International Journal of Fisheries and Aquatic Sciences 2(3): 58-64, 2013
ISSN: 2049-8411; e-ISSN: 2049-842X

Submitted: June 28, 2013 Accepted: July 25, 2013 Published: October 20, 2013

# Parasitic Copepods (Arthropoda, Crustacea, Copepoda) from Fishes in Burkina Faso, Africa

[1, 2]Magloire Boungou, [1]Yamba Sinaré, [1]Komandan Mano and [1]Gustave B. Kabré
[1]Laboratory of Animal Ecology and Biology, Department of Animal Physiology and Biology, University of Ouagadougou (Burkina Faso), 03 BP 7021 Ouagadougou 03, Burkina Faso
[2]Department of Biology, Boston University, 5 Cummington Street, Boston, MA 02215, U.S.A

**Abstract:** We investigated parasitic copepods from fishes in Burkina Faso in order to evaluate new trend in the geographical distribution of fish parasites. From all the parasites that were present in the fishes we investigated, we have found three species groups of copepods, each belonging to a distinct genus: *Dysphorus torquatus*, *Lernaeogiraffa heterotidicola*, parasites of *Heterotis niloticus* (Osteoglossidae) and *Lamproglena monodi*, parasite of *Oreochromis niloticus* (Cichlidae). Although most of the copepods appear to be tolerated by their hosts, these species pose a threat to fish farms. Their location preference on the gill arch bone and gill filaments causes these parasites to be of great interest with regard to mechanical damage and the negative physiological consequences they inflict. It is arguable that the parasite copepods collected and studied are potential pathogens as shown by their high intensity of development and their large size.

**Keywords:** Burkina Faso, copepods, freshwater fish, gill parasites, West Africa

## INTRODUCTION

Among the major fish ectoparasites, copepods are, most of the time, attached to the gills. These parasites present great interest at three different levels. First, in the wild these organisms seem to have little or no impact on mortality of fish stocks, since such parasitism often goes unnoticed (Johnson *et al*., 2004). However, this is not true in a controlled environment, because some species of copepods are able to weaken the fish and interfere negatively in the fish's weight-gain, reproduction, growth, etc., (Kabata, 1958; De Kinkelin *et al*., 1985; Neilson *et al.*, 1987; Obiekezie and Taege, 1991; Johnson *et al*., 2004). Others copepods reveal pathogens and induce mass mortality (Hewitt, 1971; Lin *et al*., 1994; Ho, 2000; Piasecki *et al*., 2004). Second, parasitic copepods serve as taxonomic, bio-geographical and even hybridization markers. Indeed, some species of these parasites can be used as a systematic marker key of their hosts. Third, copepods parasites may be good indicators of water quality (Piasecki *et al*., 2004). Finally, on the African continent especially, the ecological and taxonomic studies on parasites of freshwater fish are still fragmentary; those of fish in Burkina Faso are limited to the works of Kabre *et al*. (1995, 2002), Kabre (1997), Boungou (1998) and Boungou *et al*. (2006a, 2006b, 2007, 2008). This paucity of work in this area attests to the low availability of information on the fish parasitism of Burkina Faso.

It is known that fishes are a resource of great nutritional value. Fish farming has become a fast-growing industry in Burkina Faso and has result in the development of new fish farms both in the private and public sectors (Zerbo, 1999). This renewed interest is driven by a large demand of fishes, which is increasingly growing of this resource by a rural and an urban population, due to population growth that continues unabated (Ouattara, 2002). In many existing fish farms, cases of morbidity and mortality have been previously reported (Zigani, pers. com), presenting a challenge to biologists and veterinarians to investigate the causes. While it is well known that the main threats to fish in their natural environment are-in addition to predation by other organisms-climatic and anthropogenic, such as pollution or over fishing (De Kinkelin *et al*., 1985), note that parasitism also occupies an important place. In pisciculture, as we have already stated, parasitism is the predominant threat. Piasecki *et al*. (2004) stress the need to realize a thorough study of the taxonomy and biology of parasites and/or potential pathogens of hosts in their natural environment, before any attempt at breeding.

