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RATING LEVELS INFESTATIONS *SITOPHILUS SPP* (COLEOPTERA : CURCULIONIDAE) FROM MILLET ONE HAND AND ON THE OTHER HAND CORN, ON THE DIFFERENTS FORMULATIONS OF CORN.

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ABSTRACT : In Senegal, among the cereal crops, corn (*Zea mays* L.) is the second major cereal. Indeed, it is well established that conservation of crops ensures the availability of food resources is one of the key factors of food security in a country. But these foodstuffs are commonly attacked by some beetles (*Sitophilus oryzae*, *Sitophilus zeamais*) during storage causing considerable qualitative and quantitative losses. Order to know the impact of the change in the oviposition substrate on *Sitophilus spp* development capacity, controlled infestations *Sitophilus zeamais* (Coleoptera, Curculionidae) from corn one hand and *Sitophilus oryzae* (Coleoptera, Curculionidae) from millet secondly on the different formulations of corn (whole, husked, broken and flour) were made. These experiments were performed at a relative humidity range between 41-67% and temperatures ranging from 28.5 to 31 ° C. The development of *Sitophilus spp* has been followed after infestation controlled whole corn grains first and then husked, then broken and finally processed into flour. The development cycle was followed spawning until the appearance of adults for determining the various biodemographic parameters. The results showed that overall the nature of the substrate influences the development and future of the weight of *Sitophilus zeamais* and *Sitophilus oryzae*. Also these two insect are primary pests of corn, able to develop on whole corn, husked and broken corn except corn flour. But, it important to note that *Sitophilus oryzae* from millet is hardly develops on the whole corn. Thus, to contain the infestation of *Sitophilus zeamais* and *Sitophilus oryzae* in the corn, it is necessary to store it after processing into flour.
Key words : food security, *Sitophilus zeamais*, *Sitophilus oryzae*, biodemographic parameters, corn losses.

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INTRODUCTION

Storage of corn before consumption or transformation is often done under conditions that favor the proliferation of depredators who not only in destroy a large part but also render the grains unattacked few eatables [21]. Corn, usually kept in inadequate conditions, is attacked by insects, rodents and molds. The major cause losses in stocks is attributed to insects [11].Insect pests of corn stocks are numerous but some species of Coleoptera Curculionidae particularly *Sitophilus spp* attack the grains.If no protection is carried, after seven months of storage, the loss of foodstuffs may be total [19]. The genus *Sitophilus* enfeoffed only to cereals that generally infects in stocks. He is recognizable by the presence of a bulging rostre triangularly and with the antennas at its base. Of the three species of the genus *Sitophilus*, only two (*S. zeamais* and *S. oryzae*) are present in the tropical regions [25].

S. zeamais and *S. oryzae* are multiplying in dry seeds and cause a lot of damage to stocks. The female lays in the interior of grain, the development of Sitophilus larvae is an endogenous way until the emergence of the adult [4]. The larva, white and fleshy is apodal and measuring 2 to 4 mm. The duration of the four larval stages is approximately 20 days. This is followed by a nymph (6-7 days) and a stage pre adult (5-6 days) that remain in the grain [20]. Long considered a form of *S. oryzae* large size, *S. zeamais* is distinguished nevertheless. Some authors [15] have proposed criteria to ethological order to differentiate them. *Sitophilus oryzae* (2-5 mm) that flies good, is able to attack the stored grain from the field. He has a preference for small in size grains such as rice and millet. In contrast, *S. zeamais* (3-4 mm) flies very few and prefers large seeds like corn. Thus, in the interests to mitigate the losses due to gender *Sitophilus*, a solid knowledge on his answer to the impacts of environmental and biological factors is essential. Previous studies have shown that the larvae of *Sitophilus oryzae* would consume 10 mg grains during development while adults consume 0.49 mg per day [13; 8; 33]. Also, There is have been many studies on the biology and behavior of the species *Sitophilus*, mainly on *S. oryzae* and *S. granarius* that have been periodically reviewed by many authors [23 ; 26 ; 17]. The oviposition behavior varies depending on insect species, population density, environmental conditions, food, age and size of individuals [28]. Some studies of population dynamics was conducted by varying the number of corn kernels [24; 32; 4] or the number of weevils, or both [7 ; 32]. Other studies [9] have shown that the ambient temperature, relative humidity and type of food (whole grain and flour) have an effect on the duration of *S. zeamais* development cycle. Indeed, an understanding of the biology and behavior of the corn weevil compared with different formulations of corn, will help in the development of improved management practices for the control of this pest. However, few recent data in the literature describing the impact of changes in the substrate, on biodemographic characters (the number of adults, weight, sex ratio of descendants, duration of development, etc.) *S. zeamais* and *S. oryzae*. Thus, the objective of this study is to determine the biodemographic parameters of *S. zeamais* and *S. oryzae* in order to develop, of technical protective of corn stocks in the respect for the environment. This is to make controlled infestations of *Sitophilus zeamais* from corn and *Sitophilus oryzae* from millet, on Corn in its different formulations (whole, husked, broken and flour). Also make comparisons of these biodemographic parameters.

