(Mettler *et al.*, 1977; Knibb *et al.*, 1981) that the populations near the equator incline to have more inversions, the Iriomote population was found to have much more inversions than the mainland and Ogasawara populations (No. 3, 4, and 5). Its arm average (0.368) was less than that of the Guam populations, but the frequency of *In(3L)P* (0.347) was the highest in the present study. It confirmed the result of Inoue *et al.* (2002) that *In(3R)P* is relatively adaptive in the South-West Islands in comparison with the other regions. *Rare Cosmopolitan* inversions, *In(3R)C* and *In(3R)Mo*, were not found there as well as Guam (No. 1 and 2) and Ogasawara (No. 5).

Figure 1 shows the distributions of *In(3R)P* frequencies by almost all the data from 1944 to 2013 all over the world (see the references). The samples of less than 40 genomes examined were not used in Figure 1. A total of 241 separate local populations were used, each of which was the highest frequency in each given locality. The only one highest value among the data at differing sampling time was used in each locality. The numbers of populations of *In(3R)P* frequencies were counted by every 5% level. A total of 77 local natural populations was put between 0 ~ 5% level, 53 populations between 5 ~ 10% level, 31 populations between 10 ~ 15% level, 25 populations between 15 ~ 20% level, and 15 populations between 20 ~ 25% level. After that level, the number of populations decreased gradually to the zero point. Only a few populations showing more than 65% were found in the South-west Islands of Japan, Florida in the U.S.A., and New Guinea, among which the highest frequency (0.890) was from the Iriomote 1979 population (Inoue *et al.*, 1994). Thus, the present data of 0.940 from the Guam 2013 population with a total of 262 genomes examined is so far the highest frequency for *In(3R)P* in the world.

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References: Afonso, J.M., M. Hernandez, G. Padron, and A.M. Gonzalez 1985, Genetica 67: 3-11; Choi, Y., 1977, Genetica 47: 155-160; Choi, Y., Y.M. Ha, and S.K. Kim 1984, Dros. Inf. Serv. 60: 76; Das, A., and B.N. Singh 1991, Genome 34: 618-625; Gonzalez, A., and J.L. Mensua 1987, Genet. Sel. Evol. 297-306; Inoue, Y., R. Ogoshi, and M. Watada 2011, Dros. Inf. Serv. 94: 69-73; Inoue, Y., T. Watanabe, and T.K. Watanabe 1984, Evolution 38: 753-765; Inoue, Y., and M. Watada 2006, Dros. Inf. Serv. 89: 77-81; Inoue, Y., Y. Igarashi, and T. Watanabe 1994, Dros. Inf. Serv. 75: 49-51; Inoue, Y., and Y. Igarashi 1994, Jpn. J. Genet. 69: 105-118; Inoue, Y., and T.K. Watanabe 1979, Jpn. J. Genet. 54: 69-82; Inoue, Y., M. Watada, and M. Itoh 2002, Genetica 114: 25-33; Koryakov, D.E., D.V. Demakova, M.L. Balaso, S.A. Demakov, I.V. Makunin, and I.F. Zhimulev 1994, Dros. Inf. Serv. 75: 68-69; Knibb, W.R., J.G. Oakeshott, and J.B. Gibson 1981, Genetics 98: 833-847; Lefevre, G., 1976, In: *The Genetics and Biology of* Drosophila, Vol. 1a. (Ashburner, M., and E. Novitski, eds.), pp. 31-66. Academic Press: New York; Mettler, L.E., R.A. Voelker, and T. Mukai 1977, Genetics 87: 169-176; Mourad, A.M., and G.S. Mallah 1960, Evolution 14: 166-170; Paik, Y.K., K.C. Sung, and Y. Choi 1998, Genetica 101: 191-198; Paik, Y.K., 1979, Korean J. Genet. 1: 18-27; Roca, A., F. Sanches Refusca, C. Grana, and M.A. Comendador 1982, Dros. Inf. Serv. 58: 130-131; Sanchez-Refusta, F., and E. Garcia-Vazquez 1986, Dros. Inf. Serv. 63: 118-119; Singh, B.N., and A. Das 1990, Genome 33: 311-316; Singh, B.N., and A. Das 1992, J. Heredity 83: 227-230; Stalker, H., 1976, Genetics 82: 323-347; Warters, M., 1944, Univ. Texas Publ. 4445: 129-174; Yang, H.Y., and K-I. Kojima 1972, Univ. Texas Publ. 7213: 229-236; Zacharopoulou, A., and M. Prelecanos 1980, Genetica 15: 105-111.

