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# SOME LOSS FACTORS AND PROCESSING METHODS OF DRIED FISHES USED IN THE SAHELIAN DOMAIN OF CAMEROON

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## ABSTRACT

Fish is an important source of protein, minerals and essential fatty acids for human nutrition. To ensure its permanent availability, this highly perishable commodity is processed and stored. However, during storage, dry fishes suffer significant quantitative and qualitative losses due to the lack of efficient pest control methods and preservative processes. An intensive interview survey was conducted with 175 dry fish sellers in markets and processors' families in the Logone basin from 2020 to 2021 to identify the causes of losses and the usual tools used to limit them. It was found that losses of dry fish start during handling and transport where inadequate packaging breaks the dry fish. In addition, fishes are attacked by insect pests, losses depend on fish species and climate. In the Logone basin, 14 species of fish are caught and processed, the most represented species are *Cyprinus carpio* Linnaeus 1758 with 24.49%, *Clarias gariepinus* Burchell 1822 with 21.26% and *Brevimyrus niger* Günther 1866 with 15.40%. Their major pests are insects (53%), rodents (28%) and fungi (9%). Moreover, during handling/transport, 10% are lost. The insects identified are from the family of Cleridae and Dermestidae. Cleridae predominate in the surveyed areas with 67.76% against 32.23% of Dermestidae. Four species are identified: *Dermestes maculatus, Dermestes frischii, Dermestes ater* and *Necrobia rufipes.* Moreover, to protect their fish against these insect pests, stakeholders use industrial chemicals, generally sold as plant protection products, and local products derived from biodiversity local. The most popular chemical pesticide applied on dried fish has dichlorvos as active ingredient (83%). The most used are DD FORCE (48.51%) and PRIME SHI (16.26%), at the level of sellers and processors. It is an extremely hazardous pesticide, damaging health of consumers and polluting the environment. It would be necessary to consider the use of bio insecticides for the protection of the dried fish against pests and for the health safety of consumers.

**Key words**: Dry fish, insect pests, storage, pesticides, Cameroon, Logone basin

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## INTRODUCTION

Fish and fishery products are a valuable source of high-value protein, and also provide a wide range of essential micronutrients including several vitamins (A, B and D), minerals (including calcium, iodine, zinc, iron, phosphorus, potassium and selenium) and polyunsaturated fatty acids (omega-3) [1]. Their nutritional value is particularly important in sub-Saharan Africa, where over 34% of the population is chronically malnourished [2]. Thus, fresh fish, a highly perishable commodity in hot climatic conditions, in continental tropical environments must be processed (smoking and drying) and stored for preservation that allows its use over a longer period.

Despite these processing techniques, dry fishes are lost during storage, as they suffer both quantitative and qualitative depreciation due to microbial proliferation and infestation by ichthyophagous insects [3, 4, 5]. However, once smoked, to keep insect pests away from dry fish stocks, stakeholders use plant protection products at their disposal [6, 7, 8]. Apart from these regulatory approaches promoted, there has been for more than two decades in the Logone and Benoue basins an intensive use of pesticides whose active ingredient is dichlorvos, commonly called ‘pia-pia’, in powdery and liquid formulations, and also uses of other pesticides based on pyrethrin and imidacloprid [9]. Indeed, with the liquid formulations, actors spray the fish drying racks, as well as the cargoes and bags. They also spray all storage areas of dried fish with the same formulations. Dry fishes in storage are sprinkled with the powdery formulations of this 'pia-pia' [9]. Residues of dichlorvos, the active ingredient of this 'pia-pia', remaining on dry fish can be harmful to consumer health [10]. No studies have been done on the loss factors and the hazard of the products used for fish protection in the Logone basin. Hence, the objective of this study was to identify factors of loss, in order to develop and promote alternative tools of control that can replace dangerous pesticides and preserve the health of consumers and the environment.

## MATERIALS AND METHODS

### Study framework

The Logone basin extends over both Cameroon and Chad. In its Cameroonian part where the study was conducted, it covers the Far North Region located between 10° and 13° North Latitude, then, 13°15 to 15°50° East Longitude, the climate is of the Sudano-Sahelian type, characterised by eight months of drought against 4 months of rain [11]. The hydrographic network is composed of two basins: the Chad basin and the Niger Basin. The Chad Basin includes the Mayos from the Mandara Mountains, the large flood plains including the Grand Yaéré, the Logone basin, the Logone-Chari Delta, Lake Chad and Lake Maga [12, 13].


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Fishing activities are carried out mainly in the Logone basin. Fishing is practised mainly by people belonging to three ethnolinguistic groups: the Kotoko, the Muzgum and the Massa. The products are generally destined for self-consumption or small seasonal markets scattered throughout the study area. Despite the real potential for the development of fishing activities in the Logone basin, random obstacles such as the difficulty of preserving fresh fish for a long period and the damage caused by pests to dry fish stocks lead to a significant loss of fish. These constraining factors impact the local economy and are a powerful brake on socio-economic development.

