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EFFECT OF DIFFERENT CROPS ON THE CUTICLE LENGTH, WEIGHT AND TOTAL BODY WEIGHT OF *Kraussaria angulifera* (Krauss) IN SAHEL AND SUDAN SAVANNA ZONES OF BORNO STATE, NIGERIA

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ABSTRACT
The experiment was conducted in a screen house in Jere (13^0 9N, 11^0 4E) and Maiduguri (12^0 8N, 12^0 5E) of Borno State in 2015 to evaluate the effects of different crops on the cuticle and body weight of *Kraussaria angulifera* (Krauss) in the Sahel and Sudan Savanna zones. The experiment was laid in a completely randomized block design. Experimental cage of $6^{\times}4.5^{\times}1$m, was divided into 6 compartments of 1x1.5x1m planted to 6 crop treatments of maize, sorghum, millet, maize and sorghum, sorghum and millet, millet and maize and replicated 3 times. Seven day old F1 nymphs were introduced into each compartment. Data collection was done every week for the above variables. The results obtained in the two zones revealed that nymphs fed on millet had the longest (36.17) mean length of cuticle at instar five when compared to the other treatments. Nymphs fed on maize had the least (33.17) mean length of cuticle. The weight of cuticle also showed that nymphs fed on millet had the highest (0.065g) weight of cuticle while nymphs fed on maize had the least (0.063g). Data on total body weight showed that nymphs fed on crop mixture from nymph IV to adult recorded the highest total weight than those fed on sole crop.

Keywords: Cereal crops, *Kraussaria angulifera* (Krauss), Sahel and Savannah, nymphs, adults, cuticle, and weight

Introduction

Kraussaria angulifera is large yellowish gregarious grasshopper specie which is common and abundantly found in farm and grass land in the Soudano-sahelian zone of Nigeria and is a pest of local importance. It feeds on cereals, legumes and grasses throughout the growing phase. Eggs hatch in late July or early August and the emerging nymphs which are bright green are usually found on weeds and undergrowth on edges of cereal farms. Older nymphs change from yellowish to brown colours and move in large numbers to feed on millet, cowpea and other crops. In October/November, the adults lay eggs which enter diapause to survive the hot and harsh dry season (Wali, 1995). Egg pods, each containing 80-100 eggs, are laid under shade in shallow (15cm) holes often on abandoned agricultural lands in the shade of shrubs at a density of about 15-20/m². The first instar hopper emerge on eclosion from the egg, after the vermiform larva makes its way through the froth which plugged the egg pod holes to the surface of the soil and molts immediately to enter the first instar. The first instar is whitish green at hatching but turns green within one to two hours with the average length of 7mm and weights 1g. The second instar hopper is difficult to distinguish from the first, but with experience one can see that the pale colour pattern is more obvious with larger head and an average length of 12mm and weights 2-4 g (Popov, 1989).

The third instar hopper is easily recognized having two pairs of wing buds which are seen prominent and projecting from underneath the pronotum on each side of the thorax. The average length measured 12.5mm and weighs 2-8g, while the fourth instar hopper had black and yellow colour markings. The wing buds were larger and more visible though shorter than the length of the pronotum with an average length of 20mm and weigh 9-15g. The fifth instar hopper were bright yellow in colour with black pattern on wing buds which are now longer than the pronotum, but could not fly. The average length was 38mm and weighs 17-22g. The same instar had bright yellow colour with black markings only on their pronotum, thorax and legs and at this time longer (50mm) that other instars and weighs 28-31g (Popov, 1989). The immature adults (fledglings) had maturation period depending on the environmental conditions, and takes 3-6 months under unsuitable (cold or dry) condition. The sizes of adults differ with phase (40.5 to 64 mm in length and weigh (32-36g) and such individuals of the solitary phase are bigger than those of gregarious phase (Sehnal 1985; Popov, 1989).

This grasshopper is not habitually gregarious but can feed alone in the mornings and late afternoons as flights are made to farmland from the surrounding habitats for feeding. The hoppers at the heat of the day spend the heat hours roosting in shade in the surrounding natural habitats. The preferred food for *K. angulifera* is millet crop where both the leaves and the immature seeds are eaten at the milky grain stage, and only the grains are taken off from the head. It is the milky grain stage which is primarily attacked because it is more palatable, and this attack tends to occur the time when *K. angulifera* is in the last hopper or fledgling stage (Popov, 1989; Simpson and Raubenheimer, 1993).

As the millet crop is harvested or mature and becomes hard the hopper populations move to cowpea fields to feed on the flowers and the green pods. Both crops may be attacked at the same time if the cowpea begins flowering before the millet milky stage. Sorghum and groundnut are also vulnerable to attack in areas with no millet or cowpea crops. This incidence occurred in 1972, ccausing reasonable economic losses to the tune of £120,000 (₦ 60, 000,000) in northern Nigeria (Popov, 1988).