Organically grown banana fruit effects on reproductive fitness of *Phorticella straiata.*

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Introduction

Diet is one of the external factors known to affect on an organism's growth, development, reproduction, and survival (Sisodia and Singh, 2012). The diet consumed by an individual can be grouped

broadly into quantitative, which is dependent on food availability, and qualitative, which is dependent on nutritional constituents of the food. It is believed that consumption of diet exposed to pesticides has detrimental effects on the health of an individual. It has been shown that individuals exposed to high levels of pesticides face increased risks of developing cancers such as prostate cancer (Alavanja *et al.,* 2003).

Nowadays, popularity and consumption of organic fruits and vegetables is growing at an exponential rate due to a belief that such foods are healthier and free of pesticides. Further studies on comparison between organically and conventionally grown foods have shown that organic samples have fewer pesticide residues when compared to conventionally grown food (Baker *et al.,* 2002). A recent study has shown positive effects of organic foods on the health of *D. melanogaster*, where flies reared in organically grown food showed overall better health (Chhabra *et al.,* 2013). More studies are required in other species or genera to understand health benefits of organic fruits. Therefore, the present study has been undertaken in *P. straiata* to study effects of organic banana on reproductive performance

P. straiata (Nirmala and Krishnamurthy, 1974) is a Drosophilid insect discovered from Karnataka, India belonging to group Drosophilidae. This species also has all characteristics of a good laboratory tool to analyze genetic and evolutionary problems as that of the genus *Drosophila* (Sarat and Hegde, 2003).

Materials and Methods

Establishment of experimental stock

The experimental stock of *P. straiata* was obtained from the progenies of 50 isofemale lines collected from Chamundi hills, Mysore, India. In each generation flies obtained from these culture bottles were mixed together and redistributed to 20 different culture bottles containing wheat cream agar media (100 g of jaggery, 100 g of wheat powder, 8g of *Agar* was boiled in 1000 ml of double distilled water and 7.5 ml of Propionic acid was added) each with 20 flies (10 males and 10 females). These flies were maintained at 22°±1°C with a relative humidity of 70% in a 12 hr dark: 12 hr light cycle. This procedure was carried out for three generations to acclimatize flies to lab conditions. At the fourth generation, eggs were collected using Delcour's procedure (1969). Eggs (100) were seeded to each culture bottle containing wheat-cream agar media / organically banana based media / conventionally banana fruit based media (1 kg of fine paste of organically / conventionally banana was boiled in 1 l of double distilled water containing 10% *Agar*. To this 7.5 ml of Propionic acid was added). When pupae were formed, females and males were isolated and were allowed to eclose and aged for five days to test for virginity. These flies were used for present experiments. Organic fruits were purchased from organic food product distributors, *Hasiru Organic Shop*, Mysore, which is a unit of Karnataka State Natural Farming Movement.

Organically grown banana fruit effect on larval feeding in P. straiata

Third instar larvae obtained from eggs collected (±2 hours) from wheat-cream agar media grown flies using Delcour's procedure (1969) were used to study feeding behavior. Each larva was placed in a vial containing wheat-cream agar / organically grown fruit based media / conventionally grown fruit based media and observed under a stereomicroscope. The back and forth movement of the proboscis was recorded for a minute. A total of 50 replicates were run separately for each of organic / conventional / wheat-cream agar media grown larvae. Separate experiments were carried out for larvae of organic / conventional banana/ wheat-cream agar media.

