CHAPTER-IV

DISCUSSION
Insects, being a traditional food in many cultures, play an important role in human nutrition. As insect has been a good nutritional food source, especially for fat and protein, attempts have been made to take advantage of this resource and for promotion of these as a nutritional food source. But information on the toxicity and food safety of these insects as a nutritional food source is needed to satisfy consumer concerns.

Based on analysis and study, the nutritive value of edible insects it was reported that insects have rich protein, amino acid, fat, fatty acid, carbohydrate, mineral elements, vitamins and other activated elements that promote human health. As protein sources, the nutritive value of edible insects is as good as other animals or plants. Insects are characterized by rich species diversity and large populations, therefore as nutritive resources, edible insects can be widely used and have great development potential. In promoting insects as human food, relative nutritive values should be taken into consideration to provide the maximum benefit to human consumers.

Weaver ants (*Oecophylla smaragdina*) are valued resource in some Southeast Asian countries since they are edible and considered a
delicacy food. Among all edible insects of Assam, the weaver ant is considered as a traditional food item during festive season in upper Assam areas mostly among some tribal community. It is of common belief that this ant species are especially important in curing some diseases particularly the sinusitis. In Thailand weaver ant is the most expensive and they reported the protein content to be similar to other protein sources and they are a high priced delicacy being almost twice as expensive as beef or pork.

In recent years, the weaver ants have been considered an expensive delicacy food since they are only collected from natural habitats. Over recent decades, edible insects have been used in value-added products such as canned foods or even snacks on a commercial scale. But the knowledge on the nutritional composition of local *O. smaragdina* species of weaver ant is still very scarce. It becomes essential to determine and evaluate the nutrient composition of this ant species in different stages and castes life cycle in relation to climatic condition as the interest in insect as commercial and renewable food resource has increased to fill the gaps between demand and supply. Therefore, the present study is undertaken to investigate the variation of certain nutrients of the *Oecophylla smaragdina* in different life cycle stages of major castes, Queen and Worker.
To determine the nutrient composition in the present study—protein, essential amino acids, total lipid, cholesterol, triglyceride, vitamin-E, vitamin-C, some members of vitamin-B complex and element analysis are taken as study parameters. Two different seasons of the year as summer (March, April, May and June) and winter (November, December, January and February) depending on their availability, two different castes with their three stages of life cycle are considered to evaluate the variation on nutrient composition in these conditions of weaver ant.

**PROTEIN:**

Variation of protein in three different life cycle stages of Queen and Worker caste of *Oecophylla smaragdina* are presented in table IV. I. The results obtained in the present study clearly indicate significant differences (p<0.05) in the protein content between the two castes (Table III.1.B and fig IV.1. A to IV.1. C) from March to June but the differences are not significant from November to February in all the stages of life cycle. The differences are (fig IV.1. A to IV.1. C) and one overall scenario also observed to be significant between the life cycle stages and protein content is found to be highest in larval stage followed by pupa and adult stage. However, these differences are distinctly
observed in the month of March, April and May and June onwards up to February the differences are not clear. Highest protein content of 587 mg/g is observed in the Queen larva in the month of March. It can now be opined that there is a significant variation between castes and the life cycle stages along with seasonal impact on the protein content of this particular *Oecophylla* species.

**Fig: IV 1 A:** Showing the Comparison of Mean Values of Protein of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

**Fig: IV 1B:** Showing the Comparison of Mean Values of Protein of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
ESSENTIAL AMINO ACIDS:

A profile of the eight essential amino acids estimated in queen and worker ants at three stages of life cycle in eight months of the year shows an overall signature trend with significant variations in relative proportions, which is influenced by differences in stages and climate. Caste-wise differences in the amino acid content are quite prominent in this study. Significant differences (p<0.05) in the mean values of all the amino acids between the castes is observed in the months of the summer season (March to June). These differences are observed in all the three stages taken in this study. But it is important to note that in the months of the winter season (November to February) this difference in the amino acid content is not significant. The general depletion in the amount of all the amino acids studied in the present investigation is
observed in both queen and worker and in all the three stages. However,
depletion starts in the month of November in case of queen caste where
early decrease is observed in the month of June in case of worker caste
in general (Fig IV.2. A - IV.9. C). In the present study threonine is
found to be in highest amount (about 50 mg/g) followed by lysine (48
mg/g), Isoleucine (40 mg/g), leucine (37 mg/g), phenylalanine (36
mg/g), valine (33 mg/g) and histidine (32 mg/g). Lowest concentration
(11mg/g) is observed in phenylalanine. Similar trend is observed in
worker caste also but with some fluctuations. In worker caste lysine is
found to be most predominant.

