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Full Length Research Paper

Nature of food/egg laying material on post-harvest conservation for cereals in Côte d'Ivoire

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The reproductive behavior of maize weevil was investigated in prior research with a focus on biological traits of the insect. However, the impact of cereal food support material on some ethological and biological characteristics of *Sitophilus zeamais* had received little attention thus far. The focus of this study is to fill this void by exploring the existence of a causal relationship between grain characteristics and insect traits. Biological and ethological analysis revealed that the duration of sexual maturation was 4.25 ± 0.40 days for both rice and corn. The other parameters (fertility, duration of development, emergence of adults, descent's weight, mortality and lifetime of the insect) varied according to the nature of the food/egg laying material. The above set of key behavioral parameters provided a comprehensive analysis of the scientific environment within which the contributions of the study were derived. In addition to providing a useful prognosis of the insect's development in Cote d'Ivoire, the study confirms the causal relationship between grain characteristics and insect traits.

Key words: Rice and corn infestation, biological and ethological analysis, *Sitophilus zeamais*, reproductive behavior of rice and corn weevil, comparative analysis of weights of corn and rice weevil.

INTRODUCTION

The different kinds of rice (*Oryza sativa*) and corn (*Zea mays*) together with wheat are the most consumed three cereals worldwide (Angladette, 1966; Rouanet, 1984; Ratnadass, 1987; Anonyme, 2002a, b). They are the staple foods of the sub-Saharan African populations. Unfortunately, these cereals are subject to significant losses during their storage and conservation. The post-harvests losses which strongly depend on storage and conservation conditions are estimated to be close to 42 million tons a year in the world (Ratnadass, 1987).

Among the genus Sitophilus, there are two species which are most damaging in tropical Africa: *Sitophilus oryzae* (L) and *Sitophilus zeamais* (M). The morphological resemblance of *S. oryzae* and *S. zeamais* has very often led to confusions if only a morphological, fast identification of these two species is possible (Delobel and Tran, 1993). The rice weevil is smaller than the maize weevil. In this study, a specific effort is made to examine and ascertain the selected insect species in order to resolve the problem leading to the usual confusion between them (*S. oryzae* and *S. zeamais*).

Statistical associations between the food/egg laying material and the biological together with morphological factors including fertility, duration of development, emergence of adults, descent's weight, mortality and lifetime of the insect, could be informative. Within this context and for a tropical African country such as Cote d'Ivoire, this analysis is an effort to lay out a foundation which is likely to ascertain the determinants of insect traits in order to properly evaluate the impact of the food/egg laying material. Indeed, the study of the influence of the nature of the food/egg laying material