Copepods occupy a special place in the world of parasitism because of their extraordinary ability to adapt to very diverse aquatic hosts ranging from simple

**Corresponding Author:** Magloire Boungou, Laboratory of Animal Ecology and Biology, Department of Animal Physiology and Biology, University of Ouagadougou (Burkina Faso), 03 BP 7021 Ouagadougou 03

shape, such as sponges to more complex forms, such as vertebrates. Among these vertebrates, most fishes, amphibians and some mammals (cetaceans) are likely to harbor parasite copepods (Raibaut, 1996) cited by Ho (1998). The parasite copepods can cause pathogenic effects in farmed freshwater fish (Kabata, 1985; Piasecki *et al*., 2004). In most cases, the youngest individuals of fishes are infected (Piasecki *et al*., 2004). The effects of these parasites on the various fishes are numerous. Some parasite copepods cause the proliferation of gill tissues, while others were responsible for high mortalities in fishponds (Sarig, 1966; Fryer, 1968; Johnson *et al*., 2004).

Our work on fish parasites aims to inventory copepods associated to fishes in Burkina Faso. This contribution of the study of parasite copepods provides additional information to the geographical distribution of fish parasites. The ultimate goal of this work is to provide data that could prevent epizootics in fishponds and therefore improve fish production for greater food needs of rural and urban Burkina Faso.

## MATERIALS AND METHODS

Sampling was conducted between February 2009 and December 2010. The fish were purchased from commercial fishermen operating in selected sites (Bazèga, Bagré, Di and Loumbila). The fresh fish were brought to the laboratory. For this study, all individuals were numbered and identified to species level using identification keys established by Leveque *et al*. (1990, 1992). Size or more precisely the standard length (from snout to tail curvature) of each fish was measured to the nearest millimeter, using an ichtyometer.

Large size fish parasites, such as copepods are located most often on the gills. Some are clearly visible to the naked eye, which favors their removal by cutting the arch on which they are attached using fine scissors. Others are identified by using a dissecting microscope and are removed using fine forceps. Specimens of Copepods were fixed in 70% AFA (Alcohol Formaldehyde-Acetic acid) and 70% ethanol. Ethanol fixed specimens were cleared in 90% lactic acid. The drawings of the habitus and appendages were made using a drawing tube mounted either on a dissecting microscope (for parasites visible to the naked eye) or on a light microscope (for smaller copepods). The descriptions refer only to female copepods, as the males and larval stages are free-living and their morphology is not known.

## RESULTS

These species belonging to three different genera: *Lernaeogiraffa*, *Dyphorus* and *Lamproglena*, were collected in this survey. Each genus is represented by one species. Their descriptions are provided below, preceded by the diagnosis of each genus.

