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Incidence of the Mango Mealybug *Rastrococcus invadens* Williams on Different Mango Varieties in two Local Government Areas in Benue State, Nigeria

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ABSTRACT

Survey of five human settlements in Gboko and Buruku Local Government Areas, Benue State, showed the presence of eight mango varieties; Local, Julie, Gesha, John, Dabsha, Pittir, Germer and Hindi. Ten leaves per stand of each mango variety were sampled every month for 24 months. Numbers of different stages of mango mealybug, *Rastrococcus invadens* Williams and mummies were monitored. *R. invadens* field population per cm^2 leaf area varied significantly among eight varieties of mango. While Gesha, Julie and Local varieties favoured significant field population growth of *R. invadens* John, Dabsha and Germer contributed significantly less. Population of *R. invadens* on Gesha, Julie and Local followed the same trends and peaked in May, 2000. Population of the mealybug declined sharply along with its parasitoid *Gyranusoidea tebygi* Noyes on each variety during October, 2000 due to combined forces of wind and rainfall. Contribution to changes in *R. invadens* population by both biotic and abiotic factors were significantly higher ($P<0.05$) on Gesha ($r^2 = 60.8\%$) and Pittir ($r^2 = 59.7\%$). G.*tebygi*, though low in number, is well established on its host *R.invadens* in the zone of study. Mango varieties had significant ($P<0.05$) influence on the sex ratio of the mealybug with the male population higher than the female in each variety.

Key Words: *Rastrococcus invadens*; Mango varieties; Natural factors; Guinea Savanna; Nigeria

Introduction

Mango (*Mangifera indica* L., Anacardiaceae)**,** now naturalized in West African sub-region (Irivine, 1969; Hill, 1975), is a valuable ornamental and shade tree, which also contributes to the protection of soil against erosion. It constitutes an important source of energy and nutrients including vitamins A, C and D, amino acids, carbohydrates, fatty acids, minerals,

organic acids and protein (Bokonon-Ganta, 2002). Its different medicinal values have been reported (D' Almeida, 1995). Until recent time, damage caused to mango by insect pests and diseases was not significant. However, since 1980s, a dreadful mealybug pest described as *Rastrococcus invadens* Williams (Homoptera: Pseudococcidae) was reported on mango and citrus in West Africa (Agounke *et al*., 1988). It originated from South-east Asia (Mahmood *et al*., 1980) and was later observed on the African continent in 1981-82 in Ghana and Republic of Togo (Agounke *et al.*, 1988; Boavida *et al.*, 1992) from where it spread to other African countries including Republic of Benin, Congo, Cote D' Ivoire, Gabon, Sierra Leone, and Nigeria (Matokot *et al.*, 1992; Neuenschwander *et al.*, 1994). It spread into the country early 1988 through Nigeria/Republic of Benin border (Akinlosotu *et al*., 1992). Since then, the mealybug has been encountered at both eastern and northern parts of Nigeria (Ivbijaro *et al*., 1992) by movement of contaminated planting materials and by wind as dispersal agent (Agricola *et al*., 1989; IITA, 1992). *R. invadens* is a polyphagous pest found to attack different fruit trees, ornamental as well as shade trees in Republic of Togo (Agounke *et al*., 1988), Republic of Benin (Neuenschwander, 1989), Nigeria (Ivbijaro *et al*., 1992) and Gabon (Boussienguet and Mouloungou, 1993). Over 80% yield losses of mango due to the mealybug attack were reported in Ghana (Moore *et al*., 1989). The mealybug competes with its host plants for the products of photosynthesis when they pierce the epidermal layer to suck the chloroplasts, soluble foods and vitamins from the leaves (Edmond *et al*., 1988). Differences in infestation levels of *R. invadens* have been reported between adjacent mango trees in the Republic of Benin, Togo and Congo (Matokot *et al*., 1992; Boussienguet and Mouloungou, 1993; Bokonon-Ganta and Neuenschwander, 1995). Several local, exotic and improved varieties of mango trees are found in the Guinea Savanna of Nigeria. Casual field observation revealed that some varieties are more susceptible to *R. invadens* compared to others (Ukwela, pers.com). Such observation, when scientifically investigated could be of great value in developing a pest management programme against the mealybug. Although Odebiyi *et al*. (1989) and Okege (1995) reported on the activity of the exotic parasitoid *Gyranusoidea tebygi* Noyes of the mealybug in South-Western Nigeria, further information is required on its attack on the pest among the mango varieties and in other parts of the country. The knowledge of the relative abundance of *R. invadens* and their natural enemies on different mango varieties as well as the influence of weather factors on the population regulation of the mealybug is inadequate in Nigeria. In this study therefore, attempt will be made to assess the incidence of *R. invadens*, the influence of parasitoid and weather factors on its population

