International Journal of Pharmaceutical Science Invention
ISSN (Online): 2319-6718, ISSN (Print): 2319- 670X
www.ijpsi.org Volume 15 Issue 6 ‖ Jan. – Feb., 2026 ‖ PP. 01-11

Larval eating capacity of indigenous larvivorous fishes against larvae of *Culex quinquefasciatus* Say in field experimental conditions in south-western Republic of Benin, West Africa

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Abstract

Background: *Because of problems with insecticide resistance, alternative vector control methods are necessary. These methods include the use of biological control agents, such as larvivorous fishes.*

Objective: *This study aimed to study the larval eating capacity of indigenous larvivorous fishes against larvae of Culex quinquefasciatus Say in field experimental conditions in south-western Republic of Benin, West Africa.*

Material and Methods: *Larvae of Culex quinquefasciatus mosquitoes were collected from breeding sites using the dipping method from September to November 2024 during the small rainy season and from the March to July 2025 during the great rainy season. Alive local Clarias gariepinus fish and alive exotic fishes adapted to local life conditions Oreochromis mossambicus and Oreochromis niloticus were bought immediately once catched and carried by car from Agricultural Technical Lyceum of Adjahonmè to the Department of Sciences and Agricultural Techniques located in Dogbo district in Normal High School of Technical Teaching (ENSET) of Lokossa. Field experimental evaluation for larvivorous efficacy was conducted with unfed fishes weighed 30g, 40g and 50g respectively in swamp water and in pond water.*

Results: *The results showed that Clarias gariepinus fish ate more larvae of Culex quinquefasciatus than Oreochromis mossambicus and Oreochromis niloticus fishes for the different weights tested.*

Conclusion: *Good results were obtained in field experimental conditions regarding the use of the larvivorous fishes against larvae of Culex quinquefasciatus in the current study.*

Key words: *Larvivorous fish, larvae of Culex Quinquefasciatus, biological control, field experimental conditions, Republic of Benin*

Date of Submission: 03-01-2026 Date of acceptance: 11-01-2026

I. Introduction

Culex quinquefasciatus Say is a nocturnal mosquito that is involved in the transmission of vector-borne pathogens (e.g., West Nile virus, *Wuchereria brancrofti*) and is a nuisance in areas where it is not involved in pathogen transmission (Farajollahi *et al.* [1], Turell [2]). This mosquito is distributed in tropical and subtropical areas of the world, particularly in urban areas (Mattingly [3]). *Culex quinquefasciatus* takes advantage of improper disposal of sewage water above or below ground in urban areas to oviposit and undergo immature development (Barrera *et al*. [4], Burke *et al.* [5], Chaves and Kitron [6], Correia *et al.* [7], Mackay *et al.* [8]). *Culex quinquefasciatus* and *Aedes aegypti* (L.) have widespread distribution in urban areas and some studies have shown that the abundance of these species is correlated (Barrera *et al.* [9], Ng *et al.* [10], Smith *et al*. [11]). Given the public health importance of these mosquitoes and the need to monitor their presence and abundance, it would be advantageous to use a same monitoring device that could efficiently track both species.

Current researches have to explore several alternative avenues of controlling the bites of adult *Culex quinquefasciatus*, and one particular approach that appears to be gaining attention is an environmental management strategy that aims to reduce adult vector population by targeting their aquatic immature stages (i.e., mosquito eggs, larvae and pupae).

Among the biological control agents of mosquitoes, fishes are the most extensively used species in several countries since the beginning of the twentieth century (Gerberich and Laird [12]). Certain exotic fishes such as *Poecilia reticulata, Gambusia affinis* and *Oreochromis mossambicus* have been used in various ecological conditions in India for mosquito control (Sitaraman *et al*. [13], Chand and Yadav [14], Prasad *et al.* [15]). Use of these exotic fish has raised environmental concerns in view of their suspected adverse effects on local aquatic fauna (Hulbert *et al*.[16]). Consequently, fish fauna surveys and evaluation of larvivorous potential of native fishes have been of high research priority in the area of biological control of vectors of disease.

