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Incidence and relative abundance of rice stem borers in three selected rice fields in Lagos and Ogun States, Nigeria

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Abstract

This study was conducted to investigate the incidence of rice stem borer infestations and the species composition present in the selected rice fields. Data were collected between April 2017 and November 2018 across three locations, which include the upland rice field in Agbajege, Ogun state, rainfed lowland in Itoikin and Mangrove swamp in Igbogun, Lagos state, respectively. The incidence of rice stem borers was indicated by dead heart and white heads symptoms, while tillers were excised for rice stem borer identification and population. Results showed a high and low incidence of rice stem borers with no significant difference($p>0.05$) at $p= 0.29$ and 0.37 between the early and late planting seasons in the rainfed lowland and upland rice fields, respectively. Planting seasons were significant in the incidence of rice stem borers in mangrove swamp rice fields at $p<0.05$, $p=0.01$). This study showed that the predominant species of rice stem borers present in the three study sites were *Chilo zacconius* and *Sesamia calamistis*. *C. zacconius* was the most abundant species at 89% while *S. calamistis* was 11%. Rice stem borer populations were significantly higher at ($p<0.05$, $p=0.000$) in flooded zones while the highest rice stem borer populations were observed at the reproductive phase of the rice plants. This study showed that the planting seasons coincided with the peak period of the development of rice stem borers. Hence, conservation of natural enemies, monitoring and surveillance should be adopted in insect pest management in rice agroecosystems.

Keywords: Incidence, rice stemborer, planting seasons, Ofada rice variety, Nigeria.

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INTRODUCTION

Rice stem borers are a major group of insects that cause significant economic damage in paddy fields globally. Different species of rice stem borers of the order Diptera (Flies) and Lepidoptera(moth) have been reported as major pests across all rice agroecosystems. They cause significant yield losses in paddy rice ranging from 22-100% during major outbreaks (Ukwungwu,1984; Pathak and Khan,1994; Kega *et al.*, 2016). Rice stem borers undergo complete metamorphosis and the larva stages have been identified as the only destructive stage responsible for the economic damage in rice fields (Heinrich and Barrion, 2004). During the vegetative phase in rice plants, larvae of rice stem borers damage the leaves by feeding on the central whorl of the young plants. This causes the leaf to wither, turn brown, and later die off, hence termed "dead heart" (Ogah and Nwilene, 2017). In some cases, the actively growing plants compensate with another leaf in place of the infested one (Pathak and Khan,1994; Bonaventure *et al.,* 2018.). This, however, does not restrict or prevent further infestations as observed during the reproductive phase. Rice stem borers bore into the tillers during the panicle initiation or grain-filling stage, leading to an abortion of the panicle development or grain filling process respectively. This causes uniformly empty and chaffy panicles, known as "whiteheads". The most significant damage of rice stem borer infestations occurs during the reproductive phase, in which the rice plants are unable to compensate for the damages inflicted at this stage.

In Africa, different studies have been explored to identify the species of rice stemborers across uplands and the lowland rice fields (Bonaventure *et al*., 2018; Alfonce and Gration, 2015; Kega *et al*., 2015). In Nigeria, the major rice stem borers belong to two orders: Diptera and Lepidoptera. These insects include the stalked-eye fly *Diopsis thoracica* (Diopsidae), the African striped stem borer; *Chilo zacconius*, *Chilo diffusilineus* (Crambidae), White stem borer; *Maliarpha separatella* (Ragonot) Pyralidae, Yellow stemborer; *Scirpophaga* spp (Pyralidae) and the pink stem borer *Sesamia calamistis* (Noctuidae) (Alams *et al*., 1992; Nwilene *et al*., 2013; Ukwungwu *et al*., 1986; Heinrich and Barrion, 2004). The incidence, distribution, and abundance of rice stem borers vary within agroecosystems and rice varieties (Ogah and Nwilene, 2017). Some important factors such as flood, ecozones, years of planting, locations, planting seasons and rice variety could determine the species composition of rice stem borers across rice fields (Banwo, 2002; Alams, 2011). Significant yield loss of 55% in Faro 11 rice variety was reported in a rice field experiment in Ibadan, Oyo State, Nigeria (Ukwungwu and Odebiyi, 1984). The infestation was reportedly caused by a mixture of *M. separatella* and *C. zacconius*. While a slightly different trend was observed by Alam (1988) who reported three different rice stem borers which are *M. separatella, C. zacconius,* and *Sesamia calamistis* as the major rice stem borers in a surveyed upland and irrigated rice fields in Ibadan, Oyo state Nigeria. Furthermore, Emosauire and Shiyam (2000) reported the presence of a different composition of rice stem borers from a three-year survey in lowland rice fields in southeastern Nigeria, comprising of *Scirpophaga subumbrosa* Meyrick (Pyralidae), *Chilo sp* (Pyralidae), *Diopsis thoracica* (West) (Diopsidae) and *Diopsis apicalis*. This further emphasizes the different compositions of rice borers across the fields which vary within locations and years.

