American Journal of Bioscience and Bioengineering
2013; 1(1) : 1-6
Published online February 20, 2013 (http://www.sciencepublishinggroup.com/j/bio)
doi: 10.11648/j.bio.20130101.11

Comparison of fitness parameters in different species of *Drosophila*

Suhasini L. Kudupali[1], Shivanna N.[1,2,*]

[1]Department of Zoology. Karnatak University, Dharwad, INDIA
[2]Department of Applied Genetics, Karnatak University, Dharwad, INDIA

Email address:

suhasinikudupali@gmail.com (S. L. Kudupali), drnshivanna@rediffmail.com (S. N)

To cite this article:

Suhasini L. Kudupali, Shivanna N.. Comparison of Fitness Parameters in Different Species of *Drosophila*. *American Journal of Bioscience and Bioengineering.* Vol. 1, No. 1, 2013, pp. 1-6. doi: 10.11648/j.bio.20130101.11

Abstract: The fitness parameter has been studied in *Drosophila melanogaster*, *D. bipectinata*, *D. malerkotliana* and *D. ananassae*. 7 day aged virgin flies were used for mating experiment, it revealed that, mating latency is more in *D. malerkotliana* and less in *D. melanogaster*. Mating time of *D. melanogaster* is more and it is less in *D. ananassae* *D. bipectinata* takes more time to remate and *D. melanogaster* takes less time to remate. Mating time, fecundity, productivity and viability of virgin is more than mated male in all the species except, *D. melanogaster*. Even though *D. melanogaster* has more percentage of viability it takes more time in mating. The mating time is less in *D. ananassae* whereas, fecundity, productivity and percentage of viability is more than other species.

Keywords: *Drosophila*, Fitness Parameters, Mating Time, Fecundity, Productivity

1. Introduction

All biological processes directly related to reproduction that plays an important role in determining fitness. Reproductive capacity is particularly a good index of fitness in organisms that go through repeated cycles of rapid population growth and it has evolved as a way for species to maximize their potential of survival. Traditional models of sexual selection predict that in most animal species, male will be less discriminating in their choice of mating partners and has less investment in their offspring than female [1,2].

Fitness consists of many components such as mating latency, mating time, duration between mating, fertility, fecundity, productivity, viability and longevity, etc., Mating is the most important and fundamental process in animals to select the best partner and to produce progeny. Dipteran insects show a wide range of species-specific mating behaviour. In *Drosophil*a successful mating depends on male activity and female receptivity, but males stand to increase their fitness by multiple mating with as many females as possible. After mating, physiological changes are occurring in both male and females [1-5].

Mating latency is an important component of *Drosophila* mating behaviour. Mating latency is the time required for males and females to initiate copulation. Mating latency has been studied in natural and laboratory conditions as well as, at multiple mating in different species of *Drosophila* [4,5]. The mating latency of virgin females is significantly shorter than mated females [6].

Mating time is another important component of *Drosophila* mating behaviour. It is considered as male determined trait and is an expression of the rate of sperm transfer [7]. The mating time has been studied in both natural and laboratory conditions, 1st mating time is more than 2nd mating time in different species of *Drosophila* [4,5,8].

Fecundity is the most obvious trait that influences the reproductive ability of female and usually considered as female fitness component, it has been analysed in different species of *Drosophila*, it shows that fecundity is influenced by mating flies age, body size, environmental factors, genotype and also fecundity-enhancing substances (FES). The fecundity of virgin females is more when compare to mated female [9-12].

Productivity is the number of newly produced offspring of a mated pair. It has been extensively studied in different species of *Drosophila*. Effect of density on fecundity and productivity has been studied. Productivity of first mated flies is more than the subsequent mating. Repeated mating by females leads to a higher productivity and lower longevity [13-16]. Percentage of viability is an expression of the successive fertility. Viability decreases as density increases. Egg to adult viability and male mating success are the most important components of fitness [17,18].

