

UNIVERSITY OF YAOUNDE I

UNIVERSITE DE YAOUNDE I



FACULTY OF SCIENCES

FACULTE DES SCIENCES

DEPARTMENT OF ANIMAL BIOLOGY AND PHYSIOLOGY

DEPARTEMENT DE BIOLOGIE ET PHYSIOLOGIE ANIMALES

LABORATORY OF PARASITOLOGY AND ECOLOGY

LABORATOIRE DE PARASITOLOGIE ET ECOLOGIE

**Bedbugs: Population's perception,
prevalence and re-description of the
principal species in Obala, Centre
Region of Cameroon**

DISSERTATION

Presented towards obtaintion of a Masters Certificate in Biology of Animal Organisms

By

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DEDICATION

I dedicate this work to my beloved mother, **EYILI KOA Marie Anne**.

ACKNOWLEDGEMENTS

The realisation of this work was not an easy task and therefore could not be done by me alone. I hereby thank all those who had a participative hand towards this accomplishment and notably:

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LIST OF ABBREVIATIONS

- BCE:** Before Current Era
- CAHF:** Centre for Affordable Housing Finance in Africa
- CDHS:** Cameroon Demographic and Health Survey
- CDP:** Communal Development Plan
- CO₂:** Carbondioxide
- DDT:** Dichlorodiphenyltrichloroethane
- HBV:** Hepatitis B Virus
- mm:** millimeters
- NIS:** National Institute of Statistics
- PTSD:** Post Traumatic Stress Disorder
- UK:** United Kingdom
- USA:** United States of America
- VOC:** Volatile Organic Compounds

ABSTRACT

Human ectoparasites pose great public health significance in densely populated, overcrowded communities. They can be found living permanently on their host, like human head lice do, or can parasitise them occasionally, only during feeding periods, as it is the case with bedbugs. Many authors have described a world wide upsurge of bedbug infestations. Is this a reality in our localities? The current study aimed at evaluating the population's perception about bedbugs, estimate the prevalence of infestations due to these bugs in Obala and re-describe the species concerned. The field work was achieved during the months of July and August 2023 in randomly selected zones in the Obala sub-division, Centre region of Cameroon. A total of five hundreds and twenty (520) people and about two hundreds and fifty (250) households were sampled and checked. Participants took part in the survey, bedbug samples were handpicked from mattresses, cracks/crevices of walls and furniture in homes. The fourteen (14) collected specimens were brought to the laboratory of Zoology at the University of Yaounde I, for morphological identifications. The effective prevalence of 4.4% was obtained from the Obala population at the end of our study, for 11 infested homes out of the 250 sampled. A total of 14 specimens were collected in good state, belonging to two species (*Cimex lectularius* accounting for 78.57% with 11 specimens and *Cimex hemipterus* accounting for 21.43% with 3 specimens). A considerable part of the population knew about this infestation and could describe the structure of the parasites (56.35%), their localisations (44.59%), and symptoms (1.54%). The age, the educational level, density of the population at home, the sharing of beds and the knowledge of infestation can be considered to have a significant relation with the infestation by bedbugs. There was no observed significant relation between the infestation and the living standard. The population should be better educated and sensitized on these parasites in order that they can be eradicated.

Key words: Upsurge, infestation rate, survey, ectoparasitosis, Obala

RESUME

Les ectoparasites sont des organismes qui posent un réel et grave problème de santé publique. Selon l’OMS, ceci s’observe généralement dans des zones surpeuplées. Dans ce sens, ils peuvent vivre en permanence sur leur hôte (cas des poux) ou alors peuvent simplement entrer en contact avec l’organisme hôte uniquement lors des repas sur celui-ci (cas des punaises de lit). Selon plusieurs auteurs, les punaises de lit ont récemment connu une résurgence dans le monde entier. Ce fléau est-il aussi une réalité dans nos localités ? La présente étude vise à évaluer l’avis de la population d’Obala sur les punaises de lit, estimer la prévalence de l’ectoparasitose causée par ces punaises et ré-décrire les espèces en cause dans cette zone. L’étude de terrain a été menée pendant les mois de juillet à août 2023 dans des secteurs choisis aléatoirement de l’arrondissement d’Obala. Un total de 520 personnes a été échantillonné et environ 250 domiciles ont été inspectés au cours de l’étude par le biais d’un questionnaire rempli par des volontaires. La collecte de punaises par fouille des domiciles infestés a aussi été réalisée. Les punaises étaient fouillées dans les matelas, les fissures de murs et les fauteuils. Les collectes ont été acheminées au laboratoire de Zoologie de l’Université de Yaoundé I, pour des identifications morphologiques. Des domiciles étaient effectivement infestés de punaises de lit et nous avons collecté un total de quatorze (14) spécimens en bon état qui ont été apporté au laboratoire et observés comme appartenant à deux espèces du genre *Cimex* à savoir *Cimex lectularius* comptant pour 78,57% avec 11 spécimens et *Cimex hemipterus* comptant pour 21,43% avec 3 spécimens. Une prévalence de 4,4% a été obtenue et nous avons observés qu’une portion considérable de la population échantillonnée avait connaissance de cette infestation : 56,35% pouvait décrire les punaises comme de sortes de très petits cafards qui piquent et vivent dans les chaises, matelas et murs. Seulement 1,54% (8 repondants) pouvait bien décrire les symptômes observés suite à une infestation. L’âge, le sexe, le niveau d’étude, la taille de la population à domicile et l’usage commun de lits ont tous montré une variation significative directe avec l’infestation (facteurs de risques) pendant que le niveau de vie semble ne pas être facteur déterminant le risque d’infestation. La population devrait donc être sensibilisée sur le sujet des punaises de lit afin de réduire sa prévalence au plus bas.

Mots clés : Recrudescence, taux d’infestation, enquête, ectoparasitose, Obala

REPUBLIQUE DU CAMEROUN
Paix-Travail-Patrie

MINISTERE DE LA SANTE PUBLIQUE

DELEGATION REGIONALE DE LA
SANTE PUBLIQUE DU CENTRE

DISTRICT DE SANTE D'OBALA



REPUBLIC OF CAMEROON
Peace – Work – Fatherland

MINISTRY OF PUBLIC HEALTH

REGIONAL PUBLIC HEALTH
DELEGATION OF THE CENTER

OBALA HEALTH DISTRICT

N° 076 L/MINSANTE/DRSPC/DSO

MONSIEUR LE CHEF DE DISTRICT DE SANTE
À
MADemoiselle EYEBE DANIELLE
CHANCELINE

Objet : Avis favorable pour mener une étude intitulée SOME
ECOLOGIC PARAMETERS ON HUMAN ECTOPARASITES
(LICE) INFESTATIONS IN OBALA, CENTRE REGION OF
CAMEROUN

Mademoiselle,

Suite à votre demande d'une autorisation de recherche pour l'étude intitulée « SOME
ECOLOGIC PARAMETERS ON HUMAN ECTOPARASITES (LICE)
INFESTATIONS IN OBALA, CENTRE REGION OF CAMEROUN » ; j'ai l'honneur de
marquer mon avis favorable pour ladite recherche.

OBALA, LE 13 JUIL 2023

Ampliations :
-MINSANTE
-DRSPC
-Intéressée
-Arch/ Chrono

LE CHEF DE DISTRICT DE SANTE



Appendix 3: Information notice for the participants in French and English

UNIVERSITE DE YAOUNDE I

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UNIVERSITY OF YAOUNDE I

FACULTY OF SCIENCE

DEPARTMENT OF PHYSIOLOGY
AND ANIMAL BIOLOGY

P.O BOX: 812 YAOUNDE

INFORMATION NOTICE FOR PARTICIPANTS

INVITATION TO PARTICIPATE IN THE RESEARCH PROJECT

RESEARCH TITLE: *STUDY OF SOME EPIDEMIOLOGICAL PARAMETERS ASSOCIATED TO HUMAN ECTOPARASITES IN THE OBALA SUB-DIVISION.*

Mrs, Miss, Mr. _____ this research for which your participation is requested concerns the “*study of some epidemiological parameters associated to human ectoparasites in the Obala sub-division*”. This study aims at evaluating epidemiological parameters and risk factors associated to human ectoparasitosis in this zone. The

Objectives here are

- determine the prevalence of some human ectoparasitosis in Obala ;
- evaluate possible associations between these ectoparasites ;
- determine the risk factors associated to these infestations in the zone.

The information in this information sheet is intended to help you understand exactly what your potential participation in this research entails and to help you make an informed decision about it. We therefore ask that you read the consent form carefully and ask any questions you wish. You can take all the time you need before making your decision.

Task: Your participation in this research project consists of having an interview followed by the completion of a questionnaire and giving the samples of ectoparasites in case there is.

Risks, inconveniences, discomforts: There is in our opinion no important physical risk. However, the interviewer will ask you questions which are sometimes sensitive, for example you may be asked questions about your hygiene. If there are questions you don't want to answer, you can say so. Moreso, you might feel some pain during the collection of egg nits from your hair in case of an infestation, but this will be very light and short lived. You might also feel uncomfortable that bedbugs are collected from your house this could call on the attention of the neighbourhood and result in mockeries, to avoid this, we shall not descend in large numbers in your home during the collection. After the questioning session, the team shall depart and only one person shall remain for the collection proper, which will also be short lived. People shall also be sensitized to know that this is not a shame.

Benefits: The direct benefit you will derive from participating in this research is that, you will receive counseling on the existence of human ectoparasites, their possible means of prevention and treatment. In case of any infestation, we may, if possible help with a treatment. We cannot promise that the results from this study will help you directly, but the information we collect should help people like you in the futur.

Confidentiality: The data collected by this study is subject to the requirement of confidentiality. The research results, which may be disseminated in the form of articles, research reports or communications at scientific congresses, will be presented in aggregate and will not allow you to be identified individually. The data collected will be kept on paper and electronic media. All this data will be destroyed after the final publication of the research report and articles. They will not be used for purposes other than those described in this document.

Voluntary Participation: Your participation in this study is voluntary. You are completely free to participate or not and to withdraw at any time without prejudice and without having to provide any explanation.

Research Manager For more information or for any questions regarding this research project, you can contact Ms. EYEBE Danielle Chanceline by email at chancelineeyebe18@gmail.com or by phone 671527647.

Research Ethics Question or Complaint: This search is approved by_____. A certificate of ethical compliance bearing the number_____ was issued on____ for any questions or complaints of an ethical nature concerning this research, you must contact the permanent secretary of the ethics committee of _____, by telephone at the number_____ by e-mail_____

INFORMED CONSENT FORMS FOR ADULT PARTICIPANT (21 TO 65 YEARS)

Commitment of the researcher I, the undersigned, EYEBE Danielle Chanceline, Student in Master of Animal Biology and Physiology, undertake to carry out this study in accordance with all the ethical standards that apply to projects involving the participation of human subjects.

Participant Consent I, the undersigned, _____

_____ have read and understood information notice about the project "*study of some epidemiological parameters associated to human ectoparasites in the Obala sub-division*". I have clearly understood the conditions, risks and possible benefits of my participation. All my questions were answered to my complete satisfaction. I have had enough time to reflect on my decision whether or not to participate in this research. I understand that my participation is entirely voluntary and that I can choose to withdraw at any time, without any prejudice.

I therefore freely agree to participate in this research project.

Date and Signature of Participant:

Contact of the researcher: 671527647

Date and Signature of Researcher:

INFORMED CONSENT FORM FOR TEENAGER OF 12 TO 20 YEARS OLD

Commitment of the researcher I, the undersigned, EYEBE Danielle Chanceline, Student in Master of Animal Biology and Physiology, undertake to carry out this study in accordance with all the ethical standards that apply to projects involving the participation of human subjects.

Participant Consent I, the undersigned, _____

_____ have read and understood information notice about the project "*study of some epidemiological parameters associated to human ectoparasites in the Obala sub-division*". I have clearly understood the conditions, risks and possible benefits of my participation. All my questions were answered to my complete satisfaction. I have had enough time to reflect on my decision whether or not to participate in this research. I understand that my child's participation is entirely voluntary and that I can choose to withdraw at any time, without any prejudice.

I therefore freely agree to participate in this research project.

Date and Signature of Participant:

Contact of the researcher: 671527647

Date and Signature of Researcher:

INFORMED PARENTAL CONSENT FORM FOR CHILD (1 TO 11 YEARS OLD)

Commitment of the researcher I, the undersigned, EYEBE Danielle Chanceline, Student in Master of Animal Biology and Physiology, undertake to carry out this study in accordance with all the ethical standards that apply to projects involving the participation of human subjects.

Participant Consent I, the undersigned, _____

_____ have read and understood information notice about the project "*study of some epidemiological parameters associated to human ectoparasites in the Obala sub-division*". I have clearly understood the conditions, risks and possible benefits of my participation. All my questions were answered to my complete satisfaction. I have had enough time to reflect on my decision whether or not to participate in this research. I understand that my child's participation is entirely voluntary and that I can choose to withdraw at any time, without any prejudice.

I therefore freely agree to participate in this research project.

Date and Signature of Participant:

Appendix 4: Survey

SURVEY

RESEARCH THEME: Study of some epidemiological parameters associated to human ectoparasites in the obala sub-division

Since 1997, the United Nation High commissioner for refugee (UNHCR) and the WHO qualified Lice, Flies, Fleas and Mosquitos among others nuisances as of medical importance. In order to evaluate the presence of some favourable factors for the prevalence of these ectoparasites infestations in obala, we enquire of you to answer to some questions. All informations taken from you shall be kept confidential in order to preserve the integrity of all participants the question sheet shall be anonymous.

Identification

Name of surveyor:.....

Date:.....

Sheet number.....

Region.....

Division

Sub-

division.....

District

.....

Asphalted?..... Material used for building and roofing.....

Socio -demographic criteria

1. GENDER : a. Male b. female
2. Age a. <15 years b. 15-24 years c. 25-65years d. >65years
3. Level of education: a imary b. secondary c. tertiary d. others.....
4. Marital status: single b. married c. divorced d. others
5. Number of children :.....
6. Religious obedience: a. Christianity b. L'islam c. Others
7. Professional situation . Unemployed b. Student c. Resourceful d. Employed
8. If d, by who? a. State b. Private enterprise
9. Do you take good care of yourself? a. Yes b. No
10. If yes what Standard of living do you have? ery high b. high c. Average d. Low
11. House's size/number of rooms:.....
12. Number of people in the house

13. How the beds a. Beds are not used b. Bamboo are beds c. wooden beds d. Others specify.....

	Lice	Bed bugs <input type="checkbox"/>	Myiases	Jiggers	Others specify
Yes					
No					

13. Do you use mattress a. Yes b. No

14. If yes what type? a. Straw mattress b) Sponge mattress

15. Number of people per bed One person /bed b. More than one person per bed.

16. Use of pillows. a. Individual use b. common use

17. Use of bed sheet a. Individual use b. common use

Knowledge about the infestation and presence of symptoms

18. Do you know an ectoparasite? . Yes b. No

19. If yes which? a. Lice b. Myiases c. Jiggers d. Others

20. Can you describe these ectoparasites

21. On which body part can they be found?

Lice Bed bugs Myiases Jiggers Others specify

Head

Skin

Armpits

Pubis

Feet

Hands

Others

22. When, where, and how were you infected?

Lice Bed bugs Myiases Jiggers Bedbugs Others
specify

When

Where

How

23. Can you describe the symptoms?

Lice Bed bugs Myiases Jiggers Others specify

Itching

Rash

Redness

Fever

Migraine

Fatigue

Others
specify

24. Did you get treatment? Yes b. No

25. What treatment ?

Treatment Lice Myiases Jiggers Others specify

1.

2.

3.

4.

5.

26. Where have you been treated?

Lice Bed bugs Myiases Jiggers Others specify

Hospital

Indigenous

27. Do you know people with the infestations

Lice Bed bugs Myiases Jiggers Others specify

28. Have you noticed these symptoms?

Symptoms Put Wound Itching Pinching Tickling Anemia Fever Anxiety Discomfort

Yes

No

29. If discomfort which ?.....

30. How do you think ectoparasites could be avoided?

Lice Bed bugs Myiases Jiggers Others specify

- 1.
- 2.
- 3.
- 4.
- 5.

Hygiene

A. Hygiene of the body

31. Hair length a) Very long b) long c) short d) shaved
32. How frequently do you wash your hairs?.....
33. What oils do you use? Chemical products essentials oils
34. Hair style a) always braided b) wind hair c) both
35. Use of combs and hair products a) Common b) individual use
36. Use of caps, scarfs, brioche? a) Common use b) individual use

B. Hygiene of the body

37. How many bath do you take daily
38. Do you have difficulties to get many both?..... b) Yes c) No
39. If yes explain.....
40. How frequently do you change cloth ?.....
41. How do you wash your cloth?.....
42. Where and how do you dry your cloth
43. Do you iron all your cloth?.....
44. Do you walk bear footed?.....

INTRODUCTION

Parasites are organisms that live on or in a host organism and gets it's food from or at the expense of the host. Human parasites are generally grouped under protozoa, helminths or ectoparasites. Lice, flies, fleas, among other human ectoparasites have been qualified by the United Nation High Commissioner for Refugee (UNHCR) and the World Health Organisation (WHO), since 1997 as nuisances of medical importance.

Ectoparasites like begbugs have always been faithful companions to man, who knows them and has carried them over places and times but they still cause harm to him. Generally, added to the nuisance, they cause shame and stigmatisation to their host since they are usually associated to precarity, poverty and lack of hygiene (Speare *et al.*, 2006; Barataud, 2016).

Bedbugs are cosmopolitan and thus, are found world wide. In 2003, public health experts in Toronto reported 100% increases in phone complaints about bedbugs, in numbers of pest management company treatments for bedbugs in private homes, and a more than 50% increase in incidence of bedbugs in public shelters in the last half, as compared with the first half, of the year (Hwang *et al.*, 2005 ; Harlan, 2006). In Great Britain, reported infestations more than quadrupled each year from 1998 to 2002 (Harlan, 2006). In Berlin, Germany, a 10-fold increase in bedbug infestations was reported, rising from 5 reported cases in 1992 to 76 cases in 2004 (Harlan, 2006). An Australian government public health agency reported a 400% increase in bedbugs submitted in 2001–2004 compared with 1997–2000. They also reported increased interceptions of bedbugs in luggage by quarantine inspectors from 1986 to 2003, with 74% of those occurring from 1999 to 2003 (Doggett *et al.* 2004; Harlan, 2006). From all this, we can effectively state that bedbugs have experienced an extraordinary upsurge in the recent past across the world (Mbuta *et al.*, 2022). France has the same experience regarding the resurgence of bedbugs as several European countries, USA, Canada and Australia, especially the southern regions (Bencheton *et al.*, 2010). France has reports of 11% infestation of households between 2017 and 2022. Pest control services in France and neighbouring countries like the United Kingdom have reported increased calls and Google Trends have shown a surge in the interest in bedbugs in countries like the United Kingdom and Ireland between September and October 2023, and between 2019 and 2024 in France. These pest control services have reported 1 095 000 interventions in France, showing increased infestation by 65% in two years (O'Malley & Feighery, 2023). In the USA, about 20% of the population had a bedbug problem by January 20 according to a news cast.

