (0.16)	1.28 (0.16)
3	0.16 (0.06)	0.22 (0.04)	0.35 (0.05)	0.43 (0.10)	0.89 (0.16)	0.96 (0.11)	1.06 (0.14)
4	0.19 (0.04)	0.27 (0.06)	0.49 (0.10)	0.51 (0.04)	0.76 (0.11)	0.93 (0.17)	0.94 (0.11)
Total length	0.72 (0.16)	1.15 (0.14)	1.92 (0.27)	2.11 (0.13)	3.86 (0.29)	4.14 (0.30)	4.46 (0.31)
Femur length	0.42 (0.08)	0.63 (0.10)	1.19 (0.28)	1.33 (0.24)	2.73 (0.25)	3.22 (0.81)	3.37 (0.36)
Total leg length	1.09 (0.20)	1.58 (0.22)	2.92 (0.42)	3.81 (0.40)	7.23 (0.48)	7.80 (0.89)	8.22 (0.88)

[a]Length of each nymph and adult individual was measured from the tip of tylus to tip of abdomen.
[b]The pronotal width of adults was measured between the humeral spines.
[c]The width of the head was measured from the outer margins of the compound eyes.
[d]mm (±SD).

curve anteriorly, segments III-X curve posteriorly. Lateral margin of segments V and VI longest, lateral length of segments narrowing anteriorly and posteriorly. Segments IX and X not distinguishable on every individual. Abdomen orange with brown medial and lateral plates. Dorsal lateral plates semi-circular in shape (see Fig. 1C). Ventral lateral plates similar except one spiracle present on segments II-XIII, centrally located between midline and anterior margin, resulting in a small emargination in each lateral plate. One trichobothria present on segments III-VII, caudad to spiracle, resulting in an additional emargination in lateral plates on venter. Intersegmental sulcus, originating from center of each lateral plate on venter, extends transversely. Lateral plates decreasing in size posteriorly, those of segment I minute. Dorsal medial pattern varied. Most common pattern: brown transverse central band on suture between segments I and II, hourglass shaped plate centered on segments II and III, rectangular plate centered on segments III-V, semi-circle plate with arc towards apex centered on segment VI extending slightly onto segment V, a central oval macule on segments VII and VIII, segments IX and X completely brown (see Fig. 1B). Mediodorsal plates with three pairs of scent gland orifices and a visible connecting suture curving posteriorly (see Fig. 1B). Mediodorsal pattern size increases with each exuviation to next nymphal stage. Degree of expression of hourglass shaped plate decreases with each molt. In fully sclerotized nymphs, orange and brown colors change to red and black.

Second-Instar Nymph (Fig. 1B)

Oval, convex, widest at third abdominal segment. Head black, eyes dark red, similar in appearance to first-instar nymph. Antennal segments I,IV black, II,III gray, annuli white. Head shape and setae same as first-instar nymph.

Shape and coloration of thorax similar to first instar except as follows: Legs from coxa to tibia gray or brown with white annuli. Coxae black basally. Tarsal claws white, pulvilli gray to black. Length of pro- and mesothoracic segments equal medially, metathorax medially shorter than pro- and mesothoracic segments.

Abdominal shape and dorsal pattern same as first-instar nymph. Second ventral trichobothria present on segments III-VII lateral to first trichobothria. Abdominal sutures less distinct than in first instar and intersegmental sulci not visible. Medioventral plates vary by size, darkness, and number of black oval plates. Predominant medioventral plates dark red as follows: single large oval on segments I-IV, smaller oval on segments V and VI, third smaller oval on segments VII and VIII. Segments IX and X dark red.