The goal of the current study was to evaluate the larval eating capacity of indigenous larvivorous fishes against larvae of *Culex quinquefasciatus* Say in field experimental conditions in south-western Republic of Benin, West Africa in a context where integrated vector control is necessary.

II. Material and methods

Study area

The study area is located in Republic of Benin (West Africa) and includes the departments of Mono and Couffo. Mono department is located in the south-western Benin and the study was carried out more precisely in Lokossa and Comè districts. Regarding Couffo department, it is also located in the south-western Benin and the study was carried out more precisely in Dogbo and Djakotomey districts (Figure 1). The choice of the study site took into account the economic activities of populations, their usual protection practices against mosquito bites, and peasant practices to control farming pests. We took these factors into account to evaluate the larval eating capacity of indigenous larvivorous fishes against larvae of *Culex quinquefasciatus* Say in field experimental conditions in south-western Republic of Benin. Mono and Couffo have a climate with four seasons, two rainy seasons (March to July and August to November) and two dry seasons (November to March and July to August). The temperature ranges from 25 to 30°C with the annual mean rainfall between 900 and 1100 mm.

Figure 1: Map of Republic of Benin showing departments surveyed

Mosquito sampling

Culex quinquefasciatus mosquito larvae were collected from September to November 2024 during the small rainy season and from March to July 2025 during the great rainy season in two districts of Mono department (Lokossa and Comè) and in two districts of Couffo department (Dogbo and Djakotomey). Larvae were collected from breeding sites using the dipping method (O' Malley [17]) and kept in labeled bottles (Figure 2). The samples were then carried out to the Department of Sciences and Agricultural Techniques in Normal High School of Technical Teaching (ENSET) of Lokossa located in Dogbo district (Figure 3).

Figure 2: Mosquito larvae collection in a breeding site **Figure 3:** Larvae in labeled plastics in insectary

Fish collection

Alive local *Clarias gariepinus* fish and alive exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* were bought immediately once catched in Agricultural Technical Lyceum of Adjahonmè. They were then weighed. For each specie, the different considered weights were: 30g, 40g and 50g.Then, fishes bought were put in some jars contained water with oxygen and carried by car from Agricultural Technical Lyceum of Adjahonmè to the Department of Sciences and Agricultural Techniques located in Dogbo district in south-western Benin.

Figure 4 : *Oreochromis niloticus* **Figure 5:** *Oreochromis mossambicus*

Figure 6: *Clarias gariepinus*

Field experimental evaluation for larvivorous fish efficacy

To determine the natural propensity of the samples of local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* to prey upon mosquito larvae, field experimental evaluation was conducted on larvae of fourth instar of the mosquito specie, *Culex quinquefasciatus*. One fish of the same specie of each type was released in each of four rectangular piscicultural basins of same dimensions (Dimensions: Length = 0,70 meter ; Breadth = 0,30meter ; Height = 0,25meter) contained each 1liter of water. At each range of four rectangular piscicultural basins corresponded a rectangular piscicultural basin (without fish) containing only mosquito larvae as control for biological tests. The different water qualities tested were: swamp water and pond water. These small basins in beton were built in the field of the Department of Sciences and Agricultural Techniques. This experimental dispositive was protected during the period of larvivorous fish efficacy evaluation. A batch of one hundred (100) larvae of four instars reared in the insectary of the Laboratory was added in each rectangular piscicultural basin for the fish in the morning at 8 a.m and larval consumption was observed every two hours. The field experimental evaluation for larvivorous fish efficacy was done for each specie of fish for the different weights of 30g, 40g and 50g. Total larval consumption was recorded at the end of 24 hours when all remainder larvae removed. The test was done to establish the maximum devouring capacity of the fishes when there were in swamp water comparatively to when there were in pond water.

