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Temporal prevalence of insect pests on walnut (*Juglans regia* L.) and their associated natural enemies under temperate conditions of Kashmir

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Abstract
The field experiment on "Temporal Prevalence of pests of Walnut (*Juglans regia* L.) and their associated Natural Enemies" was conducted at Faculty of Agriculture, Wadura during 2020 to record various pests infesting walnut and their associated natural enemies. The results revealed that eight insect pest species and one non-insect pest species infested walnut crop. Among eight insect pest species, four insect pests *viz*., walnut aphid, *Chromaphis juglandicola*, dusky-veined aphid, *Panaphis juglandis*, capsid bug, *Megacoelum stramineum* and stink bug, *Apodiphus pilipes* were sucking pests, out of which three insect pests (*P. juglandis*, *C. juglandicola* and *M. stramineum*) belong to order Hemiptera and family Aphidae; one pest (stink bug) belong to order Hemiptera, family Pentatomidae; four insect pests *viz*., grey weevil (*Myllocerus viridanus*), green leaf weevil (*Polydrusus formosus*), flea beetle (*Altica himensis*) and walnut blue butterfly (*Chaetoprocta odata*) were defoliators, among them three (grey weevil, green leaf weevil and flea beetle) belong to order Coleoptera and family Curculionidae while as one insect pest (walnut blue butterfly) belong to order Lepidoptera, family Lycaenidae; one non-insect pest *viz*., blister mite (*Eriophyes erinea*) belong to order Acari, family Eriophyidae was sucking pest. With regards to natural enemies, the study revealed that nine species of natural enemies (predators) *viz*., pink ladybird beetle (*Coleomegilla maculata*), seven-spotted lady beetle (*Coccinella septempunctata*), two spotted lady beetle (*Adalia bipunctata*), spotted lady beetle (*Coleomegilla maculata*), convergent lady beetle (*Hippodamia convergens*), multi colored Asian lady beetle (*Harmonia axyridis*), green lacewing (*Chrysoperla carnea*), syrphid fly (*Sphaerophoria philanthus*) and predatory mite (*Phytoseiulos* sp.) were found associated with pests of walnut. Among them six natural enemies (predators) *viz*., *C. maculata*, *C. septempunctata*, *A. bipunctata*, *C. maculata*, *H. convergens* and *H. axyridis* belong to order Coleoptera, family Coccinellidae; two natural enemies *viz*, *C. carnea* and *S. philanthus* belong to order Hemiptera, family Miridae and order Diptera; family Syrphidae, respectively; one predatory mite, *Phytoseiulos* sp. belong to order Acari, family Phytoseiidae.

Keywords: Natural enemies, predators, walnut aphid, walnut pests

Introduction
Walnut (*Juglans regia* L.) is the most widespread tree nut in the world. It belongs to genus *Juglans* and family Juglandaceae (Ogunmoyole *et al.*, 2011) [8]. China ranks number one in walnut production throughout the world with production of 1439127.93 MT followed by US (Anonymous, 2018 a) [2]. India is the 8th largest producer of walnut in the world with production of 299.71 MT and Western Himalayan region of India produces high quality walnuts. The major walnut growing states of India include Uttarakhand, Himachal Pradesh, Arunachal Pradesh and UT of Jammu and Kashmir. Walnut is grown on 85.62 hectares in Jammu and Kashmir, with a yield of 275.45 MT, which is the most in the country when compared to other states (Anonymous, 2018 b) [3]. Jammu and Kashmir UT is having almost a monopoly in growing dry fruits like walnut. There are numerous insect pests associated with walnuts that have been reported from all over the world, inflicting severe harm to walnut trees and walnut products. Although there are various insect pests reported on walnut in Kashmir valley but among them walnut weevil, stem borer, hairy caterpillar, walnut aphid, dusky-veined aphid, leaf roller, gypsy moth, bark beetle, walnut blister mite and tortrix moth present a severe threat and cause considerable economic damage to the plant and their attack thus reduce quality as well as quantity of walnuts (Anonymous, 2011) [4]. Like in traditionally cultivated giant and isolated walnut trees, there are also apprehensions of pests and other diseases which may destroy the plant under regular orchard conditions.

