Chapter 4

Results

Chapter 4

Results

4.1 Species utilised

The study revealed twenty five species of edible insects, belonging to eight orders and fourteen families that were consumed as food by the Bodos. The respondents referred the vernacular names of edible insects and some species names were confusing as two or more species were frequently referred to by the same vernacular name. Orthoptera encompassing a variety of grasshopper species best represented the highest number of consumable species. Prior to consumption edible portions of the insect's body are cleaned by repeated washing in a mesh and the unwanted portions as wings and legs discarded. The insects are fried, roasted, smoked or boiled before consumption. Species from order Orthoptera, Hymenoptera, Coleoptera, Odonata and Hemiptera were more commonly consumed and traded as well. Table 4.1 represents the order based distribution of edible insects consumed by the Bodos. Availability of insect species for consumption throughout the changing seasons of the year differs from species to species. Among the species consumed order Coleoptera and Hemiptera includes aquatic species that remain available all throughout the different seasons of the year and hence are sold in the market year around.

Table 4.1 Order based distribution of edible insects consumed by the Bodo tribe

Order	No of Species	Percentage
Orthoptera	10	40
Hymenoptera	5	20
Coleoptera	3	12
Hemiptera	2	8
Odonata	2	8
Araneae	1	4
Isoptera	1	4
Lepidoptera	1	4

4.2 Taxonomic Investigation

All edible insects referred to in this study had unique vernacular names except two grasshopper species from order Orthoptera were referred by the same vernacular names. The scientific, common and vernacular names of edible insects synthesized and documented throughout the study are represented in Table 4.2.

Table 4.2 Taxonomic orders, scientific names and vernacular names of edible insects consumed by the Bodos of Assam.

Sl.No	Order	Scientific name	Vernacular name
1	Hymenoptera	*Vespa affinis continentalis* (Bequaert)	Handilore bere
2	Hymenoptera	*Polistis (Gyrostoma) olivaceus* (De Geer)	Jotha Bere
3	Hymenoptera	*Parapolybia varia* (Fabricius)	Mwsou salai bere
4	Hymenoptera	*Oecophylla smaragdina* (Fabricius)	Khwjema
5	Hemiptera	*Lethocerus indicus* (Lep. & Serv.)	Gangjema
6	Hemiptera	*Laccotrephes ruber* (Linn)	Lanjai gwlao
7	Orthoptera	*Tarbinskiellus portentosus*	Khusanggra
8	Orthoptera	*Gryllotalpa africana* (Beauvois)	Sosroma
9	Orthoptera	*Eupreponotus inflatus* (Uvrov)	Guma Nargi
10	Orthoptera	*Choroedocus robustus* (Serville)	Guma Khushep
11	Orthoptera	*Chondracris rosea* (De Geer, 1773)	Guma Nareng
12	Orthoptera	*Phlaeoba infumata* (Brunner Von Wallenwyi)	Guma Daosri Jagra
13	Orthoptera	*Oxya fuscovittate* (Marschall)	Guma Daosri jagra
14	Orthoptera	*Mecopoda elongata elongata* (Linnaeus)	Guma Khufri
15	Orthoptera	*Ruspolia baileyi* (Otte)	Guma Gwthao
16	Orthoptera	*Mantis inornate* (Werner)	Guma Gangu
17	Coleoptera	*Cybister tripunctatus*	Chingkhouri
18	Isoptera	*Macrotermes* sp.	wuri
19	Araneae	*Nephila* sp.	Bema Raja

20	Coleoptera	*Unidentified*	Burbila fisa
21	Coleoptera	*Unidentified*	Burbila gedet
22	Hymenoptera	*Unidentified* (Pompillidae)	Hani bere
23	Lepidoptera	*Unidentified*	Gunjet
24	Odonata	*Unidentified* (Libellulidae)	Garba fangtha
25	Odonata	*Unidentified*	Jujai Mala

4.3 Availability of edible insects in Assam

Growth and development in an insect's life cycle is strongly correlated with weather and climate changes. Most insects show that they need favourable environmental conditions for their emergence even at their pertinent brimming seasons. Many reasons were cited by the respondents in the survey study regarding the unavailability of wild edible insects which included the use of insecticides, less rainfall and deforestation. The local respondents also figured out that a rapid decline in the availability of edible insects is on procession towards the back eight to ten years especially in villages near to urban areas. The reason cited for the decline was increase in population and households which directly meant deforestation. Habitat transformation by chance has become a bigger threat to the edible insects of Assam than over- harvesting at these prevailing circumstances. However; edible insects are still abundantly available in remote villages of Assam and they are consumed reluctantly by the locals as well as supplied to the urban markets. Spring is the time when most wild edible insects starts appearing, during summer many wild edible insects are harvested, towards autumn the number again starts declining and most insects almost disappear during the winter was what the respondents spoke on the subject matter of seasonal availability of edible insects. A study on the monthly seasonal availability of the twenty five collected species shows that a minimum of two to three species are always available for consumption all throughout the year in Assam (Table 4.3).

Table 4.3 Availability calendar for the twenty species of edible insects utilised by the Bodos in Assam.

Scientific name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sold
V. affinis	✘	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✔
P. olivaceus	✘	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✔
P. varia	✘	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘
O. smaragdina	✘	✘	✔	✔	✔	✔	✔	✔	✘	✘	✘	✘	✔
L. indicus	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
L. ruber	✘	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘
T. portentosus	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
G. Africana	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘
E. inflatus	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
C. robustus	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
C. rosea	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
P. infumata	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
O. fuscovittate	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
M. elongate	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
R. baileyi	✘	✘	✘	✘	✘	✘	✘	✘	✔	✔	✔	✔	✔
M. inornate	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘	✘
C.tripunctatus	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Macrotermes sp.	✘	✘	✘	✘	✔	✔	✔	✘	✘	✘	✘	✘	✘
Nephila sp.	✘	✘	✘	✘	✔	✔	✔	✔	✔	✔	✔	✘	✘
Coleoptera sp. (Bwrbila fisa)	✘	✘	✘	✔	✔	✔	✘	✘	✘	✘	✘	✘	✘
Coleoptera sp. (Bwrbila gedet)	✘	✘	✘	✔	✔	✔	✘	✘	✘	✘	✘	✘	✘
Hymenoptera sp. (Hani bere)	✘	✘	✘	✘	✘	✔	✔	✔	✔	✔	✘	✘	✘
Lepidoptera sp. (Gunjet)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘
Odonata sp. (Garba fangthe)	✘	✘	✘	✘	✔	✔	✔	✘	✘	✘	✘	✘	✘
Odonata sp. (Jujai Mala)	✘	✘	✘	✘	✔	✔	✔	✔	✔	✔	✘	✘	✘

✔=Availability, ✘ = Unavailability, Sold = Species sold in the markets

Seven insects of the twenty five species were sold in the market. Occasionally barter system among the Bodos involved exchanging edible insects for snail, fish, meat, beetle nuts, rice and often traditional home made rice beer.

4.4 Habitats

The most frequently described habitats informed by insect collectors were considered the most productive habitats for wild edible insects. The croplands were the most described habitats from wherein a variety of grasshoppers and aquatic insects are presumed to be collected by the locals. The respondants owing tea gardens often accessed edible insects from the tea gardens. Secondly the natural vegetation comprising of small woods, grasslands, pasturelands and village forest were cited as an important collection site of wild edible insects that are pests to valuable trees. Thirdly the yard around the households suited with flower gardens, vegetable gardens, beetle nut trees and a variety of citrus fruit trees are considered favourable habitats for many edible terrestrial insects by the respondents. Aquatic insects are mostly collected from flooded croplands, small streams and rivers. For trading harvested species are transported from the rural collection site and sold by vendors mostly in local markets of urban areas.

4.5 Collection and Preparation

The traditional method for collecting and preparing edible insects for consumption among the Bodos is as old as entomophagy itself. Terrestrial insects are often handpicked from their habitats. Aquatic insects are collected by hand woven traditional tools constructed from bamboos called “Jakhai” and “Khobai” (Plate 4.1). Jakhai was used as a net for collection and Khobai was used for storing insects and fish after the collection. Prior to cooking the insects are washed repeatedly to remove dust followed by clearing or removing the unwanted portions such as wings and legs in case of insects with wings. Frying in mustard oil by adding salt and turmeric powder was the commonest primitive way of cooking insects. Roasted, smoked and boiled insects are consumed in other instances as preferred. Hymenopterans larvae in several cases were consumed raw. Women and children were more involved in the collection work than man. *Lethocerus indicus* is the most favoured insect food. Males are preferred to females because of the

luscious aroma they possess which richly enhances the taste of the food for consumers.

4.6 Mode of intake

The local insect harvesters of the studied area collected edible insects at specific times corresponding to their life cycles. Insects collected were processed and cooked by different methods. Selected portions of the insect's body were cleaned and consumed. A number of species optionally were also consumed as raw. Table 4.4 shows the different modes of intake of edible insects by the Bodos of Assam, India.

Table 4.4 Modes of intake of edible insects as consumed among the Bodos of Assam.

Modes of intake	Consumable stage		Mode of preparation					Discarded portions	
Scientific name	Larvae/Nymph	Adult	raw	fried	Roasted	smoked	Boiled	Wings	Legs
V. affinis	✔	✘	✔	✔	✔	✔	✔	✘	✘
P. olivaceus	✔	✘	✔	✔	✔	✔	✔	✘	✘
P. varia	✔	✘	✔	✔	✔	✔	✔	✘	✘
O. smaragdina	✔	✘	✔	✔	✔	✔	✔	✘	✘
L. indicus	✘	✔	✘	✔	✔	✔	✔	✔	✔
L. ruber	✘	✔	✘	✔	✔	✔	✔	✔	✔
T. portentosus	✘	✔	✘	✔	✔	✔	✔	✔	✔
G. Africana	✘	✔	✘	✔	✔	✔	✔	✔	✔
E. inflatus	✘	✔	✘	✔	✔	✔	✔	✔	✔
C. robustus	✘	✔	✘	✔	✔	✔	✔	✔	✔
C. rosea	✘	✔	✘	✔	✔	✔	✔	✔	✔
P. infumata	✘	✔	✘	✔	✔	✔	✔	✔	✔
O. fuscovittate	✘	✔	✘	✔	✔	✔	✔	✔	✔
M. elongate	✘	✔	✘	✔	✔	✔	✔	✔	✔
R. baileyi	✘	✔	✘	✔	✔	✔	✔	✔	✔
M. inornate	✘	✔	✘	✔	✔	✔	✔	✔	✔
C.tripunctatus	✘	✔	✘	✔	✔	✔	✔	✔	✔
Macrotermes sp.	✘	✔	✘	✔	✔	✔	✔	✔	✔
Nephila sp.	✘	✔	✘	✔	✔	✔	✔	✔	✔
Coleoptera sp. (Bwrbila fisa)	✘	✔	✘	✔	✔	✔	✔	✔	✔
Coleoptera sp. (Bwrbila gedet)	✘	✔	✘	✔	✔	✔	✔	✔	✔

Hymenoptera sp. (Hani bere)	✔	✘	✔	✔	✔	✔	✔	✘	✘
Lepidoptera sp. (Gunjet)	✔	✘	✔	✔	✔	✔	✔	✘	✘
Odonata sp. (Garba Fangthe)	✔	✘	✔	✔	✔	✔	✔	✘	✘
Odonata sp. (Jujai Mala)	✔	✘	✔	✔	✔	✔	✔	✘	✘

4.7 Nutritional values

Through the present study twenty five species of insects were revealed as edible. Among them twenty species were analysed for nutrient content. Five species including *Laccotrephes ruber*, *Gryllotalpa africana*, *Phlaeoba infumata and an Unidentified (Pompillidae)* could not be nutritionally analysed because sufficient samples could not be collected for the investigation. The reasons for their decline in availability during the time of collection as cited by the respondents were unfavourable weather conditions and late rainfall during the monsoons of last 3 – 4 years. The scientific names and images of these five edible insects are presented in Plate 4.2. Results of analysis showed that insects are rich source of nutrients for human consumption. Results of the analysis recorded on dry weight basis showed highest total protein content of (84.56%) recorded in *Nephila* sp. In total thirteen species of insects had protein content that was above 50% on dry weight basis. Total fat as high as (40.65%) was recorded in *Ruspolia baileyi.* Lowest range of proteins among the insects was (30.25%). In a nutshell amino acids and fatty acids analysis in the studied insects showed that many of them are rich sources of essential amino acids as well as fatty acids. Minerals have important role to play in many biological processes. The mineral content of many insects could meet the dietary reference intake (DRI 2004) recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. The result of the nutritional analysis is elaborately and sequentially presented and discussed herewith under each order specifically with reference to each selected species of edible insects. The chromatograms of 32 amino acid standards and the individual amino acid analysis for each of the sample are presented in Appendices 9.1 to 9.1t. Chromatograms of the fatty acid analysis for each of the sample are presented in Appendices 9.2a to 9.2t.

4.7.1 Order Hymenoptera

Exclusive, varied, and best known assortment of insect species has been acknowledged from the order Hymenoptera. Order Hymenoptera encompases numerous varieties of bees, ants, and a large number of other insect taxa commonly termed as wasps. They are considered as the most evolved and diverse among all terrestrial organisms (La Salle and Gauld 1993). The orders Hymenoptera evolved about 155 million years ago during Jurassic period in Mesozoic era and now the members of this order on economical, medical and biological grounds have been well eulogized. (Alfred *et al* 1998). Hymenopterans are holometabolous with complete developmental stages sequentially egg → larva → pupa → adult. Excluding the mobile joints, the whole body is covered with strong cuticle. The head bears the sense organs and can execute movements autonomous of the thorax. With an exception to worker ants most hymenopterans have two pairs of membranous wings linked together with a row of tiny hooks on the front margin which catch in a fold near the back of the fore wings which is to some extent larger than the hind wings. Female members fitted in this order have true sting which is usually a modified ovipositor of the females hence males are stingless. The stings of these insects are dreadfully toxic and can lead to anaphylactic shock and renal failure.

Hymenopterans show greater adaptation to their environment and are commonly distributed in almost every part of the world and are famous examples of social insects. They live in associations of well developed regimented social systems where each member is affiliated castes as worker, drone and queen. on the contrary solitary hymenopterans meet only for a brief mating. Social hymenopterans in a hive are descendants of a single queen. Queen in a hive is larger than the other caste and she undergoes hibernation over winter. Towards the spring she appears busy constructing nest to lay her eggs. At the onset of winter when food becomes scarce they start starving and die off while the queen hibernates until the next spring (Anonymous 2015). In this study four species of hymenoptera were deemed as edible of which three were analysed for nutrients.

4.7.1.1 *Vespa affinis continentalis*

4.7.1.1.1 Biology of *Vespa affinis continentalis*

Data on the biology of the insects is vital for reasons that they host a number of benefits to human and nature. It is also important that such resources are not overexploited and that investigations are undertaken into determining the viability of these important biological resources. Addressing such issues the biology of a common edible insect species *V. affinis* is discussed. *V. affinis* built their aerial nest generally within 1 – 2 metre above the ground attached between the branches of trees or at the rooftops of households. As an eusocial insect this species construct paper nest that hangs from natural structures (Martin 1992). The construction starts from the tip with 4 – 6 hexagonal shaped cells that result into stacked multi – comb structures linked through short vertical pillars between adjacent combs and appears like a vertically elongated ball with a single or often multiple entrances from outside (Plate 4.3). They pursue a carnivorous diet preying on other insects such as ants, flies, grasshoppers for food. *V. affinis* undergoes complete metamorphosis through four life stages - egg, larva, pupa and adult. Caste divisions among this species follow the trends of well determined hierarchy system of common hymenopterans wherein the queen dominates the sterile workers. The adult has two pairs of wings and a body measuring between 15 and 20 mm long. Queens are larger in size than the males and sterile workers. The first and second segment of the reddish brown body is segmented with distinctive thick orange yellow bands on the abdomen just below the constriction (Plate 4.3). The head is predominantly black and the thorax and mandibles entirely black (Kumar and Srinivasan 2010). Jaws are very strong and legs are simple and unmodified. The selfless act of altruism is clearly seen among this species.

4.7.1.1.2 Taxonomy

Linnaeus in 1764 for the first time described *Vespa affinis* as *Apis affinis* as most bees at that time in a simple way were classified under the genus Apis. *Vespa affinis continentalis* was first described by Bequaert in the year 1936 from South India. The scientific classification of *Vespa affinis continentalis* is represented below.

Scientific Name – *Vespa affinis continentalis* (Bequaert)

- Phylum …….. Arthropoda
- Class ……. Insecta

- Order …… Hymenoptera
- Superfamily ……... Vespoidea
- Family ……. Vespidae
- Genus …… Vespa Linnaeus, 1758
- Species …….. Vespa affinis (Linnaeus, 1764)
- Infraspecies ……..*Vespa affinis continentalis* (Bequaert,1936)
- English Name …….. Vespa bicolor
- Local Name ……. Handilore Bere

Members of the genus Vespa (Linnaeus) are generally known as Hornet wasps (Kumar and Srinivasan 2010). Twenty three valid species from the around the globe have so far been reported of which fifteen species have been reported from India (Carpenter and Kojima 1997).

4.7.1.1.3 Proximate Composition

Proximate analysis of foods is the system of analysis that divides the food into six fractions: moisture, ash, crude protein, fats, crude fibre and carbohydrates. Data on proximate analysis allows comparison of foods on the basis of specific nutrients. Next, data on the specific proximate analysis give us an idea of the nutritional compositions of the species. Thorough evaluation of the data obtained reflects the potentials of the food for health and nutrition. Data on the nutritional composition of *V. affinis* provided in Table 4.5

Table 4.5 Proximate compositions of *V. affinis* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	8.59 ± 0.04
2	Total solids	91.41 ± 0.04
3	Ash	2.55 ± 0.06
4	Fat	25.53 ± 0. 03
5	Protein	50.13 ± 0.01
6	Carbohydrate	13.29 ± 0.06
7	Calorific value kcal/100g	483.45 ± 0.03
8	Starch	0.71 ± 1.01
9	Dietary fibre	0.31 ± 0.90

Results are in means of triplicate determinations ± SD.

4.7.1.1.4 Mineral Composition

Table 4.6 present the result of mineral element composition of *V. affinis* in mg/100g dry matter and a comparision of the mineral contents of *V. affinis* with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is also provided in Table 4.8. Calcium, magnesium and sodium content of *V.affinis* can fulfill about 2.35–11.37% of the RDA requirements in adults. Phosphorus and iron content can compensate above 80% of the requirement both in males and females. The species can also provide 93.75% of RDA iron requirement in males and a lesser quantity 41.67% of the RDA requirements in females. Micronutrients as zinc can satisfy 27.28% and 37.5% of the RDA requirements in males and females.

Table 4.6 Recommended intake of essential minerals per day compared with *V. affinis.*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*V. affinis* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1600 .31 ± 1.03	34.05	34.05
Sodium	1500	1500	170.62 ± 0.45	11.37	11.37
Calcium	1000	1000	23.5 ± 0.02	2.35	2.35
Magnesium	400	310	16.0 ± 0.03	4.0	5.16
Phosphorus	700	700	585.18 ± 0.12	83.60	83.60
Zinc	11	8	3.0 ± 0.005	27.28	37.5
Iron	8	18	7.5 ± 0.05	93.75	41.67
Copper	0.9	0.9	1.0 ± 0.004	111.2	111.2

Results are in means of triplicate analysis ± SD.

4.7.1.1.5 Amino acids

The amino acid compositions of *V. affinis* are shown in Table 4.7. All amino acids were present in the species with leucine, lysine, tyrosine, histidine, valine and isoleucine constituting the main essential amino acids and phenylalanine being present in smaller amounts. Of the non essential amino acids glutamic acid, phosphoserine, aspartic acid, proline and glycine constituted the bulk. Nevertheless,

V. affinis contain adequate amounts of both non essential and essential amino acids. Table 4.8 shows the amino acid scores of *V. affinis.* All of the amino acids with the exemption of leucine surpassed the recommendation given by FAO/WHO/UNU (1985).

Table 4.7 Amino acid composition g/100g dry matter of *V. affinis*.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	10.02 ± 0.19	Threonine	3.43 ± 0.03
Aspartic acid	8.35 ± 0.45	Histidine	4.14 ± 0.09
Serine	5.38 ± 0.15	Tyrosine	4.42 ± 0.002
Glycine	6.01 ± 0.01	Valine	3.87 ± 0.001
Asparagine	0.00 ± 0.00	Methionine	2.60 ± 0.14
Taurine	3.04 ± 0.10	Tryphtophan	3.40 ± 0.16
Alanine	3.75 ± 0.03	Phenylalanine	2.34 ± 0.06
Proline	7.09 ± 0.03	Isoleucine	3.68 ± 0.21
Ornithine	2.09 ± 0.37	Leucine	6.34 ± 0.08
Glutamic acid	13.84 ± 0.07	Lysine	5.99 ± 0.08
Amino adipic acid	1.96 ± 0.04	Cysteine	0.00 ± 0.00
Total non EAA	61.53	Total EAA	40.21

Results are in means of duplicate analysis ± SD.

Leucine with an amino acid score of 96 was found to be the limiting amino acid in *V. affinis*. Cysteine was not detected in the sample. The ratio between non essential to essential amino acid was 1.53. Glutamic acid was the most abundant amino acid recorded in *V. affinis.*

Table 4.8 Amino acid score of *V. affinis* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%) of *V. affinis*
Histidine	19	217
Isoleucine	28	131
Leucine	66	96

Lysine	58	103
Methionine + cysteine	25	104
Phenylalanine + tyrosine	63	107
Threonine	34	100
Tryptophan	11	309
Valine	35	110
Amino acid score	-	96
Limiting amino acid	-	Leucine

4.8.1.1.6 Fatty acids

The fatty acid profile of *V. affinis* is shown in Table 4.9. Propionic acid and pelargonic acid formed the bulk of the total 34.85% Saturated Fatty Acids (SFAs). MUFAs constituted 42.45% of the total fatty acid profiles. Palmitoleic acid formed the major bulk of MUFAs. Arachidonic acid a long chained C – 22 fatty acid formed the main portion of PUFAs. PUFAs investigated constituted 22.69% of the total fatty acid profile in *V. affinis.* A Saturated Fatty Acid to Unsaturated Fatty Acid (SFA:UFA) ratio of 0.53 was observed.

Table 4.9 Fatty acid composition g/100g dry weight and % of total fatty acids of *V affinis.*

Lipid numbers	Common Name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
3:0	Propionic acid	13.70 ± 0.24
4:0	Butanoic acid	1.09 ± 0.14
7:0	Enanthic acid	0.48 ± 0.007
9:0	Pelargonic acid	2.85 ± 0.26
10:0	Capric acid	2.20 ± 0.01
10:0	Decanoic acid	2.48 ± 0.007
12:0	Lauric acid	3.75 ± 0.29
Other SFAs		8.30 ± 0.05
Total SFAs		34.85
Monounsaturated Fatty Acids (MUFAs)		
10:1	Decenoic acid	4.23 ± 0.09

13:1	Tridecenoic acid	2.42 ± 0.12
14:1	tetradecenoic acid	1.90 ± 0.39
16:1	Palmitoleic acid	19.88 ± 0.48
18:1	Elaidic acid	9.03 ± 0.12
	Other MUFA	4.99 ± 0.14
	Total MUFA	42.45
	Polyunsaturated Fatty acids (PUFAs)	
18:2	Linoleic acid	6.73 ± 0.45
20:2	Dihomolinoleic Acid	3.44 ± 0.05
20:4	Arachidonic acid	12.52 ± 0.38
	Total PUFAs	22.69

Results are in means of duplicate analysis ± SD.

4.7.1.2 *Polistes (Gyrostoma) olivaceus* (De Geer)

4.7.1.2.1 Biology of *Polistes olivaceus*

The genus *Polistes* is cosmopolitan and encompasses 218 species and is mainly tropical or subtropical in distribution (Pickett and Carpenter 2010). The adults builds a simple, open round flat nest consisting of a number of vertically oriented paper combs of hexagonal cells wherein the larvae develop (Plate 4.4). The nest is unprotected and one sided symmetrical with an eccentric pedicel. Cocoons are generally capped with a white colour densely woven cap. Nests are small and hence colony members are fewer rarely exceeding forty to sixty individuals. It is one of the most defensive species that do not tolerate activities near to its nesting sites. Similar to most other hymenopterans it undergoes metamorphosis and hibernation. Polistes olivaceus builds its nests at wide and airy habitats in various sites such as on trees, shrubs, abandoned houses, beneath the eaves and inside houses. The height of the nest was always seen to be carefully maintained at 1 – 5 m above the ground. Adults have a slender elongated body with a pointed, spindle-shaped abdomen (Pham 2015). Body appears yellow with variable markings and few reddish markings. The body length ranges from 15 – 20 mm (Plate 4.4). Rare morphological differences are observed between the workers and the queens. This species commonly known as the "common yellow wasp of India" is one of the most

common and abundant paper wasp species in India that can thrive through diverse type of ecosystems for survival and hence its distribution is widespread.

4.7.1.2.2 Taxonomy

The scientific classification, common and local names of *Polistes olivaceus* is represented below.

Scientific Name – *Polistis (Gyrostoma) olivaceus* (De Geer)

- Phylum …….. Arthropoda
- Class ……. Insecta
- Order ……Hymenoptera
- Superfamily ……...Vespoidea
- Family ……. Vespidae
- Subfamily ……... Polistinae
- Genus …… Polistes
- Subgenus ……. Polistis (Gyrostoma)
- Species …… *Polistis olivaceus* (De Geer 1773)
- English Name ……. Paper wasps
- Local Name ……Jotha Bere

4.7.1.2.3 Proximate composition

The proximate composition of *P. olivaceus* is shown in Table 4.10. Studies on the proximate composition of *P. olivaceus* showed that it contains a total of 51.06% of crude proteins 2.60 % crude ash, 19.92% fats nutritive value of 455.08 Kcal/100g.

Table 4.10 Proximate compositions of *P. olivaceus* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	8.53 ± 0.22
2	Total solids	92.47 ± 0.22
3	Ash	2.60 ± 0.03
4	Fat	19.92 ± 0. 08
5	Protein	51.06 ± 0.01
6	Carbohydrate	17.89 ± 0.08
7	Calorific value (Kcal/100g)	455.08 ± 0.05

8	Starch	0.94 ± 0.81
9	Dietary fibre	0.18 ± 1.41

Results are mean of triplicate determinations ± SD.

4.7.1.2.4 Mineral compositions

Table 4.11 shows the mineral contents of *P. olivaceus* and a comparison with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including calcium, magnesium, potassium, sodium and phosphorus although present in higher amounts can fulfill about 4.12 – 32.62% of the (RDA) requirement. Contrarily micronutrients including zinc, iron and copper can meet RDA requirement of around 9.09 – 75.00% in male and 12.50 – 55.55% in females. Iron content was found in higher quantities among the micronutrients and potentially could supply 75% of RDA requirement in males and a lower value of 33.33% of the RDA requirement in females.

Table 4.11 Recommended intake of essential minerals per day compared with *P. olivaceus.*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*P. olivaceus* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Males	Females		Males	Females
Potassium	4700	4700	1533.3 ± 0.89	32.623	32.623
Sodium	1500	1500	202.21 ± 0.44	13.48	13.48
Calcium	1000	1000	19.00 ± 0.01	1.900	1.900
Magnesium	400	310	16.50 ± 0.01	4.125	5.322
Phosphorus	700	700	406.94 ± 0.56	58.13	58.13
Zinc	11	8	1.00 ± 0.001	9.091	12.500
Iron	8	18	6.00 ± 0.03	75.000	33.333
Copper	0.9	0.9	0.50 ± 0.002	55.555	55.555

Results are in means of triplicate analysis ± SD.

4.7.1.2.5 Amino acid composition

Table 4.12 contains the result of amino acid compositions of *P. olivaceus.* Essential amino acids including lysine, leucine, tyrosine, threonine, and valine formed the major bulk. Phenylalanine was the least abundant amino acid. Among the non essentials phosphoserine, aspartic acid, serine, taurine, asparagine and

proline constituted the bulk. Glutamic acid was not detected among the non essentials. Phosphoserine and lysine were the most abundant among the essentials and non essential amino acids respectively. Non essential amino acids amounted to a total of 56.34% of the total amino acid. Essential amino acids including cysteine constituted 43.87% of the total investigated amino acids.

Table 4.12 Amino acid composition g/100g of *P. olivaceus*.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	11.1 ± 0.02	Threonine	5.30 ± 0.05
Aspartic acid	9.35 ± 0.04	Histidine	4.76 ± 0.14
Serine	7.77 ± 0.20	Tyrosine	5.42 ± 0.04
Glycine	4.35 ± 0.09	Valine	5.61 ± 0.09
Asparagine	6.08 ± 0.06	Methionine	2.37 ± 0.39
Taurine	7.69 ± 0.22	Tryphtophan	1.89 ± 0.28
Alanine	2.71 ± 0.08	Phenylalanine	1.71 ± 0.04
Proline	6.04 ± 0.12	Leucine	6.48 ± 0.06
Ornithine	1.25 ± 0.19	Lysine	8.17 ± 0.04
Glutamic acid	0.00	Cysteine	2.16 ± 0.09
Total non EAA	56.34	Total EAA	43.87

Results are in means of duplicate analysis.

Table 4.13 represents the amino acid scoring pattern of *P.olivaceus*. The chemical score of leucine was 98 and leucine was found to be the limiting amino acid. All of the amino acids with the exception of leucine exceeded the recommendation given by FAO/WHO/UNU (1985).

Table 4.13 Amino acid score of *P. olivaceus* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%) *P.olivaceus*
Histidine	19	250
Isoleucine	28	ND
Leucine	66	98

Lysine	58	140
Methionine + cysteine	25	181
Phenylalanine + tyrosine	63	113
Threonine	34	155
Tryptophan	11	171
Valine	35	160
Amino acid score	-	98
Limiting amino acid	-	Leucine

4.7.1.2.6 Fatty acid composition

The fatty acid profile of *P. olivaceus* is shown in Table 4.14. Capric acid and tridecylic acid formed the bulk among the SFAs. 47.11% fraction of fatty acids were constituents of the total SFAs. MUFAs constituted 34.90% of the total fatty acid profiles. Myristoleic acid a 14 carbon chained fatty acid formed the major bulk of MUFAs. Linoleic acid a long chained C – 18 fatty acid formed the main portion of PUFAs. PUFAs investigated constituted 18.31% of the total fatty acid profile in *P. olivaceus*.

Table 4.14 Fatty acid composition g/100g dry weight and % of total fatty acids of *P. olivaceus.*

Lipid numbers	Common Name	% of total fatty acids
Saturated Fatty Acids (SFA)		
10:0	Capric acid	15.43 ± 0.02
12:0	Lauric acid	1.95 ± 0.02
13:0	Tridecylic acid	20.62 ± 0.06
14:0	Myristic acid	2.88 ± 0.01
16:0	Palmitic acid	0.88 ± 0.27
	Other SFA	5.35 ± 0.12
	Total SFA	47.11
Mono Unsaturated Fatty acids (MUFAs)		
4:1	Methacrylic acid	9.63 ± 0.02
10:1	Obtusilic Acid	0.48 ± 0.07

12:1	Lauroleic acid	0.40 ± 0.06
14:1	Myristoleic acid	21.25 ± 0.07
18:1	Oleic acid	3.14 ± 0.07
	Total MUFAs	34.90
Poly Unsaturated Fatty Acids (PUFAs)		
16:2	Hexadecadienoic acid	7.57 ± 0.15
18:3	Linolenic acid	10.74 ± 0.02
	Total PUFAs	18.31

Results are in means of duplicate analysis ± SD.

4.7.1.3 *Parapolybia varia*

4.7.1.3.1 Biology of *Parapolybia varia*

Parapolybia varia is a common vespidae species. This vespidae is a predominantly tropical cosmopolitian species (Mahmood *et al* 2012). Like all Hymenoptera, *P. varia* undergoes complete metamorphosis and is a holometabolous insect. The nest consists of a number of vertically oriented combs of hexagonal cells and is found to be fitted side by side to the branches of small trees and occasionally on house tops freely hanging down, parallel to each other, the group of combs being surrounded by a fragile envelop and the open sides of the combs facing outwards (Vander Vecht 1966) (Plate 4.5). Cocoons are generally capped with a white coloured densely woven cap. Nests are long and slender and hence colony members are exceedingly above thousand individuals. House eaves, ceilings, shady trees especially bamboo gardens in Assam are the main sites wherein they built their nest. In contrast to *V. affinis* and *P. olivaceus*, *P. varia* prefers shady gardens to airy housetops and trees. Adults of this species are predominantly black with yellow markings and are highly eusocial. *P. varia* of Northeast India is a small vespidae with a body length ranging between 1.8 to 2mm in adult and 1.3 to 1.6mm in the larvae stage (Plate 4.5). The morphological differences are rare between the workers and the queens. Clear division of labour is seen among the caste. This species is omnivorous and the adults are seen foraging for food both in households and in the open wild forest. Larvae are the preferred stage for consumption by humans.

4.7.1.3.2 Taxonomy

The scientific, common and local names of *Parapolybia varia* is represented below.

Scientific Name – *Parapolybia varia* (Fabricius)

- Phylum …….. Arthropoda
- Class ……. Insecta
- Order ……Hymenoptera
- Family ……. Vespidae
- Genus …….. *Parapolybia*
- Species …… *Parapolybia varia* (Fabricius 1787)
- English Name …… Lesser paper wasps
- Local Name …….. Mwsou salai bere

4.7.1.3.3 Proximate composition

Table 4.15 represents the proximate composition of *Parapolybia varia*. Proximate composition assay data has revealed that this species contains 53.63% of protein. Energy value as high as 438.18 Kcal/100g in *P.varia* is desirable for human nutrition.

