Journal of Research in Biology

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Original Research Paper

An International Online Open Access Publication group

Effect of environmental factors on seasonal abundance of a coccid in *Pteris biaurita* L. (Pteridaceae) from Deolo hills, Kalimpong, West bengal.

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ABSTRACT:

Insect – fern interaction is reported as a rare event of phytophagy from Eastern Himalaya. The scale is a host specific opportunistic feeder, feeds exclusively on the abaxial surface of mature pinnae of *Pteris biaurita*. Population density of the scale exhibited significant linear positive correlation with environmental factors (all r > .56, p< 0.05) of the study site. Rain fall, atmospheric temperature and relative humidity have positive influence over seasonal variation in scale density.

Keywords:

Insect- fern interaction, coccid, seasonality, scale density, environmental factors, *Pteris biaurita*.

Article Citation:
Biplab Patra
Effect of environmental factors on seasonal abundance of a coccid in *Pteris biaurita* L. (Pteridaceae) from Deolo hills, Kalimpong, West bengal.
Journal of research in Biology (2011) 7: 550-556

Dates:
Received: 08 Nov 2011 /**Accepted:** 10 Nov 2011 /**Published:** 15 Nov 2011

INTRODUCTION:

Ferns are generally considered as difficult plants for herbivores to exploit (Soo Hoo CF and Fraenkel G. 1964; Kaplanis *et al* 1967; Cooper-Driver GA. 1978, Hendrix SD 1980), although it has been suggested by Auerback and Hendrix 1980, Balick et al. 1978 and Gerson 1979, that this assumption may not be well founded. However, insects feeding on ferns, other than bracken (*Pteridium aquilinum* L. Khun), have received little attention and many aspects of their relationship with the host- plants have yet to be determined. The extensively studied fern *Pteridium aquilinum* (L) Kuhn is known to support a fair population of insect fauna (Lawton JH, 1976; Strong DR and Levin DA, 1979). As ferns do not rely on pollinators, known insect-fern interactions are restricted to herbivory (Kirk AA. 1977; Rowell et al, 1983; Bera S and Ghorai N. 1995; Gilman AV and Cooper-Driver G. 1998; Jensen AS and Holman J. 2000; Patra B, Bera S and Mehltreter K. 2010; Lawton JH and MacGarvin M. 1985;), attraction to foliar nectaries (Lawton JH and Heads PA. 1984; Kopter S. 1992), soral crypsis (Barker, 2005; Patra B et al, 2003), and colonization of ferns by ants (Gomez LD. 1977; Gay H. 1991; Rico-Gray V et al 1998).

Number and abundance of phytophagous insects of a host are spatio-temporally limited (Lawton JH, 1978; Ottosson JG and Anderson JM, 1983). Environmental factors are known to influence the herbivore guilds of a host fern (Hendrix SD, 1980; Bera S and Ghorai N, 1995; Patra B and Bera S, 2007). There may have differences in population densities of herbivores within any given plant population over time due to seasonal and stochastic factors including variability in weather conditions which affects insect and plant growth or plant defenses (Ottosson JG and Anderson JM, 1983). Atmospheric temperature, rain fall and relative humidity have regulatory effect on seasonal abundance and feeding potential of fern feeding insects (Patra B and Bera S, 2007).

The present study reports feeding niche of scale insect (coccid) *Saissetia* (Homoptera: Coccidae) on the fern *Pteris biaurita* L. (Pteridaceae) and the effect of environmental factors on seasonal variation in scale density from Deolo Hills of Kalimpong, Eastern Himalaya. Some questions have been posed below in order to cater the identification of its response with the environment. Does the insect exploit all parts of the fern? Does the insect affect fern of all ages? What sort of damage they do on the host? Does the insect feed on the fern throughout the year? Is there any correlation between population density of the scale and environmental parameters? To answer these questions, we studied the feeding niche of the scale insect on *Pteris biaurita* and ecological aspects as seasonal changes in their abundance along with the variation of environmental factors of the study site.

