ORIGINAL ARTICLE

ENDOGENOUS KNOWALEDGE OF TRADITIONAL FISH AND RICE FARMERS IN LOWER-CASAMANCE (SENEGAL)

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ABSTRACT

In Lower Casamance, fish farming and rice growing are a very important socio-economic activity. The symbiosis that is often established between the two production systems by local people, explains the livelihood of traditional fish farming in the area. The objective of this study is to document the endogenous knowledge and practices of traditional fish and rice farmers. To do this, a survey was conducted in the villages of Mlomp and Bandial. Although declining, the fish farming and rice farming activities are still supported by the endogenous knowledge such as the technique of management of mangrove mudflats, the management of the water stock between the rice fields and the fish ponds and the control of the tidal rhythm in relation with the abundance of genitors and the stocking period. Ethnobotanical, ethno-astrological and, ethnozoological knowledges and circalunar attributes in reference to tidal rhythms were reported by producers. At the ethnobotanical level, these attributes are related to *Avicennia germinans* and *Parkia biglo*bosa for the determination of the stocking period of the ponds. Regarding ethnobotanical knowledge, the fruiting of *Avicennia germinans* and *Parkia biglobos*a indicate the stocking period. On the ethno-astrological level, the position of the moon allows producers to know the current or future tide. In reference to ethnozoology, they rely on the songs of some bird species, including *Arden goliat*, *Halcyon senegalensis* and *Halcyon Malimbica*, which indicate the current or next tide. Determined empirically, the duration of the high or low tide is about three hours in the study area. Producers are also aware of various fish diets in ponds (planktophagous, detritivore and carnivore). Experienced fish farmers know how to recognize fish sex in the pond. They know the potential sources of conflict related to traditional fish farming as well as the constraints that hinder the development of this production system.
Keywords'*: producers, practices, management, tides, moon, diet.*

1. INTRODUCTION

In Senegal, aquaculture is very modest while the country has great potential for development [1]. Despite this potentiality, fish farming is declining in Lower Casamance because of the deterioration of ancestral hydro-agricultural systems [2]. However, fish farming still exists in Lower Casamance and its viability is based on the endogenous knowledges of producers. Although these knowledges remain, traditional fish farming is struggling to develop. At the same time, the fish needs of the Casamance population are increasing due to population growth [3,4]. Aware that aquaculture can offset the catch fisheries gap, the Senegalese government is committed to developing this sub-sector by creating in 2006 the National Agency for Aquaculture (ANA). This institution is responsible for leading the implementation of aquaculture policy in Senegal. Senegal's commitment has been further manifested by the inclusion of aquaculture among the six priority sectors and the twenty-seven flagship projects to create jobs and wealth, capable of boosting the country's growth [1]. In this context, this article aims to know and save the endogenous knowledge of traditional fish farming bequeathed to current producers by the ancestors. The motivation of the study is the role that endogenous knowledge could play in any strategy of sustainable development of aquaculture in Casamance. In this respect, are there any attributes related to the control of traditional fish farming in Lower Casamance? To answer this question, the article describes the know-how relating to the various stages of traditional fish farming. It also deals with endogenous knowledge relating to the determination of biological clocks and the rhythm of the tides as an unavoidable component in the development and management of traditional fish farming.

2. MATERIELS AND METHODES

The study area, between the left of Casamance River and the Republic of Guinea Bissau, is home to many bolons. Villages where producers have been surveyed and interviewed are shown in Figure 1.

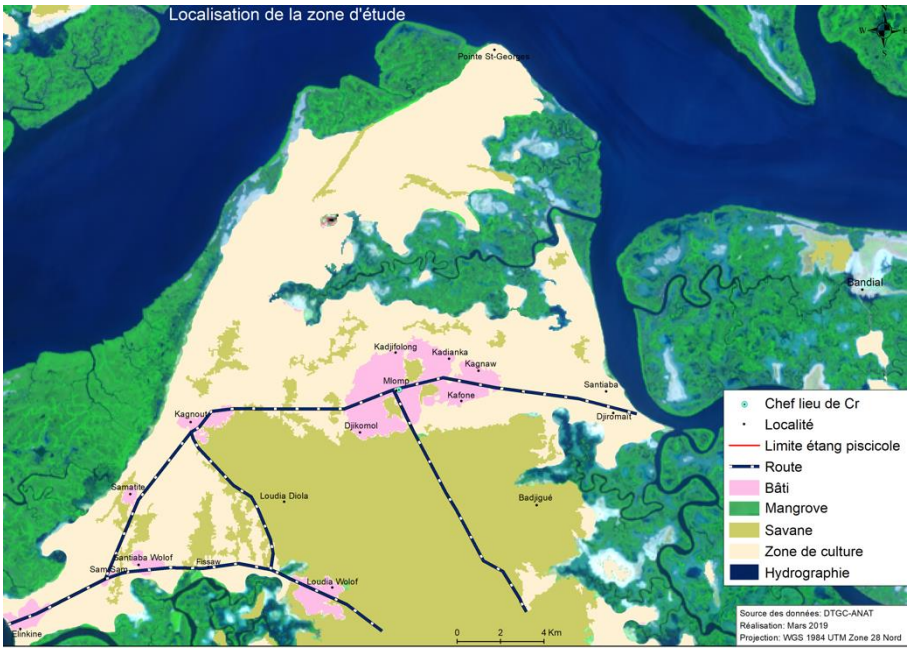

Figure 1: Location of the villages in the study area.

