Journal of the Saudi Society of Agricultural Sciences (2012) 11, 149–155

King Saud University

Journal of the Saudi Society of Agricultural Sciences

www.ksu.edu.sa
www.sciencedirect.com

FULL LENGTH ARTICLE

Comparative bio-ecological studies among two species of *Urentius* lace bugs (Hemiptera: Tingidae) in Sudan

Abdalla Abdelrahim Satti *, El Imam El Khidir

Department of Alternatives to Pesticides and Biocontrol, Environment and Natural Resources Research Institute, National Centre for Research, P.O. Box 6096, Khartoum, Sudan

Received 26 January 2012; accepted 12 March 2012
Available online 17 March 2012

KEYWORDS

Tingid bug;
Urentius hystricellus;
Urentius euonymus;
Biology;
Ecology;
Seasonality

Abstract Among the prevalent lace bugs in Sudan, *Urentius hystricellus* and *Urentius euonymus* are important pests of eggplant and pigeon pea, respectively. They attack alternative hosts, but some plants were reported as common hosts for both species. In fact, the identity of these pests and their actual host plants seems to be confusing. Therefore, the main objectives of this work were to; differentiate between such pest species based on certain morpho-biological investigations, verify their hosts' ranges and study their intra-host distributions and seasonal trends through field surveys and experiments. The results showed clear morphological and biological differences among the two lace bug species. The durations of pre-imaginal stages of *U. hystricellus* were shorter than those of *U. euonymus*, while each pest took shorter durations in autumn as compared with winter season. Each pest has its own host range, and no shared hosts were detected, as believed. Hence, the mistaken hosts were corrected and new hosts were added. Such new records included *Solanum incanum* for *U. hystricellus*, and two hosts (*Chrozophora plicata* and *Rhynchosia memnonia*) for *U. euonymus*. Counts of insects on either leaf sides have revealed variable distributions in different hosts. The seasonal trends of the two pests showed peak populations during autumn and summer seasons. In conclusion, the study made clear distinctions between *U. hystricellus* and *U. euonymus*, and gave supportive findings for ecological management.

1. Introduction

Various species of insect pests were recognized to cause economic injuries to different crops in Sudan, depending on the prevailing biotic (e.g., natural enemies and host plants) and abiotic (climatic conditions) factors (El Khidir, 1960; Venkatraman and El Khidir, 1967; Schmutterer, 1969; Gaddoura et al., 1984). Among these insects, two species of lace (tingid) bugs belonging to the genus *Urentius* were detected earlier in the country. The most important one is the eggplant lace bug, *Urentius hystricellus* (Richter, 1869), which distributed widely as a serious pest of eggplant (*Solanum melongena*) in

* Corresponding author. Mobile: +249 916017797.
E-mail address: satisattisat@yahoo.com (A.A. Satti).

Peer review under responsibility of King Saud University.
http://dx.doi.org/10.1016/j.jssas.2012.03.003

Production and hosting by Elsevier

various States. Different other hosts were also reported for this pest by several authors (Pollard, 1955; Drake and Ruhoff, 1965; Schmutterer, 1969; Salih, 1991). On the other hand, the second lace bug species is *Urentius euonymus* Distant, 1909, which reported as a pest of pigeon pea, *Cajanus cajan*, and some wild plants, viz., *Abutilon* spp. and *Sida alba* (Drake and Ruhoff, 1965; Schmutterer, 1969).

The two mentioned *Urentius* pests are widely distributed in several tropical and sub-tropical regions especially in Africa and Asia including the Arabian Peninsula (Schmutterer, 1969; Baloch et al., 1977, 1978; Tigvattn, 1990; Talhouk, 1993). Some related species belonging to the same genus (e.g., *Urentius chobauti* Horvath, 1907, and *Urentius vepris* Drake, 1945) were also found in some countries (Guilbert, 2005). However, regarding the importance of these pests, *U. hystricellus* seems to be the most distributed and deleterious species addressed in the literature worldwide. However, besides the reported local hosts, several plants including members of Solanaceae (mainly *Solanum* spp.), Malvaceae (*Gossypium* spp. & *Abutilon* spp.) and Fabaceae (e.g., *C. cajan*) were shown to be infested by this pest in some countries (Rasool et al., 1986; Tigvattn, 1990; Dhawan et al., 2005). Since some of these plants were known as hosts of *U. euonymus*, mixing between the two *Urentius* pests seemed to be occurred.