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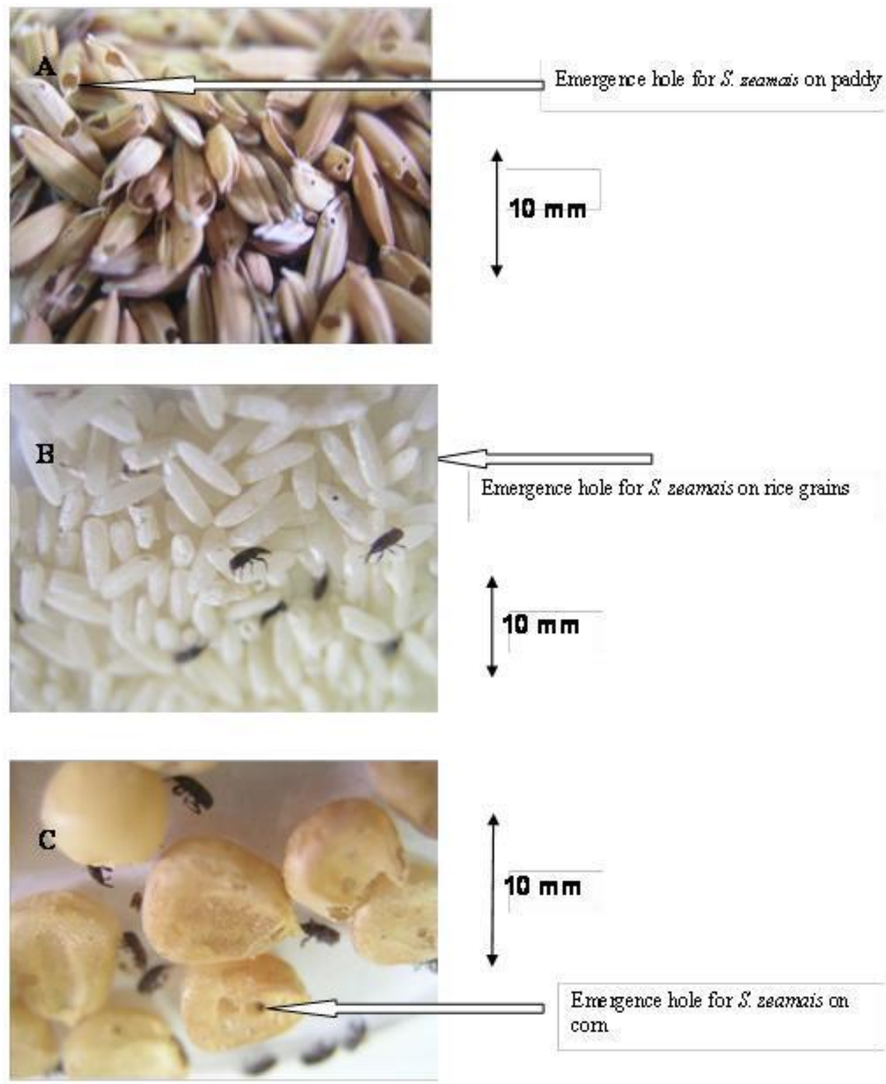

Figure 1. Snap-shots of rearing of *S. zeamais* on rice and corn taken in April 2006 during field supervision of the UNDP-GEF SGP Project in Bonon, Bouaflé; Republic of Cote d'Ivoire.

could make it possible to design effective post-harvest conservation strategies for cereals in the western center of Côte d'Ivoire and beyond.

MATERIALS AND METHODS

Insect colony and plant material

The insects used in this study were adult males and females of *S. zeamais* (Coleoptera: Curculionidae), one of the principal pest attacking the stored cereals in Côte d'Ivoire and mainly in the region of Bouaflé, located 350 km northern Abidjan (the country's economic capital).

The host plants used came from corn and rice stocks collected immediately after harvest by the peasants of Bonon. The plant material was the host plants chosen (Figure 1). These were composed of white and yellow corn ecotypes together with NERICA 1 rice (variety selected by Africa Rice ex-WARDA) and SAHIA rice (local variety) which were also selected given the comparative framework used. These products were supplied by CNRA (Centre National de Recherche Agronomique - Ivorian National Center of Agricultural Research) together with PNR (Programme National Riz - Ivorian National Rice Program). Day-to-day field monitoring activities were carried out by the employees of the afore-mentioned local government institutions under the immediate supervision of the 'principal investigator' of the study.

The technical material used included the breeding, observation and measurement materials. The material used during breeding included polypropylene dishes used to separate cereals in 5 kg batches. A sieve with square meshes of 2 mm pore size was used to separate insects from grains in order to count them. For insects breeding, the material used was Petri dishes and transparent Plexiglas boxes of various volumes.

Observations were made using a binocular magnifying glass of BMK 31162 model, a manual magnifying glass (Academy Glass Magnifier Ø 100 mm). Flexible grips were used to easily handle insects and grain kernels. The material of measurement included an automatic meter of grains MUNIGRAL (State 1800) model, a psychrometer (EXTECH Instruments) for the relative humidity and temperature measurement of the breeding room. Two Sartorius (BP 310 S) balances of 0.001 and 0.0001 g precision were used for weighing the grains and insects.

All the tests in this study were carried out in accordance with specific process requirements.

