

UC Agriculture & Natural Resources

Proceedings of the Vertebrate Pest Conference

Title

A Shift Towards Coexistence: Humane Treatment of Mice (*Mus musculus*), Norway Rats (*Rattus norvegicus*), and Black Rats (*Rattus rattus*)

Permalink

<https://escholarship.org/uc/item/9j8750sj>

Journal

Proceedings of the Vertebrate Pest Conference, 31(31)

ISSN

0507-6773

Authors

De Ruyver, Ciska
Moons, Christel P. H.
Tuyttens, F.
[et al.](#)

Publication Date

2024

A Shift Towards Coexistence: Humane Treatment of Mice (*Mus musculus*), Brown Rats (*Rattus norvegicus*), and Black Rats (*Rattus rattus*)

Ciska De Ruyver and Christel P. H. Moons

Ethology and Animal Welfare Research Group, Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium

F. Tuytens

Ethology and Animal Welfare Research Group, Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium; and Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Melle, Belgium

Claire Diederich

Namur Research Institute for Life Sciences (NARILIS), University of Namur, Namur, Belgium

ABSTRACT: Despite the lasting aversion many hold towards rats and mice owing to historical associations with diseases such as the plague, there exists a growing consensus among researchers advocating for a reappraisal of these creatures. A noticeable trend is emerging in Western Europe, wherein rodents are increasingly viewed as urban neighbors, challenging the prevailing negative perceptions. To explain the ongoing shift, we use examples from medicine, popular culture, science, and exhibitions. The recognition of rats and mice as sentient and intelligent beings necessitates human stewardship in the context of urban coexistence. We conclude that understanding the ecology and behavior of rats and mice in urban environments, as well as human behavior change, is a prerequisite for achieving harmonious urban coexistence.

KEY WORDS: animal welfare, coexistence, commensal rodents, humane pest management, methods, *Mus musculus*, *Rattus norvegicus*, *Rattus rattus*, rodent control

Proceedings, 31st Vertebrate Pest Conference (R. M. Timm and D. M. Woods, Eds.)
Paper No. 18. Published September 30, 2024. 6 pp.

FROM RODENTS AND HUMANS

If we want to take the welfare of urban animals seriously and consider them as citizens, we need to get to know them.
(C. De Ruyver)

Rats and Humans, Always Together

Where there is a human there is a rat, it seems. Burt's work from 2006 elucidates the intricate relationship between humans and rodents, particularly emphasizing the profound dependence of the latter on human activities such as migration, trade, and urbanization for their proliferation (Burt 2006). He characterizes rodents as the 'totem figure of human movement and displacement,' highlighting their ubiquitous presence wherever human populations establish themselves. However, as Delon states in his work, the liminal status of rats also comes with responsibilities (Delon 2020, 2021). In his pragmatic framework of pervasive captivity, he asserts that urban species are captive and necessitate human responsibility for their welfare: "What impact urbanization has on their (the liminal animals) freedom is ethically significant in ways that should affect urban wildlife management and policy." (Delon 2020, p. 124).

Rats pose health, property, and economic challenges for humans when living near them. Rats can transmit zoonotic diseases like leptospirosis, hantavirus, and salmonellosis through contaminated food, water, or surfaces, which can cause public health risks (Battersby 2015, CDC 2022). Rats also cause property damage by gnawing through various materials, including electrical wiring, which can lead to structural failures and fire hazards (Baker et al. 1994). The economic costs of rodent control and damage repair can reach billions of dollars due to the adaptability and resilience of rat populations (Jurišić et al. 2022). Continuous monitoring

is therefore essential for efficient population management and the prevention of infestations.

