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Intra and interspecific competition between *Drosophila rajasekari* and *Drosophila nasuta*

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Abstract

The present study investigates competition between *D. rajasekari* and *D. nasuta* species. The analysis of intra and interspecific competition by means of a serial transfer technique reveals that *D. nasuta* with its greater productivity and population size eliminated *D. rajasekari* species within a period of 13 weeks. However, the morphometric traits, wing and thorax length measured in mixed species competition was significantly different from pure culture species. The effect of interspecific competition is also observed with greater difference in pupation height of *D. rajasekari* than its competing species in mixed culture.

Keywords: Competition, *D. rajasekari*, *D. nasuta*, Pure culture, Mixed culture.

Introduction

Competition among organisms of closely related species is often thought to be a major driving force for evolutionary change. The competition operated by natural selection allows various species to survive and establish identical niches. The studies on competition have led to theoretical and experimental conclusion. Lotka (1925) and Volterra (1926) independently predicted that two species with identical needs and habits cannot survive in the same place if they compete for limited resources. The extensive experimental investigations on interspecific competition have also supported this theory (Gause 1934, Connel 1981, Demmo et al.1995, Hochkirch&Grodni 2012). Although the coexistence of competing species may be mediated by various mechanisms including resource partitioning and environmental heterogeneity. Moreover, the principle of competitive exclusion emphasized that species using the same resource cannot coexist unless interspecific competition is weak compared to intraspecific competition (Hardin 1960).

Competitions between individuals of different species are manifested by reduction in the survivorship growth and reproduction of one of the competing individuals. Interspecific competition between two sibling species of *D. melanogaster* and *D. simulans* were studied by Barker and Podger (1970), evidencing the effect of larval density on viabilitydevelopment period and adult body weight in mixed culture. Competition studies between *D. pavani* with *D. willistone* have also found significant retarded in developmental periodswith egg to adult viability (Myriam Budnik & Danko Brncik, 1974). Recent studies have shown that the outcome of interspecific competition of two closely related species may depend upon genetic variation and the environmental condition in which the experiment is carried out. In lightof this the present study investigates, theintra and interspecific competition between *D. rajasekari* and *D. nasuta.* Several measures offitness, morphological traits and pupation heightswere examined.The farmer species being endemic to peninsular India, do coexists with later species in natural population.

Materials and Methods

D. rajasekari and *D. nasuta* caught from semidometic localities of Mysuru city (Karnataka, India) constitute the material for the present study. Isofemale lines were established and multiplied in our laboratory. After 10 generation, the virgin females and bachelor males were isolated within 2hrs of their eclosion and were then aged for 5 days. These adult flies were used in the present intraspecific competition experiment in pure and mixed culture. In the pure culture 50 males and 50 females of the same species were transfer to culture bottle containing freshly prepared wheat cream agar media bottle were served as controls. In mixed culture 25 males and 25 females of each species were transferred together into media bottle. Five replicates population were made for each population and experiments were carried out at a constant temperature of 22± 1^{o} C.

In the adult competition studies, parameters such as productivity and population size were evaluated following the procedure of Krishnamurthy et al (1994). The flies of pure and mixed culture were maintained following the serial transfer techniques of Ayala (1970). The morphometric traits of wing length and thorax length were measured at the interval of 1st, 5th and 10thweek. Student's t- test was carried out on mean difference of wing and thorax length of 25 males and 25 females of each species between pure and mixed cultures. Further, the parameter such as pupation height was measured as the distance from the surface of the medium to the tip of anterior spiracles of the pupae. The pupae of two *Drosophila* species could be easily differentiated with their size and nature of spiracles. The mean pupation heights of pure and mixed culture weretaken from 5 replicate at the interval of every 5 weeks. Statistical analysis of one-way ANOVA was applied to test whether there was any difference in mean number of morphometric trait and pupation height between different weeks among the pure and mixed culture.

