Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 2720-2725

Received: 16-01-2018
Accepted: 19-02-2018

Shiv Mohan Singh
Dept. of Fish Processing Technology, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Siddhnath
Dept. of Fish Processing Technology, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Ravikant Bharti
Dept. of Fish Processing Technology, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Abdul Aziz
Dept. of Fisheries Economics and Statistics, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Subir Pradhan
Dept. of Fisheries Economics and Statistics, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Bhagchand Chhaba
Dept. of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Narinder Kaur
Central Institute of Fisheries Education, Mumbai, Maharashtra, India

Correspondence
Shiv Mohan Singh
Dept. of Fish Processing Technology, Faculty of Fishery Sciences, WBUAFS Kolkata, India

Insect infestation in dried fishes

Shiv Mohan Singh, Siddhnath, Ravikant Bharti, Abdul Aziz, Subir Pradhan, Bhagchand Chhaba and Narinder Kaur

Abstract
Dried fish forms a major source of protein in a number of equatorial countries. Dried fishery products frequently suffer severe losses due to infestation by flesh flies (*Sarcophagidae*), beetles (*Dermestes*, *Cornestes*, and *Necrobia* spp.), and mites (*Lardoglyphus* and *Lyrophagus* spp.).Dried fish contaminated by both insects and harmful insecticides comprises about 80 percent of the total dried products that is considered unfit for human consumption. The losses have been attributed to net reductions in the amount of nutrients available to the consumer (nutritive quality) resulting to declining consumer acceptability and market prices (economic losses) or both quantitative and qualitative losses. Irradiation has distinct advantages over other commercial methods of pest control. Apart from being less energy consuming than fumigation, it does not leave toxic residues in the product. It has been observed that a dose of 0.5 kGy can effectively disinfest dried fish and fishery products at a moisture level of below 40%.

Keywords: Insect infestation, dried fish, flesh flies, beetles, Irradiation

1. Introduction
Fish on a worldwide basis contributes only about 15 percent of the animal protein in the human diet, but it's more important in terms of its value [1]. This is especially true for many countries in South East Asia [2]. In India about 30% of the total fish catch is preserved by curing, i.e., salting, drying or smoking, or a combination of those treatments [3]. Drying is regarded as a traditional, low-cost and simplest method of preservation of fishes and it plays a vital part in the developing countries of the world like India [4]. About 20% of the freshly harvested fish is spoiled every year due to lack of proper preservation technique in the country and about 25% of the remaining harvested fish was dried and this amount was 0.615 million metric ton in 2012 [5]. Significant portion of dried fish approximately 53721 tons were exported that earns a good amount which is 117.66 US$ Million of foreign currency [5]. Dried fishes are not only economically important but also can provide satisfactory nutrition to the human [6].

Dried fishery products frequently suffer severe losses due to infestation by flesh flies (*Sarcophagidae*), beetles (*Dermestes*, *Cornestes*, and *Necrobia* spp.), and mites (*Lardoglyphus* and *Lyrophagus* spp.) [7-10]. These infestations are heavy in dried products containing 7–21% salt and stored under tropical conditions, at 20–32◦C and air humidity of 73–87%. Based on a conservative estimate, the loss represents about 2.75 mt of dry fish for a year in all over world [8-10]. A large quantity of dried fish is lost in India due to infestation by earwig, hide beetles, and copra beetles. The most destructive pest is the hide beetle; *Dermestes maculatus Deg*. Infestation of sun-dried fish by the blowfly and beetle larvae caused up to 30 percent loss of the products [11-12]. Dried fish contaminated by both insects and harmful insecticides comprises about 80 percent of the total dried products that is considered unfit for human consumption. The losses have been attributed to net reductions in the amount of nutrients available to the consumer (nutritive quality) resulting to declining consumer acceptability and market prices (economic losses) or both quantitative and qualitative losses [13-14]. The aim of this study was to understand the biology of the insect for effective and efficient management measures against losses caused by the insect infestation in dried fish products.

