DETERMINATION OF DIETARY CHOICE IN RELATION TO SOME BIOLOGICAL CHARACTERISTICS OF *DROSOPHILA MELANOGASTER* (MIEGEN, 1830) IN SAMARU, ZARIA

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ZARIA, NIGERIA

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BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (M.Sc.) DEGREE IN ZOOLOGY

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JANUARY, 2018

DECLARATION

I declare that the work in this dissertation entitled "**Determination of Dietary choice in relation to some biological characteristics of *Drosophila melanogaster* (Miegen 1830) in Samaru, Zaria**" was carried out by me in the Department of Zoology, under the supervision of Prof. I.S Ndams and Dr. E. Kogi. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of dissertation was previously presented for another degree or diploma at this or any other institution.

Timothy Junior EJIGAH _____ _____

Signature Date

CERTIFICATION

This dissertation entitled "**DETERMINATION OF DIETARY CHOICE IN RELATION TO SOME BIOLOGICAL CHARACTERISTICS OF *DROSOPHILA MELANOGASTER* (MIEGEN, 1830) IN SAMARU ZARIA** by Timothy Junior EJIGAH meets the regulations governing the award of the Master of Science degree in Zoology of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to God Almighty for giving me strength and inspiration; and to my family, especially my parents for their patience, support and understanding during the course of this work.

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ABSTRACT

Dietary choice in relation to some biological characteristics of *Drosophila melanogaster* (Miegen, 1830) (Diptera, *Drosophilidae*) in Samaru Zaria, were investigated. Sixty *Drosophila melanogaster* used for the experiment were identified morphologically using the hand lens, dissecting and light microscope. The fruit flies were left to select a diet of Banana, Orange and Pineapple and some number of combinations based on ratios 1:1 and 2:1. The number of *Drosophila melanogaster* found on each diet were observed and counted. The diet introduced to the fruit flies was covered with a fine mesh cloth and left to breed. The numbers of progenies found on each substrate was observed and recorded. The fecundity of fruit flies found on each of the substrate was estimated based on the number of progenies that emerged. From the result obtained, Banana food substrates recorded the highest preference (8.67) $P>0.05$ which was the most preferred fruit diet. Followed by Pineapple fruit substrates (6.00) and Orange food substrate with (3.67) which was the lowest, combination of food substrate based on equal proportion (1:1) indicates that Banana-Pineapple combination (7.33) was the most preferred diet amongst the various combinations. The (2:1) combination indicates that Banana-Pineapple (8.00) was the most preferred diet. Banana fruit diet recorded the highest number of progeny with (18.00). Pineapple fruit substrates (10.33) did not differ significantly ($P>0.05$). Orange fruit substrates recorded (9.67). The average progeny observed in each individual fruit substrates was (12.67) which was higher than Orange-Pineapple but lower than Banana fruit substrates. Similar trend was observed in various combinations based on ratios 1:1 and 2:1.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Drosophila melanogaster Meigen,1830 (Order :Diptera, Family: *Drosophilidae*) is a fruit fly that is approximately 3mm long being used as the model organism for research in genetics. The knowledge of the complete genome makes it easy to conduct experiments and research with these flies that have a comparatively short life cycle and are easily cultured. Like many insects, the *Drosophila* life cycle involves complete metamorphosis, in which there is distinct larva, pupal and adult stages. The female *Drosophila* lays its eggs, each approximately half a millimeter in length after a day of fertilization, the embryo is formed into larva then consumes food and therefore grows in a continuous manner for nine days (Manning, 2006).*Drosophila* depends on hair like structure called sensilla located on multiple parts of their body including the proboscis, legs and ovipositor. Each of these receptors contains 68 gustatory receptors that help*Drosophila*to select Food nutrients and mates.They prefer food with High sugar content and salt content (Montell, 2009). The proboscis of*Drosophila* is made up of internal and external sensilla, the external sensilla detect preferable food sources and the internal sensilla check the food before it is allowed into the digestive system. There are also the sensilla located on the ovipositor, which is used by the females to identify oviposition sites. Males on the other hand have more sensilla on their forelegs to allow them to sense pheromone levels when choosing a mate. The taste sensing neurons in the receptors are called bona fide neurons which are similar to the neurepithelial neurons found in the tastebuds of mammals. The readings from the sensilla are absorbed and transmitted to the sub esophageal ganglion region of the brain where it is then processed (Montell, 2009). These sensilla are subdivided into categories that classify them in

terms of length and function in terms of length they are separated into long (l–type), intermediate (i–type), and a short (s-type). Then another subdivision separated them by function into cells focused on fourGustatory Receptor Neurons (GRNs) in the response to sugars (s cell), water (w cell), and low concentrations of salt (L1), and high concentrations of salt (L2). These different types of sensilla act as taste buds for the *Drosophila* in search for nutritious food (Montell, 2009).

All insects including *Drosophila* have a natural ability to evaluate their nutrient requirements based on the supply from environment and translate this information into behavioural responses;there is little knowledge of this regulatory underlying mechanism that does these induced modifications (Shiraiwa and Carlson, 2007). Most animals prefer a particular food or drink based on the taste. Therefore it is very efficient to form a memory lasting for days in *Drosophila* with a single two minimum pairing of odorant and sucrose (Ryuda*et al*., 2008). Sweet taste can be an undependable indicator of nutrient value because some sugars such as sucrose and fructose cannot be metabolized. The issue is that these sugars are both detected by the same gustatory sensory in *Drosophila* therefore making it difficult to distinguish between sugars.Nutritious food generate quick and healthy memories, it is possible to train this *Drosophila* to prefer more nutritious sugar (Burke and Waddell, 2011). *Drosophila* primarily sense sugars using Gustatory Receptor Neurons (GRNs) located on tarsae and mouthparts. Contact through the tarsae of desirable sugars drives proboscis extension, while stimulation of gustatory neurons on the labellum promotes food acceptance and then ingestion (Burke and Waddell, 2011). It is a well-known fact that when there is an availability of food, there will be an increase in population of any vertebrate animal and it is no different in *Drosophila* (Elland, 2006).

For egg-laying insects, selecting the best site to lay eggs is crucial for the survival of the eggs and larvae. Once the eggs have been deposited, the maternal care of the female flies' ends: the eggs and larvae are henceforth at the mercy of their environment; their range is usually limited so suitable and sufficient food sources for the hungry larvae and protection against predators and parasites are important selection criteria for the best oviposition substrates (Elland, 2006).

