

**Tribhuvan University**  
**Institute of Science and Technology**  
**M. Sc. Zoology (Semester System)**  
**SEMESTER II**  
**FISH BIOLOGY & AQUACULTURE**

**Course Title: Fish Biology**  
**Course No: Zoo 563**  
**Nature of the Course: Theory**

**Credits: 3**  
**Lecture hrs: 48**  
**Full Marks: 75**  
**Pass Marks: 37.5**

**Course Objectives**

- To acquaint students with basic knowledge of the inter-relationships of the major groups of fishes in an evolutionary and developmental perspective
- To provide knowledge of the anatomy and function of the organ systems of fish
- To develop skills in scientific writing.

**Course Contents**

**Origin, diversity, distribution and taxonomy** **12 hrs**

1. **Origin, diversity and distribution:** Origin and evolution of major groups of fishes, evolutionary strategies and morphological innovations, zoo-geographical distribution of fishes. **4 hrs**
2. **Taxonomy:** Principles and different methods employed in fish identification (morphological, morphometric and meristic) and fish barcoding. Classification and identifying characters upto family level and representative genus of fishes available in Nepal. Taxonomic key features used to identify various species. **8 hrs**

**Anatomy & Physiology** **32 hrs**

1. **Digestive system** - General morphological feature of digestive system in fishes. Feed and feeding habits – herbivores, carnivores and omnivores. Feeding adaptations. **3 hrs**
2. **Respiratory system** - General description, aquatic respiration, respiratory gases, gaseous exchange, oxygen transport and homeostasis. Adaptations for air breathing in fishes. **4 hrs**
3. **Cardiovascular system** - General features of heart and blood circulation. **2 hrs**
4. **Excretion and osmo-regulation** - Nitrogenous excretion freshwater and marine fishes. Water and salt balance, acid- base balance. **3 hrs**
5. **Nervous System** - General features of nervous systems, lateral line system, sound production/reception system, weberian ossicles, photoreception, chemoreception, mechano-reception, electroreception. **5 hrs**
6. **Reproduction** - Reproductive organs, development of primary and secondary sexual characters and sexual dimorphism in fishes. Maturation and spawning in fishes, factors affecting maturation and spawning. Fecundity, condition factor, size at first maturity. Oviparous, viviparous and ovoviviparous fishes. **6 hrs**
7. **Endocrinology and Behaviour** - Piscine endocrine glands, hormones and their role in appetite, osmoregulation, calcium metabolism, cardiovascular regulation and behaviour. Behaviour and cognition -patterns of migration, orientation and homing, schooling, feeding, background adaptations, parental care. **9 hrs**

**Research methodology:** Tools and techniques used in fish collection and fish preservation. Fish sampling methods in rivers and lakes. Proposal, thesis, report and scientific paper writing. **4 hrs**

### **Suggested Readings**

- Gene Helfman, Bruce B. Collette, Douglas E. Facey, Brian W. Bowen. The Diversity of Fishes: Biology, Evolution, and Ecology, 2nd Edition. April 2009, Wiley-Blackwell. ISBN: 978-1-4051-2494-2.
- Hoar, W.S. and D.J. Randall (eds). Fish Physiology Vol. 1 to 9. From 1968 onwards, Academic Press, New York.
- Jayram, K.C. (1999): The Freshwater Fisheries of Indian Region, 2<sup>nd</sup> Edition Narendra Publishing House Delhi.
- Jhingran, V.G. Fish and Fisheries of India. 3<sup>rd</sup> ed. Hindustan Publishing Corporation New Delhi, 727 Pp.
- Khanna, S.S. An Introduction to Fishes. S. Chand & Co., New Delhi. Latest ed.
- Matty, A.J. 1985. Fish endocrinology. Croom Helm. 267 pp. ISBN 0-7099-1729-5.
- Paul J. B. Hart and John D. Reynolds. Handbook of Fish Biology and Fisheries, Volume 1 October 2002, Wiley-Blackwell. ISBN: 978-0-632-05412-1
- Pitcher, T.J. (Ed.) 1986. The behaviour of teleost fishes. Johns Hopkins U.P. / Croom Helm. 553 pp. ISBN 0-70992-070-9.
- Shrestha, J. (1981): Fishes of Nepal, Curriculum Development Centre, Tribhuvan University, Kathmandu.
- Shrestha, T.K. (1995): Fish Catching in the Himalayan Water of Nepal, A Study of Intercation of Man and Fish in the Himalayan Water, Published by Bimala Shrestha ,Kathmandu.
- Shrestha, T.K. (1997): The Mahaseer, Published by Bimala Shrestha, Kathmandu
- Shrestha, T.K. (2008): Ichthyology of Nepal, Published by Himalayan Ecosphere, G.P.O. Box 1633, Kathmandu Nepal.
- Smith, L.S. 1982. Introduction to fish physiology. Tetra Press. 352 pp. ISBN 0-87666-549-0.
- Talwar, P.K. and A.G. Jhingran (1991): inland Fishes of India and Adjacent Countries, Vols I and ii. Oxford and IBH Publishing Co. Pvt.
- Zupanc, G.K.H. 1988. Fish and their behaviour. Tetra Press. 185 pp. ISBN 3-92388-019-7.

