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Handicraft using corn ear husk and pest damage affecting its production

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Abstract

Family farmers use corn [*Zea mays* L (Poales: Poaceae)] ear husk to produce handicrafts. Income from selling handicrafts supplements their earnings and is used to buy food, home appliances, education (taxes) payment for children and grandchildren, etc. In addition, the extra work and income reduce artisan stress and improve physical and psychological health. EMBRAPA Corn and Sorghum, in Sete Lagoas, Minas Gerais state, Brazil, reports that corn genetic materials must have good productivity characteristics (main feature) and ears with husk of the proper color, length, texture, and width to be used for handicraft works which characteristics varies according to region and manufactured item. Moreover, plants must have good resistance characteristics to lodging and breakage, and seeds with good germination index. Birds, mammals, insects, and micro-organisms are corn pests, damaging plants and ear husks, and feeding on the kernels. Insects and micro-organisms usually cause lower damage to husks than birds and mammals. Identification of these organisms have been reported, such as an inverted «Y» on the head of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) differentiating it from the corn earworm, *Helicoverpa zea* (Lepidoptera: Noctuidae). Main pest control methods were reported, e.g. for birds: construction of refuge places; propane applied with cannons; scarecrows with colorful fabrics; pyrotechnics (fireworks releasing); hunting (firearms used according to the law); seeds colored with inert substances (generally red, making them to resemble to toxic seeds of native plants); resistant cultivars (hard husk); covering ears with cloth bags (physical barrier); biological control with birds; commercially available repellent materials, and others. Handicraft using corn ear husk is important activity and expanding worldwide, but pests can destroy or severely damage production of this material.

Keywords: artistic product, corn, craft husk, damage

Introduction

Handicraft using corn husk in Brazil

Handicraft with corn [*Zea mays* L (Poales: Poaceae)] ear husks is a traditional activity in Brazilian communities, including Campos dos Goytacazes (Rio de Janeiro state) (Marta et al, 2007); Cipotânea and Goianá (Forest Zone region), Diamantina (Jequitinhonha Valley region), and Paraopeba (Central region) in Minas Gerais state (Teixeira et al, 2007, 2011). Artisans make products, such as baskets, braided furniture, dolls, flowers, seats, etc. (Figure 1). Ear husk was once considered a by-product for poultry litter and organic fertilizer, or discarded by most farmers (Teixeira et al, 2007, 2011). Rural communities of family farmers have been making their own handicraft products with ear husks for selling directly or to other artisans (Teixeira et al, 2007, 2011). Ear husks and other plant by-products contributed as an extra income and employment for rural families (Keller, 2011). EMBRAPA Corn and Sorghum, in Sete Lagoas, Minas Gerais state (Brazil) identified and stored corn varieties in its germoplasm bank with potential for handicraft, such as husk type and color with grain yield (Teixeira et al, 2007, 2011).

Features of corn ear husks for handicraft

Artisans need corn varieties with long ears, and husks with different colors and textures depending on the techniques they used to manufacture products (Teixeira et al, 2007, 2011). Commercial corn cultivars developed for high grain yield do not have the desired ear characteristics (color and texture) or size (length and diameter) (Teixeira et al, 2011). Marketing handicraft products for domestic and foreign markets is increasing, making the activity very profitable (Teixeira et al, 2007). Light to dark husks have been selected for natural breeding programs, but varieties with greater color diversity are the most desirable ones (Teixeira et al, 2007, 2011).

Natural breeding results related to corn ear husk features for handicraft

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Figure 1 - Handicraft items made using corn husk. Source: Dr. Flávia França Teixeira (EMBRAPA Corn and Sorghum).