2. Infestation Problem
In India during monsoon, humidity levels are high, sufficient drying cannot be achieved using traditional technique, processed and stored dried fishes re-absorb moisture and become favorable conditions to insect attack [15].

Losses also result during storage from attack by insect which can gain access. The amount of quantitative loss by insect infestation was nearly 30%. This amount increases during the monsoon (35-40%) at drying areas. the huge infestations damage the dried products such as by flesh flies (*Sarcophagidae*), beetles (*Dermestes*, and *Necrobia* spp.), and mites (*Lardoglyphus* and *Lyrophagus* spp.) [7]. Mite also infests during storage and in distribution. Mainly adult females lay their eggs on fish flesh. After hatching young larvae then feed fish muscle vigorously. Most of the damage in dry fishes is caused by the larval stage [16]. [17] was reported that, in tropical climates under highly humid conditions, heavy infestation of unsalted dry fish by beetles may cause up to 30% loss of the products. [18, 13] recorded about 50% losses during the storage of smoked fish products due to deterioration. The quantitative and qualitative losses occurred through spoilage and insect attack in dry fish processing [19-20].

A B

Fig 1: Showing the infestation of dry fish by mites (A) and flies (B).

3. Types of insects on dried fish

The insect commonly found on dried fish are flesh flies (*Sarcophagidae*), beetles (*Dermestes*, *Cornestes*, and *Necrobia* spp.), and mites (*Lardoglyphus* and *Lyrophagus* spp.) [21].

3.1 Necrobia

Necrobia rufipes is a beetle of the family Cleridae and is the commonest species of Necrobia found on cured fish. Two related species, *N. ruficollis* and *N violacea*, are only rarely found on this commodity [21].

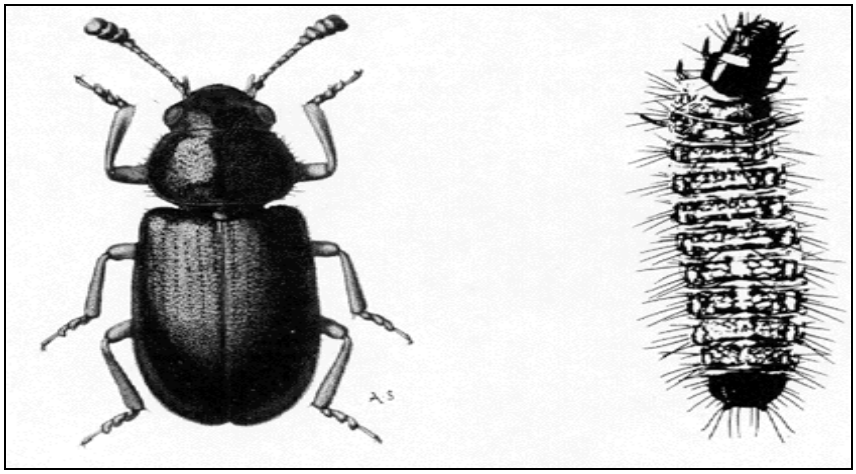

Fig 2: Dorsal views of adult (left) and larva (right) of *Necrobia rufipes*.

Table 1: Description and recognition features.

