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Rate of population expansion of *Goniodes dissimilis* Denny, 1842 (Ischnocera: Phthiraptera: Insecta)

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Abstract: The average incubation period of the eggs recorded 5.55 ± 0.19 days (range, 4-8 days, n=249), duration three nymphal instars 5.76 ± 0.12 days (range, 4-7 days, n=211), 5.53 ± 0.18 days (range, 4-7 days, n=185), 5.27 ± 0.14 days (range, 4-7 days, n=128) respectively. The average adult life span of males and females was recorded 14.20 ± 3.14 days (range, 2-26 days, n=60, 17.20 ± 3.24 days (range, 2-29 days, n=60). The obtained through *in vitro* experimentation life table was constructed. Thus, maternal frequency was determined by multiplying the daily average egg rate by a factor of 0.51. The gross reproductive rate appeared to be 13.20; the net reproductive rate 2.83, mean length of generation 23.01 and precise corrected generation time 24.43. The value of intrinsic rate of natural increase was computed by using trial values of 'r' to find the figure which satisfies the equation $\sum e^{-rmx}lxmx=1$ shows that the values of e^{-rmx} when r=0.039. With this value of 'r' the summation of $\sum e^{-rmx}lxmx$ proved to be 1.029. Likewise, at this value of 'r' the doubling time of *G.dissimilis* Denny, 1842 was found to be 23.90 days.
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1. Introduction

In vitro bionomics of the parasitic insects is an important tool for understanding the adaptation of on the hosts. Ischnocerans are non-haematophagous and sluggish parasitic insects in nature and comparatively easier to handle during *in vitro* experimentation. On the other hand, only limited success has been achieved in rearing amblyceran lice, as their active habits and haematophagous nature pose hurdles during *in vitro* experimentation.

A look on literature revels that the reproductive potential of pthirapteran species reportedly differs considerably. It may be noted the intrinsic rate of natural increase 'r' (rate increase per head in a population) of any organism provides vital clues regarding its rate of population growth.

Workers like Gupta et al. 2007; Saxena et al., 2007, 2009; Arya et al., 2009; Agarwal et al., 2011); Singh et al., 2012; Kumar and Hasan 2016 and Ahmad et al., 2020 have been noted the intrinsic rate of natural increase and the doubling time of selected avian lice on the basis of data obtained through *in vitro* experimentation. The value of intrinsic rate of natural increase of mammalian lice have been computed by Murray and Gordon, 169; Rust, 1974, Rashmi et al., 2010. The values of 'r' determined by aforesaid workers exhibit considerable diversity. A scrutiny of literature revealed that there was no information on the growth rate of poultry louse, *G. dissimilis*.

Present studies an attempt has been made to record the incubation period, duration of nymphal instars, adult longevity and rate of oviposition of ischnoceran louse, *G. dissimilis* and to compute the intrinsic rate of natural increase 'r' and the doubling time of *G. dissimilis* on the basis of data obtained through *in vitro* experimentations.

2. Materials and Methods

After lining the culture vials with filter paper, a layer of suitably chopped feathers were arranged along the side of vials. The feathers bearing fresh eggs belonging to popular resting sites were obtained from host birds and incubated in batches (at 35±1°C, 75-82% RH), to record the incubation period, duration of three nymphal instars. The humidity was maintained in culture vials by 500-1000 m.l. of saturated solution of salt (Witson and Bates, 1960). Likewise, apparently freshly moulted healthier adult lice were reared *in vitro* condition (in batches) to determine the adult longevity. Culture vials were examined daily.

The data obtained from *in vitro* experimentation were used to construct the life table and compute the intrinsic rate of natural increase 'r' ($\sum e^{-rmx}lxmx=1$), net reproductive rate (Ro=$\sum lxmx$), precise generation time (T=logeRo/rm), innate capacity of increase ($\lambda=\mathbf{e^{rm}}$), doubling time (DT=loge2/log$\sum$)) and mean length of generation ($\sum xlxmx/Ro$) were computed by on the lines suggested by Evans and

Smith (1952), Howe (1953) and also followed by Saxena et al. (2007, 2009), Gupta *et al.* (2007), Arya et al. (2009) and Ahmad et. al. (2020).

