Technical note on the health risks associated with consumption of fish *Tetraodontidae*, *Diodontidae* and *Molidae* in Senegal

Massal FALL[1], Mbaye MBENGUE[2], Khady Goudiaby DIOUF and Hortense KOUSSAYE[1]

(1) Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT), BP 2241, Dakar, Sénégal – Email : massal.fall@gmail.com
(2) Laboratoire National d'Elevage et de Recherches Vétérinaires (LNERV), BP 2057 Dakar-Hann, Dakar – Sénégal
(3) Laboratoire d'Etude des Poissons de l'Afrique de l'Ouest (LABEP-AO/IFAN), BP 206 Dakar – Sénégal
(4) Institut Universitaire de pêche et d'Aquaculture (IUPA/UCAD), BP 45 784, Dakar-Fann, Dakar – Sénégal

Abstract

In Senegal, in West Africa, due to the scarcity of conventional fish resources, consumers, tend to eat more and more categorical fish that were almost unknown in local dietary until the beginning of 70-80's years. Among those products are fish of *Tetraodontidae*, *Diodontidae* and *Molidae* families. However, their consumption is not completely free of danger because of the possible presence of a powerful neurotoxin: Tetrodotoxin. Recognizing that poisoning cases are especially reported from Japan and Pacific Islands, the authors, without being alarmists, invite their compatriots to more vigilance through a number of measures of shielding.

Keywords: Senegal, Africa West, fish toxic, tetrodotoxin, risks

{Citation: Massal Fall, Mbaye Mbengue, Khady Goudiaby Diouf, Hortense Koussaye. Technical note on the health risks associated with consumption of fish *Tetraodontidae, Diodontidae* and *Molidae* in Senegal. American journal of Research Communication, 2013:} www.usa-journals.com, ISSN: 2325-4076.

I. Introduction

Senegal (16 ° 04 N - 12 ° 20 N) is a West African country characterized by a long tradition of fishing and consumption of fishery products. Indeed, if industrial fishing is relatively recent (20th century and especially from the years 1950-1960), however, artisan, lagoon and river fishing were developed for centuries on the maritime fringe from the 17th century. The "Petite Côte" (from Dakar to the northern border with the Gambia) was the first fishing site followed by the "Grande Côte" (from Dakar to Saint-Louis) during the 18th century with canoes able to cross the bar (Guèye, 1988) (Figure 1).

Figure 1: Map of Senegal with an illustration of its long coast of about 715 km

The Senegalese take 75 % of their animal protein from fish they consume at a level of 26 kg/year/per capita. In addition, the "tiébou dieune", a local fish and rice menu, greatly contributes to the reputation of

the country. Unfortunately, "noble" fish (*Serranidae*, *Sparidae*, etc.) classically used for its preparation is presently so rare and expensive that populations are folded on fish almost scorned to the beginning of the years 1970 – 1980. Among these fish are those of family *Tetraodontidae* ("fish globes"), *Diodontidae* ("fish porcupines") and *Molidae* ("fish Moons"). E.g., the consumption of "boune fokki" or smooth compeer *Lagocephalus laevigatus* became common in households due to scarcity of groupers, breams, barracudas, snappers, etc. However, the ingestion of the flesh of fish of the previously mentioned families is not completely free of trouble… This article, far from being alarmist, presents those taxes and includes their treatment and potential toxicity for better local information and to prevent any risk of intoxication.