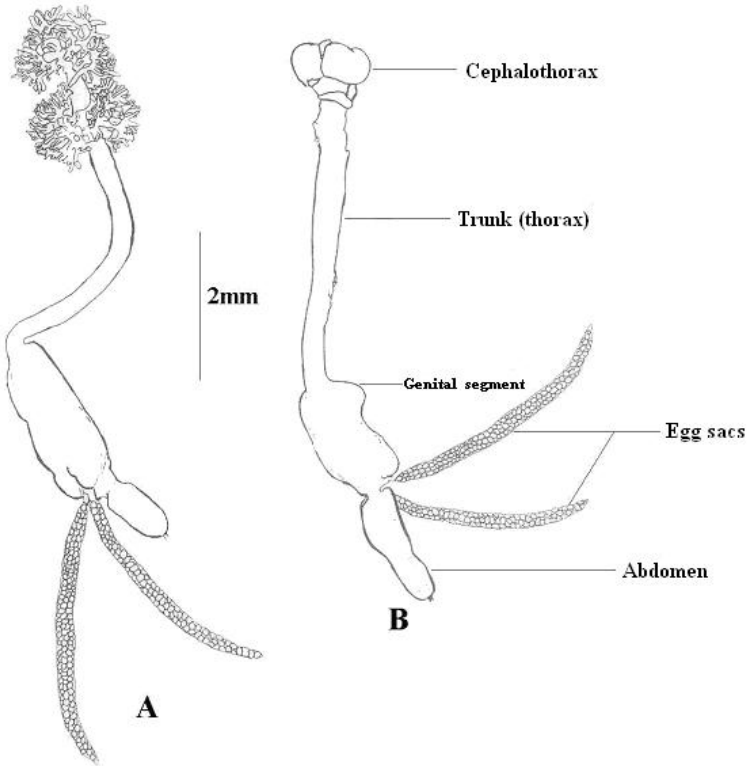


Fig. 1: (a) *Dysphorus torquatus*, (b) *Lernaeogiraffa heterotidicola*

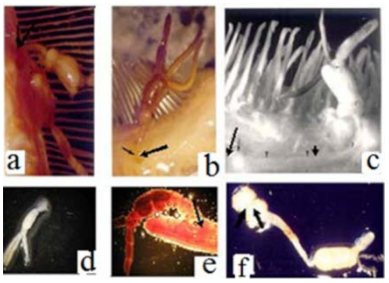


Fig. 2: *Lernaeogiraffa heterotidicola* (a-c), *Lamproglena monodi* (d-e) and *Dysphorus torquatus* (f)
a: Two parasites in toto embedded in the same area of penetration (arrow) (x 10)
b: Parasite in toto embedded in the arch. Note the penetration zone (arrow) (x 10)
c: Disposition of parasite in the arch. Note how the trunk is arranged in the gill arch (arrow heads) and the cephalothorax (arrow) (x 10)
d: Parasite in toto isolated (x 50)
e: Parasite attached to the gill lamellae (arrow head) (x 100)
f: Parasite in toto isolated. Note the two areas of tree (arrow) (x 10)

**Genus *Lernaeogiraffa* Zimmermann, 1922:** The copepods of the genus *Lernaeogiraffa* are characterized by their elongated body, twisted at angles of 90°-180°, divided into four parts; head fused with first thoracic segment; posterior part of the body (trunk) abruptly thickened and flattened dorso ventrally.

In this study, we collected and studied a single species of copepod belonging to the genus *Lernaeogiraffa*.

***Lernaeogiraffa heterotidicola* Zimmermann, 1922:**
**Host:** *Heterotis niloticus* (Cuvier, 1829) (Osteoglossidae)

**Habitat:** Gill arch bone

**Location:** Di (Sourou)

**Prevalence:** 20.86% (63 infected fish out of 302 examined)

**Description:** The parasite has a body where we can recognize four distinct regions (Fig. 1b):

- The cephalothorax previously provided four protrusions
- The trunk corresponding to the thoracic part
- A genital segment, swollen (with two anterior protuberances and two others large in the posterior part) where two egg sacs begin
- An elongated abdomen with two areas of strangulation. This ends with two vestigial oars

The parasite is deeply embedded in the gill arch. Only the genital segment emerges from the host (Fig. 2a-c). There are sometimes two individuals located in one place, along the gill arch (Fig. 2a).

Morphometric characteristics observed on our specimens are grouped in Table1.

**Remarks:** *Lernaeogiraffa heterotidicola* is a copepod that was harvested for the first time in Sudan in the Nile River on *Heterotis niloticus* by Zimmermann (1922). Fryer (1968) also documented its occurrence in Lake Victoria on the same host. The morpho-anatomical characteristics point to those that we found in Burkina Faso *Lernaeogiraffa heterotidicola*.

**Genus *Dysphorus* Kurz, 1924:** The characteristics of the genus *Dysphorus* are listed in the following diagnosis: Lernaeidae; Body elongated, twisted, to the angles of 180°, including head, neck, trunk and abdomen. The two branched head.