Our Ambiguous Relationship with Rats and Mice

In the book "Some We Love, Some We Hate, Some We Eat," Hal Herzog (Herzog and Fo 2010) addresses our ambivalent relationships with various animal species. But even within a species, we find that we love some, we hate some, and we eat some. Rats and mice, for example, are viewed in diverse ways: as pets, as pests, as food, as aids, and even as deities (Hagar 1914, Gruber 2016, Cessna 2017). Also indicative of this is the difference in legal protection (lab rat vs pet rat vs city rat). This complexity adds confusion to our relationship with them (Beumer 2014, Duffy 2015, Schuurman and Dirke 2020). Rats are frequently depicted in our popular culture, as characters in movies (Remy in *Ratatouille* or Scabbers in *Harry Potter*, tv shows (Rizzo the Rat in *The Muppet Show*) or Roland Rat, or comic books and cartoons (Anathème Percemiche in *Sybelline*) and Splinter (in *Teenage Mutant Ninja Turtles*) (Macherot 1965, Whitmire and Henson 1980, Claridge 1983, Eastman and Laird 1984, Rowling 1999, Bird and Pinkava 2007). At times cute, ugly, unreliable or fighter boss. Also, mice are well represented: Mickey Mouse, Stuart Little, Jerry (*Tom and Jerry*), Pikachu (*Pokémon*) and Fievel (*An American Tail*) almost all representing characters we can associate with (Disney 1928, Hanna and Barbera 1940, Freudberg and Geiss 1986, Nishida 1996, Shyamalan and Brooker 1999).

Rats and Mice are Sentient and Intelligent Animals

The rat holds a renowned status as the first mammal to undergo domestication explicitly for scientific research. It traces its ancestry to the wild Norway rat species, scientifically denoted as *Rattus norvegicus* (Modlinska and Pisula, 2020). The demands of research have prompted the development of various rat and mouse models (Lindsey and Baker 2006, Ellenbroek and Youn 2016). For instance, rodents have made substantial contributions to medicine and the pharmaceutical industry, notably in the realm of antidepressants (Fischer et al. 2024). This underscores researchers' recognition of their status as sentient beings and viable proxies for human subjects (Holmes et al. 2010, Sengupta 2011). Moreover, nowadays, researchers employ grimace scales for laboratory rodents and tickling, further emphasizing their status as sentient creatures (Langford et al. 2010, Sotocinal et al. 2011, LaFollette et al. 2017, Onuma et al. 2024). Across diverse scientific disciplines, recent investigations shed light on the cognitive parallels between rats and humans; for instance, Lai et al. (2023) note their ability to mentally navigate spatial environments and manipulate objects not physically present. This capacity allows them to envisage traversing distant locales or relocating objects remotely, indicative of a sophisticated cognitive mechanism akin to human cognition. This implies they can navigate places, in what humans would call, an intelligent way. Additionally, because of their advanced cognitive functions and high intelligence, rats contribute significantly to various human endeavors. Their formidable olfactory acuity serves as a prime reason for their utility (Oh et al. 2024). An illustrative example is their employment in landmine detection, contributing to efforts to enhance demining operations in regions like Cambodia (Fast et al. 2017). Thus, it is evident that rats are invaluable in addressing myriad challenges faced by humanity.

RODENT MANAGEMENT IN CITIES Pest?

In urban areas, rats have been associated with the Black Death since the Middle Ages (Burt 2006, Feng and Himsworth 2014). The Black Death, also known as the Great Plague or the Black Plague, was a plague epidemic, mainly bubonic plague, which occurred in the mid-14th century (McCormick 2003). Although there are still some questions, scientific research has revealed that fleas, living on rats and humans, were the carriers of the bacteria *Y. pestis* (Barbieri et al. 2021). According to the latest WHO report, effective antibiotic treatments are available against plague-causing bacteria, and early diagnosis coupled with quick treatment is crucial for rescuing lives. From 2010 to 2015, 3248 cases were reported worldwide, including 584 deaths. Currently, the three most endemic countries are the Democratic Republic of Congo, Madagascar, and Peru (World Health Organization 2024). Essentially, the hypothesis linking the cause of the plague to rats is not fully supported in contemporary understanding (Kosoy et al. 2015). Despite this, rats are still considered to be very dangerous to human health, even though there are other important influencing factors for disease transmission and important knowledge gaps (Himsworth et al. 2013, Robinson et al. 2024).

One Health and One Welfare?

