USE OF PLANT EPIDERMIS FOR DETERMINATION OF MACROPHYTES CONSUMED BY *Distichodus rostratus* GÜNTHER, 1864 (PISCES : DISTICHODONTIDAE), OF TAABO ARTIFICIAL LAKE (BASIN OF BANDAMA, CÔTE D'IVOIRE)

M. Y. DIETOA[1], W. M. KONE[2], J. K. YAO[1] et S. K. DA COSTA[3]

[1]UFR Sciences et Gestion de l'Environnement, Université Nangui Abrogoua, 02 BP 801 Abidjan 02, Côte d'Ivoire.
Email : dietoayehe@hotmail.fr

[2]UFR Sciences de la Nature, Université Nangui Abrogoua, 02 BP 801 Abidjan 02, Côte d'Ivoire.

[3]Centre National de Recherche Agronomique (CNRA) Station de Recherche en Pêche et Aquaculture, 08 BP 33 Abidjan 08, Cote d'Ivoire.

ABSTRACT

Fish constitutes one of the principal sources of proteins in the majority of African countries such as Côte d'Ivoire. However, its production is subjected to various constraints primarily of nutritional nature. This study was initiated to determine the plant base diet of local fish *Distichodus rostratus* for its valorisation in aquaculture. The micro-histological method was applied to the stomach contents and aquatic plants inventoried in Ahondo (Taabo Lake) in order to determine floristic composition of consumed food by *D. rostratus.* After treatment in sodium hypochlorite, the epidermis of plants were observed using an optic microscope and compared. The results revealed that the plant species consumed by this Fish species were, essentially, *Ipomoea aquatica, Echinochloa pyramidalis, Polygonum senegalense* and *Pycreus macrostachys*.

Keywords : *Distichodus rostratus*, diet, epidermis, Aquatic plants, Macrophytis.

RESUME

UTILISATION DES EPIDERMES VEGETAUX DANS LA DETERMINATION DES MACROPHYTES CONSOMMES PAR Distichodus rostratus

Le poisson constitue l'une des principales sources de protéines dans la plupart des pays africains tels que la Côte d'Ivoire. Cependant sa production est soumise à diverses contraintes essentiellement d'ordre nutritionnel. Ce travail a donc pour objectif de déterminer le régime alimentaire de Distichodus rostratus *en vue de sa valorisation en aquaculture. C'est un poisson local vivant dans plusieurs lacs et barrages. La méthode micro histologique a été appliquée aux contenus stomacaux de ce poisson et aux végétaux aquatiques inventoriés sur le site d'Ahondo du lac du barrage de Taabo afin de déterminer la composition floristique du régime alimentaire de* D. rostratus*. Il en résulte que les espèces végétales consommées par ce poisson sont* Ipomoea aquatica, Echinochloa pyramidalis, Polygonum senegalense *et* Pycreus macrostachyos*.*

Mots clés : Distichodus rostratus*, Régime alimentaire, Epidermes, Végétaux aquatiques, Macrophytes.*

INTRODUCTION

The proteins needed by human beings come mainly from two sources; plants and animals including Fish resources. Fish species ensure at least 15 % of the average requirements of animal proteins for more than 3 billion people in the world (FAO, 2010). In Africa, about 20 % of the total animal proteins consumed by the population came from fishes in 2005. However, for the countries located on the coasts of the Atlantic Ocean, this rate is set between 40 and 90 %, making fish the first source of animal proteins (Hanquiez and Oswald, 2009). In Côte d'Ivoire, the national consumption of Fish is estimated to vary between 250 000 and 300 000 tons/year for an average local production of 80,000 tons/year (Anonymous, 1997) and 70 % of this consumption is imported in frozen form. This country imports today from China, more than 10 000 tons of Tilapia, a Fish species originated from Africa.

This high level of imports and its cost in currencies, amplified by the growth of population and, consequently, the increasing of the demand for food resources and needs of proteins, pushed Côte d'Ivoire to make an effort to develop the fishery sector and aquaculture. The development of aquaculture can contribute to reduce the pressure on natural resources. Thus, it appears to be a possible solution to fill the variation growing between supply and demand (Halwart and van Prejudice, 2010).