The Predominance of amino acid content in general in the peak
period of availability with 4 to 5 times more amount of amino acids in
general clearly suggests the continuous maintenance of essential amino
acid content which is required for the constant synthesis of protein for
the ant itself making the ant a protein rich food item as well as making
these available for different metabolic purposes. Increased amino acid
content in the queen caste in general indicates the behavioural and
functional importance of protein in this caste.
Fig: IV 2A: Showing the Comparison of Mean Values of Leucine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV 2B: Showing the Comparison of Mean Values of Leucine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV 2C: Showing the Comparison of Mean Values of Leucine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV3A: Showing the Comparison of Mean Values of Isoleucine of Queen Larva and Worker Larva of *Oecophylla smaragdina* Fabricius

Fig: IV3B: Showing the Comparison of Mean Values of Isoleucine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius

Fig: IV3C: Showing the Comparison of Mean Values of Isoleucine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV 4 A  Showing the Comparison of Mean Values of Valine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV 4B : Showing the Comparison of Mean Values of Valine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV 4C :  Showing the Comparison of Mean Values of Valine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV5A : Showing the Comparison of Mean Values of Threonine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV5B : Showing the Comparison of Mean Values of Threonine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius

Fig: IV5C : Showing the Comparison of Mean Values of Threonine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV6A: Showing the Comparison of Mean Values of Lysine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV6B: Showing the Comparison of Mean Values of Lysine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV 6C: Showing the Comparison of Mean Values of Lysine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV7A: Showing the comparison of Mean Values of Histidine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV7B: Showing the comparison of Mean Values of Histidine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV 7C: Showing the comparison of Mean Values of Histidine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig:IV8A: Showing the comparison of Mean Values of Methionine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV8B: Showing the comparison of Mean Values of Methionine of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig:IV8C: Showing the comparison of Mean Values of Methionine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
**Fig:IV9A:** Showing the comparison of Mean Values of Phenylalanine of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius

**Fig:IV9B:** Showing the Comparison of Mean Values of Phenylalanine of Queen pupa and Worker Pupa of *Oecophylla smaragdina* Fabricius

**Fig:IV9C:** Showing Mean Values of Phenylalanine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius
TOTAL LIPID, CHOLESTEROL AND TRIGLYCERIDE:

The total lipid content of weaver ant in the present study shows significant differences (p<0.5) between queen caste and worker caste in all the three stages of life cycle- the larva, pupa and adult stage but these differences are not so prominent in the months of winter season. In the months of summer season i.e. from March to June and highest amount of lipid is observed in queen larva (250 mg/g) in the month of March. The notable feature of the results obtained is the gradual decline of the lipid content in all the stages of queen caste from March to June. Though the differences between the life cycle stages is only apparent and sustained throughout the months of winter from November to February (Fig IV.10.A-10.C). In worker caste the total lipid content shows a different trend. Though the results depicts a gradual declining trend from March to June and then from November to February the differences between the stages of life cycle is not significant (p>0.05). However, lowest amount of total lipid is observed in adult stage which is most predominant in the months of December, January and February. In contrast to worker caste where larval stage exhibits highest amount of total lipid, the pupal stage of Queen caste also exhibit high content of total lipid.
The cholesterol content in weaver ant of the present study shows higher values in all three stages of worker caste than those of the queen caste. The differences are found to be significant in the months of summer season. Higher amount of cholesterol in pupal stage in both the castes is a notable finding of the present study. Adult stage of both queen and worker shows lowest value (4.79 to 7.7 mg/g) followed by larva (4.66 to 9.83 mg/g) and highest value (8.21 to 11.34 mg/g) by pupal stage (Fig. IV.11.A-11.C). Seasonal variation of cholesterol content is observed to be predominant in queen larva but in other stages of both the caste differences are only fluctuating and neither consistent nor gradual.

