

## Influence of abiotic factors, causing changes in natural population of butterflies, with particular reference to climate changes, food habits and habitat in Gir Protected Areas of Gujarat

Syed Irfan Ahmed<sup>\*1</sup>, Anchal Sharma<sup>2</sup>, Hina Anjum<sup>1</sup>, Mohammed Sadique<sup>1</sup>, Sunita Rani<sup>1</sup>

1 Department of Zoology, Aligarh Muslim University, Aligarh-202002.

2 Arid Forest Research Institute, Jodhpur- 342005.

E-mail : Syedirfan\_ahmed@yahoo.co.in

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### Abstract

A maximum of 4693 individuals belonging to all the four families of butterflies were collected during the months September to November when the temperature and relative humidity ranged from 27°C to 34°C and 63 to 84 % respectively from Gir Protected Area of Gujarat during two continuous years. Whereas, a minimum count of 1448 individuals belonging to all these four families were noticed during March to May when the temperature and relative humidity ranged from 34°C to 36°C and 42 to 65 % respectively. This fact established that the most favourable and suitable condition of abiotic factors for population build up prevails during September to November when there is a availability of optimum environmental conditions which are required for better growth and development of butterfly species available in the vicinity of the GPA. The study revealed that almost all the butterfly species exhibited their feeding preference towards nectar of their food plants and for that they frequently visit the flowers several times during morning and afternoon times. The butterflies of almost all the families (Pieridae, Papilionidae, Nymphalidae etc.) having their food preference towards different food sources, along-with the nectar of flowers. Mud-puddling behaviour of different species of butterflies and their feeding on various other food sources like animal dung and rotten fruits gives more feeding opportunities and reduces inter and intra-specific competition between them.

Key words : Abiotic factors, population fluctuations, climate change, mud puddling.

### INTRODUCTION

Gujarat is located between 20°01' to 24°07' North latitudes and 68°04' to 74°04' East longitude, and covers an area of 195,984 sq. kms. The climatic conditions of Gujarat are mostly dry, and even deserted in the north-west. Whereas, Gir Protected Area (GPA) is the largest compact tract of dry deciduous forest, situated between 20° 40' N to 21° 50' N and 70° 50' N and 70° 50' E to 71° 15' E. It stretches over a length of about 70 kms from west to east and 40 kms from north to south. The total area of the forests is 1882.6 sq.kms out of which 1412.1 sq.kms has been constituted as Gir Sanctuary and National park (Protected Area). Gir Protected Area (GPA) is synonymous with the majestic 'Asiatic Lion', *Panthera leo persica*, only gene pool in the world.

An index to measure the effects of temperature change relating to feeding and nutrition on tropic interactions<sup>[1]</sup>, wherein the seasonal effects of weather and change in climatic conditions directly lead to modifications in dispersal and development of various species of butterfly species. The changes in surrounding temperature regimes certainly involve alterations in development rates, voltinism and survival of insects and subsequently act upon size and density of populations, as well as on the extent of host plant exploitation. The direct effects of climate change on insect herbivores is identified as the dominant abiotic factor directly affecting herbivorous<sup>[2]</sup>. Climate change is likely to involve a higher frequency of abiotic disturbance. Depending on the dimension of the disturbance, local to regional dynamics of butterfly populations. These alteration and gradual changes might affect the population dynamics parameters like development and reproduction, diapause and winter mortality and flight and dispersal. Climate and habitat change directly influenced the butterfly populations distributions of butterfly populations<sup>[3]</sup>. The dual forces of habitat modification and climate change are likely to cause specialists to decline, leaving biological communities

