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Studies on distribution and abundance of freshwater snail intermediate hosts of schistosomiasis along Kwanar Areh Dam in Rimi L.G.A. of Katsina State

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Various species of freshwater snails act as intermediate hosts for *Schistosoma* species. The *Bulinus* and *Biomphalaria* snails serve as intermediate hosts for *Schistosoma haematobium* and *Schistosoma mansoni*, which are the causative agents of urinary and intestinal schistosomiasis in humans, respectively. This study aims to determine the distribution and abundance of these snail intermediate hosts along Kwanar Areh Dam, Rimi Local Government Area of Katsina State, Nigeria. Three different sites were selected at Kwanar Areh dam for snail sampling. Snails were collected on monthly basis, for nine consecutive months, using scoop net technique and modified manual hand picking, and were identified using their morphological characteristics. 808 snails were collected from the three sites; 259 (32.1%), 360 (44.6%) and 189 (23.4%) snails were collected from sites A, B and C, respectively. The snails were more abundant during early rainy season and site B significantly produced the overall highest number of snails (χ^2= 82.406; *P*<0.05). From the collected snails, only one species, *Bulinus globosus* is known from the literature as an intermediate host in the transmission of schistosomiasis. No *Biomphalaria* snail was sampled in the area. Other freshwater snails identified include *Melanoides tuberculata* and *Gabiella tchadiensis.* This study revealed the presence of a species of freshwater snail that is known to serve as intermediate host in transmission of urinary schistosomiasis in the study area. More effort is needed to control the snails' population through the use of recommended molluscicides and bioremediation. Public enlightenment and health education on the risk factors and possible transmission of schistosomiasis is recommended for the Dam.

Key words: Freshwater snails, intermediate hosts, schistosomiasis, Kwanar Areh Dam, Katsina, Nigeria.

INTRODUCTION

Many freshwater snails are of clinical and veterinary importance, serving as intermediate hosts of different helminthic parasites of humans and animals (Abaje et al., 2012; Abdulhamid et al., 2018). The freshwater snails belonging to the Planorbidae family were mostly found to be the intermediate hosts of the highly infective trematode larvae of the genus *Schistosoma*, the causative agents of the disease schistosomiasis (also

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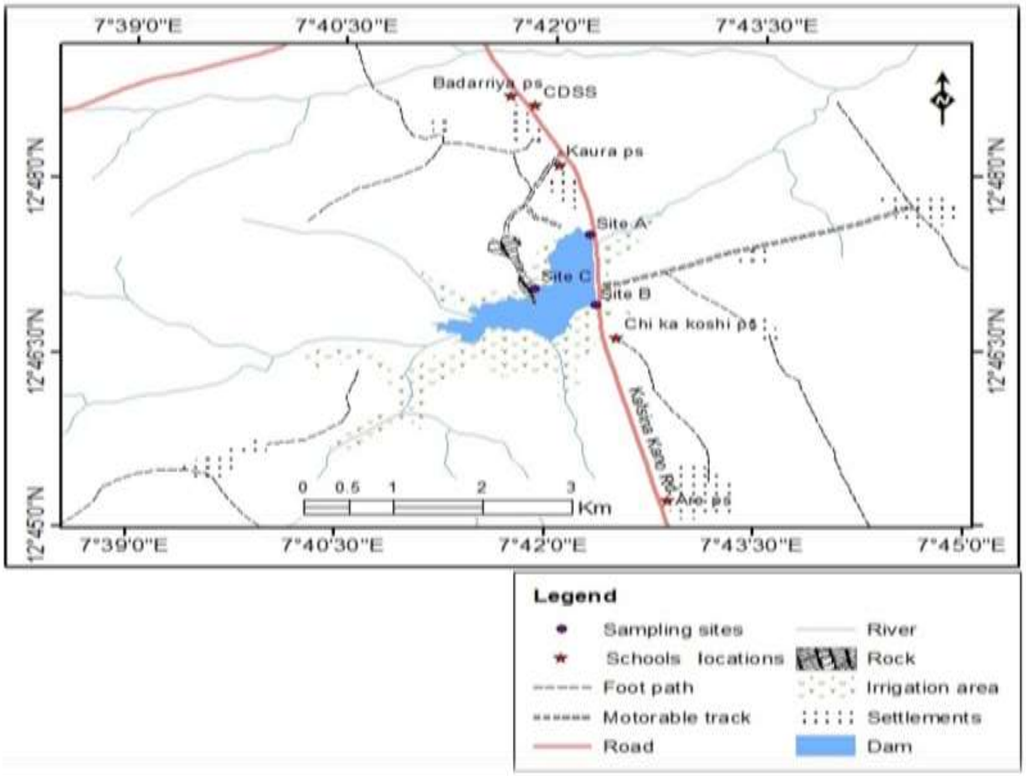

