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Practice of culture rice-fish in the lowlands of Bédiala (Côte d'Ivoire)

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Abstract
The present study aimed to describe the rice-fish culture techniques practiced in Bédiala. The methodology used was to follow the activities of the rice-fish farmers in this area. Its results of our investigations that rice sowing is done on 80% of the surface of the dam upstream from the monk. One month later, the stocking of male *Oreochromis niloticus* and *Heterotis niloticus* began. According to the monitoring and maintenance of the dams, the rice-fish farmers have been classified into three groups: the first group did not feed the fish, the second group fertilizes the ponds and the last group gives in addition to fertilizers, rice bran or maize bran to fish. After the harvest of the rice, rearing continues until the fish reach their market size. We also found that the fish biotic yield depends on the rearing environment and on whether or not a feed supplement is provided to fish.

Keywords: Cultivation techniques, rice, fish, lowland, côte d'ivoire.

1. Introduction
Per capita fish consumption in Africa increased from 10.5 kg in 2014 before falling back to 9.9 kg in 2017 [1]. In Côte d'Ivoire, fish is the primary source of animal protein for the population, contributing around 15 to 20 kg/capita/year [1]. This fish production is mainly provided by fishing, particularly artisanal fishing [2]. National aquaculture production represents only 1.5% of the country's halieutic production [3, 4]. Compared to the size of the annual national demand for fishery products, national aquaculture production remains very limited. Indeed, this low contribution of aquaculture to the melting of national fish needs is undeniably linked to the production costs that are too high for fish farmers and the insufficient popularisation of farming techniques [5, 6, 7]. The reconversion of margins areas for agricultural activities, such as the lowlands, by food crop farming and in particular by rice-fish farming, has proved to be conducive to socio-spatial recomposition, both at the local and regional levels. Globally, rice-fish farming has been practiced for more than a century in some Far Eastern countries (Japan, Indonesia, Philippines, Malaysia, and Viet Nam) in Italy, India, Tanzania and Madagascar [8, 9, 10, 11]. In contrary to these countries, rice-fish farming is almost non-existent in most African countries. It is rarely of interest to development program [12]. It's in this context that the present study was initiated. It was undertaken to describe the practice of rice-fish farming in the rice-fish lowlands of Bédiala in order to have technical references that could be used at the national level. The aim is to explain the different methods and management techniques of these rice-fish farms.

2. Materials and methods
2.1 Study zone
The trials in the present study were carried out in the rice-fish farming lowlands located in the Upper Sassandra region, precisely in the sub-prefecture of Bédiala. The sub-prefecture of Bédiala is located between 7.4° and 7.11° north latitude and between 6.0° and 6.20° west longitude [13]. It is bounded to the north by the sub-prefectures of Kanzra and Zuenoula, to the south by that of Gonaté, to the east by that of Bonon and to the west by that of Vavoua (Fig 1).

2.2. Biological material
The trials were carried out with fry of *O. niloticus*, *H. niloticus*, *Parachana Obscura* and

Chrysichtys nigrodigitatus. All fry was produced in the dam ponds in the study area. The plant material consisted of two floodable rice varieties: WITA 9 "*Amolet*" and WITA 12 "*djoukinmin*".

2.3. Technical equipment
The technical equipment consisted of the different rearing structures, seines net with a mesh size of 14 mm and a length varying between 27 and 33 meters. A precision commercial scale with 100 g as precision and a capacity of 20 kg.

A Google Position System (GARMIN ***e***Trex 20) was used to take geographical cordoned of the study zone.

2.4. Method of data collection
Data was collected by following the farmers who practice lowland rice-fish farming over an entire production cycle. The sites of the members of the Bédiala fish farmers' cooperative called "DEHIZEA" were selected in order to standardize cultivation techniques in the zone.

