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Species Composition and Abundance of Indoor Adult Resting Mosquitoes in the Male Students' Hostel at Federal University Dutse, Jigawa State, Nigeria

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Abstract

The presence of mosquitoes in an academic environment is a great threat to both staff and students' well-being due to the possibility of the transmission of mosquito-borne diseases if bitten by infected mosquitoes. Thus, this study surveyed mosquitoes in male students' hostels in Federal University of Dutse Jigawa State. The study was carried out using the pyrethroid spray catch method from 0600 hours to 0900 hours. A total of nine hundred and eighty-nine mosquitoes were collected. The predominant specie was Culex quinquefasciatus (61.53%) had a mean value of 152.25±0.20 which was significantly higher (P<0.05) than Culex papien 7.59%, Aedes aegypti (13.0%) and then Anopheles gambiae (s.l) (7.0%) while there was the least with Ae. albopictus with 0.7% value. Mosquitoes' abundance significantly varied (P<0.05) with the altitude of building floors in favour of ground floor hostel rooms. Transmission indices revealed two (2) mosquitoes/room and as well as one (1) mosquito/student. Up to 50% of mosquitoes caught were from rooms where no insecticide aerosols were used. About 19% of mosquitoes were caught from such rooms where the use of insecticide-treated bed nets and aerosol insecticide were used. Owing to the results recorded in this study, male students living in the hostel should avoid human-vector contact through the informed use of insecticides and treated bed nets.

Keywords: Pyrethroid spray catch, *Anopheles*, *Aedes*, *Culex and* Public health

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INTRODUCTION

The haematophagous habit of mosquitoes makes them transmit pathogens of various diseases (Olayemi *et al.* 2012). Some of these pathogens include *Plasmodium falciparum*, the deadliest of the malaria parasites (transmitted by species in the genus *Anopheles*) (WHO, 2014); Lymphatic filarial nematodes (transmitted by species in the genera *Culex, Aedes,* and *Anopheles*); Yellow fever, Dengue fever, Chikungunya and Zika fever viruses (transmitted by species in the genus *Aedes*); and the Japanese, St. Louis, and West Nile encephalitis viruses (transmitted by species in the genus *Culex*) (Liu, 2015). Mosquitoes, collectively, are expected to infect more than 700 million people in Africa each year, with 400 million deaths recorded (WHO, 2019). Mosquitoes are worldwide in distribution, although most species are found in the tropics and subtropics. The warmer climates in the tropical areas allow mosquitoes to be active all year round, with the ideal conditions being hot and humid with moderate rainfall (Adeogun *et al.* 2023). In hot climates, they can be more active, and the rainfall gives them aquatic sites for the larval and pupal stages of development (Pates & Curtis, 2018). Mosquitoes breed in a variety of habitats where there are stagnant water bodies including swamps, groundwater pools, edges of rivers, slow-flowing streams, tree holes, plant axils, crab holes, broken bamboo stems, tin cans, plastic containers of all sorts, and coconut shell (Ingstad *et al.* 2012). These authors reiterated further that mosquitoes equally breed in any stagnant water body containing footprints.

Indigenous mosquito vectors, abundance, feeding, resting behavior, human biting rate, and pathogen infectivity, among other characteristics, define the endemicity of mosquito-borne disease in an environment (Molta, 2000). According to the Nigeria Federal Ministry of Health in 2011, more than 50.0% of Nigerians have at least one type of the aforementioned mosquito-borne diseases, making them the most significant vectors of public health concern in Nigeria. The various mosquito nesting locations and human contact with adult female mosquito vectors contribute to the high transmission rate and incidence of mosquito-borne diseases (Chukwuocha, 2012). As a result, vector control is at the heart of vector control initiatives (Olagundoye & Adesoye, 2023)