Mode of sampling and sample size

According to Pantenius (1998a, b), sampling small amounts of cereals does not allow a correct and efficient follow-up of cereal stocks infestations. So, this study used 200 and 100 corn cobs instead of 1 to 1.5 kg of grains or 10 corn cobs stored by sample (Adam and Harman, 1977; Golob, 1976, 1981; Raboud et al., 1984). Sample size consisted of 5 kg of rice and corn to better represent in laboratory trials the real environmental conditions for cereal storage in the country. These arrangements also allowed a close monitoring of the evolution of the infestation into labs.

Chemical analysis of rice and corn grains

Studying the chemical composition of cereals used aims at determining the factors which triggered the attacks. The chemical analysis was conducted on two corn ecotypes (white and yellow), and two rice varieties (NERICA 1 and Sahia). These two rice varieties were chosen because the first one has a higher rate of infestation and the second one has a lower rate of infestation. These two varieties also represent the two types of rice (irrigated and pluvial) commonly available locally. Chemical composition of the grains was analyzed in 2007 at the Laboratoire Central de Nutrition Animal (LACENA) - LANADA/LCAE located at the University of Abobo-Adjamé - Côte d'Ivoire.

The parameters measured were: water content/rate of humidity (H), dry matter (MS), which was carried out by drying. For protein content (P), the method used was the Kjedahl method. Determination of total sugars (ST) and starch rate (A) was carried out by the method of Bertrand. The fat rate (MG) was determined by the method of Soxhlet. The above-mentioned three methods are well referenced in the relevant scientific literature (Duche et al., 1992). The resulting metabolism energy (E) is calculated by the following formula:

$$E\ (kcal/kg) = (3,52\ P + 7.85\ MG + 4.10\ A + 3,55\ ST) \times 10$$

Study of some biological parameters of the Ivorian stock of *Sitophilus zeamais*

The biological parameters of *S. zeamais* studied were: lifetime, sexual maturity duration, egg laying period, fertility, duration of development and emergence or the number of insects. For each studied parameter, three replicates were carried out and the average of the values obtained was determined.

Behavior of *S. zeamais* on two different media

Irrespective of whether the insect was initially collected on rice or corn, it was subsequently reared on both corn and rice in order to be able to examine the behavioral differences that were exhibited. This means that insects collected on corn were used to infest rice and corn separately and those collected on rice were also used to infest rice and corn, under the same laboratory conditions (T° = 25 ± 1°C; HR = 72 ± 3 %). Two Petri dishes, each one containing 100 g of corn cobs, received 10 insect couples of 48 h old from the array of insects collected on corn. Two other dishes, containing 100 g of rice grains, received each 10 insect couples of the array of insects collected on rice. After 10 days of infestation, the insects were removed from the dishes and the infested grains were developed until emergence of the adult insects under laboratory conditions. The emerged adults were placed on healthy grains to sustain the insect reproduction process so as to guarantee that they would be sufficient insects to carry out the entire experiment.

Determination of the duration of sexual maturity and the period of egg laying

The purpose of this phase of the experiment was to determine at which time the insect starts laying eggs and infesting grains. The grains were used for the corn, the white cultivar cob and the rice (NERICA variety). One breeding dish containing 100 g of grains receives 10 couples of *S. zeamais* lately emerged. Determination of the egg laying period of the insect is the actual running time from emergence to appearance of eggs in the dishes used to monitor the experiment. Therefore, daily examination of the kernels which did host the insect using the proper equipment and process – on a 24 hour basis – resulted in the identification of imagoes if any. The one-day old insects were removed and were subsequently placed in another box containing the same quantity of kernels. In practice and in accordance with the process used in the current study, the kernels having hosted the insects were observed with a magnifying glass after being colored with fuchsine, in order to seek for the egg laying holes. This was indicative of egg laying. Fuchsine A was used to color the mucilaginous buds red which meant the presence of egg laying holes. This process was repeated during several days, until the first eggs laying holes were detected. The same cycle of activities was repeated

Table 1. Biological parameters of *S. zemais* bred on rice and corn.