Different varieties of rice are planted across Nigerian rice fields, which are mostly dependent on rain for planting, rice growth, and development. However, farmers engage in planting in an overlapping manner to maximize the season for more grains at harvest. Depending on the agroecosystem, most farmers plant at the onset of the rains, while others plant a few weeks after the rains have been well established in an overlapping cycle (Showemimo *et al*., 2015).

One of the major rice species planted occasionally in Lagos and Ogun rice fields is the "Ofada gold rice". It is a premium, indigenous aromatic rice species mostly preferred for its nutritional, health benefits and taste in Nigeria. This species gained more attention in recent times among several researchers and was identified and coined as "FUNAABOR-1 variety" (Showemimo *et al*., 2015). They are sold at premium price and mostly served as a special delicacy in homes and social gatherings. Ofada gold rice is also in high demand among Nigerians in the diaspora, while the local demand is also not enough to sustain the markets. One of the major shortfalls in yield is attributed to rice stem borer attacks (Ogah and Nwilene, 2017). There is however no report on the rice stem borers associated with the Ofada gold rice grown successfully as upland or lowland rice. Hence, it is imperative to investigate the species composition of rice stem borers across different ecological zones selected. The present study aims to provide information on the incidences of rice stem borers on Ofada gold rice (FUNAABOR-1), commonly grown in upland and lowland rice fields in the southwestern part of Nigeria. Further, the species composition of the rice stem borers present in the three selected study sites in Ogun and Lagos states in Nigeria were identified. The effect of locations, growth stages and time of planting on rice stem borers populations were also investigated.

MATERIALS AND METHODS

Field survey

The survey was carried out during the early and late planting seasons in rice fields in Lagos and Ogun states, located in the southwestern part of Nigeria. Data were collected for two consecutive years over four planting cycles, from April 2017 to November 2018. The agroecosystem was selected based on their distinct characteristics which included *upland* rice fields in Agbajege in Ogun state, *rainfed lowland* in Itoikin, and *mangrove swamp* in Igbogun both in Lagos State, Nigeria. Each of the rice fields was estimated to be 80 hectares. The indigenous Ofada rice (FUNAABOR 1 variety) was planted across the three survey sites, as it can be grown successfully in upland and lowland fields (Showemimo *et al*., 2017). Planting dates in the three study sites were noted and stated as thus; In the year 2017, rice planting in Itoikin commenced on the 20th of May and August 3rd respectively, rice was planted in Igbogun on the 13th of April and 6th of June, while in Agbajege, rice was planted on the 21st of April and 9th of June for the early and late planting seasons respectively. In the year 2018, rice was planted on the 10th of May and 7th August in Itoikin, while, in Igbogun, rice was planted on the 27th of April and 20th of June, while in Agbajege, planting was carried out on the 20th of April and June 1st, 2018. A plot size of 100m by 100m was set apart for this research on each site. The plots were arranged in a randomized block design and sectioned into four equal parts for sampling. The two planting seasons were rain-dependent, the planting times were determined by the farmers, while standard agronomic practices were observed. The GPS coordinate of the study sites are; Agbajege fields 6°59'20.0"N 3°33'17.0"E, Itoikin 6°40'13.8"N 3°47'48.5"E, Igbogun 6°24'03.0"N 4°17'53.0"E and with the elevation of 125m, 6m, and 3m above sea level respectively. The map of these locations is shown in Figure 1:

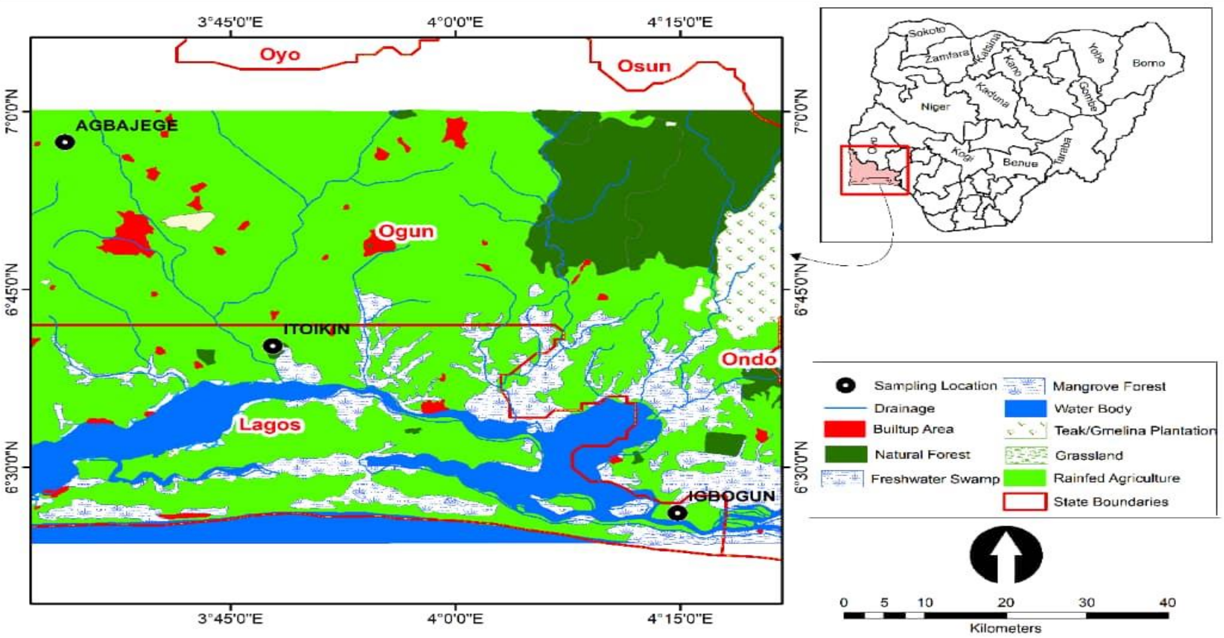


Figure 1: Map of Lagos and Ogun showing the selected rice farms (Source: Arc GIS 10.6.1s)

Samples were taken from 10 random hills per block, while data on the incidence of rice stem borers in rice fields were calculated using dead heart symptoms during the vegetative phase and whiteheads during the reproductive phase. Dead hearts were assessed at 45 and 60 Days after Planting (DAP) during the vegetative and 80 and 95DAP during the reproductive phase (Justin and Pretha,2013). The days of survey could also vary based on the growth duration of the rice variety.

b. Species abundance of Rice stemborer species.

Destructive sampling was carried out on tillers showing dead heart and whiteheads symptoms (Justin and Preetha, 2013). The infested tillers were incised for larval presence. Larvae were carefully removed and dropped in the water at a temperature of about 90º Celsius (Adams and Hall, 2003). They were hot fixed for five minutes to prevent denaturing of their protein as they tend to turn black when ethanol was poured directly on them. This aided easy identification even after they were preserved in 80% ethanol and stored in the refrigerator at 4º Celsius for further studies at the laboratory. The stem borers were identified using keys provided by (Meijerman and Ulenberg, 1996). Species of rice stem borer found were sorted, counted, and recorded. This was expressed in relative abundance as calculated below.

$$\% \text{ Relative abundance} = \frac{\text{Total no of individuals of each species} \times 100}{\text{Total no of individuals species}}$$

Data analysis

Data for the incidence of rice stem borers were analyzed using the independent samples t-test (Welch Test) and the significant difference was tested at 95% confidence intervals using R-software version 3.6.1. Species composition was expressed as relative abundance of rice stem borer using Microsoft Excel version 2010 (Microsoft Office Professional, 2010). A three-way ANOVA was conducted to investigate the effect of location, growth stages and time of planting on the population of striped stem borer and pink stemborer found across the selected fields using OriginPro 9.0 software. Means were separated at $p<0.05$, while Post–hoc tests were carried out using Tukey's Honesty Significant Difference test.

RESULTS

Symptoms indicating the presence of rice stemborers infestations:

The incidences of rice stemborer is indicated by the symptoms observed during survey which include the deadheart symptom, which occurs during the vegetative phase and whiteheads which occurs during the booting/panicle initiation stage and grain filling stage of the reproductive phase (Plate 1).

A: Dead heart symptom

B: White head at panicle initiation stage

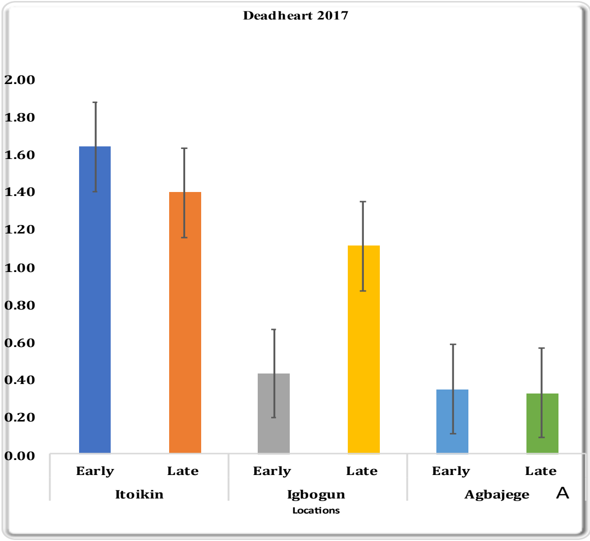
C: An infested tiller

D: Healthy rice panicle

Plate 1(a-d): Symptoms of incidence of rice stem borers and a healthy rice panicle.