Table 4.15 Proximate compositions of *P. varia* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	8.87 ± 0.26
2	Total solids	91.13 ± 0.26
3	Ash	1.81 ± 0.005
4	Fat	15.38 ± 0. 03
5	Protein	53.63 ± 0.01
6	Carbohydrate	20.31 ± 0.07
7	Calorific value (Kcal/100g)	438.18 ± 0.03
8	Starch	0.59 ± 1.23
9	Dietary fibre	0.15 ± 1.09

Results are in means of triplicate determinations ± SD.

4.7.1.3.4 Mineral composition

Table 4.16 compares the mineral contents of *P. varia* with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including calcium, magnesium, potassium, sodium and phosphorus can supplement about 1.8 – 41.72% of the (RDA) requirement. Contrarily micronutrients including zinc, iron and copper could fulfill around 22.7 – 111.1% in male and 31.25 – 111.1% in females of the RDA requirement.

Table 4.16 Recommended intake of essential minerals per day compared with *P. varia.*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*P. varia* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1960.7 ± 1.82	41.72	41.72
Sodium	1500	1500	250.18 ± 0.54	16.67	16.67
Calcium	1000	1000	18.0 ± 0.02	1.8	1.80
Magnesium	400	310	15.5 ± 0.02	3.88	5.00
Phosphorus	700	700	390.00 ± 0.98	55.71	55.71
Zinc	11	8	2.5 ± 0.001	22.72	31.25
Iron	8	18	7.5 ± 0.05	93.75	41.67
Copper	0.9	0.9	1.0 ± 0.003	111.1	111.1

Results are in means of triplicate analysis ± SD.

4.7.1.3.5 Amino acid composition

Table 4.17 contains the result of amino acid compositions of *P.varia.* Essential amino acids including tyrosine, leucine, valine, lysine and histidine formed the major bulk of essential amino acids. Threonine was not detected. Among the non essentials taurine, aspartic acid and glutamic acid constituted the bulk. Taurine and tyrosine were the most abundant among the essentials and non essential amino acids respectively. Non essential amino acids amounted to a total of 62.65% of the total amino acid. Essential amino acids including cysteine constituted 37.12% of the total

investigated amino acids. The ratio between non essential and essential amino acid were found to be 1.69.

Table 4.17 Amino acid composition g/100g of *P. varia*.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	16.29 ± 0.03	Threonine	0.00±0.00
Amino adipic acid	1.56 ± 0.01	Histidine	2.34 ± 0.08
Serine	0.80 ± 0.007	Tyrosine	9.38 ± 0.01
Glycine	3.19 ± 0.03	Valine	3.16 ± 0.02
Arginine	1.03 ± 0.02	Methionine	2.32 ± 0.007
Taurine	21.19 ± 0.12	Tryphtophan	1.47 ± 0.02
β-amino butyric acid	3.45 ± 0.08	Phenylalanine	1.04 ± 0.02
Proline	0.12 ± 0.007	Leucine	7.30 ± 0.24
Ornithine	2.02 ± 0.01	Lysine	5.90 ± 0.06
Glutamic acid	13.00 ± 0.07	Cysteine	1.24 ± 0.01
Aspargine	0.00 ± 0.00	Isoleucine	2.97 ± 0.09
Total non EAA	62.65	Total EAA	37.12

Results are in means of duplicate analysis.

Table 4.18 represents the amino acid scoring pattern of *P. varia*. The chemical score of valine was 90 and hence valine was the limiting amino acid in *P. varia*. All of the amino acids with the exception of valine exceeded the recommendation given by FAO/WHO/UNU (1985).

Table 4.18 Amino acid score of *P. varia* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	123
Isoleucine	28	106
Leucine	66	110
Lysine	58	140
Methionine + cysteine	25	142
Phenylalanine + tyrosine	63	165

Threonine	34	ND
Tryptophan	11	133
Valine	35	90
Amino acid score	-	90
Limiting amino acid	-	Valine

4.7.1.3.6 Fatty acid composition

The fatty acid profile of *P.varia* is shown in Table 4.19. Pentanoic acid, Undecanoic acid and lauric acid formed the bulk among the SFAs. 42.115% fraction of fatty acids was constituents of the total SFAs. MUFAs constituted 13.115% of the total fatty acid profiles. Palmitoleic acid a 16 carbon chained fatty acid formed the major bulk of MUFAs. Linoleic acid (19.87%) a long chained C – 18 fatty acid formed the main portion of PUFAs. PUFAs investigated constituted 44.77% of the total fatty acid profile in *P. varia*.

Table 4.19 Fatty acid composition g/100g dry weight and % of total fatty acids of *P. varia.*

Lipid number	Common name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
4:0	Butyric acid	0.34 ± 0.21
5:0	Pentanoic acid	20.72 ± 0.24
8:0	Capryllic acid	2.67 ± 0.08
10:0	Capric acid	5.81 ± 0.02
11:0	Undecanoic acid	16.44 ± 0.042
12:0	Lauric acid	15.85 ± 0.06
15:0	Pentadecanoic acid	1.61 ± 0.11
16:0	Palmitic acid	1.66 ± 0.08
17:0	Margaric acid	0.41 ± 0.14
Other SFAs		0.33 ± 0.06
Total SFAs		42.11
Mono Unsaturated Fatty acids (MUFAs)		
11:1	Undecenoic acid	2.19 ± 0.08

12:1	Linderic acid	2.03 ± 0.06
16:1	Palmitoleic acid	6.89 ± 0.20
17:1	Civetic acid	1.84 ± 0.03
Other MUFAs		0.16 ± 0.03
Total MUFAs		13.11
Poly Unsaturated Fatty Acids (PUFAs)		
18:4	Stearidonic acid	15.66 ± 0.14
18:3	Linolenic acid	9.025 ± 0.01
18:2	Linoleic acid	19.87 ± 0.01
Other PUFAs		0.215 ± 0.03
Total PUFAs		44.77

Results are in means of duplicate analysis ± SD.

4.7.1.4 *Oecophylla smaragdina* (Fabricius)

4.7.1.4.1 Biology of *Oecophylla smaragdina*

Oecophylla smaragdina is viewed as beneficial insects in terms of its significant role as pest controller. It is a dominant canopy ant found mainly in India and Australia and lives in colony of upto 500 000 ants (Tan 2003). *O. smaragdina* builds an arboreal nest made of leaves fastened and glued together by larval silk Plate 4.6. The larvae silk used for stitching leaves for building nest is a product produced by using their own larvae. This species is famed for its sophisticated nest building activities. Nest is built especially on citrus fruit trees. The nest building starts with fresh leaves and the nest is abandoned when the leaves are dried. This process is completed at around 80 – 90 days. *Oecophylla smaragdina* feeds on various insects that attack citrus fruit trees including the fruits of this trees which supplement their diets with carbohydrates rich in honey dew excreted by the citrus trees pest insects (Bharti and Silla 2011). The castes of this species are easily differentiated into major and minor workers. The body length of minor workers ranges between 5 – 6 mm and that of major workers ranges between 8 – 10 mm. The body colour of the workers is orange. Major workers get involved in foraging while the minors look after the broods. The brood undergoes metamorphic changes from eggs, larvae, pupae to adults. The large larvae that develop during the spring are the queen broods and that develops into winged reproductive females.

4.7.1.4.2 Taxonomy

Oecophylla smaragdina commonly called as Weaver ants are eusocial insects of the family Formicidae of (Order- Hymenoptera). The scientific classification of *Oecophylla smaragdina* (Fabricius) is represented below.

Scientific Name – *Oecophylla smaragdina* (Fabricius)

- Phylum …….. Arthropoda
- Class ……. Insecta
- Order …… Hymenoptera
- Superfamily ……... Vespoidea
- Family ……. Formicidae
- Subfamily …… Formicinae
- Genus …… Oecophylla
- Species …….. smaragdina (Fabricius, 1775)
- English Name ……. Weaver ant
- Local Name ……. Khwjema

4.7.1.4.3 Proximate Composition

Data evaluated on the nutritional composition of *O. smaragdina* is provided in Table 4.20. The data revealed that the consumed larvae holds protein content as high as 52.13% and fat content as high as 22.72%. Comparison of the nutrient contents show that *O. smaragdina* has higher protein content, moderate fat content, high energy value and low moisture. Low moisture in food increases the shelf life of foods. The proximate composition of this species reveals that it is a rich source of protein with adequate amount of fat content and shelf life. Ash content as high as 5.16% is indicative of the rich mineral content. The data on the proximate composition also reflected a high energy value of 467.60 in Kilocalorie/100g. Starch and dietary fibres were found in low concentrations in this sample. Carbohydrate constituted 13.65% of the total solids 93.66% in *O. smaragdina*. This result indicates that *O. smaragdina* in the diet of the consumers offers potential amounts of proteins and fats even in the dried conditions.

Table 4.20 Proximate compositions of *O. smaragdina.* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	6.34 ± 0.08
2	Total solids	93.66 ± 0.08
3	Ash	5.16 ± 0.02
4	Fat	22.72 ± 0.01
5	Protein	52.13 ± 0.02
6	Carbohydrate	13.65 ± 0.03
7	Calorific value (Kcal/100g)	467.60 ± 0.04
8	Starch	1.89 ± 0.57
9	Dietary fibre	1. 03 ± 0.92

Results are in means of triplicate determinations ± SD.

4.7.1.4.4 Mineral Composition

A comparision of the mineral contents mg/100g dry matter of *O. smaragdina* with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4. 21. Sodium can fulfill about 12.02%, calcium 20% and potassium about 25.83% of the DRI requirements in both males and females which was lower than the values of other mineral content quantified in the sample species. Magnesium was exceedingly lower than the other macro nutrients including potassium and calcium. Copper values exceeded the DRI requirement values in both males and females. In females 58.33% iron requirement could be met while it surpassed the recommended iron requirements in males. Phosphorus and zinc content was also detected to be moderately high fulfilling about 74.29% and 63.64% of the recommended dietary intake in both males and females. The percentage of RDA recorded show that *O.smaragdina* has the potential to supply the required amount of zinc, iron, copper and phosphorus for health and nutrition through the diet of the consumers.

Table 4.21 Recommended intakes of essential minerals per day compared with *O. smaragdina.*

Mineral	Intake recommended for 25 year old Adults (mg per day)	*O. smaragdina.* (mg per 100 g dry weight)	% fulfillment of recommended intake

	Males	Females		Male	Females
Potassium	4700	4700	1214 .23 ± 0.12	25.83	25.83
Sodium	1500	1500	180.33 ± 0.63	12.02	12.02
Calcium	1000	1000	200.0 ± 0.02	20	20
Magnesium	400	310	38.5 ± 0.04	9.625	12.42
Phosphorus	700	700	520.05 ± 2.30	74.29	74.29
Zinc	11	8	7.0 ± 0.003	63.64	63.64
Iron	8	18	10.5 ± 0.04	131.25	58.33
Copper	0.9	0.9	2.5 ± 0.004	277.7	277.7

Results are in means of triplicate analysis ± SD.

4.7.1.2.5 Amino acids composition

The amino acid composition of *O. smaragdina* is shown in Table 4.22. All the essential amino acids were present in the species with leucine, lysine, tyrosine, threonine and valine constituting the main essential amino acids. Of the non essential amino acids aspartic acid, amino adipic acid, glutamic acid, asparagine, proline and phosphoenolamine constituted the bulk. *O. smaragdina* contain adequate amounts of both non essential and essential amino acids (EAA) in the ratio of 1.505. The least amino acid score observed was of isoleucine with an amino acid score of 101. Among the essentials phenylalanine was not detected in the sample. Of the non essentials alanine was not detected. Leucine was the most abundant among the essentials and aspartic acid among the non essentials amino acid in *O. smaragdina*. Methionine and tryptophan content was found to be lower than the rest of the essential amino acid content in this species. Phosphoserine and glycine were detected in trace amounts among the non essential amino acids. *O. smaragdina* holds 39.9% of essential amino acids hence it is nutritionally desirable in terms of its rich quality amino acids.

Table 4.22 Amino acid composition g/100g of *O. smaragdina* dry weight.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	0.62 ± 0.007	Threonine	4.07 ± 0.01
Aspartic acid	21.45 ± 0.02	Histidine	2.29 ± 0.007

Phosphoenolamine	2.36 ± 0.01	Tyrosine	6.75 ± 0.01
Glycine	1.90 ± 0.007	Valine	4.06 ± 0.007
Asparagine	6.45 ± 0.02	Methionine	1.49 ± 0.01
Taurine	4.56 ± 0.28	Tryphtophan	1.69 ± 0.01
Alanine	ND	Phenylalanine	ND
Proline	4.82 ± 0.007	Isoleucine	2.83 ± 0.007
Ornithine	ND	Leucine	7.59 ± 0.007
Glutamic acid	6.65 ± 0.00	Lysine	7.12 ± 0.02
Amino adipic acid	11.20 ± 0.03	Cysteine	2.00 ± 0.01
Total non EAA	60.04	Total EAA	39.90

Results are in means of duplicate analysis ± SD.

The amino acid scores of *O. smaragdina* is presented in Table 4.23. All of the amino acids surpassed the recommendation given by FAO/WHO/UNU (1985). The highest amino acid score was attained by tryptophan.

Table 4.23 Amino acid score *O. smaragdina* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (2007) (mg/g protein)	Chemical score (%)
Histidine	19	120
Isoleucine	28	101
Leucine	66	115
Lysine	58	122
Methionine + cysteine	25	139
Phenylalanine + tyrosine	63	107
Threonine	34	117
Tryptophan	11	153
Valine	35	116
Amino acid score	-	101
Limiting amino acid	-	-

4.7.1.4.6 Fatty acid composition

The larvae of *O. smaragdina* are rich in lipids. The composition and concentration of fatty acid oil in *O. smaragdina* is presented in Table 4.24. The Saturated fatty acid content was found to be 43.73%. The Unsaturated fatty acids including the monosaturated and polyunsaturated fatty acids constituted 56.18% of the total fatty acids. The SFA:UFA ratio was found to be 0.778. *O. smaragdina* contain (25.030%) of poly unsaturated fatty acids. Polyunsaturated fatty acids are desirable in diet and play significant role in nutritions hence larvae of *O. smaragdina* is enviable for inclusion to any kind of diet in view of its PUFA content.

Table 4.24 Fatty acid composition g/100g dry weight and % of total fatty acids of *O. smaragdina.*

Lipid Numbers	Common names	% of fatty acids
Saturated Fatty Acids SFAs		
4:0	butyric acid,	1.22 ± 0.06
7:0	Enanthic acid	2.41 ± 0.26
10:0	Capric acid	2.87 ± 0.11
11:0	Undecylic acid	25.67 ± 0.37
12:0	Lauric acid	1.12 ± 0.02
14:0	Myristic acid	2.25 ± 0.02
15:0	Pentanoic acid	1.16 ± 0.14
18:0	Stearic acid	6.44 ± 0.26
Other SFAs		0.58 ± 0.06
Total SFAs		43.73
Mono Unsaturated Fatty acids MUFAs		
13:1	Tridecenoic acid	5.61 ± 0.32
14:1	Tsuzuic acid	2.64 ± 0.21
16:1	Palmitoleic acid	12.62 ± 0.25
17:1	Civetic acid	6.44 ± 0.19
18:1	Oleic acid	2.67 ± 0.43
Other MUFAs		1.17 ± 0.13

Total MUFAs		31.15
Poly Unsaturated Fatty Acids PUFAs		
18:2	Linoleic acid	2.26 ± 0.42
18:3	Linoleneic acid	0.645 ± 0.007
18:4	Stearidionic acid	1.31 ± 0.10
22:4	Docosatetraenoic acid	20.03 ± 0.23
Other PUFAs		0.785 ± 0.16
Total PUFAs		25.03

Results are in means of duplicate analysis ± SD.

4.7.2 Order Hemiptera

Order hemiptera encompasses extremely diverse species of insects that differ in size, contour and colour. Winged species contain membranous wings. Exceptionally some species of this order contain forewings that are hardened at the base. The mouthparts are characterized with proboscis. The head part consists of two compound eyes and a pair of antenna of varying length (CSIRO 2007a). Hemiptera are hemimetabolous insects and develop by incomplete metamorphosis. The eggs are laid by the females and safeguarded by the male. In many species of this order the males are seen to be carrying the eggs on their backs. Nymphs emerge from eggs as small wingless adults that more or less resemble the winged adults. Most Hemipteras are plant feeders and regarded as pests, some are carnivores and depends on other invertebrates. Habitually a majority of Hemipterans are terrestrial with the exception of Heteroptera that inhabits fresh water habitats.

4.7.2.1 *Lethocerus indicus*

4.7.2.1.1 Biology of *Lethocerus indicus*

Lethocerus indicus commonly called as giant water bug is a well known edible insect. It is native to South and Southeast Asia and is included in many Southasean cuisines. Its distribution in India was first described by Thirumalai (2007). *L.indicus* preys on other aquatic insects and small fish including prawns and is predatory by habit. They occupy various aquatic habitats but are mostly harvested from stagnant water bodies in the present studied areas. The females lay eggs on tall grass plants and paddy plants during the onset of rains in the spring when water

starts filling the paddy fields. The egg remains stuck to the supporting plant substratum and remains half submerged in water guarded by the male. The first instars of the nymphs appear between April to May and develops to adults towards the summer. The nymphs are wingless and undergo sequential molting subsequently developing into winged adults. The juvenile stages can be distinguished from each other by the successive growth of their wing pads. The male ranges from 64 – 73mm in length and the female is slightly larger ranging from 73 – 76 mm in length (Plate 4.7). The nymph undergoes five molts while developing into an adult.

4.7.2.1.2 Taxonomy

The taxonomic classification of *Lethocerus indicus* is presented below.

Scientific Name – *Lethocerus indicus* (Lep & Serv)

- Phylum …….. Arthropoda
- Class ……. Insecta
- Order …… Hemiptera
- Family ……. Belostomatidae
- Genus ..…… Lethocerus
- Species …… Lethocerus indicus (Lepeletier & Serville, 1825)
- English Name …….. Giant water bug
- Local Name ……. Gangjema

4.7.2.1.3 Proximate Composition

Data on the nutritional composition of *L. indicus* is provided in Table 4.25. The data reveal that *L. indicus* has a high protein content of 67.31%. The species also possesses adequate amount of fats, ash and carbohydrates. A calorific value of 434.84 kcal/100g reflected its high energy value

Table 4.25 Proximate compositions of *L. indicus* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	5.64 ± 0.01
2	Total solids	94.36 ± 0.01
3	Ash	2.81 ± 0.06
4	Fat	13.73 ± 0.06
5	Protein	67.31 ± 0.08

6	Carbohydrate	10.51 ± 0.05
7	Calorific value kcal/100g	434.84 ± 0.06
8	Starch	0.10 ± 0.21
9	Dietary fibre	1.36 ± 0.78

Results are in means of triplicate determinations ± SD.

4.7.2.1.4 Mineral Composition

A comparison of the mineral contents of *L. indicus* mg/100g dry matter with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.26. Among the macronutrients potassium can fulfill about 27.02%, sodium 21.36% and calcium about 80% of the DRI requirements in both males and females. Magnesium could fulfill exceedingly higher values in male than in females. Among the micronutrients a slightly higher fulfillment value of iron was seen in males than in females. Copper had the potential to supplement about 55.55% of the recommended copper requirements in both males and females. 68.75% of the recommended zinc requirement could be met in females while it can fulfill surpassed amount of about 212.5% of the recommended iron requirements in males. Phosphorus content in *L. indicus* can meet about 81.42% of the recommended value. The percentage of RDA in *L. indicus* show that it is a potent source of zinc, iron, copper and phosphorus, magnesium and calcium and its inclusion into the diet of humans can fulfill much of mineral requirements in both males and females.

Table 4.26 Recommended intake of essential minerals per day compared with *L. indicus.*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Lethocerus indicus* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Males	Females		Male	Females
Potassium	4700	4700	1270.80 ± 1.23	27.02	27.02
Sodium	1500	1500	320.50 ± 0.32	21.36	21.36
Calcium	1000	1000	800.0 ± 0.004	80	80
Magnesium	400	310	260.5 ± 0.06	65.125	84.03

Phosphorus	700	700	569.94 ± 0.83	81.42	81.42
Zinc	11	8	5.5 ± 0.02	50.00	68.75
Iron	8	18	17.0 ± 0.003	212.5	94.44
Copper	0.9	0.9	0.50 ± 0.007	55.55	55.55

Results are in means of triplicate analysis ± SD.

4.7.2.1.5 Amino acid composition

The amino acid composition of *L. indicus* is shown in Table 4.27. All essential amino acids were present in the species excluding leucine. Lysine, tyrosine, valine and threonine constituted the main bulk of essential amino acids. Phenylalanine was present in small amounts. Of the non essentials amino acids phosphoserine, asparagine, serine, amino adipic acid and taurine constituted the bulk. Leucine was not detected in the sample. The ratio between non essential to essential amino acid was 1.58. The most abundant amino acid in the *L. indicus* was phosphoserine. Among the essentials tyrosine 10.81% was found to be the most abundant

Table 4.27 Amino acid composition g/100g of *L. indicus*

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	21.38 ± 0.53	Threonine	3.08 ± 0.42
Serine	7.88 ± 0.39	Histidine	2.54 ± 0.34
Phosphoenolamine	ND	Tyrosine	10.81 ± 0.18
Glycine	ND	Valine	4.24 ± 0.18
Asparagine	12.92 ± 0.68	Methionine	2.64 ± 0.26
Taurine	6.55 ± 0.24	Tryphtophan	1.69 ± 0.24
Alanine	1.83 ± 0.01	Phenylalanine	1.26 ± 0.02
Proline	ND	Isoleucine	3.36 ± 0.60
Arginine	3.39 ± 0.02	Leucine	ND
Glutamic acid	ND	Lysine	7.38 ± 0.33
Amino adipic acid	7.29 ± 0.33	Cysteine	1.69 ± 0.38
Total non EAA	61.24	Total EAA	38.69

Results are in means of duplicate analysis ± SD.

Table 4.28 shows the amino acid scores of *L. indicus.* All of the amino acids with the exemption of threonine surpassed the recommendation given by FAO/WHO/UNU (1985). Threonine with an amino acid score of 90 was found to be the limiting amino acid in *L. indicus.*

Table 4.28 Amino acid score based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%) *L.indicus*
Histidine	19	133
Isoleucine	28	120
Leucine	66	ND
Lysine	58	127
Methionine + cysteine	25	173
Phenylalanine + tyrosine	63	191
Threonine	34	90
Tryptophan	11	153
Valine	35	121
Amino acid score	-	90
Limiting amino acid	-	Threonine

4.7.2.1.6 Fatty acid composition

The larvae of *L. indicus* were found to be rich in MUFAs. The composition and concentration of fatty acid oil in *L. indicus* is presented in Table 4.29. The Saturated fatty acid content was found to be 29.63%. The Unsaturated fatty acids including the monosaturated and polyunsaturated fatty acids constituted 70.98% of the total fatty acids. The SFA:UFA ratio was found to be 0.42. *L. indicus* contain 19.98% of poly unsaturated fatty acids.

Table 4.29 Fatty acid composition g/100g dry weight and % of total fatty acids of *L. indicus.*

Lipid Numbers	Common names	% of fatty acids
Saturated Fatty Acids (SFAs)		

6:0	Caprioc acid	1.09 ± 0.14
9:0	Pelargonic acid	2.17 ± 0.26
10:0	Capric acid	8.0 ± 0.84
11:0	Undecylic acid	14.26 ± 0.53
12:0	Lauric acid	4.11 ± 0.45
Total SFAs		29.63
Monounsaturated Fatty Acids (UFAs)		
12:1	Linderic acid	18.98 ± 1.11
12:1	Laurolic acid	5.71 ± 0.28
14:1	Myristoleic acid	8.27 ± 0.41
16:1	Sapienic acid	13.63 ± 0.71
16:1	Palmitvaccenic acid	4.35 ± 0.45
Total MUFAs		50.95
Polyunsaturated Fatty acids (PUFAs)		
18:3	α-Linolenic Acid	8.91 ± 0.41
18:4	Stearidionic acid	5.93 ± 0.84
20:4	Arachidonic Acid	5.13 ± 0.33
Total PUFAs		19.98

Results are in means of duplicate analysis ± SD.

4.7.3 Order Orthoptera

Order Orthoptera comprises of crickets, grasshoppers, kaytids and locusts. They are included into the same order owing to the presence of two pairs of straight wings. Forewings are narrower and hardened at the base while the hindwing is membranous and folded under the forewings. The hind legs appear larger and are modified for quick jumping. The head part is characterized by a mandibulate mouth part and large compound eyes. Antenna may be long or short (CSIRO 2007b). The body is cylindrical and wings are differently coloured. The males stridulate to attract the females by rubbing their wings or legs against each other. Development is paurometabolous; the nymphs resemble the adults but wingless and called hoppers. Eggs are laid on vegetations on plant leaves or in the ground in burrows. Moulting time varies from few weeks to months depending on food resources and weather

conditions. Feeding regime ranges from herbivores, omnivores to even scavengers for example crickets.

4.7.3.1 *Tarbinskiellus portentousus*

4.7.3.1.1 Biology of *Tarbinskiellus portentousus*

Tarbinskiellus portentousus species is subterranean and inhabits the grounds by exhuming superficial or deep burrows. The species is soft bodied nocturnal and merely defensive in nature. While burrowing the mandibles are used for loosening the soil. Loud chirping during the night hours is evidently heard while they are silent at daytime. The males generally attracts the females by their calls. The life cycle consists of an egg stage, nymph stage and adult stage. The eggs are laid on the ground and buried with dust. The nymph stage is wingless and undergoes successive moulting to develop into winged adults. The wings are short and the males appears to be smaller than that of the females. Male and females can also be distinguished by observing the pattern of their wings. The body of the females can be characterized by the presence of an ovipositor shaft for laying the eggs. The adults are capable of short clumpsy flights so when danger is sensed they quickly scamper away to places where they can hide. The head consist of a compound eye and a pair of antenna which the insect often uses for touch and smell. The length of the adults ranges between 20 -25 mm and is brownish red in appearance (Plate 4.8). *T. portentousus* is omnivorous but can survive as herbivores as well. Traditionally this species is collected by the local inhabitants from their underground burrows by filling the burrows with water thereby compelling them to get out of their homes. Others living in shallow burrows are dugged and then collected. Most of the times they are also collected abundantly during the floods as they come floating in water as their homes get flooded. Harvesting is also done by attraction with the aid of illuminating light sources during dark.

4.7.3.1.2 Taxonomy

Information on the taxonomic classification of *Tarbinskiellus portentosus* is represented below.

Scientific Name - *Tarbinskiellus portentosus*

- Phylum ….. Arthropoda
- Class …… Insecta

- Order ……. Orthoptera
- Superfamily …..... Grylloidea
- Family ……. Gryllidae
- Genus ……..Tarbinskiellus
- Species .....…….. *Tarbinskiellus portentosus* (Lichtenstein 1796)
- English Name …… *Cricket*
- Local Name …….. Khusangra

4.7.3.1.3 Proximate Composition

Data on the proximate nutritional composition of *T. portentosus* is provided in Table 4.30. The data reveal that *T. portentosus* has protein content as high as 58.00%. A high fat content 23.70 ± 0.05 was also observed in this species. Ash and carbohydrates were present in adequate amount. A calorific value of 460.82 k cal/100g reflects its high energy value.

Table 4.30 Proximate compositions of *T. portentosus* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	6.49 ± 0.41
2	Total solids	93.51 ± 0.41
3	Ash	7.93 ± 0.04
4	Fat	23.70 ± 0.05
5	Protein	58.00 ± 0.05
6	Carbohydrate	3.88 ± 0.13
7	Calorific value (Kcal/100g)	460.82 ± 0.07
8	Starch	0.15 ± 0.97
9	Dietary fibre	1.16 ± 1.01

Results are in means of triplicate determinations ± SD.

4.7.3.1.4 Mineral compositions

A comparision of the mineral contents of *T. portentosus* mg/100g dry matter with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.31. The percent fulfillment of recommended intake for both calcium and magnesium was found low. Potassium can fulfill about 26.40% and sodium about 24.7% of the DRI requirements. This species could supply adequate amounts of phosphorus and zinc.

Copper and iron values were exceedingly high and surpassed the DRI requirement values both in males as well as in females. The percentage of RDA recorded show that *T. portentosus* is a potential source of iron and copper and in capable of supplying the required amount of zinc, iron, copper and phosphorus for health and nutrition through the diet of the consumers.

Table 4.31 Recommended intake of essential minerals per day compared with *T. portentosus* .

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Tarbinskiellus poetentosus* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Males	Females		Male	Females
Potassium	4700	4700	1240.89 ± 1.05	26.40	26.40
Sodium	1500	1500	370.81 ± 0.82	24.7	24.7
Calcium	1000	1000	26.0 ± 0.02	2.60	2.60
Magnesium	400	310	10.50 ± 0.06	2.63	3.38
Phosphorus	700	700	506.1 ± 2.33	72.3	72.3
Zinc	11	8	7.0 ± 0.003	63.63	87.5
Iron	8	18	122.5 ± 0.003	1531.25	680.55
Copper	0.9	0.9	4.5 ± 0.006	500	500

Results are in means of triplicate determinations ± SD.

4.7.3.1.5 Amino acid composition

The amino acid compositions of *T. portentosus* is shown in Table 4.32. All the essential amino acids excluding histidine and leucine were present in the species with valine, lysine and tyrosine constituting the main essential amino acids. Of the non essential amino acids aspartic acid, amino adipic acid and glutamic acid, constituted the bulk. The ratio between the non essential and essential amino acids (EAA) was 1.86.

Table.4.32 Amino acid composition of *Tarbinskiellus portentosus* g/100g dry weight

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	6.99 ± 0.97	Threonine	3.81 ± 0.21
Amino adipic acid	27.24 ± 1.61	Histidine	ND

Glutamic acid	19.24 ± 1.32	Tyrosine	4.73 ± 0.13
Serine	3.17 ± 0.69	Valine	11.45 ± 0.98
Aspargine	3.27 ± 0.52	Methionine	2.42 ± 0.09
Taurine	1.25 ± 0.43	Tryphtophan	1.35 ± 0.23
Alanine	0.14 ± 0.02	Phenylalanine	2.59 ± 0.13
Proline	1.44 ± 0.39	Isoleucine	3.03 ± 0.19
Arginine	0.32 ± 0.31	Leucine	ND
Ornithine	3.10 ± 2.96	Lysine	6.10 ± 0.07
Total non EAA	66.16	Total EAA	35.48

Results are in means of duplicate analysis ± SD.

The least amino acid score observed was that of methionine with an amino acid score of 96.8%. Histidine and leucine were not detected in the sample. The chemical score of valine was recorded to be the highest and methionine was found to be the limiting amino acid in *T. portentosus*.

Table 4.33 Amino acid score based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (2007) (mg/g protein)	Chemical score (%)
Histidine	19	ND
Isoleucine	28	108
Leucine	66	ND
Lysine	58	105
Methionine	25	96
Phenylalanine + tyrosine	63	116
Threonine	34	112
Tryptophan	11	122
Valine	35	327
Amino acid score	-	96
Limiting amino acid	-	Methionine

4.7.3.1.6 Fatty acid composition

The fatty acid profile of *T. portentosus* is presented in Table 4.36. The SFAs content was found to be 50.58%. The UFAs constituted 49.3% of the total fatty acids. The SFA:UFA ratio was found to be 1.02.

Table 4.34 Fatty acid composition g/100g dry weight and % of total fatty acids of *T. portentosus*.

Lipid Numbers	Common names	% of fatty acids
SFAs		
3:0	Propanoic acid	6.48 ± 0.67
8.0	Caprylic acid	6.07 ± 0.35
11:0	Undecylic acid	9.60 ± 0.11
12:0	Lauric acid,	1.16 ± 0.16
14:0	Myristic acid	6.74 ± 0.47
15:0	Pentadecylic acid	16.74 ± 1.33
22:0	Behenic acid	2.34 ± 0.27
	Other SFAs	1.45 ± 0.13
Total SFAs		50.58
10:1	Obtisilic acid	14.80 ± 0.01
10:1	Caproleic acid	1.98 ± 0.10
12:1	Lauroleic acid	10.94 ± 1.32
	Other MUFAs	1.26 ± 0.12
Total MUFAs		28.98
18:2	Linoleic acid	18.94 ± 0.02
20:4	Arachidionic acid	0.55 ± 0.28
	Other PUFAs	0.83 ± 0.31
Total PUFAs		20.32

Results are in means of duplicate analysis ± SD.

4.7.3.2 *Eupreponotus inflatus*

4.7.3.2 .1 Biology of *Eupreponotus inflatus*

Eupreponotus inflatus is a short-horned grasshopper and limited in distribution to Uttar Pradesh, Uttaranchal, West Bengal and Northeastern parts of India. Its occurrence is mainly found in terrestrial vegetations ranging from wild to cultivated lands. The size of the adults are moderately large with a body length

ranging between 3 – 3.5 mm. Paddy fields are the preferred habitat for the adults. Nymphs start appearing towards the end of April each year. The speciality of this species is its deep velvety coloration of the head and pronotum and reddish coloured legs (Mandal *et al* 2007) (Plate 4.9).

