

## **14. Factors Causing Emerging Shrimp Diseases and Development of Their Health Management Strategies**

### **14.1 Background and Justification**

The global shrimp culture industry had a rapid growth in the 1980's mainly due to technological breakthroughs such as artificial fertilization, mass seed production, feed formulation, high prices, high profit, foreign exchange earnings and public support (Shang *et al.* 1998, Leung *et al.* 2000). Rapid expansion and intensification of shrimp farming worldwide have led to serious disease outbreaks and caused mass mortalities among cultured penaeid shrimp. The diagnosis of shrimp disease is somewhat difficult by taking shrimp out of water or observing the behavioral changes in the vast aquatic environment. Moreover, an aquatic environment encompasses a wide variety of parameters, virtually all of which influence the homeostasis, essential for growth and production of fishes. These, if alter beyond the acceptable limits, may predispose to pathogens, or actual cause the disease (Munro 1978). The infectious diseases, especially viral and bacterial diseases have become a threat to shrimp farming in Bangladesh. So the farmers and hatchery operators uses various chemicals and antibiotics indiscriminately without consulting with the shrimp /fisheries experts. But the habitual use of antibacterial agents can lead to problems with bacterial resistance and with unacceptable residues in aquaculture products environment. The resistant bacterial strains could have a negative impact on the therapy of fish diseases or human diseases and environment of the fish farms (Smith *et al.* 1994). The predominant public concerns on microbial resistance due to the use of antibiotic are the possible impacts on human health resulting from the emergence of drug-resistant bacteria in animal caused by prolonged use of low level antibiotics in animal feed (Sorum *et al.* 1992). Those antibiotic residues may persist in sediments for a long time. On the other hand, application of different chemotherapeutics against fungal diseases has some carcinogenic properties (Meinertz *et al.* 1975, Sharif *et al.* 1996). Information on the actual status of use of chemicals and drugs in shrimp hatcheries and farms are lacking. There is no scientific study on this area or aspect even though it is vital information for the shrimp sector planning and development.

The chemicals and drugs are one of the most essential in-puts in aquaculture, shrimp culture and hatchery industry. The structure and size of the most of the chemicals and drugs are different from one to another. The chemicals and drugs are also made and collected from different sources both in-country and abroad. Even many illegal chemicals and drugs are available in open market which are harmful for fish and shrimp and also harmful for human health.

A number of chemicals and drugs are used in shrimp culture practices and hatcheries. There are 58 hatcheries of *Penaeus monodon* (Bagda shrimp) in different locations of Cox's Bazar district e.g. Kalatali at Sadar Upazilla, Sonarpara at Ukhia Upazilla and Teknaf Upazilla. Hatchery operators use a number of antibiotics mainly as precautionary measures without performing antibiotic sensitivity test. Some antibiotics do not work at all against vibrios and eventually vibrios get resistance. On the other hand, the antibiotics are occupational health hazards. Skin exposure as well as inhalation of dust from antibiotic powder may cause health problems to workers and others that are present when antibiotics are being handled. Indiscriminate use of various chemicals and antibiotics in shrimp health management are leading to development of hazards of aquatic environment, shrimp and also shrimp consumers. So, the shrimp health management protocol should be environment friendly. Considering all the points, this research work has been undertaken to collect the actual information about the chemicals and drugs used in shrimp sector.

## **14.2 Literature Review**

At present, the shrimp sector is facing multifarious problems. Shrimp culture is badly affected due to severe disease infection, lack of appropriate chemical & drugs utilization, lack of proper water quality and feed management. The coastal waters are polluting due to increased and unplanned use of fertilizers, chemicals, pesticides and the effluents and discharges from the shrimp farms and industries as well. Toxic affect of high ammonia in affected water due to excessive organic decomposition and poor pond management might have reduced fish immunity, which predisposed them for bacterial invasion and consequent disease outbreaks (Khan & Hussain 2005). The white spot disease of shrimp was controlled through use of agricultural lime, application of turmeric powder and

powder made out of the plants of *Phyllanthus neruri* and *Clinacanthus nutans*, Oxytetracycline and Iodophore in Vietnam (Dung 1990). Among the 40 operating hatcheries of Bangladesh 32 (80%) were surveyed in which 8 different antibiotics and 5 disinfectants were used for controlling common diseases (Uddin *et al.* 2006). The concentration of Chloramphenicol used in Bangladesh shrimp hatcheries to control different bacterial diseases are three to four times higher than other countries (Ruangpanich 1988). A number of recent reports, press releases and on-going investigations have raised legitimate public concerns about the safety of antibiotic drug usage in aquaculture (Alderman & Hastings 1998). A typical shrimp farm in Bangladesh usually uses no chemicals, but the use of lime to curate the ponds each year during farming in the ponds (Haque 2003).

### **14.3 Objectives**

- i. To know the present status and seasonal variation of WSSV infection in shrimp by using PCR technique
- ii. To diagnose the bacterial and fungal diseases of shrimps in hatchery/culture Gher
- iii. To identify the available chemicals and drugs used in shrimp hatcheries and culture practices in Cox's Bazar region.

### **14.4 Results**

Out of the 58 Bagda shrimp hatcheries in Cox's Bazar, 15 hatcheries and 10 grow-out ponds were surveyed to explore the available chemicals and drugs used in shrimp hatcheries and culture practices in Cox's Bazar region. Disease out-break is a common phenomenon in fish and shrimp farms and hatcheries especially in winter season. Different types of disesses are recorded in the fish and shrimp farms and hatcheries of Cox's Bazar (Table 71). A variety of antibiotics and chemicals are used to treat shrimp and fishes in the hatcheries of Coz's Bazar (Table 72).

#### **14.4.1 Most deadly shrimp disease**

WSSV is a serious problem in the shrimp farms and hatcheries of Cox's Bazar. Following are the consequences of out-break of WSSV. Another disease termed as

luminous bacterial diseases is caused by *V. harveyi* that augments mass mortality in shrimp farms.

- Reduction in feed consumption
- Lethargy and loose cuticle
- Presence of WS on the carapace
- Reddish to pink coloration of body
- High mortality, 100% within 3-10 days

**Table 71** Common shrimp and fish diseases

<b>Host</b>	<b>Types</b>	<b>Pathogen/Disease</b>
<b>Fish</b>	<b>Parasitic diseases</b>	Ichthyobodosis, Ichthyophthiriasis, Chilodonellosis, Trichodiniasis, Myxoboliasis, Dactylogyriasis, Gyrodactylosis, Diplozooniasis, Argulosis, Lernaeasis, Ergasilosis, Cestod infection: Ligula, Bothriocephalus, Senga; Acanthocephala: Pallisentis, Acanthocentis; Leech infestation, Fish molluscs
	<b>Bacterial diseases</b>	Columnaris, Aeromoad septicemia, Edwardsiella infection, Streptococcus infection, Skin and fin rot, etc.
	<b>Fungal diseases</b>	Saprolegniasis, brachiomyocosis and epizootic ulcerative syndrome (eus)/aphanomycosis
	<b>Nutritional diseases</b>	Lordosis/scoliosis and crack etc
<b>Shrimp</b>	<b>Parasitic diseases</b>	Ectocommensal protozoan: Zoothamnium, Epistylis, Acineta and Ephelota
	<b>Viral diseases</b>	White Spot Baculo Virus (WSBV), Systemic Ectodarmal and Mesodarmal Baculovirus (SEMBV), White Spot Syndrome Virus (WSSV) and Monodon Baculo Virus (MBV)
	<b>Nutritional, toxic and environmental diseases</b>	Soft shell, black spot, black gill, pink gill, hepatopancreatic necrosis, swollen and cramped tail, muscle necrosis, broken appendages etc.
<b>Prawn</b>	<b>Parasitic diseases</b>	Ectocommensal protozoan: Corthunia, Epistylis, Vorticella
	<b>Bacterial diseases</b>	Vibriosis, <i>Aeromonas</i> and <i>Pseudomonas</i> spp.
	<b>Fungal infection</b>	<i>Fusarium</i> sp.
	<b>Protozoan diseases</b>	Microsporidians agmasoma and pleistophora; the gregarines nematopsis and cephalolobus
	<b>Nutritional, toxic and environmental stress and diseases</b>	Soft shell, black spot, black gill, pink gill, hepatopancreatic necrosis, swollen and cramped tail, muscle necrosis, broken appendages and suffocation

**Table 72** Antibiotics and chemicals use for treating larvae and post larvae in the shrimp hatcheries of Cox's Bazar

<b>Antibiotic</b>	<b>Doses (ppm)</b>	<b>Disease name</b>	<b>Larval stage</b>
Prefuran	0.1	Vibrio	Mysis, PL
Furazolidone	1-3	Vibrio	Mysis, PL
Oxytetracycline	10	Vibrio	Mysis, PL
Chloramphenicol	2-4	Luminiscent bacteria	Mysis, PL
Erythromycin	2-4	Luminiscent bacteria	Mysis, PL
Malachite Green	0.075	Luminiscent bacteria	Mysis, PL
Formalin	25	Shell disease	PL
Treflan	0.01-0.1	Larval mycosis	Nauplii
Methelene blue	8-10	Black gill	PL

#### **14.4.2 Chemicals used in hatcheries and grow-out ponds**

Following chemicals are generally used in the fish and shrimp farms and hatcheries in Cox's Bazar.