The complex nutritional environment of growing, developing animals contributes to shaping an equally complex suite of life history characters, such as survival, developmental time, final body size and shape, longevity, and fecundity (Simpson and Raubenheimer, 2012). Yeasts are known to play an important role in nutrition physiology and host attraction of many *Drosophila* species. Among other saprophagous*Drosophila* species, *Drosophila melanogaster* shows high attraction to *Saccharomyces cerevisiae*for oviposition. Studies on the nutritional importance of dietary yeast on *Drosophila melanogaster* show an explicit influence of different yeast species to larval and adult fitness traits (Anagnostou*et al*., 2010). Additionally, it was found that larvae and adults of *D. melanogaster* prefer specific yeast species. However, these preferences vary between adult and immature *Drosophila* stages (Anagnostou*et al*., 2010). Specific effects of single yeast species however may be less important, considering the findings of Rholfsand Kürschner (2010). Their findings suggest favourable effects of an increased species diversity and appropriate species combination of dietary yeast on *DMelanogaster*



Figure1.1: *Drosophila melanogaster Life* Cycle, the *Drosophila* develops through the first instar larva, second instar larva, third instar larva, and pupa stage to mature into an adult fly (Elland, 2006)

1.2 Statement of the Research Problem

The biological characteristics which involve the mechanism of deciding or changing food preferences in *Drosophila melanogaster* is not fully documented (Fougeron*et al*., 2011). Information on the choice of food in *Drosophila melanogaster* and how it affects the growth and development in the natural population is limited in Zaria

1.3 Justification of the Study

The knowledge on the types of food and their effects on the biology of the *Drosophila* will shade light on the nutritional requirements for *Drosophila melanogaster.*

The information on nutrition that shapes the life history character and the detailed relationships between diet, nutrient intake, lifespan and reproduction in *Drosophila melanogaster* (Lee, 2007)

1.4 Aims and Objectives of the Study

The Aim of the Study is to evaluate the natural choice of food requirement of *Drosophila melanogaster*while the Objectives of the Study are as Follows:

i. To determine the choice of food based on theprotein-carbohydrate ratios in *Drosophila melanogaster* population diet.
ii. To determine the effects of the food chosen on the fecundity of *Drosophila melanogaster.*
iii. To determine the effect of food choices on *Drosophila melanogaster* larval development.

1.5 Hypotheses

i. There is no significant difference in the choice of food *in Drosophila melanogaster* population based on the protein-carbohydrate ratio.

ii. There is no effect of the food chosen on the fecundity of *Drosophila melanogaster*.

iii. There is no significant difference on the effect of food choices on *Drosophila melanogaster* larval development time.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter presents previous research reports on *Drosophila* food preference and nutritional requirement

2.1 Nutritional Composition

The nutritional composition of animals' food strongly affects their well-being, survival and reproduction, and accordingly most species appear to seek the mixture of foods that maximizes fitness (Simpson and Raubenheimer, 2012). The behavioural, physiological and neurobiological mechanisms that underlie food selection have been studied for a long time in a wide variety of animal species including rats *(Rattusnorvegicus*), mink (*Mustelavison*), locusts (*Locustamigratoria* and *Schistocercagregaria*), moth caterpillars (e.g. *Heliothiszea*), predatory beetles (*Agonumdorsale*) and spiders (*Pardosaprativaga*) (Waldbauer and Friedmann,1991; Simpson and Raubenheimer 2000;Koehnle*et al.*,2003; Mayntz*et al*., 2005, 2009). There are still, however, fundamental questions about the abilities of animals, including humans, to actively seek food types that optimize the proportion and amounts of nutrients in their diet (Galef, 1991). These uncertainties probably reflect the enormous complexity involved in nutritional selection and regulation among the variety of species used for research on mechanisms of nutrient selection, one of the most promising animal models is the fruit fly (*Drosophila melanogaster*). Owing to the abundance of protocols available for studying its neurogenetics, behaviour, ecology and evolution, a recent research effort has been devoted to examining mechanisms of nutritional regulation in adult fruit flies (Amrein and Thorne, 2005; Burke and Waddell,2011; Fujita and Tanimura,2011; Ja*et al*., 2007; Lee *et al*., 2008). Although majority of recent research has been devoted to adult fruit flies, the larval stage could potentially be a more powerful model system for

a long-term study of the mechanisms and ecological factors that determine nutritional regulation (Scherer *et al*.,2003; Heisenberg *et al*., 1985). First, larvae show dramatic, rapid increase in body mass, which strongly depends on the nutritional composition of their food (Sang,1956, 1978).Secondly, larvae possess only a few thousands functional neurons, which make them a much simpler model system than the adults with approximately 100,000 neurons (Iyengar*et al*.,2006; Huser*et al*.,2012). Thirdly, in spite of their relative simplicity, the larvae are sensitive to the concentrations of major food components including simple sugars, yeast and sodium (Dukas, 1999;Neuser*et al*., 2005;Niewalda*et al*., 2008; Durisko and Dukas,2013).

Orange accounted for approximately 70% of citrus production in 2012 (Kimball, 1999) in 2013, 71.4 million metric tons of oranges were grown worldwide, production being highest in Brazil, Florida and California in the U.S.A (FAO, 2013).

Drosophila melanogaster preference for citrus in the wild during oviposition is fascinating that a complex behavior, such as choosing an egg-laying site in nature (Yang*et al*., 2008). A considerable proportion of *Drosophila* larvae are killed by enemies, mainly parasitoid wasps that lay their eggs inside the larvae (Singer and Thomas, 1988). It is astonishing that these wasps are repelled byCitrus odours, although Citrus should guide them to their food source; *Drosophila* larvae, the parasitoid wasp *Leptopilinaboulardii*, which specializes in *Drosophila melanogaster* is repelled by valencene. In a further choice experiment, the wasps had to choose larvae on the valencene- free substrate. Orange trees were found to be the most cultivated and widely grown in tropical and subtropical climates for their sweet fruit. The fruit of the orange tree can be eaten fresh or processed for its juice or fragrant peel (Kimball, 1999). Oranges are of different types and there are different varieties of oranges all over the

world. In Nigeria, the most common of them found is theCitrus*sinensis,* considered a sweet orange.

The sweet orange reproduces asexually (apomixes through nucellarembryony), varieties of sweet orange arise through mutations (Adres, 2013).

The sweet orange is a hybrid, between pomelo*Citrus maxima* and mandarin *Citrus reticulata*. It has genes that are 25% pomelo, 73% mandarin and 2% Dietary Fiber, Orange trees were found to be the most cultivated fruit tree in the world (Andres, 2013).It is still unknown why the wasps avoid *Citrus* (Allemand and Boaletreau-merle, 1989). However, it is certain that female fruit flies have learned to let their offspring grow on *Citrus* fruits, because their larvae are better protected against parasites (Yang *et al*., 2008).

Nutritional fact of oranges shows that it contains 11.75g of carbohydrates, 0.94g of protein, total fat of 0.12g, cholesterol 0mg and dietary fiber of 2.40g. Other vitamins content include folates, niacin, pantothenic acid, pyridoxine, riboflavin and thiamin (FAO, 2015).

Pineapple has some protein quality and can be eaten raw and the juice extracted. Adding other foods with complementary amino acid profile to this food may yield a more complete protein source and improve the quality of some types of restrictive diets. Pineapple is a wonderful tropical fruit having exceptional juiciness, vibrant tropical flavor and immense health benefits. Pineapple contains considerable amount of calcium, Potassium, Vitamin C, carbohydrates, crude fiber, water and different minerals that aregood for the digestive system and helps in maintaining ideal weight and balanced nutrition. Pineapple contains 21.6g of total carbohydrate, 2.3g of dietary fiber and 16,3g of sugar. The total fat content is 0.2g and 0.1 of poly unsaturated fat. It also contains

minerals such as calcium, iron, magnesium, phosphorus, potassium, sodium and zinc (FAO, 2015).

Banana is an edible fruit botanically a berry Produced by several kinds of large herbaceous flowering plants in the genus *Musa* (Armstrong, 2013). In some countries, bananas such as plantains are used for cooking. The fruit is variable in size, colour and firmness, but usually elongated and curved with soft flesh rich in starch covered with a rind which may be green, yellow, red, purple or brown when ripe (Salmon *et al*., 1996). The scientific names of most cultivated bananas are *Musa acuminate, Musa balbisiana,* and *Musa paradisiaca* for the hybrid *Musa acuminate balbisiana*, depending on their genomic constitution. The old scientific name *Musa sapientum*is no longer used. *Musa* species are native to tropical, indomalaya and Australia, and are likely to have been first domesticated in Papua New Guinea (Dan-Koeppel, 2005). Nutritional fact of banana shows that it contains 30g of carbohydrates, 1g of protein, absence ofTrans-fat, cholesterol and sodium. There was 450mg of potassium, 3g of dietary fiber and 19g of sugar. Other vitamins include 2% of vitamin A, 15% of vitamin C, 0% of calcium and 2% of iron (USDA, 2015).

