light of changes in climate was an important thematic issue. This was also highlighted in a talk by Jagdish Krishnaswamy (ATREE), who spoke of changes in hydrological balance due to climate change. The importance of ecosystem services in water supply to Himalayan towns and the need to protect recharge zones through better identification (through hydro-geological surveys) and legislation were discussed. Increased developmental activities, such as the building of hydropower projects, through generation of debris and changes in water flow, modify local ecosystems.

The concept of sustainability was debated. The discussions were triggered by Barry Noon's (Colorado State University) lecture on concepts underlying ecological sustainability. Providing alternatives to biomass products, use of devices such as improved cookstoves to reduce fuelwood use, and the potential of ecotourism to justify protected areas and generate local employment were discussed. The multiplier effect of forest livelihoods in generating downstream employment and potential of REDD+ to accelerate such endeavours were focused on. Rajiv Bhartari (CCF Ecotourism, Uttarakhand Forest Department) spoke on the potential of ecotourism in conserving biodiversity and generating local employments and livelihoods. NGOs such as CHIRAG, Himmothan and People's Science Institute also discussed their grassroots-level interventions to build and improve sustainable livelihoods in the Himalaya. Issues of social, capital, livelihood revival and natural resource conservation were discussed in detail.

The workshop also discussed a set of recommendations for Himalayan ecological research that can feed productively into long-term research, conservation and field-level implementation. The workshop was followed by a field trip for the invited participants to the Mussoorie–Dhanolti area where the Jabbarkhet Private Conservation Reserve and Dhanolti Eco-Park were visited. Jabbarkhet is an example of partnership among scientists, NGOs and local residents to conserve a critical watershed near Mussoorie; and Dhanolti Eco-Park is a governmental initiative to conserve high-altitude forests with local support. The success of these initiatives shows that much is possible, when different institutions both governmental and non-governmental, work together.

The workshop highlighted the glaring lack of published data from the Western Himalayan forest ecosystems, particularly related to impacts of climate change, land use change, extractive pressures and infrastructural development. Further there is little long-term data on vegetation that can help uncover dynamics with respect to the disturbances or faunal study that measures rates of extinction from the area. Forest restoration and conservation are areas in need of urgent attention, as most of the hands-on restoration work lacks documentation and the impacts of the work carried out so far is little understood. Above all, given the immense biodiversity in the Western Himalaya and the diversity of people dependent on it, it has become essential to document and understand people–nature relationships in much greater detail. There is also scope for synergy across different conservation objectives: for instance, convergence of biodiversity conservation and hydrological restoration can give rise to effective ameliorative strategies.

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MEETING REPORT

Insects related to veterinary and fisheries sciences*

Arthropod-related disorders cause significant health problems to humans, domestic animals and wildlife. In addition to causing direct damage by feeding, they act as vectors in transmitting diseases. In India, knowledge being generated on insects of economic importance affecting animals and fishes is limited to veterinary and fisheries institutes. In an attempt to take stock of the work done till date in India, identify the gaps and propose a way forward, a brainstorming session was held.

Transmission of pathogens from animals to humans has had impact on human civilization and animal husbandry. Fleas feeding on blood of humans and animals transmit diseases like murine typhus and bubonic plague. Mosquitoes feeding on blood meal of pigs infected with Japanese encephalitis virus, transmit it to humans. Hence controlling of insects that infest animals would aid to improve human health too.

Inaugurating the meeting, S. Ayyappan (Indian Council of Agricultural Research (ICAR)) stressed the need to scale down the economic damage caused by insects in veterinary and fisheries-related activities. He was of the opinion that greater collaboration among veterinarians, fisheries scientists and entomologists is needed in the field of insect systematics and in identifying the newer and safer molecules to be used for managing these pests on animals and fishes. Traditional knowledge also is to be exploited or refined while developing modern pest management techniques.