4.7.3.2.2 Taxonomy

The scientific classification, common and local names of *Eupreponotus inflatus* presented below.

Scientific Name - *Eupreponotus inflatus (Uvrov)*

- Phylum …… Arthropoda
- Class …… Insecta
- Order ……. Orthoptera
- Family ……. Acrididae
- Genus …….. Eupreponotus
- Species ……. Eupreponotus inflatus (Uvarov, 1921)
- English Name …….. Short-Horned Grasshopper
- Local Name …….. Guma Nargi

4.7.3.2.3 Proximate composition

Proximate composition of *E. inflatus* is shown in Table 4.35. Studies on the proximate composition of *E .inflatus* showed that it harbors a total of 75.38 % of crude proteins which is relatively higher than the protein content of the Hymenopterans and Hemiptera in the present study. The other nutrients were found to be present in adequate amounts.

Table 4.35 Proximate compositions of *E. inflatus g*/100g dry weight

Sl.No	Proximates	Values
1	Moisture	6.80 ± 0.03
2	Total solids	93.20 ± 0.03
3	Ash	1.32 ± 0.04
4	Fat	11.61 ± 0. 07
5	Protein	75.38 ± 0.03
6	Carbohydrate	4.89 ± 0.02
7	Calorific value (Kcal/100g)	425.25 ± 0.01

8	Starch	0.27 ± 1.32
7	Dietary fibre	0.15 ± 0.97

Results are in mean of triplicate determinations ± SD.

4.7.3.2 .4 Mineral composition

Table 4.36 compares the mineral contents of *E. inflatus* with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including potassium, calcium and magnesium could meet only about (2.40 – 25.11%) of the (RDA) requirement. Contrarily micronutrients including iron and copper surpassed the value of recommended mineral intake in males. In females the supply of zinc from this species can be excessive as it exceeds the RDA requirement.

Table 4.36 Recommended intake of essential minerals per day compared with *E. inflatus* .

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Eupreponotus inflatus* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1180.14 ± 0.89	25.11	25.11
Sodium	1500	1500	260.00 ± 0.65	17.33	17.33
Calcium	1000	1000	24.0 ± 0.03	2.40	2.40
Magnesium	400	310	19.0 ± 0.08	4.75	6.13
Phosphorus	700	700	543.52 ± 0.76	77.65	77.65
Zinc	11	8	4.5 ± 0.005	40.90	56.25
Iron	8	18	15.0 ± 0.01	187.5	83.33
Copper	0.9	0.9	4.0 ± 0.003	444.4	444.4

Results are in means of triplicate analysis ± SD.

4.7.3.2.5 Amino acid composition

Table 4.37 contains the result of amino acid compositions of *E. inflatus.* Amino acids including threonine, tyrosine, valine and lysine formed the major bulks of essential amino acids. Histidine, isoleucine and leucine were not detected in the sample. Among the non essentials amino adipic acid constituted the bulk. Arginine was the least abundant non essential amino acid in the sample. Non essential amino acids amounted to a total of 65.96% of the total amino acid. Essential amino acids

including cysteine constituted 43.82% of the total investigated amino acids. The ratio between the dispensable and indispensable amino acid was 1.50.

Table 4.37 Amino acid composition g/100g of *E. inflatus.*

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	7.10 ± 1.50	Threonine	4.69 ± 1.27
Amino adipic acid	29.55 ± 2.26	Histidine	ND
Serine	4.35 ± 0.77	Tyrosine	10.20 ± 0.59
Glycine	4.29 ± 0.04	Valine	13.03 ± 0.60
Asparagine	4.64 ± 0.36	Methionine	0.82 ± 0.18
Taurine	11.52 ± 2.39	Tryphtophan	3.25 ± 0.62
Alanine	0.24 ± 0.16	Phenylalanine	3.19 ± 0.61
Proline	2.11 ± 0.47	Isoleucine	ND
Ornithine	1.99 ± 0.65	Leucine	ND
Arginine	0.17 ± 0.09	Lysine	6.43 ± 0.86
-	-	Cysteine	2.21 ± 0.48
Total non EAA	65.96	Total EAA	43.82

Results are in means of duplicate analysis ± SD.

Table 4.38 represents the amino acid scoring pattern of *E.inflatus*. All of the amino acids surpassed the recommendation given by FAO/WHO/UNU (1985). The highest amino acid score was attained by valine.

Table 4.38 Amino acid score *E. inflatus* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (2007) (mg/g protein)	Chemical score (%)
Histidine	19	ND
Isoleucine	28	ND
Leucine	66	ND
Lysine	58	110
Methionine + cysteine	25	121
Phenylalanine + tyrosine	63	212

Threonine	34	137
Tryptophan	11	295
Valine	35	372
Amino acid score	-	110
Limiting amino acid	-	-

4.7.3.2.6 Fatty acid composition

The fatty acid profile of *E. inflatus* is shown in Table 4.39. Propionic acid was detected in higher values among the SFAs. 49.73% fraction of fatty acids were constituents of the total SFAs. MUFAs constituted 23.31% of the total fatty acid profiles. Myristoleic acid a 14 carbon chained fatty acid formed the major bulk (12.16%) of MUFAs. Eicosadienoic Acid a long chained C – 20 fatty acid formed the main portion 7.89% of PUFAs. PUFAs investigated constituted 27.74% of the total fatty acid profile in *P. Olivaceus*. The SFA UFA ratio was to be 0.97.

Table 4.39. Fatty acid composition g/100g dry weight and % of total fatty acids of *E. inflatus.*

Lipid Numbers	Common names	% of fatty acids
Saturated Fatty Acids		
3:0	Propionic acid	21.05 ± 0.20
5:0	Valerianic Acid	2.21 ± 0.31
8:0	Caprylic acid	1.31 ± 0.76
10:0	Capric acid	8.71 ± 0.07
11:0	Undecylic Acid	8.77 ± 0.74
13:0	Tridecylic acid	2.29 ± 0.31
	Other SFAs	5.39 ± 0.61
	Total SFAs	49.73
Monounsaturated Fatty Acids		
10:1	Obtusilic acid	1.29 ± 0.55
14:1	Myristoleic acid	12.16 ± 0.54
14 :1	Tsuzuic Acid	1.90 ± 0.67
16:1	Palmitoleic Acid	2.07 ± 0.32

17:1	Civetic Acid	0.76 ± 0.23
	Other MUFAs	5.13 ± 0.60
	Total MUFAs	23.31
Polyunsaturated Fatty Acids		
18:2	Linoleic acid	2.11 ± 0.32
18:2	Sebaleic acid	5.63 ± 0.38
20:2	Dihomolinoleic Acid	7.84 ± 0.91
20.2	Eicosadienoic Acid	7.89 ± 0.30
	Other PUFAs	4.27 ± 0.24
	Total	27.74

Results are in means of duplicate analysis ± SD.

4.7.3.3 *Choroedocus robustus*

4.7.3.3.1 Biology of *Choroedocus robustus*

C. robustus is large in size with aduts ranging in length between 60.5 – 70.0 mm.The nymphs start appearing mostly from the end of May and adults develop by the first week of August. Single generation is observed. *C. robustus* can be easily identified in having large size, postermal tubercle, gradually tapering apical, reddish green coloration with two large yellow striped body and two medium sized yellow antenna (Mondal *et al* 2007) (Plate 4.10).

4.7.3.3.2 Taxonomy

The taxonomic classification and other information of *Choroedocus robustus* is represented below.

Scientific Name - *Choroedocus robustus*

- Phylum …… Arthropoda
- Class …… Insecta
- Order ……. Orthoptera
- Family ……. Acrididae
- Genus …… Choroedocus
- Species …… *Choroedocus robustus* (Serville, 1838)
- English Name …….. Short-Horned Grasshopper
- Local Name …… Guma Khusep

4.7.3.3.3 Proximate Composition

Data on the nutritional composition of *C. robustus* is provided in Table 4.40. The data reveals that *C. robustus* has a high protein content of 64.50%. The species also possesses adequate amount of fats, ash and carbohydrates for nutrition. A calorific value of 413.61 kCal/100g reflected the high energy value of this species.

Table 4.40 Proximate compositions of *C. robustus* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	4.22 ± 0.05
2	Total solids	95.78 ± 0.05
3	Ash	1.51 ± 0.02
4	Fat	15.73 ± 0.03
5	Protein	64.50 ± 0.002
6	Carbohydrate	14.04 ± 0. 02
7	Calorific value (Kcal/100g)	413.61 ± 0.01
8	Starch	0.29 ± 0.57
7	Dietary fibre	0.11 ± 1.03

Results are in mean of triplicate determinations ± SD.

4.7.3.3.4 Mineral Composition

A comparision of the mineral contents of *C .robustus* mg/100g dry matter with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.41. Potassium, sodium, calcium, magnesium and zinc content in this species can accomplish low amounts of the RDA requirements in males as well as in females. Iron and copper content surpassed the requirement in males. The percentage of phosphorus could fulfill 93.56% of RDA in both males and females. Collectively *C. robustus* can be regarded as a rich source of phosphorus, iron and copper.

Table 4.41 Recommended intake of essential minerals per day compared with *C. robustus*

Mineral	Intake recommended for 25 year old Adults (mg per day)	*C. robustus* (mg per 100g) dry weight	% fulfillment of recommended intake

	Males	Females		Male	Females
Potassium	4700	4700	1160.34 ± 1.02	24.68	24.68
Sodium	1500	1500	253.00 ± 0.51	16.86	16.86
Calcium	1000	1000	27.0 ± 0.07	2.7	2.7
Magnesium	400	310	24.0 ± 0.09	6.0	7.74
Phosphorus	700	700	654.95 ± 4.22	93.56	93.56
Zinc	11	8	1.5 ± 0.002	13.64	18.75
Iron	8	18	12.0 ± 0.03	150.00	66.66
Copper	0.9	0.9	12.0 ± 0.006	166.67	166.67

Results are in means of triplicate analysis ± SD.

4.7.3.3.5 Amino acid composition

The amino acid composition of *C. robustus* is shown in Table 4.42. All essential amino acids except leucine were present in the species with lysine, threonine, methionine and valine constituting the main bulk. Of the non essential amino acids serine, carnosine, phoaphoenolamine and phosphoserine constituted the major bulk. The ratio between non essential and essential amino acids in *C. robustus* was 1.66. Table 4.43 shows the amino acid scores of *C .robustus.* All of the amino acids surpassed the recommendation given by FAO/WHO/UNU (1985).

Table 4.42 Amino acid composition g/100g of *C. robustus*.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	6.92 ± 0.48	Threonine	7.73 ± 0.12
Aspartic acid	3.78 ± 0.28	Histidine	3.00 ± 0.14
Phosphoenolamine	9.06 ± 0.84	Tyrosine	5.17 ± 0.14
Glycine	4.79 ± 0.24	Valine	3.88 ± 0.12
Asparagine	5.44 ± 0.31	Methionine	3.97 ± 0.24
Carnosine	8.63 ± 0.24	Tryphtophan	3.43 ± 0.54
Alanine	3.64 ± 0.04	Phenylalanine	1.31 ± 0.13
Proline	2.66 ± 0.14	Isoleucine	2.96 ± 0.12
Serine	11.78 ± 0.33	Leucine	ND
Glutamic acid	5.59 ± 0.41	Lysine	6.11 ± 0.22
Total non EAA	62.29	Total EAA	37.56

Results are in means of duplicate analysis ± SD.

Cysteine was not detected in the sample. Serine was the most abundant amino acid recorded in *C. robustus*.

Table 4.43 Amino acid score of *C. robustus* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (2007) (mg/g protein)	Chemical score (%)
Histidine	19	157
Isoleucine	28	105
Leucine	66	ND
Lysine	58	105
Methionine	25	158
Phenylalanine + tyrosine	63	102
Threonine	34	227
Tryptophan	11	311
Valine	35	110
Amino acid score	-	102
Limiting amino acid	-	-

4.7.3.3.6 Fatty Acid Composition

The fatty acid profile of *C. robustus* is shown Table 4.44. Undecylic acid and pentadecylic acid formed the bulk of the total 38.83% Saturated Fatty Acids (SFAs). MUFAs constituted 36.57% of the total fatty acid. Obtusillic acid formed the major bulk of MUFAs. Sebaleic Acid acid formed the main portion of PUFAs. PUFAs investigated constituted 24.47% of the total fatty acid profile in *C. robustus*.

Table 4. 44 Fatty acid composition g/100g dry weight and % of total fatty acids of *C. robustus.*

Lipid numbers	Common Name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
3:0	Propionic acid	3.01 ± 0.31
4:0	Butyric acid	1.49 ± 0.46
8:0	Caprylic Acid	1.09 ± 0.44
10:0	Capric acid	2.35 ± 0.46

11:0	Undecylic acid	14.98 ± 1.03
15:0	Pentadecylic Acid	9.58 ± 1.01
	Other SFAs	6.33 ± 1.88
	Total SFAs	38.83
Monounsaturated fatty acids (MUFAs)		
10:1	Obtusilic acid	9.70 ± 0.91
14:1	Tsuzuic Acid	2.75 ± 0.04
16:1	Sapienic Acid	2.77 ± 0.41
17:1	Civetic acid	1.67 ± 0.26
18:1	Vaccenic Acid	0.85 ± 0.41
20:1	Gadoleic Acid	5.99 ± 0.67
22:1	Cetoleic Acid	4.41 ± 0.33
24:1	Nervonic Acid	6.95 ± 1.01
	Other MUFAs	1.48 ± 0.48
	Total MUFAs	36.57
Polyunsaturated fatty acids (PUFAs)		
18:2	Sebaleic Acid	14.78 ± 0.48
20:2	Dihomolinoleic Acid	9.18 ± 0.42
	Other PUFAs	0.51 ± 0.22
	Total PUFAs	24.47

Results are in means of duplicate analysis ± SD.

4.7.3.4 *Chondracris rosea* (Fabricius)

4.7.3.4.1 Biology of *Chondracris rosea*

This species is recognized by its large and robust body size. The body colour ranges from green to pale green. The hind wings are coloured rose at the base and the hindlegs tarsi red. The adult ranges from 75 to 80 mm (Plate 4.11). It is found in dense vegeatations as tea gardens in Assam. It has wide distribution mostly in Asia. The nymphs emerge from the month of May and the adults are seen mostly during the month of August and September. Only a single generation is seen per year (Mandal *et al* 2007).

4.7.3.4.1 Taxonomy

Scientific Name - *Chondracris rosea*

- Phylum ……. Arthropoda

- Class …… Insecta
- Order ……. Orthoptera
- Family …….. Acrididae
- Genus …… Chondracris
- Species …….. *Chondracris rosea* (De Geer, 1773)
- English Name ……. Short-Horned Grasshopper
- Local Name …… Guma Nareng

4.7.3.4.2 Proximate composition

The data revealed that *C. rosea* holds high protein values 68.88% and fat content 17.52%. Comparatively the result of the nutritional analysis show that this species has higher protein content, moderate fat content, high energy value and low moisture.

Table 4.45 Proximate compositions of *C. rosea* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	5.27 ± 0.07
2	Total solids	94.73 ± 0.07
3	Ash	2.33 ± 0.02
4	Fat	17.52 ± 0.02
5	Protein	68.88 ± 0.03
6	Carbohydrate	6.00 ± 0.02
7	Calorific value (Kcal/100g)	457.20 ± 0.02
8	Starch	0.21 ± 0.97
7	Dietary fibre	0.04 ± 1.33

Results are in means of triplicate analysis ± SD.

4.7.3.4.3 Mineral composition

A comparision of the mineral contents of *C. rosea* mg/100g dry matter with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years provided in Table 4.46. RDA % fulfillment value of sodium, magnesium and calcium was exceedingly low. Phosphorus, copper and iron values exceeded the DRI requirement values. In females (58.33%) iron requirement could be met. The percentage of RDA recorded

show that *C. rosea* has the potential to supply the required amount of iron, copper and phosphorus for health and nutrition through the diet of the consumers.

Table 4.46 Recommended intake of essential minerals per day compared with *C. rosea.*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*C. rosea* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1140.01 ± 0.77	24.26	24.26
Sodium	1500	1500	186.33 ± 0.62	12.42	12.42
Calcium	1000	1000	32.5 ± 0.02	3.25	3.25
Magnesium	400	310	22.0 ± 0.04	5.50	7.09
Phosphorus	700	700	763.14 ± 1.02	109.02	109.02
Zinc	11	8	3.0 ± 0.004	27.27	37.5
Iron	8	18	10.5 ± 0.07	131.25	58.33
Copper	0.9	0.9	1.5 ± 0.006	166.66	166.66

Results are in means of triplicate analysis ± SD.

4.7.3.4.4 Amino acid composition

The amino acid composition of *C. rosea* is shown in Table 4.47. A majority of the essential amino acids were present in the species with valine, leucine, lysine, and tyrosine. Of the non essential amino acids aspartic acid, proline, alanine and glycine constituted the bulk. Adequate amounts of both non essential and essential amino acids (EAA) were found in the ratio of 1.17. Among the essentials tryptophan and phenylalanine were not detected in the sample. Valine was the most abundant among the essential and aspartic acid among the non essential amino acid recorded in *C. rosea*.

Table 4.47 Amino acid composition g/100g of *C. rosea.*

Non essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	2.73 ± 0.45	Threonine	3.33 ± 0.29
Aspartic acid	12.10 ± 0.04	Histidine	2.51 ± 0.37
Amino adipic acid	2.38 ± 0.24	Tyrosine	7.65 ± 0.30

Arginine	2.95 ± 0.40	Valine	8.73 ± 0.53
Serine	1.47 ± 0.07	Methionine	3.88 ± 0.22
Glycine	6.04 ± 0.05	Tryphtophan	ND
Asparagine	5.02 ± 0.70	Phenylalanine	ND
Taurine	1.51 ± 0.16	Isoleucine	2.81 ± 0.67
Ornithine	5.15 ± 0.10	Leucine	7.45 ± 0.16
Alanine	6.45 ± 0.87	Lysine	7.25 ± 0.65
Proline	8.30 ± 0.71	Cysteine	2.71 ± 0.67
Total non EAA	54.10	Total EAA	46.12

Results are in means of duplicate analysis ± SD.

The amino acid scores of *C. rosea* is presented in Table 4.48. All of the amino acids excluding threonine surpassed the recommendation given by FAO/WHO/UNU (1985). The amino acid score was 98 and threonine was found to be the limiting amino acid in this sample.

Table 4.48 Amino acid score of *C. rosea* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	132
Isoleucine	28	100
Leucine	66	112
Lysine	58	125
Methionine + cysteine	25	263
Phenylalanine + tyrosine	63	121
Threonine	34	98
Tryptophan	11	ND
Valine	35	249
Amino acid score	-	98
Limiting amino acid	-	Threonine

4.7.3.4.1 Fatty acid composition

C. rosea as food is a rich source of lipids owing to its 32.42 % of PUFA content. The composition and concentration of fatty acid oil in *C. rosea* is presented in Table 4.49. The SFAs content was found to be 49.27%. The UFAs constituted 51.4% of the total fatty acids. The SFAs UFAs ratio was found to be 0.95.

Table 4.49 Fatty acid composition g/100g dry weight and % of total fatty acids of *C. rosea.*

Lipid Numbers	Common names	% of fatty acids
Saturated Fatty Acids (SFAs)		
3:0	Propionic acid	7.48 ± 0.54
4:0	Butyric Acid	1.04 ± 0.55
5:0	Valerianic Acid	0.17 ± 0.05
8:0	Caprylic Acid	2.15 ± 0.32
9:0	Pelargonic Acid	1.75 ± 0.39
11:0	Undecylic Acid	8.43 ± 0.41
15:0	Pentadecylic Acid	23.78 ± 1.90
23:0	Tricosylic Acid	1.77 ± 0.09
Other SFAs		2.70 ± 0.53
Total SFAs		49.27
Monounsaturated Fatty Acids (MUFAs)		
12:1	Lauroleic Acid	4.01 ± 0.51
14:1	Tsuzuic Acid	6.14 ± 0.39
16:1	Gaidic acid	1.12 ± 0.42
16:1	Hypogeic Acid	2.94 ± 0.38
17:1	Civetic Acid	0.76 ± 0.49
Other MUFAs		4.01 ± 0.50
Total MUFAs		18.98
Polyunsaturated Fatty Acids (PUFAs)		
24:1	Nervonic Acid	1.81 ± 0.45
20:4	Eicosadienoic Acid	4.54 ± 0.68
20:4	Arachidonic Acid	5.26 ± 0.57
Other PUFAs		20.81 ± 0.78
Total PUFAs		32.42

Results are in means of duplicate analysis ± SD.

4.7.3.5 *Oxya fuscovittate*

4.7.3.5.1 Biology of *Oxya fuscovittate*

It is the most commonly found short horned grasshoppers in Assam, India. The body is medium in size and green in colour. The body size is of medium range and ranges from 30 – 40 mm in length (Plate 4.12). The nymphs develop from April and the adults emerge from the month of May. Mostly adults are seen all throughout the year. Paddy fields are the preferred habitats for egg laying and moulting. Maximum populations are observed in the month of September and October. More than one generation occurs per year.

4.7.3.5.2 Taxonomy

Scientific Name - *Oxya fuscovittate* (Marschall)

- Phylum …… Arthropoda
- Class …… Insecta
- Order ……. Orthoptera
- Family …….. Acrididae
- Genus …… Oxya
- Species …… *Oxya fuscovittate* (Marschall, 1836)
- English Name ……. Short-Horned Grasshopper
- Local Name …… Guma Daosri jagra

4.7.3.5.3 Proximate composition

Table 4.50 represents the proximate composition of *O. fuscovittate*. Proximate composition assay data has revealed that this is a remarkable source of protein 78.31%. A high energy value of 430.33 Kcal/100g was observed in this species.

Table 4.50 Proximate compositions of *O. fuscovittate* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	3.97 ± 0.10
2	Total solids	96.03 ± 0.10
3	Ash	3.81 ± 0.04
4	Fat	12.33 ± 0.02
5	Protein	78.31 ± 0.02

6	Carbohydrate	1.58 ± 0.02
7	Calorific value (Kcal/100g)	430.33 ± 0.02
8	Starch	0.37 ± 1. 22
9	Dietary fibre	0.82 ± 1.09

Results are in means of triplicate determinations ± SD.

4.8.3.5.4 Mineral composition

Table 4.51 compares the mineral contents of *O. fuscovittate* with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including calcium, magnesium, sodium and potassium can meet only about 1.85 – 23.83% of the (RDA) requirement. Contrarily micronutrients including iron and copper surpassed the RDA requirement in both males and females.

Table 4.51 Recommended intake of essential minerals per day compared with *O. fuscovittate* .

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Oxya fuscovittate* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1120.05 ± 2.07	23.83	23.83
Sodium	1500	1500	248.00 ± 0.38	16.53	16.53
Calcium	1000	1000	18.5 ± 0.05	1.85	1.85
Magnesium	400	310	15.5 ± 0.03	3.87	5.0
Phosphorus	700	700	598.10 ± 0.86	85.44	85.44
Zinc	11	8	4.5 ± 0.002	40.91	56.25
Iron	8	18	43.0 ± 0.01	537.5	238.88
Copper	0.9	0.9	2.0 ± 0.002	222.22	222.22

Results are in means of triplicate determinations ± SD.

4.7.3.5.5 Amino acid composition

Table 4.52 contains the result of amino acid compositions of *O. fuscovittate.* Amino acids including valine, threonine, lysine and isoleucine formed the major bulk of essential amino acids. Leucine was not detected. Among the non essentials taurine, aspartic acid and amino adipic acid constituted the bulk. Taurine and lysine were the most abundant among the non essentials and essential amino acids

respectively. Non essential amino acids amounted to a total of 51.98% of the total amino acid. Essential amino acids including cysteine constituted 47.89% of the total investigated amino acids. The ratio between non essential and essential amino acid were found to be 1.08.

Table 4.52 Amino acid composition g/100g of *O.fuscovittate*.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	7.64 ± 1.20	Threonine	6.42 ± 0.79
Amino adipic acid	6.54 ± 0.24	Histidine	3.66 ± 0.63
Serine	6.19 ± 0.35	Tyrosine	3.77 ± 0.09
Phoshoserine	6.21 ± 0.99	Valine	6.78 ± 0.74
Arginine	3.46 ± 0.28	Methionine	4.15 ± 0.67
Taurine	7.72 ± 0.12	Tryphtophan	2.15 ± 0.56
Phosphoenolamine	5.19 ± 0.26	Phenylalanine	3.44 ± 0.77
Proline	0.36 ± 0.09	Leucine	ND
Ornithine	2.33 ± 0.91	Lysine	7.20 ± 0.70
Aspargine	6.34 ± 1.19	Cysteine	3.56 ± 0.74
Glutamic acid	ND	Isoleucine	6.76 ± 0.78
Total non EAA	51.98	Total EAA	47.89

Results are in means of duplicate analysis.

The amino acid scoring pattern of *O. fuscovittate* is presented in Table 4.53. All of the amino acids exceeded the recommendation given by FAO/WHO/UNU (1985).

Table 4.53 Amino acid score of *O.fuscovittate* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	192
Isoleucine	28	241
Leucine	66	ND
Lysine	58	124
Methionine + cysteine	25	308

Phenylalanine + tyrosine	63	113
Threonine	34	188
Tryptophan	11	195
Valine	35	193
Amino acid score	-	113
Limiting amino acid	-	-

4.7.3.5.6 Fatty acid composition

The fatty acid profile of *O.fuscovittate* is shown in Table 4.54. Propionic acid and caprylic acid formed the main constituents of the SFAs. 28.52 % fraction of fatty acids was constituents of the total SFAs. A major fraction of fatty acids 57.28% were constituents of MUFAs. PUFAs investigated constitute 14.03% of the total fatty acid profile in *O.fuscovittate*. The SFA and UFA ratio in *O.fuscovittate* was 0.39.

Table 4.54 Fatty acid composition g/100g dry weight and % of total fatty acids of *O.fuscovittate.*

Lipid number	Common name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
3:0	Propionoic acid	10.77 ± 0.19
4:0	Butanoic acid	1.19 ± 0.36
5:0	Valerianic Acid	2.46 ± 0.58
8:0	Caprylic Acid	4.87 ± 1.05
10:0	Capric Acid	1.02 ± 0.45
12:0	Lauric Acid	0.50 ± 0.14
13:0	Tridecylic Acid	2.50 ± 0.08
15:0	Pentadecylic Acid	0.18 ± 0.03
	Other SFAs	5.03 ± 0.28
	Total SFAs	28.52
Monounsaturated Unsaturated Fatty Acids (MUFAs)		
10:1	Obtusilic acid	39.79 ± 0.60
10:1	Caproleic Acid	1.23 ± 0.14

17:1	Civetic Acid	1.12 ± 0.48
12:1	Linderic Acid	1.93 ± 0.26
14:1	Tsuzuic Acid	2.52 ± 0.47
14:1	Myristoleic Acid	2.42 ± 0.42
16:1	Palmitoleic Acid	1.98 ± 0.12
17:1	Civetic Acid	1.21 ± 0.03
Other MUFAs		5.08 ± 0.37
Total MUFAs		57.28
Poly Unsaturated Fatty Acids (PUFAs)		
18:4	Stearidonic Acid	1.79 ± 0.33
20:4	Arachidonic Acid	1.18 ± 0.39
	Other PUFAs	11.06 ± 0.80
	Total PUFAs	14.03

Results are in means of duplicate analysis.

4.7.3.6 *Mecopoda elongata elongata*

4.7.3.6.1 Biology of *Mecopoda elongata elongata*

Mecopoda elongata elongata is a common bush cricket found in Assam, India that chirp mostly during the dark hours in an aggregation with their neighbours. It is by this chirp by which people harvest this insect for consumption. The body colour ranges from brown to green and they prefer living in gardens and small bushes. The body is medium sized and appears flat. The body appears shorter (40.1mm) than the wings (60.1 mm) (Plate 4.13). The females lay their eggs in the leaves of small branches of small and short bushy shrubs.

4.7.3.6.2 Taxonomy

The scientific classification, common and local names of *M. elongata elongata* is presented below.

Scientific Name - *Mecopoda elongata elongata* (Linnaeus 1758)

- Phylum …….. Arthropoda
- Class ..…… Insecta
- Order ….……Orthoptera
- Superfamily .……Tettigonioidea

- Family ……Tettigoniidae
- Genus ……. Oxya
- Species ...…… *Mecopoda elongata elongata* (Linnaeus)
- English Name …….. Cricket
- Local Name ……Guma Khufri

4.7.3.6.3 Proximate composition

The proximate composition of *M. elongata elongata* is shown in Table 4.55. Studies on the proximate composition of *M. elongata elongata* showed that it harbours a total of (59.50%) of crude proteins, (0.56 %) crude ash, and high fat content of (19.92%). Nutritive value of 473.67 Kcal/100g is desirable for human nutrition.

Table 4.55 Proximate compositions of *M. elongata elongata* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	6.16 ± 0.06
2	Total solids	93.14 ± 0.06
3	Ash	0.56 ± 0.02
4	Fat	20.11 ± 0.04
5	Protein	59.50 ± 0.02
6	Carbohydrate	13.67 ± 0.08
7	Calorific value (Kcal/100g)	473.67 ± 0.04
8	Starch	0.72 ± 1.23
9	Dietary fibre	0.04 ± 0.68

Results are in means of triplicate analysis ± SD.

4.7.3.6.4 Mineral composition

Table 4.56 compares the mineral contents of *M. elongata elongata* with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including calcium, magnesium, sodium and potassium although present in higher amounts could meet only about 3.75 – 24.60% of the (RDA) requirement. Contrarily micronutrients including iron and copper surpassed the value of RDA requirements in males. Iron content though

found in higher quantities among the micronutrients could fulfill only 52.77 % of RDA requirement in females.

Table 4.56 Recommended intake of essential minerals per day compared with *M. elongata elongata*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*M. elongata elongata* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1160.03 ± 1.22	24.6	24.6
Sodium	1500	1500	309.33 ± 0.59	20.62	20.62
Calcium	1000	1000	37.5 ± 0.01	3.75	3.75
Magnesium	400	310	20.0 ± 0.03	5.0	6.45
Phosphorus	700	700	523.44 ± 0.88	74.77	74.77
Zinc	11	8	0.5 ± 0.006	4.54	6.25
Iron	8	18	9.5 ± 0.04	118.75	52.77
Copper	0.9	0.9	2.0 ± 0.004	222.22	222.22

Results are in means of triplicate analysis ± SD.

4.7.3.6.5 Amino Acid composition

The amino acid composition of *M. elongata elongata* is shown in Table 4.57. A majority of the essential amino acids were present in the species with leucine, lysine and isoleucine constituting the main essential amino acids. Of the non essential amino acids glycine, phosphoserine and aspartic acid constituted the bulk. Adequate amounts of both essential and non essential amino acids were found in the ratio of 1.11. Among the essential tyrosine, valine and phenylalanine were not detected in the sample. Leucine was the most abundant among the essential and glycine among the non essential amino acid recorded in *M. elongata elongata*.

Table 4.57 Amino acid composition g/100g of *M. elongata elongata*

Non essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	7.35 ± 0.09	Threonine	5.93 ± 0.57
Aspartic acid	6.54 ± 0.12	Histidine	4.89 ± 0.28
Serine	2.58 ± 0.57	Tyrosine	ND
Glycine	9.88 ± 0.24	Valine	ND

Arginine	5.48 ±1.01	Methionine	4.37 ± 0.12
Taurine	4.24 ± 0.52	Tryphtophan	4.83 ± 0.09
Proline	4.95 ± 0.78	Phenylalanine	ND
Ornithine	4.74 ± 0.41	Isoleucine	7.13 ± 0.28
Glutamic acid	3.37 ± 0.55	Leucine	8.42 ± 0.24
Amino adipic acid	3.49 ± 0.41	Lysine	8.21 ± 0.04
-	-	Cysteine	3.45 ± 0.58
Total non EAA	52.62	Total EAA	47.23

Results are in means of duplicate analysis ± SD.

The amino acid scores of *M. elongata elongata* is presented in Table 4.58. All of the indispensable amino acids present in the sample surpassed the recommendation given by FAO/WHO/UNU (1985).

Table 4.58 Amino acid score based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	174
Isoleucine	28	254
Leucine	66	127
Lysine	58	141
Methionine + cysteine	25	312
Phenylalanine + tyrosine	63	ND
Threonine	34	174
Tryptophan	11	433
Valine	35	ND
Amino acid score	-	141
Limiting amino acid	-	

4.7.3.6.6 Fatty acid composition

The fatty acid profile of *M. elongata elongata* is shown in Table 4.59. Propionic acid and lauric acid formed the bulk of the total 29.45% of Saturated Fatty Acids (SFAs). MUFAs constituted 46.07% of the total fatty acid profiles.

Myristoleic acid formed the major bulk of MUFAs. Sebaleic acid formed the main portion of PUFAs. PUFAs investigated constituted 24.30% of the total fatty acid profile in *M. elongate*.