Texture is an important corn ear husks feature for handicraft (Teixeira et al, 2007, 2011). Husk malleability is necessary to help artisans to easily make their products (Teixeira et al, 2007, 2011). Corn varieties BRS Palha Escura and BRS Palha Rosada were recovered from accesses of the corn germplasm bank of EMBRAPA Corn and Sorghum and tested for two consecutive years (Teixeira et al, 2011; Table 1). Grain yield of these varieties was lower than most modern corn cultivars (Teixeira et al, 2011). On the other hand, husks of BRS Palha Escura and BRS Palha Rosada varieties are colorful and more flexible, enhancing artisans work (Teixeira et al, 2011). In Diamantina, Minas Gerais state (Brazil), varieties local 1, MG092, BA073, MS031, and MS054 were most productive; MG082, MG092, BA093, and MG075 had longer ears; MG053 and BA100 greater color diversity, and MG092, MG093, MS031, and MG075 most malleable (Teixeira et al, 2007). In Cipotânea, Minas Gerais state (Brazil), double-cross hybrid BRS2020 and varieties MG092, SC015, Saracura, and BR451 were most productive; MG088, MGIII, and SC012 had longer ears; varieties BA143, MGIII, Composto Cristal, MS003, SC012, SC015, SP080, SC007, Saracura, and BR451 and hybrids BRS1010 and BRS2020 lighter husk. Husk color diversity is not an important characteristic in Cipotânea because colored husks are used only for few products or ornaments. Varieties MGIII and MS003 had better texture (Teixeira et al, 2007). Resistance to lodging and plant stalk breakage during a gale and seeds germination index are other important characteristics in these corn varieties (Teixeira et al, 2007, 2011).

Pests damaging corn ear husks

Caterpillars

Spodoptera frugiperda *(Lepidoptera: Noctuidae)*

Shortly after egg hatch, the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae scrape younger corn leaves (Ayala et al, 2013; de Melo et al, 2014). Larvae feed on one side of the leaf, leaving the other intact (window paning) and eliminating feces on the leaves, which can be used to identify its presence. Damage on leaves and corn whorl increase with larvae development (Cruz et al, 1999; Varella et al, 2015). Larvae of the last two instars of *S. frugiperda* consume around 95% of all the food ingested by the caterpillar in its lifespan (Waldbauer, 1968; Scriber and Slansky, 1981). Damage by *S. frugiperda* can be on the tassel and in severe infestations on the ear where it can be confounded with the corn earworm, *Helicoverpa zea* (Lepidoptera: Noctuidae) both occuring in a single ear at the same time (Rodriguez-del-Bosque et al, 2011). A mark in «Y» inverted on the head, three white-yellowish dorsal longitudinal lines and black spots on the body can be used for differing *S. frugiperda* caterpillars from those of *H. zea* (Sarmento et al, 2002). *S. frugiperda* caterpillars invade ears by the apex (small larvae), sides and base (large caterpillars) perforating the husks.