Introducing the theme, Abraham Verghese (ICAR-National Bureau of Agriculturally Important Insects (ICAR-NBAII)) emphasized the need for an interface among entomologists, veterinarians and medical scientists to churn out comprehensive ideas to solve problems arising due to insects. He mentioned that the focus of the session was to bring together the entomologists, veterinarians and fisheries scientists on a common platform to share their experiences on pests related to veterinary and fisheries.

*A report of the brainstorming session on 'Insects related to Veterinary and Fisheries Sciences', held at the ICAR-National Bureau of Agriculturally Important Insects, Bengaluru on 2 August 2014.

S. Yathiraj (Veterinary College, Bengaluru) shared his concern over the quantum of insecticides used in cattle farms and poultry, their fate in the environment and impact on non-target organisms. He mentioned the allergic reactions caused by insects on animals and the need for developing a technology to address the problem.

Placid E. D'Souza (Veterinary College, Bengaluru) presented an overview of mites, viz. *Holothyrus* sp., *Chorioptes bovis* and *Macrocheles muscadomesticae* that are parasitic on dairy animals and poultry. He suggested the use of nematophagous fungi, egg parasitic fungi and entomopathogenic nematodes for tick control. Chemoecological approach is essential for developing a robust management of insects occurring on animals and fishes. Combining behaviour modifying compounds such as guianine, O-nitrophenol and methyl salycylate with acaricide is an effective method to attract and kill ticks.

Research on ticks in India was detailed by Ghosh (ICAR-Indian Veterinary Research Institute, Izatnagar). Development of resistance to pyrethroids by ticks is a concern. Screening of newer molecules and using them with synergists is an effective insecticide resistance management tool. He informed that mutation in the sodium channel gene is the cause for insecticide resistance in ticks. He mentioned that *AcheZ* gene was not suitable for the study of insecticide resistance to organophosphorous compounds and SII-4-5 region of the Na channel gene is a suitable marker. The need for developing robust resistance monitoring tools, cross protection vaccines, manipulation of endosymbionts, entomopathogenic nematodes and use of botanicals for managing ticks was put forward by him.

K. Subaharan (ICAR-NBAII) presented on overview of insect pests of veterinary significance with reference to India. He mentioned that dipterans in addition to causing damage by feeding on animals, aid in transmission of diseases in cattle. He was of the opinion that, the use of insecticides to ward off dipterans feeding on cattle had varying results considering the duration of exposure to insecticides on the body of the animals. The use of biorationals that possess terpenoids will have a repellent effect on flies landing on the body of cattle. Resilin is essential for initiating jumps in fleas. The concept of identifying a drug to break down resilin was mooted as an effective strategy to manage fleas. Concerns on the impact of antibiotics and insecticides used in veterinary animals on ethology and population dynamics of dung beetles need to be addressed.

P. P. Sengupta (ICAR-National Institute of Veterinary Epidemiology and Disease Informatics (ICAR-NIVEDI), Bengaluru) explained the vectoral role of tabanids in transmitting Trypanosomiasis. This disease occurs in cattle, camel, horses, tigers and pigs. The vectors acquire the pathogen while feeding. The larval and pupal stages occur in moist habitats and the adult tabanids move to cattle yards using long range olfactory cues and short range visual cues. Considering the ethology, traps are to be set up near cattle sheds to trap the flies. The role of *Haemophysalis* in Kyasanur forest disease and *Rhiphicephalus* in causing babesiosis was eloborated by him. He discussed the role played by vectors in transmitting the causal organisms of diseases such as leishmaniasis, blue tongue virus, summer dermatitis and plague.

Divakar Hemadri (ICAR-NIVEDI) listed more than 20 species of *Culicoides* that transmit blue tongue virus. Among them, *C. oxystoma* is a predominat species in India. He pointed out the existing gap in studies related to the systematics and ethology of *Culicoides*. The incidence and spread of blue tongue virus in Karnataka was confined to inland areas near water bodies. High humidity and high temperature is not suitable for the multiplication of *Culicoides* in coastal region. The work done by Indian blue tongue vector network was discussed by him.