Table 4 .59 Fatty acid composition g/100g dry weight and % of total fatty acids of *M. elongata elongata.*

Lipid numbers	Common names	% of fatty acids
Saturated Fatty acids (SFAs)		
3:0	Propionic acid	13.34 ± 0.90
4:0	Butyric Acid	1.55 ± 0.26
8:0	Caprylic Acid	0.54 ± 0.07
10:0	Capric Acid	2.01 ± 0.14
12:0	Lauric acid	5.57 ± 0.14
14:0	Myristic Acid	0.43 ± 0.091
15:0	Pentadecylic Acid	0.51 ± 0.34
17:0	Margaric Acid	1.45 ± 0.31
23:0	Tricosylic Acid	2.66 ± 0.53
	Other SFAs	1.39 ± 0.41
	Total SFAs	29.45
Monounsaturated Fatty Acids (MUFAs)		
10:1	Obtusilic Acid	1.34 ± 0.15
12:1	Lauroleic Acid	4.05 ± 0.27
14:1	Tsuzuic Acid	13.56 ± 0.77
14:1	Myristoleic Acid	9.52 ± 0.95
16:1	Palmitoleic Acid	1.24 ± 0.30
16:1	Palmitvaccenic Acid	2.73 ± 0.30
17:1	Civetic Acid	2.82 ± 0.02
18:1	Oleic Acid	3.05 ± 0.12
	Other MUFAS	7.76 ± 1.01
	Total MUFAs	46.07
Polyunsaturated Fatty Acids (PUFAs)		

18:2	Sebaleic Acid	10.83 ±1.23
20:2	Dihomolinoleic Acid	4.61 ± 0.24
	Other PUFAs	8.86 ± 0.62
	Total PUFAs	24.3

Results are in means of duplicate analysis ± SD.

4.7.3.7 *Ruspolia baileyi*

4.7.3.7.1 Biology of *Ruspolia baileyi*

This species is a cone headed long horned grasshopper and is characterized by their long filiform antennae, strong hind limbs and powerful chewing mouthparts with yellow jaw base. Adult body length ranges from 30 – 30.5 mm (Plate 4.14). This insect usually dwells in open paddy fields and grassland. They mainly feed on flowers and seeds of cereals using their powerful jaws for cracking but are not regarded as pest. The eggs are mostly laid in the leaves of paddy rice and nymphs hatch in 1-2 months and mature to adults within 2-3 months. Colour polymorphism commonly occurs and the main colour forms in adults ranges from light-green and light-brown, with an array of varied intermediate forms.

4.7.3.7 .2 Taxonomy

The scientific, common and local names of *Ruspolia baileyi* collected and consumed as food by the Bodos in Assam, Northeast India is represented below.

Scientific Name – *Ruspolia baileyi*

- Phylum ……. Arthropoda
- Class …… Insecta
- Order ……. Orthoptera
- Superfamily ……... Tettigonioidea
- Family …….. Tettigoniidae
- Genus …… Ruspolia
- Species …… *Ruspolia baileyi* (Otte, 1997)
- English Name ……. Long - Horned Grasshopper
- Local Name …… Guma gwthao

4.7.3.7.3 Proximate composition

Table4.57 represents the proximate composition of *R. baileyi*. Proximate composition assay data has revealed that this species contains 30.25% of protein with a higher fat content of 40.65%.

Table 4.60 Proximate compositions of *R. baileyi* g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	6.27 ± 0.10
2	Total solids	93.73 ± 0.10
3	Ash	0.48 ± 0.03
4	Fat	40.65 ± 0.001
5	Protein	30.25 ± 0.003
6	Carbohydrate	22.35 ± 0.03
7	Calorific value (Kcal/100g)	580.25 ± 0.01
8	Starch	0.25 ± 2.02
9	Dietary fibre	0.07 ± 1.01

Results are in means of triplicate determinations ± SD.

4.7.3.7.4 Mineral composition

Table 4.61 compares the mineral contents of *R. baileyi* with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including calcium, magnesium, sodium and potassium although present in higher amounts can meet about (2.0 – 24.69%) of the (RDA) requirement. Contrarily micronutrients including zinc, iron and copper can fulfill around (31.81 – 611.1%) in male and (43.45 – 611.1%) in females of the RDA requirement. The values of iron and copper surpassed the recommended values of the RDA reference requirement. The chemical score of copper was found to be exceedingly higher than the other elements.

Table 4.61 Recommended intake of essential minerals per day compared with *R. baileyi.*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*R. Baleyi* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female

Potassium	4700	4700	1160.77 ± 0.93	24.69	24.69
Sodium	1500	1500	312.18 ± 0.92	20.81	20.81
Calcium	1000	1000	20.0 ± 0.03	2.0	2.0
Magnesium	400	310	19.5 ± 0.05	4.87	6.29
Phosphorus	700	700	467.74 ± 1.87	66.82	66.82
Zinc	11	8	3.5 ± 0.002	31.81	43.75
Iron	8	18	25.5 ± 0.08	318.75	141.67
Copper	0.9	0.9	5.5 ± 0.05	611.11	611.11

Results are in means of triplicate analysis ± SD.

4.7.3.7.5 Amino acid composition

Table 4.62 contains the result of amino acid compositions of *R. baileyi.* Amino acid phenylalanine formed the major bulk of essential amino acids. Valine and leucine were not detected. Among the non essentials aspartic acid constituted the bulk. Non essential amino acids amounted to a total of 65.99% of the total amino acid. Essential amino acids constitute 33.49% of the total investigated amino acids. The ratio between non essential and essential amino acid was found to be 1.97.

Table 4.62 Amino acid composition g/100g of *R. baileyi*.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phoshoserine	3.90 ± 0.75	Threonine	4.65 ± 0.53
Aspartic acid	15.77 ± 0.26	Histidine	3.18 ± 0.58
Glutamic acid	1.03 ± 0.38	Tyrosine	2.81 ± 0.41
Amino adipic acid	3.22 ± 0.36	Valine	ND
Serine	2.90 ± 0.55	Methionine	2.85 ± 0.53
Glycine	9.99± 1.32	Tryphtophan	1.55 ± 0.43
Taurine	1.41 ± 0.73	Phenylalanine	6.45 ± 1.85
Proline	1.38 ± 0.77	Leucine	ND
Ornithine	9.65 ± 0.77	Lysine	6.37 ± 0.89
Cystathionine	16.74 ± 0.01	Cysteine	ND
Aspargine	ND	Isoleucine	6.26 ± 0.02
Total non EAA	65.99	Total EAA	33.49

Results are in means of duplicate analysis ± SD.

Table 4.63 represents the amino acid scoring pattern of *R. baileyi*. All of the amino acids present in this food sample exceeded the recommendation given by FAO/WHO/UNU (1985).

Table 4.63 Amino acid score of *R. baileyi* based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	167
Isoleucine	28	223
Leucine	66	ND
Lysine	58	109
Methionine	25	114
Phenylalanine + tyrosine	63	146
Threonine	34	136
Tryptophan	11	140
Valine	35	ND
Amino acid score	-	109
Limiting amino acid	-	-

4.7.3.7.6 Fatty Acid composition

The fatty acid profile of *R. baileyi* is shown in Table 4.64. Undecylic acid and capric acid formed the bulk among the SFAs. 54.65% fraction of fatty acids was constituents of the total SFAs. MUFAs constituted 28.65% of the total fatty acid profiles. Lauroleic acid formed the major bulk of MUFAs. Linoleic acid 12.05% formed the main portion of 16.59% of PUFAs. The ratio between SFAs and UFAs was found to be 1.20.

Table 4.64 Fatty acid composition g/100g dry weight and % of total fatty acids of *R. baileyi*

Lipid numbers	Common names	% of total fatty acids
Saturated Fatty Acids (SFAs)		
8:0	Caprylic Acid	1.28 ± 0.19

9:0	Pelargonic Acid	0.45 ± 0.14
10:0	Capric Acid	13.36 ± 1.50
10:0	Sebacic acid	13.90 ± 1.21
11:0	Undecylic Acid	18.66 ± 1.30
12:0	Lauric acid	2.19 ± 0.28
	Other SFAs	4.81 ± 0.89
	Total SFAs	54.65
Monounsaturated Fatty acids (MUFAs)		
12:1	Lauroleic Acid	12.70 ± 1.32
12:1	Linderic Acid	11.20 ± 0.50
14:1	Myristoleic Acid	1.58 ± 0.43
	Other MUFAs	3.17 ± 0.19
	Total MUFAs	28.65
Polyunsaturated Fatty Acids (PUFAs)		
18:2	Linoleic Acid	12.05 ± 1.40
20:4	Arachidonic Acid	3.60 ± 0.82
	Other PUFAs	0.94 ± 0.31
	Total PUFAs	16.59

Results are in means of duplicate analysis ± SD.

4.7.4 Order Coleoptera

Beetles and weevils are the members of order coleoptera. The members of these groups are characterized by two pair of wings, hardened forewings and membranous hindwings, mandibulate mouthparts and a pair antenna and compound eyes. Life cycle is complete and the time for larvae development varies depending on species. Beetles may be aquatic (freshwater) or terrestrial and feeding behavior ranges from herbivorous to scavengers and predators depending on species. In terrestrial environment they are usally found living in soil as dung, in living or dead trees or in dead decomposing tree trunks (CSIRO 2007c). The aduts are capable of short flight and most species are attracted by illumination especially during nights.

4.7.4.1 *Cybister tripunctatus*

4.7.4.1.1 Biology of *Cybister tripunctatus*

Dytiscidae beetles are adult predatory water beetles with a number of varied species and many of them are preferred for consumption. The beetle is aquatic in nature but can live a terrestrial life too. It is dark brown to blackish in colour with a streamlined body shape. The legs are yellowish in colour and the body also possesses a yellowish border around (Plate 4.15). They live a carnivorous life preying on small fishes and insects. Complete metamorphosis is undergone until adult after the hatching within a few weeks. The distribution of this species is not properly known. The body of the adult ranges from 30 – 35 mm.

4.7.4.1.2 Taxonomy

- Phylum …… Arthropoda
- Class …… Insecta
- Order ……. Coleoptera
- Family …….. Dysticidae
- Genus …… Cybister
- Species …… *Cybister tripunctatus*
- English Name ……. *Diving beetle*
- Local Name …… Chingkhouri

4.7.4.1.3 Proximate Composition

Data on the proximate nutritional composition of *C. tripunctatus* is provided in Table 4.65. The data reveal that *C. tripunctatus* has protein content of 59.00%. A higher fat content (20.74%) was also observed in this species. A calorific value of 434.87 k Cal/100g reflects its energy value.

Table 4.65 Proximate compositions of *C. tripunctatus* g/100g dry weight.

Sl.No	Proximates	Values
1	Moisture	5.82 ± 0.03
2	Total solids	94.18 ± 0.03
3	Ash	2.33 ± 0.02
4	Fat	20.74 ± 0.01

5	Protein	59.00 ± 0.02
6	Carbohydrate	12.21 ± 0.02
7	Calorific value (Kcal/100g)	434.87 ± 0.04
8	Starch	0.16 ± 1.87
9	Dietary fibre	0.22 ± 0.88

Results are in means of triplicate determinations ± SD.

4.7.4.1.4 Mineral compositions

A comparision of the mineral contents mg/100g dry matter of *C. tripunctatus* with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is also provided in Table 4.66 .The percent fulfillment of recommended intake for both calcium and magnesium was found low. Potassium can fulfill about 26.39% and sodium around 21.35% of the RDA requirements. This species can supply adequate amounts of phosphorus 70.13% and zinc 25.00%. Copper and iron values were exceedingly high and surpassed the RDA requirement values both in males as well as in females. The percentage of RDA recorded show that *C. tripunctatus* is a potential source of iron and copper.

Table 4.66 Recommended intake of essential minerals per day compared with *C.tripunctatus*

Mineral	Intake recommended for 25 year old Adults (mg per day)		*C. tripunctatus* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1240.14 ± 0.79	26.39	26.39
Sodium	1500	1500	320.3 ± 0.97	21.35	21.35
Calcium	1000	1000	21.0 ± 0.08	2.10	2.10
Magnesium	400	310	24.0 ± 0.04	6.0	7.74
Phosphorus	700	700	490.91 ± 3.67	70.13	70.13
Zinc	11	8	2.0 ± 0.005	18.18	25.00
Iron	8	18	15.0 ± 0.02	187.5	83.33
Copper	0.9	0.9	1.5 ± 0.005	166.66	166.66

Results are in means of triplicate determinations ± SD.

4.7.4.1.5 Amino acid composition

The amino acid composition of *C. tripunctatus* is shown in Table 4.67. All the essential amino acids excluding phenylalanine and leucine were present in the species with tyrosine as the most abundant essential amino acids. Of the non essential amino acids aspartic acid constituted the bulk. The ratio between the non essential and essential amino acids (EAA) was 1.62.

Table.4.67 Amino acid composition of *C. tripunctatus* g/100g dry weight.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	30.06 ± 0.24	Threonine	3.59 ± 0.24
Amino adipic acid	3.41 ± 0.42	Histidine	2.17 ± 0.29
β-amino butyric acid	4.80 ± 0.84	Tyrosine	9.86 ± 1.59
Anserine	2.52 ± 0.82	Valine	4.99 ± 0.11
Serine	1.94 ± 0.33	Methionine	2.53 ± 0.07
Aspargine	4.44 ± 0.32	Cysteine	0.48 ± 0.09
Taurine	2.58 ± 0.311	Tryphtophan	1.48 ± 0.47
Phosphoenolamine	0.34 ± 0.31	Phenylalanine	ND
Proline	2.18 ± 0.28	Isoleucine	ND
Glycine	4.27 ± 0.60	Leucine	6.29 ± 0.33
Ornithine	5.45 ± 0.71	Lysine	6.86 ± 0.52
Total non EAA	61.99	Total EAA	38.25

Results are in means of duplicate analysis ± SD.

The least amino acid score observed was that of leucine 95% so leucine was found to be the limiting amino acid in *C. tripunctatus*. The chemical score of tyrosine was recorded to be the highest.

Table 4.68 Amino acid score based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	114

Isoleucine	28	ND
Leucine	66	95
Lysine	58	118
Methionine + Cysteine	25	120
Tyrosine	63	156
Threonine	34	105
Tryptophan	11	134
Valine	35	142
Amino acid score	-	95
Limiting amino acid	-	Leucine

4.7.4.1.6 Fatty acid composition

The fatty acid profile of *C. tripunctatus* is presented in Table 4.69. The SFAs content was found to be 59.61%. The UFAs constituted 40.2% of the total fatty acids. The SFAs UFAs ratio was found to be 1.48.

Table 4. 69 Fatty acid composition g/100g dry weight and % of total fatty acids of *C. tripunctatus*.

Lipid Numbers	Common Name	% of fatty acids
Saturated Fatty Acids (SFAs)		
8:0	Caprylic Acid	3.61 ± 4.31
9:0	Pelargonic Acid	5.67 ± 0.28
10:0	Capric Acid	10.21 ± 0.50
10:0	Sebacic acid	15.21 ± 0.94
11:0	Undecylic Acid	11.72 ± 0.97
12:0	Lauric Acid	2.06 ± 0.38
20:0	Arachidic Acid	1.01 ± 0.51
	Other SFAs	10.12 ± 0.35
	Total SFAs	59.61
Monounsaturated Fatty Acids (MUFAs)		
10 :1	Obtusilic Acid	17.28 ± 0.72
12:1	Lauroleic Acid	4.92 ± 0.41

14:1	Tsuzuic Acid	0.65 ± 0.47
16:1	Gaidic acid	2.37 ± 0.48
	Other MUFAs	4.42 ± 0.37
	Total MUFAs	29.64
Polyunsaturated Fatty Acids (PUFAs)		
18:2	Linoleic Acid	8.2 ± 0.55
18:2	Linoelaidic Acid	1.57 ± 0.81
20:2	Eicosadienoic Acid	0.79 ± 0.46
	Total PUFAs	10.56

Results are in means of duplicate analysis ± SD.

4.7.4.2 *Coleoptera* sp. (Bwrbila gedet)

4.7.4.2.1 Biology of Coleoptera sp. (Bwrbila gedet)

The unidentified *Coleoptera* sp. (Bwrbila gedet) is a coleopteran beetle and is characterized by the presence of 2 pairs of wings, mandibulate mouthparts and a pair of compound eyes as in most beetles. The wings are brownish in colour. The species is terrestrial and feeds on leaves of trees and shrubs. The adults are (40 – 40.5 mm) in length (Plate 4.16). They are harvested annually. They become abundant during the month of April to June. Even though the scientific name of this species is not known it has its own unique local name and has been used as food by the Bodos so considering the assigned local name given by the consumers the nutritional value of this species was investigated.

4.7.4.2.2 Taxonomy

- Scientific Name – *Unidentified (Coleoptera)*
- Order ……. Coleoptera
- Family……..Unidentified
- Local Name …….. Bwrbila gedet
- English name ……. Beetles

4.7.4.2.3 Proximate composition

Table 4.70 represents the proximate composition of the *Coleoptera* sp. (Bwrbila gedet). Proximate composition assay data has revealed that this species is a remarkable source of protein 83.44%. A high energy value of (441.52 Kcal/100g) was also observed in this species.

Table 4.70 Proximate compositions of *Coleoptera* sp. (Bwrbila gedet) g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	2.09 ± 0.03
2	Total solids	97.91 ± 0.03
3	Ash	2.09 ± 0.004
4	Fat	11.76 ± 0.03
5	Protein	83.44 ± 0.02
6	Carbohydrate	0.48 ± 0.03
7	Calorific value (Kcal/100g)	441.52 ± 0.02
8	Starch	0.30 ± 1.56
9	Dietary fibre	0.28 ± 0.65

Results are in means of triplicate analysis ± SD.

4.7.4.2.4. Mineral composition

Table 4.71 compares the mineral contents of *Coleoptera* sp. (Bwrbila gedet) with the provided recommended dietary allowance (RDA) for both male and female human adults of age between 19 - 30 years. Macro elements including calcium, magnesium, sodium and potassium were in the range of supplementing (5.12 – 24.25%) of the (RDA) requirement. Contrarily micronutrients including iron and copper surpassed the RDA requirement in males. Zinc content was found to be low in this species.

Table 4.71 Recommended intake of essential minerals per day compared with *Coleoptera* sp. (Bwrbila gedet).

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Coleoptera* sp. (Bwrbila gedet) (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1140.01 ± 1.03	24.25	24.25
Sodium	1500	1500	222.5 ± 0.95	14.83	14.83
Calcium	1000	1000	20.5 ± 0.01	5.12	5.12
Magnesium	400	310	35.0 ± 0.09	8.75	11.29
Phosphorus	700	700	689.18 ± 1.33	98.45	98.45

Zinc	11	8	1.0 ± 0.006	9.09	12.50
Iron	8	18	12.0 ± 0.02	150.00	66.66
Copper	0.9	0.9	2.0 ± 0.007	222.22	222.22

Results are in means of triplicate analysis ± SD.

4.7.4.2.5 Amino acid composition

Table 4.72 contains the result of amino acid compositions of *Coleoptera* sp. (Bwrbila gedet). Lysine was found to be the most abundant among the essentials and serine formed the major bulk of non essential amino acids. Methionine and cysteine was not detected. Non essential amino acids amounted to a total of 59.21% of the total amino acid. Essential amino acids constituted 40.61% of the total investigated amino acids. The ratio between non essential and essential amino acid were found to be 1.45.

Table 4.72 Amino acid composition g/100g of *Coleoptera sp.* (Bwrbila gedet).

Non essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	10.76 ± 0.72	Threonine	5.03 ± 1.02
Amino adipic acid	4.29 ± 0.78	Histidine	2.56 ± 0.41
Serine	13.18 ± 1.54	Tyrosine	6.18 ± 0.77
Phosphoserine	2.67 ± 0.28	Valine	4.17 ± 0.36
Arginine	ND	Methionine	ND
Taurine	5.75 ± 0.07	Tryphtophan	1.91 ± 0.37
Phosphoenolamine	3.46 ± 0.49	Phenylalanine	1.60 ± 0.28
Proline	3.65 ± 0.57	Leucine	6.57 ± 0.02
Glycine	ND	Lysine	8.69 ± 2.57
Aspargine	5.95 ± 0.81	Cysteine	ND
Glutamic acid	9.50 ± 1.30	Isoleucine	3.90 ± 0.83
Total non EAA	59.21	Total EAA	40.61

Results are in means of duplicate analysis ± SD.

Table 4.73 represents the amino acid scoring pattern of *Coleoptera* sp. (Bwrbila gedet). All of the amino acids excluding leucine exceeded the recommendation given by FAO/WHO/UNU (1985). Leucine with an amino acid

score of 99% was found to be the limiting amino acid in *Coleoptera* sp. (Bwrbila gedet).

Table 4.73 Amino acid score of *Coleoptera* sp. (Bwrbila gedet) based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	134
Isoleucine	28	139
Leucine	66	99
Lysine	58	149
Methionine + cysteine	25	ND
Phenylalanine + tyrosine	63	123
Threonine	34	147
Tryptophan	11	173
Valine	35	119
Amino acid score	-	99
Limiting amino acid	-	Leucine

4.7.4.2.6 Fatty acid composition

The fatty acid profile of *Coleoptera* sp. (Bwrbila gedet) is shown in Table 4.74 Pentadecylic Acid and Undecylic acid formed the main constituents of the SFAs. 60.47% fraction of fatty acids was constituents of the total SFAs. A major fraction of fatty acids 27.65% were constituents of MUFAs. PUFAs investigated constituted 11.54% of the total fatty acid profile in *Coleoptera* sp. (Bwrbila gedet). The SFA and UFA ratio in *Coleoptera* sp. (Bwrbila gedet) was 1.54.

Table 4.74 Fatty acid composition g/100g dry weight and % of total fatty acids of *Coleoptera* sp. (Bwrbila gedet).

Lipid Numbers	Common name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
7:0	Enanthic Acid	0.42 ± 0.14
8:0	Caprylic Acid	0.42 ± 0.13

9:0	Pelargonic Acid	0.95 ± 0.36
10:0	Capric Acid	1.60 ±0.17
10:0	Sebacic acid	8.06 ± 0.23
11:0	Undecylic Acid	16.24 ± 1.06
12:0	Lauric Acid	2.85 ± 0.24
13:0	Tridecylic Acid	1.99 ± 0.32
14:0	Myristic Acid	1.71 ± 0.37
15:0	Pentadecylic Acid	16.76 ± 1.30
19:0	Nonadecylic Acid	3.53 ± 0.26
Other SFAs		5.94 ± 0.57
Total SFAs		60.47
Monounsaturated Fatty Acids (MUFAs)		
12:1	Lauroleic Acid	14.57 ± 0.45
14:1	Tsuzuic Acid	2.00 ± 0.22
17:1	Civetic Acid	1.43 ± 0.21
16:1	Gaidic acid	1.69 ± 0.42
16:1	Palmitoleic Acid	7.56 ± 0.41
18:1	Oleic Acid	0.40 ± 0.51
	Total MUFAs	27.65
Polyunsaturated Fatty Acids (PUFAs)		
18:2	Linoleic Acid	2.88 ± 0.52
18:2	Linoelaidic Acid	4.33 ± 0.46
20:2	Eicosadienoic Acid	1.54 ± 0.61
Other PUFAs		2.79 ± 0.28
Total PUFAs		11.54

Results are in means of duplicate analysis ± SD.

4.7.4.3. *Coleoptera* sp. (Bwrbila fisa)

4.7.4.3.1 Biology of *Coleoptera* sp. (Bwrbila fisa)

The unidentified *Coleoptera* sp. (Bwrbila fisa) is a coleopteran beetle. Since its scientific name is not known it is referred to as *Coleoptera* sp. (Bwrbila fisa) throughout the study. The wings are reddish brown in colour and the body length of

the adults ranges from (20.5 – 20.8 mm) (Plate 4.17). The species is terrestrial and feeds on leaves of trees and shrubs. Little is known about its life cycle. They become abundant during the month of April to June and are collected for food by the locals. This species is favourably consumed by many and has its unique local name given by the consumers.

4.7.4.3.2 Taxonomy

The order, local and english name of *Coleoptera* sp. (Bwrbila. fisa) is represented below.

- Scientific Name ……...*Unidentified (Coleoptera)*
- Order …… Coleoptera
- Family ……Unidentified
- Local Name ……Bwrbila fisa
- English name ……Beetles

4.7.4.3.3 Proximate Composition

Data on the nutritional composition of *Coleoptera* sp. (Bwrbila fisa) is provided in (Table 4.75). The data reveal that *Coleoptera* sp. (Bwrbila fisa) has a high protein content of 72.56%. The species also possesses adequate amount of fats, ash and carbohydrates. A calorific value of 432.00 kCal/100g reflects its energy values.

Table 4.75 Proximate compositions of *Coleoptera* sp. (Bwrbila fisa) g/100g dry weight.

Sl.No	Proximates	Values
1	Moisture	2.35 ± 0.04
2	Total solids	97.65 ± 0.04
3	Ash	4.65 ± 0.02
4	Fat	12.00 ± 0.04
5	Protein	72.56 ± 0.03
6	Carbohydrate	8.44 ± 0.04
7	Calorific value kcal/100g	432.00 ± 0.03
8	Starch	0.27 ± 1.40
9	Dietary fibre	0.84 ± 2.01

Results are in mean of triplicate determinations ± SD.

4.7.4.3.4 Mineral Composition

Table 4.76 present the result of mineral element composition of *Coleoptera* sp. (Bwrbila fisa) in mg/100g dry matter and a comparision of the mineral contents with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.76 Among the micronutrients potassium can supplement about 25.11% and calcium about 2.85% of the DRI requirements in both males and females. Magnesium showed higher values of fulfillment in female than in males. Sodium content was found low. Among the micronutrients a highly surpassed fulfillment value of iron was seen in males than in females. Copper values too surpassed the recommended copper requirements in both males and females. Lower amounts of the recommended zinc requirement can be supplemented in males than in females. Phosphorus content in *Coleoptera* sp. (Bwrbila fisa) can meet nearly 96.34% of the recommended value. The percentage of RDA in *Coleoptera* sp. (Bwrbila fisa) show that it is a potent source of iron, copper and phosphorus.

Table 4.76 Recommended intake of essential minerals per day compared with *Coleoptera* sp. (Bwrbila fisa).

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Coleoptera* sp. (Bwrbila fisa) (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1180.53 ± 1.52	25.11	25.11
Sodium	1500	1500	199.6 ± 0.73	13.30	13.30
Calcium	1000	1000	28.5 ± 0.04	2.85	2.85
Magnesium	400	310	23.0 ± 0.03	5.75	7.41
Phosphorus	700	700	674.44 ± 2.11	96.34	96.34
Zinc	11	8	3.0 ± 0.003	27.27	37.5
Iron	8	18	84.0 ± 0.34	1050.00	466.66
Copper	0.9	0.9	1.5 ± 0.009	166.66	166.66

Results are in means of triplicate analysis ± SD.

4.7.4.3.5 Amino acid composition

The amino acid compositions of *Coleoptera* sp. (Bwrbila fisa) is shown in (Table 4.77). All essential amino acids were present in the species excluding threonine. Histidine and lysine constituted the main bulk of the essential amino acids. Of the non essential amino acids phosphoserine and aspartic acid constituted the bulk. Threonine was not detected in the sample. The ratio between non essential to essential amino acid was 1.01. The most abundant amino acid in the *Coleoptera* sp. (Bwrbila fisa) was phosphoserine.

Table 4.77 Amino acid composition g/100g of *Coleoptera* sp. (Bwrbila fisa).

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	14.95 ± 3.63	Threonine	ND
Aspartic acid	10.76 ± 1.30	Histidine	6.20 ± 0.99
Glutamic acid	2.93 ± 1.08	Tyrosine	5.89 ± 0.07
Amino adipic acid	8.75 ± 0.81	Valine	5.13 ± 0.44
Aspargine	2.60 ± 1.32	Methionine	4.50 ± 0.22
Alanine	4.65 ± 0.92	Tryphtophan	2.85 ± 0.73
Proline	1.80 ± 0.28	Phenylalanine	3.02 ± 0.73
Arginine	3.75 ± 0.60	Isoleucine	4.09 ± 0.10
Glycine	ND	Leucine	6.31 ± 0.28
Serine	ND	Lysine	7.14 ± 1.23
-	-	Cysteine	4.43 ± 1.03
Total non EAA	50.19	Total EAA	49.56

Results are in means of duplicate analysis ± SD.

Table 4.78 shows the amino acid scores of *Coleoptera* sp. (Bwrbila fisa). All of the amino acids with the exemption of leucine surpassed the recommendation given by FAO/WHO/UNU (1985). Leucine with an amino acid score of 95 was found to be the limiting amino acid in *Coleoptera* sp. (Bwrbila fisa).

Table 4.78 Amino acid score *Coleoptera* sp. (Bwrbila fisa) based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%) *Coleoptera* sp. (Bwrbila fisa)
Histidine	19	326
Isoleucine	28	146
Leucine	66	95
Lysine	58	123
Methionine + cysteine	25	357
Phenylalanine + tyrosine	63	141
Threonine	34	ND
Tryptophan	11	259
Valine	35	146
Amino acid score	-	95
Limiting amino acid	-	Leucine

4.7.4.3.6 Fatty acid

Coleoptera sp. (Bwrbila fisa) was found to be a rich source of PUFAs. The composition and concentration of fatty acid oil in *Coleoptera* sp. (Bwrbila fisa) is presented in Table 4.79. The Saturated fatty acid content was found to be 20.60%. The Unsaturated fatty acids including the monosaturated and polyunsaturated fatty acids constituted 79.28% of the total fatty acids. The SFAs UFAs ratio was found to be 0.25. *Coleoptera* sp. (Bwrbila fisa) contains 61.38% of poly unsaturated fatty acids.

Table 4.79 Fatty acid composition g/100g dry weight and % of total fatty acids of *Coleoptera* sp. (Bwrbila fisa).

Lipid numbers	Common names	% of total fatty acids
Saturated fatty acids (SFAs)		
8:0	Caprylic acid	0.90 ± 0.24
9:0	Pelargonic acid	4.41 ± 0.04

10:0	Capric acid	6.70 ± 0.57
18:0	Oleic acid	3.45 ± 0.67
15:0	Pentadecylic Acid	3.09 ± 0.31
19:0	Nonadecylic acid	2.05 ± 0.35
Total SFAs		20.60
Monounsaturated fatty acids (MUFAs)		
10:1	Obtisilic acid	1.35 ± 0.39
12:1	Lauroleic acid	2.28 ± 0.48
14:1	Tsuzuic acid	6.58 ± 0.01
14:1	Myristoleic acid	1.32 ± 0.43
16:1	Palmiteladic Acid	5.15 ± 0.34
20:1	Gadoleic acid	0.87 ± 0.27
24:1	Nervonic Acid	0.35 ± 0.22
Total MUFAs		17.90
Polyunsaturated fatty acids (PUFAs)		
18:2	Linoleic acid	1.97 ± 0.10
20:2	Eicosadienoic Acid	31.06 ± 0.37
20:3	Dihomo-α-linolenic Acid	17.20 ± 0.95
20:4	Arachidonic Acid	11.15 ± 0.35
Total PUFAs		61.38

Results are in means of duplicate analysis ± SD.

4.7.5 Order Isoptera

Termites are characterized by their pale elongated bodies, 2 pairs of membranous wings in reproductive casts, mandibulate mouthparts, a pair of short antenna and compounds. Isopterans live in colonies consisting of a queen, soldiers and workers. Termites take nuptial flights during warm humid nights for mating after which they shed their wings and develop new colonies that increase to over a million individuals (CSIRO 2007d).

4.7.5 *Macrotermes* sp.

4.7.5.1.1 Biology of *Macrotermes* sp.

Macrotermes sp. is a widely consumed food insect species. This species build their nest below the ground. The body length of the winged adults ranged between (8 -10mm) (Plate 4.18). For food they depend on cellulose of woody vegetations. *Macrotermes* sp. undergoes incomplete metamorphosis and most of the individuals remain as nymphs working as soldiers and workers.

4.7.5.1.2 Taxonomy

The taxonomic classification of *Macrotermes* sp. is represented below.

- Scientific Name …….. *Macrotermes* sp.
- Order ……Isoptera
- Family ……...Termitidae
- Local Name ……..Wuri
- English Name ……Termite

4.7.5.1.3 Proximate composition

Data on the nutritional composition of *Macrotermes* sp. is provided in Table 4.80. The data reveal that *Macrotermes* sp. has protein content of about 39.44%. The species also possesses good amount of fats 18.22%. A calorific value of 472.86 kcal/100g reflected the high energy value of this species

Table 4.80 Proximate compositions of *Macrotermes* sp. g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	2.91 ± 0.07
2	Total solids	97.07 ± 0.07
3	Ash	1.65 ± 0.01
4	Fat	18.22 ± 0.03
5	Protein	39.44 ± 0.02
6	Carbohydrate	37.78 ± 0.01
7	Calorific value (Kcal/100g)	472.86 ± 0.02
8	Starch	0.32 ± 1.02
9	Dietary fibre	0.83 ± 1.23

Results are in means of triplicate analysis ± SD.

4.7.5.1.4 Mineral Composition

A comparision of the mineral contents of *Macrotermes* sp. mg/100g dry weight with the provided recommended dietary allowance (RDA) (DRI 2004) for

both male and female human adults of age between 19 - 30 years is provided in Table 4.81. Potassium, sodium, calcium, magnesium and zinc content in this species can accomplish low amounts of RDA requirements in males as well as in females. Iron and copper content surpassed the requirement in males. The percentage of phosphorus content in this sample can fulfill 81.07% of RDA in both males and females. Collectively *Macrotermes* sp. can be regarded as a rich source of phosphorus, iron and copper.

Table 4.81 Recommended intake of essential minerals per day compared with *Macrotermes* sp.