Published work, particularly on baseline data that can improve mosquito management in Jigawa State, is insufficient. There is a need to update mosquito species information to establish effective mosquito management interventions through research prowess. As a result, the study would throw more light on the distribution of species, composition, and abundance and identify distinct species of mosquitoes during the study period. Therefore, this research aimed to investigate and evaluate the species composition and relative abundance of indoor resting adult mosquitoes in the male hostel at the Federal University, Dutse, Jigawa State, Northwestern Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in the male hostel which is located on the campus of Federal University Dutse. Dutse is located between latitude 11° 47′05″N and longitude 09° 36′30″E and has an estimated population of 21,704 people. It is situated on the road running between Kano and Azare with Kiyawa (30 km west), Jamma'are (35 km east), and Azare (65 km east). It falls within the Sudan savannah zone with a temperature and annual rainfall ranges of 15.86-38 °C and 491-1186 mm respectively (LGCD-Jigawa, 2022). Dutse has an estimated human density of 223.91 km^2. The main occupations of the people in the area are farming, trading, and animal grazing. United Nations Educational, Scientific and Cultural Organization, (2013) has estimated that 85% of people in Jigawa live in rural areas with a 24.2% literacy level as of 2012.

Study Design and Data Collection

A cross-sectional study design (in which a particular area is studied within a short time) was used in this research. The period for sample collection was between May to July 2021 (for 6 weeks). Three types of samples were used in this research. Cluster samples were used to select the rooms in the hostel as a study area. Then proportionate samples were used to select four (4) rooms in each block of the hostel. Random sampling was used to select two (2) rooms on each floor of two hostel blocks, and for each block, one (1) room was used from each quarter area, which is equivalent to 25 rooms adopted for the data collection.

Pyrethroid Spray Method

Adult mosquitoes were collected using pyrethroid-based insecticide knock-down method (PKC) (Service, 2019). The adult mosquitoes were collected from rooms in which at least 4 to 8 persons slept the previous night. Before the spraying exercise, the doors and windows were closed, and white spreadsheets were laid from wall to wall covering furniture and other immovable items in the room. Food items and cooking utensils were evacuated from the rooms to avoid contamination. A pyrethroid-based insecticide aerosol was sprayed in the room and allowed to remain for 20 minutes before collection. At the end of the 20-minute interval, the white spreadsheets were folded carefully starting from the edges, taken outside the room and a pair of entomological forceps was used to pick up the knock-down mosquitoes into a petri dish that was damped. The mosquito samples collected were then conveyed to the Biology laboratory, Federal University, Dutse Jigawa state, for identification.

Identification of Species of Man-Biting Mosquitoes Collected During the Study

Individual species of mosquitoes were then identified by an entomological key described by Adesoye *et al.* (2023) and Zettler *et al.* (2016) using their palps and proboscis, wing band, and body colour.

Entomological Transmission Indices of Female Mosquitoes in Male Hostels

The indoor resting density and man biting rate of collected mosquito samples were estimated as described by Aju-Ameh *et al.* 2016) as shown below:

i. **Indoor Resting Density (IRD)**

$$\textbf{IRD} = \frac{\text{Total number of vectors collected}}{\text{Total number of rooms sprayed}}$$

ii **Man biting rate (MBR)**

$$\textbf{MBR} = \frac{\text{Number of mosquitoes collected}}{\text{Number of people that slept in the room previous night}}$$

Statistical Analysis

Mosquitoes collected were calculated in means and percentages using SPSS 16.0 and were expressed in tables and charts. Statistical differences in data obtained were determined using

Analysis of Variance (ANOVA) at a 95% confidence level (P=0.05) with the aid of GraphPad prism 8.

RESULTS

Species Composition and Relative Abundance of Mosquito Species in Block A Male Hostel Federal University, Dutse

Species abundance of *Cx. quinquenfentus* (81.64%), *Cx. papiens* (99.98%), *Ae. aegypti* (99.99%), *An. gambiae* (s.l) (99.99%), *Ae. albopictus* (99.99%) recorded from samples collected (Table 1).

Table 1: Species composition and relative abundance of mosquito species in block A male Hostel Federal University, Dutse

Mosquito Species	Ground Floor (%)	First Floor (%)	Second Floor (%)	Total (%)
***An. gambiae* (s.l)**	12 (80.00)	2 (13.33)	1 (6.66)	15 (99.99)
Cx. quinquenfentus	119 (27.29)	121(27.75)	116 (26.60)	436 (81.64)
Cx. papiens	93 (63.26)	33 (22.44)	21 (14.28)	140 (99.98)
Ae. aegypti	14 (42.42)	16 (48.48)	3(9.090)	33 (99.99)
Ae. albopictus	5 (41.66)	5 (41.66)	1(8.333)	12 (99.993)
Total	**243**	**168**	**142**	**636 (183.59)**

Species Composition and Relative Abundance of Mosquito Species in Block B Male Hostel, Federal University Dutse

Mosquito species abundance varied among the hostel floors sampled. The species with the highest abundance was *Cx. quinquenfentus* (195.44%), *An. gambiae* (s.l) (174.42%*), Cx. papiens* (108.33%*), Aedes aegypti* (99.98%), *and Ae. albopictus* (99.98%) recorded from samples collected (Table 2).