Incidence of rice stemborers in the early and late planting seasons (2017)

During the vegetative phase, the presence of rice stemborers were observed via the symptoms across the sites. For % dead heart, the test was not significant at Itoikin, (t=0.8861:df = 18: p = 0.35) and Agbajege, (t= 0.1489: df=10.713: p=0.8844) at p>0.05. While the test was significant at Igbogun rice fields (t=-6.804:df=18: = -6.804: p=0.0000) at p<0.05. The group means indicate that % dead heart was significantly higher during the late planting season when compared to the early planting seasons in Igbogun rice fields (Figure 2a). Similarly, during the reproductive phase of the early and late planting seasons at the three locations, test was only significant at Igbogun (t=-2.1813: df=11.096: p=0.0427) at p < .05 and not significant at Itoikin, (t=-1.6006: df=11.096:p=0.2169,) and Agbajege,(t=-1.4831:df=11.096: p=0.1659) at p > .05. From the means, late-planted rice in Igbogun had a higher significant % whiteheads when compared to the % white heads observed during the early planted rice in the year 2017 (Figure 2b).



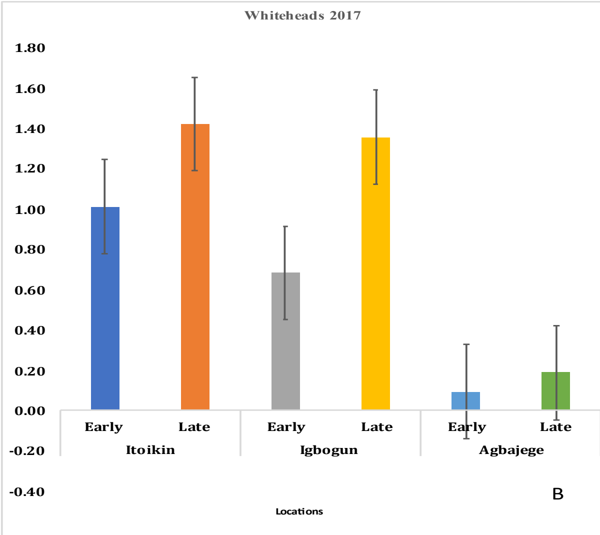


Figure 2 (a-b): Dead heart and white heads symptoms (2017)

Incidence of rice stemborers in the early and late planting seasons (2018)

On the **%** dead heart, a similar trend observed in the year 2017 in Itoikin and Agbajege was also observed in the year 2018 in the two sites. There was no significant difference between the early and late planting seasons in Itoikin (t=1.0811 df=18: p=0.2939) and Agbajege, (t=0.9305:df=11. 784: p=0.3708) at p > .05. while the test was significant in Igbogun (t=-2.866: df=18: p=0.0103) at p < .05. However, an examination of the group means indicate that the % dead heart in the late planting season was significantly higher than the % dead heart observed during the early planting season.

This showed the same trend in the dead heart symptoms when compared to that of the year 2017(Figure 3a). For the % white heads during the early planting season and late planting season at Itoikin, Igbogun and Agbajege in 2018, the test was not significant at Itoikin [t=0.7721:df=12.429: p =0.4545 at p > .05], Igbogun, [t = -0664, df= p:0.9481 at P > .05] and Agbajege, [t=-1.7381:df=12.502: p=0.1067 at p >.05].Hence, there was no significant difference in means of % white heads in early and late planting in Itoikin, Igbogun, and Agbajege in the year 2018. Also on average, % white heads in each Itoikin, Igbogun, and Agbajege in early and late planting season were not significantly different from each other (Figure 3b)

