POTENTIAL OF UTILIZING RHINOCEROS BEETLES (*Oryctes rhinoceros*) AS AN ORNAMENTAL FISH FEED SUPPLEMENT

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ABSTRACT

Oryctes rhinoceros *adult beetles which are commonly trapped in pheromone traps in oil palm plantations can be used as a supplement for ornamental fish feed.* Oryctes *beetles were ground into powder and were incorporated with wheat, rice and fish feed formula. Initial feeding experiments using* Oryctes *powder + wheat and rice were conducted on several species of ornamental fishes such as* puyu, Anabas testudineus; gold fish, Carassius auratus auratus; common carp, Cyprinus carpio carpio *and oscar,* Astronotus ocellatus. *A final experiment using* Oryctes *powder as a supplement to a fish feed formula was tested on gold fish, carp, parrot fish (*Cichlasoma*) and common gourami (*Osphronemus goramy*). In this study, the* Oryctes *powder seem to be suitable for gold fish and carp on wheat mixtures. This article highlights the potential of using* Oryctes *powder as a supplement to the fish feed formula. The evaluation of the* Oryctes*-supplemented pellets in comparison with other commercial types of fish feed are also discussed.*

Keywords: *Oryctes rhinoceros*, fish feed, pellets.

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INTRODUCTION

The rhinoceros beetle, *Oryctes rhinoceros* (L), is a pest of coconut, oil palm and another 31 genera of palms. The adult feeds at the spear region. These attacks subsequently produce fronds that have wedge or fan-shaped gaps. Repeated attacks can kill the palm or pre-dispose it to other pests (Bedford, 1976; Norman and Basri, 1995).

Adult beetles can be monitored and controlled by trapping, using the aggregation pheromone, ethyl 14-methyloctanoate (Hallet *et al.,* 1995). At the moment, the beetles can be trapped easily where there is a constant immigration of the pest, into a replanting area. The adult beetles are therefore commonly trapped in oil palm plantations. Rather than dispose of the beetles, they can be used as a supplement in ornamental fish feed.

This article suggests a method for producing *Oryctes*-supplemented fish feed pellets and analyses the nutritional contents of the fish feed. The pellets are also evaluated with other commercial fish feeds.

MATERIALS AND METHODS

Oryctes adults were collected from pheromone traps placed in two oil palm plantations in Johor and Negeri Sembilan. The beetles were packed in plastic containers and brought to the laboratory for processing.

Proximate Amino Acid and Fatty Acid Analysis of *Oryctes* Beetles

The beetles were washed clean and dried in an oven at 100°C for 24 hr, then ground into powder in a fruit blender (National MX - 798S, speed 12 000 rpm). The powder was sieved through a fine mesh (0.5 mm) to remove the dregs (wings and heads).

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Proximate analyses were carried out on the *Oryctes* powder for the following:

- protein content (Kjeldahl method);
- lipid content (cold chloroform - ether extraction);
- ash content (combustion at 500°C); and
- moisture content (oven drying at 100°C).

The above analyses were also done for common fish meal and soyabean meal used for fish feed formulation, as a comparison. The analyses were replicated three times. Results are presented in percentages of the dry weight of the ingredient. Amino acid analysis was done using a standard amino acid analyser (Gilson, Villiers le Bel, France) coupled with a WATERS HPLC system.

Fatty acid analysis was done using a Perkin-Elmer Automatic System XL equipped with a fused silica capillary omegawax 250 (30 m x 0.25 mm ID, 0.25 µm thickness; SUPELCO@) using a flame ionization detector (FID) with helium as the carrier gas at an initial temperature of 50°C (for 2 min) and increasing at 40°C min^{-1} to 220°C which was then held for 35 min.

Production of Fish Pellets

Additional ingredients such as rice bran and wheat flour were added separately to the *Oryctes* powder, later mixed with a binder solution (sodium alginate). The mixture was pippeted into a coagulating agent, calcium chloride, for forming into pellets. The pellets were then dried at room temperature (25°C).

Feeding Experiments

Fishes used. Feeding experiments was carried out on the following ornamental fishes:

Common name	**Scientific name**
Puyu, climbing perch	*Anabas testudineus*
Ikan mas, gold fish	*Carassius auratus auratus*
Common carp	*Cyprinus carpio carpio*
Oscar	*Astronotus ocellatus*
Kaloi, common gourami	*Osphronemus goramy*
Parrot fish	*Cichlasoma* sp.

