Identification of Rodent Filth Exhibits

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ABSTRACT: Three main types of rodent filth (rodent excreta pellets, gnawing, and nesting material) are described and identification procedures are listed. Suspect excreta pellets that may be encountered in foods from various animals are described in detail and presented in a dichotomous key for comparison and identification. The physical features associated with the excreta pellets (color, shape, size, weight, surface, and matrix composition) are listed for the insects and animals found in the key. Rodent gnawing and rodent nesting materials are defined and the importance of the paired incisor marks, scalloping along edges and the appearance of the building materials are described. The importance of urine, rodent excreta, hairs and/or parasites when defining nesting material, are discussed, along with the key elements used to recognize the gnawing direction by the rodents. Historical data on rodents and health/safety concerns when handling rodent filth exhibits are addressed.

Key words: identification, rodent, excreta, gnawing, nesting material

Introduction

Rodents historically have been responsible for more human illness and death than any other group of mammals (Bjornson and others 1971; Gorham 1981). Examples of rodent-associated diseases include plague from rodent fleas, murine typhus from rat fleas, Leptospirosis (Weil’s disease) spread by infected rodent urine, Salmonellosis (food poisoning) from rodent excreta pellets, and Rickettsial pox from bloodsucking mites associated with the house mouse (Bjornson and others 1971; Brown 1969; Gorham 1981; Storer 1952). More recently, outbreaks of hantavirus pulmonary syndrome associated with infected deer mice (Peromyscus maniculatus) were recognized in the western United States (Friedman and Zimmerman 1997). Besides their significance as vectors of disease, rodents are very expensive nuisances. They foul and damage millions of dollars worth of the country’s food supply yearly (Burt and Grossenheider 1976; Storer 1952).

Rodents belong to the order Rodentia whose members are recognized by two pair of prominent chisel-like incisor teeth and the lack of canine teeth (Storer 1952). Rats and mice belong to the family Muridae (Brown 1969; Burt and Grossenheider 1976; Wilson and Reeder 1993). The most common cosmopolitan rodents associated with man are the house mouse (Mus musculus), the roof rat or black rat (Rattus rattus), and the Norway rat (Rattus norvegicus) also known as brown, house, or sewer rat (Gorham 1981; Storer 1952; U.S. Food and Drug Admin. 1960). Brown (1969) reported that these three imported rodents are more destructive to man and his property than are the native rodents in the United States. These imported rodents, native to Asia, have spread throughout the world. Today, the house mouse is found all over the world from the tropics to the arctic region. The roof rat and Norway rat were carried to the Americas through ports of entry. The Norway rat is especially common along the East Coast of North America. In mixed populations, the Norway rat will dominate over the roof rat and will eventually drive it out. Roof rats are good climbers and are usually found in high places like grain elevators, whereas Norway rats’ activity occurs at ground level. Another common commensal pest of food storage and food processing facilities is the lesser bandicoot rat (Bandicota bengalensis), also called the bandicoot or the Indian mole rat (Franz and Davis 1991). Although found only in South and Southeast Asia, it is considered an important agricultural pest and evidence of these rodents is sometimes found in foods imported into the United States.

Organizations such as the U.S. Food & Drug Admin. (FDA), state and local governments, and private industry, including pest control companies, employ a host of professionals to deal with the identification, spread, and control of these pests in our food supply. Rodent filth submitted to the FDA laboratories for identification/confirmation may arrive from three sources: collected as filth exhibits in establishment inspections, recovered as extraneous material during routine surveillance sample analysis (imported and domestic products), and/or submitted as foreign objects via consumer complaint samples. In some cases, the environmental conditions in which the evidence was collected may have involved poor lighting, nonexistent temperature control, and possible moisture problems. Sometimes the rodent filth submitted for confirmation turns out to be dirt or other foreign material. Under these circumstances, the so-called rat/mouse, rodent, or just plain excreta pellets as recorded in the collection report will need to be verified and confirmed by laboratory analyses (Zimmerman and Brickey 1996). Laboratory analysts must be able to correctly identify rodent filth and report such findings accurately and clearly so that their data can be used by legal personnel and other interested parties to interpret regulatory and health issues (DeCamp 1970; Zimmerman and Brickey 1996). The correct identification is a must in order to prescribe the proper prevention/control measure.

Since rodents are widely recognized as reservoirs of diseases and hosts to numerous arthropod vectors, extra precaution needs to be applied for safety/health reasons whenever rodent filth exhibits are being handled. Care should be taken not to disturb the suspect contaminated area during specimen collection, as some rodent-associated illnesses are spread through the air. The FDA has published several articles concerning the health and safety issues of employees when working with rodent evidence. Publications include the Investigations Operations Manual (U.S. Food and Drug Admin. 1999), Next Generation Newsletter (Olsen and Sidebottom 1996), and FDA Laboratory Information Bulletin (Friedman and Zimmerman 1997). All three of these publications make reference, in part, to avoid aerosolizing of potential airborne viruses, to wear protective clothing including respirators, to handle the exhibits with gloved hands and forceps, and to place the exhibits in identified whirl-pak bags or polycon containers for storage and shipping.