Few studies were performed tackling some biological and ecological aspects of *U. hystricellus* in Sudan, but no data are available on *U. euonymus*. Therefore, due to similarities in external appearance between the two species, much confusion has been found regarding their identity and host range in the field. For instance, several alternative hosts were reported for each pest species, but some hosts were thought to be infested by the two pests together, an assumption which adds more obscurity to differentiation. However, such mistaken host plants also seemed to be occurred in other regions, as stated before. Accordingly, this research work aimed to; differentiate between the two *Urentius* spp. according to certain morphological and biological studies, indicate the real host plants and, study the intra-host distribution and seasonality of each species through field surveys and experiments.

2. Materials and methods

2.1. Field surveys of host plants

Host plants for both *Urentius* spp. were thoroughly surveyed throughout the year concentrating mainly at Khartoum State, but some areas in the Gezira, White Nile, River Nile and Northern States were also sporadically checked. Several species of cultivated and wild plants in these locations were investigated, so as to confirm or to correct the already reported hosts, and to find new hosts whenever possible. Species of plants showed that damage or infestation by lace bugs were listed, and samples of the detected insects were taken from each host to the laboratory for further studies and species confirmation.

2.2. Morphological studies

Morphological illustrations of adult and last nymphal instar were done for all specimens through slides preparation, so as to distinguish between the two *Urentius* species on their respective host plants. Certain morphological parts (viz., forewings and antennae) were also mounted on slides. The procedures for slide preparation adopted by Pruthi (1925), Scuder (1959) were followed. However, the forewings were just detached with the help of a needle and forceps, placed onto the slides, on which Euopral mountant was added and covered with cover slips. The rest of the treatments applied to other specimens in slides preparation, was found to be unnecessary, as these wings are lacy and transparent. Morphological drawings of specimens in slides were made possible with the help of a drawing tube mounted on an illuminated microscope. A micro-scaled ruler fixed to the microscope was used for morphometric studies.

2.3. Durations of the pre-adult stages

Life cycle studies were performed during autumn (August–October) and winter (January–February) seasons for pre-adult stages of the two pests, each on two of its major hosts. Such stages included pre oviposition period, egg-incubation and durations of the different nymphal instars. Each pest was collected from a cultivated and a wild hosts, then the intended durations were followed on the same hosts under laboratory conditions. *U. hystricellus* was reared on *S. melongena* and *Solanum dubium*, whereas *U. euonymus* on *C. cajan* and *Abutilon* sp. Such plants were grown in small plastic pots to study the pre-oviposition and incubation periods. Newly emerged sexed adults were released on their respective host seedlings, enclosed with glass housing and covered on its top vent with a muslin cloth tied with a rubber band. These insects were transferred daily to new pots, with each one being labelled and dated. From daily investigations, the number of days from adult's emergence up to the day of the first oviposition on seedlings was indicated as the pre-oviposition period, while the days from insects removal to egg hatching represent incubation period. Then a number of newly hatched nymphs were followed in Petri dishes where the durations of different nymphal instars were recorded for each pest.

2.4. Intra-host distribution and seasonal abundance

The same plants indicated previously for life cycle study of each *Urentius* species were chosen to monitor the intra-host distribution and seasonal abundance. To secure regular seasonal counts of insects, the cultivated crops (viz., *S. melongena* and *C. cajan*) were grown consecutively in the field, whereas the wild plants (*S. dubium* and *Abutilon* sp.) were investigated during the surveys. Such counts were done per 50 leaves (5 leaves from each 10 randomly chosen plants) per replicate (Satti and Nasr, 2000, 2006). For intra-host distribution the numbers of insects (adults and nymphs) on the upper and lower surfaces of leaves were separately recorded and compared during autumn and winter seasons. On the other hand, to study the seasonal abundance regular weekly counts (per 50 leaves) were conducted on the cultivated and wild plants indicated for the two pests.