2.2 Behavioral Mechanism in Food Regulation

The geometric framework for nutrition has been applied across a wide range of taxa, from slime moulds to humans which will help us to understand how nutrition affects life history traits and foraging decisions (Berreur*et al*., 1979; Dussutour*et al*., 2010; Simpson and Raubenheimer, 2012). In adult females of *Drosophila melanogaster* and Queensland fruit flies (*Bactrocera tryoni*), the balance of macronutrients, specifically protein to carbohydrate (P: C) ratios, affects longevity, lifetime egg production, and egg laying rate differently (Lee *et al*., 2008; Fanson *et al*., 2012). Adult females live the longest in low P: C ratios, lay the mosteggs in high P: C ratios and show the greatest

lifetime egg production at intermediate P: C ratios (; Lee *et al*., 2008;Ja*et al*., 2009; Fanson *et al*., 2012). When offered a choice between two foods, one high in protein and the other high in carbohydrates, females of both species regulate their food intake towards the P: C ratio that maximizes lifetime egg production (Lee *et al*., 2008; Fanson *et al*., 2012).

Similarly, predatory ground beetles regulate their nutrient intake towards P: C ratios that maximize egg production (Kambysellis, 1971). Thus, in these species adult females choose the macronutrient balance that maximizes reproductive success. Although studies in adult females clearly reveal the links between nutrition, life history traits, and foraging choices, the effects of the nutritional environment are both sex and stage-specific. Nutrition affects reproductive performance differently in males and females in cockroaches, *Nauphoetacinerea*, field crickets, *Teleogrylluscommodus*, and fruit flies, *D. melanogaster*, and this is accompanied by a sex-specific shift in foraging choice(Ruiz and Kohler., 1994; Markow, 2008). Furthermore, many life history characters, like body and organ size, result from the larval nutritional environment (Patterson, 1952).

Imbalanced larval nutrition affects dietary choices in later larval and adult stages in butterflies (Lee *et al*., 2008). Despite this insight to date, we understand little about how life history traits shaped by juvenile nutrition define their foraging choices. To explore the relationship between juvenile nutrition, life history traits, and foraging behavior, we applied the geometric framework for nutrition to larvae of *Drosophila melanogaster*. These larvae live and feed on rotting fruit, obtaining much of their protein and lipid from the yeast communities that aid decomposition (Begon, 1982).

The nutrition derived from their food regulates their growth (Bakker, 1959; Therese, 2006), their development time (Beadle *et al*., 1938; Bakker, 1959), and the development

of their reproductive organs (David, 1970; Therese, 2006). Protein consumption regulates body and tissue growth in larvae (Britton and Edgar, 1998; Colombani, 2003), whereas both protein and carbohydrates contribute to variation in developmental timing (Schaner, 1992). The quantity of yeast in the larval diet has profound impacts on adult fitness; larvae raised in food containing a high concentration of yeast show increased fecundity but decreased longevity and starvation resistance with respect to those reared on low-yeast food, females that are poorly fed as larvae lay larger eggs, and their offspring develop faster on dilute food (Chippindale *et al*., 1993).Nutrition by varying two nutritional variables at a time across a broad range of nutrient space, nutritional geometry allows us to explore how life history traits change with each variable and how these variables interact(Simpson and Raubenheimer, 1997; Cheng, 2008; Simpson *et al*., 2012). The nutritional landscapes derived by this framework then permit targeted questions about how foraging choices relate to life history traits. The geometric framework for nutrition has been applied across a wide range of taxa, from slime moulds to humans, to understand how nutrition affects life history traits and foraging decisions of adult females of *Drosophila melanogaster* and Queensland fruit flies (*Bactroceratryoni*)(Berreur*et al*., 1979; Simpson *et al*., 2012; Simpson and Raubenheimer, 2000).

The balance of macronutrients, specifically protein to carbohydrate (P: C) ratios, affects longevity, lifetime egg production, andegg laid at different rate (Lee *et al*., 2008; Ja*et al.*, 2007; Fanson *et al*., 2012). When offered a choice between two foods, one high in protein and the other high in carbohydrates, females of both species regulate their food intake towards the P: C ratio thatMaximize lifetime egg production (Lee *et al*., 2008; Fanson *et al*., 2012;). The *Drosophila* adult females choose the macronutrient balance that maximizes reproductive success. Furthermore, larvae adapted to poor-quality food,

via experimental evolution, metamorphose into smaller adults within the normal developmental time frame when reared on normal food (Markov and O'Grady, 2006).

On poor food, the development time and survival of these evolved lines is less affected than that of controls (Markov and O'Grady, 2006).

Despite the considerable insight into how nutrition affects these life history characters, manipulating single nutritional variables for only a few food types cannot generate sufficient resolution to identify differences in the response of life history charactersacross a nutritional landscape. Similarly, we have some understanding of how fruit flies regulate their foraging behavior in response to the protein and carbohydrate composition of the food. In both larval and adult *Drosophila melanogaster*, depriving animals of protein leads them to choose yeast over sucrose (Raubenheimer and Simpson, 1997). Reciprocally, animals deprived of carbohydrates choose sucrose over yeast (Simpson and Raubenheimer, 2000). Larvae do not survive on diet that does not contain yeast (Anagnostou*et al*., 2010; Becher*et al*., 2012), and prefer strains of yeast that maximize their survival and body size (Anagnostou*et al*., 2010). Although these studies shed light on how *Drosophila melanogaster* makes foraging choices in relation to single macronutrients, they do not tell us how larvae regulate their intake to achieve the correct balance of proteins and carbohydrates and how this macronutrient balancing relates to life history traits (David, 1970; Elland, 2006).

2.3 Reproductive Biology of *Drosophila melanogaster*

Adult flies emerge from puparium located either in the decaying plant material in the earth nearbyin the majority of species, newly emerged adults are not sexually mature (Markow, 1996, 2002). In fact, sexual maturation may require up to several weeks, depending upon the species (Markow and O'Grady, 2006). While males of some species mature more rapidly than females, *Drosophila melanogaster* males mature more

slowly than femaleswhile much of the interspecific variability in reproductive biology reflects the evolutionary relationships of the species, many differences are not constrained by phylogenetic history (Pitnick, 1995). Sexual maturity is a function not only of the ability to execute the appropriate mating behaviour but of the possession of mature, functional gametes as well. For *Drosophila*, these represent two different, yet related, processes: gametogenesis and behavioural maturation.

2.4 Behavioral Maturation

Behavioural as opposed to gonadal, Maturity constitutes the ability to deliver and receive the appropriate courtship signals, which, depending upon the particular *Drosophilamelanogaster*species, may involve one or more of several sensory modalities: olfaction, auditory, tactile and visual (Markow and O'Grady, 2005). Pheromones typically are some blend of hydrocarbons, profiles of which for both males and females commonly change, after emergence, to reflect both sexual dimorphism and maturity (Reviewed in Ferveur, 2005). Other aspects of sexual maturity also change with age: males approaching sexual maturity sometimes will follow a female but deliver incomplete courtship behaviours. Females also have courtship behaviours that include both rejection and acceptance signals either of which may employ olfactory, auditory, or visual modalities. Physiological control of behavioural maturity in *Drosophila* has not been extensively studied, but appears to be under the control of dopamine (Newby and Etges, 1998), juvenile hormone (Ringo and Pratt, 1978; Postlethwait and Handler, 1979; Wilson, 2003), and ecdysteroids (Richard *et al*., 2005). Control of female behavioural maturity relative to ovarian maturity is not well-understood. As indicated above, ovarian maturation rates vary tremendously among species. In most Species, ovarian maturity correlates positively with female insemination, indicating that both behavioural and gonadal maturity are, to some degree, correlated (Kambysellis and Craddock, 1991).