2.1. Data collection

In this research work, areas where the traditional fish farming is practiced were identified. Among the identified villages, Mlomp and Bandial were the most famous villages in aquaculture production and were selected for the study of endogenous knowledge related to traditional fish farming. A total of 74 fish farmers were randomly selected for survey. The survey was based on the socio-economic activities and the perception of ecological and environmental attributes of fish farming using a questionnaire. Additional interviews were organized to uncover other endogenous knowledge related to circatidal and circalunar rhythms and environmental resources in general (annex 2). These interviews focused on highlighting relationships between the biological rhythm of certain animal or plant species and the circatidal rythm. For this purpose, the determination of the animal species was made using the key of determination of the birds of Gambia and Senegal [5].

3. Data analysis

Data collected from fish farmers with the questionnaire are processed using CSpro and SPSS software. These softwares were used to cross-analyze the various variables studied to highlight the socio-economic and environmental attributes of traditional fish farming. Data from the follow-up interviews were summarized and analyzed.

3. RESULTS

3.1. Activities before the stocking of fish ponds

Formerly at Kagnout, the ancients installed an anti-salt dyke called *Ounago* inside the mangrove forest. Downstream of it, they installed a second dyke called *Bututa*. This dyke ensured the storage of the seawater that crossed the first dyke. A third dyke called *Buhint* was installed downstream of the second to store fresh water from the mainland. These last two dykes (*Bututa and Buhint*) allowed to store between them fresh water that will mix with the water from Elinkine' inlet. This area where fresh and salt water mixes represents the buffer zone of the piscicultural area. Depending on the extent between the rice fields and the inlet, the number of dykes could be up to four. At the end of this large-scale work, the maintenance and repair of dykes were the annual activities to be carried out before the stocking of fish ponds. The damaged parts of the three main dikes were repaired. Stems cuted from the mangrove were used to strengthen the dyke sections that cross a channel. The channel indeed facilitates the stocking of ponds and the arrival of fish species in the production units. The planning and maintenance of the ponds consisted of the reprofiling and laying of the first connection pipes between two environments separated by a dyke. This type of connection allows each pool to empty and fill depending on the tidal flow of the inlet and the runoff on the dry land side. The opening of these pipes for the filling of the ponds is done the same day and time. It is the same for the pipes located on the side of the rice fields. At the beginning of the rainy season, the rice paddy drains are opened to fill them with fresh water from the mainland. On the other hand, those of the anti-salt dyke (*Ounago*) are closed to prevent the intrusion of salt water into the rice fields. After the storage of fresh water in the rice fields, the drains are opened to evacuate the waters towards the inlet. These evacuated waters carry with them salt accumulated in the rice fields during the dry season. The means and tools used for the construction of dykes and ponds are rudimentary. It is essentially the *kandiando* and the *diateck* (Figure 2). The wooden handles of these tools come from several plant species such as Faidherbia albida, *Mangifera indica* and *Pterocarpus eurinaceus*. The wooden handles are connected to a U-shaped iron blade. To consolidate the dykes, the

producers used bamboo palisades, mangrove stakes, wheelbarrows and dugout canoes for collecting and transporting the mud during the construction of dykes and ponds. The work is done at the chain during the construction of large dykes and mobilizes youth. The women cook for the men who build the dykes. They participate sometime in the transport of mud to raise the dyke. The hard work done by men is the source of health problems including rheumatism, lumbar pain, kidney problems, problems with hernia, urine with blood stains and chest pain. During this work, producers communicate by word of mouth. This same method of communication also prevails during the education and advice sessions at the end of the work in which the transmission of endogenous knowledge takes place on the basis of a high degree of confidentiality according to the degree of initiation of the participant

Figure 2: The figure presents the Kadiando and Diateck.

3.2. Determination of the stocking period of fish ponds

In the Mlomp area, particularly in the Samatite, an ethnobotanical attribute allows fish producers to identify the period favorable for the stocking of fish ponds. This period corresponds to the flowering and fruiting of Parkia biglobosa Jacq (Benth). This flowering period usually happens in June-July of each year. In Kagnout, particularly in the Ebrouay quarter, the producers determine the stocking period according to the good tide which brings enough fish larva to the ponds based on the circalunar rhythms. Moreover, some of them, identify this period from the fructification of *Avicennia germinans* (L.) Stearn. seeds. This fructification period also happens in June-July of each year. The fish farmers of these two localities use different ethnobotanical attributes with identical consequences on the decision for the start-up period of traditional fish farming. During the stocking period, 27% of producers maintain that the fish species raised are very abundant in the natural environment. 59.5% of producers mention the abundance of fish species during this period. Some of procuders (12.2%) report that these species are less abundants while a minority of producers (1.4%) thinks that these species have become rare in the natural environment.