3. Results and discussion

3.1. Host plants detected

The results of field surveys showed eight host plants infested by *Urentius* lace bugs, including some known hosts and new re-

cords (Table 1). All the recorded infested plants were detected in several parts of the country (viz., Khartoum, Gezira, White Nile, River Nile and Northern States), except *Solanum incanum* only detected in the Northern and River Nile States. Notably, a lot of confusion has been found before between the two *Urentius* spp. and their host plants in this country, and also in other parts of the world (Singh and Mann, 1986). Some people refer to both pests on their various hosts as *U. hystricellus*; some put them as pests of the eggplant, while others show mistaken hosts for both species. However, the present results showed clear differences between *U. hystricellus* and *U. euonymus*. Accordingly, each pest has its own host range which lies in different plant families, and no single host was found infested by the same pest species together, as believed.

Regarding the three hosts indicated for *U. hystricellus*, *S. incanum* was a new record, whereas the other two hosts (*S. melongena* and *S. dubium*) were already reported by Drake and Ruhoff (1965), Schmutterer (1969), Salih (1991). However, the other hosts (i.e., *Solanum tuberosum*, *Datura stramonium* and *Datura innoxia*) reported for *U. hystricellus* in Sudan (Pollard, 1955; Schmutterer, 1969; Salih, 1991) were found free of any lace bug species or signs of damage as a result of the seasonal surveys carried out in several locations. Moreover, the obtained results contradict some previous studies which indicated *Abutilon* spp. and *C. cajan* as the hosts of *U. hystricellus* (Pollard, 1955; Rasool et al., 1986; Dhawan et al., 2005). Consequently, the present findings agree with Singh and Mann (1986) in India, who declared that *D. stramonium* and *Gossypium* spp., as well as some other plants, are not suitable hosts for *U. hystricellus*, because females were not oviposit on these plants, even though survived 1–6 days on them. Based on this discussion it can be stated that *U. hystricellus* is not infesting *Abutilon* and *Cajanus* species, which were found entirely attacked by the other lace bug species, *U. euonymus*.

On the other hand, regarding *U. euonymus* it was found that among the five hosts detected, *Abutilon* spp., and *Sida alba* were already reported by some authors (Drake and Ruhoff, 1965; Schmutterer, 1969), while the rest two hosts were new records. One of these new hosts, *Rhynchosia memnonia*, is belonging to Fabaceae, the same family of *C. cajan*, but the second new host, *Chrozophora plicata*, added Euphorbiaceae as a third new family among the host range of the pest. It is obvious that this lace bug species has a wide host range representing three families (Fabaceae, Malvaceae, Euphorbiaceae), as opposed to the narrow host range of *U. hystricellus* which was restricted only among the plant family Solanaceae. However, the inclusion of this family among the host range of the pest was not excluded, since *U. euonymus* was already reported on another Euphorbiaceous plant, *Chrozophora tinctoria*, in abroad (Anon., 2007).

Contrarily to what has been shown by *U. hystricellus*, the above results ensured that *U. euonymus* has a wide host range among three different plant families, a habit which is not generally experienced in lace bugs. As cited in the literature lace bugs are mainly restricted in their feedings either to a single host or to closely related host plants (Drake and Ruhoff, 1965). Although, no clear interpretation is found, the occurrence of different races among these insects was anticipated, a phenomenon which might have been developed through progressive adaptability of each insect to certain existing host plants over a long period of time.

