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Life Cycle, Identification and Mode of Damages of Confused Flour Beetle.

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Abstract: *The study was conducted in the laboratory of BUITEMS Beleli at Quetta, during the year 2014. During study observations of life cycle ,identification and mode of damages of confused flour beetle were examined under laboratory conditions.The Coleoptera includes more species than any other order, constituting almost 25% of all known types of animal life-forms. About 40% of all described insect species are beetles about 400,000 species and new species are discovered frequently. Many beetles are responsible for different kind of diseases in stored products. An experiment was conducted at BUITEMS.The present research studies were focused to collect, identify, life cycle and mode of damages of confused flour beetles.*

Keywords: Study, observation confused flour beetle under laboratory condition**.**

INTRODUCTION:

The confused flour beetle (*Tribolium confusum*)(Order: Coleoptera, Family: Tenebrionidae), a type of darkling beetle known as a flour beetle, is a common pest insect known for attacking and infesting stored flour and grain. They are one of the most common and most destructive insect pests for grain and other food products stored in silos, warehouses, grocery stores, and homes (Alanko *et al*. 2000; Baldwin and Fasulo, 2010). The confused flour beetle is very similar in appearance and habit to the red flour beetle, both the confused flour beetle and red flour beetle are small in length and reddish-brown in color. The primary distinguishing physical difference is the shape of their antennae , the confused flour beetle's antennae increase gradually in size and have four clubs, while the red flour beetle's antennae have only three. Additionally, red flour beetles have been known to fly short distances, while confused flour beetles do not but have a long life span that can reach three years under moderate climatic conditions (25-30°C) (Sokoloff,1972). *Tribolium* destructor is much darker than either and less common. The "confused" in the beetle's name is due to being confused with the red flour beetle and not because of its walking pattern (Baldwin and Fasulo, 2010).

Wheat (*Triticum aestivum*) is an important staple foodstuff in Pakistan. Post harvest losses of wheat are due to biotic (insects, molds, rodents and birds) as well as a biotic (temperature, relative humidity and moisture contents of the grain) environments. Among the biotic processes, insect pests are the major agent such as confused flour beetle, which cause considerable losses in terms of quantity and quality of food grains. Apart from losses of weight and quality of food grain, insect infestation also poses human health risks because insects carry diseases, cause intestinal disorders or are responsible for the presence of toxins (Howe, 1965).

This confused flour beetle is a cosmopolitan pest and belongs to the Order Coleoptera (Class Insecta; Phylum Arthropoda), it generally feeds on finely ground or broken starch materials, such as flour or meal. Grain-feeding insects and mechanical harvesting injury provide a source of cracked kernels and dust food for them. The good news is that the confused flour beetle does not bite or sting. The bad news is that this beetle likes to eat stored products such as flour, cereal, pasta, dried pet foods, dried flowers and even chocolate found in our homes. The name "confused" is linked to its frequent confusion with the red flour beetle which it resembles. Female beetles lay microscopic eggs which hatch into light yellow, slightly hairy larvae. Adults, larvae, pupae and eggs may all be found in a typical infestation. An infestation can go unnoticed for some time and may have been introduced accidentally. The adults are attracted to light, but will go towards cover when disturbed. The adults have glands on the abdomen and thorax which release a pungent gas when the insects are irritated. This in turn may produce a very undesirable odour in the grain. Contamination also occurs from the accumulation of dead bodies and waste products. Just like the *T. castaneum*, the confused flour beetle develops in crushed grain products and a constant inhabitant of flour mills especially in the temperate regions of the world. The confused flour beetle, originally of African origin, has a different distribution in that it occurs worldwide in cooler climates. In the United States it is more abundant in the northern states (Smith and Whitman, 1992)

While confused flour beetles cannot feed on whole, undamaged grain, they are often found in large numbers in infested grains, feeding on broken grain, grain dust, and other household food items such as flour, rice, dried fruit, nuts, and beans. Both types of beetles are often found not only in infested grains, but in crevices in pantries and cabinet, as well. Damage to food is caused somewhat by the beetles' feeding, but also by their dead bodies, fecal pellets, and foul-smelling secretions. In addition to creating a foul odor, the beetles' presence encourages the growth of mold. Confused flour beetles and other similar stored grain pests are common, but easily controlled and managed.