Monitoring *S. frugiperda* adult males can be performed using commercial synthetic sexual pheromones (Batista-Pereira et al, 2006; Cruz et al, 2012). Control integrates natural enemy releases, such as the egg parasitoids, *Chelonus insularis* (Hymenoptera: Braconidae); *Telenomus remus* (Hymenoptera: Scelionidae) and *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) (Figueiredo et al, 2006a, 2015) and the larval parasitoids, *Campoletis flavicincta* (Hymenoptera: Ichneumonidae) and *Exasticolus fuscicornis* (Hymenoptera: Braconidae) (Figueiredo et al, 1999, 2006b; Zanuncio et al, 2013) with selective insecticides not affecting non-target organisms, such as biologicals based on *Bacillus thuringiensis* (Bt) (Bacillales: Bacillaceae) and *Baculovirus spodoptera* (Baculoviridae); botanicals, including those based on azadirachtin (limonoid) obtained from neem, *Azadirachta indica* (Sapindales: Meliaceae) seeds and synthetics, including EC Match® (lufenuron), 300 ml ha^{-1}; Fury 200 EW® (zetacypermethrin), 90 ml ha^{-1}; Lannate BR® (methomyl), 600 ml ha^{-1}, and Tracer® (spinosad), 50 ml ha^{-1} (spraying 10 days after the threshold level) (Tavares et al, 2009, 2010a, 2010b, 2011a, 2013a, 2013b). Cost of a biofactory of *Trichogramma pretiosum* to control *S. frugiperda* in corn crops was estimated with cost of US $1.19 (currency conversion made on early July 2016) to produce 200,000 wasps to be released per hectare (Tavares et al, 2010c). Other biological agents controlling eggs, larvae and pupae of fall armyworm include predators, such as green lacewing, *Chrysoperla externa* (Neuroptera: Chrysopidae) (Tavares et al, 2011b); spotted lady beetle, *Coleomegilla maculata* (Silva et al, 2010) and ashy gray ladybug, *Olla v-nigrum* (Coleoptera: Coccinellidae) (Silva et al, 2013). These insects can be mass reared in the laboratory using alternative hosts such as mealworm, *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae and larvae and Mediterranean flour moth, *Anagasta* (= *Ephestia*) *kuehniella* (Lepidoptera: Pyralidae) eggs or artificial diets and

Table 1 - Average of features of nine assessments of corn varieties BRS Palha Escura and BRS Palha Rosada in Diamantina and Cipotânea municipalities, Minas Gerais state, Brazil.

Features	BRS Palha Escura	BRS Palha Rosada
Type and grain color	Semi-hard/Orange	Semi-hard/Orange
Number of days for female flowering	80.4	80.9
Plant height (m)	2.87	2.93
Ear height (m)	1.77	1.90
Ear length with husk (cm)	25.6	25.9
Ear diameter with husk (cm)	39.1	43.7
Husk	Completely covered	Completely covered
Productivity (Kg ha^{-1})($)	2,746.00	3,176.00
Husk features	Long, predominantly intensly colored. Predominance of corn with intense husk color	Long with predominance of ears that have husk slightly pigmented

($) Considering production of ears with husk from grain sample and moisture adjusted to 13%. Average stand of 50,000 plants per hectare. Adapted from Teixeira et al (2011).

released in the field (Zanuncio et al, 2011, 2014a).

Helicoverpa zea *(Lepidoptera: Noctuidae)*

The adult *H. zea* moth has a 40 mm wingspan. Forewings are yellowbrown with a darker transversal band, and dark spots on the wings. Hindwings are lighter than forewings, with a stripe on external edges. Eggs are spherical and with lateral bumps (1 mm diameter). Females deposit eggs, individually (about 15 eggs on each ear) (Neunzig, 1964). Above 25°C, caterpillars hatch 3-4 days after oviposition and start feeding on silk-stigma (Archer and Bynum Junior, 1994). Caterpillars perforate the corn ear husks to reach the forming kernels to feed upon. Developed caterpillar measure 35 mm long and are light-green, pink, brown, or black, with lighter parts. The larval stage lasts between 13 and 25 days according to the temperature (Matrangolo et al, 1998).

Monitoring adult males of this pest can be performed with sexual pheromone traps with virgin females (Matrangolo et al, 1996). Control can be achieved by releasing natural enemies, such as the egg parasitoid, *Trichogramma* spp. (Sá and Parra, 1993; Ciociola Júnior et al, 1998; Paron et al, 1998) and, in cases of severe infestations, spraying synthetic insecticides, such as chlorpyrifos (organophosphate) which has reduced negative effect on the predator of *H. zea* and *S. frugiperda* eggs, *Doru luteipes* (Dermaptera: Forficulidae) (Michereff Filho et al, 2002).

Sweet corn growers from north Florida (FL) to Delaware (United States) sprayed usually Bt insecticides twice a day against *H. armigera* in 2015 (information, Dr. David Owens) but some corn earworm strains are resistant to corn Bt transformed varieties (Alvi et al, 2012).

