EFFECTS OF *VITELLARIA PARADOXA* LEAF DIETS ON GROWTH AND NUTRITIONAL CONTENTS OF *CIRINA FORDA* (LEPIDOPTERA: SATURNIIDAE)

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DEPARTMENT OF ANIMAL BIOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY

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ABSTRACT

The current challenge of food security has called for exploitation of natural product, with potential nutritional and therapeutic characteristic, especially from less tapped agent. *Cirina forda* belongs to the Order Lepidoptera, family satuniidae, it's an insect that has been well described with good source of protein, fat, minerals and vitamins. Their non existence in the places of natural occurrence remained a reason of concerned to the populace that enjoys them in their dishes. This growth response study was designed to determine and evaluate the effects of different *Vitellaria paradoxa* leaves diet on laboratory reared *C. forda*. The study was carried out in Animal Biology Laboratory, Federal University of Technology Minna, Matured eggs of *C. forda* were collected from host plant where they naturally occur in lanle village, Bida, Niger State. The host plant leaves were collected for feeding the control group of the study which was tag as group A, Another set of four different host plants from different locations in Minna metropolis were collected and tagged as group B, C, D, and E for the laboratory rearing. The collected leaves were used to rear the larval stage of *C. forda* under standard laboratory condition. Morphometric characteristic, nutritional composition as well as biochemical characteristics of the reared *C. forda* was determined and recorded. Head capsule width range= (5.07-8.40 mm), Body length range= (36.99-64.50 mm), Body width range= (5.23-11.88 mm). All the leaves of the *V. paradoxa* shows high amount of phenol, saponnin and flavonoid. Protein content was highest in *C. forda* group A, (23.39 mg/100g), and the least in group D (16.66 mg/100g) carbohydrate was highest in *Cirina forda* group C (66.60 mg/100g) and the lowest in group A (58.71 mg/100g). Fat content was highest in group A (5.46 mg/100g) and lowest in group D (3.63 mg/100g). Vitamin composition was dominated by vitamin C. Vitamin C was higher in group D (56.11 mg/100g) and the lowest in group E (71.23 mg/100g) follow by vitamin A which was highest in group D (17.91 mg/100g) and lowest in group C (13.68 mg/100g). Mineral composition was dominated by sodium (Na) potassium (K) magnesium (Mg) and copper (Cu). Group E recorded highest Mg content (138.07 mg/100g) while group D (117.00 mg/100g) recorded the lowest. Copper was also highest in E (7.30 mg/100g) while the lowest in group C (5.92 mg/100g). Finding from this study thus indicated that the life cycle of *C. forda* strictly depended on the leave diet of *V. paradoxa*. The insect *Cirina forda* survived best in the naturally host plant *Vitellaria paradoxa*

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Cirina forda, the pallid emperor moth or shea defoliator, is a moth of the family *Saturniidae*. The species was first described by John O. Westwood in 1849. It is found in western Africa, including Ghana, Nigeria, Zimbabwe, Democratic Republic of Congo and South Africa, (Latham, 2003). The adults are pale creamy-brown with a small darker spot on each hind wing but lacking true eye-spots, its larvae resemble silk worm caterpillars except that they do not spin cocoons (Osasona and Olaofe, 2010). In Nigeria and Ghana, the larvae feed on *Vitellaria paradoxa*, and cause heavy defoliation, In Bas-Congo province, Democratic Republic of the Congo, they feed on *Crossopteryx febrifuga*. While in South Africa, the favoured food plant is the *Burkea africana* (Latham, 2003).

The larvae have different native names such as kanni or monimoni in yoruba language, Nupe called it pantoro or manimani, other native name include susan kadanya, abubu, kulamya fuma and egwo. *Cirina forda* is a holometabolous insect and the larvae as the only feeding stage (Ande, 1991). *Cirina forda* is indigenous to the middle belt which includes Niger, Kogi, Osun, and Oyo state, and they occur naturally where they are found.

Cirina forda life cycle is a complete metamorphosis with larvae, pupa and adult. The edible stage (larvae) have five instars, the first and the second instars feed gregariously while the third to fifth instars feeds solitarily (Ande and Fasoranti, 1995). *C. forda* egg hatches after an incubation period of 30 to 34 days into an active and voraciously-feeding larva, and

passes through 5 to 6 instars in 42 to 50 days between June and August. Although, the annual period of availability of C. *forda* vary with geographical area, but climatic condition for their development remain the same with temperature ranging from 22-27^{0}c relative humidity around 80 to 100% and little sunshine (Ande and Fasoranti, 1997). These conditions are signal for the beginning of each rainy season and larvae appear one or two month later (Ande and Fasoranti, 1996).

Cirina forda is univoltine in Nigeria and, the active periods occur during the wet months of May and August. The life cycle of *C. forda* is tightly linked to the biology of its host, *Vitellaria paradoxa,* the only savannah species of the family *Sapotaceae* in Nigeria, *V. paradoxa* blossoms fully between May and August when mature fruits become available, and sheds leaves between November and February (Keay *et al.*, 1964). The former that is May and August coincides with period of maximum population outburst of *C. forda* while pupation takes place during the dry months of November and April.

Cirina forda (Westwood) larva is widely marketed, cheap, and commonly consumed in Southwestern Nigeria (Oladele, 2013). The larvae of this insect are good source of protein for human and livestock consumption and income (Fasoranti and Ajiboye, 1993). *Cirina forda* larvae have the potential to provide substantial amount of protein, mineral and polyunsaturated fatty acids to the diets which are usually deficient in animal protein (Akinnawo and Ketiku, 2000).

1.2 Statement of the Research Problem

Vitellaria paradoxa is an indigenous plant of the savannah belt of western Africa and Nigeria in particular (Latham, 2003). *Cirina forda* in Nigeria has become restricted to the

northern dry wood savannah ecosystem, principally due to variation in the nutritional quality of the leaves diet, and this is directly related to foliage age and geographical location of the host *Vitellaria paradoxa* (Odebiyi *et al*., 2003; Odebiyi *et al*., 2009). *Vitellaria paradoxa* is common in Niger state but despite the availability C*irina forda* is found in limited locality. About 15 years ago *Cirina forda* do occur naturally on host plant *Vitellaria* paradoxa in Wuya Kanti and environs, but investigation of occurrence now showed that they no longer exist in these areas. Many authors have reported anthropogenic activities, predators and ant as the reason responsible for their non-existence in their place of natural occurrence, but little effort has been made to unravel the effects leaves of different *V. paradoxa* on the growth and biochemical composition on migration of *C. forda* population in Niger state. This work will attempt to investigate the influence of how leaves of different *Vitellaria paradoxa* nutrients will affect population distribution, growth and biochemical composition of *Cirina forda*.

1.3 Justification for the Study

Cirina forda larvae are source of protein and food supplement of the diet of many Nigerians (Ande, 1991). It has potentials for correcting malnutrition and diet related issues in children and aged. (Ande, 2003). *Cirina forda* is also sold raw, dried and processed as a source of income to the locality where they naturally occurs, but their non existence in the known geographical location where they naturally occurs in the past has become a reason for concerned. Unraveling the biochemical composition of the host plant (*Vitellaria paradoxa*) and the possible preferred leaves will encourage and boost artificial mass rearing of *Cirina forda* to meet its demand. This may also explain the reason for their non-existence in some areas of previous natural occurrence.

1.4 Aim and Objectives of the Study

The aim of this study was to evaluate the effects of leaves of different *Vitellaria paradoxa* on growth and development of *Cirina forda*.

The objectives of the study were to determine;

i. phytochemical, proximate and micronutrient contents of leaves of different *Vitellaria paradoxa*
ii. Growth indices of *Cirina forda* reared on leaves of different *Vitellaria paradoxa*.
iii. Proximate and micronutrient contents of *Cirina forda* reared on leaves of different *V. paradoxa* plant.
iv. Anti-nutrient contents of the *C. forda* reared on leaves of different *Vitellaria paradoxa*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Description of *Cirina forda* Pallid Moth

Cirina forda belong to Phylum Athropoda; Class; Insecta; Order: Lepidoptera Super family: Bombycoidea Family: Saturniidae Genus: *Cirina* Species: *Cirina forda* (Myers *et al*.,2018). It is found in western Africa, including Ghana, Nigeria, Zimbabwe, Democratic Republic of Congo and South Africa. The adults are pale creamy-brown with a small darker spot on each hind wing but lacking true eye-spots (Lathum, 2003). Its larvae resemble silk worm caterpillars except that they do not spin cocoons (Osasona and Olaofe, 2010). The larvae of this insect are good source of protein for human and livestock consumption and income (Fasoranti and Ajiboye, 1993). The larvae are consumed in Nigeria, Togo and some other African countries. They feed on *Crossopteryx febrifuga* in Bas-Congo province, DR Congo where they are also eaten. In South Africa, the favoured food plant is the tree *Burkea africana* (Lathum, 2003).

2.2 Economic Importance of *Cirina forda*

Study show that the larva of *Cirina forda* (Westwood) has the potential to provide Substantial amounts of proteins, minerals and polyunsaturated fatty acids to the diet of low income people whose diets are usually deficient in animal protein. Also, the larva has a high potassium sodium and a high polyunsaturated to saturated fatty acid (Akinnawo and Ketiku 2000)

Edible insects are of great importance in the development of poor populations who exploit them. Unfortunately, this unconventional resource is often minimized or ignored by both development program agents and the scientific community. Edible insects create profitable activities based on their collection, processing and sale on national and international markets (Tabuna, 1999; Mbétid - Bessane, 2005). Moreover, specific studies on nutritional aspect of African edible caterpillars have been carried out. Saturniidae, Notodontidae and Sphingidae are the three major families of Lepidoptera of which caterpillars are edible (Malaisse *et al.*, 2003). Edible insects constitute an important part of the daily diet of a large proportion of the population in southwestern Nigeria. These insect provide high quality of proteins and supplements (minerals and vitamins) even when dried (Banjo *et al*, 2006). Many Africans are fond of big and abundant Saturniidae larvae. Harvested in huge quantities when they appear, they are much appreciated and are exported not only to the sub-region, but also towards Diasporas settled in Europe (Tabuna, 1999). As stated earlier, among the edible Saturniidae species, the *Cirina forda* (Lepidoptera: Saturniidae) caterpillar is well accepted as food in Africa, especially in Nigeria, Zambia, Zimbabwe, South Africa, Centrafrican Republic and the Democratic Republic of Congo (Quin, 1959; Brandon, 1987; Holden, 1991; DeFoliart, 1995; Malaise 1997).

In Nigeria, especially, this caterpillar is in great demand and has become the most commercialized species (Fasoranti and Ajiboye 1993). Efforts must be geared toward investigating and improving upon their use as alternative sources of nutrients. Though, some workers have established the importance of some insects as sources of good nutrients (Bednarova *et al.*, 2013: Belluco *et al.*, 2013). In view of this, more work needed to be done in prospecting for more edible insects considering the array of nutrients they possess. The

traditional use of insects as food is widespread in tropical and subtropical countries and this provides significant nutritional, economic and ecological benefits for rural communities (DeFoliart, 1999). Edible insects are good sources of protein, fat and essential amino acids in the diet of both primates and human. Insects are capable of eliminating protein malnutrition in man (Kinyuru *et al.,* 2010). Insects provide good sources of proteins, minerals, vitamins, and energy, and they cost less than other animal protein (Bednarova *et al.,* 2013; Kinyuru *et al.,* 2013).

Different studies have shown that edible insects contain appreciable amount of proteins (Olaofe *et al*., 1998), (Ramos-Elorduy *et al*., 1997) and (Fashoranti and Ajiboye, 1993). It has also been reported that the dried form of insects commonly found in village markets of the developing world are very high in crude protein in which some species have values above 60% (DeFoliart, 1992). Insects are rich in protein; however, studies have shown that whole insects as a source of protein are somewhat of lower quality than vertebrate animals because of the indigestibility of chitin (Phelps *et al.,* 1975).

Oliveira *et al*. (1976) and DeFoliart (1992) have reported that insects like caterpillars (Saturmiidae), winged termites, and palm weevil larva are rich in Cu, Fe, Mg and Zn. Considering the fact that most edible insects are rich in protein, fat and minerals, research into the nutritional quality of insects will not only encourage the consumption of insects but also help in achieving some of the United Nations Millennium Development Goals such as eradication of hunger and extreme poverty, reducing child mortality and improving maternal health. *Cirina forda*, a Lepidoptera, is a pest of shea butter tree; its larvae resemble silk worm caterpillars except that they do not spin cocoons. Insects play major

roles in food security, health, and environmental management. Edible insects are rich in protein, fat, fibre, ash, carbohydrates, vitamins and minerals (Omotoso, 2006).

2.3 Propagation of *Cirina forda*

Pupation takes place in soft soil or sand at the base of the host plant. There is one generation per year. The larvae feed on shea butter tree *Vitellaria paradoxa*. *Cirina forda* may cause heavy defoliation in Ghana and Nigeria (Latham, 2003).

2.4 Nutritional and Functional Properties of *Cirina forda* Larva

The chemical composition of *C. forda* flour may have the moisture content of about 4.5% and (Banjo *et al*., 2006) reported 4.4 % for *C. forda.* This low value suggests that dry *C. forda* larvae are not likely to be susceptible to micro- organism attack. The crude protein content is about (20.0 ± 0.2 mg/100g) which is high compared to the reported value of 12.5 % (Uddoh, 1980) for pork. But it is also within the range of 15 to 60 % reported for various forms of Lepidoptera edible insects from the state of Oaxaca Mexico (Ramo- Elorduy *et al*., 1997). Disparity between results is possible due to the differences in processing methods; boiling and sun-drying the larvae before marketing might denatured some of the protein molecules. The minerals composition of *C. forda*, it reveals that potassium was the most abundant mineral in the flour of *C. forda*. This observation is in close agreement with the observation of Olaofe *et al.,* (1998) for *Zonocerus variegatus*. The least abundant mineral in the flour of *C. forda* was Fe with a value of 1.3 mg/100g. This value is close to the results (mg/100g) 0.68, 1.56 and 1.79 obtained for *Brachy trupes*, *Anaphe* spp and *C. forda* respectively (Banjo *et al*., 2006). The general order of the distribution of these minerals is K>P>Na> Mg>Z>Ca>Fe. The level of minerals present in edible insects indicates that

insects are good sources of minerals for the human body (Kinyuru *et al*., 2010). One hundred grams of *C. forda* larva contained 52.6 g of protein, 16.8 g of lipids, 2.6 g of ash, 268.67 mg of calcium, 5.64 mg of iron, and 15.00 mg of zinc, and yielded 458.40 kcal energy with 4.40 mg of trypsin inhibitor (Adepoju and Dabohoo, 2013).