Flour beetles do not feed on whole grain kernels such as other pantry pests like Indian Meal Moths and Drugstore Beetles. Flour Beetles are scavengers, feeding on the grain only after the seed coat has been broken. The female flour beetle places eggs directly on flour, cereals, dry pet food and similar items. They can cause considerable financial losses in food processing centers, food mills and commercial storage areas. These beetles have chewing mouthparts, but do not bite or sting. The confused flour beetle may elicit an allergic response (Alanko et al. 2000), but is not known to spread disease and does not feed on or damage the structure of a home or furniture. The confused flour beetle, originally of African origin, has a different distribution in that it occurs worldwide in cooler climates. In the United States it is more abundant in the northern states (Smith and Whitman; 1992).

Tribolium confusum, the confused flour beetle, are major pests of stored products, and when insecticides have been tested against these species, the order of susceptibility often depends on the specific insecticide and formulation that is being evaluated (Arthur, 1998 a,b,).

The original habitat of *Tribolium* spp. is thought to be under the bark of trees or rotting logs where they originally fed as saprovores or fungi ores, occasionally scavenging insect eggs and pupae (Alabi 2008).

Methyl bromide fumigation is the method of choice to manage stored-product insects infesting cereal processing facilities. Because methyl bromide damages the atmospheric ozone layer, there have been steps taken to reduce its production and use. The protocol on substances that Methyl bromide depletes the ozone layer will progressively reduce the use of methyl bromide, and only quarantine and pre shipment uses are allowed in developed countries (Anonymous, 1998). Additionally, it is becoming more difficult for processing facilities situated in urban areas to use fumigant or aerosol insecticides due to municipal ordinances. One nontoxic alternative to chemical insecticides for stored-product insect control in food processing facilities is heat treatment. Temperatures necessary to kill many species of stored-product insects have been reported (Fields, 1992).

Dennis Calvin (1990) developed control of confused flour beetle and concluded that prevention is the best strategy to avoid insect problems in stored grains. Proper bin sanitation before introduction of new grain minimizes the need for pesticides. Good sanitation involves the removal of old grain and dust in and around the grain bin. This includes removal of old grain from corners, floors, and walls. Any grain remaining when a bin is emptied can harbor insect infestations which will move into the new grain. Grain that is to be stored for longer than six months may need a protective application of an approved insecticide. Taxonomic Position of Confused flour Beetle are given below:

Phylum: Arthropoda
Class: Hexapoda (Insecta)
Order: Coleoptera
Family: Tenebrionidae

Before grain is placed in a bin, it should be screened to eliminate fine materials and broken kernels. Grain placed in a clean bin should be checked at two week intervals during warm months and at one month intervals during cooler months for the presence of hotspots, moldy areas, and live insects. If any of these conditions exist, the grain should be aerated to lower the moisture level and temperature.

Fumigation should only be used as a last resort. Because of the high toxicity of registered fumigants and technical knowledge needed for their proper use, a qualified pesticide applicator should be contacted if fumigation is required.

REVIEW OF LITERATURE:

Raychaudhuri.*et al.*(1965) exposed Single-pair crosses were made to determine the effects of parental age upon the durations of different stages of the offspring of the confused flour beetle, *Tribolium confusum* . Positive correlations were found to exist between parental age and the larval, pupal, and adult stages. Larval and adult durations were altered in a cyclic manner with increasing age of the parents. The changes in the larval stage were reciprocal to those in the adult stage. The effects of parental age upon pupal duration were very marked only when the parents were very old. The number of molts in the larvae was not found to be affected by the increasing age of the parents. The number of viable eggs produced by the female was influenced by the age of the female only. Here again the rate of egg production was cyclic with the age of the beetles. The age of the male had no effect upon the number of eggs produced by the female. It was observed also that maximum longevity of female *Tribolium* was much greater than that of the male.

Millam Stanley M.S. *et al.*(1970) stated that the fundamental developmental pattern is not unusual for a confused flour beetle. The more notable events and structures include an apparently sperm-filled tubular structure (possibly a micropyle) found on the chorion of some eggs. Peripheral energids of the presumptive blastoderm exhibit annular waves of mitoses. The mesenteron develops from a pair of posterior rudiments. An eosinophilic serosa secretes a thick external cuticle. The

well-developed pleuropodia are believed to produce secretions that lyse the serosa and the serosal cuticle.

White G.G (1982) performed that the effect of severity of grain damage on survival and development of larvae of *Tribolium confusum* in wheat was investigated. Exposure of the germ was generally necessary for survival of young larvae. Rate of development increased with degree of exposure of the germ. Survival and development would not be significantly affected by a practicable reduction in the current level of grain damage in mechanically harvested wheat.

