Community knowledge, attitudes, and practices on the use of plants to control mosquitoes: the case of Arjo Gudatu District, East Wollega Zone, Oromia Regional State, Ethiopia

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Abstract

Background

Mosquitoes in the genera *Anopheles* and *Aedes* transmit human malaria and several viral diseases, respectively. Insecticide-based mosquito control, most notably indoor residual insecticide spraying and long-lasting insecticide-treated mosquito net use, has been proven to effectively reduce malaria incidence and prevalence. However, its effectiveness is being threatened due to the resistance of its vectors to insecticides. Furthermore, synthetic insecticides have adverse impacts on the environment, ecological balance, and human health. To address these and the increasing threat of mosquito-transmitted diseases, safe, effective, and locally available control strategies are needed.

Objective

The knowledge, attitudes, and practices of the inhabitants of Arjo Gudatu District on the use of plants to control mosquitoes were assessed.

Materials and Method

A descriptive cross-sectional study was carried out among the residents of Mada Jalala, Karsa Dako, and Lalisa Dimtu kebeles (the lowest level of administrative structure) in Arjo Gudatu District, Oromia Regional State, Ethiopia. Households were selected through systematic random sampling and interviewed using a questionnaire developed for this purpose. The data were collected through house-to-house interviews, checked for completeness and consistency, subsequently entered into SPSS version 25, cleaned, and analyzed.

Results

Among the 398 household representatives who participated in the interviews, 63.5% (253/398) perceived that plants are used to control mosquitoes. Approximately 75% (190/253) used plants to control mosquitoes, and 79% (200/253) had good attitudes toward the plants. Plant smoking was the most commonly cited practice for killing and repelling adult mosquitoes. *Securidaea longes pedunculate* 31/253 (12%) was the most frequently cited plant to have repellent, adulticidal and larvicidal activities, followed by *Echinops sphaerocephalus L* 28/253 (11%) and *Millettia ferruginea (Hochst. ex nees) tender* 9/253(3.5).

Conclusion

Millettia ferruginea (Hochst. ex nees) tander, *Securidaea longe pedunculate*, and *Echinops sphaerocephalus L*. are the plants most commonly used for the control of mosquitoes. The plants were treated with adulticides, larvicides, and repellents in the traditional control of mosquitoes.

1. Background

Arthropods such as mosquitoes, ticks, and sandflies pose the greatest health and economic problems worldwide (1). More than 3.9 billion people are at risk of infection and death (2). Among arthropods, mosquitoes are the species that transmit malaria, filariasis, Japanese encephalitis, dengue fever, yellow fever, West Nile fever, chikungunya, and several others (3). Every year, mosquito-transmitted diseases infect approximately 700 million people and cause more than one million deaths (4). In Ethiopia, *Anopheles arabiensis*, *Anopheles funestus*, *Anopheles pharoensis*, and *Anopheles Nili species* transmit malaria, of which *Anopheles arabiensis* is the predominant malarial vector in the country (5, 6). *Aedes aegypti* also prevails in the country where temperatures are consistently above 10°C (50°F). It is the leading vector of arboviral diseases (7).

Malaria-associated morbidity and mortality decreased dramatically in Ethiopia as a result of the use of insecticide-based vector control tools such as indoor residual insecticide spraying (IRS) and long-lasting insecticide-treated mosquito nets (LLINs) (8). Although these methods play a significant role in reducing malaria in the country, their efficacy has been challenged for several reasons. First, the malaria vector *Anopheles arabiensis* has developed resistance to insecticides (9). Second, these methods fail to control vectors that exhibit exophagic and exophilic behaviors and bite during the early hours of the night (10). Furthermore, insecticides pose a serious threat to the environment as well as human health (11).

These challenges rekindled a need for the development of alternative or complementary vector control approaches to the existing interventions. Plants offer promising alternatives for insecticides and mosquito repellents due to their availability, ecological safety, minimal toxicity against mammals and non-target organisms, specificity against target pests, reduced likelihood of resistance, extended effectiveness requiring less frequent application, cultural acceptability, and suitability for rural settings (11, 12). In addition, natural plants contain bioactive compounds that are active against target insects, are biodegradable, are active against target insects, and have been effectively used against mosquitos. Currently, it is thought that using plant-based bio-insecticides instead of synthetic bio-insecticides is far safer and less harmful (13).

Plants also offer promising alternatives for chemical insecticides and mosquito repellents due to their ecological safety, specificity against target pests, reduced likelihood of resistance, extended effectiveness requiring less frequent application, cultural acceptability, and suitability for rural settings (14). In addition, natural plant chemicals have been effectively used against mosquitos. Currently, it is thought that using plant-based bioinsecticides instead of synthetic bioinsecticides is far safer and less harmful (15). In Ethiopia, where malaria is prevalent, traditional healthcare practices have long relied on herbal remedies to control blood-sucking insects such as mosquitoes. For instance, Karunamoorthi and Hailu 2014) reported the presence of twenty-two mosquito repellents belonging to sixteen families, with the most frequently cited being *Cupressus lusitanica*, *Eucalyptus globulus* and *Boswellia papyrifera* (16). In the Seweyna District of the Bale Zone, Southeast Ethiopia, approximately 19 plant species were used by the local community as mosquito repellents. Among these, *Mimusops kummel* and *Acokanthera schimperi* were the most frequently cited (17). *Allium sativum* (80.55%), *Echinops Jericho* (75.11%), *and Eucalyptus citriodora* (61.66%) are the most frequently used plant species for malaria prevention in the different western regions of the country (18). This indigenous knowledge underscores the potential of plant-based solutions for combating insect-borne diseases while preserving local traditions and biodiversity

To this end, documenting the traditional use of plants remains the basis for scientific evaluation of their mosquitocidal activity and analysis of bioactive compounds. This study assessed the knowledge, attitudes, and practices of the members of the communities of Mada Jalala, Karsa Dako, and Lalisa Dimtu kebeles regarding the use of plants to control mosquitoes.

2. Methods and materials

2.1. Study area

The study was conducted in the Arjo Gudatu district, Eastern Wollega Zone, Oromia Regional State, Ethiopia (Fig. 1). The district is located 343 km southwest of the capital Addis Ababa and 42 km from Nekemte town. Its altitude ranges from 1100 to 2300 meters above sea level. The district has a mean annual rainfall of 1400 mm (1200 __ 2000 mm) and a mean annual temperature ranging from 18°C to 32°C. According to the Central Statistics Agency (2021), the Oromo ethnic group constitutes 98% of the population. Maize, millet, and mango are cultivated in the district. The district is divided into fifteen rural kebeles (kebeles, the lowest administrative structure). Three of these kebeles (Mada Jalala, Karsa Dako, and Lalisa Dimtu) were selected for the study. The selected kebeles have one health center in common, and each of them has one health post. Generally, the district has one health center and 15 health posts. The selected kebeles are malarious partly because of their suitable ecology, which includes an abundance of small rivers and irrigated agriculture. Furthermore, the ongoing political unrest in the area might have exacerbated the transmission of the disease by affecting the health system (Arjo Gudatu Health Center unpublished data), which potentially forced the local people to use indigenous plants for the control of mosquito bites.

Study design and period

A community-based cross-sectional study design was employed from 30 June to 25 September 2023.