In the Far North region of Cameroon, the exploration of the Logone Basin was done specifically in the devision of Logone and Chari, and Mayo-Danay, which served as study areas. For this purpose, five localities were selected per division. In Logone and Chari, these were Holom, Zina, Sara-Sara, Evier, Karsé and in Mayo-Danay, these were Yagoua, Pouss, Alvakay, Gobo and Guisseye (Figure 1).

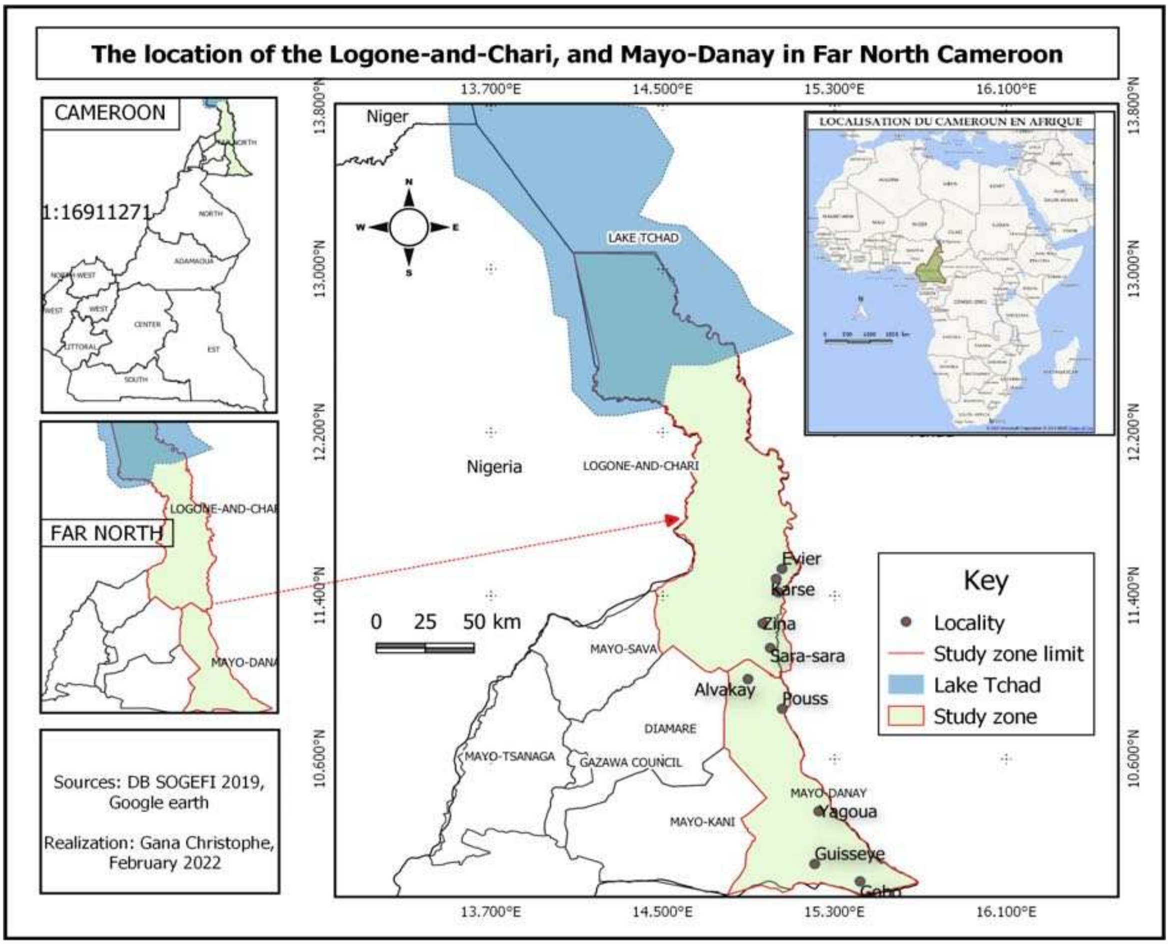


**Figure 1: Location of the study area: Logone-and-Chari and Mayo-Danay in Far North Cameroon**

**Data collection method**

During the survey, the targeted actors were processors and sellers of dry fish in Logone-and-Chari and Mayo-Danay. Thus, with the help of a survey form intended for processors, information was collected via interviews in the main fishing basins of the study area, while a form intended for the management of marketable stocks was used in families and on markets. In each Division, ten actors were sampled per locality.

Dry fish were collected from markets and family stocks. The choice of fishes samples to be collected was oriented towards batches showing signs of pest infestation. These dry fishes in stocks or on the markets were collected and then packaged in plastic bags. The different collections were kept in jars for observations and a follow-up of breeding corresponding to five batches of 100g per Division and a total of ten batches for the two Divisions; these samples were put in jars in the laboratory and observed for 90 days. The laboratory collections were checked every three days by sieving and extracting the emerging adults to determine the pest diversity per study area.

