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Authors: França, Solange Maria de, Júnior, Luiz Carlos de Melo, Neto, Antônio Viera Gomes, Silva, Paulo Roberto Ramalho, Lima, Élison Fabrício Bezerra, et al.

Source: Florida Entomologist, 101(4) : 688-691

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.101.0408

Natural enemies associated with *Phaseolus lunatus* L. (Fabaceae) in Northeast Brazil

Solange Maria de França[1,], Luiz Carlos de Melo Júnior[1], Antônio Viera Gomes Neto[1], Paulo Roberto Ramalho Silva[1], Élison Fabrício Bezerra Lima[2], and José Wagner S. Melo[3]*

Lima bean (*Phaseolus lunatus* L. (Fabaceae) is an important legume species for human consumption in tropical regions (Bitocchi et al. 2017). Its seeds are important sources of protein for the populations of South America, Africa, and Mexico (Araújo et al. 2015). There are few studies on phytophagous insects related to *P. lunatus* in Brazil. Generally, in South America insect pests are a limiting factor adversely affecting the agricultural production of Fabaceae, especially in genus *Phaseolus*. For example, *Aphis craccivora* Koch (Hemiptera: Aphididae), as well as the phytophagous mites *Eutetranychus banksi* (McGregor) (Acari: Tetranychidae) and *Tetranychus urticae* Koch (Acari: Tetranychidae) (Coceano et al. 1998; Mendonça et al. 2011) have been reported to severely affect the production of several bean species.

A number of studies on natural enemies associated with phytophagous pests of *P. lunatus* have been reported in the world literature; examples include the predatory mites *Phytoseiulus persimilis* (Acari: Phytoseiidae) in the USA and *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Acari: Phytoseiidae) in China (Bancroft & Margolies 1999; Sarwar 2014), the predatory stink bug *Podisus maculiventris* (Say) (Hemiptera: Pentatomidae) and a eulophid wasp, *Pediobius foveolatus* (Crawford) (Hymenoptera: Eulophidae) (Nottingham et al. 2016), in the USA. Currently, there is little biological information on the occurrence of natural enemies associated with phytophagous insect pests on lima beans from South America. Here we report on our efforts to document the parasites and predators on this agronomic crop in the state of Piauí, in northeastern Brazil, as well as providing information on their bioecology and trophic interactions.

Weekly leaf samples were collected during May through Sep 2016 in experimental lima bean fields located at the Department of Plant Science, Agricultural Sciences Center, Federal University of Piauí (Socopo campus), Teresina, Piauí. A total of 200 plants were sampled for the entire study (10 leaves per sample). Mites, thrips, syrphids, and coccinellids were collected from excised leaves; when thrips were observed in the fields, a 30-min manual sample effort was performed. In addition, lima bean plants were sampled in an infested greenhouse. Parasitized aphids (mummies) were removed from leaves using a probe and placed individually in Petri dishes for the emergence of parasitoids. Predatory mites were mounted on microscope slides using Hoyer's medium and identified using the morphological identification keys of Chant and McMurtry (2007), Moraes et al. (1986), and Moraes et al. (2004) using a phase contrast microscope (400×) (Brand Olympus Model BX41, St. Louis, Missouri, USA). Once parasitoids emerged, they were placed in 70% alcohol and sent for identification by Dr. Marcus Vinicius Sampaio (Federal University of Uberlândia, Uberlândia, Minas Gerais, Brazil). Syrphidae larvae were removed with a brush, placed in flat bottom tubes, 8.5 cm H × 2.5 cm, and reared at 25 ± 1 °C, relative humidity of 70 ± 10%, and 12:12 h (L:D) photoperiod. Nymphs of the aphid *Aphis craccivora* Koch (Hemiptera: Aphididae) were offered ad libitum to larvae of the predator until they reached the pupal stage. Adult syrphids were stored in alcohol at 70% and sent for identification by Gil Felipe Gonçalves Miranda (Laboratory of Systematic, Urban and Forensic Entomology, National Institute of Amazonian Research, Manaus, Amazonas, Brazil).