Remating is common in many species of *Drosophila* under both natural and laboratory conditions. Multiple mating in *Drosophila* bears a direct relation to fitness [19]. Remating time of male and female in different species of *Drosophila* has been studied [4,8]. Remating and sperm storage are specific features that can play important roles in determining female fecundity, male mating success. Remating reduces the maternal survival [20-22]. Markow, Quaid and Kerr [23] found that females are able to distinguish between mated and unmated males and those that had a previous mating experience, showing preference for virgin males.

Mating latency, mating time, remating duration, fecundity and productivities have been studied individually taking one or two species where as all the fitness parameters in more than one species has not been studied. The parameters were correlated taking one or two species. The systematic study with all the parameters of fitness in more than a species is not been analysed. Thus, the present work has been taken up to study the fitness parameters in different species of *Drosophila* to establish is there any relationship between these parameters.

2. Materials and Methods

D. melanogaster, D. bipectinata, D. malerkotliana, D. ananassae were obtained from *Drosophila* stock centre, Department of zoology, University of Mysore, Mysore. The flies were cultured in a standard wheat cream agar medium, prepared as per the procedure described by Shivanna, Siddalingamurthy and Ramesh [24] and maintained at a constant temperature of 22±1ºC.

2.1. Mating Latency, Mating Duration and Remating

The virgin males and females were separated within 1hour of their eclosion; then they were aged for 7 days in separate food vials. 7 day aged virgin male and female flies were allowed to mate in a mating chamber (10x 4.5 cm). Their virginity was assured by observing the vials for presence / absence of larvae. The pair was observed for 5 to 6 hours. The mating latency (time taken by flies to initiate mating) was recorded. After initiation of mating, 1st and 2nd mating time (time of initiation of mating till the time of release or depart of male and females) was recorded. After 1st mating the female was aspirated out and another virgin female was introduced into the mating chamber. Time required for remating (duration between mating) was recorded as per the procedure described by Singh and Singh [8].

2.2. Fecundity and Productivity

The mated females were kept in separate vials and transferred to a new culture vials every day and eggs were counted daily for a period of 30 days. Yeast was added to the culture vials containing larvae for feeding and pupae were counted after pupariation to calculate the productivity and the percentage of viability.

3. Results

Table 1 shows the mating latency, mating time, duration between first and second mating, fecundity, productivity and viability in *Drosophila melanogaster*, *D. bipectinata, D. malerkotliana and D. ananassae.* Mating latency is less in *D. melanogaster* (21.8 min) and more in *D. malerkotliana* (49 min). Mating time of *D. melanogaster* is more (I-20.4, II-18.4) and *D. ananassae* mating time is less (I-5.4, II-3.4). The difference between first and second mating (Figure.1) is 2 minutes in *D. melanogaster*, *D. bipectinata and D. ananassae* except *D. malerkotliana* (3min).

Table 1. *Mean ± SD of mating latency, Mating time, Duration between mating, Fecundity, Productivity and viability in different species of Drosophila.*

	Mating latency (min)	Mating time (min)		Duration between mating (min)	Fecundity	Productivity	viability (%)
*D. melanogaster***	21.8	I	20.4±2.7	27.4±24.3	429.0±162.8	261.0±47.9	60.84
		II	18.4±3.6		293.2±65.4	205.0±60.3	69.92
*D. bipectinata**	31.6	I	12.0±2.9	67.0±41.7	414.4±129.2	207.4±90.7	50.05
		II	10.6±1.3		371.2±93.0	154.0±56.9	41.49
*D. malerkotliana***	49	I	16.6±2.1	48.80±8.5	615.2±141.4	331.6±64.1	53.90
		II	13.8±1.9		391.8±129.0	193.2±27.7	49.31
*D. ananassae***	34.8	I	5.4±0.5	50.4±14.6	664.0±222.7	386.4±57.6	58.19
		II	3.4±0.5		362.0±284.3	188.6±73.3	52.09