Table 2: Species composition and relative abundance of mosquito species in block B male Hostel Federal University, Dutse

Mosquito Species	Ground Floor (%)	First Floor (%)	Second Floor (%)	Total (%)
***An. gambiae* S.l**	17 (26.98)	28 (44.44)	28 (14.14)	63 (174.42)
Cx. quinquenfentus	67 (33.83)	292 (147.47)	116 (26.60)	190 (195.44)
Cx. papiens	12 (33.33)	18 (50.00)	9 (25.00)	36 (108.33)
Ae. aegypti	15 (36.58)	21 (51.21)	5 (12.19)	41 (99.98)
Ae. albopictus	7 (29.16)	13 (54.16)	4 (16.66)	24 (99.98)
Total	**118**	**372**	**61**	**352 (551.17)**

Abundance of Mosquitoes for Hostel Blocks with Altitude

Table 3 presents the number of mosquito samples collected on different building floors of the hostel it can be seen that the ground floor had the highest number of mosquitoes due to its active breeding sites aided by human activities that promote and provide a conducive atmosphere for the mosquitoes to breed.

Table 3: Abundance of mosquitoes in relation to hostel block and altitude

Hostel Floor	Block A	Block B	Total	Mean ±SD
Ground Floor	336	119	456	227.50±0.50a
First Floor	168	184	351	176.0±0.20b
Second Floor	120	62	182	91.0 ±1.50c
Total	**624**	**365**	**989**	

Subscript of Mean values with the same alphabets along the column are not significantly different (P>0.05)

Entomological Transmission Indices of Female Mosquitoes in the Male Hostels

An overall approximate IRD of two (2) female mosquitoes per hostel room was recorded for *An. gambiae* s.l and *Ae. aegypti* whereas *Cx. quinquenfentus* has an IRD that was the greatest per room. The pooled result showed that *Cx. quinquenfentus* had the highest MBR per student (Table 4).

Table 4: The Indoor Resting Density (IRD) and Man Biting Rate (MBR) of Mosquito Species Sampled in Male Hostel

Mosquito species	Number of mosquitoes	Indoor Resting Density per room N = 32	Man Biting Rate per room n = 193
An. gambiae	78	2.4375	0.404
Cx. quinquenfentus	644	20.125	3.336
Cx. papiens	197	6.1562	1.020
Ae. aegypti	74	2.3125	0.383
Ae. albopictus	36	1.1250	0.186
TOTAL	1029	32.1562	5.329

N: number of rooms; **n:** number of persons per room

Usage Representation of Insecticides and Long-Lasting Insecticide Bed Nets in Male Hostel

Table 5 shows the variations in the usage of vector control tools in the form of chemical insecticide and the use of Long-lasting insecticide bed nets (LLINs). An appreciable number of mosquitoes were caught from residents where there was use of aerosol insecticides;129 (13.0%) and or LLINs;196 (19.8%)

A total number of 989 mosquitos were collected throughout the four weeks of sample collection. Across the study area, four different species; namely: *An. gambiae, Cx. quinquenfentus, Cx. papiens, Ae. Aegypti, and Ae. albopictus* were collected (Table 6). However, Table 6 depicts the week-by-week sample collection in the male hostel, Mosquitoes collected in the second week had a higher number due to the availability of rainfall in the University. The breeding habitat which had optimum temperature for the hatching of their eggs equally aided the number of mosquitoes collected during this study. The same trend regarding the number of mosquitoes collected was witnessed in the third and first week respectively.

