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Diversity and Abundance of Insects in Wukari, Taraba State, Nigeria

Emmanuel Okrikata*, Olajumoke Anuoluwa Yusuf

Department of Biological Sciences, Federal University Wukari, Taraba State, Nigeria.

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A field survey was conducted in Wukari, Taraba State to assess the diversity and abundance of insect species in selected habitats (residential, open field made up of grassland and an agroecosystem). Sampling were done biweekly using light, pitfall and yellow pan traps set in 3 replicates, 30 m apart. Insects recovered were wet preserved in 70% ethanol except butterflies and moths. Representative samples were taken to the Insect Museum of Ahmadu Bello University Zaria for identification. A total of 4,501 insects spread across 9 orders, 34 families and 77 species were recovered. The most dominant order was Coleoptera with a relative abundance of (44.41%) and, the least was Orthoptera (0.84%). The most dominant insect species were *Heteronychus mossambicus* (11.44%) followed by *Termes* sp. (7.77%) and, *Goryphus* sp. (7.71%). *Chlaenius dusaulti, Cheilomenes sulphurea, Copris* sp., *Cicindela* sp., *Pseudantheraea* sp., *Derobranchus germinatus, Glaurocara townsendi, Camponotus perrisi*, and *Gryllus bimaculatus* were the rare species with relative abundance of 0.02%. Species richness is based on number of individual insects measured. The highest species diversity was observed in the order Coleoptera (Shanon H'= 2.547) while, Isoptera was the least (H'= 0.00). However, the highest species evenness was observed in the order Isoptera (E'= 1.00). Fisher-alpha (α) index of diversity showed that the agroecosystem had the highest index of diversity (α = 14.24) while, the residential area had the least (α = 11.9). This study therefore, brings to the fore the diversity and abundance of insects in Wukari and underscores the need for sustainable actions to be taken in conserving beneficial rare species while, managing the abundant pestiferous ones.

Keywords: Abundance, diversity, Fisher-alpha (α), insects, Jaccard's similarity index, Margalef (d), Shanon index (H')

Insects are important because of their diversity, ecological role, and influence on agriculture, human health, and natural resources (1-3). They have been used in landmark studies in biomechanics, climate change, developmental biology, ecology, evolution, genetics, paleolimnology, and physiology. They make up more than 58% of the known global biodiversity. They can be found in various types of habitat and contribute to the function and stability of ecosystems (4).

There is a tight association between insects and our lives. On the other hand, many insect species, including those who are still unkown, become continuously extinct or extirpated through-out the world (5). Insect species diversity is an important factor in the balance of environmental condition (6).

*Correspondence: Department of Biological Sciences, Federal University Wukari, Taraba State, Nigeria. E-Mail: eokrikata@gmail.com

Wukari is a richly agrarian community in the North eastern part of Nigeria. The diversity and abundance of insects in Wukari has hardly been studied. Insect biodiversity studies conducted in Nigeria have largely been on the insects' diversity of specific orders and/or species of insects. Few have considered the insect community altogether (7). Both taxonomic and ecological knowledge of insects were poorly investigated in Nigeria. Therefore, regarding many insect species their territorial distribution and abundance are poorly known and their associated ecosystem services are mostly assumed (8). Anthropogenic activities have contributed to the movement and spread of invasive insects into different habitats with many of them having agricultural, medical and veterinary implications (9).

The current study was designed for the very first time to document the diversity and abundance of insects in Wukari, Taraba State, Nigeria. This information is not only useful for agricultural, medical and veterinary purposes, but will also probably for the very first time, give an insight into the insect species richness of Wukari; an information that is very critical for management and conservation purposes (10).

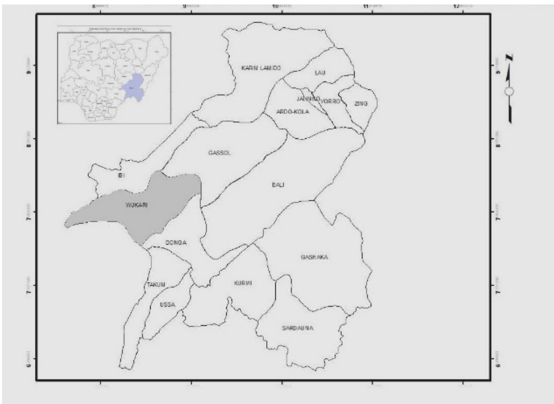
Materials and methods

Study area

The study was carried out in Wukari town. It is the headquarter of the Wukari Local Government Area of Taraba State, Nigeria. It has an area of 4,308 square kilometer, with latitude of 7.89N and longitude of 9.77E (Figure 1). It has an average elevation of 189 m and, an annual average temperature of 26.8 °C and annual precipitation of 1,205 mm. The vegetation type is guinea savanna.