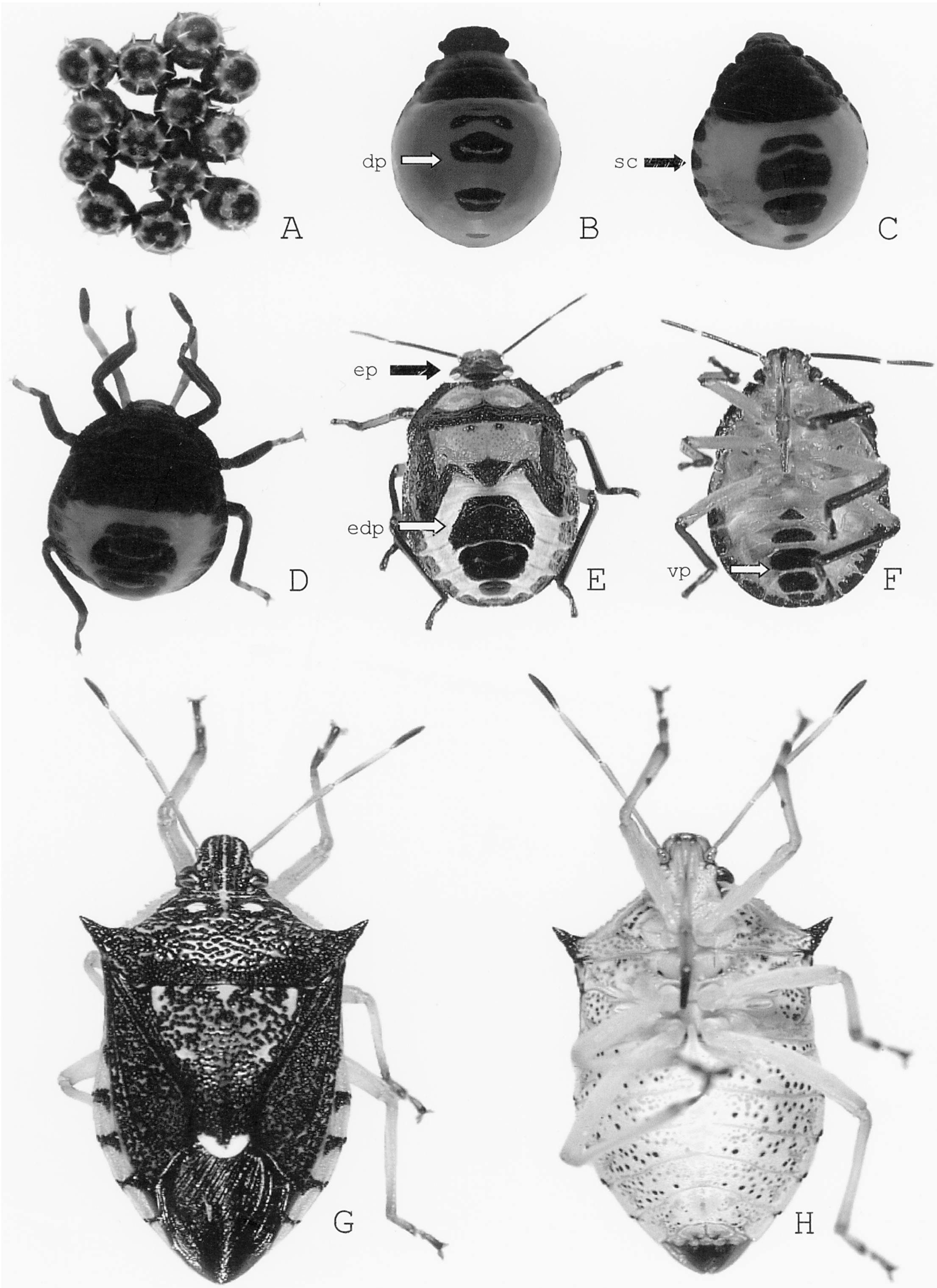

Fig. 1. *Podisus mucronatus* adults and instars. A, egg clutch; B, second instar dorsal view; C, third instar dorsal view; D, fourth instar dorsal view; E, fifth instar dorsal view; F, fifth instar ventral view; G, adult dorsal view; H, adult ventral view. *dp*, dorsal abdominal pattern; *edp*, expanded dorsal abdominal pattern; *ep,* eye pattern; *sc*, semicircle plate; *vp*, ventral abdominal pattern.