Organically grown banana fruit effect on reproductive performance in P. straiata

Four-day-old virgin females and unmated males from the wheat-cream agar / organic banana based media / conventional banana based media were aspirated into an Elens-Wattiaux chamber (Elens and Wattiaux, 1964). Each pair was observed for an hour. The pairs which did not mate within this time limit were discarded. Mating latency (time between introduction of a pair of male and female flies into the Elens-Wattiaux chamber until the initiation of copulation of each pair) and copulation duration (time between initiation to termination of copulation of each pair) were recorded. Mated pairs were transferred once in 24 hr to a new vial containing 5 ml of normal media until death. Total number of eggs laid and progeny obtained

were recorded. A total of fifty replicates were performed separately for wheat-cream agar media / organically / conventionally fruit based media grown flies.

Organically grown banana fruit effect on ovariole number in P. straiata

Four-day-old virgin females were etherized and killed. The thorax of these flies was dissected out using a pair of fine dissection needles in physiological saline under a binocular stereomicroscope. The ovaries were separated and the total number of ovarioles in either the right or the left ovary was noted (Hegde and Krishna, 1997).

Results

Figure 1 provides the larval feeding rate in different diets. It was found that highest larval feeding rate occurred in flies grown in organic fruit based media compared to conventional fruit based media and wheat cream agar media. Flies fed on conventional fruit based media performed least among the three diets studied. One-way ANOVA followed by Tukey's *post hoc* test carried out using SPSS version 10.0 on the above data showed significant variation in feeding rate between diets (Table 1). Tukey's *post hoc* test also showed that flies grown on organic banana media had significantly greater feeding rate than those flies grown in conventional fruit based media grown flies and wheat cream agar media grown flies.

Table 1. One way ANOVA on feeding rate, mating latency, copulation duration, fecundity and ovarioles number in *P. straita.*

Parameter	Source	Type III Sum of Squares	df	Mean Square	F value
Feeding rate (in no.)	Diet	34421.08	2	17210.540	524.214**
	Error	4826.180	147	32.831	
	Total	2073687.00	150		
Mating latency (in min)	Diet	85.13024	2	42.56512067	338.3274**
	Error	18.49414	147	0.125810463	
	Total	2843.6	150		
Copulation duration (in min)	Diet	45.62028	2	22.81014067	88.43846**
	Error	37.9144	147	0.257921061	
	Total	1486.729	150		
Fecundity (in no)	Diet	27033.24	2	13516.62	250.1735**
	Error	7942.26	147	54.02897959	
	Total	876477	150		
Ovarioles number (in no.)	Diet	1654.24	2	827.12	57.17097**
	Error	2126.72	147	14.46748299	
	Total	134850	150		

**Significant at 0.01 level ($P < 0.01$)

Mating latency of flies grown in different diets is provided in Figure 2. It was observed that flies grown in organic banana based media had taken lowest time to initiate copulation whereas flies grown in wheat cream agar based media had taken highest time to initiate copulation. One-way ANOVA followed by Tukey's *post hoc* test carried out on the above data showed significant variation in mating latency between

flies grown in different diets (Table 1). Flies grown on organic banana fruit took significantly greater time to initiate copulation than those flies grown on convention banana fruit or wheat cream agar media by Tukey's *post hoc* test.

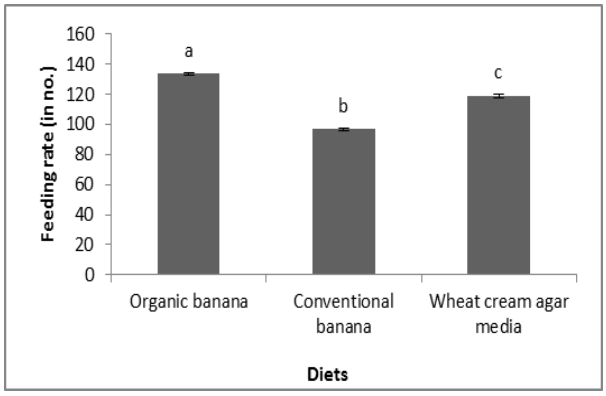

Figure 1. Diet effect on feeding rate in *P. straiata.* (Different letters on the bar graph indicate significant at 0.05 level by Tukey's *post hoc* test).

