INSECTS ASSOCIATED WITH WINE FROM RAFFIA PALM (*Raphia hookeri*) IN ALOR, NIGERIA

[1]EWUIM, Sylvanus Chima, [2]AKUNNE, Chidi Emmanuel, [3]ANUMBA, Anthonia Ifeoma and [4]ETAGA, Harrison Oghenekevwe

[12]Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

[3]Department of Biological Sciences, Wesley University of Science and Technology, Ondo State, Nigeria.

[4]Department of Statistics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Corresponding Author: Ewuim, S. C. Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. **Email:** cewuim@yahoo.com **Phone:**

ABSTRACT

The insects associated with palm wine from raffia palm (Raphia hookeri) were studied in three villages in Southeastern, Nigeria for four weeks. The insects were sieved out after 24 hours from each 10 litres of raffia palm. Gas chromatography was used to analyse the raffia palm wine after 24 hours. The daily collection of the insects lasted for 28 days between February and March, 2008. The results showed that as the number of days increased the concentration of glucose and fructose decreased with alcoholic content increasing at varying pH and temperature. A total of eight insect species made up of seven genera represented by seven families – Formicidea, Apidae, Drosophilidae, Sarcophagidae, Calliphoridae, Nitidulidae and Curculronidae were obtained. There was a preponderance in the collection of Camponotus maculatus, Maycodrosophylla sp. and Lepidoptera larvae in all the site with C. acvapimensis and Apis mellifera L. collected in fairly large numbers from all the sites (villages). There was also preponderance in the collection of Diptera larvae, even though they were collected from only one village Ide. Sparsely collected insect species from Ide village included Sarcophaga tibialis Macq, Auchmeromyia senegalensis, and Brachypeplus sp. (as a singleton). Cryptarcha sp. was found only in Ide and Okebuonye villages while Rhynchophorus phoenicis was collected in all the villages. The significant difference in the collection of Mycodrosophilla sp. in the three villages were traced to variability in the movement of the conspecifics and habitat heterogeneity while the significant difference in the collection of Diptera larvae was attributed to differences in habitat use, differences in food resource and availability, and environmental heterogeneity. The factors responsible for the recovery of insect species from raffia palm wine were traced to foraging activities on palms, accidental dropping into palm wine gourd, olfactory response of species, pestiferous activities of species, palm pollination, use of incision points on palm stems and inflorescence as food and oviposition resources, and the role of raffia palms in the life history of species.

Keywords: *Raphia hookeri,* Palm wine, Palm wine sugars, Alcohol, Insect species, Habitat heterogeneity

INTRODUCTION

Raphia palms have played significant role in the history of mankind and cultivated for many purposes including serving as food source, shelter, firewood and for aesthetic purposes, including landscaping. In Africa, *Raphia* is the largest palm and one of the most useful economically (Obahiagbon and Osagie, 2007). *Raphia* palm grows in the swampy and semi-

swampy areas of the equatorial rainforest or derived savanna, with the palm sap obtained by tapping the cut inflorescence or the succulent portion of the *Raphia* palm (*Raphia hookeri*) (Ugwu and Igboeli, 2009).

Essentially *Raphia hookeri* is tapped by cutting the terminal bud and collecting the sap oozing from the cutting (Tulley, 1964), but can only be tapped once in its lifetime because it flowers once and dies after fruit maturity (Ndon, 2003; Okolo and Abigor, 2006) after seven years of vegetative growth (Mmegwa, 1984). The duration of tapping of a particular raffia palm last for about one month depending on the maturity of the palm being tapped with the duration of tapping lasting for a shorter period for less matured palms. The palm sap obtained is sugary but fermented by microorganisms into strong palm wine (Okafor, 1975). The details of obtaining palm wine have been described (Bassir, 1962; 1968; Faparusi, 1966; Okafor, 1972; 1975).