II. Succinct presentation

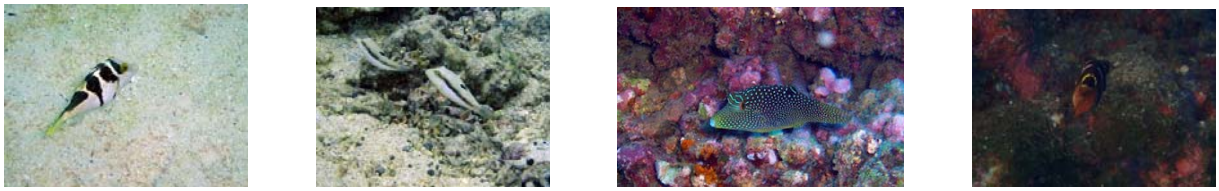
The ***Tetraodontidae*** is a family of fish comprising 19 genera and at least, 121 species among which the most common in our waters are *Lagocephalus laevigatus*, *Ephippion guttifer*, *Sphoeroides* p*achygaster* and *Tetraodon sp*. See in Figure 2 and in Blache, Cadenat and Stauch (1970), Bellemans, Sagna, Fischer and Scilabba (1988) and Séret and Opic (1990). Primarily marine and estuarine, these species are absent in cold waters and live most often in tropical – rarely temperate – environment. They chiefly evolve in coastal areas, even if some of them live in oceanic (*Lagocephalus sp*) or offshore (*Sphoeroides* p*achygaster*) conditions. Those fish are able to inflate themselves with water or air to dissuade their enemies. They have 4 large teeth, melted in an upper and lower plan (2 above and 2 below) forming a powerful beak used for crushing crustaceans and mollusks shells. In Senegal, the biology of the reproduction of *Lagocephalus laevigatus* has been studied by Diagne (1997). There are 2 periods of spawning: the first one, most important, takes place during the hot and rainy (July to October) while the second period occurs during the dry et cold season (December to January) after a slight recovery of maturation in November. Testicular activity also presents 2 periods of activities coinciding exactly with those 2 periods of female egg-laying. The sex ratio is favorable to males. In reference to the standard length of the body, the size of sexual differentiation occurs at 20-25 cm, that of first sexual maturity at 24.5 cm for males and at 27.5 cm for the female.

Figure 2: Illustration of fish species belonging to the family *Tetraodontidae*

Lagocephalus laevigatus *Ephippion guttifer* *Pachygaster sphoeroides*

To be complete and in comparison, let's mention fish of the *Canthigasteridae* family which are less large (10 cm), have a long snout and more vivid colors. Their representatives are almost unknown in Senegal (Figure 3).

Figure 3: Illustration of fish species belonging to the family *Canthigasteridae*



Canthigaster valentini *C. bennetti* *C. solandri* *C. ocellicincta*

The family ***Diodontidae*** also includes species with the ability to inflate. But, in addition, they are equipped with massive spines which may be very long with large roots under the skin. Their lengths vary from 50 cm to 1 m while their nasal organ displays small tentacles located opposite eyes. Their mouth is large and wide. Teeth are fused in a beak of crushing. There is a structure without a median suture dividing the upper and lower jaws into left and right parts. Species *Chilomycterus* antennatus and *Diodon*

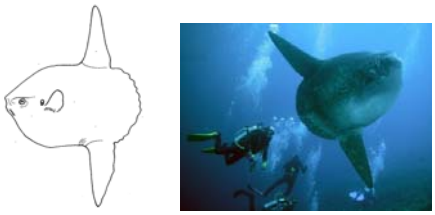
holocanthus species are quite common in Senegal (Blache, Cadenat et Stauch, 1970 – Bellemans, Sagna, Fischer et Scilabba, 1988 – Séret et Opic, 1990) (Figure 4)..

Figure 4: Illustration of fish species belonging to the familly *Diodontidae*

Global scheme of *Diodontidae* *Chilomycterus antennatus* *Diodon holocanthus*

The ***Molidae*** (Figure 5).form a family of fish with very particular specific degeneration characters: the caudal peduncle is atrophied, the body is truncated behind the dorsal and anal fins and the number of vertebrae is reduced to 16-17. The entire body is laterally compressed and nearly circular explaining the term Mola ("grinder") that designs the main genus of which representatives have an aspect of "semi-fish", "sunfish" or "moon fish". The typical example is *Mola mola* mole that can measure up to 4 m long and weighs 2 tons. This species has non swim bladder or bony plates on the skin which is thick and dense, however. A large portion of its skeleton is cartilaginous. To move, it emits a jet of water from the mouth or gills, swims especially with its dorsal and anal fins while its pectoral fins probably serve for equilibrium. The species is pelagic and seems to be indolent as it floats passively and is sometimes released on the coast. Their teeth are merged into a 2 dental plates beak by jaw without median suture; what prevents the mole to close his mouth. Their diet is mostly based on soft-bodied animals (medusa, salps, etc.), small fish and crustaceans. The eggs are tiny and give birth to pelagic larvae that undergo metamorphosis. Adults are generally heavily parasitized.