Life Stage	Description
Adult	Shape As In Fig. 2 (Left). Length C. 4.5 Mm. Upper Surface Of Body (Head, Thorax, Elytra) Entirely Shining Metallic Bluish-Green. Underside Of Abdomen Entirely Dark Blue. Legs Bright Reddish-Brown Or Orange. Antennae Mainly Reddish-Brown But With A Dark Brown Or Black Club At The Tip. Sides Of Thorax (Especially) And Elytra With Stiff Bristle-Like Hairs. Distinguished From Adults Of Similar Species By Coloration Described Above: *N. Violacea* Has Black Or Bluish Legs And Antennae; And *N. Ruficollis* Has Reddish-Brown Thorax And Base Of Elytra.
Larva	Appearance As In Fig. 2 (Right). Typical Beetle Larva With Three Pairs Of Jointed Legs; Moderately Hairy. Most Of Body Ceramic-Grey With Mottled Violet-Grey Markings On The Upper Surface. Head, And Upper Surfaces Of The 1st Thoracic Segment And The Last Large Abdominal Segment (The Ninth), With Brown Hardened Plates; 2nd And 3rd Thoracic Segments Also With Tiny Brownish Plates. Plate On Last Large Abdominal Segment With Two Horn-Like Protuberances Which Curve Strongly Upwards. Very Difficult To Distinguish From Closely-Related Species Of Cleridae, But Easily Distinguished From Dermestes Larvae By Coloration And Normal Amount Of Hairs, And From Fly Larvae By Presence Of Legs And Obvious Head.

3.1.1 Life-cycle

Adult beetles feed on the surface of dried fish, and they lay their eggs in crevices in the fish. The larvae burrow deeply into the flesh; as well as feeding on the fish. They are predatory on the larvae of some flies, and on the eggs and larvae of *Dermestes* spp [21]. The larvae pass through three or four instars. The last instar larva spins a cocoon in which pupation occurs: this may be within the fish flesh, or the larva may leave the fish and pupate in any dark crevice. The life-cycle takes about 6 weeks or longer depending on food type and physical conditions. Under optimum conditions, the rate of population increase is about 25 times per month. The adults fly actively and can thus easily disperse to new sources of food [21].

3.1.2 Damage caused to cured fish

Feeding by larvae and adults of *N rufipes* causes quantitative loss of dried cured fish, and also leads to fragmentation and to quality losses due to contamination by insect bodies and cast skins. The extent and value of losses due to *N rufipes* infesting dried fish have not been assessed either in the laboratory or the field, but they will of course be directly related to the length of storage of the fish. When associated with Dermestes infestations, *N rufipes* is usually in the minority but its contribution to the total beetle damage may be significant [21].

3.2 Dermestes

Species of Dermestes belong to the beetle family Dermestidae. Several species have been recorded infesting dried fish: *D. maculatus, D. frischii, D. carnivorus Fabr, D. lardarius, D. haemorrhoidalis,* and *D. peruvianus* [21].

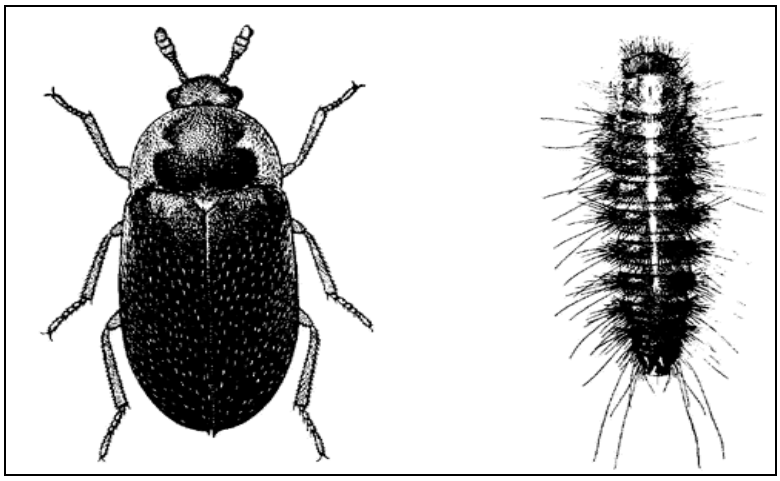

Fig 3: Dorsal views of adult (left) and larva (right) of *Dermestes maculatus*

Table 2: Description and recognition features.