Triglyceride content in the present study shows a highly significant variation (p<0.05) between the two castes. All the stages (larva, pupa and adult) of queen caste exhibit significantly higher (p<0.05) amount of triglyceride than that of the worker caste (Table III.12.B). Out of the three life cycle stages the pupa shows comparatively higher values of triglyceride than that of the larva and adult stage. Lowest amount of triglyceride is observed in adult stage in both the castes and throughout the experimental periods. It is also observed in the present study that Triglyceride content is significantly higher in all the stages of both the castes in the months of summer.
season (March to June). But abrupt and steep decline is observed in the months of the winter season which is persistent in all the test groups (Fig. IV. 12. A – 12. C). In larval and adult stage of queen caste the range of variation is very wide which is 8.77 to 130.62 mg/g, 12.49 to 166.81 mg/g and 8.69 to 100.44 mg/g in larva, pupa and worker respectively. But in worker caste though distinct variation is observed, the range is not so wide as it is observed in queen caste (8.49 to 25.77 mg/g in larva, 12.29 to 42.39 mg/g in pupa and 7.59 to 20.33 mg/g in adult worker).

Fig:IV10A : Showing the comparison of Mean Values of Total Lipid of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius
Fig: IV10B : Showing the comparison of Mean Values of Total Lipid of Queen pupa and Worker pupa of *Oecophylla smarag din* Fabricius.

![Graph showing comparison of Mean Values of Total Lipid of Queen pupa and Worker pupa.](image)

Fig: IV10C : Showing the comparison of Mean Values of Total Lipid of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

![Graph showing comparison of Mean Values of Total Lipid of Queen adult and Worker adult.](image)

Fig: IV11A : Showing the comparison of Mean Values of Cholesterol of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

![Graph showing comparison of Mean Values of Cholesterol of Queen larva and Worker larva.](image)
Fig: IV11B : Showing the comparison of Mean Values of Cholesterol of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius

![Graph showing comparison of Cholesterol values over time between Queen pupa and Worker pupa.](image)

Fig: IV11C : Showing the comparison of Mean Values of Cholesterol of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

![Graph showing comparison of Cholesterol values over time between Queen adult and Worker adult.](image)

Fig: IV12A : Showing the comparison of Mean Values of Triglyceride of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius

![Graph showing comparison of Triglyceride values over time between Queen larva and Worker larva.](image)
Fig: IV.12B: Showing the comparison of Mean Values of Triglyceride of Queen pupa and Worker pupa of Oecophylla smaragdina Fabricius

Fig: IV.12C: Showing the comparison of Mean Values of Triglyceride of Queen adult and Worker adult of Oecophylla smaragdina Fabricius.

**Vitamin- E (α- tocopherol):**

The vitamin- E (α- tocopherol) content of O.smaragdina exhibits a clear and significant difference (p<0.05) between the stages of each caste as well as between the two castes (Table III.13.B). The declining trend along with the climatic change similar to other macronutrients studied, is distinct but in case of vitamin-E steep decrease towards the
end of June is not prominent in pupa and adult stage of both the castes (Fig. IV. 13.A – 13.C). Highest amount of vitamin-E is found in larval stage of both the castes followed by pupa and lowest amount of 1.5 mg/100g and 5.6mg/100g is observed in worker and queen respectively. It is noted that almost similar amount of vit-E is shown by the larvae of both queen and worker in the month of March and April. The stage wise and caste wise differences are found to persist also in the months of the winter season.

**Vitamin- B complex :**

Thiamine, riboflavin, pantothenic acid, pyridoxine and folic acid are taken as index parameters to assess the vitamin-B complex content in *O. smaragdina*. Highest amount of about 10mg/100g thiamine and pantothenic acid is observed in queen larva of this particular ant species. Differences of these two vitamin-B content between two caste at different life cycle stages are not prominent except in the larval stage. In pupa and the adult stage, differences are found to be significant (p<0.05, Table III.14.B, III.16.B) between the two caste only during the months of their peak availability but during the months of winter season the differences are not significant (p>0.05). The pyridoxine value occupies
an intermediate position as per content of the total B complex vitamins. The variation of content of pyridoxine during the experimental period is not so prominent and caste wise differences are also not significant (p>0.05) i.e. in queen caste the mean values obtained ranges from about 5 to 7.5 mg/ 100 g and in worker the range observed as 5 to 7 mg/100g. Riboflavin content in this particular ant species is found to be highest in queen caste which is about 6mg/100g but in worker caste the amount is relatively less i.e about 2mg/100g only. The important point noted in this study is that in queen caste the variation of riboflavin content during the period of study is much more than that of worker caste where riboflavin content is almost constant throughout the experimental period.