3. Results

Three hundred fresh eggs were incubated in four colonies (75 eggs in each batch). Overall analysis of data indicates that 41 eggs hatched on 4th day, 80 eggs on 5th day, 89 eggs on 6th day, 29 eggs on 7th day and 10 eggs on 8th days. Thus overall incubation period of the eggs of *G. dissimilis* was 5.55±0.19 days (range, 4-8 days, n=249) (Figure1). Out of these 13 first instar moulted into second instars on 4th day, 67 on 5th day, 89on 6th day, and 42 on 7th days. Thus, the overall duration of first instar nymphs of *G. dissimilis* remained 5.76 ± 0.12 days (range, 4-7 days, n=211) Fig 1. 34 second instar nymph moulted into third instar nymphs on 4 th day, 56 on 5th day, 58 on 6th day and37 on 7th day. Thus, the overall duration of second instar nymphs of *G. dissimilis* was 5.53 ± 0.18 days (range, 4-7 days, n=185) (Figure 1). 26 third instar nymphs moulted into adults on 4th day, 50 on 5th day, and 43 on 6th day and 09 on 7th days. Thus, over all duration of third instar nymphs was found to be 5.27±0.14 days (range, 4-7 days, n=128) (Figure 1).

Thirty pairs of freshly moulted healthier adult lice of *G. dissimilis* were reared two colonies (60 adults in each batch). Average life span of adult male in colony A remained 13.43 ± 2.75 days (range 2-23 days) and colony B, 15.33±3.66 days (range 2-26 days). Likewise, the life span of adult females in colony 'A' remained 16.87 ± 3.02 days (range 3-29days) and Colony 'B' 17.53 ± 2.81 days (range 2-28 days) respectively. Thus, the overall life span of adult males and females was 14.20±3.14 days (range 2-26 days, n=60) and 17.20±3.24 days (range 2-29days, n=60), respectively (Figure 2). Thus, the average of adult female life span was comparatively longer than that of males. As many as 834 eggs were produced both colonies and an adult female produced an average of 6.97eggs during the life span. Thus, the rate of egg production remained 0.32 eggs/ female/ day. The overall analysis of the data indicated that average egg laying rate remained 0.20 egg/ female/ day during first 5 days, 0.50 egg/female/day during 6-10 days (reached maximum rate), 0.40 eggs/ female/ day during 11-15 days, 0.19 eggs/ female/ day during 16-20 days and exhibited decrease 0.11 eggs/female/day during 21-24 days. No eggs were found after 24 days (Figure 4).

The life table was constructed on the basis of aforesaid data (i.e. incubation period, duration of three nymphal instar, pre-oviposition period, age specific mortality/ survivorship and fecundity (Figure 3). Studies on population structure of *G. dissimilis* indicated that male, female ratio in natural population is 1:1.06. Thus, maternal frequency (mx = average number of female egg produced) was determined by multiplying the daily average egg rate by a factor of 0.51 (Table 1).

The gross reproductive rate seems to be 13.29; the net reproductive rate appeared to be 2.83. The mean length of generation recorded as 23.01 days. The value of intrinsic rate of natural increase was computed by using trial values of 'r' to find the figure which satisfies the equation $\sum e^{-rmx} lxmx=1$(Table 2) shows that the values of e^{-rmx} when r=0.039. With this value of 'r' the summation of $\sum e^{-rmx} lxmx$ proved to be 1.029, precise corrected generation time 24.43. Likewise, at this value of 'r' the doubling time of *G.dissimilis was* found to be 23.90 days.

4. Discussion

The survey of literature indicates that the intrinsic rate of natural increase gross reproductive rate, net reproductive rate, mean length of generation and the doubling time of thirteen ischoceran species have been noted by the workers (Saxena et al., 2007, 2009; Gupta et al., 2007, Arya et al., 2009 and Singh et al., 2012, Kumar and Hasan, 2016 and Ahmad *et al.,* 2020). The value of natural increase 'r' of different species studied by aforesaid workers varied from 0.031-0.074. The gross reproductive rate varied from 4.7-29.2; net reproductive rate from 2.9-14.4 and the mean length of generation from 29.64-39.4. The doubling time of different species varied from 9.0-23.5 days. During present studies the value of intrinsic rate of natural increase 'r' was recorded 0.039 and the gross reproductive rate 13.20, net reproductive rate 2.83 and the mean length of generation 23.01 and the doubling time appeared to be 23.90 days. Compare of previous studies *G. dissimilis* appears to be a slow breeder as it 'r=0.039' and the doubling was computed as 23.90 days.

