Butterflies as Indicator of Climate Change

Farkhanda Manzoor[1], Hasan Bin Sadat[2] and Hina[1]

Butterflies are often used to study the effects of climate change because of their sensitivity to climatic variables. Temperature strongly affects butterflies throughout their life histories. Direct or indirect effects of temperature have been observed in choice of oviposition sites, egg-laying rates, larval development and survival rates, and range shifts and expansions (Davies *et al.* 2006). Precipitation influences larval development and survival by controlling host plant phenology (Rodriguez *et al.*1994). Individual host plants are usually the sole source of food for prediapause larvae because inter-plant distances often exceed larval dispersal ranges (Weiss 1993). Larvae are unable to travel far to locate a new host if their natal plant becomes defoliated or senescent (Hayes 1985). If a host plant senesces before larvae reach diapause, the larvae starve unless they find another suitable plant.

Use of butterflies as "indicators" is possible because they need three types of vegetation populations for their survival and distribution. This distribution is highly related with the phenological stages of the plants, the three types of plant population categories are larval food plants, nectar plants, and shade plants.

The butterflies use food-plants as egg laying supports. Butterfly species are very selective in plants for their egg laying activities. A female butterfly lays her eggs only on a single plant on which its larva can develop by feeding on it, mainly by feeding on the leaves. These plants are so termed as food plants. Most butterflies can utilize a wide variety of flowers, including those of many cultivated varieties, as nectar sources. However, a more critical need is for the plants that provide food for the larval (caterpillar) stages, and most species will accept only one or a few species of plants at this stage.

Although the caterpillars feed on the leaves of these plants, the damage is usually minor and only temporary. It is estimated by experiments that rather doing damage to the food-plants at the developmental stages, the butterfly adults do more benefit to the host plants by pollinating and gene-flowing activities leading to population increase of the plants. Caterpillars of some species feed on plants that are usually considered weeds.

Butterfly habitats are easily defined and delineated because the larval stage is highly dependent upon host plants. As adults, most butterflies are generalists and can find food in the form of nectar, rotting fruit, and sap, however, larvae are usually specialist feeders and some require a specific host plant. Since larvae are closely tied to their host as their food source, the plant's distribution defines the potential distribution of the butterfly. This distribution is further limited by climatic factors such as temperature (Crozier 2004). Therefore impact of climate change on these plants can cause threat to butterflies.

Butterflies are sensitive to climate change, understanding their responses to climate change, especially through interactions with host plants, will aid in forecasting how other species will respond.

Climate change effect every living creature on planet, however the extent and degree of its impact vary from species to species. Some species are benefited with this change and some are damaged.

To understand how climate change threats biodiversity let us study some examples. In the mountain forests of Central America, strikingly colored Harlequin frogs (Atelopus sp.) were the first charismatic conspicuous vertebrates to succumb to global warming. Sixty-seven percent of 110 endemic species have become extinct in just two decades. (Pounds *et al*. 2006)

In United Kingdom several species of birds arrived earlier than they did in pre-warming times. Spring first-time migratory arrivals advanced an average of 1.3 to 4.4 days per decade and subsequent breeding activities too were hastened by an average of 1.9 to 4.8 days per decade over a time frame of 30-60 years (Walther *et al*. 2002). Northward shifts in bird species ranges occurred as predicted. Twelve species of U.K. birds have shifted their ranges by an average of 18.9 km over the past two decades, even after controlling for overall population expansions (Thomas *et al.* 2004).

Still much remains uncertain about the nature and magnitude of biotic impacts of climate change. The effects of climate change on biodiversity are expected to have large regional variation, particularly in areas vulnerable to biotic exchange (Sala *et al.* 2000). Additionally, the interactive effects of climate change combined with other drivers, such as habitat destruction, altering land use practices, and pollution on biodiversity are overwhelming (Sala *et al.* 2006).

One-fifth of all plant species on land face annihilation in the next 20 years. A disappearing plant can take with it 10-30 dependent species such as insects, higher animals and even other plants (Balaji 2010).

Butterflies are regarded as symbols of beauty and grace and have been studied since 18th Century. Their marvelous colours, shapes and graceful flight give pleasure to everyone. Of the 1.4 million species on earth, over 53% are insects, 19,238 species have documented worldwide by 1998 (Heppner 1998). Among the insects butterflies are the most taxonomically studied groups, and have attained reasonable attention worldwide (Ghazoul 2002). Research studies have proved that many of butterflies' species are seasonal and prefer a particular habitat (Kunte 1997).

It has already been found from the scientific experiments that, by using butterflies as indicators, increase of species richness and species assemblage have been augmented to 47% in a wild state. This wild state has been used as the healthy habitat for all kinds of animals. (Bashar 2010).

[1]Department of Zoology, Lahore College For Women University, Lahore
[2]Department of Environment Science, Punjab University, Lahore.

To date, only a small fraction of the forecasted climate changes and resultant biotic impacts have been observed, but many effects are clear already (Walther *et al.* 2002). Warmer temperatures have advanced the phenologies of plants, birds, and squirrels (Davies *et al.* 2005) and shifted butterfly and bird ranges toward the poles (Peterson *et al.* 2004). Climate change has caused extinction of butterfly populations (McLaughlin *et al.* 2002) and loss of habitats (Wilson *et al.* 2005).

With a relatively short life-cycle and host-plant reliance, butterfly communities show quick impact to climate change and can act as an early warning of portending shifts in the surrounding flora and fauna (Batra 2005).

There have been very few researches to study impact of climate change on butterfly biodiversity. There are some studies to forecast climate changes via butterfly diversity. Most of work has been done in Europe so mostly we will be observing examples from Europe.