These prolific blood suckers have direct effects of nuisance on their host and may also act as vectors and/or reservoirs in the transmission of pathogens of several infections to their hosts - man and other animals - (Okwa & Omoniyi, 2010; Oleg *et al.*, 2012; Salazar *et al.*, 2015; Sheele *et al.*, 2021). In cases of pronounced infestations, they can lead to anaemia in their hosts, which will add to allergic reactions, including itching and erythematous or popular urticaria-like dermatitis, which favours secondary bacterial infections, cellulitis, impetigo, ecthyma, lymphangitis, anxiety, insomnia, and worsening of an existing mental health, more to the stigmatisation which results from their presence (Harlan, 2006; Okoh *et al.*, 2013; Baratau, 2016). A study on

bedbugs by Mbuta *et al.* (2022) predicts that Eastern and Central African countries (like Cameroon) are more optimal for infestation with highly suitable zones in Southern countries while it can be found here and there in West African countries. The less developed and the developing countries like ours, mainly characterized by poor health infrastructure have higher entomological priorities with potentially fatal endemic vector-borne diseases such as dengue and malaria to combat so that bedbugs, being a public health pest and not a disease vector, end up ignored (Mbuta *et al.*, 2022).

For several decades now, no much literature has been presented on bedbug infestations in Cameroon and this called our attention. Haven observed the living conditions and the geography of the Obala population and taking into consideration the fact that Obala is a transition zone, we thought these could be favourable to the presence of this pest in the studied locality. We asked ourselves whether this infestation was still a reality, whether it actually known in all age groups here and what factors (human) could account for its actual situation in this zone.

Our study therefore aimed at evaluating the occurrence of the infestation caused by *Cimex* amongs the Obala population, Centre region of Cameroon. Precisely, we had to:

- make use of a survey to evaluate the population's knowledge about bedbugs with their infestation;
- estimate the global prevalence of these infestations and relate these prevalences to some characteristics so as to determine some risk factors associated to these infestations as well as evaluate the possible damages that could be caused by these parasites and
- identify and re-describe the parasites collected during the study.

After this introduction, our work includes a chapter on the litterature review, a chapter on the material and methods used and another on the results and discussion. These are followed by a conclusion, perspectives and recommendations.

CHAPTER I: LITERATURE REVIEW

I.1 GENERALITIES ON BEDBUGS

Bedbugs are haematophagous insects that feed on humans and other animals. They are poised to become a major household pest throughout the world and are a serious biting nuisance in the tropics (Karunaratne *et al.*, 2007; Alizadeh *et al.*, 2020; Ghavami *et al.*, 2021; Hamlili *et al.*, 2021). They have ovoid, wingless, red-brown, dorso-ventrally flattened bodies covered with short, golden-colored hairs (Harlan, 2006; Delaunay & Bérenger, 2017). The head is large with reduced prominent eyes, no ocelli (compound eyes), four articulated antennae, three-segment rostrum which guides the mandibular and maxillary stylus which though internal is visible during sucking. The bristling pronotum is large even wider than the head, and can go back to the eyes (figure 1). It can be used for identification of these insects and to differentiate between the two species (Delaunay & Bérenger, 2017). Bedbugs give off a distinctive, musty, buggy and sickly sweet odor containing various aldehydes which are produced by glands located in the ventral metathorax (Harlan, 2006) and have the ability to grow up to 7 mm in length with a lifespan of four months up to one or two year (s) (Harlan, 2006 ; Delaunay & Bérenger, 2017).

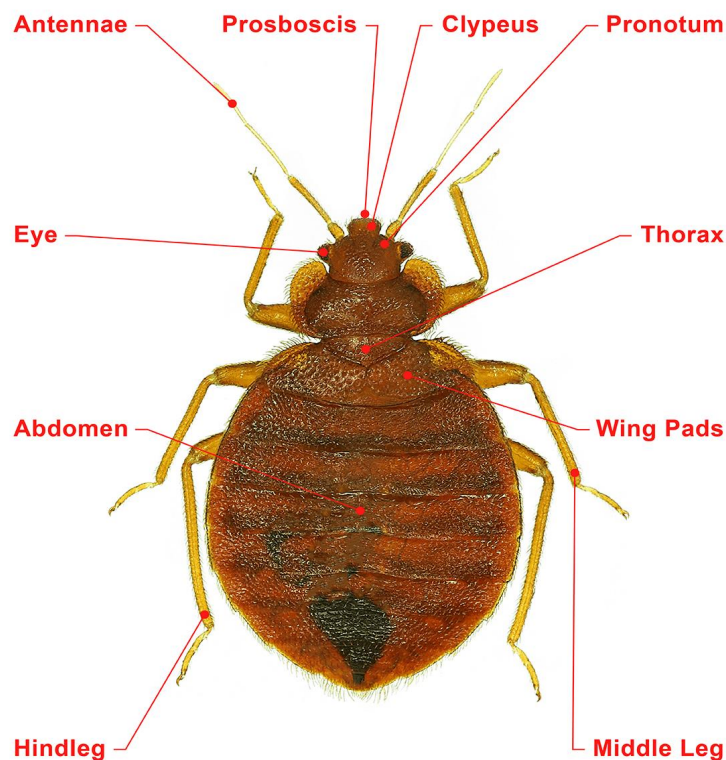


Figure 1 : General morphology of bedbug (@Homestratosphere.com)



Figure 2 : General morphology of adults of the genus *Cimex*: A; *Cimex lectularius* (Ray, 1710) and B; *Cimex hemipterus* (Stal, 1873) (Image source: bedbugsinfo.net).

The pests are normally cryptic, photophobic, and thigmotactic. In addition to the bulky smell, the presence of faecal spots, empty egg cases, eggs, nymphs, shed exoskeletons, and dead or live bedbugs are quick signs of an emerging infestation. This shows that detection mainly relies on visual inspection. It is also generally done by canine scent. These methods are said to be time consuming, to require experience, to be non-specific. Detection by Volatile Organic Compounds (VOCs) are considered an environmentally friendly alternative and a promising approach for bedbug detection (Akhoundi *et al.*, 2023).

Common bedbugs, and a few closely-related species of blood-feeding true bugs (Hemiptera: Cimicidae) like *C. lectularius*, have been persistent pests of humans throughout recorded history. They may have evolved from cave-dwelling ectoparasites of mammals (especially bats) (Harlan, 2006; Whitaker *et al.*, 2009). As humans moved from caves to tents and then into houses, the bugs went with them. Bedbugs have been mentioned in the literature and folk remedies of many cultures and countries since the times of ancient Greece (Harlan, 2006). Senabulya *et al.* (2019) report that they have been a household pest issue for more than 3,300 years, dating back to ancient Egypt (1350-1323 BCE) and that during the latter half of the 20th century, this bloodfeeding species was almost extinct in many economically developed countries due to the widespread use of synthetic pesticides such as Dichlorodiphenyltrichloroethane (DDT) (Raoult *et al.*, 1997; Harlan, 2006; Senabulya *et al.*, 2019). They were so scarce in the United States that it was hard to find specimens to use in college entomology classes, similar trends being reported for Britain, with a relatively constant or slightly declining level of public requests for control from 1967 to 1972 but in the recent years, however, there was a surge of reports of bedbug infestations among the developed countries (Harlan, 2006; Senabulya *et al.*, 2019). The United States has had steep increases over the past few years in bedbug infestations (Gooch 2005; Harlan, 2006). A global upsurge was observed by the late 1990s and evidence of the bedbug upsurge has also been documented in Africa by the local media, including reports of infestation in 4000 homes in Nakuru, Kenya (Fourie & Crafford, 2018).

Insecticide resistance (which is the ability of an individual to tolerate quantities of substances which normally should be lethal or which have a lethal effect on most individuals) is probably the key initiator of the bedbug resurgence, and resistant bedbugs have been disseminated worldwide through increased international travel (Punchihewa *et al.*, 2019). The trade in second hand furniture, changes in pest management practices, lack of awareness of bedbugs among pest controllers can contribute to this upsurge. Also, the increase in bedbug infestation may be facilitated by poor knowledge of people regarding the identification, prevention, and treatment of the infestation adding to climate changes, lack of effective monitoring and management tools and the decreased use of broad-spectrum insecticides in human dwellings (Alizadeh *et al.*, 2020; Samiei *et al.*, 2020 ; Sharififard *et al.*, 2020).

Bedbugs are considered a public health problem because they are environmentally communicable, cause ill-health, intense physical discomfort and mental distress to humans (Benchton *et al.*, 2010; Wang *et al.*, 2016; Punchihewa *et al.*, 2019). Some exposure symptoms include pain, itchiness, raised welts, loss of sleep, psychological distress, systemic symptoms of lethargy, dysphagia, chest tightness, and difficulty breathing to humans, depending on the individuals since some will show no symptoms (Wang *et al.*, 2016 ; Punchihewa *et al.*, 2019). Their bites might cause severe reactions which might be asymptomatic or itchy, swollen, and blistered, often causing secondary bacterial infections such as lymphangitis, ecthyma, impetigo, and cellulitis. Also, psychological effects like paranoia, insomnia, stress, anger, anxiety, emotional distress, embarrassment, delusions, mood changes, panic, social withdrawal, post-traumatic stress disorder and some reports of suicidality have been documented. The pest has been reported to take a large blood meal of about 13.2 ml with a possibility of resulting in anemia during high infestation instances (Mbuta *et al.*, 2022).

They have been proven to contain microbial organisms which can be of serious health importance to humans. Bed bugs collected from huts in an hepatitis B virus endemic area in northern Transvaal, South Africa, were hepatitis B surface antigen positive, 43 as were samples collected from Senegal, Egypt, the Ivory Coast, and China.

Bedbug infestation affects all socioeconomic backgrounds, comes along with financial distress. The management of bedbug infestations, including control and disinfection process has been pointed out as an expensive exercise since it involves constant inspection, quarantine of infested areas, treatments, disposal, and replacement of infested household items as well as other furnishings. Past studies have reported serious economic consequences, especially in the hospitality and tourism sectors (Wang *et al.*, 2016; Punchihewa *et al.*, 2019; Mbuta *et al.*, 2022).

I.2 SYSTEMATIC POSITION

These insects belong to the Order Hemiptera (Linnaeus, 1758), and the Family Cimicidae (Latreille, 1802). Humans are infested solely by two species of bedbugs belonging to the genus *Cimex*. They include: *Cimex lectularius* or the cosmopolitan bedbug and *Cimex hemipterus* or the tropical bedbug.

Systematic position of the Tropical bedbug

Phylum: Arthropoda (Siebold et Stannus, 1845): Bilateral symmetry, segmented legs, presence of a hard cuticle which constitutes the exoskeleton.

Sub-phylum: Mandibulata or **Antennata** (Linnaeus, 1758): Presence of a pair of mandibles and a pair of antenna.

Class: Insecta (Linnaeus, 1758): Body divided into head, thorax and abdomen; has three pairs of walking legs; respiration trachean breathing.

Super-order: Mecopteroida (Brauer, 1885): Presence of sucking or biting mouth parts.

Order: Hemiptera (Linnaeus, 1758): Mouthparts modified into an elongated sucking beak.

Sub-order: Heteroptera (Latreille, 1810): Presence of hemelytra.

Family: Cimicidae (Latreille, 1802): Flat, oval body, four segmented antennae, wingless.

Sub family: Cimicinae (Van Duzee, 1916): Bristles at sides of pronotum minutely serrate on outer sides or, rarely, only at obliquely truncate tips. Females with paragenital sinus always ventral. Metasternum commonly forming a flat plate between coxae.

Genus: Cimex (Linnaeus, 1758): Small insects 5-7 mm for adults, oval body, brown when unfed or dark brown/ reddish when fed, have no wings.

Species: Cimex hemipterus (Stal, 1873): Have a broad prothorax, but less broad than that of the other species of *Cimex*.

Systematic position of the Cosmopolitan bedbug

Phylum: Arthropoda (Siebold et Stannus, 1845): Bilateral symmetry, segmented legs, presence of a hard cuticle which constitutes the exoskeleton.

Sub-phylum: Mandibulata or **Antennata** (Linnaeus, 1758): Presence of a pair of mandibles and a pair of antenna.

Class: Insecta (Linnaeus, 1758): Body divided into head, thorax and abdomen; has three pairs of walking legs; respiration trachean breathing.

Super-order: Mecopteroida (Brauer, 1885): Presence of sucking or biting mouth parts.

Order: Hemiptera (Linnaeus, 1758): Mouthparts modified into an elongated sucking beak.

Sub-order: Heteroptera (Latreille, 1810): Presence of hemelytra.

Family: Cimicidae (Latreille, 1802): Flat, oval body, four segmented antennae, wingless.

Sub family: Cimicinae (Van Duzee, 1916): Bristles at sides of pronotum minutely serrate on outer sides or, rarely, only at obliquely truncate tips. Females with paragenital sinus always ventral. Metasternum commonly forming a flat plate between coxae.

Genus: Cimex (Linnaeus, 1758): Small insects 5-7 mm for adults, oval body, brown when unfed or dark brown/ reddish when fed, have no wings.

Species: Cimex lectularius (Ray, 1710): Have a broad prothorax which is broader than that of the other species of *Cimex*.

Identification keys (Usinger, 1966)

In this same line, the modified morphological identifications and systematics of the Cimicidae are shown below:

➤ Key to the genera of Cimicinae

Front and middle femora each with a row of short, stout spines (ctenidium) subapically. Ectospermalege in the form of a forwardly-directed, usually tubular extension of anterior margin of sixth ventral segment. Southeast Asia. Cave swiftlets (*Collocalia*): **Paracimex**

Front and middle femora without a subapical row of short, stout spines. Female with ectospermalege as a transverse thickening of anterior margin of sixth or seventh ventrite. Pronotum over twice as wide as head. Hemelytral pads with hind margins concave. Tibiae with serrate bristles on outer sides. Southern Chile and Argentina *Bertilia* Pronotum less than twice as wide as head. Hemelytral pads with hind margins convex. Tibiae with simple bristles on outer sides. Metasternum partially compressed between coxae. Bristles at sides of pronotum serrate only at obliquely truncate tips. Female seventh ventrite produced forward, conelike, into sixth at middle, the ectospermalege at middle of anterior margin of sixth segment. Neotropical Region. Parasites of Bats: **Propicimex**

Metasternum is a broad, discrete plate between coxae. Bristles at sides of pronotum more or less serrate on their convex sides. Female fifth ventrite cleft or emarginate on right side, the ectospermalege on anterior margin of sixth segment at right. Body clothed with pale hairlike bristles. Second antennal segment 2/ or less as long as interocular space. Pronotum less than 1 1/2 times as wide as head. Holarctic Region. Swallows *Oeciacus* Body with shorter, thicker bristles. Second antennal segment subequal to interocular space. Pronotum 1 1/2 or more times as wide as head. Holarctic Region on bats, cosmopolitan on man and domestic animals: **Cimex**

➤ Key to the species (modified from Usinger, 1966)

Hind margin of fifth (fourth visible) ventral abdominal segment in female narrowly cleft (paragenital sinus) on right side at spermalege. Hind femora usually more than 2.6 times as long as wide. Area around

paragenital sinus with bristles like those on other parts of abdominal venter. Hind margins of hemelytral pads broadly rounded on inner halves. Characteristics common to *Hemipterus* and *Lectularius*.

Pronotum less than $5/2$ times as wide as long at middle. Parasite of Man, bats, chickens. Common in the tropics: **Hemipterus**

Pronotum more than $2\frac{1}{2}$ times as wide as long, ratio of head width to third antennal segment 1.45. Parasite of Man, bats, chickens. Cosmopolitan species: **Lectularius**

I.3 BIOLOGY, LIFE CYCLE AND REPRODUCTION

Bedbugs are criptic, hemimetabolous and obligate haematophagous ectoparasites (Harlan, 2006). The basic construction of the mouthparts in Cimicidae involves a piercing-proboscis which is normally folded under the body when not in use and can only be extended downward. The labrum is a narrow plate, which together with parts of the head capsule forms the frontal base of the proboscis. The proboscis consists of a sheath and piercing stylets which are formed by the mandibles and the laciniae of the maxillae, entirely covered by the sheath and usually not visible from the outside. Frontally the labium forms a deep groove that completely surrounds the stylets which can be projected outward. The paired mandibles are trough-like in cross-section, with a diameter of about 20 μ m and are dentate at the apex. The paired laciniae, which they lie between, are elongate, very thin, lack teeth, are well-connected to each other through grooves and folds anteriorly and posteriorly; they form the broad food-canal, in addition to the narrower salivary canal. The labium is not the piercing organ; rather it bends back and partly telescopes together. The apex of the mandibles first punctures the skin. Both the thin mandibles and the laciniae are used to penetrate deep into the host's skin (Harlan, 2006; Krenn & Aspöck, 2011).

Hungry bedbugs are stimulated to feed when they detect an increase in ambient CO₂. When a human enters an infested room and lies down to rest, the ambient CO₂ in the room begins to increase. This increase in CO₂ stimulates the bedbug to leave the harborage and begin searching. When the bedbug is near the host, the host's body heat serves as an additional directional cue. Once in contact with the host, the bedbug begins to feed. After feeding to repletion, the bedbug will leave the host's body and presumably return to a harborage to aggregate with other bedbugs (Reis & Miller, 2011). Feeding behavior in *C. lectularius* coincides with periods of minimal host activity (Reinhardt & Siva-Jothy, 2007). A hungry bedbug can consume a volume of blood between 130% and 200% of its body weight (Reinhardt & Siva-Jothy, 2007; Krenn & Aspöck, 2011).

Adults take larger blood meals than nymphs do and larger adults take larger blood meals. A single complete blood meal precedes eclosion into the next instar, and there is a minimum meal size to achieve eclosion in *C. lectularius* (Reinhardt & Siva-Jothy, 2007). An adult *C. lectularius* fully engorges about 13.2 ml of blood in 10 to 20 minutes, after which it returns to its refugium. Under *ad libitum* conditions imaginal *C. lectularius* feeds once per week (Reinhardt & Siva-Jothy, 2007; Mbuta *et al.*, 2022). The time

between feedings is spent concealed inside the refugium. Cimicid feeding frequency depends on digestion rate, environmental conditions, temperature, and host availability (Reinhardt & Siva-Jothy, 2007). By these same authors, individuals in laboratory populations of *C. lectularius* fed approximately every 7 days and field-collected *C. hemipterus* fed every day after collection for several days in hot climates. Field surveys of other cimicid species revealed that 15% to 29% of randomly collected individuals were fully engorged, suggesting feeding cycles between 3 and 7 days.

All cimicids harbor microbial symbionts in paired structures called mycetomes which seem to be vital for the biosynthesis of key micronutrients from the nutrient-limited blood diet. Mycetomes are present in both sexes but larger in males than in females for reasons that are not apparent. These mycetomes increase in size as the insect reaches adulthood, but decrease with adult age. Senescent females cease laying eggs and no longer have mycetomes (Reinhardt & Siva-Jothy, 2007; Krenn & Aspöck, 2012).

Bedbugs mate by traumatic insemination which is the act of inseminating through the body wall, into the body cavity (rather than into the female's genital tract) involving physical breaking of the epidermis. The males therefore pierce the female's abdominal wall with their sharp intromittent organ (paramere) and inject sperm and accessory gland fluids directly into the blood, leaving visible melanized scars (Morrow & Arnqvist, 2003). Male bedbugs do not/can not pierce females at any site on their abdomen. Mating frequencies appear to be determined by males and occur at a higher rate (costly to females) than is required to maintain maximum fertility in females. The result of natural rates of traumatic insemination is a 25% reduction in female lifespan (Reinhardt *et al.*, 2003). The male ejaculatory pump is connected to the vasa deferentia (the male sperm reservoir) and regulates the transfer of sperm during insemination. In many bedbugs, the area at which the male pierces the integument of the female shows several unilateral modifications called the spermalege. It has two embryologically discrete parts: the ectodermal 'ectospermalege' and the mesodermal 'mesospermalege'. The ectospermalege consists of a groove in the right-hand posterior margin of the fifth sclerite overlying a structurally modified pleural membrane. Attached to the wall of the haemocoel, directly underneath the external groove, lies its second component: the mesospermalege. Concretely, in the human bedbug *Cimex lectularius* a specialized notch and a cuticular thickening of the right side of the fifth sternite (the ectospermalege) lies directly over a distinct pocket filled with haemocytoid cells on the inner surface of the abdominal wall (the mesospermalege) (Morrow & Arnqvist, 2003; Reinhardt *et al.*, 2003; Kamimura *et al.*, 2014).