Materials and Methods

The investigations on "Studies on Pest Complex of Walnut (*Juglans regia* L.)" were carried out at Faculty of Agriculture, SKUAST-K Wadura, situated at an altitude of 1,610 meters above mean sea level between 34°20 North Latitude and 74°24 East Longitude on nine year old established walnut orchard during cropping season 2020. The experiment was carried out on the Walnut plantation comprised of different selections at Faculty of Agriculture, SKUAST-K, Wadura. Different pests and natural enemies were recorded for which field visits were carried at weekly intervals on 10 randomly selected plants from the first week of April to the last week of October, 2020. The pests and natural enemies noticed were collected, processed to get their correct identification. For identification purposes, immature stages of pests and natural enemies were also reared in cages under laboratory conditions until adults emerged and where identified using suitable procedure

Results and Discussion

Pest complex of walnut

Different walnut pests in compact/regular orchard at FoA, Wadura were recorded for which field visits were carried at weekly intervals on 10 randomly selected plants from April to October. The results indicated that the walnut orchard was infested by the insect pests/mites at different growth stages. The observations on various pests associated with walnut presented in Table-1 revealed that eight insect pest species and one non-insect pest species infested walnut crop at Faculty of Agriculture, Wadura during 2020. Among eight insect pest species, four insect pests *viz*., walnut aphid (*Chromaphis juglandicola*), dusky-veined aphid (*Panaphis juglandis*), capsid bug (*Megacoelum stramineum*), and stink bug (*Apodiphus pilipes*) were sucking pests, out of which three insect pests (walnut aphid, dusky-veined aphid and capsid bug) belong to order Hemiptera, family Aphidae, one insect pest (stink bug) belong to order Hemiptera, family Pentatomidae; four insect pests *viz*., grey weevil (*Myllocerus viridanus*), green leaf weevil (*Polydrusus formosus*), flea beetle (*Altica himensis*) and walnut blue butterfly (*Chaetoprocta odata*) were defoliators, among them three (grey weevil, green leaf weevil and flea beetle) belong to order Coleoptera, family Curculionidae, one insect pest (walnut blue butterfly) belong to order Lepidoptera, family Lycaenidae; one non-insect pest *viz*., blister mite (*Eriophyes erinea*) was reported as sucking pest belonging to order Acari, family Eriophyidae. During present studies, three insect pests *viz*., walnut aphid (*Chromaphis juglandicola*), dusky-veined aphid (*Panaphis juglandis*), grey weevil (*Myllocerus viridanus*) and one non-insect pest blister mite (*Eriophyes erinea*) were found as major pests causing serious damage to the walnut foliage, while as the other five insect pests *viz*., capsid bug (*Megacoelum stramineum*), stink bug (*Apodiphus pilipes*), green leaf weevil (*Polydrusus formosus*), walnut blue butterfly (*Chaetoprocta odata*) and flea beetle (*Altica himensis*) were recorded as minor pests (Plate 1 and 2). Uwais *et al*. (2013) [9] also reported seven pest species on walnut trees in China including Chromaphis juglandicola (Kaltenbach), *Apocheima cinerarius* (Erschoff), *Eulecanium giganteum* (Shinji) and *Eulecanium kuwanai*. The findings of Akkopru *et al*. (2015) [1] who reported that walnut aphid, *Chromaphis juglandicola* is a serious pest of English walnut, reducing tree vigor, nut size, yield and quality are in line with our results. The results of Khan and Khundoo (2018) [5] who reported that the major pests of walnut in Kashmir include aphids and mites are in close conformity with our results.

Table 1: Different pests observed on walnut (*Juglans regia* L.)

S. No.	Common name	Scientific name	Order: Family	Period of activity
	Sucking pest			
1	Walnut aphid	*Chromaphis juglandicola*	Hemiptera: Aphidae	Apr- Oct
2	Dusky-veined walnut aphid	*Panaphis juglandis*	Hemiptera: Aphidae	Apr- Oct
3	Capsid bug	*Megacoelum stramineum*	Hemiptera: Miridae	Apr- Oct
4	Stink bug	*Apodiphus pilipes*	Hemiptera: Pentatomidae	Apr- Oct
	Defoliators			
5	Grey weevil	*Myllocerus viridanus*	Coleoptera: Curculionidae	May –Aug
6	Green leaf weevil	*Polydrusus formosus*	Coleoptera: Curculionidae	May –Aug
7	Flea beetle	*Altica himensis*	Coleoptera: Chrysomelidae	May –Aug
8	Walnut blue butterfly	*Chaetoprocta odata*	Lepidoptera: Lycaenidae	May –Aug
	Non insect pest			
9	Blister mite	*Eriophyes erinea*	Acari: Eriophyidae	Apr-Oct