Table 5: Usage of insecticide and long-lasting insecticide bed nets in the male hostel

	Block A (mosquitoes)	**Block B** (Mosquitoes)	**Total (%)**
Use of insecticide	72 (58.13)	57 (44.18)	129 (13.0)
Don't use insecticide	275 (52.58)	226 (43.21)	523 (52.8)
Uses insecticide treated net	108 (55.10)	88 (44.89)	196 (19.8)
Don't use insecticide treated net	97 (53.59)	84 (46.40)	181 (18.3)
Total	534	455	989

Table 6: Weekly abundance of indoor resting adult mosquitoes in the male hostel

Mosquito Species	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Total (%)**	**Mean ±SD**
Anopheles gambianse	18	27	14	11	70 (7.0)	17.50±0.50a
Culex quinquenfentus	129	175	154	151	609(48.5)	152.25±0.20c
Culex papiens	26	44	59	45	174(17.59)	43.50±0.20b
Aedes aegypti	11	49	56	13	129(13.0)	32.25±0.10b
Ae. albopictus	2	3	1	1	7(0.7)	1.75±1.00a
TOTAL	186	298	284	221	989	

Subscript of Mean values with the same alphabets along the column are not significantly different (P>0.05)

DISCUSSION

Pyrethroid spray catch employed in this study has been described as a common means of trapping mosquitoes that are resting inside buildings and animal shelters (Eshetu *et al.* 2023). It is normally an efficient procedure, although its effectiveness is dependent on the type of house in which it is deployed (Russell, 2022). The diversity of mosquitoes detected in the male students' hostel of the Federal University Dutse, Jigawa State, Nigeria, demonstrates the efficacy of this procedure. The presence of various mosquito species in human habitation as we observed in the male hostel of the University can have serious consequences for public health, the economy, and the overall well-being of the community (Walker & Lynch, 2017). Mosquitoes can hurt people's quality of life in the affected community (Halasa *et al*. 2014). Mosquito bites are unpleasant and irritating, causing discomfort and limiting outdoor activity (WHO, 2023; Obinna *et al*. 2014). They can induce serious allergic responses in severe circumstances. Mosquito-borne diseases can be extremely expensive. They can raise healthcare expenditures, diminish workforce productivity, and reduce tourism in impacted areas (Dahmana & Mediannikov, 2020). It has even been reported that the treatment and prevention of mosquito-borne diseases take off 25% of the income of poor families in Nigeria (Obinna *et al*. 2014). Academic and other important businesses carried out by the students may also suffer as a result of diminished economic activity in areas with high mosquito populations and illness transmission. Mosquitoes have been linked to the transmission of a number of diseases, including malaria which is a parasitic disease caused by *Plasmodium* parasites and spread by *Anopheles* mosquitoes (Walker, & Lynch, 2017) identified in the study of area. Also, *Aedes* mosquitoes transmit dengue fever and so on (Liu, 2015). The presence of these mosquitoes in human habitation raises the danger of disease transmission, which can lead to outbreaks and public health concerns (Adeleke *et al*. 2008). Efforts to manage and control mosquito populations, as well as education and prevention, are critical to mitigating these consequences and lowering the risk of mosquito-borne diseases in the University environment. *Culex quinquefasciatus* was the most dominant species collected in this study. This is in line with Adeoye *et al*. (2014) who reported that *Cx. quinquefasciatus* was the most abundant mosquito species in students' hostels of the University of Lagos and its environment. On the contrary, the study by Onyido et al. (2009) has shown *Anopheles gambiae* proportion to be predominant over other mosquito species in schools and its environs. The disparity in the Onyido *et al*. (2009) study might be a result of the implication of giant trees in the proximity of human dwellings and so *Anopheles* mosquitoes find it more convenient to breed in the tree-hole rather than polluted breeding sites available for *Cx. quinquefasciatus* to successfully breed and fly in university hostels. The presence of *Anopheles gambiae* (s.s) in this study possibly suggests that the ongoing anthropogenic activities in the Permanent site of the University have given rise to more temporary breeding sites such as tyre tracks, hoof prints, and rice paddy for *An. gambiae* to successfully breed. This is in tandem with with the report of Williams and Pinto (2012) regarding the ability of transient habitats encouraging the breeding success of *Anopheles* mosquitoes. Also, Gowelo *et al*. (2020) reported *An. gambiae* as the second most abundant mosquito in a study on endophilic mosquitoes in southern Malawi.

