Utilization and Digestion of Carbohydrates, Proteins and Lipids by the Adult 'AK' Grasshopper, Poecilocerus Pictus (Fabr.) when Fed on Three Dietary Regimes

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Abstract

The basic nutrients are usually divided into two categories essential and non-essential once. Different species of insects utilize these nutrients from their food differentially which depend mainly upon the nature of food, mode of life and the abiotic environmental factors. In order to evaluate the dietetics of Aak, Cotton and Papaya diets of *Poecilocerus pictus*, the total carbohydrates, proteins and lipids were estimated initially in the host leaves and finally in the food ingested and excreta voided by the adult 'AK' grasshoppers. Investigation were also made on coefficient of approximate digestibility (CAD), Efficiency of conversion of ingested and digested constituents to body matter (ECI and ECD) for carbohydrates, proteins and lipids of three dietary regimes.

The percent utilization of total sugar ingested by aak fed grasshopper was 67.03% during the entire feeding period which was significantly maximum than cotton and papaya fed diets. The coefficient of approximate digestibility (CAD) on an average adult 'AK' grasshopper (*Poecilocerus pictus)* fed on aak diet was maximum (75.58%) and this value for other two dietary regimes were 73.21 percent (cotton) and 70.38% (papaya). The amount of total proteins in the three dietary regimes namely aak, cotton and papaya leaves was 31.7, 26.7 and 20.5 mg/g respectively. The concentration of total lipids in dry leaves of aak was 41.20 mg/g, in cotton 39.40 mg/g and in papaya leaves 35.10 mg/g. From an analysis of interaction between dietary constituents and their parameters in the adult age, revealed that the values of CAD, ECI and ECD for carbohydrates, proteins and lipids were maximum for aak diet followed by cotton and papaya fed diets during adult development.

Keywords: Poecilocerus Pictus, Carbohydrates, Proteins, Lipids, Dietary Regimes

Introduction

'AK' grasshopper (*Poecilocerus pictus)* represents a major group of insect pest in India. Grasshopper consume considerable amount of foliage during their nymphal development stage and as adults when they are abundant, they can damage economically important crops. Food and optimal weather condition also facilitate growth and development of 'AK' grasshopper. The 'AK' grasshopper infestation problem is seasonal, in all the *kharif* crops and grasses grown during rainy season in the Jodhpur district of Rajasthan. Especially in arid part of Rajasthan, the 'AK' grasshopper problem is severe on green fodder plants during rainy season i.e., from July to September. *Poecilocerus pictus* attacked a variety of fodder crops in almost all districts of western Rajasthan in general and in the areas of relatively low rainfall in particular.

The basic nutrients are usually divided into two categories essential and non-essential. The criterion for this grouping becomes difficult to follow in a metabolic process, because the chemical constituents keep on changing from one category to another during the metabolic process. However, the major nutrients can be estimated as total carbohydrates, proteins and lipids etc. Different species of insect utilize these nutrients from their food differentially which, depend mainly upon the nature of the food, mode of life and the abiotic environment factors.

The carbohydrates in the form of total sugars are a rich source of energy in the 'AK' grasshopper. Generally present in complex form in the host leaves, which the insect, by its enzymatic process breaks down into simple diffusible and absorbable forms for its energy requirements. The requirements and utilization of carbohydrates in 'AK' grasshoppers vary with different plant dietary regimes. The level of these sugars falls in excreta more and more as the adult development progresses because of their utilization in the intermediary metabolic pathways (Poonia, 1975; Joshi, 1981; Gehlot, 2005 and Pipralia, 2012).

Lipids are also a rich source of energy in 'AK' grasshoppers. The triglycerides ingested with food may not be absorbed through the gut wall and therefore the digestive enzymes lipase acts on these glycerol esters and converts them into simpler molecules viz. diglycerides and monoglycerides for the free absorption by gut wall (House, 1965; Poonia, 1979; Gehlot, 2005 and Pipralia, 2012).

In order to evaluate the dietatics of Aak, Cotton and Papaya diets of *P. pictus* grasshoppers, the total carbohydrates, proteins and lipids were estimated initially in the host leaves and then finally in the food ingested and excreta voided by the adult grasshoppers of *P. pictus*. Investigations were also made on coefficient of approximate digestibility (CAD) and Efficiency of conversion of ingested and digested constituent to body matter (ECI, ECD) for carbohydrates, proteins and lipids under three dietary regimes (Aak, Cotton and Papaya).

Review of literature

Perusal of literature revealed that there have been a very few studies on the utilization and digestion of carbohydrates, proteins and lipids by the adult 'AK' grasshopper, *Poecilocerus pictus*. Therefore, present paper is proposed to develop the carbohydrates, proteins and lipids based metabolic pool of three dietary regimens in *poecilocerus pictus*. These pools can be used in devising the management strategies for polyphagous pest.