Initial feeding experiments using *Oryctes* powder + wheat and rice were conducted on *puyu, Anabas testudineus;* gold fish, *Carassius auratus auratus;* common carp, *Cyprinus carpio carpio;* oscar, *Astronotus ocellatus.*

A final experiment of using *Oryctes* powder as a supplement to a fish feed formula was tested on gold fish, carp, parrot fish (*Cichlasoma*) and *kaloi* (*Osphronemus goramy*). The age of fishes at the start of experiment was approximately two months.

Treatments

Testing* Oryctes *powder as sole ingredient + wheat / rice. Two types of *Oryctes* pellets: T1, *Oryctes* + wheat and T2, *Oryctes* + rice; were tested against two commercial ornamental fish feeds: T3, commercial fish feed Brand A and T4, commercial fish feed Brand B (as controls).

The ratio of *Oryctes* powder to the wheat (T1)/ rice (T2) was 80:20 w/w. As the amount of *Oryctes* powder was three times more than the wheat/rice, it was therefore assumed that the amino acids in the wheat/rice would not contribute much to the overall amino acid contents of the fish feeds.

Testing* Oryctes *powder as a supplement to commercial fish meal in fish feed. Two fish feeds were formulated at Universiti Sains Malaysia (USM) and evaluated in the laboratory at the Malaysian Palm Oil Board (MPOB). *Table 1* shows the incorporation of *Oryctes* to about half the amount of fish meal. The control diet formulation was without the incorporation of *Oryctes* powder. Both these diets were given to gold fish, carp, parrot fish (*Cichlasoma*) and *kaloi* (*Osphronemus goramy*) as described earlier.

Experimental Design

The experimental design was a randomized complete block design (RCBD). Each fish were reared separately in glass tanks measuring 24.4 x 22.8 x 28.5 cm. Water was circulated with a water pump and changed weekly. Each feeding treatment was replicated five times, on each type of fish.

Measuring Food Uptake

Each fish was weighed at the beginning of the experiment, then fed daily with the respective fish

TABLE 1. COMPOSITION OF FISH FEED, WITH AND WITHOUT *Oryctes* (100 g)

Composition	**Supplemented with *Oryctes* (g)**	**Without *Oryctes* (control) (g)**
Fish meal	11.6	29
Oryctes powder	16.5	0
Soyabean meal	7.7	7.7
Fish oil	3.7	3.9
Corn oil	5.4	5.4
Starch	8	8
Corn gluten	17	17
Wheat gluten	8.5	8.5
Cellulose	19.5	18.5
Vitamin mineral mix	2	2
Total	99.9	100

feeds at approximately 5% of its weight (2.5% in the morning and 2.5% in the afternoon). The unconsumed fish feed was collected the following morning, dried and weighed to estimate the amount eaten (g day^{-1}). Each fish was then weighed at weekly intervals. The amount of feed varies according to the average weight of fish at the start of each week.

Feed Efficiency (feed factors)

The feed efficiency was determined by the wet weight gain in biomass divided by the amount of dry weight feed provided. It is also called the feed factor.

Feed factor is defined by fish weight gain per unit of feed consumed. Feed efficiency is calculated with the gain in biomass (wet weight) divided by the amount of feed provided.

Growth Performance of Fishes Fed with *Oryctes* Powder as a Supplement to Fish Meal

The growth performances of the fishes were determined by calculating their specific growth rates (SGR), food conversion ratio (FCR) and protein efficiency ratio (PER).

SGR was calculated as 100 x natural log (ln) (final measurement) - natural log (ln) (initial measurement)/(duration of experiment in days) (Ricker, 1979; Tacon, 1987). FCR is dry feed/wet weight gain, and PER is weight gain/protein fed (Tacon, 1987; Wu *et al.*, 1996).

RESULTS AND DISCUSSION

Proximate Analysis of Adult *Oryctes*

In terms of protein content, *Oryctes* contained slightly higher protein and lipid levels compared to the common fish meal and soyabean meal (*Table 2*).