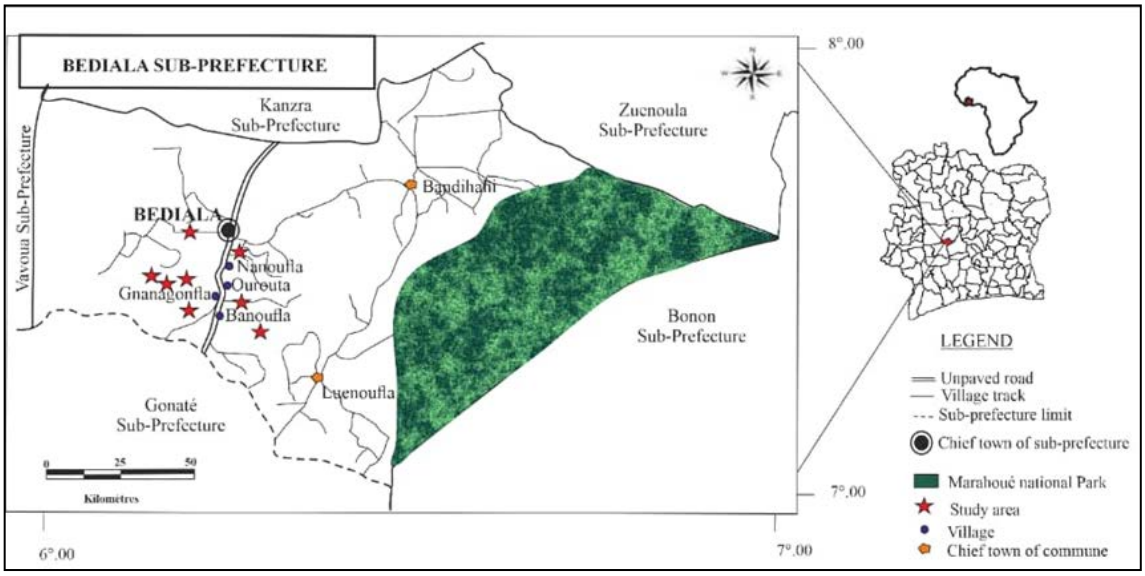

Fig 1: Presentation of the study area

3. Results
Rice-fish culture in the lowlands starts with the beginning of the rainy season, i.e. in March and April. The first activity to be done after the dam has been emptied is the preparation of the seed for the next farming cycle.

3.1 Rice seed preparation and sowing
The rice seed contained in bags is put in the water of the dam for two to three days. On the last day, it is scattered in the open air. The sowing of the rice, preceded by the emptying of the concerned dam, takes place after the roots have appeared on the seeds. It is done progressively during the days following the emptying of the dam. The sowing is done in pots or in the air over 80% of the surface of the dam upstream from the monk. The deepest part of the dam near the monk was not concerned by the sowing of rice.

3.2 Fish stocking
Two weeks after sowing the rice, the supply channel remains open and the water flows continuously through the dam. This water is stopped by closing the drain pipe at the monk's level while taking into account the size of the rice. Once the plate of the dam is filled, the water level in the dam is controlled by using planks from the monk.

The water level from upstream to downstream of the dam ponds is between 20 cm to 1m 25. One month after the sowing of the rice, fish was sexed and male *O. niloticus* and *H. niloticus*, the main species reared in the area, were stocked. Then it is the turn of *Clarias gariepinus* and *P. obscura in* order to enhance the productivity of the rice-fish basin. Sexing operations are carried out early in the morning between 6 and 8 am. The weight of *O. niloticus* fingerlings vary between 60 and 100 g with an average of 80 g depending on the rice-fish farmers. The fry of *H. niloticus* can reach up to 400 g when stocked. *C. gariepinus* and *P. obscura* have a stocking body weight of less than 60 g. Stocking densities vary between 0.5 and 1.2 fish/m^2 for *O. niloticus* and between 0.01 and 0.05 fish/m^2 for *H. niloticus.*

3.3 Livestock monitoring
For the majority of farmers, rice-fish farming is second in the rank after cash crops such as cashew nuts, coffee, cocoa and rubber. The management of rice-fish ponds is dependent on the work agricultural cultivated in the fields (Fig 2). However, rice-fish farming is the most important activity for some farmers.

The majority of farmers are divided into two sub-groups. The group of those who provide nothing as food input after stocking and the group of those who fertilize fish environments with cassava peelings and leftovers from domestic food.

The last slice brings in addition to local fertilizers, rice bran two times a day (10 am and 3 pm), fruits such as avocado, cashew apple, papaya, etc (Fig 3). The food ration is a function of the availability of inputs. It is readjusted every month until it reaches 100 kg per day in some rice-fish farmers.

3.4 Rice harvesting and control fishing
Rice harvesting takes place four to five months after sowing, usually with sickles, and its duration depends on the size of the area cultivated. The rice seedlings are cut from the water column and deposited on the surface. These seedlings are transported out of the water and placed in several rows on

tarpaulins before being threshed on empty barrels. The resulting rice grains are dried, winnowed and then stacked in 100 kg bags for consumption and/or sale.

After the rice is harvested, fish culture continues as the fish have not yet reached marketable sizes.