A field insect survey was conducted from March to May, 2016 to collect, identify and document insects in different habitats within Wukari, Taraba State, Nigeria.

The habitats/locations that were sampled are: 1. Agroecosystem (a farm land of about 10 hectares used for all year round farming). 2. Open field (a grassland community behind Federal University Wukari, football field). 3. Residential area (hostel and staff quarters environment of Federal University Wukari).



Figue 1. Map of Taraba State in Nigeria, showing Wukari. Source: satellite maps (2015).

Insect sampling and collection

The field survey was conducted from March to May, 2016. Insect's sampling was performed biweekly (11). Briefly, 3 types of traps were used. Pitfall trap was used to collect ground dwelling insects (12). A double cup design of pitfall trap with 11 cm length and 10 cm wide in which a hole was dug and 2 containers were placed in a dug hole, and soil was packed around it to the level of the rim of the inner container, was used (13). The inner cup was a removable container that allowed for setting and servicing of the trap. The outer cup kept the hole from back filling with soil. An elevated wooden tripod stand (5 cm above the ground level) was placed over the pitfall to keep off water, falling debris and small rodents. Water and 2% mild detergent were used as killing agents (14). The content of the trap was serviced after 48 h by pouring the content through a sieve and rinsing with gently running water and preserving in a container containing 70% ethanol. The second type of trap was a yellow pan trap, where a yellow plastic dish of 6 cm length and 12 cm wide containing a mixture of water with 2% mild detergent which broke the surface tension of the water was placed 25 cm above the ground level. Flying insects landing on the sur-

surface of the water were trapped (15, 16). The trap was set up for a period of 12 h (6 am to 6 pm). Insects collected were poured into a sieve and rinsed with gently running water and then preserved in a container containing 70% ethanol. The third type of trap was a light trap which was set by sinking 2 nails into a tree, 10 cm apart with the bottom one being placed 3 m above ground level. The light source was tied on the first nail up, while the container of 17 cm length and 16.5 cm wide containing the mixture of water with 2% mild detergent was tied to the second nail just below the light source. Insects that flew onto the light source fell into the container and were trapped (8). The trap was set in the evening (6 pm) and serviced in the morning (6 am). The insects collected were poured into a sieve and rinsed with gently running water and, preserved in 70% ethanol. All traps were set biweekly in 3 replicates in each habitat and were spaced about 30 m from each other (17).

Preservation of collected insects

All collected insects were preserved by immersion in 70% ethanol. However, insects like moths that have scales on their wings were preserved dry in a tight container containing silica gel. Representative samples were preserved in the Biology Laboratory, Federal University Wukari, for future reference.

Identification of insects

Representatives of all collected insects were taken for identification at the insect museum center of Ahmadu Bello University Zaria, Kaduna State, Nigeria.

Data analysis

Biodiversity indices were computed using Past3 software. The studied indices were abundance, relative abundance of insect species, the Shannon diversity index (H') which was used to compute the ecosystem diversity index, and Jaccard's similarity index. Shannon index (H') was used in calculating t' to test for significant difference in diversity of insect species between the habitats surveyed. $P < 0.05$ was considered as statistically significant.

Results

Diversity and abundance of insects

Table 1 shows the diversity and abundance of insect species recovered in the selected habitats. A total of 4,501 insects belonging to 77 species, 34 families and 9 orders were recorded. The largest number of insect species (69) was recovered from farm land, and the least (56) were recovered from the open field. Across the habitats, Heteronychus mossambicus, had the highest abundance (515) followed by Termes sp. (350) and Goryphus sp. (347), the least abundant (rare) insect species included Chaenius dusaulti, Cheilomenes sulphurea and, Derobrachus germinatus.