Females attach their 1mm long whitish eggs to substrate surfaces wherever the bugs hide in loose groups or clusters. Each female may lay 200–500 eggs in her lifetime, which can be 2 years or longer. These eggs are ovoid with slightly opaque operculum that permits to see the red eye of the nymph before hatching. They have five nymphal instars, each needing at least one blood meal to develop to the next stadium. (Harlan, 2006; Delaunay & Bérenger, 2017). The nymphs resemble the adults but have no part plate nor genital organ. The first instar nymph measures about 1.5mm and is difficult to see if not fed. The first three

nymphal stages are fragile and will not resist starving, unlike the last two nymphal stages (Delaunay & Bérenger, 2017). One life cycle from egg to egg is 5 weeks at 75–80% room humidity and temperatures between 28 and 32°C.

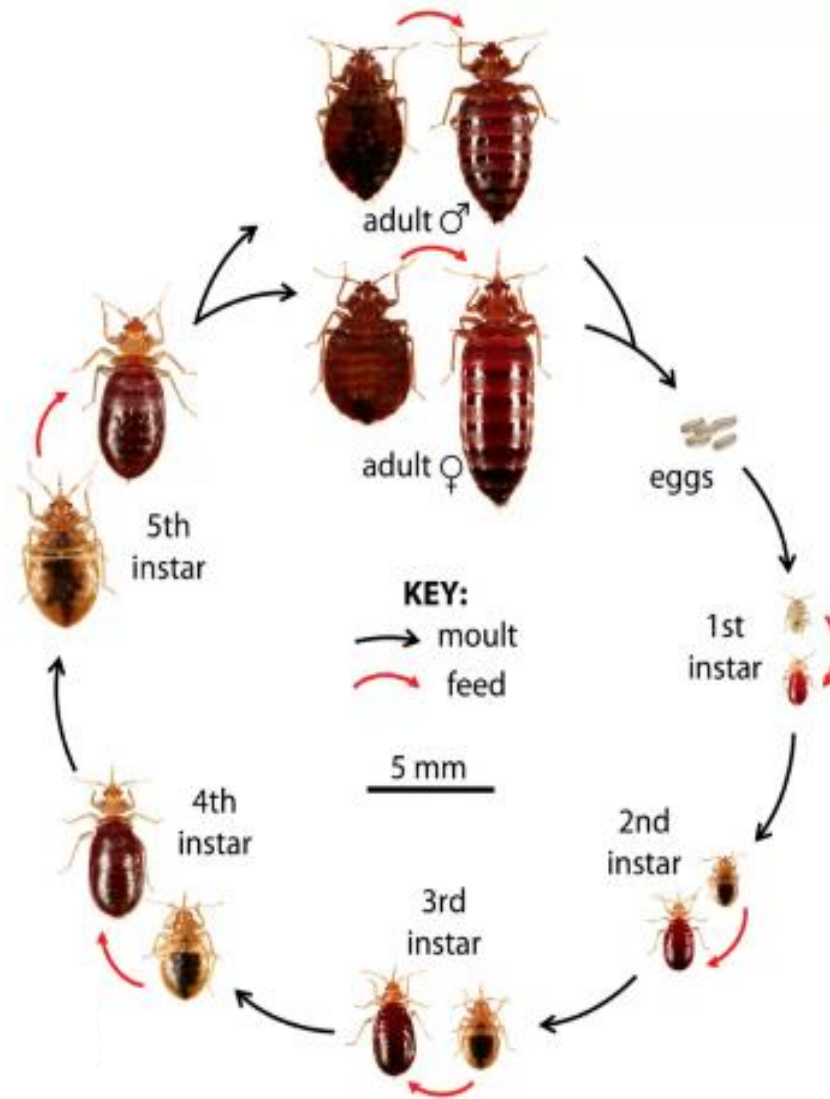


Figure 3: Diagrammatic representation of Bedbug's life cycle. (Image source: Bedbug Foundation.)

They can survive and remain active at temperatures as low as 7°C. Obligatory hematophagy of these insects is explained by the fact that egg production in adult females (and presumably sperm production in males) requires regular blood meals, the bugs have a multi-stage developmental life cycle and require a human blood meal (every 3-5 days) to progress from one stage to another. Also, feeding is an essential prerequisite for mating: *Cimex lectularius* males direct their sexual interest at recently fed females who may receive approximately five traumatic inseminations per feeding (not necessarily from the same male) (Bernardeschi *et al.*, 2013). Males transfer about one fifth of the contents of the *vasa deferentia* when mating with a virgin female but do not fertilize all virgin females offered to them. Males can sometimes be

sperm limited and so need to be prudent with their mating efforts. Multiple traumatic inseminations are costly to females. They directly affect female fitness by causing death, as well as reducing life span in *Cimex hemipterus*. Males impose a mating rate on females that is 20 to 25 times higher than is required to maintain fecundity, resulting in ~25% to 30% reduction in life span. This fitness loss does not appear to be compensated by an increase in offspring quality, a core prediction in the original arguments marshaled in support of cryptic female choice theory. Recently mated females were occasionally found dead with ruptured guts, a condition likely caused by intromission extending through the mesospermae. *Cimex lectularius* females stop laying fertile eggs approximately 35 to 50 days after sexual isolation because they are depleted of sperm or because the sperm became nonfunctional. Limited female fertility after mating with young males, probably resulting from sperm limitation in such males has been reported. (Harlan, 2006; Reinhardt & Siva-Jothy, 2007; Delaunay & Bérénger, 2017).

I.4 HUMAN HOST

Bedbugs are obligate haematogous parasites of mammals like bats and man. In the genus *Cimex*, the species *Cimex hemipterus* and *Cimex lectularius* are parasites of man. These ectoparasites are provided with mouthparts adapted for piercing so as to penetrate the human skin and get to the underlying blood capillaries that are found around 1mm beneath the skin surface (Reinhardt & Siva-Jothy, 2007).



Figure 4: Bedbug feeding on human skin (Espinosa, 2010)

The skin is the largest organ in the body with an area of 2 square metres in adults, a weight of about 5 kilograms, an average thickness of 2mm (0.5mm on eyelids to 4.0mm on heels of feet). It is composed of three main layers: the epidermis (outermost), the dermis (middle) and the hypodermis (innermost). The epidermis is a thin keratinised stratified squamous epithelium of the skin, which mainly functions in protection. Its basal layers are folded to form dermal papillae. The dermis is thicker and is the connective tissue layer of the skin, important in sensation, protection and thermoregulation. It is therefore supplied with blood capillaries amongst others. The underlying hypodermis mainly contains adipose tissues and sweat glands (Lewis & Peckham, 2023).

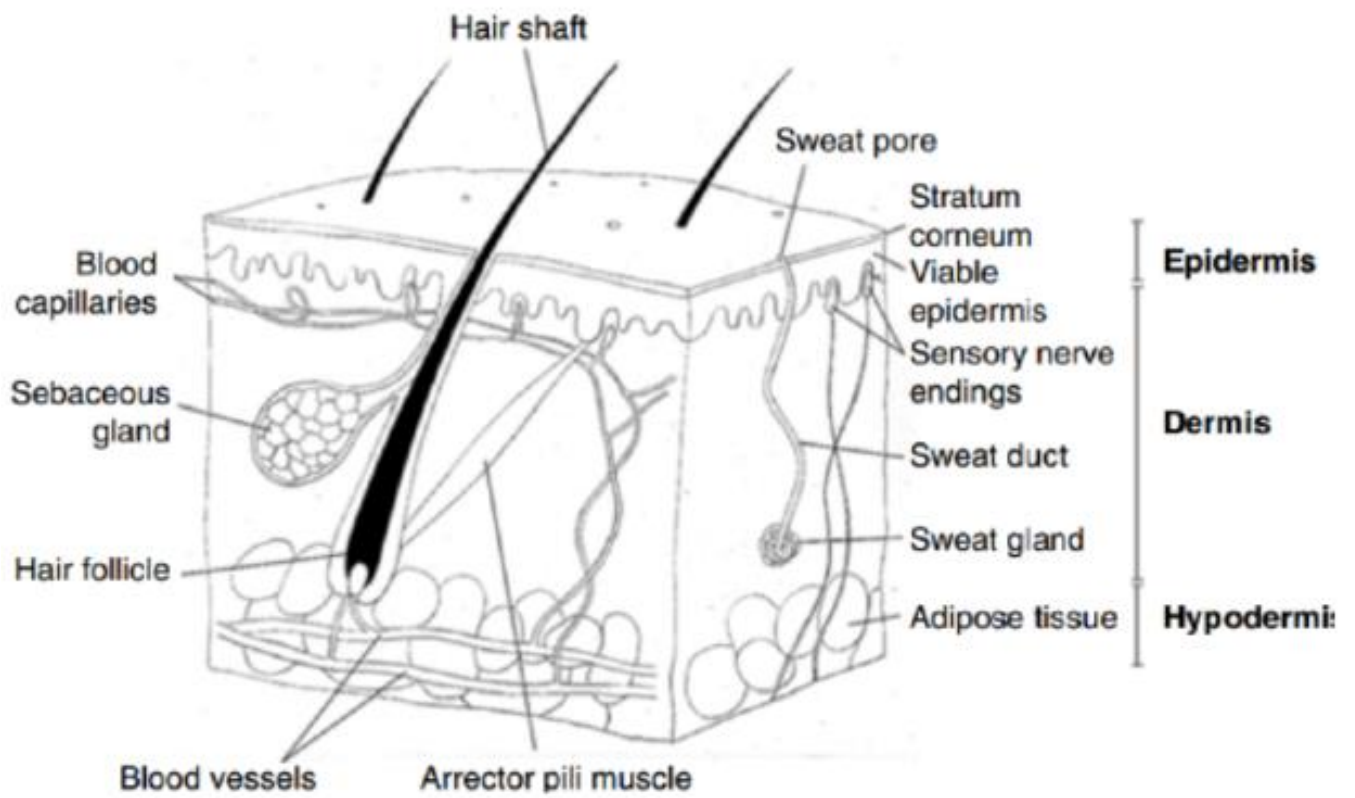


Figure 5: Structure of the Human skin (Wooi & Man, 2015)

CHAPTER II: MATERIAL AND METHODS

II.1 TYPE OF STUDY

This study was a cross and unicentric type during which we evaluated the number of infested households and this helped us get an infestation rate.

II.2. STUDY FRAMEWORK

The study was conducted in the Obala Sub-division, Lekié Division, Centre region of Cameroon. It was mainly done in Mboua I, Abokono, Belibi, Ekok-Assi, Orphelin, Ebol-Akoum, Quartier Chauffeur, Elig-Bessala, Quartier Haoussa, Nkolbikok, Elot I, Elot II, Ndzong Mezegue, Foulassi, Ekoumdouma, Nkol-melen, Nkol-Mbene, Nkol-Meting/Bile-Binomo, Minkama and Garre voyageur. On the site, the samples were collected in order to be observed at the Laboratory of Zoology at the University of Yaounde I.

II.2.1 SAMPLE SITE

According to the Communal Development Plan (CDP, 2022) from which all the pre-informations about Obala were gotten, Obala was created on the 27th June 1955 on a total surface area of 475 km². In 2021, the population size was estimated at 125,000 inhabitants for a population density of about 263.16 inhabitant/km². The principal ethnic groups here include Eton (Essele, Mbog kani, Engap, Mendum, Benyada, Adji, Menyembassa, Ipep, Elende, Indo, To, Ngoei and Issogo) and the allochtones. There are 13 quarters/districts in the urban space (Obala town) and 70 villages (or 83 from testimony by municipal agent of the Obala municipality).

The sampled localities included 7 villages (Foulassi, Nkol-Melen, Nkol-Meting/Bile Binomo, Nkol-Mbene, Minkama, Garre voyageur and Ekoumdouma) and Obala town with 13 districts (Mboua I, Abokono, Belibi, Ekok-Assi, Orphelin, Ebol-Akoum, Quartier Chauffeur, Elig-Bessala, Quartier Haoussa, Nkolbikok, Elot I, Elot II, Ndzong-Mezegue) due to easy accessibility to these areas.

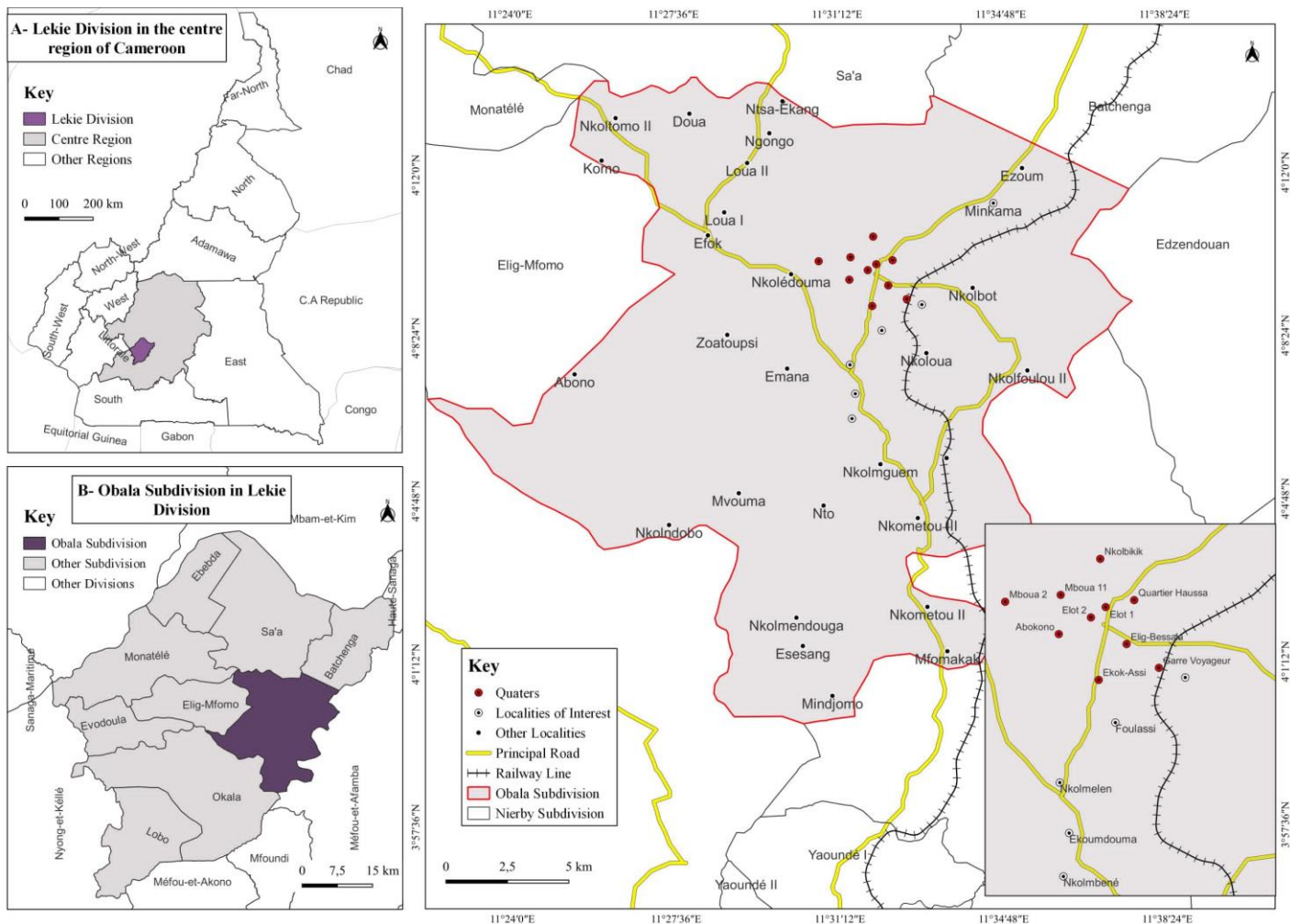


Figure 6: Sampled localities (Obala town and some villages) (Tende & Mbukwe, 2023)

Economic activities are grouped into 3 main sectors according to the CDP, 2022

- Primary sector: it mainly involves agricultural activities which provide food and livestock in the markets. Crops commonly planted here include cocoa, yam, cassava, maize, tomato, while the breeding sector which is more conventional involves more or less large and diversified farms of pig (which had the first rearing price at the Ebolowa Agric show some years back.), fowls, goats, sheep, and rabbit. For the fishing sector, it is basically done in small scales for consumption in rivers /streams like Foulou, Afamba, Doua, Va, Mbele.

-Secondary sector: though it is not well developed, we can observe artisanal practices which encounter the difficulty of promotion of the products obtained. Food stuffs are also transformed. For example maize is used to make fufu, feed for breeding; cassava for donuts, gari, flour and fufu; cocoa to produce cocoa butter, palmnuts for palm oil.

-Tertiary sector: administration, private services, pharmacies, schools, hospitals, transports amongst others. This municipality includes 13 intergrated health centres, 2 district hospitals, 4 private hospitals, 31 schools in all that is 19 public schools and 12 private schools. There are in all 10 nursery

schools of which 5 are public owned. The Council has 41 municipal councilors and 46 communal personnels. Transport is mainly terrestrial with 1,200 km asphalted and 215 km unbuilt.

Localisation of the community: Located between 4°10'00'' nord and 11°32'00'' east, the community has its headquarters bearing the same name. It is a sub-division in the Lekie division, Centre region of Cameroon. Obala is found at a distance of 40 km from Yaounde on the Yaounde - Bafia highway and 50km from monatele, with the national roads n° 1 and n° 4 passing through. It is bounded at the nord by the Sa'a and Monatele municipalities, at the west by Elig-Mfomo municipality at the south by Okola, at the east by Batschenga, Edzendouan, Soa and Yaounde I (Tende & Mbukwe, 2023).

Relief: The relief here is lightly varied with plains, hills and valleys. The slopes are of 600m in altitude.

Climate: It is the Guinean type with four annual seasons of unequal lengths: 2 dry seasons (a long dry from November to mid-March and a short dry from mid June to mid August); 2 rainy seasons (a long rainy season from mid August to October and short rainy from mid March to June). It has a pluviometry of 1600mm yearly with maximum precipitation in September. Maximum temperatures of 35°C are reached in the dry season and minimum temperature of 20 °C in the rainy season.

The soil types include:

- Ferralitic soils derived from basalts and good for plants like cocoa trees, palm trees.
- Sandy loam soils for culture of cereals, pineapples.
- Hydromorphic in wet land for cultivation out of seasons.

Plants and vegetation : this municipal community is found in forest zone of the equatorial forest .It is rich with plants e.g the iroko trees for pharmaceutic usage *Garacini cola*, *Kola cumin*, *Rininodron heudoletti* which are consumed as medicinal plants. The vegetation or forest is threatened by the increasing human population which causes a pressure and increased deforestation for crop cultivation, building of houses or harvest of wood for cooking and other uses.

Fauna: the fauna is abundant in all forest zones of all the municipality. We mainly have bitches, doe, monkeys, hares, royal antilopes, snails, varan, pangolin, viper, hedgehog, tigercat, chive, gorilles, chimpanzee endangered species. Domesticated animals include; pig, goats, dogs, cats among others.