Figure 7: Field experimental evaluation for larvivorous fish efficacy in progress

Statistical analysis

The data collected in the current study were analyzed with the logiciel SPSS software (version 10 pour windows, SPSS inc. Chicago, IL) and ANOVA.

III. Results

Larval eating capacity of indigenous larvivorous fishes of 30g on larvae of *Culex quinquefasciatus* in swamp water

The analysis of figure 8 showed that the number of *Culex quinquefasciatus* larvae introduced in the control rectangular piscicultural basins was intact during all the duration of the test. After the introduction of unfed larvivorous fishes which were local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* which weighed 30g in each of the four rectangular piscicultural basins, the number of larvae of *Culex quinquefasciatus* was intact at initial time (t=0hour). The number of larvae of *Culex quinquefasciatus* was reduced at middle time (t=12hours) in all rectangular piscicultural basins and became 32, 51 and 68 larvae for *Clarias gariepinus, Oreochromis mossambicus* and *Oreochromis niloticus s*respectively. At the end of the test (t = 24hours), there was no larvae in the all test rectangular piscicultural basins which contained *Clarias gariepinus* ($P > 0.05$), but there were a few larvae in test rectangular piscicultural basins which contained *Oreochromis mossambicus* and *Oreochromis niloticus,* 19 and 52 respectively.

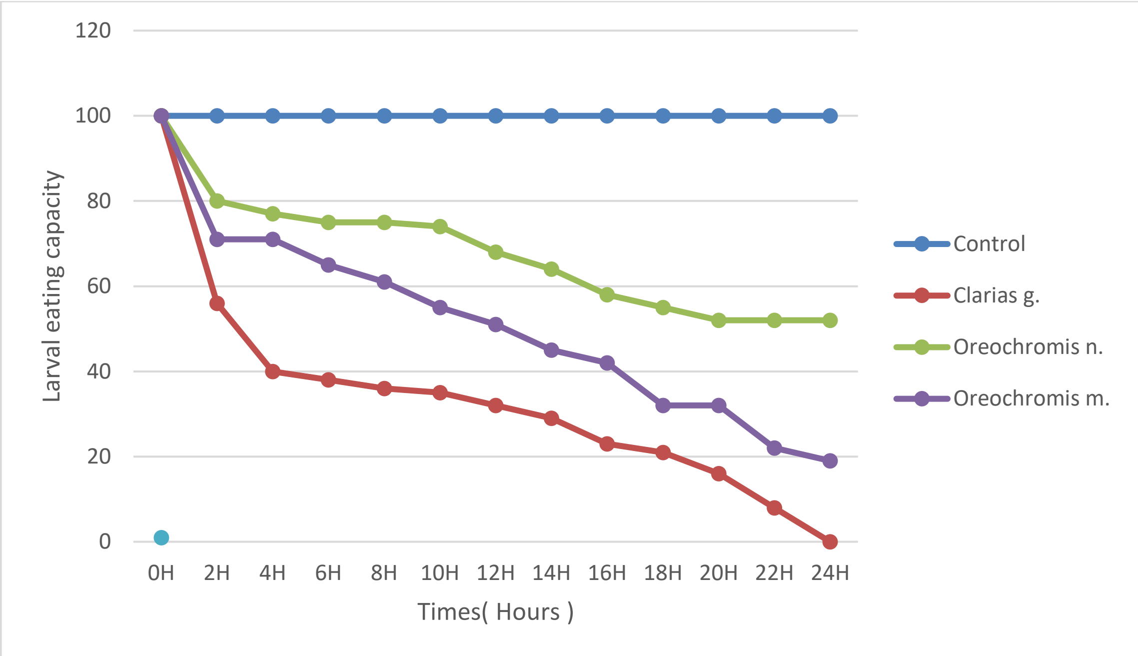

Figure 8: Larval eating capacity of unfed indigenous larvivorous fishes of 30g on larvae of *Culex quinquefasciatus* in swamp water

Larval eating capacity of indigenous larvivorous fishes of 40g on larvae of *Culex quinquefasciatus* in swamp water