Hitherto, there is no detailed scientific information on insects associated with palm wine in Nigeria. Apart from a review of the major insects of oil palm and raffia palms in some parts of the world (Wood, 1968; Obire, 2005), review of aspects of *Raphia* palm (Ndon, 2003) and *Raphia* palm wine (Otedoh, 1990) no detailed scientific report exists on the insects fauna associated with palm wine from *Raphia hookeri*.

MATERIALS AND METHODS

Palm Wine Analysis: The local tapping of palm wine and the collection of the insects were done in Alor in Anambra State of Nigeria in three different locations (Ide, Okebuonye, and Umuokwu). Alor is located between latitude 6°03′N and longitude 6°54′E in the lowland rainforest zone of Southern Nigeria (Keay, 1965; Charter, 1970). The mean annual rainfall varies from 1,500 to 2,900 mm (Jagtap, 1995; Salako and Tian, 2004) which is characteristic of the tropical rain forest zone. Typically there are two seasons in Nigeria – the wet season (April – October) and the dry season (November – March).

Palm sap was tapped as exudates from the base of the inflorescence and collected using the local gourd. The tapping of the palm wine was carried out using the procedures previously reported (Bassir, 1962; 1968; Faparusi, 1966; Okafor, 1972; Obire, 2005). Tapping of the palm sap was done simultaneously at the three sites. The collection of the insects lasted for 28 days between February and March, 2008

The methods described by Bassir (1962; 1968), Faparusi (1966), Okafor (1972) and Obire (2005) were used in storing and fermentation of palm wine twenty hours after tapping and collection of the palm sap. Gas chromatography was used to determine the percentage composition of sugars (glucose, fructose and sucrose) and alcohol in the palm wine at 24 hourly intervals at various pH and temperature (Ologunde *et al.,* 1990).

Associated Insects: After the collection of the palm sap from the *Raphia* palm tree, the insects were sieved out from each 10 liters of palm wine, 24 hours after tapping. Filtration of palm wine was effected using two layers of fine nylon mesh filter, 1 mm square, fitted round the mouth of the funnel to prevent escape of any insect into the sieved palm wine. The residue containing the insects was spread on a white plastic tray for examination using x 10 field hand lens (18 mm diameter) for effective sorting of the insects. Sorted insects were persevered in 5 % formalin and were labeled accordingly. In the laboratory all insects collected were sorted, identified (Medler, 1980) into their various taxonomic groups with the aid of a dissecting microscope and counted. Identified insects were confirmed by a taxonomist in the Department of Crop Protection, Institute of Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, where voucher specimens were kept. Collected data were subjected to Analysis of Variance (ANOVA) to ascertain whether or not statistical differences existed in sampled insects from the different sites.

Table 1: Sugar and alcohol compositions of *Raphia hookeri* palm wine at various temperatures and pH values

Days	Time (Hours)	Glucose content (mg/100ml)	Fructose content (mg/100ml)	Alcohol (%)	pH	Temperature (°C)
1.	24.00	156.79	152.00	1.80	4.80	28
2.	48.00	132.00	96.00	2.07	4.20	30
3.	72.00	114.00	40.00	2.40	4.00	32
4.	92.00	99.00	82.00	2.55	3.50	20
5.	120.00	89.20	8.00	2.62	3.50	28

Table 2: Insect species filtered from the palm wine from *Raphia hookeri*

Insect Species Collected	Sampling Locations												Total
	Ide				Okebuonye				Umuokwu				
	Week				Week				Week				
	1	2	3	4	1	2	3	4	1	2	3	4	
Formicidae													
Camponotus maculatus	83	68	66	50	53	52	62	64	40	69	84	77	768
C. acvapimensis	8	3	3	7	9	5	16	0	10	15	7	3	86
Apididae													
Apis melllifera	11	0	11	9	3	7	6	1	7	13	9	5	82
Drosophilidae													
Mycodrosophilla sp.	22	46	25	12	20	4	13	3	16	9	0	11	181
Sarcophagidae													
Sarcophaga tibialis	0	0	4	0	0	0	0	0	0	0	0	0	4
Calliphoridae													
Auchmeromyia senegalensis	3	3	0	0	0	0	0	0	0	0	0	0	6
Nitidulidae													
Cryptarcha sp.	2	0	0	0	0	1	0	0	0	0	0	0	3
Brachypeplus sp.	1	0	0	0	0	0	0	0	0	0	0	0	1
Curculionidae													
Rhynchophorus phoenicis	0	4	7	4	5	0	1	2	2	0	1	3	29
Lepidoptera larvae	3	37	40	54	80	41	34	0	33	27	33	28	410
Diptera larvae	7	15	10	15	12	0	0	0	0	0	0	0	59