The dam is completely filled by increasing the number of planks up to the top of the monk. Thus, begins the phase devoted entirely to fish culture.

The fish cycle is then followed by monthly control fishing. The fish caught during this fishing are weighed in batches of 10 kg and counted. When the mass of three to five fish per kg is reached and the first rains have started, the total fishing is scheduled.

Fig 2: Rice and fish dam one month after rice sowing

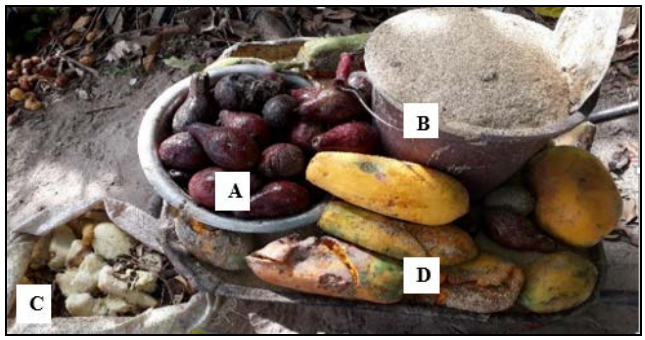

Fig 3: Feed from a rice-fish dam A: *avocado;* B: *rice bran;* C: *leftover domestic food;* D: *papaya*

3.5 Final fishing

The final catch of all fish is made at the beginning of the rainy season (table 1). To do this, the planks are removed from the monk and a 1 cm mesh is placed in front of the drain pipe to prevent the fish from escaping. The emptying time depends on the surface area of the dam. It can last from two to three days. Fishing starts this way, the day the water of the dam remains at the level of the dam's plate. Concerning the dams that cannot be completely emptied due to the lack of a adequate slope, a motor pump is necessary to suck up the water contained in the dam plate in order to capture all the *C. gariepinus* and *P. obscura* fish. The biotic yield of a rice-fish dam (table 2 and fig 4) depends on the poisoning density and on whether or not a food supplement is provided.

Table 1: Calendar of rice-fish culture in sub-prefecture of Bédiala

Activities	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Fev	Mar	Apr
Sowing rice	✚	✚										
Fish stocking		✚	✚	✚								
Livestock monitoring	✚	✚	✚	✚	✚	✚	✚	✚	✚			
Rice harvest				✚	✚	✚						
Control fishing				✚	✚	✚	✚	✚	✚			
Total fishing											✚	✚

Table 2: Yield by species according to the different groups of rice-fish farmers

Livestock monitoring Species	Without external input (Kg/ha/year)	Fertilizer supply (Kg/ha/year)	Rice bran intake (Kg/ha/year)
Oreochromis niloticus	107.19 ± 0.12	253.33 ± 1.3	1 248.71 ± 2.1
Heterotis niloticus	123.33 ± 0.39	118.45 ± 2.2	419.48 ± 0.23
Clarias gariepinus	47.36 ± 1.8	85.47 ± 1.1	155.51 ± 1.9
Parachana obscura	13.15 ± 0.92	17.85 ± 0.7	42.82 ± 0.11

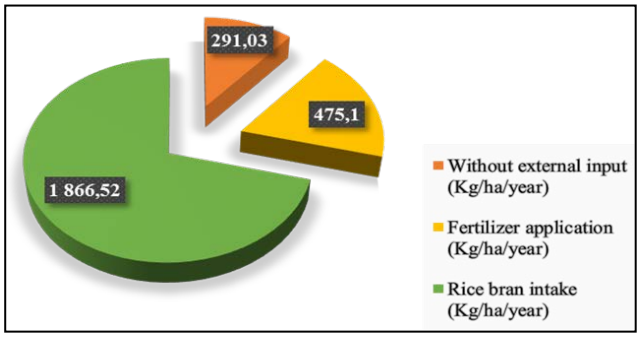

Fig 4: Total yield in relation with the livestock monitoring (Kg/ha/year)

