African Journal of Biotechnology Vol. 10(19), pp. 3938-3944, 9 May, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.2063
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Performance of taste enhancers mixed with cereal bases and evaluation of the most preferred bait composition for *Bandicota bengalensis* (Gray)

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Accepted 18 February, 2011

Baiting technique if appropriately applied is the most reliable strategy to control rodent pests. Behavior modifying components may play a significant role in developing the most attractive baits. An attempt was therefore made to investigate the behavior revolutionizing effect of taste enhancers including peanut oil, peanut butter, egg shell and fishmeal, on exploratory approaches of rodents. Precise role of additives and impact of particle size of cereal bases has been discussed aiming to minimize bait shyness, neophobia and development of the most preferred bait combination for effective control of bandicoot rat *Bandicota bengalensis*.

Key words: *Bandicota bengalensis*, cereals baits, taste enhancers, shyness, neophobia.

INTRODUCTION

No country in the world is free from quantitative and quali-tative losses inflicted by rodents. But the losses are more pronounced in the tropical countries where rodents play a significant role in retarding agricultural production through damage to field crops (Jackson, 1977). Among different rodent species, lesser bandicoot rat *Bandicota bengalensis* Gray had been reported as the most detrimental pest. The estimated losses due to attack of this pest have ranged from 7-11 and 12 % in sugar cane and wheat crops, respectively (Poche et al., 1982). The rodent has also been accounted as a serious pest of stored commodities. Numerous investigations have shown that *B. bengalensis* is widely distributed throughout the world. It has been reported as an indigenous pest of Vietnam, Penang Island, Western Malaysia, Thailand, Sirilanka, Java, Sumatra, Assam, Sikkim, Nepal, India, Pakistan, Bangladesh, Saudi Arabia (Wagle, 1927; Chesemore, 1970; Abe, 1979; Harrison and Bate, 1991; Parshad, 1999; Musser and Carleton 2005; IUCN, 2010). By virtue of its heavy built, large size and abundance, the bandicoot rat is rated as one of the most destructive pest (Smiet et al., 1980) responsible for causing heavy losses to field crops (Greaves et al., 1977; Beg et al., 1980; Fulk et al., 1981; Neena and Parshad, 2010). The most important feature of this rat is the construction of extensive burrows and hoarding large quantities of food materials (Fulk, 1977; Chanda and Garg, 1981). It may hoard paddy up to 1.75 kg/burrow (Rao and Mohan, 1980). Keeping economic importance of this pest in view, different management strategies including use of fumigants, anticoagulants and rodenticides are opted to control this noxious pest. Unfortunately, application of fumigants in field crops is quite difficult as fumigation procedures necessitate complete air tightness, which is hardly met under field conditions. On the other hand, the rodents have developed resistance against many anti-coagulants (Greaves, 1985; Hussain, 1998). Rodenticides therefore seem the only feasible remedy to combat against overwhelming population of this pest. Usually two types of rodenticides are used for their control vis-à-vis acute and chronic. However, acute poisons are more preferred and frequently applied as people are anxious to see a rapid kill and get rid of damage caused by them (Steven, 2008). Brodifacoum, Coumatetralyl, Wafarin, Zinc phosphide, Temik, Bromodiolone are commonly used for this

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Table 1. Ratio of different taste enhancers used with cracked millets.

Base material cracked millet (%)	Egg shell (%)	Vegetable oil (%)	Fish meal (%)	Peanut oil (%)	Peanut butter (%)
96	2	2	-	-	-
93	5	2	-	-	-
96	-	2	2	-	-
93	-	2	5	-	-
98	-	-	-	2	-
95	-	-	-	5	-
98	-	-	-	-	2
95	-	-	-	-	5