Mean biological parameter	Reared on corn	Reared on rice	F	P value (0.05)
Mortality rate	13.75 ± 0.47	18.75 ± 0.57	1.6	0.226554
Infestation rate	99.84 ± 0.13	40.22 ± 10.48	196.3636	0.00**
Fertility (eggs/female)	103 ± 10	38.70 ± 3	16.5819	0.00*
Lifetime (days)	70.68 ± 5.64	90 ± 9.57	1.2	0.512
Duration of sexual maturity (days)	4.25 ± 0.40	4.25 ± 0.40	0	1
Duration of development (days)	32.5 ± 5.18	35.5 ± 5.18	-	-
Emergence rate	82.43 ± 18	79.82 ± 5.66	-	-
Weight of insects (mg)	2.75 ± 0.35	1.8 ± 0.48	254.22	0.00**

In the table, the mark (*) tagged to the P value should be read as follows: * means statistically significant and ** means statistically very significant.

again during several days, until the first eggs laying holes were detected. The period after the detection of the last egg laying holes corresponds to the ageing of the insect.

Determination of the insect's lifetime

To conduct this study, a breeding box containing 100 g of grains received 10 couples of *S. zeamais* lately emerged. The one-day old insects were removed and placed afterwards in another box containing the same quantity of grain; three replicates were carried out. Then, dead insects were counted and sexed. The same process was repeated every day, until the death of the last insect. The overall estimate of the average lifetime or the average longevity of the insects is the period ranging from the emergence to the death of the insect. It is determined by the ratio of the sum of the result of the various lifetimes (xi) by the number of dead insects (ni) to the sum of the total number of dead insects. It is expressed by the following formula:

$$\text{Lifetime} = \Sigma\, x_i n_i / \Sigma\, n_i$$

After having counted the number of dead insects in the boxes, the grains were preserved and divided into two batches (A and B). The eggs in batch A were counted after being colored with fuchsine and observed with the magnifying glass, looking for the egg laying holes. The fertility translating the number of eggs laid by the females is calculated. The daily fertility of females was calculated as well.

Estimate of the development period

The grains of batch B carrying eggs laid by the insects were preserved in the breeding boxes and monitored closely until emergence of the adults. The time between the laying of eggs and emergence of the imagoes corresponds to the duration of development of the insect.

Estimate of the emergence rate

Every day, the emerging insects were counted until no more adults emerged. The rate of emergence (TE) is the ratio, expressed as a percentage, between the number of emerged insects (ne) and the number of eggs laid (no): TE = (ne / no) × 100.

Statistical analyses

The two groups used for the statistical analysis were the insects reared on corn versus the ones reared on rice. The analysis of variance (ANOVA) was used to assess if there were significant differences between the studied parameters, that is, the mean values for insects reared on rice and mean values for insects reared on corn. As an assumption test, ANOVA makes it possible to compare averages between two (ANOVA) or several samples (MANOVA) (Wonnacott and Wonnacott, 1990). ANOVA helps to answer the following question: Is there significant variability among these averages for each of the considered classification criteria, that is, mortality rate, infestation rate, fertility, lifetime, duration of sexual maturity, duration of development together with emergence rate? Obtaining the values of p (p-value) is made by comparison of the values of F to the breaking values of F. These tests were carried out with software STATISTICA version 6.0 (Standard Commercial Software).

RESULTS

Key results in respect of the impact of the nature of the food support's material on the selected ethological and biological characteristics of *Sitophilus zeamais* are presented herein.

Infestation rate of the grains

The rate of infestation recorded on corn after 14 days was 99.84 ± 0.1%. On rice, this proportion is weaker; the rate for the whole grains proposed is 40.22 ± 10.48%. ANOVA revealed that the difference between the rate of infestation recorded on corn and rice is highly significant (p = 0.000000) (Table 1).