Caterpillars in general and especially *C. forda* are known as defoliators through their nutritional activity. Badanaro *et al*., (2014) reported that raw *C. forda* caterpillars are richer in water than converted ones in nutrition so concrete measures should be taken to maintain the biodiversity of the host plant. Osasona and Olaofe (2010) concluded that *Cirina forda* is a good source of protein and fat but a poor source of calcium and iron; it can be recommended for pregnant women and be used in the formulation of infant foods but must be fortified with calcium and iron minerals. Therefore it is a good source of food for men or women (who are in menopause). The researchers further stated that *Cirina forda* flour could be useful in the formulation of viscous food like baked foods due to its high water absorption capacity. It could also find application as a flavour retainer and to improve the mouth feel of foods due to its high oil absorption capacity.

2.5 Anti- Nutrient in *Cirina forda*

The anti-nutrient contents of all insects were negligible and they will not pose any threat to the health of animals. The Ant-nutrients form part of the defensive mechanisms of plants and thus are part of food of animals, especially those that feed on plants and plant products. Processing methods such as heating, soaking, sprouting and cooking have been observed to have impact on the anti-nutritional factors of plants (Soetan and Oyewole, 2009). Foods

with lower anti-nutrient contents are good for the well-being of the people (Parul, 2014). Anti-nutrients have been observed to have positive effects on the health of animals through the contribution of dietary fibres (Palmer, 2011). Fibre is known to play important role in effecting movement of the bowels and in preventing cancer, cardiovascular diseases, diabetes and many other chronic human diseases (Rao *et al.* 2015; Yang *et al.*, 2017).

2.6 Toxicity of *Cirina forda.*

Akinnawo *et al.,* (2002) studied the t*oxicity* of the aqueous extracts of raw and processed larva of *Cirina forda* (Westwood) administered orally to white albino mice and albino rats. Preliminary investigation showed that the raw extract was toxic to mice, showing sign of irritability and muscular tremor. An LD50 value of 7,000 mg/kg body weight was obtained for the raw extract using mice. The effects of sub lethal dose of the extract on hematological and serum biochemical parameters were also studied in rats for 14 days. No significant effect was observed on most of the hematological and biochemical indices. Activities of some serum enzymes were normal in all the rats.

2.7 Harvesting Techniques of *Cirina forda.*

Edible insects which are usually classified under non-timber forest products, are a very important forest resource playing crucial roles in human diets particularly making diets more balanced and palatable (Food and Agricultural Organization, 1989; Latham 2001). Entomophagy, the practice of eating insects, is a food resource that ramifies both primitive and contemporary food traditions (De Foliart, 2002; 1990; 1989; Latham, 2001; Holden, 1991; Cherry, 1991). There has been increasing scientific attention on entomophagy because of its importance in the context of food security, poverty alleviation and indigenous knowledge particularly among rural communities (Ramos-Elorduy, 1997).

DeFoliart (1989; 1990; 2002) reported that scores of species of edible insects are prominent items of commerce in the town and village markets of Africa.

The method of collection and processing depends on the insect species and where it is found. Processing, no matter how crudely done, helps in minimizing post-harvest losses, removing toxins, facilitating packaging and also conversion of a resource into forms that are acceptable to different socio-economic classes (Galadima, 2003). *Cirina forda* larva is collected from the shea butter tree, *Vitellaria paradoxa*, its only host in Nigeria and throughout the West African sub-region. The eggs are found on the host plant from May to June and the larvae from June to August each year. The larvae are particularly harvested from shea butter trees in July and August each year (Ande and Fasoranti, 1997; Odeyemi and Fasoranti, 2000). The larvae are either collected from the leaves on the trees or pitfall traps made round the bases of trees with the larvae and descending larvae trapped and collected (Fasoranti and Ajiboye, 1993; Mbata and Chidumayo, 2003). Caterpillars are either pushed inside out with a thin stick or punctured and the contents squeezed out. Frequently, and especially if large quantities are harvested, they are boiled and dried out in the sun and stored for later use or sold in the local markets.

The insect is widely used as an ingredient in vegetable soup (Fasoranti and Ajiboye, 1993). *C. forda* (known as 'Igyô' in Tiv) is reported to be widely consumed and marketed in Benue State, Nigeria (Agbidye *et al.*, 2009). The harvesting and processing techniques for the insect have not been reported in Benue State. DeFoliart (1989; 2002) had stated that the manner of collecting and processing insects for consumption affects their nutrient content. Raw extracts of *C. forda* had been reported to contain toxins (Akinnawo *et al.*, 2002).

There were significant differences among the harvesting techniques for *C. forda* larvae employed by the Tiv people of Benue State. Picking larvae from pitfall traps was significantly highest compared to the other techniques employed. The natives excavated the soil round the bases of infested *V. paradoxa* trees prior to descent of the mature larvae for pupation in the soil. When the larvae descended for pupation in the soil, they became trapped in the pits (pitfall traps). The trapped larvae were then collected (Akinnawo *et al.*, 2002).

2.8 *Vitellaria paradoxa*, Host Plant of *Cirina forda* Larva

Vitellaria paradoxa commonly known as Shea tree, Shi tree, or *Vitellaria*, is a member of the Sapotaceae family. It is the only species of the genus *Vitellaria* (Byakagaba *et al*., 2011). The traditional African food plant is indigenous to Africa which has been claimed to have potentials to improve nutrition, and boost food supply in the 'annual hungry season' (Masters *et al*., 2010). The Shea tree grows naturally in the wild in the dry savannah belt of West Africa and it occurs in 19 countries across the African continent namely Benin, Burkina Faso, Cameroun, Central African Republic, Chad, Ethiopia, Ghana, Guinea Bissau, Cote d'ivoire, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Togo, Uganda, Democratic Republic of the Congo and Guinea. It preferably grows on alluvial soils that are deep with free drainage and predominantly sandy-clay top soils (Hall *et al*., 1996).

On a global scale, the importance of the shea nut tree is attached to the usefulness of its seed fat in food and cosmetic industries (Umali and Nikiema, 2002). In Africa, where the species occurs, the seed fat is used for cooking, in lighting of lamps, soap and pomade preparations as well as for medicinal purposes (Awoleye, 1995; ICRAF, 2000). Other parts of the plant

have been reported to possess various medicinal properties (Popoola and Tee, 2001). In addition, caterpillars of *Cirina forda* (Westwood), rich in protein and exclusive feeders on the leaves of the species, are considered a delicacy among the Yoruba, Nupe and several other Nigerian ethnic groups (Ande, 2003; Ugese *et al.*, 2010). Sale of these caterpillars is said to contribute significantly to rural household incomes (Popoola and Tee, 2001). The wood of *V. paradoxa* is hard and termite proof and is useful in constructional works and in the production of household and farm utensils. The fruit pulp has also been acknowledged to have excellent nutritional properties and is widely consumed among indigenous peoples (Maranz *et al*., 2004; Ugese *et al*., 2010).

Agroforestry species that show high potential in contributing to reduction of rural poverty, hunger and disease and enhancing environmental sustainability are considered priority species for domestication (Leakey *et al.*, 2005). Because of its various usefulness, *Vitellaria paradoxa* is threatened by over-exploitation as sources of fuel wood (Ogunkunle *et al.*, 2004) and charcoal for cooking and bread-baking activities (Oladele, 2013).

2.8.1 Botanical description of *Vitellaria paradoxa*

Vitellaria paradoxa is a small to medium-sized tree (min. 7) 10-15 (max. 25) m high; much branched, dense, spreading, round to hemispherical crown. In mature trees the hole is short, usually 3-4 m but exceptionally 8 m, with a diameter ranging from 0.3 to 1 m, but most frequently 0.6 m. Bark conspicuously thick, corky, horizontally and longitudinally deeply fissured; protects older trees against bush fires. Slash pale pink, secreting white latex, as do broken twigs or petioles. Leaves in dense clusters, spirally arranged at the end of stout twigs. They are covered by thick bark showing numerous leaf scars, petioles 5-15 cm long, leaves

oblong. Juvenile leaves rust-red and pubescent, later coriaceous, glabrous and dark green, shining, 12-25 cm long and 4-7 cm wide, leaf margin wavy and bent. The flowers develop in the axils of scale leaves, at the extremities of dormant twigs, from buds formed two years previously. Inflorescence is a dense fascicle 5-7.5 cm in diameter, at the end of a flowering twig, each usually containing 30-40 flowers, though 80-100 have been recorded. Individual flowers white or creamy-white, about 1.5 cm in diameter and subtended by scarious, brown, ovate or lanceolate bracteoles, which are abscised before flower opening. Fruit 5-8 cm long and 3-4 cm wide, elliptic, a yellow-green or yellow berry with thick butter-like, mucous pericarp; generally containing only 1 oval or round red-brown seed (the sheanut), surrounded by a fragile shining shell with a large, round, rough hilum on a broad base (Orwa *et al.*, 2009). *Vitellaria paradoxa* is in the Sapotaceae (soapberry family), (Wierseme and Leon, 1999). The genus *Vitellaria* is considered by botanical authorities as monospecific, two subspecies are recognized ssp. *paradoxa* restricted to Western Africa and ssp. Nilotica of Eastern Africa.

2.8.2 Biology of *Vitellaria paradoxa*

The hermaphroditic flowers are usually cross-pollinated, but can be self pollinated. Insects, especially bees, are important for pollination. Flowering lasts 30-75 days and the fruit takes 4-6 months to develop, reaching maturity early in the rainy season (Orwa *et al.*, 2009). The sugary pulp of the fruit makes it attractive to a wide range of animals. A large variety of birds, ungulates and primates, including humans, eat them, dispersing the seed in the process. In West Africa, fresh, de-pulped sheanuts are usually par-boiled (thought to destroy germination enzymes and fungal infections) prior to sun-drying and de-corticating (Orwa *et al.*, 2009).

2.8.3 Ecology of *Vitellaria paradoxa.*

The shea tree is a light-demanding species of open sites and parkland savannah; forming extensive pure stands in some areas but often also associated with other trees, such as *Parkia biglobosa* (nere). It avoids swampy areas, those liable to flooding for any length of time, moist heavy loam soils or watercourses. The extensive root system is essential for survival in the 5-7-month dry seasons of savannah climates and can withstand quite severe fires (Orwa, *et al.,* 2009).

2.8.4 Leaf epidermal morphology of *Vitellaria paradoxa*

Leaf morphological characteristics are important aids for identifying plant species of agricultural and other economic values. Stomata, epidermal cell and trichome characters have also been useful as excellent taxonomic markers (Ogundipe and Akinrinlade, 1999; Parveen *et al.,* 2000; Edeoga and Ogbebor, 2001; Adedeji and Faluyi, 2001; Das *et al.,* 2004). As valuable as the shea nut tree is, there is lack of information on its leaf surface anatomy from different ecological locations in Nigeria (Oyegoke *et al.,* 2014).

2.8.5 Products of *Vitellaria paradoxa*

The following are products derived from *Vitellaria paradoxa*:

Food: Shea butter extracted from the nuts is one of the most affordable and widely used vegetable fats in the Sahel. Today, shea nuts are important internationally and are sold to European and Japanese food industries. The refined fat is sold as baking fat, margarine and other fatty spreads under various trade names and finds increasing use in various foodstuffs. Shea butter has a fatty composition similar to that of cocoa butter, so is often used as a

substitute for cocoa, and in pastry because it makes highly pliable dough. Traditionally prepared unpurified, shea butter is sold in 'loaves' in markets and, if properly prepared and wrapped in leaves, is resistant to oxidative rancidity and will keep for years if not exposed to air and heat. Nuts that have been cleaned and lightly sun dried without previous maceration yield a tasteless, odourless fat. Traditionally prepared shea butter, after refining, is also tasteless and odourless (Orwa *et al.,* 2009).

The edible fruit pulp constitutes 50-80% of the whole fruit. It is allowed to become slightly overripe before being eaten raw; it can also be eaten lightly cooked. Children eat the nuts raw, while the flowers are made into fritters by some ethnic groups. Caterpillars of *Cirina butyrospermii* A. Vuilet, which feed exclusively on the leaves of the shea-butter tree, are dried and sold in markets in Nigeria and Senegal. They are rich in protein and sometimes eaten in a sauce (Orwa *et al.,* 2009).

Fodder: Shea-nut cake is increasingly used for livestock and poultry feed. Leaves and young sprouts serve as forage. Sheep and pigs eat the sugary pulp of ripe fruit that have fallen to the ground (Orwa *et al.,* 2009).

Apiculture: The tree is much sought after for placing hives in traditional apiculture. *Vitellaria* furnish the bees with a great quantity of nectar and pollen (Orwa *et al.,* 2009).

Fuel: Excellent-quality firewood that burns with a fierce heat. The charcoal is not good quality, however; it burns rapidly and is friable and, although it provides enough heat for domestic use, is not suitable for iron-working. The sticky black residue from fat extraction can also be used as a substitute for kerosene when lighting firewood. Due to its value as a fruit tree, *V. paradoxa* is seldom cut for fuel (Orwa *et al.,* 2009).