Figure 5: Illustration of *Mola mola* with its visible dorsal and anal fins



III. Fishing and treatment

The size of most of the fish studied here is common up to 55-60 cm and maximum to 100 cm (Bellemans, Sagna, Fischer et Scilabba, 1988) while the species *Mola mola* can reach up to 4 m. Fishing gear are of demersal/benthic (miscellaneous lines, bottom trawls, gill nets, beach seines, etc.) or pelagic types that operate according to a targeted way or not, like fishing nets which are specially dedicated to swordfish catches but accidentally captures moles (Table 1).

In Senegal, the presence of the species *Mola mola* has been recently mentioned, mainly in Kayar (northern coast, 70 km from Dakar). In that fishing site, artisanal fishermen catch it directly by taking up its fins when it comes alongside their canoes. Species of the genus *Lagocephalus* are caught with a line-baited hook preceded by an ordinary wire that helps to prevent the great capacity of those fish to cut nylon lines or others. Specifically, the species *Ephippion guttifer* is a banal capture of the beach seines whose height are relatively low (10 to 15 m, in general).

The mole is the less locally consumed of these fish probably due to its relative ignorance, anthropomorphic considerations and to its fat-rich flesh according to fishermen. Elsewhere, in the Asiatic and Pacific countries, all its parts from fins to internal organs are generally edible, not to mention the use of some of them in traditional Chinese medicine. For example, the sunfish is a dish enjoyed in some

regions, mainly in Taiwan and Japan. Species of the genus *Lagocephalus* are, on the other hand, the more consumed fish within households, restaurants and hotels in Senegal. For example, a crate of products of about 35 kg, can easily be assigned between 8 000 – 15 000 FCFA, that is to say 12 – 23 euro. Once captured, all those fish are generally skinned, eviscerated and slashed; heads being reserved for artisanal processing as « guedj », a famous dried, salted and fermented product particularly appreciated in the "thiébou dieune". The remaining part, let's say the flesh, is consumed through miscellaneous rice-based preparations, braised, grilled, transformed into pellets or added to the Cantonese rice.

Tableau 1: Principal size and fishing technics of the studied fish

Taxons	Tailles	Autres paramètres
Diodontidae	Up to 100 cm	4 benthic or pelagic species captured occasionally for ornamental purposes. Gear: coastal lines operating at 100 m depth approximately
Ephippion guttifer	Maximum size of 70 cm, common up to 55 cm	Common species in shallow and estuarine, especially in the South of Senegal. Present all year long. Gears: lines, bottom trawls, bottom-set gillnets and beach seines
Lagocephalus laevigatus and *L. lagocephalus*	Maximum size of 70 cm, common up to 60 cm	Inhabit coastal waters, preferably sandy and muddy biotopes. Gears: cf. previously. Those species are intensively fished around the Dakar region, throughout the year
Mole *Mola mola*	Up to 4 m !	Fishing activities are not regulated somewhere in the world. Moles are sometimes accidentally captured by fishing nets targeting swordfish (30% in California, 71 to 90% in the Mediterranean). Fishermen, who accuse them of stealing their catch, tend to section their fins; what leads to their death. There is a global declining global of stocks, probably caused by a too high number of fishing catches

IV. Toxicology

In France, fishery products derived from fish toxic belonging to *Tetraodontidae*, *Molidae*, *Diodontidae* and *Canthigasteridae* families must not be marketed according to Article 2 of the Decree of the Minister of Agriculture and Hydraulic Resources of 02/11/2006 amending and supplementing the order of the Minister of Agriculture of 19/09/1998. Within the European Union (EU), the sale of Mole meat is prohibited for hygienic reasons. In the United States of America (USA), individual import of fugu (see below) is prohibited; the Food and Drug Administration (FDA) allows it only to Japanese restaurants whose chefs are certified by their country. Indeed, those fish, known as traditional, expensive and very delicate dish for many Asian, Japanese and Polynesian consumers, expose them therefore to sanitary risks.