Currently, there is no comprehensive document identifying the steps necessary to identify rodent filth submitted to laboratories for confirmation. The main goal of this paper is to provide a
Reference document to facilitate the characterization and identification of the rodent filth exhibits such as rodent excreta pellets, gnawing, and nesting material.

**Results and Discussion**

**Animal Excreta**

Solid, metabolic waste excreted by animals is referred to by many terms such as feces, excreta, excrement, droppings, pellets, scat, dung, and manure (Duggan 1944). For purposes of this section, the solid units of discharge ejected from the intestine through the anus will be referred to as excreta pellets (U.S. Food and Drug Admin. 1994). The excreta pellet is by far the most prevalent piece of evidence collected used to describe insanitary conditions, exceeded only by actual observations of the animal itself. Fresh rodent pellets have been described as soft enough to be pressed out of shape and often exhibit a moist, glistering appearance. Old pellets have dull, dusty surfaces, are usually hard, and will crumble when depressed with a probe (Brown 1969; Frantz and Davis 1991). However, caution needs to be applied in these cases since the surrounding environmental conditions could alter the appearance of the pellets, as could the presence of moisture or dry, dusty conditions. Without additional scientific evidence, reference to the age of the pellet should be avoided.

This section will focus on rodent excreta pellets, specifically rat/mouse. Rodents frequently groom themselves, ingesting hairs during this process; these hairs (some partially digested) show up in the excreta pellets (U.S. Food and Drug Admin. 1960). The laboratory analyst, with the aid of microscopes, can use these hairs to identify the origin of the excreta pellets. For example, the initial identification of a suspect excreta pellet covered with a mucous coating, found to contain embedded striated hairs and a total length of less than 25.4 mm (1-in), would be rodent (Anonymous 1984; Storer 1952; U.S. Food and Drug Admin. 1960, 1994; Zimmerman and Brickey 1996). A hair could then be extracted from the pellet, slide-mounted, and examined microscopically to possibly determine the genus or even species of the rodent that produced the pellet. Rat/mouse excreta pellets are typically identified by the presence of rat/mouse hairs found in their excreta. Rats/mice are the most commonly encountered rodents associated with stored foods, and their presence is indicative of insanitary conditions. Remember that laboratory confirmation may be required to verify the filth evidence as reported by the investigator (DeCamp 1970).

Other forms of excreta may be encountered during inspections or recovered in samples. Birds may find their way into establishments and defecate on the product. Pigeons (*Columba livia*), starlings (*Sturnus vulgaris*), and English sparrows (*Passer domesticus*) have been reported by investigators during establishment inspections (Weber 1979). Bats belonging to the family Vespertilionidae may be found roosting in the rafters of food establishments and defecate on the product. Domestic cats and dogs (*Felis catus* and *Canis lupus familiaris*, respectively) are sometimes used as control animals to provide analysts with a means to compare and correctly identify excreta. Animal excrement is deemed objectionable when recovered from foods and food establishments. However, there may be a need to go beyond identifying an object as just “excreta.” The filth significance plays a major role in determining how specific the identifications need to be. For example, rat/mouse excreta and rabbit (*Lagomorpha: Leporidae*) excreta may give different meanings to the outcome of a regulatory case. The more specific the identifications, the stronger the filth evidence becomes when viewed by the courts. While we hope that this key would facilitate quick identifications, there may be instances where specimens will not fit the key. An attempt has been made to include the attributes found in existing references. We realize that this area is relatively new and that there will be additional discoveries that will change the design of this key.

To begin, compare the solid mass to the key using a stereo microscope. Record measurements and document the physical appearance of the suspect pellets including color, shape (pointed, blunt, spindle, spherical), size, weight, if required as in FDA’s Defect Action Levels (DAL’s) (U.S. Food and Drug Admin. 1995), surface, and matrix (Anonymous 1984). These documented observations can be matched to the key to aid the analyst in taking the identifications as far as possible. Besides visual characteristics, there are two widely used official methods for chemically identifying suspect excreta. They are the AOAC Official Method 962.20 and the AOAC Official Method 981.22 (AOAC Intl. 1997). Caution must be exercised when determining bird excreta by chemical tests, since house gecko excreta may also yield a positive result.