Figure 1. Map of the study area showing the dam and sites for snails sampling.

known as bilhaziasis). Majority of the snail intermediate hosts for human schistosomiasis belong to the three genera *Biomphalaria, Bulinus* and *Oncomelania* (Agi, and Okafor, 2005; Badger and Oyerinde, 2003). The genera *Biomphalaria* and *Bulinus* are the intermediate hosts of *Schistosoma haematobium* and *Schistosoma mansoni* in Nigeria, respectively (Barbosa and Barbosa, 1994; Brown and Kristensen, 1993). The aquatic snail hosts of *Schistosoma* occur in shallow water near the shores of lakes, ponds, marshes, streams and irrigation channels. They live on water plants and mud that is rich in decaying organic matter. The presence of snail intermediate host in an area is one of the major factors maintaining the transmission of schistosomiasis.

Development of water projects have contributed immensely to the transmission of schistosomiasis in some areas. Construction of dams has increased the chances of creating irrigation channels and have provided large source of water supply for the dwellers in neighboring areas (Brown and Kristensen, 1992). This has eventually increased the population density of the snail vectors by the provision of suitable habitat and breeding site to the freshwater snail vector. As evident from the existing literature, communities in the relevant study area have moderate prevalence and intensities of schistosomiasis (Abdulhamid et al., 2018). Prevention and control of schistosomiasis has become crucial and resource demanding through implementation of health programs. Thus, generation of data on the disease prevalence is very essential. However, being an intermediate host of *Schistosoma* species, survey on freshwater snail species will aid in ascertaining their distribution and abundance within an area as well as justifying the prevalence of the disease in that area. This study investigates the monthly distribution and abundance of snail host species along the selected sites of the study area. It will also be an important approach toward successive reduction of the disease prevalence. This study aims to investigate the monthly distribution and abundance of snail host species along selected sites of the study area.

MATERIALS AND METHODS

Study area

The study was conducted at Kwanar Areh Dam in Rimi Local Government Area (LGA) of Katsina State, Nigeria (Figure 1). The dam is located along Rimi-Charanchi road on latitude 12°46´N and longitude 7°41´E. Kaita LGA bound the area to the north (slightly), to the south by Charanchi LGA, to the east by Mani and Bindawa LGAs, and to the west by Batagarawa LGA. Katsina State is located in the Northwestern zone of Nigeria with 34 LGAs (Katsina town is the state capital and the largest settlement). Most of the inhabitants are Hausa and few are Fulani tribal groups (capable of

Figure 2. Scoop net.

speaking Hausa language). Rimi LGA covers an area of 475.6 km² with a total population of 154,092 inhabitants based on the 2006 National Population Census figures (NPC, 2010). It lies at 12°51'0"N and 7°42'56"E. The vegetation of the area is Sudan savannah type, which combines the features of both the Guinea and Sahel Savannah (Abaje et al., 2012; Tukur et al., 2013). There are many settlements around the area where the dam is situated and the inhabitants of these settlements utilize the dam water for various purposes. The villages include Tudun-Kadir, Faduma, Ci-ka-koshi, and Areh village. Situated around the villages mentioned earlier are public and community schools. The inhabitants of these villages are engaged in fishing, boating, growing of crops and some petty trading. Some of the inhabitants engage in white-collar jobs and labor work other than farming and fishing practices. The open ground surrounding the dam is fertile and is tilled extensively to produce different food crops. Communities near the study area are endemic with continuous re-infection of the disease.

Ethical aproval

Prior to the commencement of this research, introduction letter was obtained from Biology Department, Umaru Musa Yar'adua University, Katsina. The letter was addressed and submitted to Katsina State Ministry of Health to seek for ethical approval and permission to conduct the research. The protocol of the study was reviewed and given expedited approval (Assigned Number: MOH/ADM/SUB/1152/1/146) by the Katsina State Health Research Ethics Committee.