In this study we collected and studied a single species of copepod belong to the genus *Dysphorus*. We give the description.

***Dysphorus torquatus* Kurz, 1924:**
**Host:** *Heterotis niloticus* (Cuvier, 1829) (Osteoglossidae)

**Sampling site:** Di (Sourou)

**Habitat:** Gill arch bone

**Prevalence:** 12.91% (39 infected fish out of 302 examined)

**Description:** The body of the copepod parasite has four distinct regions (Fig. 1a):

- **The cephalothorax:** It is provided prior to a very complex fixture consisting of two branched head (Fig. 2f)
- The trunk part that corresponds to the thorax is very long
- A genital segment, swollen (with two anterior protuberances and two others large in the posterior part) where two egg sacs start
- A short abdomen, ending in two vestigial oars

The parasite is deeply embedded in the gill arch. Only the genital segment emerges from the host. Morphometrical measurements on the individuals studied are listed in Table 1.

**Remarks:** The copepod collected in the bony arch of the gills of *Heterotis niloticus*, represents by its morpho-anatomical characteristics, one species of copepod studied by Kurz (1924) in Sudan in the same host. Thus, we found *Dysphorus torquatus* in Burkina Faso. This extends its geographic range.

**Genus *Lamproglena* Nordmann, 1832:** Members of the genus *Lamproglena* have a body distinctly divided

Table1: Measurements (in mm) of species of copepods

| | | *Lernaeogiraffa heterodicola* | *Dysphorus torquatus* | *Lamproglena monodi* |
|---|---|---|---|---|
| Total length (without egg sacs) | | 11.35 | 7.95 | 3.432 |
| Cephalothorax | Total length | 6.60 | 2.25 | 1.949 |
| | Arborescence1 | x | 0.75 | x |
| | Arborescence2 | x | 0.80 | x |
| Genital segment | Length | 1.10 | 1.85 | 0.389 |
| | Width | 2.35 | 0.85 | 0.386 |
| Egg sacs | Length | 3.25 | 2.85 | 1.917 |
| | Width | 0.25 | 0.25 | 0.244 |
| Abdomen | Length | 2.10 | 0.90 | 1.096 |
| | Width | 0.75 | 0.55 | 0.296 |

