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Advice by the director desk Risk assessment & research about the risk of the presence of rodents bee food production and treatise for the consumer and the workers

Cause

In recent years, the Netherlands Food and Consumer Product Safety Authority (NVWA) has noted An increase by It number violations by the Commodities Act that related to the presence of rodents in hospitality establishments, artisanal food businesses, and food retail stores. Of the measures imposed at such locations in the Randstad as part of the NVWA's supervisory activities , approximately 70% are related to nuisance situations involving pests. In most cases, this concerns nuisance caused by rodents (mice, rats). It is known that these animals can directly or indirectly transmit diseases. transfer Unpleasant the man. At the same time are this nuisance situations increasingly more reasons for the urgent closure of companies. To better manage this undesirable situation It to be able to cope, is the NVWA A project has been launched to improve the approach to pest problems. Part of this project is a request for advice to the Netherlands Food and Consumer Product Safety Authority (NVWA)'s Risk Assessment & Research Office (BuRO) regarding the risks of rodent nuisance at food production or retail locations for consumers and workers (e.g., entrepreneurs, staff, NVWA inspectors, etc.), in order to inform intervention policies regarding pest problems at these businesses.

BuRO has that's why in consultation of the managing board To enforce by the NVWA asked itself the following question:

What is It risk by the presence by rodents in an environment where foodstuffs are produced or traded for consumers and workers?

Approach

To answer the question, a risk assessment was conducted. BuRO used the four steps of the risk assessment process, as described in the risk assessment methodology. microbiological hazards : hazard assessment, hazard characterization , exposure assessment and risk characterization . This methodology is based on the Codex Alimentarius Directive *Principles and Guidelines for the Conduct of Microbiological Risk Assessment* (Codex Alimentarius Commission , 2014).

BuRO has for this risk assessment literature research performed. The The search strategy used can be found in the substantiation.

The contents by this advice is subject On An external peer review.

Demarcation

This risk assessment direct himself on the microbiological dangers that are related to rodent species that are highly adapted to a lifestyle in close proximity to humans (commensals), are regularly found in a food environment and are considered pests. In Europe go It in that to the brown rat (*Rattus norvegicus*), the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*). The focus is therefore on rats and mice from urban areas.

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Only the route of infection Through excreta products, such as urine, Feces and saliva were included. Indirect transmission of pathogens via arthropod vectors such as fleas or ticks was not included, as BuRO considered transmission of these unlikely in the setting studied. The potential risk of allergens spread by the selected rodents was also not included.

Findings

Hazard assessment

- Rodents are worldwide An source by zoonotic pathogens.
- Rodents that prevent in urban area in Europe and that to House mice and brown and black rats can cause nuisance in a food environment.
- These rodents carry 16 pathogens in Europe that are transmitted via food. or via contact of this animals or their excreta products disease in humans and thus pose a risk to food and occupational safety (Table 1). This concerns the bacterial pathogens *Campylobacter* spp ., *Clostridioides difficult* , *Coxiella burnetii* , pathogenic *Escherichia coli* , *Leptospira* spp *., Listeria monocytogenes* , *Salmonella* spp ., *Streptobacillis moniliformis* and *Yersinia* spp ., the parasites *Cryptosporidium* spp ., *Giardia duodenal* and *Hymenolepis nana* and cowpox virus, lymphocytic choriomeningitis virus (LCMV), rat hepatitis E virus (RHEV), and Seoul virus (SEOV).

Hazard characterization and exposure assessment

Pathogenic microorganisms

- The transfer by this pathogens can take place via feces (feces, urine) that can directly or indirectly contaminate foodstuffs or can occur through contact (direct, indirect) with the rodent itself or its excreta (feces, urine, saliva, birth fluid) (Table 1).
- Almost already this pathogens to have the potential serious disease in the man to take precautions.
- Rodents can be either transiently infected (carriers) or a permanent reservoir (Table 1), and they can carry multiple pathogens. The prevalence of these pathogens in rodents varies widely. in place and time and excretion by the pathogens can intermittent and occur in variable concentrations over time.
- Pathogens that occur no more than in 10% of the animals tested (in Europe or otherwise in North America or other to land) prevent, are *Campylobacter jejuni* , *Coxiella burnetii* , pathogenic *Escherichia coli* (EAEC), cowpox virus and *Salmonella* . Prevalences of up to 10-25% have been reported for pathogenic *E. coli* (STEC), RHEV, *Hymenolepis nana* , SEOV, *Shigella* spp./EIEC and *Yersinia* spp . For *Clostridium difficult* , *Cryptosporidium* spp ., pathogenic *E. coli* (STEC),

Giardia duodenal and LCMV (seroprevalence) maximum prevalences were found between 25-50% described, while *Leptospira* spp . and *Listeria monocytogenes* can occur in the majority (>50%) of the animals examined. These data give of name An order by possible size of the prevalence On.

- It is not clearly what the precise contribution by rodents of food-related illnesses.
- In a place where rodents are present, they can be a source of contamination for both food and humans. Pathogens in which rodents An role in the distribution (would be able to) to play are *C. difficile* , *Cryptosporidium* spp . and in particular *Leptospira* spp ..
- For many of the inventoried zoonotic agents that are primarily related to occupational health and safety , cases of disease occur rarely to rarely in the Netherlands (this applies for *H. nana* , cowpox virus, LCMV, RHEV, SEOV and *S. moniliformis*), or that the role of rodents in the total number of infections in the Netherlands will be marginal (this applies to *C. burnetii*).