In veterinary medicine the concepts of One Health

and One Welfare are important in dealing with zoonoses (Chiesa et al. 2021). These concepts underline that humans, other animals and ecosystems are interconnected and interdependent (Alabau et al. 2020, Lindenmayer and Kaufman 2022). Any intervention can affect all three, and they should not be viewed independently from one another (Alabau et al. 2020, Rached et al. 2020, Spadetto et al. 2024). As stated by Sharp (2022) "Knowledge of when and how to manage pests, typically originates from the fields of ecology, natural resource management and economics. However, these domains generally do not provide the information necessary to address animal welfare and human elements of management. Knowledge and expertise from a wider range of disciplines that includes veterinary and animal welfare science, behavioral science and social psychology can contribute to aspects such as: justification of pest management; understanding and addressing community concerns; and development and adoption of best practice management." We can only endorse this as authors.

Towards Urban Coexistence?

Despite the lingering aversion many hold towards rats due to historical and current associations with diseases like the plague, there is a growing consensus among researchers for a reappraisal of these creatures (Gish et al. 2024). There has been a noticeable shift among certain Western European scholars and researchers toward viewing rodents as urban cohabitants and neighbors, challenging the negative connotations. We bring four examples from 2023 and 2024 to promote such coexistence, respectively in Paris, Helsinki, Lausanne, and Brussels. Two multidisciplinary research initiatives were developed in Paris and Helsinki, among other places, with the goal of advocating for changes in human behavior and promoting better coexistence with rats. In Finland, the "Urban Rats" project (University of Helsinki) was launched, described as a comprehensive research endeavor encompassing ecology, evolution, genetics, history, visual arts, educational sciences, and social sciences related to urban rats in Helsinki. Similarly, in Paris, the 'ARMAGUEDON project,' an interdisciplinary approach integrating genomics, urban ecology, and eco-epidemiology, was launched with a key focus on combating prejudice to facilitate coexistence between Parisians and rats. Ecologist Douchka Markovic emphasized that rats are "useful" in the urban ecosystem and denounced an "abnormal, unwarranted fear" of rats. The goal of the project is to develop an integrated rat management program, designing new options for managing rat populations and improving society's perception of rats. This urban coexistence idea is also echoed in two recent exhibitions in Western Europe. Both Lausanne and Brussels hosted thematic exhibitions centered around cohabiting with unwelcome animals, including rats. The "Rattus" exhibition at the Sewer Museum in Brussels (Sewer Museum Brussels 2024) and the "Undesirable!? The Unloved Animals of the City" exhibition, jointly organized by the Institute of Geography and Sustainability of the University of Lausanne and the Museum of Zoology, highlight the evolving discourse surrounding urban wildlife and human-animal interactions in contemporary urban environments (Institute of Geography and Sustainability of the University of Lausanne and Museum of Zoology 2023, Sewer Museum Brussels 2024). These exhibitions serve as platforms for fostering dialogue and shifting

societal perceptions towards a more nuanced understanding of rats and their role within urban ecosystems.

**HUMANE RODENT MANAGEMENT
Accounting for Welfare**

With the rise of Integrated Pest Management (IPM), attention has been given to humane management of rodent populations. The first focus being on prevention of rodent infestations rather than eradication (Nattrass 2022). This is part of the abovementioned shift that is occurring. This integrated approach adopts a One Health and One Welfare perspective, recognizing the interconnectedness of animal, human, and environmental health. The shift from eradication to overpopulation prevention is crucial if we are to coexist with our rodent neighbors. Given the abovementioned need to reconsider our relationship with rodents we can find further evidence of the need for that, also linked to pest controllers. Research shows that pest controllers have moral problems with not humanely addressing rodent infestation (van Gerwen et al. 2020). ‘A dilemma may occur when methods with a high impact, such as rodenticides, are oftentimes used in practice. Respondents also indicate that in different real-life scenarios (the hospital kitchen vs. the private backyard), a different weight may be attributed to the importance of animal welfare. Almost half of the respondents encounter difficulties when weighing animal against human interests. The problems are mainly related to clients who are not willing to invest sufficient money in preventive methods, where respondents do believe in’ (van Gerwen et al. 2020, p.1, 2024). We can conclude that there is a genuine necessity to consider the welfare of the targeted animal. However, we can see concurring visions on what is humane and who to consider in such

