Detection, Elimination, Protection
Science-Based Rodent Solutions

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Introduction: Commensal Rodents

Commensal rodents are defined as rodents living in close association with humans, often depending on humans for their food, water and housing. There are three common commensal rodent species: the house mouse (Mus musculus), the roof rat or black rat (Rattus rattus), and the Norway rat or ship rat (Rattus norvegicus). These rodents are pests in most countries throughout the world, producing millions of dollars of damage annually.

Rodent management in and around commercial properties can be divided into three layers of protection:

1. Exterior — reducing rodent pressure on the exterior perimeter of structures.
2. Introduction Points — minimizing rodent entrance opportunities into structures.
3. Interior — eliminating rodent activity from within structures.

Each of these layers is an important part of an integrated approach to maintaining a rodent-free facility. An emphasis on solving rodent issues on the exterior of a structure before any activity is seen inside is the basis of the Ecolab outside-in approach to rodent elimination.

Objective: Review Current Control Practices and Future Direction

Rodents have been a central part of the pest industry since its beginning[1]. Over the years many new approaches have been attempted to combat these persistent pests with new products and equipment continuing to emerge. The objective of this paper is to compare and contrast current approaches to rodent control and to provide expert recommendations on protocols and services available to minimize commensal rodent activity inside commercial structures. The paper will begin with a look at the unique biology of rodents, followed by a comparison of common monitoring and treatment methods, along with a discussion of the future direction of rodent management

Biology and Behavior: The Human-Rodent Association

Understanding behavior of commensal rodents in and around humans is an important step towards identifying management and elimination strategies. While rodent behavior is complex and these animals are capable of adapting to a broad array of situations[2], their behavior can also be predictable with identifiable patterns that aid in management. Rats and mice share many of their behaviors with one another[3]. A good general guide to commensal rodent behavior can be found in the book, Rodent Control: A Practical Guide for Pest Management Professionals, by Dr. Bobby Corrigan. The following is a few key highlights from scientific literature that are important topics related to rodent management in commercial accounts.

[1] Snetsinger 1983
[2] Hurst 1987
[3] Drai et.al. 2001

A. Rodent Learning

Rats and mice have been used for decades as research models in learning and memory studies. Learning begins at a very young age as rodents watch and mimic behaviors of their mother and other adult rats in their environment. The first bites of solid food taken by young rodents are from food being fed on by another adult[1]. Food preference and other behaviors are conservative and passed across generations. Some food preference learning may also occur prior to birth according to the diet the mother rodent is eating[2]. Some persistent behaviors may also have a genetic component, such as behavioral resistant strains of mice found in the UK[3].

Like food preferences, behavior around objects in their environment including traps and other devices is learned. Young rats have been observed watching adult rats interact with traps, and then perform the same exploratory behaviors themselves. Video observations also indicate that rats exposed to generations of trapping associate food on a device, such as a baited snap trap, to be something to avoid[4]. Avoidance behavior of food and equipment is learned in rodents and can build over generations of exposure.

B. Vision

Rodent eyes are built for night vision. They sacrifice visual acuity (their vision is more grainy then ours) for light collecting capabilities. They have poor daylight vision compared to human capabilities, but they see far better than we do in low-light situations[5]. Rodents cannot focus on close objects within a couple of inches, but have a large depth of focus beyond that. They rely on other senses for close-up inspection of their world. The placement of their eyes on the rounded edges of the skull allows for a wide perspective to avoid predators and explore their shadowy environment.

Vision is an important sense for rodents and they rely on it as they navigate through their environment. Dark shadows may indicate possible hiding spots and will often draw a passing rodent to investigate. A rodent visually searching for a place to hide will move towards dark areas or spots and will enter dark protected areas, if available[6]. This behavior is especially true for rodents in unfamiliar environments and is the main reason why multi-catch traps work as monitors near rodent entrance points. Trap catch can be enhanced by providing a high-contrast dark area at the entrances. Trap openings are naturally dark but additional black, high contrast emphasis can be placed around the opening to increase investigatory responses.