purpose (Pervez et al., 2003; Kaur and Parshad, 2005; Kaukeinen and Prescott, 2007; Hussain and Prescott, 2006; VUAT, 2008). But the rodents are very intelligent animals with a strong smelling sense, which prevents them from instant ingestion of poisons applied directly. The rodenticides are therefore applied with different bait materials. But again their behavioral characteristic termed as neo-phobia defends and restricts them to immediate switch on to poison baits. Such behavioral phenomena render the rodents control very tricky, because once shy, the rat prefers to remain hungry than eating an apprehensive food (Canby, 1977; Riley and Clarke, 1977; Owan, 1978; Owan et al., 1979; Sood and Gill, 1980, Prescott et al., 1992). Many workers have tried to find out the most attractive bait materials (Shumake, 1978). For example oats with mineral oil and sugar have been reported as preferred rodent bait than fruit or meat (Johnson, 1946). Likewise, Kumar and Gangwar (2001) reported that order of food preference for *B. bengalensis* among cereals and pulses is, wheat flour > Rice > maize > Gram > Millet > Mung > Pea > Arhar > Urd > Cowpea. The literature also reveals the use of cereals in whole-some, cracked form as well as mixed with additives such as vegetable oil, egg shell, egg yolk, minced meat, sugar, spices and flavours (Shumake, 1978; Shafi et al., 1990, Brooks et al., 1981; Marsh, 1988; Parshad and Jidal, 1991; Pervez et al.., 2003). But no irrefutable work so far has been done to explore fondness of *B. bengalensis* for cereals based baits mixed with different taste enhancers. The present investigations were therefore carried out to find out the most preferred cereal based baits synergized with some suitable taste enhancers to ensure maximum intake of poison bait and control of the pest.

MATERIALS AND METHODS

The study was carried out in Vertebrate pest Control Laboratory of the National Agricultural Research Center (NARC), Islamabad. The experiments were conducted in two phases. In the first phase, multi-choice feeding tests were performed to identify the most preferred cereal as a bait base amongst wheat, rice, maize and millet. In the second phase, the effect of taste enhancers such as egg shell, fish meal, peanut oil and peanut butter at 2 and 5% preparations was evaluated in a series of feeding tests to find out a combination to be used as the most preferred bait for *B. bengalensis*. The materials and methods employed in the present studies are given hereunder.

Trapping rats

Live individuals of *B. bengalensis* were captured from wheat, barley and groundnut crops and grassy area of NARC, Islamabad using single catch live trap measuring 41 × 14 × 14 cm. For this purpose, 75, 36, 62 and 33 traps baited with fresh guava, potato, muskmelon and onion, respectively were set in each field. The traps were set in the evening and collected on the following morning from 6.00 to 7.00 am.

Acclimatization procedure

The rat trapped from each field were brought into the laboratory and weighted using an electronic balance, segregated sex-wise and housed in individual wire-mesh cages measuring 42 × 31× 12 cm. Pregnant, lactating females and sub adults were discarded. The test animals were acclimatized for three weeks before undertaking various tests and fed on laboratory diet containing wheat flour, corn flour, egg shell, full cream dry powder milk, vegetable oil and crude sugar in ratio of 40, 40, 10, 5, 3 and 2 %, respectively (Hussain, 1998).

Composition of baits

Tests for selection of most preferred cereal base

In this phase, wheat, rice, maize ad millet was fed to the test animals. In order to evaluate the effect of particle size, millet was used in wholesome (W) form. But enhanced inclination of the animals to millet in preliminary observations urged us to use this cereal in cracked form (C) like others in later studies.

Tests for selection of most preferred taste enhancer/additive

Keeping in view the results of the first experiment, different additives were mixed with the cracked millets in different combinations (Table 1). These bait preparations were offered to each rat singly for eight days and daily food consumption of each bait was recorded both for male and female rats.

Figure 1. Mean daily food consumption in g/100 g body weight of *Bandicota bengalensis* showing preference for different cereal bases in multi choice test, focusing especially on the intake of millet wholesome in Test-1 and cracked in Test 2 for eight days.

Confirmatory tests for selection of most preferred taste enhancer

A multi-choice feeding opportunity was also provided to the test animals; wherein egg shell, fishmeal, peanut oil and peanut butter were mixed with the cracked millet at 2%. Plain cracked millet was also included in this multi-choice test. This test continued for eight days.

Preparation of baits

A grinder was used to crack the cereal grains. In the first phase of the study, the cereals were fed to the test animals without mixing of any taste enhancer. In the second phase, cracked millet was placed in a large tub. In case of egg shell and fish meal, the ingredients were slowly and gradually mixed in the cracked grain by adding vegetable oil (binder). Whereas in case of peanut oil and peanut butter, vegetable oil was not used because peanut oil and peanut butter itself worked as natural binder. Each diet was prepared afresh before the start of each test.