dilemmas. While scientists and organizations are providing outlines for an IPM approach from an animal welfare point of view, opposition can also come from where it is not expected. For example, Nattrass et al. (2019) describe a situation where animal protection organizations stopped a job-creation project aimed at trapping and drowning rats because drowning was considered intolerable. This illustrates the tension that can arise between innovative ecologically focused strategies and existing legislation and animal protection practices. The result was that rodenticides were used instead. This was not a contestation over whether animals should be protected, but over how to do this, and which animals to include (Nattrass et al. 2019). The studies by Baker et al. (2022) and De Ruyver et al. (2023) sought to assess dispatch and control methods for their animal welfare impact. These can be used in an IPM approach when weighing the welfare impact of methods.

Assessing the Welfare Impact

What would humane rodent management involve? We lack a flute akin to the Pied Piper of Hamelin, thus we must devise strategies to address infestations, if necessary, in accordance with the One Health and One Welfare concepts in IPM. However, IPM must include assessments of animal welfare in its methodologies. We used the model of Sharp and Saunders to evaluate the impact of legal dispatch and control methods on animal welfare in Belgium (Figure 1) (De Ruyver et al. 2023).

The model uses the Five Domains model of animal welfare (Mellor & Reid 1994) as a basis for the development of a system to assess the effect of experiments, teaching, and testing procedures on animals. The model has two parts (A and B) for assessing welfare impact.

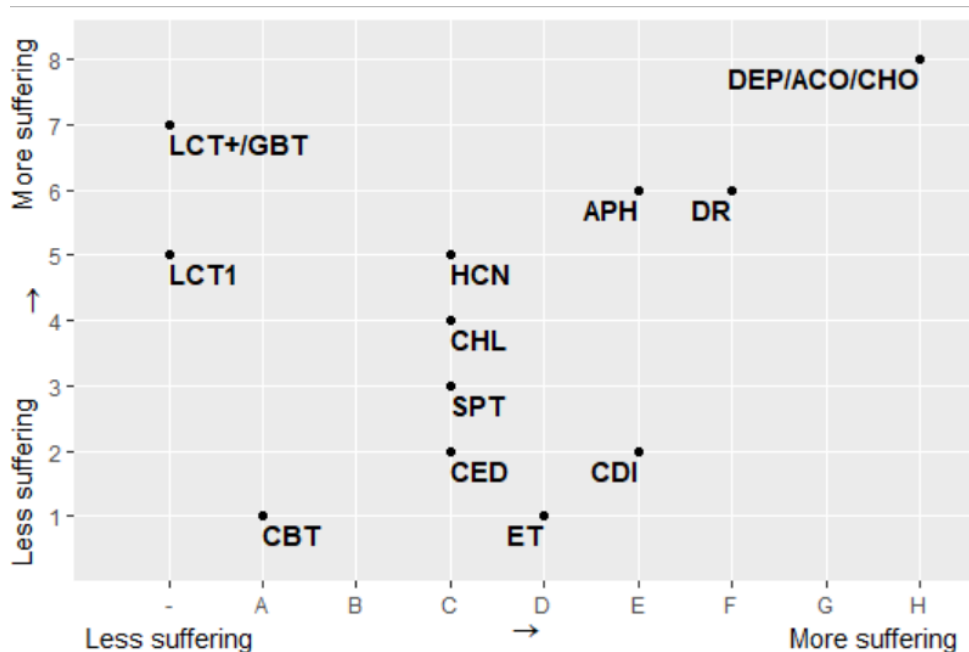


Figure 1. Graphical presentation of the expert panel consensus on the animal welfare scores of the fourteen population control methods for mice and rats. (After Sharp and Saunders 2011)

The x-axis indicates the time until unconsciousness and degree of suffering for lethal methods (part B); the y-axis indicates a method’s impact on welfare before death (non-lethal phase) (part A). LCT1: live capture trap 1 animal; LCT+: live capture trap multiple animals; GBT: glue board trap; DRO: drowning; DEP: deprivation; CED: cervical dislocation; ET: electrocution trap; BBT: break-back trap, Captive bolt trap: CBT; ACO: anticoagulants; APH: aluminium phosphide; CHL: chloralose; CDI: carbon dioxide; HCN: hydrogen cyanide; CHO: cholecalciferol.