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Macrotermes* sp. (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1160.00 ± 1.05	24.68	24.68
Sodium	1500	1500	224.00 ± 0.94	14.93	14.93
Calcium	1000	1000	30.0 ± 0.01	3.00	3.00
Magnesium	400	310	17.0 ± 0.05	4.25	5.48
Phosphorus	700	700	567.52 ± 2.01	81.07	81.07
Zinc	11	8	4.0 ± 0.007	36.36	50.00
Iron	8	18	16.5 ± 0.04	206.25	91.66
Copper	0.9	0.9	1.5 ± 0.006	166.66	166.66

Results are in means of duplicate analysis ± SD.

4.7.5.1.5 Amino acid composition

Table 4.82 contain the results of amino acid compositions of *Macrotermes* sp. Essential amino acids including threonine, tyrosine, valine and lysine formed the major bulks of essential amino acids. Tryptophan was the least abundant amino acid. Among the non essentials alanine, serine and taurine constituted the bulk. Alanine and valine were the most abundant among the essential and non essential amino acids respectively. Non essential amino acids amounted to a total of 33.44% of the total amino acid. Essential amino acids including cysteine constituted 66.49% of the total investigated amino acids.

Table 4.82 Amino acid composition g/100 g of *Macrotermes* sp.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	0.37 ± 0.04	Threonine	12.04 ± 0.57
Aspartic acid	0.42 ± 0.26	Histidine	8.38 ± 1.22
Serine	4.41 ± 0.14	Tyrosine	11.33 ± 0.28
Phosphoenolamine	1.09 ± 0.21	Valine	12.47 ± 0.48
Asparagine	0.28 ± 0.13	Methionine	ND
Taurine	6.31 ± 0.37	Tryphtophan	1.47 ± 0.14
Alanine	10.44 ± 0.28	Phenylalanine	1.74 ± 0.22
Proline	3.90 ± 0.27	Isoleucine	2.98 ± 0.28
Ornithine	2.38 ± 0.29	Leucine	6.94 ± 0.48
Glutamic acid	1.79 ± 0.19	Cysteine	ND
Carnosine	1.55 ± 0.20	Lysine	9.14 ± 0.36
Arginine	0.46 ± 0.25	-	-
Total non EAA	33.40	Total EAA	66.49

Results are in means of duplicate analysis ± SD.

Table 4.83 represents the amino acid scoring pattern of *Macrotermes* sp. All of the amino acids exceeded the recommendation given by FAO/WHO/UNU (1985).

Table 4.83 Amino acid score of *Macrotermes* sp. based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	441
Isoleucine	28	106
Leucine	66	105
Lysine	58	157
Methionine + cysteine	25	ND
Phenylalanine + tyrosine	63	206

Threonine	34	354
Tryptophan	11	133
Valine	35	356
Amino acid score	-	105
Limiting amino acid	-	

4.8.5.1.6 Fatty acid composition

The fatty acid profile of *Macrotermes* sp. is shown in (Table 4.84) Sebacic acid and capric acid formed the bulk among the SFAs. 54.36 % fraction of fatty acids were constituents of the total SFAs. MUFAs constituted 26.78% of the total fatty acid profiles. Lauroleic acid formed the major bulk of MUFAs. Linoleic acid formed the main portion of PUFAs. PUFAs investigated constituted 18.71% of the total fatty acid profile in *Macrotermes* sp. The SFA and UFA ratio was found to be 1.19.

Table 4.84 Fatty acid composition g/100g dry weight and % of total fatty acids of *Macrotermes* sp.

Lipid Numbers	Common Names	% of fatty acids
Saturated Fatty Acids (SFAs)		
3:0	Propionic Acid	0.65 ± 0.16
8:0	Caprylic Acid	0.92 ± 0.19
9:0	Pelargonic Acid	2.92 ± 0.16
10:0	Capric Acid	12.45 ± 0.28
10:0	Sebacic acid	17.36 ± 0.39
11:0	Undecylic Acid	10.00 ± 0.48
12:0	Lauric Acid	2.01 ± 0.14
16:0	Palmitic Acid	3.46 ± 0.54
18:0	Stearic Acid	3.52 ± 0.31
	Other SFAs	1.07 ± 0.38
	Total SFAs	54.36
Monounsaturated Fatty Acids (MUFAs)		
12:1	Lauroleic Acid	11.80 ± 0.62
14:1	Tsuzuic Acid	5.28 ± 0.53

16:1	Palmitoleic Acid	3.51 ± 0.21
18:1	Oleic acid	2.84 ± 0.55
	Other MUFAs	3.35 ± 0.39
	Total MUFAs	26.78
Polyunsaturated Fatty Acids (PUFAs)		
18:2	Linoleic acid	11.31 ± 0.52
18:3	Linoleneic acid	4.89 ± 0.46
20:4	Arachidonic Acid	0.89 ± 0.30
	Other PUFAs	1.62 ± 0.31
	Total PUFAs	18.71

Results are in means of duplicate analysis ± SD.

4.8.6. Order Araneae

Species of this order are called spiders and the species body characteristics include four pairs of legs**,** usually four pairs of eyes, two discernible body sections, spinnerets for spinning silk threads used for a variety of purposes such as the construction of webs, snares and retreats in which to live or to wrap prey, fangs to deliver venom and a pair of sensory palps. Feeding behavior is predatory and habitat strictly terrestrial.

4.7.6.1. *Nephila* sp.

4.7.6.1.1 Biology of *Nephila* sp.

Nephila sp. commonly called giant wood spider owing to its body size. Nephilas have striped legs for weaving. The body colour is contrasting with a mixture of black and yellow patterns (Plate 4.19). *Nephila* prefers open terrestrial habitats for building their web. Little is known about their life cycle.

4.7.6.1.2 Taxonomy

The order, family, local and English name of *Nephila* sp. is provided below.

- Scientific Name……. *Nephila sp*
- Order ……Araneae
- Family ……Nephilidae
- Local Name ……..Bema Raja
- English Name ……Giant Wood Spider

4.7.6.1.3 Proximate Composition

Data on the nutritional composition of *Nephila* sp. is provided in Table 4.85. The data reveal that *Nephila* sp. has a very high protein content of 84.56%. The species also possesses lower amount of fats and adequate amounts of ash and carbohydrates. A calorific value of 410.17 kcal/100g reflects its energy value.

Table 4.85 Proximate compositions of *Nephila* sp. g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	1.72 ± 0.03
2	Total solids	98.28 ± 0.03
3	Ash	1.02 ± 0.02
4	Fat	4.01 ± 0.02
5	Protein	84.56 ± 0.01
6	Carbohydrate	8.96 ± 0.04
7	Calorific value (Kcal/100g)	410.17 ± 0.02
8	Starch	0.16 ± 0.46
9	Dietary fibre	0.14 ± 1.83

Results are mean of triplicate determinations ± SD.

4.7.6.1.4 Mineral Composition

The mineral contents of *Nephila* sp. and a comparision of the mineral contents with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4. 86. Among the micronutrients potassium can supplement about 23.82%, sodium 21.18% and calcium about 2.75% of the DRI requirements in both males and females. Copper and iron had the potential to supplement surpassed amounts of the recommended copper and iron requirements in both males and females. Phosphorus content in *Nephila* sp. can meet about 95.50% of the recommended value. The percentage of RDA in *Nephila* sp. show that it is a potent source of zinc, iron, copper and phosphorus, magnesium and calcium.

Table 4.86 Recommended intake of essential minerals per day compared with *Nephila* sp.

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Nephila sp* (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1120.09 ± 2.30	23.82	23.82
Sodium	1500	1500	317.74 ± 0.88	21.18	21.18
Calcium	1000	1000	27.50 ± 0.02	2.75	2.75
Magnesium	400	310	21.50 ± 0.01	5.37	6.93
Phosphorus	700	700	668.52 ± 1.20	95.50	95.50
Zinc	11	8	3.00 ± 0.002	27.27	37.5
Iron	8	18	47.50 ± 0.05	593.75	263.88
Copper	0.9	0.9	1.00 ± 0.004	111.11	111.11

Results are in means of triplicate determinations ± SD.

4.7.6.1.5 Amino acid composition

Table 4.87 contains the result of amino acid compositions of *Nephila* sp. Amino acids including histidine, tyrosine and lysine formed the major bulks of essential amino acids. Phenylalanine, leucine and cysteine were not detected in the sample. Among the non essentials aspartic acid constituted the bulk. Non essential amino acids amounted to a total of 59.07% of the total amino acid. Essential amino acids constituted 40.82% of the total amino acids. The ratio between the non essential and essential amino acid was 1.44.

Table 4.87 Amino acid composition g/100g of *Nephila* sp.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	20.13 ± 1.47	Threonine	4.34 ± 0.49
Amino adipic acid	13.81 ± 0.77	Histidine	9.30 ± 0.72
Phosphoenolamine	12.71 ± 1.07	Tyrosine	6.84 ± 0.37
Phosphoserine	3.15 ± 0.29	Valine	4.75 ± 0.28
Anserine	0.28 ± 0.14	Methionine	3.27 ± 0.94

Serine	ND	Tryphtophan	0.96 ± 0.51
Alanine	ND	Phenylalanine	ND
Proline	1.18 ± 0.16	Isoleucine	4.42 ± 0.98
Ornithine	ND	Leucine	ND
Arginine	ND	Lysine	6.94 ± 0.41
Glycine	7.81 ± 0.60	Cysteine	ND
Total non EAA	59.07	Total EAA	40.82

Results are in means of duplicate analysis ± SD.

Table 4.88 represents the amino acid scoring pattern of *Nephila* sp. All of the amino acids surpassed the recommendation given by FAO/WHO/UNU (1985). The highest amino acid score was attained by valine.

Table 4.88 Amino acid score of *Nephila* sp. based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5 year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%) *Nephila* sp.
Histidine	19	ND
Isoleucine	28	ND
Leucine	66	ND
Lysine	58	110
Methionine + cysteine	25	121
Phenylalanine + tyrosine	63	212
Threonine	34	137
Tryptophan	11	295
Valine	35	372
Amino acid score	-	110
Limiting amino acid	-	-

4.7.6.1.6 Fatty acid composition

The fatty acid profile of *Nephila* sp. is shown in Table 4.89. Undecylic acid was detected in higher values among the SFAs. 57.62% fraction of fatty acids was constituents of the total SFAs. MUFAs constituted 16.81% of the total fatty acid profiles. Linoleic acid formed the major portion of PUFAs. PUFAs investigated

constituted 25.47% of the total fatty acid profile in *Nephila* sp. The SFA UFA ratio was to be 1.36.

Table 4.89 Fatty acid composition g/100g dry weight and % of total fatty acids of *Nephila* sp.

Lipid numbers	Common name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
8:0	Caprylic Acid	1.13 ± 0.29
10:0	Capric Acid	1.37 ± 0.11
11:0	Undecylic Acid	38.12 ± 2.49
12:0	Lauric acid	6.17 ± 0.55
15:0	Pentadecylic Acid	2.33 ± 0.11
17:0	Margaric Acid	2.79 ± 0.09
18:0	Stearic Acid	5.71 ± 0.28
	Total SFAs	57.62
Monounsaturated Fatty Acids (MUFAs)		
14:1	Myristoleic Acid	2.93 ± 0.35
14:1	Tsuzuic Acid	2.45 ± 0.38
16:1	Gaidic acid	2.45 ± 0.27
17:1	Civetic Acid	1.41 ± 0.19
	Other MUFAs	7.57 ± 0.48
	Total MUFAs	16.81
Polyunsaturated fatty acids (PUFAs)		
18:2	Linoleic Acid	14.20 ± 0.38
18:4	Stearidonic Acid	10.06 ± 0.53
	Other PUFAs	1.21 ± 0.52
	Total PUFAs	25.47

Results are in means of duplicate analysis ± SD.

4.7.7 Order Lepidoptera

Order Lepidoptera consists of moths and spiders. Tha adults bear two pairs of membranous wings while a few moths are wingless. Two large compound eyes and mouthparts with a sucking tube is present. The larvae undergoes complete

metamorphosis to develop into aduts. They live in terrestrial habitats and are mostly herbivores.

4.7.7.1 *Lepidoptera* sp. (Gunjet)

4.7.7.1.1 Biology of *Lepidoptera* sp. (Gunjet)

This Lepidopteran species is a pest of many valuable trees. For food this insect species is directly harvested from tree trunks or logs. This species will be referred by the name *Lepidoptera* sp. (Gunjet) in the following sections. Plate 4.20 represents the larvae or the consumable larvae stage of *Lepidoptera* sp. (Gunjet).

4.7.7.1.2 Taxonomy

A brief taxonomic classification of *Lepidoptera* sp. (Gunjet). is represented below.

Scientific Name ….. Unidentified (Lepidoptera)

Order …….. Lepidoptera

Family ……Unidentified

Local Name …….Gunjet

4.7.7.1.3 Proximate Composition

Data evaluated on the nutritional composition of *Lepidoptera* sp. (Gunjet) is provided in Table 4.90. The data revealed that the consumed larvae holds 37.13 % protein content and fat content as high as 33.91%. The proximate composition of this species reveals that this species is a rich source of fats with adequate amounts of protein content and carbohydrates.

Table 4.90 Proximate compositions of *Lepidoptera* sp. (Gunjet) g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	5.47 ± 0.04
2	Total solids	94.53 ± 0.04
3	Ash	0.92 ± 0.003
4	Fat	33.91 ± 0.02
5	Protein	37.13 ± 0.01
6	Carbohydrate	22.57 ± 0.04
7	Calorific value kcal/100g	543.99 ± 0.02
8	Starch	0.62 ± 0.98
9	Dietary fibre	0.26 ± 1.02

Results are in means of triplicate determinations ± SD.

4.7.7.1.4 Mineral Composition

Mineral composition of *Lepidoptera* sp. (Gunjet) and a comparison of the mineral contents of *Lepidoptera* sp. (Gunjet) with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.91. Calcium level was found to be exceedingly lower in this sample. Copper and iron values exceeded the DRI requirement values in males. In females 91.66% of iron requirement could be met. The percentage of RDA recorded show that *Lepidoptera* sp. (Gunjet) has the potential to supply the required amount of iron and copper to the consumers.

Table 4.91 Recommended intake of essential minerals per day compared with *Lepidoptera* sp. (Gunjet).

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Lepidoptera* sp. (Gunjet) (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1520.65 ± 2.00	32.35	32.35
Sodium	1500	1500	189.88 ± 0.63	12.65	12.65
Calcium	1000	1000	18.50 ± 0.04	1.85	1.85
Magnesium	400	310	32.00 ± 0.01	8.00	10.32
Phosphorus	700	700	596.04 ± 2.11	85.14	85.14
Zinc	11	8	4.00 ± 0.001	36.36	50.00
Iron	8	18	16.5 ± 0.07	206.25	91.66
Copper	0.9	0.9	4.5 ± 0.002	500.00	500.00

Results are in means of triplicate analysis ± SD.

4.7.7.1.5 Amino acid composition

The amino acid compositions of *Lepidoptera* sp. (Gunjet) is shown in Table 4.92. All amino acids were present in the species with leucine, isoleucine and lysine constituting the main essential amino acids. Of the non essential amino acids phosphoserine and glycine constituted the bulk. *Lepidoptera* sp. (Gunjet) contain adequate amounts of both non essential and essential amino acids in the ratio of 1.05.

Table 4.92 Amino acid composition g/100g dry matter of *Lepidoptera* sp. (Gunjet).

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	5.87 ± 0.24	Threonine	3.99 ± 0.26
Aspartic acid	4.49 ± 0.39	Histidine	4.99 ± 0.26
Serine	4.95 ± 0.33	Tyrosine	0.75 ± 0.08
Anserine	5.17 ± 0.31	Valine	4.62 ± 0.33
Glycine	5.36 ± 0.34	Methionine	2.75 ± 0.17
Asparagine	3.56 ± 0.48	Tryphtophan	0.98 ± 0.39
Taurine	1.56 ± 0.12	Phenylalanine	5.86 ± 0.46
Alanine	1.87 ± 0.29	Isoleucine	6.61 ± 0.50
OH Proline	3.90 ± 0.27	Leucine	8.15 ± 0.55
Proline	1.41 ± 0.26	Lysine	5.90 ± 1.02
Arginine	3.48 ± 2.29	Cysteine	4.47 ± 0.19
Glutamic acid	4.70 ± 0.33	-	-
Amino adipic acid	4.25 ± 0.43	-	-
Ornithine	0.52 ± 0.07	-	-
Total non EAA	51.07	Total EAA	49.07

Results are in means of duplicate analysis ± SD.

The amino acid scores of *Lepidoptera* sp. (Gunjet) is presented in Table 4.93 All of the amino acids excluding tryptophan surpassed the recommendation given by FAO/WHO/UNU (1985).

Table 4.93 Amino acid score *Lepidoptera* sp. (Gunjet) based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (1985) (mg/g protein)	Chemical score (%)
Histidine	19	262
Isoleucine	28	236
Leucine	66	123
Lysine	58	101
Methionine + cysteine	25	288
Phenylalanine + tyrosine	63	104

Threonine	34	117
Tryptophan	11	89
Valine	35	132
Amino acid score	-	89
Limiting amino acid	-	Tryptophan

4.7.7.1.6 Fatty acid composition

The fatty acid profile of *Lepidoptera* sp. (Gunjet) is shown in Table 4.94. Undecylic acid formed the main constituent of the SFAs. 49.50 % fraction of fatty acids was constituents of the total SFAs. 32.73% fraction of fatty acids was constituents of MUFAs. PUFAs investigated constituted 17.63% of the total fatty acid profile in *Lepidoptera* sp. (Gunjet). The SFA and UFA ratio in *Lepidoptera* sp. Gunjet was 0.98.

Table 4. 94 Fatty acid composition g/100g dry weight and % of total fatty acids of *Lepidoptera* sp. (Gunjet).

Lipid Numbers	Common Name	% of total fatty acids
Saturated Fatty Acids (SFAs)		
3:0	Propionic acid	0.71 ± 0.17
8:0	Caprylic Acid	0.67 ± 0.47
10:0	Capric Acid	8.23 ± 0.10
11:0	Undecylic Acid	24.77 ± 1.31
12:0	Lauric Acid	2.29 ± 0.36
13:0	Tridecylic Acid	8.65 ± 0.80
16:0	Palmitic Acid	3.05 ± 1.08
18:0	Stearic Acid	1.13 ± 0.79
	Total SFAs	49.50
Monounsaturated Fatty Acids (MUFAs)		
10:1	Obtusilic Acid	11.31 ± 0.95
10:1	Lauroleic Acid	3.55 ± 0.25
12:1	Lauroleic Acid	14.46 ± 0.43
16:1	Gaidic acid	2.06 ± 0.33
16:1	Palmitoleic Acid	0.45 ± 0.20

24:1	Nervonic Acid	0.9 ± 0.39
	Total MUFAs	32.73
Polyunsaturated Fatty Acids (PUFAs)		
18:2	Linoleic Acid	6.48 ± 0.91
20:4	Arachidonic Acid	11.15 ± 0.77
	Total PUFAs	17.63

Results are in means of duplicate analysis ± SD.

4.7.8 Order Odonata

Odonata encompasses brightly coloured fast flying insects called as dragon flies and damselflies. The nymphs spend their life underwater and emerged into winged adults after shedding their last nymphal skin. The body of the adult is characterized by a long and slender abdomen, large compound eyes, small antenna and two pairs of membranous wings. Nymphs of two odonata species are consumed by the Bodos (Plate 4.21 and Plate 4.22). The nymphs do not resemble the adults. This two species are designated as *Odonata* sp. (Garba fangthe) and *Odonata* sp. (Jujai mala) throughout the text in this study.

4.7.8.1 *Odonata* sp. (Garba fangthe)

4.7.8.1.1 Taxonomy

The order, family, local and English name of *Odonata* sp. (Garba fangthe) is presented below.

Scientific Name – *Unidentified (Odonata)*

Order …….. Odonata

Family ……Libellulidae

Local name…… Garba fangthe

English Name ……Dragonfly nymph

4.7.8.1.2 Proximate Composition

Data on the proximate nutritional composition of *Odonata* sp. (Garba fangthe) is provided in Table 4.95. The data reveal that its protein composition is as high as 76.75%. A lower fat content 4.53% was also observed in this species. Ash and carbohydrates were present in adequate amount. A calorific value of 395.77 kcal/100g reflects its energy value.

Table 4.95 Proximate compositions of *Odonata* sp. (Garba fangthe) g/100 g dry weight

Sl.No	Proximates	Values
1	Moisture	1.61 ± 0.06
2	Total solids	98.39 ± 0.06
3	Ash	5.11 ± 0.04
4	Fat	4.53 ± 0.02
5	Protein	76.75 ± 0.03
6	Carbohydrate	12.00 ± 0.05
7	Calorific value (Kcal/100g)	395.77 ± 0.03
8	Starch	0.21 ± 2.08
9	Dietary fibre	1.07 ± 1.22

Results are in means of triplicate determinations ± SD.

4.7.8.1.3 Mineral compositions

A comparison of the mineral contents of *Odonata* sp. (Garba fangthe) with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.96. The percent fulfillment of recommended intake for calcium, magnesium and zinc was found low. Potassium can fulfill about 35.95% of the DRI requirements. This species could supply adequate amounts 89.54% of phosphorus. Copper and iron values were exceedingly high and surpassed the RDA requirement values both in males as well as in females. The percentage of RDA recorded on the mineral composition of *Odonata* sp. (Garba fangthe) show that it is a potential source of iron and copper and is capable of supplying the required amount of iron, copper and phosphorus for health and nutrition to the consumers.

Table 4.96 Recommended intake of essential minerals per day compared with *Odonata* sp. (Garba fangthe).

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Odonata* sp. (Garba fangthe) (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1690.05 ± 2.04	35.95	35.95

Sodium	1500	1500	240.80 ± 0.55	16.05	16.05
Calcium	1000	1000	20.50 ± 0.03	2.05	2.05
Magnesium	400	310	22.0 ± 0.08	5.50	7.09
Phosphorus	700	700	626.78 ± 1.43	89.54	89.54
Zinc	11	8	0.50 ± 0.008	4.54	6.25
Iron	8	18	13.50 ± 0.01	168.75	75
Copper	0.9	0.9	2.00 ± 0.007	222.22	222.22

Results are in means of triplicate determinations ± SD.

4.7.8.1.5 Amino acid composition

The amino acid compositions of *Odonata* sp. (Garba fangthe) is shown in Table 4.97 All the essential amino acids except leucine were present in the species with threonine as the most abundant essential amino acids. Of the non essential amino acids aspartic acid was the most abundant.

Table.4.97 Amino acid composition of *Odonata* sp. (Garba fangthe) g/100 g dry weight.

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Aspartic acid	14.60 ± 1.44	Threonine	6.53 ± 0.42
Amino adipic acid	11.02 ± 1.53	Histidine	5.54 ± 0.97
Glutamic acid	6.21 ± 0.48	Tyrosine	4.44 ± 0.11
Glycine	2.41 ± 1.36	Valine	5.07 ±0.88
Aspargine	7.69 ± 0.30	Methionine	2.98 ± 1.01
Taurine	3.62 ± 0.53	Tryphtophan	2.29 ± 0.67
Phosphoserine	0.76 ± 0.30	Phenylalanine	3.41 ± 0.55
Proline	9.60 ± 0.23	Isoleucine	3.57 ± 0.26
Arginine	ND	Leucine	ND
Phosphoenolamine	2.87 ± 0.48	Lysine	5.54 ± 0.02
-	-	Cysteine	1.7 ± 0.31
Total non EAA	58.24	Total EAA	41.07

Results are in means of duplicate analysis ± SD.

The least amino acid score observed was that of lysine with the least amino acid score of (95%). Leucine remained undetected in the sample. The chemical score of histidine was recorded to be the highest and histidine was found to be the limiting amino acid in *Odonata* sp. (Garba fangthe).

Table 4.98 Amino acid score *Odonata* sp. (Garba fangthe) based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (2007) (mg/g protein)	Chemical score (%)
Histidine	19	291
Isoleucine	28	127
Leucine	66	ND
Lysine	58	95
Methionine + cysteine	25	187
Phenylalanine + tyrosine	63	124
Threonine	34	192
Tryptophan	11	200
Valine	35	144
Amino acid score	-	95
Limiting amino acid	-	Lysine

4.7.8.1.6 Fatty acid composition

The fatty acid profile of *Odonata* sp. (Garba fangthe) is presented in table 4.99. The SFAs content was found to be 50.62 %. The UFAs constituted 49.36 % of the total fatty acids. The SFAs UFAs ratio was found to be 1.02.

Table 4.99 Fatty acid composition g/100 g dry weight and % of total fatty acids of *Odonata* sp. (Garba fangthe).

Lipid numbers	Common names	% of total fatty acids
Saturated fatty acids (SFAs)		
5:0	Valerianic Acid	0.54 ± 0.23
8:0	Caprylic Acid	6.75 ± 0.38
10:0	Capric Acid	2.42 ± 0.66

11:0	Undecylic Acid	29.13 ± 0.24
	Lauric Acid	8.57 ± 1.68
14:0	Myristic Acid	1.60 ± 1.21
17:0	Margaric Acid	0.87 ± 0.07
19:0	Nonadecylic Acid	0.73 ± 0.516
	Total SFAs	50.62
Monounsaturated Fatty Acids (MUFAs)		
10:1	Caproleic Acid	1.83 ± 0.02
10:1	Obtusilic Acid	1.42 ± 0.09
12:1	Linderic Acid	1.17 ± 0.07
12:1	Lauroleic Acid	1.19 ± 0.19
14:1	Tsuzuic Acid	2.58 ± 0.20
18:1	Oleic Acid	8.65 ± 3.09
17:1	Civetic Acid	1.84 ± 0.70
	Other MUFAs	5.92 ± 3.03
Total MUFAs		24.60
Polyunsaturated Fatty acids (PUFAs)		
18:2	Linoleic Acid	12.76 ± 0.18
20:4	Arachidonic Acid	9.34 ± 1.43
	Other PUFAs	2.66 ± 0.35
	Total	24.76

Results are in means of duplicate analysis ± SD

4.7.8.2 *Odonata* sp. (Jujai mala)

4.7.8.2.1 Taxonomy

Scientific Name – *Unidentified (Odonata)*

Order ……. Odonata

Family …… Unidentified

Local name …….. Jujai mala

English Name ……. Unidentified

4.7.8.2.3 Proximate Composition

Data on the proximate nutritional composition of *Odonata* sp. (Jujai mala) is provided in Table 4.100. The data reveal that *Odonata* sp. (Jujai mala) has remarkable protein content as high as 82.31%. A calorific value of 418.18 k cal/100g reflects its high energy value.

Table 4.100 Proximate compositions of *Odonata* sp. (Jujai mala) g/100g dry weight

Sl.No	Proximates	Values
1	Moisture	2.61 ± 0.04
2	Total solids	97.39 ± 0.04
3	Ash	3.92 ± 0.02
4	Fat	8.86 ± 0.04
5	Protein	82.31 ± 0.04
6	Carbohydrate	2.30 ± 0.01
7	Calorific value k cal/100g	418.18 ± 0.03
8	Starch	0.26 ± 0.89
9	Dietary fibre	0.62 ± 1.12

Results are in means of triplicate determinations ± SD.

4.7.8.2.4 Mineral Composition

A comparison of the mineral contents mg/100g dry matter of *Odonata* sp. (Jujai mala) with the provided recommended dietary allowance (RDA) (DRI 2004) for both male and female human adults of age between 19 - 30 years is provided in Table 4.101. Calcium in *Odonata* sp. (Jujai mala) can supplement lower amount 2% of the RDA requirements in males. Phosphorus can compensate above 90% of the requirement in males as well in females. The species can also provide 72.22% of RDA iron requirement in females but surpassed the quantity of RDA iron requirements in males. Copper content surpassed the RDA requirement in males as well in females. These results show that the *Odonata* sp. (Jujai mala) has the potential to supply the required amount of iron, copper and phosphorus for health and nutrition through diet to the consumers.

Table 4.101 Recommended intake of essential minerals per day compared with *Odonata* sp. (Jujai mala).

Mineral	Intake recommended for 25 year old Adults (mg per day)		*Odonata* sp. (Jujai mala) (mg per 100 g dry weight)	% fulfillment of recommended intake	
	Male	Female		Male	Female
Potassium	4700	4700	1290.86 ± 2.11	27.46	27.46
Sodium	1500	1500	267.3 ± 0.62	17.82	17.82
Calcium	1000	1000	20.00 ± 0.02	2.00	2.00
Magnesium	400	310	25.00 ± 0.07	6.25	8.06
Phosphorus	700	700	644.28 ± 3.22	92.04	92.04
Zinc	11	8	0.50 ± 0.008	6.25	6.25
Iron	8	18	13.00 ± 0.03	162.5	72.22
Copper	0.9	0.9	1.50 ± 0.008	166.66	166.66

Results are in means of triplicate analysis ± SD.

4.7.8.2.5 Amino Acid Composition

The amino acid compositions of *Odonata* sp. (Jujai mala) is shown in Table 4.102 All the essential amino acids excluding phenylalanine were present in the species with histidine, lysine, tyrosine and leucine constituting the main essential amino acids. Of the non essential amino acids taurine, carnosine and arginine constituted the bulk. The ratio between the non essential and essential amino acids was 0.70.

Table 4. 102 Amino acid composition g/100g of the *Odonata* sp. (Jujai mala).

Non Essential Amino Acids	% Total Amino Acids	Essential Amino Acids	% Total Amino Acids
Phosphoserine	0.33 ±0.22	Threonine	6.58 ± 0.05
Aspartic acid	0.23 ± 0.13	Histidine	8.57 ± 0.47
Serine	5.51 ± 0.26	Tyrosine	7.64 ± 2.22
Glycine	4.68 ± 0.10	Valine	5.22 ± 0.72
Arginine	6.63 ± 0.09	Methionine	2.78 ± 0.43
Taurine	8.39 ± 0.03	Tryphtophan	3.65 ± 0.17
Asparagine	5.21 ± 0.36	Phenylalanine	ND

Ornithine	1.43 ± 0.62	Isoleucine	6.22 ± 0.21
Carnosine	7.76 ± 0.73	Leucine	7.36 ± 0.83
Amino adipic acid	1.22 ± 0.09	Lysine	8.51 ± 0.57
Glutamic acid	ND	Cysteine	2.02 ± 0.42
Total non EAA	41.39	Total EAA	58.55

Values are in means of duplicate analysis ± SD.

Table 4.103 Amino acid score of *Odonata* sp. (Jujai mala) based on FAO/WHO/UNU (1985) consultation pattern of requirement for a 2 – 5year preschool child.

Amino acids	FAO/WHO/UNU (2007) (mg/g protein)	Chemical score (%)
Histidine	19	451
Isoleucine	28	222
Leucine	66	111
Lysine	58	146
Methionine + cysteine	25	192
Phenylalanine + tyrosine	63	121
Threonine	34	193
Tryptophan	11	331
Valine	35	149
Amino acid score	-	111
Limiting amino acid	-	-

4.7.8.2.6 Fatty acids

The fatty acid profile of *Odonata* sp. (Jujai mala) is shown in Table 4.104. Capric acid and propionic acid formed the bulk of the total 42.61% Saturated Fatty Acids SFAs. MUFAs constituted 29.38% of the total fatty acid profiles. Tsuzuic acid formed the major bulk of MUFAs. Linoleic acid formed the main portion of PUFAs. PUFAs investigated constituted 27.23% of the total fatty acid profile in *Odonata* sp. (Jujai mala).

Table 4.104 Fatty acid composition g/100 g dry weight and % of total fatty acids of *Odonata* sp. (Jujai mala).

Lipid numbers	Common name	% of fatty acids
Saturated fatty acids (SFAs)		
3:0	Propionic acid	12.8 ± 2.12
10:0	Capric Acid	17.35 ± 1.93
12:0	Lauric Acid	1.18 ± 0.26
14:0	Myristic Acid	7.57 ±1.18
15:0	Pentadecylic Acid	2.22 ± 0.84
19:0	Nonadecylic Acid	1.49 ± 0.35
Total SFAs		42.61
Monounsaturated fatty Acids (MUFAs)		
10:1	Obtusilic Acid	2.09 ± 0.90
10:1	Caproleic Acid	2.93 ± 0.26
14:1	Myristoleic Acid	4.37 ± 0.96
14:1	Tsuzuic Acid	4.81 ± 0.79
16:1	Palmitoleic Acid	4.05 ± 0.65
17:1	Civetic Acid	2.62 ± 0.49
Other MUFAs		8.51 ± 0.63
Total MUFAs		29.38
Polyunsaturated fatty acids (PUFAs)		
18:2	Linoleic Acid	8.88 ± 1.11
Other PUFAs		18.35 ± 1.27
Total PUFAs		27.23

Values are in means of duplicate analysis ± SD.

4.8. Biochemical Evaluation

4.8.1 Growth performance in rats

Data relative to food ingestion, weight gain and Protein Efficiency Ratio PER of the control casein, basal, test sample diet fed animals are depicted in Table 4.105. The rats kept on the protein free diet (Basal diet) showed decreased food intake towards the end of the feeding period. In contrast, rats kept on the other diets showed normal food intake all throughout the feeding period. An increased growth rate >10.0g per week was observed in *R. Baleyi* and *C. tripunctatus* fed diets during

the course of the feeding period. There were no significant differences between the control fed casein diet and the four test diet fed animals during the 14 days feeding period whereas significant ($p < 0.05$) decrease were seen in the growth performance of rat fed the basal diet for 28 days.

Table 4.105 Feed and protein intake evaluation data for fourteen and twenty eight days.