- Lime (CaCO<sub>3</sub>)
- Dolomite
- Chemical Fertilizers (Urea,TSP)
- Bleaching Powder
- Formalin
- Copper sulphate
- Methelene Blue
- Potassium permanganate
- EDTA and
- NaCl.

#### **14.4.3 Banned/Prohibited antibiotics for fish and shrimp culture**

Due to health hazards, following antibiotics have been banned/prohibited for fish and shrimp culture in Bangladesh.

- Chloramphenicol
- Nitrofurans (Furazolidone, Nitrofurazone, Furaladone and Furfylfamide etc)
- Neomycin
- Nalidixic Acid

- Sulphamethoxazole
- Metronidazole
- Sulfonamide
- Chloroform
- Malachite green

#### **14.4.4 WSSV PCR Test**

In the shrimp hatcheries of Cox's Bazar, about 60% of brood stocks of marine tiger shrimp are affected by WSSV. In case of tiger shrimp nauplii, about 37% are affected by WSSV. However, after PCR screening, no WSSV infection was noticed in the broods and nauplii of tiger shrimp.

#### **14.4.5 Reasons behind disease outbreak**

- ⊙ Traditional method of culture system;
- ⊙ High stocking density against no or partial feeding;
- ⊙ Unrestricted water flow within different farms
- ⊙ Accessibility of cattle and other animals
- ⊙ Stress caused by sudden rise or fall of temperature, salinity
- ⊙ Reduced water level (less than a feet) due to draught
- ⊙ Insufficient supply of specific pathogen free (SPF) brood and larvae;
- ⊙ Lack of awareness and proper knowledge

#### **14.4.6 Control measures suggested**

- ⊙ Fencing around farm
- ⊙ Reducing pond size
- ⊙ Developing reservoir, separate inlet and outlet for individual farms
- ⊙ Ensuring appropriate pond preparation and disinfection
- ⊙ Ensuring SPF brood and larvae for culture
- ⊙ Restricting outer animal access
- ⊙ Maintaining optimum water quality and water depth (at least 1 m)
- ⊙ Minimizing all sorts of stresses

- ⊙ Ensuring best management practices
- ⊙ Improving water quality and liming
- ⊙ Water exchange is normally discouraged

#### **14.4.7 Hazards in fish and shrimp hatcheries**

Fish and Fishery products are susceptible to hazards. Hazards mean any biological, chemical or physical properties that may cause a food to be unsafe for human consumption. Possible route of hazards in the fish, and shrimp and fishery products are handling, storing, preparing, heading, eviscerating, shucking, freezing, changing into different market forms, manufacturing, preserving, packing, labeling, dockside unloading or holding. HACCP, Hazard Analysis Critical Control Points is able to combat biological, chemical and physical hazards in fish and fishery products.

#### **14.4.8 Biological hazards**

##### **Bacteria**

Fish and shrimp products are generally contaminated by bacteria. Following bacteria are treated as biological hazards for fish and shrimp.

*Bacillus cereus*, *Campylobacter jejuni*, *Clostridium botulinum*, type A, B, E and F, *Clostridium perfringens*, *Escherichia coli*, *Listeria monocytogenes*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Vibrio vulnificus* and *Yersinia enterocolitica*.

##### **Parasites**

Both ectoparasites and endoparasites are the biological hazards for fish and shrimp. The main parasites such as Nematodes/Roundworms (*Anisakis* spp, *Pseudoterranova* spp., *Eustrongylides* spp. and *Gnathostoma* spp.), Cestodes/Tapeworms (*Diphyllobothrium* spp.) and Trematodes/Flukes (*Chlonorchis sinensis*, *Opisthorchis* spp., *Heterophyes* spp., *Metagonimus* spp., *Nanophyetes salminicola* and *Paragonimus* spp. are found in fish and shrimp.

#### **14.4.9 Chemical hazards**

Chemical hazards are one of the main problems of fish and shrimp farms and hatcheries. The main chemical hazards include Toxin (Histamine), Pesticides: Aldrin/Dieldrin, Chlordane, Chlordecone, DDT and Diquat, Heavy metals: Arsenic, Cadmium, Lead, Nickel Mercury, Organochlorin: Heptachlor/Heptachlor Epoxide and Other chemicals such as Mirex, Polychlorinated Biphenyls (PCB's), Simazine and 2,4-D.

#### **14.4.10 Impacts of pesticides**

Pesticides are found to use in fish and shrimp farms and hatcheries. It accumulates in the bottom sediments of ponds, streams, rivers, lakes and coastal areas, and is most commonly found in the fatty tissues of fishes. Fish absorb and ingest pesticides and chemical contaminants from aquatic systems. Pesticides modify in the concentrations of sex hormones in fishes and shrimps results in abnormal gonadal morphology. It changes enzyme activity in fish. Pesticides including dieldrin, endrin, mirex, oxychlordane and DDT impacts negatively on early development in fishes. It enhances dysfunction of thyroid gland in fishes. It decreases fertility in fishes and shrimps results with decrease hatching success. Pesticides enhance birth deformities with disfunction of immune system in fishes. Prolonged or repeated exposure of DDT can result in premature birth and low birth weight, shortened duration of lactation, spontaneous abortion and nervous system damage in humans. Excessive exposure of dieldrin in humans can cause tremors, convulsions, and liver and nervous system damage. Long term exposure influences gross production of zooplankton and nekton

#### **14.4.11 Recommendations**

- Screening of broodstock and PL in hatchery
- Responsible use of chemicals and drugs: Antibiotics can be used only if necessary and against bacteria. Without diagnosing causative bacteria/without sensitivity test can not be used.
- Stop using banned chemicals/antibiotics
- Minimum water exchange to reduce risk
- Environmental stress management



- Waste water management
- Personal hygiene management
- Following HACCP approach
- Use of probiotics to replace antibiotics
- Periodical Shut-down hatchery units
- Crop rotation in grow-out ponds

## 15. References

- Achola, K. J., J. W. Mwangi and R. W. Munenge. 1995. Pharmacological activity of *Oxalis corniculata*. *Pharma. Biol.*, **33**(3): 247-249.
- ADB/NACA. 2000. The Use of Chemicals in Carp and Shrimp Aquaculture in Bangladesh, Cambodia, Lao PDR, Nepal, Pakistan, Sri Lanka and Viet Nam. Proceedings of the Meeting on the Use of Chemicals In Aquaculture in Asia 20-22 May 1996; Tigbauan, Iloilo, Philippines. Southeast Asian Fisheries Development Center Aquaculture Department Tigbauan, Iloilo, Philippines. pp. 75-86.
- Ahmed, G. U. and A. N. H. Banu. 2001. Investigation on diseases of some small indigenous freshwater fishes of Bangladesh. Final Project Report, submitted to Bangladesh Agricultural Research Council, Farm Gate, Dhaka, Bangladesh, p.67.
- Ahmed, G.U. and E.S.P. Tan. 1992. The responses to tetracycline treatment of the epidermis of injured catfish (*Clarias macrocephalus*) raised under intensive culture conditions. *Aquaculture*, **105**: 101-106.
- Ahmed, G.U. and M.A. Hoque. 1999. Mycotic involvement in epizootic ulcerative syndrome of freshwater fishes of Bangladesh: A histopathological study. *Asian Fish. Sci.*, **12**: 381-390.
- Ahmed, G.U., M. Dhar, M.N.A Khan and J.S. Choi. 2007. Investigation of disease of Thai koi, *Anabas testudineus* (Bloch) from farming conditions in winter. *J. Life Sci.*, **17**(10): 1309-1314.
- Ahmed, M. and M.A. Rab. 1995. Factors affecting outbreaks of epizootic ulcerative syndrome in farmed and wild fish in Bangladesh. *J. Fish. Dis.*, **18**: 263-271.
- Ahmed. G.U., M.M. Hossain and M.M. Hassan. 2009a. Seasonal variation of disease and pathology of a perch, *Nandus nandus* (Hamilton) from Oxbow Lake fisheries of Bangladesh. *Eco-friendly Agril. J.*, **2**(8): 761-767.
- Ainsworth, A. J. 1992. Fish granulocytes: morphology, distribution, and function. *Annual Review of Fish Diseases*, **2**(2): 123-148.
- Akhteruzzaman, M. 1999. A study on the production of Thai Koi (*Anabas testudineus*) under semi-intensive culture system. *Bangladesh J. Zool.*, **25**: 39-43.
- Alderman DJ, Hastings TS. 1998. Antibiotic use in aquaculture: Development of resistance potential for consumer health risks. *Int J Food Sci Technol*, **33**:139-155
- Alderman, D.J. 1992. Malachite green and alternatives as therapeutic agents. *Europ. Aquacult. Soc. Spec. Pub.*, **16**: 235-44.