Life Stage	Description
Adult	Shape Elongate Oval, As Shown In Fig. 3 (Left). Length 5.5-10.0 Mm. Cuticle Of Upper Surface Of Body Black Or Dark Brown, Covered With Black, Whitish-Grey, Brown Or Yellowish Hairs, Which Form A Distinct Pattern In Some Species. Underside Of Abdomen With Black, Whitish, Brown Or Golden Hairs, Often Forming A Distinct Pattern. Antennae Rather Short But With An Obvious Club At The Tip. Distinguished From *Necrobia* Spp. By The Lack Of Metallic Coloration, And Larger Size. The Adults Of The Different Species Can Be Recognized By The Characters Listed In Table L, But Some Of These Can Only Be Clearly Seen With A Low- Power Microscope; Full Identification Keys Are Given By [22-23].
Larva	Appearance As In Fig. 3 (Right). Thoracic Segments With Three Pairs Of Jointed Legs. Body Densely Covered With Hairs Of Various Lengths. Underside Of Body Usually Yellowish-Brown, But Upper Surface Of Body Mainly Dark Brown, Often With A Central Yellowish Line. Upper Surface Of Last Large Abdominal Segment (The Ninth) With Two Long Pointed Horn-Like Protuberances, Which May Be Partly Hidden By Surrounding Hairs. Identification Keys To The Species Are Given By [23-24], But These Require Specialist Knowledge. Dermestes Larvae Are Easily Distinguished From All Others Found On Cured Fish By Their Hairiness And Dark Colour.

3.2.1 Life-cycle

The adults feed on dried or drying fish, and the females lay their eggs in cracks in the flesh of the fish. The rate of egg-laying is greatly increased if water is available for the female to drink. The larvae burrow into the flesh as they feed on it [21]. The larvae normally pass through five, six or seven instars, but the number of moults is higher under unfavorable conditions. The cast larval skins are commonly found in infested fish, and may be confused with the larvae. Before pupation, the last instar larvae burrow into solid material: this may be the flesh of the fish, but it is commonly the wood of drying racks or store structures, which may be seriously weakened by the tunneling [21]. The life-cycle of the major pest species takes about 5-7 weeks or longer depending on food type and physical conditions. Under optimum conditions, the rate of population increase of *D. maculatus* and *D. frischii* is about 30 times per month. Dermestes adults can fly and can thus easily disperse to new sources of food [21].

3.2.2 Damage caused to cured fish

Feeding by the larvae and adults of *Dermestes* spp. causes

considerable quantitative loss of dried cured fish, and also leads to fragmentation. Quality loss may also be caused by the presence of insect bodies and cast skins [21]. The extent and value of quantitative losses caused to dried fish by *Dermestes* spp. have been assessed by various investigators, and estimates range from negligible up to 50% weight loss, depending on length of storage, salt content, moisture content, climatic conditions, and general hygiene during processing and storage. Weight losses due to fragmentation have also been investigated, but the contribution of *Dermestes* spp. to this process has not been separately assessed. These loss estimates have been reviewed by [25]. Additional costs may arise from damage caused to wooden drying racks and store structures by the mature larvae.

3.3 Lardoglyphus

Species of *Lardoglyphus* belong to the family Acaridae in the mite group Astigmata. Three species have been found infesting cured fish: *L. konoi, L. zacheri* and *L. angelinae*. The commonest species is *L. konoi* [21].

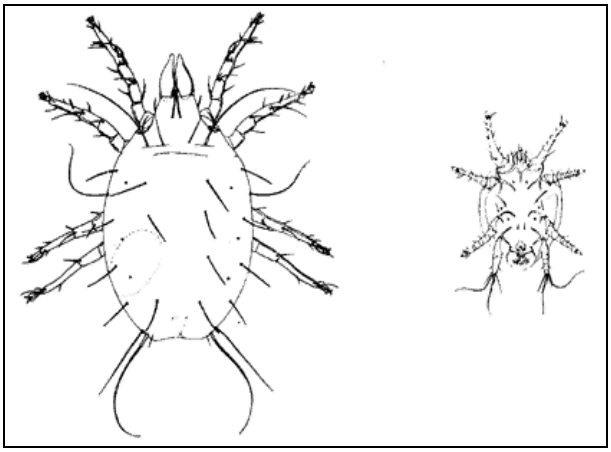

Fig 4: Dorsal view of adult female of *Lardoglyphus konoi* (left) and ventral view of hypopus of *L. zacheri* (right).