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Table 1 Overview by the 16 pathogens that relevant are found for this risk assessment and that could occur in rodents in urban areas in the Netherlands.
Indicated is bee which rodent the pathogen for can to come, via which route the pathogen is excreted, whether rodents are carriers or reservoirs, and whether the pathogen poses a risk to food safety and/or occupational health and safety.

Pathogen	Animal species [a]			Carrier/ Reservoir [b]	Secretion via [c]	Danger for [d]	
	Brown rat	Black rat	House - mouse			Food	Arbo
Bacteria							
***Campylobacter* spp .**	*			D	F	**X**	X
Clostridioides difficult	*	*	*	?	F	(X)	**X**
Coxiella burnetii	*	*		(R)	GV		**X**
pathogenic *Escherichia coli*	*	*	*	(R)	F	**X**	(X)
***Leptospira* spp .**	*	*	*	R	YOU	X	**X**
Listeria monocytogenes	*	*		D	F	**X**	
Salmonella	*	*	*	D	F	**X**	X
Streptobacilli moniliformis	*	*		R	S	X	**X**
***Yersinia* spp .**	*			R	F	**X**	X
Viruses							
Cowpox virus	*			(R)	F, YOU		**X**
LCMV [#]			*	R	F, U, S		**X**
Rats hepatitis E virus	*	*		R	F	(X)	(X)
Seoul virus	*	*		R	F, U, S	X	**X**
Parasites							
***Cryptosporidium* spp .**	*			R	F	X	X
Giardia duodenal	*	*	*	(R)	F	X	X
Hymenolepis nana	*			R	F	**X**	X

[a] *: pathogen comes for or is found bee the animal species
[b] D: carrier, R: reservoir, (): subject by discussion/research, ?: no data known
[c] F: feces, GV: birth fluids, S: saliva, YOU: urine,
[d] X: pathogen forms An danger for the food- or occupational health and safety; ( ): subject by discussion/research; **fat** printed: most important exposure route
[#] LCMV: Lymphocytic choriomeningitis virus

Factors that the exposure to influence

- The chance on exposure On pathogens originating by rodents that in The presence of rodents in a food company is determined, among other things, by the number of rodents present, the amount of urine and feces excreted, the number of germs (cfu) in the excretion product and the
- survival by the germ in the environment.
- It missing On good estimates by rodent population sizes in a business location, but a rodent is rarely alone.
- Mice deposit their urine and feces everywhere in their environment, rats also urinate everywhere, but droppings are mainly found in specific places, especially after their daily final cleaning (absence people) shall An room (for example a kitchen) are soiled by these animals.
- A house mouse can per day to 12 ml urine and 100 produce droppings, a brown rat up to 300 ml of urine and about 70 droppings.
- The information on pathogen concentrations in rat excreta and mice is very limited and only available for *Salmonella* (feces) and *Leptospira* (urine). For *Salmonella* , a concentration of 2.3×10^{5} is used in mice. cfu /droppings reported, for brown rats of 1×10^{8} cfu /poo. For *Leptospira* For mice, the average is 3.1×10^{3} cfu /ml urine and for brown rats 5.7×10^{6} cfu /ml urine.
- In An scenario whereby during 10 to dawn 10 infected animals in An company is present, in the case of mice approximately 1 liter of urine and 10,000 droppings are excreted at that location, and in the case of rats possibly 30 liters urine and 7,000 droppings. That could amount to 10^{9} until 10^{11} *Salmonella* - germs and 10^{6} until 10^{11} *Leptospira* cells.
- Below favorable circumstances be able to pathogens sometimes to soften to remain infectious in the environment for months or years. Even with low bacterial counts per excretion product and a low prevalence of a pathogen in a rodent population can because of this – in case there not Good is becoming cleaned and disinfected - An high infection pressure on An concerning location to arise which can last for some time depending on the germ.
- In case of rodent nuisance it is likely that food and prepared foodstuffs food both directly infected be able to to touch of pest droppings and - urine, but also indirectly via soiled surfaces (including work surfaces, ceilings, shelves, ledges) and utensils.
- The more risky activities in terms of occupational health and safety transmission are cleaning up droppings and urine and disposing of dead (captured) animals. However, infection can also be contracted through touching surfaces. that soiled are of (dried up) urine or manure or via An scratch or bite from an animal.
- Taking rodent-repellent measures and carrying out rodent control are essential for exposure control. Hand hygiene is essential for people working in an environment with rodent nuisance. and It clean and disinfect by the work surfaces before production starts further contribute to this.
- It wear by suitable personal protective equipment bee It Carrying out higher-risk activities (including cleaning up feces and removing dead animals) contributes to occupational safety.

There are - despite the fact that there may be (serious) pest problems at food locations - hardly cases of illness known whereby rats or mice as a source of infection (direct, indirectly) are designated. This could also be due to the registration method. However, limited research is available that turns out that presence by pests (mouse, rat) An risk factor appears to be associated with the risk of foodborne illness or correlates with low microbiological quality of the food traded at that location.