As far as the mammalian lice are concerned, the value of 'r' of sheep louse, *B. bovis* has been estimated as 0.053 per day and the doubling is 13-14 days (Murray and Gordon, 1969). The value of 'r' for rodent louse, *Geomydoecus oregonus* remained too low-0.006 per day indicating double after every 112 days (Rust, 1974).

The data clearly shows that the reproductive potentials of different phthirapterans exhibit considerable diversity. Presumably, the fast breeding species may build their population at faster rate (than moderate and slow breeders) and may cause extensive damage to feathers of the host, while slow breeders may exhibit low prevalence and intensity of infestation and thus causing minimal effect on host plumage Singh et al., (2012).

5. Conclusions

The comparison of earlier studies poultry louse, *G dissimilis* Denny, 1842 appears to be slow breeder as it rate of natural increase 0.039 and the doubling time remained 23.90 days. At this rate the population of this species supposed to be double after 23.90 days that is indicating this species seems to be slow breeder. Presumably, the fast breeding species may build their population at faster rate causing high prevalence and intensity of infestation and consequently may cause extensive damage to feathers of their hosts. On the other hand slow breeder and moderate breeders are supposed to exhibit intermediate condition in this regard and causing low prevalence and intensity of infestation and minimal effect on host plumage.

Table 1. Life table and rate of increase of *Goniods dissimilis*.

X	lx	mx	lxmx	Xlxmx	rmx	e-rmx	e-rmxlxmx
0-22	Immature stage						
23-24	Pre-oviposition period						
25	0.800	0.00	0.000	0.000	0.725	0.484	0.000
26	0.780	0.00	0.000	0.000	0.754	0.470	0.000
27	0.760	0.00	0.000	0.000	0.783	0.457	0.000
28	0.747	0.32	0.238	6.664	0.812	0.444	0.106
29	0.713	0.22	0.160	4.634	0.841	0.431	0.069
30	0.687	0.21	0.143	4.284	0.870	0.419	0.060
31	0.647	0.32	0.207	6.429	0.899	0.407	0.084
32	0.620	0.43	0.269	8.595	0.928	0.395	0.106
33	0.587	0.37	0.218	7.181	0.957	0.384	0.084
34	0.573	0.31	0.177	6.011	0.986	0.373	0.066
35	0.533	0.27	0.143	4.998	1.015	0.362	0.052
36	0.500	0.42	0.211	7.589	1.044	0.352	0.074
37	0.473	0.43	0.204	7.548	1.073	0.342	0.070
38	0.440	0.32	0.143	5.426	1.102	0.332	0.047
39	0.393	0.30	0.119	4.641	1.131	0.323	0.038
40	0.373	0.33	0.122	4.896	1.160	0.313	0.038
41	0.333	0.21	0.071	2.927	1.189	0.305	0.022
42	0.300	0.25	0.075	3.142	1.218	0.296	0.022
43	0.253	0.24	0.061	2.632	1.247	0.287	0.018
44	0.233	0.26	0.061	2.693	1.276	0.279	0.017
45	0.207	0.36	0.075	3.366	1.305	0.271	0.020
46	0.167	0.41	0.068	3.128	1.334	0.263	0.018
47	0.120	0.28	0.034	1.598	1.363	0.256	0.009
48	0.093	0.22	0.020	0.979	1.392	0.249	0.005
49	0.073	0.23	0.017	0.833	1.421	0.241	0.004
50	0.033	0.00	0.000	0.000	1.450	0.235	0.000
51	0.007	0.00	0.000	0.000	1.479	0.228	0.000
52	0.000	0.00	0.000	0.000	1.508	0.221	0.000
							1.029

Table 2. *In vitro* bionomics of different ischnoceran species.