Feeding animals

Fifty gram of plain and additive mixed baits were offered to each male and female rat simultaneously in metal food cups fixed with metal clips in each cage. The feeding cup had a stainless steel lid with a central opening of 35 mm dia to ease feeding of animals without spillage. Under each cage, a blotting paper was placed to recover spilled diet to ensure accurate measurement of consumption per animal. Ten acclimatized rats (5 males and 5 females) were used in each test. The span of each test was eight days. The rats were individually weighed before and after feeding. At least one week rest period was maintained between each test to nullify the effect of previous feeding.

Statistical procedure

Daily consumption of each diet was converted to gram consumed per 100 gram body weight and their means with standard error were also computed. Data were analysed by one way analysis of variance with test foods as main factor; where significant effects were found, individual mean comparisons were made using LSD at 0.05 % probability level.

RESULTS AND DISCUSSION

Results of the present investigations showed that dietary preferences of *B. bengalensis* depend upon many factors including particle size, palatability, taste, flavor and nutritious value of bait base and the taste enhancers. Experiments performed to evaluate inclination of the rodents towards cereal bases revealed that millet was the most preferred over the other three cereals. This preference was significant for all the males ($F_{160}=12.825$, $P=0.0002$). However, this preference was not pronounced at significant level among the females ($F_{160}=1.39$. $P>0.05$. The cereal bait bases preferred by the *B. bengalensis* were in the order of Millet (W)>wheat (C)>maize(C)>rice(C) as depicted by mean daily consumption of 2.67±0.40, 1.75±0.39, 1.12±0.33 and 0.65±0.18 g/100 g body weight, respectively (Test-1, Figure 1). Results of the subsequent test (Test 2) where millet was used in cracked form though did not alter the order of food preference, yet showed significant enhancement for intake of millet. The overall mean daily consumption of millet rose to 6.00±0.47 g/100 g body

Table 2. Analysis of variance showing comparison of mean daily food consumption of cereals with millet in wholesome and cracked form.

Form of base materials used	Population	Mean body weight (g)	Mean daily food consumption (g/100g body weight Mean ± SE)	F value	Probability	LSD at P=0.05 level
Test 1						
All grain Except millet cracked	Male rats	282.2±4.3	5.63±0.64	12.83**	P=0.0002	1.080
	Females	238.6±13.4	6.77±0.33	1.39NS	P=0.2813	-
	Mean	260.4±9.8	5.03±0.65	6.511**	P=0.0012	1.389
Test 2						
All grain in cracked form	Male rats	292.6±13.9	8.00±1.24	31.11**	P=0.000	1.343
	Females	234.8±8.04	8.68±1.40	42.494**	P=0.000	1.292
	Mean	263.7±12.3	8.34±1.31	68.533**	P=0.000	1.287

NS= Non Significant ** = Highly Significant

weight (Figure 1). Whereas the mean daily consumption for wheat, maize and rice reduced and was in the order of 1.16±0.28, 0.69±0.29 and 0.49±0.13 g/100 g body weight, respectively. The results therefore suggested that variations in the intake of different cereal bases not only depend upon type of food but also on the size of its particles. When the rodents found their best food, intake of other cereals was shrunk. An abrupt increase in overall mean daily food consumption due to use of millet in cracked form is also evident from Table 2. The findings are in line with those of Young (1946) who suggested that criteria for food selection in rats are complex and may depend upon many factors including palatability. Likewise, Jackson (1965) also revealed that texture, odour and taste play a significant role in selection of a particular bait base. Preference for millet as compared to other three is supported by Parshad and Jindal (1991) who enunciated that *B. bengalensis* prefers soft and small size grains. Watson and Perry (1954) also found that millet was preferred by *Nesokia indica* due to its small size. In the present trials, wheat, rice and maize were perhaps rejected for being hard in nature. Similar inferences were also drawn by Prakash et al. (1970) and Kumar and Khan (1978). Shafi (1991) argued that particle size of grain plays an important role in enhancing bait acceptability. Thus preference for millet was due to its small size as well as softness, which enhanced its palatability.