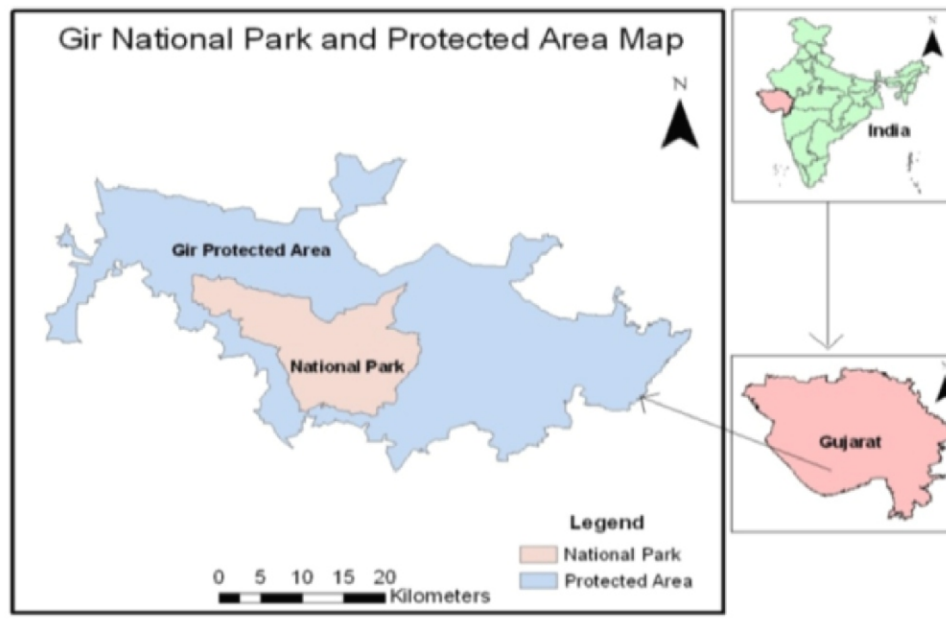
with reduced numbers of species and dominated by mobile and widespread habitat generalists.

Temperature and relative humidity are the key driving forces which may affect feeding, metabolism, and developmental rates of insects. Global climatic changes may lead to large variations in temperatures and humidity which strongly affect other underlying moisture content of the environment directly regulates the insect population and its effects are strongly modified by temperature. Insects survive in optimal range of moisture and temperature<sup>[3]</sup>. Mortality may occur only under extreme conditions of moisture which are unsuitable for the active stages of many insect species<sup>[4]</sup>. Perusal of literature reveals that no consolidated account is available on the Lepidoptera fauna of Gir Protected Area. But the information has been provided on the lepidopter of india<sup>[5,6,7,8,9,10,11,12,13,14,15,16,17]</sup>. Therefore, the present study makes a modest attempt to explore influence of abiotic factors which may cause spectacular changes in natural population of butterflies, with particular reference to climate changes, food habits and habitat in Gir Protected Areas of Gujarat.

### MATERIAL AND METHODS

**Study-sites:** The study- sites were selected in GPA and observations on assessment of host range of various species of butterflies were recorded in 10 selected study- sites which include S1. Dudhala S2. Devalia S3. kamleshwar S4. Barwania S5. Janwadala S6. Chhodavadi S7. Banej S8. Ghodavadi S9. Raval Dam and S10. Jasadhar in Gir Protected Areas, which is located in the Saurashtra peninsula of Gujarat India (20° 40' N to 21° 50' N and 70° 50' E to 71° 15' E) extended upto 1412.1 Sq. kms. The original biome in the area was very dry teak forest which falls under the type 5A/Cla.