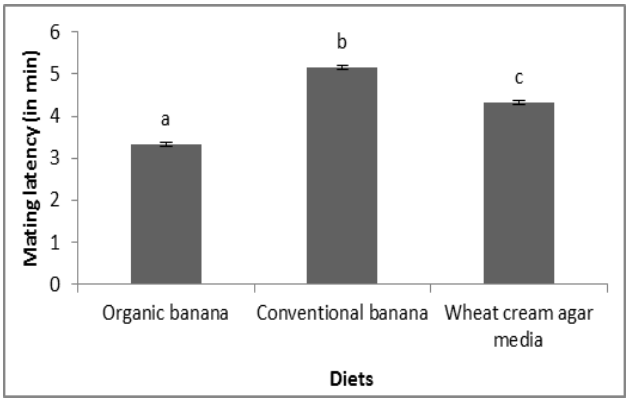

Figure 2. Diet effect on mating latency in *P. straiata.* (Different letters on the bar graph indicate significant at 0.05 level by Tukey's *post hoc* test).

Copulation duration of flies reared on different diets (Figure 3) shows that flies reared on organic banana fruit copulated longer while flies grown on wheat cream agar based media had copulated for shorter period. One-way ANOVA followed by Tukey's *post hoc* test carried out using SPSS version 10.0 (Table 1) showed significant variations in copulation duration of flies reared between different diets. Tukey's *post hoc* test also showed that flies grown in organic banana copulated significantly longer than those flies reared in conventional banana based media and wheat cream agar media.

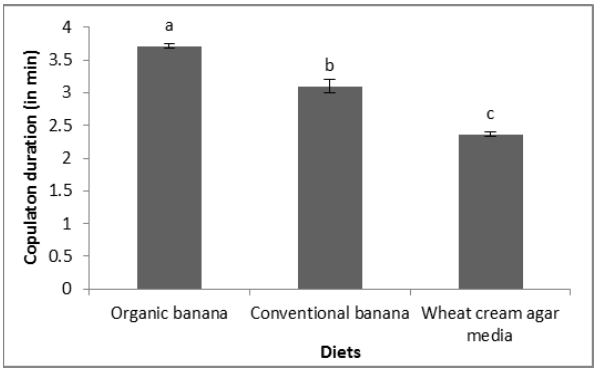

Figure 3. Diet effect on copulation duration in *P. straiata.* (Different letters on the bar graph indicate significant at 0.05 level by Tukey's *post hoc* test).

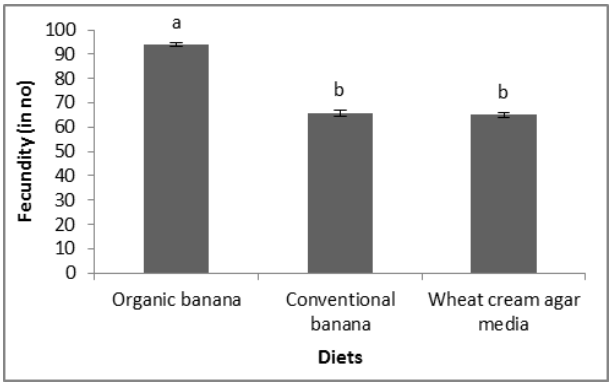

Figure 4. Diet effect of female on fecundity in *P. straiata.* (Different letters on the bar graph indicate significant at 0.05 level by Tukey's *post hoc* test).

Fecundity data of flies reared in different diets is provided in Figure 4. It was noticed that egg production was greater in flies reared on organic banana compared to flies reared on conventional banana and wheat cream agar media. Fecundity data subjected to one-way ANOVA followed by Tukey's *post hoc* test showed significant variation in fecundity between flies reared in different diets (Table 1). Tukey's *post hoc*

test also showed that flies reared on organic banana had significantly greater egg production than those flies reared in conventional banana and wheat cream agar media.