Snail sample collection

The dam site was studied periodically to determine the relative snail abundance and diversity with respect to wet and dry seasons. The collection sites were mapped using GPS reader. Three different sites (A, B, and C) around the dam were randomly selected and studied. Sites A (12°47´17.75´´N, 7°41´53.43´´E) and C (12°46´52.75´´N, 7°41´35.84´´E) are the areas engaged with fishing, water fetching and seedlings growing activities. Cattle and other animals are fed with water around these sites. Site B (1246°´45.124´´N, 7°41´55.076´´E) is a sloppy area with large volume of water supply. It serves as the major area for irrigation and farming practice, with abundant vegetation. Modified Scoop net method and Manual hand picking were employed for the collection of snails. The Scoop net consisted of a wide squared frame attached with fine-meshed net and a long handle (Figure 2). At one site (site A), the Scoop net was laid down randomly at the water edge near the vegetation (where the snails may be possibly found) by holding its handle and digging into the ground, after which it was raised with the aim of scooping/excavating up the matter and capturing the snails around the water banks. The snails captured were then cleaned with water, counted (as number of snails per scooping), and later transferred into the specimen bottles. This was repeated twice in the same site (that is three scooping). A 10 min manual picking was done using a long forceps to pick the visible snails, which were transferred into the same container used for the scoop collection. The whole procedure was repeated twice, each for the other sites (B and C), with each collection having its separate specimen bottle properly labelled to correspond the site of

Table 1. Monthly snail species distribution along KwanarAreh Dam, Rimi L.G.A. of Katsina State, Nigeria.

Sampling months	Snail species collected			Monthly total	Prevalence (%)
	Melanoides tuberculata	*Gabiella tchadiensis*	*Bulinus globosus*		
March	52	21	0	73	9.1
April	109	77	0	186	23.0
May	37	89	13	139	17.2
June	74	68	23	165	20.4
July	9	32	73	114	14.1
August	10	12	45	67	8.3
September	16	0	31	47	5.8
October	0	0	17	17	2.1
November	0	0	0	0	0.0
Total (%)	307 (38.0)	299 (37.0)	202 (25.0)	808 (100.0)	100

Table 2. Distribution of snail species by site of collection.

Sampling site	Snail species			Site total	Prevalence (%)
	Bulinus globosus	*Melanoides tuberculata*	*Gabiella tchadiensis*		
A	85	108	66	259	32.1
B	96	152	112	360	44.6
C	21	47	121	189	23.4
Total	202	307	299	808	100

χ^2= 82.406; df =4; *P*<0.0001.

collection (A, B, and C). However, the average number of snails collected monthly was calculated by dividing the total number of snails collected at all the three sites (A, B, and C) by the number of collections made. General data was then recorded and the collected samples were later transported to the laboratory and kept cool, out of direct sunlight before identification.

Sample identification

The snail samples were identified using their morphological characteristics by the help of some experts in Zoological Museum of Department of Biological Sciences, Ahmadu Bello University, Zaria, Kaduna State, Nigeria, with reference to the standard keys of Brown and Kristensen (Brown and Kristensen, 1992, 1993).

Statistical analysis

The general data obtained were statistically analyzed using the SPSS statistical software package (Version 16.0). Monthly distribution and site distribution of the snails were analyzed using one-way analysis of variance (ANOVA) and Chi square test (χ^2), respectively. *P*-value of <0.05 was considered to be significant.

RESULTS

A total of 808 freshwater snails were collected from all the three sampling sites in 9 consecutive months. The monthly collections presented slight to high variation in the distribution and abundance of the snail species. However, there was no significant difference between the number of snails sampled and the sampling months (*P*= 0.7178; Appendix 1).

Table 1 shows the monthly distribution of snail species collected and identified in the study area. The highest number of snails (186) was gotten in the month of April, with October presenting the least number of snails (17). However, no snail was available for sampling in the month of November. The distribution and prevalence of the snail species in relation to site of collection is shown in Table 2. The highest number of snails (360) was collected at Site B, followed by Site A (259) and the least number (189) of snails was collected at Site C. There was significant difference between the snail species sampled and the sampling sites (χ^2= 82.406; *P*<0.05; Appendix 1).