3.2. Morphological portrayal of lace bugs

The results of morphological studies for lace bug specimens collected from the eight mentioned plants make it possible to distinguish between the two *Urentius* species, and their host plants. The main characteristic differences recorded between the two pests were shown in Table 2. Larger sizes of adults and nymphs with longer ramified marginal tubercles (Fig. 1) and differences in colours and lacy wing patterns were the main points that discriminated *U. hystricellus* from that of *U. euonymus*. However, in both species males were relatively smaller than the females, and the last instar nymphs attained wing rudiments covering almost half of their body length, a character known in locusts and other hemimetabolous insects. Such lace bugs seem to camouflage themselves in consistence with their intimate ecological niches. For instance, body colours and spines (tubercles) were largely mimicking colours and hairs of leaves and branches of their respective host plants.

The lace bug species involved in this research were reported earlier in Sudan, around the mid of the 20th century. *U. hystricellus* was reviewed according to Pollard (1955), Drake and Ruhoff (1965), Schmutterer (1969), Gaddoura (1977), Salih (1991), whereas very meagre literature is available on *U. euonymus* (Drake and Ruhoff, 1965; Schmutterer, 1969). However, the morphological results obtained on *U. hystricellus* were comparable with those reported by Schmutterer (1969), Salih (1991). As for *U. euonymus*, the current study was the first one to be attempted in Sudan. However, the findings may partially agree with Guilbert (2005) who stated that *U. hystricellus*

Table 1 The encountered host plants of *Urentius hystricellus* and *U. euonymus*.

Lace bug species	Host plants*		
	Common/local name	Botanical name	Family name
U. hystricellus	1. Eggplant/Bazingan	Solanum melongena L.	Solanaceae
	2. Nightshades/Gubbain	Solanum dubium Fersen	Solanaceae
	3. Bitter apple/Gubbain Elbagar	Solanum incanum L.	Solanaceae
U. euonymus	1. Pigeon pea/Adasi	Cajanus cajan (L.) Huth.	Fabaceae
	2. Abutilon, Mallow/Hambouk	Abutilon spp.	Malvaceae
	3. Prickly sida/Um Shadida	Sida alba L.	Malvaceae
	4. ?/Adana (Adan Far)	Rhynchosia memnonia (Del.) DC.	Fabaceae
	5. Giradol/Tarroob	Chrozophora plicata (Vahl.) A. Juss. ex Spreng	Euphorbiaceae

* All host species recorded are wild plants, except eggplant and pigeon pea that are cultivated crops.

Table 2 Prominent morphological differences among *Urentius hystricellus* and *U. euonymus*.

Parameter	*U. hystricellus*	*U. euonymus*
1. Size	All stages were larger in sizes	They were relatively smaller
♀ (length × width)	3.1 ± 0.0 × 1.6 ± 0.1 mm	2.4 ± 0.3 × 1.1 ± 0.5 mm
Last nymph (length × width)	2.4 ± 0.1 × 1.3 ± 0.0 mm	1.9 ± 0.0 × 1.0 ± 0.0 mm
2. The lacy pattern of wings	Double rows of cells in hemelytron costal area	Single row of cells in costal area
3. Nymph marginal tubercles	Longer in sizes with clear ramifications	Shorter in sizes
4. Colour of adults	More brownish	Relatively light brown
	Terminal parts of legs (tibiae and tarsi) and antennae are darker brown than body colour	Such parts are light brown, as the colour of body
5. Colour of nymphs	Yellowish brown	More brownish with mosaic appearance