3.3. Stocking of fish ponds

Stocking points are identified at various points in the pond adjacent to the stream or its branches (channels). These points are identified as a result of the grouping of genitors seeking to go to the ponds as egg-laying sites. In these specific places are made notches so that there is a difference in level between the section of the dyke and the bottom of the pond. This allows producers to stock the ponds with fish for two weeks based on high tides. During the stocking period of the ponds, 37.58% of the producers consider that the fish larva are very abundant, 50% consider them abundant, 10% less abundant and 1.4% consider that they are rare. The stocking ponds with fish is done naturally according to 100% of the respondents. This natural stocking consists in cutting the dyke that separates the pond from the nearest stream or channel to allow genitors and fries of various species of fish to go in the pond. Since rice farmers do not want fish in their rice fields, their presence in rice fields is considered accidental. This view of producers is related to the fact that young rice plants are eaten by fish. Moreover, diola farming engineering has overcome this constraint by transplanting rice plants having exceeded the size of the vulnerability. During stocking, water management focuses mainly on opening and closing the sections operated on the dyke. At this moment, the drains of Buhint are closed to avoid contamination of rice fields by salt water. Those at the Bututa dyke are closed with straw bales or low-sealing material to promote mixing of the saline water from inlet and freshwaters in the buffer zone.

3.4. Period of fish breeding in fish ponds

During this period, producers check meticulously the ponds to identify damaged dykes and repair them. In the advanced stage of fish farming, some producers are able to recognize them. The size of the fries observed in the ponds allows the majority of fish farmers (95.9%) to identify fish for stocking. About 4.1% of respondents feel that they do not recognize fish at stocking. The recognition of fish species in the water is visibly seen by 93.3% of respondents, 4% of producers recognize them when they are captured while 2.7% refer to the shape and color of the individuals observed in water. For the sex of the fish, 32.4% of the respondents manage to recognize the males and the females of various species. The vast majority (67.6%) fail to recognize the sex of the fish. Among the experienced fish farmers, 30.3% know how to directly recognize the sex of the fish based on empirical knowledge. Some rely on various criteria such as the protection of fries by female genitors (1.3%), the fat belly of females (1.3%) and finally the size of individuals considering that males are often longer and larger than females (1.3%). Ultimately, it is the lack of attention that explains the inability of

some producers to recognize the sex of fish at all stages of their physiological development. Comparing the presence of food in the ponds, 50% of the respondents support their availability in the wild. In the focus group, producers defended the same idea in the sense that fish feed naturally from nutrients carried by rainwater runoff. In total, 19 foods are cited by producers in Lower Casamance. 73.68% of these foods are part of the diet of fish according to Bandial producers against 68.42% according to those of Mlomp. This availability of food in the environment is also a considerable asset for the development of fish farming in Casamance since without food inputs, producers manage to produce quality fish in relation to their size and biomass.On rare occasions, producers use fagots and brush parks to prevent thieves from throwing nets into the ponds at night.

3.5. Management of water in rice fields and fish ponds

Water management in rice fields is linked to water stored in fish ponds. During the preparation of rice transplanting, rice producers reduce the freshwater quantity in the fields until the ridges show on the surface. To do this, producers open rice drains at the same time as those of fish ponds during low tide. It is during this low tide that both fresh and brackish waters can flow in the same direction from the mainland to the inlet without the brackish water being able to invade the rice fields. When the rice fields are larger that several producers are concerned, the first producer who undertakes to empty his rice fields informs the others to impulse a synchronization of the emptying of the ponds concerned. The non-respect of this obligation has been highlighted as a source of conflict between rice and fish farmers themselves. At the time of rice ripening, rice fields are discharged to fish ponds or to the inlet during low tide. This stage of water management aims to facilitate the harvest of rice. Following this operation, the drains installed at the Buhint level are hermetically closed so that the saline waters cannot go up in the rice fields. This measure is scrupulously respected because of the late maturation of rice observed sometimes in some rice fields. Under these conditions, the rice farmer leaves a pad of water in his rice field that can satisfy the water requirements of the rice plants until they reach maturity. Harvesting of fish occurs during the ripening or harvesting phase of the rice. It involves the evacuation of water from the ponds to the inlets to facilitate catching fish with traps or nets. After the harvest of the fish, the drains are open, allowing the saltwater from the arm of sea to the rice fields. It is at this moment that the saline waters of the high tides can reach the rice fields. The consequence of this management strategy best explains the storage of fresh water in the rice fields at the beginning of the rainy season for the evacuation of salt formed on the surface of the rice fields during the dry season.