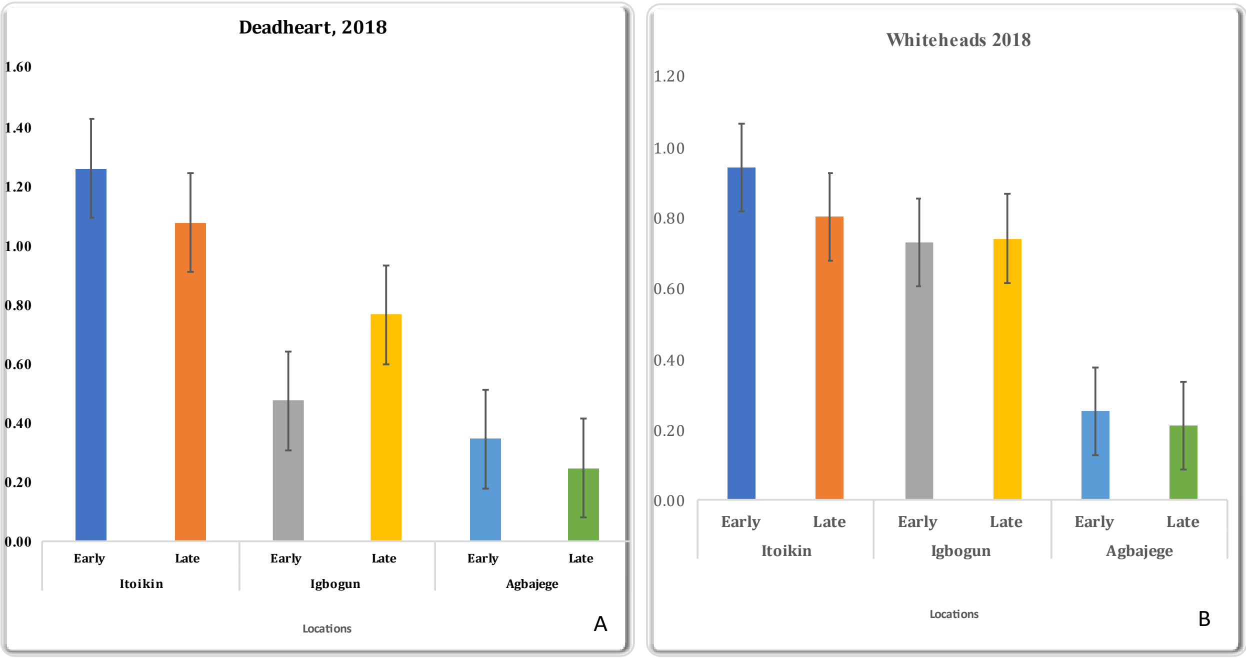
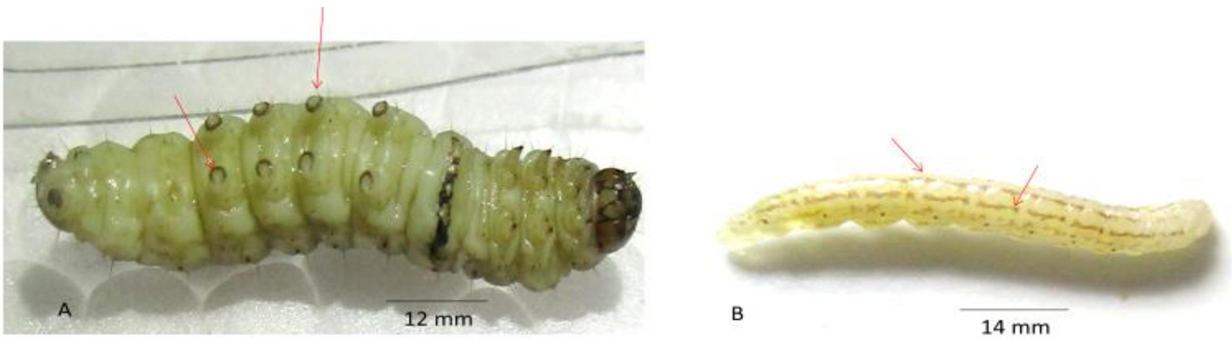


Fig 3 (a-b): Dead heart and white heads symptoms (2018)



A. Arrows showing the arrangement of Crochets on abdominal prolegs biordinal in an incomplete circle (Mesal penellipse)

B: Arrows showing the brownish-red stripes on a newly emerged 4th instar larva of *Chilo zacconius*

Morphotaxonomic keys of *Chilo zacconius*
Reference: Meijerman and Ulenberg, 1996

Plate 2: Morphological identification of *Chilo zacconius* (larval stage)

Larval morphotaxonomy of *Chilo zacconius* and *Sesamia calamistis*

The morphotaxonomic keys of *Chilo zacconius* accessed were the biordinal arrangement of crochets on the abdominal prolegs in an incomplete circle (Mesal penellipse) and the 5 visible reddish-brown stripes on the dorsal part of larvae (Plate 2). While the arrangement of crochets on the proabdominal legs of *Sesamia calamistis* were uniordinal mesoseries, curved to resemble a penellipse (Plate 3).

A: Arrows showing the arrangement of Crochets on the prolegs of *Sesamia calamistis* arranged in uniordinal mesoseries, curved to resemble a penellipse

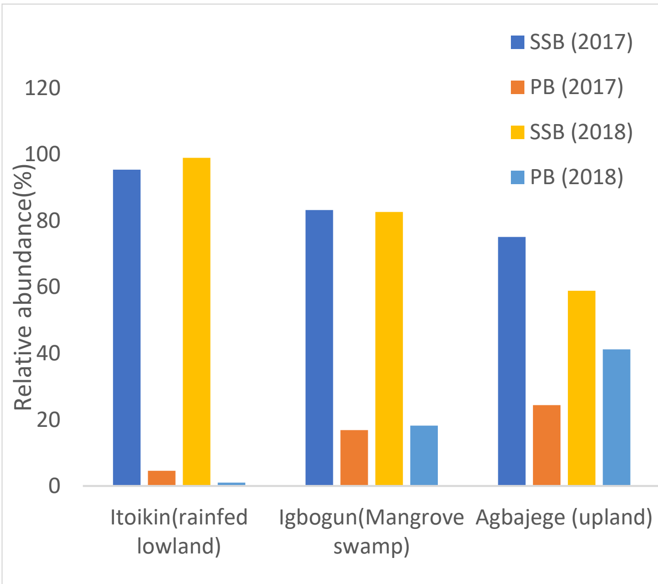
B: Arrow showing the dorsal view of pink stemborer; *Sesamia calamistis*.