Although agriculture in the broad sense plays a determining role in most African economies, the contribution of the aquaculture remains very limited in most African countries (Satia, 2011) like Côte d'Ivoire, owing to the fact that it is not a traditional activity of the populations. Less than 1 % of produced Fish comes from the fish farming, according to FAO (2010).

However, in the FAO prospective analysis, by 2030, aquaculture will be the main source of fish consumed by humans (FAO, 2002a). The importance of fish to ensure the food security of people in need has been announced in the Bangkok Declaration (Subasinghe *et al.,* 2000). This statement, and in particular the section on nutrition, particularly emphasizes a better understanding of the nutritional requirements of fish species.

Fish farming is largely (85 %) dominated by the production of freshwater fish (Kaushik, 2004). Several freshwater Fish species, for example *Distichodus rostratus* distributed in Côte d'Ivoire lakes and rivers represents a potential for aquaculture. This Fish species is a demersal potamodrous freshwater fish in Africa. *D. rostratus* is a fish economically very interesting owing to the fact that it represents half of the caught of the commercial fishery (Berté *et al.,* 2008a). *D. rostratus* plays an important role in the ecology and fisheries of West Africa and other inland waters. This fish lives in the rivers of white Bandama, N'zi, Bia and Comoé (Blache, 1964 ; Gourene *et al.,* 1999 ; Aliko *et al.,* 2010). In nature, the fish are macro-herbivores, feeds on submerged plants, *Eichornia sp* roots and periphyton. This species consumes plants and detritus, composed of Cyperaceae, Liliaceae, periphytons and plankton (Daget and Iltis, 1965 ; Planquette and Lemasson, 1975 ; Bowen, 1988 ; Reizer, 1995). In the Bandama river, *D. rostratus* consumes primarily macrophytes at 99.98 %, with a predominance of *Cymodocea sp.* (57.8 %) and 41.4 % of plant parts (Berté *et al.,* 2008b). However, the plant species, from which these detritus result, are not identified yet with precision. In addition, it is increasingly allowed that herbivorous fauna preferably consumes the native plants compared to those exotic when they all are available in a lake (Xiong *et al.,* 2009). In spite of this high number of studies on fish in Côte d'Ivoire, no attempt had been made to assess the plant species include in the diet of *D. rostratus*. This study thus aims at establishing the floristic composition of the food diet of *D. rostratus* using the micro-histological analysis of stomach contents.

MATERIALS AND METHODS

STUDY AREA

The present study was conducted in the Taabo lake in the Centre of Côte d'Ivoire (Figure 1). This dam built on the Bandama river is located between 6°20' and 6°40' N and 5° and 5°30' W (Traoré, 1996). Its surface at coast 124.0 m is of 7 000 ha. This man made lake with 53 fish species was built in 1978 (Aliko *et al.,* 2010). The area of Taabo is subjected to tropical climate, with four seasons including two dry and two rainy. The plant formations are mesophilic, dominated by Savannah.

