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Population Density and Infestation Levels of Fall Armyworm (*Spodoptera frugiperda*) in Maize Fields of Southern Niger State, Nigeria

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Abstract

Fall Armyworm is a notorious insect pest of multiple crops, belongs to the order Lepidoptera and family Noctuidae causing substantial damage to maize. This study evaluated the larval density and infestation levels of Fall Armyworm in maize fields located in Southern Niger State, Nigeria. Sampling for larval abundance and infestation levels on maize farms were conducted during 2023 cropping season across selected maize-producing communities. Results revealed that, significant variations in larval abundance and infestation levels among locations. Mean larval abundance ranged from 4.26±0.04 per 10 maize plants in Lavun Local Government Area (LGA) to 7.97±0.28 per 10 maize plants in Gbako Local Government Area (LGA) with mean average of 6.69 larvae/10 plant during the vegetative stage while during the reproductive stage of the maize, the mean larval abundance ranged from 3.17±0.33 in Lavun LGA to 6.27±0.05 in Gbako LGA with mean average of 5.05 larvae/10 plants. Mean larval abundance ranged from 2.48±0.25 in Lavun LGA to 4.86±0.98 per 10 maize plants in Gbako LGA with mean average of 3.33 larvae/10 plant during the harvest stage. The maize fields in Gbako LGA recorded the highest infestation of 40.97%, followed by infestation rate of 38.19% in maize fields of Katcha LGA

while the lowest (20.84%) infestation was recoded in maize fields of Lavun LGA. This study provide baseline information on larval abundance and infestation levels of FAW and highlight the need for effective monitoring and integrated pest management strategies.

Keywords: Fall Armyworm, Population density, Infestation, Maize, Niger State

1. Introduction

1.1 Background of the Study

Maize (*Zea smays* L.) is one of the most important cereal crops in Nigeria and worldwide, ranking third after rice and wheat in terms of global production and consumption (FAO, 2024). Maize is an annual plant, which forms the backbone of the world's food security since it is consumed by humans and cattle, as well as a source of industrial raw materials for the manufacturing of bioproducts like oil, alcohol, and starch (Bakry and Abdel-Baky, 2023). Many serious species of insect pests are attacking maize plants at different growth stages (Bakry and Abdel-Baky, 2023). The Fall Armyworm (FAW), *Spodoptera frugiperda* (Smith) is considered one of the most invasive, serious, and destructive insect species that invaded corn crops in Nigeria and other world countries recently. *S. frugiperda* larvae feed voraciously on stems and leaves of over eighty plant species (i.e., maize, sorghum, sugarcane, as well as, other vegetables and crops) which induce great damage (Dahi *et al*., 2020). Although Fall Armyworm (FAW) is highly polyphagous and can infest numerous host plants, maize remains its most preferred host for feeding, development, and reproduction (Tao *et al.,* 2024). The females of FAW oviposit their eggs in groups (egg masses) on the adaxis and the abaxis surfaces of the leaves. Each egg mass had 150-200 eggs/group in either single or multiple masses (Tendeng *et al*., 2019). FAW larvae cause substantial leaf feeding as well as direct ear damage (Bessin, 2019). New hatching larvae feed on cereal crop leaves by scrapping chlorophyll, which leads to a silvery transparent

membrane in the initial stage, ultimately resulting in white elongated patches. The larvae in the early stage consume the leaf epidermis from both sides (Bakry and Abdel-Baky, 2023), causing holes as a result of their feeding (Sisay *et al*., 2019). *S. frugiperda* infestations resulted in the yield losses of 15% to 73% when 55% to 100% of the plants were infested at various stages of development (Panigrahi *et al.,* 2023). The annual maize production losses attributable to Fall armyworm infestation in Africa have been estimated to ranged from 8.3 and 20.6 million tone in the absence of effective control measures (Day *et al*. (2017). Insect populations experience fluctuations as a consequence of shifts in ecological factors such as competition intensity, predator abundance, resource availability, and weather conditions (Abarca and Spahn, 2021). In Nigeria, the first observation on Fall Armyworm attacks was made on maize plants in the rain forest of South West Nigeria in late January 2016 and in IITA maize fields in Ibadan and a farm in Ikenne (Omoregie *et al.,* 2023) and this spread to other part of Nigeria thereby causing infestation to maize crops. Accurate information on the abundance and infestation patterns of FAW is essential for the development of sustainable management strategies (Ojumoola and Omoloye, 2023). Such information supports farmers and extension personnel in implementing timely and effective interventions to minimize crop damage and yield losses. Despite the widespread presence of Fall armyworm in Nigeria, data on its population status in Southern Niger State, Nigeria remain scarce. Therefore, the study was conducted to determine the Fall Armyworm abundance and level of infestation in maize and this will provide baseline information which will facilitating the formulation of eco-friendly management tactics to manage Fall Armyworms in maize.