**Rodent Gnawing**

Another example of physical evidence that is sometimes picked up by investigators to document the presence of rodents in a firm is rodent gnawed material. “Rodent gnawing” refers to the appearance that rodents visibly gnawed upon the product, its container, or some other physical structure. The job of the analyst is to support their findings through scientific documentation.

The key to documenting rodent gnawing as evidence of insanitation begins with the investigator. Careful handling of the filth exhibits is important for preserving the evidence as seen at the time of collection. Rodents tend to grow and shed their hairs year round so the chances of hairs being recovered from gnawing areas is great (Frantz and Davis 1991; U.S. Food and Drug Admin. 1960; Zimmerman and Brickey 1996). All rodents are distinguished from other mammals by the location and shape of their teeth. There is a single pair of prominent incisors in both the upper and lower jaws. The incisors are separated from the molars by a decided gap (Brown 1969; Burt and Grossenheider 1976; Frantz and Davis 1991; Nowak and Paradiso 1983). These two pairs of chisel-like teeth grow continuously and are self-sharpening (Storer 1952). Young rats and mice begin to gnaw as early as the second week of life, and will gnaw almost anything. To get to food, they will gnaw any material with a gnawing edge that is softer than the enamel of their teeth (Frantz and Davis 1991). This includes such things as wood, paperboard, cloth sacks, lead pipes, cinder blocks, asbestos, and aluminum (Brown 1969; Storer 1952).

The damage caused by rodent gnawing tends to leave behind typical characteristics depending on the substrate. For instance, when rodents attack cloth or burlap bags, the damage takes on a “shredded, frayed, or ragged” appearance. This is caused by the teeth of the rodent tearing and pulling at the threads. Other typical gnaw marks include paired punctures or scratches on the surface of the material caused by the gripping, holding action of the upper incisors (Gorham 1981; U.S. Food and Drug Admin. 1960). Another characteristic seen on plastic, paper, and sometimes cardboard is a scalling appearance around the gnawed area. Rodents tend to create openings on various packages or contain-
ers by removing bits and pieces of the substrate through their gnawing and tearing actions.

Typical of the appearance of rodent-eaten food are the chiseled-out gouges made by the lower incisors, and the accompanying shallow tooth marks of the upper incisors, which are used for holding food while the actual eating is done with the teeth of the lower jaw (Gorham 1981; U.S. Food and Drug Admin. 1960).

Associated with rodent gnawing is the term “rodent-gnawed hole.” This is used to define an entryway (opening) created by rodents through their gnawing action on a substrate. Quite often, the entrance is somewhat circular in shape. The direction in which the rodent first began to attack an area can be determined by studying the gnawing pattern. They will gnaw at a particular site, enlarging the opening even beyond what is necessary to pass through. In the case of multiple-layered packaging, the gnaw hole with the largest diameter is the first layer penetrated. In addition, paired incisor marks will be found surrounding this hole, confirming that the hole was chewed and not mechanically torn.

**Rodent Nesting Material**

Rodent nests are built to accommodate births (Brown 1969). The nests tend to be constructed in secluded areas. Rats and mice gather nesting materials from any convenient soft material such as paper, cloth, burlap, grasses, excelsior, small twigs, fur, and feathers (Brown 1969; Frantz and Davis 1991; U.S. Food and Drug Admin. 1960). Rodents use their incisor teeth to pull apart paper and cloth material. They tear and pull at the threads, creating a shredded, frayed, or ragged appearance (U.S. Food and Drug Admin. 1960).

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The size, shape, and location of rodent nests can be used to distinguish between rats and mice. Rat nests are usually bowl-shaped and about 203 mm (8 in) in diameter (Brown 1969; Frantz and Davis 1991). Roof rat nests are placed in any type of shelter, indoors or out, and are easily seen (under sacks or in boxes or drawers) (Storer 1952). Norway rats usually hide nests in such places as under floors, in piles of goods, and in unused packing boxes. Their nests are not always as neat or well formed as other rodent nests (Storer 1952). The house mouse makes compact nests into a round hollow ball similar to a rat’s nest but only about 127 mm (5 in) in diameter (Brown 1969; Frantz and Davis 1991; Storer 1952). The mouse nest may also hold more than one family per nest site (Brown 1969).

The criteria used to confirm rodent nesting material includes the appearance of the material, the presence of rodent gnaw marks (described in another section), and other recognizable observations including the presence of urine, rat/mouse hairs, rodent excreta pellets, or parasites such as mites or fleas (Brown 1969).

**Conclusion**

A standardized approach to identifying rodent filth suspected of contaminating the food supply was developed. These procedures provide a framework for ensuring accurate identifications and uniform reporting by regulatory officials and food sanitarions alike. The use of the techniques described will result in a higher level of consumer protection from rodent contaminated food.