Manning (1962) noted, however, that while dietary restriction could retard ovarian development in *D. melanogaster*, it had no influence on the onset of female sexual receptivity. Females of some Hawaiian *Drosophila* species (Kambysellis and Craddock, 1991) and of *D. melanogaster* and *D. simulans* (Markow, 2000), however exhibit precocious insemination from forced mating in nature. Timing of sexual maturation influences phenomena such as operational sex ratio, which in turn influences sexual selection (Markow, 2002). Other life-history characters, like ovariole number or testis size, also are thought to be associated with a species' reproductive potential (Wayne andMacKay, 1998). Although a negative relationship exists between egg size and number, larger-bodied females have been shown to allocate less of their resources to reproductive tissues compared to smaller-bodied females (Starmer*et al*., 2003). Understanding the ecological contexts in which thesereproduction patterns are found therefore is essential for understanding their role in evolutionary processes.

2.5 Ecological Control of *Drosophila melanogaster* Reproduction

Long-term evolutionary factors are expected to reflect adaptation to particular ecological parameters, but present day abiotic and biotic factors vary greatly in space and time and possess the potential to influence reproduction. Reproduction can be constrained profoundly by multiple aspects of a species' ecology, including longitude and latitude, and resource characteristics such as community composition, chemistry and spatial and temporal abundance (Markow and O'Grady, 2005). Some *Drosophila* species are found on all continents while others are restricted to the tropics, deserts, specific islands, or very high latitudes (Markow and O'Grady, 2005). Their abiotic features impact *Drosophila* reproduction directly (e.g. high temperatures leading to a decrease in fitness via water loss) or indirectly (e.g.low humidity conditions reducing the frequency and duration of breeding sites). Collection records from particular

locations reveal that, like other insects. *Drosophila* species varyin presence and abundance on a seasonal basis (Tauber andTauber, 1981)

2.6 Resource Availability

Drosophila is saprophytic insects and for the most part, utilizes decaying plant material of all sorts. Although *Drosophila* is primarily associated with plants, they are not phytophagousinsects in the strict sense. They feed upon the microbial community (bacteria, moulds, and yeasts) responsible food composition as well as upon the decomposed material itself. In some cases the microbes, through decomposition, make certain host components available to the *Drosophila* while they also may detoxify plant compounds that are otherwise harmful to *Drosophila* (Starmer*et al*., 1981).Although adults of most species will feed on a multiplicity of food sources, oviposition and larval development typically are more restricted (Carson, 1971). For example, adults of a wide range of species can be attracted to simple banana baits fermented with *Saccharomyces cerevisiae*, but natural feeding and breeding sites are not necessarily similar to these baits. The majority of *Drosophila* species belong to one of two large subgenera, *Sophophora* and *Drosophila* (Markow and O'Grady, 2006). Species in the subgenus *Sophophora*tend to breed in many rotting fruits, although some utilize other substrates as well. Members of the subgenus *Drosophila*, on the other hand, occupy a far wider range of substrate types and display a greater diversity of resource specializations (Shorrocks, 1982). Within any given species group, there may be species that are generalists and oviposit in a wide array of substrates. Commensal taxa, including *D. melanogaster*, *D. simulans*, *D. funebris*, *D. virilis*, *D. hydei*, *D. pseudoobscura*, *D. immigrans* (Patterson and Stone, 1952; Carson, 1972; Powell, 1997), associated with human activity, and species that have specialized on one particular plant or fruit (Da Cunha, 1957; Heed and Kircher, 1965; R'Kha, 1991; Spicer and Jaenike, 1996).

Development times are also correlated with the primary host resource. Species oviposition and developing in ephemeral hosts, such as fungi and flowers, tend to develop much more rapidly than those that are reliant upon longer lasting resources like necrotic cacti and rotting trees. Cosmopolitan species tend to also be rapid developers who can utilize a wide range of host types. Species of Hawaiian *Drosophila*, which oviposit in native Hawaiian tree species, relatively resource-poor substrates, tend to have much longer development times (Markow and O'Grady, 2006).

2.7 Host and Mate Location

Fruit flies locate their feeding and breeding sites using microbial decomposition of the host material which creates volatiles that also serve to attract flies to the appropriate feeding and breeding sites (Reed, 1938; Fuyama, 1976;Fogleman, 1982; Hoffmann and Parsons, 1984;Farine*et al*., 1996; Newby and Etges, 1998; Stensmyr, 2003). While flies clearly are attracted to their breeding sites by the volatile compounds produced by fermenting substrates, in some species, mating does not take place on the fermenting substrate itself (Spieth, 1978; Markow, 1988; Tompkins, 1994; Droney and Hock, 1998). Once at the resource, other mechanisms are likely to underlie the location where specific behaviours, such as mating and oviposition, take place. About a dozen *Drosophila* species have been found to produce aggregation pheromones (Shorey, 1969; Moats *et al*., 1987; Bartelt, 1988, 1989;Schaner and Jackson, 1992; Schaner, 1989b; Schaner, 1989c; Schaner*et al*., 1989a, c).

In many of these species, the pheromone is found in the male ejaculatory bulb and transferred to the female, who releases it to the substrate or the immediate environment. In those cases in which it was examined, the aggregation pheromone acted synergistically with laboratory fly food to attract flies of both sexes. Natural resources, however, were not examined, but would beexpected to produce similar synergistic

interactions. Advantages to aggregation of mated females can accrue from oviposition in that a critical number of larvae are needed to 'work' the food as well as reduce the risk of parasitism and predation (Stensmyr, 2003).

2.8 Oviposition

Several aspects of oviposition are critical to a female's reproductive success. Most essential is oviposition site selection, which exhibits variation not only among but also within species. Females use a wide range of cues in choosing oviposition sites. Interspecific differences in Oviposition site have been demonstrated to involve factors such as ambient light (WogamanandSeiger, 1983), host chemistry (Richmond andGerking, 1979;Lofdahl, 1985; Amlou, 1998; Fanara and Hasson, 2001), host microbial composition (Hoffmann andHarshman, 1985; Oakeshotte, 1989), host texture (David 1970; Rockwell andGrossfield, 1978; Fogleman, 1981; Chess andRingo, 1985), substrate temperature (SchnebelandGrossfield, 1986; Fogleman, 1979) and presence or absence of larvae (Del Solar and Palomino, 1966; Chess andRingo, 1985). Jaenike (1985, 1990) proposed oviposition as consisting of two phases: settling and actual oviposition. Females may be attracted to a prospective oviposition site, settle on it and then utilize different, more local cues for the final decision to deposit eggs. Once females have 'settled' on a prospective oviposition site, signals that they employ to decide whether to oviposit appear to be located on the ovipositor (Takamura and Fuyama, 1980; Chess andRingo, 1985). Taste receptors also are present on the proboscis, wings and legs (Stocker, 1994; Chyb, 2004) and these show sex specific responses (Meunier, 2000), such that these other taste receptors also may be used in oviposition. Species differences in oviposition site utilization must originate in intraspecific variation. Considerable intraspecific variability exists for oviposition site preference. For example, *D. melanogaster* rapidly respond to selection for oviposition