Risk characterization

- Rodents in urban areas in the Netherlands and Europe contribute to a greater or lesser extent measure pathogenic microorganisms bee himself that via food or Direct or indirect contact with these animals or their excreta (feces, urine, saliva, birth fluids) can cause disease in humans. Almost all of these pathogens have the potential to cause serious illness in humans.
- Little has been published about the role of rodents in foodborne illnesses or outbreaks, but there does appear to be an association. However, rodent nuisance occurs at food production sites (production, trade). well situations for that be able to to lead to infection by foodstuffs (ingredients, prepared foods) containing rodent excrement (feces, urine) .
- The majority of infections caused by pathogens associated with occupational health and safety transmission are (very) rare in the Netherlands. However, in a location with rodent nuisance, rodents well An source by infection forms, whereby this for the situation in The Netherlands of name applies for *Leptospira* spp . and possible for *C. difficile* and *Cryptosporidium* spp ..
- The more risky actions related to occupational health and safety related transfer are It clean up by droppings and urine and It to delete by dead (captured) animals.
- Exposure can be prevented by taking rodent-repellent measures. If rodents are present, implementing rodent control is essential, as is implementing additional hygiene measures. and It wear by personal protective equipment when performing the riskier actions.

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Uncertainty analysis

Clearly is that commensal rodents in more or inferior measure pathogens that can carry food and occupational health and safety risks at a food location (production, trade). It is unclear whether there is indeed little cases of illness related be able to become On pathogens originate from rodents at such locations, or whether these are artifacts in the surveillance and recording system. Therefore, it is impossible to estimate the contribution of pests (mice, rats) to the number of foodborne illnesses. is. Also is not Good in at treasures how big it risk (chance, The severity of a rodent population at a business location is a concern for both workers (entrepreneur, staff, NVWA inspectors, etc.) and consumers (customers). Regarding non-food-related illnesses, it seems likely that people working at that location (entrepreneur, staff) are particularly at risk.

Conclusion

Commensal rodents (rats, mice) can be carriers or reservoirs of zoonotic pathogens, that in potential serious disease be able to cause. These pathogens are mainly excreted through feces and urine. The presence of these rodents in an environment, For example, in a food processing plant, this means that pathogens may enter the environment, and thus there is a risk that people (workers, consumers) will be exposed to pathogens from these pests. Without taking measures to keep these rodents out of the environment or to control them, and in conjunction with the handling by stiffer hygiene measures ten times by this control, will The degree of potential exposure (risk) increases. This, in turn, increases the risk to human health (food and occupational health and safety). Regarding non-food-related illnesses, it seems plausible that the entrepreneur and their employees (staff) are particularly at risk, and that this applies to a lesser extent – given the nature of the work – to an NVWA inspector.

Considering on the outcome by It present research assesses BuRO that in case of rodent nuisance the chance on transfer by pathogens originating of rodents to the environment must be considered real and that a rodent infestation on An grocery location (production, trade) An poses a risk to food and occupational health and safety.

Answer by the to ask

What is It risk by the presence by rodents in an environment where foodstuffs are produced or traded for consumers and workers?

The risk of the presence of rodents in a food environment become produced or traded is becoming formed Through the real risk of introduction and the associated plausible transmission of pathogens from these rodents (mice, rats). It seems plausible that these pathogens pose a risk primarily to the entrepreneur and his staff (Occupational Health and Safety) and also to guests/customers (the consumer) through the consumption of food/foodstuffs that are contaminated with feces (feces, urine) infected are touched (food safety). It The risk for the NVWA inspector cannot be ruled out, but in most situations it is probably not (significantly) increased.

Advice from BuRO

At the Inspector General by the NVWA

- Continue to focus on tackling pest problems at food business locations (production, trade) through risk mitigation measures on at to lay bee It to encounter by rodent nuisance in these companies.

Yours faithfully,

Prof. dr. Dick THM Sim
Director desk Risk assessment & research

Justification

Contents

1 Introduction

Rodents are the most diverse group of mammals and although they perform important ecological functions and serve as a major food source for humans in many countries, there are certain species that harmful effects to have. This harmful effects concern under other food supply and human health (Akhtar et al., 2023). Harmful effects The impact on food supply concerns losses of mainly cereals before harvest and during storage and the unsuitability of cereals and other foodstuffs due to contamination with feces and urine and damage to packaging by gnawing (Meerburg et al., 2009).
Harmful effects on human health are related to the transmission of (primarily) zoonotic pathogens. This transmission can be direct, for example, through bites by rodents, via contact of feces or It inhale by pathogens from dust by dried up feces. Or indirectly Through It to eat by foodstuffs contaminated with pathogens from rodent feces.

The Netherlands Food and Consumer Product Safety Authority (NVWA) has recently observed an increase in the number of violations related to nuisance caused by pests. In the Randstad, approximately 70% of the measures imposed as part of the NVWA's supervisory activities at hospitality establishments, artisanal food businesses, and food retailers are related to nuisance situations. of pests. In the most fallen Re this nuisance by mice or Rats, but can also include cockroaches or flies. At the same time, these nuisance situations are increasingly leading to the urgent closure of businesses (NVWA, 2024). In light of this undesirable situation, the NVWA has launched a project to improve its approach to pest control. Part of this project is a question to BuRO (the Dutch Food and Consumer Product Safety Authority) about the risks of rodent nuisance in a hospitality establishment, artisanal food business, or food retail store for the business owner, staff, guests, and NVWA inspectors.
On the one hand is this ask asked to It intervention policy of relation to to substantiate pest problems at these companies and, on the other hand, to determine whether protective measures are necessary to protect the health of the inspectors.