Soliman M.H. (1987) stated that the experimental suitability of the flour beetles of the genus *Tribolium* has attracted ecologists, nutritionists, radiation biologists and geneticists for decades. I have, recently, evaluated their importance to gerontologists. This paper deals with age-related changes and parental age effects which were not included in a previous review. I have first discussed the known aspects of age-related changes in morphological, physiological, biochemical, behavioral and pathological parameters as well as on radiation-sensitivity and susceptibility to insecticides. Pre-adult biochemical and physiological changes have also been included, because of the important inter-relationship between growth and ageing. This is followed by an evaluation of parental age effects on physiological and genetic characteristics and of proposed areas for possible research.

Dowell, F. E *et al*.(1999) stated that Proper identification of insects in grain storage facilities is critical for predicting development of pest populations and for making management decisions. However, many stored-grain insect pests are difficult to identify, even for trained personnel. We examined the possibility that near-infrared (NIR) spectroscopy could be used for taxonomic purposes based on the premise that every species may have a unique chemical composition. Tests were conducted with 11 species of beetles commonly associated with stored grain. Spectra from individual insects were collected by using a near-infrared diode-array spectrometer. Calibrations were developed by using partial least squares analysis and neural networks. The neural networks calibration correctly identified >99% of test insects as primary or secondary pests and correctly identified >95% of test insects to genus. Evidence indicates that absorption characteristics of cuticular lipids may contribute to the classification of these species. We believe that this technology could be used for rapid, automated identification of many other organisms.

MATERIALS AND METHODS:

The study was conducted in the laboratory of BUITEMS Beleli at Quetta, during the year 2014. During study observations of life cycle ,identification and mode of damages of confused flour beetle were examined under laboratory conditions.

Equipments used in collection, identification and rearing of confused flour beetles.

- **Fine paint brush**
  For picking beetles
- **Petri dish**
  For placing beetles
- **Magnifying glass**
  Use for clear image and for visible appearance
- **Xylol**
  Used for washing the beetles
- **Light microscope**
  Use for identifying beetles
- **Glass jar**
  Use for rearing beetles
- **Simple scale**
  For measuring the length of beetle

METHOD

a) Collection and Identification of Beetles

The larvae of Confused Flour Beetle, (*Tribolium confusum*) were collected from local market, flours mills and food godowns, located in Quetta district and reared in the laboratory maintained in sterilized glass jars (1.0 kg capacity), after rearing it was observed that confused flour beetle and red flour beetle is very similar in appearance, Identification of confused flour beetle were based on antennae which was increasing gradually in size and had four clubs. Some of collected larvae became the adult of red flour beetle and some of them became confused flour beetle. During larval stage of confused flour beetle it was observed by using light microscope that larvae had six legs with two forked projections at the rear end and adults were examined that it had flattened, shiny, reddish-brown with an elongated body and reddish-brown in color. Identification of confused flour beetle is always confused with Red Flour Beetle and it can't be identify in larval stage .The beetles were measured by using simple scale and recorded that they were an average of 3 mm long.

Flour Mill

Flour Mill

b) Sex Identification in beetles

For identifying gender, light microscope was used by placing pupa under the microscope. Adult male and female flour beetles were physically and nearly identical, so the identification of sex of flour beetle is usually done in the pupal stage, during study following features were observed:

Focus on the tip of the abdomen as there were 2 long projections called the *urogomphi* both females and males had these protrusions. Layered on top the urogomphi and a little further up the abdomen is another set of 2 smaller projections called the genital papillae – this is what were looking at to distinguish between males and females.

On **females**, the genital papillae were pointy, with 2 darker dots on the tip of each, and roughly half the size of the urogomphi. (They resemble **tiny fingers**).

On **males**, the genital papillae were stubby, conjoined, and barely noticeable. If female papillae resemble fingers, these look more like 2 **conjoined thumbs.**

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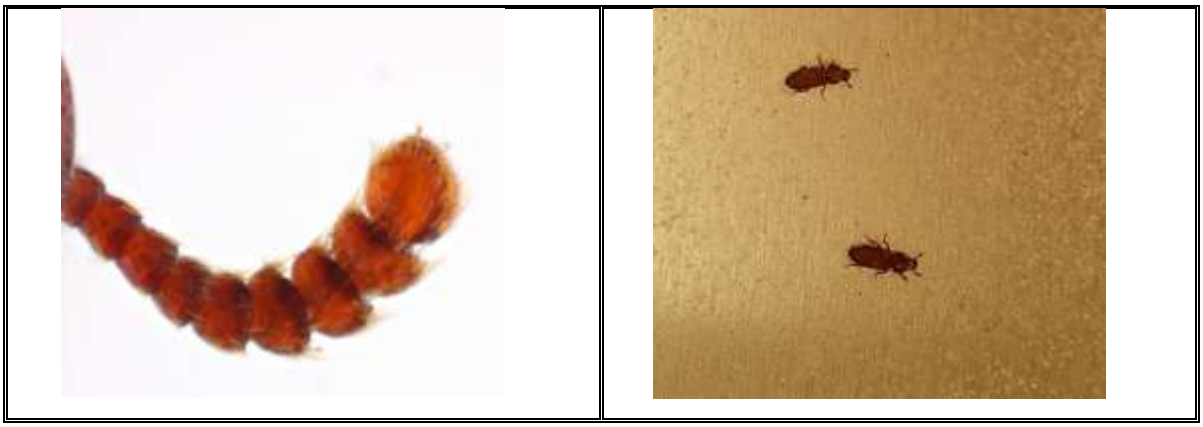
Females have finger-like papillae (left), while males have stub-like projections (right).