3.6. Harvesting in fish ponds

Harvesting of fish takes place after the maturity of the rice. The early emptying of ponds can negatively impact the maturity of the rice because of the possibility of intrusion of the salt water in the rice fields or loss of water from the rice fields depending on the topography of ponds. The tools used by the producers to harvest fish in the ponds are the Essou, the trap, the casting net and the baskets (Figure 3).

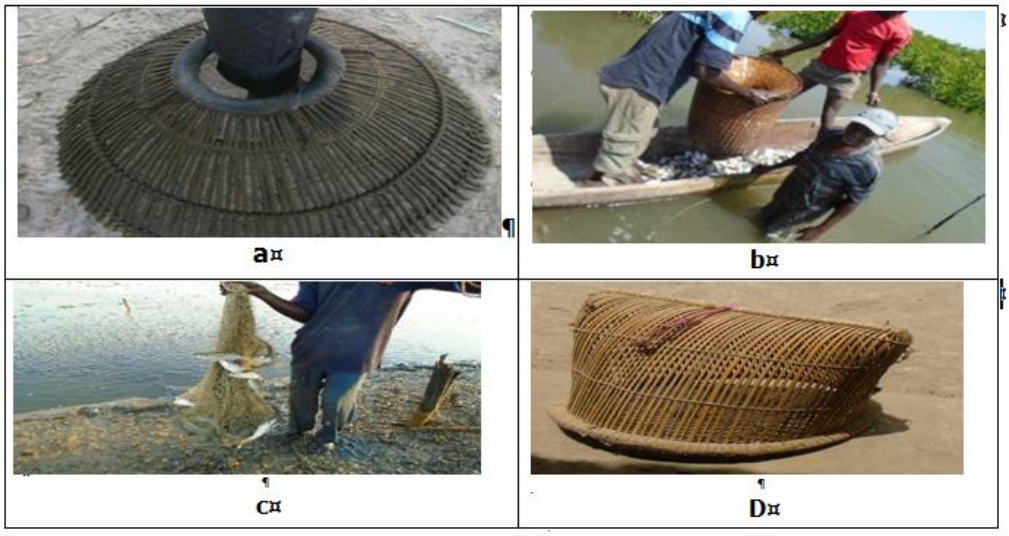

Figure 3: The figure presents the fishing tools of producers: Essou used by men and women (**a**), Trap and Casting net used by men only (**b** and **c**) and Baskets used exclusively by women (D).

During the episodic harvest of the fish, the traps are set up at the beginning of high tide on the side of the inlet. This location of the trap is explained by the fact that the fish move in countercurrent to try to return in the inlet during the flow. Once in the trap, captured fish will no longer have the opportunity to return to the pond. In their logic, the producers maintain that it is at this moment that the fish seek to join the zone which supplies the pond with water during the high tide. On the other hand, during the final harvest, the producers cut the dyke contiguous to the inlet or its channels in various places to massively evacuate the water from the pond (Figure 4). When the volume of water decreases considerably in the pond, producers begin fishing with the nets such as the seine net and the casting net. The

emptying of the pond continues until it is almost dry. At the end of the harvest, the dyke sections are closed and the drains left open until the next aquaculture season.Men are responsible for harvesting fish and women for transporting the catch to the village.

Figure 4: The figure presents the dike cut during the final harvest of the fish raised in the pond.

3.7. Commercialization and consumption of fish

Women are responsible for selling fish in the surrounding villages. Vendors announce the availability and sale of fish by screaming. The resonance of their cries indicates to the whole population the existence of fish on the local market. The sale of fish raised in the ponds takes place in the surrounding villages, the municipalities and the regional capital (Ziguinchor). In rural areas, the price of fish varies according to the fish species, the unit of measure and the locality. The price of fish varies from a single to fourfold of the village to the city for the fry of the different species of fish and in carp of medium size (12 cm) and average weight (25g). For a group of mules, the price of 7 to 8 individuals of average size (13 cm) and average weight (50 to 70 g) varies from the simple to the fivefold between the village and the city. A basin full of this category of individuals costs 25000 FCFA in Ziguinchor and 4500FCFA in village. The price change noted is 20500 F CFA that correspond to 5.55 times of the village price. Fish is more accessible at the village level than at the urban center where people are considered more affluent.

3.8. Perception of circalunar and circatidal rhythms

In Bandial, the producers refer to the position of the stars and moon to determine the moments of the different tides. Thus, the producers rely on the position of the moon in reference to different positions that the sun occupies in space during the day. When the moon occupies the same position as that of the sun between 17 and 18 hours, this moment coincides with the high tide. It is the same when the moon occupies the same position at night. When the moon occupies the position of the sun at 13 o'clock in the day, this moment corresponds to low tide. When it appears at 6 o'clock in the morning for a lapse of time, the corresponding period is locally called "Niokok". This is the period during which the moon is declared dead for 5 days before reappearing of a new moon in the East. The tides of dead waters occur fifteen days after the appearance of the new moon. The winds and their direction are also used by the producers to determine the different tides. The East winds augur the advent of the Niokok while the north winds announce the strong tides. In addition, producers also rely on ethno-zoological attributes relating to the songs of some birds such as *Halcyon senegalensis* (Woodland Kingfisher) and Halcyon Malimbica (Blue-breasted Kingfisher). These birds are locally called "Gadiawmu". They sing to announce the beginning of the high tide or the low tide.

