Welcome to the world of insects!

The editorial by Balaram[1] on 'History and Entomology: Insects and War' had addressed some fascinating aspects of entomology, the neglected science primarily dealing with insects. Insects are generally 'hated' by people, perhaps arising from the fear or contempt of these 'creepy crawlies' right from a young age. Being the biggest competitor for humans with respect to agricultural products, these 'cursed creatures' have gained notoriety. Man has always been at war to eradicate these harmful insects, but they have completely defied these efforts by taking different 'avatars'. At best we can strategize an integrated pest management instead of an eradication programme. Nevertheless, the beneficial insects such as the silk worms, honey bees or lac insects have been extensively exploited by man. Besides, how can we ignore or dislike the colourful and elegant butterflies that move around in our own garden areas and open spaces so fearlessly?

Yet another use of insects related to defence purposes, not covered in the editorial[1], is the application of spider silk for making bullet-proof vests. Some species of wild spiders (though loosely grouped with insects), produce a silk fibre that is the toughest fibre known to man, comparable to the high-grade alloy steel but only a sixth of its density. The best example is the dragline fibre produced by the Malagasy spider, known as Darwin's bark spider (*Caerostris darwini*), whose toughness averages 350 MJ/m^3. The gold standard, a little less strong, comes from the typical orb-weaving spider, *Nephilia clavipes*. The spiders themselves produce silk fibre for various purposes, ranging from catching preys to mating or protection of their eggs. The elastic properties of some of these fibres are amazing in that they protect the spiders while they jump down great heights. Partially successful efforts to express these silk proteins in alternate hosts through recombinant DNA approach have been documented in the literature. These fibres may be made commercially available by this means in the near future.

The editorial[1] also does not mention much about the fruit flies (*Drosophila*) or the mosquitoes. *Drosophila* has been the Cinderella of genetics. Most of our current understanding of developmental biology is derived from using *Drosophila* as the model. The entire concept of the operation of a 'hierarchy' in gene expression for laying out the body plan or the patterning of the internal as well as external appendages during development has been originally derived from the fruit flies. *Drosophila* continues to be a favourite tool for experimental biologists and geneticists.

Likewise, the extensive studies on mosquitoes, the different species of which are responsible for transmission of deadly diseases ranging from malaria to dengue fever, chikungunya or Japanese encephalitis, to name a few, are too significant to be ignored. Mosquitoes, as carriers of such deadly viral diseases, have attracted the attention of concerned scientists in developing tools for biological warfare.

To a great extent, in India, the emphasis in the modern biology research has been directed to the infectious diseases, and rightly so, because our country has the dubious distinction of harbouring the largest number of patients suffering from infectious diseases than anywhere else in the world. One wonders, however, whether such molecular studies will solve the problem of infectious diseases. Perhaps much more effective control can be achieved by better public health management, including sanitized water supplies and remedying the environmental problems. Most of the economically and socially advanced countries have accomplished this through such means. Success for combating viral infections (e.g. small pox, polio, measles, etc.) through the vaccine approach is abundantly clear. Bacterial and parasitic infections, by and large, evade vaccine protection. Thus, insect pest control may provide a better scope for the improved health of the nation, both animals and plants. Hence, more research efforts are called for towards understanding the insect systems in general.

1. Balaram, P., *Curr. Sci.*, 2012, **102**, 825–826.

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Insects and our lives

Our intellectual energies are generally spent in three basic areas of activity: surviving, using practical learning (application of technology); seeking pure knowledge through inductive mental processes (pursuit of science) and pursuing enlightenment to taste a pleasure by aesthetic exercises (humanities). Entomology has long been concerned with survival and pursuit of science, but little attention has been paid to investigate or address the influence of insects in our history and culture. The editorial 'History and entomology: insects and war'[1] has fulfilled this need by bringing out the relationship between history and entomology. Unfortunately, the two absolutely unrelated subjects, with little interest to a vast majority of students chasing a career in technology or more precisely 'information technology', have shaped and influenced human history and culture very strongly. As a conspicuous part of our environment, insects have captured our imaginations and become incorporated into our thinking from very early times. The ancient Egyptians revered various insects, in particular, several species of dung scarab beetles. The Japanese have a highly developed tradition of aesthetic appreciation for insects reflected in their art and literature, as also the Chinese, who hold the singing crickets in very high esteem. Insects have influenced human history by forcing shifts in pivotal events – battles have been lost (Napolean in Russia due to typhus), the direction of the march of civilization determined (Chinese Empire and silk trade) and populations decimated through the direct involvement of insects, usually as carriers of disease (plague in Europe in the 14th century). The work and life of scientists have been cut short due to insects, as is evidenced by the likely cause of death of Charles Darwin, who contracted Chagas disease after being bitten by the reduviid 'kissing' bug during his *HMS Beagle* voyage to Chile in 1835 (ref. 2).

