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Full Length Research Paper

Estimation of haulage capacity and nest activity of different sizes of harvester ant (*Messor galla* forel) for major small grain cereals in Nigeria

Zakari Goji Silas Turaki[1]*, Joy Zakari Turaki[2], Joshua Dalli Zira[2] and Abba Bukar Abba-Masta[2]

[1]Lake Chad Research Institute, Maiduguri, Nigeria.
[2]Department of Biological Sciences, Faculty of Science, University of Maiduguri, Nigeria.

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The experiment assessed the nest activity index, stock depletion rate and haulage capacity of the three ant worker-size categories as susceptibility indices of millet, sorghum, rice and wheat grains. Results of the study indicated significant (P<0.01) difference in all the assessed parameters among the test cereals, worker-ant sizes and their interaction. Millet grains were significantly more susceptible compared to other test cereal grains, sorghum, wheat and rice. Result further indicate that Minor ants were significantly more numerous at foraging site, grain depletion rate was faster for Major ants, while the capacity and activity of Media ants was significantly higher. The significant interaction expressed variation in all the parameters. Foraging activity of Minor ants was significantly higher on millet, Major on sorghum and Media ants on rice and wheat. Stock depletion and haulage capacity were significantly higher for Major ants on millet and sorghum, as the case was for Media ants on rice and wheat. In conclusion, millet was the most vulnerable to attack by *M. galla* than the other test cereal grains and losses due to Media were significantly higher.

Key words: *Messor galla*, worker-size, nest activity index, stock depletion rate, haulage capacity.

INTRODUCTION

The harvester ant, *Messor galla* Forel (Hymenoptera: Formicidae) is a serious granivorous pest of all the commonly cultivated small grain cereals in Nigeria (NRI, 1996). Sorghum [*Sorghum bicolor* (L.) Moench], millet [*Pennisetum glaucum* (L.) R. Br.], rice (*Oryza sativa* L.) and wheat (*Triticum aestivam* L.) constitute the major staple foods in Nigeria, and are extensively used in bakeries and brewing industries (CBN, 2009). Inspite of the significance of these cereal grains, however, much is lost to the activity of harvester ant. The pest causes extensive damage and losses by foraging on sown seeds, seedling herbage, mature harvested grains and stored grains, thus damage is continuous through the season (Turaki et al., 2006; Heathwole, 1996). The need to study the behaviours of harvester ant becomes apparent in view of its importance as yield reducer and the significance of the cereal grains in Nigeria. Estimation of haulage capacity and nest activity is central to the prediction of variability in the foraging activity of harvester ant on cultivated grain crops (Warburg, 2000). Harvester ants generally modulate responses during foraging based on “central place foraging theory” (Shellee et al., 1998) and “foraging time minimization strategy” (Heredia and Detrain, 2005; Azcarate et al., 2005). The present study is in response to discrepancies in previous reports on foraging behaviours of harvester ants to changes in seed attributes, availability, worker population and size (Kaspari, 1996; Warburg, 2000; Willott et al., 2000; Heredia and Detrain, 2005; Turaki et al., 2006). The challenge had been relating grain attributes to the grain haulage capacity of worker ant sizes. Foraging studies on harvester ants were mostly ecological on wild grasses (Warburg, 2000; Willott et al., 2000; Heredia and Detrain, 2005; Azcarate et al., 2005) while research on agricultural crops are limited (Turaki et al., 2006).

*Corresponding author. E-mail: drturaki@yahoo.com. Tel: +2348065555653.

The aim of the present study is to assess the relative vulnerability of the four commonly small grain cereals to attack by the field and store pest, *M. galla*, by estimation of stock depletion rate, haulage capacity and overall nest activity. The result would assist plant breeding programmes to refocus research on grain attributes in order to reduce losses to this important pest.

MATERIALS AND METHODS

Description of the experimental site, design and treatments

The study was carried out in Maiduguri (Latitude 11° 51' N; 13° 15' E) between June and July, 2011 (32.5 ± 6.1°C, 75 ± 8.3% RH), Nigeria. Four active nests of *M. galla* were identified at the experimental site, previously cropped to millet and sorghum for the past 19 years (1991 to 2010). The harvester ant species of the area had been previously identified as *M. galla* Forel (NRI, 1996). Randomized complete block design (RCBD) was employed in 4 × 3 factorial arrangement, with four replications. Treatments comprised four cereal grain types [sorghum (*Sorghum bicolor* (L.) Moench], millet [*Pennisetum glaucum* (L.) R. Br.], rice (*Oryza sativa* L.) and wheat (*Triticum aestivam* L.), and three worker-ant size categories, Minor (small), Media (medium), Major (large) of average weight of 6.9 ± 0.38, 14.3 ± 2.38 and 25.3 ± 1.63 mg, respectively. Grains of millet (var: Ex-Borno), paddy-rice (Zabarmari local), sorghum (var: ICSV 111) and wheat (var: Seri M82) were obtained from Lake Chad Research Institute, Maiduguri.