MATERIAL AND METHODS

Rearing and choice of couples

Strains of *S. oryzae* and *S. zeamais* used have been set farmed in insectarium of the Research Institute for Development (IRD). Several generations have been obtained from mass-rearing techniques.Mass-rearing has been made in glass jars full of grains of corn or millet were added wherein adults of *S. oryzae* for millet and *S. zeamais* on maize, ages and sexes undetermined.

After one or two weeks of infestation, the adults were removed from grain by sieving. Infected grains were allowed to incubate in the experiment room until the emergence of new adults. Adults obtained from these mass-rearing were placed in Petri dishes for two days at most to ensure that egg laying to begin. At *Sitophilus oryzae*, the male is distinguished from the female by thicker rostre, shorter and more deeply punctuated; also, the last abdominal sternites are more curved ventrally in males than in females [16]. For *Sitophilus zeamais* , male and female can be identified by their rostre is long and tapered in the female, short, thick and less smooth in males [27]. Thus after sexing the couples are placed in 9cm diameter Petri dishes and 1.5cm in height containing the cereal to infest.

Substrate preparation

The plant material used as the substrate in the experiments, is corn grains. Corn has been at first kept in freezer for 72 hours. After rebalancing at ambient laboratory temperature for 24 hours, the grains have been dried in the sunshine for 8 hours. With this corn four types of substrates are prepared: a whole grain substrate (unhulled), a base of husked grains, for one with broken grains and latest with flour weight respectively (10g) (Table 1).

Table 1: Morphologies and characteristics of different substrates of corn

Substrates	Morphologies	Characteristics
Whole corn		Unhusked, the bran and the germ are intact
Husked corn		Husked, bran, and part of the germ are removed
Broken corn		Unhusked, broken to 50%
Corn flour		Grain reduced to fine particle after grinding

All experiments were performed at a temperature of between 28.5 to 31 ° C and a relative humidity of 41-67%.

Development of *Sitophilus spp* on four substrates of corn

We dispose of 20 boxes numbered from 1 to 20 for each substrate of corn (whole, husked, broken and flour) and corresponding to 20 repetitions. 10 grams of each substrate were used by repetition in order to offer insectsa oviposition surface substantially identical. Each box was infested by a couple of *S. zeamais* from corn the one hand and a couple of *S. oryzae* from millet on the other hand ; aged from at least three days and 10 days at the most. Each couple has been used to infest one box. The couple pass 24 hours in each box before being removed. The boxes were then placed into the experimental room. At the end of development, the observation of emergences begins in the third week and performs daily basis. The total number of insects per box per day was counted and each individual is subsequently weighed less than 24 hours after its emergence.

At the end of these experiments, biodemographic parameters that follow are determined:

- **Cumulated Emergence** has been obtained by collecting the number of adult emergence per day ;
- **Duration of Development** : in Beetles, egg laying is spread out and lasts almost all life of the adult. The duration of development ranges from egg laying to adult emergence ;
- **The number of adults** : who represents the total number of emerged adults ;
- **The weight** : the average weight is calculated by dividing the sum of individual weights by the number of individuals ;
- **The sex ratio** who gives the percentage of females compared to the set of descendants. If the sex ratio is above 50%, the sex ratio is in favor of femalesin the opposite case it is in favor of males.

Statistical Analyses

The results expressed as tables or graphs were constructed by using the software Excel version 14.0.7140.5002 (32bits). Statistical analyzes were performed with the software XLSTAT version 6.1.9. The raw data were subjected to an analysis of variance (ANOVA) the averages (± ecartype) were compared using the multiple comparison Kruskal-Wallis test and the Student t test was used for the pairwise comparison of averages. The values of p inferior to 0.05 were considered significant.

RESULTS AND DISCUSSION

Biodemographic parameters of *S. zeamais* on four substrates

Cumulated Emergence

The analysis of figure 1 shows that the rate of emergence of adults of *Sitophilus zeamais* on the different brackets alimentary (whole corn, husked corn, broken corn and corn flour) is done discontinuous manner throughout the 15 days of observation. Indeed, the emergence of adults has taken place in the first seven days of observation for *Sitophilus zeamais* that have emerged in the whole corn. However, that occurrence of *Sitophilus zeamais* adults stopped at the thirteenth day in corn broken and fourteenth in husked corn. It must be noted that there is has been no adult emergence in corn flour even after 15 days of observation.