MATERIALS AND METHODS:

Study site

This study was carried out during January – December 1998 at Deolo hills of Kalimpong (27^0 04' N 88^0 35' E), Eastern Himalaya at elevations 1250 m above mean sea level (AMSL). Five climatic seasons can be recognized within this region viz. winter normally extends from mid November to mid February, spring from end of February to March, summer from April to mid June, rainy from mid June to August, and autumn from September to October. Continuous rain, clouds, fog and mist mark the rainy season. The clean sky and sunny days are frequent in autumn. The summer exhibits a cloudy sky throughout the region with variation in sunlight brightness. The other seasons are moderately cloudy while winter is very cool and frequent snowfall occurs.

Material collection and microscopy

The Scale insects were collected along with a portion of host plant and kept in cellophane bags and labeled properly. Some scales were isolated and kept in small vials (4cm × 5cm) with 70% alcohol and were sent to Zoology Department, West Bengal State University, Barasat, India for identification. For Scanning Electron Microscopy (SEM) the material was prepared following the methods of Trivedi and Bhandari (Trivedi A and Bhandari NN. 1999). Then the material was scanned under scanning electron microscope (S-440, Leica Leo, Cambridge, UK) and photographs were taken by the High Resolution Record Unit (HRRU) through 35mm automatic camera.

Sampling design and Statistical analyses-

Fifty scale infested fronds from 25 individuals of the host fern were randomly sampled at fortnightly intervals from January – December, 1998. Scale density was determined by counting the number of scales occurring per pinna. Finally arithmetic mean was calculated and scale density was expressed as mean. All plants were sampled within a 1 hour period (10.30 – 11.30 hrs) in the 1st and the 4th week of every month to minimize diurnal fluctuations in environmental factors. Average monthly climatological data (rain fall, mean temperature and maximum relative humidity) for the year 1998 of Kalimpong were obtained from meteorological department. Seasonal variation in scale density, average rain fall, mean atmospheric temperature and mean maximum relative humidity were analysed by Student's t-test. Influence of rain fall, temperature and relative humidity on the seasonal variation of scale density was analyzed by regression analysis. Significance of regression coefficient was tested by t-test.

RESULTS AND DISCUSSION:

Host range, feeding site and feeding mode of the scale

The feeding niches of the scale *Saissetia* were found exclusively on the abaxial surface of the mature pinnae and rachises of *Pteris biaurita* (Figure1. a) while the young and green pinnae were remaining uninfested. Both the nymphs as well as the adults were infesting the pinnae and were sucking plant sap by aspiration. Sign of visible damage in the form of chlorotic patches were noticed on the pinnae (Figure1. b). Under SEM the scale showed wart like structures on the dorsum (Figure1.c). Other ferns associated with the host-fern in the study site belonging to the genera *Athyrium nigripes, Pteris quadriaurita, Pteridium aquilinum, Dicranopteris linearis, Polystichum auriculatum etc.* were remain unexploited by the scale.