Health: this sectors can be considered more or less developed in the municipality with 13 intergrated health centres, 2 district hospitals, 4 private hospitals. Anonymous testimonies by some health agents in these health centers reveal that there are generally high cases of anemia reported in children. They generally justify that this could be due to malaria and/or typhoid fever which prevail in this zone. The population is also attached to traditional medicin, using herbs, barks of trees to treat themselves when ill.

II.2.2 STUDY PERIOD AND POPULATION

The study was conducted over a period of two months including July and August 2023 in Obala urban and rural zones. The study targeted people from 1-75 years old, of any sex, tribe and faith, living permanently in Obala for atleast the last six (6) months. Only willing people were considered in the study.

- **INCLUSION CRITERIA**

Were included in this study the following categories of people:

- Males and females of age 1-75 years old living permanently in Obala for the last six months.
- People of the majority age (>20 years old) haven given their consent voluntarily and freely to participate in the study without any conditioning nor pressure and with no identity disclosure.
- All children (1-11 years old) and teenagers (12-20 years old) haven accepted to participate and haven received parental consent.

- **NON INCLUSION CRITERIA**

Were not included in the study all of the below:

- Any people not permanently living in Obala.
- All children of age <1 year old and elderly persons of age >75 years old, or any other person who could be fragile and vulnerable.
- Any non-volunteering person.
- Any volunteering child that has not been given parental approval or consent.
- Any person presenting symptoms of a severe transmissible infection or infestation (except if the infestation is by the ectoparasite of interest).

- The minimum sample size for this study was obtained using the formula given by Cochran which is given as
$$N = \frac{Z^2 * PQ}{E^2}$$
 and gave the value of 384 individuals. Where N= sample height; Z²= normal standard deviation (with Z=1.96); P= estimated proportion of the population with the inclusion characteristics; Q= estimated proportion of the population void of the inclusion characteristics (Q=1-P) with P=Q=0.5 and E= desired precision of 0.05.

II.2.3 ETHICAL CONSIDERATIONS

During our study, considering the fact that we work with living organisms and particularly human beings, we always made sure to get consent before any action. We were polite and always presented the study to the population so as to avoid them from feeling offended or feeling their rights being violated. During the presentation of the study, we presented to the subjects what was expected from them, what were the risks and the ways by which the risks were to be minimized and also what would be their gains or advantages. After this, some time was given to the subjects so as to think and chose if they accepted or refused to participate, either fully or partially in the study.

II.2.4 PROCEDURE

For us to obtain results in this research, we proceeded as follows using survey, sample collections, observations, analysis and identifications.

We first got to the selected site, at Obala, where we got an authorization from the sub-divisional officer to exercise our research on the population and another authorization from the chief of health district for the Obala zone. Following that, we selected the districts in the town and some 07 villages around (Minkama, Mboua I, Foulassi, Nkol Melen, Nkol Mbene, Bile Binomo, Nkol Meting, Toh, and Abokono) as sample sites.

On reaching each of the sites, we first went to meet the chiefs to whom we presented the study with the aim of obtaining permission into the zone. Once we obtained this permission, we selected houses randomly, atleast 10 houses where possible. In each of the selected houses, we presented the study to the family heads (to get their permissions) by reading the information notice to them, both in French and in English and at times even translated into the local language (Eton) thanks to a translator. In case the consent was not given, we just departed from the home to another. Those who received and accepted our study were asked to give written consent via the consent form, respecting anonyma. After this consent from the family head, we invited willing family members to participe, the survey was presented to individual participants so as to get some detailed informations about their knowledge of given parameters to complete our study but for all participants of a home we considered a single status of bedbugs infestation for their home.

After the survey sheet was completely answered and that there was a suspected infestation, we entered the rooms of the household to check. Prior consent of the household heads was taken for the inspection of their houses. Bedbugs were checked by searching the beddings, mainly mattresses, cracks and crevices of walls and furniture, essentially on chairs. When Bedbugs were present, they were handpicked using broomsticks and the hands in rubber hand gloves. Each of the collected insects from a given household were kept in an eppendorf tube filled to 2/3 with 70% alcohol at room temperature before identification (Okwa & Omoniyi, 2010; Farzard *et al.*, 2014). These activities on the field are seen in figure 7 below:



Figure 7: Field activities: a. administrating the survey to a consenting participant, b. checking bedbugs on walls, c. checking bedbugs in a sofas

A. Observation and identification :

The collected samples were transported to the zoology laboratory of the animal biology and physiology department, at the University of Yaounde I where they were observed via an OMRON binocular lens for morphological and morphometric identification (fig. 8). For the morphological identifications, we observed the whole animal, considering the coloration, presence of bristles essentially. On the other hand, the morphometric identification involved some measurements on the insects, using the software omron which was connected to the binocular lens. This software consists of an option for mensurations which is provided with scales (millimetres and micrometers). For the mensurations, the part on the animal to be measured was fixed on the scale and the measurement noted.



Figure 8: Laboratory activities: A. Morphological identifications of the specimens using a lens B. Bedbugs: egg, nymphs, and adults.

The identification was done using identification keys proposed by Usinger, 1966. The measured parameters were chosen in reference to his works, with some modifications. They included: Head length(Hl) ;head width (Hw) ; pronotal length (PrL) ; pronotal width (Prw) ; mesonotal length(Msl) ; mesonotal width (Msw) ; Metanotal length (Mtl) ; metanotal width (Mtw) ; length of tibia of pronotal leg (PrLti) ; width of tibia of pronotal leg (Prwti) ; length of tarsus on prothoracic leg (Plta) ; width of tarsus on prothoracic leg (Pwta) ; length of femora on prothoracic leg (Plfe) ; width of femora on prothoracic leg (Pwfe) ; length of tibia on mesothoracic leg (Mslti); width of tibia on mesothoracic leg (Mswti); length of tarsus on mesothoracic leg (Mslta); width of tarsus on mesothoracic leg (Mswta); length of femora on mesothoracic leg (Mslfe); width of femora on mesothoracic leg (Mswfe); length of tibia on metathoracic leg (Mlti); width of tibia on metathoracic leg (Mtwti); length of tarsus on metathoracic leg (Malti); width of tarsus on metathoracic leg (Mtawti); length of femora on metathoracic leg (Mtlfe); width of femora on metathoracic leg (Mtwfe), maximum width of abdomen (abmaxw), body length (bl); length of abdominal segment (Las); length of terminal bristle (Ltb); width of abdominal segment (Was). The modifications

essentially included Prlti, Prwti,Plta, Pwta,Plfe, Pwfe, Mslti, Mswti, Mslta, Mswta, Mslfe, Mswfe, Mlti, Mtwti, Mtalti, Mtawti, Mtlfe, Mtwfe, abmaxw, Las, Ltb and Was.

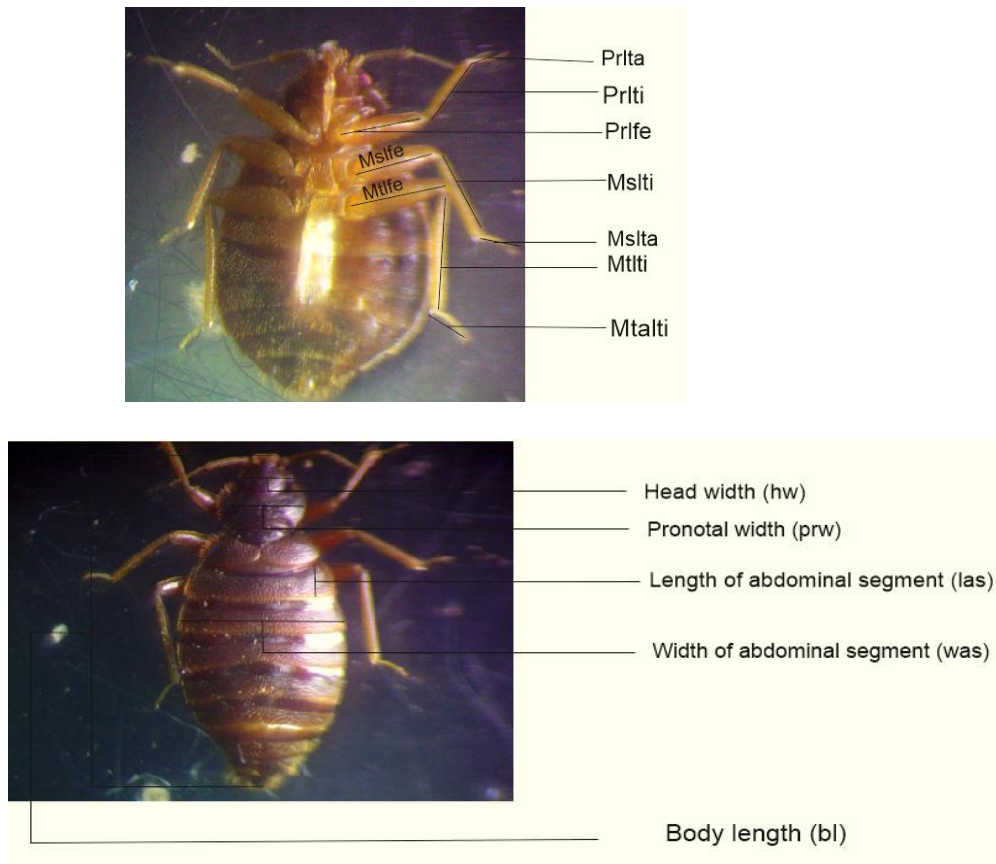


Figure 9: Mensurations taken on the Bedbugs

As mentioned above, these mensurations were done on the mounted insects using the software Amscope. This software is provided with measuring options scaled to the micrometers, the millimeters and the meters. The millimeter scale was used during our works for convenience. Pictures were taken with Amscope. During the observation, the image seen was captured by pressing on the button “capture” and saved. These images were used in coreldraw to draw the organisms as follows: the image was placed on the page and the pencil provided by the software was used to reproduce the contours on the image until the drawing was obtained.

B. Data analysis :

The data collected was entered into a database of the Excel 2013 software and analysed by SPSS 16.0 (STATISTICAL PACKAGE FOR SOCIAL SCIENCES)) in order to get the frequencies and percentages of qualitative variable using the chi-squared test and PAST (PALEONTOLOGICAL STATISTICS SOFTWARE FOR EDUCATION AND DATA ANALYSIS) to get the means with the maximum and minimum values of the measured parameters. The confidence interval considered was 95%, a significant difference was in case $P < 0.05$.

Source: National Institutes of Health (NIH).

$$Bedbug's\text{Prevalence} = \frac{\text{total number of infested houses}}{\text{Total number of sampled houses}} \times 100\%$$

CHAPTER III: RESULTS AND DISCUSSION

III.1. RESULTS

III.1.1 POPULATION'S PERCEPTION AND KNOWLEDGE OF BEDBUGS

III.1.1.1 SOCIO-DEMOGRAPHIC CHARACTERISATION

A total of 520 people were sampled during the study, of which 104 males (20%) and 416 females (80%). In this population, 185 people (35.58%) were aged <15 years, 176 (33.85%) were aged 15-24 years, 151 people (29.04%) were aged 25-64 years and the rest (08 people) were above 64 years of age. The educational situation of this population was such that 30 people (5.76%) were non literates, 219 (42.12%) had a primary level of education, 230 (44.23%) had atleast reached a secondary level, 38 (7.30) had reached the tertiary level, two people claimed another level of education while someone gave no response. The results from the marital status were such that 30 people (5.77% of the sample) lived as concubines, 4 people (0.775%) were divorced, 119 (22.89%) were married, 356 people (68.46%) were single, 10 people (1.92%) were widows and one person did not reply. Three hundred and twenty six (326) people were not parents. Among the parents, 38 had a child, 46 had 2 kids, 48 had 3 kids, 23 had 4 kids, 23 had 5 kids, 8 had 6 kids, 6 had 7 kids, 1 had 8 kids and 1 had 14 kids. The religious status was such that 292 (56.15%) were Christians, 223 (42.89%) were Muslims, 2 (0.38%) were traditionalists and 2 (0.38%) were pegans (Table I, figure 9).

The professional situation of the population was also evaluated and the results here were such that 02 people were civil servants, 23 people (4.43%) were employed by private owners, 110 (21.15%) were resourceful, 1 (0.1%) was retired, 315 (60.58%) were students and 66 (12.69%) were unemployed while 03 (0.57%) gave no reply. An important portion of the sample (83.85% notably 436 people) had an average living standard while 23 people (4.42%) had a low living standard, 33 people (6.35%) had a high living standard and only 3 (0.58%) claimed a very high living standard while the 25 others gave no indications. The population sizes varied per home so that though 34 people did not reply, 22 (4.23%) people lived alone, 31(5.96%) people lived 2 per home, 74 (14.23%) people lived 3 per home, 63 (12.12%) people lived 4 per home, 105 (20.19%) people lived 5 per home, 71 (13.65%) people lived 6 per home, 55 (10.58%) people lived 7 per home, 12 (2.31%) people lived 8 per home, 24 (4.62%) people lived 9 per home, 12 (2.31%) people lived 10 per home and 17 (3.27%) people lived more than 10 in a house. Anyways, houses were of different sizes such that 117 (22.50%) people lived in a houses of a single room, 127 (24.42%) lived in houses with 2 rooms, 142 (27.31%) lived in houses with 3 rooms, 40 (7.69%) lived in houses with 4 rooms, 47 (9.04%) lived in houses with 5 rooms, 26 (5.00%) lived in houses with 6 rooms and 1 (0.19%) each lived lin a house with 7, 8 and 10 rooms. The remaining 18 people did not reply to the question. In these rooms, out of the 513 people who replied, 509 (97.89%) people used wooden beds, 3 (0.58%) used bamboo beds and 1 used an iron bed. Individual bedding was admitted by 84 people (16.15%) while 436 people (83.85%) shared beds. Apart from the 3 non respondents, 20 people (3.80%) did not use pillows but 497 (95.58%) used them. Among these later, 350 (67.31%) people shared their pillows. Almost everyone

(516 respondents or 99.23%) claimed the usage of bed sheets and 429 (82.50%) people shared them (Table I).

Table I: Socio-demographic characterisation of the studied population

Socio-demographic characteristics	Criteria	Males	Females	Total
Age	<15	25 (4.81%)	160 (30.77%)	185 (35.58%)
	15-24	38 (7.31%)	138 (26.54%)	176 (33.85%)
	25-64	38 (7.31%)	113 (21.74%)	151 (29.04%)
	>64	3 (0.58%)	5 (0.96%)	8 (01.54%)
Educational level	none	5 (0.96%)	25 (04.81%)	30 (05.76%)
	No response	0 (0.00%)	1 (0.19%)	1 (0.19%)
	primary	34 (6.54%)	185 (35.58%)	219 (42.12%)
	secondary	49 (9.42%)	181 (34.81%)	230 (44.23%)
	tertiary	16 (3.08%)	22 (4.23%)	38 (07.30 %)
	other	0 (00.0%)	2 (0.39%)	2 (0.39%)
Marital status	single	68 (13.08%)	288 (55.39%)	356 (68.46%)
	concubine	9 (1.73%)	21 (4.04%)	30 (5.77%)
	married	25 (04.81%)	94 (18.08%)	119 (22.89%)
	widower/widow	2 (0.39%)	8 (01.54%)	10 (1.92%)
	divorced	0 (00.0%)	4 (0.78%)	4 (0.78%)
	No response	0 (0.00%)	1 (0.19%)	1 (0.19%)
Religious obedience	christianity	73 (14.04%)	219 (42.12%)	292 (56.15%)
	islam	30 (5.77%)	193 (37.12%)	223 (42.89%)
	traditionalist	1 (0.19%)	1 (0.19%)	2 (0.38%)
	other	0 (00.0%)	2 (0.38%)	2 (0.38%)
	No response	0 (0.00%)	1 (0.19%)	1 (0.19%)
Professional status	student	54 (10.39%)	261 (50.19%)	315 (60.57%)
	unemployed	8 (01.54%)	58 (11.15%)	66 (12.69%)
	private employee	9 (1.73%)	14 (2.69%)	23 (4.43%)
	civil servant	1 (0.19%)	1 (0.19%)	2 (0.38%)
	resourceful	31 (5.96%)	79 (15.19%)	110 (21.15%)
	retired	0 (0.00%)	1 (0.19%)	1 (0.19%)
	No response	1 (0.19%)	2 (0.38%)	3 (0.58%)
Living standard	No response	3 (0.58%)	22 (4.23%)	25 (4.81%)
	low	7 (1.35%)	16 (3.07%)	23 (4.42%)
	average	82 (15.77%)	354 (68.08%)	436 (83.85%)
	high	11 (2.12%)	22 (4.23%)	33 (6.35%)
	very high	1 (0.19%)	2 (0.38%)	3 (0.58%)
Population density home	No response	14 (2.69%)	20 (3.84%)	34 (6.53%)
	1/home	9 (1.73%)	13 (2.50%)	22 (4.23%)
	2/home	3 (0.58%)	28 (5.38%)	31 (5.96%)
	3/home	14 (2.26%)	60 (11.54%)	74 (14.23%)
	4/home	12 (2.31%)	51 (9.81%)	63 (12.12%)
	5/home	18 (3.46%)	87 (16.73%)	105 (20.19%)
	6/home	10 (1.92%)	61 (11.73%)	71 (13.65%)
	7/home	18 (3.46%)	43 (8.27%)	55 (10.58%)
	8/home	2 (0.38%)	10 (1.92%)	12 (0.23%)
	9/home	6 (1.15%)	18 (3.46%)	24 (0.46%)
	10/home	4 (0.77%)	8 (01.54%)	12 (0.23%)
>10/home	3 (0.58%)	14 (2.69%)	17 (3.27%)	
Number of children	0 child	55 (10.58%)	271 (52.11%)	326 (68.69%)
	1 child	12 (2.31%)	26 (5.0%)	38 (7.31%)
	2 children	10 (1.92%)	36 (6.92%)	46 (8.85%)

	3 children	13 (2.5%)	35 (6.73%)	48 (9.23%)
	4 children	4 (0.78%)	19 (3.65%)	23 (4.42%)
	5 children	8 (01.54%)	15 (2.88%)	23 (4.42%)
	6 children	1 (0.19%)	7 (1.35%)	8 (1.54%)
	7 children	1 (0.19%)	5 (0.96%)	6 (1.15%)
	8 children	0 (0.0%)	1 (0.19%)	1 (0.19%)
	14 children	0 (0.0%)	1 (0.19%)	1 (0.19%)
Number of rooms	No response	11 (2.12%)	7 (1.35%)	18 (3.46%)
	1room	16 (5.0%)	101 (19.42%)	117 (22.50%)
	2rooms	16 (3.08%)	111 (21.35%)	127 (24.42%)
	3rooms	32 (6.16%)	110 (21.15%)	142 (27.31%)
	4rooms	6 (1.15%)	34 (6.54%)	40 (7.69%)
	5rooms	15 (2.88%)	32 (6.15%)	47 (9.04%)
	6rooms	8 (01.54%)	18 (3.46%)	26 (5.00%)
	7rooms	0 (0.0%)	1 (0.19%)	1 (0.19%)
	8rooms	0 (0.0%)	1 (0.19%)	1 (0.19%)
	10rooms	0 (0.0%)	1 (0.19%)	1 (0.19%)
Bed type	No response	2 (0.38%)	5 (0.96%)	7 (1.35%)
	bamboo beds	100 (19.23%)	409 (78.65%)	509 (97.88%)
	iron beds	0 (0.0%)	1 (0.19%)	1 (0.19%)
	wooden beds	2 (0.38%)	1 (0.19%)	3 (0.58%)
Sharing of beds	No response	0 (0.0%)	0 (0.0%)	0 (0.0%)
	yes	81 (15.58%)	355 (68.27%)	436 (89.04%)
	no	23 (4.42%)	61 (11.73%)	84 (16.15%)
Use of pillows	No response	1 (0.19%)	2 (0.38%)	3 (0.57%)
	yes	98 (18.85%)	399 (76.73%)	497 (95.58%)
	no	5 (0.96%)	15 (2.88%)	20 (3.85%)
Sharing of pillows	No response	7 (1.35%)	0 (0.0%)	7 (1.35%)
	yes	62 (11.92%)	284 (54.61%)	346 (66.54%)
	no	35 (6.73%)	132 (25.38%)	167 (32.12%)
Use of bed sheets	No response	1 (0.19%)	3 (0.57%)	4 (0.77%)
	yes	103 (19.81%)	413 (79.42%)	516 (95.58%)
	no	0 (0.0%)	0 (0.0%)	0 (0.0%)
Sharing bed sheets	No response	1 (0.19%)	3 (0.57%)	4 (0.77%)
	yes	83 (15.96%)	346 (66.54%)	429 (82.50%)
	no	20 (3.85%)	67 (12.88%)	87 (16.73%)

The four age groups included childhood (<15 years old), adolescence (15-24 years old), adulthood (25-64 years old) and old age (above 64 years) (Gratz, 1997).