Flies

Euxesta *spp. (Diptera: Ulidiidae, formely Otitidae)*

Adult picture-winged flies, *Euxesta* spp. (Diptera: Ulidiidae), with an average of 5 mm long, have dark and colorless wings with dark spots. Eggs are laid on the silk-stigma and larvae eclode 2-3 days after oviposition (Kameneva and Korneyev, 2005/2006; Goyal et al, 2011a). They are considered secondary pests in Brazil, but *Euxesta* spp. larva feeding damage to corn has been increasing, especially on corn with softer grain when they can eventually cause small holes in the husks to reach the kernels. Larvae penetrate kernels in the milk stage and feed on the embryo, leaving only the external membrane intact (Hentz and Nuessly, 2004). Two species of picture-winged flies occur on corn in Brazil, *Euxesta eluta* and *Euxesta mazorca*, identified by the intensity of stripes on the wings, complete in the first species (Cruz et al, 2011). Four species (*Chaetopsis massyla*, *Euxesta annonae*, *E. eluta*, and *Euxesta stigmatias)* occour in FL, where they are primary pests to corn crops (Goyal et al, 2010, 2011b, 2012).

Damage by *Euxesta* spp. in corn crops can be determined with rating scales (Scully et al, 2002), but they are not really used by commercial sweet corn growers; presence of a single larva anywhere in the ear will reject it and the pallet will be downgraded (information, Dr. David Owens). Control of *Euxesta* spp. can be performed with growing good quality tight husk materials (total coverage of grains) and resistant genetic materials due to high maysin content in the silk (Scully et al, 2000; Nuessly et al, 2007). In cases of severe infestations, insecticides, including chlorpyrifos, cyfluthrin, esfenvalerate, lambda-cyhalothrin, methomyl, methyl parathion, and thiodicarb should be sprayed (Nuessly and Hentz, 2004). Insecticide sprays on sweet corn is the only management tactic to control picture-winged flies used in 2015 and previous years in FL (information, Dr. David Owens). Low rates (0.56 Kg active ingredient ha^{-1}) of chlorpyrifos and methyl parathion provided the most efficient control of *E. stigmatias*, controlling 100% and 93%, respectively, within two hours of direct contact (Nuessly and Hentz, 2004). A single insecticide can be sprayed to control picture-winged flies and other pests (Lepidoptera) at the same time; corn growers were seen applying insecticides by air as frequently as twice a day from first silk to harvest in 2015 in FL (information, Dr. David Owens).

Parasitoids, such as the wasps, *Dettmeria euxestae* (Hymenoptera: Eucoilidae) (Valicente, 1986) and

Pachycrepoideus vindemmiae (Hymenoptera: Pteromalidae) (Owens et al, 2015) parasitize *Euxesta* spp. in Brazil and in US, respectively. The last parasitoid is not a viable control agent and is not being released or mass produced against picture-winged flies because it does not dig in the soil to locate picture-winged flies' pupae and it is very susceptible to insecticides (Owens et al, 2015). *Dettmeria* sp. (Hymenoptera: Figitidae) parasitizes *Euxesta* spp. larvae in Argentina and possibly it occours in other countries of the Americas (Bertolaccini et al, 2010).

Moths

Anagasta kuehniella *and* Sitotroga cerealella

Anagasta (= *Ephestia*) *kuehniella* and Angoumois grain moth, *Sitotroga cerealella* (Lepidoptera: Gelechiidae) are secondary corn pests, consuming stored meals and brans. These insects can also damage corn ear husks when unhusked ears are stored under inappropriate conditions such as wood barns and corn severely infested by primary pests, especially Coleoptera (Fouad et al, 2014).