among the different varieties of mango in two neighbouring Local Government Areas of Benue State.

Materials and Methods

Incidence of *R. invadens* among the mango varieties

Survey, identification of mango varieties and incidence of *R. invadens*

A survey of two neighbouring Local Government Areas, Gboko and Buruku, was carried out in Benue State during the first week of November, 1999 and five (5) settlements with records of several mango varieties and mealybug infestation were selected across the zone. The choice of the two Local Government Areas for the study was based on the incidence of the mealybug. Eight different varieties of mango comprising Local (naturalized variety), Julie, Hindi, John, Pittir, Germer, Gesha and Dabsha were found in the zone and identified with the help of a plant breeder in the Benue State Agricultural and Rural Development Authority (BNARDA).The different varieties were identified by considering their morphological characters with particular reference to their leaf features. All the mango varieties found were observed to have been naturally infested at different levels by *R. invadens*.

The approximate age in years of individual tree for every variety utilized was determined through oral interview held with the owners.

Field Sampling

Monitoring of *R. invadens*, parasitoid and hyperparasitoids

Those mango varieties, especially Dabsha, Germer, John and Gesha with minimum of three to four stands found only in one or two of the settlements were all numbered and utilized for the population count of *R. invadens*. Others, including Julie, Pittir, Hindi and Local varieties each with several individual stands in each settlement were numbered and one (1) stand per variety was selected randomly per settlement such that five (5) stands of each were utilized for sampling *R. invadens* population across the zone. Population counts of *R. invadens* was carried out between the last week of January, 2000 and last week of December, 2001 (24 months). In every month and on each stand, ten leaves were picked from the shoot canopy that was previously marked into 5-quadrats at an arm-reach height (2.0-2.5m) such that two (2) leaves were sampled randomly per quadrat. Each leaf sample was carried in a 35 × 30 cm envelope to the laboratory for analysis.

Different stages of *R. invadens* (first, second and third instar larvae, pupae and adults) and their mummies (parasitized, dead and hardened) *R. invadens* collected from the leaves were identified and counted separately under the stereobinocular dissecting microscope with x 5 objective lens. The mummified mealybugs were collected from the leaf sample with the aid of a camel hair brush and transferred into Petri-dishes. Each mummy was then preserved and observed on a daily basis till every parasitoid or hyperparasitoid were recorded and transferred into different vials.

Each mummy from which no parasitoid or hyperparasitoid emerged was observed for three weeks and then preserved in 70% ethanol for 2-3 days before dissection to detect the presence of any dead larva or pupa of parasitoid or hyperparasitoids.
Some hyperparasitoid that could not be identified locally were sent out and identified at the insect museum of the IITA Plant Health Management Division, Cotonou.

Meteorological data

Monthly rainfall, relative humidity, temperature and wind speed readings of January, 2000 to December, 2001 were obtained from the Meteorological Weather Station located at the common border of the two Local Government Areas (Gboko and Buruku) (Table 1).

Data collection

In order to explain the variation in the mealybug population among the different varieties of mango and for the purpose of comparison, twenty (20) different flushes were picked at random from different sides of shoot canopy of each variety and the average number of leaves per flush length was determined in the main flushing period of October, 2000 to February, 2001. Also, twenty (20) leaves were picked at random from each variety and leaf area (in cm^2) was determined by measuring the size of individual leaf by using graph sheet and counting the number of unit squares in the traced portion. Mean leaf area was obtained by dividing the total leaf area by the number of leaves recorded. The leaf areas for each candidate variety were determined thereafter. The population densities of the various life stages of *R. invadens* and that of mummies from which the parasitoid or hyperparasitoid emerged were determined for each month and for the whole period. The number of *R. invadens* per square centimeter of leaf was calculated for each mango variety. Field collected adult mango mealybug was sorted into males and females and the sex ratio was determined for every variety.