Behavioral characteristics of rodents have further revealed that their choice for food depends upon many factors including caloric value (Hausmann, 1932), deliciousness (Young, 1946) and behavior modifying components (Barnett, 1956). Some food items are intermittently preferred because of the energy they provide (Stenseth, 1977), chiefly due to their carbohydrate and protein contents (Smythe, 1976). There has been found a positive correlation between the weight of male *Microtus agrestis* and the protein content of grasses (Evans, 1973). Taste of food plays a significant role in food preference. According to Marsh (1986) taste often supersedes any earlier influence of odour in food selection to a degree that is not paralleled in humans. These findings support our results where we observed huge variations among the food preferences for different taste enhancers. For example, addition of egg shell at 2% did not show a significant increase in relative consumption for the cereal base. Rather we observed an inverse trend indicating decreased preference for plain millet based bait when mixed with 5% egg shell (Figure 2). The results are in conformity with those of Shafi et al. (1993) who observed that *B. bengalensis* show a high preference toward minced meat bait than egg shell and egg yolk mixed bait. But Pervez et al. (1999; 2003) found an additive effect of 2% egg shell on enhancement of bait preference. The difference might be due to difference in the base material used in the bait. Further studies are therefore required to determine the precise effect of egg shell on different base materials used as bait. Likewise, addition of fish meal at 2 and 5% did not show statistically significant effect on food consumption. Although addition of peanut oil at 2 and 5% showed a slight increase in consumption of bait, the increase was again statistically non significant (Table 3). On the other hand literature reveals significant effect of peanut oil in bait consumption by *B. bengalensis*. For example, Kumar and Gangwar (2001) observed significant enhancement in consumption of wheat flour by Bandicoot rat when the flour was mixed with peanut oil. Similarly, peanut oil at 10% proportion in broken rice was also found as the most preferred bait for *B. bengalensis* (Sridhara and Srihari, 1986). In the same way, broken rice based bait with 7-10 % peanut oil had also proved as the most preferred for *B. indica* (Sridhara and Srihari, 1983). These contradictory results may primarily be attributed to the concentration of peanut oil and secondarily to the nature of bait material used in the investigations. We may therefore assume that use of peanut oil at high concentration may enhance bait intake as compared to using plain millet. A major breakthrough was witnessed when we used peanut butter instead of peanut oil. Both 2 and 5% concentration of peanut butter significantly enhanced mean daily consumption of millet based bait. The mean daily consumption of all the rats showed significant difference at 2% concentration ($F_{160} = 168.44$,