The analysis of figure 9 showed that the number of *Culex quinquefasciatus* larvae introduced in the control rectangular piscicultural basins was intact during all the duration of the test. After the introduction of unfed larvivorous fishes which were local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* which weighed 40g in each of the four rectangular piscicultural basins, the number of larvae of *Culex quinquefasciatus* was intact at initial time (t=0hour). The number of larvae of *Culex quinquefasciatus* was reduced at middle time (t=12hours) in all rectangular piscicultural basins and became 1, 24 and 52 larvae for *Clarias gariepinus, Oreochromis niloticus* and *Oreochromis mossambicus* respectively. At the end of the test (t = 24hours), there was no larvae in the all test rectangular piscicultural basins which contained *Clarias gariepinus* and *Oreochromis niloticus* ($P > 0.05$), but there were 30 larvae in test rectangular piscicultural basins which contained *Oreochromis mossambicus*.

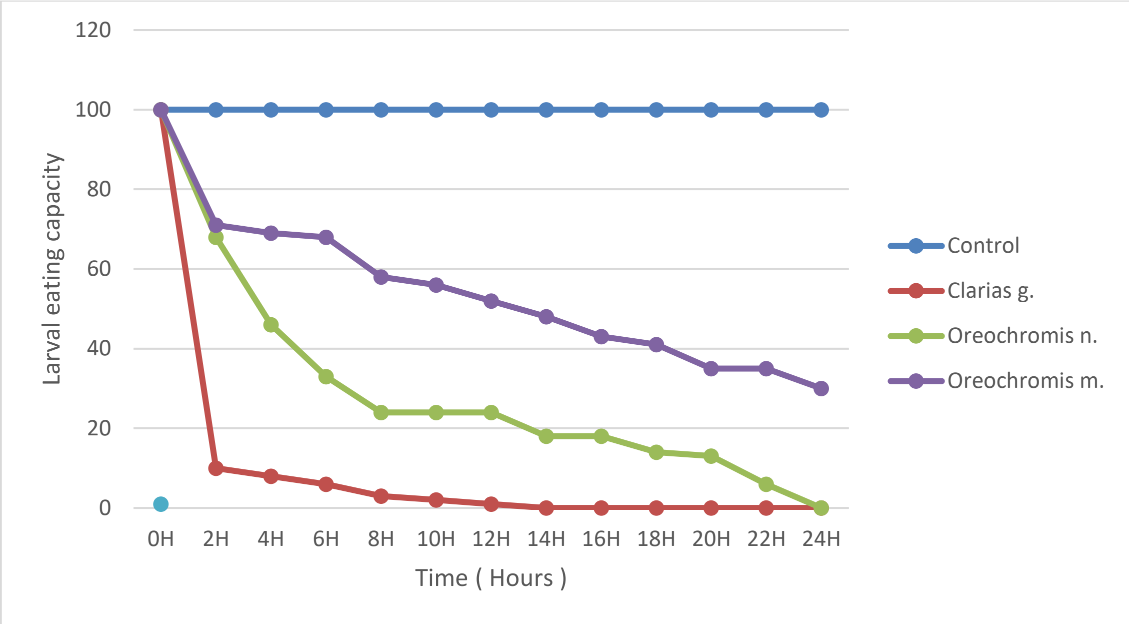

Figure 9: Larval eating capacity of unfed indigenous larvivorous fishes of 40g on larvae of *Culex quinquefasciatus* in swamp water

Larval eating capacity of indigenous larvivorous fishes of 50g on larvae of *Culex quinquefasciatus* in swamp water

