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ORIGINAL ARTICLE

Fecundity Preference of *Pieris brassicae* L. (Lepidoptera: Pieridae) on Different Cole Crops

Arshad Ali

Department of Zoology, Gandhi Faiz-e-Aam (P.G.) College- 2420071, UP, India

Email: drarshadali@yahoo.com

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ABSTRACT

In an experiment, Pieris brassicae *showed significant variations in fecundity and pivotal age of butterfly with respect to different cole crops. The higher fecundity was recorded as 160 eggs in 5 days pivotal age of butterfly on cabbage. The percent reduction in fecundity with respect to cabbage was recorded as 11.86% on cauliflower, 28.13% on gobhi sarson, 33.13% on yellow sarson and 38.13% on Indian mustard. The life table parameters i.e., superior net reproductive rate and inferior length of generation was recorded as 42.13 females/female/generation and 29.85 days on cabbage. As far as rate of development was concerned, the higher intrinsic rate and lower finite rate was observed as 0.1081 and 1.3282 females/female/day on cabbage. The shortest doubling time and highest annual rate of increase of butterfly recorded as 6.41 days and 1.42E+17/annum, when it reared on cabbage. The fecundity of cabbage butterfly showed preference in an order of cabbage (*Brassica oleracea *var.capitata) > cauliflower (*Brassica oleracea *var. botrytis) > gobhi sarson (*Brassica napus *var.neelam) > yellow sarson (*Brassica rapa *var. jhumka) > Indian mustard (*Brassica juncea *var. varuna).*

Key words: *Annual rate of increase, Doubling time, Net reproductive rate, Potential fecundity*

INTRODUCTION

The crops grown in winter season are known as cole crops. It consist several vegetables of family Brassicae, including broccoli, cabbage, cauliflower, collards, rapeseed etc. The nutrient content in cole crops varies considerably. It contains vitamins like vitamin A, vitamin B, vitamin C and vitamin D, and also contains carbohydrates and minerals like Calcium, Phosphorus etc. Cabbage is a major cole crop of India, cultivated in both hills and plain regions (Khalid, 2006). It is annual or biennial polymorphous, glabrous and dicotyledon flowering plant and derived from leafy wild mustard found in mediterranean region around 100 AD. Cabbage is a hardy vegetable, grows in fertile soil and can be harvested any time after formation of head (Ali *et al.*, 2017). Cauliflower is also closely related to cabbage and has a compact head. It is less hardy than cabbage, requires cold and moist climate for satisfactory growth. It is rich in minerals, namely, iron, magnesium, phosphorous etc (Ali and Rizvi, 2007, Iqbal *et al.*, 2014). Besides cabbage, cauliflower, rapeseed-mustard also has commercial importance under oilseeds belonging to cruciferae grown in India. It is most important oilseed crop next to groundnut in the country. These crops are grown both in sub-tropical and tropical part of the country (Rizvi *et al.*, 2009).

The most important factor limiting crop production is the presence of pests especially insects, mites, nematodes and pathogens, cause regular qualitative as well as quantitative losses in diverse ecological conditions. It has been estimated that insect pest alone in different vegetable crops causes more than 40 % of yield loss annually. There are about 38 insect pests, which are known to attack different crops (Pajmon, 1999, Bhati *et al.*, 2015). Among them, *Pieris brassicae* is one of the most destructive pests causing damage at all growing stages such as vegetative, flowering and seedling stage of cabbage, cauliflower and mustard (Sachan and Gangwar, 1980; Lal and Ram, 2004, Khan and Kumar, 2017).

The strategy for insect control in vegetables is necessarily different from other crops because of their nature of utilization. Hence, emphasis must be given to minimize pesticidal load by adopting eco-friendly approaches for insect pest management. Such management initially requires the detailed study on the habits, habitat, life cycle and occurrence of target pests. Therefore, present

experiment designed on the study of fecundity preference of cabbage butterfly *Pieris brassicae* on different cole crops.