\*\*\*\*\*

Tribhuvan University  
Institute of Science and Technology  
M. Sc. Zoology (Semester System)  
SEMESTER II  
FISH BIOLOGY & AQUACULTURE

**Course Title: Aquatic Ecosystem and Dynamics**

**Course No: Zoo 564**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 48**

**Full Marks: 75**

**Pass Marks: 37.5**

**Course Objectives**

- To develop the understanding of freshwater ecosystem.
- To provide knowledge of the interrelationship of fish with its environment

**Course Contents**

**Aquatic Ecosystem:** Elements, functions and processes in fresh water. Energy flow in aquatic ecosystems negative and positive feedbacks and resilience; energy efficiency, nutrient dynamics and circulation. Concepts of productivity; primary and secondary productivity. Homeostasis of the Ecosystem. **5 hrs**

**Physico-chemical characteristics of water:** Physical characteristics of water: Water colour, transparency, turbidity, depth, bottom structure, temperature, thermal exchange and thermal stratification, water velocity and light. Chemical characteristics of water: Total hardness, alkalinity, acidity, pH, chlorides, nitrates, total phosphates, orthophosphate, dissolved oxygen, free carbon dioxide, biochemical oxygen demand (BOD), chemical oxygen demand (COD), potassium, sodium, iron, zinc. **10 hrs**

**Biotic Community: Plankton, zoobenthos and aquatic microbiology** **16 hrs**

**Phytoplankton ecology:** Oxygen production, aquatic biology, growth strategy and environmental concept. **Zooplankton ecology:** Role of zooplankton in aquatic food web ecology and biogeochemical cycling; introducing zooplankton as grazers and predators and the use of 'alternative' food resources and indicators of climate change. **Benthic ecology:** Classification schemes: infauna, epifauna, aufwuchs, etc. Dynamics between benthic fauna linked to surface water ecology. **Aquatic Microbiology:** Role of microbes in regeneration of nutrients-conversion of Carbon, Nitrogen, Phosphorus and other nutrients. Role of autotrophic, heterotrophic microorganisms, autochthonous and allochthonous micro-organisms in culture pond.

**Impacts on aquatic ecosystem, biota and restoration** **17 hrs**

**Impact of eutrophication, toxic substances and pollution in aquatic environment:** Eutrophication, algal blooms and their impact on aquatic biota. **Environmental Toxicology:** Toxic components, aquatic contaminants and their biodegradation and bio-transformation. **Aquatic pollution** - impact of pollution on aquatic organisms. **5 hrs**

**Invasive or alien species:** Introduction and impact upon indigenous fishes; environmental, biological, economic and social impacts of invasive species; Invasive species as pest. Effects of invasive species expansion on the conservation of biodiversity and ecosystem function, as well as their global environmental and potential future changes in invasive species distributions under a changing climate. **5 hrs**

**Impacts of climate change on fishery:** Evidence of recent and current climate trends: globally and regionally. Building adaptive capacity of fish farmers to face climate change and bringing appropriate changes in the existing fish breeding, stocking and harvesting practices in the light of climate change.

**3 hrs**

**Ecological restoration of fresh water:** Knowledge of ecotechnology for management of lakes - catchment area treatment, biomanipulation, aeration, withdrawal of hypolimnetic water (siphoning of hypolimnion), probability of desiltation and water dilution, selective use of weed removal, waste water treatment, recycling and utilization in aquaculture.

**4 hrs**

### **Suggested Readings**

- Alabaster, J.S. and Lloyd, R. 1982. Water quality criteria for freshwater fish. 2nd. ed. Butterworth. 384 pp. ISBN 0-408-10849-5.
- Boyd, C.E. 1982. Water quality management and pond fish culture. Developments in Aquaculture and Fisheries Science, 9. Elsevier Scientific Publishing Co. Amsterdam. 318 pp.
- Boyd, C.E. 1991. Water quality in ponds for aquaculture. Auburn University, printed by Birmingham pub. 36849.
- Boyd, C.E. 1979. Water quality in warmwater fish ponds. Auburn University. 359 pp.
- Charkoff, M. 1978. Freshwater pond culture and pond management., Mt. Rainier, VITA Publications, Manual Series 36: 196 pp. 2nd ed.
- Edwards, P. 1980. Food potential of aquatic macrophytes; ICLARM studies and reviews. ICLARM. 51 pp. ISBN 0-89955-382-6.
- Greenberg A.E; Eaton, A.D. and Cleresci, L.S. (Eds.) 1991. Standard methods for the examination of water and wastewater: 1991 supplement to the 17th edition. American Public Health Association, American Water Works Association, Water Pollution Control Federation.
- Fogg, G.E. and Thake, B. 1986. Algal cultures and phytoplankton ecology. 3rd ed. University of Wisconsin. 175pp.
- Moriarty, D. J. and Pullin, R. S. V. 1987. Detritus and microbial ecology in aquaculture. ICLARM. 420 pp. ISBN 971-1022-29-X.
- Murty, A.S. 1986. Toxicity of pesticides to fish, Vol. 1CRC Press. ISBN 0-8493-6058- 7.
- Murty, A.S. 1986. Toxicity of pesticides to fish. Vol. 2. CRC Press.ISBN 0-8493-6059- 5.
- Stirling, H.P. (Ed.), Beveridge, M.C.M; Ross, L.G. and Phillips, M.J. 1985. Chemical and biological methods of water analysis for aquaculturists. Stirling. 119 pp. ISBN 0-90163-662-2.
- White, A.W. 1990. Toxic algal blooms; An international directory of experts in toxic and harmful algal blooms and their effects on fisheries and public health. International Marine Science Cooperation Program; W.H.O.I. Sea Grant. 221 pp.