At the level of sellers of dry fish in markets and processors storing fish in shops, information was collected on products used to protect fish and avoid losses due to pests. Where available, empty packages of these treatment products were snapped and all technical information on their packaging noted.

**Identification**

The fish species brought back to the field were identified with the help of civil servants from the extension services of the Ministry in charge of livestock and animal industries, the insect pests were identified using the identification key of Cedric Alonso 2010, and with the help of Laboratory Entomologists of Applied Entomology from the University of Ngaoundere.

**Evaluation of abundance and specificity indices**

- The **abundance index of Dajoz** (1982) was used to categorize the abundances of fish species within a given community according to the following criteria:
  - very abundant if $Pi \geq 50\%$;
  - abundant if $25\% \leq Pi < 50\%$;
  - low abundance if $1\% \leq Pi < 25\%$ and;
  - rare if $Pi < 1\%$; with $Pi=ni/N$ where ni is the numerical abundance of species i over the total number of individuals in the community studied.

  The specific diversity of the different pest species was assessed. Several indices were calculated; the diversity indices of:



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- **Shannon** (H), $\mathbf{H = -\sum pi \log_2 pi}$; with $\mathbf{Pi=ni/\sum ni}$; Pi = relative frequency of individuals of species i; ni = mean recovery of individuals of species i; n = total coverage of pest individuals. From
- **Simpson** (1/D); $\mathbf{D=\sum P^2i}$; Pi = relative frequency of individuals of species i. Its inverse 1/D expresses the diversity and varies from 1 to the specific diversity S.
- From the fairness of **Piélou** (E); **E=H/log2 S**; S designates the specific richness. Equitable is low when Eq < 0.6; medium when Eq is between 0.6 and 0.8 and high if Eq ≥ 0.8.

## RESULTS AND DISCUSSION

### Abundance of fish species

In the Sahelian zone, 14 species of caught fish are processed (smoked or dried) and sold on the markets. According to the abundance index classification of Dajoz (1982), the most abundant species are: *Cyprinus carpio* Linnaeus, 1758 with 26.63%, *Clarias gariepinus* Burchell, 1822 with 22% and *Brevimyrus niger* Günther, 1866 with 13.96% considered as scarce, *Micralestes* and *Citharinus citharus* Geoffroy Saint-Hilaire, 1809 are rare species because the Pi<1% (Table 1).

In the Logone basin, the fish species caught are processed (smoked or dried) and sold in the markets because, in hot climatic conditions, fresh fish perish, deteriorate and enhance microbial proliferation. The post-harvest losses of fish are a major concern and occur in most fish distribution chains in the world [14]. However, in rural Cameroon, especially in the areas surveyed, locally caught fish are directly smoked or dried to improve their preservation and availability [15]. To this end, processed fish are stored in bags (dried fish) and cartons (smoked fish) and kept in shops or family stocks for an average of three to six months.

Even when processed, dry fish remains a commodity that can be lost during a few months of storage due to pest depredations [8, 16]. Long storage times expose dry fish to pest attacks. The quantitative losses of dried fish due to *Dermestes* spp. in a 6-month storage period to be estimated in the order of 26-34% [14].

### Diversity of factors of loss identified in the study area

During the surveys, three factors of loss were identified: pests, moulds and rodents (Table 2). The damage caused by these pests varies from one area to another. According to the results of surveys conducted in the Logone basin, the main loss of dry fish stocks is due to ichtyophagous insects (52.35%), followed by rodents (27.75%). Mould is observed among fish traders who keep fish in family stocks. All the actors interviewed by the department mentioned insects as the main factor in losses. Of the 175 quotations recorded, 100 mentioned insects (53%), 56

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mentioned rodents (28%), 19 mentioned mould (9%) and the remaining 10% were packaging methods (Figure 2). According to the actors considered, the criteria for determining dry fish losses are the presence of fishmeal in the stock, the loss of fish weight, the presence of insects in the stock and mould.