2 Approach

2.1 Methodology

To answer the question posed, a qualitative risk assessment was conducted. BuRO used the four steps of the risk assessment process: such as described in the methodology risk assessment microbiological dangers :

- **Hazard assessment** : Based on literature and selection criteria (see Scope) a number of zoonotic agents selected that are relevant to food safety and occupational health and safety for the situation that there in The Netherlands pests (rodents) present are in an environment where foodstuffs are produced or traded.
- **Hazard characterization** : It has been determined which diseases these pathogens cause in humans via food or via (indirectly contact of this animals or their excreta products and the route of infection by which a human contracts such an infection through these pests. Information was also sought about the amount of particles (bacteria, viruses, parasites) that could lead to disease in humans.
- **Exposure assessment** : Subsequently, it was investigated to what extent these identified hazards prevent bee pests in urban area in The Netherlands or in Europe (because of the proximity). In the absence of such data, data from countries in North America (because of (partly) It same climate and same Western culture) and Where appropriate, data from other countries (worldwide). Information was sought on how and to what extent pests contaminate their environment with excreta (feces, urine) and the concentration of pathogens in these excreta. We investigated whether cases of the zoonoses in question occur in the Netherlands and whether it is generally known to what extent rodents play a role in this – through food or (in)direct contact.
- **Risk characterization** : It has been assessed whether the presence of pests in a food environment (production, treatise) An danger for the man forms what concerns food safety and/or occupational health and safety.

BuRO conducted a literature study to identify the relevant information for hazard characterization and exposure assessment at to collect. For this is used made using a limited set of search terms in Scopus and PubMed . For a more detailed description, please refer to the appendix.

The contents by this risk assessment is subject On An external peer review.

2.2 Demarcation

This risk assessment focuses on the microbiological hazards associated with rodent species that are highly adapted to a lifestyle in close proximity to humans (commensals), are regularly found in food environments, and are considered pests. In Europe, this applies to brown rats (*Rattus norvegicus*), black rats (*Rattus rattus*) and house mice (*Mouse muscle*) (Frankova and al., 2015). This means that rodent species that only occasionally visit humans and cannot otherwise be considered commensals, such as the bank vole, were not included in this study. Therefore, the focus is on rats and mice from urban areas.

What the microbiological dangers Re are only the agents investigated of which It it is plausible that they can actually be transmitted in the setting of a food business (production, trading), for example through rodent bites, inhalation of pathogens with dust from dried droppings or eating food contaminated with droppings containing pathogens.

Pathogens that are transmitted only via an intermediate step, such as fleas or ticks (vector-borne microorganisms), were not included. In addition, no studies were conducted pathogens of which only very incidentally fallen at the man have been described, such as the rat threadworm *Syphacia obvelata* .

Companies that produce and trade food are usually located in built-up areas. Therefore, the focus of this risk assessment is on rodents from urban areas. The situation in national area can namely An other image give than for this research relevant For example, it has been found that the extent to which pathogens occur in rats – both in diversity and quantity – is higher in rural areas than in urban areas (Battersby et al., 2002).

This risk assessment is qualitative by design, usage using quantitative data where possible. Exposure was determined by the extent to which the identified pathogens occur. bee pests. The data out the various studies are not Good at to compare, through the use of different methods, matrices, and sample sizes. However, the data do provide an indication of the order of magnitude of the prevalence.

Not brought in this risk assessment is the danger by allergens that Through the Selected rodents are spread. Literature research shows that rats and mice can pose a health risk to humans due to the production of proteins that can act as allergens and trigger allergic reactions in sensitized individuals (Phipatanakul et al., 2012). These allergens are excreted in urine, hair, or skin flakes. This danger is particularly relevant for people who spend extended periods in an area where these rodents are also present (employees/staff working at that location). This risk is separate from the microbiological risks and increases with the number of rodents present in a food business.

3 Hazard assessment

In An overview article identified Meerburg and already (2009) 61 viruses, bacteria and Parasites of which rodents can serve as global reservoirs or carriers. Strand & Lundkvist (2019) systematically reviewed the occurrence of pathogenic microorganisms in brown and black rats in 55 European countries between 1995 and 2016. They identified 53 agents with zoonotic potential, 48 in brown rats and 20 in black rats. A selection of the hazards identified by these authors was made for this risk assessment. The selection criteria are described in section 2.2. Demarcation . Based on this selection criteria were used to identify 16 pathogens by BuRO based on literature research that for be able to to come bee rats (brown, black) and house mice in Europe and that in the vicinity of a food business (production, trading) may pose a risk to food safety and/or employee health (occupational health and safety).

This concerns the bacterial pathogens *Campylobacter* spp ., *Clostridioides difficile* , *Coxiella burnetii* , pathogenic *Escherichia coli* , *Leptospira* spp *., Listeria monocytogenes* , *Salmonella* spp ., *Streptobacilli moniliformis* and *Yersinia* spp ., the parasites *Cryptosporidium* spp ., *Giardia duodenal* and *Hymenolepis nana* and cowpox virus, lymphocytic choriomeningitis virus (LCMV), rat hepatitis E virus (RHEV), and Seoul virus (SEOV).

4 Hazard characterization and exposure assessment

The risk of pest-related pathogens has two components: the pathogen and the pest. This section first addresses the pathogens themselves (4.1), followed by on aspects that associated are of the pests (4.2) and then on the transmission of pathogens to humans in the setting of a food business (production, trading) (4.3).

4.1 Pathogens

4.1.1 Campylobacter spp .

Campylobacter spp . are bacteria that in the intestines by various wild and domesticated animals occur.

The main reservoir of *Campylobacter* spp . causing human infections in the Netherlands is poultry (and birds in general), followed by cattle, sheep, pigs, and primarily young dogs and cats (RIVM, 2024b). The importance of rodents in the epidemiology of human *Campylobacter* infections is unknown, but likely of secondary importance. On other animal sources. Rodents become than also not as reservoir, but considered an incidental carrier of *Campylobacter* (Meerburg et al., 2009).