2. Materials and Methods

2.1 Description of the study Area

The study on Fall Armyworm larval abundance and infestation in maize fields was conducted in four communities in each of three selected Local Government Area (LGA) in Southern Niger State, Nigeria. The Southern Niger State is located in Guinea savannah lies between latitude 8.194410- 9.746881^{0}N and longitude 4.593107-6.834949^{0}E. The region experiences two distinct seasons, dry and rainy season with annual rainfall of about 1,600mm falling between mid April to October with its peak in August and dry season between November to March. The average monthly temperature ranges from 23^{0}C to 29^{0}C

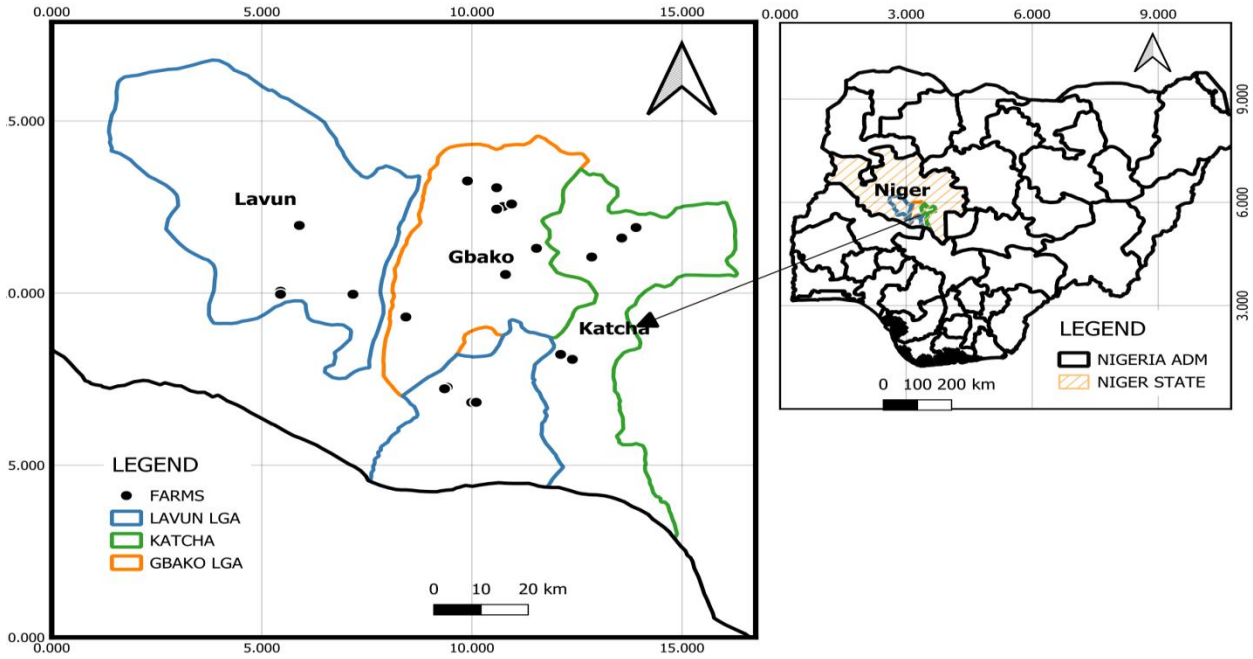


Figure 1: Location of the Sampling Sites

2.2 Experimental Design, Sampling Procedures and Data collection

Field survey on incidence of Fall Armyworm larvae and infestation in maize fields was conducted in twenty-four maize farms (Not less than one hectare) in the study area (8 maize