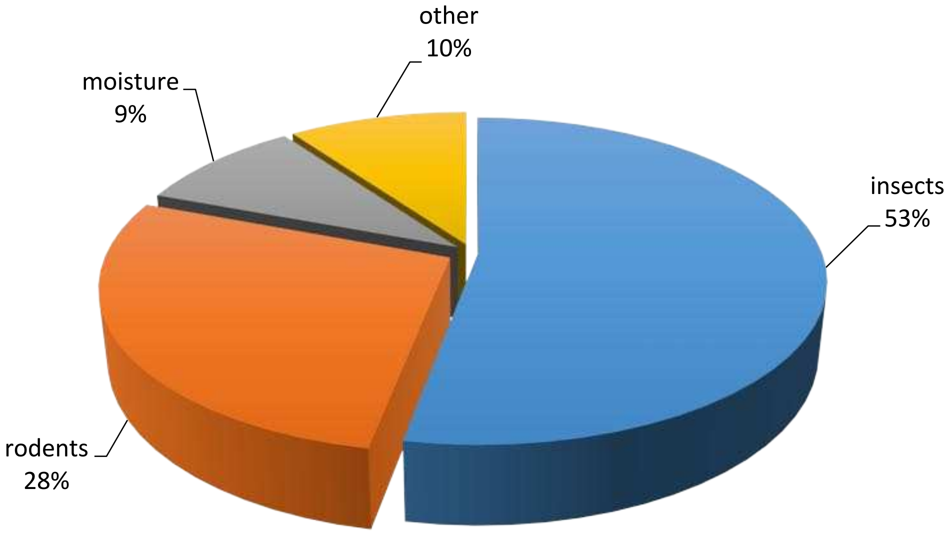


**Figure 2**: **Importance of the factors of losses on dry fish stocks in the Logone basin between 2020 and 2021**

Fish losses due to insect pests are related to larval and adult feeding activities. Heavy infestation of dry fish by beetles can cause up to 30% product loss [17]. Insects can also increase the incidence of micro-organisms and their toxins, which are one of the causes of foodborne diseases. According to Sameza *et al.* [4] mould strains, some of which are mycotoxin producers, can cause illness in consumers of mouldy fish. In addition to developing mycotoxins, moulds also alter the appearance of fish and reduce their nutritional and market value [18].

Rodents, in addition to consuming the fish in stock, break through storage modules such as bags and cartons, thus favouring attacks by insect pests and the loss of fish in quantity.

**Diversity of insect pests of dry fish**

After progressive observation of fish samples collected in the field and observed in the laboratory, the fish-eating species identified are from two families: Dermestidae and Cleridae. These insects emerging from the samples of dry fish collected in the study area and observed are distributed according to the sampling sites. The abundance of species varies from one area to another (Table 3).

From ten batches of dry fish put under observation in the laboratory, a total of 1035 emerged pest adults were extracted. These pests obtained were present in the departments considered. The abundance of Cleridae predominates in the two

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departments surveyed with 77.16% against 22.84% Dermestidae and 58.37% against 41.63% Dermestidae, respectively in Logone and Chari, and Mayo-Danay (Table 3).

Despite the population dynamics of Cleridae being 67.76% of the number, Dermestidae remains the primary pest of dry fish stocks in the Logone basin, because according to laboratory observations, when put under the same conditions on the same substrates, Dermestidae is more voracious than Cleridae. According to Tamgno *et al.* [16], *Dermestes* and *Necrobia* are the most damaging insects for fish storage in Cameroon. Insect pest infestation is the main cause of fish losses in stocks. Dried fish products frequently suffer severe losses due to infestation by beetles (*Dermestes*, *Cornestes* and *Necrobia spp.*) [19, 20].

The diversity of pests is unevenly distributed in the areas surveyed. The values of the diversity indices are low. Shannon index values; H< 2 and Piélou's equitability; Eq<0.6 for Logone and Chari and Eq> 0.6 for Mayo-Danay (Table 4). The low values of H and Eq lead to the conclusion that the study area represents a homogeneous and specialized environment. The inverse of Simpson's dominance index (1/D) is close to 1, thus showing the low abundance of pest species. According to Akpo [21], greater diversity implies greater equality of individual contributions. Conversely, a lower diversity means a lower regularity in the distribution of individuals. Four species are identified: *D. maculatus, D. frischii, D. ater* for the family Dermestidae and the single species of *Necrobia rufipes* for the family Cleridae. The abundance of *Necrobia* predominates in both divisions, which opposes the work of Osuji [22] which has shown that, 71.5% of dried fish infestation in most production areas is caused by *D. maculatus* Akinwumi *et al*. [23] These species are all present in Mayo-Danay, unlike in Logone and Chari where the species *D. ater* was not found. This difference can be explained by the techniques used for the conservation of dry fish, the treated fish limit the development of insect pests. The losses due to these pest species are related to the feeding activities of the larvae and adults which lead to a decrease in the finished product. The presence of pests in dry fish causes physical and chemical damage leading to loss of nutritional value. This loss of quality is reflected in a change in the smell and taste of the product. The activities of insect pests favour the development of micro-organisms and the incidence of their toxins, which are one of the main causes of food poisoning following the consumption of dry fish.