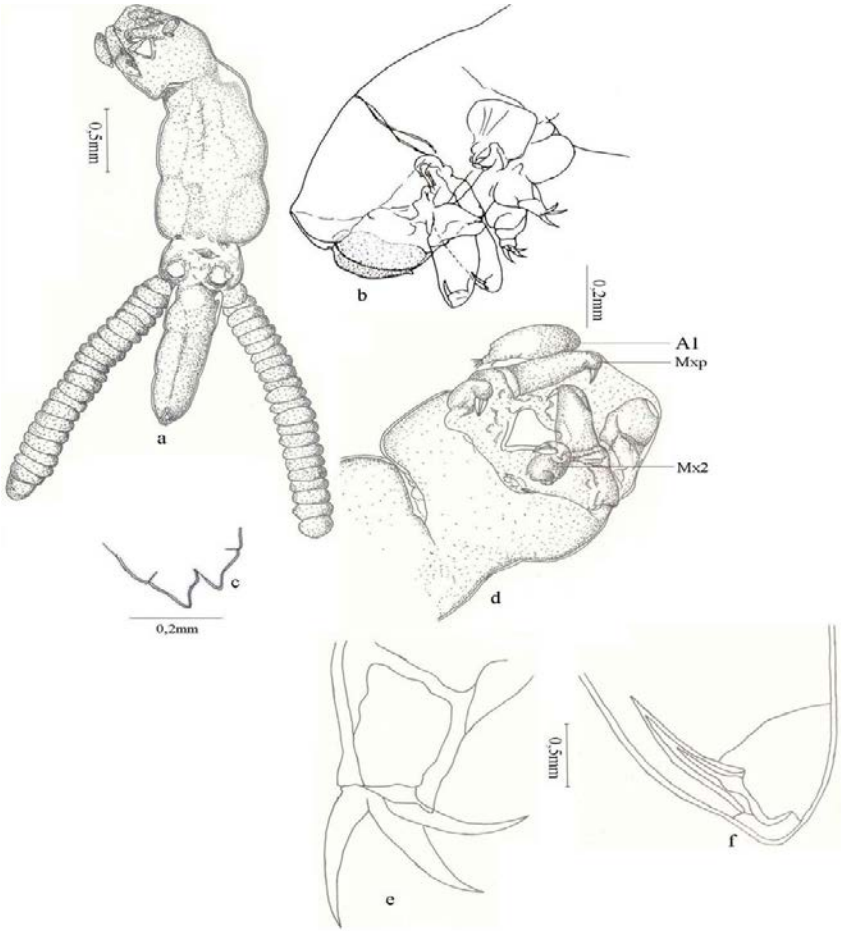


Fig. 3: *Lamproglena monody*, a) Ovigerous female (in toto), b) Cephalothorax (side view), c) Furca; d) Cephalothorax (front view), e) Maxilliped (Mxp), f) Maxilla II (Mx2)

into cephalothorax, thoracic segments bearing legs and abdomen; the cephalothorax is partially separated from the thoracic segment; the abdomen has three segments; the antennae are fringed setae; the maxillipeds are armed with one to five curved claws; thoracic legs indistinctly or distinctly segmented.

During our inventory on the copepod parasites in Burkina Faso, we harvested and studied one species of copepods belong to the genus *Lamproglena*.

***Lamproglena monodi* Capart, 1944:**

**Host:** *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae)

**Sampling site:** Bagré, Bazèga and Loumbila

**Location in host:** Gill filaments

**Prevalence:** 3.60% (9 infected fish out of 250 examined)

**Description:** The body is slender; its greatest width contained at least five times in total length (Table 1). The head of the copepod is longer than wide and is fused to the first thoracic segment, forming the cephalothorax. It shows two rounded lobes ventrally whose the posterior edge is at the basis of the first pair

of legs. The body has a very marked segmentation (Fig. 3a). The fifth segment and genital segment are welded; they are narrower than the body. The three abdominal segments are equal and slightly marked.

The antenna I (A1), very characteristic, is arranged parallel to the axis of the body and forms a groove with the head (Fig. 3b). Each antenna is formed of two separate segments: the basal, very wide and the distal rather small. The maxilla II (Mx2) robust and truncated (Fig. 3f), ended with a sharp claw and curve whose base is covered by a thin chitinous fold forming a collar (Fig. 3d). The maxilliped (Mxp) is armed with three curved claws subequal in length (Fig. 3e); the basal segment bears a papilla. The furca branches bifid at which the internal branch, larger and conical is ended with three to four short papillae; the external branch is sharper for longer (Fig. 3c).

The parasite is fixed by the maxillae II and maxillipeds almost at the end of the gill filaments of the host. Its body remains parallel to the axis of the filaments (Fig. 2). Morphometric characteristics identified in specimens studied are grouped in Table 1.

**Remarks:** *Lamproglena monodi* is a parasite copepod harvested for the first time by Capart (1944) in the former Belgian Congo (DRC) in *Seranochromis thumbergii* (Cichlidae). The morpho-anatomical characteristics of our specimens are comparable to the same parasites described by Capart (1944). The presence of *Lamproglena monodi* in Burkina Faso extends its geographic range.