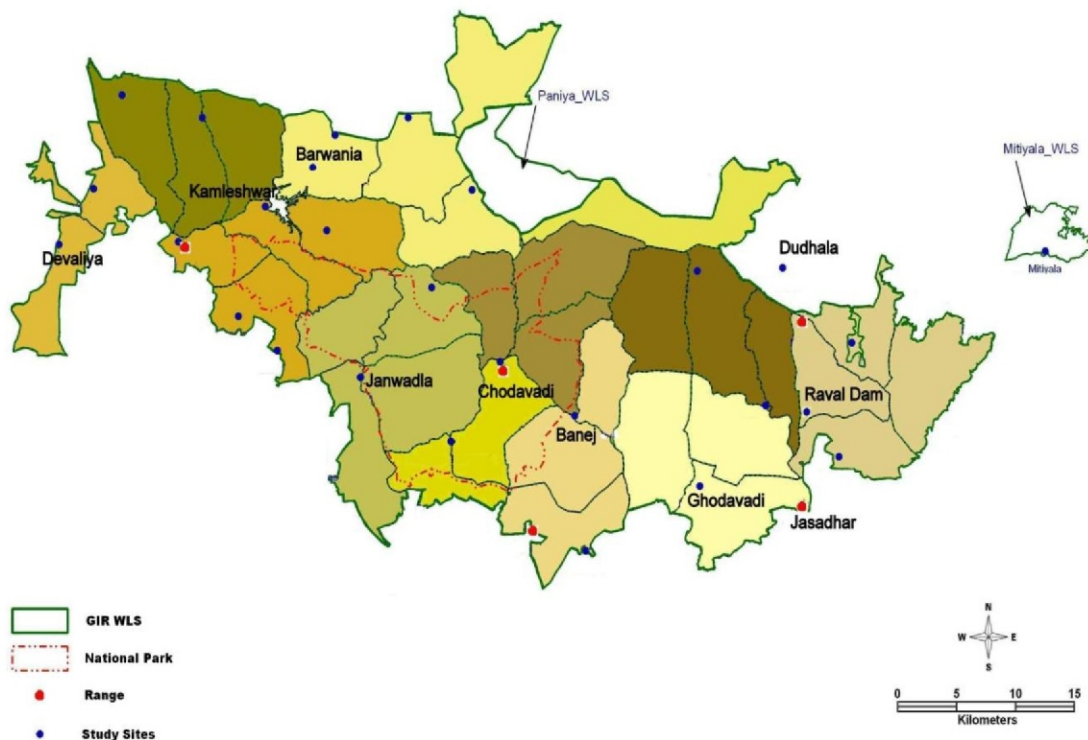
Constitution of the above study sites contained Teak forest mixed with dry deciduous species. The flora of Gir forest



published by the FRI in 1955 is comprised 403 species of plants which was updated later to 606 species by some later identification<sup>(18)</sup>.

The survey was conducted during two continuous years *i.e.*, 2011 and 2012 following the 'Pollard Walk' methodology by using fixed transects in order to enumerate the butterfly species in ten different habitats of Gir PAs<sup>[19,20,21,22,23,24,25,26]</sup>. Existing patrolling paths were used as transects for surveys.

The data on the different abiotic factors such as temperature and relative humidity of Gir Protected Area was obtained from the Meteorological Department, Veraval, Gujarat. The data, thus, obtained was subjected to further analysis so as to determine the impact of such factors on the natural population of butterflies recorded from GPA. The data on the fluctuation of butterfly population was collected monthly from the selected study-sites at randomly and by visual counts of various species of butterflies.



Ten selected study-sites in GPA

**Table 1:** Influence of the abiotic factors on the population fluctuation of different species of butterflies in GPA during different months

Months	Temperature Range (°C)	Relative Humidity (%)	Percentage of Species (%)	Percentage of individuals (%)
Sep- Nov	27-34	63-84	96	47.50
Dec- Feb	26-29	35-84	97	22.40
Mar- May	34-36	40- 65	91	14.66
June- Aug	30-32	57-84	94	15.41

## RESULTS

A total of 67 species of butterflies were recorded, identified and grouped under 4 different families. 23 species of family Nymphalidae, 22 species of family Pieridae, 16 species of family Lycaenidae and only 6 species of family belonging to family Papilionidae were recorded throughout the study period in GPA. A maximum of 4693 individuals belonging to all the four families (Papilionidae, Pieridae, Nymphalidae, Lycaenidae) were recorded during the months August to October when the temperature and relative humidity ranged from 27°C to 34°C and 63 to 84 % respectively, whereas a minimum count of 1448 individuals belonging to all these four families were noticed during February to April when the temperature and relative humidity ranged from 34° C to 36° C and 42 to 65 % respectively. This fact reveals that the most favourable and suitable condition of abiotic factors prevails during September to November when there is a optimum environmental condition required for better growth and development of butterfly species available in the vicinity of the GPA.

An average maximum number of 575 individuals of *Eurema hecabe* (Pieridae) followed by 390 individuals of *Junonia almana* (Nymphalidae) , 172 individuals of *Zizeera lysimon* (Lycaenidae) and 86 number of individuals of *Papilio demoleus* (Papilionidae) were recorded during 2011-2012 in GPA.