More than 40 species of lice associated with poultry responsible for poor health of the birds was listed by M. R. Reddy (ICAR-Directorate of Poultry Research, Hyderabad). He mentioned that *Argas persicus* the soft tick and house fly, *Musca domestica* were of concern in the poultry sector. *Alphitobius diaperinus* (darkling beetle) and *Cimex lectularius* were pests of minor importance.

N. Krishna Kumar (Indian Council of Agricultural Research (ICAR), New Delhi) emphasized the need to identify the commonality in insects related to medical and veterinary sciences. He opined that forensic entomology has a great scope in India to assist in criminal investigations. In the context of biological warfare he felt that it was imperative to understand the vectoral role of insects between humans and animals.

The second technical session on insects related to fisheries was chaired by J. K. Jena (ICAR-National Bureau for Fish Genetic Resources, Lucknow). The static level of knowledge on insects related to fisheries science was put forth by him. He indicated that though insects are considered pestiferous, their beneficial role cannot be overlooked as they could be exploited as feed for fish and poultry.

Vijayagopal (ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi) informed that insects are poised to replace fishmeal in aquatic feeds. Feeding of fish with fish meal is not economically sound as the cost of fishmeal is on the rise. Insects as fish feed are superior to plant protein and are source of animal protein. Dipterans are widely exploited for use as fish feed as the nutritional composition is close to fishmeal and is superior to soymeal in terms of amino acid profile. In India, the suitability of silkworm pupae as fishfeed was demonstrated but it failed to be a commercial success as there is a weak link in the transfer of technology to entrepreneurs. Though insect extracts are good feed substrates, there is concern over the disposal of heavy metals derived from the extracts of insect feed. The possibility of scaling up the use of chironomid larvae as fish feed was discussed.

The role played by isopods like *Joryma hilsae* and *J. sawayah* in causing economic damage to the fishes was briefed by Dinesh Babu (ICAR-CMFRI, Kochi). The crustaceans that are closely related to insects in evolutionary terms colonize the aqautic environments as insects do in the terrestrial environment. He listed the spectrum of species adversely affected by isopods. Isopods kill or impair the immature fishes. He described the entry of isopods into fishes through mouth, gill and anus causing weakness in fish and finally results in mortality. They cause damage to the fishes trapped in nets. R. Jeyakumar (ICAR-CMFRI, Mandapam) informed that more than 23 copepods and 2 isopods infest marine fishes, fingerlings and subadults. He mentioned that treating the infested fishes with fresh water helps to ward off the copepods.

The role of aquatic insects belonging to Coleoptera, Hemiptera and Odonata in causing economic damage to fisheries sector was detailed by N. Sridhar

(ICAR-Central Institute for Freshwater Aquaculture (CIFA), Bengaluru). The scope of using oil and soap emulsion to manage aquatic insects in ponds was detailed but the mobility of aquatic insects poses a threat of reoccurrence.

The ability of crustacean parasites to cause host mortality and morbidity in fresh water aquaculture was highlighted by Hemaprasanth (ICAR-CIFA). The parasitic role of sucking lice, *Argulus* was explained. The need for developing a vaccine to overcome this problem was suggested. Crustaceans are currently controlled by applying organophosphates, pyrethroids and carbamates. The need to identify bioagents and endosymbionts associated with crustaceans was put forth during the discussion.

Bhaskaran (ICAR-Central Institute of Fisheries Technology, Kochi) explained the role of *Chrysomya* causing damage to fishes during processing. Damage by this insect is curtailed using vegetable oil as repellent. Plant extracts from fenugreek are effective in repelling the pest but has adverse effect on organoleptic test. Coleopterans infest dried fish and render them unsuitable for consumption. Organophosphates are used to contain stored pests of dried fish. During the discussion it was suggested that post-harvest losses by insects in the fisheries sector need to be identified. Sathyanarayana Sethi (ICAR-CIBA, Chennai) listed the problems caused by *Argulus* and *Lernathropas* and *Myxobloxus* on brackish water aquaculture.

At the end of the session, C. A. Viraktamath (UAS, Bengaluru) summarized the salient features of the meeting.

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Smile with Science: *Interpretation*

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