Results

D. nasuta species were very efficient competitor of *D. rajasekari*. Virtually, the complete elimination of *D. rajasekari* took place within 13th week. Table 1, Depicts the mean value of productivity and population size of the pure and mixed cultures. The student t-test carried out on mean productivity of pure and mixed culture of *D. rajasekari* showed significantly higher in 5th and 10th week ($t= 3.667$, $P< 0.001$ and $t= 23.801$. $P < 0.001$) while, the population size in both the culture were found to be predominantly greater in 5th and 10th week ($t= 4.983$, $P <0.001$ and in mixed culture $t= 15.767$. $P< 0.001$). Besides the mean productivity of *D. nasuta* species was insignificant but their population size showed significantly higher than control only in the 10th week ($t= 3.746$; $P < 0.001$).

Tables 1. Mean (± SD) of Productivity and Population size of *D. rajasekari* and *D. nasuta* in pure and mixed cultures.

	D. nasuta			***D. rajasekari***		
Weeks	**Pure culture**	**Mixed culture**	**t-value**	**Pure culture**	**Mixed culture**	**t- value**
Productivity						
1	0	0	-	0	0	-
5	114.001 ± 11.529	141.201 ± 13.265	1.546	110.401 ± 5.556	73.401 ± 8.424	3.667**
10	117.601±9.689	88.401±9.749	2.124	127.202±4.769	10.601±1.123	23.801**
Population size						
1	100	50	-	100	50	-
5	205.601 ± 2.205	222.601 ± 22.932	0.738	206.001 ± 20.804	93.401± 8.293	4.983 **
10	207.601± 9.092	170.801 ± 3.721	3.746**	181.501 ± 10.229	17.201± 2.084	15.767**

Note: df= 8; * P < 0.05; ** P < 0.001.

The morphometric trait of wing and thorax length analyzed by Student t-test reviled greater significance during the 10th week. The metric trait of wing length measured in pure and mixed culture of both male and female of two species isdepicted in table 2. The analysis of ANOVA suggested the significant increase in male wing length during different weeks in both pure culture (F= 9.468; P<0.001) and mixed culture (F= 43.067; P < 0.001). Corresponding with female wing length in pure culture (F= 23.002; P< 0.001) and mixed culture (F= 66.388; P < 0.001). Nevertheless, in *D.nasuta* also showed a greaterincrease in male wing length in pure (F= 3.956; P<0.05) and in mixed culture (F= 3.175; P< 0.05). Whereas in female wing length during different weeks found significant increase specifically in pure culture (F= 8.067; P< 0.001) but were insignificant in the mixed culture flies.

Table 2: Mean (±SE) wing lengths of *D. rajasekari* and *D. nasuta* flies in pure and mixed cultures

D.rajasekari	**Weeks**	**N**	**Pure culture (mm)**	**N**	**Mixed culture (mm)**	**t-value**
Male	1	125	1.744 ± 0.016	125	1.733±0.013	0.542
	5	125	1.683 ± 0.014	125	1.678 ± 0.017	0.263
	10	125	1.663 ± 0.012	22	1.382 ± 0.037	8.636**
Female	1	125	1.924 ± 0.013	125	1.931± 0.024	0.269
	5	125	1.797 ± 0.011	125	1.766 ± 0.011	2.048*
	10	125	1.859 ± 0.016	24	1.431 ± 0.041	10.666**
D. nasuta						
Male	1	125	2.017 ± 0.012	125	2.001 ± 0.022	0.651
	5	125	1.993 ± 0.013	125	1.946 ± 0.023	1.836
	10	125	1.959 ± 0.019	125	1.911 ± 0.031	1.267
Female	1	125	2.244 ± 0.013	125	2.194 ± 0.014	2.745**
	5	125	2.186 ± 0.017	125	2.208 ± 0.016	0.099
	10	125	2.154 ± 0.015	125	2.163 ± 0.012	0.041

Table 2.1. Analysis of variance for mean wing lengths of *D. rajasekari* and *D. nasuta* flies in pure and mixed cultures.