A. kuehniella can be controlled with spraying chemicals, including extracts and crude resin of *Croton urucurana* (Euphorbiales: Euphorbiaceae), and lectin of *Annona coriacea* (Magnoliales: Annonaceae) (botanicals) (Silva et al, 2009; Coelho et al, 2007) and diflubenzuron and hexaflumuron (synthetics) (Ashouri et al, 2014) or by releasing natural enemies. Important natural enemies of this pest include the grain itch mite, *Pyemotes tritici* (Acari: Pyemotidae) (predator) (Hoschele and Tanigoshi, 1993) and *Venturia canescens* (Hymenoptera: Ichneumonidae) (parasitoid) (Belda and Riudavets, 2012), both reported in the US.

Control of *S. cerealella* includes spraying botanicals such as *Labiatae* sp. (Lamiales: Lamiaceae) oil as fumigant and powder and extract of *Aristolochia ringens* (Piperales: Aristolochiaceae); African mahogany, *Khaya ivorensis* (Sapindales: Meliaceae), *Strophanthus hispidus* (Gentianales: Apocynaceae), and *Zanthoxylum zanthoxyloides* (Rutales: Rutaceae) as contact insecticides (Shaaya et al, 1997; Ashamo and Akinnawonu, 2012), tilling of resistant corn varieties, control barn temperature as lower as possible to reduce the number of kernels damaged by *S. cerealella* (Butrón et al, 2008), and timely harvest (Santos et al, 1997).

Coleoptera pests of stored ears and pathogens (especially fungi) associated with them

Severe infestations of stored products and by-products by millions of maize weevils, *Sitophilus zeamais* (Coleoptera: Curculionidae) and other coleopterans pests, per cubic meter of grain masses damage bulk grain and ears (Zanuncio et al, 2014b). Wood barns are widely to store ears covered by leaves of palm tree (Arecales: Arecaceae) or other plants or have holes in the roofs that allow rainwater in. The floors consist of wood flooring or bare ground, increasing moisture contact. This leads to severe damage. Ears left in the field to dry in the sun can be infested by these pests and contaminating storage areas after harvest (cross infestation).

Coleoptera pests of stored grains can be monitored with sticky cards (color according to the species), commercial available pheromone traps and sampling evaluated by the techniques of Iwao's patchness, Taylor's power law and Morisita's index (Santos et al, 2003). Sawtoothed grain beetle, *Oryzaephilus surinamensis* (Cucujidae); red flour beetle, *Tribolium castaneum* (Tenebrionidae) and other Coleoptera of this group were controlled and/or repelled with plant-based chemicals, including compounds derived from *Lepidoploa aurea* (Asterales: Asteraceae) and *Memora nodosa* (Lamiales: Bignoniaceae) and astilbin from fava d'anta, *Dimorphandra mollis* (Fabales: Fabaceae) flowers (Fouad et al, 2012; Tavares et al, 2014), carbon dioxide, phosphine (Casella et al, 1998), and ozone (Sousa et al, 2012).

Moisture in places with stored corn ears and presence of primary (some Coleoptera) and secondary (some moths and Coleoptera) pests facilitate proliferation of fungi and other phatogens. Microbial colonization, including *Aspergillus* spp., *Penicillium* spp. (Eurotiales: Trichocomaceae), *Gibberella* sp., *Haematonectria* sp. (Hypocreales: Nectriaceae), and *Rhizopus* sp. (Mucoralis: Mucoraceae) destroys stored grain and contributes to diseases in humans and animals due to mycotoxins (e.g. aflatoxin and fumonisin) (Hell et al, 2000; Li et al, 2004; Kangolongo et al, 2009), especially in some regions of Africa, where corn storage facilities are poor.