RESULTS

The concentrations of glucose and fructose decreased with increasing alcoholic content at varying pH and temperature as fermentation progressed in days. The relative quantity of glucose (mg/100ml) was however consistently higher than that of fructose over 5 days fermentation period (Table 1). Seven insect families made up of seven genera and eight insect species were obtained from the palm wine residues in the fine nylon mesh filter after the filtration processes (Table 2). The adult families included Formicidae, Apididae, Drosophilidae, Sarcophagidae, Calliphoridae, Nitidulidae and Curulionidae (Table 2). There was preponderance in the collection of *Camponotus maculatus, Mycodrosophilla* sp. and Lepidoptera large numbers larvae in all the sites, with *Camponotus acvapimensis* and *Apis mellifera* were also collected in fairly from all the sites.

There was also preponderance in the collection of dipteran larvae even though they were collected from only one village (Ide). Sparsely collected insect species from Ide village included *Sarcophaga tibialis*, *Auchmeromyia senegalansis* and *Brachypeplus* sp. *Cryptarcha* sp. was found only in Ide and Okebunye villages while *Rhincephorus phoenicis* was collected in all the villages.

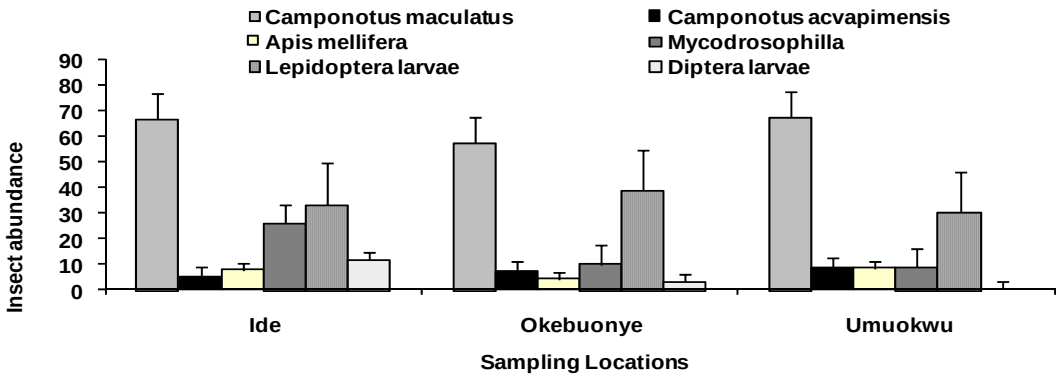

Figure 1: Histogram showing the most abundant insect species sifted from palmwine of *Raphia hookeri* during the sampling period.

There was preponderance in the collection of *C. maculatus* from the *Raphia* palm wine followed by Lepidoptera larvae, *Mycodrosophilla* sp., *C. acvapimensis* and then *Apis mellifera,* with all these species encountered in all the three sampling locations (Figure 1).

The ANOVA showed no significant differences ($P \leq 0.05$), in insect collection among the sampled sites (Ide, Okebuonye, and Umuokwu) except in the collection of *Mycodrosophilla* ($P \leq 0.10$) and Diptera larvae ($P \geq 0.05$) when compared with the collection of *C. maculatus, Mycodrosophilla* sp., Diptera larvae, *C. acvapimensis* and Lepidoptera larvae.