Experimental procedure

The experiment was carried out on the four active nests of *M. galla* which was previously enticed with 200 g mixture of all experimental grain types, millet, rice, sorghum and wheat, twice at weekly interval. This was meant to adapt the ants to the other offered cereal grain types hitherto not grown in the study area. At the beginning of the experiment, 300 selected seeds of each of the crop types were placed in turn at a distance of 5.0 m away from the nests (Turaki et al., 2006). The method described by Shellee et al. (1998) and later modified by Warburg (2000) was adopted for the study. Relative population of active foraging (grain-laden) workers in the different ant-sizes was estimated by counting the number of foraging ants in the different categories within 1 m trunk trail. Stock depletion rate was measured as the time grain-laden ants used to cover 1 m on meter rule placed beside the trunk trail recorded using a Scientific Quartz Digital stop watch in seconds. Thereafter, the grain-laden ants were each captured along with the grains in batches of ten in order to determine ant and grain weights using a sensitive electronic balance (Sartarius LC201S). This was repeated in ten batches, the mean of which was determined for three ant-size categories, four grain types and four nests, giving a total of 48 entries. Nest activity index was then computed as product of speed of grain-laden ant (estimated as the distance of 1.0 m covered divided by the time taken to cover the distance) and active ant population.

Relative haulage force (capacity) of the harvester ants was also computed as product of total weight (grains + harvester ants) and ant speed in Newton.

Data analysis

Data collected was subjected to statistical analysis using the statistical software, Statistix Version 8.0. Means were computed using least significant difference (LSD) at both 1 and 5% probability level.

RESULTS

Table 1 shows that grains of millet followed by sorghum were lighter than that of rice and wheat that were highly variable in weight. Furthermore, foraging activity was significantly higher on millet compared to the other test cereals. *Minor* ants significantly ($P<0.01$) outnumbered the Media and Major at foraging sites, constituting 44.2, 32.1 and 23.7% of the active foraging population, respectively. Results revealed that stock depletion rate differed significantly among the test cereals, ant-sizes and their interaction (Table 2). Stock depletion rate was faster for millet than other test cereals followed by rice and wheat with faster depletion rate than sorghum. Results indicated significantly ($P<0.01$) faster depletion rate for Major than Minor and Media that were statistically at par. Result of the interaction show that Major ants depleted millet and sorghum faster than other ants, in contrast to faster depletion by Media for rice and wheat. Nest activity index was significantly higher on millet than other test cereals followed by wheat which in turn had higher nest activity than rice and sorghum. Activity of Media was significantly higher than Minor which in turn had higher nest activity than Major. Result of the interaction shows significantly higher activity of the Minor on millet, Media on rice and wheat, and Major on sorghum. In general, the lowest ant activity was by Major on rice, while the highest activity was recorded from Minor on millet. Haulage force (capacity) by Media was significantly higher than both Major which in turn was significantly higher than by Minor ants.

Ants exerted significantly higher force (capacity) on rice, closely followed by wheat than sorghum and millet which were at par. Haulage force increased with ant-size in millet and sorghum, however, in respect of rice and wheat media exerted more force than major.

DISCUSSION

The study revealed that foraging preferences for cereal grains by *M. galla* was dependent on grain weight and the haulage capacity of the worker sizes. Result on depletion rate indicates that the lighter grains of millet and sorghum were more vulnerable to foraging than the relatively heavier grains of rice and wheat. Population of Minor ants that exhibited the lowest haulage capacity was highest on lighter millet grains while that of Media with high foraging capacity was highest on the heavier grains of rice and wheat. Other studies also indicated higher foraging activities on smaller grains of grasses (Kaspari, 1996; Azcarate and Peco, 2007). Conversely though, Shellee et al. (1998) working with the harvester ant genus, Pogonomyrmex, found that both seed selection

Table 1. Weight of the different cereal grains and active ant population in the different cereals and the different size category.

Treatment	Mean±SD	Range	Confidence interval (95%)
Grain type		**Grain weight (mg)**	
Millet	13.1±2.71	10.30 - 18.10	11.42 - 14.86
Rice	36.7±5.61	29.00 - 48.00	33.14 - 40.26
Sorghum	26.6±2.00	24.00 - 29.30	25.31 - 27.85
Wheat	34.5±4.90	27.30 - 41.90	31.35 - 37.58
$LSD_{0.05}$	2.94		
$LSD_{0.01}$	3.95		
		Active ant population	
Millet	60.9±16.39	40.0 - 86.0	50.50 - 71.33
Rice	52.1±14.02	35.0 - 71.0	43.18 - 60.99
Sorghum	53.7±14.44	36.0 - 75.0	44.49 - 62.84
Wheat	55.4±14.90	37.0 - 78.0	45.95 - 64.89
$LSD_{0.05}$	2.7945		
$_{0.01}$	3.7543		
Ant size			
Small	73.69±2.73 (44.2)[w]	63 - 72	66.01 - 67.75
Medium	53.50±2.70 (32.1)	45 - 53	47.29 - 50.71
Large	39.38±3.42 (23.7)	31 - 41	33.91 - 38.26
$LSD_{0.05}$	1.3973		
$LSD_{0.01}$	1.8772		

[w]Figures in parenthesis represent percentage population composition.