Part A examines the ‘impact on the animal’ and the ‘duration of the suffering caused’ of a non-lethal method or the preceding, non-lethal stage of a lethal method. For the lethal control and dispatch methods, part B is added to the score and incorporates the ‘actual mode of death’ and the ‘duration of the induced suffering to unconsciousness.’ Assessment of the welfare impact of a non-lethal method is thus based on part A (score range 1-8) only, whereas for a lethal method parts A and B are combined (score range 1A-8H). Combining the assessment of part A (the impact on animal welfare during the period the animals are still alive) and part B (the impact of the killing itself) allows identification of the control methods’ overall effect on the suffering of the target animal. Our findings revealed that the captive-bolt trap and the electrocution trap are deemed to cause the least suffering, with suitable alternatives being decent snap traps or single-capture live traps, combined with cervical dislocation for animal dispatch. The use of anticoagulants or cholecalciferol was judged to cause considerable suffering.’ (De Ruyver et al. 2023, p.3-5). Baker et al. (2022) reached similar conclusions using the same model, substantiated by the findings of other experts. Such findings can certainly be utilized within an IPM framework.

CONCLUSION

The dynamic interplay between the environment, humans, and animals is pivotal in finding a delicate balance regarding the presence of rats and mice in human settlements, whether it be acceptable, excessive, or limited. Rats and mice, possessing sentience and intelligence, need human stewardship in the context of urban and rural coexistence. The principles of One Health and One Welfare underscore the imperative interconnectedness between the welfare of humans and animals within urban landscapes. The use of IPM is a vital approach to address urban rodent populations, necessitating multiple strategies for effective management. Furthermore, IPM should incorporate scientific research on the welfare implications of rodent control methods. This will help prevent uninformed debates regarding the most humane approach to pest management. However, the crux of the matter lies in the necessity for a fundamental shift in human attitudes and behavior. Without such a change, efforts to manage rodent populations may fall short. The impact on animal welfare will be huge when there is overpopulation, and action would be needed before there is a problem of overpopulation. In cases where the nuisance stemming from overpopulation exceeds tolerable thresholds, humane management practices become imperative. Conducting more research into the ecology and behavior of rats and mice in urban environments, as well as human behavior change, is essential for achieving harmonious coexistence.