Folic acid content of *O. smaragdina* of the present study is found in a minimum amount which is only 0.12mg/ 100g in the queen larva during the months of their availability. In contrast the workers contain a very low amount of (0.01mg/100g) folic acid throughout the experimental period and in all the three stages of life cycle. The depletion in the amount of folic acid is very distinct only in queen larva from the month of December to February but in pupa and adult stage of queen the steep decline is not observed (Fig IV. 18. A- 18.C).
Fig: IV 13 A  Showing the comparison of Mean Values of $\alpha$-tocopherol of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV 13 B  Showing the comparison of Mean Values of $\alpha$-tocopherol of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV 13 C  Showing the comparison of Mean Values of $\alpha$-tocopherol of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV14A: Showing the comparison of Mean Values of Thiamine [Vitamin B$_1$] of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV14B : Showing the comparison of Mean Values of Thiamine [Vitamin B$_1$] of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV14C : Showing the comparison of Mean Values of Thiamine of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig:IV15A : Showing the comparison of Mean Values of Riboflavin [Vit-B₂] of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV15B : Showing the comparison of Mean Values of Riboflavin [Vit-B₂] of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig:IV15C : Showing the comparison of Mean Values of Riboflavin [Vit-B₂] of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV16A: Showing Mean Values of Pantothenic Acid [Vit-B₅] of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV16B: Showing the comparison of Mean Values of Pantothenic Acid [Vit-B₅] of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig: IV16C: Showing the comparison of Mean Values of Pantothenic Acid [Vit-B₅] of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig:IV17A : Showing the comparison of Mean Values of Pyridoxine [Vit-B₆] of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV17B : Showing the comparison of Mean Values of Pyridoxine [Vit-B₆] of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig:IV17C : Showing the comparison of Mean Values of Pyridoxine [Vit-B₆] of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig:IV18A : Showing the comparison of Mean Values of Folic Acid [Vit-B9] of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV18B : Showing the comparison of Mean Values of Folic Acid [Vit-B9] of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.

Fig:IV18C : Showing the comparison of Mean Values of Folic Acid [Vit-B2] of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Fig: IV19A : Showing the comparison of Mean Values of Ascorbic Acid [Vit-C] of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV19B : Showing the comparison of Mean Values of Ascorbic Acid [Vit-C] of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius

Fig: IV19C : Showing the comparison of Mean Values of Ascorbic Acid [Vit-C] of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.
Elements:

Sodium and Potassium which are estimated as representative macro element in the present study exhibit significant differences (p<0.05) between the two caste throughout the experimental period and in all the three life cycle stages. Out of the three life cycle stages the adult stage in case of queen caste the sodium concentration is observed as lowest but in workers almost similar concentration is observed in all the three stages except some fluctuations. Potassium amount is found as 6.5mg/100g tissue as highest amount in queen and worker caste. In queen caste distinct differences are observed between the stages and highest amount is recorded in the adult stage followed by pupa and lowest amount in larval stage. This difference is observed throughout the experimental period. But in worker caste differences are not prominent though in some study period adult shows higher amount followed by pupa and larva similar to that of the queen caste.

Calcium content of *O. smaragdina* is found to be highest in adult stage of worker caste (4mg/100g) and in larval stage of queen which is 4.5mg/100g. Distinct differences in calcium content amongst the stages is evident. But the impact of climate is not clear. The content however is
observed to be higher in queen caste throughout and at all stages of the study.

Iron content in the present study is found to be high and it is observed to be maximum in queen adult which is recorded to be 20mg/100g whereas in worker caste highest amount of 8mg/100g only is observed in pupal stage. In both the castes noticeable differences between the stages are found to exist throughout the period of study. Larvae shows the lowest amount of only 2mg/100g in both the caste. The amount of iron though it is found to be highest amount, it is similar to that of queen pupa. Seasonal variation is distinct only in queen caste but it is not clear in worker caste. Caste wise differences is highly significant (p<0.05) in both larva and adult stage but is only apparent in pupal stage.