\*\*\*\*\*

Tribhuvan University  
Institute of Science and Technology  
M. Sc. Zoology (Semester System)  
SEMESTER II  
FISH BIOLOGY & AQUACULTURE

**Course title: Fish Biology & Aquatic Ecosystem**  
**Course No.: Zoo 565**  
**Nature of the course: Practical**

**Credits: 2**  
**Lecture hrs: 90**  
**Full Marks: 50**  
**Pass Marks: 25**

**Course Objective**

- To provide students with practical knowledge on Fish Biology and aquatic ecosystem dynamics

**Course Contents**

1. Orientation on collection, preservation and labeling of fish before field visit.
2. Collection of different species of fishes from natural habitats (fish markets)
3. Orientation and application of morphometric techniques in fish identification
4. Study of museum specimens
5. Study of hill stream modifications (*Glyptosternum* sp. *Pseudoecheinus sulcatus*, *Schizothorax* sp. *Psylorhynchus pseudoecheinus* and *Garra* sp. etc.)
6. Permanent mountings and slide preparation of scales, ampullae of Lorenzini, eggs, hatchlings, fry and fingerlings.
7. Preparation of fish skeleton for osteological study.
8. Microtome preparation of gonads and different organ tissues.
9. Dissection of some typical siluroid and cyprinoid fishes such as *Wallago* spp., *Clarias* spp. *Heteropneustes fossilis*, rohu and mrigal to study: General anatomy, respiratory and accessory respiratory organs, cranial nerves, weberian ossicles and internal ear.
10. Report writing on field visit.
11. Study of water quality parameters: pH, turbidity, dissolved oxygen, carbon dioxide, alkalinity, hardness, acidity.
12. Sampling, preservation and identification of planktons and aquatic macro invertebrates.
13. Methods for qualitative and quantitative estimation of planktons.
14. Assessment of primary productivity by light and dark bottle method.
15. Study of the impact of pollution on ponds and rivers (.....Bagmati).

\*\*\*\*\*

Tribhuvan University  
Institute of Science and Technology  
M. Sc. Zoology (Semester System)  
SEMESTER III  
FISH BIOLOGY & AQUACULTURE

**Course Title: Fisheries, Population Dynamics and Conservation**

**Course No: Zoo 613**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 48**

**Full Marks: 75**

**Pass Marks: 37.5**

**Course Objectives**

- To provide knowledge of inland fish resources.
- To acquaint students with basic knowledge of fish population dynamics and conservation of aquatic resources.

**Course Contents**

**A. Inland fish resources (Riverine, lake and reservoir fisheries) 17 hrs**

1. **Riverine fisheries:** Riverine ecology, capture fisheries, fishing methods, Fish stock assessment, problems in riverine fisheries development in Nepal. Impact of damming on riverine fisheries and mitigation (fish ladders). Cold water fisheries - importance and scope cold water fishery in aquaculture, sport and recreation in Nepal. **7 hrs**
2. **Lake fisheries:** Origin, morphology, distribution, classification, ecology, capture fisheries, potentialities, problems and sustainable management of fisheries. **5 hrs**
3. **Reservoir fisheries-** Phases in the establishment, types, development and management of reservoir fisheries, potentialities, problems and sustainable management. **5 hrs**

**B. Fish Population Dynamics 8 hrs**

1. **Fish population dynamics:** Age, growth, length frequency analysis, growth curves (VBGF and Gompert), estimation of growth of fish stocks, gear selection, estimation of mortality rates, dynamic pool models for determining optimal fishing strategies (surplus yield models and length based stock assessment methods). Optimal harvesting rates (exploitation rate and exploitation ratio). **8 hrs**

**C. Fish conservation 23 hrs**

2. **Fish Conservation Biology:** Impact of environmental and habitat degradation on biodiversity, fishing and aquaculture. Concept of minimum viable population size, stock recruitment and regulation of fishing pressure (closed season, mesh size regulations). Current practices employed in the conservation and management of aquatic habitats and faunal diversity - restoration ecology, important fishing regulations (AAPA, National Parks and Wildlife Conservation Acts), sanctuaries - Ex-situ and In-situ conservation, Red Data Book, threatened and endangered fish species. **10 hrs**
3. **Sustainable fisheries and conservation:** Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Application of renewable energy in aquaculture: solar energy, wind, and tidal energy. Seed certification, Sustainable use of antibiotics. **6 hrs**

4. **Fisheries Management:** Introduction to fisheries management, problems associated with the management of fisheries, steps of a management procedure, past and present management devices, community-based fisheries, alternative approaches to fisheries management and relevance of co-management, conflict resolution, reservoir management, concept of Maximum economic yield and maximum social yield, economics in fisheries. **7 hrs**