site preference (Takamura and Fuyama, 1977; Bird and Semionoff, 1986; Ruiz-Dubreuil and Del Solar, 1986). Barker and Starmer (1999), Barker *et al*. (1986) and Barker(1994) demonstrated that in natural populations of the *Opuntia*-breeding *D. buzzatii*, there is high heritability for oviposition site based upon the composition of the yeast communities presented to the females. In nature, microbial communities vary among patches of necrotic opuntia, resulting in the maintenance of intraspecific genetic variation for oviposition site. *Drosophila tripunctata*, a species that uses both mushrooms and various fruits, exhibits genetic variation both for settling behaviour and for subsequent oviposition, supporting the complex nature of oviposition site selection (Jaenike, 1985). Fanara and Hasson (2001) reported a similar finding for *D. buzzatii*and*D. koepferi*. Depending upon the species and its reproductive ecology, ovipositing females have different patterns of egg laying (Kambysellis and Heed, 1971). In some species, females insert the eggs deep into the substrate while in others the egg is positioned on the surface; some species in which the eggs are completely inserted into the substrate have long filaments while eggs of species ovipositing on surfaces may lack filaments completely (Kambysellis and Heed, 1971). In some species, females lay aggregates of eggs while in other species females oviposit individual eggs seemingly randomly (Del Solar and Palomino, 1968; Ruiz-Dubreuil and Kohler, 1994). Physiological mechanisms of oogenesis may underlie this difference. In some species, such as the cactophilic *D. mulleri*, oogenesis is synchronous among ovarioles and eggs are matured in clutches as opposed to species like *D. melanogaster*, in which oocytes in each ovariole are at different developmental stages (Kambysellis, 1968).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of study area

Ahmadu Bello University Zaria is located in latitude, 11^0N, Longitude $70^0$42'East and Altitude 660m above sea level. The sample for the Experiment was carried out at the biological garden of Ahmadu Bello university, Zaria.

The trapped fruit fly (*Drosophila melanogaster*) from the garden was taken to the Entomologyand parasitology laboratory were the research was properly carried out

3.2 The collection of sample

The adults *Drosophila melanogaster*were trapped using fruit such as mango, all over-ripened. The baits were kept in kilner jars and kept at strategic location in the Biological Science garden of the Department of Zoology, Ahmadu Bello University, Zaria.. Baits were checked at least every hour, as flies do not necessarily stay on the baits for long periods. The greatest activity occurs during the cooler hours, between 8 AM to 11AM but flies may appear at any time. The attracted adult flies that were found in the jar were covered with fine mesh cloth. They were taken afterwards to the laboratory where the fruit flies were transferred into an already prepared culture medium after morphological identification.

3.3 Morphological Examination and Identification

The *Drosophila melanogaster* were sorted and identified using hand lens, microscope and the keys by Markow and O'Grady(2006).

The morphological features of *Drosophila melanogaster* includes red eyed with medium sized wings and body, male with sex comb and the female abdomen is bigger than that of the male. Translucent and reflective compared to other species (Markow and O'Grady, 2006**).**

3.4 Culturing of *Drosophila Melanogaster*

3.4.1 Requirement of the culture medium for *Drosophila Melanogaster*

1. Distilled water 500ml
2. Agar-agar 9gm
3. Cornmeal 30gm
4. Dry yeast 5gm
5. Propionic acid 5ml
6. Acid mix 25g

Preparation of Acid mix: This was prepared in advance and kept. It was prepared by mixing thoroughly the following: Sugar 300g, sodium Nitrate 30g, potassium chloride 5g, D1-Potassium hydrogen, orthophosulphate (K_2HPO_4) 10g, ferrous sulphate 0.1g.

3.4.2 Preparation of culture medium

Agar and cornmeal were mixed in cold water and then heated with continuous stirring until they dissolved completely, after three minutes the yeast and acid mix were added and cooked for further five minutes. The mixture was then removed and allowed to cool slightly for three minutesbefore thePropionic acid was added and mixed thoroughly. The acid mix is a complete diet on its own but also acts as mite control while the Propionic acid acts as anti-fungal growth. The mixture was then shared into an already sterilized culture bottle inch deep. In the culture medium is a strip of paper for holding

unconscious flies was placed so as not to fall into the culture and get drowned when awake. Then two or three drops of thick yeast suspension were added. The culture medium was prepared five times during the cause of this research.

3.5 Experimental Procedures

The collected *Drosophila melanogaster* from the culture mediawere kept in a Glass jar measuring 18cm in height without food for six (6) hours before the initiation of the Experiment (Geiger, 2002)

3.5.1 Experimental Diets

Three (3) fruits; Banana, Orange and Pineapple were used singly and in various combination for the experiment based on ratios 1:1 and 2:1. Six (6) grams of the squashed fruit were used singly on 1:1 while 4 grams and 2 grams were used in a combined state of 2:1.One gram of yeast was added to supplement the protein nutrients in the various food compositions. The protein-carbohydrate ratio was also determined based on the various compositions of each fruits offered in the following P.C ratios of 1:1 and 1:2.

The preference index was determined by using the formula of (Larrinaga, 2010).

Formula: $X_{ijk} = \frac{t_{ijk}0 - t_{ijk}1}{\sum_{k=1}^{n} (t_{ijk}0 - t_{ijk}1)/n}$

Where, X_{ijk} is the preference value of the subject (fruit fly) i for fruitdiet k in trial replicate j, $t_{ijk}0$ is the weight of available k-fruit diet at the beginning of the trial and n is the number of fruit diets included in the experiment.$t_{ijk}1$ is the weight of uneaten k-fruit diet at the end of the trial, The magnitude of X indicates the degree of preference. Thus,

values of X >1 indicate a relative preference for fruitdiet k, while values of X <1 indicate relative avoidance.

Proximate analysis: the proximate analysis was carried out at national agricultural production research institute at shika, Ahmadu Bello University, Zaria.

3.5.2 Food choice treatment

Experimental flies were one (1) week old and they were kept without food for six (6) hours prior to the experiment (Mirth *et al*., 2005). Sixty (60) *Drosophila melanogaster* flies in each of the culture stock were transferred into a box measuring 25cm in diameter 24cm in heightby first making them unconscious to avoid any of them escaping.

They were kept in the refrigerator for five (5) minutes to make them unconscious. When they regained consciousness, both sexes were able to select their diet from a choice of three fruits (Orange, Pineapple and Banana). After twenty four hours (24) of exposure to the diet, the flies that made their choice were counted based on the number of flies found in the vials, The number of male and females found on each substrates were counted. The flies were let go after counting and the diets were covered with fine mesh cloth and placed under observation. The number of eggs and larvae that eventually emerged was counted based on the estimate of adult that finally emerges. The experiment wasreplicatedto determine the difference in terms of the adults that finally emerged (Elland, 2006).

3.5.3 Determination of the number of progenies

Twenty four (24) hours after exposure of*Drosophila melanogaster*to the various fruit diets which were kept in a separate plastic container covered with a fine mesh cloth and

allowed to breed. Each of the various eggs and the number of larvae were estimated based on the number of *Drosophila melanogaster* adult that emerged from the food substrates (Elland, 2006). Time and development of the larval on each of the diet were observed and recorded. The number of progeny produced on each diet were counted and related to the protein carbohydrate ratios in each diet.