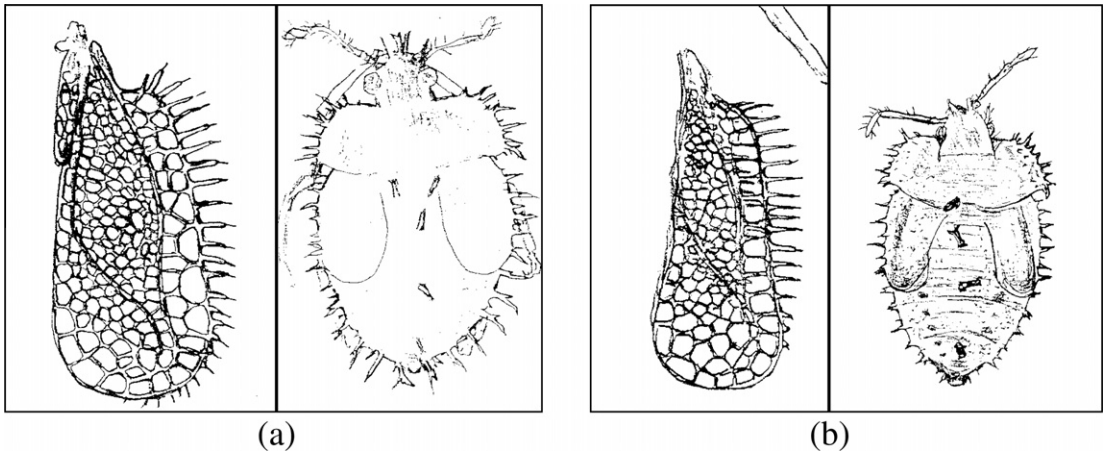

Figure 1 Adult (♂) right wing and last nymphal instar for; (a) *Urentius hystricellus* and (b) *Urentius euonymus*.

Table 3 The durations of pre-adult stages of *Urentius hystricellus* on *Solanum melongena* and *Solanum dubium* during autumn and winter seasons.

Season/host	Mean (X ± S.E.) durations							
	Pre-oviposition	Incubation	Nymphal instars					
			1st	2nd	3rd	4th	5th	Total
Autumn:								
S. melongena	1.5 ± 0.2	4.9 ± 0.1	1.9	1.1	1.0	1.2	2.2	7.5 ± 0.1
S. dubium	–	–	1.8	1.4	1.1	1.1	2.1	7.4 ± 0.1
Winter:								
S. melongena	3.7 ± 0.2	11.9 ± 0.1	3.1	2.1	2.6	2.9	4.3	14.5 ± 0.3
S. dubium	–	–	2.5	2.0	2.2	2.3	4.3	12.5 ± 0.4

– Not studied.

has longer tubercles, with two to three short ramifications and *U. euonymus* has short bifid tubercles.

3.3. Durations of the pre-adult stages

The results of the life cycle studies were explained in Tables 3 and 4 for *U. hystricellus* and *U. euonymus*, respectively. It is worthy to state that pre-oviposition and incubation periods for the former species were followed only on eggplant seedlings, due to the growth failure of *S. dubium*. However, the pre-oviposition time on eggplant took a shorter period in autumn (av. 1.5 ± 0.2 days) than in winter season (3.7 ± 0.2). The means of incubation periods and total nymphal durations on eggplant were also shorter in autumn (4.9 ± 0.1 and

Table 4 The durations of pre-adult stages of *Urentius euonymus* on *Cajanus cajan* and *Abutilon* sp. during autumn and winter seasons.

Season/host	Mean (X ± S.E.) durations							
	Pre-oviposition	Incubation	Nymphal instars					
			1st	2nd	3rd	4th	5th	Total
Autumn:								
C. cajan	1.6 ± 0.2	5.7 ± 0.1	1.3	1.2	1.3	1.3	2.5	7.9 ± 0.1
Abutilon sp.	1.5 ± 0.2	6.1 ± 0.1	1.6	1.2	1.2	1.2	2.2	8.0 ± 0.2
Winter:								
C. cajan	4.0 ± 0.2	13.4 ± 0.2	3.7	2.3	2.3	3.2	5.1	16.2 ± 0.3
Abutilon sp.	4.1 ± 0.2	13.2 ± 0.1	3.3	1.7	1.9	2.6	4.5	13.9 ± 0.5

Table 5 The intra-host distribution of adults and nymphs of *Urentius hystricellus* between the upper and lower leaf surfaces of *Solanum melongena* and *Solanum dubium*, at different seasons.