2.2. Sample size calculation and sampling technique

The sample size was calculated using the formula for single population proportions because this formula provides a clear, understandable measure of the practice's prevalence in the community. $n = Z^2 (1-p)/d^2$ and a nonresponse rate of 10%. Z= (1.96) is the value under the standard normal table for a confidence level of 95%, and d = margin of error = 4%. Accordingly, the final sample size used for this study was 403. The total sample size was distributed proportionally based on the proportion of households in each kebel relative to the total number of households. Accordingly, 150 households were allocated to Mada Jalala, 144 to Lalisa Dimtu, and 104 to Karsa Dako. In each kebel, the first household was selected from a list of the first encountered 6 households by the lottery method. Then, a representative of every 6th household, aged greater than 18 years, was interviewed using a questionnaire developed for this purpose. The questionnaire was first prepared in the English language and later translated into the local language (Afan Oromo) to make the interview easy to understand and finally translated back to English for data entry, analysis, and interpretation.

2.3. Collection of knowledge, attitudes, and practices data

Each interviewee was asked for his/her knowledge, attitudes, and practices in relation to the use of local plants to control mosquitoes. The main questions included (1) the sociodemography of the participant, 2) knowledge of plant use in the control of mosquitoes, 3) the practices in using plants for the control of mosquitoes, 4) attitudes toward plant-based mosquito control, and 5) the local names of the plants used for the control of mosquitoes/insects, the mode of plant application, the preparation method and the parts of the plant used. The cited plants were categorized on the basis of their affordability, accessibility, growth form, degree of management (wild/cultivated), and indigenous knowledge transfer. Plant specimens were collected during field surveys conducted at various locations within Arjo Gudatu District, Oromia Regional State, Ethiopia. The specimens were identified using herbarium materials, experts, and taxonomic keys in various volumes of the Flora of Ethiopia (19, 20). Voucher specimens were deposited at the National Herbarium of Addis Ababa University, Ethiopia, for future reference.

2.4. Data Management and Analysis

The data were checked for completeness and consistency, entered into SPSS version 25, cleaned, and analyzed. The results are presented as simple frequencies with percentages in tables and graphs. Chi-square analysis was performed to test the knowledge, attitudes, and practices of the Mada Jalala, Karsa Dako, and Lalisa Dimtu kebeles residents about the plants used to control mosquitoes. The significance level was determined using 95% confidence intervals (CIs) and the p value. An MS Excel spreadsheet was also used to create bar graphs and calculate proportions. For the most cited plants, a simple preference ranking was used. Participants were asked to list their preferred plants for vector control from the most to the least among the top twelve plants to identify the most preferred plants by the communities.

2.5. Ethics statement

The study was approved by the Institutional Research Ethics Review Committee (IRERC) of Aklilu Lemma Institute of Pathobiology (ALIPB), Addis Ababa University, Ethiopia (Ref.No. ALIPB IRERC/108/2015/23). Prior to the commencement of the survey, meetings were held with the Arjo Gudatu Health Center, district leaders, and members of the neighborhood associations in which case the objectives of the study were explained. Informed written consent was obtained from each participant prior to the interview. Every participant was assured to withdraw from the interview at any phase if he/she wished to do so. Study identification numbers were used instead of participant names, and the information collected was kept confidential.

3. Results

3.1. Sociodemographic characteristics

Among a total of 403 expected respondents, 398 participated in the interview (a response rate of 98.7% among the anticipated respondents). As shown in Table 1, 67.6% (269) of the participants were males. The ages of the participants ranged from 25 to 75 years. Among the respondents, 74.9% (298) were farmers, and 50.8% (206) had more than six family members. Approximately 21.8% (83) of the respondents reported monthly incomes of 901–1100 Ethiopian women. Close to 50.5% (201) of the respondents could not write or read. Overall, 63.6% (253/398) perceived that plants are used to control mosquitoes, among which 39.9% (101/253) heard from family and 60% (152/253) from the community.

Table 1
Sociodemographic characteristics of Lalisa Dimtu, Karsa Dako, and Mada Jalala kebele residents, Arjo Gudatu district, Oromia Region, Ethiopia

Variable	Category	Frequency (%)
Sex	Male	269 (67.6)
	Female	129 (32.4)
Age	19–30	21(5.3)
	31–40	61 (15.3)
	41–50	121(30.4)
	51–60	124 (31.2)
	> 60	71(17.8)
Family size	1–2	16(4)
	3–4	62(15.6)
	5–6	114(28.6)
	>6	206(51.8)
Educational level	Illiterate	201(50.5)
	Read & write	75 (18.8)
	1–5	70(17.6)
	6–8	27(6.8)
	9–10	25(6.3)
Occupational	Farmer	298(74.9)
	Merchant	30(8)
	Civil servant	16(4)
	Housewife	54(13.6)
	Daily labor	27(6.8)
Income	< 500	89 (22.4)
	501–700	63(15.8)
	701–900	67(16.8)
	901–1100	92 (23.1)
	> 1100	87 (21.9)
Do you know Plants are used to control mosquitoes (n = 398)	Yes	253 (63.5%)
	No	145(36.5%)
Source of knowledge regarding plants used for mosquito control (n = 253)	Community	152 (60%)
	Family	101(40%)

3.2. Knowledge of the respondents on the use of plants to control mosquitoes

A total of 20 plants were cited, among which 12 were the most frequently cited for their adulticidal and repellent properties against mosquitoes. As shown in Table 2, the traditionally perceived insecticidal plants belonged to the Euphorbiaceae, Acanthaceae, Agavaceae, Pasteaceae, Combreteceae, Anacardiaceae, Moraceae, Asteraceae, Polygaleae, Compositeae, Cucurbitaceae, and Fabaceae families. The most commonly used plant species was *Securidaea longe pedunculate* (31/253, 12.3%), followed by *Echinops sphaerocephalus L (*28/253, 11%). Most plant species (60%) were herbaceous, and the rest (40%) were trees. Among them, 8/20 (40%), namely, *Ficus thonningii Blume*, *Terminalia schimperiana Hochst*, *Faurea speciosa Welw.*, *Echinops kebericho*, *Securidaea longe pedunculate*, *Millettia ferruginea (Hochst. ex nees) tender* and *Guizotia scabra* were uncultivated and were harvested from forests. *Allium sativum Linn. Ruta chalepensis L.*, *Lippia adoensis, Lepidium sativum Linn.* and *Brassica nigra Linn. Koch.* (5/20; 25%) were harvested from home gardens or farmland. The remaining *Nicotiana tabacum, Momodicafoetida schumach, Vernonia amygdalina Del., and Ocimum lamiifolium Hochst* (7/20; 35%) were harvested from both the forest and home garden. All reported plant species had their own specific vernacular names, voucher numbers, and frequencies of citation in terms of their insecticidal, larvicidal, and repellent properties against mosquitoes, cockroaches, and other insects.

Table 2
Plants Used to Control Insects in Lalisa Dimtu, Karsa Dako and Mada Jalala Kebele, Arjo Gudatu district, Oromia Region, Ethiopia

