MORPHOMETRIC CHARACTERIZATION OF *Oryzaephilus surinamensis* L. (COLEOPTERA: SILVANIDAE) REARED IN DIFFERENT TYPE OF GRAINS

Nurul Huda, A.* & Noor Amni, M.
[1] Department of Plant Science,
Kulliyyah of Science,
International Islamic University Malaysia,
25200 Kuantan, Pahang, Malaysia.
*Corresponding author email: *anhuda@iium.edu.my*

ABSTRACT

The host on which *Oryzaephilus surinamensis* choose to lay eggs and multiply can have a great influence on their development. In this study, morphometric characterization has been used to measure size variability of this insect pest reared in different types of culture and verify whether the food preference has an impact on the morphology of the insect. Measurement of body length, body width at the widest point, head width, length of antenna, length of thorax and length of hind femur of 3rd generation of saw-toothed grain beetle from four cultures; barley, rice, oat groat and dried maize were measured using stereoscopic microscope equipped with LAS EZ imaging software. All data were analyzed using IBM SPSS. The present morphometry study showed significant differences between populations thus proved that food preference or host range choices play important role in development and growth of the insect. Significant differences were recorded for body length (F = 8.250), body width at the widest point (F = 4.620), and head width (F = 4.300) at $P < 0.05$ among the cultures. Thus, body length, body width at the widest point, and head width were the most suitable measurements to be used in observing the effect of food on *O. surinamensis* biological growth.

Keywords: *Oryzaephilus*, morphology, stored product, pest, life history.

ABSTRAK

Perumah di mana *Oryzaephilus surinamensis* memilih untuk bertelur dan membiak boleh mempunyai pengaruh yang besar terhadap perkembangan mereka. Dalam kajian ini, pencirian morfometrik telah digunakan untuk mengukur kepelbagaian saiz serangga perosak yang diternak dalam pelbagai jenis kultur dan menentukan sama ada pemilihan makanan mempunyai kesan terhadap morfologi serangga. Pengukuran panjang badan, lebar badan pada titik terluas, lebar kepala, panjang antena, panjang toraks dan panjang femur belakang generasi ke-3 kumbang bijirin bergerigi dari empat kultur; barli, beras, bijirin oat dan jagung kering diukur menggunakan miskroskop stereo yang dilengkapi dengan perisian pengimejan LAS EZ. Semua data dianalisis menggunakan IBM SPSS. Kajian morfometri ini menunjukkan perbezaan yang ketara di antara populasi yang mana membuktikan bahawa pilihan makanan atau perumah memainkan peranan penting dalam pertumbuhan dan perkembangan serangga. Perbezaan ketara telah direkod untuk panjang badan (F = 8.250), lebar badan pada titik terluas (F = 4.620), dan lebar kepala (F = 4.300) pada $P < 0.05$ di antara kultur. Dengan demikian, panjang badan, lebar badan pada titik terluas dan lebar kepala adalah ukuran paling sesuai untuk digunakan dalam memerhatikan kesan makanan pada pertumbuhan biologi *O. surinamensis*.

Kata kunci: *Oryzaephilus*, morfologi, produk simpanan, perosak, jangka hayat.

INTRODUCTION

Among all stored product pests, the saw-toothed grain beetle *Oryzaephilus surinamensis* L. (Silvanidae) is one of the most widespread pests and its infestation can originate at the manufacturing, storage or retail levels. The distribution of the beetle is significantly affected by various factors such as food availability, processing practices, temperature conditions in different areas, and interaction between species. They may occur in both food products in the pantry area as well as in other adjacent rooms. Foods that may be infested include cereals, flours, pastas, dried fruits, nuts, dries meats, candies, and other similar packaged goods (Nettles 2008; Trematerra et al. 2016).

The presence of the saw-toothed grain beetles in foodstuffs cause quantitative and qualitative losses by rendering the food unsalable or unpalatable (Trematerra & Sciarretta, 2004). The beetle's flattish form allows it to penetrate apparently tightly wrapped packages. Although the attack usually followed by the other insect's infestation such as rice weevil, loses caused by the saw-toothed grain beetles are often significant. The beetle is nearly omnivorous, so it is important to frequently update in detail of its feeding habits in order to establish suitable and sustainable control methods to reduce this pest infestation.