Stage	*Solanum melongena*				*Solanum dubium*	
Leaf side	Summer	Autumn	Winter	Summer	Autumn	Winter
Adults:						
Upper	12.46^{ns}	62.06^{ns}	11.72^{ns}	2.12	5.21	2.62
Lower	6.71	25.09	9.61	8.73^{ns}	21.77^{*}	20.80^{**}
Nymphs:						
Upper	6.21	49.82	81.81	1.27	1.18	3.22
Lower	136.71^{*}	170.06^{**}	117.22^{*}	48.03^{ns}	68.36^{**}	152.05^{**}

Table 6 The intra-host distribution of adults and nymphs of *Urentius euonymus* between the upper and lower leaf surfaces of *Cajanus cajan* and *Abutilon* sp., at different seasons.

Stage	*Cajanus cajan*				*Abutilon* sp.	
Leaf side	Summer	Autumn	Winter	Summer	Autumn	Winter
Adults:						
Upper	9.79^{ns}	6.50^{**}	1.92^{ns}	44.85^{ns}	28.10	33.97^{*}
Lower	4.71	1.11	1.84	2.27	29.30^{ns}	9.61
Nymphs:						
Upper	18.13	22.50	5.70	170.69^{ns}	51.20	179.90^{*}
Lower	52.00^{ns}	22.83^{ns}	26.17^{ns}	1.51	84.90^{ns}	10.72

7.5 ± 0.1 days, respectively) than in winter season (11.9 ± 0.1 and 14.5 ± 0.3 days). Similarly, the pre-oviposition and incubation periods of *U. euonymus* were nearly the same on the two host plants (*C. cajan* and *Abutilon* sp.) during both seasons, and such periods were longer in winter than in the other season (Table 4). Notably, this is the first study to be conducted on the life cycle of *U. euonymus* in the country. In comparison, the durations of all pre-imaginal stages of this species on its two hosts were somewhat longer than those of *U. hystricellus*. However, regarding the total nymphal periods of the two insects, each species exhibited more or less similar durations on its two studied hosts during autumn, whereas such durations were slightly shorter on wild plants than on cultivated crops (*S. melongena* and *C. cajan*) during winter. This may demonstrate the hazards posed by wild plants in the multiplication of these pests during certain periods. Thus, the two *Urentius* spp. were found biologically different regarding the

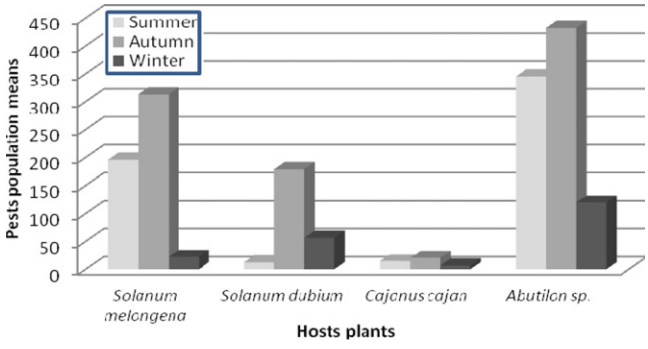

Figure 2 Seasonal population means of *Urentius hystricellus* (recorded on two *Solanum* spp.), and *U. euonymus* (on *Cajanus cajan* and *Abutilon* sp.).

Table 7 The monthly mean population (per 50 leaves) of *Urentius hystricellus* and *Urentius euonymus*, each on two of its main host plants at Khartoum area.

Month	*Urentius hystricellus*	*Urentius euonymus*		
	Solanum melongena	*Solanum dubium*	*Cajanus cajan*	*Abutilon* sp.
January	28.50	136.60	1.93	52.93
February	33.59	11.25	3.34	17.75
March	262.87	13.33	5.42	232.00
April	250.17	10.34	10.60	657.59
May	74.67	12.20	28.75	602.33
June	–	12.50	14.00	148.08
July	311.08	32.87	4.20	86.80
August	333.33	49.25	3.00	153.83
September	388.58	182.83	38.17	398.34
October	217.50	306.00	20.53	747.00
November	8.50	40.83	17.25	231.67
December	17.89	35.75	4.20	176.50

durations of their life cycle. This confirmed the differentiation made between the two pest species based on the previous morphological results.