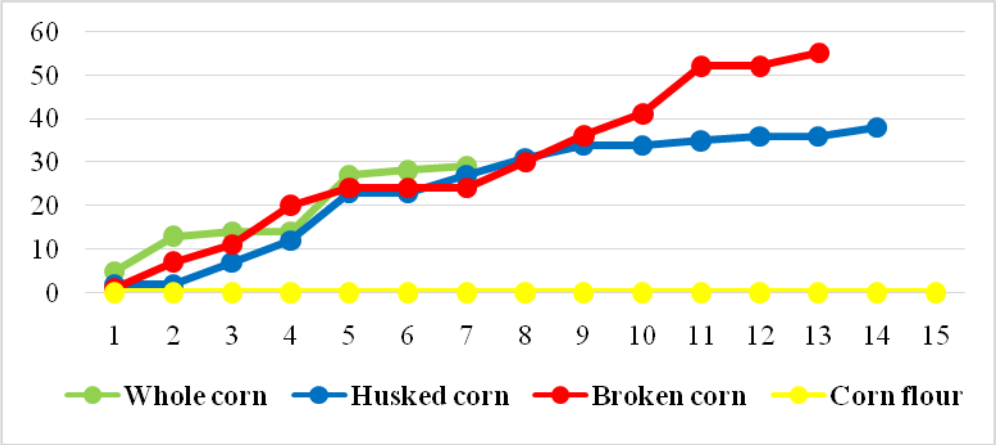

Figure 1: Cumulated emergences of adults *Sitophilus zeamais* on four corn states depending of the observation days

Average duration of development

The biodemographic parameters observed vary according to different substrates of corn (whole, husked, broken and flour). The average duration of development is 30,23 ± 2,29 days in the whole corn ; 26,07 ± 2,23 days in husked corn and 47,45 ± 5,52 days in the broken corn. Next There are currently has been no development of *S. zeamais* on corn flour. Same after five days of infestation, no developments was observed. Thus, the biodemographic parameters are not determined. These results are shown in Table 2.

Table 2: Average duration of Development *Sitophilus zeamais* on four substrates corn from 28.5 to 31 ° C and 41-67% R.H.

	Whole Corn	Husked Corn	Broken Corn	Flour Corn
Average duration of Development (days)	30,23 ± 2,29**a**	26,07 ± 2,23**a**	47,45 ± 5,52**a**	0

For each parameter averages followed by the same letter indicates that the values do not differ from each other at the risk threshold α = 0,05 (Student test).

The pairwise comparison of average duration of development by the Student t-test shows that the difference average durations of development is not significant risk threshold of alpha = 0,05 between populations of *S. zeamais* having completed their cycle in the whole corn and those that have evolved in husked corn (p = 0,17 > 0,05) ; also between the whole corn and broken corn (p = 0,60 > 0,05). These same results were found between husked corn and broken corn (p = 0,05 0,20>).In additionThe results of the analysis of variance with a confidence interval of 95% to the average development depending on the different substrates, reveal the absence of a significant difference between *S. zeamais* that developed in whole corn, husked and broken (F = 0,99 > 0.05). The data are represented in Table 3.

Table 3: Analysis of differences between groups with a confidence interval of 95%

Source of variations	Sum of squares	Degree of freedom	Average of squares	**F**	Critical value for F
Between Groups	619,5583333	2	309,779167	**0,9879274**	3,158842719
Inside the groups	17873,1875	57	313,564693		
Total	18492,74583	59			

Number of adults

The number of emerged adult is more important in the broken corn (55 adults). On husked corn, there have been 38 adults and the whole corn, 29 adults have emerged (Table 4). Alsoit should be remembered that there has been no development of *S. zeamais* on corn flour. Thus, even after 15 days of observation, no adult emergence were observed.

Table 4: Number of adults of Sitophilus zeamais on four substrates corn from 28.5 to 31 ° C and 41-67% R.H.

	Whole Corn	Husked Corn	Broken Corn	Corn Flour
Number of adults	29	38	55	0

Average weight of adult

The insects that emerge in each substrate are individually weighed 24 hours after discharge. Our results indicate that the average weight of 2,63 ± 0,29 mg in the whole corn ; 2,55 ± 0,36 mg in husked corn and 2,23 ± 0,19 mg in the broken corn. These results are shown in Table 5.

Table 5: Average weights of *Sitophilus zeamais* on four substrates corn from 28.5 to 31°C and 41-67% R.H.

	Whole Corn	Husked Corn	Broken Corn	Corn Flour
Average weight (mg)	2,63 ± 0,29 **a**	2,55 ± 0,36 **a**	2,23 ± 0,19**a**	0

For each parameter averages followed by the same letter indicates that the values do not differ from each other at the risk threshold α = 0,05 (Student test).