Figure 1

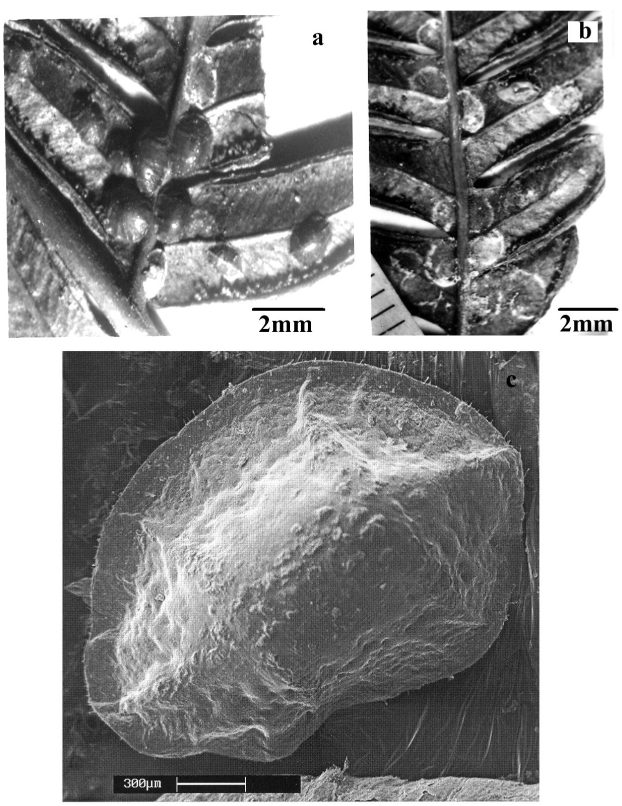

Figure 1. *Pteris biaurita*.
a. Fertile frond infested with scale insect.
b. Necrotic patches on the frond surface.
c. Dorsal view of the scale under SEM.

Environmental variation in the study site

The study site represents a distinct environmental gradient with respect to rain fall, relative humidity and atmospheric temperature through seasons (Table 1). Mean atmospheric temperature exhibited a distinct pattern of variation where winter experienced the lowest temperature (13.28 ºC in January) and then gradually increases through spring, being the highest in summer (24.63 ºC in May) followed by gradual decrease through autumn to winter (Table 1). Monthly average rain fall showed a decreasing trend from rainy season (502.4 mm in July) to autumn (278.6 mm in September) and being the lowest in winter (12.5 mm in December). Pattern of seasonal variation in maximum relative humidity was identical to the pattern followed by rain fall (Table 1). Average rain fall, mean temperature and mean maximum relative humidity were varied significantly through months/ seasons ($t = 3.14$, $p < 0.01$; $t = 18.19$, $p < 0.001$; and $t = 75.66$, $p < 0.001$ respectively).

Pattern of variation in scale density

The scale infested the fern throughout the year but their mean densities varied along with the variation of environmental factors like rainfall, temperature, relative humidity of the study area through seasons (Table 1). Mean densities of scale followed a distinct pattern of seasonal variation where the host fern typically supported higher scale densities in the months of rainy season (18.5, 26 and 21.5 scales per pinna in June, July and August respectively) than did the host- fern in the months of autumn (16 and 11.5 scales/ pinna in September and October) and in the months of winter (8.5, 4.5, 9 and 7.5 scales/ pinna in November, December, January and February respectively) (Table 1). Test of significance indicated highly significant differences in scale densities among months / seasons ($t = 6.25$, $p < 0.001$).

Scale densities and environmental variation

Mean densities of scale showed an increasing pattern from end of summer (May) and reached to pick density (26 and 21.5 scales/ pinna)