MATERIAL AND METHOD

Different cole crops *viz.,* cabbage (*Brassica oleracea* var. capitata), cauliflower (*Brassica oleracea* var. botrytis), gobhi sarson (*Brassica napus* var. neelam), yellow mustard (*Brassica rapa* var. jhumka) and Indian mustard (*Brassica juncea* var. varuna) were raised at experimental field in the Department of Plant Protection, Aligarh Muslim University, Aligarh. The seeds of cabbage and cauliflower were sown initially in seed beds (2 x 1 m) in the month of September. Transplanting of seedling of these crops were done in randomly selected experimental plots (4 x 5 m, replicated thrice) in the month of October with spacing of 15 x 45 cm. In another experiment, seeds of gobhi sarson, Indian mustard and yellow mustard were sown directly in the experimental field of same measurements. All the plants species were monitored regularly so as to find the initial attack of *P. brassicae*. The egg laying of *P. brassicae* commenced on cabbage and cauliflower in the second week of November, and on mustard (Indian, yellow and gobhi sarson) in the last week of November. The female butterfly laid eggs in clusters on lower surface of leaves. They were collected, counted and allowed to hatch on respective crop plants in controlled conditions. After hatching, 100 uniformed zero day age old caterpillars were distributed on each host plant in captivity (covering plant from nylon mesh cages). When caterpillars transformed in to third instar, were distributed individually on cabbage and cauliflower in cage (30 x 30 x 30 cm), however, size of cage for the plant of rapeseed-mustard was 30 x 30 x 50 cm. On account of adult emergence, longevity of male and female were calculated with respect to each crop plant.

To record fecundity, females emerged from cohort of 100 were released in the net on respective crop plant. Moreover, some ornamental plants were also placed in cages as food source of female butterfly. The observations for age specific survival of female and eggs laid were also recorded daily with respective to host crop plant.

After collecting data, fertility table of *P. brassicae* was constructed as per suggestions of Birch (1948) and Southwood (1978) with the following assumptions:

x = Pivotal age of the famale butterfly in days.

I_x = Number of female butterflies alive at the beginning of the age interval x (as fraction of initial population of one).

m_x = Average number of eggs laid per female in each age interval assuming 50:50 sex ratio and computed as:

Besides 'm_x' total number of female off springs in each age interval *i.e.,* female eggs laid in an age interval (x), $I_x.m_x$ was also computed by multiplying the column I_x with m_x. This is also termed as 'Reproductive expectation'.

A number of the parameters were computed from the age specific survival and fertility life-table of female butterfly, it include:

1. POTENTIAL FECUNDITY (Pf):

It expresses the total number of eggs laid by an average female in her life span. It is obtained or calculated by adding up the age specific fecundity column,

$$Pf = \sum m_x$$

2. NET REPRODUCTIVE OR REPLACEMENT RATE (R_o):

This is also referred to as the "carrying capacity" of the average insect under defined environmental conditions. The information on the multiplication rate of a population in one generation is obtained from it. It is denoted as,

$$R_o = I_x\, m_x$$

3. MEAN LENGTH OF GENERATION (T):

It is defined as the mean period between the birth of the parent and the birth of their off springs. This period is a weighed approximate value since the progeny is produced over a period of time and not at a definite time. Calculation followed the method suggested by Dubin and Lotka (1925) as

$$T = \Sigma\, [l_x.m_x.x] \,/\, \Sigma\, [l_x.m_x]$$

4. INTRINSIC RATE OF INCREASE (r):

It is also denoted by 'r' or 'r_m' or 'r_{max}' and called as 'biotic potential'. It is defined as the instantaneous rate of increase of a population in a unit time under a set of ecological conditions (Birch, 1948). A rough estimate of the intrinsic rate of increase (r) can be calculated by using the following equation:

$$r = [\text{Log}_e R_o] / T$$

Where, R_o represents net reproductive rate, which is calculated by multiplying I_x and m_x. *i.e.*, $R_o = l_x.m_x$.

'T' represents mean length of generation. For an accurate estimate of 'r' Birch (1948) introduced some approximation method to minimize the experimental errors in the formula suggested by Lotka (1925). This is as under:

$\Sigma e^{-rx} I_x m_x . d_x = 1$ Lotka (1925)

$e^{-rx} I_x . m_x = 1$ Birch (1948)

5. DOUBLING TIME (DT):

It is defined as the time required for the population to double and is calculated as follows:

$$DT = \text{Log}_e 2/r$$

6. FINITE RATE OF INCREASE (λ):

It provides information about the frequency of population multiplication in a unit of time (Birch, 1948). It is denoted as

$\lambda . = e^r$. Taking log on both sides we get; $\log_e \lambda . = \log_e e^r$

where, λ = Antilog e^r

This was used for computing the rate of increase of population per year.