- Alderman, D.J. and T. S. Hastings, 1998. Antibiotic use in aquaculture, development of resistance potential for consumer health risks. *International J. Food Science Techno.*, **33**: 139-155.
- Alderman, D.J., 1992. Malachite green and alternatives as therapeutic agents. *Europ. Aquacult. Soc. Spec. Pub.*, **16**:235-44
- Alderman, D.J., H. Rosenthal, P. Smith, J. Stewart and D. Weston, D., 1994. Chemicals used in mariculture. *ICES Coop. Res. Rep.*, **202**:100p.
- American Veterinary Medical Association. 2012. Minor Use for Minor Species Animal Health Act. Available at: <http://www.avma.org/scienact/mums/default.asp>. Accessed September 21, 2012.
- Anawer, M. (ed.). 2001. Vesoj Udvider Homeopathic Baboher: Bangladesh Prakhit (Homeopathic uses of medicinal plants; Bangladesh perspective). Published by text book division, Bangla Academy, Dhaka-1000, Bangladesh, 545p.
- Anderson, D.I. and B.R. Levin. 1999. The biological cost of antibiotic resistance. *Curr. Opin. Microbiol.*, **2**: 489-493.
- Anderson, W.C., S.B. Turnipseed and J.E. Roybal. 2005. Quantitative and confirmatory analyses of malachite green and leucomalachite green residues in fish and shrimp. *USFDA Lab. Inform. Bull. LIB No. 4363*. **21**(11): 12-15.
- Aregheore, E. M. and D. Perera. 2004. Effects of *Erythrina variegata*, *Gliricidia sepium* and *Leucaena leucocephala* on dry matter intake and nutrient digestibility of maize stover, before and after spraying with molasses. *Anim. Feed Sci. Technol.*, **111**(1-4): 191-201.
- Arthur, J.R. M.J. Phillips, R.P. Subasinghe, M.B. Reantaso and I.H. MacRae. 2002. Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development. FAO Fish. *Tech. Pap.* No. 406.
- Arufe, M.I.; Arellano, J.; Moreno, M.J. & Sarasquetec, C. 2004 Toxicity of a commercial herbicide containing terbutryn and triasulfuron to seabream (*Sparus aurata* L.) larvae: a comparison with the Microtox test. *Ecotoxicology and Environmental Safety*, **59**(2): 209-216.
- ASTDR. 2012. Agency for Toxic Substances and Disease Registry Web site. Available at: <http://www.atsdr.cdc.gov/>. Accessed September 21, 2012.
- Atamanalp, M.; Keles, M.S.; Haliloglu, H.I. & Aras, M.S. 2002. The effects of cypermethrin (a synthetic pyrethroid) on some biochemical parameters (Ca, P, Na and TP) of rainbow trout (*Oncorhynchus mykiss*). *Turkish Journal of Veterinary Animal Sciences*, **26**(5): 1157-1160.
- Autstin, D. F. 1982. *Operculina turpethum* (Convolvulaceae) as a medicinal plant in Asia. *Econ. Botany*, **36**(3): 265-269.
- Balint, T.; Szegletes, T.; Szegletes, Z.; Halasy, K. & Nemesok, J. 1995. Biochemical and subcellular changes in carp exposed to the organophosphorus methidathion and the pyrethroid deltamethrin. *Aquatic Toxicology*, **33**(3-4): 279-295.
- Barron MG, Tarr BD, Hayton WL. 1987. Temperature dependence of Di-2-ethylhexyl phthalate (DEHP) pharmacokinetics in rainbow trout. *Toxicol Appl Pharmacol.*, **88**:305-312.
- Barua, G., A. N. H. Banu and M. H. Khan. 1991. An investigation in to the prevalence of fish disease in Bangladesh during 1988. *Bangladesh J. Aquacult.* **11-13**: 27-29.

- Baser, S.; Erkok, F.; Selvi, M. & Kocak, O. 2003. Investigation of acute toxicity of permethrin on guppies *Poecilia reticulata*. *Chemosphere*, **51**(6): 469-474.
- Belmonte, A.; Garrido, A. & Martinez, J.L. 2005. Monitoring of pesticides in agricultural water and soil samples from Andalusia by liquid chromatography coupled to mass spectrometry. *Analytica Chimica Acta*, **538**(1-4): 117-127.
- BFRI, 1999. Fish diseases: prevention and control. Bangladesh Fisheries Research Institute, Circular leaflet no 6. 2<sup>nd</sup> edition. 7 pp
- Biagiatti-Risbourg, S. & Bastide, J. 1995. Hepatic perturbations induced by a herbicide (atrazine) in juvenile grey mullet *Liza ramada* (Mugilidae, teleostei): an ultrastructural study. *Aquatic Toxicology*, **31**(3): 217-229.
- Bjorklund H, Bylund G. 1990. Temperature-related absorption and excretion of oxytetracycline in rainbow trout (*Salmo gairdneri* R.). *Aquaculture*, **84**:363-361.
- Bondada, A. S., B. L. Velega. Srikanthi and K. Reddy. 2001. Effect of mulberry (*Morus indica* L.) therapy on plasma and erythrocyte membrane lipids in patients with type 2 diabetes. *Clinica Chimica Acta*, **314**(1-2): 47-53.
- Bradbury, S.P. & Coats, J.R. 1989. Toxicokinetics and toxicodynamics of pyrethroid insecticides in fish. *Environmental Toxicology and Chemistry*, **8**(5): 373-380.
- Brown, D. and A. Brooks. 2002. A survey of disease impact and awareness in pond aquaculture in Bangladesh, the Fisheries and Training Extension Project- Phase 11. In: Arther, J.R., M.J. Phillips, R.P. Subasinghe, M.B. Reantaso and I.H. MacRae (eds.). Primary Aquatic Animal Health Care in Rural, Small Scale and Aquaculture Development. *FAO Fish. Tech. Pap.*, No. **406**: 85-93.
- Buriro, M. A. and M. Tayyab. 2007. Effect of *Nigella sativa* on lipid profile in almino rates. *Gomal J. Med. Sci.*, **5**(1):28-31.
- Cabello FC. 2006. Heavy use of prophylactic antibiotics in aquaculture: a growing problem for human and animal health and for the environment. *Environ Microbiol.*, **8**(7):1137-1144.
- Caisu, J. F. 1986. The medicinal and poisonous plants of India. Scientific Publ., Jodhpur, India, pp. 323-325.
- CEC 2002a. Commission Decision (2002/249/EC) concerning certain protective measures with regard to certain fishery and aquaculture products intended for human consumption
- CEC 2002b. Commission Decision (2002/250/EC) concerning the extension of the protective measures provided by Decision 2001/699/EC, with regard to the fishery and aquaculture products imported from Vietnam.
- CEC 2002c. Commission Decision (2002/251/EC) concerning certain protective measures with regard to poultrymeat and certain fishery and aquaculture products intended for human consumption and imported from Thailand.
- Cengiz, E.I. 2006. Gill and kidney histopathology in the freshwater fish *Cyprinus carpio* after acute exposure to deltamethrin. *Environmental Toxicology and Pharmacology*, **21**(2): 1093-1096.
- Cerejeira, M.J.; Viana, P.; Batista, S.; Pereira, T.; Silva, E.; Valerio, M.J.; Silva, A.; Ferreira, M. & Silva-Fernandes, A.M. 2003. Pesticides in Portuguese surface and ground waters. *Water Research*, **37**(5): 1055-1063.
- Chevallier, A. 1996. The encyclopedia of Medicinal Plants. Dorling Kindersley. London, 256p.

- Chinabut, S. and J. H. Lilley. 1992. The distribution of EUS lesions on snakehead fish, *Channa striatus* (Bloch). *AAHRI Newsletter*, **1**(2): 1-2.
- Chopra, R. N., S. L. Nayar and I. C. Chopra. 2002. Glossary of Indian Medicinal Plants, NISCAIR, CSIR, New Delhi, 153p.
- Chopra, R. N., S.L. Nayar and I. C. Chopra. 1956. Glossary of Indian Medicinal plants CSIR, New Delhi, 259p.
- Chowdhury, M. B. R. 1993. Research priorities for microbial fish disease and its control in Bangladesh. In: *Proceeding of the Workshop on Research Priorities of Bangladesh for fish health, disease prevention and pathology* (ed. A. Tollervey), 8-11 pp.
- Chowdhury, M. B. R. and M. Muniruzzamna. 2003. Shrimp diseases and its consequences on the coastal shrimp farming in Bangladesh. Pp. 39-48. In: Wahab, M. A. (ed.) Environmental and Socioeconomic impacts of shrimp farming in Bangladesh. Technical Proc. BAU-NORAD Workshop, 5 March 2002, BRAC Center, Dhaka, Bangladesh. Bangladesh Agricultural University, Mymensingh, Bangladesh. 101p.
- Chowdhury, M.B.R. 1997. Bacterial involvement in fish diseases in Bangladesh. In: International Symposium on Diseases in Aquaculture, 3-6 October, 1997. Hirosima, Japan. Abstract: III-2:24.
- Chowdhury, M.B.R. 1998. Involvement of aeromonad and pseudomonads in disease of farmed fish in Bangladesh. *Fish Pathol.*, **33**: 247-254.
- Chowdhury, M.B.R., M.A. Islam, M. I. Hossain, M. A. Sarker and B. Mojumder, 1999. Involvement of aeromonads in ulcer disease in farmed fishes. *BAU Res. Prog.*, **10**: 140-146.
- Corsin, F. 2001. An epidemiological study of white spot disease in the rice-shrimp farming system of Vietnam. PhD Thesis, University of Liverpool, Liverpool, UK. 171 pp.
- Corsin, F., Thakur, P.C., Padiyar, P.A., Madhusudhan, M., Turnbull, J.F., Mohan, C.V., Hao, N.V. and Morgan, K.L. 2002a. Feeding farmed shrimp with shrimp waste - the lessons for aquaculture from BSE, P192. Book of Abstracts, 5th Symposium on Diseases in Asian Aquaculture, 24-28 November 2002. Gold Coast, Australia.
- Craigmill AL, Cortright KA. Interspecies considerations in the evaluation of human food safety for veterinary drugs. *AAPS PharmSci.* **4**(4):E34.
- Crain, D.A.; Guillette, L.J.; Rooney, A.A. & Pickford, D.B. 1997. Alterations in steroidogenesis in alligators (*Alligator mississippiensis*) exposed naturally and experimentally to environmental contaminants. *Environmental Health Perspectives*, **105**(5): 528-533.
- Cravedi, J.P., G. Chouber and G. Delous, 1987. Digestibility of chloramphenicol, oxolinic acid and oxytetracycline in rainbow trout and influence of these antibiotics on lipid digestibility. *Aquacult.*, **60**:133-41.
- Cremllyn, R.J. 1990. *Agrochemicals; Preparation and mode of action*. John Wiley & Sons Ltd., ISBN 0471929921, West Sussex UK.
- Crestani, M.; Menezes, C.; Gluszczak, L.; Miron, D.D.; Spanevello, R.; Silveira, A.; Goncalves, F.F.; Zanella, R. and Loro, V.L. 2007. Effect of clomazone herbicide on biochemical and histological aspects of silver catfish (*Rhamdia quelen*) and recovery pattern. *Chemosphere*, **67**(11): 2305-2311.