Relative abundance of insects

Table 2 shows the relative abundance of the insect species in the selected habitats. Heteronychus mossambicus had the highest relative abundance (11.44%) followed by Termes sp. (7.78%) and Goryphus sp (7.71%). Insects such as Chaenius dusanlti, Cheilomenes sulphurea, Copris sp., Cicindela sp. and Debrachus germinatus had the least abundance of 0.02% each.

Table 3 shows the pooled relative abundance of insects based on orders. The Coleopteran insects have the highest relative abundance (46.42%) followed by Hymenoptera (18.59%) and the least is Orthoptera (0.84%). The diversity indices shows that Coleopteran insects have the highest diversity index (H'= 2.547) and species richness (d = 2.65). Isoptera have the least (H'= 0) and (d = 0). Isoptera was noted to have the highest evenness index (E'= 1) and have no equitability. However, Dictyoptera which have the second highest evenness after Isoptera, have evenness (E') of 0.9484 and the highest equitability of 0.9614. Diptera have the least evenness and equitability; (E'= 0.372) and (J=0.5706).

Diversity indices of insects

Table 4a shows that agroecosystem have the highest relative abundance of insects (39.91%), while the open field have the least (28.51%).

Table 1. Diversity and abundance of insect species in the study area

Order	Family	Genus/species	RA	OF	AG	Total
Coleoptera	Scarabaeidae	*Anomala mixta* Fab.	38	70	42	150
	Curculionidae	*Alcidodes brevirostris* Boh.	7	3	3	13
	Carabidae	*Aulacoryssus* sp.	12	18	27	57
	Chrysomelidae	*Aspidomorpha nigromaculata* Herbt.	2	1	2	5
	Carabidae	*Arsinoe biguttata* Chaud.	16	37	49	102
	Coccinellidae	*Chlaenius dusauti* Dufour.	1	0	0	1
	Carabidae	*Cheilomenes sulphurea* Oliv.	0	0	1	1
	Scarabaeidae	*Callida* sp.	0	0	2	2
	Cicindelidae	*Copris* sp.	0	0	1	1
	Carabidae	*Cicindela* sp.	0	1	0	1
	Carabidae	*Callida faciata*	0	15	11	26
	Curculionidae	*Colliuris* sp.	7	24	26	57
	Carabidae	*Cylas brunneus* Fab.	0	11	24	35
	Carabidae	*Dichaetochilus vagan* Dej.	22	12	26	60
	Thrysomelidae	*Dichaetochilus aciculatus* Dej.	1	8	22	31
	Tenebrionidae	*Disonycha* sp.	15	28	55	98
	Carabidae	*Derophaerus* sp.	0	11	2	13
	Carabidae	*Edagrome* sp.	16	15	0	31
	Hesteridae	*Hister* sp.	21	0	3	24
	Scarabaeidae	*Heteronychus mossambicus* Peringuey.	137	106	272	515
	Elateridae	*Melanoxanthus* sp.	40	0	1	41
	Scarabaeidae	*Onthophagus* sp.	35	79	85	199
	Scaphidiidae	*Paussus* sp.	2	1	5	8
	Elateridae	*Prosephus* sp.	43	51	32	126
	Cerambycidae	*Paroeme nigripes*	58	69	57	184
	Chrysomelidae	*Stobiderus* sp.	10	13	47	70
Coleoptera	Scarabaeidae	*Serica* sp.	7	59	47	113
	Scarabaeidae	*Schizonycha africana*	51	9	31	91
	Tenebrionidae	*Tenebriodes* sp.	37	0	34	71
	Cerambycidae	*Derobrachus germinatus*	0	0	1	1
Dictyoptera	Blatidae	*Blattella* sp.	2	8	7	17
	Blatidae	*Deropeltis* sp.	9	8	3	20
	Blatidae	*Gyna costalis*	8	22	3	33
Diptera	Stratiomniidae	*Acrodesmia pennicornis* Berri.	0	0	2	2
	Calliphoridae	*Chrysomyia albiceps* Wield	0	1	6	7
	Trachinidae	*Glaurocara townsendi* Emden.	0	0	1	1
	Trachinidae	*Latigenell rufogrisea villeneuve*	18	7	55	80
	Muscidae	*Musca lorosia* Wied	3	2	1	6
	Muscidae	*Musca* sp.	0	0	2	2
	Muscidae	*Musca domestica*	25	25	27	77
	Muscidae	*Morelia nilotica*	0	0	2	2