The genus *Campylobacter* contains 57 species of which *C. jejuni* is the most common source of human infections. Most *Campylobacter* infections in humans are asymptomatic. Cases with clinical symptoms result from intestinal inflammation and are mainly characterized Through diarrhea and stomach ache. *Campylobacter* infections become mainly Through Transmission occurs through eating contaminated food. Infections can also be acquired through contact with infected animals or a contaminated environment (RIVM, 2024b). In wealthy countries, human infections mainly occur as isolated cases (Veronese & Dodi , 2024).

Intake by An small quantity campylobacter germs can already to disease lead (RIVM, 2024b). The ID_{50} - the dose at which 50% of exposed people become infected - is estimated at 37 cells in milk, for example (Rose et al., 2014).

There are no data available about It prevent of *Campylobacter* spp . bee pests in the Netherlands.

Several studies have investigated the occurrence of *Campylobacter* spp . in brown rats; by mice are no to research found. The prevalence varies by 3-41% for *Campylobacter* spp . and 1-7% for *C. jejuni* . This involves various research methods (PCR, culture) and matrices (feces, gut contents), as well as rats from urban areas. Below is a summary of these studies:

- Of brown rats collected in New York, United States of America (USA), 4% (5/133) tested positive for C. *jejuni* (PCR, droppings). The PCR method (Polymerase Chain Reaction) is a molecular analysis method for It demonstrate by hereditary material (DNA, RNA)) (Firth et al., 2014).
- Bee 8% by brown rats that in and to Helsinki, Finland, captured became, *Campylobacter* spp . was detected in feces (culture method, 19/259 animals). This mainly involved *C. jejuni* (7% of animals, 17/259) (Aivelo et al., 2024).
- By brown rats caught in It sewer by Barcelona, Spain (212 animals), became bee 7% *C. jejuni* demonstrated (intestinal contents) (Montalvo et al., 2018).

- Bee brown rats captured by in the city center in Vancouver, Canada, was at 41% (9/22) *Campylobacter* spp . demonstrated (PCR, thick intestinal contents) (Lee and al., 2023).

4.1.2 Clostridioides difficult

The spore-forming bacterium *C. difficile* occurs in the environment (water, soil), but can also be demonstrated in feces by poultry and mammals such as cattle, horses, Pigs, dogs, and rodents. Based on ribosomal DNA typing, more than 400 ribotypes can be distinguished. There are toxin-producing and non-toxin-producing strains of
C. difficile . Only toxin-producing strains can cause inflammation of the intestinal wall and thus disease. The disease is characterized by mild to severe colitis with diarrhea. (RIVM, 2014a). Risk groups are people of elevated exposure (that is generally in hospitals and healthcare institutions), people who use antibiotics and people with reduced immunity, for example due to old age or underlying conditions.

An infection with *C. difficile* can arise after a disruption of the microbiome , such as after a course of antibiotics. The infection expires via It of the mouth to receive by tracks originating from human or animal feces. This can occur via the hands or objects.
Traces be able to months to years in It environment survival (RIVM, 2014a). Warrior and already (2020) argue that spores of *C. difficile* can survive in rodent droppings for extended periods of time.

Certain ribotypes of *C. difficile* are known as the cause of outbreaks in hospitals and nursing homes. Humans are the main source of infection. In addition, there are also individual cases of illness in the general population. In these cases, the infection may have been contracted from other people or through contact with animals (RIVM, 2014a). Given that *C. difficile* also in meat and meat products can be demonstrated, is food-related Transmission is a topic of discussion (Durovic et al., 2018). Foodborne outbreaks of *C. difficile* have not yet been described. In Europe, the most frequently found ribotypes in humans are 001 and 014/020. In the Netherlands, there have been several outbreaks in hospitals and nursing homes caused by ribotype 027. Infections with ribotype 078 are more often found outside of institutions in the Netherlands. and bee younger people seen. *C. difficile* infections to come organized for in Netherlands (RIVM, 2014a).

In Utrecht captured house mice (80 animals) were under other investigated on the presence of *C. difficile* in intestinal contents. In 35% of the cases *C. difficile was found* demonstrated. In descending order of frequency, these were ribotypes 014/020, 258, 002, 005, 013, 056, and 081, all of which are known to cause human disease (Burt et al., 2018).

Studies conducted in cities in other countries (Europe, North America) also show that both mice and rats carry *C. difficile* can carry with them and that this may vary depending on location by 0% to 17% then well 47% bee mice respectively rats. A infestation of mice or direct contact with mouse droppings can therefore be considered a risk factor for the contamination of indoor spaces with *C. difficile* or transmission to humans are considered (Burt et al., 2018).
Here An Overview by the various studies:

- Bee brown rats captured in New York, US, became bee 1% (1/133) *C. difficult* demonstrated (PCR, feces) (Firth et al., 2014).
- In house mice captured in New York (USA, multi-borough), 4% (18/416) were found to have *C. difficile* demonstrated (PCR, anal swabs). The prevalence varied per location (district) and ranged from 0% to 17%. The prevalence also varied over time. Among the ribotypes found were also types that of disease bee the man become associated, such as RT106 (Williams and al., 2018).
- Of rats collected in Vancouver, Canada, 13% (95/724) were found to be *C. difficile* positive (culture, gut contents): brown rats 13% (89/684), black rats 15% (6/40). Between sampling sites, prevalence varied from 0-47%. In addition to 21 new ribotypes , also nine ribotypes identified that known pathogen are for man and animals, including human pathogenic ribotypes 001 and 078 (Himsworth et al., 2014).
- By brown rats captured in the city center by Vancouver, Canada, became bee 14% (3/22) *C. difficile* demonstrated (PCR; colon contents) (Lee et al., 2023).