In the developing country such as Malaysia, food product losses due to saw-toothed grain beetle's infestation during storage are considered a very serious threat to food security (Syarifah Zulaikha et al. 2018). Although people were very well aware of the relationship between insects and stored products, but the source of infestations was likely being poorly understood. According to Nurul Huda and Noor Amni (2019), *O. surinamensis* showed preferences to certain types of food thus not all of the plant products are equally susceptible to this insect pest. The host on which a *O. surinamensis* choose to lay eggs and multiply can have a great influence on the developmental rate and on the number of offspring the beetle eventually produces (Beckel et al. 2007) which undeniably become a major factor for prevalent infestation. The optimality theory predicts that females of phytophagous insects choose oviposition sites associated with high expected fitness for their offspring (i.e. find enough food resources, high-quality food resources or enemy-free spaces) (Szentesi 2003; Wilson & Lessells 1994).

According to Devi and Devi (2014), morphometric characterization can be a suitable approach to verify whether the food preference has an impact on the morphology of the insect. Thus, this study is conducted to gain information on intraspecific variation in *O. surinamensis* and searched for significant differences among populations from different host types. Since understanding the diversification of organisms and their biological life were both historically based on descriptions of morphological forms, we used the morphometrics characterization to investigate variability in the pest.

MATERIALS AND METHODS

The insects, *O. surinamensis* were sampled manually from any infested stored grain such as rice and barley and were mass reared in the laboratory using modified method of Beckel et al. (2007). In this study gender bias was ignored following literatures (e.g. Mason 2003; Moawad & El-Ghamdi 2012) which have noted that male and female *O. surinamensis* are similar in morphology and range of size except in a few fine structures of the fore wing, pronotum, hind legs and external genitalia. About 25-30 individuals of *O. surinamensis* adult (ratio between sexes are random) were reared in 300 ml containers, each containing 100 g of barley, rice grains, dried maize, and oat groat (Figure 1). These cultures were chosen due to high content of carbohydrates in the grain; similar with wheat grains thus have potential to increase the population of the insect rapidly (Beckel et al., 2007). Insects were allowed to mate and reproduce until 3rd generations in the laboratory under temperature of 27 °C and 64% relative humidity.