Sr.no	Family name	Scientific name	Vernacular name (Afan oromo)	Voucher no.	Frequency of citation (%)	Origin (wild or cultivated)	Growth form	Activities	Types of insects
1	Euphorbiaceae	*Croton macrostachyus Del*	Bekenisa	L11	19(7.5)	Both	Tree	Adulticidal, repellent	Mosquitoes
2	Moraceae	*Ficus thinning Blume*	Bifti	L03	15(5.9)	Wild	Tree	Adulticidal, repellent	Mosquitoes
3	Combretaceae	*Terminalia schimperiana Hochst*	Debeka	L05	19(.5)	Wild	Tree	Adulticidal	Mosquitoes
4	Acanthaceae	*Justicia schimperiana(hochst.ex Nees) T Ander*	Dhumuga	L10	17(6.7)	Both	Herbs	Adulticidal, repellent	Mosquitoes
5	Proteaceae	*Faurea speciosa Welw.*	Garree	L06	21(8.3)	Wild	Tree	Adulticidal, repellent	Mosquitoes and cockroach
6	Agavaceae	*Agave sisalana Perrine ex Engel*	Kacaa	L08	21(8.3)	Both	Herbs	Adulticidal	Mosquitoes and thick
7	Asteraceae	*Echinops sphaerocephalus L*	Kebericho	L02	28(11.1)	Wild	Herbs	Adulticidal, repellent	Mosquitoes
8	Polygalaceae	*Securidaea longe pedunculate*	Tebenaye	L04	31(12.3)	Wild	Tree	Adulticidal, repellent	Mosquitoes, houseflies, thick and snail
9	Anacardiadceae	*Lannea schimperi(A Rich) Engl.*	Warake	L01	10(3.9)	Wild	Tree	Adultcidal	Mosquitoes, houseflies, and cockroaches
10	Verbanaceae	*Lippia adonis*	Kosorota	L20	2(0.7)	Cultivate	Herbs	Larvicidal	Mosquitoes and cockroach
11	Brassicaceae	*Lepidium sativum Linn*	Shinfa	L13	8(3.2)	Cultivate	Herbs	Larvicidal	Mosquitoes, thick and cockroach
12	Cruciferae	*Brassica nigra Linn. Koch*	Sinafica	L14	6(2.4)	Cultivate	Herbs	Larvicidal	Mosquitoes, thick and cockroach
13	Fabaceae	*Millettia ferruginea (Hochst.ex nees) tander*	Sotolo	L07	9(3.5)	Wild	Tree	Larvicidal	Mosquitoes, thick, crustaceans, fish, and cockroaches
14	Rutaceae	*Ruta chalepensis L.*	Tenadema	L18	3(1.2)	Cultivate	Herbs	Larvicidal	Mosquitoes
15	Lamiaceae	*Ocimum lamiifolium Hochst*	Damakase	L17	3(1.2)	Both	Herbs	Repellent	Mosquitoes
16	Asteraceae	*Vernonia amygdalina Del.*	Ebicha	L16	5(1.9)	Both	Tree	Repellent	Mosquitoes
17	Compositeae	*Guizotia scabra*	Hadaa	L12	15(5.9)	Wild	Herbs	Repellent	Mosquitoes
18	Cucurbitaceae	*Momodicafoetida schumach*	Imbayoo	L09	12(4.7)	Both	Herbs	Repellent	Mosquitoes and housefly
19	Alliaceae	*Allium sativum Linn.*	Kulubi	L15	6(2.3)	Cultivate	Herb	Repellent	Mosquitoes
20	Solanaceae	*Nicotiana tabacum*	Tambo	L19	3(1.2)	Both	Herb	Repellent	Mosquitoes

3.2.1. Affordability and accessibility of frequently cited plants

The affordability and accessibility of frequently cited plant species (n = 12) are summarized in Table 3. *Momordica foetida Schumach* (12/12; 100%) and *Echinops sphaerocephalus L.* (28/28; 100%) were perceived as the most accessible plants, followed by *Justicia schimperiana* (16/17; 94%), *Croton macrostachyus Del* (17/19; 89%), and *Millettia ferruginea (Hochst. ex Nees) T. Anders*. (8/9; 88.9%). *Croton macrostachyus Del* was perceived as the most affordable (19/19; 100%), followed by *Justicia schimperiana (Hochst. ex Nees) T. Anders* (17/17; 100%), *Agave sisalana Perrine ex Engelm* (20/21; 95.2%), *Faurea speciosa Welw* (18/21; 85.7%), and *Millettia ferruginea (Hochst. ex Nees) T. Anders* (9/9; 100%). On the other hand, *Lannea schimperi (A. Rich) Engl.* was perceived as the least accessible (6/10; 60%) and the least affordable (7/10; 70%).

Table 3
Accessibility and affordability of the most cited plants used to control insects in Lalisa Dimtu, Karsa Dako, and Mada Jalala kebele, Arjo Gudatu District, Oromia, Ethiopia

Sr.no.	Scientific name	Accessibility		Affordability	
		Yes n/N(100%)	No n/N(100%)	Yes n/N(100%)	No n/N(100%)
1	*Croton macrostachyus Del*	17/19(89%)	2(10.5)	19(100)	0
2	*Ficus thonningii Blume*	11/15(73)	4(27)	12(80)	3(20)
3	*Terminalia schimperiana Hochst*	15/19(78.9%)	4(21%)	16(84.2%)	3(15%)
4	*Justicia schimperiana (hochst.ex Nees) T Ander*	16/17(94%)	1(5.8%)	17/17 (100)	0
5	*Faurea speciosa Welw.*	14/21(66.6)	7(33.3)	18(85.7%)	3(14.3%)
6	*Agave sisalana Perrine ex Engel*	17/21(80.9%)	4(19%)	20(95)	1(5%)
7	*Echinops sphaerocephalus L.*	28/28(100%)	0	28(100%)	
8	Securidaea longe pedunculate	20/31(64.5%)	11(35.5)	25(80.6%)	6(19.4%)
9	*Lannea schimperi(A Rich) Engl.*	6/10(60%)	4(40%)	7(70%)	3(30%)
10	*Millettia ferruginea (Hochst.ex nees) tander*	8/9(88.9)	1(11)	9(100%)	0
11	*Momodicafoetida schumach*	12/12(100)	0	12(100%)	0
12	*Guizotia scabla*	10/15(66.6)	5(33.3%)	12(80%)	3(20%)

3.3. Attitudes of respondents toward using plants for mosquito control

Of the respondents with knowledge, 79% (200 out of 253) expressed positive attitudes toward using plants for mosquito control. Close to 60.8% (154/253) of the respondents agreed that these plants are effective against mosquitoes. Additionally, 57.7% of the 253 respondents indicated that they would recommend that others use 144 (56.9%) of them believe the safety of the plants, and 125 (49.4%) of the respondents believe Lalisa Dimtu, Karsa Dako and Mada Jalala kebele residents agree.

Table 4
Attitudinal score of Meda Jalala, Karsa Dako, and Lalisa Dimtu kebeles residents on the use of plants to control mosquitoe**s**

Variable	Strongly agree (%) n = 253	Agree (%) n = 253	Unsure (%) n = 253	Disagree (%) n = 253	Strongly disagree (%) n = 253
Efficacy	46(18.2)	154 (60.8)	34(13.4)	19(7.5)	0
Safety	56(22)	144(56.9)	38(15)	15(5.9)	0
Acceptance	75(29.6)	125(49.4)	53(20.9)	0	0
Modernize	57(22.5)	143(56.5)	47(18.5)	6(2.3)	0
Recommendation	54(21.3)	146(57.7)	44(17.4)	9(3.5)	0

3.4. Practice of respondents on the use of plants to control mosquitoes

In total, 75% (190/253) of the respondents had practiced plants for insecticides and repellents. The respondents cited 3, 5, and 6 plant species as adulticidal, larvicidal, and repellent, respectively, and 6 plants were used for both repellent and adulticidal purposes. Plants belonging to the species *Millettia ferruginea (Hochst. ex nees) tander* were the most reported plant species for their larvicidal properties. In addition, the species *Securidaea longe pedunculate* is the most reported plant for adulticidal and repellent insects.

3.4.1. Plant parts used for the control of mosquitoes

As shown in Fig. 2, the whole body of the plant was the most extensively used for adulticidal applications (25%), followed by roots (13%) and leaves (4%). For larvicidal applications, seeds were the most commonly reported plant part (6%), followed by leaves (4%). For repellent purposes, leaves were the most commonly used plant part (8.4%), followed by whole plants (14.7%) and roots (10.5%).