7. ANNUAL RATE OF INCREASE (ARI):

This can be calculated from the intrinsic rate of increase (r) or finite rate of increase (λ) or doubling time (DT) or the net reproductive rate (R_o) assuming that the rate of increase was constant throughout the year.

$$ARI = 365 = e^{365r} = 2^{365/DT} = R_o{}^{365/T}$$

RESULTS AND DISCUSSION

The observations on fecundity of *Pieris brassicae* showed significant variations in egg laying capacity with respect to their pivotal age and food plants. The maximum pivotal age of butterfly was recorded as 5 days on cabbage (*Brassica oleracea* var. capitata) and cauliflower (*Brassica oleracea* var. botrytis), whereas, on other cole crops *viz.*, gobhi sarson (*Brassica napus* var neelam), yellow sarson (*Brassica rapa* var. jhumka) and Indian mustard (*Brassica juncea* var. varuna), it was recorded as 4 days (Table 1). The higher number of eggs laid by female *P. brassicae* was recorded as 58.90 eggs on 34.5 day, 53.50 eggs on 35.5 day, 42.30 eggs on 37.5 day, 38.50 eggs on 38.5 day, and 35.50 eggs on 40.5 day on cabbage, cauliflower, gobhi sarson, yellow mustard and Indian mustard, respectively (Table 1). The fecundity of butterfly also varied and showed variable pattern with respect to different cole crops, and peak fecundity was observed on cabbage (160 eggs/female), followed by cauliflower (141 eggs/female), gobhi sarson (115 eggs/female), yellow sarson (107 eggs/female), Indian mustard (98 eggs/female), respectively (Table 1). The findings of Chew (1980), Eltez (1999), Thakur *et al.*, (1998), Gupta (2002), Metspalu *et al.*, (2003), Lal and Ram (2004), Younas *et al.*, (2004), Khalid (2006), Lytan and Firake (2012), Geiselhardt *et al.*, (2013), Sadozai and Khan, (2014) stated that among different crops, *P. brassicae* showed preference on cabbage and given strengthen to present findings.

The percent reduction in fecundity with respect to cabbage (highest fecundity 160 eggs) was recorded 11.86% on cauliflower, 28.13% on gobhi sarson, 33.13% on yellow sarson and 38.13% on Indian mustard (Table 1 & 2). In previous finding Chandra and Lal, (1976), Gupta (2002) and Geiselhardt *et al.*, (2013) also recorded highest fecundity of *P. brassicae* on cabbage and also showed corroboration with present findings. While comparing other life table parameters, it was observed that superior net reproductive rate of female butterfly was observed on cabbage (42.13 females/female/generation) and inferior on Indian mustard (15.19 females/female/generation).

Table 1: Fecundity preference of cabbage butterfly, *Pieris brassicae* on different cole crops

Pivotal age (Days) (x)	Age specific female survivorship (l_x)	Natality rate (m_x)	Net Reproductive Rate ($l_x.m_x$)	($l_x.m_x.x$)	Value of $e^{-rx}.l_x.m_x$ when	% contribution of each age group towards 'r'
Cabbage (*Brassica oleracea* var. capitata) 0.5 to 31.5 immature stages and pre-oviposition period					r= 0.1082	
32.5	0.11	18.40	2.02	65.78	0.06	6.01
33.5	0.24	28.50	6.84	229.14	0.18	18.23
34.5	0.33	58.90	19.44	670.58	0.46	46.50
35.5	0.28	45.80	12.82	455.25	0.28	27.53
36.5	0.12	8.40	1.01	36.79	0.02	1.94
SUM		160	42.13	1457.54	1.00	100.00
Cauliflower (*Brassica oleracea* var. botrytis) 0.5 to 32.5 immature stages and pre-oviposition period					r= 0.0951	
33.5	0.09	16.50	1.49	49.75	0.06	6.14
34.5	0.18	26.60	4.79	165.19	0.18	18.00
35.5	0.28	53.50	14.98	531.79	0.51	51.20
36.5	0.21	33.40	7.01	256.01	0.22	21.80
37.5	0.1	11.00	1.10	41.25	0.03	3.11
SUM		141	29.37	1043.98	1.00	100.00
Gobhi sarson (*Brassica napus* var. neelam) 0.5 to 35.5 immature stages and pre-oviposition period					r= 0.0824	
36.5	0.16	23.50	3.76	137.24	0.19	18.58
37.5	0.25	42.30	10.58	396.56	0.48	48.12
38.5	0.19	36.60	6.95	267.73	0.29	29.14
39.5	0.09	12.60	1.13	44.79	0.04	4.38
SUM		115	22.42	846.32	1.00	100.00
Yellow mustard (*Brassica rapa* var. jhumka) 0.5 to 36.5 immature stages and pre-oviposition period					r= 0.0757	
37.5	0.14	21.60	3.02	113.40	0.18	17.69
38.5	0.23	38.50	8.86	340.92	0.48	48.02
39.5	0.17	32.40	5.51	217.57	0.28	27.69
40.5	0.1	14.50	1.45	58.73	0.07	6.76
SUM		107	18.84	730.61	1.00	100.00
Indian mustard (*Brassica juncea* var. varuna) 0.5 to 37.5 immature stages and pre-oviposition period					r= 0.0677	
38.5	0.08	15.50	1.24	47.74	0.09	9.15
39.5	0.17	28.00	4.76	188.02	0.33	32.83
40.5	0.20	35.50	7.10	287.55	0.46	45.76
41.5	0.11	19.00	2.09	86.74	0.13	12.59
SUM		98	15.19	610.05	1.00	100.33