Table II: Distribution of the population sample with respect to educational level and professional status

Educational level/ Professional status	No response	None	Other	Primary	Secondary	Tertiary	Total
No response	01 (0.19%)	02 (0.38%)	00 (0%)	00 (0%)	00 (0%)	00 (0%)	03 (0.57%)
Students	00 (0%)	02 * (0.38%)	00 (0%)	133 (25.58%)	158 (30.38%)	23 (4.42%)	316 (60.77%)
Unemployed	00 (0%)	14 (2.69%)	00 (0%)	34 (6.54%)	13 (2.50%)	04 (0.77%)	65 (12.50%)
Resourceful	00 (0%)	11 (2.12%)	01 (0.19%)	47 (9.04%)	48 (9.23%)	03 (0.58%)	110 (21.15%)

Employed by private	00 (0%)	01 (0.19%)	01 (0.19%)	05 (0.96%)	09 (1.73%)	07 (1.35%)	23 (4.42%)
Civil servant	00 (0%)	00 (0%)	00 (0.19%)	00 (0%)	01 (0.19%)	01 (0.19%)	02 (0.38%)
Retired	00 (0%)	00 (0%)	00 (0.19%)	00 (0%)	01 (0.19%)	00 (0%)	01 (0.19%)
Total	01 (0.19%)	30 (5.58%)	02 (0.38%)	219 (42.12%)	230 (44.23%)	38 (7.31%)	520 (100%)

Key: *= nursery level of education. Responses at this level and the lower primary level were actually confirmed by parents before consideration. The percentages are gotten out of the total population sample (520 respondents).

III.1.1.2 POPULATION'S PERCEPTION OF THE INFESTATION

A number of 23 out of 520 (4.42%) respondents reported a present or past infestation by bedbugs. About 273 (52.50%) people could describe these insects while 237 (45.58%) could not. All those who had gotten an infestation could describe the bugs and give their localisation, as well as a few of those who had not encountered the parasite personally. In sum, the identified localisations of the parasite included walls (60 people), mattresses (40 people), chairs/ furnitures (74 people). Out of all those who claimed to know the localisation of these insects, 4 people mentioned the head and others made mention of the skin (Table III).

As symptoms we got reports of itching (19 people), redness (15 people), pain (14 people), rash (8 people), and migraine (1 person). No one recognised fatigue to be a symptom, as much as they did not recognise a medical follow up, but 475 respondents (91.35%) instead named traditional follow up to treat their ectoparasitic infestations in general, and this had a very significant importance ($p < 0.001$). Only 64 respondents (12.31%) said they got a treatment. The treatments generally used included chlorine (9 respondents), hot water (22 people), insecticides (5 people), kerosene (32 people) and motor oil (5 people) (Table III, fig. 9). It is important to note tht of these respondents, one person could report one or more of these treatments.

There was a significant relation between knowledge of the parasite and infestation ($p < 0.001$) such that 52.5% of the total population sample knew the parasites, 8.06% of the later were infested. Of those who could describe bedbugs, 8.1% were infested and 17.6% were not but 0.4% of those unable to describe these insects were infested while 99.6% were not. Of those who were infested, 66.7% (22 out of 33 respondents) knew the localisation of bedbugs and 2.4% of these did not know. About this localisation, 55% of the infested people said bedbugs were found on mattress, as well as 7.5% of the non-infested; 29.7% of the infested homes reported bedbugs on chairs and furnitures as well as 12.2% of the non infested. All the people in the homes infested by bedbugs did not know where and how they got the infestation, 84.2% of the infested homes reported itching; 92.9% of the infested reported pains, 80% reported redness, 40% knew other infested homes (Table III).

A total of 421 (80.96%) people said bedbugs could be prevented by hygiene. In this line, 268 (51.53%) people in the total sample had just one bath daily and 236 (45.38%) respondents had more than a daily bath but the rest of the sample did not respond to this question. Most of these people (333 or 64.04%) said they had difficulties to effectively practice hygiene notably because of no water availability (377 respondents) (Table III).

Table III: Population's perception and knowledge of bedbugs

knowledge of the infestation	criteria	males		females		Total	
infestation by any ectoparasite	yes	7	(1.35%)	67	(12.88%)	74	(14.23%)
	no	97	(18.65%)	349	(67.12%)	446	(85.77%)
infestation by bedbugs	yes	4	(0.77%)	19	(3.65%)	23	(4.42%)
	no (by others)	3	(0.58%)	48	(9.23%)	51	(9.81%)
	(not infested)	97	(18.65%)	349	(67.12%)	446	(85.77%)
can describe bedbugs	yes	45	(8.65%)	228	(43.85%)	273	(52.50%)
	no	58	(11.15%)	179	(34.42%)	237	(45.58%)
	no reply	1	(0.19%)	9	(1.73%)	10	(1.92%)
know localisation	yes	4	(0.77%)	29	(5.58%)	33	(6.65%)
	no	3	(0.58%)	41	(7.88%)	44	(8.46%)
	no reply	97	(18.65%)	346	(66.54%)	446	(85.77%)
bedbugs on walls	yes	9	(1.73%)	51	(9.81%)	60	(11.54%)
	no	92	(17.69%)	327	(62.88%)	419	(80.58%)
	no reply	3	(0.58%)	38	(7.31%)	41	(7.88%)
bedbugs on chairs/furnitures	yes	12	(2.31%)	62	(11.92%)	74	(14.23%)
	no	89	(17.12%)	316	(60.77%)	405	(77.88%)
	no reply	3	(0.58%)	38	(7.31%)	41	(7.88%)
bedbugs on mattress	yes	7	(1.35%)	33	(6.35%)	40	(7.69%)
	no	94	(18.08%)	345	(66.35%)	439	(84.42%)
	no reply	3	(0.58%)	38	(7.31%)	41	(7.88%)
bedbugs on both wall & mattress	yes	7	(1.35%)	33	(6.35%)	40	(7.69%)
	no	89	(17.12%)	316	(60.77%)	405	(77.88%)
where got infestation	know	0	(0.0%)	0	(0.0%)	0	(0.0%)
	do not know	1	(0.19%)	4	(0.77%)	5	(0.96%)
	no reply	103	(19.81%)	412	(79.23%)	515	(99.04%)
how got infestation	know	0	(0.0%)	0	(0.0%)	0	(0.0%)
	do not know	0	(0.0%)	0	(0.0%)	0	(0.0%)
	no reply	104	(20.0%)	416	(80.0%)	520	(100%)
	pain	3	(0.58%)	11	(2.12%)	14	(2.69%)

symptoms of bites	itch	3	(0.58%)	16	(3.08%)	19	(3.65%)
	rash	3	(0.58%)	5	(0.96%)	8	(1.54%)
	redness	3	(0.58%)	12	(2.31%)	15	(2.88%)
	fever	0	(0.0%)	1	(0.19%)	1	(0.19%)
	migraines	1	(0.19%)	1	(0.19%)	2	(0.38%)
know or followed a treatment	know	26	(5.0%)	122	(23.46%)	148	(28.46%)
	followed	10	(1.92%)	54	(10.38%)	64	(12.31%)
	none	68	(13.08%)	270	(51.92%)	338	(65.0%)
treatment followed or known for any infestation	traditional	90	(17.31%)	285	(54.81%)	375	(72.12%)
	medical	0	(0.0%)	0	(0.0%)	0	(0.0%)
	none	13	(2.50%)	4	(0.77%)	17	(3.27%)
	no reply	1	(0.19%)	157	(30.19%)	158	(30.38%)
treatment for bedbugs	chlorine	0	(0.0%)	9	(1.73%)	9	(1.73%)
	hot water	4	(0.77%)	17	(3.27%)	21	(4.04%)
	insecticide	2	(0.38%)	3	(0.58%)	5	(0.96%)
	kerosene	3	(0.58%)	30	(5.77%)	33	(6.65%)
	motor oil	0	(0.0%)	5	(0.96%)	5	(0.96%)
	unspecified	81	(15.58%)	231	(44.42%)	312	(60.0%)
know others with bedbugs	yes	1	(0.19%)	4	(0.77%)	5	(0.96%)
	no	103	(19.81%)	412	(79.23%)	515	(99.04%)
preventing bedbugs	hygiene	77	(14.81%)	344	(66.15%)	421	(80.96%)
	no reply	27	(5.19%)	72	(13.85%)	99	(19.04%)

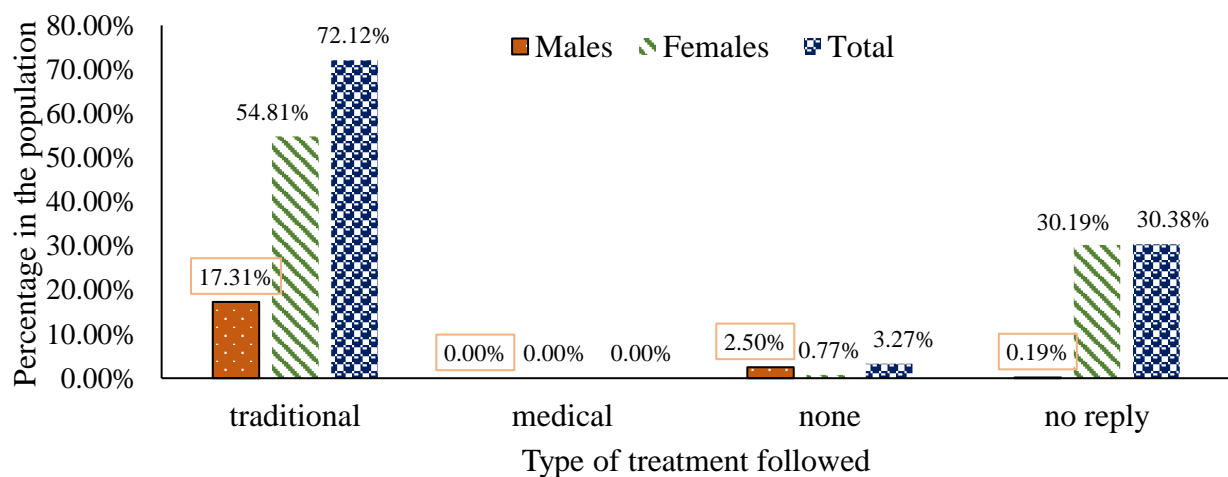


Figure 10: Variation of treatment types followed by the population when generally infested by an ectoparasite

III.1.2. PREVALENCES AND RISK FACTORS

An effective prevalence of 4.4% infestation was obtained for 11 households infested out of 250 sampled. There were 8 out of 13 districts infested for a prevalence of 61.54% in the urban zone against 14.29% in the rural zone for 1 infested village out of 7 sampled villages. The highest infestation was gotten at the boundary between Nkolbikok and quartier Haoussa (20%), followed by Elig-bessala (11.9%) then quartier Haoussa (8.2%), Nkol-mbene (6.9%), Minkama (6.2%), Nkolbikok (5.7%), Elot II (5.6%) and Elot I (1.1%). Foulassi, Nkol-Melen, Nkol-Meting, Bile Binomo, Garre voyageur, Mboua I, Abokono, Belibi, Ekok-Assi, Orphelin, Quartier chauffeur and Ndzong-Mezegue had no infestations. From the perception of the religious status, 7.6% of the Muslim homes were infested while 2.1% of the Christian homes were infested and the others (traditionalists and pegans) showed no infestations for $p < 0.01$ and the total prevalence of 4.4% (Table IV).

Prevalences in the age groups were such that six (6) respondents out of 185 (3.2%) reported a present or recent infestation amongst the <15 years, eight (8) out of 176 respondents (4.50%) in the age group 15-24 years, six (06) out of 151 respondents (4.0%) reported an infestation in the age group 25-64 years and three (3) respondents out of eight (8) (37.5%) in the group of elders (>64 years). This showed a significant difference ($p < 0.001$) and a total prevalence of 4.4%. Concerning the educational level, one (1) out of 30 non-educated respondents (3.3%), twelve (12) out of 219 (6.4%) respondents with primary education, eight (8) of 230 (3.5%) in the secondary level and zero (0) out of 38 with tertiary education level reported infestations (Table IV).

The repartition of the infestation in the population with respect to the educational level reached and per gender is shown in table VI below with females abundant in all categories compared to males. Mo male in the group of the non-literates reported an infestation while 4.35% (1 respondents) of the infested population was a non-literate female. For those who got a different type of education than the conventional type (Other), no one reported an infestation (0.00%). Those whose educational level of education was the primary level accounted for 60.87% (14 respondents) of the total infestations such that 52.17% (12 respondents) were females while 8.69 (02 respondents) were males. The secondary level of education counted the highest number of people in the population (230 respondents) but did not have the highest infestation rate (34.78% for 08 respondents). This infestation rate was shared between the genders such that females carried 26.09% (06 respondents) while males carried 08.69% (02 respondents). The tertiary level of education with 39 respondents in the total sample (07.50%) had no reports of infestation (table VI).

The prevalences per age group with gender were such that 0% (0) infestation was obtained for males aged <15 years and 25-64 years. Two (2) males of the age group 15-24 years (08.7%) and the age group >64 years were infested with bedbugs. In sum, 04 males (17.39%) signalled infestations. For the females, 26.09% (6) was obtained for the age groups <15 years, 15-24 years and 25-64 years while 4.35%

(1) of the infested persons was a female aged >64 years so that a total of 19 infested persons were females (Table IV).

As far as the marital status is concerned, no concubine nor divorcee reported an infestation (0%). Five (5) married out of 119 (4.2%), fifteen (15) single out of 356 (4.2%) and three (3) widows out of 10 (30%) reported infestations. A total prevalence of 4.4% in this group was obtained with a p-value of 0.02. For the professional status, there were no infestations in the group civil servants and the retired. Those who reported infestations were: one (1) private employee out of 24 (4.2%), three (3) resourcefuls out of 107 (2.8%), thirteen (13) students out of 314 (4.1%), and six (6) unemployed out of 66 (9.1%). The total infestation prevalence for professional status was 4.5% and the chi-square gave no significant difference ($p=0.52$) (Table IV).

The living standard showed a total prevalence of 4.4% with no significant difference ($p>0.05$) such that no infestations (0%) were reported by both the low and the very high class. Twenty (20) out of 436 (4.6%) in the average class and two (2) out of 33 (6.1%) reported infestations. The population size at home and the population density all showed a significant difference but no linear variation. Five percent (5%) of the infested houses shared beds while 1.2% did not for $p=0.025$ (Table IV).

Generally, all the socio-demographic characters considered and evaluated in the population had a total prevalence of 4.4% which equals the effective prevalence obtained from the checking of the households (Table IV). This means that even if we just proceeded by evaluating the socio-demographic prevalence for this study, we would have had a good estimate of its infestation rate. This could suggest that a good survey can be sufficient to evaluate an infestation by just considering the socio-demographic prevalence.

Socio-demographic characteristics	Criteria	Individual prevalences	Total prevalence	P value
Religious status	Christianity	2.1% (6/292)	4.4%	0.024 *
	Islam	7.6% (17/223)		
	Tradition	0% (0/2)		
	None	0% (0/2)		
Age	<15 years	3.2% (6/185)	4.4%	0.000 ***
	15-24 years	4.5% (8/176)		
	25-64 years	4.0% (6/151)		
	>64 years	37.5% (3/8)		
Educational level	None	3.3% (1/30)	4.4%	0.352
	Primary	6.4% (12/219)		

	Secondary	3.5% (8/230)		
	Tertiary	0% (0/38)		
Marital status	Concubine	0% (0/30)	4.4%	0.002 **
	Divorced	0% (0/4)		
	Maried	4.2% (5/119)		
	Single	4.2% (15/356)		
	Widow	30.0% (3/10)		
Living standard	Low	0% (0/23)	4.4%	0.698
	Average	4.6% (20/436)		
	High	6.1% (2/33)		
	Very high	0% (0/3)		
Professional status	Civil servant	0% (0/2)	4.5%	0.519
	Private employee	4.2% (1/24)		
	Resourceful	2.8% (3/107)		
	Retired	0% (0/1)		
	Unemployed	9.1% (6/66)		
Effective prevalence			4.4%	

Table IV : Socio-demographic prevalence of infestation

Key: *=Significant difference ($p < 0.05$), **= very significant difference ($p < 0.01$), ***= very very significant difference ($p < 0.001$). The values in brackets are the number of infested persons in the category by the total number of people in that category.