*Significant *productivity,**fecundity and productivity, df = 29, P< 0.05*

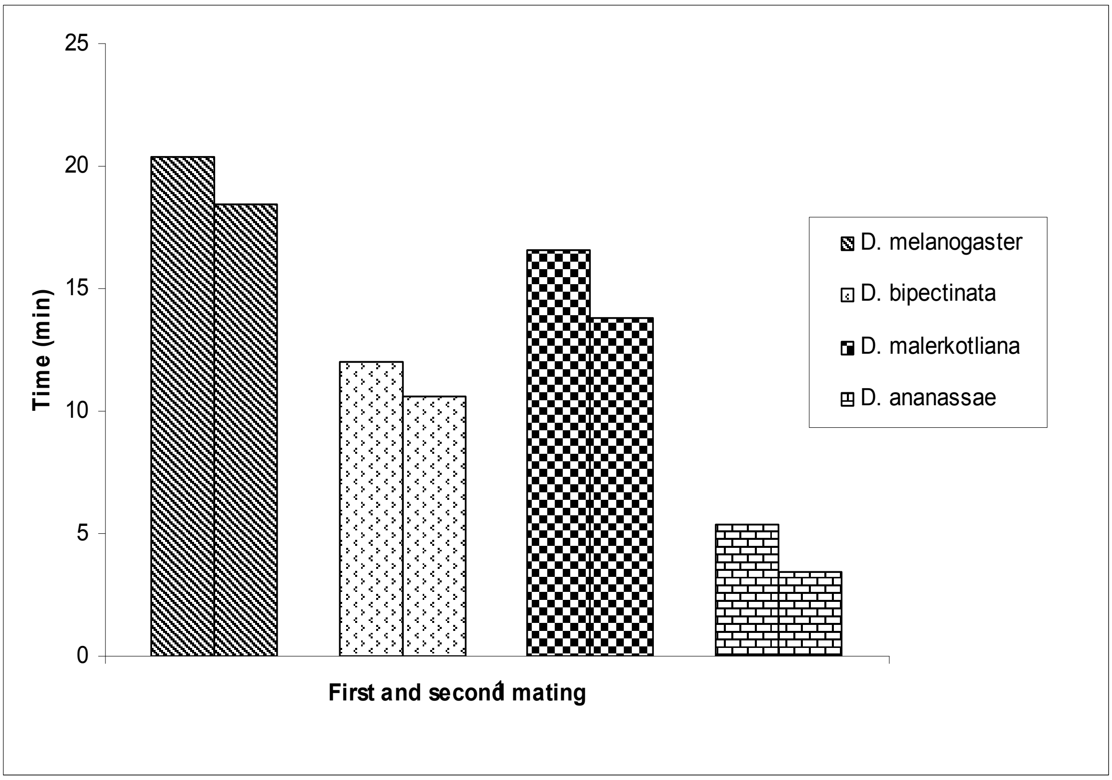

Figure 1. *First and second mating time in different species of Drosophila.*

D. melanogaster takes less (27.4) time to remate and *D. ananassae* takes approximately double (50.4) and remating time increases approximately 20 minutes sequentially in *D. melanogaster*, *D. malerkotliana*, and *D. bipectinata* in first mating (27.4, 48.8, 67.0).

D. ananassae and *D. malerkotliana* shows more fecundity in first and second mating (I-664.0, II-362.0 and I-615.2, II-391.8). Fecundity of *D. melanogaster* and *D. bipectinata* in first mating (429.0 and 414.4), and *D. bipectinata* and *D. malerkotliana* in second mating (371 and 391) is almost equal.