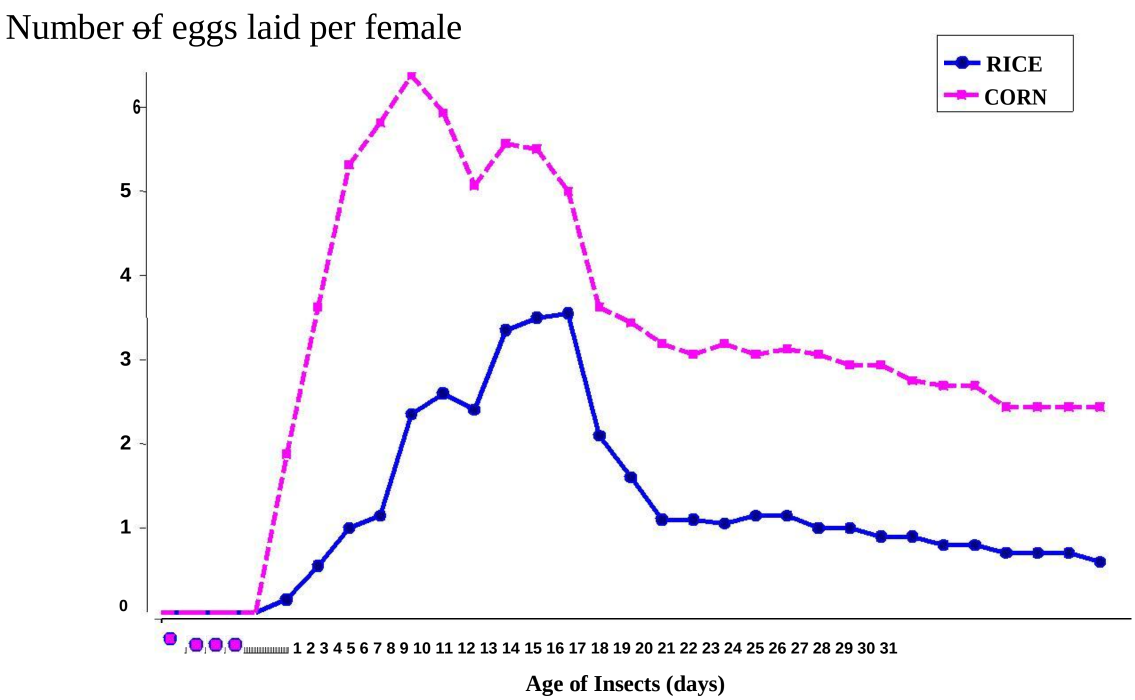

Figure 2. Evolution of the daily fertility (number of eggs laid per day) of *S. zeamais* according to the egg laying support's material.

Sexual maturation and oviposition

When rice or corn was offered to *S. zeamais*, as an egg laying material, the mating occurred as of the emergence of the adults. The first eggs were observed at day 5 after emergence on both substrates (Figure 1). The egg laying period of the insect or the duration of sexual maturation was therefore 4.25 ± 0.40 days.

Fertility

The insect starts to lay eggs by the 4th day after emergence. The number of eggs increased and reached a maximum at the 9th day when the insect was bred on corn, and at day 13 when it was reared on rice. Then fertility decreased gradually (Figure 2). The fertility of *S. zeamais* was 38.70 ± 3 eggs per female after one month of life on rice. Under the same conditions, this value was 103 ± 10 eggs per female for corn, that is, 2.6 times higher than the result obtained for rice (Table 1). The fertility of *S. zeamais* therefore depended on the food product used as egg laying material. ANOVA revealed that the difference between the fertility of those insects bred on corn and that of the ones bred on rice was significant. The fertility of *S. zeamais* was therefore significantly higher on corn than on rice.

Duration of development

The duration of development of *S. zeamais* on corn lies between 25 and 40 days (32.5 ± 5.18 days in average). On rice, the duration of development was delayed, ranging between 27 and 44 days (35.5 ± 5.18 days in average) (Table 1).