LITERATURE CITED

- Alabau, E., G. Mentaberre, P. R. Camarero, R. Castillo-Contreras, I. S. Sánchez-Barbudo, C. Conejero, M. S. Fernández-Bocharán, J. R. López-Olvera, and R. Mateo. 2020. Accumulation of diastereomers of anticoagulant rodenticides in wild boar from suburban areas: implications for human consumers. *Science of the Total Environment* 738:139828.
- Baker, R. O., G. R. Bodman, and R. M. Timm. 1994. Rodent-proof construction and exclusion methods. Pages B-137-B-150 in S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. *Prevention and control of wildlife damage*. Cooperative Extension, University of Nebraska, Lincoln, NE.
- Baker, S., M. Ayers, N. Beausoleil, S. Belmain, M. Berdoy, A. Buckle, C. Cagienard, D. Cowan, J. Fearn-Daglish, P. Goddard, H. Golledge, E. Mullineaux, T. Sharp, A. Simmons, and E. Schmolz. 2022. An assessment of animal welfare impacts in wild Norway rat (*Rattus norvegicus*) management. *Animal Welfare* 31:51-68.
- Barbieri, R., M. Drancourt, and D. Raoult. 2021. The role of louse-transmitted diseases in historical plague pandemics. *The Lancet Infectious Diseases* 21:17-25.
- Battersby, S. A. 2015. Rodents as carriers of disease. Pages 81-100 in A. P. Buckle and R. H. Smith, editors. *Rodent pests and their control*. Second edition. CABI, Boston, MA.
- Beumer, K. 2014. Catching the rat: understanding multiple and contradictory human-rat relations as situated practices. *Society and Animals* 22:8-25.
- Bird, B., and J. Pinkava. (Producers) 2007. *Ratatouille*. [Film] Pixar Animation Studios, Walt Disney Pictures, Emeryville, CA.
- Burt, J. 2006. *Rat*. Reaktion Books, London, U.K.
- Centers for Disease Control and Prevention (CDC). 2022. Leptospirosis. Retrieved August 20, 2024 from <https://www.cdc.gov/leptospirosis/index.html>.
- Cessna, L. M. 2017. A good coming and a bad coming: the dual symbolic roles of mice in ancient Egyptian representations. MA thesis, University of British Columbia, Vancouver, BC, Canada.
- Chiesa, F., L. Tomassone, S. Savic, A. Bellato, A. D. Mihalca, D. Modry, B. Häsler, and D. De Meneghi. 2021. A survey on one health perception and experiences in Europe and neighboring areas. *Frontiers in Public Health* 9:8-22.
- Claridge, D. 1983. *Roland Rat*. Longman. London. UK.
- Delon, N. 2020. Pervasive captivity and urban wildlife. *Ethics, Policy and Environment* 23:123-143. <<https://doi.org/10.1080/21550085.2020.1848173>>.
- Delon, N. 2021. Animal capabilities and freedom in the city. *Journal of Human Development and Capabilities* 22:131-153.
- Disney, W. (Producer). 1928. *Steamboat Willie* [Film]. Pat Powers.
- Duffy, J. 2015. *Rat ethics: morally encountering Rattus norvegicus*. University of Prince Edward Island.
- Eastman, K., and P. Laird, producers. 1984. *Teenage Mutant Ninja Turtles* [Film]. Mirage Studios.
- Ellenbroek, B., and J. Youn. 2016. Rodent models in neuroscience research: is it a rat race? *Disease Models and Mechanisms* 9(10):1079-1087 <<http://dmm.biologists.org/lookup/doi/10.1242/dmm.026120.supplemental>>.
- Fast, C., H. Bach, P. McCarthy, and C. Cox. 2017. Mine detecting rats make an impact in Cambodia. *Journal of Conventional Weapons Destruction* 21:32-35.
- Feng, A. Y. T., and C. G. Himsworth. 2014. The secret life of the city rat: a review of the ecology of urban Norway and black rats (*Rattus norvegicus* and *Rattus rattus*). *Urban Ecosystems* 17:149-162.
- Fischer, L. W., M. Nunes, T. B. Mendes, J. N. Simas, M. M. Bernardi, S. U. de Oliva, and S. M. Miraglia. 2024. Effects of chronic mild stress induced from peripuberty on sexual behavior in male rats, with or without escitalopram treatment. *Andrology* 1:11.