### **Selected Readings**

- Alverson, D.L., Freeberg, M.H., Murawski, S.A. and Pope J.G . 1994. A Global Assessment of Fisheries Bycatch and Discards. FAO Technical Paper 339. Rome.
- Atlantic States Marine Fisheries Commission (ASMFC). 1997. Proceedings of the Workshop on Maintaining Current and Future Fisheries Resource Survey Capabilities. Special Report No. 63. ASMFC, Washington, D.C.
- Bagenal, T. (ed). 1978. Methods of assessment of fish production in fresh water. Blackwell Scientific Publications Ltd. Oxford, IBP Hand b., (3): 365 pp. 3rd ed.
- Beverton, R.J.H., and Holt S.J. 1993. On the Dynamics of Exploited Fish Populations. Chapman and Hall, London.
- FAO. (2011). FAO Aquaculture Newsletter. 63p
- FAO. (2009). Fisheries Management. FAO Technical Guideline for responsible Fisheries (4).
- Gulland, J.A. 1966. Manual of Sampling and Statistical Methods for Fisheries Biology . FAO Manual of Fisheries Science 3. U.N. Food and Agriculture Organization, Rome.
- Gulland, J.A. 1969. Manual of Methods of Fish Stock Assessment. FAO Manual of Fisheries Science 4. U.N. Food and Agriculture Organization, Rome.
- Gupta, S.K. and Gupta, P.C. 2014. General and applied ichthyology (fish and Fisheries) By Pub. S.Chand& Company Pvt. Ltd. India.
- King: Fisheries biology, assessment and management. Fishing News Books. (ISBN 0-85238-223-5)
- Shrestha, J. 1994. Fishes, fishing implements and Methods of Nepal ISBN 974-7315-55-6.

\*\*\*\*\*

Tribhuvan University  
Institute of Science and Technology  
M. Sc. Zoology (Semester System)  
SEMESTER III

**FISH BIOLOGY & AQUACULTURE**

**Course Title: Fish Breeding, Production and Fish Economics**

**Course No: Zoo 614**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 48**

**Full Marks: 75**

**Pass Marks: 37.5**

**Course Objectives:**

- To enable students to cultivate and produce fish seeds (fry, fingerlings and juveniles)
- To provide student with knowledge of commercial production of fish
- To acquaint students with basic knowledge of fish economics

**Course Contents**

- A. Breeding, hatching and rearing: 7 hrs**  
Pituitary gland/synthetic agents for induced breeding of important fishes. Brood stock management, sexing and mechanism of ovulation. Development of eggs in different hatcheries. Rearing of hatchlings, fry, fingerling and grow-out fishes. Transport of fish seed and brood fishes and use of anaesthetics.
- B. Biology and production of fishes (Commercial, ornamental, larvivorous and fish feed) 25 hrs**
1. **Commercial fishes:** Carps (Indian major carps, Chinese carps and common carp), air-breathing fishes (*Clarias batrachus*, *C. gariepinus*, *Channa marulius*), trout, *Tilapia*, *Pangasius*, *Macrobrachium*, crabs, frog. Indigenous potential fishes (*Schizothorax* spp., *Tor* and *Neolissocheilus hexagonolepis*). **10 hrs**
  2. **Ornamental fishes:** Introduction to aquarium, ornamental fishes and aquarium accessories - aerators filters, bio-filters, temperature, fish diseases and ailments maintenance. **Freshwater Ornamental Fishes:** biology of ornamental fishes - Gold fish and koi, gourami, barbs and tetras, angel fish, cichlids. **Aquarium plants:** Morphology, types and multiplication. **8 hrs**
  3. **Larvivorous fishes-** characteristics, selection and introduction in different water bodies. **2 hrs**
  4. **Fish live feeds:** Culture of fish food organisms (plankton groups) and mass culture of *Artemia* – hatching, decapsulation, enrichment and production of *artemia* cyst. Utility of live feed for larval development, nutritional value of live feed, importance in aquaculture. **5 hrs**
- C. Fish economics (Transportation, marketing, co-operative, extension and tourism) 16 hrs**
1. **Basic concepts of economics-** goods, services, wants, utility, price determination, problems and prospects of export and import of fish and fishery products in Nepal. **3 hrs**
  2. **Fish transportation** – Different methods of transportation of fishes (Live fish, wet fish, dry fish) in different containers like baskets/boxes, vans/crates and others. **2 hrs**
  3. **Marketing** – Introduction, basic marketing trend in Nepal, different types of market, advertising and sales promotion. Secondary institutions – merchant and middlemen. **3 hrs**
  4. **Co-operatives:** Fishermen co-operatives and importance. Role of National Cooperative Development Corporation in uplifting socioeconomic conditions of fishermen. **2 hrs**



5. **Fisheries Extension:** Extension - meaning, importance and various methods (individual, group and mass, farm and home visits, seminars, discussions, exhibition and personal contacts). Principles, steps of fisheries extension and role of NGO's, INGO and Government agencies in fisheries extension and development. **4 hrs**
6. **Fishery tourism** - recreational fisheries, linkages with tourism industry, growth potential. Role of recreational fishery in fish conservation. **2 hrs**