farms in each of the study Areas (Lavun, Gbako and Katcha Local Government) between May and August 2023 and four communities were selected from each of the three Local Government. Three spots measuring 3m x 3m were randomly selected from each maize farm and ten maize plants were randomly selected from each spots. Number of live FAW larvae collected were counted, preserved in 70% alcohol for identification using the method described by Prasanna *et al*. (2018). Larval density was expressed as: Population Density = Total Number of Larvae counted /Total Number of plants. Examined Infestation caused by Fall Armyworm to the maize plants in 10 randomly selected maize plants from each spot were recorded, percentage infestation level was determined. $\%\ \text{Level of infestation} = \frac{Number\ of\ infested\ plants}{Total\ number\ of\ plants\ inspected} \times 100$

2.3 Statistical Analysis

The larval abundance and infestation data acquired through survey, were subjected to ANOVA using a computer software, Statistics 8.1 while means were compared through Turkey's HSD test at $P = 0.05$.

3. Results

3.1 Population density of Fall armyworm (*Spodoptera frugiperda*) among the three life growth stages in maize plants in selected Local Government Area of Southern Niger State

The mean population density of FAW (*Spodoptera frugiperda*) among the three life growth stages in maize plants in selected LGA of Southern Niger State are detailed in Table 1. Mean larvae abundance of Fall Armyworm in Southern Niger State was found between the ranged of 2.48 – 7.97 per 10 maize plants in all the three life stages of maize. Mean larvae abundance of Fall Armyworm on maize was highest (7.97±0.28) in Gbako LGA and lowest (4.26±0.04^{c}a) in Lavun LGA. The maize farms in Katcha LGA, however, had an intermediate mean larvae abundance (7.84±2.11). Mean larvae abundance of Fall Armyworm on maize farms was

significantly higher ($p < 0.05$) in Gbako LGA than Lavun LGA but there was no significantly different ($p > 0.05$) between the mean larvae abundance of Fall Armyworm in maize farms of Gbako LGA and Katcha LGA during vegetative growth stage of maize. Similar results were also obtained during reproductive growth stage of maize, which recorded 6.27±05, 5.70±1.06 and 3.17±0.33 mean larvae abundance of Fall Armyworm in Gbako, Katcha and Lavun LGA respectively. Mean larvae abundance of Fall Armyworm ranged between 2.48±0.25 and 4.86±0.98 were recorded during the harvest or matured growth stages of maize in the study areas with highest mean larvae of 4.86±0.98/10 plants were recorded in maize field of Gbako LGA.

Table 1: Mean population density of Fall armyworm among the three life growth stages in maize plants in selected Local Government Area of Southern Niger State

Maize growth stages	Selected Local Government Area			Mean
	Lavun	Katcha	Gbako	average
Vegetative	4.26±0.04[a]	7.84±2.11[b]	7.97±0.28[b]	6.69
Reproductive	3.17±0.33[a]	5.70±1.06[b]	6.27±0.05[b]	5.05
Harvest	2.48±0.25[a]	2.67±0.17[a]	4.86±0.98[b]	3.33
Mean average	3.30	5.40	6.37	5.02

(n=10) Values are presented in mean ± standard error of mean for three replicates

*Values followed with the same super-script alphabet along the same row are not significantly different at $p \leq 0.05$

3.2 Population density of Fall armyworm (*Spodoptera frugiperda*) among the three life growth stages in maize plants in selected communities of Lavun Local Government.

Table 2 shows population density across the three life growth stages in maize plants in specific Lavun LGA communities. The findings revealed that Fall Armyworm larvae were present in

every corn field examined. The findings varied significantly ($P < 0.05$) between the communities and the three periods of maize life growth. The Batati community's maize fields had the highest mean larvae abundance of FAW per ten maize plants (5.15±0.82), followed by the Kutigi community's maize fields (4.48±0.58). The mean larval density in the maize fields of the Doko and Jima communities, which recorded the mean larvae abundance of FAW 4.02±1.34 and 3.37±1.20, respectively, per 10 plants during the vegetative stage of maize, did not differ significantly ($P > 0.05$). In all of the farms surveyed, the mean larval abundance of FAW declines between the reproductive and harvest/matured stages; there was no significant difference ($P > 0.05$) between the maize fields in the villages of Doko and Jima. During the vegetative, reproductive, and harvest stages, the average number of larvae per ten plants was 4.26, 3.17, and 2.48, respectively.