The Fisher's LSD (Least Significant Difference) indicated significant difference in the collection of *Mycodrosophilla* sp. from Ide village with those from Okebuonye village ($P = 0.051$) with a mean difference of 16.2500. Similarly, *Mycodrosophilla* from Ide village differed significantly from those of Umuokwu village ($P = 0.041$; mean difference = 17.2500). Significant differences in the Diptera larvae collection existed between collections from Ide and Okebuonye villages ($P = 0.015$; mean difference = 8.7500) while the Diptera larvae collections at Ide and Umuokwu villages showed significant difference at $P = 0.003$ (mean difference = 11.7500).

DISCUSSION

The data on the composition of sugar and alcohol in the *R. hookeri* (Table 1) indicated that palm wine was used for the study and not pure unfermented sap. For instance the consistent drop in the pH of the palm wine was an indication of fermentation (Faparusi and Bassir, 1972), while the glucose and fructose content of pure unfermented sap was often markedly decreased (Eze and Ogan, 1988). The consistent declined in the alcoholic content of raffia palm wine with increasing number of days agreed with the report of Amoa-Awua *et al.* (2006) who linked the observation to the activity of yeasts, acetic and lactic acids in the palm wine. The absence of sucrose at 24 hours and thereafter may be attributable to fermentation of the sucrose to monosaccharides and organic acids by yeasts and various bacteria (Faparusi 1969; Eapen, 1970/71, Van Pee and Swings, 1971).

The recovery of seven insect families Formicidae, Apididae, Drosophilidae, Sarcophagidae, Calliphoridae, Nitidulidae, Curculionidae from the palm wine was contrary to the view of Howard (1999) that the insects significantly represented on palms are concentrated in certain families of the orders Orthoptera, Phasmida, Thysanoptera, Hemiptera (including Homoptera), Coleoptera and Lepidoptera. Majority of the hymenopterous species especially the very large number of the family Formicidae (e.g. *Camponotus* spp.) were sifted out from the palm wine and recorded significant presence on the raffia palm tree largely as a result of their foraging activities. It has been reported earlier by Ewuim (1997, 1998) that *Camponotus* contain certain species which are wholly ground nesting. *Camponotus* also form dense populations in the low zones in the rain forest (Wilson, 1959; Ewuim and Ezenwugo, 1997). It is therefore possible that that *Camponotus maculatus* and *C.*

acvapimensis dropped into the palm wine gourds in the course of their foraging activities on the raffia palm tree as a result of odour response to the raffia palm sap.

Camponotus maculatus and *C. acvapimensis* have been reported to exhibit aggregate movement (Dejean *et al.,* 2000). This must have been responsible for their recovery in high numbers from the raffia palm wine filtrate (Table 2) even though most ants are not specific to a particular lost plant but rather ecologically suitable habitats (Kranz *et al.,* 1977).

Similarly the collection of *Apis mellifera* from the filtrate in all the sampled wines from the three sites studied may be related to their behaviour and ability of the species to scout out new food resource. McNamara and Houston (1980) in this regard implicated *Apis mellifera* as typical Bayesian forayer. Report on pollination studies of *R. hooker* also suggest the possibilities of insect pollination by the bees, wasps, beetles and flies (Listabarth, 1994; Scariot *et al*., 1995; Borchsenius, 1997; Frvik and Feil, 1997), thus implicating *Apis mellifera* as a pollinator.

Again the collection of *Mycodrosophilla* from the residue of raffia palm after filtration might be attributed to olfactory response to the palm wine odour after tapping, since according to Chapman (2003), insects are not only able to discriminate between odours but tend to exhibit a sensory response to many odours in the environment.