The pairwise comparison of average weights by the Student t test shows that the difference average weights is not significant risk threshold of alpha = 0,05 between populations of *S. zeamais* having completed their cycle in the whole corn and those that have evolved in husked corn (p = 0,57 > 0,05); also between the whole corn and broken corn (p = 0,06 > 0,05). These same results were found between husked corn and broken corn (p = 0,14 > 0,05).
In addition, the results of the analysis of variance average weights based on different substrates corn, with a 95% confidence interval, show that the difference in average weight was not significant between *S. zeamais* that developed in the whole corn, husked corn and broken corn (F = 2,12 > 0,05). The data are represented in Table 6.

Table 6: Analysis of differences between groups with a confidence interval of 95%

Source of variations	Sum of squares	Degree of freedom	Average of squares	F	Critical value for F
Between Groups	6,019	2	3,0095	**2,1187**	3,1588427193
Inside the groups	80,965	57	1,42043		
Total	86,984	59			

Sex-ratio

The sex ratio (percentage of female) is in favor of males of *S. zeamais* as well in the whole corn (34,48%) ; husked corn (34,12%) and broken corn (34,55%).

Table 7: Adults emergence and sex ratio (R) of *Sitophilus zeamais* on different food materials.

Substrates	Number of adults sexed	Number of males	Number of females	R (%)
Whole Corn	29	19	10	34,48%
Husked Corn	38	25	13	34,12%
Broken Corn	55	36	19	34,55%
Corn Flour	0	0	0	0%

Biodemographic parameters of *S. oryzae* on four substrates

Cumulated Emergence

The analysis of Figure 2 shows that the emergence of adults of *Sitophilus oryzae* was made in a variable manner on the different formulations of corn. Indeed this emergence of adults has taken place in the first ten days of observation for *S. oryzae* that have emerged in the broken corn. However this emergence of adults stopped at the eleventh day for *S. oryzae* that have emerged in husked corn and broken corn.
There has not been a adult emergence in corn flour same after 15 days of observation.

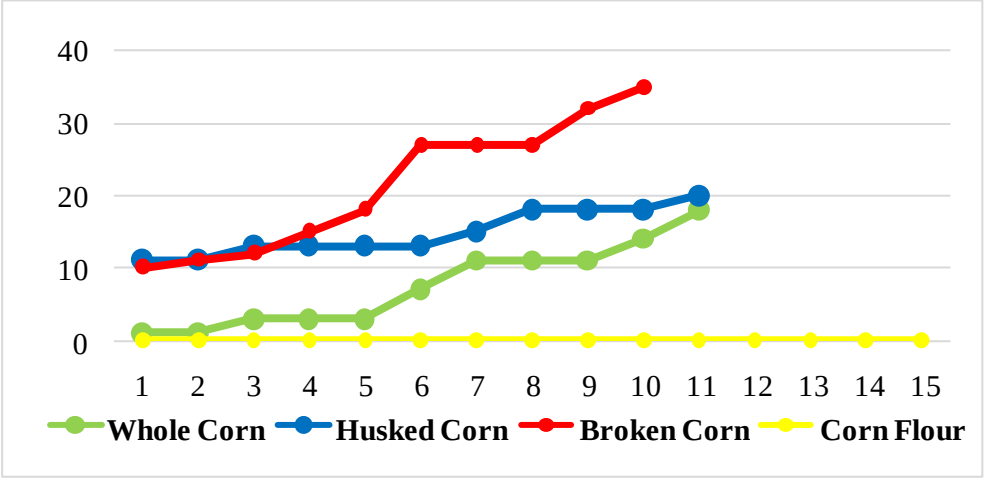

Figure 2: Cumulated emergences of adults *Sitophilus oryzae* on four corn states depending of the observation days

Average duration of development

Biodemographic the properties observed in Sitophilus oryzae vary according to different substrates corn (whole, husked, broken and flour).

The average duration of development is 31,04 ± 2,70 days in the whole corn ; 26,83 ± 1,48 days in husked corn and 30,36 ± 2,26 days in the broken corn. There has not been development of *S. oryzae* on corn flour. Same after five days of infestation, no development was observed. Thus, the biodemographic parameters have not been determined. These results are shown in Table 8.

Table 8 : Average duration of development *Sitophilus oryzae* on four substrates corn from 28.5 to 31 ° C and 41-67% R.H.

	Whole Corn	Husked Corn	Broken Corn	Flour Corn
Average duration of Development (days)	31,04 ± 2,70 **a**	26,83 ± 1,48 **a**	30,36 ± 2,26 **a**	0

For each parameter averages followed by the same letter indicates that the values do not differ from each other at the risk threshold α = 0,05 (Student test).

The pairwise comparison of average duration of development by the Student t test shows that the difference of the average durations of development is not significant risk threshold alpha = 0,05 between populations of *S. oryzae* having completed their cycle in the whole corn and those that have evolved in husked corn (p = 0,42 > 0,05) ; and between the whole corn and broken corn (p = 0,25 > 0,05). These same results were found between husked corn and broken corn (p = 0,70 > 0,05).