### **Selected Readings**

- Adhikari, R. 1993. Report on Fish Marketing and Consumption Survey in Nepal. Second Aquaculture Project. NEP/85/034, HMG Nepal. Ppl 13-40
- Browne, R., Sorgeloos, P. and Trotman, C. 1991. *Artemia* biology. CRC Press. 374 pp.
- Chaudhuri, H. and Singh, S.B. 1984. Induced breeding of carps. Indian Council of Agricultural Research. 82 pp. ISBN.
- Chondar, S.L. 1980. Hypophysation of Indian major carps (formerly Handbook on breeding of Indian major carps by pituitary hormone injection). 2nd enlarged revised ed. Satish. 146 pp. ISBN
- Eddie, G.C. 1990. Engineering, economics and fisheries management. Blackwell Scientific. 108 pp. ISBN 0-85238-0127-1.
- Fogg, G.E. and Thake, B. 1986. Algal cultures and phytoplankton ecology. 3rd ed. University of Wisconsin. 175pp. LC 85-40895. ISBN 0-299-10560-1.
- Hawkins, A.D. (Ed.) 1981. Aquarium systems. Academic Press. 452 pp. ISBN 0-12-333380- 6.
- Huet, M. 1972. Text book of fish culture: Breeding and cultivation of fish. Fishing News (Books) Ltd. Farnham, Surrey, U.K. 436 pp.
- Jhingran, V.G. and Pullin, R.S.V. 1985. A hatchery manual for the common, Chinese and Indian major carps. ICLARM. 191 pp.
- Kumar, S. and Tembhre, M. 2011. Fish & Fisheries, Pub. New Central Book Agency (P) Ltd. 8/1 Chintamani Das Lane, Kolkata
- New, M. and Singholka, S. 1985. Freshwater prawn farming. a manual for the culture of *Macrobrachium rosenbergii*; FAO Fisheries Technical Paper No. 225. F.A.O. UNIPUB. 118 pp. ISBN 92-5-101265-2.
- Pandey & Shukla. 2005. Fish & Fisheries, Pub. Rastogi Publication, U.P. India
- Richmond, A. 1986. CRC Handbook of microalgal mass culture. CRC Press. 576 pp.
- Santhanam R., Sukumaran, N., and Natarajan, P. 1999. A manual of Fresh- Water Aquaculture by Oxford & IBH Publishing Co. Pvt. Ltd. India.
- Shang, Y.C. Aquaculture economics: basic concepts and methods of analysis. Westview Press Boulder, Colorado, 153 pp.
- Sorgeloos, P., Bengtson, D.A., Declar, W. and Jaspers, S. (Eds.) 1987. *Artemia* research and its application: proceedings of the second International Symposium on the brine shrimp *Artemia*, organised under the patronage of His Majesty the King of Belgium. Universa Press. No ISBN.
- Srivastava, C.B.L. 1995. A Text Book of Fishery Science and Indian Fisheries, Pub. Kitab Mahal 22A, S.N. Marg, Allahabad, India.
- Vollmann-Schipper, Von F. 1975. Transport. Lebender Fish Verlag Paul Parey, Hamburg, 102 pp.
- Woyanovich, E. and Horvath, L. 1980. The Artificial propagation of warm-water finfishes - A manual for extension. FAO Fish. Tech. Paper 201. F.A.O. UNIPUB. 183 pp

\*\*\*\*\*

Tribhuvan University  
Institute of Science and Technology  
M. Sc. Zoology (Semester System)  
**SEMESTER III**  
**FISH BIOLOGY & AQUACULTURE**

**Course Title: Aquaculture and Management**

**Course No: Zoo 615**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 48**

**Full Marks: 75**

**Pass Marks: 37.5**

### Course Objectives

- To provide a better understanding of aquaculture techniques and fisheries management;
- To introduce to principles of fish nutrition and its importance to fish growth and health
- To introduce students to common infectious and non-infectious diseases that affect fish.

### Course Contents

**Aquaculture:** Scope and growth of aquaculture; **Types:** Extensive, semi-intensive and intensive culture; monoculture, polyculture, composite culture, mono-sex culture; cage culture, pen-culture, raceway culture, culture in re-circulatory systems; warm and coldwater aquaculture; sewage fed fish culture. **Integrated fish farming:** Basic principle and advantages of paddy cum fish culture, fish cum livestock, pig cum fish farming, duck cum fish farming, mulberry cum fish farming, open water stocking and ranching. **10 hrs**

**Farm Engineering:** Criteria for the selection of site and layout for aquaculture. Different components of farms – peripheral dikes, secondary dikes, feeder canals, sluice gate, monks and hatchery equipments. Mechanical and biological filters. Role of aeration in culture ponds - Paddle wheel aerators aspirators, compressors and blowers. Different types of pumps in aquaculture. **8 hrs**