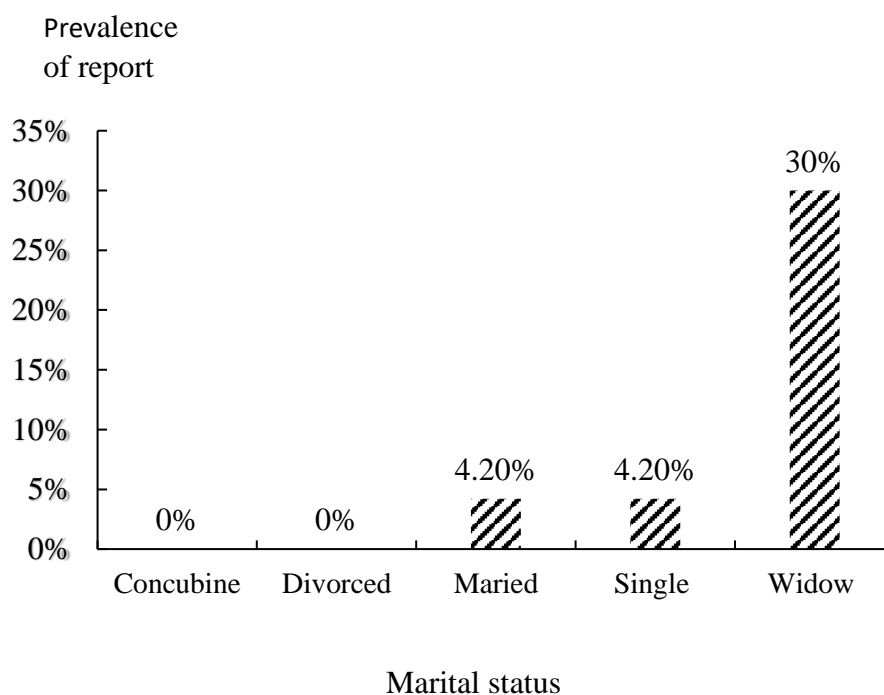
Table V: Distribution of infestation reports in males and females per age

Criteria		Males with infestation in homes	Females with infestation in homes	Total with infestation in homes
age	<15	0 (0%)	6 (26.09%)	6 (26.09%)
	15-24	2(8.7%)	6(26.09%)	8 (34.78%)
	25-64	0(0%)	6 (26.09%)	6 (26.09%)
	>64	2(8.7%)	1(4.35%)	3(13.04%)
Total		4(17.4%)	19 (82.61%)	23 (100%)

Table VI: Distribution of reports of infestation in males and females per educational level

Educational level	Males in the category	Males with infestation in homes	Females in the category	Females with infestation in homes	Total in the category	Total with infestation in homes
None	5 (0.96%)	00 (0.00%)	25 (4.81%)	01 (4.35%)	30 (5.77%)	01 (4.35%)
Other	00 (0.00%)	00 (0.00%)	02 (0.38%)	00 (0.00%)	02 (0.38%)	00 (0.00%)

Primary	34 (6.54%)	02 (8.69%)	185 (35.58%)	12 (52.17%)	219 (42.12%)	14 (60.87%)
Secondary	49 (9.42%)	02 (8.69%)	181 (34.81%)	06 (26.09%)	230 (44.23%)	08 (34.78%)
Tertiary	16 (3.08%)	00 (0.00%)	23 (4.4%)	00 (0.00%)	38 (7.3%)	00 (0.00%)
Total	104 (20%)	04 (17.39%)	416 (80%)	19 (82.61%)	520 (100%)	23 (100%)



Figure

11:

Prevalence of reports of infestation per marital status

III.1.3 IDENTIFICATION OF BEDBUGS AND RE-DESCRIPTION

The study enabled us to collect a total of 14 live (not making mention of the dried) bedbugs belonging to the genus *Cimex* of which three (21.43%) were identified to be male *Cimex hemipterus* and 11 (78.57%) were *Cimex lectularius* (14.29% were female adults, 28.57% male adults, 35.71% nymphs and 7.14% egg).

III.1.3.1. IDENTIFICATION

A total of 14 specimens, belonging to the genus *Cimex*, were collected during the study. The identification of these specimens, using identification keys by Usinger, 1966 permitted us to identify three male adults of *C. hemipterus*, six adults of *C. lectularius* of which four males and two females, two fifth instar nymphs, one fourth instar nymph, one third instar nymph, one first instar nymph and an egg.

III.1.3.2. RE-DESCRIPTION (MORPHOLOGICAL)

✚ *Cimex lectularius* (Stal, 1873)

→ Nymphal stages

First instar nymph

More or less shapeless, uniform pale brown small body, small red lateral eyes on eyes. Soft non-sclerotised cuticle. Bristles not very long nor dense (Fig. 12).



Figure 12: First instar nymph on ventral view

Third instar nymph

Body length (as obtained with amscope's scale) 2.02mm by maximum width (at the abdomen) 1.35mm. Head length 0.36mm by width 0.56mm.

Head: Antennal segments more or less equal, cuticle very less sclerotised and more transparent, unfed organism has a blisting yellowish coloration due to dense bristles cover. Labrum of length 0.08mm. Length of antennae 1.08mm, of rostrum 0.5mm. **Thorax:** Pronotum of length 0.29mm by width 0.71mm. Mesonotum of length 0.21mm by width 0.83mm. Metanotum of length 0.16mm by width 0.94mm. The thorax shows sorts of wing-like extensions. **Abdomen** of length 1.00mm (Fig. 13). Cuticle light-brown or golden-brown.

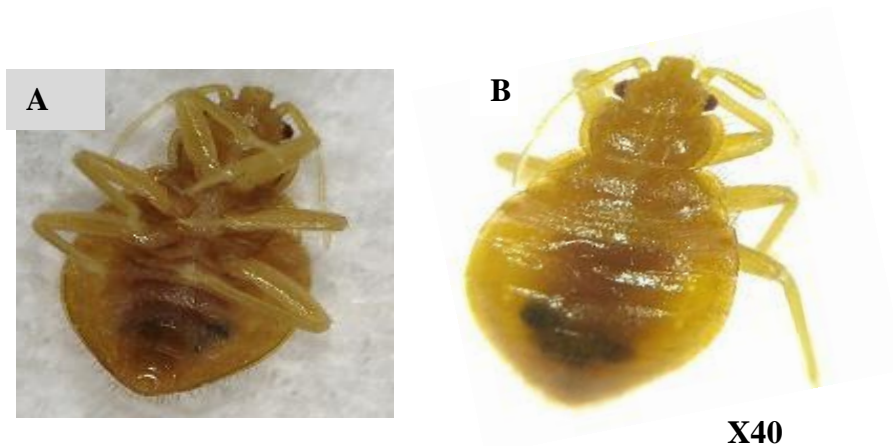


Figure 13: Third instar mynph of *Cimex lectularius* A. ventral view B. dorsal view

Fourth instar nymph (fed)

Body length 3.10 mm by maximum width on abdomen 1.68mm. **Head:** Hind margin of mesonotum not concave in the middle such that it is almost straight. Head length 0.54mm by width 0.69mm. Labral length 0.10mm, antennal length 1.29mm, rostral length 0.62mm. **Thorax:** Pronotal length 0.49mm by width 1.01mm, mesonotal length 0.32mm by width 1.21mm, metanotal length 0.19mm by width 1.34mm. **Abdomen:** Abdominal length 1.56mm by maximum width 1.68mm.

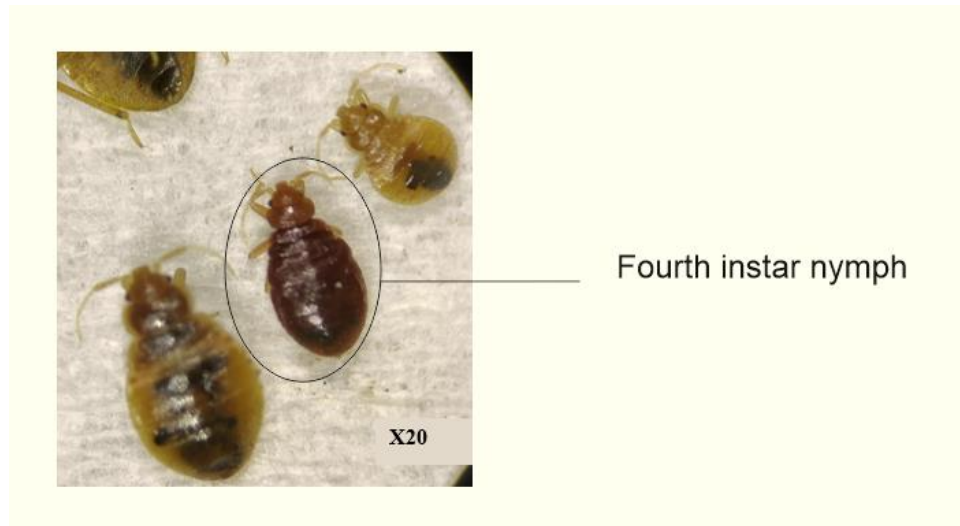


Figure 14: Fourth instar nymph (fed)

Last instar nymph

Body length about 3.80mm and largest width (on abdomen) not more than 2.30mm. **Head:** Stringy brownish to golden yellow antennae of length between 1.50mm- 1.80mm covered with numerous bristles has three segments attached to head by scape of length 0.12mm. First antennale segment is averagely of length 0.50mm, second segment 0.50mm long, third segment with pale brown to yellowish colour of length 0.30-0.40mm and a round end (enlarges on its anterior end). Short labrum of length 0.16mm by width 0.32mm extends freely in-between the scapes of the antennae, is seperated from the head by a clypeo-labral suture. The clypeus, very visible, forms a v-shape and continues as a clypeo-frontal line which appears to divide the rest of the head and thorax into two lateral lobes. Head length around 0.28mm by width 0.84mm, ecdysial line of length 0.37mm. Ventral rostrum is 0.77mm long by 0.12mm wide.

Thorax : Prothoraxic length 0.52mm by width 1.27mm, mesothoraxic length 0.34mm by width 1.60mm. Prothoraxic legs with length to width ratio of femora 21:6, of tibia 9:2, of tarsus 10:3. Mesothoraxic legs with length to width ratio of femora 14:5, of tibia 7:1 and of tarsus 16:3. Hind legs with length to width ratio of femora 17:5, of tibia 1:1 and tarsus 19:3 with claws of length around 0.05mm.

Abdomen: Abdominal segments of variable sizes such that the first is of length 0.13mm by width 1.64mm; second of length 0.25mm by width 1.77mm; third of length 0.41mm by width 2.00mm; fourth segment of length 0.39mm by width 2.18mm; fifth of length 0.38mm by width 2.22mm; sixth with length 0.31mm and

1.89 mm; seventh of length 0.26mm and width 1.53mm, eighth of length 0.19mm and width 0.92mm and ninth with length 0.11mm by width 0.42mm. Scent glands found dorsally on segments 3 to 5 of abdomen. First and second form semi-circles of heights 0.18mm and 0.15mm with diameters 0.74mm and 0.40mm respectively. Third is more or less triangular with base length 0.49mm and height 0.24mm.

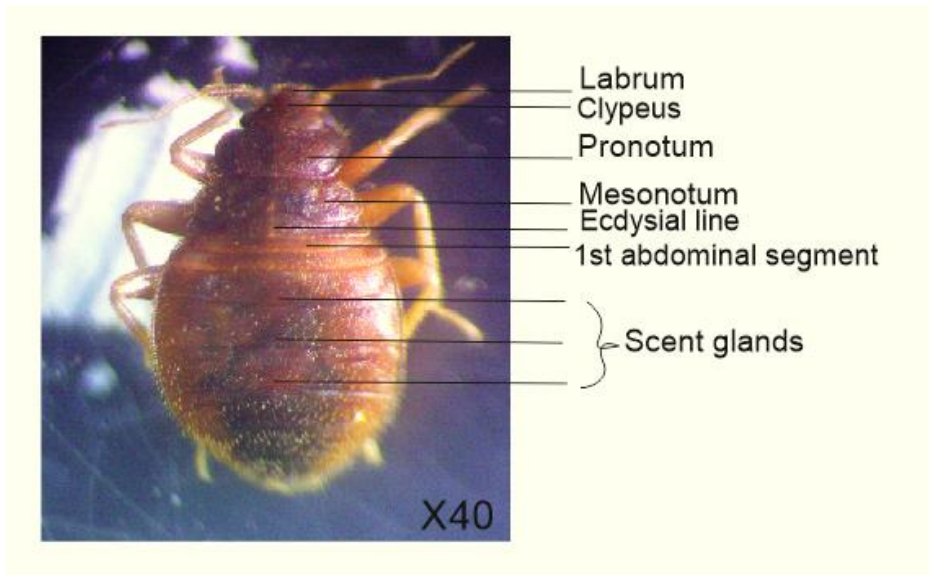


Figure 15: Dorsal view of last instar nymph

➔ Adult : (TableVII, figure 16)

Generally brownish of length between 4.35-5.78mm ($4.83\text{mm} \pm 0.34$) and width (abdomen) 1.77-3.52mm ($1.96\text{mm} \pm 0.39$), considering the six adults. **Head:** Stringy brownish antennae of length $0.85 \pm 0.02\text{mm}$ covered with numerous bristles has three segments attached to the head by scape of length 0.14 mm by 0.09mm width. First antennale segment brown of length 0.49 mm and width 0.06 mm, second segment 0.5mm long by 0.05 mm wide, third segment with pale brown to yellowish colour of length 0.3-0.4mm by 0.05 mm width and a round end. Labrum extends freely in-between the scapes of the antennae, seperated from the head by clypeo-labral suture. Clypeus forms a v-shape and continues as a clypeo-frontal line which appears to divide the rest of the head into two lateral lobes. Reddish lateral eyes of diameter 0.1mm give way to lines that form jaws below them. Very short setae on dorsal head such that pores on which setae should be seem empty.

Thorax: Wing-like pronotum of width by length ratio three (not much less or more than three) with blisting edges extends upwards at the lateral sides towards eyes. Bristles here longer (0.087mm) at the extremities than middle body. Mesonutum-scutellum short (0.21 ± 0.01 mm) and less wide (0.67 mm) than pronotum. Very short setae here. Hemelytral pads less dense in coloration than the rest of the thorax because of high density of setae on them, are of length 0.17mm on the middle body and 0.37mm at extremities. Ventrally, mesothoracic sternum of length not more than 0.40mm and maximum width 0.3mm. Metathoracic sternum of length 0.35mm and width less than 0.3mm, densely covered with setae of length greater than distance

between their bases. Legs all same in coloration covered with bristles longer at extremities. Prothoracic legs with length to width ratio of femora 3:1, of tibia 17:3, of tarsus 8:1. Mesothoracic legs with length to width ratio of femora 11:9, length to width ratio of tibia 28:3 and length to width ratio of tarsus 91:8. Hind legs with length to width ratio of femora 3:1, of tibia 16:1 and tarsus 7:1 claws 0.05mm long. Tarsus pale compared to tibia and femora.

Abdomen: First segment under hemelytral pads, just after scutellum with length not more than 0.5mm. Total abdominal length around 3.2mm and maximum width 1.96 ± 0.39 mm. Nine segments visible dorsally with width to length ratios ranging from 7:16 on the last to 4:23 on the 3rd and 8th with long setae extending laterally. Cuticle folds on abdomen enabling it to extend when it fills during a blood meal thereby behaving like a balloon. Folds or interspaces separating main segments are more or less transparent and reflective with length varying between 0.07 and 1.3mm. Rows of bristles on the abdomen alternate with the inter-abdominal spaces (folds) such that it appears to be a series of dark and pale brown bands alternating with each other, very visible when bedbug fed.

Mensurations

Table VII: Mensurations done on the collected *Cimex lectularius* adults

Parameters	Male (n=4)	Female (n=2)	Global (n=6)
Hl	0.84±0.01 (0.81-0.92)	0.88±0.04 (0.81-0.87)	0.85±0.02 (0.84-0.92)
Hw	0.72±0.04 (0.65-0.86)	0.85±0.02 (0.65-0.82)	0.76±0.04 (0.83-0.86)
Prl	0.76±0.01 (0.74-0.79)	0.75±0.01 (0.74-0.79)	0.76±0.01 (0.74-0.76)
Prw	1.95±0.03 (1.84-2.01)	1.91±1.07 (1.89-2.01)	1.93±0.03 (1.84-1.98)
Msl	0.20±0.01 (0.18-0.24)	0.24±0.01 (0.18-0.21)	0.21±0.01 (0.23-0.24)
Msw	0.66±0.01 (0.64-0.70)	0.67±0.03 (0.64-0.67)	0.66±0.01 (0.64-0.70)
Mtl	0.50±0.01 (0.47-0.55)	0.55±0.01 (0.47-0.52)	0.51±0.01 (0.54-0.55)
Mtw	0.72±0.01 (0.69-0.77)	0.76±0.02 (0.69-0.76)	0.73±0.01 (0.69-0.77)
Prl ti	0.67±0.04 (0.28-0.85)	0.57±0.29 (0.59-0.73)	0.63±0.08 (0.28-0.85)
Prwti	0.11±0.01 (0.08-0.14)	0.11±0.02 (0.08-0.14)	0.11±0.01 (0.09-0.12)
Plta	0.42±0.07 (0.14-0.60)	0.23±0.09 (0.27-0.60)	0.35±0.06 (0.14-0.31)
Pwta	0.06±0.00 (0.05-0.07)	0.06±0.01 (0.05-0.07)	0.06±0.0 (0.05-0.07)
Plfe	0.90±0.07 (0.56-0.98)	0.67±0.11 (0.70-0.98)	0.82±0.07 (0.56-0.77)
Pwfe	0.19±0.06 (0.03-0.33)	0.25±0.04 (0.03-0.33)	0.21±0.04 (0.21-0.28)
Mslti	0.98±0.16 (0.55-1.27)	0.82±0.22 (0.55-1.27)	0.93±0.12 (0.60-1.04)
Mswti	0.11±0.01 (0.05-0.14)	0.08±0.03 (0.09-0.14)	0.10±0.01 (0.05-0.10)
Mslta	0.37±0.06 (0.20-0.48)	0.33±0.10 (0.20-0.48)	0.36±0.05 (0.23-0.43)
Mswta	0.06±0.00 (0.04-0.07)	0.05±0.01 (0.05-0.07)	0.05±0.00 (0.04-0.05)
Mslfe	0.90±0.09 (0.50-1.03)	0.77±0.27 (0.63-1.01)	0.85±0.09 (0.50-1.03)
Mswfe	0.30±0.03 (0.22-0.34)	0.29±0.06 (0.22-0.34)	0.29±0.02 (0.23-0.34)
Mlti	1.40±0.08 (0.89-1.96)	1.43±1.54 (1.26-1.63)	1.41±0.15 (0.89-1.96)
Mtwti	0.12±0.01 (0.09-0.16)	0.11±0.02 (0.09-0.16)	0.12±0.01 (0.09-0.13)
Mltta	0.43±0.08 (0.20-0.51)	0.36±0.10 (0.20-0.51)	0.41±0.06 (0.26-0.46)
Mtwta	0.08±0.02 (0.04-0.12)	0.05±0.01 (0.05-0.12)	0.07±0.01 (0.04-0.05)

Mtlfe	0.97±0.05 (0.74-1.20)	0.97±0.23 (0.82-1.06)	0.97±0.07 (0.74-1.20)
Mtwfe	0.40±0.07 (0.24-0.59)	0.29±0.05 (0.28-0.59)	0.36±0.05 (0.24-0.34)
abmaxw	1.62±0.37 (0.52-3.52)	2.65±1.88 (0.52-2.13)	1.96±0.39 (1.77-3.52)
bl	4.72±0.44 (3.95-5.85)	5.07±4.72 (3.95-5.85)	4.83±0.34 (4.35-5.78)
Las1	0.41±0.07 (0.29-0.54)	0.41±0.09 (0.29-0.54)	0.41±0.05 (0.32-0.50)
Las2	0.33±0.08 (0.18-0.55)	0.41±0.14 (0.18-0.46)	0.36±0.06 (0.27-0.55)
Las3	0.29±0.07 (0.15-0.55)	0.40±0.16 (0.15-0.42)	0.32±0.06 (0.24-0.55)
Las4	0.29±0.06 (0.20-0.48)	0.35±0.14 (0.20-0.44)	0.31±0.05 (0.21-0.48)
Las5	0.28±0.06 (0.15-0.43)	0.26±0.10 (0.15-0.43)	0.27±0.05 (0.16-0.35)
Las6	0.24±0.06 (0.10-0.40)	0.22±0.12 (0.12-0.40)	0.23±0.05 (0.10-0.33)
Las7	0.23±0.05 (0.11-0.37)	0.20±0.09 (0.14-0.37)	0.22±0.04 (0.11-0.28)
Las8	0.24±0.09 (0.09-0.47)	0.19±0.07 (0.09-0.47)	0.22±0.06 (0.12-0.25)
Ltb	0.11±0.01 (0.05-0.13)	0.07±0.02 (0.10-0.13)	0.10±0.01 (0.05-0.09)
Was1	1.91±0.17 (1.49-3.07)	2.28±1.79 (1.55-2.37)	2.04±0.24 (1.49-3.07)
Was2	2.12±0.20 (0.32-2.66)	1.01±2.69 (1.70-2.66)	1.75±0.32 (0.32-1.70)
Was3	2.17±0.19 (1.77-3.50)	2.64±2.87 (1.83-2.69)	2.32±0.27 (1.77-3.50)
Was4	2.01±0.16 (1.59-3.52)	2.56±2.97 (1.70-2.46)	2.19±0.29 (1.59-3.52)
Was5	1.68±0.14 (1.23-3.39)	2.31±1.08 (1.42-2.07)	1.89±0.32 (1.23-3.39)
Was6	1.08±0.16 (0.72-2.10)	1.45±1.65 (0.72-1.51)	1.21±0.21 (0.80-2.10)
Was7	0.79±0.08 (0.51-1.23)	0.87±0.36 (0.58-0.97)	0.81±0.11 (0.51-1.23)
Was8	0.46±0.05 (0.29-0.62)	0.46±0.17 (0.36-0.55)	0.46±0.05 (0.29-0.62)

Key : Head length(Hl) ;head width (Hw) ; pronotal length (Prl) ; pronotal width (Prw) ; mesonotal length(Msl) ; mesonotal width (Msw) ; Metanotal length (Mtl) ; metanotal width (Mtw) ; length of tibia of pronotal leg (Prlti) ; width of tibia of pronotal leg (Prwti) ; length of tarsus on prothoracic leg (Plta) ; width of tarsus on prothoracic leg (Pwta) ; length of femora on prothoracic leg (Plfe) ; width of femora on prothoracic leg (Pwfe) ; length of tibia on mesothoracic leg (Mslti) ; width of tibia on mesothoracic leg (Mswti) ; length of tarsus on mesothoracic leg (Mslta) ; width of tarsus on mesothoracic leg (Mswta) ; length of femora on mesothoracic leg (Mslfe) ; width of femora on mesothoracic leg (Mswfe) ; length of tibia on metathoracic leg (Mlti) ; width of tibia on metathoracic leg (Mtwti) ; length of tarsus on metathoracic leg (Mlti) ; width of tarsus on metathoracic leg (Mtwti) ; length of femora on metathoracic leg (Mtlfe) ; width of femora on metathoracic leg (Mtwfe), maximum width of abdomen.