In addition, the results of the analysis of variance with a confidence interval of 95% to the average duration of development depending to the different substrates, reveal the absence of a significant difference between *S. oryzae* that developed in the whole corn, husked corn and broken corn (F = 0,77 > 0,05). The data are summarized in Table 9.

Table 9 : Analysis of differences between groups with a confidence interval of 95%

Source of variations	Sum of squares	Degree of freedom	Average of squares	**F**	Critical value for F
Between Groups	344,721879	2	172,36093	**0,7775**	3,15884
Inside the groups	12635,72578	57	221,67939		
Total	12980,44766	59			

Number of adults

The number of emerged adult is more important in the broken corn (35 adults). On husked corn, there have been 20 adults and the whole corn, 18 adults emerged (Table 10). It should be recalled that there has not been development of *S. oryzae* in corn flour. Thus, even after 15 days of observation, no adult emergence was noted.

Table 10 : Number of Adults of *Sitophilus oryzae* on four substrates corn from 28,5 to 31 ° C and 41-67% R.H.

	Whole Corn	Husked Corn	Broken Corn	Corn Flour
Number of adults	18	20	35	0

Average weight of adult

The insects that emerge in each substrate are individually weighed 24 after discharge. Our results indicate that the average weight is 2,13 ± 0,18 mg in the whole corn ; 2,03 ± 0,26 mg in husked corn and 2,19 ± 0,20 mg in the broken corn. These results are summarized in Table 11.

Table 11: Average weight of adults *Sitophilus oryzae* on four substrates corn from 28.5 to 31 ° C and 41-67% R.H.

	Whole Corn	Husked Corn	Broken Corn	Corn Flour
Average weight (mg)	2,13 ± 0,18 **a**	2,03 ± 0,26 **a**	2,19 ± 0,20 **a**	0

For each parameter averages followed by the same letter indicates that the values do not differ from each other at the risk threshold α = 0,05 (Student test).

The pairwise comparison of average weight by the Student t test shows that the difference in average weight is not significant risk threshold alpha = 0,05 between populations of *S. oryzae* having completed their cycle in the whole corn and those having evolved in husked corn (p = 0,26 > 0,05) ; and between the whole corn and broken corn (p = 0,19 > 0,05). These same results were observed between husked corn and broken corn (p = 0,81 > 0,05).In addition, an analysis of variance of the average weights based on different substrates corn, with a 95% confidence interval (Table 12), shows that the difference in average weight is not significant between *S. oryzae* that developed in the whole corn, husked corn and broken corn (F = 1,03 > 0,05).

Table 12 : Analysis of differences between groups with a confidence interval of 95%

Source of variations	Sum of squares	Degree of freedom	Average of squares	F	Critical value for F
Between Groups	2,39810	2	1,19905	**1,03757**	3,15884
Inside the groups	65,87079	57	1,15562		
Total	68,26889	59			

Sex-ratio

The sex ratio (percentage of female) is in favor of males of *S. oryzae* as well as whole corn (27,78%); husked corn (40%) than in the corn broken (28,57%).

Table 13: Adult Emergence and sex ratio (R) of *Sitophilus oryzae* on different food materials.

Substrates	Number of adults sexed	Number of males	Number of females	R (%)
Whole Corn	18	13	5	27,78
Husked Corn	20	12	8	40
Broken Corn	35	25	10	28,57
Corn Flour	0	0	0	0

Comparison biodemographic parameters according to the origin of *Sitophilus*

Average duration of development

The biodemographic parameters vary depending on the origin of *Sitophilus*.

The average duration of development in the whole corn is 30,23 ± 2,29 days for *S. zeamais* and 31,04 ± 2,70 days for *S. oryzae*. In husked corn, the average duration of development is 26,07 ± 2,23 days for *S. zeamais* and 26,83 ± 1,48 days for *S. oryzae*. Thus, the average duration of development in the broken maïs is 47,45 ± 5,52 days for *S. zeamais* and 30,36 ± 2,26 days for *S. oryzae* (Figure 3).

For each substrate of corn, the same letter on the histograms shows that the values do not differ from each other the threshold p <0,05 (Student's t test).