In first mating, productivity of *D. ananassae* is more when compared to other species (386.4) and in *D. bipectinata, D. melanogaster* and *D. malerkotliana* it increases approximately by 60 pupae (207.4, 261.0, 331.6 respectively). Productivity of second mating is more in *D. melanogaster* (205.0) and less in *D. bipectinata* (154.0) and it is almost equal in *D. malerkotliana* and *D. ananassae* (193.2 and 188.6). The first mating viability is almost equal in *D. melanogaster* and *D. ananassae*. The difference in fecundity and productivity between 1^{st} and 2^{nd} mating of all species is significant (t- test) except fecundity of *D. bipectinata*. The difference in fecundity and productivity between species is significant in first mating ($F=8.026$ and $F=2.698$, $df_1=3$, $df_2=116$).

Percentage of viability in *D. malerkotliana* (53.90) and *D. bipectinata* (50.05) of first mating is almost equal to second mating of *D. ananassae* (52.09). In all the species, viability of second mating is lesser than first mating except in *D. melanogaster* (69.92). The percentage of viability gradually increased from *D. bipectinata* to *D. malerkotliana* is with 8% and *D. malerkotliana* to *D. ananassae* is with 3% in second mating.

4. Discussion

Courtship behaviour in *Drosophila* consisting of a chain of stimulus response reaction between male and female and also transfer of sperm from male to female is the primary function of mating in sexually reproducing animals. Once a virgin female *Drosophila* has mated, she is usually unwilling to accept another male for sometime because, after mating behavioral and physiological changes occur, including decrease in receptivity to further mating, male attractiveness and life span, increase of oogenesis ovulation and oviposition rates, storage and utilization of sperm [5,25,26].

The reproductive behavior of a male can be affected by its interaction with other sexually mature males during its early immature stage [27,28]. Male density prior to assay can have major effect on male courtship. *Drosophila* males held at high density tend to have lesser courtship intensity compared to males held in isolation [29]. In the present experiment males were assayed in the absence of a competitor to nullify the interference.

The basic asymmetry between the sexes results in sexual conflict over remating, which suggests that male fitness increases monotonically with increased mating rate. Remating results in sperm competition and increases the fitness; each mating provides an opportunity to produce more offspring [8]. Female intensify their reproductive success by increasing the viable eggs produced and also depends on female age. While single or a few mating are sufficient for females to maximize their reproductive success [1-3,5,30].

Mating latency is a measure of female receptivity and male courtship efficiency and intensity. Mating latency indicates both vigor of males and females receptivity. Higher the vigor of males and receptivity of females, shorter is the mating latency during this period courtship acts are performed mostly by males to increase receptivity to females and to make her sexually excited [31]. *D. melanogaster* shows more vigorous compared to other species and *D. malerkotliana* is less vigorous.

Mating time and remating speed is not an exclusive part of male mating activity. It is determined by both males and females involved in the cross, it depends on their body size and environmental parameters [32]. Mating time varies due to different courtship patterns in different species of *Drosophila* [33,34]. Mating time differs in different species and between first and second mating. First mating time is more than second mating time in all the species analysed (Table.1).

Longer copulation is an adaptation of males which could reduce the risk of sperm competition with future ejaculates with the help of a mating plug, which prevent the female from remating before oviposition [35]. Longer copulation leads to a higher reproductive success for male. Males that mated with non virgin females experienced sperm competition and lesser duration of copulation than virgin females [5,8]. Present study shows that, *D. melanogaster* has longer mating time and more productivity; where as *D. ananassae* has less mating time and high productivity. Even though the virgin female were introduced in second mating, mating time is less than first mating time, it indicates that the mating time depends on male virginity.

The duration of copulation is also affected by age [19]. Old males consistently less active than young ones [36] but older males were found to be more successful under competitive conditions compare to young males [37]. Mating duration is species specific it varies from 5 seconds (Scaptodrosophila) to 62 minutes in *D. n. nasuta* [38,39]. For the present experiment, same aged flies were used. *D. melanogaster* shows more mating time (I-20.4, II-18.4) and *D. ananassae* shows less mating time in both first and second mating (I-5.4, II-3.4).