The data, collected on the availability and presence of different species of butterflies during different months and seasons, revealed that a maximum percentage of species, as being 97%, has been recorded during December to February when the temperature and humidity conditions ranged from 26 to 29° C and 35- 84% respectively. Whereas, the presence of minimum percentage (91%) of all the species belonging to various families were observed during March to May, when the temperature and relative humidity ranged from 30° C to 36° C and 40 to 84% respectively during two continuous years.

The above finding has suggested that increase in temperature and decrease in humidity during February to April reduces the population of butterflies, whereas decrease in temperature and increase in relative humidity positively affects the increase in relative abundance in populations of various species of butterflies in Gir Protected Areas.

The findings obtained and presented in the above Table reveals that the individual counts of the species belonging to the family Papilionidae (*Graphium nomius*, and *Faegana sp.*) were completely absent during the months from Sep to Nov, whereas individuals belonging to family Nymphalidae i.e., *Ariadne ariadne* , was absolutely absent during the months from Dec to Feb. Furthermore, individual counts of 5 species such as *Tarucus therophrastus*, *Charaxes solon*, *Mycalesis spp.*, *Ariadne*

*merione*, *Graphium nomius*, belonging to different families, were not encountered or observed during the months from March to May, likewise individuals of 3 species such *Faegana sp* (indet.), *Ariadne ariadne* and *Graphium nomius* were not observed during the months from June to Aug when the temperature and relative humidity ranged from 30° C to 36° C and 40 to 84% respectively in both the years.

### Influence of the food habits on the population fluctuation:

Adult butterflies of few species such as *Catopsilia pomona* were observed to visit a wide variety of food substrates, but with the exception of flower visitation, they used to feed on number of food, nutrient and mineral sources such as, animal dung, rotten fruits, mud puddling etc. During the present study, it has been observed that almost all the butterfly species exhibited their feeding preference towards nectar of their food plants and for that they frequently visit the flowers several times during morning and afternoon times. But at the same time, many other butterflies of the same as well as different species were seen feeding on animal dung of chital, *Axis axis*, nilgai, *Boselaphus tragocamelus* etc. Such activity and behaviour of butterflies was also seen as one of the most common behaviour in many species present in GPA. Mud puddling behaviour near to the river with shallow water has also been seen in almost all the species of Pieridae. A detail account of the number of genera and the number of species feeding on the different nutrient source has been providing in the following table.

It has been observed that maximum number of species (40) and genera (25) were found feeding on the nectar food source of flowers belonging to different families of butterflies. These all species belong to mainly family Nymphalidae (*Hypolimnys missipus*, *Junonia almana*, *J. hierta*, *J. orithiya* , *J. lemonias*, *Phalanta phalantha* etc.), Pieridae (*Eurema hecabe*, *E. laeta*, *E. brigitta*, *Delias*, *eucharis*, *Catopsilia pyranthe*, *C. crocale*, *C. pomana*, *Colotis danae*, *C. eucharis*, *C. etrida*, Lycaenidae (*Catochrysops strabo*, *Leptotes plinius*, *Castalius rosimon*, *Tarucus nara*, *Curetis thetis*) and Pailionidae (*Papilio polytes* and *P. demoleus*), but almost all these species were also exhibiting mud puddling behaviour (35 species) with special emphasis to a few species belonging to 15 different genera such as *Eurema*, *Catopsilia*, *Anaphaeis*, *Euthalia*, *Junonia*, *Phalantha*, *Graphium*, *Papilio*, *Tarucus*, *Colotis*, *Euchrysops*, *Zizeera* , *Castalius*, *Catochysops* and *Spindasis*. Nevertheless, a few individuals belonging to two species, *Taucus nara* and *Spindasis ictis* were also seen feeding on the rotten fruits whereas 3 species of Pieridae belonging to genus *Eurema* and *Catopsilia* were found feeding on animal dung. Some butterflies such as *Tarucus nara* and *Spindasis vulcanus* were recorded on the rotten fruits of *Zizypus* species but at the same time a few individuals of the same species were exhibiting the mud puddling behaviour.