The collection of *Sarcophaga tibialis* (Sarcophagadae) and *Auchmeromyia senegalensis* (Calliphoridae) sparingly from only Ide village is also an indication of odour response of these fly species to environment cues. The dipterans in the families of Sarcophagidae and Calliphoridae, both of which are called Metopidae by some authorities (Tripplehorn and Johnson, 2005), are not only forensically important insects (Zahid and Tanzeela, 2004) but exhibit marked odour response. In the blow fly (Calliphoridae) for instance the palpus is equipped with small sensilla basiconica and sensilla chaetica which provide sensory reception for detecting environmental information (Ngern-Klun *et al.,* 2007). Evidently the palm wine served as a modality (Immelmann and Beer, 1989). It is also being suggested that the habit of the sarcophagid and calliphorid flies predispose their females to use the injuries inflicted on the raffia palms during tapping as resource for oviposition and even feeding for all the adult species. This was in line with earlier report of Tripplehorn and Johnson (2005) that adults of Sarcophagidae feed on various sugar-containing materials such as sap.

Similarly the collection of *Cryptarcha* sp and *Brachypeplus* sp. (both of which are members of Nitudulidae), might be attributable to the presence of flavour volatiles of the fermenting sap which Okafor (1977) attributed to fermentation. This suggestion agrees with the earlier report of Tripplehorn and Johnson (2005) who observed that most sap beetles (nitidulids) were found where fluids were fermented. Further research needs to be done to ascertain whether these beetles fell into the gourd while trapping or after removal of the gourd from tapping panel. Again the collection of *Rhynchophorus phoenicis* (adults) further strengthened the pest status of this coleopteran (Youdeowei and Adeniyi, 1986; Howard, 1999), which lays eggs through entry caused by stem damage (NFMA and ODABG, 1996). *Rhynchophorus phoenicis* also use plants under stress or even fallen palms as breeding sites (Fasoranti and Ajiboye 1993), hence their recovery from the *raffia* palm wine. It is suggestive therefore that possible search for breeding site in the tapping panel may predisposed this species to dropping into the palm wine gourd leading to the recovery after filtration of the palm wine. Searching for an oviposition site probably involves several sensory systems operating simultaneously and sequentially with olfaction believed to be the most important sensory system for many phytophagous species (Zhao and Kang, 2002).

The collection of the Diptera larvae and Lepidoptera larvae from the residue of the raffia palm wine after filtration was an indication that the raffia palm wine may have offered nutrient to the insects thus may have dropped into the palm wine accidentally. Palms offer unique advantage to insects that are adapted to them

with their caterpillars also seen among the principal pests (Howard, 1999). In addition the recovery of Lepidoptera larvae from the raffia palm wine reinforces the view of Rhainds *et al.* (1996) that Lepidoptera larvae were found on apical and subapical foliates as palm defoliators. Similarly the presence of Diptera larva in the filtrate from the palm wine strongly supports the use of incision point with fermenting sap for oviposition by female dipterous species. This view was in line with the report of Archer and Elgar (2003) that access to food is critical for insect larvae, with the adult female insects strongly selected to deposit offspring in safe, nutritious locations.

There is also evidence of the presence of systems for processing, detection and olfactory response in the larvae of cyclorrhaphous flies (Cobb, 1999) hence predisposing the dipterans to be attracted to the palm wine in gourds during tapping, apart from the additional possibility of some of the dipterous larvae accidentally dropping into the tapers' gourds from the tapping panel.

The significant differences in the collection of *Mycodrosophylla* from the three villages using Fishers LSD test ($P < 0.05$) is a reflection of variability in the movement of the conspecifics (Lidicker, 1995; Van Dyke, 2005) and habitat heterogeneity (Ostfeld *et al.,* 1997, Van Dyke, 2005) of these dipterous insect species. Equally the significant differences in the collection of Diptera larvae from the three villages using Fisher's LSD test ($P < 0.05$) is indicative of differences in habitat use which can differ among individuals in a population (Van Dyke, 2005) for the dipterous species that laid the eggs, differences in food resource and availability, and environmental heterogeneity for the dipteran larvae.