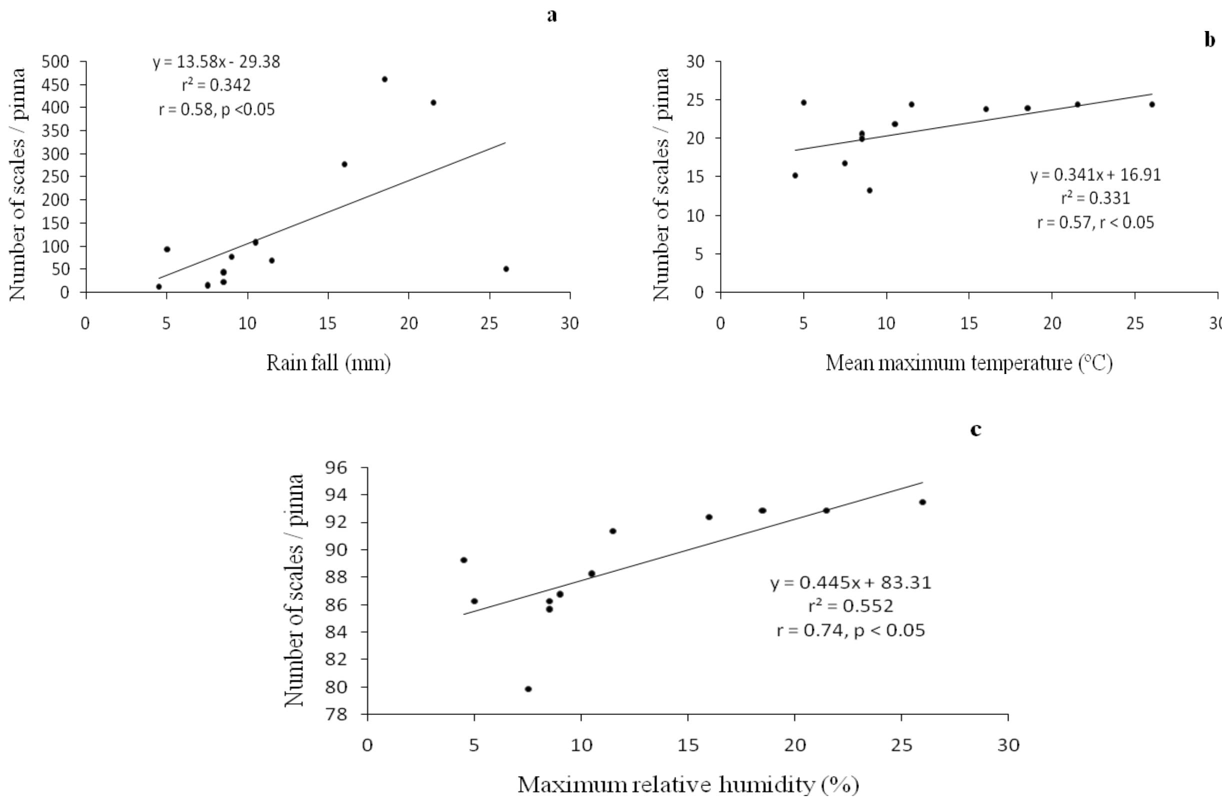

Figure 2. The influence of rain fall (a), temperature (b) and relative humidity (c) on seasonal variation in density of *Saissetia* in *Pteris biaurita* (Dots show the points used for drawing the regression line).

in rainy season (July – August) along with substantial increase in monthly average rainfall and relative humidity. From the end of rainy season scale density decreased through autumn (September - October) to first part of winter (November-December) with the substantial decrease in rainfall, relative humidity and temperature (Table 1).

Monthly variation in mean scale density showed a linear positive correlation with the variation in monthly average rain fall (Figure 2. a, $r = 0.58$, $p< 0.05$, $b = +13.58$), mean maximum temperature (Figure 2. b, $r = 0.57$, $p< 0.05$, $b = + 0.341$) and maximum relative humidity (Figure 2. c, $r = 0.74$, $p < 0.05$, $b = + 0.445$) of the study site through seasons. Such correlation between scale density and environmental factors is significant (all $t = > 2.23$, $p< 0.05$) where 34.2%, 55.2% and 33.1% of the variations in scale density are positively influenced by rain fall ($r^2 = 0.342$), atmospheric temperature ($r^2 = 0.552$) and relative humidity ($r^2 = 0.331$) respectively.

Seasonal variation in herbivores abundance is often ascribed to geographical range and growth form (Lawton JH and Price PW, 1979), nutritional status (Ottosson JG and Anderson JM, 1983), defensive chemical (Lawton JH, 1976) and environmental factors (Ottosson JG and Anderson JM, 1983; Bera S and Ghorai N, 1995; Patra B and Bera S, 2007). In the present study we have demonstrated: 1) Significant seasonal variation in the population density of the scale feeding on *Pteris biaurita*; 2) Significant variation in environmental factors viz. rain fall, atmospheric temperature and relative humidity through seasons. The seasonal pattern displayed by the scale feeding on *Pteris biaurita* can largely be explained by the seasonal variation in rain fall, temperature and relative humidity.