Percentage of remating frequency and remating time in different species of *Drosophila* in both natural and laboratory population shows significant variation [4]. Male remating time varies from 7.41 to 21.59 and mating frequency varies 84 to 96 percent [8]. In the present experiment, *D. bipectinata* takes (67.0 min) more time to remate than other species. Pavkovic and Kekic [6] studied mating latency and mating time in *D. melanogaster* and reported that, mating time lost within 20 minutes and 18 minutes in first and second mating respectively. The present result of *D. melanogaster* is in confirmation with pavkovic and kekic [6].

Fecundity is the major determinate of female fitness and influenced by her mate [40] and also the larval food availability can generate large variance in adult female body size, which is known to be positively associated with fecundity [41]. Fecundity influences other life history and trade offs and affects reproductive and mortality costs. Co relation between fecundity, mortality and longevity has been studied in various species [42].

The number of offspring produced by different mating in 12 hour mating period of *D. melanogaster* from 1 to 10 mating decreased from 68 to 24.86 [43]. Hiremani and Shivanna [15] reported that, the fecundity and productivity decreases from first time mating to fourth time mating in *D. ananassae* (639 to 274.7 and 407.4 to 214.4) and in *D. varians* (680 to 180 and 544 to 141). Egg viability decreases as larval density increases [17]. In the present experiment fecundity and productivity of first mating is more than second mating in all the species.

The above result reveals that fecundity, productivity and viability depend on mating latency, mating time and remating duration. First mating time is more than second mating time in all the species. The productivity and percentage of viability increase with mating time in all the species except, *D. ananassae* whereas it showed more fecundity and productivity even though the mating time is less. Mating time, fecundity, productivity and viability is more in first mating than second mating except viability of second mating in *D. melanogaster*.

5. Summary

By observing these we confirmed that mating latency and remating duration is less and mating time is more in *D. melanogaster* and mating time is less in *D. ananassae*. Mating time, fecundity, productivity and viability of first mating is more compared to second mating irrespective of species except the second mating viability of *D. melanogaster*, because of less duration between mating. Duration between first and second mating is more, whereas mating time and viability is less in *D. bipectinata*. Fertility increases with mating time except in *D. ananassae*. Fecundity, Productivity and fertility vary with species. Even though *D. melanogaster* has more percentage of viability it takes more time in mating. Whereas, mating time is less in *D. ananassae*, fecundity, productivity and percentage of viability is more compared to other species. Thus, *D. ananassae* is more fit than other species. Female fitness varies with virginity of male.

Acknowledgement

Thanks are due to *Drosophila* Stock Centre Department of Zoology, University of Mysore, 'Manasagangotri' Mysore, for *Drosophila* stocks, UGC- SAP and UGC-MRP F No.37-241/2009 for financial assistance to Dr. N. Shivanna.

References

[1] A. J. Bateman, “Intra-sexual selection in Drosophila”. Heredity, vol. 2, pp. 349-368. 1948.

[2] R. L. Trivers, “Parental investment and Sexual Selection” .In: Campbell. B. (ed.) Sexual Selection and the Descent of Man. pp.136- 179. 1972.

[3] M. Andersson, “Sexual selection. Princeton”, NJ: princeton University Press. 1994.

[4] S. R. Singh, B. N. Singh and H. F. Hoenigsberg, “Female remating, sperm competition and sexual selection in Drosophila”. Genetics and Molecular Research, vol. 1(3), pp. 178-215. 2002.

[5] S. R. Singh and B. N. Singh, “Female remating in Drosophila: comparison of duration of copulation between first and second mating in six species”. Current Scince, vol. 86(3) pp. 465-470. 2004.

[6] S. Pavkovic-lucic and V. Kekic, “Influence of mating Experience on mating latency and copulation duration in Drosophila melanogaster females”. Russian Journal of Genetics, vol. 45(7) pp. 875–877. 2009.