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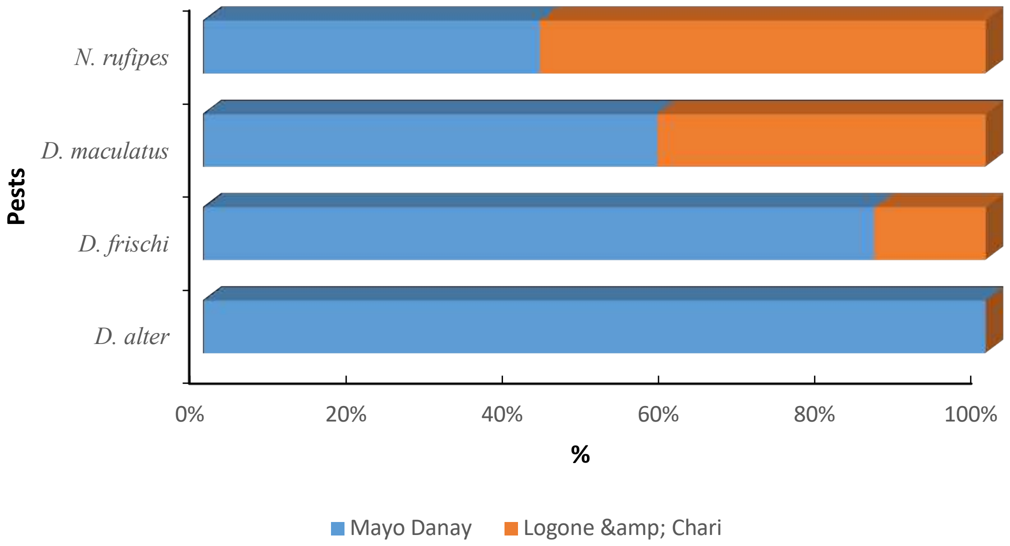


**Figure 3a: Importance of fish-eating insect pests of dry fish stocks collected from stakeholders in the Logone basin (by Department) between 2020 and 2021**

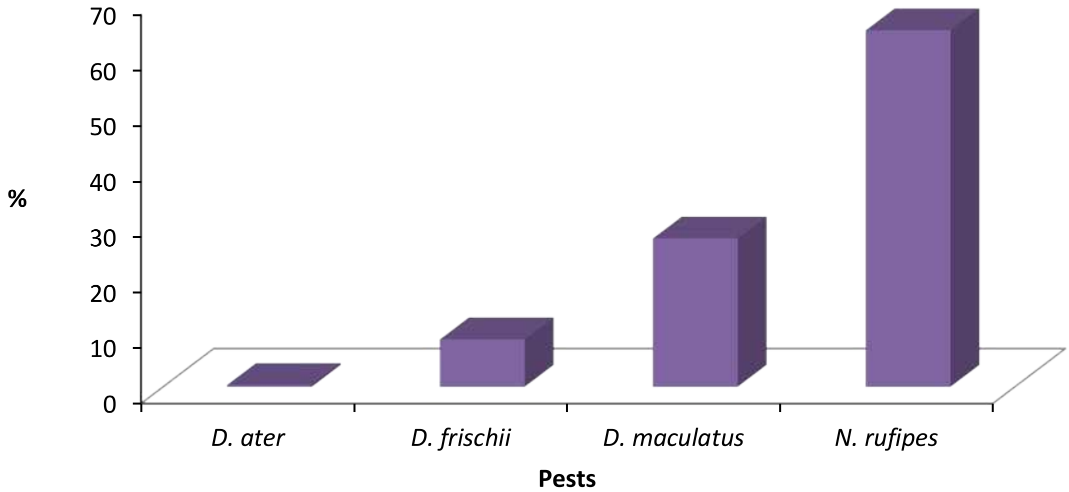


**Figure 3b: Importance of fish-eating insect pests of dry fish stocks collected from stakeholders across the area between 2020 and 2021**

In the study area, pest species are unevenly distributed. Thus, *N. rufipes* of the family Cleridae is the majority species with 77% in Logone and Chari and 58% in Mayo-Danay, followed by *D. maculatus* with 21% in Logone and Chari and 29% in Mayo-Danay (figure 3a). Climatic factors and the various fish species present may be the parameters influencing the development of insect pests.

According to Gredilha *et al*. [24], the industry standard of 12% humidity in animal feed bags provides suitable conditions for the proliferation of insect pests. Thus, in the Logone basin, the high population of *Necrobia* (Table 4) is vaporized by the humidity created by the storage modules in the fish stocks. The success of infestation by *N. rufipes* is related to the environmental conditions provided to the insects [25]. When humidity levels are high, sufficient drying cannot be achieved using the traditional technique, dried, processed and stored fish reabsorb moisture and become favorable for the growth of molds and insects [17, 24].

**Losses in dry fish due to packaging and handling**
Besides these living factors, mainly pests, non-living factors and mainly the packaging method, which is the storage module or the packaging of the goods, cause more than 19% of the losses (Table 2). This loss increases when the smoked fish undergoes the pressure of several manipulations from one destination to another. Packaging such as bags and cartons does not preserve the dry fish during handling and causes the breakage observed during fish delivery, especially smoked fish (Figure 4). These qualitative and quantitative losses are observed from the processing site during loading to the storage places during unloading. Eyo and Mdaihli [26] also noted that the breakage of fish accelerates the rapid infestation of beetle pests, particularly *D. maculatus*, and could endanger whole fish left in storage for too long.