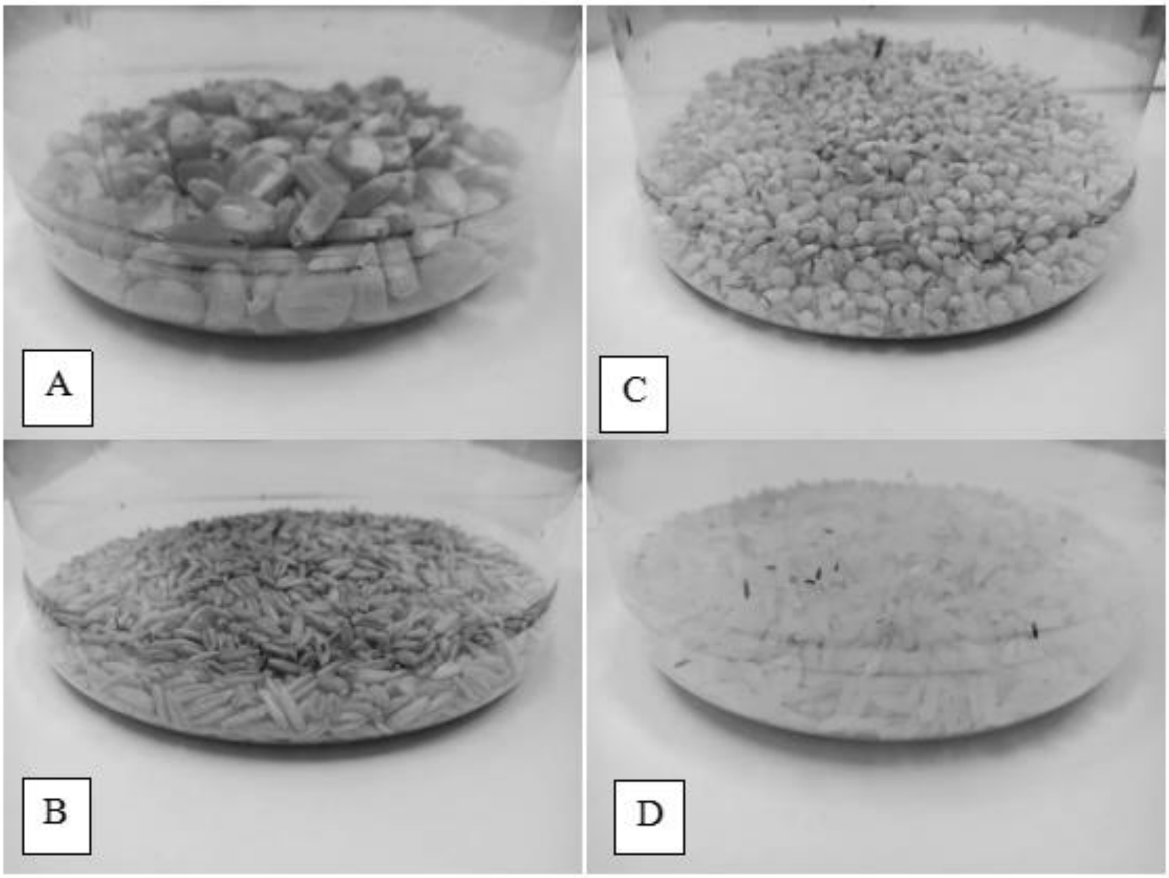

Figure 1. *Oryzaephilus. surinamensis* was reared in four different cultures; dried maize (A), oat groats (B), barley (C) and rice (D)

Third generation of saw-toothed grain beetle from four cultures (barley, rice, oat groat and dried maize) was used for morphometric characterization. Morphometric measurement (body length, body width at the widest point, head width, length of antenna, length of thorax and length of hind femur) were made on 10 emerged beetles (adult stage regardless of sex) of all cultures by using stereoscopic microscope equipped with LAS EZ imaging software (Leica Microsystem SEA Pte. Ltd.) (Figure 2).

Figure 2. Variables measured for *O. surinamensis*'s morphometric characterization; a) Length of antenna, b) Head width, c) Length of thorax, d) Body length, e) Body width at the widest point, f) Length of hind femur

Data were analyzed using the software of IBM Statistical Package for the Social Sciences (SPSS) for Window®. Significant differences in morphometric data measured were analyzed using MANOVA test. Multiple mean comparisons were conducted using post-hoc test of Tukey's HSD.

RESULTS

Table 1 shows body measurements [mean±standard error (SE)] of insects reared in different cultures. In general, all the measurement recorded showed not much different among four cultures. Even so, slightly higher value of insect body measurement recorded from dried maize and oat groat. Body length and body width were measured longer in insect reared in dried maize with an average of 2.75 mm and 0.72 mm respectively. Meanwhile head width, antenna length, thorax length and hind femur length recorded longer in insect from oat groat culture. The smallest length was shown in the barley culture (i.e. body length, body width and thorax length), rice (i.e. head width and hind femur length) and dried maize recorded shortest antennae length.

However, based on statistical analysis (MANOVA) (Table 2), significant differences of measurements only recorded for body length (F = 8.250), body width at the widest point (F = 4.620), and head width (F = 4.300) at *P* < 0.05, among the cultures. Other measurements were insignificant. This analysis indicated that, there was significant effect of food type used for rearing on development of certain part of the insect body.

Table 1. Insect's body measurements (mean±SE) (mm) reared in four different cultures; rice, barley, oat groat and dry maize

Morphology	**Food Group**	**(Mean±SE)**
Body Length	Rice	2.64±0.029
	Barley	2.48±0.048
	Oat groat	2.65±0.033
	Dried maize	2.75±0.044
Body Width	Rice	0.69±0.008
	Barley	0.67±0.012
	Oat groat	0.72±0.010
	Dried maize	0.72±0.019
Head Width	Rice	0.47±0.005
	Barley	0.47±0.007
	Oat groat	0.49±0.005
	Dried maize	0.49±0.006
Antenna Length	Rice	0.73±0.006
	Barley	0.74±0.007
	Oat groat	0.74±0.012
	Dried maize	0.71±0.009
Thorax Length	Rice	0.61±0.007
	Barley	0.59±0.009
	Oat groat	0.61±0.006
	Dried maize	0.61±0.009
Hind Femur Length	Rice	0.39±0.006
	Barley	0.41±0.008
	Oat groat	0.41±0.005
	Dried maize	0.40±0.006

Table 2. Analysis of variance (MANOVA) of insect's morphometric measurements cultured in different food group with significant value of *P* = 0.05

Parameter	**df**	**F**	**Sig.**
Body Length	3	8.250	0.000
Body Width at The Widest Point	3	4.620	0.004
Head Width	3	4.300	0.006
Antenna Length	3	1.098	0.353
Thorax Length	3	2.462	0.066
Hind Femur Length	3	2.364	0.075

Figure 3 shows the post-hoc test of Tukey's HSD analysis for three significant measurements; body length, body width, and head width respectively. Multiple mean comparisons showed that body length, body width, and head width of insect reared in barley was found significantly different from oat groat but not much differed from other cultures.