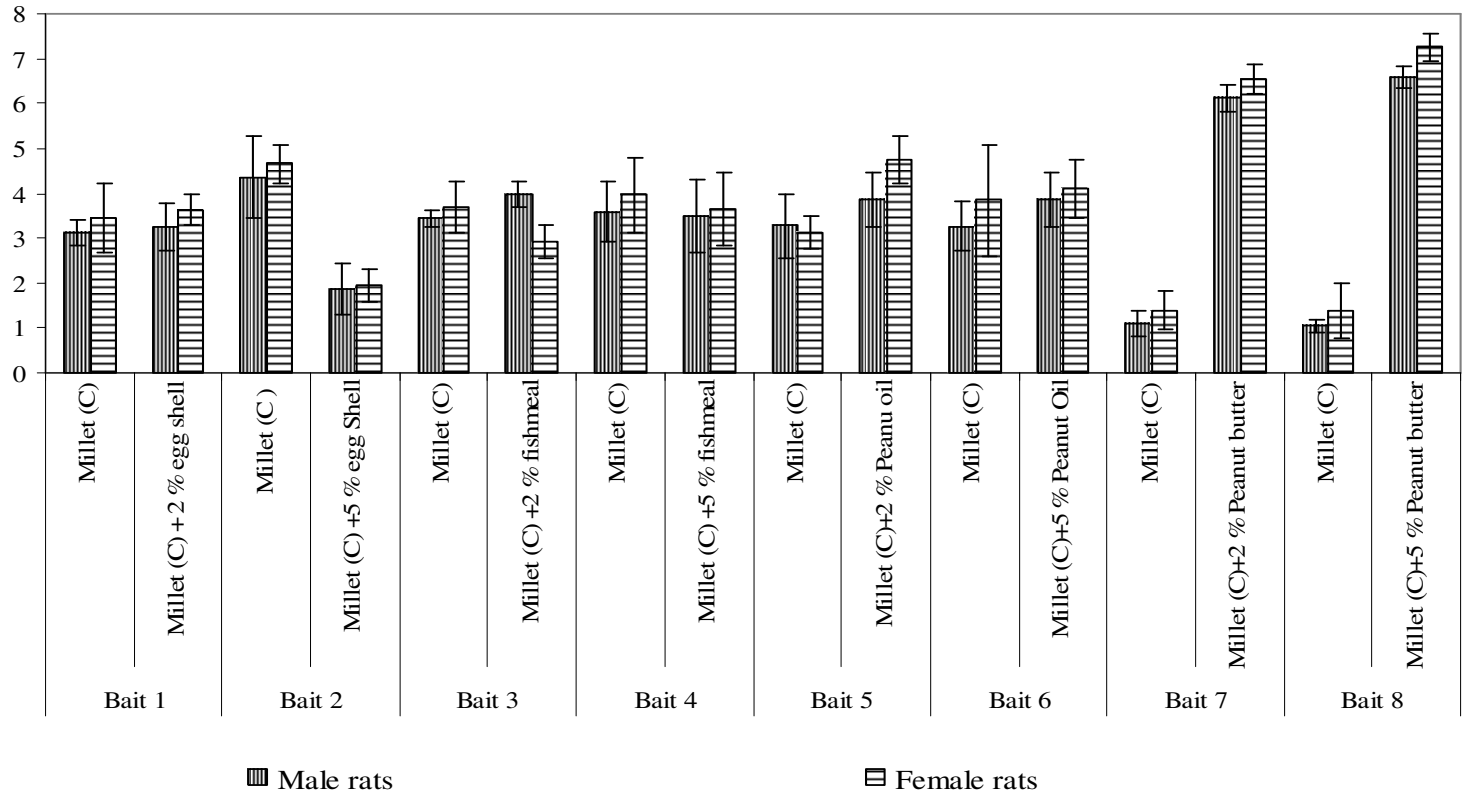

Figure 2. Preference of taste enhanced baits over plain millet bait expressed as mean daily consumption (g/100 gram body weight of *B. bengalensis*.

Table 3. Analysis of variance showing preference of different taste enhanced baits over plain bait.

S/N	Bait composition	Mean daily food consumption (g/100g body weight) (mean ± SE)	*F* value	Probability
Bait 1	Plain Millet (C) Millet (C) + 2 % egg shell+2% Vegetable oil	6.73 ± 0.44	1.833 NS	
Bait 2	Plain Millet (C) Millet (C) +5 % egg Shell+2% Vegetable oil	6.41 ± 1.86	40.259**	P=0.0000
Bait 3	Plain Millet (C) Millet (C) +2 % fishmeal+2% Vegetable oil	7.00 ± 0.20	1.040 NS	
Bait 4	Plain Millet (C) Millet (C) +5 % fishmeal+2% Vegetable oil	7.34± 0.02	0.002 NS	
Bait 5	Plain Millet (C) Millet (C)+2 % Peanut oil	7.51 ± 0.05	0.000NS	
Bait 6	Plain Millet (C) Millet (C)+5 % Peanut Oil	7.53 ± 0.12	0.093 NS	
Bait 7	Plain Millet (C) Millet (C)+2 % Peanut butter	7.58 ± 0.12	168.447**	P=0.0000
Bait 8	Plain Millet (C) Millet (C)+5 % Peanut butter	8.13 ± 0.06	138.655**	P=0.0000