Timber: Wood brownish-red, darkens readily on exposure; strong, hard, heavy, durable, resilient, and weathers and wears well. Despite its hardness, it saws and planes well, takes an excellent polish, and glues, nails and screws well, but pre-boring is advisable to prevent splitting. Wood is used in engineering structures, house posts and support poles, also in ship building, for shingles, stakes and fencing, sleepers, medium and heavy-duty flooring, joinery, seats, household utensils, durable platters and bowls, pestles and mortars and tool handles. It is termite resistant (Orwa *et al.,* 2009).

Latex or rubber: The latex is heated and mixed with palm oil to make glue. Latex obtained from the bark of the trees could be used as a chewing-gum base, but it does not have a very pleasant taste. Washing improves the taste but detracts from the chewing quality of the gum. The sap has been used traditionally to prepare punctured drums (Orwa *et al.,* 2009).

Lipids: The shea-butter tree is an important oil-producing plant, especially as it occurs where other such plants are rare. It is also useful in soap making, but it is unique in having a high fraction of oil (8%) that does not convert into soap; this fraction has numerous medicinal qualities. The sticky black residue that remains after the clarification of butter is used for filling cracks in hut walls (Orwa *et al.,* 2009).

Wax: The high melting point of the fat renders it especially suitable for candle manufacture.

Poison: Waste water from traditional shea-butter extraction is believed to keep white ants away. Traditionally, shea butter, at a rate of 5 ml oil/kg of seed, has been shown to protect *Vigna subterranea* against *Callosobruchus maculatus.* A root-bark extract (100 ppm) is effective against *Bulinus globosus*; when mixed with tobacco, the roots are used as a poison by the Jukun of Taraba state, northern Nigeria. Infusions of the bark have selective

antimicrobial properties, being effective against *Sarcina lutea* and *Staphyllococus aureus* (Orwa *et al.*, 2009).

Medicine: Shea butter protects against sunburn, so is a useful ingredient in sun-protection or post-sun-exposure products. It also encourages wound healing and soothes skin irritation. Shea butter is stable and permits the fast release of medicaments; it can therefore be used as a base for suppositories and ointments. Shea butter is traditionally used in medicines, particularly for the preparation of skin ointments, and is used to treat inflammation, rashes in children, dermatitis, sunburn, chapping, irritation, ulcers and as a rub for rheumatism. Although the smell is not pleasant to many, it was the pomade of Babur people of southern Borno for decades in the past. Leaf decoctions are used for stomach-ache, headache and as an eye lotion. Roots and bark are ground to a paste and taken orally to cure jaundice, or are boiled and pounded to treat chronic sores and girth sores in horses. They are also used for the treatment of diarrhoea and stomach-ache. A bark decoction is used in a bath to facilitate childbirth in Cote d'Ivoire; it is drunk to encourage lactation after delivery, although in northern Nigeria such a concoction is said to be lethal. A bark infusion is used as an eyewash as a footbath to help extract jiggers, and to neutralize the venom of the spitting cobra. Infusions have been taken for the treatment of leprosy in Guinea-Bissau and for gastric problems as well as for diarrhoea and dysentery. Macerated with the bark of *Ceiba pentandra* and salt, infusions have been used to treat cattle with worms in Senegal and Guinea. *Tapinanthus globifera*, one of the most common parasitic plants on *Vitellaria*, also has many medicinal uses (Orwa *et al.*, 2009).

Other products: Shea butter is used as a base for many commercial preparations. Increasingly, cosmetics, especially those that prevent skin drying and good-quality lipsticks,

use shea butter. As a result, cosmetic industries in the Sahel and elsewhere market this ingredient in many soap, shampoo and skin-cream preparations. Today, *Vitellaria* is the 2nd most important oil crop in Africa, after oil palm, but it takes on primary importance in areas in West Africa where annual precipitation is less than 1000 mm and therefore unsuitable for oil palm. The residual meal of the seed cake is applied to the exterior walls of mud huts, doors, windows and traditional beehives, in a similar way to shea butter, to provide a waterproof layer.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

This study was carried out in Minna, the capital of Niger State, North Central Nigeria. Minna is located within the longitude 6^0 33'E and latitude 9^0 37'N, The study area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20^0 C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons: a rainy season (May-October) and dry season (November-April) (Office for Coordination Hummantarian Affairs, 2016).

3.2 Source and Collection of *Cirina forda* Eggs

Egg clusters of *C. forda* were handpicked from host plant *Vitellaria paradoxa* in a rural community, Lanle Village, located in Lavun Local Government Area about 90 km on Bida-Mokwa road, Minna Niger State, Nigeria. The eggs were placed and maintained in larvae rearing box before transportation to the Laboratory of Animal Biology Department, Federal University of Technology Minna for rearing.

3.3 Selection of Host plant, *Vitellaria paradoxa*

The individual plants were selected based on the nature of their leaves, structures and fruits and were tagged as B, C, D, E while the leaves where they naturally occur as A which serve as the control of the study.

Plate i: Field photograph of *Vitellaria paradoxa* plant A

Plate ii: Field photograph of plant A leaves

Plate iii: Field photograph of *Vitellaria paradoxa* plant B

Plate: iv: Field photograph of plant B leaves

Plate v: Field photograph of *Vitellaria paradoxa* plant C

Plate vi: Field photograph of plant C leaves

Plate vii: Field photograph of *Vitellaria paradoxa* plant D

Plate viii: Field photograph of plant D

Plate ix: Field photograph of *Vitellaria paradoxa* plant E

Plate x: Field photograph of plant E leaves

3.4 Morphology of the Plants Selected

Plant A. has a long, broad and soft leaves, green Colour leaves, big fruit and thick back of plant, infested with *C. forda*, Plant B. has a Narrow, long and hard leaves, dark green colour leaves, and big fruit with rough back, no presence of *C. forda*. Plant C. has a Narrow, Short leaves, hard strong leaves with reddish green colour and rough back, medium size fruit and no presence of *C. forda*. Plant D. has a Long, broad and soft leaves, green in Colour leaves, small fruit and soft back of plant and no *C. forda* on the tree. Plant E. has a Narrow, long leaves, green in colour, big fruit and soft thick back of plant no *C. forda* on the tree.

3.5 Experimental Design

The eggs were maintained in the laboratory with daily sprinkling of water to stimulate rainfalls in order to maintained moisture. Fresh leaves from the five selected plant were replace daily waiting for the hatching of the neonate. After hatching five different rearing troughs were tag as A B C D and E and 100 larvae of the *C. forda* were introduced accordingly with two replicates. The larvae were fed with the different leaves of the *V. paradoxa* under laboratory condition. Daily records of their growth were recorded.

Plate vi: field photograph of *Cirina forda* group A

Plate vii: field photograph of *Cirina forda* group B

Plate viii: field photograph of *Cirina forda* group C

Plate ix: field photograph of *Cirina forda* group D

Plate x: field photograph of *Cirina forda* group E

3.6 Procedures for Measurement of Morphometric Indices of Reared *C. forda*

Ten (10) *Cirina forda* larvae were selected randomly from each rearing trough daily for measurement, the average of head capsule width, body length and body width were calculated and recorded, mortality rate were also recorded, and average growth of every week and every instar were also recorded. All measurement was in millimeter (mm) (Odeyemi, 2008).

3.7 Morphometric Parameters Measured

Cirina forda head capsule, total body length, and the width of the abdominal segment were the parameters measured. Ruler, divider and a cardboard paper were used in taking measurements. After rearing the larvae were harvested for analysis with the leaves used as the feed (Odeyemi, *et al*., 2013).

3.8 Sample Collection and Preparation for Analysis

Fresh samples of emperor moth caterpillar larvae at maturity were handpicked from all treatments. The samples were wash separately in warm water and dry in the laboratory at room temperature of 27^0c-28^0c to remove moisture. The samples were separately milled into powder ready for proximate, minerals, vitamins and anti-nutrients analysis (Odeyemi *et al.,* 2018).

3.9 Determination of Phytochemicals Contents of *V. paradoxa* and Anti-nutrient of the *C. forda* Reared.

Determination of total phenol was carried out using the method described by (Edeoga *et al*., 2005) 2 g of the sample were defatted with 100ml of diethyl other using a soxhlet apparatus

for 2 hr. the fat free sample was boiled with 50 ml of petroleum ether for the extraction of the phenolic component for 15min. 5ml of the extract was pipette into a 50 ml flask, then 10 ml of distilled water was added. 2 ml of ammonium hydroxide solution and 5 ml of concentrated amyl alcohol were also added. The samples were made up to mark and left to react for 30 min for colour development. This was measured at 505 nm. Tannic acid was used to establish the calibration curve.

Total flavonoid was determined using aluminum chloride colorimetric method (Chang *et al*., 2002). Quercetin was used to establish the calibration curve. Exactly 0.5 ml of the diluted sample was added into test tube containing 1.5 ml of methanol. 0.1 ml of 10% $AlCl_3$ solution and 0.1 ml sodium acetate ($NaCH_3COO^-$) were added, followed by 2.8 ml of distilled water. After incubation at room temperature for 30min, the absorbance of the reaction mixture was measured at 415 nm. The amount of 10% $AlCl_3$ was substituted by the same amount of distilled water in blank.

Determination of saponins was carried out using (Oloyed, 2005) method 0.5 g of the samples *Cirina forda* and *V. paradoxa* was weighted into different 50 ml beaker and then added to 20 ml of 1NHCl and was boiled for 4 h. After cooling it was filtered and 50 ml of petroleum ether was added to the filtrate for ether layer and evaporated to dryness. 5 ml of acetone ethanol was added to the residue. 0.4 mls of each was taken into 3 different test tubes. 6 ml of ferrous sulphate reagent was added into them followed by 2 ml of concentrated H_2SO_4. It was thoroughly mixed after 10 min and the absorbance was taken at 490 nm. Standard saponin was used to establish the calibration curve.

Total tannin was carried out using (AOAC, 1984) method 0.2 g of the samples *Cirina forda* and *V. paradoxa* were measured into a different 50 ml beaker. 20 ml of 50 % methanol was

added and covered with parafilm and placed in a water bath at 77-80^{O} C for 1 hr. it was shaken thoroughly to ensure a uniform mixture. The extract was quantitatively filtered using a double layered whatman No.41 filter paper into a 100 ml volumetric flask, 20 ml water added, 2.5 ml Folin-Denis reagent and 10 ml of Na_2CO_3 were added and mixed properly. The mixture was made up to mark with water mixed well and allowed to stand for 20 min for the development of a bluish-green colour. The absorbances of the tannic acid standard solutions as well as samples were read after colour development on a UV-spectrophotometer model 752 at a wavelength of 760 nm.

The phytic acid content was determined using a modified indirect colorimetric method of Wheeler and Ferrel (1971). The method depends on an iron phosphorus ratio of 4:6 and is based on the ability of standard ferric chloride to precipitate phytate in dilute HCI extract of the sample. 5 g of the samples of *Cirina forda* and *V. paradoxa* were extracted with 20 ml of 3% trichloroacetic acid and filtered. 5ml of the filtrate were used for the analysis; the phytate was precipitated as ferric phytate and converted to ferric hydroxide and soluble sodium phytate by adding 5 ml of IM NaOH. The precipitate was dissolved with hot 3.2M HNO_3 and the absorbance and immediately at 480 nm. Preparation of standard curve for phytic acid was done as follows: standard curve of different Fe $(NO_3)_3$ concentrations were plotted against the corresponding absorbance of spectrophotometer to calculate the ferric iron concentration. The phytate phosphorus was calculated from the concentration of ferric iron assuming 4:6 irons: phosphorus molar ratio.

Cyanide content was determined by alkaline picrate method according to Wang and Filled method as described by (Onwuka, 2005). 5 g of powdered sample was dissolved in 50 ml of distilled water in a cooking conical flask and the extraction was allowed to stand over-

night, and then filtered. 1ml of sample filtered was mixed with 4ml alkaline picrate in a corked test tube and incubated in a water bath for 5 mins. After colour development (reddish brown colour) the absorbance was read at 490 nm, the absorbance of the blank containing 1ml distilled water and 4ml alkaline picrate solution was also recorded. The cyanide content was extrapolated from cyanide standard curve prepared from different concentration of KCN solution containing 5-50 μg cyanide in a 5001 conical flask followed by addition of 25ml of INHCI.

Oxalate in the sample was determined by permanganate titrimetric method as described by (Oke, 1966). Two grams (2 g) of the *Cirina forda* and *V. paradoxa* samples flour was suspended in 190 ml of distilled water in 250 ml volumetric flask. 10ml of 6M HCI was added and the suspension digested at 100^0 C for 1 hr, cooled, then made to the mark before filtration. Duplicate portion of 125 of the filtrate were measured into beakers and 4 drops of methyl red indicator added. This is followed by the addition of cone. NH_4OH solution drop wise until the test solution changes from salmon pink colour to a faint yellow colour (pH 4-4.5). Each portion is then heated to 90^0C, cooled and filtered to remove precipitate containing ferrous ion. The filtrate is again heated to 90^0 C and 10 ml of 5% $CaC1_2$ solution added while being stirred constantly. After heating, it was cooled and left overnight at 5^0 C. The solution was then centrifuged at 2500 rpm for 5 mins, the supernatant decanted and the precipitate completely dissolved in 10 ml of 20% (v/v) H_2SO_4 solution. The total filtrate resulting from the digestion was made up to 300 ml. Aliquots of 125 ml of the filtrate was heated until near boiling and then titrated against 0.05M standardized $KMnO_4$ solution to a faint pink colour which persisted for 30s. The calcium oxalate content is calculated using the formula:

$$\frac{T \times (Vme)\,(Df) \times 10^5}{(ME) \times Mf} \quad (mg/100g)$$

Where T is the titre of $KMnO_4$ (ml), Vme is the volume-mass equivalent ($1cm^3$ of 0.05M $KMnO_4$ solution is equivalent to 0.00225 g anhydrous oxalic acid), Df is the dilution factor V_T/A (2.5 where V_T is the total volume of titrate (300 ml) and A is the aliquot used (125ml), ME is the molar equivalent of $KMnO_4$ in oxalate ($KMnO_4$ redox reaction) and Mf is the mass of flour used.