Table 2: Mean population density of Fall armyworm among three life growth stages in maize plants in selected communities of Lavun Local Government, Niger State

Maize growth stages	Selected communities in Lavun Local Government				Mean average
	Doko	Jima	Kutigi	Batati	
Vegetative	4.02±1.34^{b}	3.37±1.20^{ab}	4.48±0.58^{b}	5.15±0.82^{ba}	4.26
Reproductive	2.80±0.76^{a}	2.93±1.02^{a}	3.00±1.01^{ab}	3.93±1.29^{b}	3.17
Harvest	2.63±0.67^{a}	2.04±0.57^{a}	2.69±0.33^{a}	2.56±0.28^{a}	2.48
Mean average	3.15	2.78	3.39	3.88	3.30

(n = 10) *Values followed with the same Subscript alphabet along the same row are not significantly different at $p \leq 0.05$

3.3 Population density of Fall armyworm (*Spodoptera frugiperda*) among the three life growth stages in maize plants in selected communities of Gbako Local Government

Table 3 displays the population density of FAW across the three life history stages in maize plants in a subset of Gbako Local Government villages. The findings show that during the vegetative maize growth stage, there was no significant difference ($p > 0.05$) in the mean larvae abundance between 7.65±1.39 and 8.37±0.51 per 10 maize plants on the farms of different communities in Gbako LGA. There was no significant different ($p > 0.05$) among the mean larvae abundance recorded during the reproductive maize growth stage except the mean larvae abundance recorded in Edozhigi community (5.09±1.11). The lowest mean larvae abundance, ranging from 4.06±0.91 to 5.46±0.74 per 10 maize plants, was found in all communities in Gbako LGA. The mean larvae abundance throughout the three life growth stages of maize was substantially different ($p < 0.05$) from each other. During the vegetative, reproductive, and harvest stages, the average number of larvae per ten plants was 7.97, 6.27, and 4.86, respectively.

Table 3: Mean population density of Fall armyworm (*Spodoptera frugiperda*) among three life growth stages in maize plants in selected communities of Gbako Local Government

Maize growth stages	Selected communities in Gbako Local Government				Mean Average
	Lemu	Akote	Etsu Audu	Edozhigi	
Vegetative	8.37±0.51^{a}	7.96±0.38^{a}	7.89±1.43^{a}	7.65±1.39^{a}	7.97
Reproductive	6.98±0.71^{b}	6.48±1.08^{b}	6.54±1.03^{b}	5.09±1.11^{a}	6.27
Harvest	4.59±0.97^{ab}	5.33±0.70^{ab}	5.46±0.74^{ab}	4.06±0.91^{a}	4.86
Mean average	6.65	6.59	6.63	5.60	6.37

(n = 10) Values are presented in mean ± standard error of mean for three replicates
*Values followed with the same Subscript alphabet along the same row are not significantly different at $p \leq 0.05$

3.4 Population density of Fall armyworm (*Spodoptera frugiperda*) among the three life growth stages in maize plants in selected communities of Katcha Local Government

Population density of FAW (*Spodoptera frugiperda*) among the three life growth stages in maize plants in selected communities of Katcha LGA are presented in Table 4. This results showed that, mean larvae abundance of FAW ranging between 7.37±0.56 - 8.35±0.64 in all the communities of Katcha LGA during the vegetative stage of maize growth. Mean larvae abundance of 5.20±0.76 - 6.30±0.15 and 2.41±0.21 - 3.19±0.50 per 10 maize plants were also recorded during reproductive and harvest stages respectively in all the communities. There was no significant different ($p > 0.05$) among the mean larvae abundance in all the communities and in all the three stages of maize growth in Katcha LGA. The mean average of 7.84, 5.70 and 2.67 larvae/ 10 plants were recorded during vegetative, reproductive and harvest stage respectively.