Highest amount of copper (1.3mg/100g) and (5mg/100g) is observed in queen pupa and worker adult respectively. Differences are only apparent in case of queen caste whereas distinct differences are evident amongst the different stages of the worker caste. In case of queen caste the range of copper content in three stages is from 1.2 to 1.3 mg/100g only whereas in workers it ranges from 1.00 to 5.1 mg/100g. Highest amount is recorded in adult stage followed by larva and lastly the pupa. Climate wise decline is also found to be minimum.
Zinc content of weaver ant of the present study shows highest amount in pupa and adult stage of queen and worker caste respectively. In queen caste comparatively higher value is observed in pupa but in workers it is predominant in both pupa and adult. Lowest amount of zinc is observed in larval stage which is recorded as 2mg/100g in queen larva and 1.2mg/100g in worker larva. Caste wise differences are quite distinct and in larval and pupal stage of queen caste shows higher amount but in pupal stage worker caste amount of zinc are found to be more. Impact of seasonal variation is not so clear in case of zinc content.

Chromium content of weaver ant of this study shows less amount of chromium which ranges from 0.1 to 0.24 mg/100g in queen caste and 0.08 to 0.18mg/100g in worker caste. Decline in the content with season is quite evident but caste wise differences are not clear. In larval stage worker caste shows higher amount whereas pupal and adult stage of queen caste exhibit higher amount of chromium. Among the three life cycle stages the adult stage shows higher amount of chromium than those of the larval and pupal stage and this is more distinct in queen caste during summer season.

In present study lead content is estimated as a representative heavy metal is found in the range of 0.9- 1 mg/100g tissue throughout the study period in both the caste. However, it is to be noted that
relatively higher amount is exhibited by larvae and pupae than the adult stage. Though slight decline in the content is observed in both the castes towards the winter season but consistent amount is observed in all the stages of both the caste and throughout the study period.

**Fig:IV20A** : Showing the comparison of Mean Values of Sodium of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

**Fig:IV20B** : Showing the comparison of Mean Values of Sodium of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig:IV20C : Showing the comparison of Mean Values of Sodium of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig:IV21A : Showing the comparison of Mean Values of Potassium of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV21B : Showing the comparison of Mean Values of Potassium of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig:IV21C : Showing the comparison of Mean Values of Potassium of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig:IV22A : Showing the comparison of Mean Values of Calcium of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig:IV22B : Showing the comparison of Mean Values of Calcium of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig:IV22C : Showing the comparison of Mean Values of Calcium of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig:IV23A : Showing the comparison of Mean Values of Iron of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius

Fig:IV23B : Showing the comparison of Mean Values of Iron of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig: IV 23 C: Showing the comparison of Mean Values of Iron of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig: IV 24 A: Showing the comparison of Mean Values of Zinc of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV 24 B: Showing the comparison of Mean Values of Zinc of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig: IV 24 C : Showing the comparison of Mean Values of Zinc of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig: IV 25 A : Showing the comparison of Mean Values of Copper of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV 25 B : Showing the comparison of Mean Values of Copper of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig : IV 25 C : Showing the comparison of Mean Values of Copper of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig:IV26A : Showing the comparison of Mean Values of Chromium of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius.

Fig: IV 26 B : Showing the comparison of Mean Values of Chromium of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig: IV26C: Showing the comparison of Mean Values of Chromium of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

Fig: IV27A: Showing the comparison of Mean Values of Lead of Queen larva and Worker larva of *Oecophylla smaragdina* Fabricius

Fig: IV27B: Showing the comparison of Mean Values of Lead of Queen pupa and Worker pupa of *Oecophylla smaragdina* Fabricius.
Fig:IV27C : Showing the comparison of Mean Values of Lead of Queen adult and Worker adult of *Oecophylla smaragdina* Fabricius.