Species	Hosts	Gross Reproductive rate	Net reproductive rate	Mean length of generation	Rate of natural increase	Doubling time	References
Brueelia amandava	*Amandava amandava*	4.98	3.31	35.4	0.031	23.45	Gupta *et al.* 2007
Brueelia cyclothorax	*Passer domesticus*	4.7	2.9	34.2	0.032	21.35	Saxena *et al.*2009
Sturnidoecus bannoo	*Acridotheres tristis*	9.3	5.0	33.1	0.049	14.21	Saxena *et al.* 2009
Neopsittaconirmus elbeli	*Psittacula eupatra*	7.9	5.2	33.5	0.050	13.93	Saxena *et al.* 2009
Columbicola columbae	*Columba livia*	9.9	8.0	39.4	0.053	14.2	Saxena *et al.* 2009
Anaticola crassicornis	*Anas platyrhynchos*	29.2	14.4	36.6	0.074	9.01	Saxena *et al.* 2009
Brueelia plocea	*Ploceus phillipinus*	7.74	3.74	28.19	0.045	15.41	Arya *et.al.* 2009
Goniocotes gallinae	*Gallus g. domesticus*	12.49	8.3	36.9	0.059	11.73	Saxena *et al.* 2007
Upupicola upupae	*Upupa epops*	6.08	3.67	37.15	0.035	19.1	Agarwal *et al.* 2011
Columbicola bacillus	*Streptopelia decaocta*	12.37	6.20	35.93	0.054	12.95	Singh *et al* 2012
Bovicola caprae	*Copra hircus*	11.62	6.73	35.27	0.055	12.6	Rashmi *et al* 2010
Lipeurus caponis	*Gallus gallus domesticus*	12.53	3.9	29.64	0.046	16.1	Kumar and Hasan 2016
Goniocotes jirufti	*Francolinus francolinu*	13.89	4.606	37.09	0.042	16.50	Ahmad et al. 2020
G. dissimilis	*Gallus g. domesticus*	13.20	2.83	23.01	0.039	23.90	Present study

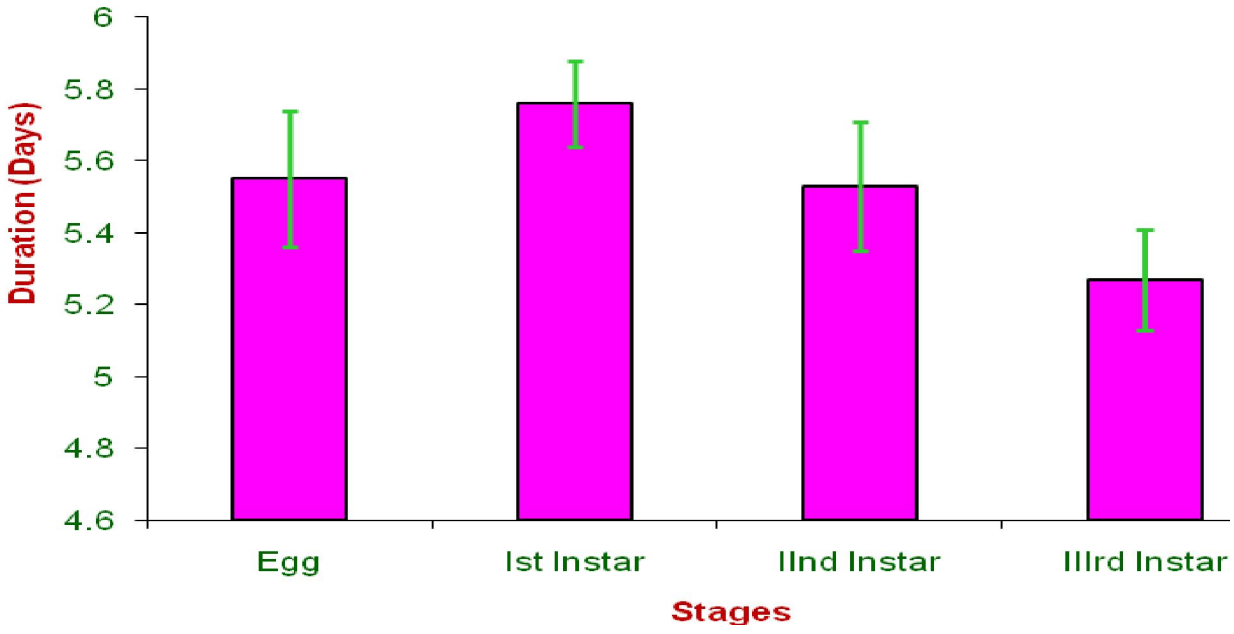

Figure 1. Duration of egg stage, three nymphal instars of *G.dissimils* reared at 35± 1° C, 75-82% RH, at feather diet, mean duration bar are represented by Standard deviation (SD).

