Original Article

Growth and Development of *Bactrocera carambolae* Drew & Handcock (Diptera: Tephritidae) on three artificial diets

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Abstract

Pollard and tofu waste as main component of food for Fruit fly (*Bactrocera carambolae*) gave better nutrition to support their growth and development than tapioca waste. Pollard, tofu waste and tapioca waste contributed to finish fruit fly life cycles 16, 47, 17, 83 and 18.77 days respectively. Oviposition period of fruit fly on pollard was longer than others. Total number of eggs was laid by fruit fly on pollard about twice to three times higher than others. In addition, longest period of male and female adults was shown by pollard. Net reproduction rate (Ro), mean of life span period (T), intrinsic rate of increase (rm), rate of limit rate of increase (λ) and reproduction value (RVx) shown by life table explained that pollard was suitable material for rearing of *B. carambolae* as diet.

Keywords: artificial diet, *B. carambolae*, pollard, tofu waste, tapioca waste

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INTRODUCTION

Rearing of insects is important activities to support fundamental research such as physiology, biology, genetic, control by using sterile insect male. Artificial diet is needed in case of insect rearing. In artificial diet, some material such as pollard is important material to substitute natural diet for insect.

Natural diet is difficult to use in the large volume, and artificial diet will be solution when large volume of diet needed to rear insects in large number. Generally, pollard is the best material for artificial diet and used by scientists. In the other hand, sugarcane fiber waste, rice skin waste, and corn seed isn't optimal substitution for insect diet.

We provided information related to tofu waste and tapioca waste as fundamental material for oriental fruit fly. In addition we explained life table of oriental fruit fly based on three different materials.

MATERIALS AND METHODS

Research was arranged by Simple Random Design and replicated three times for each treatment. There was three kinds of material for fruit fly diet i.e.: pollard as control, tofu waste, and tapioca waste.

Diet making procedure was same for all materials. Firstly sterile water was boiled then sugar and bread yeast put into it and mixed till sugar completely mixed with water. Secondly, mixed boiling water was moved and waited till water to be cool. Secondly Sodium benzoate and nipagen was put into water and mixed it completely then put material such as pollard, tofu waste and tapioca waste into the water for each. Composition materials for each artificial diet were described in Table 1.

Table 1. Composition of three artificial diets with pollard, tofu waste and tapioca waste as fundamental material.

Materials	Pollard based	Tofu waste	Tapioca waste
Sodium benzoate (gr)	0.1	0.2	0.2
Nipagen (gr)	0.1	0.2	0.2
Bread yeast (gr)	3.6	3.6	3.6
Sugar (gr)	12	12	12
Aquadest (ml)	58	58	58
Pollard* (gr)	26.2	-	-
Tofu waste* (gr)	-	26	-

Completed artificial diet was put into petri-dish 15 cm in diameter. For each artificial diet, 100 eggs were put on each artificial diet. Petri-dish with contained artificial diet and eggs were put into plastic tray (35 x 27 x 10 cm). Saw dust was put under plastic tray as pupation medium. On the top of plastic tray, muslin was used as cover of tray to maintain humidity and to protect from *Drosophila* infestation. Each treatment was replicated into three times.

Percentage of hatching eggs was counted by counting of 100 eggs which were put on petri-dish with wet black fabric under bottom of petri-dish. Observation was conducted from one to two days by using microscope. Percentage of hatching eggs was replicated into three times.

Five days after eggs was put on the artificial diet, generally larvae became third instars' larva and continued to be pupae. Pupae was separated from sawdust by filter, and counted their number and measured their weight.

Period of larvae was counted from the day of egg infestation to pupae stage, and then number time was reduced by period of eggs. Pupa was put into the small bottles one by one, and period of pupae was calculated from pupa occurred to imago occurred. Thirty couples of imago with same ages were observed their productivities and life span of imago.

For each couple of imago was put into plastic cup (10 cm in diameter) with the top of plastic cup covered by net fabric for air circulation. Two centimeters of hole located in side was created for their eggs place. Egg place was created from small cup (3 cm in diameter) and then made hole (0.2 mm in diameter). Imago was provided diet with combination material i.e. sugar and hydrolisate protein (4:1) and put on the bottom of cage ca. 1 teaspoon during rearing. Imago was also gave water by using sponge contained much water. Room temperature was kept between 27-33^{o}C.