Natural enemies associated with walnut pests

For recording natural enemies, field visits were carried out at weekly intervals from April to October on 10 randomly selected plants. The data presented in Table-2 revealed the presence of nine species of natural enemies (predators) *viz*., pink ladybird beetle (*Coleomegilla maculata*), seven-spotted lady beetle (*Coccinella septempunctata*), two spotted lady beetle (*Adalia bipunctata*), spotted lady beetle (*Coleomegilla maculata*), convergent lady beetle (*Hippodamia convergens*), multi colored Asian lady beetle (*Harmonia axyridis*), green lacewing (*Chrysoperla carnea*), syrphid fly (*Sphaerophoria philanthus*) and predatory mite (*Phytoseiulos* sp) associated with walnut pests. Among them, six natural enemies (predators) *viz*., pink ladybird beetle (*Coleomegilla maculata*), seven-spotted lady beetle (*Coccinella septempunctata*), two spotted lady beetle (*Adalia bipunctata*), spotted lady beetle (*Coleomegilla maculata*), convergent lady beetle (*Hippodamia convergens*), multi colored asian lady beetle (*Harmonia axyridis*) belong to order Coleoptera, family Coccinellidae; two natural enemies *viz* green lacewing (*Chrysoperla carnea*) and syrphid fly (*Sphaerophoria philanthus*) belong to order Hemiptera, family Miridae and order Diptera, family Syrphidae, respectively; one predatory mite, *Phytoseiulos* sp. belong to order Acari, family Phytoseiidae (Plate 3). The results further revealed that among all the recorded natural enemies, the most diverse species of lady bird beetles were found. Our findings were supported by the findings of Flint (2014) [7] who during his investigations found that lady beetles are voracious aphid feeders. Atlihan *et al*. (2015) [1] reported in Turkey commonly observed predators and parasitoids including *Chrysoperla carnea*, *Orious majuscules*, *Anthocoris nemorum*, and

Hemerobius humulinus of Hemiptera, *Adalia fascioptera*, *Oenopia* sp., *Hippodomia variegate*, *Adalia bipunctata* and *Scymnus rubromaculatus* of Coloeptera as predators and *Trioxy spallidus* of Hymenoptera as parasitoid, which largely support our findings.

Table 2: Different natural enemies associated with walnut (*Juglans regia* L.) pests

S. No.	Common name	Scientific name	Order: Family
1	Pink ladybird beetle	*Coleomegilla maculata*	Coleoptera: Coccinellidae
2	Seven-spotted ladybeetle	*Coccinella septempunctata*	Coleoptera: Coccinellidae
3	Two-spotted lady beetle	*Adalia bipunctata*	Coleoptera: Coccinellidae
4	Spotted lady beetle	*Coleomegilla maculata*	Coleoptera: Coccinellidae
5	Multi colored Asian lady beetle	*Harmonia axyridis*	Coleoptera: Coccinellidae
6	Convergent ladybeetle	*Hippodamia convergens*	Coleoptera: Coccinellidae
7	Green lacewing	*Chrysoperla carnea*	Hemiptera: Miridae
8	Syrphid fly	*Sphaerophoria philanthus*	Diptera: Syrphidae
9	Predatory mite	*Phytoseiulos* sp.	Acari: Phytoseiidae