According to Rivolier and Rivolier (1969), there is in fact a poisoning due to the consumption of flesh (taken in the broad sense) of nearly 50 species of toxic fish of *Tetraodontidae* (± 40 species including those of the genus *Takifugu* with fish known as fugu, strongly incriminated in Japan: see Figure 6), *Diodontidae* (± 10 species) and *Molidae* (1 single toxic species) families. These species are common in all warm (tropical) waters of the globe. In Japan, fugu is mainly fished in Shimonoseki. For several decades, it tends to colonize the Eastern Mediterranean with other vegetal and animal species.

Figure 6: Fish called fugu

The causative agent is Tetrodotoxin (TTX), a neurotoxin of formula $C_{11}H_{17}O_8N_3$ (Figure 7), isolated for the first time in 1909 and which, in its crystalline form, can have sugar cane properties in terms of taste, color, etc.

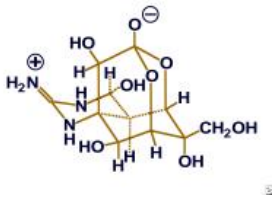


Figure 7 : Chemical structure of tetrodontoxine

Its presence within fish is due to its production by 4 different strains of bacteria: *Pseudomonas sp*, *Vibrio fischeri*, *V. altermonas* and *V. alginolyticus*. The TTX toxin is primarily localized in gonads (chiefly ovaries), liver, skin and intestine (gut, in general), with an increased toxicity at the end of the spring and before the spawning period (Rivolier and Rivolier, 1969). From this last point of view, females are considered more toxic than males due to high toxin concentrations noticed in their ovaries. The TTX, almost absent of flesh and especially blood, is present in fish via the food chain as it can be synthesized by bacteria or algae (ex: *Dinoflagellae*) species associated with them. So, TTX traces were found in the red algae species *jania* (genus *Rhodophyta*) from which it is possible to isolate a bacterium which will produce this poison during its growing. The bacterium is likely digested with the alga by the fugu. After what, the later accumulate the toxin it does not produce in artificial conditions and in relation to which it is normally resistant. The TTX toxin is not only described in fish but also in other animals such as newt, eastern salamander and blue Octopus (Bradley and Kilka, 1981). According to Rivolier and Rivolier (1969), the toxin is, fortunately, heat-labile, that is to say sensitive to heat. However, its destruction occurs only after several hours of boiling; so, even cooked, these fish may kill human-being within an hour. Tetrodotoxin is part of a group of 7 derivatives or similar products acting all as powerful neurotoxins in the site 1 of excitable membrane voltage-dependent sodium channels. Such action blocks the sodium influx and, consequently, the potential of action. In other words, these substances actions are linked to the blockade of synaptic transmission at the level of cholinergic pre-ganglionaric fibers and neuromuscular junction (Rivolier and Rivolier, 1969) and to the the selective blocking of nerve and muscle calcium channel (Hommel, Hulin, Saignavong and Desbordes, 1992). Clinically, the poisoning begins with a paresthesia appearing 10 to 45 minutes after ingestion with tingling (langue surface and interior of the mouth), vomiting, dizziness, anxiety and weakness. An ascending paralysis is developed and death can occur within 6 – 24 h, due to a secondary breach of respiratory muscles (Hommel, Hulin, Saignavong and Desbordes, 1992). Other signs can also be mentioned such as salivation, muscle spasms, profuse sweating, pleuretic pain, dysphagia, aphonia and convulsions. Serious poisonings are detected by signs of hypotension, bradycardia, corneal reflexes depression, etc. The diagnosis is based on history (type of ingested fish clearly, for example), clinic and laboratory toxin identification or its derivatives. The treatment is symptomatic in case of absence of a specific antitoxin. Thus, various approaches exist such as provoked vomiting (if not spontaneous), gastric cleaning (alkaline solution), endoscopy, activated carbon, oxygen, assisted respiration, atropine (bradycardia), dopamine (hypotension), etc. In terms of prognosis, TTX may cause the death of 60 % of consumers who ate intoxicated flesh (Ellenhorn and Barceloux, 1988). A dose of 1-2 mg of purified toxin can be lethal. Centers for Disease Control and Prevention (CDC) in the USA mention poisoning cases posterior to ingestion of relatively low quantities (1.4 ounces) of fish. Mortalities are more important in