The preponderance in the collection of *Camponotus maculatus* followed by Lepidoptera larvae, then *Mycodrosophilla* sp., in the histogram representing the six most abundant species obtained from *R. hookeri* during the sampling (Figure 1), was an indication of the role of *R. hooker* in the life history characterization of these species, including those of *C. acvapimensis, Apis mellifera* and Diptera larvae. There was evidence from this study that the purpose of visitation of these insects to the raffia palm wine and indeed *R. hookeri* were variable as reflected in the collected insect species and varies from one insect species to the other. The nutrient status of the raffia palm wine had enhanced the presence of most of these insect species. This supports the views that since insects cannot synthesize mineral elements and nutrients; consumed macro-nutrients in the saps would obviously play significant roles as structural components of their body organs, constituents of body fluids and electrolytes (McDowell, 1992; Obahiagbon and Osagie, 2007). It has also been argued in earlier reports (Auclair, 1969) that the act of selection of host plants may be influenced by the relative nutritional superiority of the host plant.

Overall, the study has revealed that the factors responsible for the presence and recovery of insect species from *R. hookeri* palm wine include foraging activities on palms, accidental dropping into palm wine gourd olfactory response of species, pestiferous activities, palm pollination, use of points of incision on palm inflorescence and stems as food and oviposition resources thus predisposing them to falling into palm wine being tapped, and the role of raffia palms in the life history of insect species.

REFERENCES

AMOA-AWUA, W. K., SAMPSON, E. and TANO, D. (2006). Growth of yeasts, lactic and acetic acid bacteria in palm wine during tapping and fermentation from felled palm (*Elaeis guineensis)* in Ghana. *Journal of Applied Microbiology,* 102(2): 599 – 606.

ARCHER, M. S. and ELGAR, M. A. (2003). Female breeding site preferences and larval feeding strategies in carrion feeding Calliphoridae and Sarco-phagidae (Diptera): a quantitative analysis: *Australian Journal of Zoology,* 51(2): 165 – 174.

AUCLAIR, J. L. (1969). Nutrition of plant-sucking insects on chemically defined diets.

Entomologia Experimentalis et Applicata, 12: 623 – 641.

BASSIR, O. (1962). Observations on fermentation of palm wine. *West African Journal of Biology and Applied Chemistry,* 6: 20 – 25.

BASSIR, O. (1968). Some Nigerian wines. *West African Journal of Biology and Applied Chemistry,* 10: 41 – 45.

BORCHSENIUS, F. (1997). Flowering biology of *Geonoma irena* and *G. euneata* var. *Sodiroi.* Plant *Systematics and Evolution,* 208: 187 – 196.

CHAPMAN, R. F. (2003). Contact chemo-reception in feeding by phytophagous insects. *Annual Review in Entomology,* 48: 455– 484.

CHARTER, J. R. (1970). *Vegetation Ecological Zones*. Federal Department of Forest Research, Ibadan, Nigeria.

COBB, M. (1999). What and how do maggots smell? *Biological Research,* 74: 425 – 459.

DEJEAN, A., BOURGOIN, T. and OLIVEL. J. (2000). Ant defense *Euphyonarthex phyllostoms* (Homoptera: Tettigomet-tridae) during trophobiotic associations. *Biotropica,* 32(1): 112 – 119.

EAPEN, P. I. (1970/71). Palm wine studies. Pages 78 – 79. *In: 17th Annual Report of the Nigerian Institute of Oil Palm Research*, Benin, Nigeria.

ERVIK, F. and FEIL, J. P. (1997). Reproductive biology of the *nonoecious* understory palm *Prestoea schultzeana* in Amazonia Ecuador. *Biotropica,* 29: 309 – 317.

EWUIM, S. C. (1997). A comparative study of ant species from a tropical rainforest and a fallow farmland using pitfall technique. *Journal of Science, Engineering and Technology,* 4(1): 696 – 702.

EWUIM, S. C. (1998). A study of the insect fauna in Awka in relation to their diel activities. *Entomology Society of Nigeria Occasional Publication,* 31: 63 – 71.

EWUIM, S. C. and EZENWUGO, M. (1997). Formicid fauna of three contrasting habitats in the Nnamdi Azikiwe University Awka, Nigeria. *Journal of Science, Engineering and Technology,* 4(2): 771 – 779.