## DISCUSSION

The term global change embraces a range of natural and anthropogenic environmental changes in the population of butterflies. According to Intergovernmental Panel on Climate Change, it is defined as “Change in climate over time, either due to natural variability or as a result of human activity”<sup>[27]</sup>. The global mean surface temperature is predicted to increase by 1.4 to 5.8°C from 1990 to 2100. If temperatures rise by about 2°C over

the next 100 years, negative effects of global warming would begin to extend to most regions of the world<sup>[27]</sup>. These may arise not only as a result of direct effects on the distribution and abundance of populations in butterflies but also indirect effects on the host plants, competitors and natural enemies<sup>[28]</sup>. Keeping these facts in view the topic is discussed the influence of factors causing changes in natural populations of butterflies in Gir Protected Area (GPA) in Gujarat with particular reference to

**Table 2:** Availability of 66 species of butterflies under different 4 families in different months in GPA

S. No.	Butterfly species	Aug- Oct	Nov- Jan	Feb -April	May- July
<b>Family</b>	<b>Papilionidae</b>				
1.	<i>Papilio polytes</i>	+	+	+	+
2.	<i>Papilio demoleus</i>	+	+	+	+
3.	<i>Pachilioptia aristolochiae</i>	+	+	+	+
4.	<i>Pachilioptia hector</i>	+	+	+	+
5.	<i>Graphium Agamemnon</i>	+	+	+	+
6.	<i>Graphium nomius</i>	-	+	-	-
<b>Family</b>	<b>Nymphalidae</b>				
1.	<i>Danaus chrysippus</i>	+	+	+	+
2.	<i>Danaus genutia</i>	+	+	+	+
3.	<i>Euploea core</i>	+	+	+	+
4.	<i>Hypolimnas missipus</i>	+	+	+	+
5.	<i>Hypolimnas bolinia</i>	+	+	+	+
6.	<i>Junonia orithiya</i>	+	+	+	+
7.	<i>Junonia lemonias</i>	+	+	+	+
8.	<i>Junonia hierta</i>	+	+	+	+
9.	<i>Junonia iphita</i>	+	+	+	+
10.	<i>Junonia almana</i>	+	+	+	+
11.	<i>Acraea violae</i>	+	+	+	+
12.	<i>Ariadne ariadne</i>	+	-	+	-
13.	<i>Ariadne merione</i>	+	+	-	+
14.	<i>Phalanta phalanta</i>	+	+	+	+
15.	<i>Trirumala limniace</i>	+	+	+	+
16.	<i>Cynthia cardui</i>	+	+	+	+
17.	<i>Melanitis leda</i>	+	+	+	+
18.	<i>Melanitis phedima</i>	+	+	+	+
19.	<i>Byblia ilithiya</i>	+	+	+	+
20.	<i>Ypthima asterope</i>	+	+	+	+
21.	<i>Mycalesis spp.indet</i>	+	+	-	+
22.	<i>Euthalia nais</i>	+	+	+	+
23.	<i>Charaxes solon</i>	+	+	-	+



Family	Pieridae				
1.	<i>Delias eucharis</i>	+	+	+	+
2.	<i>Ixias pyrene</i>	+	+	+	+
3.	<i>Ixias marianne</i>	+	+	+	+
4.	<i>Anaphaeis aurota</i>	+	+	+	+
5.	<i>Eurema brigitta</i>	+	+	+	+
6.	<i>Eurema hecabe</i>	+	+	+	+
7.	<i>Eurema laeta</i>	+	+	+	+
8.	<i>Eurema blanda*</i>				
9.	<i>Cepora nerissa</i>	+	+	+	+
10.	<i>Appias libythea</i>	+	+	+	+
11.	<i>Parenonia valeria</i>	+	+	+	+
12.	<i>Catopsilia pomomna</i>	+	+	+	+
13.	<i>Catopsilia pyranthe</i>	+	+	+	+
14.	<i>Catopsilia florella</i>	+	+	+	+
15.	<i>Catopsilia crocale</i>	+	+	+	+
16.	<i>Catopsilia duvivieri</i>	+	+	+	+
17.	<i>Colotis etrida</i>	+	+	+	+
18.	<i>Colotis danae</i>	+	+	+	+
19.	<i>Colotis eucharis</i>	+	+	+	+
20.	<i>Colotis fausta</i>	+	+	+	+
21.	<i>Colias fieldii</i>	+	+	+	+
22.	<i>Colotis amata</i>	+	+	+	+
Family	Lycaenidae				
1.	<i>Tarucus nara</i>	+	+	+	+
2.	<i>Euchrysops cnejus</i>	+	+	+	+
3.	<i>Zizera lysimon</i>	+	+	+	+
4.	<i>Curetis thetis</i>	+	+	+	+
5.	<i>Rapala airbus</i>	+	+	+	+
6.	<i>Callius rosimon</i>	+	+	+	+
7.	<i>Spindasis vulcanus</i>	+	+	+	+
8.	<i>Catochysops strabo</i>	+	+	+	+
9.	<i>Leptotes plinius</i>	+	+	+	+
10.	<i>Lampides boeticus</i>	+	+	+	+
11.	<i>Spindasis ictis</i>	+	+	+	+
12.	<i>Tarucus therophrastus</i>	+	+	-	+
13.	<i>Azanus ubaldus</i>	+	+	+	+
14.	<i>Faegana sp.indet</i>	-	+	+	-
15.	<i>Dendoryx epijarbas</i>	+	+	+	+