The analysis of figure 10 showed that the number of *Culex quinquefasciatus* larvae introduced in the control rectangular piscicultural basins was intact during all the duration of the test. After the introduction of unfed larvivorous fishes which were local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* which weighed 50g in each of the four rectangular piscicultural basins, the number of larvae of *Culex quinquefasciatus* was intact at initial time (t=0hour). The number of larvae of *Culex quinquefasciatus* was reduced at middle time (t=12hours) in all rectangular piscicultural basins and became 1, 38 and 41 larvae for *Clarias gariepinus, Oreochromis mossambicus* and *Oreochromis niloticus s*respectively. At the end of the test (t = 24hours), there was no larvae in the all test rectangular piscicultural basins which contained *Clarias gariepinus* and and *Oreochromis niloticus* ($P > 0.05$), but there were only 3 larvae in test rectangular piscicultural basins which contained *Oreochromis mossambicus.*

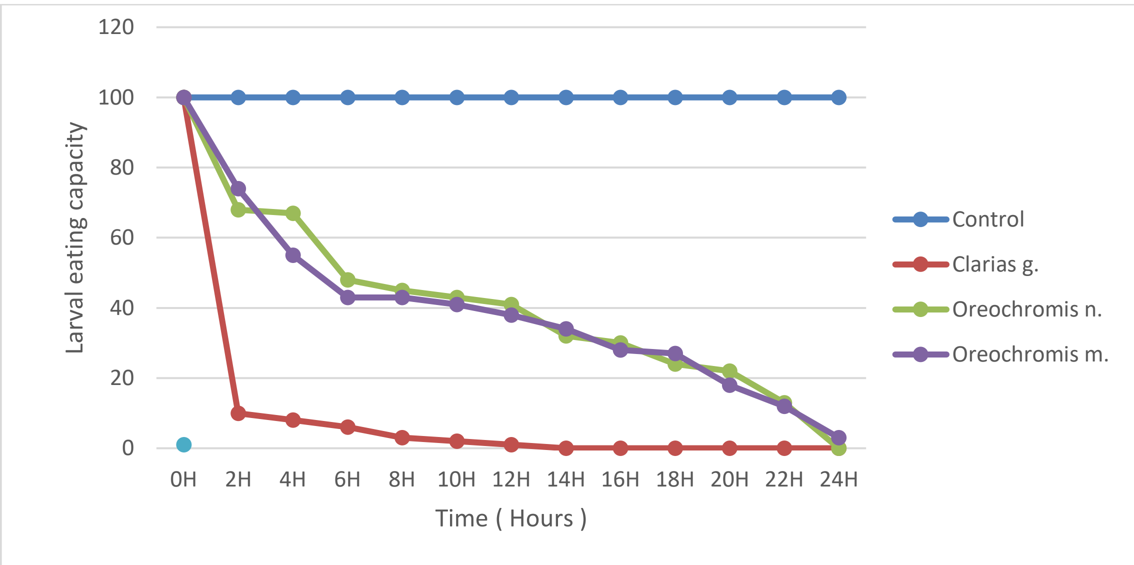

Figure 10: Larval eating capacity of unfed indigenous larvivorous fishes of 50g on larvae of *Culex quinquefasciatus* in swamp water

Larval eating capacity of indigenous larvivorous fishes of 30g on larvae of *Culex quinquefasciatus* in pond water

The analysis of figure 11 showed that the number of *Culex quinquefasciatus* larvae introduced in the control rectangular piscicultural basins was intact during all the duration of the test. After the introduction of unfed larvivorous fishes which were local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* which weighed 30g in each of the four rectangular piscicultural basins, the number of larvae of *Culex quinquefasciatus* was intact at initial time (t=0hour). The number of larvae of *Culex quinquefasciatus* was reduced at middle time (t=12hours) in all rectangular piscicultural basins and became 28, 50 and 63 larvae for *Clarias gariepinus, Oreochromis niloticus* and *Oreochromis mossambicus* respectively. At the end of the test (t = 24hours), there was no larvae in the all test rectangular piscicultural basins which contained *Clarias gariepinus* (P > 0.05), but there were a few larvae in test rectangular piscicultural basins which contained *Oreochromis niloticus* and *Oreochromis mossambicus,* 27 and 48 respectively.