- Freudberg, J., and T. Geiss, producers. 1986. *An American Tail*. [Film]. Universal Pictures.
- Gish, M., M. Hisano, and M. Soga. 2024. Does aversion to insects affect insecticide use? An elusive answer calls for improved methods in biophobia research. *People and Nature* 6:1001-1014.
- Gruber, K. 2016. Rodent meat - a sustainable way to feed the world? *EMBO reports* 17:630-633.
- Hagar, S. 1914. *The Maya Zodiac at Acanceh*. New Series. Volume 16.
- Hanna, W., and J. Barbera, producers. 1940. *Tom and Jerry* [Animated series]. Turner Entertainment.
- Herzog, H., and M. Fo. 2010. Some we love, some we hate, some we eat. Tantor Audio.
- Himsworth, C. G., K. L. Parsons, C. Jardine, and D. M. Patrick. 2013. Rats, cities, people, and pathogens: a systematic review and narrative synthesis of literature regarding the ecology of rat-associated zoonoses in urban centers. *Vector-Borne and Zoonotic Diseases* 13(6):349-359.
- Holmes, R. S., M. W. Wright, S. J. F. Laulederkind, L. A. Cox, M. Hosokawa, T. Imai, S. Ishibashi, R. Lehner, M. Miyazaki, E. J. Perkins, P. M. Potter, M. R. Redinbo, J. Robert, T. Satoh, T. Yamashita, B. Yan, T. Yokoi, R. Zechner, and L. J. Maltais. 2010. Recommended nomenclature for five mammalian carboxylesterase gene families: human, mouse, and rat genes and proteins. *Mammalian Genome* 21:427-441.
- Institute of Geography and Sustainability of the University of Lausanne, and Museum of Zoology. 2023. *Indésirables? Undesirables. Unwanted animals in the city*. https://igd.unil.ch/projrech/index.php?idPage=69&page=viewDetail&lang=en&id_proj=344.
- Jurišić, A., A. I. Čupina, M. Kavran, A. Potkonjak, I. Ivanović, O. Bjelić-Čabrilo, M. Meseldžija, M. Dudić, L. Poljaković-Pajnik, and V. Vasić. 2022. Surveillance strategies of rodents in agroecosystems, forestry and urban environments. *Sustainability* 14(15):1-32.
- Kosoy, M., L. Khlyap, J. F. Cosson, and S. Morand. 2015. Aboriginal and invasive rats of genus *Rattus* as hosts of infectious agents. *Vector-Borne and Zoonotic Diseases* 5(1):3-12.
- LaFollette, M. R., M. E. O'Haire, S. Cloutier, W. B. Blankenberger, and B. N. Gaskill. 2017. Rat tickling: a systematic review of applications, outcomes, and moderators. *PLoS ONE* 12(4):e0175320.
- Langford, D. J., A. L. Bailey, M. L. Chanda, S. E. Clarke, T. E. Drummond, S. Echols, S. Glick, J. Ingraio, T. Klassen-Ross, M. L. Lacroix-Fralish, L. Matsumiya, R. E. Sorge, S. G. Sotocinal, J. M. Tabaka, D. Wong, A. M. J. M. Van Den Maagdenberg, M. D. Ferrari, K. D. Craig, and J. S. Mogil. 2010. Coding of facial expressions of pain in the laboratory mouse. *Nature Methods* 7:447-449. <<http://www.nature.com/naturemethods/>>.
- Lindenmayer, J. M., and G. E. Kaufman. 2022. One Health and one welfare. Pages 1-382 in T. Stephens, editor. *One welfare in practice: the role of the veterinarian*. CRC Press.
- Lindsey, J. R., and H. J. Baker. 2006. Historical Foundations. Pages 1-52 in M. A. Suckow, S. H. Weisbroth, and C. L. Franklin, editors. *The Laboratory Rat*. Second edition. Academic Press, Cambridge, MA.
- Macherot, R. 1965. *Sybelline*. [Comic book]. Dupuis. Marcinelle, Hainaut, Belgium.
- McCormick, M. 2003. Rats, communications, and plague: toward an ecological history. *Journal of Interdisciplinary History* XXXIV:1-25.
- Pisula, W., K. Modlińska, A. Chrzanowska, and K. Goncikowska. 2021. Response to novelty induced by change in size and complexity of familiar objects in Lister-Hooded rats, a follow-up of 2019 study. *Scientific Reports* 11(1):10281.
- Natgrass, N. 2022. Waste, rodents and integrated pest management at UCT. CSSR Working Paper No. 469. University of Cape Town, South Africa. <https://humanities.uct.ac.za/cssr/waste-rodents-and-integrated-pest-management-uct>
- Natgrass, N., J. Stephens, and J. J. Loubser. 2019. Animal welfare and ecology in the contested ethics of rodent control in Cape Town. *Journal of Urban Ecology* 5(1): DOI: 10.1093/jue/juz008
- Nishida, A. 1996. *Pokémon Red and Blue*. [Video game]. Nintendo.
- Oh, Y., Miha Kim, O. Seok Kwon, S. Seek Min, Y. B. Shin, K. Kim, M. K. Oh, and Moonil Kim. 2024. A versatile odor detection system based on automatically trained rats for chemical sensing. *Journal of Industrial and Engineering Chemistry* 131:400-409.
- Onuma, K., M. Watanabe, and N. Sasaki. 2024. The grimace scale: a useful tool for assessing pain in laboratory animals. *Experimental Animals* 24:1-29.
- Rached, A., M. A. Moriceau, X. Serfaty, S. Lefebvre, and V. Lattard. 2020. Biomarkers potency to monitor non-target fauna poisoning by anticoagulant rodenticides. *Frontiers in Veterinary Science* 23:7:616276.
- Robinson, S. J., D. L. Pearl, C. G. Himsworth, J. S. Weese, L. R. Lindsay, A. Dibernardo, C. Huynh, J. E. Hill, C. Fernando, and C. M. Jardine. 2024. Environmental and sociodemographic factors associated with zoonotic pathogen occurrence in Norway rats (*Rattus norvegicus*) from Windsor, Ontario. *Zoonoses and Public Health* 71(4):416-428.
- Rowling, J. K. 1999. *Harry Potter and the prisoner of Azkaban*. Arthur A. Levine Books, New York, NY.
- De Ruyver, C., K. Baert, E. Cartuyvels, L. A. L. Beernaert, F. A. M. Tuytens, H. Leirs, and C. P. H. Moons. 2023. Assessing animal welfare impact of fourteen control and dispatch methods for house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*) and black rat (*Rattus rattus*). *Animal Welfare* 32:e2
- Schuurman, N., and K. Dirke. 2020. From pest to pet: liminality, domestication and animal agency in the killing of rats and cats. *Journal for Human-Animal Studies* 6:1-25.
- Sengupta, P. 2011. A scientific review of age determination for a laboratory rat: how old is it in comparison with human age? *Biomedicine International* 2:81-89.
- Sewer Museum Brussels. 2024. *Rattus*. <https://sewermuseum.brussels/en/rattus-3/>.
- Sharp, T. 2022. One welfare and the management of vertebrate pest animals: a complex problem needing an interdisciplinary approach. Pages 139-168 in T. Stephens, editor. *One welfare in practice: the role of the veterinarian*. First edition. CRC Press.
- Sharp, T., and G. Saunders. 2011. A model for assessing the relative humaneness of pest animal control methods. Department of Agriculture, Fisheries and Forestry. Canberra, Australia
- Shyamalan, M. N., and G. Brooker. 1999. *Stuart Little*. Sony Pictures Releasing.
- Sotocinal, S. G., R. E. Sorge, A. Zaloum, A. H. Tuttle, L. J. Martin, J. S. Wieskopf, J. C. S. Mapplebeck, P. Wei, S. Zhan, S. Zhang, J. J. McDougall, O. D. King, and J. S. Mogil. 2011. The rat grimace scale: a partially automated method for quantifying pain in the laboratory rat via facial expressions. *Molecular Pain* Jul 29:7:55. doi: 10.1186/1744-8069-7-55.