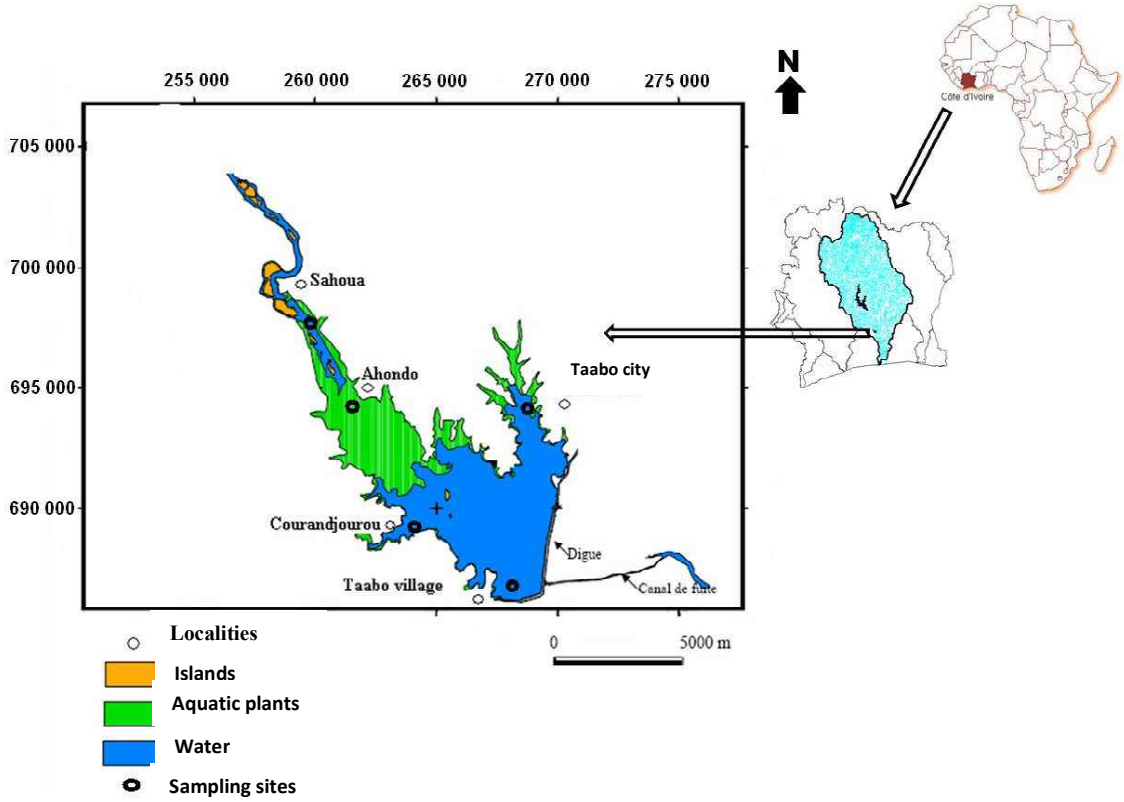

Figure 1 : Lake of the Taabo hydroelectric dam and location of sampling sites (Kouassi, 2007 modified).

Lac du barrage hydroélectrique de Taabo et localisation des stations d'échantillonnage (Kouassi, 2007 modifié).

FISH SAMPLING

Fish sampling was carried out at the station of Ahondo in Taabo Lake. Forty four specimens of *D. rostratus* collected from commercial fishery using monofilaments gillnets with meshs sizes from 10 to 70 mm, and the casnets of different sizes. After dissection, the stomachs of the examined fish specimens were collected and preserved in a solution containing 5 % formaldehyde. At the laboratory, the stomachs were dried on a blotting paper and weighed. Then, the stomach contents were emptied and maintained in water in Dolfuss dish.

PLANT SPECIES SAMPLING

Various plant species were sampled in the dam according to the method of itinerant assessment. Two samples per plant species were collected, one for the micro-histological analysis and the other for the herbarium. The plant identification was made by using botanical nomenclature of the flora of Côte d'Ivoire (Aké Assi, 2001) and the flora of West Tropical Africa (Hutchinson and Dalziel, 1954 - 1972 ; Lebrun and Stork, 1991, 1992, 1995, 1997). Voucher specimens of the recorded medicinal plants were harvested and processed according to standard practice, identified and then stored together with photos at Nangui Abrogoua University.

MICRO-HISTOLOGICALANALYSIS

Stomach content analysis was used to determine the floristic composition of the diet of *Distichodus rostratus*. This method is based on the identification of the epidermis of plants whose shape is specific for each species. On various points of Taabo Lake, plants were sampled and, then, subjected to micro-histological analysis. This method has already been used to determine both diets of herbivorous mammals (Chapuis, 1980) as galliform birds (Chapuis and Didillon, 1987). This identification of plant species consumed by *D. rostratus* resulted from the

comparison of epidermis characteristics of each species in a catalog previously established with those components of plant debris from stomach contents.

IDENTIFICATION OF PLANT SPECIES PRESENT IN THE STOMACH CONTENTS

Stomach contents were soaked in tap water during 24 h, then filtered using a very thin mesh sieve to separate detritus from water. Then these detritus were soaked in bleach during 10 to 15 min in order to empty the cell contents. After, debris were rinsed with tap water, and assembled between slide and cover glass in a drop of glycerol-coated water. The epidermis were observed under optical microscope then photographed. The plant species consumed by *D. rostratus* were identified by extrapolation of stomach contents. The criteria considered were shape and size of cells, structure, density, localization and distribution of stomata (Garcia-Gonzalez, 1984).