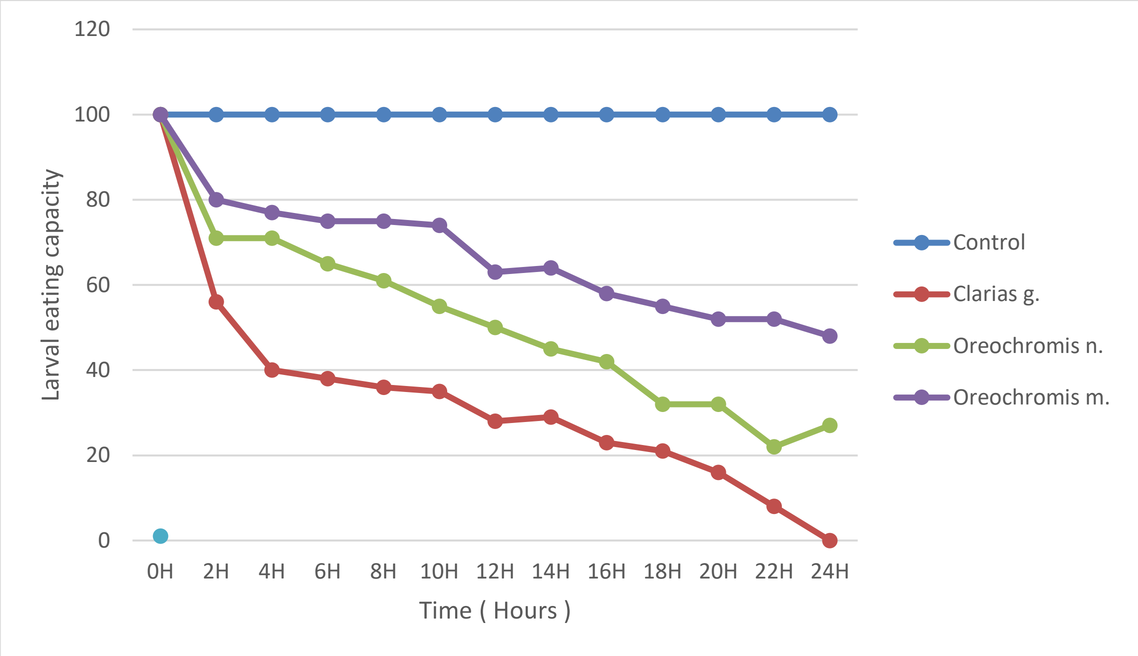

Figure 11: Larval eating capacity of unfed indigenous larvivorous fishes of 30g on larvae of *Culex quinquefasciatus* in pond water

Larval eating capacity of indigenous larvivorous fishes of 40g on larvae of *Culex quinquefasciatus* in pond water

The analysis of figure 12 showed that the number of *Culex quinquefasciatus* larvae introduced in the control rectangular piscicultural basins was intact during all the duration of the test. After the introduction of unfed larvivorous fishes which were local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* which weighed 40g in each of the four rectangular piscicultural basins, the number of larvae of *Culex quinquefasciatus* was intact at initial time (t=0hour). The number of larvae of *Culex quinquefasciatus* was reduced at middle time (t=12hours) in all rectangular piscicultural basins and became 1, 20 and 43 larvae for *Clarias gariepinus, Oreochromis mossambicus* and *Oreochromis niloticus* respectively. At the end of the test (t = 24hours), there was no larvae in the all test rectangular piscicultural basins which contained *Clarias gariepinus* and *Oreochromis mossambicus* (P > 0.05), but there were 23 larvae in test rectangular piscicultural basins which contained *Oreochromis niloticus*.