Table 3: Description and recognition features

Life Stage	Description
Adult	Appearance as in Fig. 4 (left). Oval-bodied with four pairs of legs. Length of body c. 0.3-0.6 mm; females larger than males. As in most acarid mites, the body is smooth and translucent ceramic-white with several pairs of hairs, which are only visible under a good hand lens or a low-power microscope. The females differ from other acarid mites found on stored food in having paired (rather than single) claws, and the males are distinctive because the third legs end in two blunt spines instead of claws: these characteristics of *Lardoglyphus* spp. are only visible with a high-power microscope. Precise identification of specie requires specialist microscopic techniques and knowledge.
Hypopus	Appearance as in Fig. 4 (Right). Length of body c. 0.2 mm. Legs rather stouter than those of adult. The body hairs are short, and are sometimes thickened into small spines. There are no functioning mouthparts. The underside of the body has numerous small suckers, especially concentrated on a sucker plate behind the bases of the fourth legs.

3.3.1 Life-cycle

Adults and nymphs of *Lardoglyphus* feed on drying or dried fish. The adult female lays eggs on the fish; after hatching into a six-legged larva, the mite passes through the eight-legged protonymph and tritonymph stages during its development into an adult [21]. This development can be very rapid. At 23°C and 87% RH the life-cycles of *L. konoi* and *L. zacheri* take only 9-11 and 10-11 days, respectively; at optimum temperatures, development may be even faster. Potential rates of increase have not been estimated for these mites, but they are probably of the order of thousands of times per month under optimum conditions. In such situations, the mites can increase to vast numbers within a few days and, because moderate populations of *Lardoglyphus* are easily overlooked, a heavy infestation may seem to occur quite suddenly [21].

3.3.2 Damage caused to cured fish

Feeding by the adults and nymphs of *Lardoglyphus* spp. will cause quantitative loss of dried cured fish. Quality loss may result from the contamination by live and dead bodies, which can be very numerous. The extent and value of losses caused to dried fish by *Lardoglyphus* spp. have not been assessed in either the laboratory or the field [21].

3.4 Diptera

Most flies found on cured fish belong to the subfamilies Calliphorinae and Sarcophaginae in the family Calliphoridae. The commonest of these are various species of *Chrysomia*, but *Calliphora*, *Lucilia, Sarcophaga* and *Wohlfartia* have also been reported [21]. Other families represented in records of flies infesting cured fish are: Muscidae, Piophilidae, Milichidae, Phoridae and Ephydridae. All these flies are rather similar in general form, though they show a variety of size and coloration, and their identification requires specialist knowledge [21].

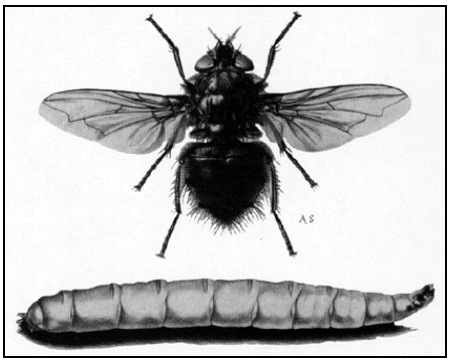

Fig 5: Dorsal view of adult of *Calliphora vicina* (top) and lateral view of larva of *Piophila casei* (bottom).