- Spadetto, L., P. Gómez-Ramírez, J. M. Zamora-Marín, M. León-Ortega, S. Díaz-García, F. Tecles, J. Fenoll, J. Cava, J. F. Calvo, and A. J. García-Fernández. 2024. Active monitoring of long-eared owl (*Asio otus*) nestlings reveals widespread exposure to anticoagulant rodenticides across different agricultural landscapes. *Science of the Total Environment* Mar 25:918:170492. doi: 10.1016/j.scitotenv.2024.170492.
- University of Helsinki. Urban Rats project. <https://www.helsinki.fi/en/projects/urban-rats/research>. Accessed 20 August 2024.
- van Gerwen, M. A., J. Nieuwland, H. A. van Lith, and F. L. B. Meijboom. 2020. Dilemmas in the management of liminal rodents: attitudes of Dutch pest controllers. *Animals* 10:1614. <<https://www.mdpi.com/2076-2615/10/9/1614>>.
- van Gerwen, M. A., T. B. Rodenburg, S. S. Arndt, B. G. Meerburg, and F. L. Meijboom. 2024. Attitudes of clients of Dutch pest controllers towards integrated pest management (IPM) and preventive measures in relation to rodent nuisance. *Pest Management Science*. <<https://onlinelibrary.wiley.com/doi/10.1002/ps.8113>>.
- Whitmire, S., and J. Henson, producers. 1980. *The Muppet Show* [television series].
- World Health Organization. 2024. Peste. <https://www.afro.who.int/health-topics/plague#:~:text=Antibiotic%20treatment%20is%20effective%20against,Congo%2C%20Madagascar%2C%20and%20Peru>.