ELABORATION OF A REFERENCE CATALOGUE OF INVENTORIED PLANT SPECIES

Metcalfe and Chalk (1965) method has been used to compile a reference catalogue of the plants epidermis consumed by *D. rostratus.* For that, fragments of plant organs (leaves, sheaths, ribs, etc) were lied on a glass slide. Then, few drops of sodium hypochlorite (bleach water) were added to the preparation and, then, conjunctive tissues were scraped using a razor blade under a binocular. The whole sample is rinsed with tap water. The purpose of this operation is to clear up the epidermis (Butet, 1985). Fragments of epidermis thus obtained were mounted between slide and cover glass in a drop of glycerol-coated water then, observed under the optical microscope. Fragments were photographed and used to constitute the epidermis reference catalogue of the identified plants.

RESULTS

PLANT SPECIES INVENTORIED

On the site of Ahondo, 13 plant species, belonging to seven families and eight genera were inventoried (Table 1). The most richness families were Poaceae, with three species and Polygonaceae, with two species.

REFERENCE CATALOGUE OF PLANT EPIDERMIS

The elaborated catalogue (Figures 2 - 5) was used to recognize epidermis of the different parts of nine of the 13 inventoried plants. These different types of epidermic cells were rounded, puzzle, puzzle-round-off and polygonal. The stomata were isocytic, anisocytic and paracytic. These stomata were abundant on the faces of the leaves of the studied plant species (Tables 2 and 3).

Table 1 : Plant species inventoried at Ahondo station in Taabo lake.

Plantes inventoriées à la station d'Ahondo sur le lac de Taabo.

Plant species	Family	Life forms and phytochories
Ceratophyllum demersum L.	Ceratophyllaceae	Hyd, Cosm, GC-SZ
Echinochloa pyramidalis (Lam.) Hitchc. et Chase	Poaceae	H, A, GC-SZ
Echinochloa stagnina (Retz.) P.Beauv.	Poaceae	Hyd, PT, GC-SZ
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Hyd, AN, GC-SZ
Ipomoea aquatica Forsk.	Convolvulaceae	Lnp (Hyd), Pt, GC-SZ
Ludwigia stolonifera Guill. & Perr., Raven	Onagraceae	np, A, GC-SZ
Polygonum lanigerum R.Br. var. *africanum* Meisn.	Polygonaceae	np, PT, GC-SZ
Polygonum senegalense Meisn.	Polygonaceae	np, PT, GC-SZ
Pycreus macrostachys (Lam.) J.Rayn.	Cyperaceae	Th, pt, SZ
Vossia cuspidata (Rottb.) Griff.	Poaceae	Hyd, PT, GC-SZ

Life form : Hyd = Hydrophyte, L = Liana, np = Nanophanerophyte, Th = Therophyte.
Distribution : A = African Taxa (Intertropical Africa), GC = Taxa of the Guineo-Congolian endemics (rainforest), Pt = Paleotropical Taxa common to Africa, Asia, Australia, Pacific islands, PT = Taxa common to all tropical countries of the world, SZ = Taxa of the Sudano-zambezian region (savanna, steppes), Cosm = cosmopolitan.

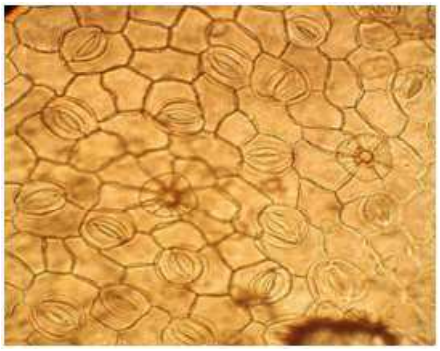

Figure 2 : Epidermis of *Ipomoea aquatica* leaves.

*Epiderme de la feuille d'*Ipomoea aquatica.