Aim of the Study

In this study, detailed work was undertaken on the utilization and digestion of carbohydrates, proteins and lipids by the adult 'AK' grasshopper, *Poecilocerus pictus*. The major aspects of present study is to investigate the coefficient of approximate digestibility (CAD), efficiency of conversion of ingested and digested constituents to body matter (ECI and ECD) for carbohydrates, proteins and lipids of three dietary regimes by the adult 'AK' grasshopper, *Poecilocerus pictus*..

Material and Methods

The 'AK' Grasshopper, *Poecilocerus pictus* is usually found during the monsoon and post monsoon season immensely on *calotropics* plants. The adults of *P. pictus* were collected from the vicinity of villages around Jodhpur district as well as in field of Central Arid Zone Research Institute, Jodhpur and New Campus of JNV University, Jodhpur. These 'AK' grasshoppers were kept in breeding cage in the laboratory, the bottom of breeding cage was provided with 10 cm layer of moist soil. The soil in the breeding cage was regularly moistened with water for proper breeding. The grasshoppers were kept for culture and breeding which was maintained at 30 to 35°C and with proper relative humidity.

Quantification of Utilization of Various Dietary Constituent

During adult grasshopper development under each dietary regimen, coefficient of approximate digestibility (CAD), efficiency of conversion of digested food (ECI) and the efficiency which with digestible portion (ECD) of constituent x converted to body substance calculated as:

$$(CAD\ (x) = \frac{\text{Amount of } x \text{ in food ingested} - \text{Amount of } x \text{ in excreta}}{\text{Amount of } x \text{ in food ingested}} \times 100$$

$$ECI\ (x) = \frac{\text{Amount of } x \text{ in body}}{\text{Amount of } x \text{ in food ingested}} \times 100$$

$$ECD\ (x) = \frac{\text{Amount of } x \text{ in body}}{\text{Amount of } x \text{ in food ingested} - \text{amount of } x \text{ in faeces}} \times 100$$

Where *x* denotes the types of dietary constituents (Total carbohydrates, proteins and lipids).

Protein

The proteins were estimated by employing the method of Lowery *et al.* (1951). The food and excreta were homogenized in a pestle and mortar in distilled water with some acid-washed sand. The extract was centrifuged at 100 rpm for 10 minutes and the supernatant thus obtained was used for the estimation of proteins by adding 1 ml reagent C and allowing it to stand for ten minutes at room temperature 0.1 ml of the reagent E (Folin reagent) was added to develop the colour. After 30 minutes the concentration of total protein was read on spekol at 750 nm. Standardization protein curve was prepared from egg albumen. The total protein was than determined by comparing with standardized curve of protein.

Total Carbohydrates

The total carbohydrates were estimated from food and excreta by following Anthrone method (Seifter *et al.*, 1950). The material was crushed in a pestle mortar in 10 ml of distilled water with acid washed sand. The supernatant obtained after centrifugation of the homogenate at 1000 rpm for 15 minutes was used directly for the estimation of water soluble total sugars. In 0.5 ml of the supernatant 6 ml of Anthrone reagent was added. The control tube received 0.5 ml of water instead of the material. The contents of the tubes were diluted to 10 ml and kept in a boiling water bath for three minutes. The solution was cooled and absorbency was read at 620 nm on spekol. The total sugars were then determined by comparing it as the standard curve of glucose.

Lipids

The soluble lipid in dry food and excreta was estimated by employing the 'Soxhlet Unit Method'. The vacuum dried material was extracted in petroleum ether for three hours on water bath. The yellowish lipid from the material was collected in round bottom flask and the percentage of lipid was calculated in the terms of mg/gram.

Result and Discussion

Quantification of utilization of various dietary constituent by three parameters namely coefficient of approximate digestibility (CAD), efficiency of conversion of digested food (ECI) and the efficiency which with digestible portion (ECD) for carbohydrates, proteins and lipids under three dietary regimes (Aak, Cotton and Papaya) for 'AK' Grasshopper, *Poecilocerus pictus*.

Carbohydrates

The carbohydrate occupy very important role in the feeding behaviour and in orientation of certain phytophagous insects to the host plants. The importance for carbohydrates for the 'AK' grasshopper depends mainly on three factors. (a) Phagostimulant property of the carbohydrates (b) types of monosaccharide required for energy production (c) the complement of digestive enzyme available to reduce complex carbohydrates to their constituents' monomers. Dietary carbohydrates are mainly useful for 'AK' grasshopper as a source of energy and for the synthesis of lipid and glycogen.