TABLE 2. PROXIMATE ANALYSIS OF *Oryctes* POWDER, COMPARED TO TWO OTHER COMMON PROTEIN SOURCES FOR COMMERCIAL FISH FEED

	Oryctes powder	Common (Danish fish meal)	Soyabean meal
Moisture	10.47 ±1.34	10.60	11.2
Protein	72.70 ± 1.21	69.84	54.3
Ash	6.56 ± 0.32	14.16	4.3
Lipid	12.39 ± 2.1	10.45	8.5

The body of the *Oryctes rhinoceros* adults is a source of protein, which included all the essential amino acids (EAA) for fish (*Table 3a*). The EAA for fish are histidine, arginine, threonine, cystein, tyrosine, valine, methionine, lysine, isoleucine, leucine, phenylalanine and tryptophan (Tacon, 1987).

Aspartic acid, glutamic acid, glycine, cystein, tyrosine, valine, leucine and phenylalanine were all much higher than the conventional protein sources in fish feed (Danish fish meal or soyabean meal). However, some amino acids (serine, histidine, arginine, threonine, proline, lysine and isoleucine) were slightly low, while the rest - alanine, methionine and tryptophan were found to be comparable to both the Danish fish meal and soyabean meal (*Table 3a*).

TABLE 3a. AMINO ACID CONTENT OF *Oryctes* POWDER COMPARED TO TWO OTHER CONVENTIONAL INGREDIENTS OF FISH MEAL

	Oryctes powder (g per 100 g of dried sample)	*Oryctes* powder (g per 100 g protein)	Danish fish meal (g per 100 g protein)	Soyabean meal (g per 100 g protein)
Aspartic acid	9.67	13.30	11.56	11.68
Serine	3.12	4.29	4.52	5.63
Glutamic acid	11.01	15.14	12.67	7.39
Glycine	5.43	7.47	7.13	4.81
Histidine	1.13	1.55	2.43	3.34
Arginine	4.39	6.04	6.18	7.24
Alanine	3.89	5.35	6.82	4.77
Threonine	1.21	1.66	3.95	3.27
Proline	2.28	3.14	5.68	5.21
Cysteine	3.47	4.77	0.48	1.17
Tyrosine	3.21	4.41	3.66	2.88
Valine	4.64	6.38	5.93	5.83
Methionine	1.39	1.91	3.28	1.24
Lysine	1.67	2.29	9.69	5.35
Isoleucine	2.14	2.94	5.70	5.79
Leucine	6.50	8.94	8.79	8.27
Phenylalanine	3.24	4.46	4.33	5.12
Tryptophan	0.64	0.88	0.81	1.95

Each of the EAA in the beetles was then calculated as a percentage over the total EAA + cystein + tyrosine (Tacon, 1987), and compared against the EAA requirement (expressed as % of total EAA) for fish (Ogino, 1980) (*Table 3b*).

Limiting EAA is defined as those which is below 30% of the mean fish requirement (Tacon, 1987). From *Table 2*, it can be seen that almost all EAA in *Oryctes* were not limiting to fish, except for lysine, which was 29.2%, only slightly below 30% of the mean fish requirement. Although lysine was slightly low, it seems to be compensated with the higher EAA such as valine, cystine, leucine, phenylalanine, tyrosine, arginine and tryptophan, which were more than the actual requirement by fish (101% - 382%).

TABLE 3b. ESSENTIAL AMINO ACID (EAA) CONTENT OF *Oryctes* BEETLES COMPARED TO THE REQUIREMENT OF EAA BY FISH

EAA	% of total EAA (+cysteine & tyrosine) in *Oryctes*	% of EAA required by fish*	% of EAA in *Oryctes* over % EAA required by fish*
Threonine	3.6	10.6	34.0
Valine	13.8	9.5	145.3
Methionine	4.1	5.4	75.9
Cystine	10.3	2.7	381.5
Isoleucine	6.4	7.5	85.3
Leucine	19.3	13.5	143.0
Phenylalanine	9.6	9.5	101.1
Tyrosine	9.5	6.5	146.2
Lysine	4.9	16.8	29.2
Histidine	3.4	4.8	70.8
Arginine	13.1	11.6	112.9
Tryptophan	1.9	1.7	111.8

Source: *Ogino (1980).

Thus, it can generally be accepted that *Oryctes* powder can be used as a fish feed.

Fatty acid analysis. Fatty acid analysis showed that *Oryctes* beetle contained several essential fatty acids, especially the unsaturated fatty acids. The essential fatty acids required by fish are eicosaenoic, arachidonic and eicosapentaenoic (March, 1993; Takeuchi, 1996) *(Table 4)*. However, the amount detected was less than 0.1%. The highest amount of fatty acid was oleic acid (5.5%). However, the best weight gains and feed conversions are obtained in fish receiving a diet containing both 1% C18:2 and 1% C18:3 (FAO, 2004).