Materials and Methods

The study was carried out in Jere (13^0 9N, 11^0 4E) and Maiduguri (12^0 8N, 12^0 5E) areas of Borno State in 2015 where a quadrant of $1m^2$ was thrown randomly in each of the selected zones at 1km distance to serve as sample units. In each zone, the quadrant was thrown 16 times toa sample field population of adult grasshoppers. Mature adults were captured using the sweep net for egg laying. To carry out study on the nymphal development, Adults were put in a transporting wire gauze (1mm mesh) cage of $0.64m^2 \times 1m$ and taken to the egg laying/hatching cage immediately. The egg laying/hatching cage had 4 compartments of $1m^2$ each and floors overlaid with soil to the depth of 8cm. Thirty unsexed adults were kept in each of the 4 compartment and fed with water, spear grass (*Imperata cylindrica*) twice daily (morning and evening), skipping the heat period over a period of 4weeks. Experimental cage (1mm wire mesh) of $27m^2 \times 1m$, divided into 6 compartments of $1.5m^2 \times 1m$ was planted with 6 crop treatments of maize, sorghum, millet, maize and sorghum, sorghum and millet, millet and maize and this was replicated 3 times. Seven (7) day old F1 nymphs were introduced into each compartment which was laid in completely randomized block design (CRBD).

Data collection began on sighting the F1 at an interval of one day as not to miss out any activity during the instar development. Data were analysed using one-way analysis of variance (ANOVA) by Microsoft excel 2007 software. Mean separation was done using least significant difference (LSD).

Results and Discussion

Table 1 showed no significant ($P>0.05$) difference in the length of cuticle for nymph I – II, however, the combined figure for nymphs III and IV showed significant difference ($P<0.05$). There was significant ($P<0.05$) difference in Sahel zone for nymph IV ($P<0.05$). The weight of cuticles (Table 2) showed no significant ($P>0.05$) difference for nymph I – II. There was a significant ($P<0.01$) difference in both zones and the combined analysis for nymph III and fourth nymphal stage, there was significant ($P<0.05$) difference in Sahel zone and Sudan savannah zone ($P<0.01$), while the combined analysis showed no significant ($P>0.05$) difference. Result for nymph V also showed no significant ($P>0.05$) difference for the weight of cuticle. In Table 3, the result on the total body weight showed no significant ($P>0.05$) difference at the first nymphal stage. The second stage showed significant ($P<0.05$) difference for the Sahel zone and the combined analysis, while the Sudan zone showed no significant ($P>0.05$) difference. There was a significant ($P<0.05$) difference for nymph III, V ($P<0.001$), and adult stage ($P<0.001$), while only the combined analysis showed a significant ($P<0.001$) difference at the fourth nymphal stage.

Arthropods are covered by a cuticle which mainly functions as an exoskeleton, the linear and weight changes in nymphs occur as a results of molting by replacing the old cuticle with a new one. Millet is the preferred diet for *K. angulifera* grasshopper due to its high value in crude protein which is required for faster development of new exoskeleton (Popov 1988 and Fisher *et al*. 1996). Those fed on maize and sorghum had significant cuticle length which may be due to the similarities in the nutritional quality of the two crops. Das *et al* (2012) and Fisher *et al*. (1996) also reported that the rate of nymphal development is dependent on nutritional quality of the food plants and length of time the nymphs (being homoeothermic organism) required to raise their body temperatures to optimal levels and become active to feed. The change in weight from the forth nymphal to adult stage in both zones including the combined analysis was as a result of the nymphs and adults being fed on crop mixtures and the voracious feeding on the selected crop by these stages. Weight grew faster resulting in heavier adults than those that were fed on the other plants.

Simpson and Raubenheimer (1993) reported that insects can regulate their feeding ability by regulating the amount of a particular food eaten or selecting palatable foods among alternatives. To balance their nutritional requirements insects can consume food until they achieve their requirements for carbohydrate, while still in deficit in terms of protein and can also consume food to fulfil their requirement for protein though deficit in carbohydrate. The variations in weight at the second and third nymphal stages in the two zones could be as a result of the environmental differences in vegetation cover and palatable diet available, which is in line with Bamidele and Muse (2014) who reported on the variation of body weight of *Z. variegatus* grasshopper with location.

Conclusion

The results show that nymphs fed with millet in both zones and the combined results had significantly higher length of cuticles while those fed on crop mixtures had significantly higher total weight, grow faster and were heavier than those that were fed on other single food crops.

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Table 1: Length of Cuticle of Instar I - Instar V (millimeter) on different crops (2015)