The coefficient of approximate digestibility (CAD) on an average adult 'AK' grasshopper fed on Aak diet was maximum (75.58%) therefore other two dietary regimes was (73.21%) in cotton and 70.38% in papaya (Table 1). From the above quantitative analysis, it can be concluded that the regime 'Aak' had maximum amount of carbohydrates, whereas, the regime papaya show the opposite trend and it had minimum amount of carbohydrates. The trend of CAD in dietary regimes as follows:

Aak (75.58%) > Cotton (73.21%) > Papaya (70.38%)

From an analysis of interaction between dietary constituent and their parameter in the adult age, revealed that the values of CAD, ECI and ECD for carbohydrates were maximum under three dietary regimes and they increase with the age because more energy is required for survival and growth (Table 1). The activity of hydrolytic enzymes in the mid-gut increased and most of the carbohydrates are utilized to form body substances by various inter-mediary path ways in glycolysis and citric acid cycle. The enzymatic activity in the gut region was reported by Pant and Morris (1969) in *P. ricini* for carbohydrate utilization. The sugars in the form of pentoses and hexoses are derived from food assimilation and are not available in free state. They are mostly utilized in the body in the nucleiotides and nucleic acid utilization in the intermediary metabolic pathways. The level of these sugars fall in the excreta more and more as the adult development progresses. Due to this reason, in carbohydrate, the value of CAD, ECI and ECD increased in later age of the 'AK' grasshopper. This result confirms the previously reported results by Buck (1953), Treherne (1958b) and Poonia and Misra (1975) in tasar silk worm *Antheraea mylitta.*

According to Wigglesworth (1963) the carbohydrates utilization in insect varies with the stage of development, nutritional ability of insect to digest poly and oligo saccharides to diffusible and absorble forms for energy requirement. Fraenkel (1940) studied the utilization and digestion of a numbers of mono, di, tri and poly saccharide and polyhydric alcohol in *Caliphora* and found hat there is a correlation between the corresponding enzyme present in gut region for carbohydrate utilization.

Protein

Protein is the basis of entire biological activity. The primary function of food protein is to supply the free amino acids needed for the growth, development and maintenance of the structural and biochemical machinery of the organism. The value of protein in nutrition however, depends upon the quantitative and qualitative amino acids composition. It is yet to be investigated whether orthopteran insects require specific dietary protein and polypeptides. It is also not definitely known whether at least the simple proteins, present in plant leaves are observed as such or are first reduced to their component free amino acid before absorption by gut.

The coefficient of Approximate Digestibility (CAD) of total protein was maximum on the Aak fed diet (67.02%) followed by cotton (64.56%) and papaya (56.80%) fed diets respectively (Table 1). From analysis of interaction between dietary constituents and their parameter in the adult age was revealed that the values of CAD, ECI and ECD for proteins were maximum under dietary regimen Aak and in adult age they increased with the age because more energy is required for survival and growth of 'AK' grasshopper.

P. pictus adult during the entire feeding period consume largest amount of proteins on Aak fed diet and also utilized the maximum of ingested protein on this diet, which resulted in production of the heaviest grasshopper in weight as far as the adult development is concerned these value were highest in old aged grasshoppers, the reason for these parameters increasing in magnitude with age might be the increase in enzyme activity involved in digestion of protein in mid-gut in *P. pictus*. The protolytic enzyme consists of two main group: proteinases and peptidases. The former causes the degradation of large protein molecules in smaller fragments and the latter split the peptides and thus lead to the libration of the various free amino acids freely absorb for various functions as reported earlier by Pant and Morris (1969), Poonia (1985) in *P. ricini*, Gehlot (2005) in *C. trachypterus* and Godara (2013) in *P. pictus*.

Similar observations were made by Morals (1975) and Malik (1978), who have reported that dietary regimen containing higher protein content act as a most suitable host for the growth and development of insects as compare to the dietary regimes containing lower amount of protein. The present finding are in agreement with those of Pooina (1979) in *P. ricini*, Sachan and Sachan (1991) in *L. erysimi*, Patyal and Nath (1992) in *S. gregaria*, Seo (1993) in *Pieris rapae* and Gehlot (2005) in *C. trachypterus*. They observed that higher protein content act as most suitable ingredients for the growth and development of insects as compare to the lower amount of proteins.

Lipid

In recent years increasing attention has been paid to the possibility that the insect lipids may be a site of intermediary metabolism, has distrinct from its more passive role of serving as a depot for the storage of fats, proteins and carbohydrate reserves. One prime impetus to the study of lipid biochemistry in Orthopteran insects in recent years has been the finding that many, if not all of the insect growth hormone, pheromones and sex attractants are lipoidal in nature. An understanding of the the biosynthetic pathway and means of catabolizing these humoral and airborne messengers necessitates a vigrus experimental approach to the fields of insect lipid chemistry and biochemistry. The various types of lipids are also of vital importance to many Orthopteran insects including 'AK' grasshopper as substrates for embryogenesis, metamorphosis and flight.