C. Tactile Sensing

Rodents use the sense of touch instead of vision in close-up examination of their environment[7]. Rodents have specialized sensor hairs termed vibrissae throughout their fur and a high concentration on their heads. Head vibrissae, often called whiskers, are used not only as touch indicators[8], but can be used to determine shape and even texture of objects and surfaces contacted[9]. Whiskers are used for a broad range of other functions including communication with other rodents and monitoring environmental conditions such as wind direction[10]. They may even be used in detecting vibration[11].

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[1] Bennett and Clark 1971; Bennett 2003; Bennett et. al. 2005; Chou et.al. 2000
[2] Nolte and Mason. 1995
[3] Humphries and Meehan 2000
[4] IR camera recordings of wild roof rats, Ecolab
[5] Lashly 1932; Wiesenfeld and Branchek 1976; Powers and Green 1978
[6] Welker 1959
[7] Williams and Kramer 2010
[8] Lottem and Azouz 2009, O'Connor et.al. 2010, Metha and Kleinfeld 2004
[9] Diamon et.al. 2008a&b, Grant et. al. 2009, Kleinfeld et. al. 2006, Lottem and Azouz 2008, Nelson and McIver 2006
[10] Ahl 1986, Blanchard et. al. 1977, Crish et.al. 2003
[11] Shats and Christensen 2008

Vibrissae form a cone-shaped sensory field around head of the rodent. This sensory field allows detailed examination of objects up close with very little contact. Traps and other devices can be carefully examined without triggering. Once a rodent learns to avoid a specific device such as a snap trap, it will recognize and avoid direct contact with all devices having similar structures and design. Video monitoring of wild roof rats has shown that rats are not afraid or shy around trapping devices. They readily approach and whisk snap traps but do not directly contact these traps even when baited with foods they are known to be eating in the area. This results in a challenge to find ways to capture rodents such as roof rats. Traps placed where rats are forced to contact them can be more successful than baited traps.

D. Hiding and Foraging Behavior

Rodents have complex suites of behaviors that allow them to find food, water, harborage, avoid predation, and reproduce. In spite of this complexity, general patterns of behavior can be predicted in some situations such as when a rodent is placed in a new environment[1]. The first response of a rodent in a new environment is hiding behavior[2]. They look for a protected spot to temporarily hide until a more permanent home can be found[3]. Once an initial hiding spot has been located they begin looking for better, long-term harborage locations. The initial location becomes a home-base[4] from which they begin to explore their new surroundings.

Once a rodent has found a suitable harborage location near food and water, it begins to establish regular patterns of foraging behavior[5]. There are important differences between foraging behavior and hiding behavior. With foraging behavior, the rodent is familiar with its environment and has established routes of travel. When items such as traps and other devices are placed in an area where rodents are foraging, these items will be recognized as “new” objects by the rodents and they will exhibit neophobic behavior around them.

E. Neophobia

Neophobia is a fear of new objects. While it is commonly believed that rats are neophobic and mice are neophilic (love of new objects – curious), both have been shown to exhibit an avoidance response to new objects placed in a familiar environment[6].

New food items will also be avoided by mice when placed in a familiar environment[7]. Studies show that mice can develop neophobic behaviors in the presence of trapping pressure[8]. Neophobic responses are much stronger with new objects than with new foods[9]. Rodents in a new environment do not exhibit neophobia. They will readily approach traps and other devices looking for protection. It is for this reason that multi-catch traps work near entrances and not so well where there is an established infestation.

Rodent Management Strategies

A successful rodent program requires a risk assessment approach. From the property line to internal customer and food handling areas, layers of protection need to be put into place to achieve success. Prevention can be divided into three general layers of protection: exterior, introduction points and interior discussed below. These layers of protection are referred to as the Outside –In Approach. The unique behaviors that rodents exhibit in each of these three zones require unique approaches to maintain protective barriers.