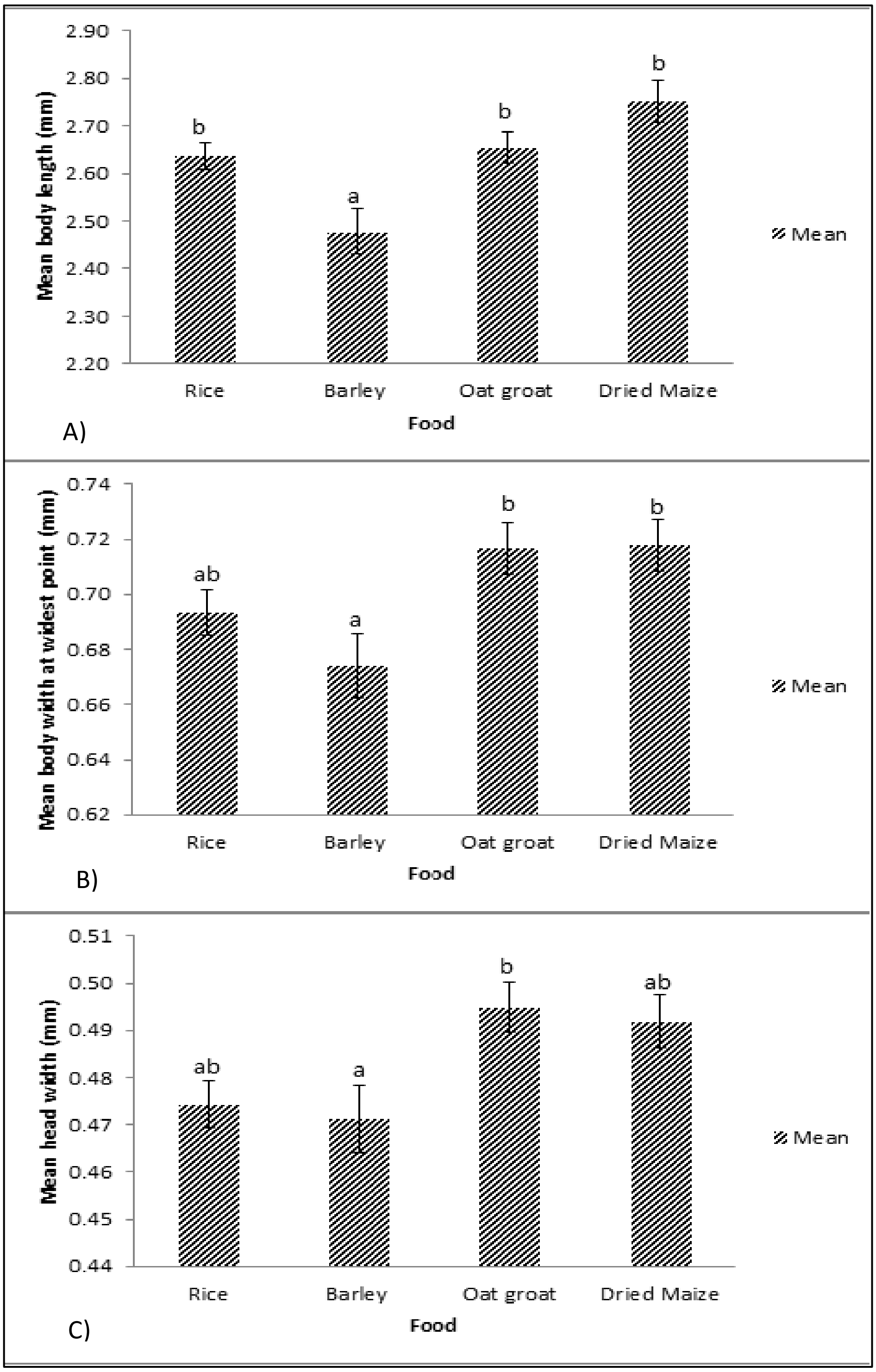

Figure 3. *Oryzaephilus surinamensis*'s measurements (mean ± SE) reared in four different type of culture. Body length (A), body width at widest point (B) and head width (C). Small letter indicated significant of multiple mean comparisons at $P < 0.05$

DISCUSSION

Body size varies considerably among species and among populations within species, exhibiting many repeatable patterns. Size is an important indicator of fitness in insect ecology (Beukeboom 2018). For many animals, resource quality and intraspecific competition may mediate selection on body size producing large-scale geographic patterns (Amarillo-Suárez et al. 2011). In this study, influence of food preferences on life history (i.e. body size) of insects was explored using morphometric characterization. According to Khaliq et al. (2014) and Al-Shami et al. (2014), different environmental conditions (e.g. habitat quality, temperature and humidity) could affect direct or indirectly the insect morphology. In this study, the four populations have been maintained under the same environmental conditions but with different host/feeding culture.