In Mlomp, producers refer to the position of the moon to determine the different tides. As in Bandial, when the moon occupies the same position as that of the sun between 17 and 18 hours, this moment coincides with the high tide. When the moon takes the position of the sun between 11 and 12 o'clock, it indicates low tide. When the position of the moon indicates that of the sun between 16 and 17 hours, it is high tide. In this zone, the dead water tides last between 7 and 10 days while the time interval between two strong tides is estimated at 14 days. During the dry season, the high tide of the night is always greater than that of the day. When the high tide of the day becomes larger than that of the night, this period announces the rainy season. The ephemeral position of the moon in the west indicates the high tide and presage of the death of the moon (period during which the moon is no longer observable at night). When the position of the moon occupies that of the sun at 15 o'clock, it is the beginning of the high tide. When its position indicates that of the sun at 13 o'clock, it indicates low tide. Between 20 and 21 hours of the same day, high tide returns. The time between high tide and the next low tide is about 6 hours. In addition, the duration of the tide is estimated at 3 hours of time

regardless of the tide (high or low) In terms of astrological landmark, producers also rely on a sparkling star that appears in the East in the morning (star polar) and indicating low tide. When it stops twinkling, comes high tide. The second astrological marker corresponds to the constellation of stars called Scorpion. When the tail of the scorpion is rolled, it indicates the high tide. When it is unfolded, it corresponds to the low tide. On the ethno-zoological level, the producers also rely on bird songs, especially those of *Numenius phaeopus* Lennaeus, 1758 and *Numenius arquata* Linaeus, 1758, which indicate the beginning of high tide or low tide. The song of the Goliath heron (*Arden goliath* Cretszchmar, 1929) is also used as an indicator of the different tides at Djicomol and Samatite where the bird sings to indicate the beginning of the high tide or that of the low tide or the open sea slab. Mangrove rhizophores are also used to learn about the tides. After the open sea, the mark left on the stilt root shows the tide down. In Samatite, oyster observation indicates high tide when oysters are open (feeding period) and low tide when they are closed. Producers consider these animals (birds and molluscs) as biological clocks in phases with the circatidal rhythm. In the Mlomp area, producers have noted a tide shift between the ocean and the inlets. In other words, the high tide is slow to be felt in arm of seacompared with the ocean and similarly for low tide.

4. DISCUSSION

On the basis of endogenous knowledge, the main results show that dike rehabilitation is the first activity of each rearing cycle. Determination and planning of stocking fish ponds by the producers is done after the dike rehabilitation. Producers use several methods to determine the timing and plan the stocking of fish ponds. For this purpose, ethnobotanical attributes related to the flowering and fruiting of plant vegetation are used by producers. The stocking points are identified according to the aggregation areas of the fry and the brood fish. During this period, dikes are cut and closed after fish pond stocking. It is then that fish farming and water management begin between rice fields and ponds. The water management of the ponds is synchronized with that of the rice fields following an agreement in principle between the producers. Producers recognize fish and sometimes their sex (67.3%) on the basis of multiple criteria. They also know the fish feed in the ponds. At the harvest; dikes are cut a second time to facilitate the harvest of fish using various fishing gear. The marketing of fish is done in villages and sometimes in town where prices are 5.55 times more interesting.

4.1 Activities before the stocking of fish ponds

The main work done before stocking the ponds is essentially the repair of large anti-salt dikes and dikes separating the rice fields. Between the rice fields and the bolon, are located the typical ponds of Lower Casamance. These aquatic spaces of the village soil are the subject of an old, sophisticated and sophisticated development, of which there is no equivalent in Senegal [6]. Moreover, when fish farmers improvise in the way of landscaping ponds, it follows a significant proportion of poor workmanship. This situation was observed in Bessir after the departure of the Taiwanese. Producers eager to deepen their ponds to increase their carrying capacity, eventually exposed the pyrite deep layers to the air. This resulted in oxidation-reduction and acidification of the medium decimating an entire cohort after stocking [7]. Nowadays, work prior to stocking is difficult to do in the area. In this respect, the aging of fish farmers has been observed with an average age of 50 years for most producers, which is a hindrance to the development of large anti-salt dikes. This situation does not favor the respect of certain technical prescriptions relating to the construction of ponds able to retain a blade of water of average height of 50 to 70 cm [2]. This situation has led to the decline of traditional fish farming in Lower Casamance mainly through the abandonment of fish ponds following frequent breaks in the large anti-salt dikes [8].