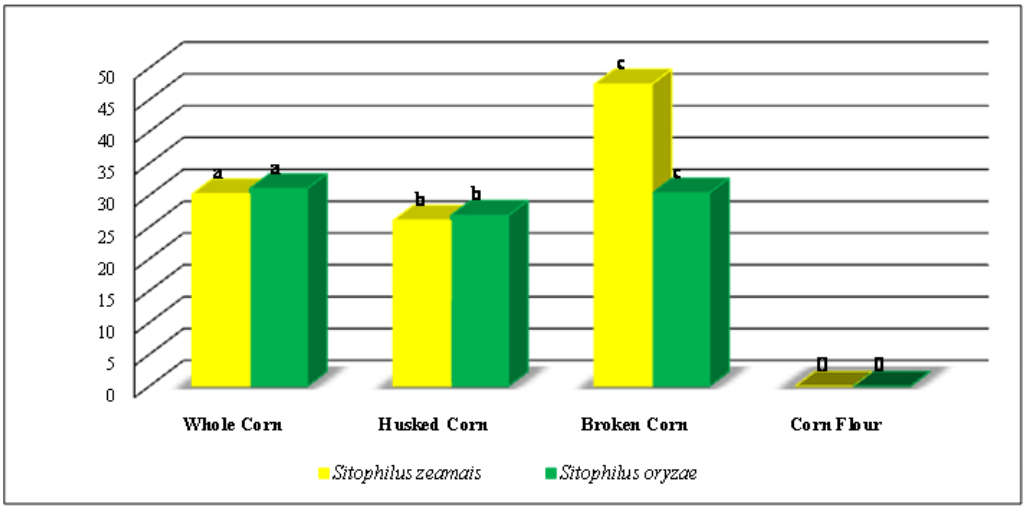

Figure 3: Average duration of development of *S. zeamais* and *S. oryzae* depending on the nature of the substrate

In addition, in the whole corn, the difference in average duration of development is not significant risk threshold alpha = 0,05 between *S. zeamais* and *S. oryzae* (p = 0,06 > 0,05) as well in husked corn (p = 0,83 > 0,05) and broken corn (p = 0,29 > 0,05).

Number of adults

In the whole corn, the number of adults is more important for *S. zeamais* (29) than for *S. oryzae* (18). The number of adults is also higher for *S. zeamais* (38) than for *S. oryzae* (20) in husked corn. In broken corn, that number is more important for *S. zeamais* (55) than for *S. oryzae* (35).
The results are shown in Table 14.

Table 14: Comparison of adult *Sitophilus* numbers according to its origin and nature of the substrate

Insects	Substrates	Number of adults
Sitophilus zeamais	Whole Corn	29
Sitophilus oryzae		18
Sitophilus zeamais	Husked Corn	38
Sitophilus oryzae		20
Sitophilus zeamais	Broken Corn	55
Sitophilus oryzae		35
Sitophilus zeamais	Corn Flour	0
Sitophilus oryzae		0

Average weight of adult

The average weight of adults in the whole corn is 2,63 ± 0,29 mg for *S. zeamais* and 2,13 ± 0,18 mg for *S. oryzae*. In the husked corn, this average weight is 2,55 ± 0,36 mg for *S. zeamais* and 2,03 ± 0,26 mg for *S. oryzae*. Thus, the average weight of adults emerged in the broken corn is 2,23 ± 0,19 mg for *S. zeamais* and 2,19 ± 0,20 mg for *S. oryzae* (Figure 4).

In addition, in the whole corn, the difference in average weight is very significant risk threshold alpha = 0,05 between populations of *S. zeamais* and *S. oryzae* (p = 0,008 < 0,05). However, in husked corn, the comparison of average weight between populations of *S. zeamais* and *S. oryzae*, reveals a value of p = 0,20 > 0,05. The difference between theaverage weight is not significant risk threshold alpha = 0,05. Similarly, in the broken corn, the difference in average weight is not significant (p = 0,85 > 0,05).
For each substrate of corn, the same letter on the histograms shows that the values do not differ from each other the threshold p <0,05 (Student's t test).

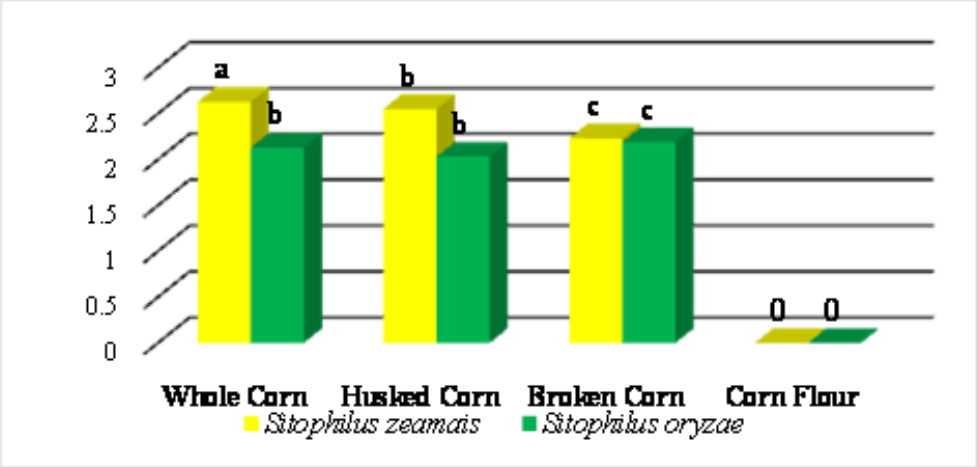

Figure 4: Average weight of *S. zeamais* and *S. oryzae* depending on the nature of the substrate

Sex-ratio

In whole corn, the sex ratio in favor of males for *S. zeamais* (34,48%) and *S. oryzae* (27,78%). Also, the number of males is higher among *S. oryzae*.