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[1] Avni 1986, Belsung, 1999, Ennaceur 2006, Kalueff 2006, Welker 1959
[2] Ecolab term for initial hiding behavior in a new environment. Ennaceur 2006
[3] Welker 1959
[4] Avni 1986, Belzung 1999, Dvorkin 2010, Tchernichovski et. al. 1998
[5] Normal rodent behavior within an established territory. Jensen 2003
[6] Humphries et al. 2000, Inglis et.al. 1996, Misslin 1982, Misslin and Cigrang 1986, Misslin and Ropartz 1981
[7] Bedroy and Drickamer 2007
[8] Kronenberger and Medioni 1985
[9] Inglis et.al. 1996

A. Exterior - Reducing Rodent Pressure Near Structures

The exterior of the facility from the fence line to the walls of the buildings serve as the first line of defense for commensal rodents. This area includes fence lines, grounds, exterior storage, receiving zones, garbage areas and exterior perimeters of structures. Reducing pest pressure in these areas is the first line of defense against pest invasion and is often the most effective long-term solution of the outside-in approach.

Conditions that support pest activity near the structure should be corrected to reduce pressure on the facility. Some of the most common conducive conditions include:

- Debris and spilled garbage near the building or under dock plates
- Exterior storage of old equipment or construction material that provide protection and harborage
- Standing water or saturated soil that remains wet for extended periods of time
- Overgrown vegetation or trees, especially if they are in contact with the structure

As global discussions continue around the proper use of rodenticides, Ecolab will continue to provide exterior rodent suppression that meets third party audit standards and customer agreements. Ecolab will also continue evaluating methods and approaches to find sustainable solutions that reduce impact on the environment and non-target organisms. While minimum guidelines for spacing equipment allows for easier quality control and is the natural tendency of auditing standards, a more sustainable practice is a risk assessment approach to pest elimination.

Risk Assessment Approach to Rodent Management

A risk assessment approach to rodent management on the exterior of structures would include the following steps.

1. Determine the extent of rodent activity on the exterior. This can be done using a variety of monitoring devices including bait stations with rodenticide or monitoring blocks, snap traps and multi-catch traps. Visual inspections should also be conducted to identify rodent harborage sites and runways.
2. Identify the actual species in the area through the use of traps. Snap traps and multi-catch traps placed in tamper resistant stations in areas of activity can verify the presence of rodents.
3. Assess the risk of structural invasion at potential rodent entrance points using the information gathered above. It should be assumed that non-commensal rodent species pose very limited risk to structures because they seldom invade structures and establish interior populations.
4. Adjust exterior protection program to protect vulnerable entry points where commensal rodent pressure has been verified. If there is a known location where rodents are entering the structure, placing more then one station on each side of the entrance point has been shown to reduce entry[1]. These additional placements should be temporary until the access point is removed.

A risk assessment approach will result in a sustainable rodent program with focused protection at high risk locations. While this approach is not currently appropriate in all locations due to auditor spacing requirements, it is a goal at Ecolab to continue to move towards this sustainability goal.

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[1] Knote 1988

CheckPoint® Exterior Rodent Stations

Ecolab uses the CheckPoint® Rodent Station to provide monitoring, baiting and trapping solutions for the exterior of structures. This versatile equipment can be configured to meet specific needs at each account with non-toxic monitoring, baiting, mouse multi-catch and snap trap options available.

Rodent research, service team input and customer needs have all been included in the design of the CheckPoint® line of equipment. Whether a bait station, monitoring station or trap station is needed, CheckPoint® stations deliver a durable and discreet solution. Equipment innovation is just one of the benefits of having a dedicated staff of scientists at Ecolab.




B. Introduction Points - Minimizing Rodent Entry Opportunities

Rodents caught at introduction points inside the facility are evidence that the physical barrier of the structure has been compromised. The rodent barrier of a facility is comprised of the physical structure between the exterior of the building and the interior, such as walls and doors. It also includes protected areas such as wall interiors, plenums, chases and tracks that lead to exterior access points.