Table 4: Mean population density of Fall armyworm (*Spodoptera frugiperda*) among three life growth stages in maize plants in selected communities of Katcha Local Government

Maize growth stages	Selected communities in Katcha Local Government				Mean
	Katcha	Badeggi	Kataeregi	Bisanti	Average
Vegetative	8.28±0.43[a]	7.37±1.11[a]	8.35±0.64[a]	7.37±0.56[a]	7.84
Reproductive	6.30±0.15[a]	5.20±0.76[a]	5.43±0.35[a]	5.87±0.37[a]	5.70
Harvest	3.19±0.50[a]	2.41±0.21[a]	2.65±0.36[a]	2.43±0.18[a]	2.67
Mean average	5.92	4.99	5.48	5.22	5.40

n = 10 Values are presented in mean ± standard error of mean for three replicates
*Values followed with the same Superscript alphabet along the same row are not significantly different at $p \leq 0.05$

3.5 Percentage infestation levels of Fall Armyworm in maize growth stages of Southern Niger State

The percentage infestation of Fall Armyworm in maize growth stages of southern Niger State are presented in figure 2. Results showed that, the highest infestation of FAW in maize fields was observed during the vegetative stage in all the maize fields of the study Areas recording above 34% infestations. However, the maize fields in Gbako LGA recorded the highest infestation of 40.97%, followed by infestation rate of 38.19% in maize fields of Katcha LGA while the lowest (20.84%) infestation was recorded in maize fields of Lavun LGA.

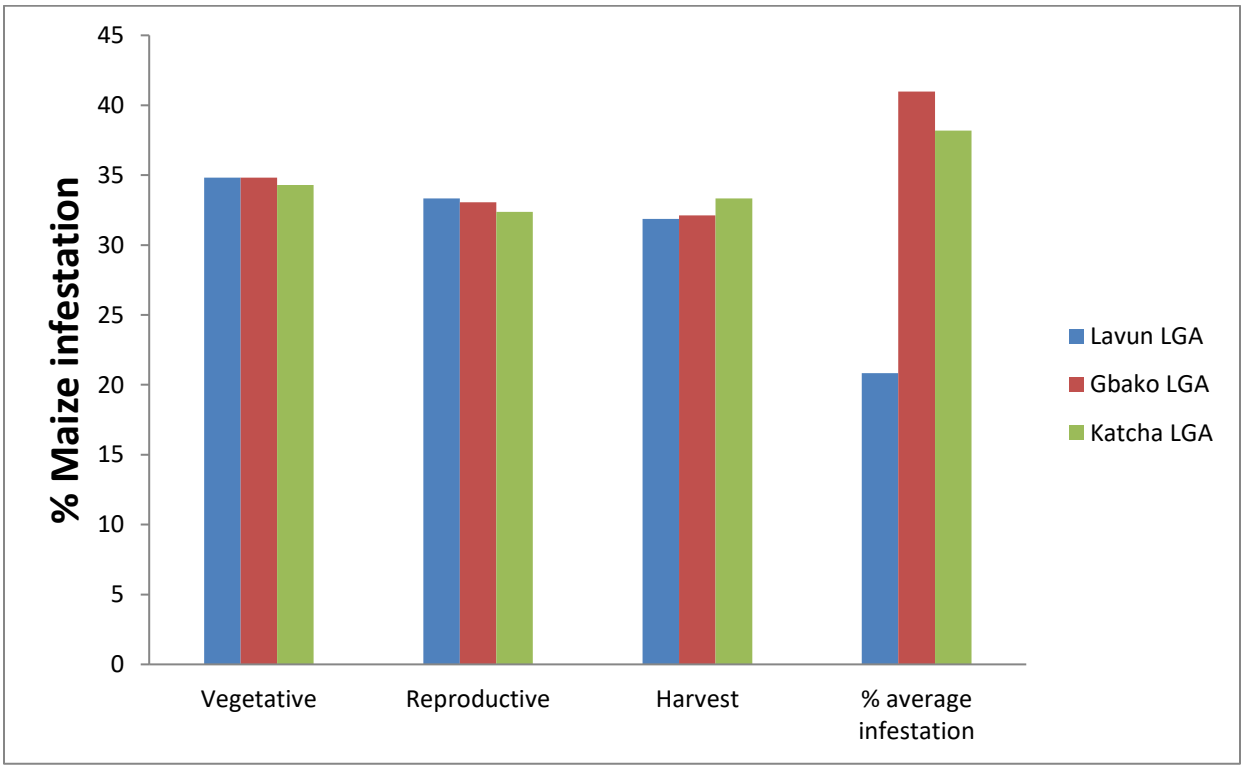


Figure 2: Percentage infestation of Fall Armyworm in maize growth stages in Southern Niger State Nigeria