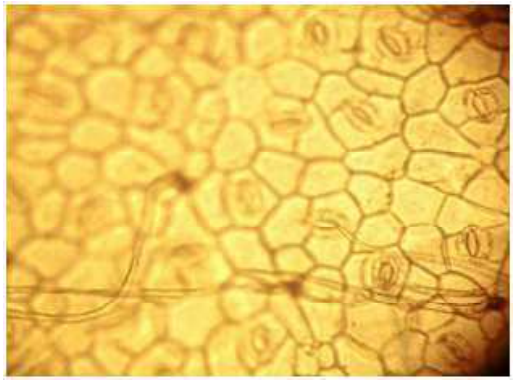

Figure 3 : Epidermis of *Polygonum lanigerum* leaves.

Epiderme de la feuille de Polygonum senegalense.

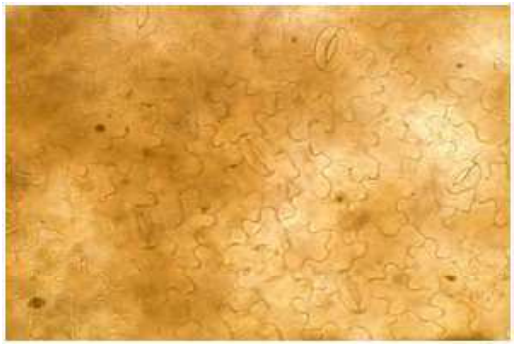

Figure 4 : Epidermis of *Ludwigia stolonifera* leaves.

Epiderme de la feuille de Ludwigia stolonifera.

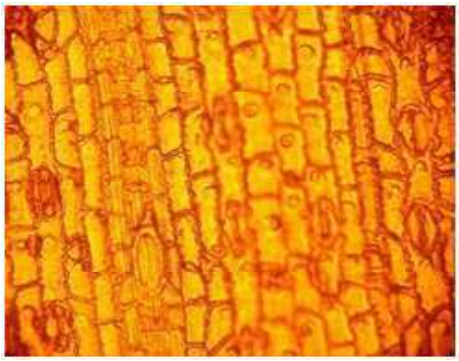

Figure 5 : Epidermis of *Echinochloa stagnima* leaves.

Epiderme de la feuille de Echinochloa stagnima.

Table 2 : Epidermic characters of non graminoid plant species of Taabo dam.

Caractères épidermiques des plantes non graminoïdes du lac de Taabo.

Plant species	Organs	Cells		Stomata	
		form	wall	form	abundance
Ceratophyllum demersum L.	Leaves	Ss	S		
	Stem	Ss			
	Roots	Ss			
Ipomoea aquatica Forsk.	Leaves	L	S	A	+++ (coat)
	Stem	Ss			
	Roots	Ss			
Ludwigia stolonifera Guill. & Perr. Raven	Leaves	L	S	D	+
	Stem	Ss			
	Roots				
Polygonum lanigerum R. Br. var. *africanum* Meisn.	Leaves	L	S	D	++
	Stem	L			
	Roots	L			
Polygonum senegalense Meisn.	Leaves	L	S	A	+++
	Stem	L			
	Roots				

Stomata : A = anisocytic, D = diacytic, + = few abundant, ++ = abundant, +++ = high abundant. Cellular wall : S = smooth, Cells : L = Long, Ss = spindle-shaped.

Table 3 : Epidermic traits of graminoid plant species of Taabo dam.

Caractères épidermiques des graminées du lac de barrage de Taabo.

Plant species	Organs	Cells		Stomata	
		form	wall	form	abundance
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	Leaves	Ss	S		
	Stem				
	Roots	Ss			
Echinochloa stagnina (Retz.) P. Beauv.	Leaves	Ss	S	Td	+++
	Stem	Rc	S	Ni	Ni
	Roots	Rc	S	Ni	Ni
Eichhornia crassipes (Mart.) Solms	Leaves	Rc	S	Rc	++
	Stem	Ss	S	Ni	Ni
	Roots	Rc	S	Ni	Ni
Pycreus macrostachyos (Lam.) J. Rayn.	Leaves	Rc/ Ss	R	Ni	Ni
	Stem	Ss	S	Ni	Ni
	Roots	Ni	Ni	Ni	Ni
Vossia cuspidata (Rottb.) Griff.	Leaves	Ss	R	O	++
	Stem	Rc	R	Ni	Ni
	Roots	Ss	R	Ni	Ni

Cells : long, form : Rc = rectangular, Ss = spindle-shaped
Paroi : S= Smooth, N = nodular, R = rough, Stomata : Rc = rectangular, O = oval-circular, Td = turgid, + = few abundant, ++ = abundant, +++ = high abundant, Ni = non identified.