Conditions that support pest activity in this exclusion zone of the structure should be corrected to reduce pressure on the facility. Some of the most common conducive conditions include:

- Doors left open for long periods of time, especially in the evening after dark
- Doors that do not close properly
- Holes and structural damage that allow rodents and other pests to enter the structure
- Gaps in expansion joints and/or around pipes, holes and structural damage that may allow rodents to enter the structure
- Unscreened vents and pipe chases
- Delivery docks that are not rodent proofed on the exterior with climb guards (usually a metal plate on the wall under docks that prevent rodents from climbing)
- Product deliveries that are not inspected adequately to prevent introduction of rodents transported in the material

Interior Rodent Stations

Monitoring the interior perimeter of structures for invading rodents is usually done through the use of interior rodent stations. While there are a number of monitoring options, multi-catch traps are often the station of choice. These stations take advantage of the unique behavior rodents exhibit when they first enter a structure. Multi-catch traps are most effective when placed on either side of possible rodent entrance points. The number and spacing of interior rodent stations should be determined by a rodent risk assessment, auditor and customer requirements. If there is a known location where rodents are entering the structure, a temporary placement of more then one station on each side of the entrance point will increase the likelihood of capture and reduce the possibility of an interior infestation.

Ecolab evaluates available stations for durability and effectiveness. Ecolab field research has shown that there are differences in the failure rates of multi-catch traps available to the industry. A study comparing three types of traps showed that currently the most reliable type of trap consisted of traps with one-way, ramp entrances[1]. Increased failure rates were found with wind-up traps due to rodents getting caught in the wind-up mechanism and because the large size of these traps resulted in frequent displacement. Increased failure in PVC tube traps was due primarily to dust collection on the glue board.

Ecolab will continue to use the best station options available to the industry and develop proprietary stations when the need arises.

C. Interior – Eliminating Rodent Activity

The presence of rodents on the interior of a facility indicates that there has been breech across the other layers of protection. Elimination of interior rodent populations can be divided into two phases: harvesting and elimination. These two phases usually require different approaches. Depending on the extent and complexity of the infestation one or both of these phases may be applied.

- **Harvesting** – is the removal of large numbers of rodents through trapping and other means to quickly reduce the interior population. During harvesting the best choice of trap is the snap trap. Large numbers of snap traps, placed in areas of known rodent activity can quickly remove the majority of rodents in a short period of time. Snap traps can be placed in protected areas, inside protective stations, or placed in the open. Traps placed in the open are usually left overnight and removed before business hours. Snap traps, unless placed inside stations, should be temporary placements.

  During harvesting, more frequent service visits may be necessary to remove captured rodents. Large numbers of temporarily placed traps should be left in place until trap rates subside. Harvesting phase should be followed by an Elimination phase to ensure that all rodents are removed.

- **Elimination** – is the complete removal of all rodent activity from inside a facility through precise placement of traps and other means to locate and remove all animals. Elimination of a resident rodent population requires skill and strategic placement of traps and attractants. Success is achieved when the last rodent is found and removed from the inside of the structure.

  During elimination efforts, more frequent service visits may be required to adjust placement of devices as elimination efforts are narrowed to remaining active areas. If increased service frequency is necessary during the elimination phase, a minimum of three days between visits is recommended except for emergency situations. This allows time for rodents to interact with traps and other devices.

  Note - daily checking of traps and other monitoring devices may produce false negatives (no rodent activity apparent even though rodents are present) during elimination as rodents acclimate to new items in their environment[2].

  Ecolab also provides access to advanced attractant technology that is highly attractive to both mice and rats. The Rat and Mouse Attractant has been produced in cooperation with a leading manufacturer of rodenticide baits. This product has shown to be as effective as peanut butter with mice as well as being highly effective with rats, even the roof rat. This science-based solution increases the catch rates of elimination equipment.