The following predatory arthropods were recovered from leaf samples: *Scymnus* (*Pullus*) *rubicundus* Erichson (Coccinellidae: Scymninae), *Pseudodorus clavatus* (F.) (Diptera: Syrphidae: Syrphinae), as well as their prey, *A. craccivora*. *Aphelinus* sp. (Hymenoptera: Aphelinidae) was reared from the aphid *A. craccivora*. *Franklinothrips vespiformis* (Crawford) (Thysanoptera: Aeolothripidae) was reared from *Tetranychus neocaledonicus* André (Acari: Tetranychidae) and *Caliothrips phaseoli* (Hood) (Thysanoptera: Thripidae) (Table 1).

Table 1. Natural enemies collected with phytophagous insects on lima bean (*Phaseolus lunatus*) in northeastern Brazil.

Natural enemies	Associated phytophagous arthropods
Scymnus (*Pullus*) *rubicundus* Erichson (Coccinellidae: Scymninae) *Pseudodoros clavatus* (Fabricius) (Diptera: Syrphidae: Syrphinae) *Aphelinus* sp. (Hymenoptera: Aphelinidae)	*Aphis craccivora* Koch (Hemipetra: Aphididae)
Franklinothrips vespiformis (Crawford) (Thysanoptera: Aeolothripidae)	*Tetranychus neocaledonicus* André (Acari: Tetranychidae) *Caliothrips phaseoli* (Hood) (Thysanoptera: Thripidae)
Euseius concordis (Chant) (Acari: Phytoseiidae) *Amblyseius tamatavensis* Blommer (Acari: Phytoseiidae) *Proctolaelaps bickleyi* Bram (Acari: Ascidae)	*T. neocaledonicus*

[1]Programa de Pós-Graduação em Agronomia-Agricultura Tropical, Agricultural Science Center-Entomology, Universidade Federal do Piauí, Campus Universitário Ministro Petrônio Portella, Teresina, Piauí, 64049-550, Brazil; E-mail: solangeufrpe@yahoo.com.br (S. M. F.); luizcarlos.melo@ifpi.edu.br (L. C. M. J.); netoagronomia@gmail.com (A. V. G. N.); pramalhoufpi@yahoo.com.br (P. R. R. S.)
[2]Campus Amilcar Ferreira Sobral, Universidade Federal do Piauí, Floriano, Piauí, 64808-605, Brazil; E-mail: efblima@ufpi.edu.br (E. F. B. L.)
[3]Center of Agricultural Sciences, Department of Plant Science, Universidade Federal do Ceará, Fortaleza, 60020-181, Brazil; E-mail: wagnermelo@ufc.br (J. W. S. M.)
*Corresponding author; E-mail: solangeufrpe@yahoo.com.br