Table 1: Records of monthly weather conditions obtained at Akperan Orshi College of Agriculture Meteorological Weather Station, Yandev-Gboko between January, 2000 and December, 2001.

Month / year		Weather factors (or variables)			
		R/fall (mm)	R.H (%)	Temp (^{0}c)	Wind speed (km/hr)
Jan.	2000	0.0	77.4	26.5	121.2
Jan.	2001	0.0	81.4	26.7	123.1
Feb.	2000	0.0	75.0	29.5	170.2
Feb.	2001	12.3	77.7	29.9	155.7
Mar.	2000	0.0	74.8	29.9	162.5
Mar.	2001	0.0	79.6	30.2	185.4
Apr.	2000	162.1	73.5	29.6	174.5
Apr.	2001	57.4	80.0	29.3	175.5
May	2000	197.2	75.2	28.0	121.7
May	2001	37.5	78.4	28.2	123.7
Jun.	2000	260.4	71.9	27.0	97.8
Jun.	2001	152.0	81.0	27.3	114.0
Jul.	2000	155.6	75.0	26.0	97.9
Jul.	2001	55.4	76.6	25.9	101.0
Aug.	2000	120.7	74.3	26.5	77.0
Aug.	2001	123.9	84.3	26.8	80.0
Sept.	2000	90.0	78.8	26.6	20.9
Sept.	2001	420.6	67.8	26.4	25.0
Oct.	2000	160.3	78.4	27.3	65.6
Oct.	2001	85.8	77.2	27.0	70.0
Nov.	2000	0.0	79.9	28.8	86.8
Nov.	2001	0.0	77.5	28.0	92.1
Dec.	2000	0.0	80.0	28.1	111.9
Dec.	2001	0.0	80.5	28.3	102.6

Statistical analysis

The sex ratios of the male and female mealybug obtained on individual mango variety were compared by Chi-square (X^2) test at 5% level.

Mealybug population density was correlated with each of the leaf parameters and abiotic variables; rainfall, relative humidity, temperature and wind speed. Also, mealybug population density was regressed on both biotic (parasitoid and hyperparasitoids) and abiotic variables.

Results

Incidence of mango varieties on *R. invadens*

Table 2 shows population densities of *R. invadens* on eight different mango varieties. Number of *R. invadens* per cm^2 of leaf was significantly different ($P<0.05$) among the varieties. Number of mealybug on Gesha variety was significantly higher ($P<0.05$) compared to those on other varieties. Leaf density (or average number of leaves per flush) and mean leaf area differed with mealybug infestation among the varieties. Gesha, Julie and Local each had an average of eight leaves per flush but they varied in *R. invadens* density (decreasing from 0.159-0.079/cm^2).

Similarly, Pittir, Dabsha and John had a common average number of leaves per flush (7) with decreasing magnitude of *R. invadens* population density (0.037- 0.002/cm^2). Generally, mean leaf area increased with decrease in average number of leaves, and population density of *R. invadens* increased with increase in average number of leaves per flush. *R. invadens* population per cm^2 of leaf was lowest on John with the largest mean leaf area (183.7 cm^2), and highest on Gesha with the second to smallest average leaf area (79.9cm^2).

Most of the mealybugs observed on the mango varieties were male (74.7%). The proportion of male to female population was similar on Local (3:1), Germer (3:1), Julie (3.4:1) and Gesha (2.5:1) varieties (Table 3). Sex ratios of the mealybug recorded on Hindi (2.2:1) and Dabsha (2.1:1) were also similar. Chi-square analysis showed that the mango varieties had a significant ($\chi^2 = 46.13$; df = 6, $P<0.05$) influence on the sex ratio of *R. invadens*. The proportion of the male in the field population of the mealybug was significantly higher on John variety.