[7] E. B. Spiess, “Mating Propensity and Its Genetic Basis in Drosophila, Essays in Evolution and Genetics in Honor of Theodosius Dobzhansky, Hecht, M. K. and Sreere, W .C ., Eds., Amsterdam”. pp. 315-379. 1970.

[8] S. R. Singh and B. N. Singh, “Male remating in Drosophila ananassae: Evidence for interstrain variation in remating time and shorter duration of copulation during second mating”. Zoological Science, vol.17, pp. 389-393. 2000.

[9] L. Partridge, K. Flower, S, Trevitt and W. Sharp, “An examination of the effects of males on the survival and egg-production rates of Drosophila melanogaster”. J. Insect Physiol. vol.32, pp. 925-929. 1986.

[10] R. Bonduriansky, “The evolution of male mate choice in insect: a synthesis of ideas and evidence”. Biological reviews of the cambridge philosophical society. vol 76, pp. 305-339. 2001.

[11] C. Gillott, “Male accessory gland secretions: Modulators of Female Reproductive Physiology and Behavior”. Annu. Rev. Entomol. vol. 48, pp.163-184. 2003.

[12] S. Roopashree, K. Ravi Ram, and S. R. Ramesh, “Genotype environment interaction and fecundity in Drosophila”. Drosophila information service. vol. 84, pp. 93-95. 2001.

[13] M. S. Krishna, and S. N. Hegde, “Reproductive success of large and small flies in Drosophila bipectinata complex”. Curr. Sci. vol. 72, pp.742- 750. 1997.

[14] D. D. Sameoto and R. S. Miller, “Factors controlling the productivity of Drosophila melanogaster and D. Simulans”. Ecology. vol. 47, pp. 695-704. 1966.

[15] R. B. Hiremani and N. Shivanna, “Accessory gland secretory proteins in relation to fitness parameters of Drosophila ananassae and Drosophila varians”. Entomological research, vol. 40, pp. 251- 258. 2010.

[16] M. E. Turner and W. A. Anderson, “Multiple mating and female fitness in Drosophila melanogaster”. Evolution, vol. 37, pp. 714-723. 1983.

[17] D. E. L. Promislow, C. F. Jung and M. L. Arnold, “Age-specific fitness components in hybrid female of Drosophila pseudoobscura and Drosophila persimilis”, The American Genetic Association, vol. 92, pp. 30-37. 2001.

[18] G. Ribo, J. Ocana, and A. Prevosti, “Effect of larval crowding on adult mating behaviour in D. melanogaster”. Heredity. vol. 63, pp. 195-202. 1989.

[19] S. Koref- Santibanez, “Effects of age and experience on mating activity in the sibling species Drosophila pavani and Drosophila gaucha”. Behavior Genetics, vol. 31, pp.287-297. 2001.

[20] L. Levine, M. Asmussen, O. Olvera, J. R. Powell, M. E. Delarosa, V. M. Salceeda, M. I. Gaso, J. Gujman, and W. W. Anderson, “Population genetics of Mexican Drosophila. V. A. high rate of multiple inseminations in a natural population of Drosophila pseudoobscura”. Am. Nat. vol. 116, pp. 493-503. 1980.

[21] L. Partridge, and M. Farquhar, “Sexual activity reduces lifespan of male fruit flies”. Nature, vol. 294, pp. 580-582. 1981.

[22] K. P. Nicholas, F. G. Laura and A. Deborah, Roach. “Mating frequency and inclusive fitness in Drosophila melanogaster”. The American naturalist, vol. 171, pp. 10-21. 2008.

[23] T. A. Markow, M. Quaid, S. Kerr, “Male mating experience and competitive courtship success in D. melanogaster”. Nature. vol. 276, pp.821-822. 1978.

[24] N. Shivanna, G. S. Siddalingamurthy, and S. R. Ramesh, “Larval pupation site preference and its relationship to the glue proteins in a few species of Drosophila”. Genome, vol. 39, pp. 105-111. 1996.