Three different species of snails were identified in the area: *Bulinus globosus* (intermediate host of *S. haematobium*), *Melanoides tuberculata,* and *Gabiella tchadiensis* (Figures 3, 4 and 5). The overall snail counts for the whole nine months of sampling showed that *M. tuberculata* was the most abundant snail species in the area, followed by *G. tchadiensis* and then *B. globosus* being relatively less abundant. Table 2 also shows the number of different species identified by site of collection. *M. tuberculata* had the highest number in Sites A and B,

Figure 3. *Bulinus globosus* identified

Figure 4. *Melanoides tuberculata* identified.

while *G. tchadiensis* emerged as the most abundant in Site C.

DISCUSSION

The results of this research showed that aquatic snails are present in the study area. Even though statistical analysis showed no significant difference in terms of monthly snail distribution, it was observed from the raw data that variation existed in the number of snails sampled monthly. This means that irrespective of the sampling month, variation in number of snails may exist. Izah and Angaye (2016) had earlier reported in a review paper, that environmental parameters have influence on the density and population dynamics of freshwater snails. The resulting variations in the number of snails collected monthly might therefore, be due to changes in climatic and other environmental factors. It was also observed from this study that seasonal change and fluctuation of rainfall have affected the number of snail species in the area. Most snail species cannot survive without water and too much water reduces snail population (Simoonga et al., 2009).

More snail species were collected between the months of March and June, when there was less abundant rainfall on average in the study area. Ngele et al. (2012) also made similar observations in their study carried out in Abia State, Nigeria, which showed the highest number of snails collected at the beginning of wet season when there was no heavy rainfall. This may be attributed to the fact that such period marks the beginning of rainy season

Figure 5. *Gabiella tchadiensis* identified

when snails are capable of repopulating their natural habitat with onset of rain after a period of water shortage (Kristensen et al., 2001; Ejehu et al., 2017). This tend to increase the moisture to a certain level and provide an ambient temperature conducive for the snails to thrive as well as promote water plants growth on which the snails feed and oviposit during period of reproduction.

A decrease in population of the snails was observed between the months of July and October. A similar observation was made by Taofiq et al. (2017). Other findings elsewhere showed that snail population and their infection rate are relatively reduced at the peak of rainy season (Idris and Ajanusi, 2002). This may be due to hazardous effect of heavy rainfall (that is the peak of rainy season; starting in the month of July) on the survival of the snails that tends to wash them away leading to their mortality. The overall snail population began to decline with emergence of heavy rainfall by the end of July and early August, which may have washed away the snails into the deep water, leading to their destruction. The lower population of snails collected in the month of October also suggests that heavy rainfall had negative effect on the survival of the snails (Taofiq et al., 2017). The reduction in snail populations at the end of rainy season also agrees with the report of Ejehu et al. (2017) which linked it to flushing away of snails from their habitat by increased water flow. The Word Health Organization deducted that strong water current tends to dislodge and wash away the snails (WHO, 2005).

No snail species were sampled during the month of November. A similar result was currently reported in South-Eastern region of Nigeria by Ejehu et al. (2017). This may be due to subsequent drying out of most parts of the dam, especially the water edges where the snails reside in moist surroundings near vegetation. This can lead to the death of many snail species, notwithstanding their ability to resist drought (Barbosa and Barbosa, 1994), and can also be supported with the explanation made by Brown (1994) who pointed out that lack of moisture and drying up of habitat has a negative effect on snail population. On a different perception, Taofiq et al. (2017) showed that the snails might have aestivated due to water shortage, pending the return of rainfall. Some of the snail might survive before the onset of the next rainy season and remained in aestivation, as they depend on some crucial factors for their survival (Badger and Oyerinde, 2003). The rapid increase in the number of snails between the months of March and April may also be due to onset of wet season, the moment at which the snails can rapidly repopulate their natural habitat within a short period.

Site B significantly produced the highest population density of snail species, relative to other sampling sites. Several authors have shown the impact of environmental factors on snail population (Jan, 1997; Salawu and Odaibo, 2013). Van Schayck (1985) showed that snails might prefer a habitat with aquatic vegetation, which will provide them with available food and shelter. The present findings may be explained by the fact that site B harbour many snail species because of some conditions favoring their survival, growth and development. For instance, there are increased farming activities at the site, which may have provided enough vegetation to serve as shelter, feeding substrate and ovipositional niche for the snails. The plants there may have also provided protection to the snails against predator or natural enemy.