3.10 Determination of Minerals Element of *Vitellaria paradoxa* and *Cirina forda*

The milled C*irina forda* sample and the milled *Vitellaria paradoxa* were ashes. The ashing was desolved in hydrochloric acid and the mineral elements are estimated using atomic absorption spectrophotometry (180) 3889 determination of aluminum, copper, lead and zinc by flame atomic absorption method).

Six grams (6 g) of the each sample into a pressure dust ignited, cooled, and weighed crucible. The milled *Cirina forda* samples and the milled *Vitellaria paradoxa* were heated gently over a Bunsen burner until the sample was charred and transferred the crucible to muffle furnace at about 550^o C until a light grey ash was produced. The residue is black in colour moisten with a small amount of water, to dissolve salts, dry in an oven and repeated and cooled in a desiccator. About 5 ml of concentrated hydrochloric was added into the crucible containing the ash was added and the mixture was turn for 5 min in a hot plate in a fume cupboard and acid was added as necessary to maintain the volume. The samples were transferred to a beaker and wash the crucible into the beaker with distilled water. The volume was adjusted to about 40 ml and boil for 10 min over a Bunsen burner. The sample was Cooled and filtered through glass wool into a 100 ml volumetric flask and rinsed the

beaker with distilled water into the volumetric flask. Cool and make up to volume. This ash samples solution was used for the determination of individual minerals.

3.11 Proximate Composition Analysis *Vitellaria paradoxa* and *Cirina forda*

The proximate analysis of the samples for moisture, total ash, crude fibre, fat were carried out in triplicate using methods described by (Onwuka 2005). The nitrogen was determined by micro Kjeldah method described by (Onwuka 2005) and the nitrogen content was converted to protein by multiplying by a factor of 6.25. Total carbohydrate content was estimated by 'difference. All the proximate values were reported in percentage (%).

Moisture was determined by oven drying method. 2 g of well-mixed samples was accurately weighed in clean, dried crucible (W_1). The crucible was allowed in an oven at 100-105 C for 6-12 h until a constant weight was obtained. Then the crucible was placed in the desiccator for 30 min to cool. After cooling it was weighed again (W_2), the percentage moisture was calculated by following formula.

$$\% \text{ Moisture} = \frac{W_1 - W_2 \times 100}{\text{Weight of sample}}$$

Where

W = Initial weight of crucible + Sample 1

W = Final weight of crucible + Sample 2

For the determination of ash, clean empty crucible was placed in a muffle furnace at 550^0 C for an hour, cooled in desiccator and then weight of empty crucible was noted (W_1). Two gram of each of sample was taken in crucible (W_2) and was purchased over a burner, until it was charred. Then the crucible was placed in muffle furnace for ashing at 550^0 C for 2-4 h.

the appearance for gray white ash indicate complete oxidation of all organic matter in the sample. After ashing the crucible was cooled and weighed (W_3). Percentage ash was calculated by the following formula.

$$\% \text{ Ash} = \frac{\text{Difference in Weight of Ash}}{\text{Weight of Sample}}$$

Difference in weight of ash = $W_3 - W_1$

Protein in the sample was determined by kjeldahl method. 0.25 g of dried samples was taken in digestion flask, with 6 ml of concentrated H_2SO_4 and a speck of kjeldah1 catalyst (mixture of 10 g Na_2SO_4+5g CuSO4+ 0.05g selenium). The flask was swirled in order to mix the contents thoroughly then digested on the digestion block till the mixtures become clear (colourless or greenish in color). The digest was cooled and transferred to 50 ml volumetric flask and volume was made up to mark by the addition of distilled water. Distillation of the digest was performed in Markham Distillation Apparatus. Ten milliliters of digest was introduced in the distillation tube then 10 ml of 40 % NaOH was gradually added through the same way. Distillation was continued for at least 10 min and NH_3 produced was collected as NH_4OH in conical flask containing 5 ml of 4% boric acid solution with few drops of methyl red indicator. During distillation yellowish color appears due to NH_4OH. The distillate was then titrated against standard 0.1 N HCI solutions till the appearance of pink color. A blank was also run through all steps as above. Percentage crude protein content of the sample was calculated by using the following formula;

% Crude Protein = 6.25* x %N (*. Correction factor)

$$\%N = \frac{(S-B) \times N \times 0.014 \times D \times 100}{\text{Weight of the sample} \times V}$$

Where

S = Sample titration reading B = Blank titration reading

N = Normality of HCI D = Dilution of sample after digestion

V = Volume taken for distillation 0.014 – Milli equivalent weight of Nitrogen

Crude fat was determined by ether extract method using Soxhlet apparatus. Approximately 2 g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. A weighed, cleaned and dried receiving flask was filled with petroleum ether and fitted into the apparatus. The soxhlet apparatus was assembled and allow refluxing for 6hrs; extract was transferred into clean glass dish with either washing which was evaporated on water bath. Then the dish placed in an oven at 105^0 C-110^0 C for 1hr and cooled it in a desicator. The percentage crude fat was determined by using the following formula:

$$\% \text{ Crude Fat} = \frac{\text{Weight of either} \times 100}{\text{Weight of sample}}$$

Determination of crude Fiber content 2 g of sample was defatted with per ether; boiled under reflux for 30 min with 200 ml a solution containing 1.25g of H_2SO_4 per 100 ml of solution. The solution was filtered through linen or several layers of chees cloth on fluted funnel, washed with boiling water until the washings are no longer acidic then the residue was transferred into a beaker and boiled for 30 min with 200 ml of solution containing 1.25 g of carbonate free NaOH per 100 ml, the final residue was filtered through a thin but close pad of washed and ignited asbestos in a Gooch crucible, then dried in an electric oven and weighed after which it was incinerated, cooled and reweighed. The loss in weight after incineration x 100 is the percentage crude fiber.

Determination of carbohydrate content of *Cirina forda* and *V. paradoxa* by nitrogen free method described by (Association of Official Agricultural Chemists AOAC, 1990) was used. The carbohydrate is calculated as weight by difference between 100 and the summation of other proximate parameter as Nitrogen free Extract (NFE) percentage carbohydrate (NFE) = 100- (m+p+F+A+F_2).

Where M=moisture, P=protein, F_1=Fat, A=ash, F_2=crude fiber.

3.12 Determination of Vitamin Contents of *Cirina forda* and *Vitellaria paradoxa*

The vitamin A, B_1, B_2, B_3 and C contents of the insect samples were carried out using various standard analytical procedures. Vitamin A content was determined by the method described in the (Marck index 2001). Two gram (2 g) of insect sample *Cirina forda* and *V. paradoxa* was weighed into a different flat bottom flask and 10 ml of distilled water was added to each sample. Twenty five millilitre (25 ml) of alcoholic KOH solution was then added. The mixture was heated on a water bath for 1 hour and allowed to cool and 30 ml of water was added. The hydrolysate obtained was transferred into a separatory funnel. The solution was extracted three times with 250 ml of chloroform. Two gram (2 g) of anhydrous Na_2So_4 was added to the extract to remove any trace of water. The mixture was then filtered into 100 ml volumetric flask and made up to mark with chloroform. Standard solution of Vitamin A of range 0 – 50 µg/ml was prepared by dissolving 0.003 g of standard Vitamin A in 100 ml of chloroform. Absorbances of sample and standards were read on the Spectrophotometer (Metrohm Spectronic 21D Models) at a wavelength of 328 nm and vitamin A content calculated.

$$\text{Vitamin A in µg/100g} = \frac{\text{Absorbance of sample} \times \text{Gradient factor} \times \text{Dilution factor}}{\text{weight of sample}}$$

Determination of vitamin B_1 was according to the methods of (Onwuka 2005). Briefly, two grammes (2 g) of the samples *Cirina forda* and *V. paradoxa* was weighted out into different beaker and 50 ml of alcoholic NaoH was added and allowed to stand for few minutes before being filtered out. Ten milliliter (10 ml) of filtrate was measured out and 10 ml of potassium dichromate added. The absorbance was read at 430 nm

Calculation of vitamin B_1 was done as follows

Weight of sample $= \frac{100}{as} \times au \times c \times \frac{Vf}{Va} \times D$

Where au= absorbance of sample, ac= absorbance of standard, c= concentration of the standard (mg/l), Vf= total volume of extract Va= volume of the extract analyzed, D= dilution factor.

determination of vitamin B_2 was carried out according to the specifications of British (Pharmacopoedia 1988). Two gram (2 g) of insect sample *Cirina forda* and *V. paradoxa* was weighed into a beaker, crushed and dissolved in 20 ml of glycerinated phosphate buffer. This was centrifuged for 10 minutes. The supernatant of the sample was obtained and 10 ml of the sample was taken into a 100 ml volumetric flask and made up to the mark with distilled water.10 ml of both test and standard solutions (Riboflavin) were pippetted into separate 50 ml volumetric flasks and 2ml of 2% citric acid solution and $KMnO_4$ were added to the samples and allowed to stand for 2 minutes. Finally 1ml of H_2O_2 was added to both flask containing the test and standard solutions and solutions were allowed to stand for 5 minutes. The absorbance of the test and standard solutions were taken at 450 nm. Vitamin B_2 content was calculated using the formula

Vitamin B2 in mg/2g = $\frac{AT}{AS} - 0.085 \times \frac{WS}{500} \times 2$

Where AT is absorbance of Test

AS is absorbance of standard sample

WS is weight of standard sample

Determination of niacin (vitamin B_3) content of the *Cirina forda* and *V. paradox* Five grams (5g) of the samples *Cirina forda* and *V. paradoxa* was treated with 50 milliliters of in sulphuric acid and shaken for 39 minutes, 3 drops of ammonia solution was added to the sample and filtrate into a 50 mililitre volumetric flask and 5 milliliters of potassium cyanide was added. This was acidified with 5 milliliters of 0.02N sulphuric acid and absorbance was measured in the spectrometer at 470 nm wavelength. A standard niacin solution was prepared and diluted. 10 mililiters of the solution was analyzed as discussed above. The reading were made reagent blank at zero. The formula below was used

Niacin mg/100g=$\frac{100}{w} \times \frac{Au}{as} \times c \times Vf/Va \times D$

Where w= weight of the sample analyzed, Au= absorbance of the test sample, As= absorbance of the standard solution, Vf= total volume of filtrate, Va= volume of filtrate analyzed, c= concentration of the standard solution, D= dilution factor where applicable.

Determination Vitamin C content of the *Cirina forda* and *V. paradoxa* was determined using the method described by (Onwuka 2005). Five gram (5 g) of the sample *Cirina forda* and *V. paradoxa* was homogenized each in 45 ml of distilled water. The suspension was then filtered. Five milliltre (5 ml) of the filtrate was measured into a 250 ml conical flask

and 0.1ml of glacial acetic acid was added. Dichlorophenol indophenol was titrated against the filtrate in the flask until the solution became faint pink. The titre value was taken and the vitamin C content was then calculated.

3.13 Data Analysis

Data obtained from the study were analyzed using ANOVA to determine the difference in growth parameters. The proximate, anti-nutrients, phytochemical and morphometric data of each plant and the insect species were analyzed using analysis of variance couple with Duncan multiple range test (DMRT). The results of the insect were compared with that of the host plant using paired sample t test. Analysis was assumed significant at $p < 0.05$. All analysis were carried out using Microsoft excel 2010 version and statistical package of social sciences version 23.

CHAPTER FOUR

4.0 RESULTS AND DISCUSION

4.1 RESULTS

4.1.1 Phytochemical analysis of different *Vitellaria paradoxa* leaves

Phytochemicals compositions of five *Vitellaria paradoxa* leaves used as feed is presented in Table 4.1. Cyanide content of *Vitellaria paradoxa* was highest in plant A (36.94±0.15 mg/100g) and lowest in plant B (26.64 ± 0.67 mg/100g). However there was no significant difference in plant A (36.94± 0.15 mg/100g) the control (leaves where they naturally occur) and plant D (35.86 ± 0.00 mg/100g) and also no significant difference in plant C (32.56 ± 0.13 mg/100g) and plant E (31.36 ± 0.22
mg/100g).

Phytate content of the plant *V. paradoxa* is highest in plant A (95.16 ± 0.34 mg/100g) the control and the lowest were recorded in plant E (53.05 ± 0.45 mg/100g). However there was no significant difference ($p>0.05$) in plant A (95.16 ± 0.34 mg/100g) the control and plant D (93.50 ± 1.00 mg/100g).

The oxalate content was highest in plant C (4.20 ± 0.15 mg/100g). However there was no significant difference in plant A (5.39 ± 0.00 mg/100g), plant B (5.22 ± 0.03 mg/100g) and plant E (5.78 ± 0.27 mg/100g) as well as no significant difference ($p>0.05$) in plant C (4.20 ± 015 mg/100g) and plant D (4.46 ± 0.16 mg/100g).

Phenol content in the plant was recorded highest in plant D (852.31 ± 0.71 mg/100g) while the lowest was recorded in plant B (782.75 ± 1.83 mg/100g). However there was no significant difference in plant C (824.77 ± 1.13 mg/100g) and plant E (821.77 ± 0.86 mg/100g) respectively at $P> 0.05$.

Saponnin content was recorded highest in C (746.23 ± 1.75 mg/100g) which show poor growth while the lowest was recorded plant B (505.72 ± 1.60 mg/100g). However there was no significant difference ($p>0.05$) in plant D (515.96 ± 1.35 mg/100g) and plant E (511.01 ± 0.00 mg/100g).