	Treatment							
Location	Maize	Sorghum	Millet	Maize and Sorghum	Sorghum and Millet	Millet and Maize	S.E(±)	Sig.
Nymph I								
Sahel zone	10.00	10.00	10.67	10.33	10.33	10.33	0.41	NS
Sudan zone	10.00	10.33	10.67	10.00	10.67	10.33	0.39	NS
Combined	10.00	10.17	10.67	10.17	10.50	10.33	0.18	NS
Nymph II								
Sahel zone	12.33	12.33	13.00	12.67	12.67	12.67	0.44	NS
Sudan zone	12.33	12.67	13.00	12.33	12.67	12.00	0.39	NS
Combined	12.33	12.50	13.00	12.50	12.67	12.34	0.25	NS
Nymph III								
Sahel zone	13.67	14.67	15.67	14.33	14.33	14.33	0.615	NS
Sudan zone	14.00	14.33	16.00	14.67	14.67	14.00	0.607	NS
Combined	13.84	14.50	15.84	14.50	14.50	14.17	0.39	*
Nymph IV								
Sahel zone	18.00	17.67	19.67	18.33	18.33	18.33	0.51	*
Sudan zone	18.33	18.67	19.67	19.00	18.67	19.67	0.58	NS
Combined	18.17	18.17	19.67	18.67	18.50	19.00	0.35	*
Nymph V								
Sahel zone	32.00	34.33	35.33	35.33	34.33	34.33	2.31	NS
Sudan zone	34.33	35.33	37.00	33.00	32.33	36.00	2.09	NS
Combined	33.17	34.83	36.17	34.17	33.33	35.17	1.74	NS

L.S.D= Least significant difference at 5% probability level. NS = Not Significant at P = 0.05; * = Significant at P = 0.05; +Measurements were assessed following Dyar's rule

Table 2: Weight of the Cuticle of nymph I- nymph V (milligram) on different crops (2015)

	Treatment							
Location	**Maize**	**Sorghum**	**Millet**	**Maize and Sorghum**	**Sorghum and Millet**	**Millet and Maize**	**S.E(±)**	**Sig.**
Nymph I								
Sahel zone	0.033	0.028	0.035	0.021	0.024	0.029	5.282	NS
Sudan zone	0.028	0.031	0.042	0.036	0.034	0.035	6.356	NS
Combined	0.030	0.030	0.039	0.029	0.029	0.032	5.618	NS
Nymph II								
Sahel zone	0.042	0.042	0.043	0.042	0.042	0.042	5.092	NS
Sudan zone	0.042	0.043	0.050	0.042	0.042	0.042	1.050	NS
Combined	0.042	0.043	0.047	0.042	0.042	0.042	4.068	NS
Nymph III								
Sahel zone	0.045	0.047	0.052	0.047	0.044	0.045	1.704	**
Sudan zone	0.049	0.049	0.053	0.049	0.048	0.049	9.389	**
Combined	0.047	0.048	0.053	0.048	0.046	0.047	9.343	**
Nymph IV								
Sahel zone	0.049	0.050	0.052	0.049	0.045	0.045	1.919	*
Sudan zone	0.050	0.049	0.057	0.050	0.050	0.049	1.520	**
Combined	0.050	0.050	0.055	0.050	0.048	0.047	1.950	NS
Nymph V								
Sahel zone	0.064	0.063	0.066	0.066	0.064	0.063	2.723	NS
Sudan zone	0.062	0.063	0.065	0.066	0.067	0.065	2.463	NS
Combined	0.063	0.063	0.065	0.066	0.065	0.062	1.217	NS

L.S.D= Least significant difference at 5% probability level. NS = Not Significant at P = 0.05, *= significant at P=0.05, **= significant at P=0.01; +Measurements were assessed following Dyar's rule

Table 3: Total weight of Nymph I - Adult insect (gram) on different crops (2015)

Location	Treatment							
	Maize	Sorghum	Millet	Maize and Sorghum	Sorghum and Millet	Millet and Maize	S.E(±)	Sig.
				Nymph I				
Sahel	1.22	1.53	1.39	1.35	1.08	1.46	0.20	NS
Sudan	1.69	1.26	1.36	1.51	1.54	1.12	0.17	NS
Combined	1.46	1.40	1.38	1.43	1.31	1.29	0.21	NS
				Nymph II				
Sahel	4.77	4.80	5.30	4.70	4.53	4.70	0.18	*
Sudan	4.53	4.57	5.13	4.47	4.77	4.83	0.28	NS
Combined	4.65	4.69	5.22	4.59	4.65	4.77	0.15	*
				Nymph III				
Sahel	7.47	7.67	7.97	7.27	7.73	7.60	0.14	**
Sudan	7.27	7.53	7.80	7.33	7.33	7.23	0.17	*
Combined	7.37	7.60	7.89	7.30	7.53	7.42	0.12	*
				Nymph IV				
Sahel	13.27	13.00	13.43	13.80	14.53	13.47	0.46	NS
Sudan	12.40	12.73	12.73	13.03	14.17	13.00	0.58	NS
Combined	12.84	12.87	13.08	13.42	14.35	13.24	0.17	***
				Nymph V				
Sahel	17.87	18.40	19.23	19.83	20.90	20.33	0.39	***
Sudan	17.47	18.27	19.43	19.47	21.47	19.50	0.29	***
Combined	17.67	18.34	19.33	19.65	21.19	19.92	0.35	***
				Adult				
Sahel	28.77	28.87	29.00	31.33	30.87	31.37	0.57	***
Sudan	28.47	28.90	28.93	31.63	36.75	31.60	0.55	***
Combined	28.62	29.39	28.97	31.48	30.77	31.49	0.37	***

L.S.D= Least significant difference at 5% probability level. NS = Not Significant at P = 0.05, *=significant at P=0.05,**=significant at P=0.01,***=significant at P= 0.001