**Diversity of pest control measures applied on dry fish during processing and storage**

**Phytosanitary chemical insecticides**
In the Logone basin, 12 synthetic chemicals have been identified as protecting dry fish stocks. Among these products, the most used are DD FORCE (48.51%) and PRIME SHI (16.26%), at the level of sellers and processors (Table 5). The use of these products varies according to the zones. The abusive use of these products in shops by wholesale traders who keep fish for a long time is a constant in the study area.

Various chemical products for phytosanitary purposes are used by traders and processors for the conservation of dry fish. Twelve synthetic chemical products were found on the markets of the vendors and in the family stocks (processors) in the sectors surveyed. The vendors used more products than the processors in the treatment of fish, ten of these products are not registered in Cameroon. These products are used much more in the shops of wholesale traders. This is explained by the fact that the actors store large quantities of fish for a period of three to six months, enhancing its availability on the markets. Among these products, the *pia-pia* whose commercial names are: PRIME SHI, DARKSH, DD FORCE, DDVP


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1000EC, PESTOFF100%EC, DIZVAN and the active ingredient *dichlorvos* is the most popular among sellers and processors, as 83% of the actors interviewed used it (Figure 4). It should be noted that *pia-pia* is the main chemical used by almost all traders, as almost 100% of the actors interviewed per division mentioned *pia-pia* as a product to protect fish against insect pests. The reasons given by some traders for not using chemicals include an insufficient quantity of fish stored, short shelf life and lack of shops.

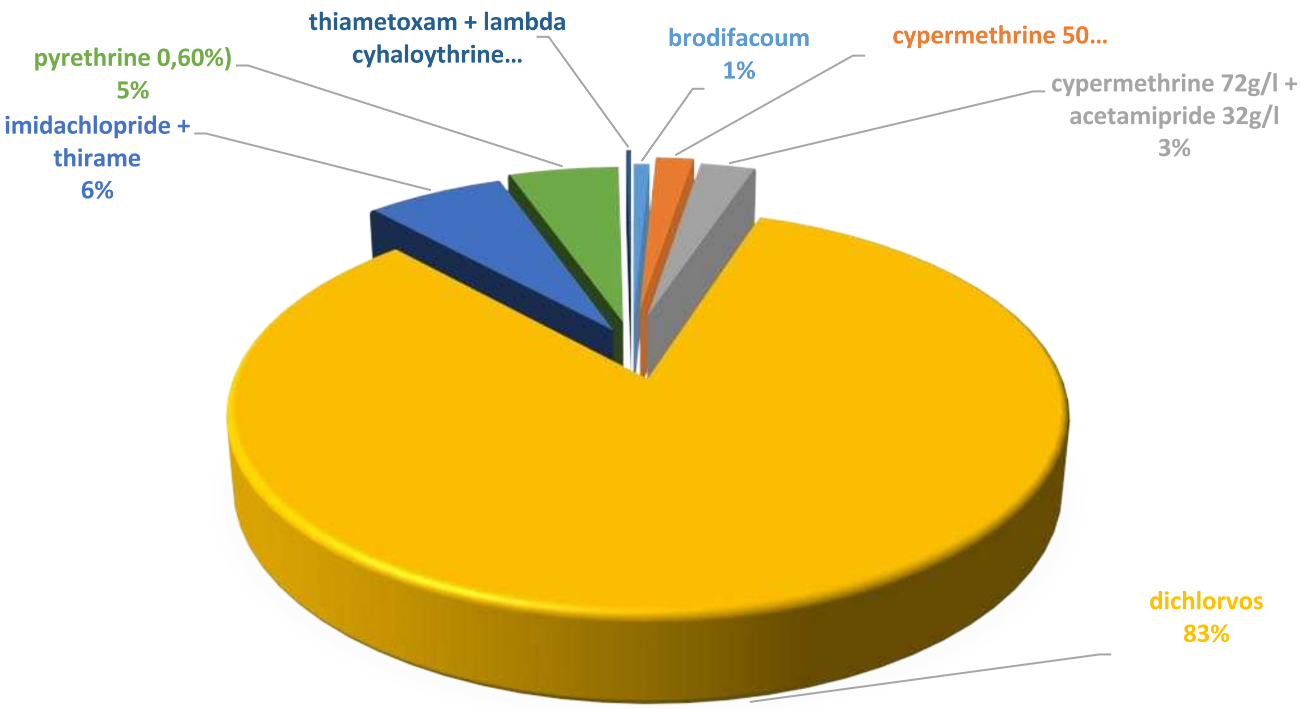


**Figure 4**: **Relative importance of active ingredients of pesticides applied to stored dry fish, on packages or sprayed in shops to limit pest attacks in the Logone basin between 2020 and 2021**

These products are either applied directly to bags already containing dry fish or sprayed in shops. This active ingredient, dichlorvos, is classified as an extremely hazardous pesticide to health [27], as it is carcinogenic and neurodegenerative [28].