Morphotaxonomickeys of *Sesamia calamistis*
Reference: Meijerman and Ulenberg, 1996

Plate 3: Morphological identification of *Sesamia calamistis* (larval stage)

Relative abundance of rice stem borers

The distribution of rice stemborers across the selected rice farms varied within locations, the population of striped stemborer (*C. zacconius*) was significantly higher than that of pink stemborer (*S. calamistis*) across the three sites all through the survey period. In 2017, rainfed lowland in Itoikin(A) had the highest population of *C. zacconius* (95.37%) while *S. calamistis* had the lowest population of 4.62% all through 2017 (Figure 4). Also, in the upland rice field in Agbajege, pink stemborer had the highest population at 24.39% when compared to the two other sites while *C. zacconius* (75.06%) at Agbajege rice field was the lowest when compared to the other study sites (Figure 4). In 2018, pink stemborer population was 1.03% in the rainfed lowland in Itoikin, while 98.96% of rice stemborers found were *Chilo zacconius*, while in Igbogun, the population of *S. calamistis* was 18.18%, while *Chilo zacconius* was 82.2%. Upland rice field in Agbajege had the highest population of pink stemborers at 41.18% compared to other rice fields while *Chilo zacconius* was 58.82% (Figure 4). Total abundance of rice stem borer observed across fields showed a high population of *C. zacconius* (89%) and lower populations of *S. calamistis* (11%) (Figure 5).



Ef **Fig 4: Relative abundance of rice**
po **stemborer**

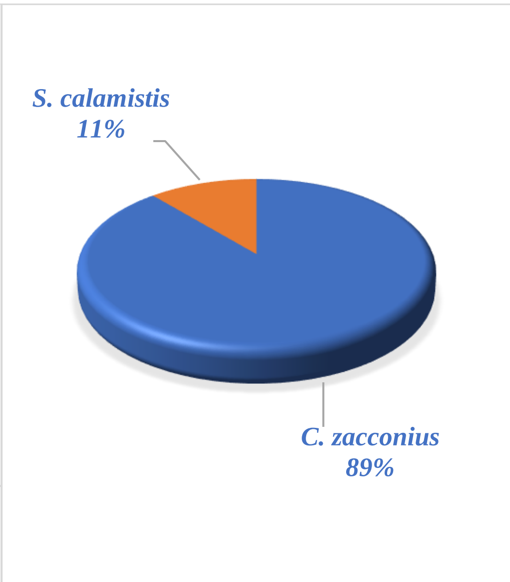


Fig 5: Total population of rice stem borers collected across fields

The effect of location on the population of *C. zacconius* and *S. calamistis* were observed to be significantly different from each other at $p<0.05$(Table 1). Highest population of *C. zacconius* was observed in Itoikin rice field which was significantly different at $p<0.05$ from the population of *C. zacconius* found in Igbogun rice fields. The lowest population of *C. zacconius* was observed in Agbajege rice field (Table 1). Also, a different trend was observed among the *S. calamistis* populations across the three locations, the population of *S. calamistis* found in Agbajege was significantly higher at $p<0.05$ than the populations found in Igbogun and Itoikin. Lowest populations were however found in Itoikin which was significantly different at $p<0.05$ from the population found in Igbogun rice fields (Table 1).

Effect of growth stages on rice stemborer populations

The population of rice stemborers also varied significantly across the growth stages in rice plants, the maximum tillering stage had a significantly lower population of *C. zacconius* at $p<0.05$ when compared to the maturity phase (Table 2). Furthermore, the population of *S. calamistis* was significantly higher at the panicle initiation and maturity phase at $p<0.05$ (Table 2).

Effect of planting times on rice stemborer populations

Time of planting had no significant effect on the population of *C. zacconius* and *S. calamistis* observed across the field (Table 3)

Table 1: Effect of location on rice stemborer populations

Location	*Chilo zacconius*` Means ± SE	*Sesamia calamistis* Means ± SE
Itoikin	7.31 ± 0.88a	0.208 ± 0.07b
Igbogun	4.46 ± 0.45b	1.13 ± 0.26ab
Agbajege	1.06 ± 0.26c	1.55 ± 0.46a
$F_{2,138}$	33.17344	5.36298
P-value	0.000	0.0004