R . invadens population followed a similar trend on Gesha, Julie and Local varieties between March 2000 and July 2001(Figure 1). The mealybug population showed a uni-modal peak in 2000 and bi-modal peaks in 2001 on Gesha variety. There was a sharp decline in mealybug population on the different varieties from the month of June to October 2000. Its

population was consistently higher on Gesha variety with the exception of the period between August and December 2000 when its number was highest on Julie variety.

Respective average age in years (21, 22,24,28,28,28,34 and 45) of individual trees for every candidate variety (Dabsha, Germer, Hindi, Julie, Gesha, Local, Pittir and John) utilized in this study was different among the mango varieties. Stands of different mango varieties found across the zone of study belong to different owners and age groups. *R. invadens* was quite scanty on John variety, which appeared much older in age than others. Its population was also very low on Dabsha.

Influence of some natural factors on R. invadens

In order to understand the conditions leading to high or low mealybug infestation, multiple regression analysis involving six variables (*G. tebygi*, hyperparasitoids, rainfall, relative humidity, temperature and wind) were performed (Table 4). The joint influence of the independent factors on *R. invadens* population differed from one mango variety to another. Contribution to variation in *R. invadens* population on Gesha (r^2 = 60.8%) and Pittir (r^2 =59.7%) by these variables were statistically significant ($P<0.05$). Generally, contribution to variation in the mealybug population density by the variables was lowest on Hindi (32.1%) and highest on Gesha (60.8%). Five of the independent factors (with wind removed) and four (with wind and temperature removed) accounted for 59.1% ($P<0.05$) and 51.7% ($P<0.05$) of the variation on Pittir variety, respectively. *G.tebygi*, hyperparasitoids and rainfall accounted for 49.1% ($P<0.05$) of the variation on Pittir variety.

There were both positive and negative relationships between the mealybug population and various independent factors in this study. In their joint contribution to mealybug populations on mango varieties, temperature, relative humidity and rainfall showed negative relationship. Wind and *G. tebygi* contributed positively to fluctuations in *R. invadens* population on the six mango varieties (Table 4). Among the varieties, wind showed a highly significant (t_b = 3.791, 2.382; df = 21) influence on *R. invadens* population on Gesha and Hindi varieties.

Discussion

The present study has established the extent of spread and seasonal distribution of *R. invadens* on eight different varieties of mango among the five human settlements across the

zone. The result of field sampling showed that each mango variety supports the population growth of *R. invadens* at varying degrees, and with John variety showing the least and insignificant support. Although the reason for extremely low incidence of *R. invadens* on John even in the vicinity of other infested varieties at Usuh settlement is not quite clear, average age for individual tree considered for the field sampling showed that John variety was much older compared to other varieties. Leaf water (% fresh weight) and nitrogen (% dry weight) of terrestrial trees are known to decline with age (Scriber and Slansky, 1981) although the much younger varieties (Dabsha and Germer) observed in this study had relatively lower incidence of *R. invadens* compared to others.

In this study, *R. invadens* population density increased with increase in number of leaves per flush and decreased with increase in leaf area (or leaf size) among the mango varieties. Hence, Gesha variety with more closely set leaves and relatively smaller leaf area (or leaf size) compared to other varieties has the highest mealybug population density. In a similar study, Tingle and Copland (1988), on the basis of leaf area, recorded differential level of infestation of *Plannococcus citri* on two different host plants, being more on *Cristolochia passiflora* plants, and lower on Vesnerriaceae plants. Leaf size is probably an important variable that could influence *R. invadens* population since leaves from other varieties have smaller leaf areas and much greater mealybug population density to indicate a negative correlation. John variety with the largest leaf area had the lowest number of *R. invadens* per cm^2 of leaf compared to numbers recorded for other varieties with smaller leaf areas. Determination of *R. invadens* population density in terms of number of mealybug per cm^2 of leaf instead of per leaf is to give sound basis for ease of comparison of the population levels of this pest among the different host varieties.

Within the two-year study period, the mealybug attained its population peak about the month of May, which is usually the beginning of rains and declined sharply towards the month of October. This might be due to combined forces of wind and rainfall characteristics of this zone, among other environmental factors. A similar windy rain condition (stormy weather) could have accounted for similar sharp decline in the mealybug population from its bi-modal peaks observed on Gesha variety in the second year. Such drastic reduction in *R. invadens* population on each variety due to the washing-off of the pest from the leaves by the windy rain conditions could for a long period limit a reasonable increase in natural population of the

pest in a situation where environmental conditions are highly favourable for its growth as was observed on Gesha variety.