4.2. Determination of the stocking period of fish ponds

The determination of the stocking period is based on ethnobotanical, ethno-zoological and ethno-astrological attributes. The ethnobotanical attributes are related to the flowering and fruiting phenophases of Avicennia germinans L Stearn. This strategy has not yet been described by researchers in the field of traditional fish farming. However, in another locality, the existence of a relationship between the environment, photoperiod and circadian clock of *Arabidopsis thaliana* (L.) Heynh has been demonstred [9]. The ethno-zoological attributes are more used during fish farming relative to the management of water in fish ponds. This know-how of fish farmers is the techniques of obstruction drains to let the water flow and ebb without losing the fish. This water management strategy aims to change the waters of the pond and promote the arrival of a body of oxygen-rich water in the pond. Circalunar rhythms are the most used for planning the stocking of ponds. Those corresponding to the high tide waters are chosen as likely to bring the quantity and diversity of fish species for the mixed farming practiced in Lower Casamance. In this respect, it is the high tides of high-amplitude waters that are identified by the producers as the stocking of fish ponds. In the end, the ingenuity and technicality of the diolas in the field of traditional fish farming shows the existence of an endogenous knowledge of this model of development in Lower Casamance. Moreover, fish ponds are a perfect illustration of an endogenous development of fish farming in Lower Casamance [8,10].

4.3. Stocking and breeding of fish in ponds

The method of stocking fish ponds in Lower Casamance is done naturally which does not guarantee the achievement of the critical load of the production units. This constraint has already been mentioned by [10, 2]. Moreover, it's also

demonstred that the loading, initial very strong, that the pond quickly reaches a load close to its maximum capacity [11]. Thus, the determination of fish density is also a key factor in the success or failure of pond culture [12, 13]. In any case, the stocking method fish ponds inevitably lead to polyculture, which seems to explain the fact that the simultaneous presence of phytophagous species and microphagous species, improves the exploitation of the pond and allows the best to exploit all its possibilities [11]. Since the diola does not establish the quality of the fish in relation to their size, the stocking method used does not allow harvesting of fish of equivalent size by species. In order to avoid multiple categories of fish. During the harvest, an author argues that where the population has certain requirements for fish size, the so-called "even-aged" breeding method should be recommended [11]. With regard to the natural feeding of fish, there is the problem of the availability and quantity required for good fish growth. This difficulty was chosen as a weak point in that these ponds constitute a closed environment that is too dependent on external sources of food [11]. However, these ponds can provide significant production without artificial feed if flocks frequent the fish farm [11,4]. Nevertheless, the weak point of this fish farming system is the lack of knowledge of the quantity of food available in the pond [12]. One of the solutions to these various constraints would be fish stocking control, stocking complementary feeds and creating additional ecological niches in the pond [2].

4.4. Harvesting fish ponds

Generally, the fish produced at the beginning of the harvest are small (less than 100g) depending on the tides determined by lunar phases. In this respect, the fishing takes place during the first 15 days of the lunar month with 5 days of fishing per week. From the full moon, all fishing is stopped until the next new moon. This fishing planning by fish farmers is explained by the tendency of fish to migrate to bolon, noted first among large fish as mulletsand *Tilapia guineensis* (Guinean tilapia) that jump over the dike [14]. This phenomenon is noted from the end of October to November when the salinity of the water begins to increase due to evaporation [10]. During the harvest, the fish caught are of various categories. However, during the final harvest, individuals of Mugil cephalus in classes [20.43-25.21] and [34.77-39.55] cm and biomass ranging between 148,28 and 394 grams with the respective percentages of 41.05 and 2.10% of the total population. Similarly, individuals of *Elops lacerta* C.V.,1846 were caught in classes [24.40-29.80 [, [29.80-35 [and [35-40] cm [2]. These categories represent 47.71% of the catch of the final fishery [10]. These biometric parameters suggest that the identification of the size of the fry that gave these large fish should be able to help selective one-sex stocking of the ponds to avoid harvesting small fish. In fact, their presence is largely explained by the reproduction of *Tilapia guineensis* Bleeker, 1852 and *Sarotherodon melenotheron* Rüppel, 1852 and other species during the rearing period. In this regard, various authors note that traditional fish farming produces very little salable fish and therefore does not arouse sufficient interest in the fish farmer [11,10,2]. Despite Bandial's performance, fish farming remains a subsistence activity whose revenues are hardly appreciable in Lower Casamance [2,15].

4.5. Management of water stored in rice fields and fish ponds

Water management in ponds and rice fields is based on a synchronization of the filling and emptying of the production units. The drainage system is based on the use of hollow trunks of Borassus akeassi B.O.G. or PVC pipes [2]. Overall, water management is dependent on rice cultivation where ponds and rice fields are connected, particularly at Kagnout and Samatite. In these villages, the rice fields benefit from the rain and runoff water that leaches the soil from the rice paddies [6,2]. In Bandial, the current position of the ponds offers producers a relatively independent management option for rice cultivation. The ponds in the low-lying area can receive water from the rice fields without the salty waters being able to climb the slope towards the rice fields.