- Dad, N.K. and Tripathi, P.S. 1980. Acute toxicity of herbicides to freshwater fish and midge larvae, *Chironomus tentans*. *Environment International*, **4**(5-6): 435-437.
- Das, B. B. 1996. Rasraj Mahodadhi, Khemraj Shri Krishnadas Prakashan, Bombay, 437p.
- Das, B. B. 1999. Rasraj Mahodadhi, Khemraj Shri Krishnadas Prakashan, Bombay, 437p.
- Das, P.C.; McElroy, W.K. and Cooper, R.L. (2000). Differential modulation of catecholamines by chlorotriazine herbicides in pheochromocytoma (PC12) cells in vitro. *Toxicological Sciences*, **56**(2): 324-331.
- Davies, P.E.; Cook, L.S.J. and Goenarso, D. 1994. Sublethal responses to pesticides of several species of Australian freshwater fish and crustaceans and rainbow trout. *Environmental Toxicology and Chemistry*, **13**(8): 1341-1354.
- DeLorenzo, M.E.; Scott, G.I. and Ross, P.E. 2001. Toxicity of pesticides to aquatic microorganisms: A review. *Environmental Toxicology and Chemistry*, **20**(1): 84-98.
- Dewey, S.L. 1986. Effects of the herbicide atrazine on aquatic insect community structure and emergence. *Ecology*, **67**(1): 148-162.
- Dobsikova, R.; Velisek, J.; Wlasow, T.; Gomulka, P.; Svobodova, Z. and Novotny, L. 2006. Effects of cypermethrin on some haematological, biochemical and histopathological parameters of common carp (*Cyprinus carpio* L.). *Neuroendocrinology Letters*, **27**(2): 101-105.
- DoF (Department of Fisheries). 2011. Jatiyo Matshya Soptaho. Ministry of Fisheries and Livestock, The Government of Peoples republic of Bangladesh, Dhaka. pp. 56.
- DoF, 2002. Fish Fortnight Compendium. 10-24 August 2002, Department of Fisheries, Matsha Bhaban, Dhaka. pp. 44-45.
- Dong, X.; Zhu, L.; Wang, J.; Wang, J.; Xie, H.; Hou, X. and Jia, W. 2009. Effects of atrazine on cytochrome P450 enzymes of zebrafish (*Danio rerio*). *Chemosphere*, **77**(3): 404-412.
- Dorucu, M. and Girgin, A. 2001. The effects of cypermethrin on some haematological parameters of *Cyprinus carpio*. *Aquaculture International*, **9**(2): 183-187.
- Draft Guidance CDER. 2012. Estimating a safe starting dose in clinical trials for therapeutics in human volunteers. Food and Drug Administration Web site. Available at: <http://www.fda.gov/cber/gdlns/dose.pdf>. Accessed September 21, 2012.
- Duke, J. A. and E. S. Ayensu. 1985. Medicinal plants of China, Reference Publications, Inc., **2**:705p.
- Dung, L, 1990. Herbs and their application for control fish diseases in Vietnam. Technical paper. National Aquaculture Research Institute, Vietnam. p.7.
- Edwards, R.; Millburn, P. and Hutson, D.H. 1986. Comparative toxicity of cypermethrin in rainbow trout, frog, mouse and quail. *Toxicology and Applied Pharmacology*, **84**(3): 512-522.
- Ellman, G.L. 1959. Tissue sulfhydryl groups. *Archives of Biochemistry and Biophysics*, **82**(1): 70-77.
- EPA-U.S. Environmental Protection Agency. 2012. Guidelines for Ecological Risk Assessment, Risk Assessment Forum, EPA/630/R095/002F, 1998. Available at: <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12460>. Accessed September 21, 2012.

- Erhardt P W. 2003. A human drug metabolism database: potential roles in the quantitative predictions of drug metabolism and metabolism-related drug-drug interactions. *Curr Drug Metab.* **4**:411-422.
- Eshleman, A.J. and Murray, T.F. (1991). Pyrethroid insecticides indirectly inhibit GABAdependent <sup>36</sup>Cl-influx in synaptoneurosomes from the trout brain. *Neuropharmacology*, **30**(12): 1333–1341.
- European Commission 1999. Study on the prioritisation of substances dangerous to the aquatic environment. Office for Official Publications of the European Communities, Luxembourg 120.
- Fan, W.Q.; Yanase, T.; Morinaga, H.; Gondo, S.; Okabe, T.; Nomura, M.; Komatsu, T.; Morohashi, K.I.; Hayes, T.B.; Takayanagi, R. and Nawata, H. 2007. Atrazine-Induced aromatase expression Is SF-1 dependent: implications for endocrine disruption in wildlife and reproductive cancers in humans. *Environmental Health Perspectives*, **115**(5): 720-727.
- FAO Fishery Information Data and Statistics Unit. 2005. FISHSTAT+Databases and Statistics. Rome, Italy: Food and Agriculture Organization of the United Nation; 2005.
- FAO. Assessment and management of seafood safety and quality. Huss, H.H., Ababouch, L., and Gram, L. 2004. Rome, FAO. FAO Fisheries Technical Paper vol. 444.
- FAO/NACA, 1995. Regional Study and workshop on the environmental assessment and management of aquaculture development. NACA *Envir. Aquacult. Dev. Ser.*, **1**:492 p
- FARAD. 2012. Food Animal Residue Avoidance Databank Homepage. Available at: <http://www.farad.org/>. Accessed September 21, 2012.
- Faruk, M.A.R., Alam, M.J., Sarker, M.M.R. and M.B. Kabir, 2004. Status of fish disease and health management practices in rural freshwater aquaculture of Bangladesh. *Pakistan J. Biol. Sci.*, **7**(12): 2092-2098
- Faruk, M.A.R., Ali, M.M. Ali and Z.P. Patwary. 2009. Evaluation of the status of use of chemicals and antibiotics in freshwater aquaculture activities with special emphasis to fish health management. *J. Bangladesh Agril. Univ.* **6**(2): 381–390,
- Faruk, M.A.R., M.J. Alam, M.M.R. Sarker and M.B. Kabir. 2004. Status of fish disease and health management practices in rural freshwater aquaculture of Bangladesh. *Pakistan J. Biol. Sci.*, **7**(12): 2092-2098.
- Faruk, M.A.R., M.M. Ali and Z.P. Patwary. 2008. Evaluation of the status of use of chemicals and antibiotics in freshwater aquaculture activities with special emphasis to fish health management. *J. Bangladesh Agril. Univ.*, **6**(2): 381-390.
- Faruk, M.A.R., N. Sultana and M.B. Kabir. 2005. Use of chemicals in aquaculture in Mymensingh district, Bangladesh. *Bangladesh J. Fish.*, **29**(1-2): 1-10.
- FDA/CVM. 2012. CVM and aquaculture. Food and Drug Administration Web site. Available at: <http://www.fda.gov/cvm/aqualibtoc.htm>. Accessed September 21, 2012.
- FDA/CVM. 2012. CVM Guidance For Industry. Guidance No. 3, General Principles for Evaluating the Safety of Compounds Used in Food-Producing Animals. Revised July 1994. Available at: <http://www.fda.gov/cvm/guidance/guideline3toc.html>. Accessed September 21, 2012.