Fourteen days					
Sample	Feed intake (g)	Protein intake (g)	Weight gain (g)	PER	PER % of casein
LI	78.28 ± 13.22	7.82 ± 1.32	10.36 ± 3.65	1.34 ± 0.47	87.88 ± 41.47
RB	88.49 ± 16.89	8.84 ± 1.68	12.66 ± 5.50	1.42 ± 0.52	90.19 ± 27.78
CT	89.8 ± 5.50	8.97 ± 0.54	14.06 ± 2.23	1.37 ± 0.59	89.10 ± 47.24
OS	81.91 ± 5.66	8.18 ± 0.56	10.66 ± 1.09	1.55 ± 0.42	96.00 ± 32.21
Casein	87.79 ± 11.84	8.77 ± 1.18	10.71 ± 2.55	1.57 ± 0.61	100.00 ± 0.00
Basal	73.63 ± 11.25	-	-6.85 ± 1.61	-	-
Twenty Eight Days					
LI	87.50 ± 1.59	8.76 ± 0.16	9.28 ± 1.26	1.05 ± 0.14*	64.56 ± 5.63*
RB	89.468 ± 6.21	8.93 ± 0.62	11.26 ±3.14	1.24 ± 0.28	75.86 ± 16.57*
CT	89.254 ± 3.74	8.92 ± 0.37	11.42 ± 0.99*	1.40 ± 0.16	86.15 ± 8.53*
OS	84.256 ± 4.16	8.42 ± 0.41	9.72 ± 0.71	1.28 ± 0.13*	78.92 ± 8.14*
Casein	90.61 ± 6.422	9.06 ± 0.64	9.81 ± 0.82	1.53 ± 0.12	100.00 ± 0.00
Basal	83.66 ± 3.75		-5.86 ± 0.97		-

Values are in means ± SD (*n* = 5 in each group). Values with the asterisk (*) superscripts are significant at P< 0.05.

The Net Protein Retention (NPR), Biological Value (BV), True Digestibility (TD) and Net Protein Utilization (NPU) of the animals fed different diets are shown in Table 4.106. The biological value, true digestibility and net protein utilization were all significantly ($p<0.05$) higher in casein fed rats than that of the test diets during the 14 days feeding regime. The net protein retention values were not significant at ($p < 0.05$). The NPU values of the test diets were not significant ($p < 0.05$) for the 28 days fed diet except *L.indicus*. The NPR, BV, TD and NPU values of *R. Baleyi* were not significant ($p < 0.05$) to the control.

Table 4.106 Protein quality evaluation data for fourteen and twenty eight days

Fourteen days				
Sample	NPR	BV	TD	NPU
LI	2.59 ± 0.86	76.8 ± 4.60*	88.8 ± 1.78*	67 ± 5.58*
RB	2.98 ± 1.11	84.0 ± 2.0*	90.6 ± 0.54*	75 ± 2.50*
CT	2.37 ± 0.93	85.0 ± 2.23*	90.8 ± 0.44*	76 ± 2.68*
OS	2.69 ± 0.65	84.6 ± 1.51*	93.4 ± 0.54*	78 ± 1.51*
Casein	2.59 ± 0.64	88.8 ± 1.09	95.4 ± 0.55	88 ±1.30
Basal	-	-	-	-
Twenty eight days				
LI	2.10 ± 0.25	83.2 ± 2.28*	92.6 ± 1.51*	76.6 ± 2.70*
RB	2.24 ± 0.30	85.8 ± 5.16	92 ± 3.27	79.2 ± 7.98
DM	2.31 ± 0.37	84.0 ± 4.94*	91.4 ± 3.20*	76.4 ± 6.84
OS	2.33 ± 0.12	85.4 ± 2.60*	91.6 ± 1.34*	77.6 ± 3.36
Casein	2.39 ± 0.40	89.8 ± 1.48	95.0 ± 0.70	81.2 ± 2.16
Basal	-	-	-	-

Values are in means ± SD (n = 5 in each group). Values with the asterisk (*) superscripts are significant at P< 0.05.

4.8.2 Organ Weights

Table 4.107 shows the relative organ weights of animals fed the casein, basal and different test diets 14 and 28 days. No apparent differences were observed in the organ weights of the animals fed on casein and test diets thus indicating no gross deformities due to the consumption of the test diets (Ekpo 2011). Whereas animals fed on the protein free basal diet showed significant decrease in the relative organ weights in comparison to the reference casein diet fed animals towards the twenty eight day feeding periods. The relative organ weights of the animals fed the diets for 14 days were comparable to that of the reference casein diet fed animals. Relative organ weights of most of the test diet animals were not significant to the control except the values represented with asterisk superscripts showed significance (P < 0.05) to the control.

Table 4.107 Organ weights (g) of control and experimental animals at the end of fourteen days and twenty eight days.

Fourteen Days						
Organs	Liver	Spleen	Kidney	Heart	Testis	Brain
LI	3.10 ± 0.09	0.25 ± 0.05	0.25 ± 0.01	0.33 ± 0.04	0.32 ± 0.02*	0.86 ± 0.03
RB	3.18 ± 0.48	0.23 ± 0.04	0.26 ± 0.02*	0.35 ± 0.03	0.35 ± 0.02	0.88 ± 0.03
CT	3.91 ± 0.09*	0.18 ± 0.01*	0.25 ± 0.01	0.35 ± 0.008	0.33 ± 0.03	0.84 ± 0.03*
OS	3.23 ± 0.26	0.26 ± 0.01	0.24 ± 0.02	0.34 ± 0.01*	0.32 ± 0.01*	0.84 ± 0.008*
Casein	3.49 ± 0.40	0.26 ± 0.01	0.23 ± 0.02	0.36 ± 0.01	0.35 ± 0.01	0.89 ± 0.01
Basal	3.41 ± 0.13	0.24 ± 0.01	0.19 ± 0.02*	0.36 ± 0.01	0.36 ± 0.03	0.87 ± 0.02
Twenty Eight Days						
LI	4.94 ± 0.36	0.42 ± 0.04	0.51 ± 0.08*	0.44 ± 0.06*	0.59 ± 0.08	1.13 ± 0.08*
RB	3.88 ± 0.35*	0.32 ± 0.05*	0.62 ± 0.12	0.39 ± 0.02*	0.46 ± 0.08*	0.85 ± 0.07
CT	4.52 ± 0.45	0.28 ± 0.04*	0.58 ± 0.05*	0.39 ± 0.04*	0.43 ± 0.05*	0.86 ± 0.10
OS	4.95 ± 0.39	0.39 ± 0.02	0.58 ± 0.04*	0.40 ± 0.06*	0.50 ± 0.15	0.87 ± 0.04
Casein	4.59 ± 0.25	0.41 ± 0.04	0.69 ± 0.05	0.52 ± 0.04	0.66 ± 0.05	0.91 ± 0.04
Basal	2.72 ± 0.48*	0.32 ± 0.02*	0.57 ± 0.05	0.41 ± 0.07*	0.51 ± 0.04*	0.75 ± 0.11*

Values are in means ± SD (n = 5 in each group). Values with the asterisk (*) superscripts are significant at $P < 0.05$.

4.8.3 Biochemical parameters

4.8.3.1 Hepatic indices

There was significant ($P < 0.05$) decrease in the levels of AST fed the test diets *R. Baleyi* and *C. tripunctatus* in the 28 days feeding period. Significant ($P < 0.05$) increase in ALT activity was observed in *C.tripunctatus* in the 14 days feeding period. Besides the basal diet fed rat, the ALT and ALP levels were not significantly different from the control (Table 4.108).

Table 4.108 The activities of liver function enzymes in rats fed different diets for fourteen and twenty eight days.

Fourteen Days				
Sample	AST (UL^{-1})	ALT (UL^{-1})	ALP (UL^{-1})	GGT (UL^{-1})
LI	39.51 ± 2.75	35.20 ± 8.16	63.40 ± 3.38	29.84 ± 5.17
RB	40.92± 11.51	25.67 ± 9.52	60.09 ± 12.95	23.50 ± 7.07*

CT	29.73 ± 10.27	24.22 ± 8.30*	106 .88 ± 31.34*	35.34 ± 20.78
OS	46.49 ± 7.34	26.41 ± 8.41	61.20 ± 3.59*	23.85 ± 2.40*
Casein	35.61 ± 8.52	35.64 ± 5.14	66 .72 ± 3.02	32.69 ± 6.03
Basal	49.98 ± 8.56*	41.90 ± 2.75*	73.88 ± 5.29*	34.05 ± 3.59
Twenty Eight Days				
LI	34.01 ± 10.42	54.14 ± 10.43	106.85 ± 18.90	28.92 ± 5.40*
RB	28.99 ± 11.23*	51.49 ± 14.69	93.73 ± 10.89	17.37 ± 4.33
CT	26.73 ± 7.71*	49.49 ± 10.31	95.94 ± 20.76	21. 30 ± 6.32
OS	32.82 ± 11.21	57.17 ± 8.05	116.89 ± 6.03	16.67 ± 4.82*
Casein	41.20 ± 2.92	58.87 ± 6.15	108.97 ± 21.19	24.08 ± 2.22
Basal	26.19 ± 6.65*	43.73 ± 9.87*	84.32 ± 11.99*	18.06 ± 2.40

Values are mean ± SD (n = 5 in each group). The values with the asterisk (*) superscripts are significant ($P < 0.05$).

4.8.3.2 Renal indices

The decrease in the serum proteins, Serum Urea and Blood Urea Nitrogen (BUN) were significant ($P < 0.05$) in *L. indicus* fed test diets for the 14 days and *C. tripunctatus* fed diet for the 28 days. The basal or non protein fed group showed significant ($P < 0.05$) decrease towards the end of the 28 days feeding period.

Table 4. 109 The activities of renal function enzymes in rats fed different diets for fourteen and twenty eight days.

Fourteen Days			
Sample	Total serum proteins (gdL^{-1})	Urea ($mg\ dL^{-1}$)	BUN ($mg\ dL^{-1}$)
LI	4.59 ± 0.37*	33.39 ± 3.53*	15.59 ± 1.65*
RB	4.33 ± 1.00	25.81 ± 1.75	12.05 ± 0.81
CT	3.25 ± 0.59*	23.10 ± 3.84	10.79 ± 1.79
OS	4.96 ± 0.44	24.69 ± 8.93	11.53 ± 4.17
Casein	5.53 ± 0.72	25.96 ± 4.98	12.12 ± 2.33
Basal	2.89 ± 0.64*	20.96 ± 5.72	9.79 ± 2.68
Twenty Eight Days			
Sample	Total serum proteins (g/dL)	Urea (mg dL−1)	BUN (mg/dL)
LI	4.90 ± 0.42	29.61 ± 3.32	13.95 ± 1.55

RB	5.03 ± 0.52	28.89 ± 4.06	13.36 ±1.89
CT	3.47 ± 0.43*	23.43 ± 3.29*	10.93 ±1.53*
OS	4.92 ± 0.59	27.42 ± 1.95	12.79 ± 0.91
Casein	5.39 ± 0.79	29.03 ± 1.93	13.55 ±0.90
Basal	3.23 ± 1.02*	23.13 ± 2.97*	10.80 ±1.38*

Values are mean ± SD (*n* = 5 in each group). Values with the asterisk (*) superscripts are significant at $P < 0.05$.

4.8.3.3 Serum Cholesterol

The decreases in serum cholesterol level were not significantly different from the control while significant ($P < 0.05$) decreases in Low Density lipoproteins (LDL) were observed in *L. indicus* and *O. smaragdina* fed animals for 14 days. In the basal diet fed rats significant ($P < 0.05$) decreases in total cholesterol, triglycerides and LDL levels were observed. Among animals fed the diet for 28 days significant ($P < 0.05$) increase in HDL level was observed in *O. smaragdina* diet fed animals and significant ($P < 0.05$) decrease in HDL level was seen in basal diet fed animals.

Table 4. 110 Serum cholesterol levels of rats fed different diets for 14 and 28 days.

Fourteen Days				
Sample	Total cholesterol (mg dL^{-1})	Triglycerides (mg dL^{-1})	HDL (mg dL^{-1})	LDL (mg dL^{-1})
LI	97.94 ± 15.69	56.92 ± 8.40	18.05 ± 2.55	68.48 ± 14.18*
RB	105.11 ± 19.62	59.59 ± 6.58	16.17 ± 1.81	76.94 ± 18.43
CT	111.17 ± 16.71	60.06 ± 5.29	20.19 ± 4.97	78.97 ± 14.98
OS	104.97 ± 13.29	72.46 ± 17.27	19.76 ± 4.35	70.72 ± 12.50*
Casein	113.91 ± 8.87	64.89 ± 10.66	16.46 ± 1.44	85.30 ± 6.49
Basal	97.64 ± 3.19*	91.49 ± 6.78*	19.11 ± 3.47	60.24 ± 5.15*
Twenty Eight Days				
LI	88.95 ± 5.01	64.52 ± 9.75	25.86 ± 4.19	50.32 ± 6.49
RB	86.96 ± 11.34	57.57 ± 5.06	22.97 ± 5.07	52.48 ± 14.21
CT	89.15 ± 2.49	60.58 ± 7.24	17.89 ± 1.79	59.15 ± 3.69

OS	72.76 ± 5.33	52.74 ± 8.01	26.41 ± 3.81*	35.81 ± 4.31
Casein	79.95 ± 10.09	56.68 ± 4.96	21.21 ± 3.65	47.40 ±11.55
Basal	76.46 ± 6.69	46.76 ± 22.69	13.58 ± 2.41*	53.52 ± 4.30

Values are in means ± SD (*n* = 5 in each group). Values with the asterisk (*) superscripts are significant at P < 0.05.

4.8.3.4 Haematological indices

Significant increase (P < 0.05) in the Haemoglobin (Hb) and Mean Corpuscular Haemaglobin (MCH) were observed in *L.indicus* fed diet for the 14 days. The animals fed the basal diet showed significant decreases (P < 0.05) in four haematological parameters (Table 4.111 and Table 4.112). Significant decrease (P < 0.05) in platelets count in all the test diet fed rats were examined in groups fed 28 days period. There were no significant differences in the Red Blood Cells (RBC) count in all the rats fed different test diet and the control within the 28 days period. The Mean Corpuscular Volume (MCV fL) and Mean Corpuscular Haemoglobin Concentrations (MCHC gdL^{-1}) values of all the the four test diets were not statiscally significant at P< 0.05 for the 14 days feeding period. A significant decrease in the MCV (fL) was observed in *C. tripunctatus* towards the 28 days feeding period. The Packed Cell Volume (PCV%) of *R. baleyi* and *C. tripunctatus* were not significantly different from that of the standard casein diet in the 14 days feeding period. But significant decrease in PCV% was seen in *C. tripunctatus* fed the test diets for 28 days. Significant decrease in the White Blood Cell (WBC) count were found in *R. Baleyi* during the 14 days feeding period whereas comparable values for *R. Baleyi* were obtained towards the 28 days feeding regime. On the contrary significant differences were observed in *C. tripunctatus* and *O. smaragdina* fed diet rats towards the 28 days.

4.9 Histological studies

Histological studies of animal organs fed the test diets for the fourteen and twenty days period revealed that the liver, kidney, testis and spleen had no relative differences to those of the control. Mild cellular infiltrates and necrosis were observed in rats fed the protein free basal diet. Histological observations showed no evidence of toxicity in the test samples.

Table.4.111 Haematological indices in Rats Fed Different Diets for 14 days

Parameters	LI	RB	CT	OS	Casein	Basal
PCV (%)	41.36 ± 3.32*	44.15 ± 2.84	41.19 ± 5.33	40.20 ± 3.49*	46.56 ± 3.11	44.15 ± 7.31
Hb (g/dL)	13.2 ± 0.44*	12.1 ± 0.41	12.8 ± 0.27*	12.1 ± 0.41	12.2 ± 0.57	11.3 ± 0.57*
RBC(million/mm^3)	4.39 ± 0.55*	5.73 ± 0.83	5.17 ± 0.22*	5.38 ± 0.74	6.05 ± 0.40	4.54 ± 0.38
WBC (thousands/mm^3)	5.65 ± 0.64	5.24 ± 0.51*	5.62 ± 0.52	6.47 ± 0.48	6.10 ± 0.64	4.82 ± 0.59*
Platelets (cells x 10^9/L)	152.25 ± 10.96	161.26 ± 4.70	162.69 ± 7.02	157.30 ± 6.97	158.23 ± 5.93	154.81 ± 7.14
MCV (fL)	75.29±12.33	78.6±14.33	79.53±12.37	75.63±10.63	74.04±8.53	97.72±17.74*
MCH (pg)	30.39 ± 3.43*	21.52 ± 3.86	24.95 ± 2.73*	22.78 ± 2.87	20.18 ± 1.06	25.04 ± 2.62*
MCHC (gdL^{-1})	30.04 ± 2.43	27.48 ± 1.73	31.49 ± 4.18	30.27 ± 2.87	27.51 ± 2.98	26.43 ± 6.53

Table.4.112 Haematological indices in Rats Fed Different Diets for 28 days

Parameters	LI	RB	CT	OS	Casein	Basal
PCV (%)	42.58 ± 2.90	41.26 ± 6.62	39.47 ± 2.98*	43.24 ± 2.16	45.69 ± 3.64	41.79 ± 7.25
Hb (g/dL)	12.60 ± 0.41	12.60 ± 0.65	12.2 ± 1.15	11.1 ± 0.65*	12.9 ± 0.65	10.3 ± 0.75*
RBC(million/mm^3)	6.19 ± 0.48	5.84 ± 0.59	6.22 ± 0.49	5.34 ± 0.63	6.08 ± 0.49	4.89 ± 0.91*
WBC (thousands/mm^3)	5.89 ± 1.42	6.18 ± 1.27	3.94 ± 0.47*	4.41 ± 0.75*	5.42 ± 0.69	4.51 ± 0.66*
Platelets (cells x 10^9/L)	158.61 ± 5.38*	144.91 ± 11.62*	156.48 ±7.23*	153.54 ± 6.30*	172.36 ± 6.41	143.49 ± 8.42*
MCV (fL)	69.43±8.03	70.92±11.94	63.76±7.18*	85.95±11.81	75.32 ± 6.60	88.93±25.45
MCH (pg)	20.41 ± 0.95	21.66 ± 1.10	19.58 ± 0.88*	20.89 ± 1.37	21.24 ± 0.71	21.79 ± 5.21
MCHC (gdL^{-1})	30.3 ± 0.75	31.23 ± 5.57	31.1 ± 4.41	25.72 ± 2.12	28.33 ± 2.13	25.26 ± 4.87

Values are mean ± SD (*n* = 5 in each group). The superscripts asterisk * are significant at P < 0.05. LI – *Lethocerus indicus* RB – *Ruspoliya Baleyi* CT – *Cybister tripunctatus* OS - *Oecophylla smaragdina*

4.9 Histological studies

Histological studies of animal organs fed the test diets for the fourteen and twenty eight days period revealed that the liver, kidney, testis and spleen had no relative differences to those of the control. Mild cellular infiltrates and necrosis were observed in rats fed the protein free basal diet. Histological observations showed no evidence of toxicity in the test samples.

Pictomicrographs of the haematoxylin and eosin stained sections of liver, testis, kidney and spleen of rats fed the casein diet (control), test diets are presented in Plate 4.23, 4.24, 4.25 and 4.26. The different abbreviated capital letters indicate different portions of the sectioned organs. Liver section of the control and test animals showed normal hepatic cells with well-preserved cytoplasm, prominent nucleus, nucleolus and visible central veins. Liver sections of basal diet fed rats for 28 days showed mild necrosis and cellular infiltration.Light microscopic examinations of the kidneys of the test animals from control showed no structural alterations in renal tissues (Plate 4.24). The proximal tubules showed complete viable cells without any signs of initial cellular degenerations. The testicular sections of the control, basal and test diet represent normal histoarchitecture consisting of uniform and well structured seminiferous tubules with absolute spermatogenesis and normal interstitial connective tissues. The architecture of the red pulp, white pulp and their cells appeared normal with well stained nucleus. A summary result of diagnosis of various histological observations in liver, kidney, spleen and testis in animals fed the test, casein and basal diet are listed in (Table 4.10). The results of different diagnosis are specified as the percentage of normal animals, with the number of animals in parentheses.

Table. 4.113 Histological findings in various organs of rats fed different diets.

Organs	Diagnosis	LI	RB	CT	OS	Casein	Basal
1. Liver	Normal Mild Necrosis Cellular infiltrates Fatty liver	90 (10) 0 1 0	100 (10) 0 0 0	100 (10) 0 0 0	100(10) 0 0 0	100 (10) 0 0 0	90(10) 1 1 0
2. Kidney	Normal Degenerated tubules Hypercellularity Congestions	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0

	Cellular cast	0	0	0	0	0	0
3. Testis	Normal Degenerated tubules Decreased germ cells	100 (10) 0 0	100 (10) 0 0	100 (10) 0 0	100 (10) 0 0	100 (10) 0 0	100 (10) 0 0
4. Spleen	Normal Fibrosis Proliferations Vacuolations	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0	100 (10) 0 0 0

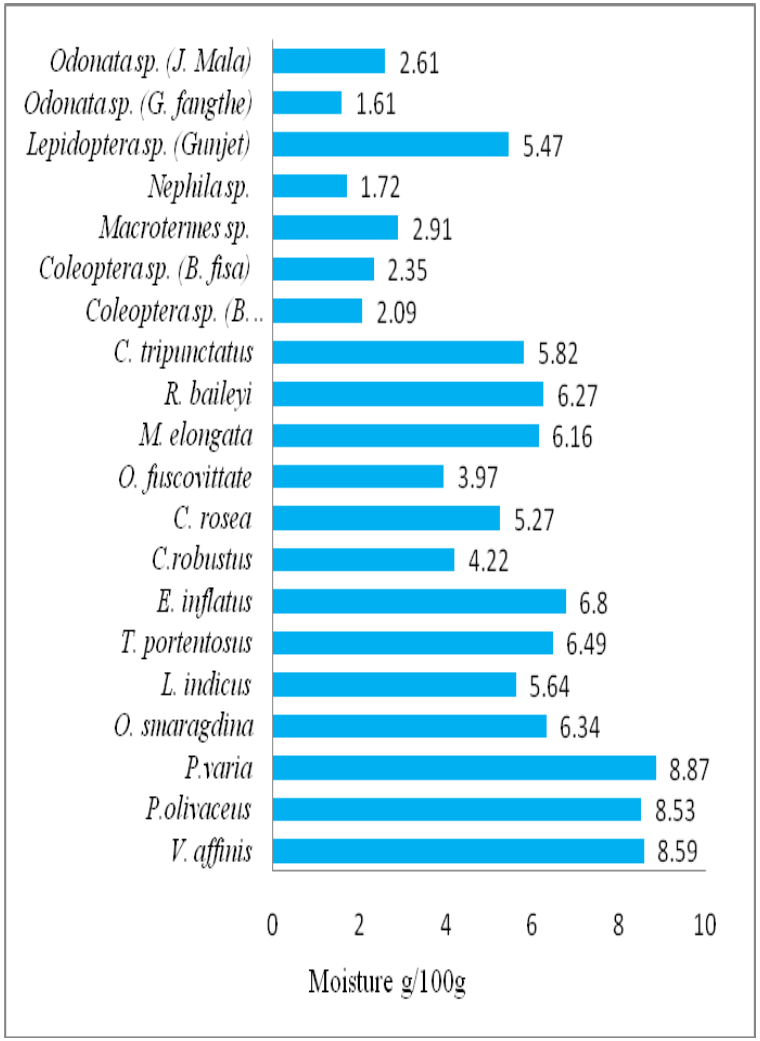
4.10 Comparative Nutritional Data

A comparison of the total proximate, minerals, amino acids and fatty acid compositions of twenty wild edible insects consumed by the Bodos is represented in Figure 4.1 to Figure 4.4. The comparison data reveals that *P.varia* had the highest 8.87% of moisture content. The ash content of *T.portentosus* was much higher than that of other insects. *R.Baleyi* had excessively higher amount 40.65% of fats. Carbohydrate content 37.78% of *Macrotermes* sp. was found to be the highest. A higher energy value of 580.25 kcal/100g was observed in *R.Baleyi* that is relative to its high fat content. Higher amount of starch 1.89% was detected in *O. smaragdina* and higher amount of dietary fibre 1.36% was observed in *Lethocerus indicus*.

Comparative data of the individual mineral content showed that *P.varia* possesses higher level of potassium 1960.7 mg/100g. While highest level of sodium 370.81 mg/100g was observed in *T.portentosus.* Exceedingly higher values of calcium and magnesium was observed in *L.indicus* compared to the other insects. Highest values of phosphorus 763.14 mg/100g was detected in *Chondracris rosea*. Zinc content 7.00 mg/100g in *T. portentosus* and *O. smaragdina* were found higher. Excessive amounts of iron was found in *T. portentosus* and copper in *C. robustus*.

Data on the comparison of essential and non essential amino acid composition of twenty insects revealed that higher values 66.49%of essential amino acid composition was found in *Macrotermes* sp. *T. portentosus* had the highest concentration non essential amino acid composition.

Highest values of SFA concentration 60.47% was observed in *Coleoptera* sp. (Bwrbila gedet). MUFAs concentration 57.28% was higher in *Oxya fuscovittate. Coleoptera* sp. (Bwrbila fisa) with its 61.38% fraction of fatty acids was found to be the species containing the highest amount of PUFAs.



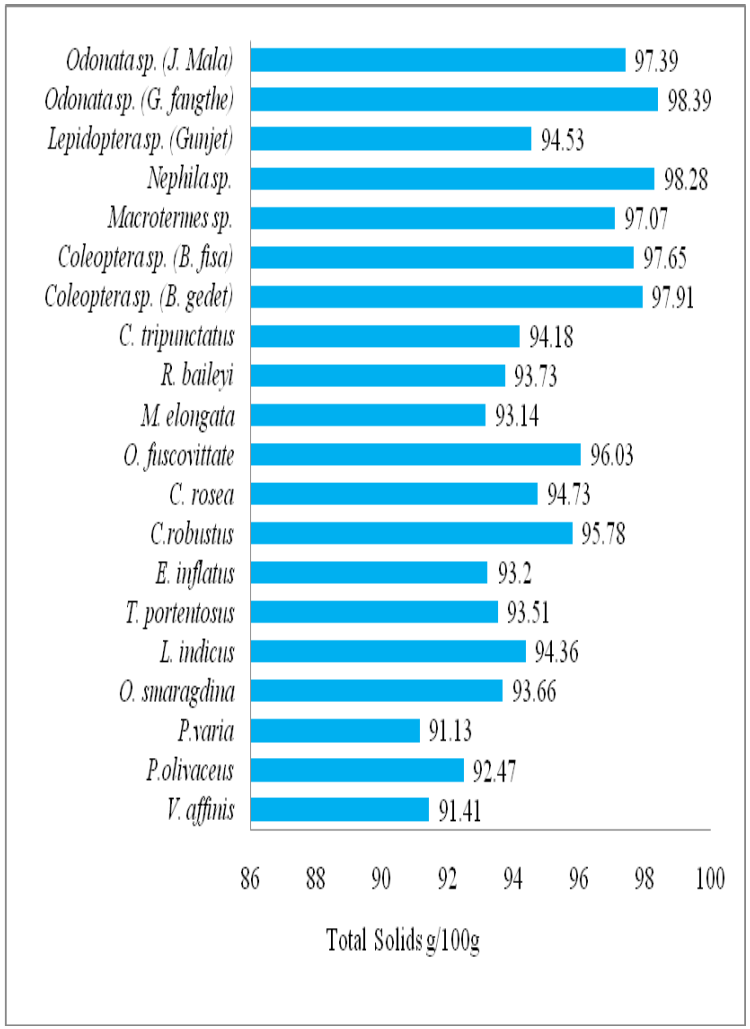
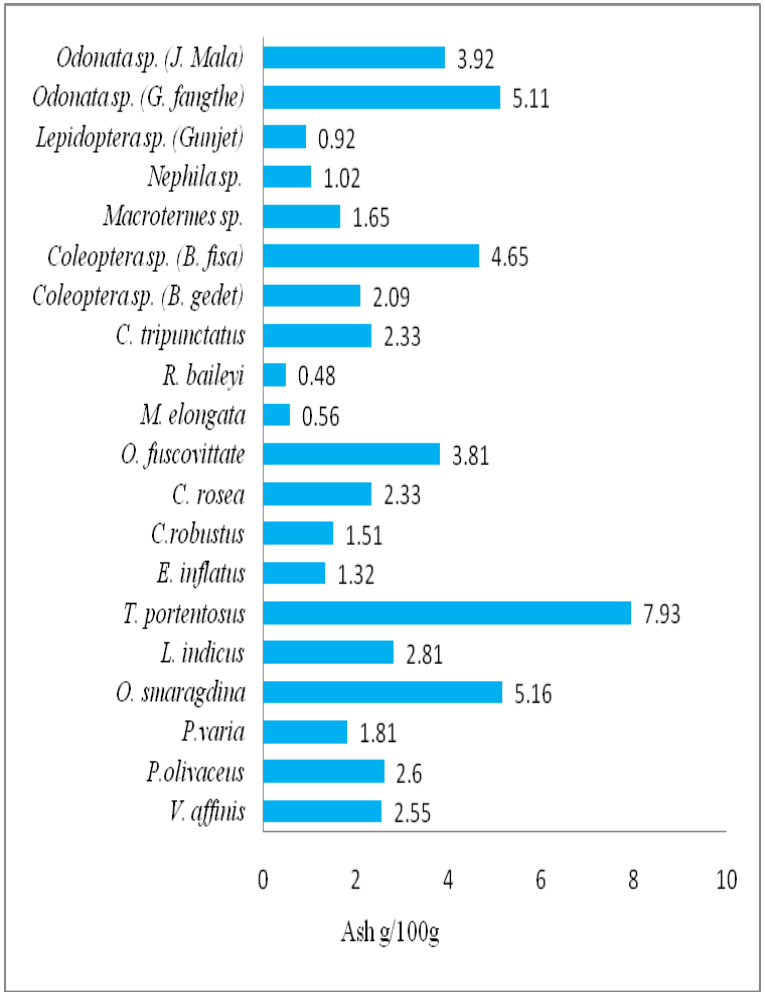


Figure 4.1a Comparative data of proximate compositions (Moisture and Total Solids) of the twenty wild edible insects.



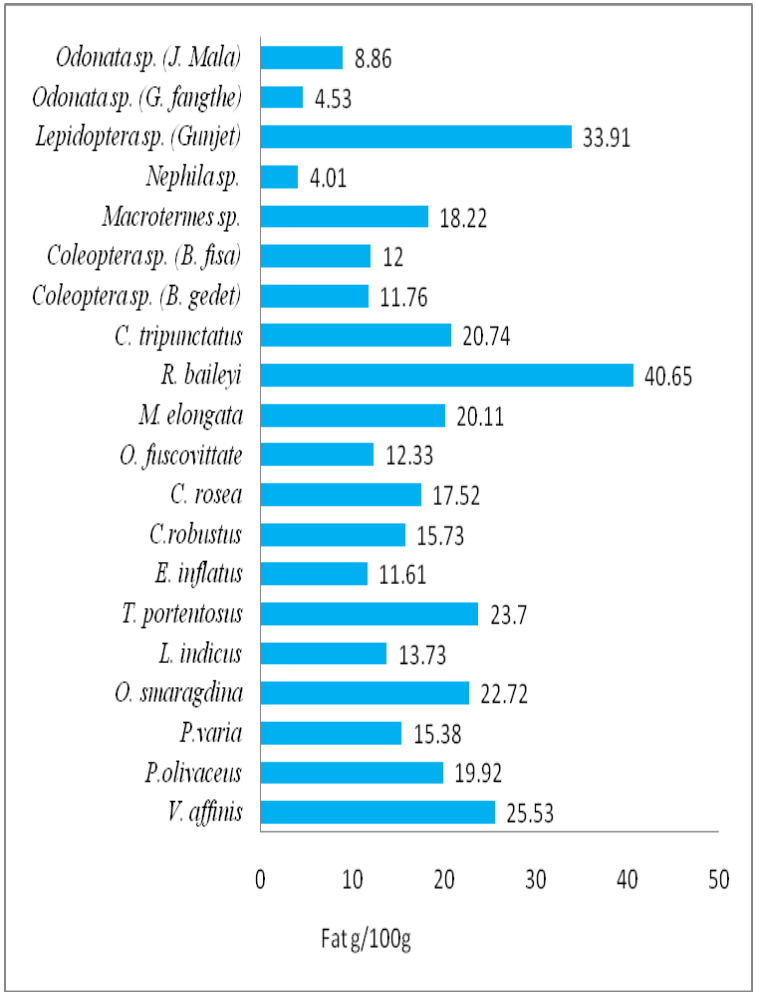
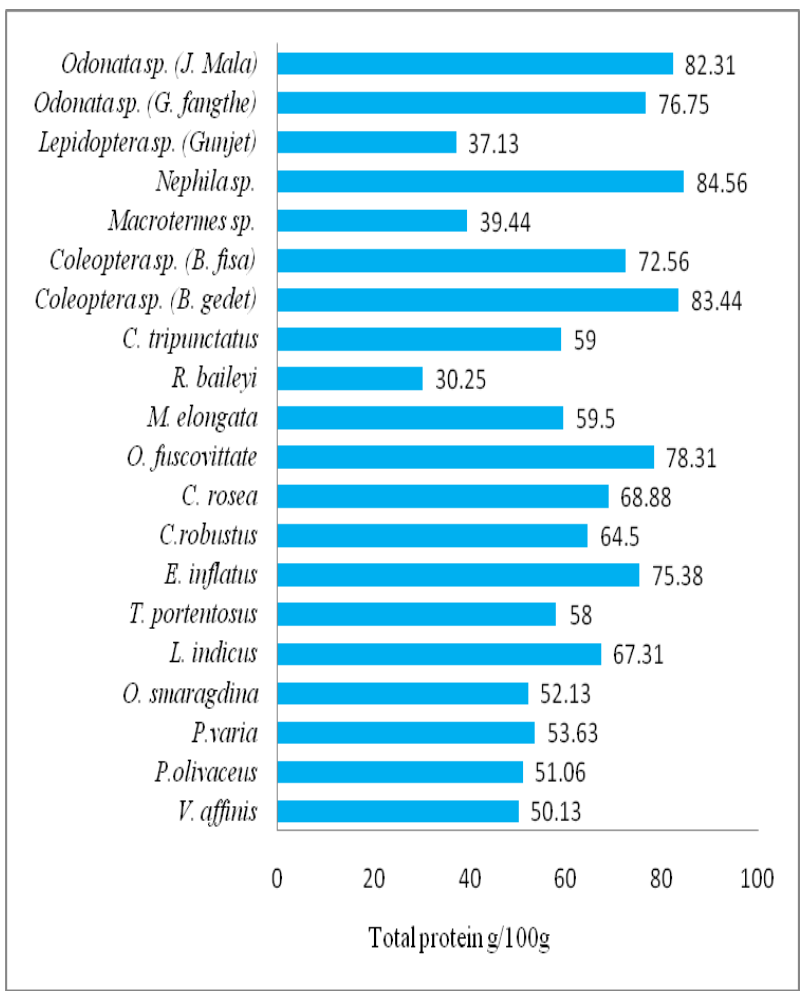


Figure 4.1.b. Comparative data of proximate compositions (Ash and Fat) of the twenty wild edible insects.