### Appendix

Key to identifying suspect excreta encountered with foods:

1. Contains white residue .......................... .......................... Urine acid test for bird excreta
   - The color of bird excreta will vary but almost always contains chalky white material. The shape varies from liquid to semisolid state with no definitive size range. It may appear as a splatter to a rounded or coiled dropping. There is no mucous coating and the matrix is a mixture of chalky white discharge containing chiefly urine mixed with darker food and watery residues. Feather fragments are frequently encountered. Undigested insect fragments may be seen (Anonymous 1984; Gorham 1981; U.S. Food and Drug Admin. 1960, 1994). Use the AOAC Uric Acid Test to confirm (AOAC Intl. 1997).

**No white residue present** ............................................................... 2

2. No symmetrical shape. Appears amorphic or damaged.
   - Matrix consists of apparent digested plant material and no visible hairs .......................... APT for mammalian excreta
     - The color of mammalian excreta will vary. The shape varies from amorphic to cylindrical. The overall size may exceed 25.4 mm (1 in) in length. A mucous coating may be present. The matrix will vary with excreta from domestic farm animals containing undigested plant fragments bound together in a dark colored, gummy mass, coated with mucilage. Cat excreta will usually contain cat hairs (Anonymous 1984; Duggan 1944; Scott 1951, 1957; U.S. Food and Drug Admin. 1960). Use the AOAC Alkaline Phosphatase Test (APT) to confirm (AOAC Intl. 1997).
   - 2' Shape is symmetrical (spherical, barrel-shaped, cylindrical, or spindle-shaped).
     - Note: Damaged or fragmented suspect excreta can be tested by APT or taken through the rest of the key ........................................... 3
   - 3. Total length exceeds 25.4 mm (1 in) .............................................. APT for mammalian excreta

3' Total length is 25.4 mm (≤ 1 in) ........................................................................ 4

4. Shape is spherical. No intact mucous coating present.
   - Matrix consisting of undigested plant material in a less dense, loosely fibrous aggregate .................................................. Rabbit
     - The color of rabbit excreta will vary. The excreta are usually relatively small and spherical, 8mm to 10mm (5/16 in to 3/8 in) in diameter. A mucous coating is present but not continuous. The matrix consists of undigested plant material in a loosely fibrous aggregate (U.S. Food and Drug Admin. 1960, 1994).

4' Shape is cylindrical ............................................................................. 5

5. Mucous coating present ........................................................................ 6

5' Mucous coating absent .......................................................................... 9

6. Matrix contains mostly insect fragments ............................................. 7

6' Matrix not as above ................................................................................ 8

7. Matrix contains bat hairs ................................................................. Bat
   - The color of bat excreta varies. The excreta of commensal bats are spindle-shaped and similar to mouse excreta in size, 2 mm to 6.5 mm (1/16 in to 1/4 in). A mucous coating is present and the matrix consists mainly of insect fragments and bat hairs (U.S. Food and Drug Admin. 1960).

7' Matrix is a dark amorphous mix of insect fragments with plant material, bagging, paper, and textile fibers. No hairs present ......................... Commensal shrew
   - The color of shrew excreta varies. The excreta of commensal shrews are cylindrical in shape, sometimes bent or twisted with strongly tapered ends. The size range is 4mm to 14.5 mm (3/16 in to 9/16 in). A mucous coating is present. The matrix consists of embedded insect fragments along with plant and textile fibers but no animal hair (Olsen 1984).
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8. Matrix varies. May contain partially digested plant matter and fibers. Striated hairs present but not further identified. Rat/mouse excreta have the same identifying characters as excreta identified to the rodent level with the addition of embedded hairs/hair fragments identified as rat/mouse (Brown 1969; Hudson and Davis 1980; Scott and Borom 1967; Storer 1952; U.S. Food and Drug Admin. 1960). Note: Rat/mouse excreta pellets may be identified to species by using hair identification and the additional information given below for each species. Norway rat excreta is spinel-shaped and between 10 mm to 20 mm (3/8 in to 3/4 in). Roof rat excreta is sausage-shaped and curved and slightly smaller than Norway rat. House mouse is spinel-shaped and between 2 mm to 9 mm (1/16 in to 3/8 in).

9. Barrel-shaped with truncate, blunt ends and longitudinal ridges. The color of the cockroach (Dictyoptera: Blattaria) excreta varies. The excreta are cylindrical with longitudinal ridges and squared-off blunt ends. The size range is 0.5 mm to 4.5 mm (1/16 in to 3/16 in). There is no mucous coating and the matrix consists mainly of cellulosic plant material and sometimes cockroach cast skins (Brown 1969; Gorham 1981; Scott and Borom 1967; U.S. Food and Drug Admin. 1994).

References

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