- FDA/CVM. 2012. Guidance 61- FDA Approval of New Animal Drugs for Minor Uses and for Minor Species. Food and Drug Administration Web site. Available at: <http://www.fda.gov/cvm/guidance/minorgde.pdf>. Accessed September 21, 2012.
- Ferrington, E. A. 1990. Clinical material medica (reprinted) B. Jain publ. Pvt. Ltd., New Delhi, Ganapath. Kalyani Publishers, Ludhiana, India, pp. 347-353.
- Flammarion, P.; Brion, F.; Babut, M.; Garric, J.; Migeon, B.; Noury, P. and Thybaud, E. 2000. Induction of fish vitellogenin and alterations intesticular structure: preliminary results of estrogenic effects in chub (*Leuciscus cephalus*). *Ecotoxicology*, **9**(1-2): 127-135.
- Floyd, R.F. 1993. The Veterinary Approach to Game Fish. Pergamon Press. pp. 395-408.
- Friedlander LG, Brynes SD, Fernandez AH. 1999. The human food safety evaluation of new animal drugs. *Vet Clin North Am Food Anim Pract.*, **15**:1-11.
- Gangolli, E.D. 1999. *The dictionary of substances and their effects*. (2nd ed.), Royal of Society of Chemistry, ISBN 0-85404-833-2, Cambridge, UK
- GESAMP 1997. Towards safe and effective use of chemicals in coastal aquaculture. GESAMP Reports and Studies No: 65 Publ. IMO/FAO/UNESCO/IOC/WMO/WHO/IAEA/
- GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), 1991. Reducing environmental impacts of coastal aquaculture. Rep.Stud.GESAMP, **47**:35 p.
- GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). 1997. Towards safe and effective use of chemicals in coastal aquaculture. *Rep. Stud.* (IMO/ FAO/ UNESCO/ IOC// WMO/ WHO/ IAEA/ UN/ UNEP, **65**: 40 pp
- Ghani, A. 2003. Medecinal plants Bangladesh. Asiatic Society of Bangladesh. 460p.
- Ghosh, N. C. 1988. Comparative Materia Medica Hannemann Publ. Co. Pvt. Ltd. Colicata, India, pp. 347-353.
- Gingerich WH, Stehly GR, Clark KJ, Hayton WL. 1998. Crop grouping: a proposal for public aquaculture. *Vet Human Toxicol.*, **40**(suppl 2):24-31.
- Gräslund, S. and Bengtsson, B.-E. 2001. Chemicals and biological products used in south-east Asian shrimp farming, and their potential impact on the environment – a review.
- Graslund, S., K. Holmstrom and A. Wahlstrom. 2003. A field survey of chemicals and biological products used in shrimp farming. *Mar. Poll. Bull.*, **46**: 81-90.
- Gunier, R.B., Harnly, M.E., Reynolds, P., Hertz, A. and von Behren, J. 2001. Agricultural pesticide use in California: Pesticide prioritization, use densities, and population distributions for a childhood cancer study. *Environmental Health Perspectives*, **109**(10): 1071-1078.
- Habig, W.H.; Pabst, M.J. and Jakobi, W.B. 1974. Glutathione-S-transferases. The first enzymatic step in mercapturic acid formation. *Journal of Biological and Chemistry*, **249**(22): 7130-7139.
- Hanioka, N.; Jinno, H.; Tanaka-Kagawa, T.; Nishimura, T. and Ando, M. 1999a. In vitro metabolism of chlorotiazines: characterization of simazine, atrazine, and propazine metabolism using liver microsomes from rats with various cytochrome P450 inducers. *Toxicology and Applied Pharmacology*, **156**(3): 195-205).

- Hanioka, N.; Jinno, H.; Tanaka-Kagawa, T.; Nishimura, T. and Ando, M. 1999b. In vitro metabolism of simazine, atrazine, and propazine by hepatic cytochrome P450 enzymes of rat, mouse and guinea pig and oestrogenic activity of chlorotriazines and their main metabolites. *Xenobiotica*, **29**(12): 1213-1226.
- Haque A. K. E. 2003. Sanitary and phyto-sanitary barriers to trade and its impact on the environment; the case of shrimp farming in Bangladesh. International Institute for Sustainable Development, Canada, pp. 1-56.
- Harvey, S.C. 1975. Antiseptics and disinfectants; fungicides; ectoparasites. In: Goodman LS, Gilam A. eds. *The Pharmacological Basis of Therapeutics*. p. 987-1017. Macmillan Publishing Co. Inc., New York, NY.
- Hashimoto, Y. and Nishiuchi, Y. 1981. Establishment of bioassay methods for the evaluation of acute toxicity of pesticides to aquatic organisms. *Journal of Pesticide Science*, **6**(2): 257-264.
- Haskell SR, Gehring R and Payne MA, 2003. Update on FARAD food animal drug withholding recommendations. *J Am Vet Med Assoc*. **223**:1277-1278.
- Haskell SR, Payne MA, Webb AI, Riviere JE and Craigmill AL. 2004. Current approved drugs for aquatic species. *J Am Vet Med Assoc*. **224**:50-51.
- Haya, K. 1989. Toxicity of pyrethroid insecticides to fish. *Environmental Toxicology and Chemistry*, **8**(5): 381-391.
- Hayes, A.W. 1994. *Principles and methods of toxicology*. Raven Press, ISBN 0-7817-0131-7, New York, NY.
- Herwig, N. 1979. *Handbook of Drugs and Chemicals used in Treatment of Fish Diseases*. Charles C. Thomas, Springfield, IL
- Holmström, Katrin et al. 2003. "Antibiotic use in shrimp farming and implications for environmental impacts and human health." *International Journal of Food Science and Technology*. **38**: 255-266.
- Hoq, M.E., M.M. Islam and M.M. Hossain. 1996. Polyculture of freshwater prawn (*Macrobrachium rosenbergii*) with Chinese and Indian carps in farmer's pond. *J. Aquacult.*, **57**: 135-141.
- Hoque, M., S. K. Maiti, N. Hoque, G. R. Singh, H. P. Aithal, N. Kumar and Kalichnam. 2004. Evaluation of alcoholic extracts of bamboo (*Bambusa arundinacea*) buds on fracture healing in rabbit. *Indian Journal Animal Science*, **74**(9): 915-917.
- Howgate P. 1998. Review of the public health safety of products from aquaculture. *Int J Food Sci Technol*, **33**:99-125.
- Hunter, G.A., E.M. Donaldson. 1983. Hormonal sex control and its application to fish culture. In: Hoar WS, Randall DJ, Donaldson EM. eds. *Fish Physiology*. Vol. IXB, p. 223-303. Academic Press, New York, NY.
- Hussain, M.G. 2009. A future for the tilapia in Bangladesh. *AQUA Culture AsiaPacific Magazine*. pp 38-40.
- Hussein, S.Y.; El-Nasser, M.A. and Ahmed, S.M. 1996. Comparative studies on the effects of herbicide atrazine on fresh water fish *Oreochromis niloticus* and *Chrysichthyes auratus* at Assiut, Egypt. *Bulletin of Environmental Contamination and Toxicology*, **57**(3): 503-510.
- Inglis, V. 1996. Antibacterial chemotherapy in aquaculture: review of practice, associated risks and need for action. In: *Use of Chemicals in Aquaculture in Asia*. Arthur, J.R., C.R. Lavilla-Pitogo and R.P. Subasinghe (eds.). Southeast Asian



- Fisheries Development Centre, Aquaculture Department Tigbauan, Iloilo, Philippines. pp.7-22.
- Inoue, M.H.; Oliveira, R.S.; Regitano, J.B.; Tormena, C.A.; Constantin, J. and Tornisiolo, V.L. 2006. Sorption-desorption of atrazine and diuron in soils from southern Brazil. *Journal of Environmental Science and Health Part B, Vol. 41, No. 5, (June 2006)*, pp. 605-621, ISSN 0360-1234.
- International Council for the Exploration of the Sea (ICES), 1988. Environmental impact of Mariculture. Cooperative Research Report No. 154, Denmark.
- Islam, S. 2006. Sweet potato (*Ipomoea batatas* L.) Leaf: Its potential effect on human health and nutrition. *J. Food Sci.*, **71**(2): 13-21.
- IUCN (International Union for Conservation of Nature), 2003. *Red Book of Threatened Fishes of Bangladesh*, IUCN- The World Conservation Union.
- Jee, L.H.; Masroor, F. & Kang, J.C. (2005). Responses of cypermethrin-induced stress in haematological parameters of Korean rockfish, *Sebastes schlegeli* (Hilgendorf). *Aquaculture Research*, **36**(9): 898-905.
- Johnston, P., Santillo, D., Stringer, R., Ashton, J., McKay, B., Verbeek, M., Jackson, E., Landman, J., van den Broek, J., Samsom, D., and Simmonds, M. 1998 Greenpeace Report on the World's Oceans. Greenpeace Research Laboratories Report, May 1998. Publ: Stichting Greenpeace Council. ISBN: 90/73361/45/1: 154 pp.
- Jones J, Kinnel M, Christenson R, Reimschuessel R. 1997. Gentamicin concentrations in toadfish and goldfish Serum. *J Aquat Anim Health*. **9**:211-215.
- Kane, A.S.; Salierno, J.D. and Brewer, S.K. 2005. Fish models in behavioral toxicology: Automated techniques, updates and perspectives. In: *Methods in Aquatic Toxicology*, Ostrander, GK, pp. 559-590, Lewis Publishers, ISBN 978-1-56670-664-3, Boca Raton, FL
- Kashem, M. A. 1998. Studies on the virulence of *Pseudomonas* spp. and pathogenicity of *Flexibacter columnaris*. M.S. Thesis. Bangladesh Agricultural University, Mymensingh.
- Katsumata, H.; Fujii, A.; Kaneco, S.; Suzuki, T. and Ohta, K. 2005. Determination of simazine in water samples by HPLC after preconcentration with diatomaceous earth. *Talanta*, **65**(1): 129-134.
- Katz, G. 1989. Towards safe and effective use of chemicals in coastal aquaculture. *Rep. Stud. GESAMP*, **65**: 40p.
- Keller F, Frankewitsch T, Zellner D, Simon S, Czock D, Giehl M. 1998. Standardized structure and modular design of a pharmacokinetic database. *Comput Methods Programs Biomed*. **55**:107-115.
- Khan, M. H., S. Sultana, K. M. A. Uddin and M. Zaher, 2005. Study of regional differences in soil-water characteristics and their relevance to aquaculture productivity and fish disease. *Bangladesh J. Fish. Reas.* **9**(1); 57-58.
- Khan, M. R., A. D. Omoloso and Y. Barewai. 2006. Antimicrobial activity of the *Derris elliptica*, *Derris indica* and *Derris trifoliata* extractives. *Fitoterapia*, **77**(4): 327-330.
- Khan, M.R., M.M. Rahman, M. Shamsuddin, M.R. Islam and M. Rahman. 2011. Present status of aqua-drugs and chemicals in Mymensingh district. *J. Bangladesh Soc. Agric. Sci. Technol.*, **8**(1&2): 169-174.