[25] Y. Fuyama, “Genetic evidence that ovulation reduces sexual receptivity in Drosophila melanogaster females”. Behaviour Genetics, vol. 25, pp. 581-587. 1995.

[26] U. Tram, and M. F. Wolfner, “Seminal fluid regulation of female sexual attractiveness in Drosophila melanogaster”. Proceedings of National Academy Science, vol. 95, pp. 4051-4054. 1998.

[27] D. A. Gailey, F. R. Jackson, and R. Siegel, “Male courtship in Drosophila: The Conditioned response to immature males and its genetic control”. Genetics, vol. 102, pp. 771-782. 1982.

[28] S. P. McRobert and L. Tompkins, “Two consequences of homosexual courtship performed by Drosophila affinis males”. Evolution, vol. 42, pp. 1093-1097. 1988.

[29] M. A. F. Noor, “Environmental effects on male courtship intensity in Drosophila pseudoobscura (Diptera:Drosophila)”. Journal of Insect behaviour, vol.10, pp. 305-312. 1997.

[30] M. Prathibha and M. S. Krishna, “Greater mating success of middle- agd females of D. ananassae”. Zoological Studies, vol. 49(6), pp. 806-815. 2010.

[31] M. Nazari and S.N. Hegde, “Effect of fluoxetine on the courtship latency, mating latency and copulation duration of Drosophila melanogaster”. J.Postgrade. Med. Inst. vol. 20, pp. 58-63. 2006.

[32] S. Pavkovic-lucic and V. Kekic, “Is body size a sexually-selected trait in Drosophila hydei males?”. Archives of Biological sciences, vol. 59, pp. 21-22. 2007.

[33] A. Hoikkala, and P. Welbergen, “Signal and responses of females and males in successful and unsuccessful courtship in three Hawaiian lek mating Drosophila species”. Anim. Behav. vol. 50, pp. 177-190. 1995.

[34] A. Hoikkala, S. Crossley and C. Castillo-Melendez. “Copulatory courtship in Drosophila birchii and Drosophila serrata, species recognition and sexual selection”. J. Insect Behav. vol.13, pp. 361-373. 2000.

[35] A. S. Gilchrist, and L. Partridge, "Why it is difficult to model sperm displacement in Drosophila melanogaster: The relation between sperm transfer and copulation duration”. Evolution. vol. 54, pp. 534-542. 2000.

[36] Kazuhiko-Kosuda. “The aging effect on male mating activity in Drosophila melanogaster”. Behavior genetics, vol. 15(3), pp. 297-303. 1985.

[37] E. L. Cruz, A. M. Therese and Peter Yaeger. “Relative male age, fertility, and competitive mating success in Drosophila melanogaster”. Behavior genetics. vol. 10(2), pp. 163-170. 1980.

[38] J. Grossfield, and R. F. Rockwell. “Courtship behaviour of endemic Australian Drosophila. Scaoptodrosophila - the lativitata and fumida groups”. Am. Midl. Natur. vol. 101, pp. 257- 268. 1979.

[39] H. Spieth. “Mating behavior with the genus Drosophila”. Bull. Am. Mus. Nat. Hist. vol. 99, pp. 401-474. 1952.

[40] S. Pitnick. “Male size influences mate fecundity and remating interval in Drosophila melanogaster”. Animal Behaviour. vol. 41(5), pp.735-745. 1991.

[41] A. Lefranc, and J. Bundgaard. “The influence of male and female body size on copulation duration and fecundity in Drosophila melanogaster”. Hereditas. vol. 132, pp. 243-247. 2001.

[42] V. N. Novoseltsev, J. A. Novoseltseva and A. I. Yashin, “What does a fly’s individual fecundity pattern look like? The dynamics of resource allocation in reproduction and ageing”. Mech. Age. Develop. vol.124, pp. 605 – 617. 2003.

[43] O. Stromnaes and I. Kvelland. “Sexual activity of Drosophila melanogaster males”, Hereditas. vol. 48 pp. 442-470. 1962.