The sex ratio is always in favor of males in husked corn. But the number of female is important for *S. oryzae* with a sex ratio of 40%.

In the broken corn, the sex ratio is always in favor of males. But this number of males remains important for *S. oryzae* (28,57%) than for S. zeamais with a sex ratio of 34,55%.

The results are shown in Table 15.

Table 15: Comparison of Sex ratio of *Sitophilus* according to their origins and nature of the substrate

Insects	Substrates	Number of males	Number of females	Sex-ratio (%)
Sitophilus zeamais	Whole Corn	19	10	34,48
Sitophilus oryzae		13	5	27,78
Sitophilus zeamais	Husked Corn	25	13	34,12
Sitophilus oryzae		12	8	40
Sitophilus zeamais	Broken Corn	36	19	34,55
Sitophilus oryzae		25	10	28,57
Sitophilus zeamais	Corn Flour	0	0	0,00
Sitophilus oryzae		0	0	0,00

Discussion

This study focused on the effect of different states of corn (whole, husked, broken and flour) on development capabilities of *S. zeamais* and *S. oryzae* at a relative humidity varying between 41-67% and at ambient temperatures oscillating between 28.5 to 31 ° C.The crucial question is to know if the variation of egg laying substrate affects the development cycle, the weight and sex ratio of *Sitophilus oryzae* L. (Coleoptera Curculionidae) from the millet and *Sitophilus zeamais* M. (Coleoptera Curculionidae) from corn.

The results obtained on cumulated emergence of adults of *S. zeamais*, show that the appearance of adults is made in a variable manner on different formulations of corn, also, the whole corn is more favorable to the development of *S. zeamais*.These fluctuations may be related to the lifetime larval stage IV which would vary according to the individual. Indeed, almost all species of *Sitophilus* pass more than half of their larval life stage IV and the duration of this stage varies widely from one individual to another [14].

The differences found in the speed appearance would thus be linked to the specificity of individuals in each alimentary support.In addition, 38 adults were enumerated on corn husked and 29 on the whole corn. The largest number of adults (55 adults) was noted in the broken corn.Indeed, there has been no development of *S. zeamais* on corn flour. This report, allows to say that this lack of egg laying on corn flour could be related to the biology of *S. zeamais*.Because, the female of *S. zeamais* lays its eggs by placing each of them in a small hole dug into the grain and sealing thereof with a saliva stopper mucilaginous [21].In contrast, there have been fewer adults in the whole corn over corn husked and broken. The number of progeny seems to depend on the resistance that the grain opposes the insect.

But this result is enough to confirm the ecological status of *S. zeamais* already signaled as a primary pest [5; 4 ; 30 ; 29].One must remember that the primary pests are capable of breaking a hard envelope healthy grains. They are the most dangerous because they damage the intact grains, allowing the larvaefrom developing inside.They also allow the infestation of the stock by the secondary and tertiary pests for which damaged grains are a source of food.

The results obtained for the average duration of development of *S. zeamais* show that the difference between the average duration of development is not significant. Moreover, one must remember that for *S. zeamais*, a temperature between 25-27 ° C and a relative humidity of 70% are needed for its development. Indeed, the optimum development of *S. zeamais* between 27 and 31 ° C to 70% humidity is 36 days [6].

Moreover, for the weight growth of insects, our results indicate that the difference in average weight is not significant between *S. zeamais* that developed in the whole corn, husked corn and broken corn. However, in case of heavy infestation, these insects subsequently reduce the weight of the food and grain quality, resulting of diet of larvae on the endosperm. The estimated rate can be huge in just six months, estimated at nearly 18% with shelled corn [10].

The sex ratio was broadly in favor of males of *S. zeamais*as well as whole corn (34,48%) ; husked corn (34,12%) and broken corn (34,55%). In fact, the sex ratio is an important biological index, because the proportion of male and female can affect reproductive success. Indeed, the works on Callosobruchus maculatus [12] have affirmed that if females dominate in the new generation, they will a prominent role in the infestation of seeds stored since there will be more of eggs laid thus the importance of the damage in seeds sensitive. Which will not be the case for our results because here it will there probably be a competition between males for females available. Which could reduce the infestation during storage.

S. zeamais is a primary pest capable of developing on the whole corn, corn husked and broken corn. The corn flour seems not to be favorable at development of *S. zeamais*.