Observation of *B. carambolae* growth and development was started from infestation of eggs to death of imago. Production capacity of imago was related to life table. Observation was conducted to: (1) ages of larvae and pupae, (2) number and weight of pupa, (3) number of imago, (4) production capacity of imago (5) life span of imago.

RESULTS AND DISCUSSION

A. Growth and Development of *B. carambolae* on Artificial Diet with Pollard, Tofu Waste and Tapioca Waste as Fundamental Materials

Based on Table 2, there were significant differences between all kind of material diet on growth and development of fruit fly larvae. In addition, there was no different on pupae stage.

Table 2. Mean of egg, larva, pupa and life cycle periods of *B. carambolae*

Phase *)	Artificial diets with fundamental material of		
	Pollard (X ± SE)	Tofu waste (X ± SE)	Tapioca Waste (X ± SE)
Egg (days)	2	2	2
Larva (days)	6.33 ± 0.17 *a*	7.50 ± 0.00 *b*	8.17 ± 0.17 *c*
Pupa (days)	8.13 ± 0.13	8.30 ± 0.3	8.43 ± 0.3
Life cycle (days)	16.47 ± 0.033 *a*	17.83 ± 0.0 *b*	18.77 ± 0.19 *c*

*) notation shown that there is differences between phases and artificial diets with three fundamental material (α: 0.05).

Period of larva on Pollard material, Tofu waste and tapioca waste shown the differences i.e. 6.33, 7.5 and 8.13 days respectively. Pollard material shown the best result for growth and development of each fruit fly stages. Fruit fly can finish their stages on shortest period.

There were significant differences between pupal weights on three fundamental material of artificial diet based on Table 3. In the case of number of pupae and imago, there was no different each other.

Based on pupal weights, occurred number of imago and percentage of occurred imago shown in Table 3, pollard is better material for artificial diet than remaining materials. Pupal weight is related to number of occurred imago. Quality of diet should be important factor to produce pupa with good enough of weight. Between Tofu and Tapioca waste, tofu waste was better than tapioca waste and it was shown by pupal weights and number of occurred imago.

Quality of artificial diet can be indicated by quality and quantity of pupa. Based on the suitable diet, growth and development of fruit fly should be faster than unsuitable one. Figure 1 showed period of female and male adults of fruit fly. If there is enough nutrition on artificial diet, it will suppose growth and development previous stage of fruit fly to be good quality of imago. Kuswadi et al. (1997) reported that on the bad quality of pupa, occurred imago will be easy to die.

In addition, on female adult with shortest period has to finish their pre-oviposition, oviposition and post-oviposition stages shortly than longer one. Period of all oviposition stages between pollard, tofu and tapioca waste was shown on Figure 2. It seemed differences between three artificial diets. In general, pollard can produce good quality of female fruit fly because period of pre-oviposition, oviposition and post-oviposition relatively longer that others. Longer period of all oviposition stage can support good quantity and quality of offspring. Adrewartha et al. (1974) stated that quantity and quality of diet is related to number of offspring produced, life span of imago and development of insect.

Table 3. Mean of pupal weights, number of pupa and imago and also percentage of occurred imago on three fundamental material of artificial diet

Variables *)	Artificial diet with fundamental material of		
	Pollard (X ± SE)	Tofu Waste (X ± SE)	Tapioca Waste (X ± SE)
Pupal weights (mg)	1.31 ±18.56*10^{-5} *a*	1.16 ± 14.98*10^{-5} *b*	1.14 ± 6.71*10^{-5} *bc*
No. of occurred pupa	67.33 ± 14.97	57.33 ± 8.97	70.33 ± 1.76
No. of occurred imago	62.00 ± 11.93	47.67 ± 6.06	39.67 ± 1.20
Occurred imago (%)	92.10	83.20	56.40

*) notation shown that there is differences between phases and artificial diets with three fundamental material (α: 0.05).