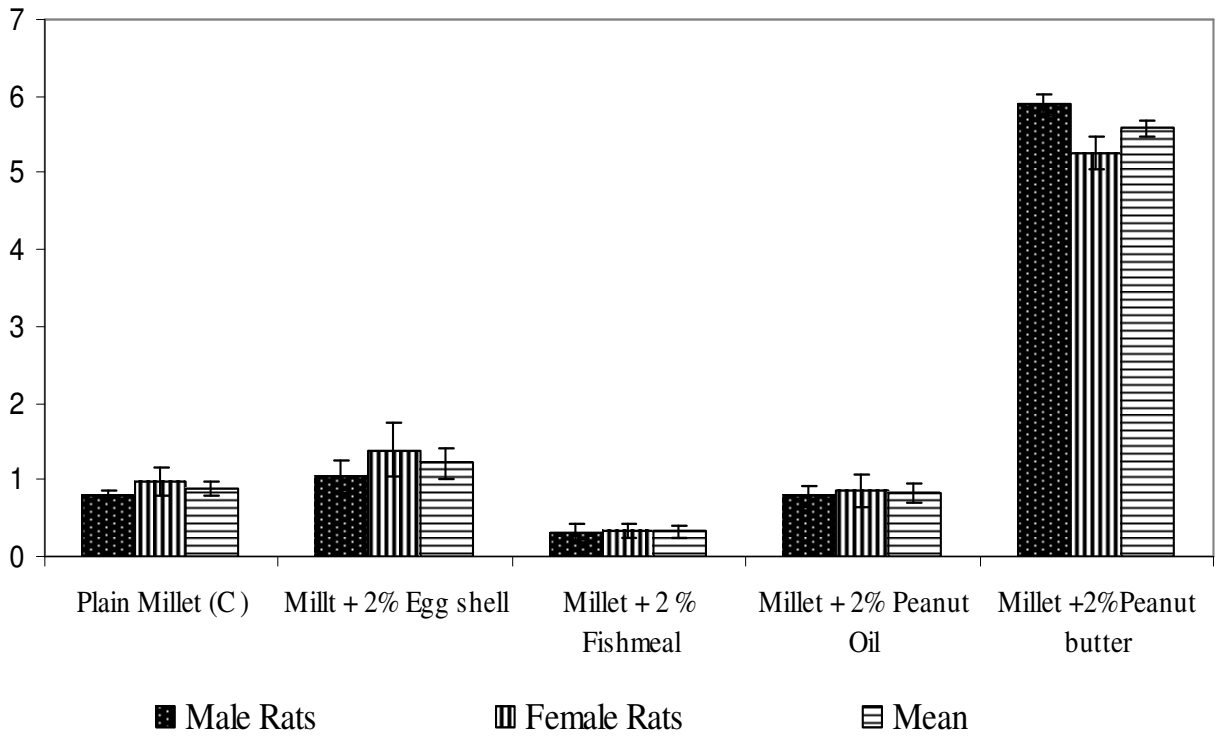

Figure 3. Preference of *Bandicota bengalensis* for plain and all additives added millet food served over eight days in a multi choice test in terms of daily food intake g/100 gram body weight.

P=0.000) with mean intake of 6.33±0.24 g/100 g body weight against 1.25±0.20 g in case of plain millet. Likewise, significant difference was observed when we used peanut butter at 5% (F, 160=138.655, P=0.0000) with average daily consumption of 6.91±0.33 g as compared to plain bait; where mean daily consumption was recorded as 1.21±0.15/100 g body weight (Table 3). The findings are in agreement with the work done by Buckner (1957) who maintained that peanut butter when mixed with oats was found to be the most effective in attracting many species of rats. These results were reconfirmed and the rats were offered an opportunity of multi-choice feeding of all bait additives. Again, the millet with 2% peanut butter was significantly more consumed as compared to the other four taste enhancers. The difference in consumption of millet + 2% egg shell, millet plain, millet + 2% peanut oil and millet + 2% fish meal was found non significant among all the test animals. The relative order of food preference in multi-choice test was observed as miilet + 2% peanut butter > millet +2 % egg shell > millet plain > millet + 2% peanut oil > millet + 2% fish meal, as illustrated by their mean daily food consumption at 5.58±0.12, 1.22±0.20, 0.89±0.09, 0.82±0.12 and 0.33±0.08 g/100 g body weight, respectively (Figure 3). Our investigations have therefore revealed that 2% peanut butter mixed in cracked millet is the most preferred cereal bait. One may assume that enhanced consumption of this bait combination may be due to the fact that 2% peanut butter might have made the texture of bait base more attractive and palatable. We may conclude that use of poison baits is still the most reliable strategy for controlling field as well as commensal rodents. However, baiting techniques should be modified according to the psychological characteristics like neophobia, bait shyness as well as feeding behaviour, exploratory behaviour, transporting, hoarding and territoriality behaviour of the target species (Lund, 2008). Nutshell of the present investigations is that use of 2% butter oil greatly enhance intake of cracked millet. This combination would yield significant control of *B. bengalensis* if used as poison bait.

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