the Japan due to local dietary habits. They vary a lot (1 to 100) with, for example, 3 cases in 2003 against 176 in 1958, year from which began the fugu preparation regulation. According to the Fugu Research Institute in Japan, 50 % of victims ingest the liver against 43% for the ovaries and 7% for the skin. One of the most famous victims of the fugu is Mitsugoro Bando VIII, a Kabuki's actor. Described as a National living treasure, he died January 16, 1975 after ingesting 4 fugu livers in a restaurant in Kobe.

V. General considerations and actions to be implemented in Senegal

In Haiti, Tetrodotoxin has been for a longtime used in Voodoo rituals: condemned persons within a community were paralyzed with a TTX-based mixture plunging them into a state close to death. Later, they were brought back to normal life with plant decoctions containing atropine (ex: datura) then, with various psychotropic drugs to annihilate any willingness on their part. This led to transform them into "zombies", kind of undead – living persons maintained in slavery. In Japan, in order to prevent any TTX poisoning, only graduated chefs with a State diploma of State issued by the Ministry of health since 1958 are allowed to prepare fugu which is a very traditional, popular and expensive food served as *sashimi* (fine slices, visible through the fish dishes) or *nabe* (family winter dish). Consequently, negative and severe sanctions are applied without any hesitation. For example, a chef of a famous restaurant in Japan was definitively excluded of fugu preparation due to the poisoning of a 35 years woman in 2011. The residents of the Tuamotu Archipelago, in Polynesia, prepare fugu according to a tradition transmitted through from generations.

Very far away from these realities, in particular in Senegal, the consumption of incriminated fish has become quite common, due to the scarcity of "noble fish": groupers, breams, etc. But, is population's consciousness good about the potential poisoning hazards linked to the eating of fish of *Tetraodontidae*, *Molidae* and *Diodontidae* families?

Without recourse to any questionnaire, the few discussions made here with our compatriot edified us of the contrary. Some are even very surprised we talk them about potential poisoning risks with these fish they eat for a long time and of which them, their relatives and clients are very satisfied (white flesh, "chicken of the sea", as they say). Of course, our culinary traditions in terms of long cooking at high temperatures would, at least, destroy any trace of tetrodontoxine. On the other hand, the consumed products are previously skinned and eviscerated; what eliminates de facto the most dangerous organs: skin, liver, intestines and gonads. Last but not least, in the present state of our knowledge, the synthesis of TTX by bacteria and dinoflagellate off the Senegalese maritime waters seems not to be yet effective.

Despite all of this and without being alarmist, we think it is still useful to draw the attention of the populations on the risk of intoxication and especially the means of preventing it. Beforehand, an important step could be crossed in analyzing the content of TTX in the flesh of the targeted fish (*Tetraodontidae*, *Molidae* and *Diodontidae*) within the framework of a doctorate in veterinary, human medicine, animal biology or environmental sciences. Then, it would be good that local health personnel, particularly physicians and especially emergency ones keep in mind tetrodotoxin poisoning risks due to related fish consumption as late or wrong diagnosis can be lethal. Finally, the following prevention measures should be promoted in direction of local populations:

- Learn to identify, even poorly, fish belonging to *Tetraodontidae*, *Molidae* and *Diodontidae* families of our coasts. A plasticized guide would perfectly match the goal
- Avoid the consumption of brightly colored, "strange" or unknown fish, and especially their viscera and skins
- Provide special care to the butchering and evisceration of the incriminated fish whose skin, liver, gastrointestinal tract and gonads (ovaries, mainly) will be properly disposed
- Proceed as soon as possible to these operations once those fish captured to prevent the post-mortem diffusion of the abdominal tissues (gut, especially) within the flesh, especially during the warm season and in case of lack of refrigeration or related technical methods of conservation
- Clean finely flesh in order to get it maintain it free of any trace of TTX

- Persevere in the observance of a long time cooking at very high temperatures ensuring the destruction of TTX and ban, from this point of view, any grilling remembering the "Tartar steak"

VI. Conclusion

The dosage of Tetrodotoxin in the flesh, skin and viscera of fish of the family Tetraodontidae, Molidae and Diodontidés off the Senegalese coasts could be instructive in terms of possible toxicity of these fisheries products. In the meantime, consumers are invited to better recognize it as well as to demonstrate vigilance in their preparation (long and high times temperatures cooking) and consumption (exclusion of skin and viscera). At last, the medical staff must be conscious and trained on the possibility of poisoning cases related to the ingestion of these products.

References

Anonyme, 2011. Les produits de la pêche toxiques. Bulletin d'information des Services vétérinaires, France. Bulletin d'information n° 6 : mars 2011, 28 pages

Bellemans M., Sagna A., Fischer W. et Scilabba N. 1988. Guide des ressources halieutiques du Sénégal et de la Gambie (espèces marines et d'eaux saumâtres). *Fiches FAO d'identification des espèces pour les besoins de la pêche*. Rome, FAO, 277 pages

Blache J., Cadenat J. et Stauch A. 1970. Clé de détermination des poissons de mer signalés dans l'Atlantique Oriental entre le 20ème parallèle Nord et le 15ème Sud. Editions de l'ORSTOM, 479 pages

Bradley S. G and Kilka L. J. 1981. Une intoxication mortelle par le triton *Taricha granulosa*. JAMA 1981; 246:247

Dia A. R. D. 1997. Biologie de la reproduction d'une espèce de *Tetraodontidae*, *Lagocephalus laevigatus* (poisson téléostéen) des côtes sénégalaises. Mémoire de DEA en Biologie et physiologie animales - Faculté des Sciences et Techniques, Université Cheikh Anta Diop, Dakar, Sénégal : 69 p.

Ellenhorn M. J and Barceloux D. G. 1988. Toxicologie médicale: diagnostic et traitement des intoxications humaines. New York: Elsevier Science Publishing Company, Inc

Guèye B. 1988. La politique des pêches du Sénégal et le nouveau droit de la mer. Thèse de Doctorat d'Etat. Université Cheikh Anta Diop de Dakar, Faculté des Sciences Juridiques et Economiques, 456 pages

Hommel D., Hulin A., Saignavong S. et Desbordes J. M. 1992. Intoxication par le poisson – coffre (tétrodotoxine). Médecine d'Afrique Noire : 39 (2) : 3 pages

Rivolier J. et Rivolier C. 1969. Accidents provoqués par les animaux venimeux et vénéneux marins. Cahiers Sandoz, Fr. (1969), n° 14, pp. 1 - 62, bibl. (2 p.)

Séret B. et OPIC P. 1990. Poissons de mer de l'Ouest africain tropical. Volume 49, Initiations – documentations techniques IRD Editions, 450 pages

Internet sites :

- http://emedicine.medscape.com/article/818763-overview#a0199
- http://fr.wikipedia.org/wiki/T%C3%A9trodotoxine
- http://medical-dictionary.thefreedictionary.com/Fugu+Poisoning
- http://www.diallotours-africa.net/images/sc092f0.jpg
- http://www.larousse.fr/archives/grande-encyclopedie/page/13495n