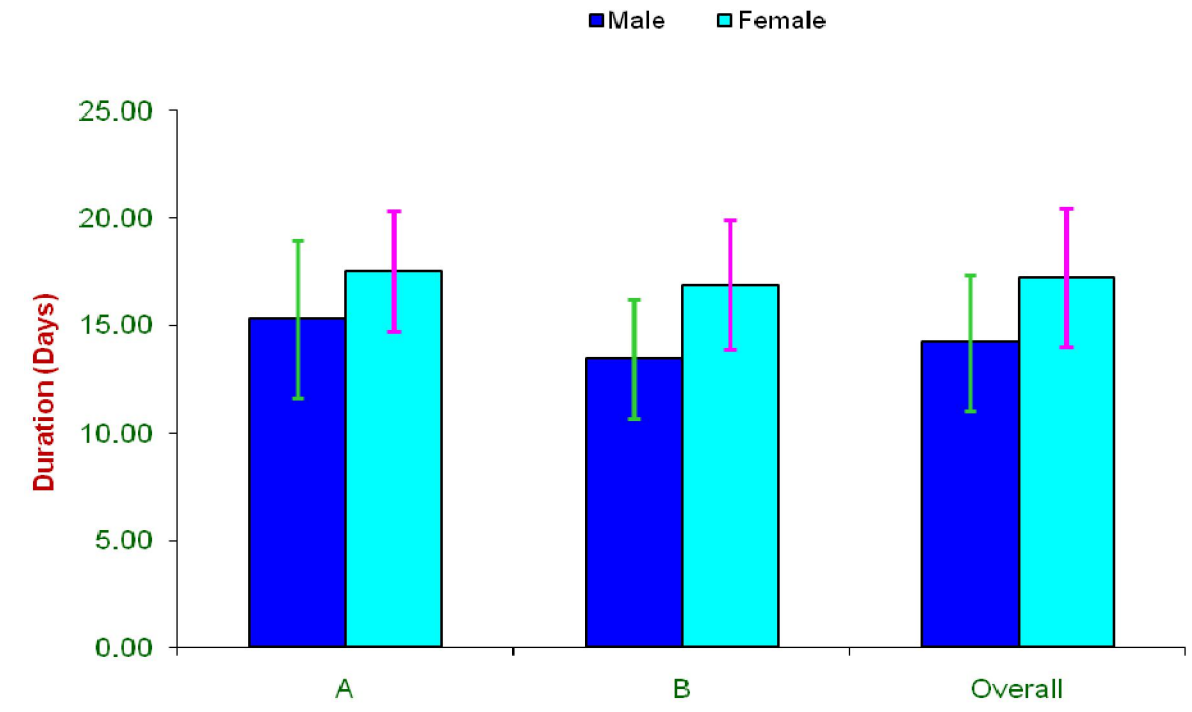

Figure 2. Duration of adult longevity of male and female of *G.dissimils* reared at 35± 1° C, 75-82% RH, at feather diet, mean duration bar are represented by Standard deviation (SD).