In nearly 100 analysed edible insects at egg, larva, pupa or adult stages by different workers at different times reported a range of 20-70 percent raw protein content which however, was found to be lowest in Coleoptera and Lepidoptera larvae with a wide range of 23-66% and 20-70% respectively. Xiaoming *et al*. (2010), evaluated the protein content of 100 species from a number of insect orders and reported the range of 13-77 percent dry matter and that there was large variation between and within insect orders. The difference is also due to varying water content. Protein content is high in insects therefore using insects as food can help increase dietary quality when including animal source proteins. The present study revealed a range of 26% to 59% protein content with highest amount is observed in queen larva and lowest amount in queen adult. Relatively lower protein content is observed in respective stages
of worker caste. The protein content observed in the present study supports the earlier reports of Yang (1998); Hu (1996); Mitsuhashi (1992); DeFoliart (1991); Comby (1990); Ramos-Elorduy and Pino (1989). They reported an average of 59.39% raw protein content in Diptera. Life cycle stage wise difference along with impact of climate change cannot be ruled out in assessing the protein content. In this present study it can be clearly demonstrated that this ant species exhibits a highest amount of protein in the month of March which is the peak period of their availability.

Among the 20 amino acids the eight are most essential amino acids which are necessary for human nutrition as they cannot be synthesized in the body. Analysis of nearly 100 types of edible insects showed 10 to 30 percent essential amino acid content but in the present study slightly lower value of 3.5 to 12 percent essential amino acid content is recorded where threonine and lysine is observed to be predominant. Bukkens (2005) reported that insects have amino acid scores for lysine is higher but cereal proteins that are key staples in diets around the world are often low in lysine and in some cases lack the amino acid threonine. In the present study on *O. smaragdina* with higher
amount of these two amino acids may complement lysine and threonine poor staple proteins.

Total lipid content in the present study with weaver ant is recorded as 20-25 percent in queen caste (highest in larval stage) whereas 12 to 13 percent in worker caste which conforms with the reports of the previous workers as 10-50 percent in different edible insects. However, they reported that these values are variable in different orders, families and species and with the differences in food habit, and habitat. The cholesterol and triglyceride content in the present study is recorded as 6-11 percent and 10-17 percent in queen caste and 4 to 10.7 percent and 2 to 4.5 % in worker caste respectively. Raksakantong et al. (2010), found the percentage of lipid ranged from 5 to 37% in Thai edible insects as ground cricket, silkworm pupae, grasshopper, Bamboo caterpillar and June beetle.

Vitamins essential for stimulating metabolic processes and enhancing immune system functions are present in most edible insects. Vitamin E analyses appear to be higher than those of the values reported for other species of captive bred insects (Barker et al, 1998; Finke, 2002; Oonincx and Dierenfeld, 2011; Pennino et al 1991). In the present
investigation highest values of 80 mg per 100g of α-tocopherol in the larval stage of queen and worker cast is noticeable as daily recommended intake in man is 15 mg (Bukkens, 2005) and for zoo animals 50-200mg per kg of diet (Dierenfeld, 1989, 1994) whereas 18 mg per kg diet was suggested by National Research Council, Washington, DC for rats. Tong et al. (2011), reported 9.65 mg per 100g vitamin E content in ground and freeze-dried silkworm powder (Bombyx mori) with reference to the previous findings the relatively higher amount of vitamin E in Oecophylla smaragdina from this locality can agree with the belief of the local people that the use of this ant species is helpful in curing some diseases like cold, sinusitis etc. However, the present study also revealed the fact that larva (80mg/100g) and pupa (57mg/100g) contains high amount of vitamin E in both the castes but the adult contains low content of only 17mg/100g. Caste wise differences as well as impact of climate change are not significant.

There is little information published about the B- vitamin levels of live insects. Finke (2002) reported relatively low levels of thiamine in Turkestan cockroaches, tebo worms, crickets and super worms. However, the present study depicts relatively high content of thiamine (10mg/100g) against 0.1mg- 4mg/100g reported by Bukkens (2005) for
a range of insects. Riboflavin ranged from 1.25-6.52mg/100g which is almost similar to 0.11 to 8.9 mg/100g reported by previous workers. Whereas wholemeal bread provides 0.16 mg and 0.19 mg per 100g of thiamine and riboflavin respectively. Pyridoxine and pantothenic acid content are also found to be high which supports the earlier reports of Finke (2012) in some selected insect species (Soldier flies and Teboworms larvae, Turkestan cockroach nymphs and adult houseflies). Low folic acid content observed in the weaver ants of the present study supports the very low content reported by previous workers. Studies on vitamins in edible insects are insufficient. But according to analysed results (Feng et al 2001a,b,c, 2000a,b; 1999; Chen and Feng 1991; He et al 1999; Lu 1992; DeFoliart 1991 ), edible insects are rich in vitamins for human health and nutrition. High amount of ascorbic acid (10.35 to 12.33mg/100g) is a notable observation of the present study which supports the previous report of Alamu et al (2013) on Hymenopteran insects with average of 10.25mg/100g of ascorbic acid. The results of the present study with higher amount of ascorbic acid and α-tocopherol supports the fact that these ants are nutritious and strengthen immune defences by the antioxidant property of these two vitamins.