There are anecdotes of a number of ways in which insects have crept into our lives. A moth is supposed to have prevented an accident of a train on which Queen Victoria was riding. The moth was attracted to the head light of the train and in the fog the flapping wings of the moth looked like the image of a man flagging the train to stop. The driver jammed the brakes and later found that the bridge ahead had collapsed; thus an accident was averted by the moth. The Chinese inventor of paper Ts'ai Lun (AD 89–106) is believed to have been shown the process by wasps making their nests by chewing tree bark and mixing it with their saliva. 'Butterflies in my stomach' is a common expression to convey anxiety, fear, nervousness about a forthcoming activity and the feeling very aptly describes what it must feel like to actually have real butterflies in your stomach, fluttering and sitting on your stomach walls.

Almost no aspect of our culture and history is untouched by these creatures. In spite of a hard exoskeleton, extra appendages and robot-like instincts, insects sufficiently parallel humans in structure and behaviour to serve as models in various human activities. A good example is the navigational and cognitive capacities of ants and honey bees with brains weighing just a few milligrams, which are lessons for us in traffic regulation and management and for solving the problem of a 'travelling salesman' for the most efficient itinerary to visit different locations. There is a dire need to explore our classics, history, culture, music, religion, poetry and prose, recreation, museums of art, archaeology, anthropology, psychology, science and technology and all around us for more evidence of insects in our lives. Studies in 'cultural entomology' could be useful in understanding the role of insects in all facets of humanity, and provide an insight into our attitudes towards insects in particular and nature in general[3]. This would vastly help project entomology from being an 'esoteric activity' and 'unglamorous subject of study', to one with myriad exciting possibilities in science and humanities.

1. Balaram, P., *Curr. Sci.*, 2012, **102**, 825–826.
2. Clayton, J., *Nature*, 2010, **465**, S4–S5.
3. Hogue, C. L., *Annu. Rev. Entomol.*, 1987, **32**, 181–199.

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Bt and bollworms: clearing a few clouds

Ranjith *et al.*[1] have recently demonstrated the survival and reproduction of the bollworm *Helicoverpa armigera* on *Bt*-cotton hybrids in India. This work has been discussed in the print and electronic media[2–5] for discovering tolerant insect populations. Opinions were also expressed in this journal[6,7]. The intent of this note is to clarify issues, especially the ones that Ranjith *et al.*[1] had to contend with since its publication.

While demonstrating field survival of the target insect on *Bt*-cotton, the study[1] confirmed that the plants were producing *Bt*-toxin. However, toxin concentration in the plant and inherent tolerance in the insect population remained to be quantified. Therefore, while rationalizing the observed survival, both possibilities exist – reduced toxin concentration and enhanced tolerance. This has been highlighted in some later articles[6,8]. One of the prominent opinions expressed was that the environmental state during the year of study (2009) may have reduced toxin concentration in the plant[6]. To verify this, we looked for deviations in three major climatic elements – temperature, relative humidity and rainfall between 2009 and the respective average values for the preceding 22 years (1986–2008) at Raichur. Figure 1 shows that with the exception of rainfall, the other two factors were near normal for 2009. What is interesting is that rainfall was higher than normal during 2009, and one expects higher moisture to increase toxin concentration in the plants[9,10]. Moreover, plants were subjected to optimum growth conditions under the supervision of the University of Agricultural Sciences (UAS), Raichur. Yet, the pest thrived on *Bt*-cotton.

The effectiveness of *Bt* hybrids decreases when concentration of the toxin significantly varies with factors like environmental states[11]. In this connection, we suggest that regulatory authorities take cognizance of data on the extent of variation in the concentration of *Bt*-toxins against different environmental states for the present and future commercial *Bt*-hybrids. Conditions that may be inappropriate for the expression of the gene should be clearly mentioned for each hybrid. This, on one hand, would assist farmers to take precautionary measures when climatic or other factors vary beyond sensitivity limits of the hybrids. And, on the other, scientists will be able to verify the hypotheses before interpreting insect survival.

Field entomologists, interested in working independently on the efficacy of *Bt*-cotton, find it hard to estimate the extent of resistance in insect populations due to difficulties in obtaining pure toxins in the country. They have to depend on the technology providers for pure toxins, which, sometimes, can impede independence in research. To overcome this, a Government or an independent body may maintain a repository of each gene-toxin, which, upon request, may be made available to any researcher. A similar repository is maintained in China by the Chinese Academy of Agricultural Sciences[12].