Table 4: Description and recognition features

Life Stage	Description
Adult	The Many Different Species Of Fly Found On Cured Fish All Have The Same General Form. As Shown In Fig. 5 (Top). Length 2.5-15.0 Mm. Depending On Species. Colour Of Body Often Black And Grey But Many Of The Common Species Have A Metallic Green. Blue Or Purple Sheen On The Upper Surface. The Eyes Are Large. The Two Fore-Wings Are Membranous And Transparent. But The Hind-Wings Are Modified Into Small Club-Like Halters. Identification Of The Many Species Requires Specialist Knowledge.
Larva	General Form Usually As Shown In Fig. 5 (Bottom). Length Varies Greatly. Depending On Species And Stage Of Growth. Body Generally Cylindrical. But Often Tapering Towards The Head. And Sometimes With Numerous Protuberances That May Act As False Legs (Not Present In The Species Illustrated In Fig. 4). Colour Usually Grayish-White Or Ceramic. Distinguished From All Other Pests Found On Cured Fish By Their Lack Of Jointed Legs, Their Very Small Head, And The Reduced Mouthparts (Mainly Consisting Of Two Hook-Like Mandibles). Differentiation Of The Species Is Very Difficult, Even With Specialist Knowledge, And Specimens Of Fly Larvae Collected For Identification Should Therefore Be Kept Alive Until They Become Adults.

3.4.1 Life-cycle

Adult female flies lay their eggs (or, in some species, small larvae), usually in batches, on the flesh of fish. Flies in the family's Calliphoridae, Ephydridae and Muscidae only infest moist fish in the early stages of the curing process; those in the family's Milichidae, Phoridae and Piophilidae can infest partially and fully cured fish [21]. The larvae (usually known as maggots) feed on the surface of the flesh and may also burrow deeply into it. In moist fish, particularly, the burrowing can cause serious fragmentation. The larvae of Calliphoridae and Muscidae often tend to aggregate in discrete areas, where they cause severe damage. There are only three larval instars in the types of fly found on cured fish. Larval development of the major fly pests of moist fish can take as little as three days. At pupation, the last larval skin is retained and modified to form a hard protective puparium [21]. Larvae that infest moist fish usually leave the fish in order to pupate, and often burrow into the soil beneath drying racks or mats. The emerging adults are, of course, strong fliers and quickly disperse to new sources of suitable food. The life-cycle of the main pest species of moist fish (notably *Chrysomia* spp. and other Calliphoridae) can be completed in about seven days under suitable conditions. The species that infest dried fish develop more slowly: e.g., under ambient conditions in Malawi, *Piophila casei* completes its life-cycle in about 20 days [21].

3.4.2 Damage caused to cured fish

The feeding of the larvae of Calliphoridae on moist fish causes quantitative losses. These losses can be severe if conditions are optimal for fly development: under such conditions, i.e., if unsalted or poorly salted fish is dried slowly because of rain or high humidity, weight losses of 10-30% can be caused by fly larvae [21]. Fragmentation of the fish by fly attack can cause quality loss and may lead to increased risk of damage by beetles and mites. Substantial weight losses due to fragmentation of fish during processing have been recorded, but the contribution of blowfly damage to this has not been separately assessed. Additional costs are implicated in the role of flies as the agents of myiasis and as carriers of pathogens [21].

4. Protection

The infestation problems during storage of dried fish have prompted many processors to illegally apply household insecticides while processing. Application of fumigants such as ethylene dibromide (EDB), methyl bromide, ethylene oxide, phosphine, and sulphur oxide has been practiced for the control of insects and nematodes in food items for several decades. In recent times, these chemicals are being phased out for health, environmental, or occupational safety reasons [26]. The U.S. Environmental Protection Agency, for example, has banned EDB. Further, the import of any food treated with EDB is also prohibited for sale in the United States [27].