Table 4.1 Phytochemical Contents of different *Vitellaria paradoxa leaves*

Plant	Cyanide	Phytate	Oxalates	Flavonoids	Phenol	Saponnins
pA	36.94±0.15^{c*}	95.16±0.34^{d}	5.39±0.00^{b}	66.01±0.60^{c}	845.09±1.60^{c}	632.76±1.87^{c}
pB	26.64±0.67^{a}	81.67±2.43^{c}	5.22±0.03^{b}	43.73±2.19^{b}	782.75±1.83^{a}	505.72±1.60^{a}
pC	32.56±0.13^{b}	65.56±0.45^{b}	4.20±0.15^{a}	35.91±0.50^{a}	824.77±1.13^{b}	746.23±1.75^{d}
pD	35.86±0.00^{c}	93.50±1.00^{d}	4.46±0.16^{a}	132.70±1.16^{c}	852.31±0.71^{d}	515.96±1.35^{b}
pE	31.36±0.22^{b}	53.05±0.45^{a}	5.78±0.27^{b}	83.00±1.20^{d}	821.77±0.86^{b}	511.01±0.00^{b}

* Values are presented in mean ± standard error of three replicate. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05 Key: pA, pB, pC, pD and pE are the leaves of different *V. paradoxa* plant used as fed

4.1.2 Proximate composition of different *Vitellaria paradoxa* leaves

The proximate composition of the different *V. paradoxa* leaves are shown in Table 4.2. Moisture content was recorded highest in plant E (4.11± 0.00 mg/100g) this was not significant difference (p>0.05) with plant A (4.02±0.10 mg/100g) and the lowest was recorded in plant C (3.40±0.00 mg/100g). However there was no significant difference in plant B (3.68±0.54 mg/100g), plant C (3.40±0.00 mg/100g) and plant D (3.50±0.10 mg/100g) respectively at p>0.05

Ash content was highest in plant B (5. 96 ± 0.36 mg/100g) and the lowest was recorded in the plant A (4.47±0.16 mg/100g) which is the control, where they naturally occur. There was no significant difference (p>0.05) in plant B (5.96 ± 0.36 mg/100g), plant C (5.21± 0.39 mg/100g) and plant D (5.90 ± 0.00 mg/100g).

The amount of fiber content in the plant leaves *V. paradoxa* was higher in plant A (5.00 ± 0.12 mg/100g) the control (where they occur naturally) while plant C has the lowest fiber content C (3.24 ± 0.38 mg/100g). There was no significant difference (p>0.05) in plant B (93.48±6.44 mg/100g), plant C (3.24±0.38 mg/100g) and plant D (3.86±0.00 mg/100g).

The protein content of *V. paradoxa* leaves, was highest in plant A (6.75±0.18 mg/100g) the control while the lowest was recorded in plant B (2.91±0.72 mg/100g) and there was no significant difference (p>0.05) in plant C (3.56±0.06 mg/100g) and plant E (3.50±0.00 mg/100g) at (p >0.05), respectively.

The fats content in the plant *V. Paradoxa,* was highest in plant B (8.30±0.00 mg/100g) while the lowest was recorded in plant E (4.58±0.46 mg/100g). However there was no significant difference (p>0.05) in plant A (7.20±0.28 mg/100g) the control and plant D (7.68±0.43 mg/100g).

The carbohydrate content was highest in plant in plant E (78.83±0.58 mg/100g) while the lowest was recorded in plant A (72.58±0.28 mg/100g). However there was no significant difference ($p>0.05$) in plant B (75.69±0.46 mg/100g), plant C (76.77±1.54 mg/100g) and plant E (78.83±0.58 mg/100g).

Table 4.2 Proximate composition of the different *Vitellaria paradoxa* leaves

Grp	Moisture	Ash	Fiber	Protein	Fat	Carbohydrate
pA	4.02±0.10^{b}	4.47±0.16^{a}	5.00±0.12^{c}	6.75±0.18^{c}	7.20±0.28^{c}	72.58±0.28^{a}
pB	3.68±0.54^{a}	5.96±0.36^{b}	3.48±0.44^{a}	2.91±0.72^{a}	8.30±0.00^{d}	75.69±0.46^{c}
pC	3.40±0.00^{a}	5.21±0.39^{b}	3.24±0.38^{a}	3.56±0.06^{a}	6.61±0.40^{b}	76.77±1.54^{c}
pD	3.50±0.10^{a}	5.90±0.00^{b}	3.86±0.00^{a}	4.25±0.14^{b}	7.68±0.43^{c}	74.82±0.47^{b}
pE	4.11±0.00^{b}	4.90±0.28^{a}	4.09±0.17^{b}	3.50±0.00^{a}	4.58±0.46^{a}	78.83±0.58^{c}

Values are presented in mean ± standard error of three replicate. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05 Key: pA, pB, pC, pD and pE are the leaves of different *V. paradoxa* plant used as feed

4.1.3 Minerals Content of different *Vitellaria paradoxa* leaves

Mineral analysis of *V. paradoxa* is presented in Table 4.3 Sodium content was highest in plant C (365.70±0.06 mg/100g) whiles the lowest was recorded in plant D (286.49 ± 025 mg/100g). The content of potassium was highest in plant E (553.17±0.02 mg/100g) while the lowest was recorded in plant A (501.33±0.08 mg/100g) and C (501.0.07±0.07 mg/100g) with no significant difference (P>0.05) between plant B and D, respectively.

The magnesium content was highest in plant D (191.43±0.03 mg/100g) with lowest in plant C (150.00±0.00 mg/100g) with no significant difference (p>0.05) in plant A (150.00±0.58 mg/100g). The calcium content of the *Vitellaria paradoxa* leaves was highest in plant D (111.20±0.06 mg/100g) and plant C (98.40±0.06 mg/100g) with the lowest. However there was no significant difference (p>0.05) between plant A (107.11±0.01 mg/100g) and plant B (109. 14±0.01 mg/100g) and plant E (109.31±0.10 mg/100g).

Copper content was highest in *Vitellaria paradoxa* leaves of plant A (15.14 ± 0.01 mg/100g) the control, with lowest in plant D (9.14 ± 0.01 mg/100g) with no significant difference (p>0.05) in C (9.16 ± 0.01 mg/100g).

Iron content was highest in *Vitellaria paradoxa* leaves of plant D (69.20±0.06% mg/100g) while plant C (36.39±0.01 mg/100g) was the lowest. However there was no significant difference (P>0.05) in plant A (41.60±0.160 mg/100g) the control and plant B (39.10±0.06 mg/100g).

Table 4.3 Mineral Analysis of different *V. paradoxa* Leaves

Plant	Sodium	Potassium	Magnesium	Calcium	Copper	Iron
pA	317.23±0.12^{b*}	501.33±0.88^{a}	150.00±0.58^{a}	107.11±0.01^{b}	15.14±0.01^{d}	41.60±0.16^{b}
pB	337.33±0.33^{d}	529.43±0.22^{c}	164.33±0.33^{b}	109.14±0.01^{b}	13.50±0.06^{c}	39.10±0.06^{b}
pC	365.70±0.06^{e}	501.07±0.07^{a}	150.00±0.00^{a}	98.40±0.06^{a}	9.16±0.01^{a}	36.39±0.01^{a}
pD	286.49±0.25^{a}	520.30±0.06^{b}	191.43±0.03^{d}	111.20±0.06^{c}	9.14±0.01^{a}	69.20±0.06^{e}
pE	320.20±0.12^{c}	553.17±0.02^{d}	174.87±0.03^{c}	109.31±0.10^{b}	11.39±0.01^{b}	45.82±0.01^{d}

* Values are presented in mean ± standard error of three replicate. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05 Key: pA, pB, pC, pD and pE are leaves of different *V. paradoxa* plant used as feed

4.1.4 Vitamin Contents of different *V. paradoxa* leaves

Vitamin analysis of *V. paradoxa* is presented in Table 4.4 Vitamin A was highest in plant C (10.32±1.00 mg/100g) while the lowest was in plant D (6.73±0.58 mg/100g). However there was no significant difference ($p>0.05$) in plant A (9.96±0.35 mg/100g), plant B (9.92±0.60 mg/100g) and plant C (10.32±1.00 mg/100g) respectively. The vitaminB_1 content was highest in plant A (6.48±0.44 mg/100g) the control with no significant difference ($p> 0.05$) in plant B (5.18 ± 0.14 mg/100g) and plant E (6.30± 0.00 mg/100g) with the lowest in plant C (3.76 ± 0.15 mg/100g). Vitamin B_2 content was highest in plant D (18.30 ± 0.00 mg/100g) while plant B (9.71 ± 0.30 mg/100g) was the lowest. However, there was no significant difference ($p> 0.05$) in plant A (12.05±0.00 mg/100g) the control with plant C (14.40±0.91 mg/100g) and plant E (11.31±0.74 mg/100g).

Vitamin B_3 content was highest in plant E (5.51 ± 0.04 mg/100g) while plant C (2.92 ± 0.00 mg/100g) has the lowest. However there was no significant difference ($p> 0.05$) in plant A (4.90 ± 0.10 mg/100g), plant B (3.78 ± 0.18 mg/100g) and plant D (4.85 ± 46 mg/100g) respectively. Highest amount of vitamin C was recorded in plant E (97.65±0.55 mg/100g) while the lowest was in plant C (82.21±1.00 mg/100g). However there was no significant difference ($p> 0.05$) in plant A (95.70 ± 0.9 mg/100g) the control, plant B (94.76±0.95 mg/100g) and plant E (97.65 ± 0.55 mg/100g).

Table 4.4 Vitamins Contents of different *Vitellaria paradoxa* leaves (mg/100g)

Plant	Vitamin A	Vitamin B1	Vitamin B2	Vitamin B3	Vitamin C
pA	9.96±0.35^{c*}	6.48±0.44^{c}	12.05±0.00^{b}	4.90±0.10^{b}	95.70±0.00^{c}
pB	9.92±0.60^{c}	5.18±0.14^{c}	9.71±0.30^{a}	3.78±0.18^{b}	94.76±0.95^{c}
pC	10.32±1.00^{c}	3.76±0.15^{a}	14.40±0.91^{b}	2.92±0.00^{a}	82.21±1.00^{a}
pD	6.73±0.58^{a}	4.80±0.00^{b}	18.30±0.00^{c}	4.85±0.46^{b}	90.20±0.00^{b}
pE	8.96±0.36^{b}	6.30±0.00^{c}	11.31±0.74^{b}	5.51±0.04^{c}	97.65±0.55^{c}

* Values are presented in mean ± standard error of three replicate. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05; Key: pA, pB, pC, pD and pE are the leaves *V. paradoxa* plant used as fed

4.5 Growth Indices of *Cirina forda* Fed with Five Leaves of Different *Vitellaria paradoxa* Plant.

The measurement of the head capsule width of *Cirina forda* reared on five leaves of different *Vitellaria paradoxa* plant is presented in Table 4.5a The result of reared *C. forda* under laboratory condition with 5 different leaves of *Vitellaria paradoxa* shows a significant difference ($p > 0.05$) within and across instars on the growth of head capsule, body width and body length when compared with the growth on the leaves where they naturally accur (the control). The first instar growth of the head capsule shows significant difference in the 5 groups fed with different leaves of *V.paraxoxa*. Group A (2.47±0.15 mm) was recorded highest growth and the least was recorded in group C (1.95±0.06 mm). However there was no significant difference ($p > 0.05$) on the growth of the head capsule in group A (2.47±0.15 mm), group D (2.33±0.11 mm) and group E (2.33±0.07 mm) respectively.

In the second instar, the best growth was recorded in group A (4.94±0.33 mm) which is the control while the least was recorded in group C (3.11±0.19 mm). However there was no significant difference ($p > 0.05$) in all the groups. In the third instar, the best growth was recorded in group A (7.11±0.14 mm) that is the control while the least growth was recorded in group C (4.51±0.33 mm). However there was no significant difference ($p > 0.05$) in group A (7.11±0.14 mm) the control and B (6.03±0.06 mm) and also there was no significant difference ($p > 0.05$) in group D (5.91±0.03 mm) and E (5.21±0.16 mm) respectively. Fourth instar, the best growth was recorded in group A (7.90± 0.07 mm) the control while

the least was recorded in group C (4.91± 0.83 mm) with D (6.20±0.06 mm) as the best in the group fed with *V. paradoxa* leaves in Minna.

Fifth instar recorded high mortality in group B, C, and D with group A (8.40±0.04 mm) still the best growth and group D (6.63±0.05 mm) as the only group that encourage growth to the fifth instar among the groups fed with *V. paradoxa* leaves from Minna.

Table 4.5a Measurement of the Head Capsule Width, (HCW) of *Cirina forda* Reared on Leaves of Different *V. paradoxa* Plant

Instar stage	A	B	C	D	E
1st	2.47±0.15^{b*}	2.05±1.90^{b}	1.95±0.06^{a}	2.33±0.11^{b}	2.33±0.07^{b}
2nd	4.94±0.33^{a}	4.11±0.36^{a}	3.11±0.19^{a}	4.24±0.29^{a}	3.50±0.23^{a}
3rd	7.11±0.14^{b}	6.03±0.06^{b}	4.51±0.33^{a}	5.91±0.03^{ab}	5.21±0.16^{a}
4th	7.90±0.07^{b}	5.36±0.89^{a}	4.91±0.82^{a}	6.20±0.06^{ab}	5.07±0.85^{a}
5th	8.40±0.04^{c}	0.00±0.00^{a}	0.00±0.00^{a}	6.63±0.05^{b}	0.00±0.00^{a}

Values are presented in mean±standard error of three replicates. Values followed with the same superscript alphabets on the same row are not significantly different at P>0.05 A, B, C, D, E are the groups of *C. forda* with fed leaves pA, pB, pC, pD and pE respectively.