Emergence of the adults

The mean rate of infestation recorded, after the breeding of 80 couples of *S. zeamais* on 250 g of rice, during 21 days was 40.22% ± 10.48.

In this proportion, 98% of the grains show only one emergence hole and 2% showed 2 emergence holes after the evolutionary cycle of the insect. Regarding the corn, the mean rate of infestation of the grains under the same conditions was 99.84% ± 0.13. More than half of the grains (58%) showed one emergence hole, 35% showed 2 emergence holes and 7% recorded three holes of emergence. The corresponding average rates of emergence were 79.82 ± 5.66% for the insects reared on rice and 82.43 ± 18% for those reared on corn (Table 1).

Weight of the descent

The average weight of the insects having emerged from rice was 0.0018 ± 0.00095 g and the average weight of the insects having emerged from corn was 0.0027 ± 0.00052 g. On rice, the weights of the insects lie between 0.0009 and 0.0022 g for the males with an average value of 0.0014 ± 0.0004 g. The weight of the females bred on the same grain varied from 0.0013 to 0.0035 g for an average value of 0.0022 ± 0.0005 g. On corn, the weights go from 0.0011 to 0.0033 g for the males and 0.0020 to 0.0035 g for the females; the middle weights are of 0.0024 ± 0.005 g and 0.0031 ± 0.0004 g respectively for the males and the females.

Mortality and lifetime of the insect

The mean mortality rate of *S. zeamais* after one month is assessed to 13.75 ± 0.47% on corn. On rice, this proportion was 18.75 ± 0.57%. The first dead ones counted both on corn and on rice appeared between the second and the fourth day after infestation. ANOVA revealed that there is no significant difference between mortality rate of *S. zeamais* recorded on rice and on corn (p = 0.226554) (Table 1). After three months, the rates observed reached 48.75 ± 16% and 64.37 ± 20.03% respectively on corn and rice. However, the insect can live for a long time (127 days) with an average lifetime of 90 ± 9.57 days on rice, while for corn it can live for 103 days with an average lifetime of 70.68 ± 5.64.

Assessment of the behavior of *S. zeamais*

Physical characteristics of the corn cobs and rice grains

The corn differs from the rice grain by several physical characteristics which are the length, width, surface, the water content and hardness. The corn grain has 13 ± 1.1 mm length, 9.10 ± 1.6 mm width and 11.60 ± 0.28% water content. It is tender and offers a broader surface for egg laying to the insect. The rice grain on the other hand, has 8 ± 0.7 mm length and 2.05 ± 0.51 mm width. The water content recorded is 12.40 ± 0.39%; it is harder and has a reduced surface.

Impact of the chemical composition and the nutritional quality of the corn and rice grains on the insect’s behavior

The chemical analysis of the cereals used made it possible to determine the composition of the corn and rice grains and the respective proportions of their nutrients. Relevant parameters are the water content, the metabolizable energy as well as the nutrients of the grain (dry matters, proteins, fat, sugar and starch). As for NERICA 1 rice, it was richer in dry matter (87.60%), proteins (7.08%), fat (2.00%) and starch (62.43%) than the Sahia variety. The latter rice variety’s chemical composition is as follows: 86.5% in dry matter, 7% in protein, 1.3 % in fat and 62.05% in starch.

The metabolizable energy is higher for NERICA 1 (2992.48 kcal/kg) if compared with the Sahia variety (2922.66 kcal/kg) (Table 2).

Regarding the corn, the white ecotype has a water content of 11.60% compared with 11.30% for the yellow ecotype. The proportions of total sugar (1.53%) and starch (56.34%) are higher than those of the white corn which are 1.20% in total sugar and 55.80% in starch (Table 3).