EZE, M. O. and OGAN, U. (1988). Sugars of the unfermented sap and the wine from oil palm *Elaeis guineensis* tree. *Journal of Plant Foods for Human Nutrition,* 38(2): 121 – 128.

FAPARUSI, S. I. (1966). *A biochemical study of palm wine from different varieties of Elaeis guineensis.* PhD Thesis University of Ibadan, Nigeria.

FAPARUSI, S. I. and BASSIR, O. (1972). Factors affecting palm wine I: Period of tapping. *West African Journal of Biology and Applied Chemistry,* 15: 24 – 32.

FASORANTI, J. O. and AJIBOYE, D. O. (1993). Some edible insects of Kwara State, Nigeria. *American Entomologist,* 39(2): 113 – 116.

HOWARD, F. W. (1999). An Introduction to insect pest of palms. *Acta Horticulturae,* 486: 133 – 139.

IMMELMANN, K. and BEER, C. (1989). *A Dictionary of Ethology:* Harvard University Press, Cambridge.

JAGTAP, S. S. (1995). Changes in annual seasonal and monthly rainfall between 1961 – 1990 and consequences for agriculture. *Discovery and Innovation,* 7: 337 – 348.

KEAY, W. J. (1965). *An outline of Nigerian Vegetation*. Federal Ministry of Information Lagos, Nigeria..

KRANZ, J., SCHMUTTERER, H. and KOCH, W. (1977). Disease*, Pests and Weeds in Tropical Crops.* 2nd edition, John Wiley and Sons, New York.

LIDICKER, W. J. (1995). The landscape: something old, something new. Pages 3 – 19. *In:* LIDICKER, W. Z. (Ed.). *Landscape Approaches in Mammalian Ecology and Conservation.* University of Minnesota, Press, Minneapolis.

LISTABARTH, C. (1994). Pollination and pollinator breeding in Desmoncus. *Principes,* 38: 13 – 23.

MCDOWELL, L. R. (1992). *Minerals in Animals and Human Nutrition.* Academic Press Incorporated, New York.

MCNAMARA, J. M. and HOUSTON, A. I. (1980). The application of statistical decision theory to animal behaviour. *Journal of Theoretical Biology,* 85: 673 – 690.

MEDLER, J. T. (1980). *Insects of Nigeria – Checklist and Bibliography.* Memoirs of the American Entomological Institute, Number 30, 919 pp.

MMEGWA, A. (1984). *Aspects of the Preparation of Palm Wine.* M.Sc Thesis University of Nigeria, Nsukka.

NDON, B. A. (2003). *The Raphia Palm Wine.* 1st Edition, Concept Publications Limited, Lagos, Nigeria.

NFMA and ODABG (1996). Nigerian Federal Ministry of Agriculture (NFMA) and Natural Resources and Resources Development Administration of the British Government (ODABG). *Insect Pests of Nigerian Crops: Identification, Biology and Control*. Natural Resources Institute, Chalham, United Kingdom.

NGERN-KLUN, R., SUKONTASON, K., METHANITIKORN, R., VOGTSBERGER, R. C. and SUKONTASON, K. L. (2007). Fine Structure of *Chrysomyanigripes* (Diptera: Calliphoridae), a fly species of medical importance. *Parasitology Research,* 100: 993 – 1002.

OBAHIAGBON, F. I. and OSAGIE, A. U. (2007). Sugar and macro-minerals composition of sap produced by *Raphia hookeri* palms. *African Journal of Biotechnology*, 6(6): 744 – 750.

OBIRE, O. (2005). Activity of *Zymomonas* species in palm sap obtained from three areas in Edo State Nigeria. *Journal of Applied and Environmental Management,* 9(1): 25 – 30.

OLOGUNDE, M. O., AYORINDE, F. O. and SHEPARD R. L. (1990). Chemical evaluation of defatted *Vernonia galamensis* meal. *Journal of America Oil Chemist Society,* 67(2): 92 – 95.