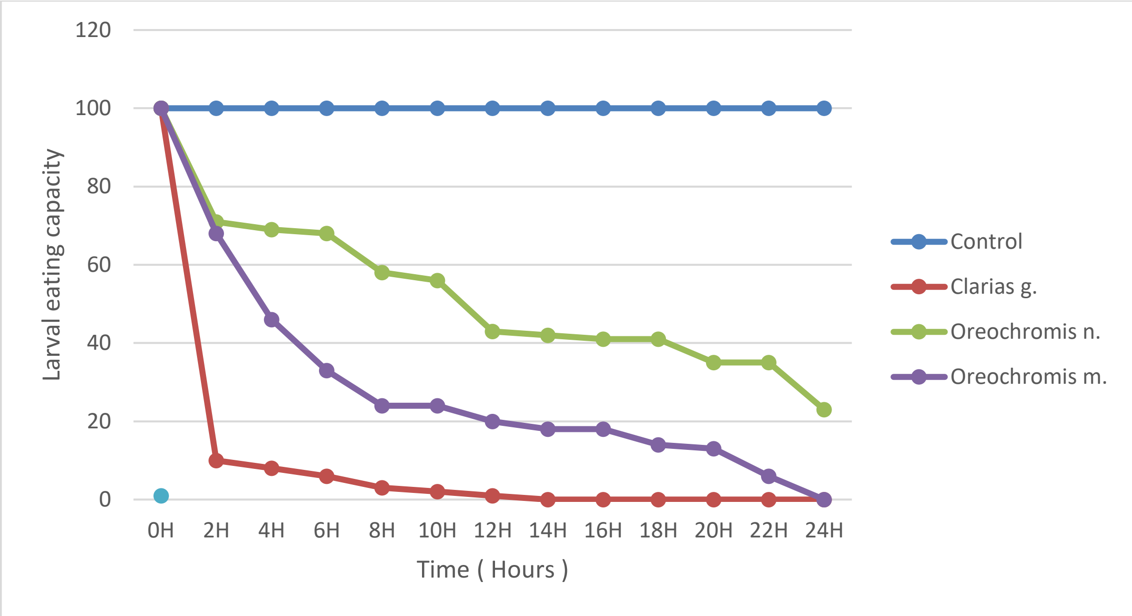

Figure 12: Larval eating capacity of unfed indigenous larvivorous fishes of 40g on larvae of *Culex quinquefasciatus* in pond water

Larval eating capacity of indigenous larvivorous fishes of 50g on larvae of *Culex quinquefasciatus* in pond water

The analysis of figure 13 showed that the number of *Culex quinquefasciatus* larvae introduced in the control rectangular piscicultural basins was intact during all the duration of the test. After the introduction of unfed larvivorous fishes which were local *Clarias gariepinus* fish and exotic fishes adapted to local life conditions *Oreochromis mossambicus* and *Oreochromis niloticus* which weighed 50g in each of the four rectangular piscicultural basins, the number of larvae of *Culex quinquefasciatus* was intact at initial time (t=0hour). The number of larvae of *Culex quinquefasciatus* was reduced at middle time (t=12hours) in all rectangular piscicultural basins and became 1, 30 and 32 larvae for *Clarias gariepinus, Oreochromis mossambicus* and *Oreochromis niloticus* respectively. At the end of the test (t = 24hours), there was no larvae in the all test rectangular piscicultural basins which contained *Clarias gariepinus* ($P > 0.05$), but there were only 1 and 2 larvae in test rectangular piscicultural basins which contained *Oreochromis mossambicus* and *Oreochromis niloticus* respectively.