Third-Instar Nymph (Fig. 1C)

Oval, convex, widest at third abdominal segment. Head shape, setae, and color same as second-instar nymph. Thorax color similar to second-instar nymph, except tarsi vary in color from brown to gray.

Abdominal shape and patterns slightly different from second-instar. Longest lateral margin varies from segment V-VII. Dorsal abdominal sutures no longer visible, otherwise, dorsal and ventral pattern and coloration similar to second-instar.

Fourth-Instar Nymph (Fig. 1D)

Oval, convex, widest at second abdominal segment. Head shape and color similar to third-instar nymph. Last segment of rostrum dark brown, all others black. Ocelli dark red. Thorax similar to third-instar nymph except wing pads present on mesothoracic segment and median length of metathoracic segment shortened.

Abdominal morphology similar to third-instar nymph with few exceptions. A ventral intersegmental sulcus reappears, similar to first-instar nymph. Segment VIII with black ventral lateral pattern. Coloration of some nymphs vary from orange and black to red and black.

Fifth-Instar Nymph (Fig 1E, 1F)

Oval, convex, widest at third abdominal segment. Head shape consistent with fourth-instar nymph. Head color varying from red to black, base of head usually black. Eyes and ocelli red. Antennal segment I red to black depending on maturity, segment II gray to black, segments III and IV black, annuli white. Posterior portion of eye white in color and possibly lacking ommatidia (see eye pattern, Fig. 1E). Last rostral segment brown, remaining segments black.

Thorax color variable black, red or orange. Legs typically with coxa, trochanter, and femur red, tibia, tarsi and tarsal claws black, annuli white. Legs all black if entire thorax black. Ventral pattern as in fourth-instar nymph. Dorsal pattern differing from previous stages. Scutellum and wing pads evident. Wing pads extending approximately to end of abdominal segment III. Lateral margins of thorax serrate, black and flattened dorso-ventrally.

Abdominal shape and color same as fourth-instar nymph. All sutures and patterns more defined. Ventral patterns and dorsal patterns similar to fourth-instar nymph, but central dorsal pattern further expanded (see expanded dorsal pattern, Fig. 1E).

Adult Male

Shape elliptical, wider anteriorly, dorsally flattened, ventrally convex, widest between humeral spines. Head dorsally punctate. Punctures becoming more dense towards thorax, except for small white lateral area anterior to thorax. Head ventrally white to green with small punctures. Eyes red to dark red and similar to fifth-instar. Antennae 5-segmented, segments I-IV light brown, segment V brown, annuli tan. Rostrum 4-segmented, each segment, base to apex, increasingly darker from white and green to medium brown.

Thorax dorsally covered with dark brown punctation. Humeral spines dark brown and projecting forward (Thomas 1992). Anterolateral margins of pronotum serrate and green to yellow. Pronotum with 2 yellow cicatrices. Scutellum triangular, apex and basal angles white to yellow. Corium and clavus red with same dark punctures as thoracic dorsum, claval suture white. Hemelytral membrane light brown. Hindwing iridescent with brown venation. Thorax gray to brown punctured ventrally. Coxa, trochanter, femur, and tibia green with terminus of tibia brown. Three tarsal segments brown, tarsal claws dark brown, and pulvilli brown to dark brown. Protibia with brown spur two-thirds distance from apex to base. Legs setose, setae denser toward apex. Scent gland ostiole located on intercoxal region of metathoracic epimera. Ostiolar ruga white, yellow or green. A white, elliptical callus also occurs on sternum of mesothorax, anterior to mesocoxae.

Abdomen eight-segmented, length of segments medially equal except first, which is much shorter. Lateral margin of segment IV usually longest, lateral length of segments narrowing anteriorly and posteriorly. Ventrally, single spiracle on each side of segments III-VII. Sternum white to green, concolorously punctate laterally, punctures lacking medially. Tergum brown to red with small punctures. Connexiva green with larger punctures than tergum. Dorsal and ventral sutures light in color. Basal spine occurring ventrally on second abdominal segment and extending to middle of metasternum. Ventral posterior margin of male pygophore setose, setae most dense mesially.