3.6 Data Analysis

Analysis of variance (ANOVA) was used to compare the difference between the preference index of the various diets, fecundity and the number of progeny of *Drosophila melanogaster* found on each of the food substrates fed to them.Data collected were analyzed at $p< 0.05$ level of significance.SPSS software was used for the Analysis.

CHAPTER FOUR

4.0 RESULTS

4.1 Carbohydrate and Protein Contents of Banana, Orange and Pineapple

The carbohydrate and protein contents of the sampled fruitsis Presented on Table 4.1. Banana had the highest carbohydrate (64.35%) with the lowest protein (6.13%) contents. Pineapple was next to banana with carbohydrate and protein contents of (53.75%) and (8.81%) respectively. Orange recorded the least level of carbohydrate (30.23%) and had the second highest protein content (8.31%) after pineapple.

4.2 *Drosophila melanogaster* fruit preference in laboratory condition.

The fruit preference of *D. melanogaster* is shown in Table 4.2. There was significant difference ($P<0.05$) in fruit preference of *Drosophila melanogaster*. Banana fruit substrate (8.67) was significantly the most preferred fruit diet; however, orange fruit substrate (3.67) was significantly the lowest. Banana and orange fruit substrates for*Drosophila melanogaster* were comparable to Pineapple fruit substrates (6.00). Analysis based on gender for fruit preference also differed significantly ($P<0.05$). There was no significant difference between Orange (1.67) and Pineapple (2.00) substrates preference by the male *Drosophila melanogaster*; but both substrates were significantly lower than the preference for Banana fruit substrates. Similar trend was observed in fruit preference by female counterpart of *Drosophila melanogaster*. The female preferred Banana (5.00) and it was significantly higher than the one recorded for orange (1.67) and Pineapple (2.00).

Table 4.1 Proximate Analysis of Nutritional content of Banana, Orange and Pineapple (P: C) Content

		Percentage of Nutrient Content					
Substrate	gm	DM	ASH	EE	CF	CP	NFE
Banana	6.00	87.66	2.40	5.22	9.56	6.13	64.35
Orange	6.00	83.56	2.13	8.84	34.05	8.31	30.23
Pineapple	6.00	90.57	2.96	6.45	18.60	8.81	53.75

DM=Dry matter, ASH=Inorganic content, EE=Either extract (oil), CF=Crude fiber (insoluble carbohydrate), CP=Crude protein, NFE=Nitrogen free extract (soluble carbohydrate)**.**

Table 4.2: Food preference of *Drosophila melanogaster*to Banana, orange and pineapple

Substrate	Gm	Mean ± SE		
		Male	Female	Overall
Orange	6.00	1.67±0.33[b]	1.67±0.67[b]	3.67±0.67[b]
Banana	6.00	3.67±0.33[a]	5.00±0.58[a]	8.67±0.58[a]
Pineapple	6.00	2.00±0.58[b]	2.00±0.58[b]	6.00±1.16[ab]
Average	6.00	2.44±0.38	2.89±0.61	6.11±0.82

Means with the same superscript letter per column are not significantly different (P>0.05)

Banana-Pineapple combination (7.33) and Banana-orange combination (6.00) were significantly the most preferred fruit substrates as shown in Table 4.3; however, Orange-Pineapple combination (3.67) was the least preferred. Analysis based on gender for fruit preference showed that the male *Drosophila melanogaster* preferred the Banana-orange (3.67) P>0.05 and the Banana-Pineapple combination (2.33) but both were significantly higher than that of orange-Pineapple combination (1.33). The female *Drosophila melanogaster* preferred the Banana-Pineapple combination (4.67) and it was significantly higher than the one recorded for orange-Pineapple combination (1.67) and that of Banana- Orange combination (2.33).

Combination of the Food substrates (2:1) two ratio one

Table 4.3: There was a significant difference in the preference of Banana-Pineapple fruit combination (8.00) P>0.05 which was significantly the most preferred fruit. Orange-Pineapple (6.00) was the second most preferred fruit substrates However; Banana-orange fruit substrates (4.33) were significantly the lowest. Analysis based on gender for fruit preference showed that the male *Drosophila melanogaster* preferred more of orange-Pineapple diet (2.67) which was significantly higher than that of Banana-Pineapple (2.33) and Banana-Orange (1.33) however; the female *Drosophila melanogaster* preferred a diet combination of Banana-Pineapple combination (3.67) which was significantly higher to that of orange-Pineapple (3.00). The least preferred diet was that of Banana-orange but there was no significant difference between all of them.(Table 4.4)

Table 4.3: **Combination of Food Substrates (1:1) One Ratio One by gender.**

Substrate/g	Gm	Mean ± SE		
		Male	Female	Overall
Orange/Pineapple	4:2	1.33±0.88[b]	1.67±0.67[b]	3.67±0.33[b]
Banana/orange	4:2	3.67±0.33[a]	2.33±0.88[ab]	6.00±0.58[a]
Banana/Pineapple	4:2	2.33±0.33[ab]	4.67±0.67[a]	7.33±0.88[a]
Average	4:2	2.44±0.44	2.89±0.59	5.67±0.62

Means with the same superscript letter per column are not significantly different (P>0.05)

Table 4.4: Combination of Food Substrates of Banana, orange and pineapple on (2:1) Two Ratio One

		Mean±SE		
Substrate	gm	Male	Female	Overall
Orange/pineapple	4:2	2.67±0.33[a]	3.00±0.58[a]	6.00±0.58[b]
Banana/orange	4:2	1.33±0.33[b]	2.67±0.33[a]	4.33±0.33[b]
Banana/pineapple	4:2	2.33±0.33[ab]	3.67±0.33[a]	8.00±0.58[a]
Average	4:2	2.11±0.26	3.11±0.26	6.11±0.59

Means with the same superscript letter per column are not significantly different (P>0.05)

There was a significant difference in the progeny of *Drosophila melanogaster* obtained in the three sampled fruits in Table 4.5. Banana substrates (18.00) ±0.58[a]were significantly higher than orange and pineapple substrates among the substrates. Orange fruit substrates (9.67)±0.1.20 and Pineapple fruit substrates (10.33)±0.33 did not differ significantly (P>0.05). The average progeny observed in the individual fruit substrates was 12.67 which was higher than Orange-Pineapple but was lower than Banana fruit substrates.

There was significant difference in the progeny of *Drosophila melanogaster* obtained in the three fruit combination in Table 4.6.Pineapple-Banana fruit substrates (16.00) P>0.05 were significantly the highest among the substrates. Orange-Pineapple (11.33), orange-Banana (13.00) did not differ significantly. The average progeny observed in the individual fruit combination (13.44) was higher than Orange-Pineapple, Orange-Banana but was lower than the Pineapple-Banana combination of fruit substrates.

The Table 4.7Shows that Banana-Pineapple combination (16.33) recorded the highest number of progeny compared to the combination of Banana-Orange which recorded the second highest (12.67) and Pineapple-Banana combination (12.33). Orange-Banana (10.67), Orange-Pineapple (8.67), Pineapple-Orange (8.00) did not differ significantly. The average progeny observed in the fruit combination of 2:1 of all the fruit substrates was 11.44 which was higher than Orange-Banana (10.67), Orange-Pineapple (8.67), and Pineapple-Orange (8.00) but was lower than Banana-Orange (12.67), Pineapple-Banana (12.33), and Banana-Pineapple (16.33).

Figure 4.2 shows that there was no significant difference in the number of days it took *Drosophila Melanogaster* to develop in various diets. There was difference however in the fecundity; Banana/Pineapple combination recorded the highest fecundity while Banana/Orange recorded the lowest fecundity.