TABLE 4. FATTY ACID CONTENT OF *Oryctes* POWDER

Fatty acid	*Oryctes* (mg per 100 mg sample)
C14:0 (myristic)	0.05
C16:1n7 (palmitoleic)	0.10
C18:1n9 (oleic)	5.48
C18:2n6 (linoleic)	0.19
C20:1n9 (eicosaenoic)	0.09
C20:4n6 (arachidonic)	0.02
C20:4n3 (arachidonic)	0.07
C20:5n3 (eicosapentaenoic)	0.06
C22:5n3 (docosapentaenoic)	0.06

Fish Weight in Relation to Food Uptake

Based on experimental results up to 26 weeks, there were some good correlations ($R^2 > 0.5$) indicating confident response between food uptake and fish weight when fed with the *Oryctes* powder. This shows its potential to be developed for fish feed. However, different types of fish showed different responses towards the feed and its additional mixtures (either wheat or rice).

Gold fish. This fish showed good response with *Oryctes* + wheat ($R^2 = 0.55$), but low response to *Oryctes* + rice ($R^2 = 0.1$). Responses to both commercial feeds were very high ($R^2 = 0.94 - 0.99$).

Common carp. This fish showed better response to *Oryctes* + wheat ($R^2 = 0.70$) than *Oryctes* + rice ($R^2 = 0.23$), and a high response to both commercial feeds ($R^2 = 0.88 - 0.92$).

Puyu. This fish showed low response to *Oryctes* + wheat ($R^2 = 0.17$) but better response to *Oryctes* + rice ($R^2 = 0.66$), and medium to high response to both commercial feeds ($R^2 = 0.59 - 0.89$).

Oscar. This fish showed inconsistent response to *Oryctes* + wheat ($R^2 = 0.02$) with some consistent response to *Oryctes* + rice ($R^2 = 0.21$), and very high response to both commercial feeds ($R^2 = 0.98 - 0.99$).

The above results indicate that although the wheat proteins may not contain high concentration of the nutritionally indispensable amino acids, but when combined with other food proteins *(i.e.* animal products) the proteins of wheat exhibit excellent nutritional complementarity (Young and Pellett, 1985). It was also shown that *Oryctes* + wheat performed better on gold fish and common carp, while *Oryctes* + rice showed better performance on *puyu* and oscar.

Body Weight Increase Against Time

Up to 26 weeks, the percent weight increase had also corresponded to the results of growth studies, based on the relations of body weight to the food intake (*Table 5*). The mean feed factors over 28 weeks are also shown (*Table 6*).

Gold fish. The weight of gold fish had tripled its initial weight, when fed with *Oryctes* + wheat. This complied with the results of the correlation analysis, discussed earlier. However, it is also interesting to note that although very high correlations of weight and food intake were observed in the commercial feeds, *Oryctes* + wheat had increased the fish weight

TABLE 5. PERCENTAGE INCREASE IN WEIGHT OF FISHES FED WITH *Oryctes* PELLETS AND COMMERCIAL FISH FEEDS

	% weight increase after 26 weeks			
	Oryctes powder+ wheat	*Oryctes* powder + rice	Commercial fish feed A	Commercial fish feed B
Gold fish	365	171	242	335
Carp	182	57.5	83.8	16.8
Puyu	6.2	25.3	76.8	46.5
Oscar	24.6	34.6	167	222

TABLE 6. MEAN FEED FACTORS OVER 28 WEEKS

	Oryctes + wheat	Commercial fish feed A	Commercial fish feed B
Gold fish	0.92a	0.82a	1.35a
Common carp	0.29a	0.40a	0.33a

Note: Means in rows with the same letters are not significantly different at p = 0.05.

much higher than both commercial fish feeds (123% and 30% higher than commercial fish feeds A and B respectively), suggesting better absorption of *Oryctes* tissue by the fish in producing body mass (*Table 5*). The mean feed factors (*Table 6*) indicated that there was no significant difference between the commercial fish feed and *Oryctes* + wheat pellets.

Common carp. Similarly, the weight of common carp had increased much higher when fed with *Oryctes* + wheat than commercial fish feeds A and B (by 98% and 165% respectively) (*Table 5*). The mean feed factors (*Table 6*) also indicated that there was no significant difference between the commercial fish feeds and *Oryctes* + wheat pellets.