Female flies reared in organic media had greater number of ovarioles when compared to both conventional banana fruit based media as well as wheat-cream agar media (Figure 5). One-way ANOVA followed by Tukey's *post hoc* test carried out on the above data showed significant variation in ovarioles between different diets (Table 1). Flies reared in organic banana media had significantly greater number of ovarioles than flies reared in conventional banana fruit based and wheat cream agar media.

Mean wing length of female grown in different diets is provided in figure (not shown). It was noticed that mean wing length of females reared in organic banana had slightly larger wing length than those females grown in conventional banana and wheat cream agar media. Mean wing length data of females reared in different diets subjected to one-way ANOVA showed insignificant variation in female wing length between different media.

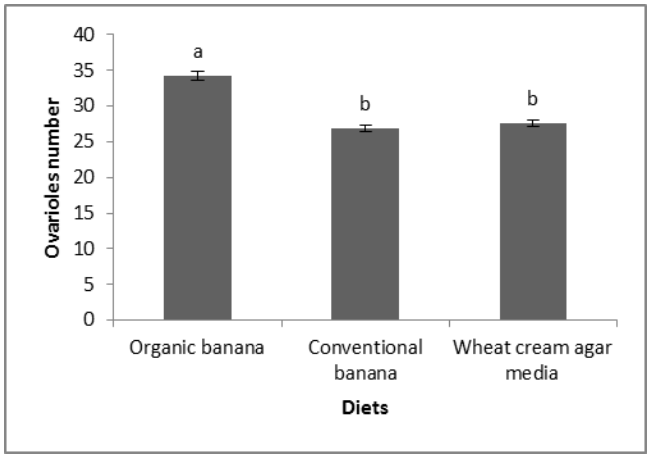

Figure 5. Diet effect on ovarioles in *P. straiata.* (Different letters on the bar graph indicate significant at 0.05 level by Tukey's *post hoc* test).

Discussion

Diet is one of the important environmental factors known to affect organism's growth and development (Sisodia and Singh, 2012). The quality and quantity of food consumed by the organism has an impact on health and reproductive fitness of an organism. Therefore, in the present study *P. straiata* flies were fed with a diet made of organic banana / conventional banana/ wheat cream agar based media to study its effect on reproductive performance.

In *P. straiata* larval stage is the active feeding stage; they feed continuously accompanied by a massive increase in mass. This is true with other *Dipteran* species too (Melcher *et al.,* 2007). However, inhibition threshold exists for feeding on new or full tasting food (Melcher et al., 2007). Such inhibition threshold is not observed in larvae of *P. straiata* fed on organic banana fruit when compared to larvae feeding on conventional banana fruit or wheat cream agar media (Figure 1 and Table 1). The greater the larval feeding, the greater is the quantity of food taken inside the organism. Therefore, larvae of *P. straiata* had taken significantly greater quantity of organic banana than larvae grown on conventional grown banana fruit and wheat cream agar media.

All biological processes are directly related to reproduction that plays an important role in determining fitness. It was shown that reproductive capacity of an organism is a good index of fitness that go through repeated cycles of rapid population growth, and it is evolved as a way of species to maximize their potential of survival. Quality and quantity of food taken by an organism has an influence on reproductive performance (Sisodia and Singh, 2012). In the present study, effect of organic banana fruit on fitness traits, such as mating latency, copulation duration, fecundity, and ovariole number, has been tested in *P. straiata.*

Time taken to initiate copulation forms mating latency; it is an important component of mating behavior in *P. straiata.* Flies which took a shorter time to initiate copulation were fast maters than those flies which took longer time to initiate copulation. In the present study in *P. straiata* organic banana fruit grown males took the shortest time to initiate copulation while males grown on wheat cream agar media had taken the longest time to initiate copulation (Figure 2 and Table 1). This suggests that males grown on organic banana fruit were fast maters whereas males grown on wheat cream agar media were slow mated. This difference in mating latency between different diets could be attributed to the difference in the nutrients level. Organic banana fruit had greater nutrient qualities than conventional banana fruit (Chabra *et al.,* 2013). In species of