The measurement of the body length of *Cirina forda* reared on five leaves of different *Vitellaria paradoxa* plant is presented in Table 4.5b

The growth in the first instar shows no significant difference (p> 0.05) in group C (9.53±0.51 mm) D (11.99±01 mm) E (10.99±0.50 mm). However the best growth was observed in group A (14.35±1.49 mm) the control while the least was recorded in group C (9.53±0.51 mm) respectively. The second instar shows no significant difference in the control with the other groups A (35.32±3.36 mm), B (29.00±3.05 mm) and D (31.42±422.82 mm) at p>0.05 respectively. However the best growth was recorded in group A (35.32±3.36 mm) which is the control and D (31.42±422.82 mm) was recorded as the best among groups fed with *Vitellaria paradoxa* leaves from Minna with C (20.09±1.21 mm) as the least and shows no significant difference (p> 0.05) with E (22.94±1.77 mm). In the third instar there was a significant difference (p> 0.05) in the control group and the other groups fed *Vitellaria paradoxa* leaves from minna. The best growth was the control groups A (55.60±1.38 mm) and D (47.67±1.06 mm) was recorded as the best among groups fed with *Vitellaria paradoxa* leaves from Minna while the least was recorded in group C (33.34±148 mm). In the fourth instar the increase in the body length was significantly highest in group A (62.96±0.44 mm) with D (57.44±0.62 mm) was recorded as the best among groups fed with *Vitellaria paradoxa* leaves from Minna while the least was recorded in group C (32.50±5.42 mm) with high rate of *Cirina forda* mortality however there was no significant difference (p> 0.05) in B (39.71±6.65 mm) and E (36.99±6.17 mm) respectively which also recorded high rate of mortality. Fifth instar shows a significant difference (p> 0.05) in the body length of group A (64.50±0.07 mm) which is the control and D (59.40±0.04 mm) which survived to the fifth instar

Table 4.5b The Measurement of the Body Length (BL) of *Cirina forda* Reared on Leaves of Different *Vitellaria paradoxa* Plant

Larval Instars	A	B	C	D	E
1st	14.35±1.49^{b*}	12.10±0.91^{ab}	9.53±0.51^{a}	11.99±0.81^{a}	10.99±0.50^{a}
2nd	35.32±3.36^{b}	29.00±3.05^{b}	20.09±1.21^{a}	31.42±2.82^{b}	22.94±1.77^{a}
3rd	55.60±1.38^{e}	43.43±0.58^{c}	33.34±1.48^{a}	47.67±1.06^{d}	37.69±1.67^{b}
4th	62.96±0.44^{d}	39.71±6.65^{b}	32.50±5.42^{a}	57.41±0.62^{c}	36.99±6.17^{b}
5th	64.50±0.07^{c}	0.00±0.00^{a}	0.00±0.00^{a}	59.40±0.04^{b}	0.00±0.00^{a}

*Values are presented in mean±standard error of three replicates Values followed with the same superscript alphabets on the same row are not significantly different at P>0.05 A, B, C, D, E are the groups of *C. forda* fed with leaves of different *V. paradoxa* pA, pB, pC, pD and pE respectively.

The measurement of the body width of *Cirina forda* reared on five leaves of different *Vitellaria paradoxa* is presented in Table 4.5c First instar body width shows no significant difference ($p > 0.05$) in all the groups and the control at $p>0.05$ A (2.31±0.13 mm), B (2.05±0.10 mm), C (1.82±0.11 mm), D (2.17±0.12 mm), and E (2.05±0.07 mm) respectively. Second instar shows no significant difference in all the groups fed with 5 different leaves of *V. paradoxa.* Third instar shows a significant difference in the body width of *Cirina forda* fed with 5 different leaves *V. paradoxa,* group A (8.03±0.19 mm) the control as the best growth, while the least growth was recorded in C (4.91±0.15 mm). However there was no significant difference in B (6.36±0.04 mm) and D (6.36±0.04 mm) with no significant difference ($p > 0.05$) in C (4.91±0.15 mm) and B (5.56±0.19 mm) respectively. Forth instar shows a significant difference in the *Cirina forda* fed with 5 different leaves *V. paradoxa,* group A (10.66±0.32 mm) which is the control recorded the best growth, with D (7.06±4.32 mm) was recorded as the best among groups fed with *V. paradoxa* leave from Minna while there was no significant difference ($p > 0.05$) in group B (5.46±0.91 mm), C (4.84±0.81 mm) and E (5.23±0.88 mm) respectively. Fifth instar shows no significant difference ($p > 0.05$) in group B, C and E with high mortality while group A (11.88±0.09 mm) has the best growth follow by D (7.48±0.09 mm).

Table 4.5c The Measurement of the Body Width (BW) *Cirina forda* Reared on Leaves of Different *Vitellaria paradoxa*.

Larval Instar	A	B	C	D	E
1st	2.31±0.13[a]	2.05±0.10[a]	1.82±0.11[a]	2.17±0.12[a]	2.05±0.07[a]
2nd	4.96±0.48[a]	4.21±0.42[a]	2.93±0.12[a]	4.34±0.39[da]	3.34±0.21[a]
3rd	8.03±0.19[c]	6.23±0.05[b]	4.91±0.15[a]	6.36±0.04[b]	5.56±0.17[a]
4th	10.66±0.32[c]	5.46±0.91[a]	4.84±0.81[a]	16.06±4.32[b]	5.23±0.88[a]
5th	11.88±0.09[c]	0.00±0.00[a]	0.00±0.00[a]	7.48±0.09[b]	0.00±0.00[a]

Values are presented in mean±standard error of three replicates Values followed with the same superscript alphabets on the same row are not significantly different at P>0.05 A, B, C, D, E are the groups of *C. forda* fed with leaves of different *V. paradoxa* pA, pB, pC, pD and pE, respectively.

Table 4.5d Mortality Recorded during Laboratory Rearing of *C. forda* Fed with 5 Leaves of Different *V. paradoxa* Plant.

Larval Instar	A	B	C	D	E
1st	1.91±0.44^{a*}	4.18±0.84^{a}	15.09±4.21^{b}	3.36±1.11^{a}	4.09±1.26^{a}
2nd	0.33±0.17^{a}	9.89±1.69^{cd}	10.78±1.48^{d}	6.22±2.05^{c}	2.78±1.39^{b}
3rd	0.43±0.20^{a}	9.57±1.51^{c}	4.29±0.99^{b}	9.71±1.27^{c}	4.29±2.63^{b}
4th	0.43±0.20^{a}	1.57±0.30^{b}	8.57±3.12^{d}	1.57±0.37^{b}	4.14±1.86^{c}
5th	0.20±0.20^{b}	0.00±0.00^{a}	0.00±0.00^{a}	0.40±0.24^{c}	0.00±0.00^{a}

*Values are presented in mean±standard error of three replicates. Values followed with the same superscript alphabets on the same row are not significantly different at P>0.05 A, B, C, D, E are the groups of *C. forda* fed with leaves of different *V. paradoxa* pA, pB, pC, pD and pE, respectively.

4.6 Proximate Composition of *Cirina forda* Fed with Five Leaves of *Vitellaria paradoxa*

The proximate composition of *Cirina forda* fed with leaves of different *V. paradoxa* is presented in Table 4.6. Moisture content was significantly highest in the group fed with leaves D (5.32 ± 0.00 mg/100g), while the lowest moisture content was recorded in the *C. forda* fed with leaves A (4.07 ± 0.08 mg/100g) of the *Vitellaria paradoxa* which is the control. However there was no significant difference (P> 0.05) in the *Cirina forda* fed with leaves B (4.97 ± 0.36 mg/100g), C (4.12 ± 0.13 mg/100g), and E (4.71± 0.11 mg/100g) of the *Vitellaria paradoxa* respectively.

The highest ash content was recorded in the *Cirina forda* fed with leaves A (7.45 ± 0.45 mg/100g) the control while the lowest was recorded in group C (6.59 ± 0.11 mg/100g). There was no significant difference (p<0.05) in *C. forda* fed with leaves A (7.45± 0.45 mg/100g) the control, B (7.01± 0.02 mg/100g) and D (7.08 ± 0.03 mg/100g) also there was no significant difference between group C (6.59± 0.11 mg/100g) and E (6.79± 0.69 mg/100g) at (P> 0.05) respectively.

The fiber contents was in *C. forda* group C (1.15 ± 0.25 mg/100g) with lowest group E (0.87 ± 0.06 mg/100g) however there was no significant difference (p> 0.05) in group A (0.92 ± 0.00 mg/100g) the control and the group fed with plant E (0.87 ± 0.06 mg/100g), and also there was no significant difference (p> 0.05) in group B (1.11 ± 0.19 mg/100g), C (1.15 ± 0.25 mg/100g) and D (1.10 ± 0.06 mg/100g).

The protein contents of *C. forda* fed with five leaves of different *V. paradoxa* plant protein content was heghest in group A (23.39± 0.62 mg/100g) the control while group D(16.66±0.86 mg/100g) with the lowest, there was no significant difference ($p>0.05$) in B (17.99±0.85 mg/100g), C (17.39±0.56 mg/100g), and D(16.66±0.86 mg/100g)

The fats content in the *Cirina forda* was highest in group fed with leaves A (5.46±0.46%) with the lowest in group D (3.63±0.00 mg/100g). There was no significant difference ($p> 0.05$) in *Cirina forda* group A (5.46±0.46 mg/100g) the control and B (5.37±0.26 mg/100g) as well as no significant difference ($p> 0.05$) in group C (4.15±0.14 mg/100g) and E (4.73±0.14 mg/100g) respectively.

The carbohydrate content was highest in *Cirina forda* fed with leaves C (66.60±0.86 mg/100g) while the lowest was recorded in group A (58.71±0.37 mg/100g) which is the control. However there was no significant difference ($p> 0.05$) in group B (63.56±0.23 mg/100g) and E (61.47±0.72 mg/100g) as while as no significant difference ($p> 0.05$) in group C (66.60±0.86 mg/100g) and D (66.22±0.73 mg100g) respectively.

Table 4.6 proximate composition of *Cirina forda* fed with five leaves of different *V. paradoxa* plant

Grp	Moisture	Ash	Fiber	Protein	Fat	Carbohydrate
A	4.07±0.08^{a}	7.45±0.45^{b}	0.92±0.00^{a}	23.39±0.62^{c}	5.46±0.46^{c}	58.71±0.37^{a}
B	4.97±0.36^{b}	7.01±0.02^{b}	1.11±0.19^{b}	17.99±0.85^{a}	5.37±0.26^{c}	63.56±0.23^{b}
C	4.12±0.13^{b}	6.59±0.11^{a}	1.15±0.25^{b}	17.39±0.56^{a}	4.15±0.14^{b}	66.60±0.86^{c}
D	5.32±0.00^{c}	7.08±0.03^{b}	1.10±0.00^{b}	16.66±0.86^{a}	3.63±0.00^{a}	66.22±0.73^{c}
E	4.71±0.11^{b}	6.79±0.69^{a}	0.87±0.06^{a}	21.45±0.00^{b}	4.73±0.14^{b}	61.47±0.72^{b}

* Values are presented in mean±standard error of three replicates. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05. Key: A, B, C, D, E are the groups of *C. forda* fed with leaves of different *V.paradoxa* pA, pB, pC, pD and pE, respectively.

4.1.7 Minerals Analysis of *Cirina forda* Fed with Leaves of Different of *V. paradoxa* Plant

The minerals analysis of *Cirina forda* fed with five different leaves of *V. paradoxa* plant is presented in Table 4.7 Sodium content was highest in *C. forda* fed with plant D (309.40 ± 0.06 mg/100g) while the lowest was recorded in group C (218.14± 0.00 mg/100g). However there was no significant difference (p> 0.05) between group A (284.45 ± 0.04 mg/100g) the control, B (289.17 ± 0.09 mg/100g) and E (291.01 ± 0.01 mg/100g) respectively.

The potassium content was highest in *C. forda* group E (271.30 ±0.06 mg/100g) while the lowest was recorded in B (220.43 ± 0.02 mg/100g). However there was no significant difference (p> 0.05) in group A (241.87± 0.03 mg/100g) and C (236.03± 0.03 mg/100g) while in the plant the highest was recorded in plant E (553.17±0.02 mg/100g) and the lowest was recorded in plant A (501.33±0.08 mg/100g) and C (501.0.07±0.07 mg/100g) with no significant difference between the plant B and D respectively.

The magnesium content was highest in group E (138.07±0.07 mg/100g) while the lowest was recorded in group D (117.00±0.580 mg/100g). However there was no significant difference (p> 0.05) in group A (137.00 ± 0.58 mg/100g) and E (1138.07 ± 0.07 mg/100g) as well as no significant difference (p> 0.05) with group B (130.00 ± 0.58 mg/100g) and C (130.07 ± 1.21 mg/100g).

The calcium content of the *Cirina forda* was recorded highest in group fed with plant B (74.53±0.15 mg/100g) with no significant difference (p> 0.05) with group C (74.50±0.06 mg/100g) while group A (64.43± 0.12 mg/100g) which is the control with the lowest. In the plant the highest amount of calcium was recorded in plant D (111.20±0.06 mg/100g) while plant C (98.40±0.06 mg/100g) with the lowest. However there was no significant difference

(p> 0.05) between plant A (107.11±0.01 mg/100g) and plant B (109. 14±0.01 mg/100g) and plant E (109.31±0.10 mg/100g) respectively.

Copper content was highest in *Cirina forda* fed with leaves E (7.30 ± 0.10 mg/100g) with no significant difference (p> 0.05) with B (7.22 ± 0.01 mg/100g) and D (7.21± 0.070 mg/100g) while the lowest was recorded in group C (5.92 ± 0.01 mg/100g) with no significant difference (p> 0.05) with A (5.93 ± 0.01 mg/100g) the control.

Iron content was highest in *Cirina forda* fed group D (34.13 ± 0.09 mg/100g) while the lowest was recorded in group A (21.27 ± 0.15 mg/100g) the control with no significant difference (p> 0.05) with group B (21.40 ± 0.06 mg/100g) respectively.