### Use of self-made products from local resources

Other strategies used by traders and other actors in the conservation of dry fish focused on developing processing products from available local resources. The products used include salt, palm oil from the nuts of the *Eleais guineensis*, ash from the seed of *Moringa oleifera* and chilli pepper, *Capsicum frutescens*.

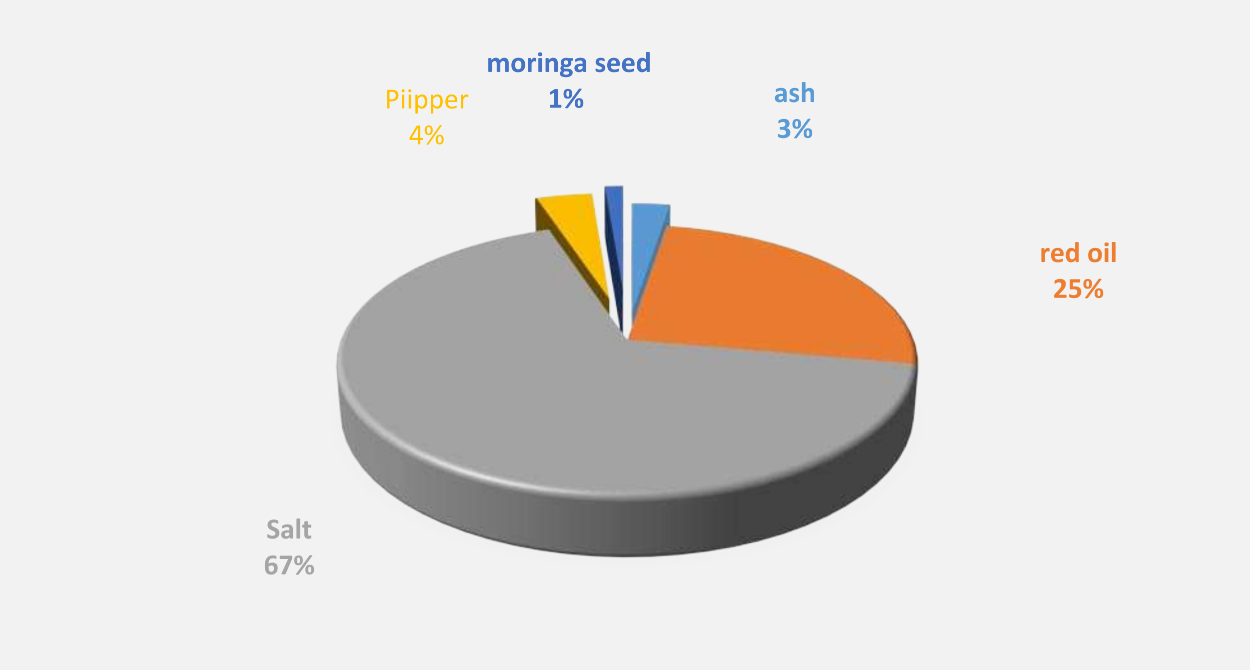


**Figure 5**: **Diversity and importance of sources of active ingredients used in the development of self-made insecticides by stakeholders in the Logone basin for the protection of dry fish during storage**

Five self-made formulations based on ingredients from local biodiversity were used for the protection of dry fish stocks. These are ash, red oil, sal, and powders of crushed *Moringa oleifera* seeds and chilli. Salt was widely used in the conservation of fish (67%), this technique is the most widespread for the protection of family stocks, it is used for sprinkling or in the form of brine for soaking fish in a fresh state for treatment before smoking and drying; large fish are cut up. Among the sellers, red oil (25%) was the most widely used self-made product, it is sprinkled on dry fish in stock or already on the markets.

## CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

The main losses of dry fish stocks in the Logone basin are the consequence of the packaging and wrapping devices which cause qualitative losses in the form of broken fish on the one hand and pest attacks on the other. Three (3) groups of pests of dry fish are identified: insect pests, rodents, and moulds. To limit losses, stakeholders used 17 formulations, 12 of which were industrial chemicals, of which ten 10 were based on dichlorvos, which are extremely hazardous and are widely used (83%). In addition, five (5) self-made formulations from local resource ingredients were used. This practice is not popular and the consumption of dry fish in this area carries a real health risk for the consumer.