### Pond management

**Soil and water interaction:** Productivity Vs nutrient quality and quantity of soil and water. **Fertilizers and manures:** Different kinds of fertilizers and manures, liming, biofertilizers and use of treated sewage for pond fertilization. **Eradication:** Predatory and weed fishes, algal bloom, aquatic weeds, predatory aquatic insects through biological and chemical methods. **Water quality management:** use of chlorination, ozonization and UV radiation. **7 hrs**

### Fish nutrition

**Principles of fish nutrition and nutritional requirements** of cultivable fin fish: larvae, juveniles and adults. Role of natural food in fish nutrition. Role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals. **3 hrs**

**Nutritional bioenergetics:** Energy requirement of fishes, Protein to energy ratio, digestible energy, nitrogen balance index, Protein sparing effect, high energy feeds, isocaloric diets. **Feed technology:** Preparation of formulated feed and evaluation; digestibility of feeds, feed additives (attractants, growth stimulants and probiotics) and binders, stability and storage properties of feed. **Nutritional pathology:** Anti-nutritional factors and anti-metabolites, microbial toxins and methods of elimination. **8 hrs**

**Fish Pathology:** Introduction to fish diseases. **Protozoan diseases** (finfish) – Costiasis, whirling diseases, trypanosomiasis. **Bacterial disease** (finfish) – furunculosis, columnaris, bacterial gill disease, gill rot, vibriosis. **Fungal Diseases** (finfish) – Brachiomyxosis. **Viral diseases** (finfish) – IPN, IHN, Viral Hemorrhagic Septicemia, Spring Viremia of carps. **Nutritional deficiency and Immunology:** Nutritional pathology – lipid liver degeneration , deficiency diseases due to vitamin A,D,E,K, B-Complex, C. Application and development of vaccines, Diagnostic tools: microscopy, immune detection DNA/RNA techniques. **12 hrs**

### **Selected Readings**

- ADCP, 1980. Fish Feed Technology - Lectures presented at FAOUNDP Training course in Fish Feed Technology held at the College of Fisheries University of Washington, Seattle, Washington, 9 October - 15 December, 1978. Rome, FAO/UNDP, ADCP/REP/ 80/11, 395 pp.
- Bardach, J.E., Ryther, J.H. and McLaren, W.D. 1972. Aquaculture. The farming and husbandry of fresh water and marine organisms. Wiley - Intersciences New York, 868 pp.
- Bell, F.W. and Canterbury, E.R. 1976. Aquaculture for the developing countries: A feasibility study. Belinger Publ. Co., Cambridge, Mass. 264. 26 pp.
- Cho, C.Y., Cowey, C.B., Watanabe, T. 1985. Finfish nutrition in Asia: methodological approaches to research and development. IDRC. 160 pp. ISBN
- Duyn Jr. C. Van. 1973. Diseases of fishes. London, Iliffa Books, 372 pp. 3rd ed.
- Halver, J.E. and Tiews, K. (ed) 1979. Fin fish nutrition and fish feed technology. Schr. Bunderforschungsant. Fisch., Hamb., (14/15). Vol. 1. 593 pp, Vol. 2: 622 pp.
- Kumar, S. and Tembhe, M. 2011. Fish & Fisheries by Pub. New Central Book Agency (P) Ltd. 8/1 Chintamani Das Lane, Kolkata
- Lovell, T. 1989. Nutrition and feeding of fish. AVI / Van Nostrand Reinhold. xi, 260 pp. ISBN 0-442-25927-1
- Muir, J.F. and Roberts, R.J. 1985. Recent advances in aquaculture Vol.2. Croom Helm. vii, 282 pp. ISBN 0-8733-0221-8.
- Muir, J.F. and Roberts, R.J. (Eds.) 1988. Recent advances in aquaculture. Vol. 3. Croom Helm. x, 420 pp. ISBN 0-70993-592-7. (no price given) ISBN 0-88192-122-X.
- Pandey & Shukla. 2005. Fish & Fisheries By Pub.Rastogi Publication ,U.P. India
- Pillay, T.V.R., 1977. Planning of Aquaculture Development - An introductory guide. FAO, Rome and Fishing News Books Ltd., Farnham, England. 77 pp.
- Pillay, T.V.R. and Dill, W.A (Ed) 1979. Advances in Aquaculture. Fishing News Books Ltd., Farnham, Surrey, England.
- Santhanam, R., Sukumaran, N., Natarajan, P. 1999. A manual of Fresh- Water Aquaculture by Oxford & IBH Publishing Co. Pvt. Ltd. India.
- Srivastava, C.B.L. 1995. A Text Book of Fishery Science and Indian Fisheries by Pub. Kitab Mahal 22A, S.N. Marg, Allahabad, India.
- Stickney, R.R. 1979. Principles of warmwater aquaculture. John Wiley & Sons, New York, Wiley Interscience, 376 pp.
- Wheaton, F.W. 1977. Aquaculture Engineering. Wiley Interscience, New York, 708 pp.
- Wijkstrom, V. and Jul-Larsen, E. 1986. Aquaculture: Tackling of the major constraints. CERES. 112: 19 – 22.