4.1.3 Coxiella burnetii

C. burnetii is a bacterium that occurs mainly in ruminants, but also in other animals such as rats, rabbits, dogs, cats, and horses. In the Netherlands, small ruminants are the most important source by human infections (RIVM, 2018). By rodents is becoming suspected that They can act as a reservoir (Meerburg et al., 2009), but this is unclear (RIVM, 2023). Compared to other modes of transmission, their role in establishing human infections is likely limited (Meerburg et al., 2009).

Infected animals themselves are usually not sick and excrete the bacteria with birth products. *C. burnetii* is becoming after It release out for example placenta or amniotic fluid spread through the air from infected animals. People become infected by inhaling contaminated dust. The majority (60%) of human Q fever infections are asymptomatic. The remaining 40% of infections are accompanied by a varied clinical picture from mild flu-like symptoms to severe disease courses (RIVM, 2018).

C. burnetii is very resistant to environmental influences and can survive outside the host for a long time (RIVM, 2018). *C. burnetii* survives years in infected buildings, foodstuffs and surfaces (PHAC, 2011).

In the Netherlands, research was conducted at the time of the Q fever outbreak in goats (2007-2010) the role by rats in the distribution from *C. burnetii* . The animals were originating out the city, nature and various farms. *C. burnetii was found in 5% of brown rats and 3% of black rats.* found (in the spleen, PCR). Of the brown rats serologically examined, 16% had *C. burnetii* antibodies in It blood, what indicates that this animals ever An infection of this pathogen None of the serologically tested black rats tested positive. Positively tested rats were detected not only on various livestock farms but also in urban areas. Examination of a number of actively infected animals showed that *C. burnetii* also occurred in kidney and intestinal tissue of these animals (PCR method). According to the authors, this could indicate excretion of the bacteria in urine and feces. This would mean that rats can contribute to the transmission and spread of the pathogen (Reusken et al., 2011). In a later study (2020-2021) on the occurrence of pathogens in brown rats In three Dutch cities no *C. burnetii was found* found (0%, 0/405; PCR, spleen) (de Cock et al., 2023).

Studies out It abroad (city, countryside) to leave also to see that rats (brown, black) An source by *C. burnetii* be able to are, of prevalences that vary by 1-15%. Also bee mice can this pathogen occurs (13% serologically positive):

- By brown rats out urban and national area in Germany became bee 1% (7/524) *C. burnetii* found (PCR, spleen) (Runge and al., 2013).
- In Franceville , Gabon, pale 2% (1/54) by the researched black rats positive for *C. burnetii* (PCR, liver) (Mangombi et al., 2021).
- On It island Corsica pale 9% (9/103) by the black rats and 13% (2/15) by the house mice serologically positive for *C. burnetii* (Izquierdo-Rodríguez et al., 2019).
- By rats captured in suburban area by It Giza Governorate, Egypt, came bee 4% (2/55) of brown and 15% (3/20) of black rats *C. burnetii* in the feces for (PCR) (Abdel- Moein & Hamza , 2018).

4.1.4 Cryptosporidium spp .

Cryptosporidium spp . are single-celled parasites with a simple life cycle completed in a single host. The genus *Cryptosporidium* contains more than 30 species. Although the different species are associated with specific hosts, host specificity varies. in It general low. The most human infections, more than 90%, are caused by two species: *C. hominis* of *C. parvum* . From *C. hominis* is the primary host of *C. parvum* Cattle, especially calves, but also humans. However, both species can also cause infections in various other animal species. *C. parvum* is considered responsible for most zoonotic infections in humans. Nevertheless, zoonotic infections are rare. Cases of illness are attributed to rodents as well as cattle (Fayer et al., 2000; RIVM, 2014b).

Rodents are considered one of the reservoirs of *Cryptosporidium* spp . They may play a role in sporadic infections in urban areas due to contamination of food establishments. and living spaces of infected feces (Meerburg and al., 2009). An infected host excretes mature oocytes in the feces, which are immediately infectious again.

A *Cryptosporidium* infection causes acute diarrhea that usually resolves spontaneously. In immunocompromised individuals, the disease can be severe (RIVM, 2014b; Gerace & Di Marco Lo Presti , 2019). Infections are acquired via the fecal -oral route, for example, through contact of animals, via infected food or fecal contaminated surfaces or (swimming) water. The median infectious dose (ID $_{50}$) is around 130 oocysts (Fayer et al., 2000).

Oocytes by *C. parvum* be able to for months viable to stay. Bee 20 °C for example Oocysts remain infectious for 6 months (Fayer et al., 2000).

There are no data available about It prevent of *Cryptosporidium* spp . bee pests in the Netherlands.

Studies conducted in cities in other countries in Europe and North America showed prevalences by 2-39% bee brown rats; data by mice were not found. Hereby An Overview of the studies consulted:

- Bee brown rats captured in New York, US, became *C. parvum* found in the stool by 2% (2/133) of these animals (Firth et al., 2014).
- By brown rats out the city center by Vancouver, Canada, pale 23% (5/22) *Cryptosporidium* spp . positive (PCR, thick intestinal contents) (Lee and al., 2023).
- By brown rats captured in It sewer (n=85) by Barcelona became bee 39% *Cryptosporidium* spp . demonstrated (PCR, intestinal contents) (Galán-Puchades and al., 2021).