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[1] Ecolab field test, ~450 locations, 3 months monitoring
[2] Ecolab field data

Summary and Recommendations for Actions

Commensal rodents continue to be serious pests globally. Adapted for life with humans they easily find ways to use our homes and businesses as their own. Creating a rodent free environment in commercial structures requires a partnership between the owner/manager of the property and the pest service provider. Both play a critical role in identifying conditions that may lead to rodent invasion and correcting those issues before problems arise.

An outside-in approach based on rodent biology and behavior is the best means to secure long-term protection against rodents. Rats and mice are considered ‘flashpoint pests.’ A single sighting on the interior can result in serious and long-lasting damage to the brand reputation. Rodent activity inside commercial structures cannot be tolerated. An aggressive elimination plan should be followed that uses the right tools, placed in the right locations by trained professionals.

What You Should Do

The following specific recommendations will help reduce conditions that allow rodents to find food, water and harborage in and around the facility.

Exterior

- Minimize food, water and harborage on the exterior of the facility.
    - Eliminate spillage of garbage
    - Close all garbage receptacles with tight-fitting covers
    - Move garbage receptacles away from the facility whenever possible
    - Eliminate standing water around the facility
    - Remove weeds, tall grass and other excessive vegetation
    - Remove clutter and items stored on the ground near the facility
    - Consider other sources of rodent pressure (adjoining structures, distribution centers, product vendors, etc.) and carefully inspect incoming goods for the presence of these pests

Introduction Points

- Minimize rodent access into the facility.
    - Trim trees so that no branches are touching the facility
    - Seal holes and gaps on the exterior of the facility
    - Seal openings and chases around pipes
    - Seal all doors, inspect and repair entrances on a regular basis
    - Seal holes and gaps noted on the interior perimeter

Interior

- Minimize conditions that support rodent activity on the inside of the structure.
    - Minimize product spillage and regularly clean under shelves and gondolas
    - Eliminate all standing water and accumulated condensation
    - If present, remove all rodent droppings (after they have been documented by your pest service provider)
    - Seal potential access to hidden runways and harborages

What Your Pest Service Provider Should Do

- Provide a science-based, risk assessment approach to monitor and address commensal rodent activity in and around structures.
- Use an outside-in approach to provide layers of protection based on behavioral patterns on commensal rodents.
- Provide regular, visual inspections of the outside and inside of structures by trained professionals.
- Document sanitation and structural issues that are conducive to rodent activity and that may lead to interior infestation of commensal rodents.
- Meet with management to review findings and make recommendations on corrective actions.
- Respond to interior rodent activity aggressively using science-based methodology to eliminate interior infestations.

For more information, contact Douglas Gardner, BCE, RS, Ecolab Sr. Scientist, at 1.800.325.1671

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Doug Gardner provides 18 years of industry experience and 9 years of academic research to the Ecolab Pest Elimination team. His background as a biologist includes a B.S. degree in biochemistry from the University of Arizona and an M.S in Entomology from Texas Tech University. He is a Board Certified Entomologist, a Registered Sanitarian and a Certified Black Belt in Lean Six Sigma. In his professional career he has served in a broad variety of positions including service specialist (technician), operations manager, technical support Manager and scientist. As the manager of the technical support team at Ecolab, Doug was responsible for field support and field training across North America. He has faced and solved pest challenges in most commercial environments. He is currently a senior scientist providing expertise and driving innovation for Ecolab's rodent, small fly and large fly programs. He is a member of the National Pest Management Association, Entomological Society of America, National Environmental Health Association, and Pi Chi Omega (a professional fraternity for urban pest control).

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BIBLIOGRAPHY

Ahl, A.S. 1986. **The role of vibrissae in behavior: a status review**. Vet. Res. Commun. 10:245-268.

Avni, Ruet, Pazit Zadicario and David Eilam. 19--. **Exploration in a dark open field: a shift from directional to positional progression and a proposed model of acquiring spatial information**.

Bedroy, M. and C. Drickamer. 2007. **Comparative social organization and life history of Rattus and Mus**. Rodent Societies, An Ecological & Evolutionary Perspective. pp 380-92

Belzung, Catherine, 1999. **Measuring Rodent Exploratory behavior**. Handbook of Molecular-Genetic Techniques for Brain and Behavior Research (Techniques in the behavioral and Neural Sciences, Vol. 13). W.E. Crusio and R.T. Gerlai (eds). Chapter 4.11.