\*\*\*\*\*

Tribhuvan University  
**Institute of Science and Technology**  
**M. Sc. Zoology (Semester System)**  
**SEMESTER III**  
**FISH BIOLOGY & AQUACULTURE**

**Course Title: Fish Genetics and Biotechnology**

**Course No: Zoo 616**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 48**

**Full Marks: 75**

**Pass Marks: 37.5**

**Course Objectives**

- To acquaint students with basic knowledge of fish biotechnology
- To provide knowledge of fish immune system
- To provide basic knowledge of Fish preservation and quality

**Course Contents**

1. **Selection and Hybridization:** Principles of fish genetics- Genetic constitution of a population and genetic variations. Genetic selection and genetic management of brood-stocks. Inbreeding and population size and breeding plans to avoid inbreeding depression. Hybridization: Planning cross-breeding programs, heterosis and hybrid vigor, effects of unplanned hybridization. **6 hrs**
2. **Aquaculture Biotechnology:** Recombinant DNA technology, cloning, vectors, gene manipulation, growth enhancement, cold and disease resistance - transgenic fish production. Chromosome manipulation - triploidy, polyploidy, gynogenesis, androgenesis. Monosex production, super male and super female fish production techniques. **6 hrs**
3. **Genetic engineering:** Molecular markers used in fisheries and aquaculture: allozymes, mitochondrial DNA, multiple arbitrary primer markers techniques - RAPD, AFLP, nuclear DNA markers-RFLP, microsatellites. Fish genomics, proteomics and comparative genomics. Biotechnology in fish conservation, health management: molecular (nucleic acid and antibody based) diagnostics, vaccines, GMOs. Cryopreservation of gametes and embryos. **8 hrs**
4. **Defense mechanism:** Nonspecific immunity, acquired immunity and humoral immunity in fishes. Types of antibodies produced in fish. Types of immune reaction; Genetic control of immune response; Different theories of immune specificity; Immune complex mediated inflammatory reactions; Defective immune mechanisms; Auto-immune reactions; Interaction of antibody with antigen and applications in laboratory investigations; Immunization in fish and vaccination. **6 hrs**
5. **Fish Processing Technology:** Post-harvest fish spoilage: rigor mortis, rancidity, autolysis, microbial spoilage. Significance of preservation. **Different types of drying:** Packing and storage of dried products, spoilage of dried products and preventive measures. **Cold smoking:** Principles of freeze drying, accelerated freeze drying and packing of freeze dried products. **Freezing:** Fundamental principles involved in chilling and freezing of fish and fishery products. Different types of cold storages: Insulated and refrigerated vehicles. Distribution of frozen products by cold chain. Preparation of fish fillets. **Principles involved in canning of fish:** Spoilage of canned products. **10 hrs**
6. **Fishery By-Products:** Fish meal, fish protein concentrate, fish maws, isinglass, fish liver oil, fish body oil, fish hydrolysates, chitin, chitosan, glucosamine hydrochloride, squalene, pearl essence, ambergris, gelatin, beche-de-mer, fish silage, fish ensilage and seaweed products like agar, alginic acid and carragenan. **Advantages of value addition:** Fish mince and Surimi. Preparation of products

viz. fish/prawn pickle, fish wafers, prawn chutney powder, fish soup powder, fish protein hydrolysate, fish stacks, fillets, fish curry, marinated products. **6 hrs**

7. **Quality control and quality assurance:** Basic concepts, necessity of quality control. Salient features of quality factors. Risk factors - biotoxins, food pathogens, endogenous parasites, physical, chemical and biological hazards. **Methods of evaluating fish freshness and quality** – organoleptic, sensory, physical, chemical, microbiological and instrumental methods. Different quality control programs - In-process quality control (IPQC), Modified in-process quality control (MIPQC), Hazard Analysis Critical Control Points (HACCP), Good manufacturing practice (GMP) and sanitary standard operating procedure (SSOP). **6 hrs**