3.4.2. Modes of preparation and application of the plants

As shown in Fig. 3, 41.6% (79/190) of the respondents claimed to use insecticide plants by burning or smoking them with a traditional charcoal stove for adulticidal purposes, and 27.9% (53/190) claimed to use insecticide plants for repellent purposes against mosquitoes. This is followed by powdering the plants and applying them to the exposed body as repellents (20%) (338/190) and powdering and adding them to stand water for larvicidal purposes (10%) (20/190).

3.4.3. Time of plant use for the control of most by the residents

As shown in Fig. 4, participants utilized the plants for various activities at different times of the day. For adulticidal activities, usage was highest in the evening (30%), followed by any time (22%) and the morning (8.9%). For repellent activities, the evening was again the most common time (46.3%), followed by any time (17.4%) and the morning (8.9%). For larvicidal activities, the plants were used most frequently at any time (8.9%), followed by the afternoon (4.5%) and the morning (0.5%).

3.5. Associations of Socio-demographic Factors with the Knowledge, Attitudes, and Practices of Insecticide Plants among Residents of Lalisa Dimtu, Meda Jalala, and Karsa Dako Kebeles

The chi-square analysis in Table 5 reveals significant differences in the knowledge of insecticidal plants based on several demographic factors. Males were found to be more knowledgeable than females. Similarly, respondents with low incomes had greater knowledge than did those with high incomes. Additionally, the Mada Jalala community showed greater awareness than did the Lalisa Dimtu and Karsa Dako kebeles communities ($p < 0.05$). No significant differences in knowledge were observed by age ($p > 0.05$). In terms of attitudes toward using plants for mosquito control, significant differences were found based on age ($p < 0.05$), with older respondents exhibiting more positive attitudes than younger respondents. However, there were no significant differences in attitudes by sex or income ($p > 0.05$). The practice analysis indicated significant differences by sex and income: males were more likely to apply plants for vector control than females were, and respondents with low incomes were more likely to use these plants than were those with high incomes were ($p < 0.05$). No significant differences in practice were observed by age ($p > 0.05$).

Table 5
Chi-square analysis of knowledge, attitudes, and practices of Lalisa Dimtu, Karsa Dako and Mada Jalala Kebele, Arjo Gudatu district, related to insecticide plants

Variable	Variable category	Number responders	Knowledge of mosquitocidal plants		p value	Attitude on plants as mosquitocidal		p value	Practice of mosquitocidal plants		p value
			No	Yes		No	Yes		No	Yes	
Sex	Male	269	79	186	X^2 = 13.2df = 1 P = 0.00	29	145	X^2 = 0.25 9, df = 1 P = 0.611	130	138	X^2 = 4.5 df = 1, P = 0.034
	Female	129	62	67		12	55		77	52	
Income	< 500	90	42	46	X^2 = 19.9df = 4 P = 0.001	8	37	X^2 = 3.01 df = 4 p = 0.55	58	32	X^2 = 18.269, df = 4, p = 0.001
	501–700	63	32	31		8	20		40	23	
	701–900	67	16	51		6	41		23	44	
	901–1100	91	62	29		9	50		44	46	
	> 1100	87	63	22		10	52		42	45	
Kebele	Mada jalala	150	37	110	X^2 = 12.3df = 2 P = 0.002	19	88	X^2 = 0.12df = 2 P = 0.94	65	84	X^2 = 8.051 df = 2 P = 0.018
	Lalisa dimtu	144	59	84		13	67		79	65	
	Karsa dako	104	45	59		9	45		63	41	
Age	19–30	21	6	15	X^2 = 9.1 df = 4 P = 0.058	6	6	X2 = 10.7 df = 4, p = 0.031	13	8	X2 = 7.2 df = 4, p = 0.125
	31–40	61	25	36		8	25		37	24	
	41–50	121	49	70		6	63		63	58	
	51–60	124	46	76		12	63		66	57	
	> 60	71	15	56		9	43		28	43	

4. Discussion

The findings of this study showed the high dependence of people in the Arjo Gudatu District of the East Wollega Zone on traditional herbal medicine for their day-to-day primary healthcare needs, as demonstrated by the high number of plants reported for their insecticide properties. The knowledge, attitudes, and practices of insecticide plants data also revealed that 64.6% of the respondents had knowledge, 75% had practiced or applied those plants, and 79% had a good attitude toward the use of indigenous plants for insect vector control, such as mosquitoes. A similar study conducted in Bechobore Kebele, Jimma Zone, Oromia Regional State, Ethiopia, reported that 70.2% and 91.8% of the respondents had ample awareness and usage of repellent plants, respectively (16); hence, greater knowledge and practice of insecticide plants were reported in the Bechobore Kebele than in the current study.

This study revealed a lower level of community familiarity with traditional insecticidal plants for controlling insect vectors than did previous research findings. For instance, Addis Zemen town (97.2%)(21), Kofe Kebele (83.6%)(22), the Western Hararghe Zone (92.1%)(23) and the Tigray region (95%) (24) were reported. Community knowledge of insecticidal plants was reported to be greater. This variation in knowledge could be attributed to differences in the accessibility and availability of modern personal protection tools in these study areas, unlike in the kebeles of the current study district, where there was notably high awareness of traditional insect repellent plants. However, there is still a lack of cultural knowledge and traditional practices related to insect-repellent plants. Therefore, it is imperative to conduct more ethnobotanical surveys to adequately document and preserve indigenous knowledge and cultural practices. Additionally, further studies are needed to verify that plants have insecticidal effects on mosquitoes and to identify and quantitatively analyze the bioactive molecules responsible for these properties.

Seventy-two percent of the respondents were well aware of the existence of repellent plants in various epidemic-prone areas of Ethiopia (16). Studies that were conducted on two kebeles of Sisiga woreda, Karsa Mojo (78.3%) and Mada Jalala (74.4%), reported that they had knowledge about traditional medicinal plants that are used for malaria prevention and treatment in their localities (18). Statically, there was no significant difference between the current and previous studies; therefore, the previous findings are strongly in agreement with the present study. The majority of participants in the study acquired information about insecticide plants from their community, with 60% citing this source, while 40% reported gaining from their families. Knowledge transmission appears to be predominantly oral and passed through generations, ensuring that valuable ethnobotanical practices persist. These practices contribute significantly to household health management, particularly in rural areas where conventional healthcare services are limited.

In total, twenty plants were identified by respondents as effective larvicidal, adulticidal, and repellent agents against insects. Among these, the twelve most commonly cited plant families renowned for their insecticidal properties include *Croton macrostachyus Del, Ficus thonningii Blume, Terminalia schimperiana Hochst Justicia schimperiana (hochst.ex Nees) T Ander, Faurea speciosa Welw., Agave sisalana Perrine ex Engel, Echinops sphaerocephalus L., Securidaea longe pedunculate, Lannea schimperi (A Rich) Engl., Millettia ferruginea (Hochst.ex nees) tander, Momodicafoetida schumach*, and *Guizotia scabla*. These plants represent rich reservoirs of traditional knowledge and practical solutions for insect control for study area residents. Different studies conducted in Ethiopia have indicated that varying numbers of plants are utilized for vector control. For instance, eight plants are employed as insecticides and repellents in West Gojjam's Jabitehnan District (25), and 19 plant species in the Bale Zone of the Seweyna district have been reported for repellent purposes (17).