4. Discussion

All of the maize farms assessed in the three chosen LGAs of Southern Niger State, Nigeria, had FAW and the spatial variation in population density and infestation levels recorded in this study

may reflect differences in farming practices, weather conditions, and management strategies adopted by farmers. The capacity of adult FAW to travel over great distances may be the reason for their presence in every maize farms in the chosen LGA. According to Nagoshi *et al*. (2017), FAW's ability to fly up to 100 kilometers every night may be the reason for its prevalence in all agro-ecological sites. The majority of the maize plants surveyed had a maximum of two larvae per plant, which may be related to the FAW larva's cannibalistic behavior. According to Dhobi *et al*. (2020), the cannibalistic behavior of FAW caterpillars ultimately caused their densities to drop to one or two per plant. The cannibalistic behavior of Fall armyworm larvae in their fifth and sixth instars was documented by Deole and Paul (2020). They found that the prevalence of cannibalism in these larvae is considerably higher than in earlier instars. Fall armyworm larvae are more prevalent during early maize planting, which corresponds with low rainfall, and less prevalent throughout the reproductive and mature stages of maize, which correspond with high rainfall. This suggests that the mean larval abundance is positively correlated with light rainfall and negatively correlated with heavy rainfall. The data analysis results demonstrated that the presence of FAW varies significantly in each research location ($P < 0.05$). This variation in the level of Fall Armyworm incidence might be due to differences in weather parameter (Rainfall, temperature and relative humidity), differences in cultural practice of farming and sowing date. Darshan *et al.* (2024) reported that, variation in the level of Fall Armyworm incidence might be due to, difference in cultural practices, sowing date of maize in all the farms surveyed, disparity among cultivars used, distribution of weather elements (temperature, rainfall and relative humidity) coupled with geographical variation and edaphic factors which may have the direct impact on the level of fall armyworm infestation. The effect of climatic factors on Fall armyworm incidence was observed by Darshan *et al.* (2024) who reported that heavy rainfall

was detrimental to the pest, as water droplets accumulating in maize whorls caused larval suffocation and increased mortality. Fall armyworm caused infestations at all stages of growth of the maize plants but infestations were high during the vegetative growth stage in almost all the study areas, this might be the age of the maize plants or preference of FAW feed on succulent portion of the leaves of maize plant which affect the photosynthetic activities of the plant and led to reduction of crop yield. Odeyemi *et al.* (2020) observed that, the attack by FAW was found to cut across the various growth stages of the maize plants (leaves, tassels and cobs) and larvae of FAW may have preference for younger plants probably, because of their succulent nature, thereby reducing the photosynthetic potentials, the general plant growth and development, which may consequently lead to yield reduction. In Southern Niger State, Nigeria, 56.2% of maize fields are infested with Fall Armyworm, which could reduce productivity. According to Panigrahi *et al*. (2023), yield loss ranged from 15% to 73% when 55% to 100% of the plants were affected at different stages of growth. These findings emphasize the importance of regular scouting and timely intervention to prevent population buildup and minimize economic losses.

5. Conclusion

The study verified that Fall Armyworm larvae were abundant in infesting maize fields, with the highest populations occurring during the vegetative growth stage. Increased larval density was associated with greater crop damage, highlighting the need for effective monitoring and evaluate seasonal population dynamics of Fall armyworm..

Clinical trial Number:

Not applicable

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Authors contributions.

Cece, M. A: collection of the data,, writing the first draft, Olayemi, I. K: Conceptualized the idea, methodology, validation, Salaudeen, M. T: Supervision, writing original draft, writing review, Ukubuiwe, A. C: writing review and editing, Salihu, I. M: Conduct data analysis and revised second draft.

Consent for publication

All the authors agreed that the submitted work has not been published previously, that the work is not under consideration for publication elsewhere and that all authors agreed to the publication of this work

Conflict of interest

All the authors has agreed that, there is no conflict of interest,

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Data availability

All data supporting the findings of this study are available within the paper

Animal ethic declaration:

Not applicable

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