Bennett, Galef G. 2003. **Social Learning: Promoter or Inhibitor of Innovation.** Chapter 6 in **Animal Innovation**. By Simon M. Reader and Kevin N. Laland. Oxford University Press.

Bennett, Galef G., Merice M. Clark. 1971. **Social factors in the poison avoidance and feeding behavior of wild and domesticated rat pups.** Journal of Comparative Physiological Psychology 75(3):341-357.

Bennett, Galef G., Wing Yee Lee, Elaine E, Whiskin. 2005. **Lack of Interference in long-term memory for socially learned food preferencesin rats (*Rattus norvegicus*)**. Journal of Comparative Psychology 119(2): 131-135.

Blanchard, R.J., L.K. Takahashi, K.K. Fukunaga and D.C. Blanchard. 1977. **Functions of vibrissae in the defensive and aggressive behavior of the rat**. Aggressive Behavior 3:231-240.

Chou, Lien-Siang, Rex E. Marsh, Peter J. Richarson. 2000. **Constraints on social transmissionof food selection by roof rats, *Rattus rattus***. Acta Zoologica Taiwanica 11(2): 95-109.

Corrigan, Robert M. 2001. **Rodent Control: A Practical Guide for Pest Management Professionals**. GIE Media. 355 pages.

Crish, Samuel D., Frank L. Rice, Thomas J. Park and Christopher M. Comer. 2003. **Somatosensory organization and behavior in naked mole-rats I: Vibrissa-like body hairs comprise a sensory array that mediates orientation to tactile stimuli**. Brain Behav. Evol. 62: 141-151.

Diamond, Matthew E., Moritz von Heimendahl, Ehsan Arabzadeh. 2008a. **Whisker-mediated texture discrimination**. PLoS Biol 6(8): e220. doi:10.1371/journal.pbio.0060220.

Diamond, Matthew E., Moritz von Heimendahl, Per Magne Knutsen, David Kleinfeld and Ehud Ahissar. 2008b. **'Where' and 'What' in the whiskersensormotor system**. Nature Reviews: Neuroscience 9: 601-612.

Drai, Dan, Neri Kafkafi, Yoav Benjamini, Greg Elmer. 2001. **Rats and mice share common ethologically relevant parameters of exploratory behavior**. Behavioural Brain Research 125: 133–140.

Dvorkin, Anna, Henry Szechtman and Ilan Golani. 2010. **Knots: Attractive places with high path tortuosity in mouse open field exploration**. PLoS Comput Biol 6(1): e1000638. doi:10.1371/journal.pcbi.1000638.

Ennaceur, A., S. Michalikova, and P.L. Chazot. 2006. **Models of anxiety: Responses of rats to novelty in an open space and an enclosed space**. Behavioural Brain Research 171: 26–49.

Grant, Robyn A., Ben Mitchinson, CharlesW. Fox and Tony J. Prescott. 2009. **Active touch sensing in the rat:Anticipatory and regulatory Control of whisker movements during surface exploration**. J. Neurophysiol. 101:862-874.

Humphries, R.E., R.M. Sibly, A.P Meehan. 2000. **Cereal aversion in behaviourally resistant house mice in Birmingham, UK**. Applied Animal Behaviour Science 66, 323-333.

Hurst, Jane L. 1987. **Behavioural variation in wild house mice *Mus domesticus* Rutty: a quantitative assessment of female social organization**. Animal Behaviour 35, 1846-1857.

Inglis, I.R., D.S. Shepherd, p. Smith, P.J. Hatnes, D.S.Bull, D.P. Cowen, D. Whitehead. 1996. **Foraging behavior in wild rats (Rattus norvegicus) towards new foods and bait containers**. Applied Animal Behaviour Science 47: 175-190.