		Source of variation	df	MS	F
D. rajasekari	Male wing length				
	Pure culture	Between weeks	2	0.225	9.648**
		Within Weeks	374	0.024	
	Mixed culture	Between weeks	2	1.156	43.067**
		Within weeks	269	0.027	
Female wing length					
	Pure culture	Between weeks	2	0.506	23.002**
		Within weeks	372	0.0219	
	Mixed culture	Between weeks	2	2.770	66.388**
		Within weeks	271	0.0418	
D. nasuta	Male wing length				
	Pure culture	Between weeks	2	0.108	3.956*
		Within weeks	372	0.0273	
	Mixed culture	Between weeks	2	0.253	3.175*
		Within weeks	372	0.07972	
	Female wing length				
	Pure culture	Between weeks	2	0.266	8.067**
		Within weeks	372	0.0329	
	Mixed culture	Between weeks	2	0.06553	2.810
		Within weeks	372	0.02332	

Note: MS- Mean square; * P< 0.05; ** P< 0.001.

Proportionately the measurement of thorax length of pure and mixed culture of 2 species is shown in Table 3. The ANOVA applied on mean male thorax length of *D. rajasekari* between different weeks showed predominantly higher in mixed culture (F= 47.315, P< 0.001) but were insignificant in pure culture. Further, the female thorax length of *D. rajasekari* were significant different in both pure culture (F= 17.734; P< 0.001) and mixed culture (F= 92.957; P< 0.001). The mean male thorax length of *D. nasuta* found to be greater increase in pure culture (F=8.885; P<0.001) and mixed culture (F= 19.4060; P< 0.001).Similarly for the female thorax length in pure culture (F= 8.830; P< 0.001) and also in mixed culture (F= 7.385; P<0.001) during different weeks.

Table 3. Mean (±SE) thorax length of *D. rajasekari* and *D. nasuta* in pure and mixed culture.

		Weeks	N	Pure culture (mm)	N	Mixed culture (mm)	t-value
D.rajasekari	Male	1	125	0.879 ± 0.008	125	0.896 ± 0.007	1.751
		5	125	0.869 ± 0.007	125	0.861 ± 0.012	0.638
		10	125	0.875 ± 0.007	22	0.653 ± 0.038	10.038^{**}
	Female	1	125	0.986 ± 0.008	125	0.987 ± 0.009	0.034
		5	125	0.913 ± 0.011	125	0.905 ± 0.007	0.634
		10	125	0.969 ± 0.009	24	0.716 ± 0.023	10.625^{**}
D. nasuta	Male	1	125	1.084 ± 0.007	125	1.091 ± 0.017	0.352
		5	125	1.044 ± 0.009	125	1.033 ± 0.009	0.901
		10	125	1.039 ± 0.009	125	0.976 ± 0.013	4.145^{**}
	Female	1	125	1.189 ± 0.012	125	1.168 ±0.008	1.611
		5	125	1.162 ± 0.008	125	1.147 ± 0.007	1.514
		10	125	1.129 ± 0.011	125	1.112 ± 0.015	0.932

Table 3.1. Analysis of variance for mean thorax length of *D.rajasekari* and *D.nasuta* flies in pure and mixed cultures.

D. rajasekari		Source of variation	**df**	**MS**	***F***
Male thorax length					
	Pure culture	Between weeks	2	0.0031	0.512
		Within weeks	372	0.061	
	Mixed Culture	Between weeks	2	0.553	47.315^{**}
		Within weeks	269	0.0117	
Female thorax length					
	Pure culture	Between weeks	2	0.184	17.734^{**}
		Within weeks	372	0.0104	
	Mixed culture	Between weeks	2	0.785	92.957^{**}
		Within weeks	271	0.0085	
D.nasuta					
Male thorax length					
	Pure culture	Between weeks	2	0.0773	8.885^{*}
		Within weeks	372	0.0087	
	Mixed culture	Between weeks	2	0.413	19.406^{**}
		Within weeks	372	0.02130	
Female thorax length					
	Pure culture	Between weeks	2	0.112	8.830^{**}
		Within weeks	372	0.0127	
	Mixed culture	Between weeks	2	0.0967	7.385^{**}
		Within weeks	372	0.0131	

Note: MS Mean square, * P< 0.01, ** P< 0.001.