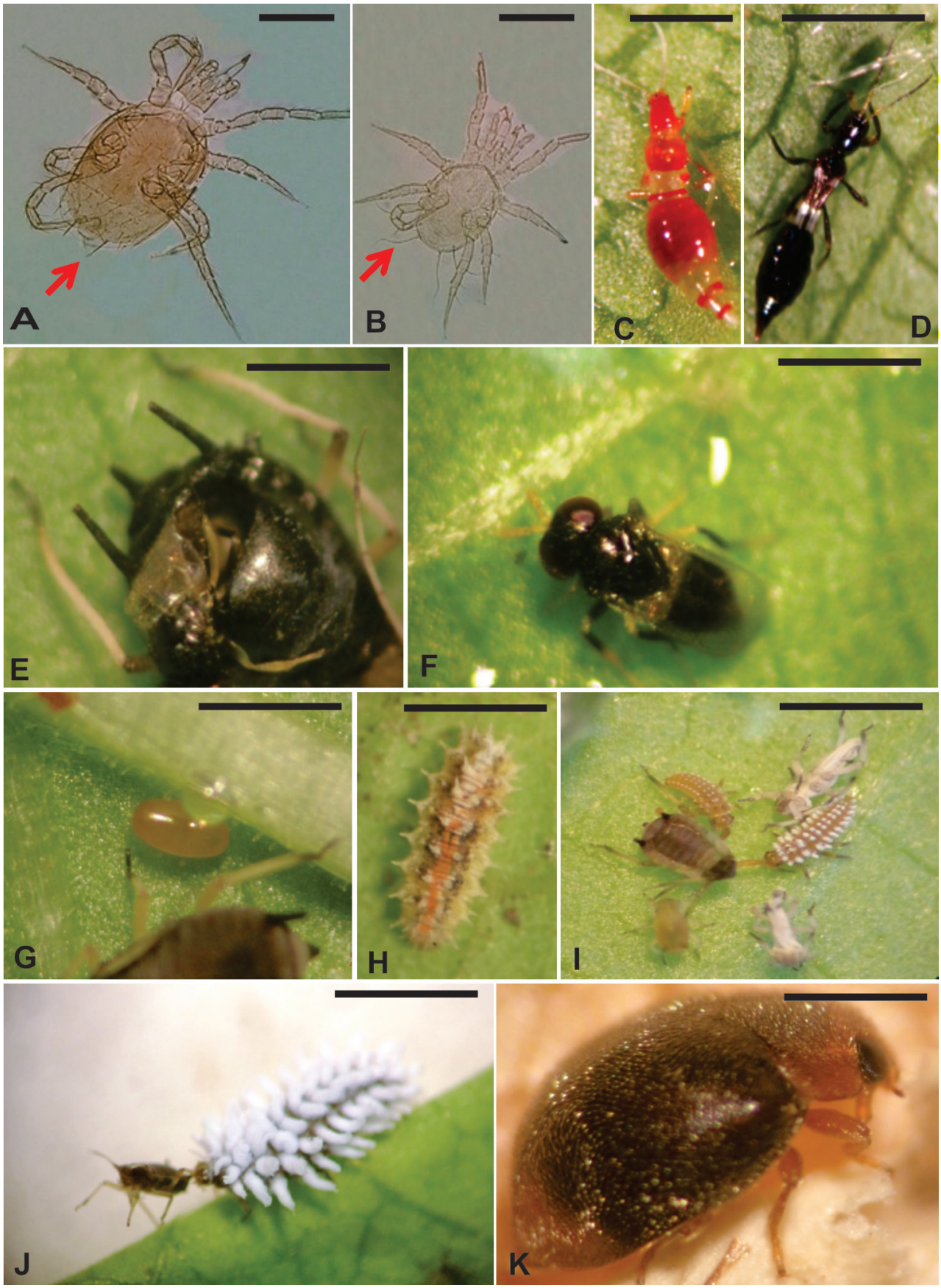

Fig. 1. (A) *Proctolaelaps bickleyi*; (B) *Amblyseius tamatavensi* male, highlight for the long arrows; (C–D) *Franklinothrips vespiformis*; (E) emergence of *Aphelinus* sp. parasitizing *Aphis craccivora*; (F) *Aphelinus* sp. adult; (G) *Pseudodorus clavatus* larva; (H) *Scymnus* (*Pullus*) *rubicundus* egg; (I) *S. rubicundus* larva at different instars; (J) larva feeding on *A. craccivora*; (K) *S. rubicundus* adult.

Franklinothrips vespiformis, and its prey *C. phaseoli*, were collected from lima bean plants. The occurrence of both species on *P. lunatus* provides new information regarding their ecological association in this habitat. It is also the first report of this predator on lima bean since thrips surveys were conducted by Lima and Zucchi (2016) on fabaceous plants and weeds in northeastern Brazil. Earlier, Sampaio et al. (2009) had reported that *F. vespiformis* was collected from *P. vulgaris* (common beans). On the other hand, *C. phaseoli* is widely distributed in Brazil, and can be found on *Macroptilium lathyroides* (L.) Urb (Fabaceae) (Lima & Zucchi 2016), common beans (Jesus et al. 2010), and soybeans (Link et al. 1981).