Female Adult (Fig. 1G and 1H)

Female similar in shape but generally larger than male. Apex of eighth and ninth paratergites moderately setose, apex of first gonocoxae sparsely setose. Other characteristics similar to adult male.

Life History Parameters

Eggs collected from laboratory colonies were laid in parallel rows, creating circular or elliptical masses of 28.18 (±10.25) eggs per group. Eyespots were apparent under the pseudoperculum 1-2 days before eclosion. Rates of nymphal development differed significantly among diets (Table 2). When held with only moistened filter paper (Diet 1), three individuals (15%) survived to the second nymphal stage but did not develop further.

When held with moist filter paper and a freshly excised melaleuca tip (Diet 2), development of *P. mucronatus* was extended: 90% of those tested developed to the second nymphal stage and 15% of these successfully molted to the third nymphal stage (Table 2). Developmental times were similar for most within stage comparisons when held with prey, except second-instar nymphs held with *O. vitiosa*, which required approximately one additional day to molt into third-instar nymphs. When compared over the entire developmental period, individuals feeding on *T. molitor* developed faster than those on *O. vitiosa* (Table 2). Survivorship was similar among both prey diets, with 5% mortality occurring among fifth-instar nymphs regardless of prey. Differences in sex ratios were also observed between diets ($P = 0.04$, $F = 4.16$, df = 1,37). Nymphs reared with *T. molitor* larvae were male biased (74:26; ♂:♀; $\chi^2 = 4.26$, $P = 0.039$) whereas those reared with *O. vitiosa* were not (53:47; $\chi^2 = 0.053$, $P = 0.819$). The interval between last nymphal molt and first mating for females was 2.67 (±0.71) days. Under laboratory conditions, females began ovipositing 4.75 (±0.39) days after mating.

Discussion

Generalist predators are integral components of most natural ecosystems due to their abilities to regulate population densities of lower trophic levels in the absence of specialist predators (McMurtry 1992, Chang & Kareiva 1999, Hagen et al. 1976). However, rarely have trophic level interactions of generalist predators and their prey been reported for unmanaged systems (Chang & Kareiva 1999). One explanation for the paucity of studies concerning generalist predators may be related to a limited knowledge of their identity and life history traits, specifically in immature stages. The predaceous pentatomid *P. mucronatus*, for instance, is widely distributed in south Florida. To date the immature stages have never been described. The descriptions provided herein should facilitate future research on predator-prey interactions with *P. mucronatus*.

Morphological characteristics described herein are useful for distinguishing various life stages of *P. mucronatus* from other commonly occurring *Podisus* species, specifically *P. maculiventris* and *P. sagitta* (Fab.). For instance, *P. mucronatus* eggs possess 7-11 ($\bar{x} = 8.25$, ±0.90) micropylar processes compared to 13-16 on eggs of *P. maculiventris* and *P. sagitta* (De Clercq & Degheele 1990). Nymphal stages 1-4 of both *P. sagitta* and *P. maculiventris* exhibit distinctive orange and white patterns on the abdominal tergum, which are not present in *P. mucronatus* (De Clercq & Degheele 1990, DeCoursey & Esselbaugh 1962). Unlike *P. sagitta* or *P. maculiventris*, adult *P. mucronatus* possess 3 distinctive white callused spots on the scutellum and forward projecting humeral spines (Thomas 1992).

Consistent with other predatory pentatomids, *P. mucronatus* successfully completed the first nymphal stage in the absence of prey, although individuals were observed imbibing free water from the filter paper or from condensation in the petri dish. Without prey, survivorship from second to third nymphal-instars was 0% when reared with only filter paper and 15% when reared with a fresh *M. quinquenervia* bud. These findings suggest that the presence of *M. quinquenervia* foliage increased nymphal survivorship but it remains unclear if this is related to facultative plant feeding or to an increase in relative humidity from the vegetation within the arena. Not surprisingly, survivorship increased to 95% in the presence of either coleopteran diet (Table 2).