- Kidd, H. and James, D.R. 1991. *The Agrochemicals Handbook*. (3rd ed.), Royal Society of Chemistry Information Services, ISBN 0 85186 416 3, Cambridge, UK.
- Konstantinou, I.K.; Hela, D.G. and Albanis, T.A. 2006. The status of pesticide pollution in surface waters (rivers and lakes) of Greece. Part I. Review on occurrence and levels. *Environmental Pollution*, **141**(3): 555-570.
- Larsen, L.; Sorensen, S.R. and Aamand, J. 2000. Mecroprop, isoproturon, and atrazine in and above a sandy aquifer: vertical distribution of mineralization potential. *Environmental Science and Technology*, **34**(12): 2426-2430.
- Leung, P., Tran, L. T. and Fast, A. W., 2000. A logistic regression of risk factors for disease occurrence on Asian shrimp farms. *Dis. Aquat. Org.*, **41**: 65-76.
- Liu, T.L.; Wang, Y.S. and Yen, J.H. 2005. Separation of bifenthrin enantiomers by chiral HPLC and determination of their toxicity to aquatic organism. *Journal of Food and Drug Analysis*, **12**(3): 357-360.
- MacMillan JR. 1998. Drug development for use by the aquaculture industry: the producers' perspective. *Vet Hum Toxicol*. **40**(suppl 2):7-9.
- Mahmood I. 2004. Interspecies scaling of protein drugs: prediction of clearance from animals to humans. *J Pharm Sci*. **93**:177-185.
- Mahmood I. 2001. Interspecies scaling: is a priori knowledge of cytochrome p450 isoenzymes involved in drug metabolism helpful in prediction of clearance in humans from animal data? *Drug Metabol Drug Interact*. **18**:135-147.
- Masopust, J. 2000. *Clinical biochemistry*. Karolinum, ISBN 8071846493, Praha, (In Czech). Meister, R.T. (1992). *Farm Chemicals Handbook*. Meister Publishing Company, Willoughby.
- Matekaire, T., J. F. Mupangwa, and E. F. Kanyamura. 2005. The efficacy of banana plants (*Musa paradisiacal*) as a coccidiostat. *Intern. J. Appl. Res. Vet. Med.*, **3**(4): 326-332.
- Mauck, W.L.; Olson, L.E. and Marking, L.L. 1976. Toxicity of natural pyrethrins and five pyrethroids to fish. *Archives of Environmental Contamination and Toxicology*, **4**(1): 18-29.
- Mazid, M.A. 2001. Fish diseases and prevention. Bangladesh Fisheries Research Institute (BFRI). Mymensingh. pp. 36.
- Meinertz, R., Stehly, G. R., Gingerich, W.H., and Allen, J. L. 1975. Residues of malachite green eggs and fry of rainbow trout, *Oncorhynchus mykiss* (Walbaum) after treatment of eggs. *J. Fish. Path.* **18**: 239-247.
- Mekebri, A.; Crane, D.B.; Blondina, G.J.; Oros, D.R. and Rocca, J.L. 2008. Extraction and analysis methods for the determination of pyrethroid insecticides in surface water, sediments and biological tissues at environmentally relevant concentrations. *Bulletin of Environmental Contamination and Toxicology*, **80**(5): 455-460.
- Mekkawy, A.A.; Hussain, S.Y. and Ahmed, S.M. 1996. Comparative studies on the effects of herbicide atrazine on some blood constituents and protein electrophoretic patterns of *Oreochromis niloticus* and *Chrysichthyes auratus* at Assiut, Egypt. *Journal of the Egyptian German Society of Zoology*, **19**(4): 283-319.
- Monteiro, M.; Quintaneiro, C.; Noqueira, A.J.A.; Morgado, F.; Soares, A.M.V.M. and Guilhermino, L. 2007. Impact of chemical exposure on the fish *Pomatoschistus*

- microps Krøyer* (1838) in estuaries of the Portuguese Northwest coast. *Chemosphere*, **66**(3): 514-522.
- Moore, A. and Waring, C.P. 1998. Mechanistic effects of a triazine pesticide on reproductive endocrine function in mature male Atlantic salmon (*Salmo salar* L.) parr. *Pesticide Biochemistry and Physiology*, **62**(1): 41-50.
- MPEDA/NACA. 2003. Shrimp Health Management Extension Manual. Prepared by the Network of Aquaculture Centres in Asia-Pacific (NACA) and Marine Products Export Development Authority (MPEDA), India, in cooperation with the Aquatic Animal Health Research Institute, Bangkok, Thailand; Siam Natural Resources Ltd., Bangkok, Thailand and AusVet Animal Health Services, Australia. MPEDA, Cochin, India.
- Muir, D.C. 1980. Determination of terbutryn and its degradation products in water sediments, aquatic plants, and fish. *Journal of Agricultural Food Chemistry*, **28**(4): 714-719.
- Muniruzzaman, M. 2004. Etiopathology and control measures of ulcer diseases in the cultured fishes of Bangladesh. A Ph. D. Thesis, submitted to the Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh, 302p.
- Munro, A.L. S. 1978. The aquatic environment. In: Roberts, R. J. (Eds) Fish pathology. Bailliere Tindall, London: 1-12 p.
- Niimi, A.J. 1987. Biological half-lives of chemicals in fishes. *Reviews Environmental Contamination and Toxicology*, **99**(1): 1-46.
- Ormad, M.P.; Miguel, N.; Claver, A.; Matesanz, J.M. and Ovelleiro, J.L. 2008. Pesticides removal in the process of drinking water production. *Chemosphere*, **71**(1): 97-106.
- Oropesa, A.L.; Garcia-Camero, J.P.; Gomez, L.; Roncero, V. and Soler, F. 2009. Effect of long-term exposure to simazine on histopathology, hematological, and biochemical parameters in *Cyprinus carpio*. *Environmental Toxicology*, **24**(2): 187-199.
- Osime, E. O., G. E. Ediale, C. E. Omoti and A. A. Famodu. 2008. Effect of sweet potato leaf (*Ipomoea batatas*) extract on some haematological parameters using rabbits. *J. Med. Biomed Res.*, **7**(1&2): 12-15.
- Oudhia, P. and R. S. Tripathi, 1998. Proc. National conference on health care and development of herbal medicines, IGAU, Raipur, India 29-30 August, 1997. pp. 71-78.
- Philip, G.H.; Reddy, P.M. and Sridevi, G. 1995. Cypermethrin-induced *in vivo* alterations in the carbohydrate metabolism of freshwater fish, *Labeo rohita*. *Ecotoxicology and Environmental Safety*, **31**(2): 173-178.
- Philips, M. 1996. The use of chemicals in carp and shrimp aquaculture in Bangladesh, Cambodia, Lao PDR, Nepal, Pakistan, Sri Lanka and Vietnam. In: J.R. Arthur, C.R. Lavilla-Pitogo, R.P. Subasinghe (eds.). Use in aquaculture in Asia. Southeast Asian Fisheries Development Centre, Aquaculture Department Tigbauan, Iloilo, Philippines. pp. 75-85.
- Plumb, J.A., 1992. Disease control in aquaculture. In: Disease in Asian Aquaculture (edited by I.M. Shariff, R.P. Subasinghe and J. R. Arthur) Fish Health Section of the Asian Fisheries Society, Manila, Philippines, pp.3-17.