DISCUSSION

The investigation carried out in this study illustrated the extent to which the nature of the egg laying material impacted the behavior of the pest-insect. The results show that *S. zeamais* starts to lay eggs from the 4th day on both substrates. These observations are similar to those reported by Richards (1974) who mentioned that under environmental conditions of 27°C and 70% HR, 2% of the females were gravid after 3 days and 70% after 6 days (Walgenbach and Burkholder, 1987). According to Danho (2000), only one fertilization allowed the female to lay eggs during two to three months, before the spermatheca was emptied. The egg laying repeats multiple times up to a total of 200 to 400 eggs (Delobel and Tran, 1993). The results of this study show that the fertility of *S. zeamais* was significantly higher on corn than on rice. The difference in the number of eggs laid would be due to the fact that the corn cob was larger than the rice grain. Therefore, it would offer a larger laying surface and more important nutrient reserves to the insect.

The above findings are also consistent with those of many authors who indicate that *S. zeamais* females lay their eggs preferably on large grains (Segrove, 1951; Tyagi and Girish, 1975; Stejskal and Kucerova, 1996). The fertility of *S. zeamais* depends on the grain. The assimilation of the nutrients contained in the grain by the larvae emerging from the eggs, could generate a competition between them. This line of argumentation is in accordance with studies of Russell (1968), Fox and Mousseau (1995) and Stejskal and Kucerova (1996) who reported that the grain, having a limited reserve of nutritive resources, conditions a possible competition between the larvae.

The difference observed about the fertility and the number of eggs hosted by grain would be due not only to the size of egg laying support’s material, but also to its hardness. The corn cob is, indeed, relatively softer than the rice grain which is hard and richer in starch than in proteins. The insect would then be more amenable to perforate the corn cob to lay its eggs (owing to the fact that it is relatively soft). On the grain of rice, it will have to deploy much more effort. A sensible inference that can be drawn is that the above process could realistically exhaust it and therefore result in its early death before laying totally its eggs. Hence, the finding shows that there is higher mortality rate of the insects bred on rice. In essence, the observed early mortality recorded for certain individuals of *S. zeamais* could also be attributed to the stress and injuries undergone by insects during sieving to separate lately emerged insects from the cereal grains.

Table 2. Chemical composition of rice varieties SAHIA and NERICA 1.

Parameter	Grain				Pulp			
	SAHIA		NERICA 1		SAHIA		NERICA 1	
	Gross product	Dry matter	Gross product	Dry matter	Gross product	Dry matter	Gross product	Dry matter
Humidity (%)	13.50	0	12.40	0	8.75	0	8.50	0
Dry matter (%)	86.5	100	87.60	100	91.25	100	91.5	100
Protein (%)	7	8.09	7.08	8.08	3.50	3.83	3.50	3.84
Fats (%)	1.30	1.50	2	2.28	0.60	0.66	0.60	0.66
Total sugars (%)	0.85	0.98	0.75	0.86	-	-	-	-
Starch	62.05	71.73	62.43	71.27	-	-	-	-
Metabolic energy (Kcal /kg)	2922.66	3378.82	2992.48	3416.10	170.30	186.12	170.30	186.63

Table 3. Chemical composition of corn cobs.

Parameter	White corn		Yellow corn	
	Gross product	Dry matter	Gross product	Dry matter
Humidity (%)	11.6	0	11.3	0
Dry matter (%)	88.4	100	88.7	100
Protein (%)	7.88	8.91	9.63	10.86
Fats (%)	4.13	4.67	5	5.64
Total sugars (%)	1.53	1.73	1.2	1.35
Starch (%)	56.34	63.73	55.8	62.91
Metabolic energy (Kcal/Kg)	2965.85	3355	3061.88	3451.95

Generally, the mortality rates recorded on rice and those observed on corn are sensibly equal.

In addition, the analysis of the chemical composition of the two types of grains shows that the corn is richer than the rice. Its higher content in fat, total sugars and proteins could favor fertility on corn rather than on rice. Therefore, the nutritional quality of the egg laying material influences the duration of the insect development. These observations are in line with those of Segrove (1951), reporting that the shape and hardness of a grain can influence the oviposition rate of the insect. The average duration of the insect's development on corn is shorter than that recorded on rice. The results also revealed that the number of laid eggs does impact the emergence of adults. The number of insects emerged is, indeed, higher on corn than on rice. The insects bred on corn have more descendants than those that emerged on rice. This difference is as a result of the number of eggs laid on the two materials.