c) Identification of Antennae and Body

By placing the Confused flour beetle under the microscope it was noticed that antennae was increasing gradually in size and had four clubs, while the red flour beetle's antennae had only three. The "confused" in the beetle's name is due to being confused with the red flour beetle. Confused flour beetle had a straight-sided thorax, while the thorax of the red flour beetle had curved sides. Body was flattened, shiny, reddish-brown with an elongated body and reddish-brown in color. Pupae were white to light brown. *Tribolium confusum* had the notched eye.



Antennae of Confused flour beetle ***Adult of Confused flour beetle***

d.Studying Life Cycle of Flour Beetle

Experiments on the life cycle of confused flour beetle on the wheat flour were performed in the laboratory. The wheat flour variety used in these experiments was about 4 months old. All experiments were conducted in a climate controlled room temperature. The adults of confused flour beetles were obtained from a stock, reared in the laboratory. Newly emerged adult beetles were used in this experiment. Tests were conducted in March 2014 by placing flour into 3 separate glass jars topped with muslin handkerchief and secured with rubber bands and newly emerged adults were placed in these jars. The standard weight of samples were used in the experiment was 100 g, kept in glass jars. After a two weeks female laid eggs which cannot be seen by naked eyes, females laid eggs about 5 to 8 days with an average of 2-3 eggs per day under optimum conditions 30°C and 60-80% relative humidity (Raymond ,1935), after a few days some of eggs hatched about 4, 3 and 2 respectively in each jar were hatched into cylindrical, white larvae tinged with yellow. The larva was measured by simple scale whose length was 8 mm and changes into several instars, the length of larval period took 18-22 days to emerge as pupae and took 5 days to become adult. In each jar the populations of beetles were different. The same process was repeated again in May ,2014 and observed 5, 3, 4 larvae but at last study in July 2014 it was observed that only 2 ,1 and 3 eggs were hatched respectively in each jar. The speed of development of *Tribolium confusum* were studied over a series of constant temperatures between 15° and 40° C. Eggs did not hatch at 15° or 40° C. at any humidity. Humidity does not affect the egg period.

Observing life cycle of beetles

Reared Confused flour beetle in laboratory

Egg hatching of beetles from March to August

	Months	Jar 1 Larvae T1	Jar 2 Larvae T2	Jar 3 Larvae T3	Mean
R1	March- April	4	3	2	3
R2	May-June	5	3	4	4
R3	July-August	2	1	3	2

Time taken by life stages of beetles

	Egg	Larva	Pupa	Adult
1st generation	5 days	18 days	5 days	Emergence
2nd generation	6 days	19 days	7 days	Emergence
3rd generation	5 days	19 days	6 days	Emergence