- Plumb, J.A., 1995. Chemotherapy vs. vaccination: a reality for Asian aquaculture. *In: Diseases in Asian aquaculture II*, edited by M. Shariff, J.R. Arthur and R.P. Subasinghe. Manila, Philippines, Fish Health Section, Asian Fisheries Society, pp.43-53.
- Prasad, Y., S.A. Mastan, T.A. Qureshi and C.H. Samuel. 1996. Effect of different antibiotic on EUS affected fish *Channa striatus* (Bloch). *In: The Fourth Indian Fisheries Forum*. Asian Fisheries Society, Indian Branch. pp. 191.
- Rahman, M. M. and M. B. R Chowdhury, 1996. Isolation of bacterial pathogen causing an ulcer disease in farmed carp fishes of Mymensingh. *Bangladesh J. Fish.*, **19**: 103-110.
- Rahman, M.M. and M.B.R. Chowdhury. 1999. Incidence of ulcer disease in African catfish (*Clarias gariepinus*) and trial for its chemotherapy. *Bangladesh J. Fish. Res.*, **3**: 193-200.
- Rastogi, R. P. and B. M. Mehrotra. 1991. Compendium of Indian medicinal plants. Publ. central drug research institute, Lucknow and publications information directorate, N. Delhi, pp. 70-73.
- Richter, S. and Nagel, R. 2007. Bioconcentration, biomagnification and metabolism of <sup>14</sup>Cterbutryn and <sup>14</sup>C-benzo[a]pyrene in *Gammarus fossarum* and *Asellus aquaticus*. *Chemosphere*, **66**(4): 603-610.
- Rioboo, C.; Prado, R.; Herrero, C. and Cid, A. 2007. Population growth study of the rotifer *Brachionus* sp. Fed with triazine-exposed microalgae. *Aquatic Toxicology*, **83**(4): 247-253.
- Riviere JE, Martin-Jimenez T, Sundlof SF and Craigmill AL. 1997. Interspecies allometric analysis of the comparative pharmacokinetics of 44 drugs across veterinary and laboratory animal species. *J Vet Pharmacol Ther.* **20**:453-463.
- Roberts, T. and Hudson, D. 1999. *Metabolic pathway of agrochemicals. Part 2: insecticides and fungicides* (1st ed.), The Royal Society of Chemistry, ISBN 085404499X, Cambridge.
- Roberts, T.R.; Hutson, D.H.; Lee, P.W.; Nicholls, P.H. and Plimmer, J.R. 1998. *Metabolic Pathways of Agrochemicals. Part 1: Herbicides and Plant growth regulators*. (1st ed.) The Royal Society of Chemistry, ISBN 0854044949, Cambridge, UK.
- Ruangpanich, N. 1988. Some problems in tiger shrimp hatcheries. Brackish water division, Department of Fisheries, Bangkok, pp; 1-11.
- Ruskin, F. R. 1992. Neem: a tree for solving global problems. Report of an Ad Hoc panel of the board on science and technology for international development national research council, national academy press, Washington D.C., 141p.
- Samuelson, O.B., E. Solheim and B.T. Lunestad. 1991. Fate and microbiological effects of furazolidone in a marine aquaculture sediment. *Sci. Total Environ.*, **108**: 275-283.
- Sarkar, B.; Chatterjee, A.; Adhikari, S. and Ayyappan, S. 2005. Carbofuran- and cypermethrin-induced histopathological alterations in the liver of *Labeo rohita* (Hamilton) and its recovery. *Journal of Applied Ichthyology*, **21**(2): 131-135.
- Sarker, M.G.A., 2000. Activities of *Aeromonas* bacteria and *Aphanomyces* fungus causing EUS in fresh water fishes of Bangladesh. An M.S. Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh. 93 pp.

- Sayeed, M. A. B., G. S. Hossain, S. K. Mistry, and K. A. Huq. 2008. Growth performance of Thai Pangas (*Pangasius hypophthalmus*) in polyculture system using different supplementary feeds. *Rajshahi Univ. J. Zool.*, **27**: 59-62.
- Schnick R A 1999. Use of chemicals in fish management and fish culture: past and future. In: Smith DJ, Gingerich WH, Beconi-Barker MG, eds. *Xenobiotics in Fish*. New York, NY: Kluwer Academic/ Plenum Publishers;pp 1-14.
- Schnick R A1992. Aquaculture chemicals. In: Kirk-Othmer Encyclopedia of Chemical Technology. 4<sup>th</sup> edition, Volume 3. New York, NY: John Wiley and Sons, Inc.:pp. 608-623.
- Schnick RA, Gingerich WH, Griffin BR and Erdahl D 2001. Progress of the Federal-State Aquaculture Drug Approval Partnership Project. *American Fisheries Society Fish Health Newsletter*, **29**:6-9.
- Sebastiao, F. A., F. Pilarski1 and M. V. F. Lemos. 2010. Isolation and molecular characterization of *Flavobacterium columnare* strains from fish in Brazil. *Journal of Bacteriology Research*. **2**(3): 22-29.
- Setser M D. 1985. Pharmacokinetics of gentamicin in channel catfish (*Ictalurus punctatus*). *Am J Vet Res.*; **46**:2558-2561.
- Shan, G.; Hammer, R.P. and Ottea, J.A. 1997. Biological activity of pyrethroid analogs in pyrethroid-susceptible and –resistant tobacco budworms, *Heliothis virescens* (F.). *Journal of Agricultural Food and Chemistry*, **45**(11): 4466-4473.
- Shang, Y. C., Leung, P. and Ling, B. H., 1998. Comparative economics of shrimp farming in Asia. *Aquaculture*, **164**: 183-200.
- Shariff M., Nagaraj, G. Chua, F. H. C. and Wang, Y. G. 1996. The use of chemicals in aquaculture in Malaysia and Singapore. In: Proceeding of the meeting on the use of chemicals in aquaculture in Asia, 20- 22 May 1996, Tigbauan, II, Philippines. pp 127-138.
- Sharma, N. K., D. Ahirwar, D. Jhade and S. Gupta. 2009. Medicinal and pharmacological potential of *Nigella sativa*: A Review *Ethnobot. Rev.*, **13**:946-955.
- Shelton, W.L., D. Rodriguez-Guerrero and J. Lopez-Macias. 1981. Factors affecting androgen sex reversal of *Tilapia aurea*. *Aquaculture*, **25**:59-65.
- Shires S.W. 1985. Toxicity of a new pyrethroid insecticide, WL 85871, to rainbow trout. *Bulletin of Environmental Contamination and Toxicology*, **34**(2): 134-137.
- Singh, S. K., A. N. Kesari, P. K. Rai and G. Watal. 2007. Assessment of glycemic potential of *Musa paradisiacal* stem juice. *Indian J. Clinic. Biochem.*, **22**(2): 48-52.
- Siroka, Z.; Krijt, J.; Randak, T.; Svobodova, Z.; Peskova, G.; Fuksa, J.; Hajslova, J.; Jarkovsky, J. and Janska, M. 2005. Organic pollutant contamination of the River Elbe as assessed by biochemical markers. *Acta Veterinaria Brno*, **74**(2): 293-303.
- Smith, P., Heny, M. P. and Samuelsen, S. B. 1994. Bacterial resistance to antimicrobial agent used in fish farming: a critical evaluation of method and meaning. *Annual Review of Fish Diseases* **4**: 273- 313.
- Sohlberg S, Ingebrigtsen K, Hansen M K, Hayton W L and Horsberg T E 2002. Flumequine in Atlantic salmon *Salmo salar*: disposition in fish held in sea water versus fresh water. *Dis Aquat Organ.*, **49**:39-44.
- Solomon, K.R.; Baker, D.B.; Richards, R.P.; Dixon, K.R.; Klaine; S.J.; Point, T.W.; Kendall, J.; Weisskopf, C.P.; Giddings, J.M.; Giesy, J.P.; Hall, L.W. and

- Williams, W.M. 1996. Ecological risk assesment of atrazine in North American surface waters. *Environmental Toxicology and Chemistry*, **15**(1): 31-76.
- Solomon, K.R.; Giddings, J.M. and Maund, S.J. 2001. Probabilistic risk assessment of cotton pyrethroids: I. Distributional analysis of laboratory aquatic toxicity data. *Environmental Toxicology and Chemistry*, **20**(3): 652-659.
- Sopinska, A. and Guz, L. 1998. Influence of permethrin on phagocytic activity of carp. *Medycyna Weterynaryjna*, **54**(2): 126-128.
- Sorum, H. 1999. Antibiotic resistance in aquaculture. *Acta vet. Scand. Suppl.* **92**: 29-36.
- Sorum, H. 2000. Farming of Atlantic salmon: an experience from Norway. *Acta vet. Scand. Suppl.* **93**: 129-134.
- Sorum, H., Roberts, M. C. and Crosa J. H. 1992. Identification and cloning of a tetracycline gene from the fish pathogen *Vibrio salmonicida*. *Antimicrobiological agent and chemotherapy*. **36**. 611-615.
- Spalding, R.F.; Exner, M.E.; Snow, D.D.; Cassada, D.A.; Burbach, M.E. and Monson, S.J. 2003. Herbicides in ground water beneath Nebraska's management systems evaluation area, *Journal of Environmental Quality*, **32**(1): 92-98.
- Spano, L.; Tyler, C.R.; van Aerle, R.; Devos, P.; Mandiki, S.N.M.; Silvestre, F.; Thomec, J.P. and Kestemont, P. 2004. Effects of atrazine on sex steroid dynamics, plasma vitellogenin concentration and gonad development in adult goldfish (*Carassius auratus*). *Aquatic Toxicology*, **66**(4): 369-379.
- Stehly G R, Meinertz J R, Gingerich W H 2000. Effects of temperature on the elimination of benzocaine and acetylated benzocaine residues from the edible fillet of rainbow trout (*Oncorhynchus mykiss*). *Food Addit Contam.*; **17**:387-392.
- Stoskopf M K, Kennedy-Stoskopf S, Arnold J, Andrews J, Perlstein M T 1986. Therapeutic aminoglycoside antibiotic levels in brown shark, *Carcharhinus plumbeus* (Nardo). *J Fish Dis.*, **9**: 303-311.
- Subasinghe, R.P., U. Barg and A. Tacon. 1996. Chemicals in Asian aquaculture: need, usage, issues and challenges. In: Arthur, J.R., C.R. Lavilla-Pitogo and R.P. Subasinghe (eds.). Use of Chemicals in Aquaculture in Asia. Southeast Asian Fisheries Development Center, Aquaculture Department Tigbauan, Iloilo, Philippines. pp. 1-6.
- Sundlof SF. 1998. Drug development for the aquaculture industry: a perspective from the Center for Veterinary Medicine. *Vet Hum Toxicol.*; **40** (suppl 2):5-7.
- Svobodova, Z.; Pravda, D. and Palackova, J. 1991. Unified methods of haematological examination of fish. *Research Institute of Fish Culture and Hydrobiology, Vodnany*, Methods No. 20, pp. 31.
- Takashima, F. and Hibiya, T. 1995. *An atlas of fish histology: Normal and pathological features*, (2<sup>nd</sup> ed.), Kodansha Ltd., ISBN 987-3437307829, Tokyo.
- Tamuli, K.K. and S.L. Shanbhogue. 1996. Efficacy of some commonly available chemicals in the treatment of anchor worm (*Lernaea bhadransis*) infection. *Environ. Ecol.*, **14**(2): 259-267.
- Tarja, N.; Kirsti, E.; Marja, L. and Kari, E. 2003. Thermal and metabolic factors affecting bioaccumulation of triazine herbicides by rainbow trout (*Oncorhynchus mykiss*). *Environmental Toxicology*, **18**(4): 219-226.