Table 4.5: **The Number of *Drosophila melanogaster*Progeny Recorded in Banana, orange and pineapple Food Substrates**

Substrate	No. of progeny	Progeny(Mean±SE)
Orange	24	9.67 ± 1.20^{b}
Banana	42	18.00 ± 1.53^{a}
Pineapple	29	10.33 ± 0.33^{b}
Average	31.67	12.67±1.45

Means with the same superscript letter per column are not significantly different (P>0.05)

Table 4.6: The Number of *Drosophila melanogaster* Progeny Recorded in the Different Food Combination (1:1) One Ratio One

Substrate	No. of progeny	Progeny(Mean±SE)
Orange/banana	39.00	13.00±0.58[a]
Pineapple/banana	48.00	16.00±1.15[a]
Orange/pineapple	34.00	11.33±2.33[a]
Average	40.33	13.44±1.03

Means with the same superscript letter per column are not significantly different (P>0.05)

Table 4.7: **Number of Progeny that Emerged Based on (2:1) Combination of Each of the Fruit Diet**

Substrate	No. of progeny	Progeny (Mean±SE)
Banana/orange	38.00	12.67 ± 0.33^{b}
Orange/banana	32.00	10.67 ± 0.33^{bc}
Banana/Pineapple	49.00	16.33 ± 0.88^{a}
Pineapple/banana	37.00	12.33 ± 0.33^{b}
Orange/pineapple	26.00	8.67 ± 1.33^{cd}
Pineapple/orange	24.00	8.00 ± 0.58^{d}
Average	34.33	11.44±0.72

Means with the same superscript letter per column are not significantly different (P>0.05)

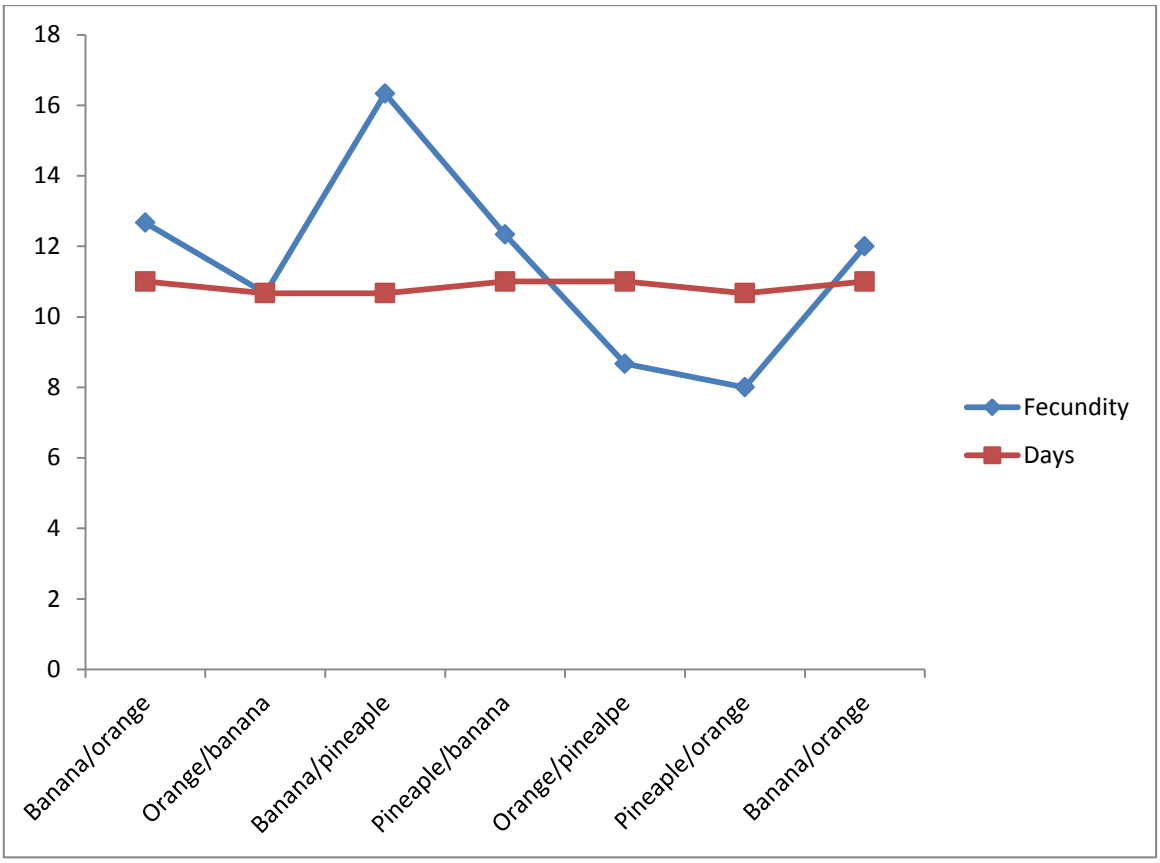


Figure 2: The fecundity and days of development

CHAPTER FIVE

5.0 DISCUSSION

5.1 The Choice of Food Based on the Protein Carbohydrate Ratio

The first step in analysis of macronutrient selection under the food choice is to establish the self-selected point of nutrient intake over a given period. This provides an essential reference point for interpreting patterns of nutrient balancing when *Drosophila melanogaster* are restricted to other diets, and also provides the basis for relating patterns of performance (e.g. human health and weight regulation) to nutrient intake (Raubenheimer and Simpson (1997). Hence, the first phase of the current experiment involved allowing *Drosophila melanogaster* a free choice of foods and thus the opportunity to select a preferred ratio and amount of two macronutrient dimensions (Protein versus carbohydrate ratio) Having established free-choice macronutrient intake points, the nutritional quality of food is very important to any living organism, vertebrate or invertebrate and *Drosophila melanogaster* is not an exception. The nutritional importance of fruits to *Drosophila melanogaster* has increased substantially because of the beneficial effects of eating food that are rich in protein, carbohydrate, minerals, fat and oil. The result in Table 4.2 revealed that *Drosophila melanogaster* preferred Banana substrate the most (8.67), this is attributed to the fact that Banana is known to have a sweet smell and it is prone to rotten faster than any of the two fruits (orange and Pineapple) and it's also because it does not become as juicy as the other fruits. In nature, the typical source of protein for fruit fly larvae is yeast, which naturally contains carbohydrates (Lee *et al*., 2008). This finding agrees with the findings of Elland (2006), Chhabra *et al*. (2013) and Ware (2009) who also observed that more of the fruit flies made the choice of Banana they could be attributed to the high carbohydrate content present in Banana compared to the protein level which is low. From the result obtained, there was a significant difference ($P<0.05$) in food preference of *Drosophila melanogaster*, Banana substrate was significantly the most preferred diet

by the female *Drosophila melanogaster* (5.00) but was statistically higher than that of the male fruit fly (3.67) who also preferred Banana. Pineapple was the second most preferred substrate by both the male (2.00) and the female (2.00) fruit fly. This could be as a result of the sweet taste and also the presence of high carbohydrate (53.75) and protein content (8.81). Some of the reason why Banana was the most preferred despite the addition of one gram of yeast to all the fruit substrates was not in any way a major factor in their choice of Banana. In the research work done by Elland, (2006), Chhabra*et al*. (2013) and Ware (2009), yeast was not added to the substrate introduced to the fruit flies, yet there was a significant difference in the preference of Banana compared to Apple, strawberry and orange.This remains to be experimentally tested, but appears rather unlikely based on the current results (yeast supplementation). In principle, activities of micro-organisms and fungi may provide additional resources that are able to enhance insect reproductive output; accordingly, incorporation of yeast has shown to dramatically increase egg production in various insect species, accompanied by a decreased life span (Chippindale *et al*., 1993; McEwen and Kidd, 1995; Simmons and Bradley 1997; Good and Tatar, 2001). Likewise feeding on orange substrates by *Drosophila melanogaster* recorded the lowest (1.67) among the male and female and the reason for these could be attributed to the nature of the carbohydrate content (30.23) which is low compared to Banana (64.35) and Pineapple (53.75). From the analysis of the results, it is obvious that *Drosophila melanogaster* prefers diets that are rich in carbohydrate than protein.