Table 4.7 Minerals Analysis of *C. forda* Fed with Leaves of Different *V. paradoxa* Plant

Grp	Sodium	Potassium	Magnesium	Calcium	Copper	Iron
A	284.45±0.04^{b*}	241.87±0.03^{b}	137.00±0.58^{c}	64.43±0.12^{a}	5.93±0.01^{a}	21.27±0.15^{a}
B	289.17±0.09^{b}	220.43±0.02^{a}	130.00±0.58^{b}	74.53±0.15^{d}	7.22±0.01^{b}	21.40±0.06^{a}
C	218.14±0.00^{a}	236.03±0.03^{b}	130.07±1.21^{b}	74.50±0.06^{d}	5.92±0.01^{a}	27.82±0.01^{b}
D	309.40±0.06^{c}	264.20±0.06^{c}	117.00±0.58^{a}	71.20±0.06^{c}	7.21±0.01^{b}	34.13±0.09^{d}
E	291.01±0.01^{b}	271.30±0.06^{d}	138.07±0.07^{c}	66.01±0.01^{b}	7.30±0.10^{b}	31.33±0.0^{c}

* Values are presented in mean±standard error of three replicates. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05 Key: A, B, C, D, E are the groups of *C. forda* fed leaves of different *V. paradoxa* pA, pB, pC, pD and pE, respectively.

4.1.8 The vitamin Contents of the *Cirina forda* Fed with Five Leaves of Different *V. paradoxa* Plant

The vitamin contents of the *Cirina forda* fed with leaves of different *V. paradoxa* is presented in Table 4.8 Vitamin A content was highest in group fed with leaves D (17.91 ± 0.61 mg/100g) which supports growth better, while group C (13.68±0.00 mg/100g) was the lowest. However there was no significant difference ($p > 0.05$) in group A (1606±5.55 mg/100g) the control and group D (17.91 ± 0.61 mg/100g) and also no significant difference ($p > 0.05$) in group B (14.28±0.98 mg/100g), C (13.68±0.00 mg/100g) and E (14.60±0.92 mg/100g) respectively.

The vitamin B_1 content was highest in the *C. forda* fed with leaves D (3.71±0.21 mg/100g) with no significant difference ($p > 0.05$) with group A (3.17±0.24 mg/100g) the control while the lowest was recorded in group C (13.68 ± 0.00 mg/100g) with no significant difference ($p > 0.05$) with B (2.67±0.26 mg/100g), C (2.41±0.00 mg/100g) and E (2.21±0.20 mg/100g) respectively. The of vitamin B_2 content was recorded highest in *C. forda* fed with leaves D (8.78 ± 0.16 mg/100g) with no significant difference ($p > 0.05$) with group A (7.18 ± 0.13 mg/100g) the control, and the group fed with leaves E (4.17 ± 0.36 mg/100g) as the lowest with no significant difference($p > 0.05$) C (5.66±0.26 mg/100g). Vitamin B_3 content was the highest in *Cirina forda* group A (2.21 ± 0.09 mg/100g) while the lowest was recorded in group C (1.23 ± 0.00 mg/100g) with no significant difference ($p > 0.05$) in B (1.64 ± 0.29 mg/100g), D (1.58 ± 0.355 mg/100g) and E (1.39 ± 0.16 mg/100g) respectively.

Vitamin C content was highest in *Cirina forda* group D (86.11 ± 0.00 mg/100g) with the lowest amount of vitamin C in group C (55.93 ± 1.61 mg/100g). However there was no significant difference ($p > 0.05$) in B (71.97 ± 1.65 mg/100g) and E (71.23 ± 1.82 mg/100g) respectively.

Table 4.8 Vitamin Analysis of *Cirina forda* Fed with Leaves of Different *Vitellaria paradoxa* Plant

GRP	Vitamin A	Vitamin B1	Vitamin_B2	Vitamin_B3	Vitamin C
A	16.06±5.55^{b}	3.17±0.24^{b}	7.18±0.13^{c}	2.21±0.09^{b}	76.78±1.47^{c}
B	14.28±0.98^{a}	2.67±0.26^{a}	6.31±0.00^{b}	1.64±0.29^{a}	71.97±1.65^{b}
C	13.68±0.00^{a}	2.41±0.00^{a}	5.66±0.26^{a}	1.23±0.00^{a}	55.93±1.61^{a}
D	17.91±0.61^{b}	3.71±0.21^{b}	8.78±0.16^{c}	1.58±0.35^{a}	86.11±0.00^{d}
E	14.60±0.92^{a}	2.21±0.20^{a}	4.17±0.36^{a}	1.39±0.16^{a}	71.23±1.82^{b}

* Values are presented in mean±standard error of three replicates. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05 Key: A, B, C, D, and E is the group of *C. forda* fed leaves of different *V. paradoxa* pA, pB, pC, pD and pE, respectively.

4.9 The Anti-nutrient Compositions of the *Cirina forda* Fed with Five Leaves of Different *V. paradoxa* Plant

The Anti-nutrient composition of the *Cirina forda* fed with leaves of different *V. paradoxa* is presented in Table 4.9 The content of cyanide in *C. forda* was highest in group E (5.02 ± 0.23 mg/100g) while the lowest was recorded in C (0.82 ± 0.22 mg/100g). However there was no significant difference (p> 0.05) in group A (4.47 ± 0.20 mg/100g) which is the control and E (5.02 ± 0.23 mg/100g).

The phytate content was higher in *Cirina forda* group fed with leaves A (25.60 ± 0.40 mg/100g) which is the control and the lowest was recorded in group B (15.51 ± 1.51 mg/100g). However there was no significant difference (p> 0.05) in group B (15.51 ± 1.51 mg/100g) and C (17.20 ± 1.89 mg/100g) and also no significant difference (p> 0.05) in group A (25.60 ± 0.40 mg/100g) and E (24.35 ± 0.85 mg/100g) respectively.

The oxalate content was highest in *Cirina forda* group D (3.40 ± 0.00 mg/100g) which supported the growth of *C. forda* better while the lowest was recorded in group C (2.10 ± 0.00 mg/100g). However there was no significant difference (p> 0.05) in group A (2.65 ± 0.15 mg/100g) the control and E (2.65 ± 0.15 mg/100g) respectively.

Phenol content in the *Cirina forda* was highest in group D (333.28 ± 2.66 mg/100g) while group E (260.53±0.53) with the lowest. However there was no significant difference (p> 0.05) in group B (2.66.31 ± 1.17 mg/100g) and E (260.53 ± 0.53 mg/100g) respectively.

Saponnin content was recorded highstr in *Cirina forda* fed with leaves E (335.39 ± 1.31 mg/100g) while the lowest was recorded in group A (151.32 ± 1.30 mg/100g) which is the control. However there was no significant difference (p> 0.05) in group A (151.32 ±1.30 mg/100g) and C (153.58 ± 0.89 mg/100g) respectively

Table 4.9 the Anti-nutrients Content of *Cirina forda* Reared on Leaves of Different *V. paradoxa* Plants

Grp	Cyanide	Phytate	Oxalates	Flavonoids	Phenol	Saponnins
A	4.47 ± 0.20^{d}	25.60 ± 0.40^{b}	2.65 ± 0.15^{c}	89.41 ± 0.00^{c}	286.35 ± 0.96^{c}	151.32 ± 1.30^{a}
B	3.51 ± 0.19^{c}	15.51 ± 1.51^{a}	3.11 ± 0.30^{d}	167.20 ± 1.05^{d}	266.31 ± 1.17^{a}	319.27 ± 0.87^{c}
C	0.82 ± 0.22^{a}	17.20 ± 1.89^{a}	2.10 ± 0.00^{c}	182.36 ± 1.95^{c}	270.05 ± 1.16^{b}	153.58 ± 0.89^{a}
D	3.07 ± 0.26^{b}	29.97 ± 0.83^{c}	3.40 ± 0.00^{b}	64.29 ± 1.22^{b}	333.28 ± 2.66^{d}	277.73 ± 1.31^{b}
E	5.02 ± 0.23^{d}	24.35 ± 0.85^{b}	2.65 ± 0.15^{a}	53.18 ± 0.86^{a}	260.53 ± 0.53^{a}	335.39 ± 1.31^{d}

* Values are presented in mean ± standard error of three replicates. Values followed with the same superscript alphabets on the same column are not significantly different at P>0.05 Key: A, B, C, D, E is the groups of *C. forda* fed leaves different *V. paradoxa* pA, pB, pC, pD and pE, respectively.

4.2 Discussion

4.2.1 Phytochemical compositions of five different *V. paradoxa* leaves

This study shows that *Vitellaria paradoxa* contains phenols, saponins, flavonoids, oxalate and phytate in various quantities. These metabolites in *V. paradoxa* in this study have proved it to be of high medicinal importance (Okwulehie and Nosike, 2015). Phytate acid content varies among plants leaves. This is due to the type of seed, environmental condition climate, and soil quality. They are energy source for the sprouting seed. A food with higher phytic content seems to enhance the activity of natural killer cell and inhibits tumor growth. Phytic acid plays a role in pancreatic function and insulin secretion. Phytate anti-nutrient can also help in the prevention of chronic diseases (Okwulehie and Nosike, 2015). The *Cirina forda* reared on leaves of different *Vitellaria paradoxa* plants contains certain amount of phytate acid, therefore enhancing the value of *C. forda* as medicinal.

Flavonoids are synthesized in all parts of plants. They provide colour, fragrance and taste to the fruit, flower, and seed which make them attractive for insect. Flovoniod have important biological activities such as protect skin from ultra violet light exposure, protect DNA from damage and strengthening of capillaries and anti-inflammation effect (Saul *et al*., 2017). The result from this study shows that plant D which was the plant from Minna that support the growth of *C. forda* contain higher amount of flavonoid which may be the reason for the *C. forda* to fed on it compared to plant C which contain lower amount of flavoniod and shows poor growth. Cyanide is a rapidly acting potentially deadly chemical that can exist in various forms, they are lethal chemical that impair and kill quickly, it inhibit cellular oxygen metabolism of energy production (Center for Disease Control and preventions, 2018). This study shows that *V. paradoxa* contains cyanide that varies among plant

significantly at ($p>0.05$), in this study plant A (the control) has higher amount of cyanide while plant B has the lowest, and these variation may be attributed to the environmental factors, such as soil nutrient, and climatic conditions. These in turn may have effects on the pest that feed on it.

This study shows that *V. paradoxa* contain low amount of oxalate and it varies among the leaves used to feed *C. forda*, with no significant difference in plant A, B, and C at ($p>0.05$) Oxalates are a natural substance in many foods, they are bind to calcium during digestion in the stomach and intestine and the leave the body in stool. Oxalate can reduce mineral absorption one of the main health concern of oxalate (NKF, 2019). The result from this study show that *V. paradoxa* contain high amount of phenol and it varies significantly among leaves. Phenol is an aromatic organic compound, it is toxic to consume on its own, but can be used in many medical procedures for numerous treatment e.g vaccine preservation. (Arvind and Arun, 2018). This study shows that *V. paradoxa* contain high amount of saponins, and it varies significantly ($p>0.05$) among leaves. In this study plant C has the higher amount of saponins with plant B with the lowest. Saponins are chemical compounds that occur in a wide range of herbs, seeds and vegetables. In medicine, they're used in vaccine formulations to regulate immune function. Several studies conducted over the years confirm the health benefits of saponins. These chemicals may help reduce cholesterol levels, kill disease-causing bacteria, scavenge oxidative stress and inhibit tumor growth.

4.2.2 Minerals compositions of five different *V. paradoxa* leaves

The study shows that *Vitellaria paradoxa* is dominated by potassium, sodium, magnesium and calcium. The amount of this minerals varies among leaves at ($p>0.05$), Minerals are naturally occurring inorganic nutrient found in the soil and food, it is essential for the proper functioning of animal and plant body. Minerals are vital elements necessary for the body of both the plants and animals. Minerals are important for the body to stay healthy; Body uses minerals for many different functions, including keeping strong bones, muscles, heart, and brain to work properly. Minerals are also important for production of enzymes and hormones (Maathuis and Diatloff, 2013).

This study shows that *Vitellaria paradoxa* also contains vitamin C, A, B2, B1, and B3 which varies among leaves. Vitamins are essential to animals; Vitamin A helps form and maintains healthy teeth, bones, soft tissue, mucous membranes, and skin. Vitamin C, also called ascorbic acid, is an antioxidant that promotes healthy teeth and gums. It helps the body absorb iron and maintain healthy tissue. It is also essential for wound healing. Niacin is a B vitamin that helps to maintain healthy skin and nerves. It also has cholesterol-lowering effects at higher doses. Riboflavin (vitamin B2) works with the other B vitamins. It is important for body growth and the production of red blood cells. Thiamine (vitamin B1) helps the body cells to change carbohydrates into energy. Getting enough carbohydrates is very important during pregnancy and breastfeeding. It is also essential for heart function and healthy nerve cells (Mason, 2016 and Salwen, 2017).

4.2.3 Morphometric indices of *C. forda* fed with five leaves of different *V. paradoxa* plant

Diets of organisms have been observed to have effect on the growth, body weight and carcass quality of meat (Iqbal *et al.,* 2012; Nualchuen *et al.,* 2017,).The growth of the head capsule width, body length and body width in this study shows significant difference at ($p>0.05$) in all instar among the groups. The first instar of all the groups in this study can be compared to those of (Odeyemi *et al.,* 2003; Odeyemi *et al.,* 2018) control study in the head capsule width, and body width with little differences in the body length. The third instar shows differences in all the groups fed with different *V. paradoxa* plants in terms of body width, head capsule width and body length including appearance in colour which may be as a results of the leaves used as feed and this differences may be attributed to the location of the plant, soil nutrient, environmental factors, age of the plant which was recorded earlier by (Ande and Fasoranti, 1997). This show that the nutrients of the plant *V. paradoxa* leaves diet may have result to the non-existence of *C. forda* in the places they are known to occur years back. Some groups recorded high mortality of *C. forda* which may be as a result of high phytochemicals such as saponnin (Foerster *et al.,* 2006) stated that high amount of saponnin is life threatening and deadly to insect and cool blooded animals.