Population densities of scale increased with the corresponding increase of rain fall. This indicates a positive linear correlation between scale density and rain fall and rain fall exerts positive influences on scale density. Such explanation is supported by regression analysis where the positive value of regression co-efficient ($b = 13.58$) indicates that variation in scale densities is influenced by rain fall. So rain fall seems to play a significant individual or synergetic role with other environmental factors and 34.2% of the variations in scale density in *Pteris biaurita* is influenced

Table 1. Mean density of scale per pinna in *Pteris biaurita* and average rain fall, atmospheric temperature and relative humidity at Deolo hills, Kalimpong, Eastern Himalaya, India (January – December 1998).

Month	Density (mean) of scale/ leaflet	Average Rainfall (mm)	Temperature (C^0)			Relative Humidity (%)	
			Max	Mini	Mean	Mini	Max
Jan	9	76.5	18.09	8.48	13.28	55.60	86.76
Feb	7.5	15.2	21.69	11.79	16.74	60.20	79.86
Mar	8.5	43.7	26.98	14.21	20.59	52.68	85.68
Apr	10.5	108.5	27.28	16.43	21.84	55.20	88.26
May	5	92.7	29.06	20.21	24.63	56.28	86.25
Jun	18.5	462.6	26.83	20.98	23.90	54.38	92.85
July	26	502.4	27.20	21.64	24.42	78.29	93.46
Aug	21.5	412.5	27.63	21.14	24.38	85.29	92.86
Sept	16	278.6	27.51	20.08	23.79	60.46	92.37
Oct	11.5	68.7	30.64	18.17	24.40	75.23	91.73
Nov	8.5	22.7	24.88	15.06	19.97	76.25	86.25
Dec	4.5	12.5	19.54	10.80	15.17	62.32	89.23

alone by the changes in rain fall (r^2 =0.342). However, the remaining 65.8% variations can be attributed to other factors. In drawing such conclusion there may have less than 0.1% chances of errors ($t = 14.29$, $p< 0.001$).

Similarly, atmospheric temperature and relative humidity also have positive linear correlation with population density of the scale. Further, positive values of regression co-efficient ($b = 0.341$ for temperature and $b = 0.445$ for relative humidity) indicates that seasonal variation in population density is positively influenced by atmospheric temperature and relative humidity in which 33.1% and 55.2% of the variations in scale density are influenced by temperature (r^2=0.331) and relative humidity (r^2 =0.552) respectively. However, the remaining 66.9% and 44.8% variations in scale density can be attributed to other factors like geographical range and growth form, chemical composition of the host fern and natural predators. In drawing such conclusion there may have less than 5% chances of errors (t =2.24, $p<$ 0.05 and t = 2.4, $p<$ 0.05). At present we are unable to ascertain the effect of all these factors on seasonal variation of scale density. However, it is worth mentioning that the chemical composition of ferns was known to vary seasonally (Ferguson WS and Armitage ER, 1944; Ottosson JG and Anderson JM, 1983) and there were major seasonal changes in foliage chemistry with marked seasonal changes in the insect community of ferns (Lawton JH. 1978; Ottosson JG and Anderson JM. 1983). Therefore, the doctrine of fern herbivores could be that 'environmentally induced changes in the chemistry of ferns could regulate seasonal distribution of their herbivores,' how and to what extent? are yet to be established.

CONCLUSION:

Finally, we can conclude that seasonal variation in scale density of *Pteris biaurita* is a function of variation of environmental factors. Further, the study may provide database to refute the hypothesis that "ferns are a difficult group of plants for insects to exploit".

ACKNOWLEDGEMENTS

The authors are thankful to the Director of Paleontology Division II, Geological Survey of India, Kolkata for providing necessary facilities regarding SEM studies. We also thank Prof. Narayan Ghorai, Department of Zoology, West Bengal State University, Barasat, India for necessary help during identification of the insect.

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