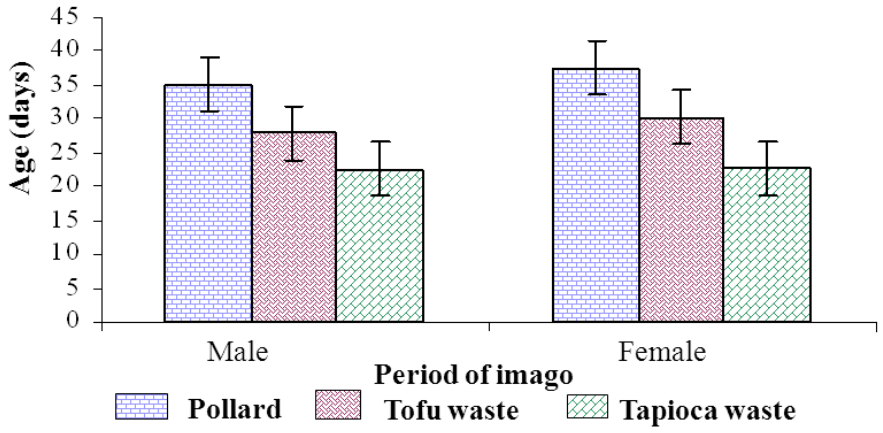

Figure 1. Life spans of male and female fruit fly on three artificial diets

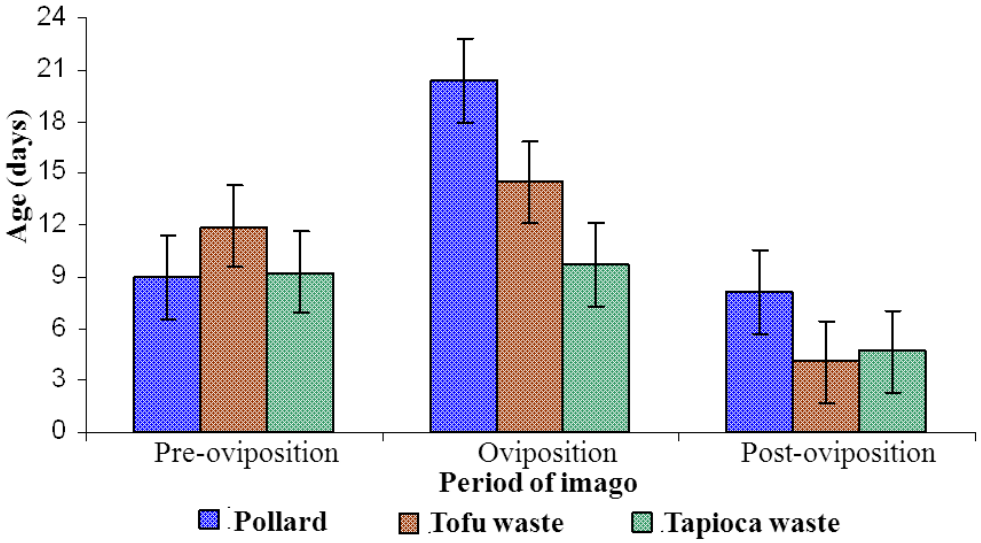

Figure 2. Periods of pre-oviposition, oviposition and post-oviposition of female fruit fly on three different artificial diets.

Table 4. Mean of number of eggs was laid by female adult *B. carambolae* on three different artificial diets

Fundamental material of artificial diets	Mean of number of eggs during female life spans (X ± SE)*)	Mean of number of eggs was laid by female in a day (X ± SE)*)
Pollard	643.33 ± 50.37 *a*	31.63 ± 1.11
Tofu waste	324.37 ± 40.15 *b*	21.05 ± 2.15
Tapioca waste	296.67 ± 102.31 *bc*	33.34 ± 6.31

*) notation shown that there is differences between phases and artificial diets with three fundamental material (α: 0.05).

There were significant differences between three different artificial diets on number of eggs produced by female fruit fly during their life spans (Table 4). In addition the differences of artificial diets were no different on number of eggs produced and laid in a day. Pollard can produce female fruit fly with the better fertility than others. Number of eggs produced by female in their life spans was no different with others.