In Tanzania, different plants were mentioned by the community, such as "mwarobaini" (*Azadirachta indica)* (22.5%), “mtopetope” (*Annona* spp) (20.8%), “mchungwa/mlimau” (*Citrus* spp) (8.3%), “mvumbashi/uvumbati” (*Ocimum* spp) (7.4%), “mkorosho” (*Anacadium occidentale*) (7.1%), “mwembe” (5.4%) (*Mangifera indica*), “mpera” (4.1%) (*Psidium* spp) and “maganda ya nazi” (4.1%) (*Cocos nucifera*) (26). Although this study highlights the richness of ethnobotanical knowledge in the study area, it is limited by its regional focus and the specific plant species identified. Future research should aim to explore a broader range of regions and plant species to gain a more comprehensive understanding of ethnobotanical practices for insect control. Additionally, scientific validation of the efficacy and safety of these plants is essential to promote their wider adoption.

A total of 74% of respondents reported that insecticidal plants are easy to access, and 89% stated that they are affordable, underscoring the significant impact of biodiversity and other ecological factors on the availability of these plants. This finding is consistent with that of Karunamoorthi K. (2009) (22), who reported that many people in Ethiopia use insecticidal plants, likely due to the country's rich biodiversity and distinctive ecological environment. The easy accessibility and affordability of insecticidal plants also suggest the potential for sustainable vector control strategies that are locally sourced and culturally accepted. Public health initiatives can influence this advantage by promoting the use of indigenous insecticidal plants, supporting community-based harvesting practices, and ensuring that these resources are preserved and sustainably managed.

The study results show a strong positive attitude toward conventional insecticidal plants among the respondents, with 79% expressing satisfaction and slightly more than 84% acknowledging their effectiveness. This high level of approval suggests that conventional insecticidal plants are well regarded in the community, as they are not only effective but also safe and acceptable. However, the small percentage of respondents with negative opinions about these plants is noteworthy. This minority perspective may be influenced by a variety of factors, including religious beliefs and cultural practices. For instance, certain religious doctrines may discourage the use of specific plants or methods, viewing them as incompatible with spiritual or cultural values. Cultural preferences for alternative methods, such as synthetic insecticides or other traditional practices, might also play a role in shaping these negative attitudes.

Approximately 75% of respondents practiced using plants for insecticidal and repellent purposes, indicating a strong reliance on traditional methods for vector control. This high percentage reflects widespread knowledge and trust in botanical solutions, possibly due to their accessibility, cost-effectiveness, and historical efficacy. Approximately 91.8% of the respondents reported using repellant plants in various epidemic-prone areas of

Ethiopia (16). This percentage is greater than that of the current research findings, possibly due to insufficient health facilities in the area, lack of current control and prevention methods applied by the government, and the high endemicity of malaria. In Tanzania, approximately 22.8% of respondents reported familiarity with traditional insecticidal practices (26). In contrast, our research indicated that a greater percentage of respondents were familiar with and practicing insecticidal plant methods. This difference may be due to variations in sample sizes and demographic characteristics between the studies.

Approximately 27.8% and 36.8% of people burned and smoked for repellent and adulticidal activities, respectively. Most of them in the community used their whole parts, but only a few plants used their roots and leaves. In Guinea-Bissau, 55% of people burn plants to repel mosquitoes, (27) and up to 100% of Kenyans burn plants to repellent mosquitoes (28), which is higher than the current result. The other finding in the Tigrayi region was that approximately 73% of respondents smoked by burning a particular plant part (24). Smoking was a common practice among the majority of the community, likely because burning or smoking plants releases volatile compounds that can deter or kill mosquitoes. This method is effective for immediate, localized mosquito control and is rooted in traditional practices. For instance, phytochemical analysis of *Ficus thonningii Blume*, one of the plants cited in the present study, revealed the presence of alkaloids, terpenoids, flavonoids, tannins, and essential oils (29). The plants identified by respondents in the current study as being used for adulticidal and repellent purposes through smoking include *Croton macrostachyus Del, Agave sisalana Perrine ex Engel, Echinops* sp., *Securidaea longe pedunculate, Terminalia schimperiana Hochst, Justicia schimperiana (Hochst. ex Nees) T. Ander, Faurea speciosa Welw.*, and *Lannea schimperi (A. Rich) Engl.*

The respondents in the study also reported applying crushed plants, such as *Momordica foetida, Guizotia scabra, Vernonia amygdalina*, and *Ocimum lamiifolium*, directly to their skin to prevent insect bites, especially before bedtime and during farming. This practice effectively targets mosquitoes and other harmful insects. Similar procedures were observed in the West Gojjam district of Jabitehnan, where plant infusions were applied to exposed body parts for insect repellent purposes (25). In another study conducted in Ethiopia, 7.53% of repellent plant extracts were sprayed after being crushed or ground. Additionally, 0.86% of respondents reported hanging crushed plants, and 0.11% mentioned sprinkling leaves of repellent plants on the ground (30). These results highlight the diverse methods employed by different communities to utilize plant-based insect repellents. Crushing and applying plants directly to the skin is a common and effective practice for immediate protection, while spraying and other methods involve a variety of traditional approaches to insect repellency. The varying percentages also suggest differing levels of reliance on and effectiveness of these methods within different regions and communities.

The practice of using ground plants added to water to kill mosquito larvae is an effective, sustainable, and culturally significant method of mosquito control. The specific plants used—*Lippia adoensis*, *Lepidium sativum*, *Brassica nigra*, *Millettia ferruginea*, and *Ruta chalepensis*—demonstrate the community's extensive ethnobotanical knowledge and their ability to utilize natural resources for insect management. These findings provide a valuable foundation for developing natural insecticidal products and integrating traditional methods with modern scientific approaches to enhance mosquito control strategies.

A chi-square test revealed a statistically significant relationship between respondents' income and sex as well as their knowledge of insecticide plants but not between respondents' age. Male respondents knew more about insecticide plants in this study than female respondents did. This is most likely connected to their duty to shield their families and themselves from illness and insect bites. Furthermore, the majority of the respondents to the survey were men. However, these findings are inconsistent with those of the study by Karunamoorthi and Hailu 2014 (16). The study was conducted in western Jamaica, and gender was a significant factor in respondent knowledge (31). The findings of the study supported the current finding that male respondents were more knowledgeable than female respondents.

These results are comparable to those of previous studies conducted in Ethiopia in endemic-prone settings on insect-repellent plants, in which sex and average monthly income were significantly associated (16). Nevertheless, insecticide use was not significantly associated with age but was significantly associated with the monthly income and sex of the respondent. Interestingly, the study also revealed that the use of insecticides was significantly associated with sex and monthly income but not with age. This divergence indicates that economic factors and gender roles might play a crucial role in the decision-making process regarding insecticide use. For instance, higher income levels might provide better access to commercial insecticides, which are often more expensive than natural alternatives. Additionally, gender dynamics could influence household responsibilities and exposure to insects, thereby affecting insecticide usage patterns.

The lack of a significant association between insecticide use and age suggests that age-related factors, such as generational knowledge, might not strongly influence the decision to use insecticides. This could imply a broader acceptance or need for insecticides across all age groups within the community, potentially driven by the effectiveness and convenience of these products compared to natural methods.

5. Conclusion and Recommendations

The diversity of reported insecticide plants (20 species) employed to control insect vectors is indicative of plant-related rich knowledge of traditional medicine practices to control mosquitoes in the Arjo Gudatu district. Whole plants and leaves have been reported to be the most commonly utilized plant parts in insect vector control, and smoking is the most commonly reported mode of application (usage) of whole plants, plant parts, and their extracts. As communities embrace and preserve these traditions, positive attitudes toward indigenous plant-based insect control strategies become essential. Through practical implementation, these plants not only prove effective in insect management but also contribute to sustainable and ecologically friendly alternatives. Moreover, these plants are easily available, accessible, and affordable; therefore, the use of traditional insecticide plants should be promoted within the local community to reduce mosquito-borne diseases. The efficacy of adulticidal, larvicidal, and repellent treatments for these plants has not yet been validated in the study area; therefore, there is a need to scientifically validate the insecticidal properties of these plants. Moreover, based on the good knowledge, positive attitudes, and practical application of insecticide plants by communities, it is imperative to use potential indigenous plants as an alternative, plant-based insect control strategy while respecting cultural heritage and promoting sustainability.