Morphometric study on emerged adult (3rd generation) of *O. surinamensis* showed a meaningful result as the insect's biological growth was affected by type of grain cultures particularly in oat groat and dried maize. Larger size of insect recorded suggested that important nutrients for optimum growth may abundant in these two cultures compared in rice and barley. According to NutritionValue. Org (2020), oat groat and dried maize have high calorie, fat and protein in 100 g serving but low in carbohydrate (around 66 g). Meanwhile rice and barley have low content for three former nutrients but high carbohydrate between 78 g to 80 g. Similar conclusion also previously suggested by Curtis and Clark (1974). It was proven that insects need certain nutrients to grow and to avoid mortality in any stage in its life cycle and details of insect nutrition has been reviewed in last four decades by Dadd (1973). However, further analysis on chemical contents is necessary to validate this statement.

In general, polyphagous species of herbivorous insects are sometimes morphologically variable, but with more specialize appetites (Mozaffarian et al. 2007). The ability of many insect species to survive on diverse foods is a useful strategy and adaptive advantage for their better survival in the ecosystem and the selective use among diverse resources may lead to evolution of ecological specialization and adaptation. It is argued that if host constitute different selective to herbivorous insects, genetic differentiation and host-associated local adaptation may occur (Cañas-Hoyos et al. 2014). In this case, adaptation can be in the form of physiological changes either increased or decreased in body size. Sheikh et al. (2017) in their review on diverse adaptation in insects noted that, to survive in extreme environment, to escape or alleviate adversities of environment, insects have evolved a number of physiological, behavioral and morphological adaptations. Some insect might become smaller in size but more fitted to the environment by producing higher number of individuals (Szentesi 2003). Meanwhile, others might have larger size but produce less number of individuals (Beukeboom, 2018). In the case of stored product pests, smaller size of insect with high fitness (i.e. produce more individual in shortest development time) was found more precarious compared to large size insect with less fitness. However, in this study, although some culture showed increased in insect numbers during visual observation but fitness of insect in term of real number of offspring produced and developmental time per generation was not determined to justify this statement.

According to Amarillo-Suárez et al. (2011) and Szentesi (2003), heavy infestation might reduce body size of the insect due to high competition for limited resources. At the beginning of this experiment, number of insects introduced to each culture is almost the same (25-30 individuals) but ratio of female and male is random. Even so, based on visual observation (approximately after 6 months), higher number of individuals can be seen in oat groat and barley but least individuals were observed in dried maize. The outcome from this observation is contrary with statement by two previous studies (as mentioned above) because result shows that oat groat produced larger size of insect while barley culture produced the smallest insect. With that being said, the effect of intraspecific competition for resources on body size can be excluded in this study.

Besides, changes in insect body size also might be due to adaptation to size and shape of food. Higher-quality grains/seeds, determined in part by grains size, are expected to offer greater fitness benefits such as greater probability of larval survival, larger progeny size, and support for larger numbers of progeny than smaller grains (Campbell 2002). Among all grains used in this study, dried maize has larger size of grain with average of 7 x 11 mm, followed by oat groat (2.5 x 7.2 mm) and rice (2.1 x 7.5 mm). Barley on the other hand has similar width with oat groat but more rounded in shape and considered as the smallest (2.5 x 2.8 mm). The bigger size of the grains with more air space may provide better penetration and infestation at depth (Kumar 2017). However, this adaptation is more likely to be shown by internal feeder insects such as *Sitophilus oryzae* and *Callosobruchus maculatus* where there were highly significant interactions between the effects of grain/seed size and larval density on body size as reported by Amarillo-Suárez and Fox (2006) and Amarillo-Suárez et al. (2011). According to their study, progeny size increased with increasing seed size, but the probability of an adult emerging was not affected. Although the result observed on body size of insect in all cultures meet this theory but *O. surinamensis* on the other hand, are external feeder with larval are highly mobile and developed outside the grain (Arthur 2001) therefore effect of availability of oviposition and developmental site correspond to grain size is more likely unrelated.

CONCLUSION

It was proven that food preference or host range choices play important role in development and growth of the insect. Among all body measurement used in this study, only body length, body width at the widest point, and head width were the most suitable to be used in observing effect of food on *O. surinamensis* biological growth. In the present study, morphometry provided significant differences among the populations of *O. surinamensis*, although overlapping of the minimum and maximum values for the different measures were observed. This morphometric approach proven that basic nutritional requirements for development and survival of insects is a crucial data for further research of stored product insect. For example, the rearing of such insects in suitable culture is important in finding methods for preventing damage to man's food supply and to produce artificial diets as the seasonal unavailability of the natural diet would be a concern in entomological research.

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