Out of the three snail species identified, only one species, *B. globosus* is known from the literature to be the intermediate host of *Schistosoma* parasite (that is *S. haematobium*). This species was confirmed in some parts of Nigeria as an important vector of *Schistosoma* spp. (Owojori et al., 2006; Ekwunife et al., 2008). Thus, there is high possibility and tendency for transmission of urinary schistosomiasis around the area, as the specific vector for such disease is present.

Abdulhamid et al. (2018) recently confirmed the prevalence of *S. haematobium* in the same study area. The *Bulinus* snails were found in shallow waters around the edges of the dam where some water plants including water lilies (Nymphaeaceae) are situated. Some authors in other places (Malann et al., 2017) previously made similar observations. Unlike in other identified species that were relatively less abundant in the month of July, *B. globosus* had its peak abundance in that same month. This is in agreement with the report of Okafor (1990), which showed that the month of July marks the time when *B. globosus* is highly abundant.

M. tuberculata appeared to be the most abundant snail species in the study area. This might possibly be due to certain conditions that are more favourable to such species. Salawu and Odaibo (2013) reported that snails vary in their adaptive capability to adjust to the biotic and abiotic factors determining their population and distribution in a specified area. Malann et al. (2017) also reported that distribution and abundance of snails varies depending on the effect of their interacting physicochemical parameters. *Biomphalaria* species (*S. mansoni* intermediate host) were not found in the area. Their absence may be attributed to the fact that *Biomphalaria* snails do not maintain stable populations due to fluctuations occurring non-seasonally because of human activities such as diversion of watercourses, land filling, and pollution, which can have negative effect on the snail population (Barbosa and Barbosa, 1994). The species possibly may not be present in the area generally.

Cognition on snail host abundance is an important approach for snail control as one of the crucial measures considered for the control of schistosomiasis. Kamel (1984) recommended that measures taken in control of snail should coincide with the time of greater abundance and when conditions are optimal for survival.

Conclusion

Kwanar Are Dam provides habitats for freshwater snails including the intermediate host of *S. haematobium* (*B. globosus*). The snails are abundant between the months of April to June. However, there should be regular use of recommended control methods such as bioremediation to reduce or totally eradicate the specific-snail intermediate hosts. This may provide a clue of discovering an organism or its source, previously not known, that will aid in the control of such snail species. Future research on freshwater snail intermediate host in the same area should focus on search for *Biomphalaria* snails, which are yet to be found in the area. Application of molluscicides against *B. globosus* found in the relevant study area should be timed to begin in mid-rainy season (that is between June and August) in order to target the month of July, when such species is highly abundant. Emphasis should be given to molecular studies on different snail intermediate host strains, especially in endemic areas with continuous re-infection of schistosomiasis in order to confirm the exact strain of the snail intermediate host present in a particular study area, for feasible control.

LIMITATIONS OF THE STUDY

This study had some limitations. Cercarial determination, which would have investigated the infectivity of the identified snail intermediate hosts, was not carried out. Secondly, the study also failed to relate the snail species population dynamics with factors other than rainfall. Lastly, sites near water bodies other than the dam within the study area were not surveyed for the presence of the snail intermediate hosts, which might have increase the chances and accuracy of revealing other species not found in the area been surveyed.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix 1. Statistical analyses results.

	Group A	Group B	Group C
Col. title	Bg	Mt	Gt
Mean	22.4444444444	34.1111111111	32.6666666667
Standard deviation (SD)	24.414	37.741	35.043
Sample size (N)	9	9	9
Std. error of mean(SEM)	8.138	12.580	11.681
Lower 95% conf. limit	3.678	5.101	5.730
Upper 95% conf. limit	41.210	63.121	59.603
Minimum	0.000	0.000	0.000
Median (50th percentile)	17.000	16.000	21.000
Maximum	73.000	109.00	89.000
Normality test KS	0.1576	0.2399	0.1860
Normality test P value	>0.10	>0.10	>0.10
Passed normality test?	Yes	Yes	Yes

Appendix 1. Statistical analyses results.