### **Suggested Readings**

- Azam, K. 2002. Fishermen Community of Kuakata, Bangladesh: Fisheries Activities and Quality of Dried Fish, SUFER Project (DFID-UGC), Khulna University, p. 2.
- Balachandran, K.K. 2001. Post-harvest Technology of Fish and Fish Products, Daya Publishing House, Delhi-110035, p. 77.
- Beaumont, A.R. and Hoare, K. 2002 Biotechnology and genetics in Fisheries and Aquaculture Blackwell publishing.
- Connell, J.J. 1990. Control of fish quality, 3rd. Edition. Fishing News Books Ltd. / Blackwell Scientific. 240 pp. ISBN 0-85238-169-7.
- Gall, G.A.E. and Busack, C.A. (Eds.) 1986. Genetics in aquaculture II. Proceedings of the 2nd international symposium on genetics in aquaculture, University of California, Davis, California, 23 - 28 June 1986. Elsevier Amsterdam, New York. 386 pp.
- Gjedrem, T. 1990. Genetics in aquaculture III., Proceedings of the 3rd International Symposium on genetics in aquaculture. Elsevier. 340 pp.
- Kirpichnikov, V.S. (Trans. G.G. Gause.) 1981. Genetic bases of fish selection. Springer-Verlag Berlin, New York; and Nauka, Leningrad. Pages unknown. ISBN 3-540-10911-0 Berlin.
- Kramer, D.E. and Liston, J. (Eds.) 1987. Seafood quality determination: International Symposium Proceedings. Elsevier. 678 pp. I
- Jeremy, W. Dale, Malcolm von Schantz and Nick Plant. 2012: From Genes to Genomes Third Edition Concepts and Applications of DNA Technology Wiley-Blackwell.
- Manning, M.J. and Tatner, M.F. 1984. Fish immunology. Academic Press, London. 430 pp.
- Palmer, R. (Compiler) 1984. Packaging your seafood products. New Zealand F.I.B. 104 pp. No ISBN.
- Parker, N.C. et al. (Eds.) 1990. Fish marking techniques. Proceedings of International Symposium and Educational Workshop at University of Washington, Seattle. 27 June - 1 July, 1988. American Fisheries Society. xiv, 879 pp.
- Peters, J. 1985. Effect of temperature on storage life of seafood. Washington Sea Grant. Pages, ISBN Ranga M.M. and Dr. Q. J. Shammi. 2002. Fish Biotechnology by pub. Agrobios (India).
- Rex, A. Dunham 2004: Aquaculture and Fisheries Biotechnology; Genetic Approaches CABI Publishing, CAB International 875 Massachusetts Avenue Oxfordshire OX10 8DE Cambridge, MA 02139 UK
- Tave, D. 1986. Genetics for fish hatchery managers. AVI / Van Nostrand Reinhold. 299 pp.
- Wilkins, N.P. and Gosling, E.M. (Eds.) 1983. Genetics in aquaculture. Developments in aquaculture and fisheries science, No. 12. Elsevier, Amsterdam, New York. 436 pp.
- Windsor, M. and Barlow, S. 1981. Introduction to fishery by-products. Fishing News Books / Blackwell Scientific. 208 pp.

**Tribhuvan University**  
**Institute of Science and Technology**  
**M. Sc. Zoology (Semester System)**  
**SEMESTER III**  
**FISH BIOLOGY & AQUACULTURE**

**Course title: Practical on Zoo 613 & 614**  
**Course No.: Zoo 617**  
**Nature of the course: Practical**

**Credits: 2**  
**Lecture hrs: 90**  
**Full Marks: 50**  
**Pass Marks: 25**

**Course Objectives**

To impart practical knowledge on topics of theory papers Zoo 613 & 614 (Fish estimation, sampling methods, stock assessment and growth. Induced breeding by hormones. Fish transportation. Aquarium fishes. Fish markets).

**Course Contents**

1. Introduction of different fishing gears – both conventional and non-conventional methods.
2. Estimation of fish density by using CPUE, rate removal methods, capture and recapture
  1. Methods and others.
  2. Preparation of bathymetric map of water body (.....Toudah Lake).
  3. Determination of growth and mortality of fishes.
  4. Determination of length and weight relationship of fishes (correlation).
  5. Determination fish stocking methods.
  6. Report on the study of fishing communities and their involvement in fish conservation.
  7. Determination hormone doses for artificial breeding of carp.
  8. Determine gonado-somatic index of fish.
  9. List different methods of transportation of eggs, fry and brood fishes used in Nepal.
10. Visit aquarium and ornamental fish shops to make check lists of fishes and different items requirement for the management of aquarium.
11. Prepare a report on different items (baskets/boxes, vans/crates) used in the transport of fishes.
12. Report on marketing strategies of fishes / Fish co-operatives established/various methods used in fishery extension/tourism and recreational fisheries in Nepal.

\*\*\*\*\*

Tribhuvan University  
**Institute of Science and Technology**  
**M. Sc. Zoology (Semester System)**  
**SEMESTER III**  
**FISH BIOLOGY & AQUACULTURE**

**Course title: Practical on Zoo 615 & 616**

**Course No.: Zoo 618**

**Nature of the course: Practical**

**Credits: 2**

**Lecture hrs: 90**

**Full Marks: 50**

**Pass Marks: 25**

**Course Objectives**

- To impart practical knowledge on topics of theory papers Zoo 615 & 616 (Fish pond designs, farm machineries, Feed formulation, fertilization. Weed controls. Fish markets study. Fish quality & preservation)

**Course Contents**

1. Study on design and construction of earthen fish ponds for carps and raceways for rainbow trout.
2. Feed composition and formulation by Peterson Square Methods.
3. Permanent slide preparation or mounting of fish parasites and identification.
4. Study on farm machineries (aerators, pumps....) used in Intensive Fish Farming in Nepal.
5. List and calculate doses of different kinds of fertilizers and manures, liming in fish ponds as per rate prescribed by Nepal Government.
6. List and calculate doses of different kinds of chemicals used in fish ponds to eradicate aquatic weeds/predatory aquatic insects/algal bloom.
7. Prepare a report on any one fish farm which has adopted integrated fish farming
8. Calculate the amount of ice needed for the preservation of fishes.
9. Lists imported fishes with different packaging and canning systems.
10. Study different indigenous fish preservation methods.
11. Methods of evaluating fish freshness and quality – organoleptic, sensory, physical, chemical, microbiological and instrumental methods.
12. General molecular practical methods like PCR, Electrophoresis.....
13. Report on national policy on quality control and quality assurance of fish and fishery products.

\*\*\*\*\*