## DISCUSSION

The genera *Dysphorus* and *Lernaeogirrafa* are each represented by only one species namely *L. heterotidicola* and *D. torquatus*. *Lernaeogiraffa heterotidicola* was described for the first time in Sudan in the Nile in *Heterotis niloticus* by Zimmermann (1922); *Dysphorus torquatus* meanwhile was described two years later in the same river and in the same fish host by Kurz (1924 ). Work by Fryer (1968), Kabata (1979) and Ho (1998) suggest that the genera *Dysphorus* and *Lernaeogirrafa* are restricted to *Heterotis niloticus* as a host. Regarding the genus *Lamproglena*, it is represented by more than 40 known species (Piasecki, 1993). Among these, *Lamproglena monodi* is known to many lakes and rivers in Africa (Capart, 1944; Fryer, 1968; Thurston, 1970; Shotter, 1977; Douëllou and Erlwanger, 1994). Cichlid fishes are the preferred hosts of *L. monodi*, as has often been reported in *Serranochromis* sp. and *Hemichromis* sp., (Capart, 1944), *Haplochromis* sp., (Fryer, 1968), *Tilapia* sp., (Shotter, 1977), *T. rendalli*, *S. macrophalus* and *S. codringtonii* (Douëllou, 1992).

The copepods *Lernaeogiraffa heterotidicola* and *Dysphorus torquatus* collected and studied in this study have an absolute host specificity (oioxene specificity). Indeed, these species of copepods remain linked in *Heterotis niloticus* (host-type). In Tunisia, Benmansour *et al*. (2001) noted that the copepod *Clavellotis briani* was linked to the mottled fish (*Lithognathus mormyrus*). The oioxene specificity of copepods can be used for the taxonomy of the host species.

We also noted that the species *Lernaeogiraffa heterotidicola* and *Dysphorus torquatus* infest only the fish *Heterotis niloticus* in the area of the Sourou River, but not others rivers in Burkina Faso. Is this a case of the site determining the infestation of the host? Is this particular parasitism of *Heterotis niloticus* related to environmental conditions?

The copepod parasites belonging to the family of Lernaeidae namely *Lernaeogiraffa heterotidicola*, *Dysphorus torquatus* and *Lamproglena monodi* encountered during this study could constitute a real threat to fish. It is certain that the parasitic penetration into the branchial arch bone, especially *Lernaeogiraffa heterotidicola*, alters gill circulation and can cause morbidity and or mortality in its host especially in young fish. The degradation of the gill can cause secondary infections and even respiratory problems. Indeed, some copepods of the family Lernaeidae with the same mode of parasitism, that is to say access into the gill arch of bone, are the cause of necrotic lesions and the formation of fibromatous encapsulations (Fryer, 1968; Kabata, 1979, 1985). Others are at the origin of epithelial hyperplasia and bleeding tissue (Piasecki *et al*., 2004). Callinan (1988) and Piasecki *et al*. (2004) have already reported cases of mortality in several fish hatcheries, due to copepod parasites of the family Lernaeidae in Australia and Brazil. It is arguable that the copepod parasites collected and studied are potential pathogens in case of high intensity of development and given their large size. Their preferred location on the gill bony arch and gill filaments gives these parasites great interest with regard to mechanical damage and they create negative physiological consequences of its locations.

Although most of copepods appear to be tolerated by their hosts, some species seem to be very dangerous in fish farms, causing large economic loss when it comes to commercial fish.

## REFERENCES

Benmansour, O., C. Diebaka and A. Raibaut, 2001. Deux espèces de copépodes lernaeopodidae (Siphonostomatoida) parasites du marbré *Lithognathus mormyrus* (Linnaeus, 1758) (Pisces, Sparidae). Zoosystema, 23(4): 695-703.

Boungou, M., 1998. Study of Helminth Systematics of Fishes in the dam of Loumbila in Burkina Faso. University of Ouagadougou, pp: 56.

Boungou, M., 2007. Diversity of gill parasites (Myxosporideans, Monogeneans and Copepods) of few fishes consumed in Burkina Faso: Systematic and occurrence of *Oreochromis niloticus*. Ph. D. Thesis, University of Ouagadougou, pp: 158.

Boungou, M., G.B. Kabre, C.F. Bilong- Bilong, J. Nack and L. Sawadogo, 2006a. Observations on some monogeneans parasites of *Oreochromis niloticus* (LINNE, 1758) (PISCES, Cichlidae) in Burkina Faso (West Africa). RASPA, 4(3-4): 149-156.