In United Kingdom with earlier onset of warm temperatures in spring, many organisms advanced spring life history activities significantly earlier than before. Eighteen butterfly species advanced their spring appearance dates by 2.8-3.2 days per decade over the past 23 years (Walther *et al.* 2002).

Climate change is already having an impact on butterflies. Over 60 mobile species with widespread food-plants are known to have spread north in Europe over recent decades, including the Comma *Polygonia c-album*, which is spreading north in the UK at 10km per year. Other species have moved further up mountains. The Atlas shows for the first time how the majority of European butterflies might respond to climate change. Most species will have to shift their distribution radically to keep pace with the changes (Settele *et al* 2009).

Butterflies and birds were not able to withstand and keep pace with present climate change patterns and fluctuations. Compared with twenty years ago, butterflies are now 135 kilometers behind the shifting climate zones and birds more than 200 kilometers (Vincent *et al*.2012).

Several butterfly species have shown marked northward shifts in ranges in association with northward warming. For thirty-eight species (in Europe and North America), the shift in range has been up to 200 km over a span of 27 years (Parmesan 2003). Such poleward shifts in distributions have been reported for a wide variety of taxonomic groups (Hickling *et al*. 2006).

Healthy presence of butterflies ensures the healthy status of a forest ecosystem. Butterflies have got reciprocal relations with the related plants. Because of that, they are distributed at all heights in the forest areas. The butterflies have got access to the plants of all heights at equal frequency. Some of these plants are dependent on the butterflies for their pollination and gene-flow activities.

The evidence has mounted from the plant kingdom as well. Flowering and leafing among several European plant species has occurred earlier in the year by an average of 1.4-3.1 days per decade in a study covering a time period of 30- 48 years (Walther *et al*. 2002). Tree line on mountain slopes has moved up significantly. Alpine plants too have displayed this trend. Some species have shifted upwards in elevational distribution by an average of 1-4 m per decade (Walther et al. 2002). Even lichens (in Netherlands) have shown long term responses to global warming (Parmesan & Yohe 2003).

It is revealed that, in the day time the butterflies take rest during afternoon 1:30 pm to 3.30-4.30 pm. The resting is not seen to occur on nectar plants or food plants. They take rest under or on the leaves of hedges under a big shade tree. During this resting time butterflies do not move and do not feed on anything, but resting place need to be with high humidity and temperature comfortable for them. Compared to the density of nectar plants and food plants area, the shade/resting plant area must be more dense and with assemblage of high species composition. This means that species-richness of the plants (either related or not related to the butterflies) needs to be very high (Bashar 2010).

Life cycle changes in the butterflies are deeply related with phenology of the host plants and other related plants. Butterfly wings and its entire body is covered with billions of dust particles which are capable of absorbing quantum of light coming from the solar system and the photons received by the dust particles produce (by prismic system) the beautiful colorations on the genetically characteristic basis for each of the species differently. At the same time, these (arrangements of dust particles on the body) are very much sensitive to the climatic changes i.e. the changes in photoperiodism and thermoperiodism of the habitat where they are living (Bashar 2010).

The Edith's Checkerspot Butterfly (*Euphydryas editha*) of western United States has also shown such an expansion. The species has been reported to have experienced a 124 m upward elevational and a 92 km northward shift since the beginning of the 20th century (Parmesan *et al*. 1999). More populations of this species have become extinct in southern latitudinal bands than in northern latitudinal bands.

In Bangladesh Environmental Biology and Biodiversity Laboratory (EBBL), University of Dhaka has been conducting research on the butterfly conservation and conservation of forest biodiversity. They studied that the most affected areas are under the Cox's Bazar forest region. In the study on the Fashiakhali forest it was revealed that the largest butterfly "bird wing" (*Troides* spp.) were the most burning victim of the climate change. From 1999 to 2003 representative of the largest butterfly in the forest was found decreasing and from the year 2004 no trace of the "birdwing" in the forest was found. Reasons were accumulated in the EBBL lab. The plants on which the "birdwings" depend (special vine: climbers) were very sensitive to climate change and human interference their phenological changes had occurred drastically and the dependent butterfly could not survive (Bashar 2010).

In Australia in a study they found that over a 65 year period, the mean emergence date for adults of the Common Brown butterfly (*Heteronympha merope*) has shifted 1.6 days earlier per decade in Melbourne, Australia. The findings are unique because the early emergence is causally linked with a simultaneous increase in air temperatures around Melbourne of approximately 0.14°C per decade, and this warming is shown to be human-induced (anthropogenic). Dr. Michael Kearney from University of Melbourne says the

findings could help our ability to forecast future impacts of climate change on biodiversity.

"Shifts in these seasonal life cycle events represent a challenge to species, altering the food and competition present at the time of hatching. Studies such as ours will allow better forecasting of these shifts and help us understand more about their consequences," (Sands and New 2002).

Pakistan is blessed with Nature in having unique landscape, high mountains, plateau, plains, deserts and sunny beaches. In North it has high coniferous forests which are home to many exotic plant and animal species. Habitat deterioration, degradation and fragmentation as a result of deforestation, climate change and change of land use has led to the decline of several butterfly populations in Pakistan, and many species believed to be common during the early part of the 20th Century have now become endangered in much of their range. This decline in species populations, is an indication of the ongoing global environmental crisis, and if not checked will perhaps reach a point where downward trends could no longer be reversed. Butterflies act as important indicators of environmental health and the 'ecosystem services' provided by *Lepidoptera*, the group of butterflies and moths, are immense. However a contemporary discourse regarding butterfly conservation and their importance is lacking amongst the public, so there is dire need to conduct research on this important aspect of Environment.

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