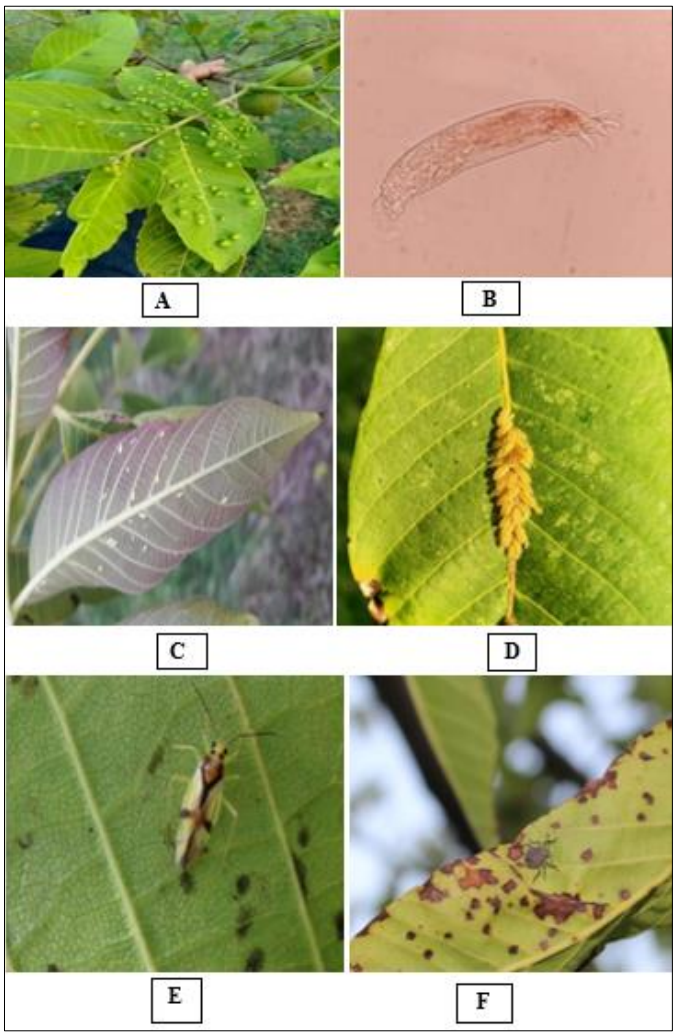

Plate 1: Sucking pests of walnut
A. Galls caused by blister mites B. Microscopic view of blister mite, *Eriophyes erinea* C. Walnut aphid, *Chromaphis juglandicola* D. Dusky-veined aphid, *Panaphis juglandis* E. Capsid bug, *Megacoelum stramineum* F. Stink bug, *Apodiphus pilipes*

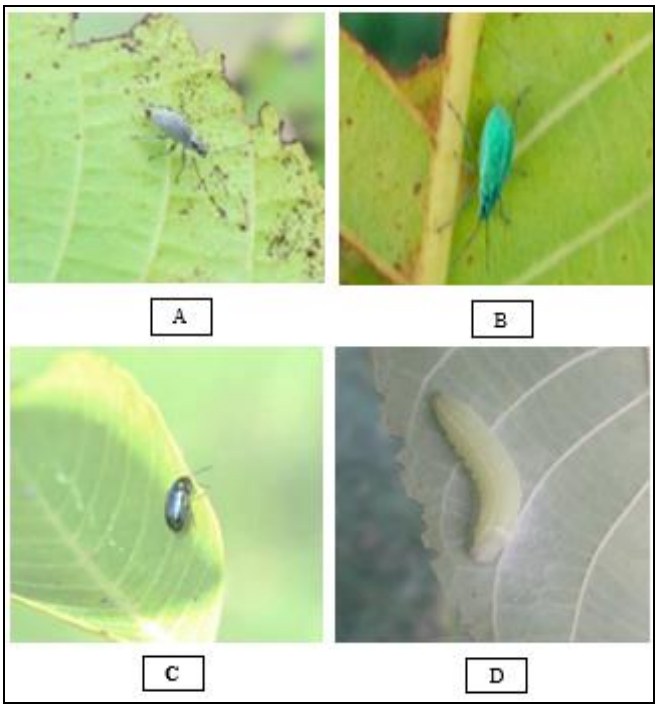

Plate 2: Leaf defoliators of walnut
A. Grey weevil, *Myllocerus viridanus* B. Green weevil, *Myllocerus discolor* C. Flea beetle, *Altica himensis* D. Larva of Walnut blue butterfly, *Chaetoprocta odata*