4.6. Perception of circalunar rhythms

The circalunar rhythms are perceived by the producers from various angles of reading the position of the moon in space and in relation to that of the sun during the day. The positions of the moon which indicate the tides of strong waters are the same as those indicated during the new and full moon. The estimated duration between two successive strong tides is 14 days depending on the producers. This endogenous knowledge is not astronomically accurate, however, an estimate of 14.5 days has been advanced between a new moon and the next full moon [16]. However, according to some authors, the strong tides occur every 14 days and those of dead water similarly, it being understood that the two phases are nested over 7 days of their phase [17]. The phenomenon of the tides is also perceived on the basis of ethno-zoological attributes relating to waterbird songs and the behavior of some marine animals not yet studied in Lower Casamance. In this regard, it was noted that it would be important to take into account the important but unformalized endogenous knowledge of modern scientific approaches, as is the case in Benin [18]. Elsewhere in developed countries, it has already been shown that biological rhythms allow organisms to measure time and anticipate cyclical changes in their environment [19,20]. These authors argue that marine species occupy a much more complex environment, strongly influenced by several lunar cycles including the tide. This reasoning is based on the fact that biological rhythms are endogenous, produced by the internal clock of the body, synchronized and trained, by environmental factors [21,19,22]. In the same way that the biological rhythms are endogenous, their perception, by the fish producers of Lower Casamance, is an endogenous knowledge acquired over time. Note, therefore, that the biological rhythms of waterbirds (aerial animals) have not yet been studied molecularly and genetically in Lower Casamance. Nevertheless, our results support the idea that the diversity of life cycles that shape the marine environment is reflected in the rhythms expressed by the organisms living there. In the same vein, researchers have already demonstrated these rhythms by carrying violin

crabs of the same species from three of Minnesota's habitats. After being held under constant tidal conditions in a controlled laboratory, the crabs could time their driving activity synchronously with the tides of their original range, even if they had left them several thousand miles behind them. This study on animals from various phyla has also shown remarkably precise circa-rhythms in the genus Uca [16]. This perceived problem in marine animals and waterbirds could mean that the circadian clock in air animals has evolved from a circadian clock already present in marine animals [19]. In view of this scientific dimension, the results obtained on the endogenous knowledge of fish farmers in Basse-Casamance give rise to more questions and potentially open avenues for reflection in ecology, particularly in chronobiology.

5. CONCLUSION

The present study shows that fish farmers hold endogenous knowledge useful for the development of traditional fish farming. Most of the knowledge is ethno-astrological, ethnobotanical and ethno-zoological. The moon is the first star used to know the tide period progress or to predict the coming one. Nevertheless, other stars and constellation are also used to learn about the phenomenon of tides. In addition, ethnobotanical and ethno-zoological knowledges are also used to determine and to predict the tide as a function of the natural clocks empirically perceived by producers for centuries. In this respect, waterbirds are most prominent in the mangrove zone. The technique of water management between the rice field and aquaculture is the strategy that can ensure the viability of traditional fish farming despite the constraints noted. Pilot project and pratical applications of endogenous knowledge can help the scientific community to develop traditional fish farming in Senegal particularly in Casamance.

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Annex

Annex1: Questionnaire

Contrée :……**Quartier** :……

1. Identification de l'enquêté

Prénom……Nom……GMS……..…….. ……..……
Age……..Ethnie……..……..……..
Catégorie socioprofessionnelle : ☐ Riziculteur ☐ Pisciculteur ☐ Autres à préciser…….……...……

2. Abondance de la ressource poisson dans le milieu naturel,

2.1. Les espèces élevées sont-elles abondantes dans le milieu naturel ?

☐ Très abondantes ☐ Abondante ☐ Peu abondantes ☐ Rares

2.2. Les alevins sont- abondants dans la zone?

☐ Très abondants ☐ Abondants ☐ Peu abondants ☐ Rares

3. Modes de gestion des bassins piscicole

3.1. Les bassins sont-ils intégrés dans la mangrove ?

☐ Bien intégrés ☐ Assez bien intégrés ☐ Autre à préciser……...……..
Donner vos raisons :……....

3.2. Comment ensemencez-vous votre étang ?

☐ Empoisonnement naturel *in situ* ☐ Empoisonnement par des alevins importés

3.3. Identifiez-vous les espèces élevées dans l'étang ?

☐ Oui ☐ Non Pourquoi :……..……
……

3.4. Reconnaissez-vous les mâles des femelles dans l'étang ?

☐ Oui ☐ Non Pourquoi :……..……
……

3.5. Comment nourrissez-vous les poissons dans l'étang ?

☐ Naturellement (*sans apport extérieur de nourriture*)
☐ Apport d'aliment (*préciser la composition et la fréquence d'alimentation*) :……..……
……..……..……..