When compared between prey diets, total development time was slower with *O. vitiosa* larvae than with *T. molitor* larvae (Table 2). One explanation for this may pertain to the antipredatory activity of the viscous coating that covers imma-

Table 2. Developmental rates and survivorship of *Podisus mucronatus* when reared under differing dietary regimes.

Diet[a]	Duration (days) of nymphal stages: mean (SD)					Total	Survivorship
	1	2	3	4	5		
1	1.00 (0.00) b[b]	—	—	—	—	—	0.00 a
2	0.95 (0.22) ab	2.33 (0.58) ab	—	—	—	—	0.00 a
3	0.70 (0.47) a	3.65 (1.18) a	2.45 (0.76)	2.55 (0.69)	3.87 (0.69)	13.60 (1.88) a	0.95 b
4	0.90 (0.45) ab	2.70 (0.66) b	2.35 (0.59)	2.35 (1.18)	4.00 (0.56)	12.30 (1.59) b	0.95 b
P-value	0.04[c]	0.01	0.64	0.52	0.80	0.02	<0.00

[a]Diets consisting of: 1) moistened filter paper only, 2) diet 1 plus the addition of a *M. quinquenervia* tip, 3) diet 2 plus a single *O. vitiosa* larva (2-3 instar) or 4) diet 2 plus a 2-4[th] *T. molitor* larval instar.

[b]Student-Newman-Keuls all pairwise multiple comparison procedure (SigmaStat 1995).

[c]One-way ANOVA.

ture stages of *O. vitiosa* (Purcell & Balciunas 1994). Montgomery & Wheeler (2000), for instance, demonstrated that larvae covered with this coating were repellent to the red imported fire ant, *Solenopsis invicta* Buren. While *P. mucronatus* readily attacks *O. vitiosa* larvae under field conditions, it is unclear whether this larval coating influences development of nymphs.

When comparing immature developmental rates with those of other *Podisus* species, *P. mucronatus* (11-18 d at 25°C) appears to have a shorter developmental time than *P. maculiventris* (25-31 d at 27°C), *P. placidus* (33.1 d at 27°C) and *P. sagitta* (18-32 d at 23°C) (De Clercq & Degheele 1990). DeBach (1964) suggests that a short developmental time is a desirable characteristic of insect biological control agents. Assuming differences in developmental times are not due to prey suitability or experimental design, rates of population increase for *P. mucronatus* may be higher than those *Podisus* species commonly introduced for pest suppression in other agroecosystems. These findings suggest that *P. mucronatus* may be a useful biological control agent of pest coleopteran and lepidopteran larvae.

Podisus mucronatus has been observed as the most common predator associated with the weed biological control agent, *O. vitiosa*. Our laboratory-based data suggested that *P. mucronatus* readily feeds and completes development when provided *O. vitiosa* prey. However, it remains unclear if *P. mucronatus* regulates populations of this weed biological control agent under field conditions, and what impact this predation has on weed suppression. Future studies will focus on assessing the association, predator-prey interactions and population dynamics of this native pentatomid and the introduced herbivore.

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References Cited

ALDRICH, J. R. 1986. Seasonal variation of black pigmentation under the wings in a true bug (Hemiptera:Pentatomidae): a laboratory and field study. Proc. Entomol. Soc. Wash. 88(3):409-421.

ALDRICH, J. R., J. P. KOCHANSKY, W. R. LUSBY, AND M. BORGES. 1991. Pheromone blends of predaceous bugs (Heteroptera: Pentatomidae: *Podisus* spp.) Z. Naturforsch. 46c: 264-269.

CENTER, T. D., T. K. VAN, M. RAYACHHETRY, G. R. BUCKINGHAM, F. A. DRAY, S. WINERITER, M. F. PURCELL, AND P. D. PRATT. 2000. Field colonization of the melaleuca snout beetle (*Oxyops vitiosa*) in South Florida. Biological Control 19: 112-123.