G. tebygi was recorded from all mango varieties having the presence of *R. invadens* and at the five settlements situated across the zone of study, and even during the windy rain conditions in the months of May to October when *R. invadens* population declined sharply. This suggests that *G. tebygi* is well established on its host mealybug in this area of infestation which lies in the Southern Guinea ecology. Although the parasitism of *R. invadens* reported in this study is quite low, this observation agrees with the report of the earlier authors which shows that the parasitoid could be established in different ecological conditions (Agricola *et al.*, 1989; Boavida *et al.*, 1992; Pitan *et al.*, 2000). Low parasitism of *R. invadens* observed in this study can be explained from the fact that the parasitization determined in this work has to do with only mortality due to development of the immature stages of the parasitoid in the host mealybug.

In conclusion, this study has shown that mango varieties had significant influence on the changes in *R. invadens* population. Combined contributions to variations (or changes) in *R. invadens* population by some environmental factors were significantly higher on some varieties (Gesha and Pittir) than on the others. Those varieties with more closely set leaves (Gesha, Julie and Local) and relatively small size leaves favoured *R. invadens* population increase than on others (Germer, Hindi and Pittir) with lower population density. Such varieties with low incidence of *R. invadens* may be more useful for plantation agriculture as the varieties with higher incidence could serve as reservoir to this mealybug pest.

Table 2: Mean population density of *R. invadens* obtained for the period of 24 months on eight different mango varieties.

Mango varieties	Leaf parameters		*R. invadens* per cm^2 of leaf	
	Mean leaf area	Mean leaf number per flush	Mean mealybug number	Highest mealybug number
Local	110.1	8.0	0.0790c	0.47
Julie	76.2	8.0	0.1136b	0.84
Pittir	136.5	7.0	0.037d	0.22
Hindi	145.2	6.2	0.031de	0.29
John	183.7	7.0	0.002e	0.04
Dabsha	92.9	7.1	0.014de	0.25
Gesha	79.9	8.3	0.159a	1.55
Germer	106.2	5.3	0.029de	0.25

Means in each column followed by the same letter are not significantly different at 5% level (DNMRT)

Table 3: Ratio of total field population and Chi-square analysis of adult male and female *R. invadens* obtained on eight mango varieties during field sampling

Mango varieties	Total No of Adults	No. of males	No of females	Ratio (male : female)
Local	985	740	245	3:1
Julie	1184	918	266	3.4:1
Pittir	705	565	140	4:1
Hindi	462	316	146	2.2:1
Gesha	1479	1055	424	2.5:1
Dabsha	127	86	41	2.2:1
Gerrner	357	270	87	3.1:1
John	53	48	5	9.6:1
Overall	5352	3998	1354	3:1

$\chi^2 = 46.13;$ 6, $P < 0.05$

Table 4: Regression Statistics of six variables (*G. tebygi*, hyperparasitoids, rainfall, relative humidity, temperature and wind) that jointly influenced the mango mealybug populations on six mango varieties.

Mango varieties	Regression Statistics								
	t_b values						R^2	R	Fcal
	G. tebygi	Hyperparasitoid.	Rainfall	Relative Humidity	Temperature	Wind			
Hindi	**1.029**	**0.185**	**1.162**	**0.589**	**0.686**	**2.382***	**0.321**	**0.567**	**1.342**
Gesha	**1.099**	**0.443**	**2.055**	**1.444**	**-0.227**	**3.791***	**0.608***	**0.780**	**4.389***
Julie	**2.491***	**1.672**	**-0.274**	**0.048**	**-1.090**	**1.740**	**0.433**	**0.658**	**2.168**
Local	**1.272**	**0.022**	**1.0371**	**1.187**	**-0.357**	**1.954**	**0.433**	**0.638**	**2.168**
Pittir	**1.225**	**0.832**	**0.069**	**-0.821**	**-1.666**	**0.487**	**0.597***	**0.773**	**4.195***
Germer	**1.073**	**1.068**	**1.156**	**0.496**	**0.163**	**0.283**	**0.330**	**0.574**	**1.395**