Boungou, M., G.B. Kabre, N.G. Sakiti, A. Marques and L. Sawadogo, 2006b. Description of four new *Myxosporean* species (Myxozoa: Myxosporea) from genus *myxobolus*, fish parasites of Burkina Faso. West Africa J. Biol. Sci., 6: 861-867

Boungou, M., G.B. Kabre, A. Marques and L. Sawadogo, 2008. Dynamics of population of five parasitic monogeneans of *Oreochromis niloticus* Linne, 1757 in the dam of Loumbila and possible interest in intensive pisciculture. Pak. J. Biol. Sci., 11: 1317-1323.

Callinan, R.B., 1988. Diseases of Australian native fish. In Fish diseases: Post Graduate Committee in Veterinary Science University of Sydney. Proceedings of 106, Sydney, Australia: Post Graduate Committee in Veterinary Science University of Sydney, pp: 459-474.

Capart, A., 1944. Notes sur les Copépodes parasites des poisons d'eau douce du Congo Belge. Bull. Inst. R. Sci. Nat. Belg., 22: 1-24.

De Kinkelin, P., C. Michel and P. Ghlttlno, 1985. Specific pathology Fish. I.N.R.A. Paris (Éd.), pp: 339.

Douëllou, L., 1992. A survey of fish parasites in Lake Kariba. University Lake Kariba Research Station Bulletin, 1/92. Kariba: University of Zimbabwe, pp: 1-71.

Douëllou, L. and K.H. Erlwanger, 1994. Crustacean parasites of fishes in Lake Kariba, Zimbabwe, preliminary results. Hydrobiologia, 287: 233-242.

Fryer, G., 1968. The parasitic Crustacea of African freshwater fishes: Their biology and distribution. J. Zoology, 156: 45-95.

Hewitt, G.C., 1971. Two species of Caligus (Copepoda: Caligidae) from Australian water, with a description of some developmental stages. Pac. Sci., 25: 145-164.

Ho, J.S., 1998. Cladistics of the Lernaeidae (Cyclopoida), a major family of freshwater fish parasites. J. Marine Syst., 15: 177-183.

Ho, J.S., 2000. The major problem of cage aquaculture in Asia relating to sea lice. In: Liao, I.C. and C.K. Lin (Eds.), Proceedings of the 1st International Symposium on Cage Aquaculture in Asia: 2-6 Nov. 1999, Tungkang, Manila: Asian Fisheries Society and Bangkok: World Aquaculture Society-Southeast Asian Chapter, pp: 13-19.

Johnson, S.C., J.M. Treasurer, S. Bravo, K. Nagasawa and Z. Kabata, 2004. A review of the impact of parasitic copepods on marine aquaculture. Zoolog. Studies, 43(2): 229-243.

Kabata, Z., 1958. Lernaeocera obtuse n. sp. Its biology and its effect on the haddock. Mar. Res. Dept. Agri., Fish. Scotl., 3: 1-26.

Kabata, Z., 1979. Parasitic Copepoda of British fishes. London: Ray Society, pp: 148.

Kabata, Z., 1985. Parasites and diseases of fish cultured in the tropics. Taylor. Francis Publishers, London, pp: 318.

Kabre, B.G., 1997. Parasites des poissons du Burkina Faso: Faunistique, Ultrastrusture, Biologie. Thèse d'Etat, Univ. Ouagadougou, pp: 265.

Kabre, G.B., G.N. Sakiti, A. Marques and L. Sawagodo, 1995. *Myxobolus comoei*n. sp. et *Myxobolus burkinei* n. sp. nouvelles Myxosporidies histozoïques chez *Clarias anguillaris* et *Labeo coubie* capturés dans les pêcheries au Burkina-Faso (Afrique de l'Ouest). Bull. 1. F. A. N., 48: 49-55.