Table 4, shows the result of pupation height measured in pure and mixed culture of the two species. The mean pupation height of *D. rajasekari* species in Mixed culture is considerably greater than Pure culture (F= 33.450; P<0.001). However, similar trend was also observed in *D. nasuta* species with significant height of pupation in mixed culture (F=6.245; P<0.001) than in pure culture.

Table.4. Mean (±SE) Pupation height of *D. rajasekari* and *D. nasuta* in pure and mixed culture.

	Weeks	N	Pure culture (cms)	N	Mixed culture (cms)	t- value
D.rajasekari	1	336	7.405 ± 0.175	162	7.555 ± 0.253	0.491
	5	740	7.318 ± 0.098	219	5.739 ± 0.217	7.316**
	10	672	7.451 ± 0.119	63	4.042 ± 0.277	8.627
D.nasuta	1	320	6.026 ± 0.114	377	6.212 ± 0.152	0.953
	5	705	6.293 ± 0.089	563	6.788 ± 0.133	3.200**
	10	661	6.459± 0.108	573	6.242 ± 0.118	1.361

Table 4.1. Analysis of variance for pupation height of *D. rajasekari* and *D. nasuta* flies in pure and mixed culture.

	Source of variation	df	MS	F
D.rajasekari				
Pure culture	Between weeks	2	3.223	0.375
	Within weeks	1745	8.603	
Mixed culture	Between weeks	2	318.401	33.450**
	Within weeks	441	9.519	
D.nasuta				
Pure culture	Between weeks	2	20.302	0.036
	Within weeks	1683	6.107	
Mixed culture	Between weeks	2	55.083	6.245**
	Within weeks	1510	8.820	

Note: MS, Mean square; ** P<0.001

Discussion

Competition between two species are determinants of relative fitness, ecological factors and ability to exploit resources. In this present competitive experiment *D. nasuta* population out view *D. rajasekari* within 13 weeks. The productivity and population size of *D. nasuta* in mixed culture was greater than *D. rajasekari*. Essentially the populations which have greater productivity have larger population size. Here the outcome of competition is determined by increased population size is one of the competing species. Similar observation between productivity and population size have been reported in competitive studies with *Drosophila* by Bruce Wallace (1974) and Krishnamurthy, et al (1994). *D. nasuta* having the highest productivity and population size is considered to be the best adapted than the *D. rajasekari*.

The present study evidence the differential ability of the *D. nasuta* to exploit the experimental environment is striking. If adaptedness forms one of the important parameters of the population and that the other being is its relative fitness. The outcome of competition was primarily analyzed by flies that emerged during 10th week. Flies of *D. rajasekari* emerging later were usually smaller and fewer in number than *D. nasuta* species. The analysis of morphometric character between control and mixed culture were strikingly significant demonstrating that *D. rajasekari* flies had smaller wing and thorax length with the increase in weeks. This difference provides evidence for the nature of competitive interaction in the mixed culture on the morphometric traits of two contrasting species. Consistent results were found between competition of *D. melanogaster* and *D. simulans* stock (Philip. W.Hedrick, 1972). The distance a larva pupates is an interaction of genotype with environment (War. B. Solwlouski, 1989). Further the studies on pupation height have revealed an interesting result. In mixed culture *D. nasuta* had a significant greater pupation height than the control while just opposite occurred with *D. rajasekari*. Although the studies have suggested that pupation height can facilitate niche partitioning between related species and in this way, they also coexist in natural population (Schnebel and Grossfield, 1968).

Competitive ability of a species is the sum of numerous factors that interact exceeding in complex ways under experimental setup, each species manifesting different levels of adaptedness and relative fitness. Thus, our results have shown that individual of *D. nasuta* being the stronger competitor to *D. rajasekari* has also evident different competitive abilities with relative fitness components exhibiting profound significant changes with the experimental period.

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