The difference in mosquito abundance with variation in altitude of hostel floors possibly suggests that mosquitoes prefer the ground floor level. This is due to the presence of a high number of students at dusk in the area which directly translates to a high number of volatile compounds being exuded on the ground flat. In like manner, Onyido *et al.* (2016) got most of their mosquito catches on the first-floor rooms of hostel building of the Nnamdi Azikiwe University Awka, Anambra State South-eastern Nigeria. In the present study, several students living in the hostel neither use aerosol spray insecticide nor use the LLINs as a means of controlling the menace of mosquito vectors. This is related to Malede *et al.* (2019) who assessed major barriers militating against the persistent long-lasting insecticidal net utilization in villages around Lake Tana, Northwest Ethiopia. The study showed that non-persistent LLIN use was associated with inconvenient bed net design and early damage. This is synonymous with the low usage of LLINs by students in the present study. Non-potency of the insecticide against other arthropods, and wrong perceptions about malaria and mosquitoes generally among other factors are limiting the use of LLINs (Malede *et al.* 2019).

CONCLUSION

The mosquito populations under this study are suspected to be insecticide-resistant in hostel rooms. Mosquito resistance monitoring programmes should be developed in the University community. It is recommended that students avoid human-vector contact through the informed use of insecticides and long-lasting insecticide-treated

Conflicts of Interest

The authors declare that there is no conflict of interest.

REFERENCES

Adeleke, M., Mafiana, C., Idowu, A., Adekunle, M. and Sam-Wobo, S. (2008). Mosquito larval habitats and public health implications in Abeokuta, Ogun State, Nigeria. *Tanzan J Health Res*, 10 (2): 103-107. doi: 10.4314/thrbv10i2.14348.

Adeogun, A., Babalola, A., Okoko, O., Oyeniyi, T., Omotayo, A., *et al*. (2023). Spatial distribution and ecological niche modeling of geographical spread of *Anopheles gambiae* complex in Nigeria using real-time data. *Scientific Reports*, 13: 13679. DOI:10.1038/s41598-023-40929-5

Adeoye, G., Edeh, I., Olayiwola, O., Ayodele, E. and Adeleke, A. (2014). The Abundance and Composition of Endophilic Mosquitoes in the University of Lagos and its Environment. *Nigerian Journal of Parasitology*, 33: 1117-4145

Adesoye, O. A., Adeogun, O., Adeniyi, A. K. and Ande, A. T. (2023). Nutritional Composition of House Cricket (*Acheta domesticus*) and Dung Beetle Larva (*Oryctes boas*) in Osun State: Implication to Dietary Improvement in Nigeria. *PAJOLS, 7(2)*: 662-667. DOI:10.36108/pajols/3202/70.0250

Aju-Ameh, C.O., Awolola, T. S., Mwansat, G. S. and Mafuyai, H. B. (2016). Malaria transmission indices of two dominant *Anopheles* species in selected rural and urban communities in Benue State North Central Nigeria. *International Journal of Mosquito Research*, 3(4): 31-35

Chukwuocha, U. M. (2012). Malaria control in Nigeria. *Primary Health Care*, 2: 118. doi:10.4172/2167-1079-000118

Dahmana, H. and Mediannikov, O. (2020). Mosquito-Borne Diseases Emergence/Resurgence and How to Effectively Control It Biologically. *Pathogens*, 29(4): 310. doi: 10.3390/pathogens9040310

Eshetu, T., Eligo, N. and Massebo, F. (2023). Cattle feeding tendency of *Anopheles* mosquitoes and their infection rates in Aradum village, North Wollo, Ethiopia: an implication for animal-based malaria control strategies. *Malaria Journal*, 22: 81.

Gowelo, S., Chirombo, J., Koenraadt, C., Mzilahowa, T., Berg, H., Willem T. and McCann, R. (2020). Characterisation of anopheline larval habitats in southern Malawi. *Acta Trop*, 2: 10. doi: 10.1016/j.actatropica.2020.105558

Halasa, Y., Shepard, D. S., Fonseca, D. M., Farajollahi, A., Healy, S., Gaugler, R., *et al*. (2014). Quantifying the Impact of Mosquitoes on Quality of Life and Enjoyment of Yard and Porch Activities in New Jersey. *PLoS One*, 9(3): e89221

Ingstad, B., Munthali, A. C., Braathen, S.H. and Grut, L. (2012). The evil circle of poverty: a qualitative study of malaria and disability. *Malaria Journal*, 11: 15. doi:10.1186/1475 2875-11-15

Liu, N. (2015). Insecticides resistance in Mosquitoes: impact, Mechanisms, and research directions. *Annu. Rev. Entomol*, 60: 537-559.