In insects, metamorphic stage and diet highly influence nutritional value (Bukkens, 2005) making the statements on the micronutrient content of insect species of little value. Moreover, the mineral and vitamin contents of edible insects are highly variable across species and orders. Consumption of the entire insect body generally elevates nutritional content. The present study also in conformity as it depicts differences in content in different metamorphic stage and in different season. In present study lower values of lead, chromium suggest this ant species as safe and below toxic level for consumption (Fig: IV 28).
Fig: IV 28: Overall scenario of different nutrient components of Queen and worker castes of *Oecophylla smaragdina* Fabricius.

*Oecophylla smaragdina* commonly used edible insect of South east Asia is rich in protein, essential amino acid particularly lysine and threonine. This insect can supply rich fat, mineral element particularly iron, copper, zinc and vitamins. The insect is observed to be rich source of two important antioxidant vitamins as α-tocopherol and ascorbic acid. From the observations of the present study carried out in *Oecophylla smaragdina* collected from different parts of Assam, it is in agreement
with the previous researchers worked in different edible insects from
different parts of the world that this particular ant species is also good
nutrient source with sufficient amount of macro and micronutrients. The
findings can justify the use of this insect as a traditional food item by
rural communities.

As a nutritional resource and medicinal value these edible insects
and their commercialization/industrialization should be focussed on in
future studies. This insect could be a valuable renewable natural
resource. This particular edible insect as food may fit comfortably
within the environmentally sound scenario and by extension, can be
considered as a suitable staples food item and supplements as well as for
their role in sustainable diets. But more research is needed to determine
each and every component of the nutrients in detail and their variation
with change of host plant, climate and other environmental factors.

The shortage of resources has become an important issue
involved in the development. Insects have been widely used as food and
medicine and as an important natural, biological and sustainable utilized
resource; insects should be well developed to assist people dealing with
food crisis. In China, Thailand and some other eastern countries, insect
resources are used widespread and they have rich experiences in insect utilization.

In conclusion, the present study provides clear evidence of presence of substantial amount of nutritional ingredient in this particular ant species, *Oecophylla smaragdina* during months of summer season with clear impact of seasonal variation. Caste wise and life cycle stage wise differences in nutrient composition are clearly indicated in the study.

The nutritional components in the present study show variable values with the impact of season and life cycle stages. The protein is recorded as highest followed by lipid content, vitamin- C, vitamin- B complex, vitamin- E and elements. This insect may be taken as good supplement of protein, fat, minerals particularly iron, copper, zinc and vitamins. The highest amount of protein content and richness in vitamin–C, vitamin-B and vitamin- E suggest that this particular ant species, *Oecophylla smaragdina* as a good source of protein and vitamins. A high amount of essential amino acids and some important elements as iron, zinc and copper in all the three stages of life cycle in
both the Queen and worker castes are the important observations of the present study.

Reports of different investigators from various parts of the world have not mentioned about the changes occurred due to cooking processes in different places. But literature review suggests the data from both dry matter and raw matter reported increased amount of lipid after deep frying. But details of investigation regarding the other nutrient components are still lacking. It may be opined that as the other sources of these nutrient components as meat, fish etc, similar changes may occur due to different cooking processes. But for a definite conclusion further study with this objective is required.

From the present investigation it is revealed that out of all the life cycle stages, the larva and pupa stages of the Queen caste of the weaver ant contain a good amount of nutrients composition during the period of availability. As the present study suggests the lower values of heavy elements like lead and chromium as safe and below toxic level this ant species can be taken as a choice from consumer point of view.

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