Declarations

We, the authors of this manuscript, hereby declare the following regarding ethics and funding:

Ethics Declaration:

- This research was conducted in accordance with the Declaration of Helsinki.
- All human participants in this study provided their informed consent to participate.
- Ethical approval for this study was obtained from the Aklilu Lemma Institute of Pathobiology Research Ethics Review Committee, including members Prof. Birhanu Erko (chairperson) and Dr. Alemtsay Teka, (secretary) with the approval number (Ref. No. ALIPB IRERC/108/2015/23). Ethical clearance documentation has been included in the manuscript.

Human Ethics and Consent to Participate Declarations:

- All necessary declarations regarding human ethics and consent to participate have been included in the manuscript.

Funding Declaration:

- This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Signed,

1: Lensa Tesfaye, corresponding author

2: Esayas Aklilu, co-author

3: Ketema Tolossa, co-author

4 : Abebe Animut, co-author

Consent to participate declarations

Title: Community Knowledge, Attitudes, and Practices on the Use of Plants to Control Mosquitoes: The Case of Arjo Gudatu District, East Wollega Zone, Oromia Regional State, Ethiopia
Name of Principal Investigator: Lensa Tesfaye
Name of Organization: Aklilu Lemma Institute of Pathobiology, Addis Ababa University
Name of Proposal: PhD Dissertation

Good morning/afternoon,

My name is ________________________, and I am the data collector for a research study being conducted by a PhD student from the Aklilu Lemma Institute of Pathobiology, Addis Ababa University. I am here to collect information about the knowledge, attitudes, and practices of the community in Arjo Gudatu district, East Wollega Zone, Oromia Region, West Ethiopia, regarding the use of indigenous plants for traditional insect control. I would like to ask you some questions as part of this study.

Participation Information:

- **Purpose:** This study aims to gather data on community knowledge, attitudes, and practices related to the use of indigenous plants for mosquito control.
- **Duration:** Your participation will take approximately 30 minutes.
- **Confidentiality:** Your responses will be kept confidential, and your name will not be included in the information collected.
- **Voluntary Participation:** Your participation is entirely voluntary, and you have the right to withdraw at any time without any consequences.
- **Benefits and Risks:** There is no immediate monetary benefit for participating. However, your contribution will provide valuable information that may benefit the community's welfare. There are no risks associated with your participation.

Your honest responses are crucial for the success of this study, and I sincerely request your participation.

Contact Information: If you have any questions or need further clarification, you can contact the principal investigator:

- **Name:** Lensa Tesfaye
- **Address:** Addis Ababa
- **Cell phone:** +251-908983288
- **Email:** lensat003@gmail.com

Informed Consent Form

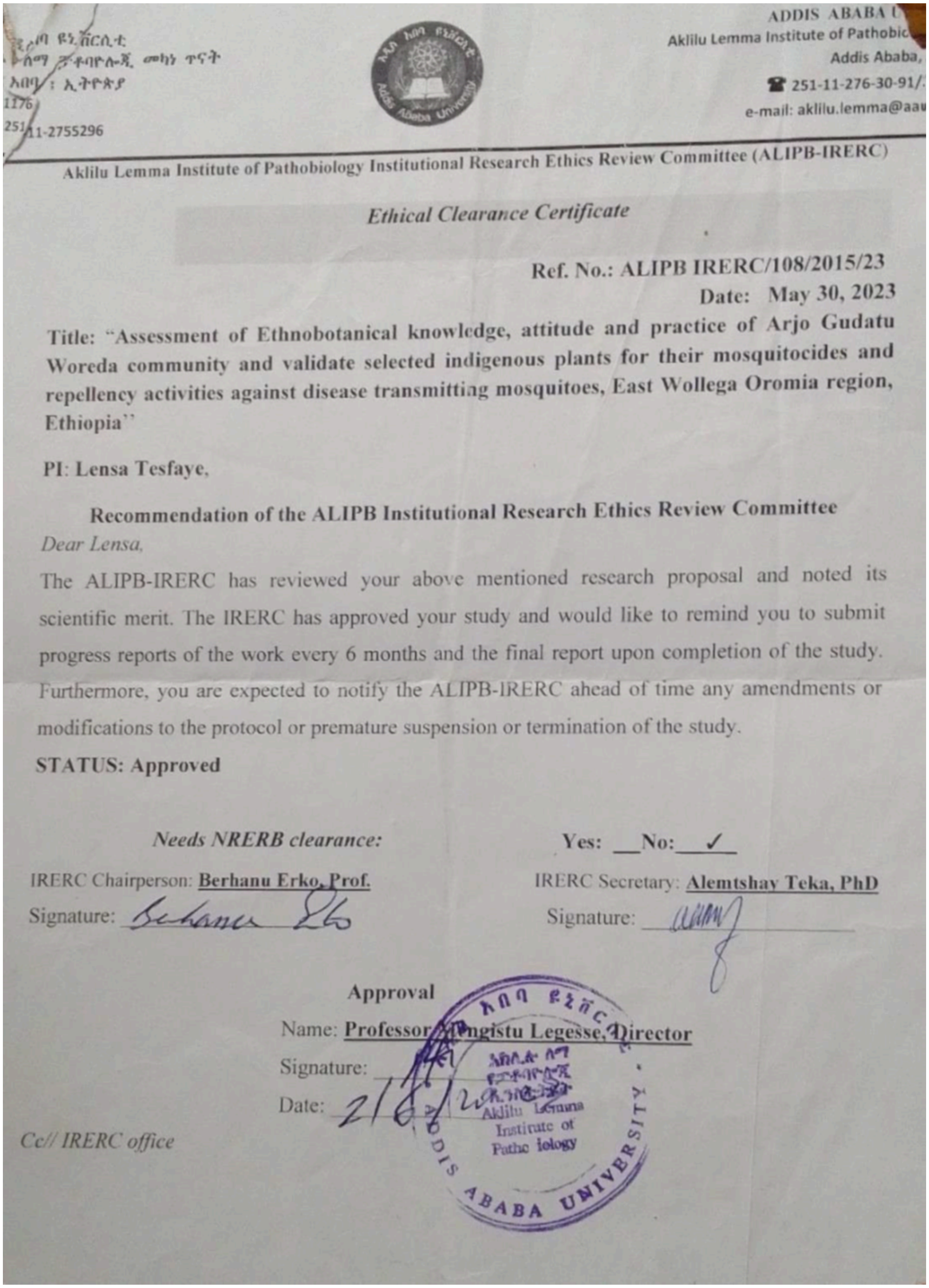
Based on the information provided, are you willing to participate in this study?

a) Yes, I agree to participate. (Proceed to interview)

b) No, I do not agree to participate. (Thank the respondent and end the interview)

Name of the Interviewer: ____________________________
Signature of the Interviewer: ________________________
Date: ___________________

Thank you for your time and participation.