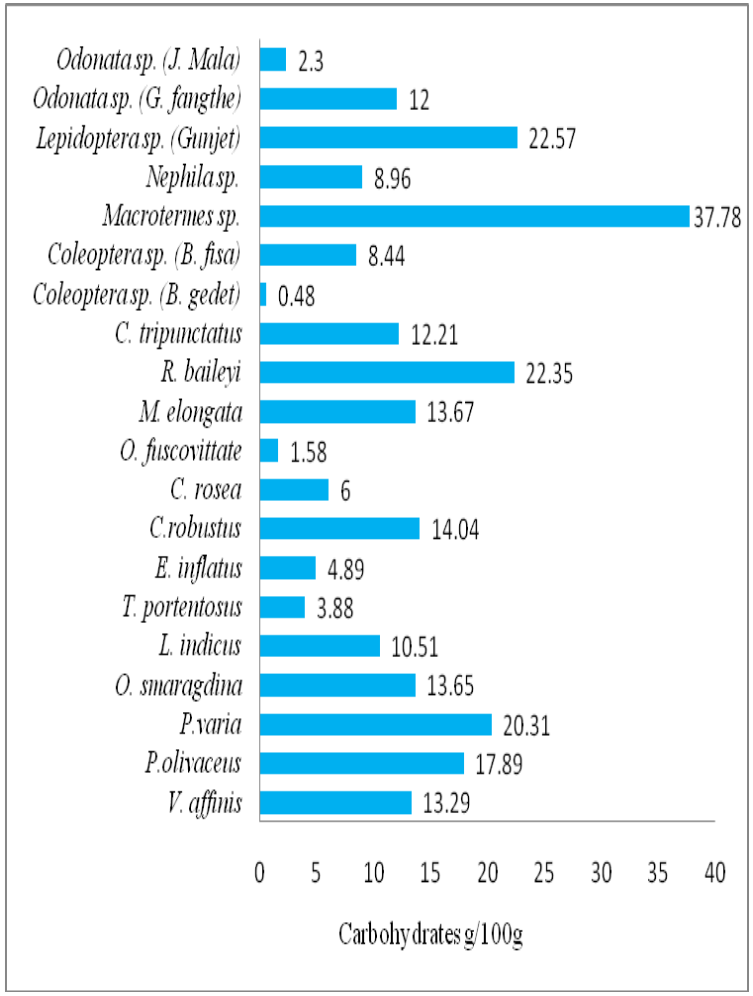
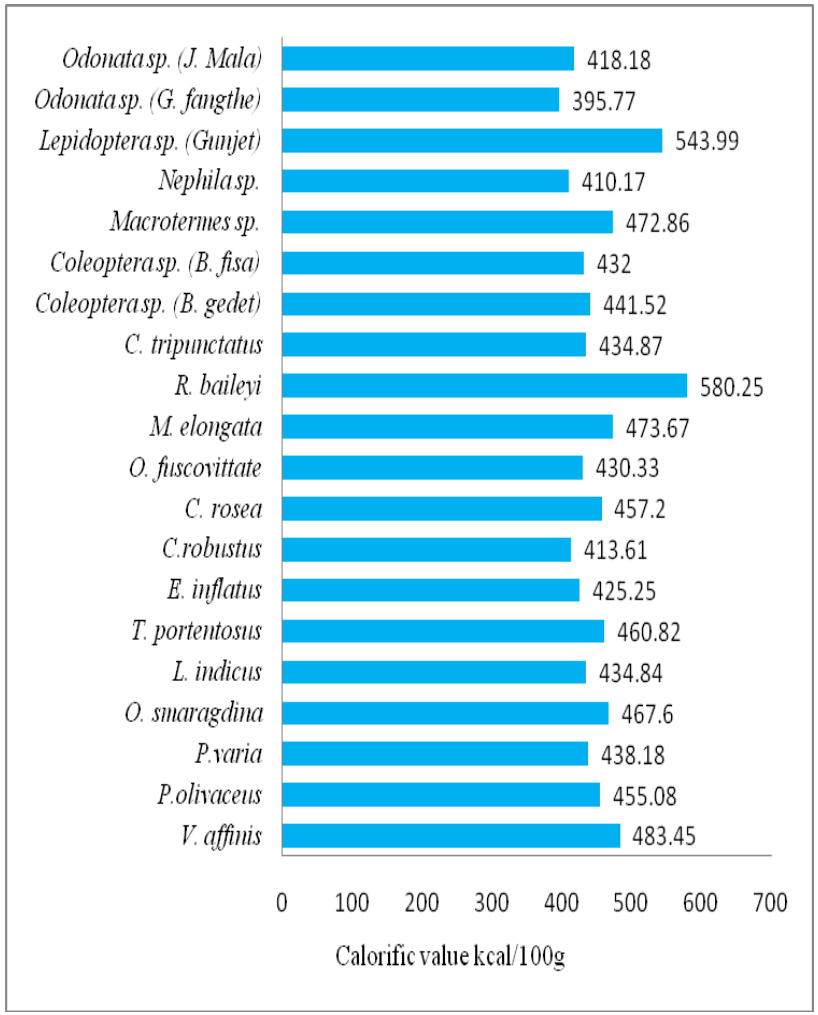


Figure 4.1.c. Comparative data of proximate compositions (Total Proteins and Carbohydrates) of the twenty wild edible



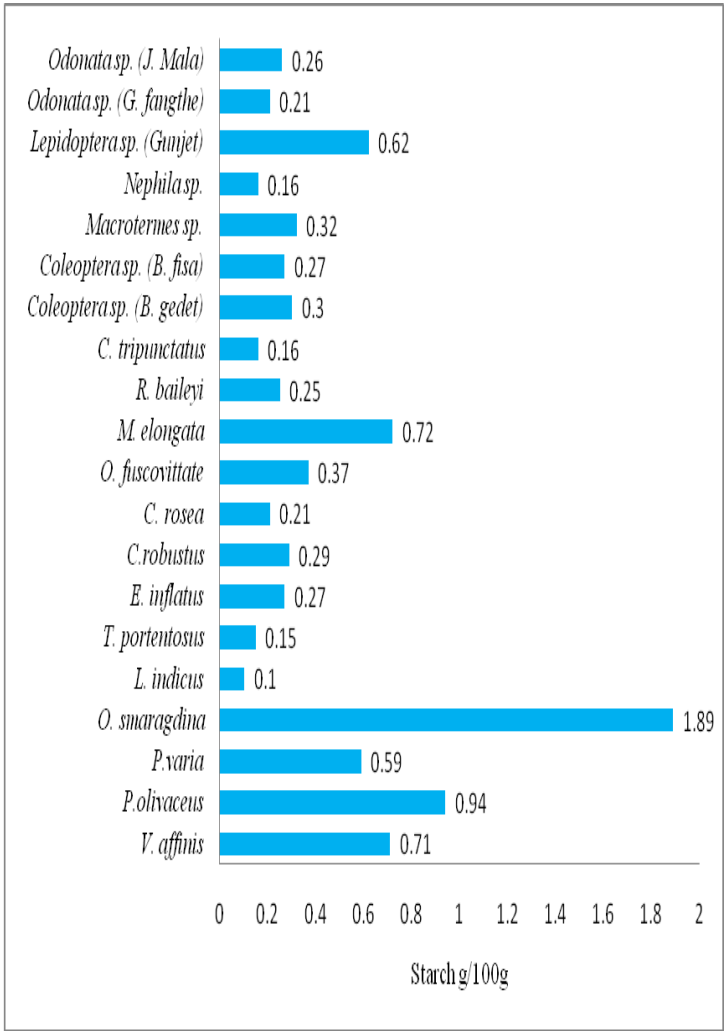


Figure 4.1.d. Comparative data of proximate compositions (Calorific value and Starch) of the twenty wild edible insects.

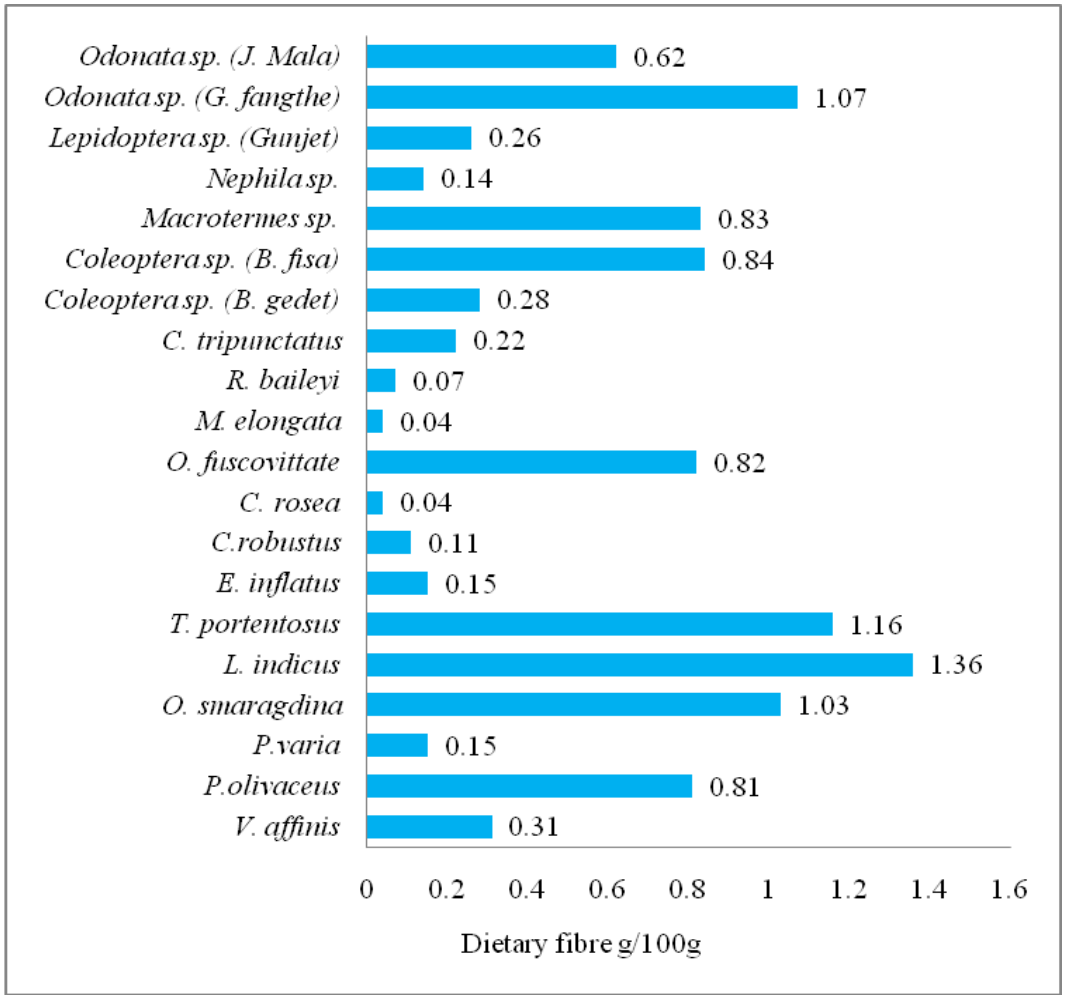
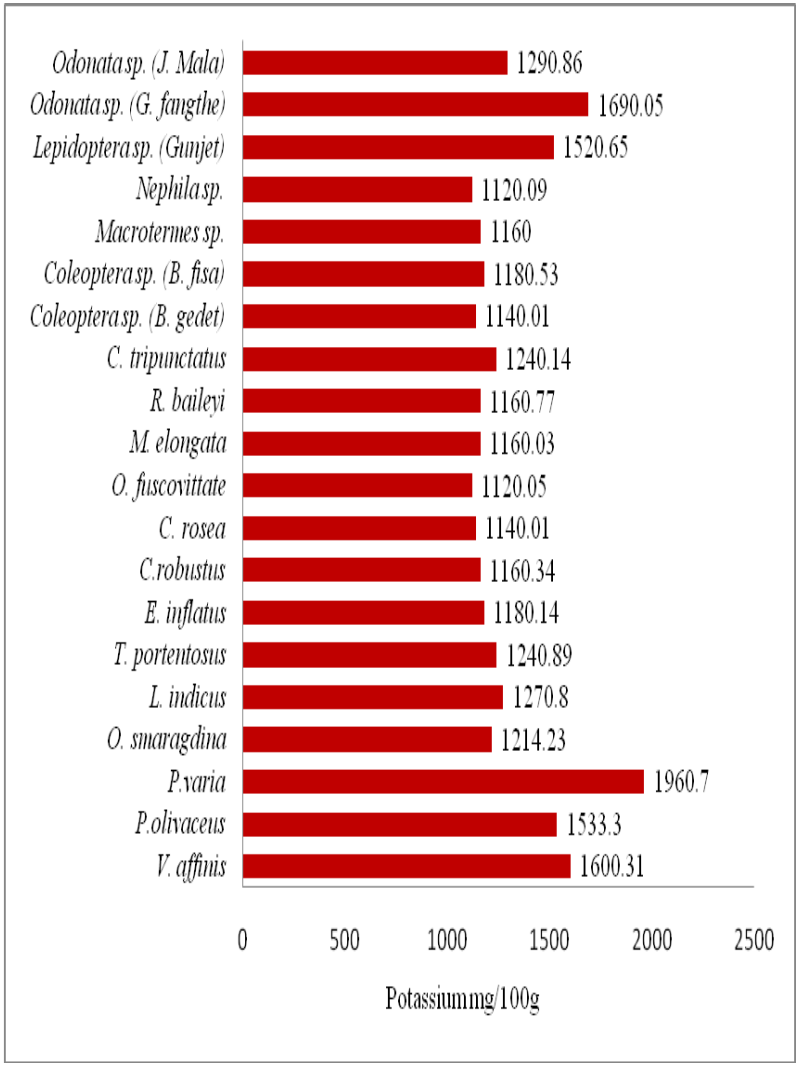


Figure 4.1.e. Comparative data of proximate compositions (Dietary fibre) of the twenty wild edible insects.



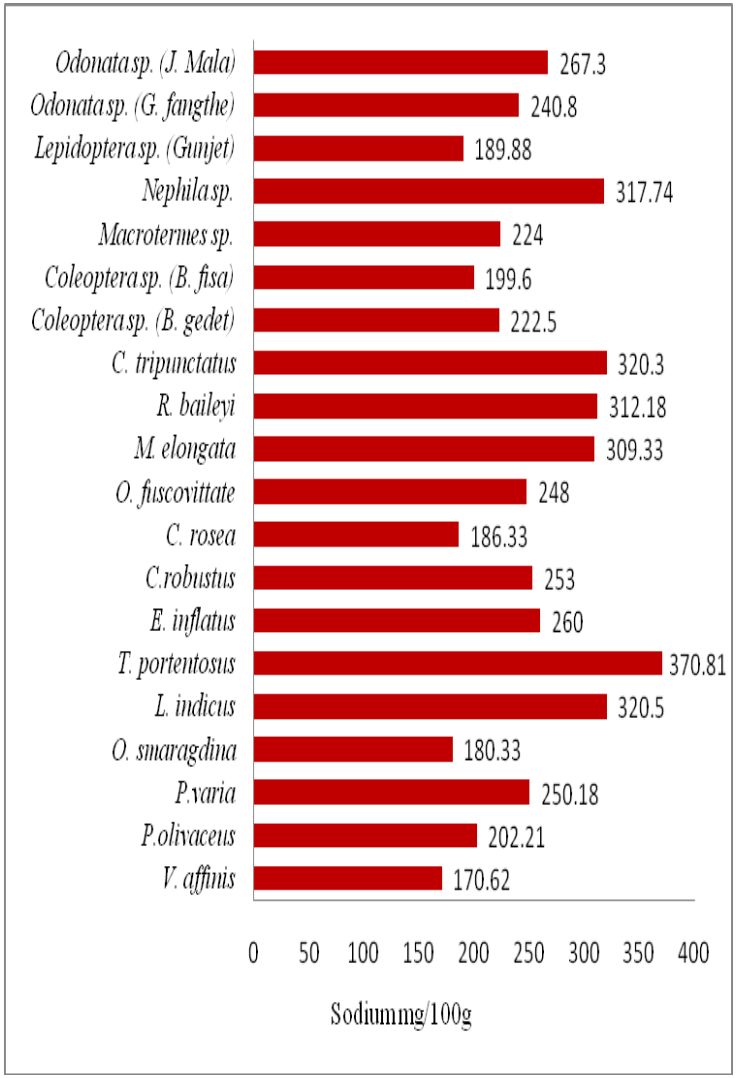


Figure 4.2.a. Comparative data of individual mineral composition (Potassium and Sodium) of twenty wild edible insects

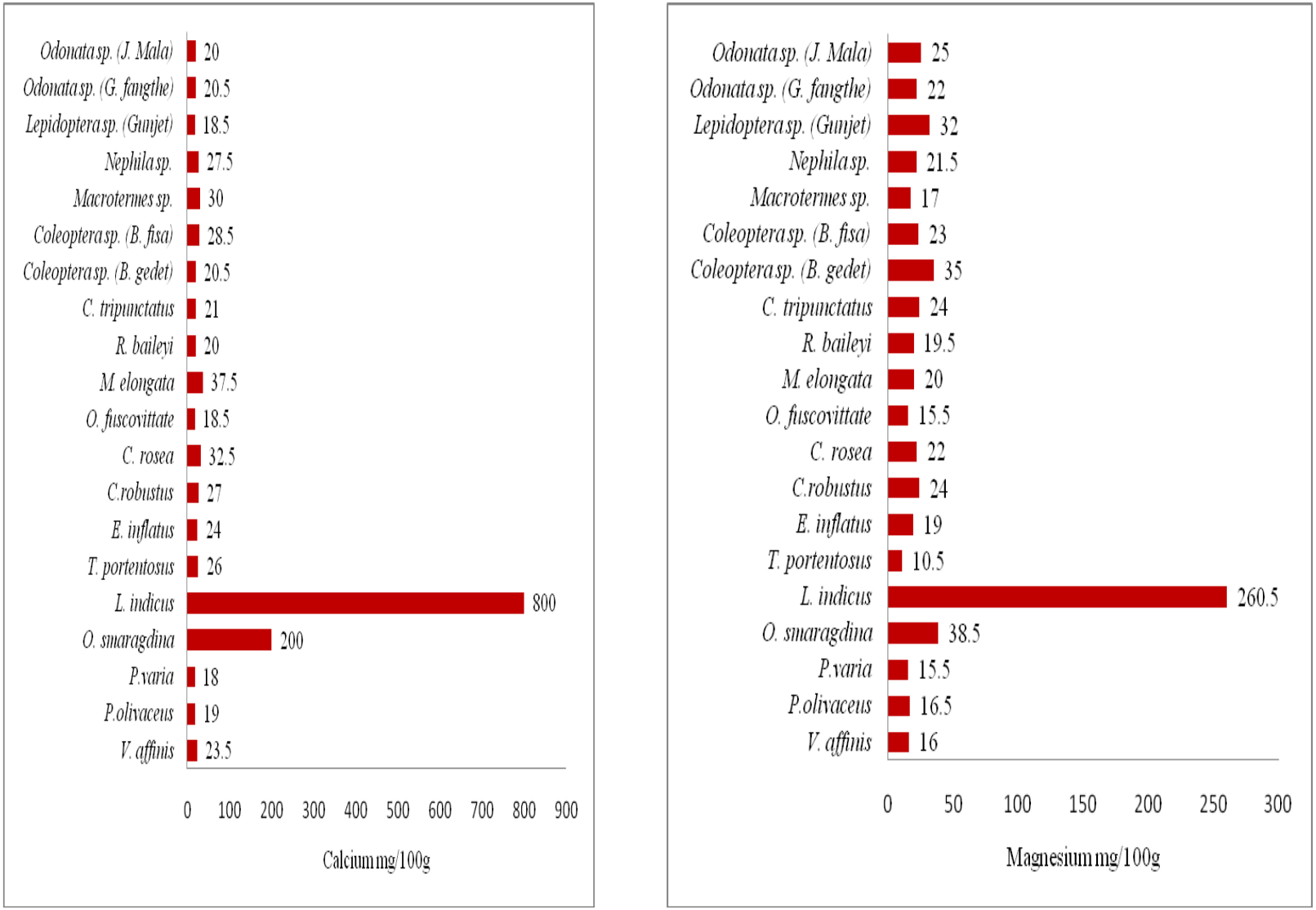
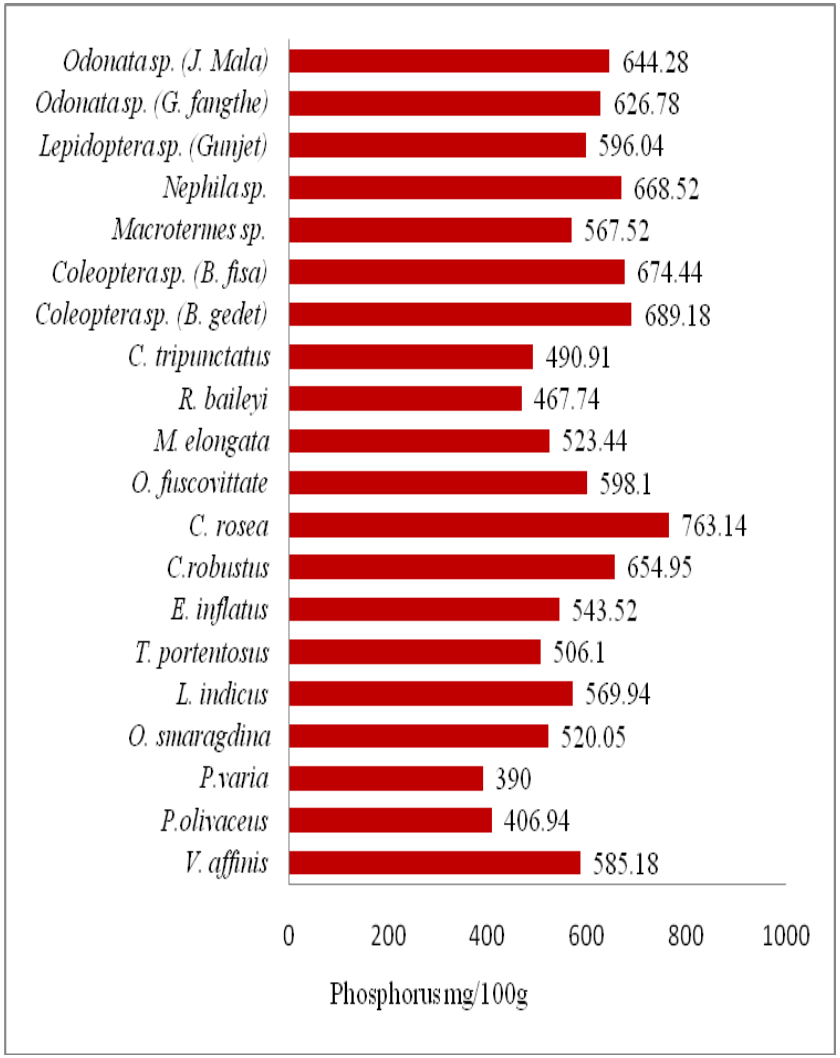


Figure 4.2.b. Comparative data of individual mineral composition (Calcium and Magnesium) of twenty wild edible insects



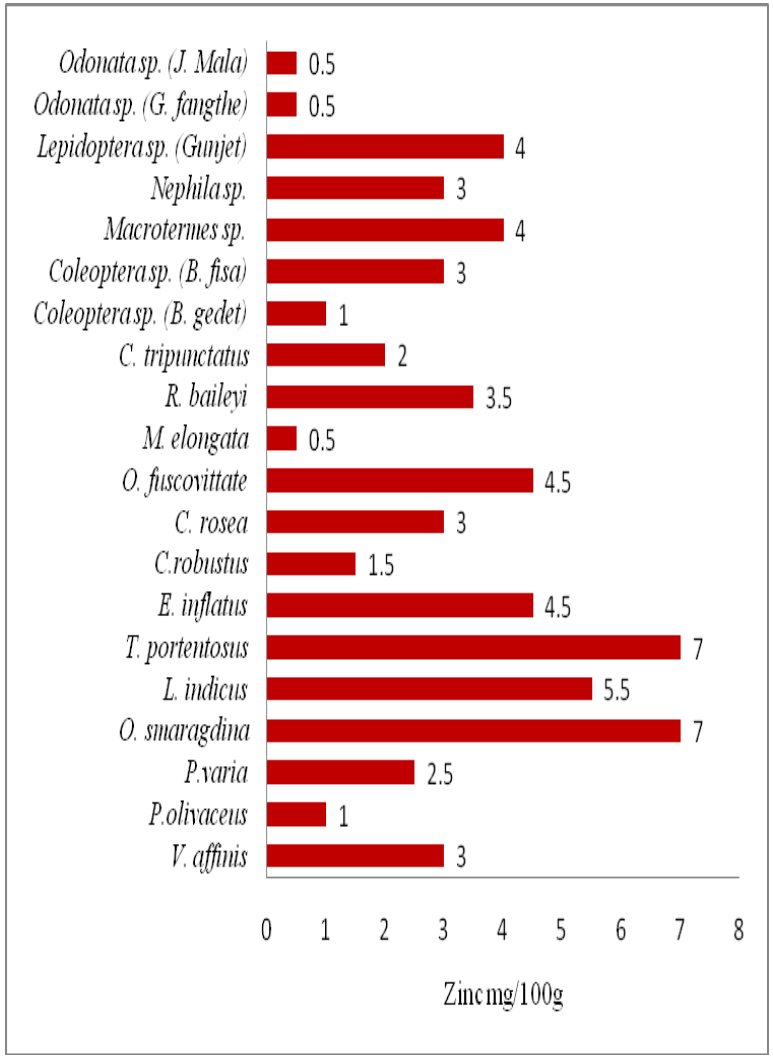
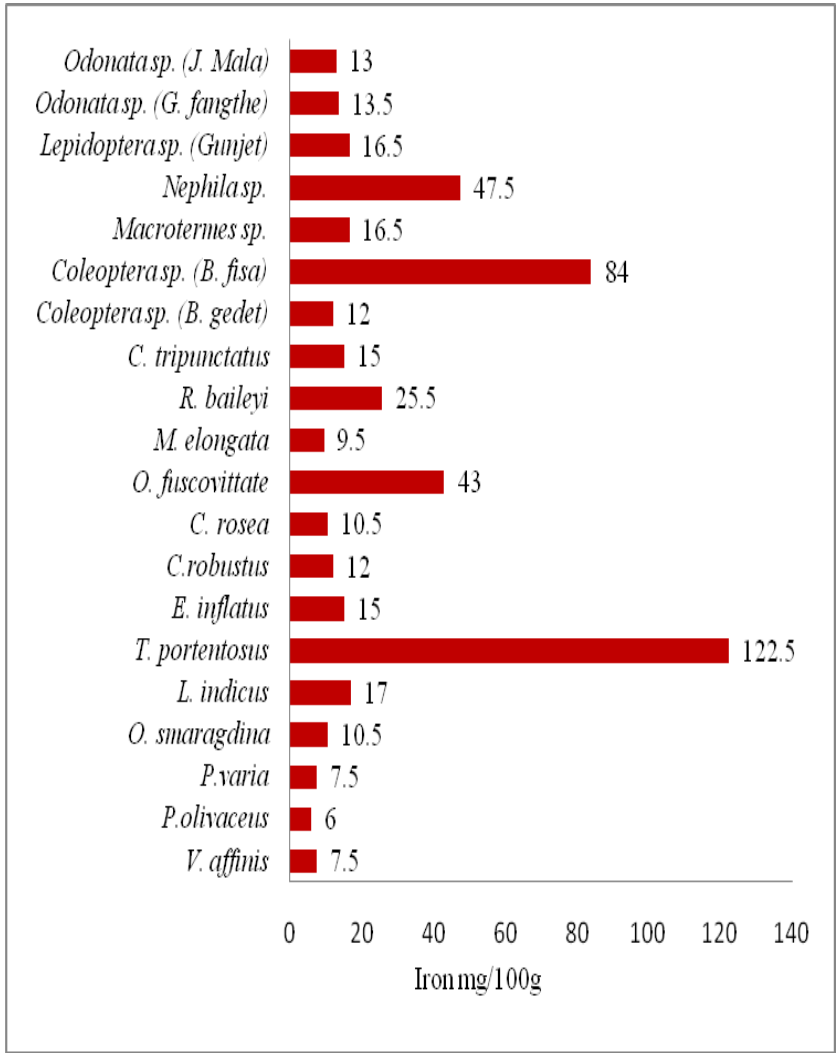


Figure 4.2.c. Comparative data of individual mineral composition (Phosphorus and Zinc) of twenty wild edible insects



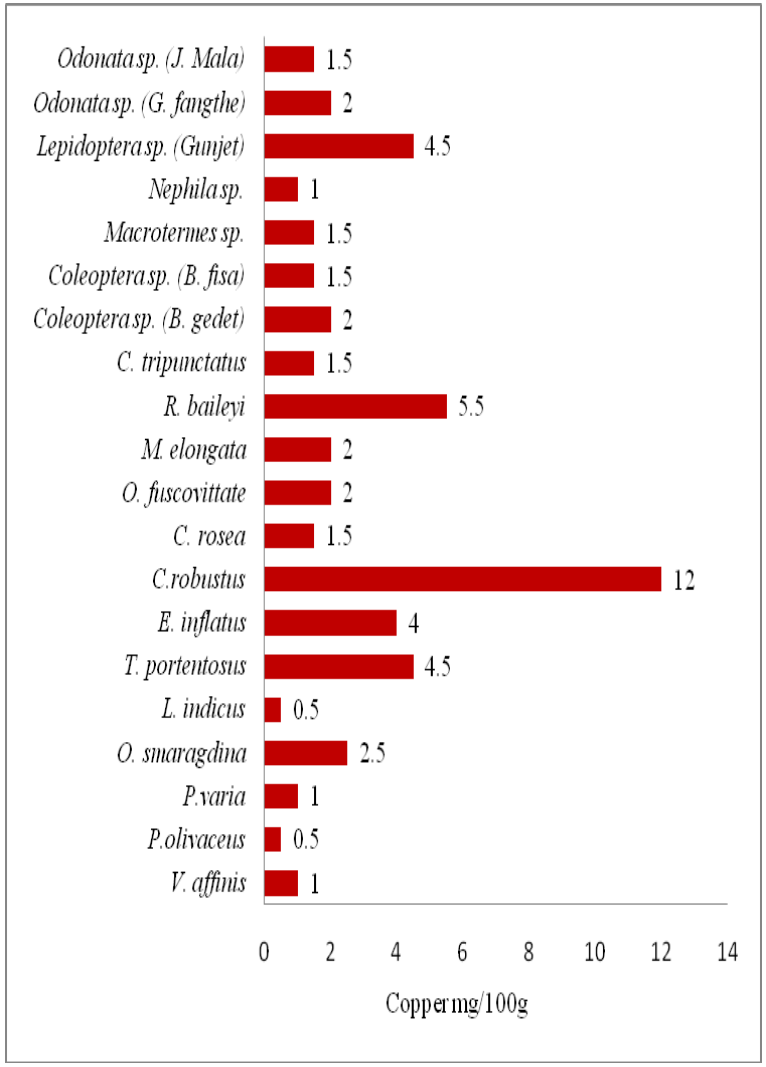
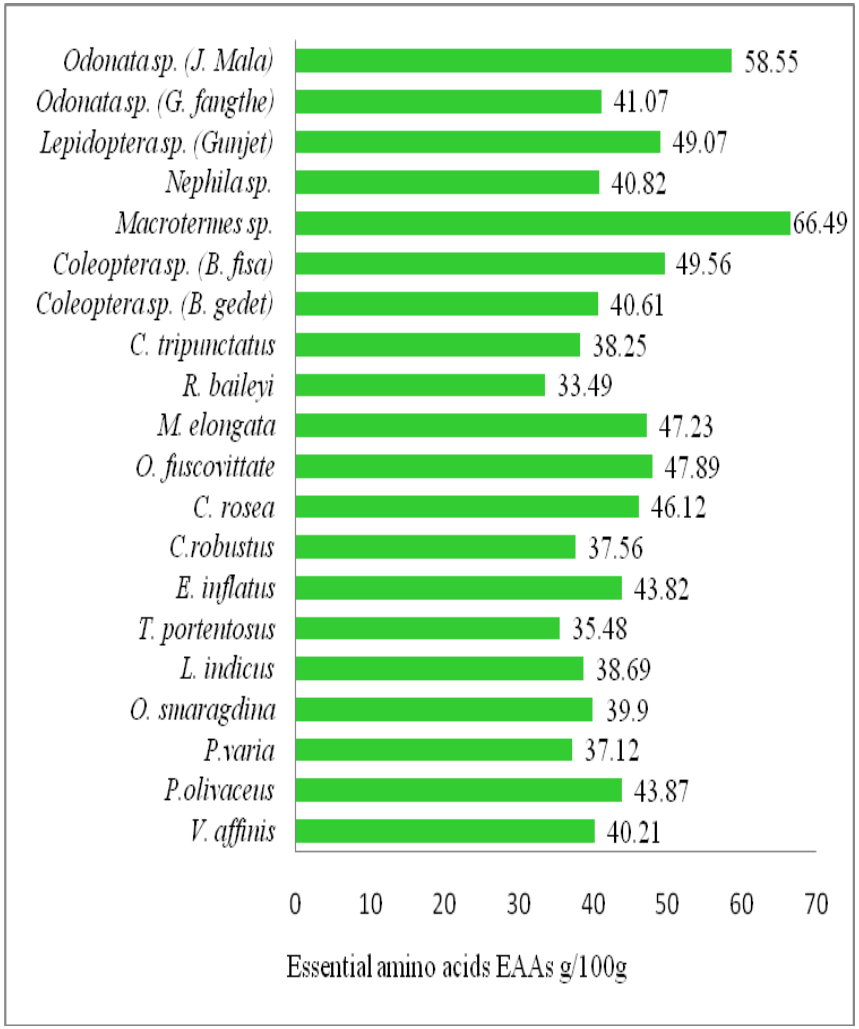