One-way Analysis of Variance (ANOVA)

The P value is 0.7178, considered not significant.
Variation among column means is not significantly greater than expected by chance.

Post tests

Post tests were not calculated because the P value was greater than 0.05.

Assumption test: Are the standard deviations of the groups equal?

ANOVA assumes that the data are sampled from populations with identical SDs. This assumption is tested using the method of Bartlett.

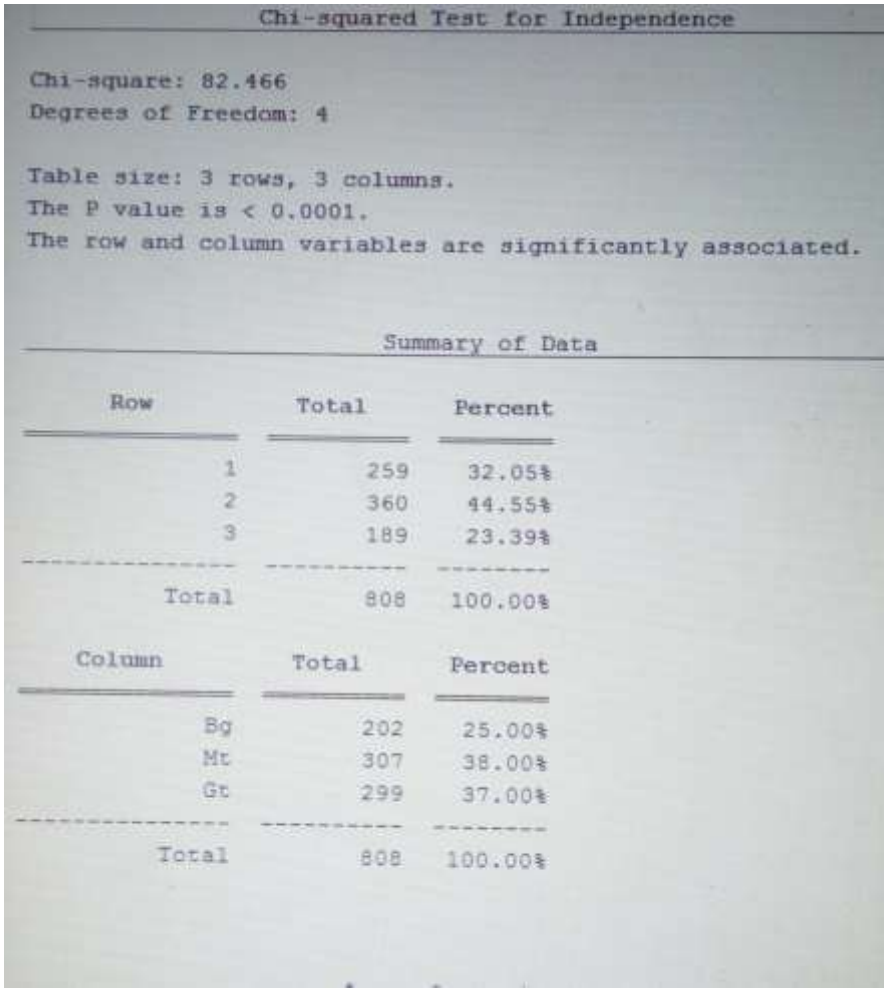
Bartlett statistic (corrected) = 1.493
The P value is 0.4740.
Bartlett's test suggests that the differences among the SDs is not significant.

Assumption test: Are the data sampled from Gaussian distributions?

ANOVA assumes that the data are sampled from populations that follow Gaussian distributions. This assumption is tested using the method Kolmogorov and Smirnov:

Group	KS	P Value	Passed normality test?
Bg	0.1576	>0.10	Yes
Mt	0.2399	>0.10	Yes

Appendix 1. Statistical analyses results.



Chi-squared Test for Independence

Chi-square: 82.466
Degrees of Freedom: 4

Table size: 3 rows, 3 columns.
The P value is < 0.0001.
The row and column variables are significantly associated.

Summary of Data

Row	Total	Percent
1	259	32.05%
2	360	44.55%
3	189	23.39%
Total	808	100.00%

Column	Total	Percent
Bg	202	25.00%
Mt	307	38.00%
Gt	299	37.00%
Total	808	100.00%