CHANG, G. C., AND P. KAREIVA. 1999. The case for indigenous generalists in biological control, pp. 103-115. *In* B. Hawkins and H. V. Cornell [eds.], Theoretical Approaches to Biological Control. Cambridge Univ. Press, London 412 pp.

DEBACH. 1964. Biological Control by Natural Enemies. Cambridge University Press, Cambridge 323 pp.

DE CLERCQ, P., AND D. DEGHEELE. 1990. Description and life history of the predatory bug *Podisus sagitta* (FAB.) (Hemiptera: Pentatomidiae). Can. Ent. 122: 1149-1156.

DE CLERCQ, P. 2000. Podisus online. http://allserv.rug.ac.be/~padclerc/ Last updated: May, 4 2000.

DECOURSEY, R. M., AND C. O. ESSELBAUGH. 1962. Descriptions of the nymphal stages of some North American Pentatomidae (Hemipera-Heteroptera). Ann. Ent. Soc. Amer. 55: 323-342.

DRUMMOND, F. A., R. L. JAMES, R. A. CASAGRANDE, AND H. FAUBERT. 1984. Development and survival of *Podisus maculiventris* (Hemiptera: Pentatomidae), a predator of the Colorado potato beetle (Coleoptera: Chrysomelidae). Environ. Entomol. 13: 1283-1286.

GENUNG, W. G. 1959. Notes on the syntomid moth *Lymire edwardsi* (Grote) and its control as a pest of *Ficus* in south Florida. Florida Entomol. 42: 39-42.

GENUNG, W. G., E. GREEN, JR., AND C. WELBERG. 1964. Inter-relationship of stinkbugs and diseases to Everglades soybean production. Proc. Soil Crop Sci. Soc. Florida 24: 131-137.

HAGEN, K. S., S. BOMBOSCH, AND J. A. MCMURTRY. 1976. The biology and impact of predators, pp. 93-142. *In* C. B. Huuaker and P. S. Messenger [eds.], Theory and Practice of Biological Control. Academic Press, New York 788 pp.

LEGASPI, J. C., AND R. J. O'NEIL. 1993. Life history of *Podisus maculiventris* given low numbers of *Epilanchna varivestis* as prey. Environ. Entomol. 22(5): 1192-1200.

LEGASPI, J. C., AND R. J. O'NEIL. 1994. Developmental response of nymphs of *Podisus maculiventris* (Heteroptera: Pentatomidae) reared with low numbers of prey. Environ. Entomol. 23(2): 374-380.

MCMURTRY, J. A. 1992. Dynamics and potential impact of 'generalist' phytoseiids in agroecosystems and possibilities for establishment of exotic species. Exp. Appl. Acarol. 14: 371-382.

MONTGOMERY, B. R., AND G. S. WHEELER. 2000. Antipredatory activity of the weevil *Oxyops vitiosa*: a biological control agent of *Melaleuca quinquenervia*. J. Ins. Behav. 13 (6): 915-926.

PURCELL AND BALCIUNAS. 1994. Life history and distribution of the Australian weevil *Oxyops vitiosa*, a potential biological control agent for *Melaleuca quinquenervia*. Ann. Entomol. Soc. Amer. 87: 867-873.

SIGMASTAT 1995. Version 2.0, Jandel Corporation.

STAMOPOULOS, D. C., AND A. CHLORIDIS. 1994. Predation rates, survivorship and development of *Podisus maculiventris* (Het.: Pentatomidae) on larvae of *Leptinotarsa decemlineata* (Col.: Chrysomelidae) and *Pieris Brassicae* (Lep.: Pieridae), under field conditions. Entomophaga 39(1): 3-9.

THOMAS, D. B. 1992. Taxonomic Synopsis of the Asopine Pentatomidae (Heteroptera) of the Western Hemisphere. Entomol. Soc. Amer., Lanham, MD. 156 pp.