Figure 4.2.d. Comparative data of individual mineral composition (Ironand Copper) of twenty wild edible insects



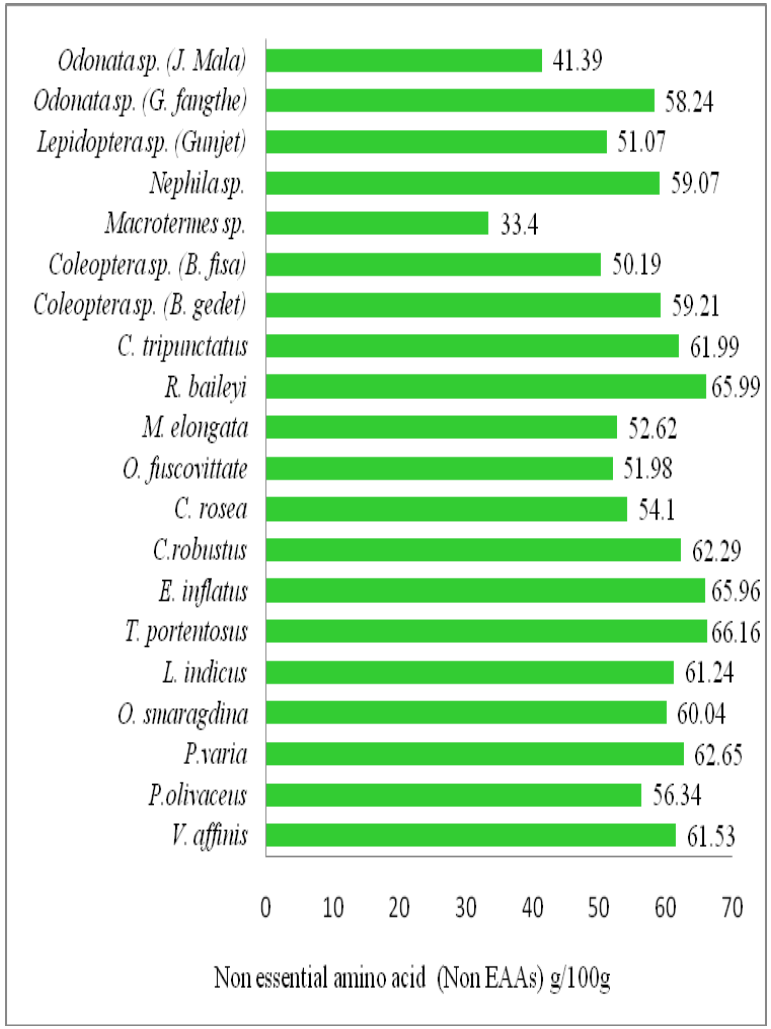
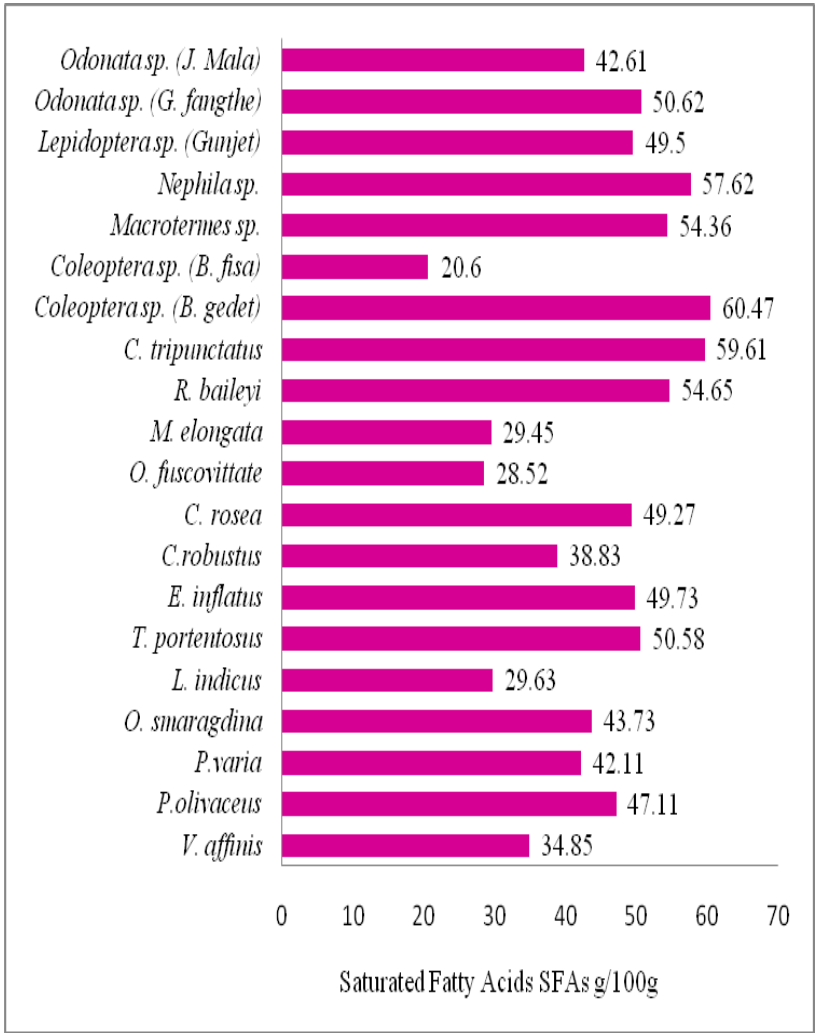


Figure 4.3. Comparative data of essential and non essential amino acid compositions of twenty wild edible insects.



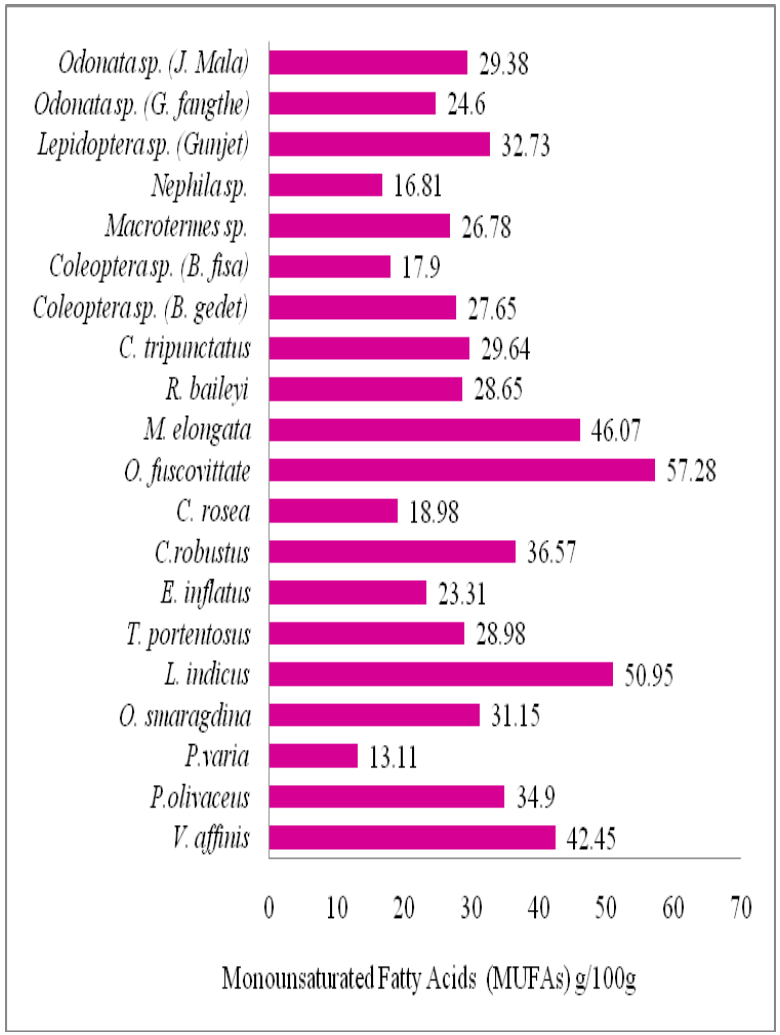


Figure 4.4.a. Comparative data on Saturated Fatty Acidss and Mono Unsaturated Fatty Acids composition of twenty wild edible insects.

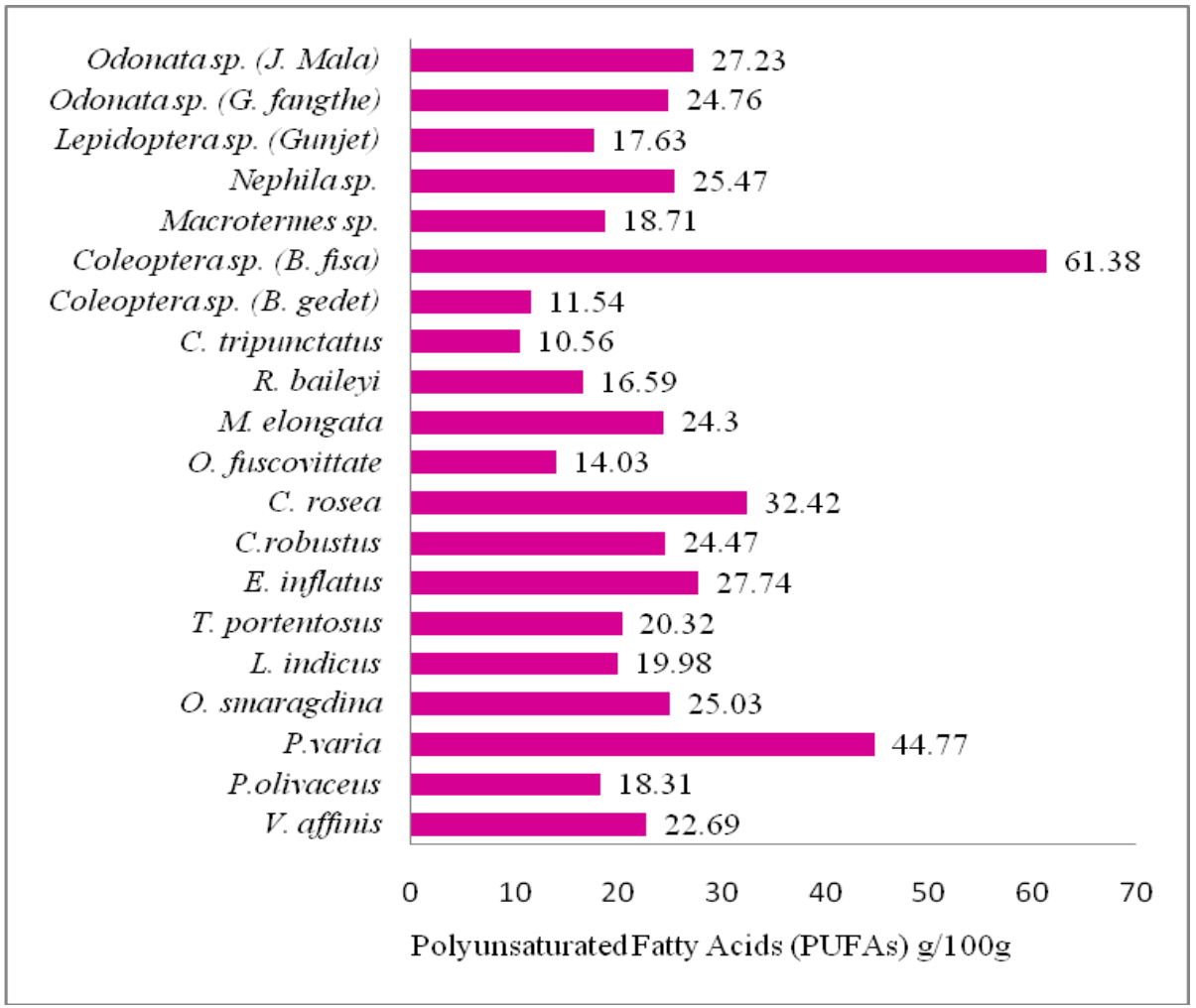


Figure 4.4.b Comparative data on Poly Unsaturated Fatty Acids composition of twenty wild edible insects.

Plate 4.1a Jakhai **Plate 4.1b Khobai**

Plate 4.1 Traditional collecting tools used for collection of aquatic insects

Plate 4.2a *Laccotrephes ruber* **Plate 4.2b *Gryllotalpa Africana***

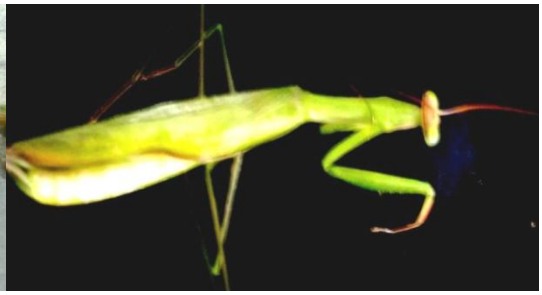


Plate 4.2c *Phlaeoba infumata* **Plate 4.2d *Mantis inornate***

Plate 4.2e *Hymenoptera* sp. (Hani bere)

Plate 4.2 Scientific names and images of five wild edible insects consumed by Bodos.

Plate 4.3 Nest with a single entrance (left) and adult of *V. affinis* (right).

Plate 4.4 Nest (left) and adult of *P. olivaceus*

Plate 4.5 Nest of *Parapolybia varia* with larvae (left) and adult of *P. varia* (right)

Plate 4.6 Nest and larvae (left) and queen of *O. smaragdina* (right)

Plate 4.7 Nymphs and adults of *L. indicus*

Plate 4.8 Adult of *T. portentosus*

Plate 4.9 Adult of *E. inflatus*

Plate 4.10 Adult of *C. robustus*

Plate 4.11 Adult of *C. rosea*

Plate 4.12 Adults of *O. fuscovittate*

Plate 4.13 Adult of *M. elongata elongata*

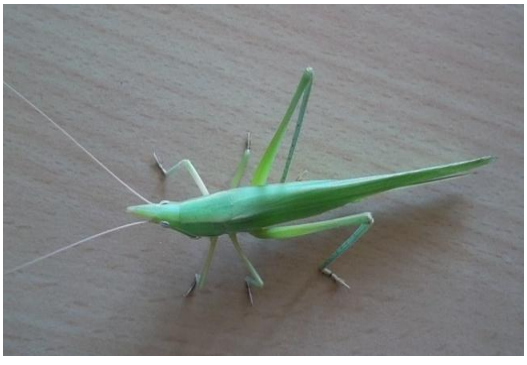


Plate 4.14 Adults of *R. baileyi*

Plate 4.15 Adult of *C. tripunctatus* gedet)

Plate 4.16 Adult of *Coleoptera* sp. (B.

Plate 4.17 Adults of *Coleoptera* sp. (B. fisa)

Plate 4.18 Adults of *Macrotermes* sp.

Plate 4.19 Adults of *Nephila* sp.

Plate 4.20 Larvae of *Lepidoptera* sp. (Gunjet)

Plate 4.21 Nymph of *Odonata* sp. (G. fangthe)

Plate 4.22 Nymph of *Odonata* sp. (J. mala)

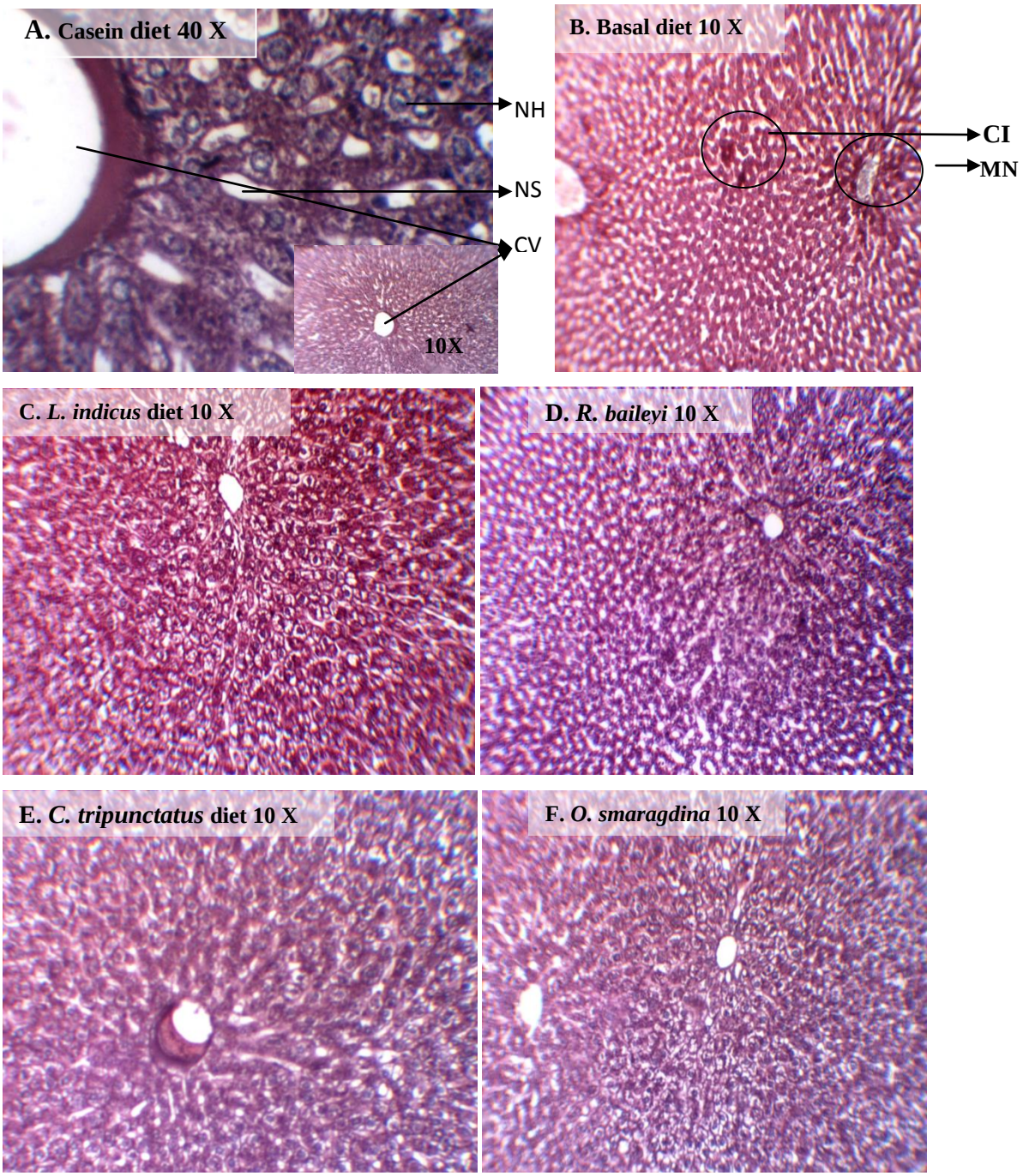


Plate 4.23 Pictomicrographs of H&E stained sections of liver in rats fed different diets. NCV – Normal Central vein. NH – Normal Hepatocytes. NS – Normal Sinusoides**.** CI - Cellular infiltrates. MN – Mild Necrosis.

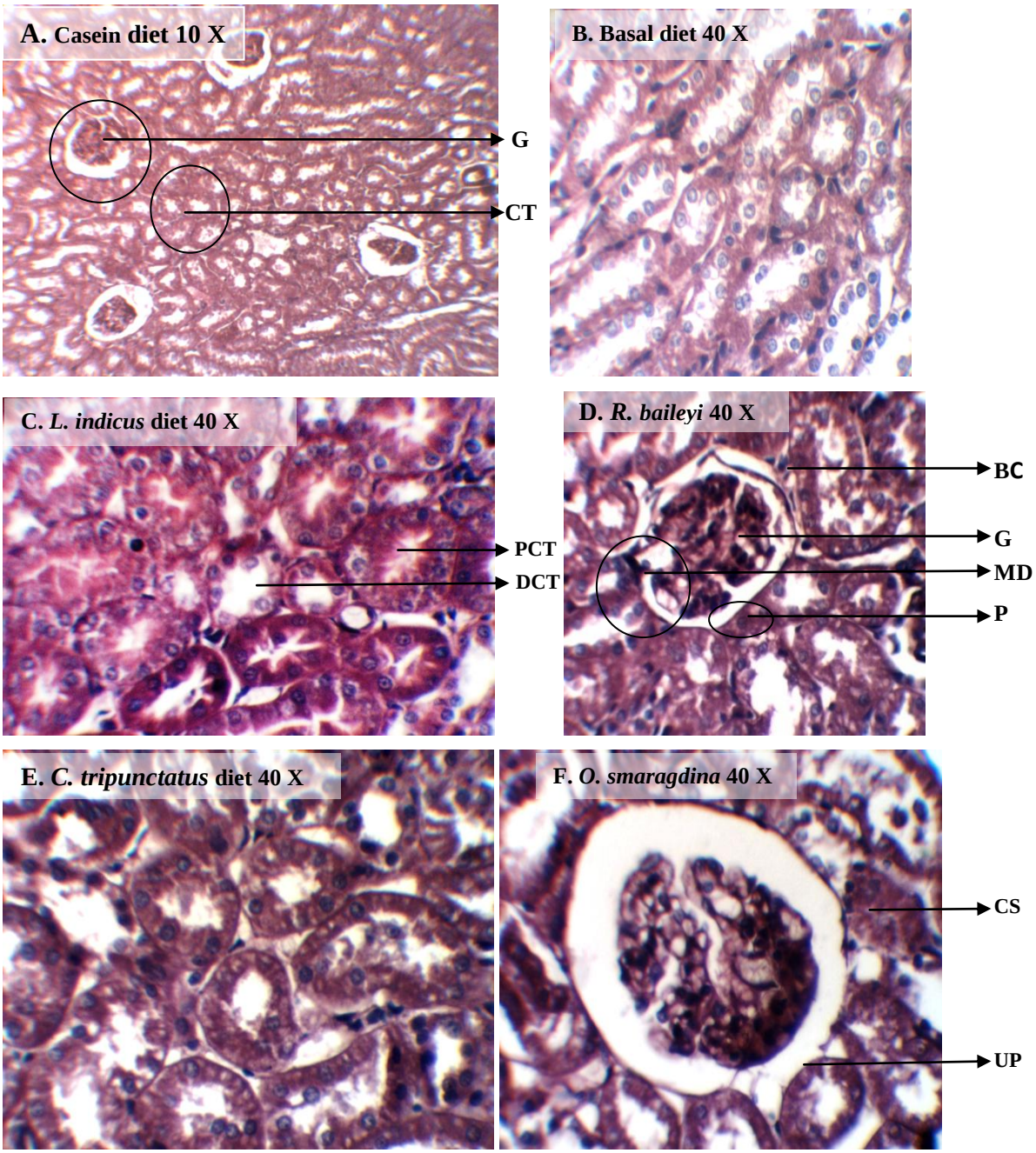


Plate 4.24 Pictomicrographs of H&E stained sections of kidney in rats fed different diets showing normal histology. G – Glomerulus. CT – Convoluted tubules. PCT - Proximal Convoluted Tubule. DCT - Distal Convoluted Tubules. BC – Bowman's capsule MD – Macula Densa. P – Podocytes. CS – Capsular space UP – Urinary pole.

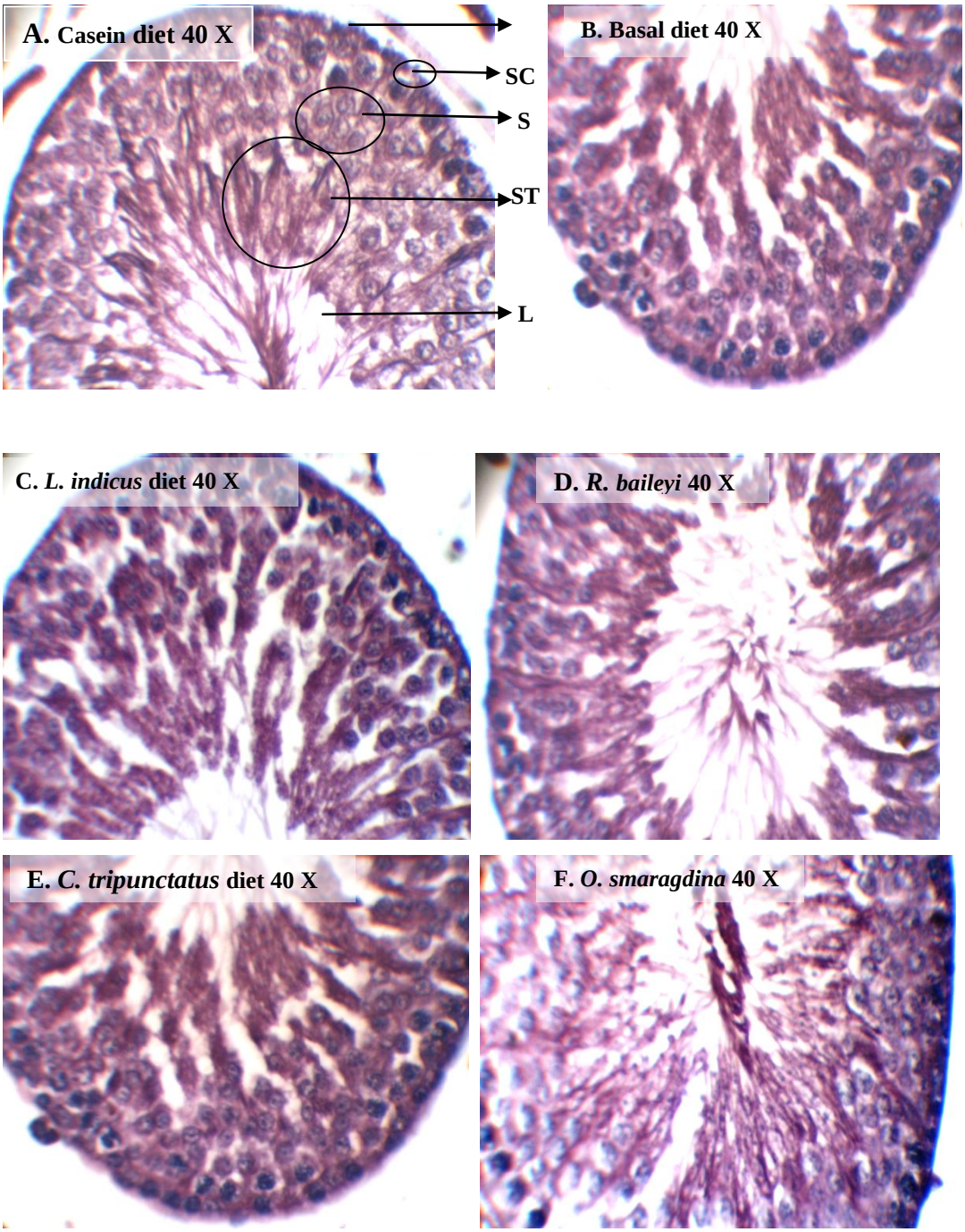


Plate 4.25 Pictomicrographs of H&E stained sections of testis in rats fed different diets showing normal histology. SG – Spermatogonia. SC- Sertoli Cells. S – Spermatocytes. ST- Sperm tails. L – Lumen.

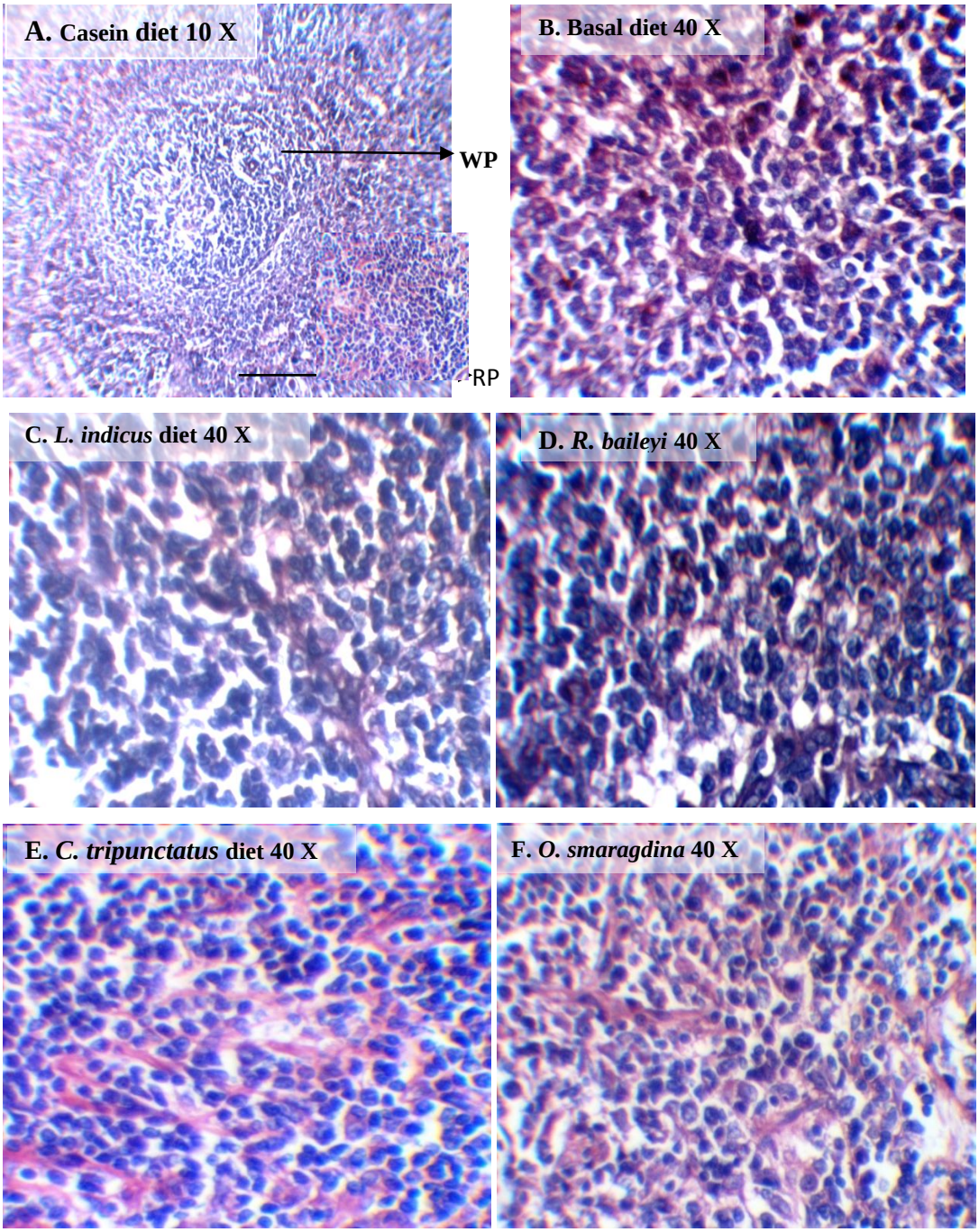


Plate 4.26 Pictomicrographs of H&E stained sections of spleen in rats fed different diets showing normal histology. WP – White Pulp. RP – Red Pulp