Table 2: Life-table parameters of female cabbage butterfly, *Pieris brassicae* on different cole crops

S.No.	Life table Parameter	Cabbage	Cauliflower	Gobhi sarson	Yellow mustard	Indian mustard
1	Potential Fecundity (PF)	160.00	141.00	115.00	107.00	98.00
2	Net Reproductive Rate (R_o)	42.13	29.37	22.42	18.84	15.19
3	Mean Length of Generation (T)	34.59	35.55	37.74	38.79	40.16
4	Intrinsic Rate of Increase (r)	0.1081	0.0951	0.0824	0.0757	0.0677
5	Finite Rate of Increase (λ)	1.3282	1.3842	1.4463	1.4832	1.5314
6	Doubling Time (DT)	6.41	7.29	8.41	9.16	10.24
7	Annual Rate of Increase	1.42E+17	1.19E+15	1.15E+13	9.99E+11	5.39E+10

The shortest length of generation favour to high multiplication of a population, in present investigations, shortest mean length generation was recorded as 29.85 days on cabbage followed by 35.55 days on cauliflower, 37.74 days on gobhi sarson, 38.79 days on yellow sarson and 40.16

days on Indian mustard, respectively (Table 2). In another experiment Ali and Rizvi (2007), Lytan and Firake (2012), Mehrkhou and Sarhozaki (2014) recorded favourable developmental response of *P. brassicae* on cabbage than other crops, and this statement is in agreement with the present findings.

As far as developmental rate was concerned, the higher intrinsic rate and lower finite rate favours the healthy growth of a population. During present investigations, the maximum intrinsic rate was recorded as 0.1081 females/female/day on cabbage and minimum as 0.0677 females/female/day on Indian mustard (Table 2). However, minimum finite rate of increase was recorded as 1.3282 females/female/day on cabbage and the maximum as 1.05314 females/female/day on Indian mustard (Table 2). The shortest doubling time of butterfly again recorded as 6.41 days when it reared on cabbage and longest as 10.24 days on Indian mustard. Similarly, there was a marked variation in annual rate of increase (ARI) of *P. brassicae* and highest ARI (1.42E+17/annum) was observed on cabbage followed by (1.19E+15/annum) on cauliflower, (1.15E+13/annum) on gobhi sarson, (9.99E+11/annum) on yellow mustard and lowest (1.10E+09/annum) on Indian mustard (Table 2). Similar parameters were also recorded for *Spilosoma obliqua*, *Helicoverpa armigera*, *Corcyra cephalonica, Coccinella transversalis, Pieris brassicae* by Choudhary and Bhattacharya (1986), Veera Reddy and Bhattacharya (1998), Naqvi (1998), Ali and Rizvi (2008), Mehrkhou and Sarhozaki (2014), respectively.

CONCLUSION

The results can be concluded that different fecundity parameters of cabbage butterfly, *P. brassicae* showed speedy development or fecundity preference on cabbage followed by cauliflower, gobhi sarson, yellow mustard and Indian mustard under controlled conditions.

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