3.4. Intra-host distribution and seasonal abundance

Regarding the distribution of *U. hystricellus* on plant leaves, generally all stages were found almost significantly confined to the lower leaf surfaces of the two host plants in all seasons, except that the adults showed higher populations only on the upper surfaces of the top leaves in eggplant (Table 5). On the other hand, the distribution of adults and nymphs of *U. euonymus* on the leaves were somehow different on the two studied plants (Table 6). Adults were mainly higher on the upper leaf surfaces of both crops in all seasons, but nymphs showed contrasting results. A complex of ecological and biological factors may be contributed in governing such distributions of lace bugs, including for instance the morphology of plant leaves (e.g., differences in shape and texture between leaf surfaces among the various plant species) and the condition of micro-climate in plant canopies. No detailed studies concerning this aspect were found. However, Elamin (1998), observed that more bugs of *U. hystricellus* were found on the lower surfaces of eggplant leaves at all levels of the plant height

The monthly population means of *U. hystricellus* and *U. euonymus*, each on two hosts, were presented in Table 7, and depicted as seasonal means in Fig. 2. It is clear that there were two population peaks during autumn (August–October) and early summer (March–May) periods. Both adults and nymphal stages were recorded in almost all counts throughout the year, which proved that activity and breeding of these pests occur all the year round. According to Salih (1991), no diapausing stage of eggplant tingid bug was found in Sudan. However, counts of *U. hystricellus* were always higher on eggplant than on the wild host (*S. dubium*), contrarily to what have been shown by *U. euonymus* which reflected higher incidences on wild *Abutilon* species. Such matter may be affected by some factors including the food preference. Although, rain showers were observed to have a negative effect in suppressing the lace bugs mechanically, but high rains were found to be followed by a tremendous population build up in the field. This could be attributed to high breeding rates enhanced by suitable climatic conditions (e.g., high humidity) and availability of fresh host plants, besides the short durations of the life cycles (Tables 3 and 4) during autumn, as compared with winter season. Therefore, two eggplant experiments conducted during August–September, a period that witnessed highest rainfalls (> 90 mm), were completely wiped at seedling stage due to high infestations, which necessitated re-sowings. These results were in consistency with those obtained by Singh and Mann (1986) in India. They reported peak population and shorter life cycle duration of *U. hystricellus* to be found in autumn coinciding with high humidity and temperature. On the other hand, the negative effects of rainfalls on populations of other pests were reported by Hanna (1950) and El Khidir (1960).

4. Conclusion

The study verifies the presence of both *U. hystricellus* and *U. euonymus* as different pest species based on morphological and biological discrepancies. A new host range for each pest was indicated, with mistaken hosts being corrected and new hosts added, but no shared hosts were encountered. The restricted hosts of *U. hystricellus* as opposed to a wide host range of *U. euonymus* among different plant families, besides the variations shown in their intra-host distributions, may necessitate extra deep studies. However, the results reflected the importance of the two pests as they showed continuous activity and breeding throughout the year. Hence, two population peaks were depicted during autumn (August–October) and early summer (March–May) seasons, with their life cycle durations being shorter in autumn than in winter. So, these findings were anticipated to contribute to ecological management of these pests.

References

Anonymous 2007. Heteroptera d'Israel. < http://www.naturamediterraneo.com/forum/topic.asp?TOPIC_ID = 37621 > .

Baloch, G.M., Khan, A.G., Zafar, T. 1977. Investigations on the insect enemies of Abutilon, Amaranthus, Rumex and Sorghum in Pakistan. Report of Commonwealth Institute of Biological Control, 1975–1976, Pakistan Station. p. 44.

Baloch, G.M., Khan, A.G., Zafar, T. 1978. Natural enemies of Abutilon, Amaranthus, Rumex and Sorghum in Pakistan (for the USA). Trinidad, Commonwealth Institute of Biological Control, Report of work carried out during 1976. pp. 61–62.

Dhawan, S.C., Gautam, R.D., Govil, J.N. 2005. Occurrence of Urentius hystricellus (Richt.) on pigeonpea in the net-house. International Chickpea and Pigeonpea Newsletter 12:47, 7 ref.