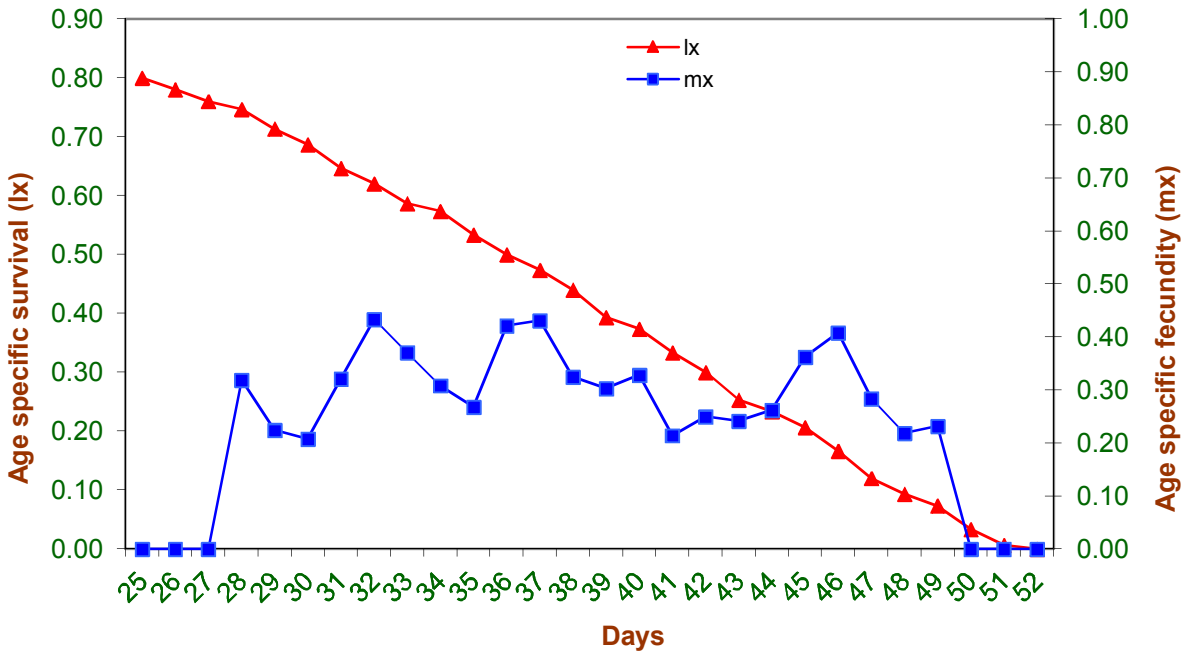

Figure 3. Age specific survival (lx) and fecundity (mx) of *G. dissimils*, reared at 35± 1° C, 75-82% RH, at feather diet.

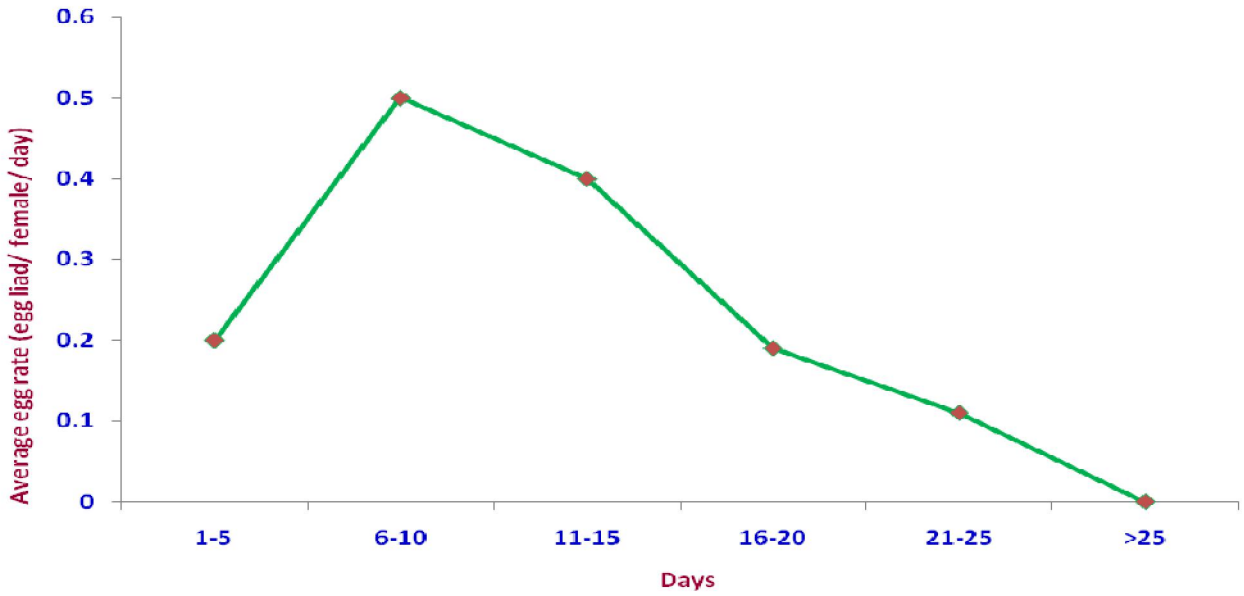

Figure 4. Egg rate of *G. dissimils*, reared at 35± 1° C, 75-82% RH, at feather diet.

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