Survival rate of imago (l_x) and offspring of female in a day (m_x) on Figure 3 described suitability of diet to the growth and development of *B. carambolae*.

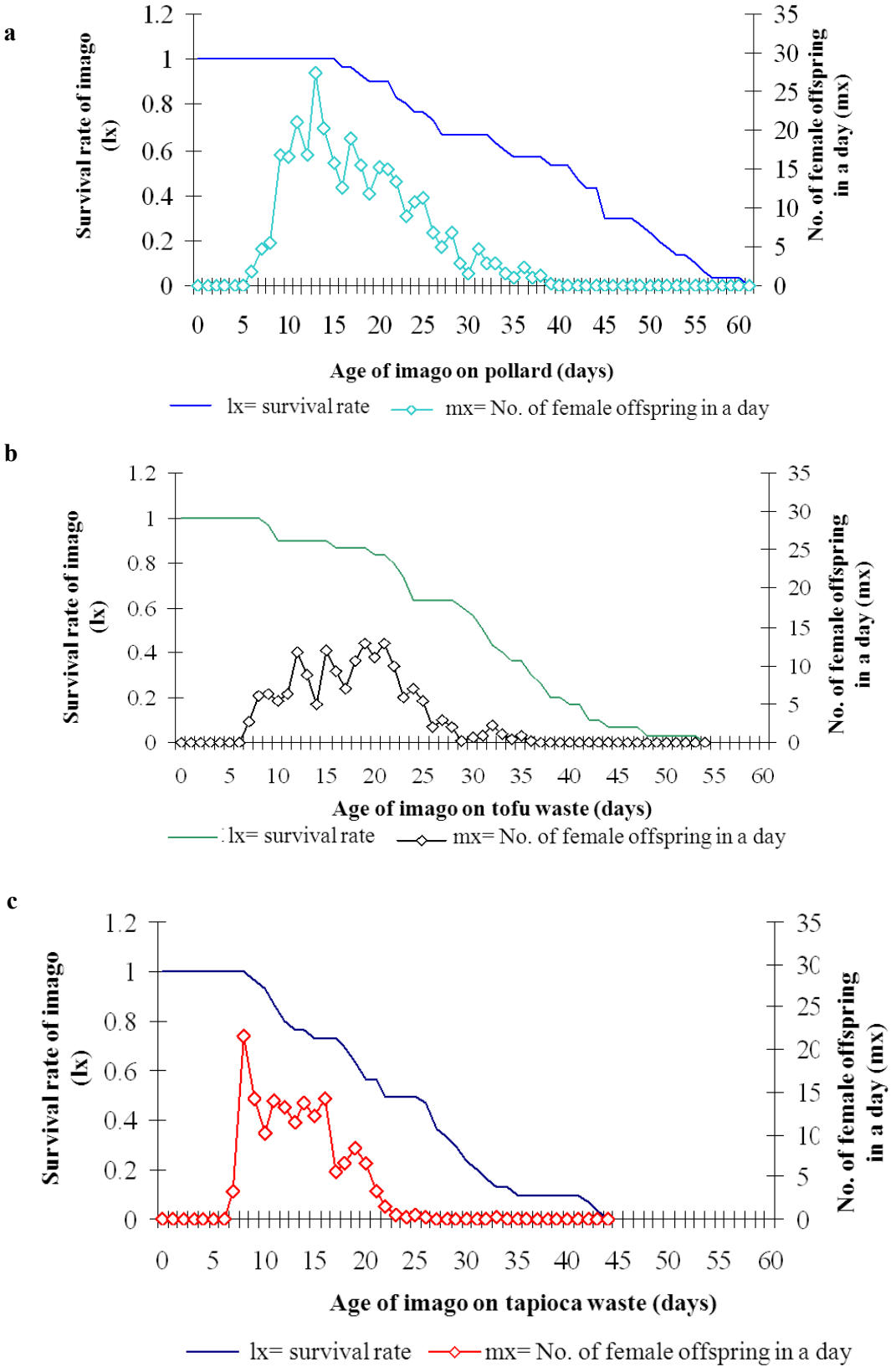

Figure 3. Survival rate of Imago (l_x) and number of female offspring in a day (m_x) was produced based on adult ages of *B. carambolae*. a. Pollard, b. Tofu waste and c. Tapioca waste.