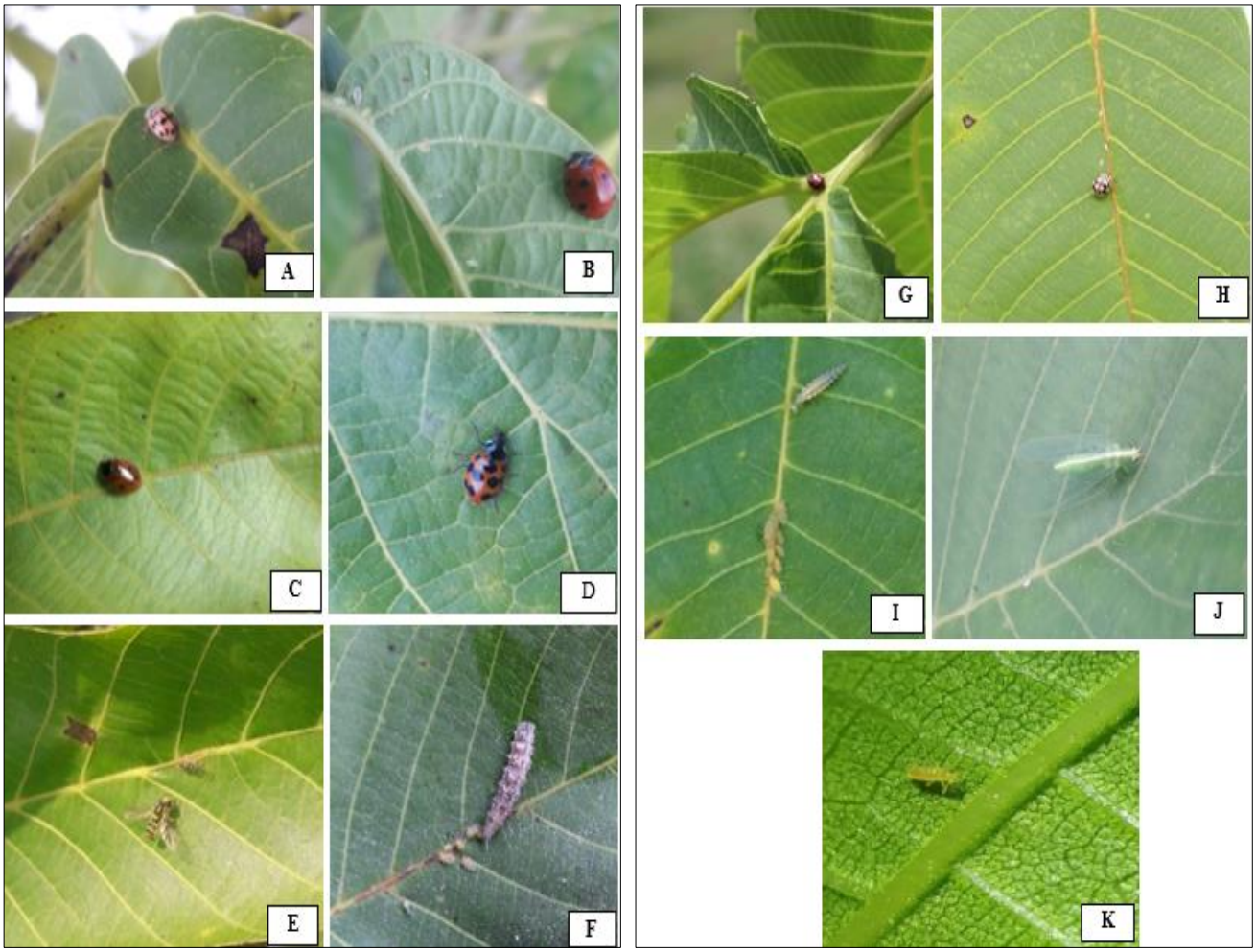

Plate 3: Natural enemies of walnut pests
A. Pink ladybird beetle, *Coleomegilla maculate* B. Seven-spotted lady beetle C. Two- spotted lady beetle**,** *Adalia bipunctata* D. Spotted lady beetle, *Coleomegilla maculate* E. Syrphid fly larva F. Adult syrphid fly, *Sphaerophoria scripta* G. Convergent ladybird beetle, *Hippodamia convergens* H. Multi colored Asian lady beetle, *Harmonia axyridis* I. Larva of green lacewing, *Chrysoperla carnea* J. Adult of green lacewing, *Chrysoperla carnea* K. Predatory mite, *Phytoseiulos* sp.

Conclusion

Pests of walnut crop recorded were walnut aphid (*Chromaphis juglandicola*), dusky-veined aphid (*Panaphis juglandis*), grey weevil (*Myllocerus viridanus*), capsid bug (*Megacoelum stramineum*), stink bug (*Apodiphus pilipes*), green leaf weevil (*Polydrusus formosus*), walnut blue butterfly (*Chaetoprocta odata*), flea beetle (*Altica himensis*) and blister mite (*Eriophyes erinea*). The natural enemies of walnut pests recorded were convergent ladybeetle (*Hippodamia convergens*), seven-spotted lady beetle (*Coccinella septempunctata*), two-spotted lady beetle (*Adalia bipunctata*), pink ladybird beetle (*Coleomegilla maculata*), green lacewing (*Chrysoperla carnea*), syrphid fly (*Sphaerophoria philanthus*), multi-colored Asian lady beetle (*Harmonia axyridis*), spotted lady beetle (*Coleomegilla maculata*) and predatory mite (*Phytoseiulos* sp.).

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