Puyu. Both *Oryctes* mixtures (+ wheat and + rice) had performed poorly on the fish, indicated by very low weight increase (less than 30% of its initial weight), compared to the commercial fish feeds. However, the commercial fish feeds too had only increased between 47% - 77% of its initial weight (*Table 5*). This showed that for good growth, *puyu* needed different kind of diet than those tested in this study.

Oscar. Similarly, both *Oryctes* mixtures performed poorly (less than 40% increase than its initial weight), compared to the commercial fish feeds, between 167% to 222% increase of its initial weight (*Table 5*). This showed that the *Oryctes* pellets were less suitable for rapid growth of oscar.

Growth Performance of Fishes Fed with *Oryctes* Powder as a Supplement to Fish Meal

Both these diets were given to gold fish, carp, parrot fish and *kaloi*, as described earlier. Two of the low performing fishes, *i.e.* oscar and *puyu* were terminated from further evaluation as they had not performed well with the *Oryctes* formulation fed during the earlier trials.

It was shown that both gold fish and carp had improved their growth by feeding the *Oryctes* supplemented fish feed pellets. The weight increase after 23 weeks was almost once or twice its initial weight (*Table 7*). These phenomena as reflected in the specific growth rates (SGR) were within 0.6% - 1.4%, which indicated good growth rates. The food conversion ratio (FCR) was lowest (1.85) in gold fish, indicating that smaller amounts of feed were enough for it to grow. However, the opposite was true for carp, where its FCR was the highest (16.8), indicating that it needed to feed much more than other fishes in order to grow at equivalent rates. This was likely due to its low PER compared to other fishes (*Table 7*).

TABLE 7. GROWTH PERFORMANCE OF FISHES FED WITH THE *Oryctes* SUPPLEMENTED FISH FEED FORMULA (after 23 weeks)

Types of fish	Weight increase (%)	SGR (%)	FCR	PER
Gold fish	287.2	0.84	1.85	0.67
Carp	172.4	0.62	16.8	0.07
Kaloi	40.5	0.26	2.04	0.61
Parrot fish	27.7	0.18	3.28	0.38

Note: SGR- specific growth rates; FCR- food conversion ratio; PER- protein efficiency ratio.

Potential of *Oryctes* Powder as a Supplement to Fish Meal in a Fish Feed Formula

Based from correlations between the food uptake and fish weight, it was observed that *Oryctes* powder can be combined with fish meal in a fish feed formula, at about 60:40 ratio *(Table 1).* There was a high correlation ($R^2 > 0.90$) between the two parameters for both fish feeds, for all types of fish tested. There was no significant difference ($p > 0.05$) in the correlation slopes for *Oryctes* supplemented diet compared to control, indicating its potential as a supplement.

CONCLUSION

In terms of protein content, the *Oryctes rhinoceros* beetles contained higher protein levels than most ingredients traditionally used in aquaculture. Lipid content is also generally high. This points to the suitability of *Oryctes* beetles as a partial substitute or complement for fish meal as a protein source. It can be seen that almost all EAA in *Oryctes* were not limiting to fish, except for lysine, which was 29.2%, only slightly below 30% of the mean fish requirement. Although lysine was slightly low, it seems to be compensated with the higher EAA such as valine, cystine, leucine, phenylalanine, tyrosine, arginine and tryptophan, which were more than the actual requirement by fish (101% - 382%). Thus, it can generally be accepted that *Oryctes* powder can be used as a fish feed. In this study, the *Oryctes* can be suitable for gold fish and common carp on mixtures with wheat.

Apart from the above, other amino acids in *Oryctes* such as aspartic acid, glutamic acid, glycine, alanine and methionine were found to be higher than or comparable to both the Danish fish meal and soyabean meal.

Although it may not be possible to utilize *Oryctes* alone as the protein source for fish diet it can always complement the ordinary fish meal in making a fish feed formula.

There is a need to supply a combination of several protein sources to ensure a balanced supply of amino acids. A mixed ratio of *Oryctes* beetles: fish meal: soyabean might be a good possibility. Fatty acid analysis results showed that *Oryctes* contains several essential fatty acids, especially the unsaturated fatty acids. However, the levels might not be adequate to fulfill the requirements of aquaculture species, especially marine species. The use of several types of oils such as fish oil, squid oil, palm oil or soyabean oil might be able to compensate the low essential fatty acids levels.

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