Rašková et al. (2013) describe a case of severe diarrhea in an immunocompetent patient due to co-infection with *Cryptosporidium tyzzeri* and *C. parvum* . During fieldwork, the patient had contact with wild house mice. The presence of the same *Cryptosporidium* subtypes bee captured mice and patient confirmed contact of mice as most likely source of the infection.

4.1.5 Pathogenic Escherichia coli

Escherichia coli is a bacterium that belongs to the normal microbiota of humans and animals. However, some strains are pathogenic. The spectrum of possible clinical symptoms of the pathogen tribes (pathovars) is wide and can intestinal infections of diarrhea, urinary tract infections or renal failure. Pathogenic *E. coli* strains found in rodents include Shiga toxin -producing *E. coli* (STEC), enteropathogenic *E. coli* (EPEC), enteroaggregative *E. coli* (EAEC) and enteroinvasive *E.* coli (EIEC *)* / *Shigella* . EPEC is associated with acute and prolonged diarrhea in children, EAEC with acute and chronic diarrhea as well as traveler's diarrhea, EIEC with severe, bloody diarrhea and watery diarrhea. EPEC can be divided into typical (tEPEC) and atypical (aEPEC) forms. While the reservoir of tEPEC is humans, aEPEC are associated with both humans and animals. However, STEC is the most important pathogenic *E. coli* when it comes to *E. coli* infections acquired in the Netherlands via food or the environment. In addition to bloody inflammation of the colon (gastroenteritis), STEC also causes the more serious condition of kidney failure (HUS, hemolytic uremic syndrome). STEC occur naturally in the intestines of ruminants. Rodents are considered a potential reservoir for STEC (Meerburg et al., 2009; EFSA, 2015; Jenkins, 2018; Pokharel et al., 2023).

The man touches of STEC infected via the fecal -oral route. Generally is that indirectly Through It to eat from food contaminated with animal feces. However, direct exposure through contact with animal feces (such as manure or infected livestock, but possibly also through rodents (feces)) also occurs as a cause of STEC infection (RIVM, 2010).

Ingestion of even a small amount of STEC germs can lead to illness, especially in risk groups (young children, elderly people, immunocompromised people) (Forsythe , 2000; Teunis et al., 2004; FDA, 2012).

E. coli is free stable in It environment. In feces by experimental infected Rats survived *E. coli* O157 for up to 9 months (Ĉižek et al., 2000).

There are no facts about It prevent by pathogenic *E. coli* bee mice or rats in The Netherlands or other countries in Europe.

However, data are available from cities in other parts of the world, particularly regarding brown rats. STEC prevalences vary from 2-12% (culture, PCR). Other pathogenic *E. coli* types were also found: for brown rats, ranging from 9% for EAEC, 5-14% for EIEC, and 12-45%. EPEC, and for mice by 4% EPEC to 14% for *Shigella* /EIEC. Below An Overview of these studies:

- In the feces of rats (brown, to a lesser extent black) captured in downtown Vancouver, Canada, became bee 2% STEC (15/633) demonstrated (week). Partly (10/633) went This concerns a STEC serotype that belongs to the top 7 most important human pathogenic STEC serotypes (Himsworth et al., 2015b).
- Bee black rats out Baghdad, Iraq, became An STEC culture prevalence by 7% (8/120) found (intestinal contents) (Ayyal et al., 2019).
- By brown rats captured in New York, US, pale 38% (50/133) positive for EPEC (PCR, feces) (Firth et al., 2014).
- In brown rats (22 animals) captured in downtown Vancouver, Canada, 9% EAEC was found demonstrated (PCR, intestinal contents), bee 45% EPEC and bee 14% *Shigella* spp./EIEC (Lee and al., 2023).
- Of brown rats (67 animals) captured from slums in Salvador, Brazil, 31% tested positive for pathogenic *E. coli* . It concerned STEC (12%), EPEC (12%), EIEC (5%) and STEC/EIEC (5%). Of the 5 black rats, two were positive for pathogenic *E. coli* , one of which was a STEC isolate (Sobrinho et al., 2021).
- Bee house mice (416 animals) captured in New York, US, became a *Shigella* /EIEC PCR prevalence of 14% in anal swabs observed. Bee 6% by the animals became pathogenic *E. coli* found, including atypical EPEC (4%) (Williams et al., 2018).

4.1.6 Giardia duodenal

Giardia duodenal (synonyms *G. lamblia* , *G. intestinalis*) is a unicellular parasite belonging to the flagellates belongs. *Giardia* knows An 8-piece genotypes, assemblies named. Bee the man Assemblages A and B are mainly found, and sometimes these assemblages also occur in animals. However, in animals, assemblages that do not cause illness in humans are mainly found. In rodents, this is assemblage G (Vrbova et al., 2018; RIVM, 2019). Only assemblages A and B are (possibly) zoonotic , but the zoonotic potential of *Giardia* is still subject to discussion (RIVM, 2019).

Infections in humans are asymptomatic in half of the cases, symptomatic in half of the cases is there talk by diarrhea whereby also chronic disease courses be able to prevent. *Giardia* has a simple life cycle that is completed within the same host. An infected host excretes cysts in the feces, which serve as a survival stage and are immediately infectious (RIVM, 2019).

The human route of infection is fecal -oral via cyst-contaminated drinking water, food, or surfaces (e.g., eating utensils, but also hands). One *Giardia outbreak has been described in which* zoonotic transmission was suspected to have occurred. rodents. In this outbreak became An of rodent droppings contaminated Christmas pudding has been identified as a source (Smith et al., 2007; RIVM, 2019).