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**Table 1: Abundance index of the most processed freshwater fish most represented on the markets in the study area**

| N° | Species found | local names | Mayo-Danay | Logone and Chari | Pi (%) |
|---|---|---|---|---|---|
| 1 | *Cyprinus carpio* Linnaeus, 1758* | Carp | 55 | 63 | 26.63 |
| 2 | *Clarias gariepinus* Burchell, 1822* | Catfish | 54 | 43 | 22 |
| 3 | *Brevimyrus niger* Günther, 1866 | Soudamouka | 29 | 35 | 13.96 |
| 4 | *Brycinus nurse* Rüppell, 1832 | Sardine | 19 | 15 | 7.42 |
| 5 | *Arius africanus* Günther, 1867* | Machoiron | 31 | 3 | 7.42 |
| 6 | *Labeo sp.* | Bidé | 12 | 19 | 6.77 |
| 7 | *Synodontis sp.** | Kouroungou | 16 | 24 | 5.24 |
| 8 | *Oreochromis niloticus* Linnaeus, 1758* | Tilapia | 14 | 8 | 4.82 |
| 9 | *Lates niloticus* | Captain | 1 | 4 | 1.08 |
| 10 | *Hydrocynus sp.* | Sagaie | 4 | 2 | 1.40 |
| 11 | *Anguilla sp.* | Angus | 5 | 2 | 1.52 |
| 12 | *Heterotis niloticus* Cuvier, 1829 | Kanga | 4 | 1 | 1.08 |
| 13 | *Micralestes sp* | Gamré | 1 | 1 | 0.44 |
| 14 | *Citharinus citharus* Geoffroy Saint-Hilaire, 1809 | Falia | 0 | 1 | 0.22 |
| | **Total** | | 245 | 221 | 100 |

*specimen found in the Sudan-Guinean zone

**Table 2: Diversity of loss factors in the study areas**

| Sites | Insects (%) | Rodents (%) | Moisture (%) | Other (*) | T |
|---|---|---|---|---|---|
| Mayo-Danay | 6024 | 27.71 | 2.41 | 9.64 | 1 |
| Logone and Chari | 46.29 | 27.78 | 15.74 | 10.19 | 1 |
| **Logone basin** | 52.35 | 27.75 | 9.95 | 9.95 | 1 |

*handling and transport

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**Table 3: Pest abundance index in the study areas**

| *Zones* | Total number | Dermestidae (%) | Cleridae (%) |
|---|---|---|---|
| Logone et Chari | 324 | 22.84 | 77.16 |
| Mayo-Danay | 711 | 41.63 | 58.37 |
| **Logone basin** | 1035 | 32.23 | 67.76 |

**Table 4: Biodiversity index of ichthyophagous species per study area**

| Species | Logone and Chari | | Mayo-Danay ) | |
|---|---|---|---|---|
| | n | Pi(%) | n | Pi (%) |
| *Dermestes maculatus* | 69 | 21 | 208 | 29 |
| *Dermùestes frischi* | 5 | 2 | 84 | 12 |
| *Dermestes ater* | 0 | 0 | 4 | 1 |
| *Necrobia rufipes* | 250 | 77 | 415 | 58 |
| H (Shannon's index) | 0.85 | | 1.38 | |
| E (Pielou's indx) | 0.42 | | 0.69 | |
| D (Simpson's index) | 0.64 | | 0.43 | |

n=number

**Table 5: Diversity of pesticides and other protective products for dry fish during storage among processors and sellers**

| N° | Active ingredient | Trade name | transformers | sellers | Total | % |
|---|---|---|---|---|---|---|
| 1 | brodifacoum | RODENTICIDE | 2 | 6 | 8 | 1.32 |
| 2 | cypermethrin 50 g/l ec | CYPER-SAM (1) | 6 | 1 | 7 | 1.15 |
| 3 | cypermethrin 72g/l + acetamiprid 32g/l | EMIR FORT 104 EC* | 0 | 10 | 10 | 1.65 |
| 4 | cypermethrin 100ec | CYPER-COT | 0 | 6 | 6 | 0.99 |
| 5 | dichlorvos | **DD FORCE** | **89** | **269** | **358** | **58.98** |
| | | DAKSH* | 8 | 2 | 10 | 1.65 |
| | | DIZVAN* | 8 | 0 | 8 | 1.32 |
| | | PESTOFF 100% EC*. | 19 | 12 | 31 | 5.10 |
| | | **PRIME SHI *** | **70** | **50** | **120** | **19.77** |
| 6 | imidachloprid + thiram | IMIDALM (1) | 10 | 15 | 25 | 4.12 |
| 7 | pyrethrin 0.60%) | RAMBO* | 5 | 15 | 20 | 3.29 |
| 8 | thiametoxam + lambda cyhalothrin | MIRIDOR | 0 | 4 | 4 | 0.66 |
| T | | | **217** | **390** | **607** | **100** |

*not registered in Cameroon; (1)registered for the control of fruit flies in tomato crops


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