However, comparing the parameters biodemographic *S. oryzae* from millet on four substrates of corn, the observation is the emergence is made in a variable manner on different food substrates. In addition, the number of emerged adults is more important in the broken corn where 35 adults were counted. On husked corn, there have been 20 adults and in the whole corn, 18 adults emerged. Indeed, there has been no development of *S. oryzae* on corn flour. And no adults were observed. Our results are similar to those of the Canadian Commission of seeds which states that *S. oryzae* does not grow on flour unless it is compacted.Moreover, following our results, it appears that the broken corn is more favorable at development of *S. oryzae*. Indeed, one must remember that for broken corn, the whole grains were reduced to pieces which apparently facilitate the development of the insect. In addition, females of *S. oryzae* lay only in grains or bits of grains sufficiently large [14]. But *S. oryzae* is a primary pest which has a preference for small grains such as millet and rice [25 ; 2]. Thus, this finding clearly shows that when the grain size is large, the number of infested grains decreases, which would lead a significant decrease in the number of adults. All these factors preclude laying eggs in great numbers by female *S. oryzae*, promoting, and, the downsizing in the whole corn.

Concerning the average duration of development, the difference between the average duration of development is not significant. Indeed, we have the same support alimentary who is corn on different formulations. However, it should be noted that *S. oryzae* is not as selective as *T. castaneum* which is commonly used in bioassays for the evaluation the overall nutritional quality of foods [1].

Regarding the average weight of insects, the results show that the difference in average weight is not significant between *S. oryzae* that developed in the whole corn, husked corn and broken corn.

The sex ratio is towards males of *S. oryzae* as well as whole corn (27,78%); husked corn (40%) and broken corn (28,57%). However, there are more male in the whole corn, which would lead to a reduction of the infestation during storage.

S. oryzae from millet is capable of developing on all formulations except of corn flour that seems to be more resistant to attack of *S. oryzae*. But, this last expands hardly in whole grains.

However, by comparing biodemographic parameters according to the origin of *Sitophilus*, the fact is that in the whole corn, the difference in average duration of development is not significant risk threshold alpha = 0,05 between *S. zeamais* and *S. oryzae* ($p = 0,06 > 0,05$) as well as in husked corn ($p = 0,83 > 0,05$) and broken corn ($p = 0,29 > 0,05$). It appears that the origin of *Sitophilus* does not affect the development of the insect. Indeed, *S. zeamais* and *S. oryzae* are both present in the corn stocks in Senegal [18]. Besides, most producers think that the cob provides some protection at grain against attacks by insects, hence greater sensitivity shelled corn [10].

Moreover, for the adults, the report is that there is a significant difference in favor of *S. zeamais* with a larger number of adults irrespective of the status of corn.Indeed, it is noted that the origin of *Sitophilus* affects the number of emerged adults.Thus, there is a certain preference of *S. zeamais*for corn particularly when it comes to it.

According to some authors [25; 3], *S. zeamais* prefers large grains such as corn.Moreover, the abundance ofS. zeamais , primary pest in corn, is explained by the fact that the appearance of conditions favorable environment for its development forms of this insect pre imaginal transform more quickly and cause an increase in the population of the insect [22]. Also, this preference of *S. zeamais* for corncould be explained either by the storage form or the intrinsic properties of corn suitable for development the insect [31]. But we must not neglect the development capacity of *S. oryzae* from millet on all formulations except of corn flour. Would it even if it *S. oryzae* used for the experiments were from corn?Concerning the average weight of insects, it is also interesting to note that when addressing the same food support (whole corn), there is a clear difference in the future of the average weight of insects between populations *S. zeamais* and *S. oryzae* ($p = 0{,}008 < 0{,}05$). Indeed, the weight of *S. zeamais* emerged is greater than that of *S. oryzae*. This difference makes it clear that theprotection of the grain by an envelope, not only limits the degree of infestation of the grain but also limits the growth of insects infesting the grain.

The sex ratio for *S. zeamais* and *S. oryzae*, remains in favor of males matter what the formulation of corn. This is going to cause a reduction of the infestation during storage.

CONCLUSION

This study on the development of *Sitophilus zeamais* and *Sitophilus oryzae* on the various formulations of corn, allowed to show that the whole corn, husked or broken corn is favorable to development of*Sitophilus zeamais* and *Sitophilus oryzae*. But, corn seems more to hold attacks from both *Sitophilus* when it is processed into flour. Thus, to limit infestation of *Sitophilus*on corn, it is necessary to stored her after processing into flour. However, it is necessary to note that the corn seems to be less attacked by *Sitophilus oryzae* whenhe is whole.

He does not exist method of universal protection enabling controlthe insect pest populations. Considering the diversity of ecological conditions, insect populations adapt, while their cycles undergo variations. In fact, the appetence than *Sitophilus oryzae* and *Sitophilus zeamais*have for corn, should invite for more vigilance during storage of corn. Each cereal should, in these conditions and to the extent possible, be specially stored in remote locations of those reserved to conservation or storage of another stuff. Moreover, it would be important to ensure the good sanitary state of the cereals before they are stored.

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