OKAFOR, N. (1972). The source of microorganisms in palm wine. *Symposium of the Nigerian Society of Microbiology,* 1: 97.

OKAFOR, N. (1975). Preliminary microbial studies on the preservation of palm wine. *Journal of Applied Bacteriology,* 38: 1 – 7.

OKAFOR, N. (1977). The microbial method for palm wine preservation. *Journal of Applied Bacteriology,* 43: 159 – 161.

OKOLO, E.C. and ABIGOR, R. D. (2006). Components of exudates of Raphia *hookeri* Mann. and Wendl. *Journal of Agricultural, Forestry and the Social Sciences,* 4(2): 83 – 88.

OSTFELD, R. S., PICKETT, S. T. A., SHACHACK, M. and LIKENS, G. E. (1997). Defining the Scientific Issues. Pages 3 – 10. *In:* PICKET, S. T. A., OSTFELD R. S., SCHACHACK, M. and LIKENS, G. E. (Eds.). *The Ecological Basis of Conservation: Heterogeneity, Ecosystem and Biodiversity*, Chapman and Hall, New York.

OTEDOH, M. O. (1990). Sweet raphia palm wine. *The Nigerian Field,* 55: 59 – 64.

RHAINDS, M., GRIES, G. and CHINCHILLA, C. (1996). Development of sampling method for first *Instariketicus kirbyi* (Lepidoptera: Psychidae) in oil palm plantations. *Journal of Economic Entomology,* 89(2): 396 – 401.

SALAKO, F. K. and TIAN, G. (2004). Soil conservation and rehabilitation as a basis for sustainable agriculture in the tropics. *In:* BADEJO, M. A. and TOGUN, A. O. (Eds.). *Strategies and Tactics of Sustainable Agriculture in the Tropics,* Volume 2, College Press and Publishers Limited, Ibadan, Nigeria.

SCARIOT, A., LLERAS, E. and HAY, J. D. (1995). Reproductive biology of the palm *Acrocamia aculeate* in central Brazil. *Biotropica,* 23: 12 – 22.

TRIPPLEHORN, C. A. and JOHNSON, N. F. (2005). *Borror and Delong's Introduction to the Study of Insects.* 7th Edition, Thomson Learning Incorporated, London.

TULLEY, P. (1964). How to tap *Raphia* palm. *The Nigerian Field*, 3(2): 120 – 132.

UGWU, S. O. C and IGBOELI, G. (2009). Motility and fertilizing capacity of boar semen stored in raffia palm (*Raffia hookeri*)

sap extender at 15^{o}C. *African Journal of Biotechnology,* 8(8): 1984 – 1967.

VAN DYKE, F. (2005). *Conservation Biology, Foundation, Concepts, Applications.* McGraw-Hill Companies, Incorporated, New York .

VAN PEE, W. and SWINGS, J. G. (1971). Chemical and microbial studies on Congolese palm wines (*Elaeis guineensis*). *East Africa Agriculture and Forestry Journal,* 26: 331 – 344.

WILSON, E. O. (1959). Some ecological characteristics of ants in New Guinea rainforest. *Ecology* 48(3): 437 – 447.

WOOD, B. J. (1968). *Pests of Oil palm in Malaysia and their control.* Incorporated Society of Planters, Malaysia.

YOUDEOWEI, A. and ADENIYI, M. O. (1986). Crop production. Pages 132 – 159. In: YOUDEOWEI, A., EZEDINMA, E. O. C. and ONAZI O. C. (Eds.) *Introduction to Tropical Agriculture.* Longman Group Limited, London.

ZAHID, A. S. and TANZEELA, S. (2004). The effect of flesh Age, Trap colour decomposition stage, temperature and relative humidity on the visitation pattern of blow and flesh flies. *International Journal of Agriculture and Biology,* 6(2): 370 – 374.

ZHAO, Y. X. and KANG, L. (2002). Role of plant volatiles in host plant location of the leafminer, *Liriomyza sativae* (Diptera: Agromyzidae).*Physiological Entomology,* 27: 103 – 111.