3.6. Connaissez-vous le régime alimentaire des poissons ?

☐ Non ☐ Oui (*préciser la nourriture et l'espèce concernée*) **:.....**

3.7. Entretenez-vous votre étang ?

☐ Reprofilage de l'étang ☐ Réfection des digues ☐ Vidange de l'étang ☐ Autres….……..……

3.8. Quel est le mode d'exploitation des bassins piscicoles ?

☐ Familiale ☐ Individuel ☐ Associatif ☐ Autres :……..……..….

3.9. Comment améliorez-vous la qualité des sols dans les bassins ?

☐ Apport de composte ☐ Apport d'engrais ☐ Autres à préciser :……..……..…….

Si composte, indiquer la composition de l'intrant :……..…….

3.10. Apportez-vous des soins aux poissons élevés ?

☐ Non ☐ Oui (*préciser les moyens utilisés*) :…… ..……

1. Impacts de la pisciculture traditionnelle

4.1. Quelle est la superficie de votre étang ?

(Ha ou m²)…… ……. ……..……

4.2. Quelle quantité de poisons produisez-vous par an ?

……..Kg ou autres unités de mesure :……..……

4.3. Quelle est la destination des poissons récoltés ?

☐ Autoconsommation ☐ Vente ☐ Don ☐ Autres :……..……..

4.4. Quel est votre gain annuel ?

En ***FCFA*** :……ou autres biens (*préciser la nature*) :……..……

4.5. Qu'avez-vous réalisé avec votre gain annuel ?

☐ Achat de nourriture ☐ Santé de la famille ☐ Scolarité des enfants ☐ Autres

4.6. Quels sont les effets de la pisciculture sur la mangrove ?

☐ Positifs ☐ Négatifs ☐ Expliquer votre réponse……..……
……
4.7. Quels sont les effets de la pisciculture sur la qualité des sols ?
☐ Positifs ☐ Négatifs ☐ Expliquer votre réponse……
……
4.8. Quels sont les effets de la pisciculture sur la riziculture ?
☐ Positifs ☐ Négatifs ☐ Expliquer votre réponse……
……
4.9. Quelle quantité de riz produisez-vous par an ?
☐ 200-300 Kg ☐ 300-500 Kg ☐ 500-1000 Kg ☐ Autres :……..…. ……
4.10. Quels sont les effets de la pisciculture sur la nappe phréatique ?
☐ Positifs ☐ Négatifs ☐ Expliquer votre réponse…… ..……
……
4.11. Quelle est la période couverte par l'autoconsommation du riz produit dans votre étang
☐ Trois (3) mois ☐ six (6) mois ☐ Neuf (9) mois ☐ Autres :……..……

4.12. Quels sont les effets de la pisciculture sur la salinisation des terres du continent ?
☐ Positifs ☐ Négatifs ☐ Expliquer votre réponse……
……

2. Connaissance des nouveaux systèmes de production piscicole

5.1. Connaissez-vous un système moderne de pisciculture ?
☐ Oui ☐ Non
5.2. Acceptez-vous ce nouveau système?
☐ Oui ☐ Non pourquoi ?……
……
5.3. Accepteriez-vous de nouveaux systèmes de production piscicole ?
☐ Non ☐ Oui (*préciser les conditions s'il y a lieu*)……..……
……

3. Conflits liés à la pisciculture

6.1. Quels sont les conflits liés à la pisciculture ?
☐ Riziculteurs/éleveurs ☐ Riziculteurs/pisciculteurs ☐ Pisciculteurs/pisciculteurs ☐ Autres :……..
6.2. Quelle est la source principale par type de conflit?
☐ Divagation du bétail ☐ Délimitation des bassins ☐ Autres à préciser ……..……..…….
6.4. Quel est le mode de résolution des conflits?
☐ A l'amiable ☐ Chez le chef du village ☐ Conseil des sages ☐ Autres :……

Annex 2: Guide d'entretient

1. **Perception des rythmes circalunidiennes**
- Comment la lune vous permet-elle de déterminer la période des marées?
- Quelle est la position de la lune qui indique la marée haute?
- Donner le référentiel :……...
- Quelle est la position de la lune qui indique la marée basse ?
- Donner le référentiel :……...
- Quelle est la position de la lune qui indique la marée de vives eaux?
- Donner le référentiel :…….
- Quelle est la position de la lune qui indique la marée de mortes eaux?
- Donner le référentiel :…….
- Quelle est la durée qui sépare une marée de vives eaux et une autre de mortes eaux ?
- Durée:……..

2. **Savoirs endogènes sur les horloges biologiques et le rythme circatidal**
- Les plantes :……et phénomènes perçus……..
  ……
- Les oiseaux : …… et phénomènes perçus……
  ……
- Autres animaux : …… et phénomènes perçus……..
  ……
- Quel est l'indicateur de l'horloge biologique de la marée chez les végétaux notés?

……
……
……

.....

- Quel est l'indicateur de l'horloge biologique de la marée chez les animaux?

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.....
.....
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