4. Discussion

Rice and fish culture in the lowlands starts with the beginning of the rainy season. Indeed, the water level in the lowlands cannot reach the desired level for fish farming. The dam ponds built in the lowlands retain the water necessary for fish farming and prevent the development of weeds. The water level from upstream to downstream of the ponds between 20 cm and 1.25 m is reached with indirect and direct runoff water. These results confirm the assertion that the best rice yields are obtained by maintaining an almost stagnant water level of 15-20 cm during cultivation [9]. Rice sowing is done after the roots appear on the rice seeds. It is done in pots or in the air over 80% of the dam surface upstream from the monk. This contrasts with the technique described by [14]. These authors proceeded by setting up a rice nursery which lasted 15 days in a nearby pond followed by transplanting according to the technical itinerary defined by [15]. The dam bed is not sown, partly because of its depth and partly because it is reserved for fish stocking. The difference between the method used in this study and that used by [14] would be due to the cultivated area. This trial was carried out on surface twice as large as those used by these authors. After sowing the rice, the

supply channel remains open and the water level in the dam is controlled by planks from the monk. Stocking was done one month after sowing the rice. This practice corroborates that of [14]. These authors proceeded to a progressive rise in the water level and stocked fish 45 days after the transplanting of the rice. For [9], fish stocking should take place huit days after rice transplanting. The time between transplanting and stocking allows the rice seedlings to take root and to resist possible fish degradation. Only male individuals of *O. niloticus* are selected for rearing in rice fields because according to [16], male tilapia grows twice as fast as females.

In spite of the importance given to fish farming in the Upper Sassandra region because of the plethora of lowlands, it must be said that rice-fish farming is not the main activity of the farming population. Thus, the interest in rice-fish farming in Bédiala varies from one rice-fish farmer to another. This observation could be explained on the one hand by the importance given to cash crops (cashew nuts, coffee, cocoa, rubber tree), and on the other hand by the inexistence of technical data on rice-fish farming. In other words, some rice-fish farmers do not provide any food supplements after fish stocking, others only provide fertilisers and a third group also provide local fertilisers, rice bran, maize bran and fruits (avocado, cashew apple, papaya...). For fertilisation, cassava peelings, rice straw and leftover domestic food are poured at the edge of the ponds in a thin layer of water. The decomposition of these organic materials by bacteria produces fish food. This is in line with [9] who states that the daily ration is about 1/10th of the weight of the fish in the rice field. In addition, the remaining rice and maize bran that is not consumed directly would also contribute to the enrichment of the fish environment. In this regard, [12] conclude that the nutritional quality of rice bran, as a direct food in the fish diet, needs to be qualified. Indeed, it is necessary to consider that in addition to this direct effect, uneaten rice bran can play a significant fertilising role in the production of the trophic chain after degradation. Four to five months after sowing, the rice is harvested. The rice seedlings are cut with sickles in the water column. This technique is different from that used in the work of [12] in Forest Guinea. According to this author, rice is harvested six months after transplanting and with the ponds completely dry. The discrepancy between the two practices is thought to be due to the variety of rice used and the changes made to the livestock structures. In this study, the structures used are rice dam ponds that have been developed for integrated fish farming. In contrast to this study, the work of [12] was carried out in rice ponds with refuge holes.

The biotic yields that vary between 291.03 and 1,866.52 Kg/ha/year. These results are consistent with [9] assertion. This author asserts that by developing his pond, it is possible to improve the living conditions of the fish and to reach yields of 10 to 400 Kg/ha/year depending on the nature of the soil and without initial stocking. Then he qualifies this type of fish farming practice as extensive rice-fish farming. The group of rice-fish farmers having practiced stocking, pond fertilisation and frequent feeding of fish in the rice field (twice a day) obtained an average yield of 1,866.52 Kg/ha/year. These data are better than those obtained (504 kg/ha) by [14]. In this study, two majority species are raised in polyculture while [14] use only *O. niloticus*. The difference between the yield of the latter and the present study would be due to the numbers of species reared and the initial density of fish in the two works. The chronogram of rice-fish work established in this work does not agree with that established by [12]. There is, however, a similarity between the two calendars. It is the fact of starting the work with the first rains. The periodic shift observed between the chronograms seems to be related to the requirements of the climates. In fact, as the work has been carried out in different geographical areas, the climates are not identical.

5. Conclusion

This work made it possible to observe that fish farming in the rice-growing lowlands is practiced in Côte d'Ivoire, more precisely in Bédiala. The rice-fish farming techniques that were previously unknown to the rural population have now been standardized and become available for popularisation. Rice fields are stocked with fish to ensure better yield and better organisation of production. It is an extremely simple practice that provides inexpensive fish and is therefore well adapted to rural purchasing power. It satisfies the food needs of the countryside by providing quality fish that improves food rations. In spite of the above, we recommend that the advantages of this commercially oriented family agro-ecological system be promoted. Intensive systems adapted by very large farms, impossible with peasant farms, remain the norm and phagocytize the majority of development funding.

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