- Tennant, M.K.; Hill, D.S.; Eldridge, J.C.; Wetze, L.T.; Breckenridge, C.B. and Stevens, J.T. 1994. Possible antiestrogenic properties of chloro-s-triazines in rat uterus. *Journal of Toxicology and Environmental Health*, **43**(2): 183-196.
- Tiwari, T. N., V. B. Pandey and N. K. Dubey. 2002. Plumieride from *Allamanda cathartica* as an antidermatophytic agent. *Phytotherapy Research*, 16(4): 393-394.
- Tomlin, C. 2003. *The Pesticide Manual: A World Compendium*. (13<sup>th</sup> ed.), British Crop Protection Council, ISBN 0901436445, Hampshire, UK
- Tort, L.; Puigcerver, M.; Crespo, S. and Padros, F. 2002. Cortisol and haematological response in sea bream and trout subjected to the anesthetics clove oil and 2-phenoxyethanol. *Aquaculture Research*, **33**(11): 907-910.
- Treasurer, J.W. and Wadsworth, S.L. 2004. Interspecific comparison of experimental and natural routes of *Lepeophtheirus salmonis* and *Caligus elongatus* challenge and consequences for distribution of chalmus on salmonids and therapeutic screening. *Aquaculture Research*, **35**(8): 773-83.
- U.S. EPA - Environmental protection agency 1994. Atrazine, simazine and cyanazine: notice of initiation of special review. Federal register 59 FR60412, **59**: (225): 30000-30060.
- Uddin, S. A. and A. Kader, 2006. The use of antibiotics in shrimp hatcheries in Bangladesh . *Journal of Fisheries and Aquatic Sciences, USA*. **1**(1): 64-67.
- van der Oost, R.; Beyer, J. and Vermeulen, N.P.E. 2003. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. *Environmental Toxicology and Pharmacology*, **13**(2): 57-149.
- Van Eeckhout N J, Van Peteghem C H, Helbo V C, Maghuin-Rogister G C and Cornelis M R 1998. New database on hormone and veterinary drug residue determination in animal products. *Analyst.*, **123**:2423-2427.
- van Ginneken VJTh, Nouws JFM, Grondel JL, Driessens F and Degen M. 1991. Pharmacokinetics of sulphadimidine in carp (*Cyprinus carpio* L.) and rainbow trout (*Salmo gairdneri* Richardson) acclimated at two different temperature levels. *Vet Q.*; **13**(2):88-96.
- Velisek J, A. Stara and Z. Svobodova 2011. The Effects of Pyrethroid and Triazine Pesticides on Fish Physiology, *Pesticides in the Modern World - Pests Control and Pesticides Exposure and Toxicity Assessment*, Dr. Margarita Stoytcheva (Ed.), ISBN: 978-953-307-457-3, pp 377-402.
- Velisek, J., Dobsikova, R., Svobodova, Z., Modra, H., Luskova and V. 2006b. Effect of deltamethrin on the biochemical profile of common carp (*Cyprinus carpio* L.). *Bulletin of Environmental Contamination and Toxicology*, **76**(6): 992-998.
- Velisek, J., Jurcikova J., Dobsikova, R., Svobodova, Z., Piackova, V., Machova, J. and Novotny, L. 2007. Effects of deltamethrin on rainbow trout (*Oncorhynchus mykiss*). *Environmental Toxicology and Pharmacology*, **23**(3): 297-301.
- Velisek, J., Stara, A., Machova, J. and Svobodova, Z. 2011b. Effects of long-term exposure to simazine in real concentration on common carp (*Cyprinus carpio* L.). *Ecotoxicology and Environmental Safety*, in press, ISSN 0147-6513.
- Velisek, J., Sudova, E., Zlabek, V., Kolarova, J. and Svobodova, Z. 2011a. Effects of chronic exposure to terbutryn in common carp (*Cyprinus carpio* L.). *Veterinarni Medicina*, in press, ISSN 0375-8427.

- Velisek, J., Svobodova, Z. and Machova, J., 2009c. Effects of bifenthrin on some haematological, biochemical and histopathological parameters of common carp (*Cyprinus carpio* L.). *Fish Physiology and Biochemistry*, **35**(4): 583-590.
- Velisek, J.; Stastna, K.; Sudova, E.; Turek, J. and Svobodova, Z. 2009a. Effects of subchronic simazine exposure on some biometric, biochemical, hematological and histopathological parameters of the common carp (*Cyprinus carpio* L.). *Neuroendocrinology Letters*, **30**(Suppl. 1): 236-241.
- Velisek, J.; Sudova, E.; Machova, J. and Svobodova, Z. 2010. Effects of sub-chronic exposure to terbutryn in common carp (*Cyprinus carpio* L.). *Ecotoxicology and Environmental Safety*, **73**(3): 384-390.
- Velisek, J.; Svobodova, Z. and Piackova, V. 2009b. Effects of acute exposure to bifenthrin on some haematological, biochemical and histopathological parameters of rainbow trout (*Oncorhynchus mykiss*). *Veterinarni Medicina*, **54**(3): 131-137.
- Velisek, J.; Svobodova, Z.; Piackova, V.; Novotny, L.; Blahova, J.; Sudova, E. and Maly, V. 2008. Effects of metribuzin on rainbow trout (*Oncorhynchus mykiss*). *Veterinarni Medicina*, **53**(6): 324-332.
- Velisek, J.; Wlasow, T.; Gomulka, P.; Svobodova, Z.; Dobsikova, R.; Novotny, L. and Dudzik, M. 2006a. Effects of cypermethrin on rainbow trout (*Oncorhynchus mykiss*). *Veterinarni Medicina*, **51**(10): 469-476.
- Wackett, L.P.; Sadowsky, M.J.; Martinez, B. and Shapir, N. 2002. Biodegradation of atrazine and related s-triazine compounds: from enzymes to field studies. *Applied Microbiology and Biotechnology*, **58**(1): 39-45.
- Wendelaar Bonga, S.E. 1997. The stress response in fish. *Physiology Reviews*, **77**(3): 591-625).
- Weston, D.P. 1996. Ecological effects of the use of chemicals in aquaculture. Proc. of the meeting on the use of chemicals in aquaculture in Asia, 20-22 May, 1996. Tigbauan, Iloilo, Philippines. pp. 23-30.
- Willis, C; Booth, H; Westacott, S and Hawtin P. 1999. Detection of antibacterial agents in warm water prawns. *Communicable Diseases and Public Health*, **2**(3): 210-214.
- Yadav, R.S.; Srivastava, H.C.; Adak, T.; Nanda, N.; Thapar, B.R.; Pant, C.S.; Zaim, M. and Subbarao, S.K. 2003. House-scale evaluation of bifenthrin indoor residual spraying for malaria vector control in India. *Journal of Medical Entomology*, **40**(1): 58-63.
- Yan Q and Sadee W. 2000. Human membrane transporter database: a Webaccessible relational database for drug transport studies and pharmacogenomics. *AAPS PharmSci.*, **2**(3):E 20.
- Yang, N. Y., Li, Y. F. Yang and Y. H. Li. 2009. Aromatase inhibitory fatty acid derivatives from the follen of *Brassica campestris* L. var. *oleifera* DC. *J. Asian Nat. Prod. Res.*, **11**(2): 132-137.
- Zumrutdal, M. Emin. Ozaslan, M. Tuzcu, M. E. Kalender, K. Daglioglu, A. Akova, I. D. Karagoz, I. H. Kilic, O. Colak and F. Koksall. 2008. Effect of Lawsonia inermis treatment on mice with sarcoma. *African J. Biotechnol.*, **7**(16): 2781-2786.