5.2 Choice of Food Based onRatio (1:1)

Considering exclusively the significant difference in the preference of Banana, the combination of the various substrates based on equal proportion of 3 grams each showed that *Drosophila melanogaster* preferred most, the combination of Banana-

Pineapple (7.33) and Banana-orange (6.00) and these could be as a result of the combined high carbohydrate content that is present in Banana and Pineapple, Banana-Orange. From our findings, it shows that male *Drosophila melanogaster* preferred the diet combination of Banana-Orange the most (3.67) which was significantly higher than the average (2.44) and these could be attributed to their need for energy which can be gotten from a carbohydrate rich diet. Sucrose as a carbohydrate source and yeast extract as a protein source is very essential for the survival and growth of *Drosophila melanogaster*. The female *Drosophila melanogaster* however, preferred a rather different combination to that of the male counterpart. The female fruit flies preferred the Banana-Pineapple diet the most (4.67) which was significantly higher than the average (2.89) and these could be attributed to the nutritional value it will add and not only to the feeding adult but also to their progeny. Banana (64.35)-Pineapple (53.75) is also known to have high concentration of carbohydrate and protein content compared to the other combination. It could also be as a result of sweet taste of these diets which appears preferentially formed with sugars that also provide nutrient benefit. Therefore, nutrient value of this diet is quickly assigned to memory processing so that flies can exhibit preference behaviour to the nutrient associated with the Aroma of the fruit. These experiments also suggest that nutrient content of these fruit also played an important contribution to the immediate memory performance in their behavioral choice assay.

5.3 Choice of Food Based on Ratio(2:1)

The preference for Banana-Pineapple (8.00) continued in the combination of the diet based on (2:1). In these experiments, Banana- Pineapple was the most preferred by *Drosophila melanogaster* and this was significantly higher than the average (6.11) and this could not be far from the fact that they preferred diets that are rich in carbohydrate. Similar trend was also observed in the choice of food by the female *Drosophila*

melanogaster (3.67). In mammals and flies, sweet taste plays an important role in promoting the ingestion of sugars, which serve as valuable source of energy (Yarmolinsky *et al*., 2009). From observation based on ratio 2:1, the fruit flies especially the female *Drosophila melanogaster* consistently made their feeding preference much more in line with nutritional content. This could be the reason why they usually go for the Banana- Pineapple diet. Other reason could be the smell, texture and the ability of the fruits to generate yeast on its own when getting over ripped. However, the male *Drosophila melanogaster* in the combination of (2:1) favored the Orange-Pineapple combination (2.67) which is significantly higher than the average (2.11) but comparable to the Banana-Pineapple combination (2.33). The preference for Orange-Pineapple could be as a result of the sex difference in the nutritional intake of the male *Drosophila melanogaster*. Adult body mass is also important because feeding and reproductive success is positively correlated with adult body mass in both male and female fruit flies (Partridge and Farquhar, 1983; Patridge *et al*., 1987; Lefranc and Bundgaard, 2000).

5.4 The Effects of Choice of Foods on the Fecundity of *Drosophila melanogaster*.

In the choice experiment, it was observed that fruit flies found simply preferred diets that are rich in carbohydrate and low in protein, preferentially fed on the diets providing the missing macronutrient. The number of progeny that emerged from the Banana substrates (18.00) was the highest and it was the most preferred diet during the choice assay. The reason for this outcome could be from the number of fruit flies that fed on the substrates. From the choice experiment, there was a large presence of female *Drosophila* (5.00) that made the choice of Banana, so during feeding, the females may have laid a large number of eggs on the substrates which brought about the high number

of progeny compared to their male counterpart (3.67) who were few on that particular diet. Another reason could be as a result of the nutritional intake in larvae, although the Banana substrates is known to contain more of carbohydrate (64.35) than protein (6.13) the larvae of tephritid fruit fly (*Ceratitiscapitata*) is said to prefer protein rich diet to facilitate development, whereas older larvae (6 days old) tend to choose carbohydrates as energy for the movements during wandering state for pupation (Zucoloto, 1987). Pineapple was the second highest in terms of the number of progeny that emerged (10.33) but was not significantly higher than the orange diet (9.67).

5.5 Number of Progeny Recorded in Ratio(1:1)

The number of progeny recorded in Banana-Pineapple combination was (16.33), in these combinations, there were 4 grams of Banana and 2 grams of Pineapple which shows that the number of progeny was significantly higher than the average (11.44). Banana-Orange recorded the second highest in the number of progeny that emerged in the substrates. Thisis also due to the number of *Drosophila melanogaster* that made the choice of this diet during feeding; this could also be the reason for the high number of progeny that emerged from these substrate. Other reasons could be the nutritional viability of this substrate to support the eggs and larval stages of this fruit fly providing the necessary nutrient for survival to an adult stage. The results here also indicateswhere there is more of Banana (4g) and less of the other fruits (Orange 2g, and Pineapple 2g) there was a higher number of progeny that emerged from these diets compared to the other combinations where there is less of Banana. Banana (4g)-Pineapple (2g) recorded the highest number of progeny (16.33) whereas Pineapple (4g)-Banana (2g) recorded the third highest number of progeny (12.33) and the reason for these could be the nutritional content of the diet that can also support the development of the progeny. Banana (4g)-Orange (2g) recorded the second highest number of progeny (12.67)

compared to Orange (4g)-Banana (2g) which recorded the fourth highest number of progeny that emerged. Orange-Pineapple (8.67), Pineapple-Orange (8.00) did not differ significantly.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i. *Drosophila melanogaster* has a significant preference for banana (8.67) than pineapple and orange in combined and independent treatment.

ii. The number of adults that emerged from the banana substrates (18.00) was significantly higher hence the most preferred diet during the choice assay.

iii. Choice of food has no effect on larval development time.

6.2 Recommendations

The use of *Drosophila melanogaster* as a research tool in the laboratory and feeds to those rearing frogs for commercial purpose could be further improved by:

i. The need to carry out research for other different types of fruit at different ripening stages and also the nutritional preference with the larvae of *Drosophila melanogaster* on the different fruit diet should be conducted.

ii. The genome of these fruit flies that made the choice of any of the diet should be checked if there is any genetic difference.

iii. Other than carbohydrate and protein, other trace nutrients should be checked to see their effect.

6.3 Contributions to knowledge

The study has contributed to scientific knowledge as follows:

i. *Drosophila melanogaster* preferred Banana fruit diet (8.67) the most when exposed to the three diets (Banana, Orange and Pineapple) substrates.

ii. Banana fruit substrates produced the highest number of Progenies (18.00) compared to the other diets of Pineapple (10.33) and Orange (9.67).

iii. The choice of these diets had no effect on the larval development time.

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APPENDICES



Plate 1: Vials containing the breeding progenies



Plate 2: Hand Lence and dissecting microscope used for the research