Table 1 Cont. Diversity and abundance of insect species in the study area

Order	Family	Genus/species	RA	OF	AG	Total
Diptera	Asilidae	*Ommatius* sp.	0	5	2	7
	Scarcophagidae	*Scarcophaga* sp.	0	3	0	3
Hemiptera	Reduviidae	*Oncocephalus* sp.	1	3	3	7
	Pentatomidae	*Piezodorus* sp.	2	26	27	55
	Pentatomidae	*Aspavia acuminate* Mont.	1	0	2	3
	Flatidae	*Cryptoflata unipunctuntata* Oliv.	0	0	6	6
	Reduviidae	*Coranus lugubris*	1	0	4	5
Hymenoptera	Braconidae	*Braunsia biluntata*	2	0	2	4
	Formicidae	*Camponotus perrisi* Forel.	0	1	0	I
	Formicidae	*Camponotus vestitus* Smith.	5	5	2	12
	Formicidae	*Camponotus maculates* Fab.	118	41	16	175
	Formicidae	*Camponotus* sp.	65	24	33	122
	Formicidae	*Dorylus* sp.	7	4	1	12
	Apidae	*Halictus* sp.	5	16	9	30
	Braconidae	*Ipiaulax* sp.	35	38	40	113
	Braconidae	*Macrocentrus* sp.	6	0	0	6
	Ichneumonoidae	*Goryphus* sp.	125	100	122	347
	Braconidae	*Apanteles* sp.	6	7	2	15
Lepidoptera	Arctiidae	*Ovenna* sp.	95	95	108	298
	Saturniidae	*Pseudantheraea* sp.	1	0	0	1
	Arctiidae	*Eilema* sp.	76	63	52	193
	Geometridae	*Heterocrita* sp.	50	30	39	119
	Arctiidae	*Spilosoma* sp.	25	23	15	63
	Arctiidae	*Metatarcta* sp.	12	12	8	32
Mantodea	Amorphoselidae	*Amorphoscelis* sp.	23	15	16	54
	Mantidae	*Hoplocorypha nigerica* Beir.	3	9	12	24
	Mantidae	*Pygromantis nasuta*	0	4	23	27
	Mantidae	*Empusa* sp.	1	1	1	3
Isoptera	Termitidae	*Termes* sp.	104	36	210	350
Orthoptera	Acrididae	*Eurycorypha* sp.	0	1	1	2
		Gastrimargus amplus Sjost.	2	1	2	5
	Gryllidae	*Gymnogryllus* sp.	1	0	1	2
	Gryllidae	*Gryllus bimaculatus* Dej.	0	0	1	1
	Acrididae	*Oedaleus nigeriensis* Uvarov.	1	5	1	7
	Acrididae	*Stobbea* sp.	2	0	18	20
	Gryllidae	*Scapsipedus marginatus*	1	1	0	2
		Total	**1,421**	**1,283**	**1,797**	**4,501**

RA: residential area; OF: open field (grassland); AG: agroecosystem

Table 2. Relative abundance of insect species recovered from selected habitats in Wukari

Order	Genus/ Species	Relative abundance (%)
Coleoptera	*Anomala mixta*	3.33
	Alcidodes brevirostris	0.28
	Aulacoryssus sp.	1.26
	Aspidomorpha nigromaculata	0.11
	Arsinoe biguttata	2.27
	Chlaenius dusaulti	0.02
	Cheilomenes sulphurea	0.02
	Callida sp.	0.04
	Copris sp.	0.02
	Cicindela sp.	0.02
	Callida faciata	0.58
	Colliuris sp.	1.26
	Cylas brunneus	0.78
	Dichaetochilus vagas	1.33
	Dichaetochilus aciculatus	0.68
	Disonycha sp.	2.17
	Derophaerus sp.	0.28
	Egadrome sp.	0.68
	Hister sp.	0.53
	Heteronychus mossambicus	11.44
	Melanoxanthus sp.	0.13
	Onthophagus sp.	4.42
	Paussus sp.	0.18
	Prosephus sp.	2.8
	Paroeme nigripes	4.09
	Strobiderus sp.	1.56
	Serica sp.	2.51
	Schizonycha africana	2.02
	Tenebriodes sp.	1.58
	Derobrachus sp.	0.02
Dictyoptera	*Blattella* sp.	0.38
	Deropeltis sp.	0.44
	Gyna costalis	0.73