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Aklilu Lemma Institute of Pathobiology Institutional Research Ethics Review Committee (ALIPB-IRERC)

Ethical Clearance Certificate

Ref. No.: ALIPB IRERC/108/2015/23
Date: May 30, 2023

Title: "Assessment of Ethnobotanical knowledge, attitude and practice of Arjo Gudatu Woreda community and validate selected indigenous plants for their mosquitocides and repellency activities against disease transmitting mosquitoes, East Wollega Oromia region, Ethiopia"

PI: Lensa Tesfaye,

Recommendation of the ALIPB Institutional Research Ethics Review Committee

Dear Lensa,

The ALIPB-IRERC has reviewed your above mentioned research proposal and noted its scientific merit. The IRERC has approved your study and would like to remind you to submit progress reports of the work every 6 months and the final report upon completion of the study. Furthermore, you are expected to notify the ALIPB-IRERC ahead of time any amendments or modifications to the protocol or premature suspension or termination of the study.

STATUS: Approved

Needs NRERB clearance: **Yes: __No: ✓**

IRERC Chairperson: **Berhanu Erko, Prof.**
Signature: Berhanu Erko

IRERC Secretary: **Alemtshay Teka, PhD**
Signature:

Approval

Name: **Professor Mengistu Legesse, Director**
Signature:
Date: 2/6/2023

Cc// IRERC office

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Figures

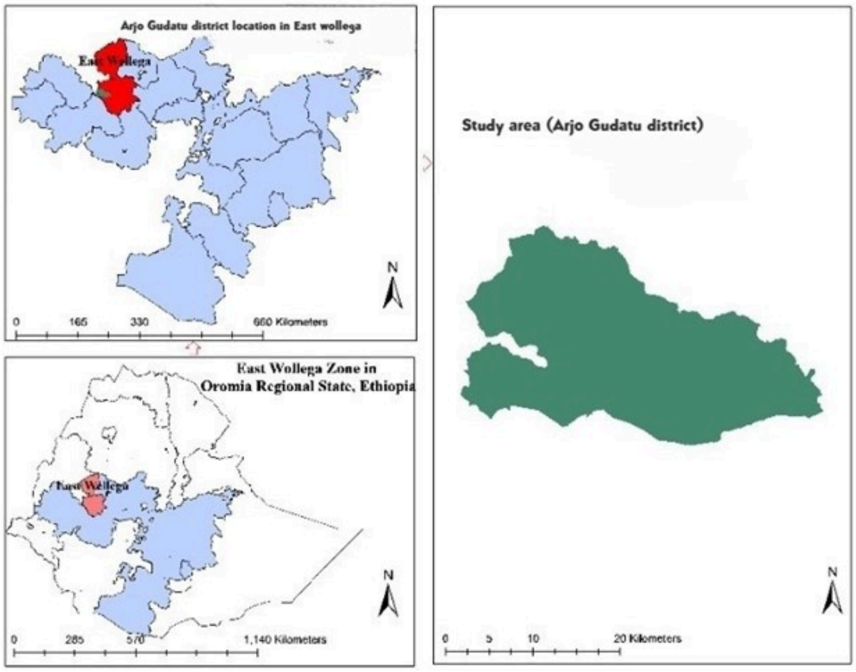

Figure 1

Map of the East Wollega Zone in the Arjo Gudatu District, Oromia Regional State, Ethiopia. (Source: ARC map)

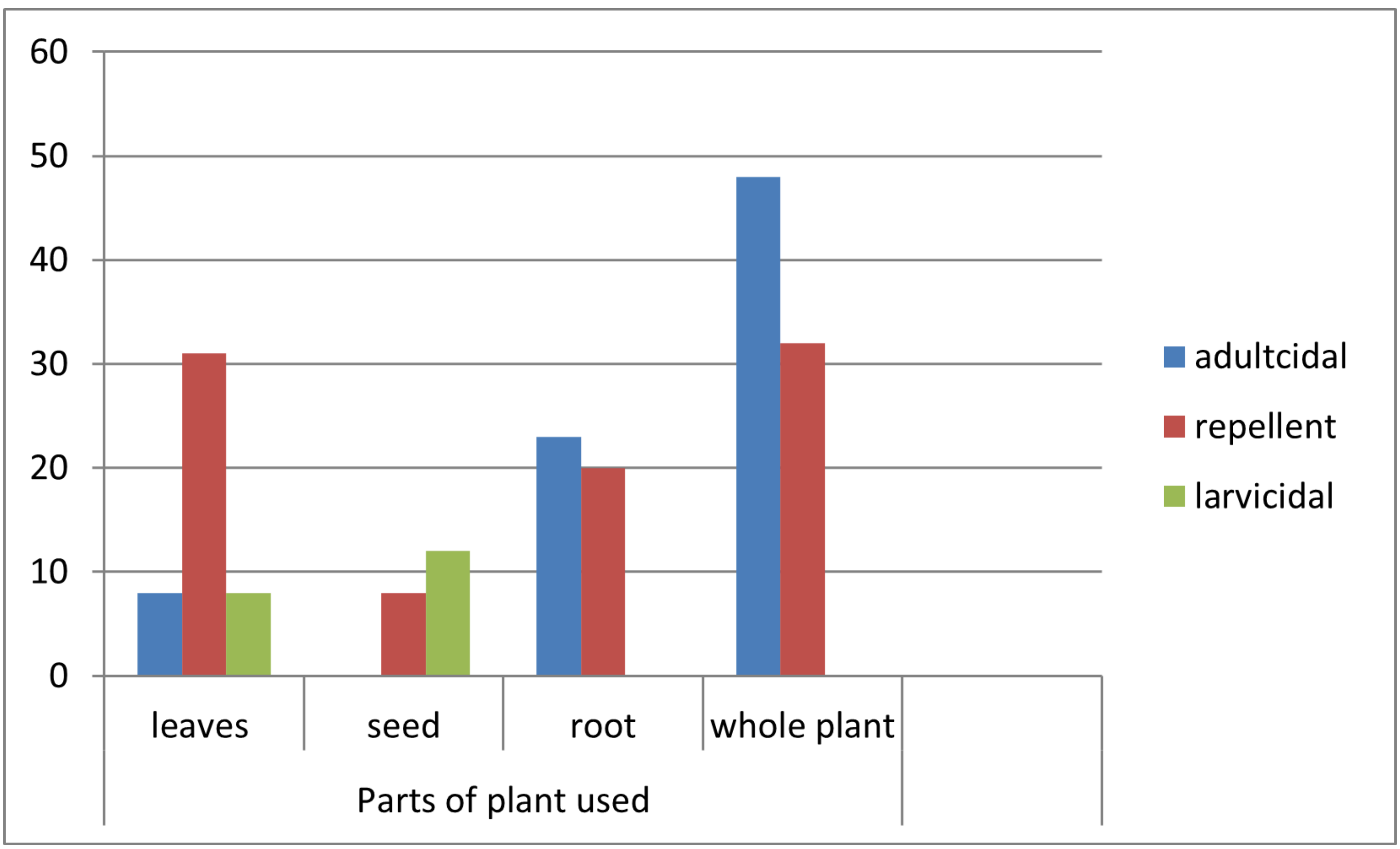

Figure 2

Frequency of plantparts used for adulticidal, larvicidal, and repellent activities by Lalisa Dimtu, Karsa Dako, and Mada Jalala in Arjo Gudatu district, Oromia, Ethiopia.