The population means of location are significantly different at $p< 0.05$

Table 2: Effect of growth stages on rice stemborer populations

Growth stages	*Chilo zacconius* Means ± SE	*Sesamia calamistis* Means ± SE
Maximum Tillering	2.23 ± 0.304b	0.00 ± 0.00b
Panicle Initiation	4.50 ± 0.65a	1.23 ± 0.33a
Maturity	6.10 ± 0.88a	1.65 ± 0.41a
$F_{2,138}$	12.85	8.439
P-value	0.000	0.00034841

The population means of growth stages are significantly different at $p<0.05$

Table 3: Effect of planting times on rice stemborer populations

Planting times	*Chilo zacconius* Means ± SE	*Sesamia calamistis* Means ± SE
Early	3.74 ± 0.46	0.93 ± 0.20
Late	4.82 ± 0.66	0.97 ± 0.31
$F_{1,138}$	2.98	0.02668
P-value	0.0864	0.87049

At the 0.05 level, the population means of planting times are not significantly different.

DISCUSSION

The incidence of rice stemborers is indicated by the symptoms observed during the developmental stages in rice plants, these symptoms (dead heart and white heads) could vary during seasons and planting cycles. From this study, several factors played significant roles in the distribution of rice stemborers across the agroecosystems which includes flood, presence/ of nectar crops, pesticides, location and growth stages.

The populations of rice stemborers in Igbogun (mangrove swamp) and Itoikin (rainfed lowland) were observed to be higher than that of the rice field in Agbajege(upland), this is due to the favorable environmental conditions encouraging the proliferation of the rice stemborers in the lowland areas (Alams,1992; Kega *et al.,* 2015). This agrees with Sarwar (2012) and Kega *et al* (2015) that reported a notable increase in stemborer activities under high humid conditions, while Alam *et al* (1984) and Ukwungwu (1984) also reported a similar trend of increased activities among rice stem borers in lowland rice fields in Nigeria. Also, Luo *et al* (2021) reported that *Chilo suppressalis* survived under high water conditions as they tend to move away quickly when compared to *Scirpophaga incertulas* Walker, which further explains the ability of striped stemborer colonizing the late planted rice almost immediately after migrating from the early sown rice and over wintering sites.

Also, the influence of planting dates was significant in Igbogun rice fields, the late sown rice was observed to have a higher incidence rate of rice stem borer infestations compared to the early sown rice. This is due to the coincidence of the planting times with the peak season, in which higher populations of rice stem borers already established during the early planting seasons move to the late-planted rice to feed and continue with their destructive activities (Ukwungwu and Odebiyi 1984; Sarwar 2012; Alfonce and Gration, 2015, Luo *et al*., 2021). Furthermore, the reports of Hugar *et al* (2014) and Shalaby (2018) also agrees that early planted rice had lesser infestations compared with the late planted rice, as most late planted rice had a record of higher incidence of rice stemborers compared to the early sown rice due to a reservoir of pests from the early sown rice crop.

Furthermore, the incidence of rice stem borers in Agbajege, an upland rice field, was observed to be very low during the planting seasons all through the survey period. This could be due to the absence of floods coupled with the presence of nectar plant (*Celosia argentea* and *Celosia flamingoes)* which also doubles as an edible vegetable commonly intercropped with rice plants in this area. There seems to be a possibility of enhancement in the ecological function of the beneficial insects (parasitoids and predators) attracted to the nectar crop, which helps to control the insect pests' activities, which however requires further investigations in future research. This agrees with the report of Brotodjojo *et al* (2019) which stated that nectar crops or refugia plants around farms provide beneficial ecological functions such that natural enemies of rice stem borers and other pests are conserved. Similar reports of Macfadyen et al. (2015) also agrees to the beneficial effects of natural enemies in most cropping systems enhanced by the presence of the nectar plants. Hence, this study suggests that the presence of nectar-producing plants might be one of the possible factors for the lower incidence of rice stem borers observed in Agbajege rice fields. It is also imperative to state that no pesticides were applied during the planting seasons in Agbajege rice fields, hence distribution patterns of insects were not disrupted such that the sequence of colonization followed a natural pattern and this might have aided the reduced population of stem borers observed. Furthermore, floods are not common in Agbajege rice field compared to the other agroecosystems where flood is a major factor for further proliferation of stemborers and other insect pests.

Also, incidence of rice stem borers for both early and late-planted rice in Itoikin were high but not significantly different between the seasons, this may be due to the presence of alternative host plants that serve as a reservoir for the rice stem borers, hence migrating to rice plants during the cropping seasons. Early planted rice also serves as reservoirs of insect pests for late planted rice if appropriate controlled measures are not taken before planting. This agrees with Hugar *et al* (2014) who stated that the severity of the incidence of rice stem borers may be due to the plants harboring them before the planting seasons. The planting times however doubles as the peak period for the rice stem borers in June through August. Conversely, manipulation of planting dates within the wet seasons remains a major challenge in Itoikin, as the seasons overlap under the same conditions unlike that of Igbogun rice fields subjected to an influx of the Lagoon during the planting seasons. This caused an alternation in the level of water in

Igbogun rice fields when compared to standing floods in Itoikin rice fields. Adoption of irrigation systems with controlled water level is essential for the sustainability of the Itoikin rice fields, as well as the inclusion of restorative means of conserving beneficial insects within the fields and environment which can be integrated into insect pest management techniques in rice fields.