Remark:

Male: endosoma in paramere groove form paramere of about 0.7mm long, is evenly curved, conical, found ventrally on last abdominal segment. Body length about 4.72±0.44 mm (3.95-5.85 mm) depending on age and whether fed or not since abdomen widens if fed (Table VII).

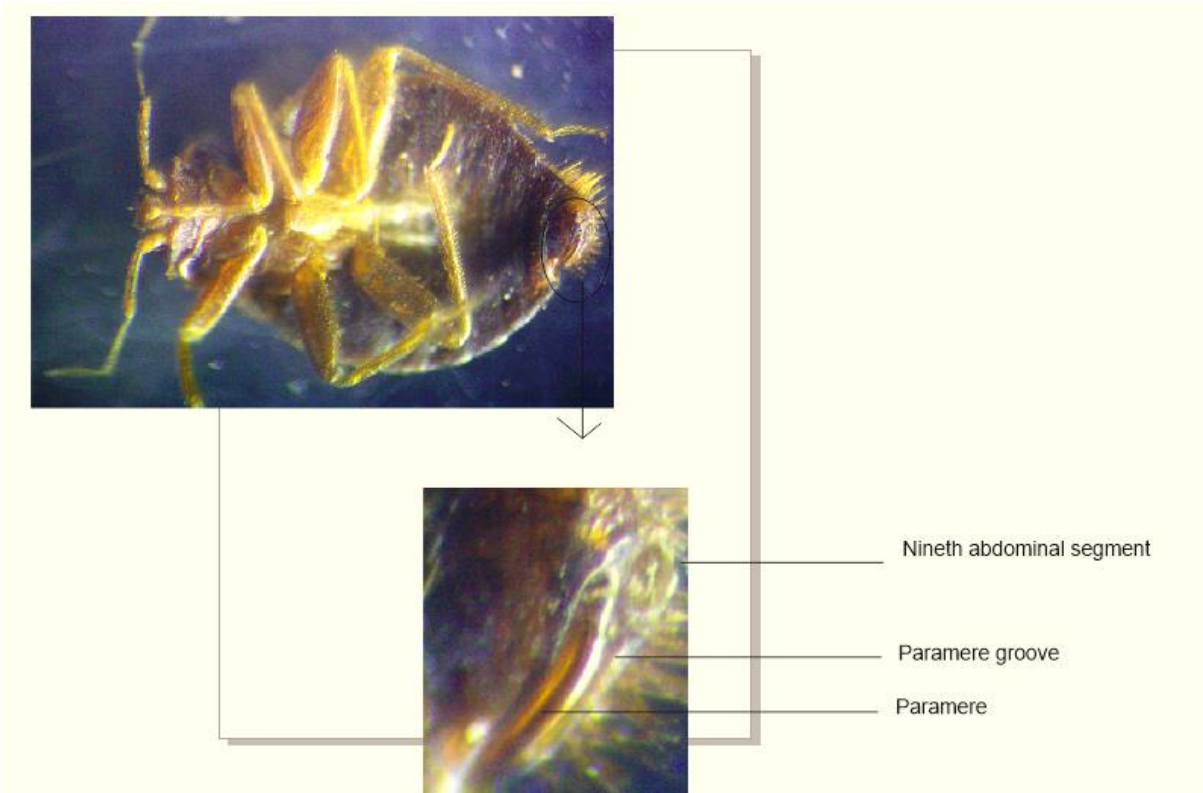


Figure 16: Paramere of male *Cimex lectularius*

Female: paragenital sinus found ventrally on left of fifth abdominal segment with sinusoidal shape. Female of body length 5.07 ± 4.72 mm (3.95-5.85 mm) (Table IV).

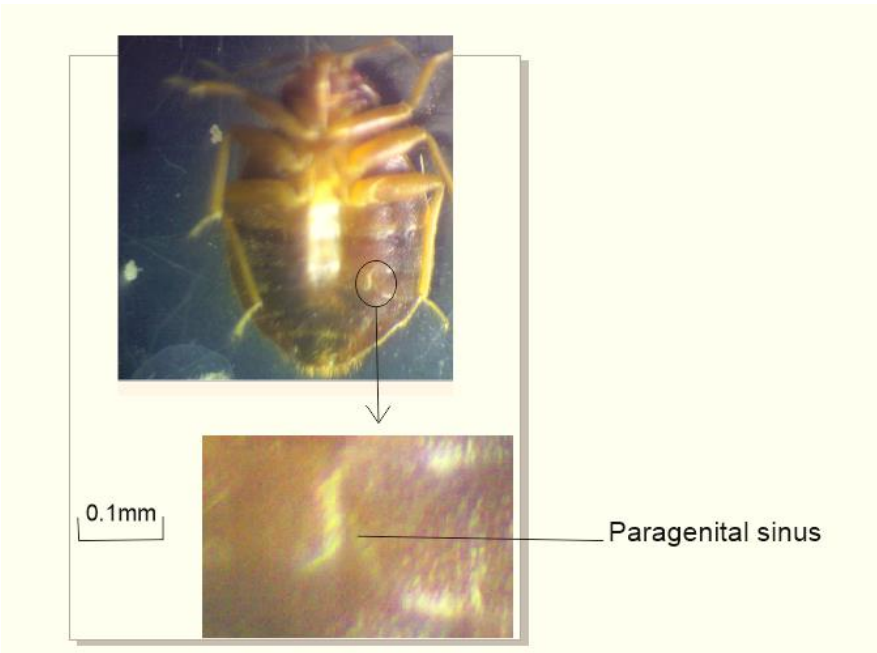


Figure 17: Paragenital sinus in female *Cimex lectularius*

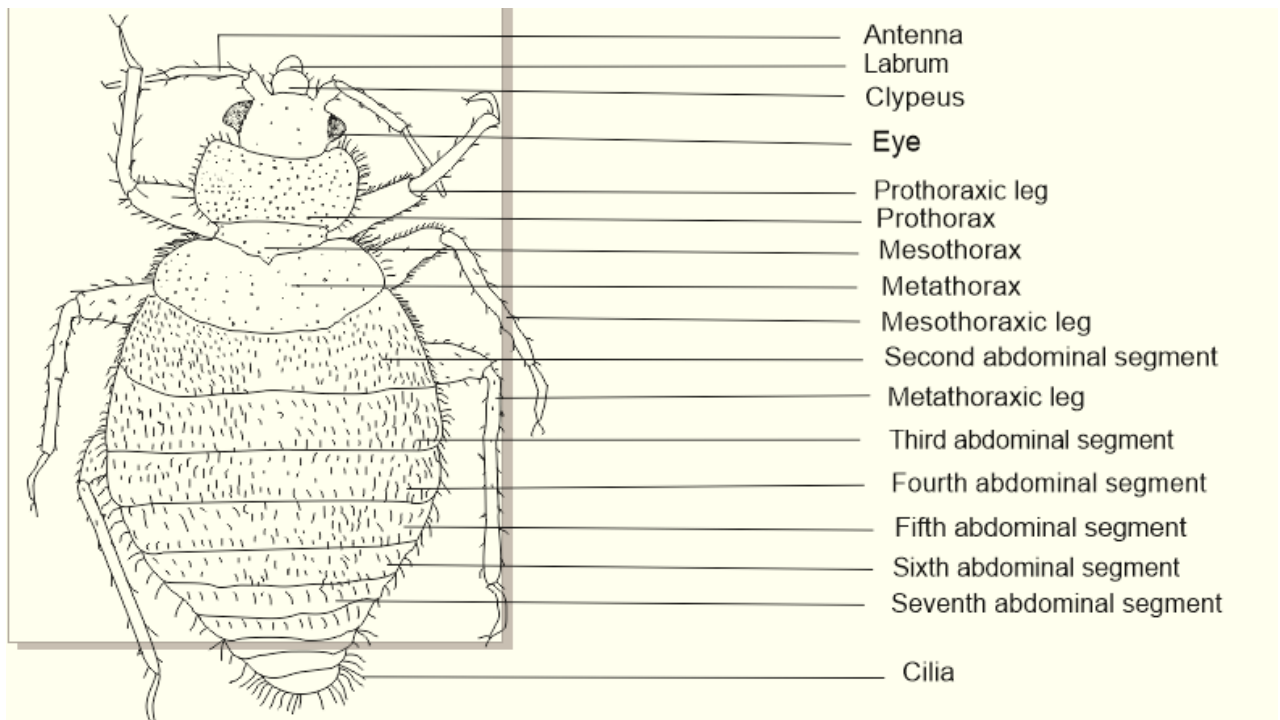


Figure 18: Dorsal view of an adult male *Cimex lectularius*

✚ Adult *Cimex hemipterus* (Ray, 1710) (Table VIII, fig 20)

Head: Dorsally, width of value between 0.65-0.71mm (0.69±0.02mm) and length 0.84±0.01mm. Interocular space about 0.515mm, interantennal space about 0.365mm. Antennae not by far less than 0.200mm long. Ventrally, interocular space about 0.820mm and interantennal space about 0.511mm. Labium about 0.270mm long, rostrum of average length 1.023 mm (~ 0.372-0.375mm for segment 1, 0.235-0.237mm for segment 3, 0.410-0.414mm for last segment), maximum width lightly > 0.180mm (segment 2) and minimum width about 0.065mm, reaching the apices of front coxae, second segment surpasses base of head.

Thorax: Pronotum wider than longer with width by length ratio 2, wing-like with blisting edges but do not extend much. Longest bristles of length about 0.075 (more or less) at edges. Mesonutum-scutellum short (0.21±0.02 mm) and less wide (0.585mm) than pronotum. Very short but dense bristles here. Hemelytral pads less dense in coloration than the rest of the thorax because of high density of bristles on them, are of length 0.17 mm on the middle body and 0.41 mm at extremities. Ventrally, mesothoracic sternum of length not more than 0.45mm and maximum width 0.26 mm. Metathoracic sternum of length 0.35 mm and width about 0.3 mm, densely covered with bristles of length a little more than distance between their bases. Legs all same in coloration covered with bristles longer at extremities. Prothoracic legs with length to width ratio of femora 35:13, of tibia 9:1, of tarsus 10:1. Mesothoracic legs with length to width ratio of femora 7:2, of

tibia 9:1 and of tarsus 9:1. Hind legs with length to width ratio of femora 17:5, of tibia 14:1 and tarsus 8:1. Tarsus pale compared to tibia and femora.

Mensurations

Table VIII: Mensurations done on the collected *Cimex hemipterus* adults

Parameters	Male (n=3)	
Hl	0.84±0.01	(0.82-0.85)
Hw	0.69±0.02	(0.65-0.71)
Prl	0.71±0.01	(0.68-0.73)
Prw	1.58±0.16	(1.40-1.90)
Msl	0.21±0.02	(0.19-0.25)
Msw	0.68±0.01	(0.66-0.70)
Mtl	0.52±0.03	(0.47-0.58)
Mtw	0.74±0.03	(0.70-0.79)
Prl ti	1.03±0.24	(0.78-1.50)
Prwti	0.12±1.01	(0.09-0.14)
Plta	0.44±4.04	(0.36-0.51)
Pwta	0.05±0.00	(0.05-0.05)
Plfe	0.9±9.16	(0.66-1.20)
Pwfe	0.27±2.02	(0.25-0.30)
Mslti	0.99±9.10	(0.87-1.19)
Mswti	0.11±1.01	(0.10-0.13)
Mslta	0.46±4.02	(0.43-0.51)
Mswta	0.05±0.01	(0.04-0.07)
Mslfe	1.05±0.12	(1.92-1.29)
Mswfe	0.34±3.06	(0.26-0.45)
Mlti	1.46±4.13	(1.27-1.72)
Mwti	0.11±1.02	(0.09-0.16)
Mlta	0.51±5.03	(0.46-0.57)
Mwta	0.07±0.01	(0.06-0.09)
Mtlfe	1.22±2.15	(1.07-1.52)
Mtwfe	0.36±3.03	(0.32-0.41)
abmaxw	2.36±3.29	(2.02-2.93)
bl	5.04±0.31	(4.47-5.55)
Las1	0.38±3.04	(0.33-0.46)
Las2	0.38±3.03	(0.33-0.41)
Las3	0.36±3.04	(0.29-0.43)
Las4	0.37±3.05	(0.29-0.45)
Las5	0.33±3.08	(0.21-0.48)
Las6	0.33±3.07	(0.22-0.46)
Las7	0.12±1.01	(0.10-0.14)
Las8	0.32±3.12	(0.14-0.56)
Ltb	0.12±1.02	(0.10-0.16)
Was1	1.84±8.04	(1.76-1.90)

Was2	2.06±0.04	(2.02-2.13)
Was3	2.08±0.06	(1.96-2.18)
Was4	1.94±9.15	(1.76-2.23)
Was5	2.00±0.48	(1.31-2.93)
Was6	1.16±1.08	(1.02-1.31)
Was7	0.61±6.15	(0.31-0.80)
Was8	0.4±4.12	(0.20-0.62)

Key : Head length(Hl) ;head width (Hw) ; pronotal length (Prl) ; pronotal width (Prw) ; mesonotal length(Msl) ; mesonotal width (Msw) ; Metanotal length (Mtl) ; metanotal width (Mtw) ; length of tibia of pronotal leg (Prlti) ; width of tibia of pronotal leg (Prwti) ; length of tarsus on prothoracic leg (Plta) ; width of tarsus on prothoracic leg (Pwta) ; length of femora on prothoracic leg (Plfe) ; width of femora on prothoracic leg (Pwfe) ; length of tibia on mesothoracic leg (Mslti) ; width of tibia on mesothoracic leg (Mswti) ; length of tarsus on mesothoracic leg (Mslta) ; width of tarsus on mesothoracic leg (Mswta) ; length of femora on mesothoracic leg (Mslfe) ; width of femora on mesothoracic leg (Mswfe) ; length of tibia on metathoracic leg (Mlti) ; width of tibia on metathoracic leg (Mtwti) ; length of tarsus on metathoracic leg (Mlti) ; width of tarsus on metathoracic leg (Mtwti) ;length of femora on metathoracic leg (Mtlfe) ; width of femora on metathoracic leg (Mtwfe), maximum width of abdomen (abmaxw), body length (bl) ; length of abdominal segment (Las) ; length of terminal bristle (Ltb) ; width of abdominal segment (Was).

➔ Male: Two parameres were observed.

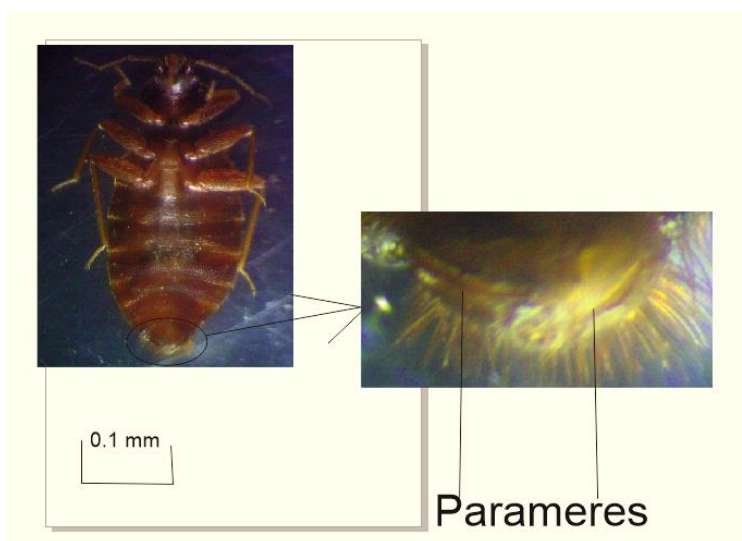


Figure 19: Male Cimex hemipterus with two parameres

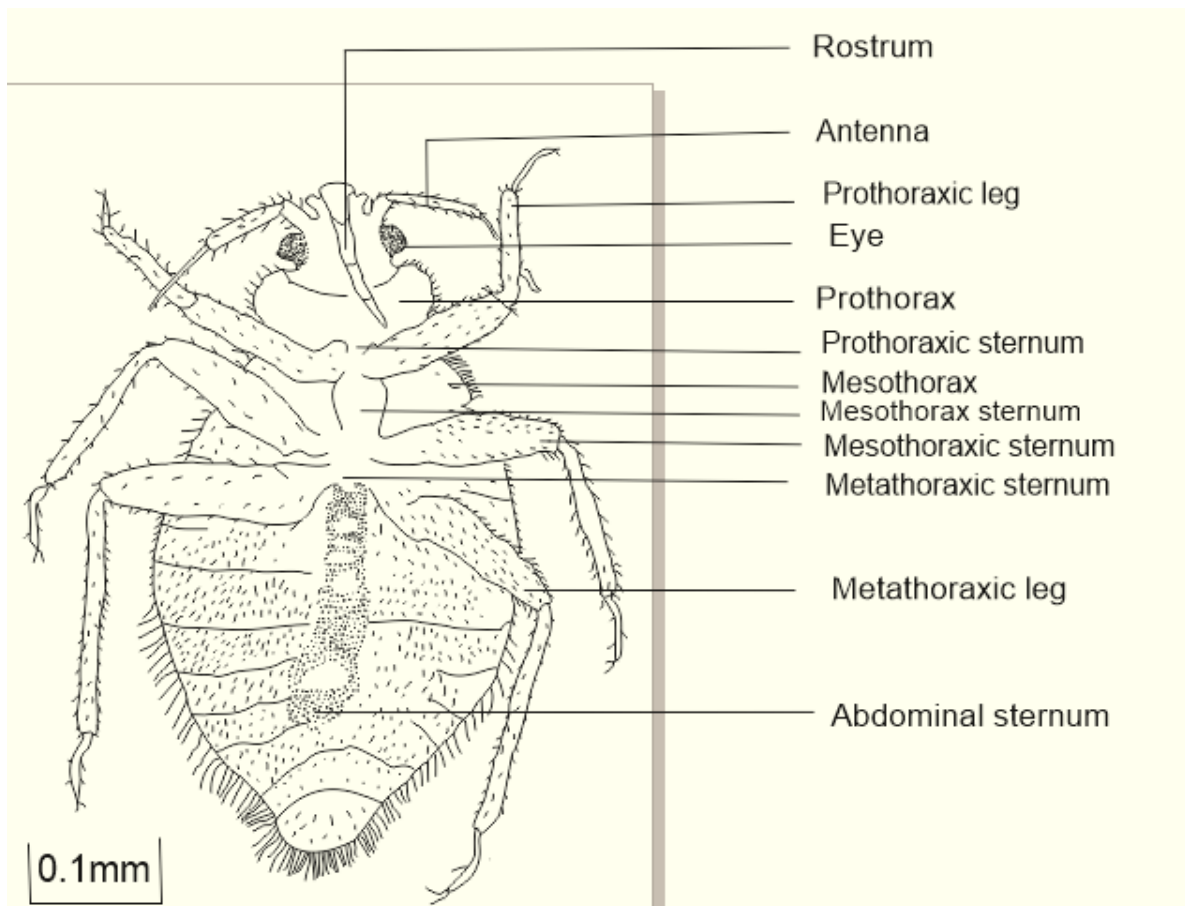


Figure 20: Ventral view of a male Cimex hemipterus

III.2 DISCUSSION

III.2.1 POPULATION'S PERCEPTION AND KNOWLEDGE OF BEDBUGS

III.2.1.1 SOCIO- DEMOGRAPHIC CHARACTERISATION

A total of 520 respondents were interviewed during the survey. This is about 0.42% of the Obala population in 2022 (CDP, 2022). The ratio of females to males was 4:1 showing that the population in this zone is essentially female. Among the four age groups considered, the highest proportion of respondents was made up of the youths (35.58% of the sample was <15 years old) while only 1.54% constituted the old age group. These results are similar to those of the CDHS, 2018 who reported during a survey that about 45% of Cameroon's population in households is made up of children <15 years old. They are also similar to the 33.2% obtained in Douala and 36.8% in Yaounde, during a study in 2005 (De Vreyer & Roubaud, 2013). The National Institute of Statistics (NIS) reported that 42.5% of the Cameroon's population is made up of children <15 years old while only 3.6% was constituted of people age 65 years and above.