Malede, A., Aemero, M., Gari, S., Kloos, H. and Alemu, K. (2019). Barriers of persistent long lasting insecticidal nets utilization in villages around Lake Tana, Northwest Ethiopia: a qualitative study. *BMC Public Health,* 13: 3. https://doi.org/10.1186/s12889-019-7692-2

Ministry for Local Government and Community Development (LGCD), Jigawa State (2022). Brief History of Dutse Local Government. https://mlg.jg.gov.ng/dutse/index.php

Molta, N. B. (2000). Burden of malaria in Africa. A Paper Presented at the African Summit on Roll Back Malaria, Abuja Technical Session, *World Health Organization, Geneva*, pages 2-9.

Obinna, O., Enyi, E., Nkoli, U., Benjamin, U. and Alex, A. (2014). Towards Making Efficient Use of Household Recourses for Appropriate Prevention of Malaria. *BMC Public Health*, 14, 315-1186.

Olayemi, I. K., Omali, I.C., Abolarinwa, S. O., Mustapha, O. M. and Ayanwole, V. I. (2012). Knowledge of Malaria and Implication for Control in Endemic Urban Area of North Central, Nigeria. *Asia Journal of Epidemiology*, 5 (3): 42-49.

Olagundoye, E.O. and Adesoye, O.A. (2023). Larvicidal Efficacy of *Azadirachta indica*, *Ocimum gratissimum* and *Cymbopogon citratus* Ethanolic Extracts against *Culex quinquefasciatus* Larvae. *Pajols*, 7(1): 554-560. DOI: 10.36108/pajols/3202/70.0150

Onyido, A.E., Ezike, V.I., Nwankwo, E.A., and Ozumba N.A. (2009). Public health implication of giant trees in the proximity of human dwellings. Tree-hole breeding mosquitoes of the Government reservation areas (GRA) of Enugu metropolis in Southeastern Nigeria, on proceeding 3rd National conference of the Society for Occupational Safety and Environmental Health (SOSEH), 8-11th November, pages 140- 143.

Onyido, A.E., Obi, N.C., Umeanaeto, P.U., Obiukwu, M.O. and Egbuche, M.C. (2016). Malara prevalence and indoor-biting mosquito vector abundance in Ogbunike. *African Research Review*, 5: 1-13

Pates, H. and Curtis, C. (2018). Mosquito behavior and vector control. *Annu Rev Entomology,* 50: 53-70.

Russell, T., Staunton, K., Burkot. T. (2022). Standard Operating Procedure for collecting resting mosquitoes with pyrethrum spray catch. *James Cook University*, 13:7 DOI: dx.doi.org/10.17504/protocols.io.kqdg3pb67l25/v1

Service, M.W. (2019). The Medical Entomology for students. Edn 5, *Cambridge University Press*, New York.

UNESCO (2013). Programme and meeting document. https://unesdoc.unesco.org/ark:/48223/pf0000220416

Walker, K. and Lynch, M. (2017). Contributions of *Anopheles* larval control to malaria uppression in tropical Africa: a review of achievements and potential. *Med. Vet. Entomol*, 10: 2-21.

William, J. and Pinto, J. (2012). Training Manual on Malaria Entomology for Entomology and Vector Control Technicians (Basic Level). *RTI International*, 5: 11-48.

World Health Organization (2014). Malaria Fact Sheet, WHO Geneva, Published in 2014. http://www.who.int/mediacentre/factsheets/fs094/en/

World Health Organization (2019). Malaria Fact Sheet, WHO Geneva. https://www.who.int/news-room/fact sheets/detail/malaria.

World Health Organization. (2023). Question and Answer on the Global Plan for InsecticideResistance Management in Malaria Vector, http://www.who.int/malaria/media/insecticide_resistance_management_qa/en/

Zettler, J., Link-Pérez, M., Bailey, J., Ness, T., Mateer, S. and Demars, G. (2016). To Key or Not to Key: A New Key to Simplify & Improve the Accuracy of Insect Identification. *The American Biology Teacher*, 78 (8): 626-633. DOI:10.1525/abt.2016.78.8.626

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