Table 2. Mean stock depletion rate, nest activity index and haulage capacity of the different ant sizes for the four cereal grains.

Crop grain	Ant size			
	Minor	Media	Major	Crop mean
	[x]Stock depletion rate (seconds per meter length)			
Millet	50.5	42.4	30.6	41.2
Rice	79.8	50.4	61.2	63.8
Sorghum	103.9	61.7	43.8	69.8
Wheat	79.6	49.9	60.3	63.2
Ant size mean	78.4	51.1	49.0	
	[y]Nest activity index			
Millet	1.60	1.39	1.42	1.47
Rice	0.87	1.00	0.60	0.82
Sorghum	0.69	0.84	0.88	0.81
Wheat	0.93	1.07	0.65	0.88
Ant size mean	1.02	1.07	0.89	
	[z]Haulage capacity (%)			
Millet	0.219 (21.9)	0.375 (37.5)	0.408 (40.8)	0.334 (33.4)
Rice	0.417 (41.7)	0.812 (81.2)	0.589 (58.9)	0.606 (60.6)
Sorghum	0.237 (23.7)	0.459 (45.9)	0.626 (62.6)	0.440(44.0)
Wheat	0.405 (40.5)	0.768 (76.8)	0.543 (54.3)	0.572 (57.2)
Ant size mean	0.320 (32.0)	0.603 (60.3)	0.541 (54.1)	

[x]Relative stock depletion rate: SE± = 0.8661, $LSD_{0.01}$ = 3.3479 (crop grain type); SE± = 0.7501, $LSD_{0.01}$ = 2.8994 (ant size); SE± = 1.5002, $LSD_{0.01}$ = 5.7987 (interaction). [y]Nest activity index: SE± = 0.0129, $LSD_{0.01}$ = 0.0498 (crop grain type); SE± = 0.0112, $LSD_{0.01}$ = 0.0431 (ant size); SE± = 0.0223, $LSD_{0.01}$ = 0.0862 (Interaction). [z]Haulage capacity: SE± = 0.0178, $LSD_{0.01}$ = 0.0687 (crop grain type); SE± = 0.0154, $LSD_{0.01}$ = 0.0595 (ant size); SE± = 0.0308, $LSD_{0.01}$ = 0.1190 (interaction).

and running speed were less affected by ant-size and load carriage. This could be attributed to the types of grains used in the earlier report, the size of which did not also differ significantly and the ant species. Warburg (2000) also found that *M. arenarius* preferred halves of wheat seeds over whole-wheat seeds, but that the average returning time of ants to the nest did not differ significantly. However, from the findings of the present study, ant haulage speed (stock depletion rate) was significantly faster for millet than other grains of rice, sorghum and wheat. The implication of the present finding is that losses due to *M. galla* would be higher on small grain cereals with lighter seeds that are easier to carry than larger ones. Turaki et al. (2006) working on similar cereals also reported ant preferences for grains with lower weights and that the number of grains picked irrespective of grain type decreased with the weight of grains.

The present result shows that Minor ants that were the most numerous at foraging sites did not have the faster speed of both Media and Major, thus limiting the overall nest foraging activity. In contrast, Heredia and Detrain (2005) observed that Media ants were the most numerous at the foraging arena probably due to differences in species *M. barbarus*. This study therefore suggests that the Major ants forage faster than Media ants which in turn forage faster than Minor ants. However, the revelation that Minor and Media ants were more numerous at foraging sites clearly suggests that the overall nest activity of the most efficient Major ants will be less since they were least in number. Foraging activity of *M. galla* was found to be faster on millet than other cereal grain types in which millet-laden ants run faster and had shorter relative haulage time. In conclusion, millet was more vulnerable to attack among the studied grain types; however, *M. galla* has been established as the pest of all common small grains in the sudano-sahalian environment, which calls for adequate attention on this important pest in both field and store. However, the revelation that millet was more prone to attack by *M. galla* and the crop being an important subsistent cereal grain in the savanna, points to the need to control this pest.

It is also recommended that further study be carried out on incidences of multiple haulage in order to better comprehend the effects of grain weight on *M. galla* activity.

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