Granivorous birds

Brazilian granivorous birds

Granivorous birds damage corn crops by feeding on seed sown in the soil and kernels on ears, which also leads to husk damage. Six main species were found in Piracicaba, São Paulo state feeding on sown corn seeds: domestic pigeon, *Columba livia*; ruddy ground dove, *Columbina talpacoti*; picazuro pigeon, *Patagioenas picazuro*; eared dove, *Zenaida auriculata* (Columbiformes: Columbidae); shiny-cowbird, *Molothrus bonariensis* (Passeriformes: Icteridae); and ruffous-collared sparrow, *Zonotrichia capensis* (Passeriformes: Emberizidae) (de Almeida et al, 2010). These species probably also feed on kernels in ears, thus causing husk damage.

Granivorous birds in Canada, Germany, Haiti, and US

Flocks of granivorous birds have been reported as pests of corn ears in Canada, Germany, Haiti, and US. However, birds were also reported damaging corn plants in other countries. Two major studies have been conducted in US to estimate bird-caused yield loss and how to sample or estimate their damage (Granett et al, 1974; Wywialowski, 1996). Estimated

yield loss by granivorous birds and other wildlife on corn plants was 1.7 bushels ha^{-1} with an estimated yield loss of 35 million bushels in 10 states; monetary losses were estimated to be US $92 million for the 1993 agricultural year in US (Wywialowski, 1996).

In Haiti, damage by birds and other animals on corn plants as the Hispaniolan woodpecker, *Melanerpes striatus* (Piciformes: Picidae); glossy cowbird, *Molothrus bonariensis* (Passeriformes: Icteridae); African village weavers, *Ploceus cucullatus* (Passeriformes: Ploceidae); Hispaniolan parakeets, *Psittacara chloroptera* (Psittaciformes: Psittacidae); and Norway rats, *Rattus norvegicus* (Rodentia: Muridae) was severe and without differences between plant fertilization levels and maturation stage (Engeman et al, 1985).

In North Dakota, US, millions of dollars are spent annually to control three species of blackbirds (Icterinae): the red-winged blackbird, *Agelaius phoeniceus*; common grackle, *Quiscalus quiscula*, and yellow-headed blackbird, *Xanthocephalus xanthocephalus* (Passeriformes: Icteridae). They damage corn and sunflowers, *Helianthus* spp. (Asteraceae) crops. *A. phoeniceus* is the most damaging one because cutting through the husk and exposing and feeding on the grain. Corn producers in North Dakota constantly report losses by blackbirds, but few studies have been conducted to document the damage level (Klosterman et al, 2013). One study observed ears appearance after bird feeding and the presence of plant debris in the field (Sterner et al, 2003). Damage on plants was more severe in corn with than without ears and damage peak occurred in August and September during R3 (R = reproductive; milky grain) and R4 (dough grain) stages, when grains are tender. After corn harvest, birds migrate to sunflower crops, which have longer cycles (Klosterman et al, 2013). A total of around 2/3 of a large planting may be eaten by birds; they went down the rows plucking out every single seed and seedling in FL in 2015 (information, Dr. David Owens).

The most commonly used method to control or reduce damage by granivorous birds are planting or preserving corridors as refuge places for their predators. Application of propane cannons, scarecrows made of colorful fabrics, pyrotechnics (fireworks releasing), hunting (firearms permitted under law), seeds colored with inert substances (generally red, which makes corn seeds resemble to toxic seeds of native plants), resistant cultivars (hard husk), covering ears with cloth bags (physical barrier), biological control using birds of prey (most used families, Accipitridae, Falconidae, Strigidae, and Tytonidae), commercially available repellent materials (anthraquinone-based Flight controlTM and methyl anthranilate-based ReJeX-iTTM AG-36) are methods used to manage bird populations (Dolbeer et al, 1995; Blackwell et al, 2001; Curtis et al, 2004; Werner et al, 2009).

In Canada, anthraquinone-based and other non-lethal bird repellents applied to corn plants with ears has been satisfactory for *Q. quiscula, A. phoeniceus*, *Branta canadensis* (Anseriformes: Anatidae), sandhill cranes *Grus canadensis* (Gruiformes: Gruidae), ring-necked pheasants *Phasianus colchicus* (Galliformes: Phasianidae), and other birds (Carlson et al, 2013).