Also, due to high prevalence of insect's pests in Itoikin rice fields, chemical pesticides were used indiscriminately for control, which may also be a contributing factor to the high population of rice stemborer observed after treatments. This may be an indicating factor of some level of resistance among pesticides used. Pesticides applications during the early planting seasons was also observed to be more effective when compared to the treatments during the late seasons, this also agrees with the reports of Shalaby (2018) on the effectiveness of pesticides during the early planting seasons.

The study sites further revealed the species of rice stem borers, *C. zacconius* and *S. calamistis* as the predominant rice stemborers present across the three rice fields. *C. zacconius* were highly abundant across all sites, possibly due to their short life cycle which causes the population to build up so rapidly, Alfonce and Gration (2015) and Bonaventure *et al* (2018) reported a similar trend of the high abundance of *C. zacconius* compared to *Sesamia species* in Tanzania. However, this seems to differ from the reports of Alam (1998) who reported *Maliarpha separetella* as the major rice stem borer in Ibadan, Nigeria. Akinsola(1990) reported that *C. zacconius* is polyphagous and tends to attack both cultivated and wild plant species, which further explains, the potential of wild plants serving as reservoirs aiding the quick colonization by *C. zacconius* on rice plants upon planting (Heinrich and Barrion,2004: Ogah and Nwilene, 2017).

S. calamistis occurred in fewer numbers across the rice fields but were more abundant in the upland rice fields in Agbajege where floods were absent all through the survey period, this agrees with the earlier reports of Heinrich and Barrion (2004), on the preference of *Sesamia calamistis* to inhabit the lower internodes where it cuts off the rice plant at the base (Pathak and khan1994). While in lowland and mangrove swamps, few species of *S. calamistis* were found in tillers right above the water levels possibly to avoid drowning.

Furthermore Itoikin, a rain-fed lowland had a significantly higher population of *C. zacconius*, while the maturity phase witnessed the highest abundance of rice stem borer populations. This agrees with Bonaventure *et al* (2018) who reported a higher abundance of rice stem borers during the reproductive stage in rice plants in Tanzania. A similar trend was also reported by Alfonce and Gration (2015) that rice stem borer populations increase with increased tillers, while Muhammad (2012) and Sarwar et al (2010) suggested that the increased diameter observed within the tillers, created more quality food for the rice stem borers during the reproductive phase. It is also important to state that, *C. zacconius* and *Sesamia calamistis* may occur simultaneously on the same tiller during the reproductive phase, while *Chilo zacconius* prefers the upper tiller close to the panicle, *S. calamistis* prefers the lower internode with wider width due to their size, feeding prowess and damage patterns which cuts off the tiller at the base. Also, *S. calamistis* were not found during the maximum tillering phase in the rice field and this agrees to the report of Hamadoun (1992) and Heinrich and Barrion (2004) who reported the presence of *S. calamistis* from the booting phase to the maturity phase. Also, the effect of planting times was observed to have no significant difference among the stemborer populations, when compared to locations and growth stages in rice plants.

CONCLUSION

This study reveals that rice stemborers in rice fields varied across locations and growth stages, rice stem borers are highly abundant in flood-prone areas and in rice fields where pesticides use is inevitable with enabling factors. Among the three sites, Itoikin, a rainfed lowland, had the highest incidence of rice stem borers compared to Igbogun and Agbajege. Incidence of rice stem borers during early and late planting seasons were significant in Igbogun, and they also exhibited some level of fluctuations in the two-year study which is typical of rice stem borer infestations. Hence, monitoring and surveillance remain a key factor in the prompt control of rice stem borers, this will aid a faster decision on how to control the population before they inflict economic damage in farmer's fields. Furthermore, adoption of irrigation systems during the dry season should be considered, this may lower the incidence of rice stemborers which may give better rice yield during harvest. *C. zacconius* was the most abundant compared to *Sesamia calamistis.* The highest population of *C. zacconius* was observed in Itoikin(rainfed lowland) while rice maturity phase had the highest population of rice stem borers across the three sites. Regarding the low incidence rates of rice stem borers observed in upland rice fields in Agbajege, extensive research needs to be done to investigate the possible influence of *Celosia species* on beneficial insects in the rice fields. This could provide a safer alternative that can be integrated into insect pest management in rice fields.

Conflict of interest

The authors have no conflict of interest to declare.

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Availability of data and materials

Data collected and analyzed during the study are available from the corresponding author on reasonable request.

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