Jensen, Susanne Plesner, Samantha J. Gray and Jane L. Hurst. 2003. **How does habitiat structure affect activityand use of spaceamong house mice?** Animal Behaviour 66: 239-250.

Kalueff, Allan V., Tiina Keisala, Anna Minasyan, Marianne Kuuslahti, and Pentti Tuohimaa. 2006. **Temporal stability of novelty exploration in mice exposed to different open field tests**. Behavioural Processes 72: 104–112.

Kleinfeld, David, Ehud Ahissur and Matthew E. Diamond. 2006. **Active sensation: insights from the rodent vibrissa sensorimotor system**. Current Opinion in neurobiology 16: 435-444.

Knote, Charles E., 1988. **Stopping house mice building infestations through exterior control**. Proceedings of the Thirteenth Vertebrate Pest Conference.

Kronenburger, J.P. and J. Medioni.1985. **Food neophobia in wild and laboratory mice (Mus musculus domesticus)**. Behavioural Processes 11 (1): 53-59.

Lashley, K.S. 1938. The mechanism of vision: XV. **Preliminary studies of the rat's capacity for detailed vision**. Journal of General Psychology18: 123-193.

Lottem, Eran and Rony Azouz. 2008. **Dynamic translation of surface coarseness into whisker vibrations**. J. Neurophysiol. 100: 2852-2865.

Lottem, Eran and Rony Azouz. 2009. **Mechanisms of tactile information transmission through whisker vibrations**. J. Neurosci. 29(37): 11686-11697.

Metha, Samar B. and David Kleinfeld. 2004. **Frisking the whiskers: Patterned sensory input in the rat vibrissa system**. Neuron 41(2): 181-184.

Misslin, Rene. 1982. **Some determinants of the new object reaction of the mouse**. *Biology of Behavior* 3:209-14.

Misslin, Rene and Marc Cigrang. 1986. **Does neophobia necessarily imply fear or anxiety?** Behavioural Processes 12 (1): 45-50.

Misslin, Rene and Philippe Ropartz. 1981. **Resposes in mice to a novel object.** Behaviour 78(3/4): 169-177.

Nelson, M.E. and M.A. MacIver. 2006. **Sensory Acquisition in Active Sensing Systems**. Journal of Comparative Physiology 192: 573-586.

Nolte, Dale L. and J. Russell Mason. 1995. **Maternal ingestion of ortho-aminoacetophenone during gestation affects in takeby offspring**. Physiology & Behavior 58(5): 925-928.

O'Connor, D.H., N.G. Clack, T. Komiyama, E.W. Myers and K. Svoboda. 2010. **Vibrissa-based object localization in head-fixed mice.** J. Neurosci. 30(5): 1947-1967.

Powers, Maureen K. and Daniel G. Green. 1978. **Single retinal ganglian cell responses in the dark-reared rat: Grating acuity, contrast sensitivity, and defocusing**. Vision Research 18: 1533-1539.

Shats, L.F. and C.W. Christensen. 2008. **The frequency response of rat vibrissae to sound**. J. Acoust. Soc. Am. 123(5):2918-2927.

Snetsinger, Robert. 1983. **The Ratcatcher's Child: The History of the Pest Control Industry**. Franzak & Foster Co.. 294 pages.

Tchernichovski, Ofer, Yoav Benjamini and Ilan Golani. 1998. **The dynamics of long-term exploration in the rat. Part I. A phase-plane analysis of the relationship between location and velocity**. Biol. Cybern. 78: 423-432

Weisenfeld, Z. and T. Branchek. 1976 **Refractive state and visual acuity in the hooded rat**. Vision Res.16: 823-827.

Welker, W.I. 1959. **Escape, exploratory, and food seeking responses of rats in a novel situation**. Journal of Comparative Physiological Psychology 52(1): 106-111.

Williams, Christopher M. and Eric M. Kramer. 2010. **The advantages of a tapered whisker**. PLoS ONE 5(1): e8806. doi:10.1371/journal.pone.0008806.