Irradiation has distinct advantages over other commercial methods of pest control. Apart from being less energy consuming than fumigation, it does not leave toxic residues in the product. It has been observed that a dose of 0.5 kGy can effectively disinfest dried fish and fishery products at a moisture level of below 40% [28]. It is important that the material has to be packaged prior to irradiation to prevent reinfestation by insects. Disinfestation studies on dried mackerel showed that eggs, larval, and pupal stages of hide beetles *Dermestes maculatus Deg* could be inactivated at a dose of 0.2 kGy. Fungal organisms, which are not inactivated at this dose, could be controlled by reducing the final moisture content of the product to about 13% and use of proper packaging [29-30]. Results of studies on dried fish in Bangladesh, Philippines, and Indonesia have shown that irradiation of packaged, salted, dried fish products at doses in the range of 0.1–1.0 kGy prevented development of beetle larvae and adults [29-30]. Commercially dried marine fish such as mackerel, shark, tuna, and saram (*Scomberomorus commersoni*) contain 36–50% moisture and 10–12% salt. The products often harbor molds such as *Fusarium* spp., *Aspergillus* spp., and *Penicillium* spp. giving a dip in potassium sorbate solution prior to dehydration, packaging in 0.1-mm polyethylene pouches and irradiation at 0.5–0.75 kGy could enhance the acceptability of the product up to 6 months at ambient temperature [28]. Precautionary measures that need to be taken for successful disinfestation of dried fishery products include good sanitation practices to prevent deposition of insect eggs on fish products and use of suitable packaging to prevent reinfestation after the radiation treatment.

5. Conclusion

The dried fishes play important role in the upliftment of socio-economic condition of the rural area of the India. Insect infestation in dried fish products is as serious a problem as attack by pathogenic flora. Not only direct infestation during open-air sun drying but also reinfestation during storage is to be stopped. Identification and required information about these diverse species of insects is very uncommon amongst farmers and academia of fishery world. Along with correct insect identification, preventive and curative measures need to be known by farmers and dry fish processors for array of

different insects which cause economic and health losses. Perhaps it would be best to take recourse to artificial drying not from any other considerations but for avoiding pest infestation from the surrounding, it is necessary to carry out further investigation to standardize the conditions.

6. Acknowledgement
Authors are thankful to Dr. Supratim Chowdhury, Associate Professor, Department of Fish Processing Technology, Faculty of Fishery Sciences, Kolkata for his consistent guidance, constructive suggestions, motivation. His guidance made us capable of planning and conducting the present study and preparation of this paper.