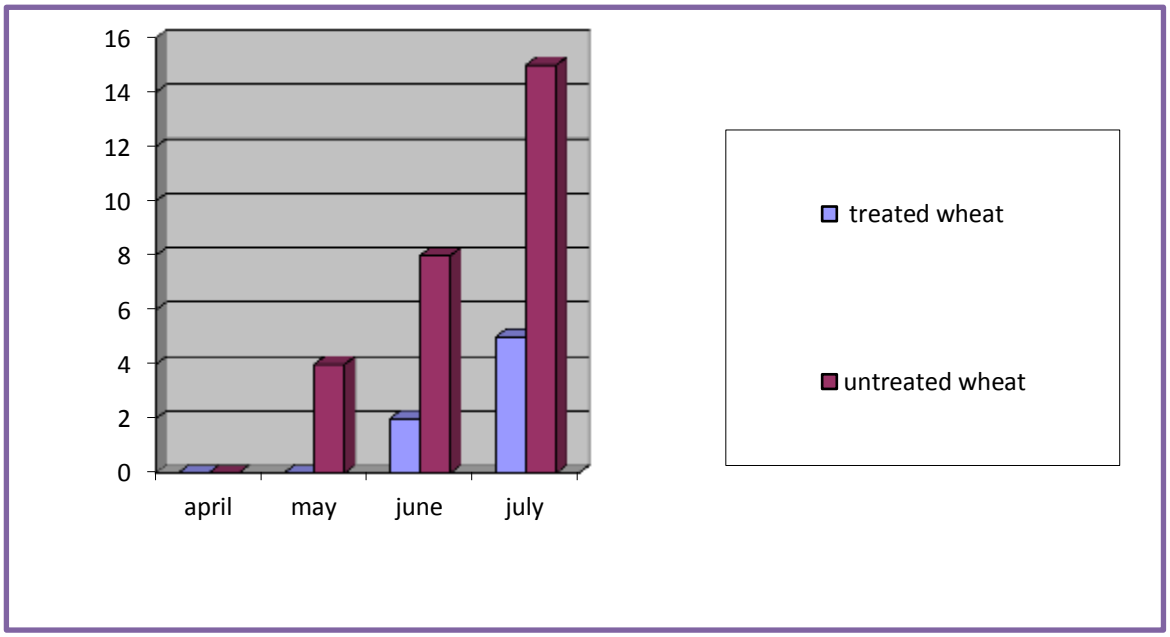
e) Studying mode of Damages

The wheat grains for the study were bought from the market and placed in a two glass jars, in each jar 100 gm of wheat grains were placed in march 2014 in first jar 100 gm of wheat were fumigated with phosphotoxin and on another jar wheat were not fumigated with phosphotoxin and reared confused flour beetles in those two jars after a one month, data of damages were recorded on monthly bases. It was noticed that in first few months the effect of damages were very low but as their population gained the wheat started to lose their weight. After three months the non-fumigated grains were placed at Petri dish under light microscope it was noticed that small tiny cracks were observed on wheat grains and then the grains that were fumigated with phosphotoxin were placed at Petri dish and observed that very few grains were damaged. After that at last week of july the weight of two jars grain were weighted and recorded that the fumigated grains loosed only 5% weight (loosed 5gm) where as the non-fumigated grains loosed 15% (loosed 15gm) weight. Below are photos showing the results of research with fumigated and non-fumigated grains.

Monthly percentage of wheat grain damages

Treatment	Months			
	April	May	June	July
Wheat without fumigation	00%	4%	8%	15%
Wheat with fumigation	00%	00%	2%	5%

Graph of wheat damages in different months



Fumigated grain* damages** ***Non-fumigated grain damages

Wheat grains in jars Observing damages in laboratory

Slides of Confused flour beetle la;rva

RESULTS AND DISSCUSSION:

The result of this study showed the life cycle, identification and mode of damages of confused flour beetle from March 2014 to August 2014 under laboratory conditions. wheat flour and grains were used in this research collected from different flour mills and the beetles were reared in these flours and grains. In this research different equipments were used i.e. light microscope, glass jar, Petri dish, magnifying glass, fine paint brush etc. Identification of beetles were based on the antennae which increase in size gradually from the base to the tip and observed that it formed a club of four segments and it was also observed that in larval stage it can't be identify that either it is a red or confused flour beetle. Females beetle laid eggs about 5 to 8 days with an average of 2-3 eggs per day under optimum conditions 30°C and 60- Identification of beetles were based on the antennae which increase in size gradually from the base to the tip and observed that it formed a club of four segments and it was also observed that in larval stage it can't be identify that either it is a red or confused flour beetle. Females beetle laid eggs about 5 to 8 days with an average of 2-3 eggs per day under optimum conditions 30°C and 60-80% relative humidity. During larval stage of confused flour beetle it was observed that larvae had six legs with two forked projections at the rear end Larva took 18-22 days to reach pupa stage and after 5 days it emerged as adult and observed that it had flattened, shiny, reddish-brown with an elongated body and reddish-brown in color. Pupae were white to light brown .In this study some wheat grains were fumigated and non- fumigated with phosphotoxin in two different jars and observed that the grains fumigated with phosphotoxin did not lose weight as compare to non-fumigated grains and it was also observed that the non-fumigated grains damaged by the larvae and adult.

Conclusions

humidity. During larval stage of confused flour beetle it was observed that larvae had six legs with two forked projections at the rear end Larva took 18-22 days to reach pupa stage and after 5 days it emerged as adult and observed that it had flattened, shiny, reddish-brown with an elongated body and reddish-brown in color

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