The percentage of the non-literate population was 5.76 so that about 94.25% of our sampled population was made up of literates. In 2005, 4.2% of the Douala and 2.7% of the Yaounde population was not educated (De Vreyer & Roubaud, 2013) On the other hand, the literacy rate in Cameroon was reported to be 78.2% in 2020 (Knoema, 2020). The greatest portion of the sampled population has attended school

up to secondary education level (44.23%) or atleast primary education (42.12%) whereas only 7.30% got into the tertiary educational level. This is similar to the results of the CDHS (2018) that got 8% of women and 11% of men (for a total estimate of 9.5%) were literates in Cameroon in 2018 while 20% of women and 10% of men were non literates. The educational facilities in Obala are such that in 2022, there were 31 primary schools (19 public and 12 private), 19 secondary schools (10 public and 9 private) and one tertiary institute (has risen to three in 2023) (CDP Obala, 2022). This can explain why there are more people with primary, then secondary than tertiary education in this locality. Another reason could be early pregnancies and dropouts for early money quest. According to the CDHS (2018), 24% of the adolescent female population in Cameroon, 30% in the Centre Region and 19% in Yaounde has begun child bearing. This happens because of early introduction into sexual activity (averagely 17 years for females and 19.3 years for males) (CDHS, 2018). Since the primary sector is the main revenue source of the population here (CDP Obala, 2022), it is difficult for a parent to still cater for their girl child that has put to birth and for the baby, so that the adolescent mother will dropout from school. This could be the reason why majority of the population is composed of resourceful people (20.58%).

The highest percentage for educational status being in primary the level of education (6.4%) shows that parents atleast encourage their kids to be educated so that majority of the youths can atleast read and write. Many respondents seem to explain their dropout by the fact that they were not well oriented and had no motivations, or they just needed to be able to read and count in order to begin their business. Thus most of them are resourceful, engaged in selling, farming, tayloring, hair dressing which they practice with no certifications as they say that high unemployment rate makes studies useless. The results obtained from child bearing give an average of 2.89 children per parent. This is not much different from the 4.8 children per parent in Cameroon, 5.2 in the Centre Region and 3.5 in Yaounde, obtained by the CDHS, 2018. Their results could be justified by the fact that family planning was effectively used by 19% of married women in Cameroon.

The employment status seems to be greatly influenced (not significantly though) by the educational level reached. Anyways, 60.38% (314 respondents) of our population was in the category of students distributed in the primary (25.19% for 131 respondents), in the secondary (30.38% for 158 respondents) and in the tertiary (4.42%). In the group of the unemployed population, the highest percentage is obtained for those who limited themselves at the primary level (6.73% for 35 respondents) followed by those who completely got no education (2.69% for 24 respondents). Those who got to the tertiary level actually occupy the lowest percentage (0.77%) in the group of unemployed people. This shows that getting education increases chances of getting employed (Ali & Jalal, 2018). This is confirmed by the fact that the civil servants encountered had completed secondary education and 01 (50% of the civil servants) furthered his studies to the tertiary level. The retired (ex-employed) had also completed secondary education. This therefore goes to encourage the youths into being educated. Researches have even proven that there is a significantly positive relationship between higher education and employment (Ali & Jalal, 2018).

Religious diversity and freedom shows to be effective here, especially between the Christian (56.15%) and the Muslim (42.89%) faiths. The light difference (69 respondents) can be explained by the fact that during colonisation, it is Christianity that was adopted here so that it is the main religious practice of the autochtones. Islam is more or less imported by the allochtones (mainly the Haoussa and the Bamoun) who have even occupied some defined districts (mainly quartier Haoussa, Elig-Bessala, Nkolbikok, Elot 1 and Elot 2 where they are in majority). These results go along to show that the Obala natives are very welcoming and the place is actually a transition zone which people from different regions of Cameroon with different cultures can access.

Only 0.38% of our sample was composed of civil servants, with 0.19% retired, 4.62% of respondents were employed by private owners, 12.69% unemployed, 20.58% of them were resourceful, and 60.39% students. These results can be compared to those presented by De Vreyer & Roubaud (2013), showing public administration and public enterprises accounted for 4.8% and 1.8% of the labor force while the formal private sector accounted for 30.7% and 23.8% in Douala and Yaounde respectively. This shows that the greatest portion of this population goes in quest for knowledge though they dropout early in quest for fast money (high number of resourceful youths). This might be due to the living standard offered by their parents which they wish to better by helping out when they reach adolescence. These results are similar to those of De Vreyer & Roubaud (2013) who presented a study in 2005 of Sub-saharan Africa for which it was observed that labor force participation rates were consistent with the stages of the life cycle. People aged 20 and less accounted for 35% of the working population (when they are supposed to be in school). Therefore, children of Africa enter the labor market at a very young age, and more females than males. About 10.2% and 4.5% of the age group 10-14 years in Douala and Yaounde respectively, while 52.2% and 50.3% of the age group 15-29 years in these same cities, constituted the labor force participation rates in 2005. They also got that the unemployment rates that year in Yaounde was about 14.7% based the International Labor Organization (ILO) definition of unemployment. This value is not far from the 12.69% obtained during this study.

The living standard almost pulled the total population sampled in the average class due to the type of employment situation observed. There were about 4.91 people per home during this survey. This is similar to the 5.1 people per home presented by De Vreyer & Roubaud (2013) and the 5 members per household declared by the CDHS (2018). Also, the average number of rooms per household obtained from this study was about 2.66. This value is not far from that obtained by the Centre for Affordable Housing Finance in Africa (C.A.H.F), 2022 (about 2-4 rooms per household with the percentages varying such that 24.65% of households have 2 rooms, 41.83% have 3 rooms and 18.28% have 4 rooms). Comparing the percentages, this study also obtains the highest prevalence for households with 3 rooms (27.31%) followed by households with 2 rooms (24.42%).

III.2.1.2 POPULATION'S PERCEPTION AND KNOWLEDGE ABOUT THE INFESTATION, PRESENCE OF SYMPTOMS

A number of 23 out of 520 (4.42%) respondents reported a present or past infestation by bedbugs. About 273 (52.50%) people could describe these insects and distinguish them from lice, jiggers, while 237 (45.58%) could not. All those who had gotten an infestation could describe the bugs and give their localisation, as well as a few of those who had not encountered the parasite personally. In sum, the identified localisations of the parasite by the population included walls by 11.54% of the sample, mattresses by 7.69%, chairs/ furnitures 14.23%. Out of all those who claimed to know the localisation of these insects, 4 people mentioned the head and others made mention of the skin. In a study by Mbuta *et al.* (2022), most of the respondents could identify bedbugs from other known ectoparasitic arachnids like ticks, fleas, mites, and jiggers. But in a survey conducted in three counties in the United Kingdom, only 10% of 358 people identified them from pictures (Bernadeschi *et al.*, 2013).

As symptoms we got reports of itching (3.65%), redness (2.88%), pain (2.69%), rash (1.54%), and migraine (0.19%). No one recognised fatigue to be a symptom, as much as they did not recognise a medical follow up, but 475 respondents (91.35%) instead named traditional follow up to treat their ectoparasitic infestations in general, and this had a very significant importance ($p < 0.001$). Only 64 respondents (12.31%) said they got a treatment. The treatments generally used included chlorine (1.73%), hot water (4.23%), insecticides (0.96%), kerosene (6.15%) and motor oil (0.96%). These include what scientists describe as chemical (chlorine, kerosene, insecticides, and motor oil are chemical substances) and non-chemical or physical (use of heat) methods to combat bedbug infestations. Kells (2006), described a number of nonchemical methods that can be used to control bedbugs together with chemical methods since the chemical methods have proven to be insufficient.

There was a significant relation between knowledge of the parasite and infestation ($p < 0.001$) such that 52.5% of the total population sample knew the parasites, 8.06% of the later were infested. Of those who could describe bedbugs, 8.1% were infested and 17.6% were not but 0.4% of those unable to describe these insects were infested while 99.6% were not. Of those who were infested, 66.7% (22 out of 33 respondents) knew the localisation of bedbugs and 2.4% of these did not know. About this localisation, 55% of the infested people said bedbugs were found on mattress, as well as 7.5% of the non-infested; 29.7% of the infested homes reported bedbugs on chairs and furnitures as well as 12.2% of the non-infested. All the homes infested by bedbugs did not know where and how they got the infestation. Eighty four point two percent (84.2%) of the infested homes reported itching; 92.9% of the infested reported pains, 80% reported redness, 40% knew other infested homes. Public education and increasing the knowledge of people can lead to successful management, prevention and elimination of this nuisance pest (Sharififard *et al.*, 2020).

III.2.2. PREVALENCES AND RISK FACTORS

The effective prevalence obtained was 4.4%. This value is by far different from the 69.9% prevalence obtained during a study in Uganda some years ago (Senabulya *et al.*, 2019). This value is enough to signify that these parasites have not yet colonised a large number of houses and therefore is a sign of the absence of these pests few years ago so that it confirms the recent upsurge of this parasite since the parasite is gradually diffusing (Dogett *et al.*, 2004; Harlan, 2006; Fourie & Crafford, 2018). This resurgence in other parts of the world, especially in European countries, is reported to be due to increased resistance to pesticides by bedbugs. This goes in line with says that increased international travels enable the world wide spread of these insects (Dogett *et al.*, 2004; Kaylor *et al.*, 2015; Fourie & Crafford, 2018). This explanation also fits the places that were observed to have the infestations. The highest infestation was gotten in the boundary between Nkolbikok and quartier Haoussa (20%), followed by Elig-bessala (11.9%) then quartier Haoussa (8.2%), Nkol-mbene (6.9%), Minkama (6.2%), Nkolbikok (5.7%), Elot II (5.6%) and Elot 1 (1.1%). All these zones are mainly inhabited by the alien (nonnatives) than the natives. These inhabitants upon coming from other places could have transported these parasites along to their new locals. The indigines in the other zones with no infestations did not observe travels and therefore did not come across these insects hence no infestation. This goes in-line with the localisation of these infested zones. They are in majority on the national road N° 1 and mainly inhabited by other tribes than the natives. These in-coming inhabitants may have carried this infestation along with them into the locality (Kaylor *et al.*, 2015; Fourie & Crafford, 2018).

The infestation rate in the urban zone (Obala town) (61.54%) was more than three (3.69) times greater than the one in the rural zone (16.67%).

The results obtained for the age showed that bedbugs infestation or risk of having an infestation varied very significantly with age ($p=0.000$). These results corroborate with those of Ralph *et al.* (2013) who also said that the age influences the probability of infestation by bedbugs. In this study, the elderly (>64 years) has the highest prevalence (37.5%) while the younger age group (<15 years) has the lowest prevalence (3.2%). Ralph *et al.* 2013 found that the younger age group had more chances to be found in infested places but the elderly were less motile and therefore had less chances to be infested. In this line, their results are therefore different from ours. This difference could be explained by the fact that the survey considered present and recent infestations (about five years back). The reduced population in the group of elderly compared to the large population size in the young population can also have affected the prevalences. The group of people aged >64 years constituted 1.54% of the total sample. This value is different from the 3% obtained by the NIS (2019). This difference could have influenced these results.

The prevalences per age group with gender were such that 0% (0) infestation was obtained for males aged <15 years and 25-64 years. Two (2) males of the age group 15-24 years (08.7%) and the age group >64 years were infested with bedbugs. In sum, 04 males (17.39%) signalled infestations. For the females, 26.09% (6) was obtained for the age groups <15 years, 15-24 years and 25-64 years while 4.35%

(1) of the infested persons was a female aged >64 years so that a total of 19 infested persons were females. This corroborates with the 27.7% and 73.1% infestations obtained in Uganda in 2019 (Senabulya *et al.*, 2019) so that the gender influences the risk of being infested.

The educational level varied such that those of the primary level reported more infestations than the rest and those in the tertiary level reported less. This variation was not however significant. This goes in line with the results published by Fung *et al.* (2021) who showed that people who received a low education (primary or less) were more susceptible to be infested than those who got tertiary education.

The infestation rate had no significant variation with living standard ($p>0.05$). This result is not similar to the results of Kaylor *et al.* (2015) which suggest that bedbugs may be an environmental issue affecting low-income populations. Fung *et al.* (2021) also showed that being of low income could be a risk factor to infestation by bedbugs. This difference in our results could be explained by the fact that the variations in living standard were not that much different and almost all the sampled population was from the average class with just a very few from the low and the high income classes. However, the results (high living standard having a greater prevalence than the average living standard) are similar to those of Rukke *et al.* (2022) which say that districts with habitants of a higher socio-economic standing than the average show a significantly higher prevalence of infestation. Professional status can be considered reflected by the living standard since no literature consulted here seemed to elaborate on this criteria. The unemployed therefore have a low living standard compared to the workers.

III.2.3 IDENTIFICATION AND MORPHOLOGICAL RE-DESCRIPTION

Following characteristics and the identification keys by Usinger (1966) we got three adult males *C. hemipterus* as well as an egg, a third instar nymph, a fourth instar nymph, two fifth instar nymphs, four adult females and three males of *C. lectularius*, as well as some dried specimens not considered during observations. Therefore both species were found. This is similar to the result obtained by Fourie & Crafford (2018), who reported that the continued incidence of bedbugs in Africa resulted in the mention of both species in South Africa. The collections had showed a greater number of specimens for *C. lectularius* (78.57%) than for *C. hemipterus* (21.43%). This is similar to the results obtained by Gbakima *et al.* (2002) who also got more specimens of *C. lectularius* (56.1%) than *C. hemipterus* (46.9%).

Organisms here were observed to have more or less short thick bristles, second antennal segment not by far different from the interocular space, pronotum at least one and a half (1.5) times wider than head. By these characteristics, they were considered to belong to the genus *Cimex*. This description corroborates with that of Usinger (1966). The hind margins of their hemelytral pads were broadly rounded on inner halves. This grouped them under the *hemipterus* and *lectularius* groups according to Usinger (1966). Of these organisms, all those whose pronotum was less than two and a half times ($5/2$) as wide as long at the middle were placed under the species *hemipterus* while those that had a head width to third antennal segment ratio around 1.5 (3:2) were grouped under the *lectularius* group, still according to the

identification key by Usinger (1966). After classifying them under their different species, we brought in some other criteria which were notably morphometric to aid in identifying these organisms in future.

CONCLUSION

This study aimed at evaluating the occurrence of bedbugs infestations in the Obala Sub-division, Centre region of Cameroon, including the identification and redescription of the species concerned by these infestations in this zone. These ectoparasitosis are effectively present in our study site with two species of *Cimex*: *Cimex lectularius* (more abundant, 80% of the collected specimens) and *Cimex hemipterus* (20%) for the Bedbug. These species are found to be of medical importance by the nuisance and social stigma they are responsible of these they have not yet been proven to have a vector role. Their bites are followed by secondary skin infections due to heavy scratching, excoriations, irritability, discomforts, and pains. The population, especially the young one did not much know about these infestations that is their existence, as some heard these names for their ever first time and even some adults wondered if they still existed these days. This behaviour from the population can therefore indicate that these parasitosis are observing a resurgence in this zone so that there is need for sensitization to avoid the spread. It was noticed that these infestations got concentrations in given zones surely due to nearby contaminations than contaminations from afar. In most contaminated zones, we noticed that the people did not seemed to consider their infestation as a health problem in this sens that they did not look for solutions to fight this. Such behaviours can only favour the spread of the infestation and increase the prevalence in less than no time. Even when the people were conscious of the dangerousity of these, their methods of fight were even more dangerous. Usage on the hair of: motor oil, chlorine, insecticides, among other toxic substances which will have destructive effects on their scalp or cause pollution in the households. The population should therefore be educated both the the health damages and on the good attitudes to be adopted with these infestations and with the infested people or households even without stigmatizing them. They should be told where to go in case of any such infestations and what to use in order to get ride of the pests without harming themselves.

RECOMMENDATIONS

After realising this study and from the results obtained, we recommend to:

- **The Ministry of Public Health**

To finance and encourage such studies whose results could be important in the identification and planification of important pesticidal fights.

- **Researchers**

To enterprise such studies in other localities in Cameroon so that the epidemiology will be better known so that these parasites will be better fought.

Organise restitution sessions per study site of the data obtained during researches so that sensitizations will be more effective.

- **Populations**

Be receptive to such studies and participate by permitting the collection of samples from their bodies and their homes. Implement the advices and recommendations given by researchers during their sensitizations in order to avoid the spread and persistence of these pests.

PERSPECTIVES

From the different results obtained during this study we preview that: (1) Further studies should be enterprised, not only in this zone but also in other localities so that the epidemiological status of our country is known as far as these parasitosis are concerned so that effective measures of fight can be taken in order to stop the spread but also to eradicate these infestations before they are out of control. (2) Better studies on Bedbugs should be done in order to effectively know the risk factors per society. (3) Biomolecular studies should also be done on these insects to verify that they donot effectively carry parasitic and microbial organism. (4) Effective biomedical or phytotherapeutic treatment mesures, which can be accessible to all income categories should be created and implemented with the help of authorities in order to ensure complete eradication of these parasites. (5) Evaluation of parasitic associations between Bedbugs and other parasites and the impact of these associations.

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