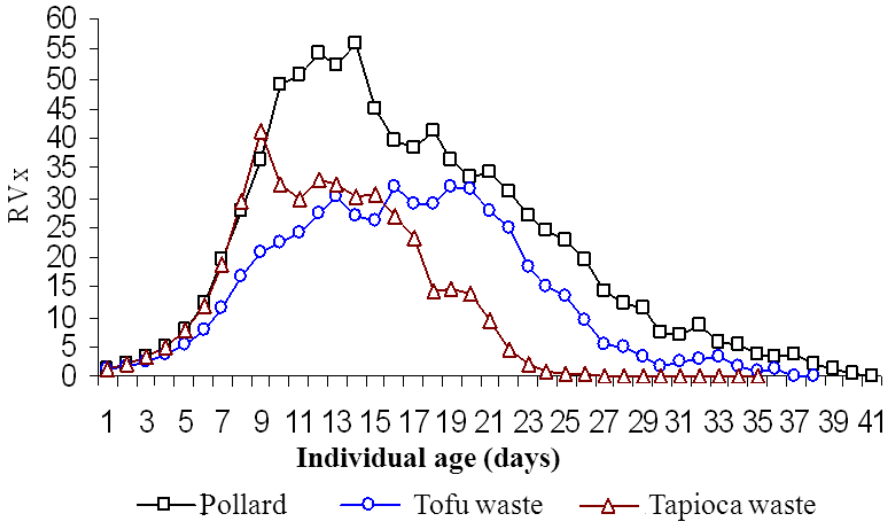

Figure 4. Reproduction of *B. carambolae* was shown based on three different artificial diets when it fed for larva.

Based on our result, pollard is suitable diet for *B. carambolae*, it can be shown survival rate of imago and number of female offspring higher than others.

Based on Figure 4, reproduction of imago on pollard was better than others. It seemed to be better colonization for fruit fly when they got pollard as artificial diet.

B. Life table of *B. carambolae* on three different artificial diets

Intrinsic rate of increase (r_m), mean of offspring periods (T), rate of net reproduction (R_0), and limit rate of increase (λ) was shown in life table (Table 5). On pollard r_m value was better than others. It showed that number of female offspring was higher for every adult. It will supposed to be reason why pollard better than other however tofu waste showed growth and development of fruit fly was better than tapioca waste.

Table 5. Demography parameters in life table of *B. carambolae* on three different artificial diets for larva.

Parameter	Pollard	Tofu waste	Tapioca waste
Net reproduction rate (R_o)	289,82	139,36	128,13
Period of offspring (T)	12,40	13,18	10,76
Intrinsic rate of increase (r_m)	0.,46	0,38	0,45
Limit rate of increase (λ)	1,58	1,45	1,57

Table 6. Survival rate for each stadium *B. carambolae* on three different artificial diets for larva stage.

Development stage	No. of living			Death (%)		
	Pollard	Tofu waste	Tapioca waste	Pollard	Tofu waste	Tapioca waste
Eggs	100	100	100	30	30	30
Larva	70	70	70	4,30	18,60	0
Pupa	67	57	70	7,50	15,80	42,90
Imago	62	48	40			
• No. of female	32	23	18			
• No. of male	32	25	22			
• Ratio ♂ : ♀	1 : 1	9 : 10	9 : 11			

Based on the r_m value there is suitability of diet to the rate of increasing population of *B. carambolae*. Survival rate for each stadium of *B. carambolae* was provided by mortality data (Table 6.). In addition, suitability of artificial diet was also from mean of survival number and percentage of death on each stadium.

CONCLUSION

1. Artificial diet composed by pollard is better than tofu and tapioca waste to rear *B. carambolae* in laboratory condition.
2. Tofu waste is better material to rear *B. carambolae* especially larva stage than tapioca waste.
3. Based on life table, all parameter such as rate of net reproduction (R_o), mean of offspring period (T), intrinsic rate of increase (r_m), limit rate of increase (λ) and reproduction value (RV_x) showed that pollard is the best material for artificial diet to rear *B. carambolae*.

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