Drosophila it was also shown that mating latency is also affected by body size, age, and diet (Hegde and Krishna, 1997; Somashekar and Krishna 2011; Singh and Sisodia, 2012). In *P. straiata* courtship activities of male and female culminate in copulation (Latha and Krishna, 2014). Longer copulation is an adaptation of males which could reduce the risk of sperm competition with future ejaculations with the help of mating plug which prevents the female from remating before oviposition (Gilchrist and Partridge, 2000). In the present study it was found that flies grown on organic banana fruit had copulated significantly longer compared to flies grown on non-organic banana and wheat cream agar media (Figure 3 and Table 1). Our results in *P. straiata* confirm work of organic banana fruit on reproduction (Chabra *et al*., 2013). Longer the duration of copulation, greater is the transfer of accessory gland proteins and sperm to the mated female (Hegde and Krishna, 1997; Somashekar and Krishna, 2011).

Fecundity is the most obvious trait that influences the reproductive ability of female usually considered as female fitness component. It is known that fecundity is influenced by age, body size, and diet of an organism (Krishna and Hegde 1997). In *P. straiata* flies grown on organic banana fruit based media had greater number of ovarioles compared to flies grown in other two media (Figure 4 and Table 1). In the present study, flies used were of same age and were grown in same conditions but foods were different. Therefore, in the present study quality of food had influenced fecundity in *P. straiata*. Ovariole number was positively correlated with fecundity (Krishna and Hegde, 1997). They also pointed out that greater the ovariole number the greater is the fecundity. Therefore, in the present study ovariole numbers of flies grown on different diets were analyzed in *P. straiata*. Flies grown on organic banana fruit had significantly greater number of ovarioles than those flies grown in conventional banana fruit and wheat cream agar media (Figure 5 and Table 1). Thus these studies in *P. straiata* suggest that organic fruit has positive effect on reproduction**.** Organic banana fruit flies had greater reproductive performance and fitness.

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References: Sisodia, S., and B.N. Singh 2012, PLoS ONE: 7(10): 1-9; Alavanja, M.C.R., C. Samanic, M. Dosemeci, J. Lubin, R. Tarone, C.F. Lynch, C. Knott, K. Thomas, J.A. Hoppin, J. Barker, J. Coble, D.P. Sandler, and A. Blair 2003, American Journal of Epidemiology 157(9): 800-814; Baker, B.P., C.M. Benbrook, E. Groth III, and K.L. Benbrook 2002, Food Additives and Contaminants 19(5): 427-446; Chhabra, R., S. Kolli, and J.H. Bauer 2013, PLoS ONE 8(1): 1-8; Delcour, J., 1969, Dros. Inf. Serv. 44: 133-134; Elens, A.A., and J.M. Wattiaux 1964, Dros. Inf. Serv. 39: 118-119; Hegde, S.N., and M.S. Krishna 1997, Current Science 72: 747-750; Melcher, C., R. Bader, and M.J. Pankratz 2007, Journal of Endocrinology 192(3): 467-472; Sarat, C., Yenisetti, and S.N. Hegde 2003, Zool. Stud. 42(1): 203-210; Nirmala, S.S., and N.B. Krishnamurthy 1974, J. Mysore Univ. 26: 162–167; Somashekar, K., and M.S. Krishna 2011, Zool. Stud. 50: 1-15; Gilchrist, A.S., and L. Partridge 2000, Evolution 54: 534-542; Latha, M., and M.S. Krishna 2014, International Journal of Current Research 6(01): 4705-4713.

Female reproductive traits of the model Hawaiian fly *Drosophila grimshawi.*

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Introduction

The evolutionary success of the endemic Hawaiian Drosophilidae, a monophyletic group of ~1,000 species, owes much to the diversity of reproductive strategies of these flies (Kambysellis and Heed, 1971), in conjunction with adaptation of female reproductive function and oviposition behavior to a broad array of breeding substrates and plant hosts (Heed, 1968; Montgomery, 1975; Kambysellis and Craddock, 1997). Members of the well-studied picture wing group of over a hundred species are typically large, long-lived flies