**Table 3:** Data of number of different butterfly genera and species feeding on different nutrient source.

Nutrient Source	Number of genera	Number of species
Animal dung	3	6
Rotten fruits	2	2
Flowers	25	40
Puddling	15	35

climate changes, food habits and habitats. The population dynamics is the aspect of population ecology dealing with factors affecting changes in population densities. The seasonal effects of weather and ongoing changes in climatic conditions will directly lead to modifications in dispersal and development of various species of butterflies. The changes in surrounding temperature regimes certainly involve alterations in development rates, voltinism and survival of insects and subsequently act upon size and density of populations, as well as on the extent of host plant exploitation<sup>[1]</sup>.

Climate change can cause major changes to the dynamics of individual butterfly species and to those communities in which they interact. The occurrence of climate changes is evident from increase in global average temperature, changes in the rainfall pattern and extreme climatic events. These seasonal and long term changes would affect the fauna, flora and population dynamics of butterflies in Gir Protected areas. Moreover, the abiotic parameters are also to have direct impact on butterfly population dynamics through modulation of developmental rates, survival, fecundity, voltinism and dispersal. Among the climatic factors, temperature is an important factor. The present study showed that, declined survival rate of some butterfly species in GPA at higher temperature indicates the impacts of rising temperature could do the changes in the pest population dynamics of forest ecosystem. Therefore, climate change would result in changes in the population dynamics of butterflies. Thus, temperature rise plays a vital role in the population dynamics of butterfly species in GPA.

Temperature and relative humidity are the key driving forces which may affect feeding, metabolism, and developmental rates of insects. Global climatic changes may lead to large variations in temperatures and humidity which strongly affect other underlying interactions<sup>[30]</sup>. Moisture content of the environment directly regulates the butterfly population and its effects are strongly modified by temperature. Some of the butterfly species in GPA survive in optimal range of moisture and temperature. Mortality may occur only under extreme conditions of moisture which are unsuitable for the active stages of many insect species<sup>[30]</sup>. Hence, during the present studies, specific observations were recorded in Gir Protected Area in order to work out the influence of factors causing changes in natural populations of butterflies with particular reference to climate changes and food habits. The present findings suggest that the pattern of feeding of various species of butterflies overlap considerably at a same time. The above finding also reveals that the butterflies of almost all the families (Pieridae, Papilionidae, Nymphalidae *etc.*) having their food preference towards different food sources, along with the nectar of flowers. Mud-puddling behaviour of different species of butterflies and their feeding on various other food sources like animal dung and rotten fruits gives more feeding opportunities and reduces inter and intra-specific competition between them.

## CONCLUSION

Maximum individuals of butterflies belonging to four different families were found when the temperature and relative humidity ranged from 27°C to 34°C and 63 to 84 % respectively whereas a minimum counts were noticed when the temperature and relative humidity ranged from 34° C to 36° C and 42 to 65 % respectively in Gir Protected Area of Gujarat. This fact established that the most favourable and suitable condition of abiotic factors for population build up prevails during September to November when there is abundant availability of optimum environmental conditions.

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