*** Significant at P = 0.05**

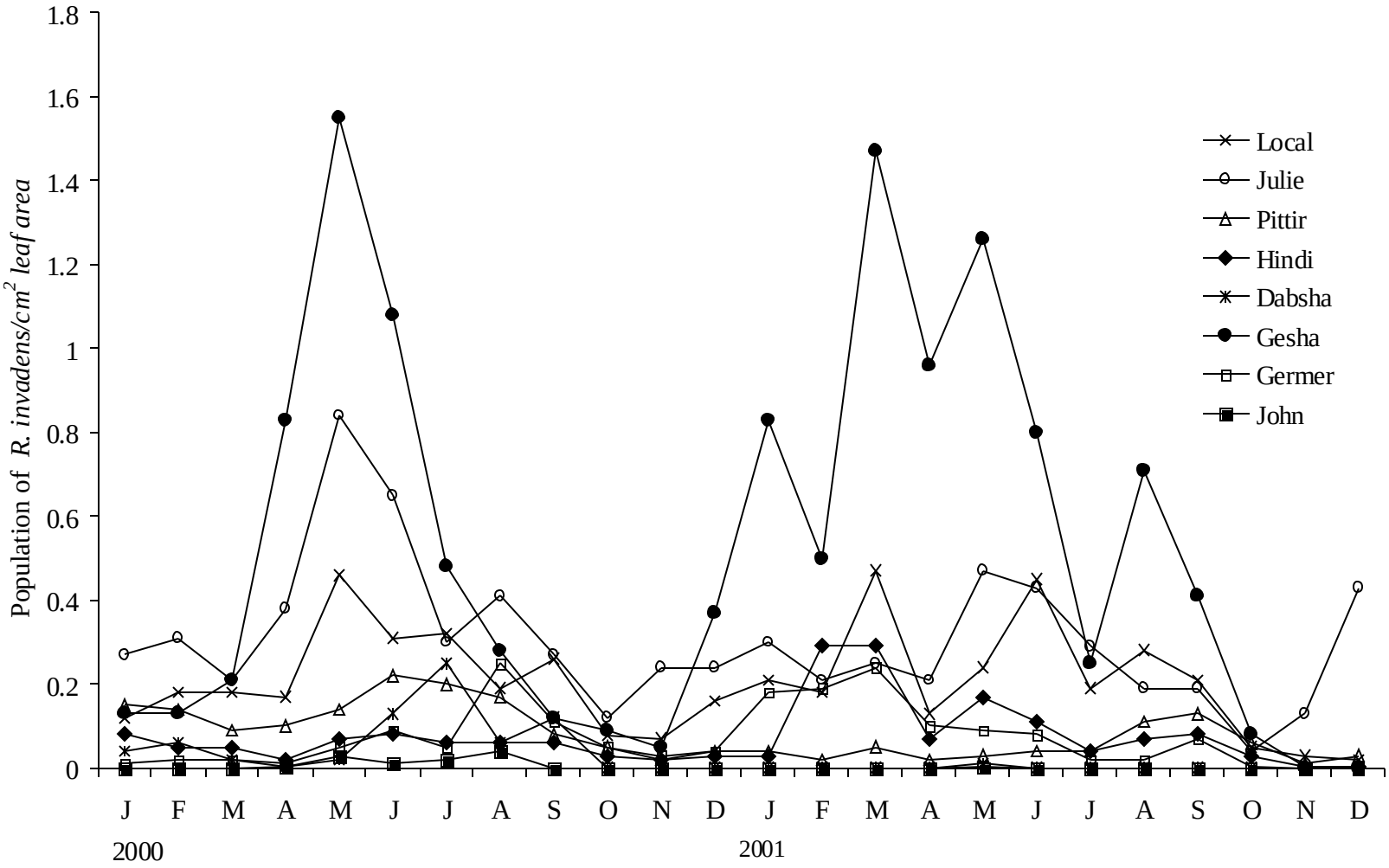

Figure 1: The mean monthly population of *R. invadens* obtained on different mango varieties in the mealybug infested areas of Benue State

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