Table 2 Cont. Relative abundance of insect species recovered from selected habitats in Wukari

Order	Genus/Species	Relative abundance (%)
Diptera	*Acrodesmia pennicornis*	0.04
	Chrysomyia albiceps	0.15
	Glaurocara townsendi	0.02
	Latigenella rufogrisea villeneuve	1.78
	Musca lorosia	0.13
	Musca sp.	0.04
	Musca domestica	1.71
	Morellia nilotica	0.04
	Ommatius sp.	0.15
	Scarcophaga sp.	0.07
Hemiptera	*Oncocephalus* sp.	0.15
	Piezodorus sp.	1.22
	Aspavia acuminata	0.07
	Cryptoflata unipunctata	0.13
	Coranus lugubris	0.11
Hymenoptera	*Brausia biluntata*	0.09
	Camponotus perrisi	0.02
	Camponotus vestitus	0.26
	C. maculatus	3.89
	Camponotus sp.	2.71
	Dorylus sp.	0.27
	Halictus sp.	0.67
	Iphiaulax sp.	2.51
	Macrocentrus sp.	0.13
	Goryphus sp.	7.71
	Apanteles sp.	0.33
Lepidoptera	*Ovenna* sp.	6.62
	Pseudantheraea sp.	0.02
	Eilema sp.	4.29
	Heterocrita sp.	2.64
	Spilosoma sp.	1.40
	Metatarcta sp.	0.71
Mantodea	*Amorphoscelis* sp.	1.20
	Hoplocorypha nigerica	0.53

Table 2 Cont. Relative abundance of insect species recovered from selected habitats in Wukari

Order	Genus/Species	Relative abundance (%)
Mantodea	*Pygromantis nasuta*	0.60
	Empusa sp.	0.07
Isoptera	*Termes* sp.	7.78
Orthoptera	*Eurycorpha* sp.	0.04
	Gastrimargus amplus	0.11
	Gymnogryllus sp.	0.04
	Gryllus bimaculatus	0.02
	Oedaleus nigeriensis	0.15
	Stobbea sp.	0.44
	Scapsipedus marginatus	0.04

Table 3. Relative abundance of insect orders recovered from selected habitats in Wukari

Order	Relative abundance (%)	Community dominance (%)	Shannon index (H')	Evenness (E')	Margalef (d)	Equitability (J)
Coleoptera	46.41	11.65	2.547	0.6082	2.65	0.8367
Dictyoptera	1.55	36.29	1.056	0.9484	0.4708	0.9614
Diptera	4.13	36.05	1.314	0.372	1.722	0.5706
Hemiptera	1.68	50.52	1.086	0.4936	1.144	0.606
Hymenoptera	18.59	25.72	1.625	0.4618	1.486	0.6778
Lepidoptera	15.68	29.13	1.384	0.6651	0.7622	0.7724
Mantodea	2.4	36.27	1.127	0.7715	0.6407	0.8129
Isoptera	7.78	100	0	1	0	Nil
Orthoptera	0.84	23.02	1.465	0.6182	1.638	0.7525

Table 4a. Diversity indices of insect species recovered from selected habitats in Wukari

Location	Relative abundance (%)	Fisher – alpha (α)
Residential area	31.57	11.9
Open field	28.51	11.95
Agroecosystem	39.91	14.24

The Fisher–alpha diversity indices show that the farm has the highest index of diversity (14.24) while, the residential area has the least (11.9).

The open field showed the least species richness (d= 7.685), but, has the highest diversity (H' =3.345), evenness (E'=0.5617) and, equitability (J = 0.8565). However, the agroecosystem showed the highest species richness (d = 9.074) (Table 4b).

The t- test analysis on the Shannon diversity index showed that there was a significant difference between residential area and open field (P=0.0002), residential area and agroecosystem (P= 0.005) in terms of species diversity. However, there was no significant difference between open field and agroecosystem in term of species diversity (P= 0.45).

Table 5 shows the Jaccard similarity index values. The levels of species similarity between the habitats surveyed were high as they were all above 0.5. However, the highest similarity index was observed between residential area and the agroecosystem (0.718).