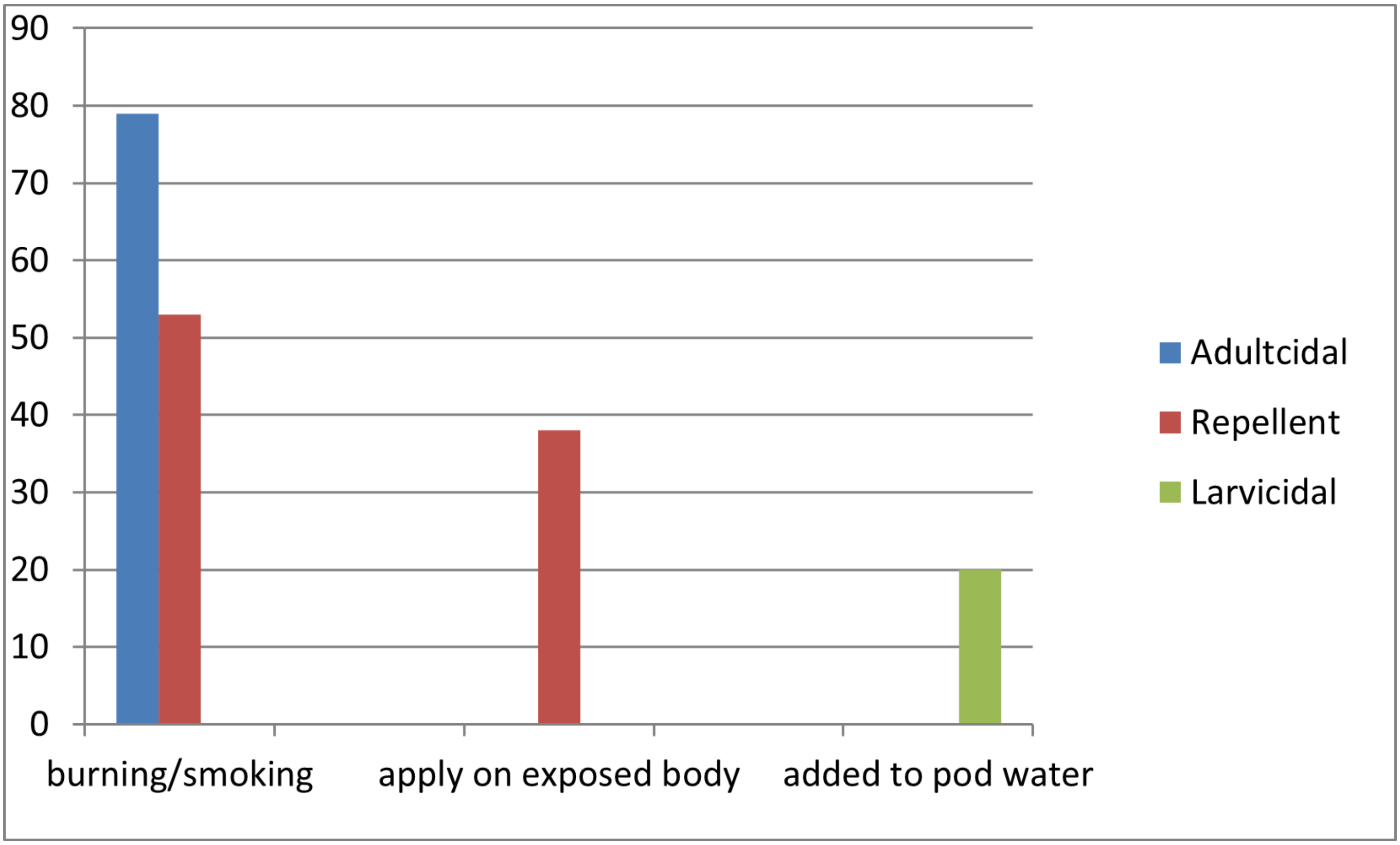

Figure 3

Frequency of plant application methods for adulticidal, larvicidal, and repellent activities by Lalisa Dimtu, Karsa Dako, and Mada Jalala kebele, Arjo Gudatu district, Oromia Region, Ethiopia

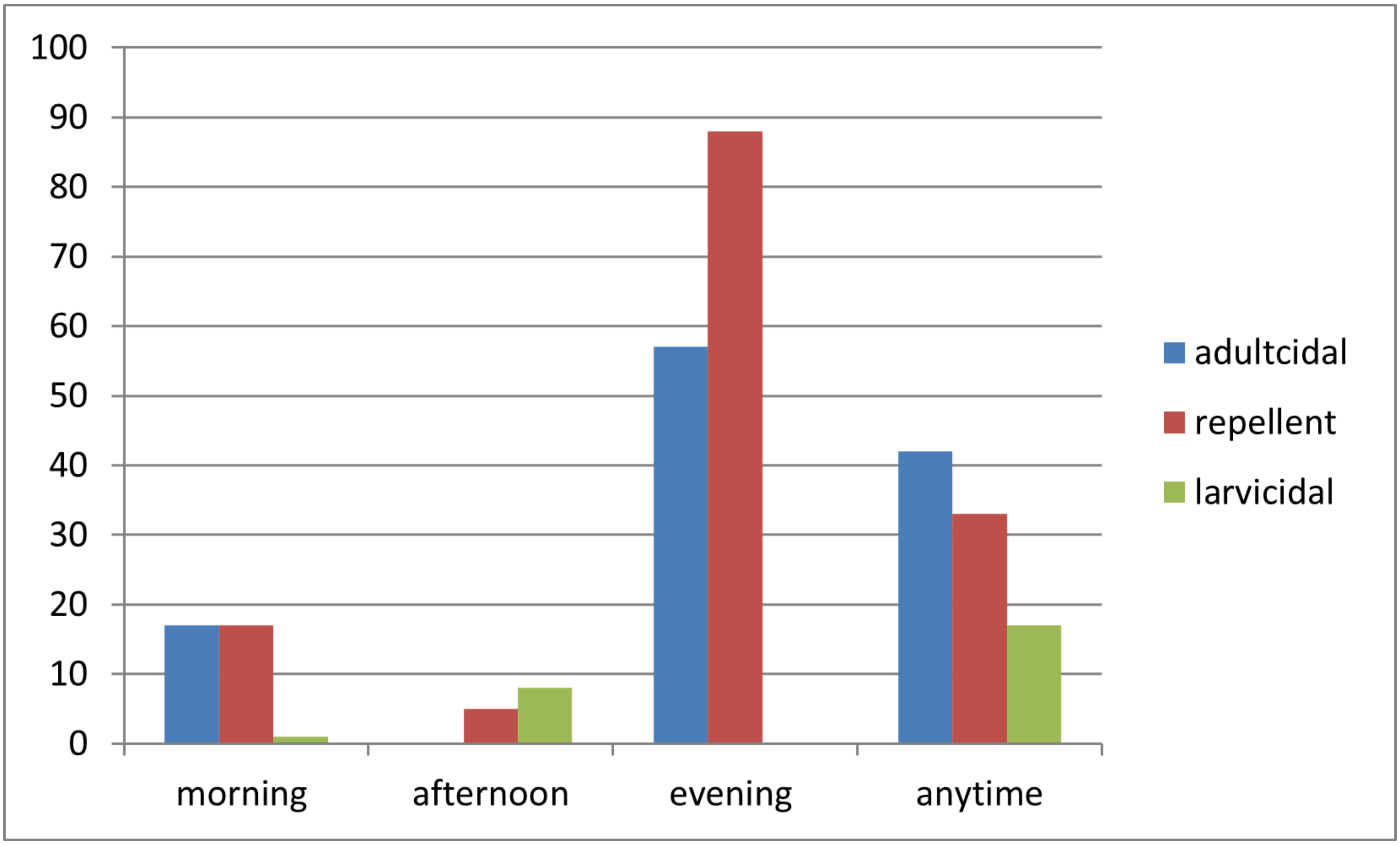

Figure 4

Frequency of plantusage time for adulticidal, larvicidal, and repellent activities in Lalisa Dimtu, Karsa Dako, and Mada Jalala kebele, Arjo Gudatu district, Oromia Region, Ethiopia