The fourth instar shows a significant difference ($p<0.05$) in the growth from body length, head capsule and body width with high mortality rate in group fed with plant C, B and E with D as the only plant that support the growth well among the leaves collected in Minna and the leaves used as control (where they naturally occurs) which give a strong reason to consider the leaves diet of *V. paradoxa* while being use as a feed in rearing *C. forda*. The growth and development of the fifth instar in group A of this study can be comfortably

compared with the growth recorded in control study (Odeyemi *et al.,* 2018) and also the group fed with plant D also support growth, group B, C, E shows poor growth and development with high rate of mortality and could not survive after molting of fifth instar.

4.2.4 Proximate analysis of *C. forda* fed with five leaves of different *V. paradoxa* plants

Moisture content analysis in food is the cornerstone of prevention. Water is found in all food products. Little or too much can alter food properties, Moisture content can affect the physical and chemical properties of food, which directly correlate to the freshness and stability of food products for consumers. The proximate analysis of this study shows that the moisture content of the least from group of *C. forda* fed with different leaves of 5.32 % this low value suggest that dry *C. forda* larvae are not likely to be susceptible to micro organism attack if properly package. It has the stability possibility of extending the shelf life of the product and the value are in agreement with the reported value of 4.4 % for *C. forda* (Banj *et al.,* 2006).

The crude protein content in all the groups in this study varies significantly ($p>0.05$) , the least in all the groups fed with leaves of different *V. paradoxa* is group D, and is still high compared to the reported value of 12.5 % (Uddoh, 1980) for pork. However it is also within the range of 15 to 60% reported for various forms of Lepidoptera edible insect from the state of Oaxaca Mexico (Ramo elorduy *et al.,* 1997) it is low compare with the 55 % recorded for grasshopper (Oloaf *et al.,* 1998) and 33.127 recorded for *C. forda* (Akinnawo *et al.,* 2000) the disparity obtained in this study, group A which is the highest in this study still falls within the recommended daily protein requirement but the differences in protein content between the other groups of this study and (Akinnawo *et al.,* 2000) might be due to

the differences in processing method and variation of the nutritional content of leaves used as fed which also shows a significant difference in term of growth of *C. forda* reared. Protein is an important building block of bones, muscles, cartilage, skin, and blood it help to build and repair tissues Insects are good sources of proteins and other nutrients hence, they are very important in future food security (Tiencheu and Womeni, 2017).

The carbohydrate content in all the groups in this study varies significantly ($p>0.05$), the highest in all the groups fed with leaves of different *V. paradoxa* is the group fed with plant C and it was considerably higher than those reported for other popular edible insect namely cricket (5:1%) and large grasshopper 2.2% (Dunkel, 1998), and also in *C. forda* recorded by (Odeyemi *et al.,* 2018) even with the exposure to gamma irradiation. This result shows that environment or the feed has effect on the carbohydrate constituent of *C. forda*. Thus enhancing its status not only as rich sources of protein but carbohydrate as well. This will no doubt, change the popular belief among entomologist and nutritionist that insects are not a good sources of carbohydrate for meeting human needs as accorded in (Alamu *et al.,* 2013). The average human adult required about 400g to 500g of carbohydrate intake as starch. Carbohydrates provide the body with the energy it needs and are a good source of many vitamins and minerals. Carbohydrates are an essential compound of all organic life on this planet. Both plants and animals use carbohydrates as a primary source of energy, which keeps the body functioning at the most basic level. Carbohydrates also fulfill other needs by helping in the synthesizing of other chemicals and providing structure for cells within the body.

The crude fiber content in this study is very low in all the groups, and it is low compared to the 2.0-3.0% reported for other edible insects e.g. honeybee, yam beetle and palm weevil in

Nigeria (Banjo *et al.,* 2006). The poor fiber content may be attributed to the thin flexible cuticle and hence little amount of chitin that characterize insect larvae generally which also characterize the insect *C. forda* that result to variation in the five (5) groups fed with different leaves that was used as feed. Dietary fiber, also known as roughage or bulk, includes the parts of plant, foods fiber helps to move stool through your digestive tract and colon, and it actually helps to prevent colon cancer as it keeps your colon clean and healthy.

The fat content of all the groups varies; the highest amount of fat was recorded in the group fed with plant A, these indicate that the insect is a good source of energy. This must have been derived from the diet of the *C. forda*. Insect fat are good sources of proteins and unsaturated oils (Abdalbasit, 2013). Fats are vital for body processes such as digestion, transport, conversion, and energy extraction. It's our body's primary source for stored energy, and by weight, it contains three times the amount of energy provided by glucose which must be provided to the brain in a continuous supply throughout the day. The fats contents obtained in all the groups of *C. forda* in this study are lower than the values obtained in the same insects by some authors (Osasona and Olaofe, 2010; Blasquez *et al.,* 2012; Adepoju and Daboh, 2013). The variation may be attributed to the plant used as feed and the environmental factors surrounding it.

4.2.5 Minerals composition of *C. forda* fed with five leaves of different *V. paradoxa* plant

This study shows that mineral composition of *C. forda* insect was significant dominated by sodium (Na), potassium (K) and magnesium (Mg). While in the plant is dominated by potassium (K), sodium (Na), magnesium (Mg) and calcium (Ca) and the least was copper (cu). This mineral plays a crucial role in proper metabolic and physiologic functioning of

living system. The larval stages of *C. forda* eat so much, and it is at this stage that insects eat so much to derive all the nutrients they would require for their growth and development to the adult stage. The larval stage is usually the most destructive stage in the life of most insects because at this stage they eat so much in preparation for both the pupal and adult stages which make them to be good sources of minerals. All the groups of *C. forda* in this study are good sources of sodium (Na), potassium (K) and magnesium (Mg). For example potassium and sodium are electrolytes needed for the body to function normally and help maintain fluid and blood volume in the body. Lowering the blood pressure, reduces the risk of heart disease and stroke (center for diseases control and prevention, 2018), and Mg Prevent muscle degeneration, poor growth, immunologic dysfunction e.t.c. iron strengthen the immune system as an anti-oxidant co-factor (Talwar *et al.,* 1989). Therefore *C. forda* can be consumed as rich sources of necessary nutrition mineral elements for proper function of human body. This study shows a disparity in the dominant mineral element in *C .forda* in (Osasona and Olaefe, 2010), and control study in (Odeyemi *et al.,* 2018). The differences might be as a result of the plant use as fed which can be attributed to the environmental factors.

4.2.6 Vitamins composition of *C. forda* fed with five leaves of different *V. paradoxa* plant

This study shows that vitamin composition in *C. forda* is significant and dominated by vitamin C, vitamin A, B_1, B_2 and B_3. Vitamins are important to animals including human beings which help the body in different ways from normal vision, maintaining energy level of the body. It also helps to maintain bones skin, blood vessel and slow down body aging process.

The result confirm the fact that insect are indeed a good sources of vitamins and nutrient. The consumption of Non-toxic insect therefore should be encouraged. Insects are traditional foods in most cultures, playing important roles in human nutrient and have much nutrient to offer. They can be reared for their high nutritional qualities and sold to the populace that regards them as delicious. The result obtained from this study showed *C. forda* contained higher vitamins than what is obtained in (Banjo *et al.,* 2006) these differences may be attributed to the variation in the dietary of the leaves used as fed which may be as a result of environmental factors and soil nutrient of the host plant that the *C. forda* feed on.

4.2.7 Anti-nutrient contents of *C. forda* fed with five leaves of different *V. paradoxa* plant.

The anti-nutrient content of *C. forda* reared on leaves of different *V. paradoxa* in this study were significantly high in phenol and saponnin which also varies among the groups, the amount of anti-nutrient in this study is significantly higher when compared to what is obtain in (Omotoso, 2015.; Omotoso and Adesola, 2018). The differences may be as a result of the different leaves diet of the *V. paradoxa*, location of the plant and processing method. Anti-nutrients form part of the defensive mechanism of plants and thus are part of food of animals, especially, those that feed on plants and plant products. Processing methods such as heating, soaking, sprouting and cooking have been observed to reduce the effects of the anti-nutritional factors of plant (Soetan and Oyewale, 2009). Foods with lower anti-nutrient content are good for the well being of the people (Pa'rul' 2014). Anti-nutrient has been observed to have positive effect on the health of animals through the contribution of dietary fibre (palmer, 2011). Fibre is known to play important role in

effecting movement of the bowels and preventing cancer, cardiovascular disease, diabetes and many other chronic human diseases, (Rao *et al.* 2015; Yang *et al.*, 2017).

CHAPTER FIVE

5.1 Conclusion and Recommendations

5.1 Conclusion

Phytochemical, proximate and micronutrient contents different *Vitellaria paradoxa* leaves varies significantly among the plants used as feed

Growth indices of *Cirina forda* reared on leaves of different *Vitellaria paradoxa* plants varies significantly among the groups.

Proximate and micronutrient contents of *Cirina forda* reared on leaves of different *V. paradoxa* plants varies among the entire groups

Anti-nutrient contents of the *C. forda* reared on the leaves of different *Vitellaria paradoxa* plants vary significantly among the groups.

5.2 Recommendations

i Further studies should be carried out on the preferred age leaves of *Vitellaria paradoxa* eaten by *Cirina forda* larvae.

ii The effect of some anti-nutrient on the growth and nutritional contents of *Cirina forda* should also be carried out.

5.3 Contributions to Knowledge

The study revealed variation in growth indices of *C. forda* reared on five different leaves of *Vitellaria paradoxa* one leave from where they naturally occur and four leaves around Minna. Group A recorded the best growth while group C recorded poor growth. Head capsule (range=8.40mm-4.91 mm), Body length (range= 64.50-32.50 mm) and Body width (range=11.88-4.84 mm). the proximate composition of *Cirina forda*, protein content of *C. forda* ranging from 16.66 to 23.39 %, carbohydrate, 58.71 to 66.60 %, fat content, 3.63 to 5.46 %. Vitamin C ranged 56.11 to 71.23 %. Vitamin A ranged from 13.68 to 17.91 %. Mineral composition was dominated by Sodium (range= 309-218 mg/100g), potassium (range=271-220mg/100g) magnesium (range= 117-138 mg/100g) and low in copper (range= 64-74 mg/100g), phytochemical and anti nutrient analysis shows all the leaves and the *C. forda* reared them are rich in phenol (ranging= 852-782 mg/100g) and (333-266 mg/100g) in the *C. forda.*

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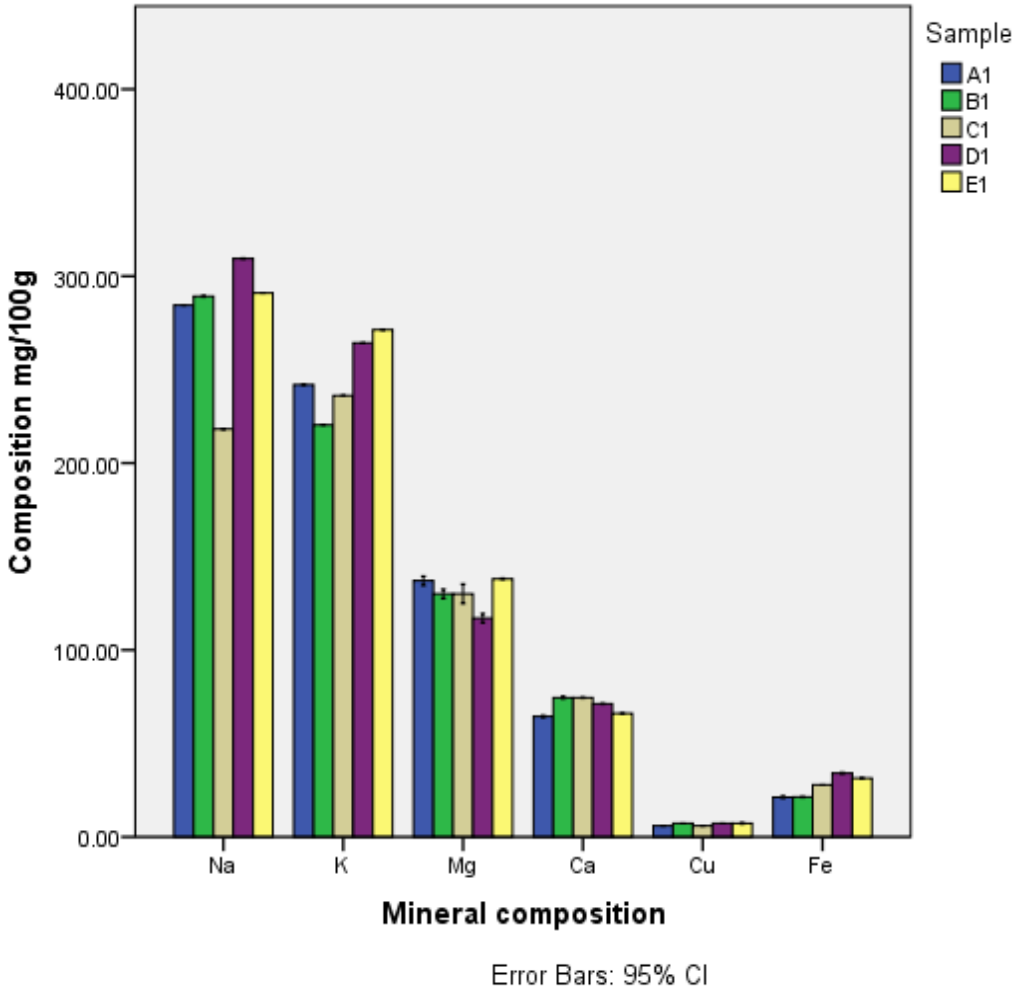
APPENDICES

Appendix A: Mineral composition of *Cirina forda*



Appendix B: **Mineral composition of *Vitellaria paradoxa***