Economic importance of insects in the study area

Table 6 shows that 2 of the overall dominant

Table 6 shows that 2 of the overall dominant insect species are beneficial serving as natural enemies of insect pests and soil formation and aeration and protein source for man.

Table 7 shows that the rare species are made up of beneficial and pestiferous insect species.

Table 4b. Diversity indices of insect species recovered from selected habitats in Wukari

Location	Community dominance (%)	Shannon index (H')	Evenness (E[I])	Margalef (d)	Equitability (J)
Residential area	4.96	3.316	0.4835	7.714	0.8202
Open field	4.23	3.345	0.5617	7.685	0.8568
Agroecosystem	5.78	3.344	0.4107	9.074	0.7898

Table 5. Jaccard similarity index values

	RA	AG	OF
RA	1	0.718	0.6911
AG		1	0.689
OF			1

RA: residential area; OF: open field (grassland); AG: agroecosystem. * - Significantly different at 5% level of significance.

Table 6. Economic importance of dominant insect species in the study area

Insect species	Economic importance
Heteronchyus mossambicus	Pest of crops
Goryphus sp.	Parasitoid
Termes sp.	Entomophagy/Soil formation

Table 7. Economic importance of rare insect species in the study area

Insect species	Economic importance
Cicindela sp.	Predator
Chlaenius dusaulti	Predator
Copris sp.	Decomposer
Camponotus perrisi	Predator
Derobranchus germinatus	Pest of crops
Gryllus bimaculatus	Pest crops
Cheilosomes sulphurea	Predator
Glaurocara townsendi	Parasitoid
Pseudantheraea sp.	Pest of crops

Discussion

A total of 9 orders, 34 families and 77 insect species were found in the habitats surveyed in Wukari. A total of 4,501 individual insect species were collected during the survey period using pitfall, light and yellow pan traps. Different trapping methods were used to attract different kinds of insects. This is in line with the report of John (18) who showed that using a combination of traps gives better species richness data.

The overall most abundant insect was *Heteronychus mossambicus* followed by *Termes* sp. and *Goryphus* sp. Insects species such as *Chlaenius dusaulti, Cheilomenes sulphurea, Copris* sp., *Cicindela* sp. *Pseudantheraea* sp., *Derobranchus germinatus, Glaurocara townsendi, Camponotus perrisi*, and *Gryllus bimaculatus* were rarely found.

Overall, Coleoptera was the most abundant (46.41%) insect order in the study area. This was followed by Hymenoptera (18.59%), Lepidoptera (15.68%) and the least; Orthoptera (0.84%). This agrees with the report of Tscharntke and Brandl (19) who acknowledged Coleopterans as the most predominant insect order.

Diversity indices showed that Coleoptera was the most diverse (Shannon H' = 2.547) and had a high evenness and equitability indices (0.6082 and 0.8367) which is in agreement with the report of Bradshaw et al. (20) on high diversity of Coleopterans in tropical environments.

Overall, the agroecosystem was notably the highest in terms of species diversity (α = 14.24) and richness (d = 9.074). The least was the residential area; (α = 11.9) and (d =7.714). Therefore, as plant species increase, insect species also increase. This agrees with previous reports (21-23) that substantiated that plants and insects interact by way of mutualism and phytophagy. The highest similarity was observed between the agroecosystem and residential area with 71.8% overlap. However, the t'-test statistical analysis showed no significant difference in species diversity between the open field (grassland) and the agroecosystem. This can be understood from the standpoint that, both communities are highly plant based and plants have been believed to co-evolve with their insect herbivores (19, 22). They are also found where there is a favorable condition for their survival (24, 25).

Each insect plays an ecosystem service and contributes to the stability of the ecosystem. The dominant and rare species were noted to cut across beneficial and noxious species. This is in agreement with the findings of Maina and Maina (26).

In conclusion, the present survey has shown that Wukari is rich in insect biodiversity. It has also documented probably for the very first time, the insect fauna in Wukari. This information will assist all stakeholders to optimize the beneficial insects, while managing noxious species.

Further studies should be conducted using other sampling techniques and by also expanding the geographical scope of the study. There is need to also expand the duration of the study as seasonal variations affect population dynamics of insects.

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Conflict of interest

The authors declared no conflict of interest.

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