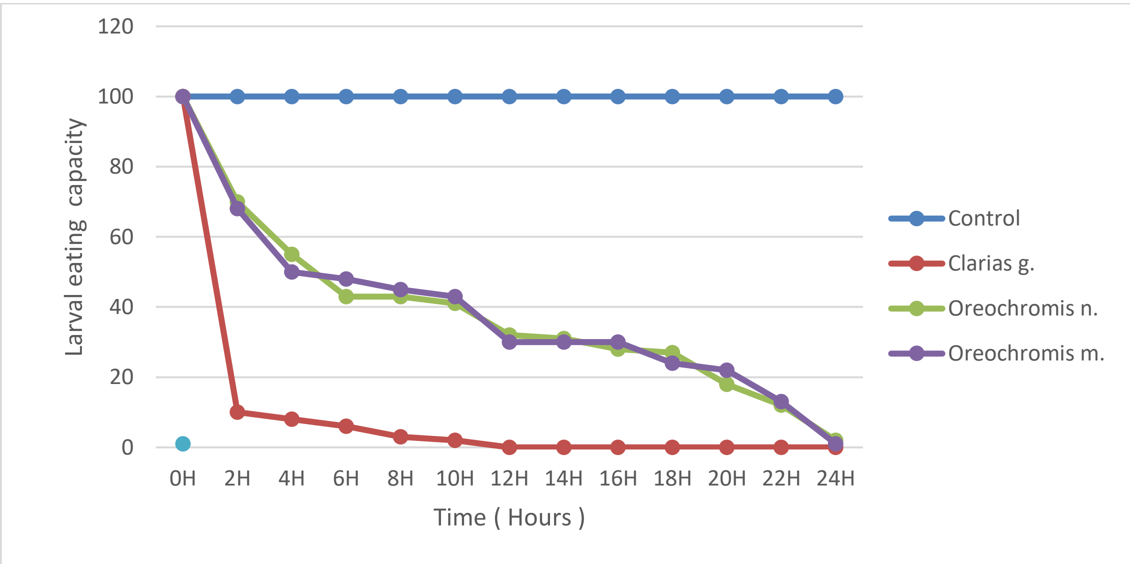

Figure 13: Larval eating capacity of unfed indigenous larvivorous fishes of 50g on larvae of *Culex quinquefasciatus* in pond water

IV. Discussion

Larval eating capacity of *Clarias gariepinus* was higher than that of *Oreochromis mossambicus* which was higher than that of *Oreochromis niloticus* when these larvivorous fishes weighed 30g and unfed in swamp water in field experimental evaluation. In similar way, larval eating capacity of *Clarias gariepinus* was higher than that of *Oreochromis niloticus* which was higher than that of *Oreochromis mossambicus* when these larvivorous fishes weighed 40g and unfed in swamp water in field experimental evaluation. Also, larval eating capacity of *Clarias gariepinus* was higher than those of *Oreochromis niloticus* and *Oreochromis mossambicus* which were similar when these larvivorous fishes weighed 50g and unfed in swamp water in field experimental evaluation.

Larval eating capacity of *Clarias gariepinus* was higher than that of *Oreochromis niloticus* which was higher than that of *Oreochromis mossambicus* when these larvivorous fishes weighed 30g and unfed in pond water in field experimental evaluation. In similar way, larval eating capacity of *Clarias gariepinus* was higher than that of *Oreochromis mossambicus* which was higher than that of *Oreochromis niloticus* when these larvivorous fishes weighed 40g and unfed in pond water in field experimental evaluation. Also, larval eating capacity of *Clarias gariepinus* was higher than those of *Oreochromis mossambicus* and *Oreochromis niloticus* which were similar when these larvivorous fishes weighed 50g and unfed in pond water in field experimental evaluation. The results obtained in the current study showed that the quality of water did not influence the larval eating capacity of larvivorous fishes. Our results corroborated with those obtained by Bhattacharjee *et al* [18] who had shown that in field experimental evaluation, some species of fishes including *Clarias batrachus* (specie of same genus as *Clarias gariepinus*) had reduced significantly abundance of larvae of *Culex quinquefascais* mosquitoes.

V. Conclusion

The use of larvivorous fishes against larvae of *Culex quinquefasciatus* has given good results in field experimental conditions in the current study. However, researches must also be carried out in field operational conditions in a context where it is useful to search for alternative solutions to damages cause by chemical insecticides to environment and human health.

Acknowledgements

The authors would like to thank people from districts surveyed who had helped us in mosquito collection. The data used in the current study concerned those of the doctoral training of Habib Tamègnon.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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