7. Reference

1. James, D. The future of fish in nutrition. Infofish Marketing Digest. 1984; 4:41-44.
2. Sivagnanam KJ. Evaluation and Assessment of Economic Losses on Account of Inadequate Post Harvest Infrastructure Facilities for Fisheries Sector in Tamil Nadu. AERC Research Study No. 2016; 159:98.
3. The Marine Products Export Development Authority. Annual Report, Cochin 2016, 262.
4. Basu KP, Gupta K. Biological value of protein of some species of Bengal fish by balance and growth methods. Journal of Indian Chemical Society Calcutta. 2004, 543-548.
5. The Marine Products Export Development Authority. Annual Report, Cochin. 2012, 139.
6. Flowra FA, Tumpa AS, Islam MT. Biochemical analysis of five dried fish species of Bangladesh. University Journal of Zoology, Rajshahi University. 2013, 9-11.
7. Venugopal V, Doke SN, Thomas P. Radiation processing to improve the quality of fishery products. Critical *Reviews* in Food Science and Nutrition. 1999; 39(5):391-440.
8. Gopakumar K, Devadasan K. The fish curing industry in India. Production and Storage of Dried Fish. FAO Fisheries Report No. 279 Supplement, Food and Agriculture Organization of the United Nations, Rome, 1982, 63.
9. Esser JR, Sunarya, Wiryante J. Assessment and reduction of insect infestation and losses of cured fish in Indonesia. Post-Harvest Technology Preservation and Quality of Fish in Southeast Asia. International Foundation for Science, Sweden, 1990, 149.
10. Wood CD. Loss of traditionally cured fish: a case study. The Production and Storage of Dried Fish. FAO Fisheries Report No. Supplement, Food and Agriculture Organization of the United Nations, Rome, Italy, 1982; 279:172.
11. Bala BK, Mondol MRA. Experimental Investigation of Solar Drying of Fish using Tunnel Dryer, Drying Technology. 2001; 19(2):1-10.
12. Nowsad AK. Low cost processing of fish in coastal Bangladesh. BGD/97/017 Field Doc: 05/2005. Food and Agriculture Organization of the United Nations. Dhaka. 2005, 73.
13. Odeyemi OO, Owoade RA, Akinkurolere O. Toxicity and population Suppression effects of *Parkia clappatoniana* on dried fish pests (*Dermestes maculatus* and *Necrobia rufipes*). *Global* Journal of Pure and Applied Sciences. 2000; 6:191-195.
14. Atijegbe SR. Infestation of smoked fish in Ghana. M.Phil. Thesis in Entomology University of Ghana, Legon, Ghana. 2004, 103.
15. Immaculate K, Sinduja P, Velammal A, Patterson J. Quality and shelf life status of salted and sun dried fishes of Tuticorin fishing villages in different seasons. International Food Research Journal. 2013; 20(4):1855-1859.
16. Flowra FA, Tumpa AS, Islam MT. Insect infestation of dry fishes at singra. Journal of the Asiatic Society of Bangladesh, Science. 2013; 39(2):273-277.
17. Bala BK. Adaptive research on solar dryer for drying mango, pineapple and fish. Annual Research Report. Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh. 2000, 24.
18. Lale NES, Sastawa BM. The effects of sun drying on the infestation of the African catfish (*Clarias gariepinus*) by post harvest insects in the Lake Chad District of Nigeria. International Journal of Pest Management. 1996; 42: 281-283.
19. Doe PE. A polythene tent drier for improved sun-drying of fish. Food Technol. Aust. 1977; 29(11):437-441.
20. Ahmed M. Radiation disinfestations studies on sun-dried fish. Proc. IPFC. 1978; 18(3):310-321.
21. Haines CP. Ed. A field guide to the types of insects and mites infesting cured fish Food & Agriculture Org. 1989; 33:303-304.
22. Freeman P. Common insect pests of stored food products. Edn 6, Bulletin of the British Museum (Natural History), Zoology. 1980; (15):69.
23. Peacock ER. *Dermestes peruvianus Cast, D haemorrhoidalis Küst*. And other *Dermestes* spp. (Coleoptera, Dermestidae). The Entomologist's monthly magazine. 1975; 111:1-14.
24. Hinton HE. The Histeridae associated with stored a product. Bulletin of Entomological Research. 1945; 35(4):309-40.
25. Wood CD. The prevention of losses in cured fish. Technical paper, FAO, 1981; (219):87.
26. Diehl JF. Safety of Irradiated Foods. Edn 2, Marcel Dekker, New York, 1995, 173.
27. Loaharanu P. Food irradiation: current status and future prospects. New Methods of Food Preservation. Gould GW. Ed. Blackie Academic and Professional, London, 1995, 90.
28. Venugopal V. ed. Seafood processing: adding value through quick freezing, retortable packaging and cook-chilling. CRC press, 2005, 467.
29. Ahmed M, Karim A, Quaiyum MA, Bhuiya AD, Matin MA, Siddiqui AK *et al*. Economic feasibility studies on radiation preservation of dried and cured fishery products, onions and potatoes. Radiation preservation of fish and fishery products. International Atomic Energy Agency, Rome, 1989, 29.
30. Hussain AM, Haz I, Chaudry MA. Radiation preservation of dried fish indigenous to Asia. Radiation Preservation of Fish and Fishery Products, Technical Report Series 303, International Atomic Energy Agency, Vienna, 1989, 77.