In our study, the presence of *Pseudodorus clavatus* (F.) (Diptera: Syrpidae) feeding on *A. craccivora* on bean plants also was observed. Larvae of *P. clavatus* have a high efficiency in the predation of *A. craccivora*, besides being considered the most abundant and important syrphid predator in South America (Auad 2003). This predator occurs in several agronomic crops, such as citrus, cabbage, cucumber, and wheat, and may be associated with other aphid pests, e.g., *Toxoptera citricidus* (Kirkaldy), *Brevicoryne brassicae* (L.) (Hemiptera: Aphididae), *Aphis gossypi* (Glover) (Hemiptera: Aphididae), *A. spiraecola* (Patch) (Hemiptera: Aphididae), *Myzus persicae* (Sulzer) (Hemiptera: Aphididae), and *B. brassicae* (L.) (Hemiptera: Aphididae) (Auad & Trevizani 2005; Bächtold & Del-Claro 2013; De La Pava & Sepulveda-Cano 2015).

The predatory mites *Euseius concordis* (Chant) (Acari: Phytoseiidae), *Amblyseius tamatavensis* Blommer (Acari: Phytoseiidae), and *Proctolaelaps bickleyi* Bram (Acari: Ascidae) were collected together feeding on *T. neocaledonicus* (Fig. 1). *Amblyseius tamatavensis* proved to be the most abundant mite in our collections. This is the first report in Brazil of the natural occurrence of these 3 mite species on lima beans.

In summary, there is potential for natural enemies to be used in the management of phytophagous pests in lima bean production in Brazil. Further research on the ecological relationships of these various predators, parasites, with phytophagous pests found on *P. lunatus* is needed including, but not limited to, characterizing their bionomic attributes, preferences, and ultimate effectiveness in the field at reducing crop damage.

The authors thank the Coordination for the Improvement of Higher Education Personnel for the scholarship granted; to the scientific initiation fellow Clovyedson da Silva Pereira for the help in obtaining the images of the mites; to Lúcia Massutti de Almeida (Department of Zoology, Federal University of Paraná) for identification of predatory beetles, and to Marcus Vinicius Sampaio (Federal University of Uberlândia) for identification of Hymenoptera parasitoids.

Summary

In Brazil, characterization of the natural occurrence of insect predators and parasites affecting phytophagous pests of *Phaseolus lunatus* is limited. Our objective was to identify which natural enemies were present in lima bean fields in northeast Brazil. Also, this is the first report of the natural occurrence of thrips and mite predators on lima bean. The following species were identified as predators of *Aphis craccivora*: *Scymnus rubicundus* (Coccinelidae), *Pseudodoros clavatus* (Syrphidae), as well as the parasitoid *Aphelinus* sp. (Aphelinidae). In addition, *Franklinothrips vespiformis* (Aeolothripidae) was collected along with its prey, the phytophagous mite *Tetranychus neocaledonicus*, and the phytophagous thrips *Caliothrips phaseoli*. Predatory mites were identified as *Euseius concordis* (Phytoseiidae), *Proctolaelaps bickleyi* (Ascidae), and *Amblyseius tamatavensis* (Phytoseiidae). These 3 mite species were observed to prey on *T. neocaledonicus* and represents the first report of these predators occurring on *P. lunatus* in Brazil.

Key Words: Lima bean; parasitoid; predators; phytophagous

Sumário

No Brasil, a caracterização da ocorrência natural de insetos predadores e parasitas sobre insetos fitófagas de *Phaseolus lunatus* é escassa. Nosso objetivo foi identificar quais inimigos naturais estavam presentes em cultivo de fava no nordeste brasileiro. Além disso, este é o primeiro relato da ocorrência natural de tripes e ácaros predadores em fava. As seguintes espécies foram identificadas como predadoras de *Aphis craccivora*: *Scymnus rubicundus* (Coccinelidae), *Pseudodoros clavatus* (Syrphidae), bem como o parasitoide *Aphelinus* sp. (Aphelinidae). Além do mais, *Franklinothrips vespiformis* (Aeolothripidae) foi coletado juntamente com suas presas, o ácaro fitófago *Tetranychus neocaledonicus* e o tripes fitófago *Caliothrips phaseoli*. Ácaros predadores foram identificados como *Euseius concordis* (Phytoseiidae), *Proctolaelaps bickleyi* (Ascidae) e *Amblyseius tamatavensis* (Phytoseiidae). Essas três espécies de ácaros foram observadas predando *T. neocaledonicus* e servem como o primeiro relato desses predadores ocorrendo em *P. lunatus* no Brasil.

Palavras Chaves: Feijão fava, parasitoide, predatores, fitófagos

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