PLANT SPECIES CONSUMED BY *Distichodus rostratus*

Comparison of the epidermis observed in stomach contents with those of the reference catalogue revealed that plant species consumed by *D. rostratus* were,essentially, *Ipomoea aquatica, Echinochloa pyramidalis, Polygonum senegalense* and *Pycreus macrostachyos* (Figures 2 - 5). These plants seem to represent a significant portion in the diet of this fish because of the frequency of their fragments in the analyzed stomach contents.

DISCUSSION

Most species inventoried on the site of Ahondo were macrophytis including hydrophytis and nanophanerophytis such as *Polygonum senegalense* and *Eichhornia crassipes*. Only one species, *Ipomoea aquatica* was climbing plant. Etien and Arfi (1996) showed that free floating plants (*Eichhornia crassipes*), plants with floating leaves (*Polygonum senegalense*) and those with emerged leaves (*Echinochloa pyramidalis*) constitute the most common

species in the aquatic environments in the South-eastern, Center, Mid-western and Northern Côte d'Ivoire. These plants have generally invaded these areas since ten years and cover approximately 70 % of the water surface (Etien and Arfi, 1996).

Some of the plants consumed by *D. rostratus* such as *Ipomoea aquatica* are common species of the aquatic environments of the Côte d'Ivoire. The list of these plants is not exhaustive. The fragments of certain plants present in the stomach contents could not be identified due to lack of correspondence in the reference catalogue. It will be thus necessary to carry out an exhaustive floristic inventory in the Lake Taabo in order to have a complete atlas of plant epidermis. With the success of the application of micro-histological approach in determination of diet of fish, this study may be extended to other herbivorous fish species of economic interest present in Côte d'Ivoire hydrosystems. This method already has been used to establish the food consumed by certain animal species such as *Apodemus sylvaticus* (Butet, 1985 ; Mandret, 1991). This approach seems precise for animals that are herbivorous (Butet, 1985). The micro-histological method was thus adapted to investigate the diet of *D. rostratus* which, exclusively, consumes plants from Cyperaceae, Lialiaceae, etc. (Daget and Iltis, 1965 ; Planquette and Lemasson, 1975 ; Reizer, 1995).

Our study confirms the presence of Cyperaceae in the stomach contents of studied specimens of this fish species, notably, *Pycreus macrostachyos*. According to our knowledge, the floristic composition of the food consumed by a Fish species from Côte d'Ivoire, is reported here for the first time.

At a nutritional level, *Ipomoea aquatica* contains various minerals such as calcium, magnesium, iron as well as carbohydrates, lipids and fibres (Umar *et al.,* 2007). These various nutritive elements are essential to the development and the growth of fishes. These studies on the biochemical, mineral and vitamin composition of identified plants are important in order to know their nutritional values for *D. rostratus*. This study showed that five plant species enter in the diet of this local fish.

CONCLUSION

The micro-histological analysis method of plant epidermis is used for the first time in the identification of the plants consumed by Fish species. This opens up the way for a better knowledge of the floristic composition of the diet of herbivorous fishes and, so to develop some nutrition process to improve the nutrition of breeding Fish species in aquaculture farms. According to the list of the five plants identified as part of the food of *D. rostratus*, breeding of this local fish in control condition is possible. However, it will be important to evaluate the contribution of each macrophyte consumed by *D. rostratus.* The valorisation of these identified plants will contribute to the development of aquaculture of this Fish species in Côte d'Ivoire using natural foods. Thus, we plan to look further into this study by a more exhaustive inventory of the aquatic plants in order to have a complete catalogue of plant epidermis consumed by *D. rostratus.*

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