Drake, C.J., Ruhoff, F.A., 1965. Lace bugs of the world; a catalog (*Hemiptera: Tingidae*). Smithsonian Institution, Washington, p. 634.

Elamin, E.M. 1998. Ecological studies on eggplant tingid bug. Annual Report 1997/98, Agricultural Research Corporation, Wad Medani, Sudan.

El Khidir, E. 1960. Morphological and biological studies on whiteflies in the Sudan. M.Sc. Thesis, Faculty of Agriculture – University of Khartoum, Sudan.

Gaddoura, E. 1977. Studies on the Heteroptera of the Sudan with special reference to species of agricultural importance. Ph.D. Thesis, Faculty of Agriculture – University of Khartoum, Sudan.

Gaddoura, E., Fadl, G.M., Burgestaller, H., 1984. A survey of insect pests, diseases and weeds on vegetable crops in Khartoum Province. Acta Horticulture 143, 359–367.

Guilbert, E., 2005. Morphology and evolution of larval outgrowths of Tingidae (Insecta: Heteroptera), with description of new larvae. Zoosystema 27 (1), 95–113.

Hanna, A.D., 1950. The effect of rainfall on the cotton jassid, *Empoasca lybica* (de Berg.) in the Sudan Gezira. Bull. Ent. Res. 41, 359–369.

Pollard, D.G. 1955. The insect pests of vegetables in the Sudan. Bulletin No. 16. Agricultural Publication Committee, Ministry of Agriculture. Khartoum, Sudan. p. 76.

Pruthi, H.S. 1925. The morphology of the male genitalia in Rhynchota. Transactions of the Royal Entomological Society of London. Parts. 1, 11. pp. 127–267.

Rasool, G., Ahmed, N., Malik, N.A., 1986. The bringal lace bug (*Urentius sentis* Distant) as a pest of cotton and its chemical control. Journal of Agricultural Research. Lahore 24 (4), 321–323.

Salih, T.M. 1991. Bionomic, varietal susceptibility and control of the eggplant tingid bug, Urentius hystricellus (Richter) (Hemiptera: Tingidae). M.Sc. Thesis, Faculty of Agriculture – University of Khartoum, Sudan.

Satti, A.A., Nasr, O.E. 2000. Evaluation of neem (*Azadirachta indica* A. Juss) seed kernels aqueous extract in controlling the main insect pests on eggplant (*Solanum melongena* (L.)). The 7th Annual Scientific Report for the year 1999, Environment and Natural Resources Research Institute, National Centre for Research, Khartoum, Sudan. pp. 52–61.

Satti, A.A., Nasr, O.E., 2006. Effect of neem (*Azadirachta indica* A. Juss) seed powder and aqueous extract on the control of some major foliage insect pests of eggplant. Al Buhuth 10 (1), 1–16.

Schmutterer, H., 1969. Pests of crops in Northeast and Central Africa. Gustav Fisher Verlag, Stuttgart, Germany, p. 296.

Scuder, G.G.E., 1959. The female genitalia of the Heteroptera: Morphology and bearing on classification. Transactions of the Royal Entomological Society of London 111, 405–467.

Singh, L., Mann, H.S., 1986. Seasonal activity and population build-up of tingid bug, *Urentius hystricellus* Richter (Hemiptera: Tingidae) in the Punjab. Indian Journal of Ecology 13 (2), 301–306.

Talhouk, A.S., 1993. Some insect species injurious to crops in Middle East countries: 1. Hemimetabola. Journal of Applied Entomology 116 (1), 105–111.

Tigvattn, A.S., 1990. Studies on the bionomics and local distribution of some lace bugs in Thailand. 111. *Urentius echinus* Distant (Hemiptera: Tingidae). Kaen-Kaset-Khon-Kaen Agricultue Journal 18 (5), 251–260.

Venkatraman, T.V., El Khidir, E., 1967. Observations on crop pests in the Sudan in 1966/67. FAO Plant Protection Bulletin 15, 115–116.