The findings of the current exploration bear some resemblance with those by Foua-Bi (1982) which showed that *Aspidiella hartii* bred on two different varieties of yams had different behaviors: on *Dioscorea alata* (florido variety) indeed, the fertility was higher, the development cycle was longer and the progeny number was higher than those bred on *D. cayenensis* (klenglé variety). These observations happened despite the fact that the same product was offered as laying material to the pest-insects. Under the same conditions, the results recorded on the emergence of the insects were significantly different. The size of grains and its nutrient contents are therefore responsible for both the distribution of the eggs and the number of emerging adult insects.

Close scrutiny of the results showed that with rice, in the majority of the cases, grains present only one emergence hole, which means that only one adult insect emerged from a grain of rice. These results are consistent with those of Richards (1974) and Philogène et al. (1989) who reported that only one adult *Sitophilus spp*, emerged from a grain infested by several eggs. From all eggs laid, only 30 to 50% individuals emerged on the grains having a strong egg density (5 to 6 eggs per corn cob and 2 to 3 eggs per grain of rice). From 2 to 3 eggs on rice, the larvae devote themselves to a competition inside the grain. The survival of a larva would therefore depend on the amount of nutrient available. Very often, only one adult insect emerges from a grain of rice. Studies carried out by Longstaff (1981), Farjan (1983), Bekon (1984) and Seri-Kouassi (1991) had similar results. This is why, the difference in size, therefore in weight between the individuals resulting from the corn cobs and the grains of rice kept up for a long time the mistake to regard *S. oryzae*, the rice weevil, to be smaller and *S. zeamais* to be larger and heavier.

With regard to corn, the findings of this study showed that several adults can emerge from only one grain. These observations slightly modify those of Richards (1974) and Philogène et al. (1989). They are however close to those of Danho (2003) whose research showed that a corn cob can host several individuals. During the study of the fertility phase, a number of eggs were observed from one to six on a corn cob. On the other hand, with respect to the emergences, the corn cobs can carry only three to four holes by generation. The difference between the number of eggs and the number of insects having emerged reveals that all the eggs do not reach the emergence stage. Generally, only larvae resulting from the first eggs laid entirely developed. The (late) other ones died for lack of food available. The size of the grain and the quality of food do have an impact on the size, weight and number of individuals that emerged. With respect to corn, taking into account the very strong density of eggs, larvae could share the same niche or very close nests. This situation therefore triggers a competition between larvae, and all these larvae could not reach the emergence stage. Dispersion of eggs on the surface of the grain gives the opportunity to the larvae in different nests to reach the emergence stage. The results of this study show that the weight of insects bred on corn is higher than those bred on rice. The weight of the insects is then related to the underlying nature or characteristics of the egg laying support's material, the quality and/or quantity of food available for the development of the larvae. The difference in weight observed for insects reared on rice and corn was highly significant. This difference could be due partly to availability of food resources in the various grains and to their chemical and nutritional content. The analysis of the chemical composition of the grains revealed that the physico-chemical factors could be responsible, on the whole, for these differences. The corn contains more nutrients for the development of the insect than the rice.

Conclusion

Reproductive behavior of *S. zeamais* in a comparative framework has been investigated when the weevil is reared on corn and rice. The findings of the exploration have established a close association among infestation rate, fertility, insect weight and the underlying physical and biological traits of the cereal egg-laying support or medium. The benefits of this study are dual. Firstly, the prognosis has, indeed, merits in that it provides useful insight on possible scientific development paths in connection with widely observed infestation phenomena on staple foods cereals at the heart of hunger crises in Africa and beyond. Secondly, it is quite revealing that the extent of the above association together with the sharp differences in the infestation rates were observed when the weevil was reared on corn versus rice, which are likely to capture the thrust of future strategies to mitigate post-harvest cereal loses due to *S. zeamais*.

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