In Germany, carrion crow, *Corvus corone*; rook, *Corvus frugilegus* (Passeriformes: Corviae); domestic pigeon, *Columba livia domestica*; common wood pigeon, *Columba palumbus* (Columbiformes: Columbidae), and other birds damage grain and corn seedlings with four or fewer leaves. Losses by birds and other bioagents are greater in fields planted without seed treatments, such as in organic fields where synthetic pesticidal seed treatment is prohibited (Esther et al, 2013).

Rats and other small rodents in Brazil and US

Small rodents such as rats destroy corn husk by exposing them to feed on the kernels. Brazilian small rodents attacking corn ears are mainly rats (*Rattus* spp.) and mice (*Mus* spp.) (Rodentia: Muridae) and other rat species of the families Bathyergidae, Cricetidae, Diatomyidae, and Heteromyidae. These pests can destroy ten times more food than they need for survival. In addition to these wastes and losses, rodents can transmit diseases to humans, such as leptospirosis through contaminated urine (Wasiński and Dutkiewicz, 2013). Protecting the base and sides of barns with zinc plate siding can help preventing rodent entry. Control of these small mammals can be done by protecting base and side of barns with zinc plates, which material is sliding, biological control with cats, *Felis silvestris catus* (Carnivora: Felidae), use of chemical repellents and lethal means, including strychnine-based rodenticides and capture traps, such as mousetraps and adhesive tape.

Rodents reported to damage corn husk for feeding on ears in the US include the hispid pocket mouse, *Chaetodipus hispidus*; ord's kangaroo rat, *Dipodomys ordii*; olive-backed pocket mouse, *Perognathus fasciatus*; plains pocket mouse, *Perognathus flavescens*; silkypocket mouse, *Perognathus flavus* (Rodentia: Heteromyidae); prairie vole, *Microtus ochrogaster*; meadow vole, *Microtus pennsylvanicus*; northern grasshopper mouse, *Onychomys leucogaster*; deer mice, *Peromyscus maniculatus*; western harvest mouse, *Reithrodontomys megalotis*; plains harvest mouse, *Reithrodontomys montanus* (Rodentia: Cricetidae); house mouse, *Mus musculus*; norwayrat, *Rattus norvegicus* (Rodentia: Muridae); spotted ground squirrel, *Spermophilus spilosoma*; and thirteen-lined ground squirrel, *Spermophilus tridecemlineatus* (Rodentia: Sciuridae) (Sterner et al, 2003).

Large rodents

Large mammals like pacas, *Cuniculus paca* (Rodentia: Ciniculidae) and capybaras, *Hydrochoerus hydrochaeris* (Rodentia: Caviidae) invade cornfields to feed on plants, including ears, leaving husks totally damaged. Agricultural science students of the Federal University of Viçosa (UFV) in Viçosa, Minas Gerais state, Brazil reported damage by these mammals in research fields even after screens were placed in the areas. Animals perforate screen fences or dig under them to get into the crops. These animals are usually nocturnal and are difficult to be detected. They are also protected by laws which prevent their removal from the site or controlling them.

Cattle, buffaloes, goats, horses, and mules: possible causes of damage

Domestic animals, such as cattle, *Bos taurus*; buffalo, *Bubalus* spp.; goats, *Capra aegagrus hircus*; sheep, *Ovis aries* (Arctiodactyla: Bovidae); donkeys, *Equus africanus asinus*; horses, *Equus ferus caballus*; and mules, *E. cabalus* × *E. asinus* (Perissodactyla: Equidae) can consume the entire ear area or damage husk to expose and feed on the kernels. These animals often are raised by the owner of the corn crop or by a neighbor. They can invade cultivated areas, especially with inadequate fencing. Boards including flat and barbed wires and electric fencing can prevent invasion by these animals in areas with corn plants.

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