Kabre, G.B., G.N. Sakiti, A. Marques and L. Sawagodo, 1997. Presence of myxosporeans (Myxozoa, Myxosporea) of the genus *Henneguya* (Thelohan, 1882) parasites of fishes caught in fisheries of Burkina faso. Bull. Eur. Ass. Fish Pathol., 17: 43- 46.

Kabre, G.B., G.N. Sakiti, A. Marques and L. Sawagodo, 2002. *Thelohanellus bicornei* n. sp. myxosporidia (Myxosporea, Bivalvulida) a gill parasite of *Labeo coubie* Ruppel, 1832 (Osteichthyen, Cyprinidae) from burkina Faso, West Africa. Parasite, 9: 219-223.

Kurz, H., 1924. Eine revision des genus *Lernaeogiraffa* Zimmerm; und *Dysphorus torquatus* no. gen. nov.sp; Sher. Akad. Wiss. Wien (Math- naturwiss. KI), 133: 423- 429.

Leveque, C., D. Paugy and G.G. Teugels, 1990. Faune de poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Faune Tropicale XXVIII, MRAC, TERVUREN. ORSTOM, Paris, pp: 902.

Leveque, C., D. Paugy and G. G. Teugels, 1992. Faune des Poissons d'eaux douces et saumâtre de l'Afrique de l'Ouest. Tome 2. O.RS. T .O.M. (Éds.), Paris, pp: 389-902.

Lin, C.L, J.S. Ho and S.N. Chen, 1994. Two species of Caligus (Copepoda: Caligidae) parasitic on black sea bream (*Acanthopagrus schlegeli*) cultured in Taiwan. Fish Pathol., 29: 253-264.

Neilson, J.D., R.I. Perry and S.P. Valerio, 1987. Interactions of caligid ectoparasites and juvenile gadids on Georges Bank. Mar. Ecol. Prog. Ser., 39: 221-232.

Obiekezie, A.I. and M. Taege, 1991. Mortality in hatchery-reared fry of the African catish, *Clarias gariepinus*. Bull. Eur. Ass. Fish Pathol., 11(2): 82-85.

Ouattara, B., 2002. Suivi de captures des pêcheurs (1989-2001). Projet Gestion de la pêche dans le Sud-Ouest (Direction des Pêches de Ouagadougou, Burkina Faso).

Piasecki, W., 1993. Comparative morphology of the three species of *Lamproglena* (Copepoda, Cyclopoida, Lernaeidae) described by Von Nordmann, based on re-examination of the types. Mitt. Zool. Mus. Berlin, 69: 307-315.

Piasecki, W., A.E. Goodwin, J.C. Eiras and B.F. Nowak, 2004. Importance of copepoda in freshwater aquaculture. Zoolog. Studies, 43(2): 193-205.

Raibaut, A., 1996. Copépodes II. Les Copépodes parasitesin: Traité de Zoologie. Crustacés VII, fasc.2. J. Forest, Eds. Masson, Paris, pp: 639-718.

Sarig, S., 1966. A review of diseases and parasites of fishes in warm water pond in the near east and Africa. FAO Symposium on Warm-Water Pond Fish Culture, Mimeo.

Shotter, R.A., 1977. Copepod parasites of fishes from northern Nigeria. Bull. L'I.F.A.N.39, ser a (3): 583-600.

Thurston, J.P., 1970. The incidence of Monogenea and parasitic Crustacea on the gills of fish in Uganda. Revue de Zoologie Botanique Africaine, 82: 111-129.

Zerbo, H., 1999. Rapport national sur la situation des pêches au Burkina Faso (Direction des peches de Ouagadougou).

Zimmermann, F., 1922. Wissenschaftliche Ergebnisse der mit Understützung der Akademie der Wissenschaften in wien aus der Erbschaft treitl von F. Werner unternommenen Zoologischen Expedition nach dem AngloAegyptschen Sudan (Kordofan) 1914. IX. Bearbeitung der parasitischen Copepode von Fishen. Denkeschr. Akad. Wivv. Wiem (Math-Nat) 98: 101-111.