The food consumed by the grasshoppers during their life is converted into lipids and stored in the cells of the fat body by intermediary metabolism. Some of the lipids disapper during the developmental stages and it is broken down to provide the energy and perhaps the starting material for some of the biosynthetic processes associated with metamorphosis, but much of it may persist in adult life.This continuous to serve as energy reserviour in the adult (Buck, 1953). Lipid metabolism is therefore, of great importance in the development of adult 'AK' grasshopper. The coefficient of Approximate digestibility (CAD) of lipid was maximum on Aak (50.92%) fed diets, followed by cotton (43.73%) and papaya (32.96%) fed diets, respectively (Table 1). From an analysis of interaction between dietary constitutions and their parameters in adult age, it revealed that the values of CAD, ECI and ECD for lipids were maximum under dietary regimes Aak followed by cotton and papaya diets.

Aak > Cotton > Papaya

In our study the patteran of the CAD, ECI and ECD of total lipids was almost similar to that observed for total proteins. The maximum lipids were utilized when 'AK' grasshoppers fed on Aak followed by cotton and papaya leaves.

The lipid utilization mostly depends on the activity of the lipase in mid gut, if the lipase activity in mid gut increases the lipids utilized maximum. The results further showed that the amount of lipids were less in quantity in food material than in insect body. The increased amount in body presumed to be synthesized from carbohydrates and proteins has been earlier reported by Hiratsuka (1920) in *B. mori*. Our results are in general agreement with the finding of Evans (1939a, b) in *A. urticae* and *P. bucephala*; Evans and Goodliffe (1939) in *T. molitor*; Poonia (1976) in *P. ricini*; Rimoldi *et al.* (1985) in *Tratoma infestans* and Cookman *et al.* (1984) in Anticarsia gemmatalis. Kent *et al.* (1997) in migratory grasshopper, Rouske and Gibbs (1999) in general insect, Matsumoto *et al.* (2002) in *B. mori* and Gehlot (2005) in *C. trachypterus*.

From an analysis of interaction between dietary constitutions and their parameters in adult age of 'AK' Grasshopper, *Poecilocerus pictus*, it revealed that the values of CAD, ECI and ECD for carbohydrates, proteins and lipids were maximum under dietary regimes Aak followed by cotton and papaya diets.

Aak > Cotton > Papaya

The earlier workers have reported only co-efficients of approximate digestibility (CAD). In the present paper, author reported first time details about the efficiency with which the digestible portion of the lipid is converted into the body substance (ECI, ECD) was given in 'AK' grasshopper *P. pictus*.

Conclusion

The present study revealed that the dietetics of Aak, Cotton and Papaya diets of *P. pictus*, the total carbohydrates, proteins and lipids were estimated initially in the host leaves and finally in the food ingested and excreta voided by the adult 'AK' grasshoppers. The coefficient of approximate digestibility (CAD), efficiency of conversion of ingested and digested constituents to body matter (ECI and ECD) for carbohydrates, proteins and lipids of three dietary regimes were also estimated. The values of coefficient of approximate digestibility (CAD) of total carbohydrates, proteins and lipids were maximum on aak fed diet followed by cotton and papaya fed diet. From an analysis of interaction between dietary constituents and their parameters in the adult age, revealed that the values of CAD, ECI and ECD for carbohydrates, proteins and lipids were maximum for aak diet followed by cotton and papaya fed diets during adult development. The ranking of three dietary regimens is as:

Aak > Cotton > Papaya

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Table 1

CAD, ECI and ECD for Total Carbohydrates, Proteins and Lipids (%) during the Adult Age of *P. Pictus* When Fed on Aak, Cotton and Papaya Leaves

Dietary Regimes	CAD			ECI			ECD		
	Carbohydrates	Proteins	Lipids	Carbohydrates	Proteins	Lipids	Carbohydrates	Proteins	Lipids
Aak	75.58	67.02	50.92	65.28	57.32	41.90	70.6	63.3	47.6
Cotton	73.21	64.56	43.73	57.30	51.80	38.30	64.8	57.7	40.5
Papaya	70.38	56.80	32.96	54.60	47.70	28.90	66.3	51.2	30.6
S. Em. ±	1.503	3.080	5.219	3.206	2.787	3.875	1.738	3.496	4.930
C.D. at 5%	9.427			8.682			9.495		

*CAD = Coefficient of Approximate Digestibility
ECI = Efficiency of conversion of Ingested Food
ECD = Efficiency of conversion of digested food

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