Giardia cysts stored at 8°C remain viable for up to 77 days. Cysts stored at 21°C remained viable during 5 to 24 to dawn, while cysts saved at 37 °C never longer remained viable for more than 4 days (Smoguła et al., 2023).

There are no facts about It prevent by *Giardia* spp . bee mice or rats in The Netherlands.

Studies from other countries (cities, worldwide) show that *Giardia* spp . can occur in rats and mice (3-38%). However, it is often unclear which assemblage is involved, but zoonotic assemblies are demonstrated. Hereby An Overview by the consulted studies:

- By brown rats captured in Barcelona, Spain, turned out to be 38% (32/85) by the sewer rats positive for *Giardia* (PCR, gut contents) and 20% (3/15) of rats from parks. The assemblage is unknown (Galán-Puchades et al., 2021).

- In brown rats caught in the city center from Vancouver, Canada, became at 5% (1/22) *G. duodenalis* encountered (PCR, thick intestinal contents; assemblies unknown) (Lee and al., 2023).
- Bee house mice, brown and black rats captured in Shiraz, Iran, became *G. duodenal* found in 3% of house mice (1/40) and brown rats (1/40) and in 5% of black rats (2/40) (PCR, in feces). The *G. duodenal* findings bee house mice and black rats affected the non -zoonotic assemblage G. In black rats, the zoonotic assemblage B was also found (Asghari et al., 2022).

4.1.7 Hymenolepis nana

Hymenolepis nana , the dwarf tapeworm, is the most common tapeworm in humans worldwide. Children become more often infected than adults. Infections become associated with bad hygiene and inadequate sanitary facilities. If final host (reservoir) from *H. nana* serve rodents, other small mammals, and also humans. Unlike other *Hymenolepis* species, which are infectious through ingestion of an insect intermediate host, humans are mainly infected with *H. nana* by ingesting tapeworm eggs through the fecal -oral route, such as through poor hand hygiene or Contaminated food or drinking water. Transmission is also possible through contact with fecal-contaminated objects or surfaces (such as eating utensils or hands). A specific feature of *H. nana* infections is so-called internal autoinfection .
In this case, eggs hatch in the intestines of the final host, including humans. This can lead to infections, Despite An short lifespan (4 to 6 to soften) from *H. nana* for years to stay Symptoms range from absent to anemia, abdominal pain, and diarrhea.

Infections with *H. nana* are rare in the Netherlands (Willcocks et al., 2015; Ito & Budke , 2021; Mathison & Pritt , 2022; CDC, 2024a; MMMIG, 2024). Eggs by *H. nana* be able to to 2 to soften in surviving the environment (Thompson, 2015).

In The Netherlands is research done Unpleasant It prevent from *H. nana* bee brown and black rats which were captured on farms, in rural areas or in suburbs (Franssen et al., 2016). In 3% (3/117) of the brown rats examined, *H. nana was found* demonstrated (microscopy). The three animals that tested positive came from a farm or rural area. Of the brown rats caught on a farm, 3% (1/30) tested positive, and of the brown rats caught in a rural area, 4% (2/49). The 44 black rats caught were all negative for *H. nana* .
Although no by the brown rats that in suburban area were captured (n=38) If the test was positive, this doesn't mean that rats in the city can't carry dwarf tapeworms. The sample size is too small to make a definitive statement, given the observed overall prevalence.

In other European towns lie the observed prevalences in brown rats just what higher, namely between 3-17%. No data from mice were found.

- Brown rats (131 animals) captured in Budapest, Hungary were found to have 3% *H. nana* in intestinal contents demonstrated. *Hymenolepis* eggs were bee 16% by the animals demonstrated (Juhász et al., 2024).
- Bee brown rats (288 animals) captured in and to Helsinki, Finland, became bee 10% *H. nana* demonstrated (intestinal contents) (Aivelo and al., 2024).
- By brown rats (42 animals) captured in Liverpool and Sefton , United Kingdom (UK), a *H. nana* prevalence of 14% was observed (feces) (McGarry et al., 2015).
- By brown rats (40 animals) captured in London, UK, became bee 17% *Hymenolepis* spp . demonstrated (parasitologically , feces) (Battersby et al., 2002).
- By brown rats (100 animals) caught in Barcelona, Spain (sewer, parks), became bee 17% *H. nana* demonstrated (microscopy, intestines) (Galán-Puchades et al., 2018).

4.1.8 Cowpox virus

Cowpox virus is a DNA virus from the genus Orthopoxviruses , family Poxviruses. The virus has a wide host range, with rodents as a suspected reservoir. Bank voles (*Clethrionomys) are considered reservoir species. glareolus*), earth mice (*Microtus agrestis*) and wood mice (*Apodemus sylvaticus*) is mentioned. It is not known whether brown rats also as primary reservoir function or as so-called *amplifying host* that the infection only from a primary reservoir (Chantrey et al., 1999; Hazel et al., 2000).

Most infections in humans result from direct contact with infected cats or cows (hence the name), men can also become infected Through contact with sheep and rodents. Cats to walk It virus on Through predation on small rodents. The disease manifests himself as A localized infection of the skin. In immunocompetent individuals, the disease course is relatively benign. Infected rats excrete the virus in urine and feces (RIVM, 2023; PHAC, 2024).

In the Netherlands, two human cases of cowpox infection associated with rodents have been described. In one case, the infection was contracted through a bite of a suspected rodent. An brown rat (Postma and al., 1991). In It other case Through contact of An A sick wild brown rat (Wolfs et al., 2002). Cowpox infections in humans are rare in the Netherlands (RIVM, 2023).

There are two studies out The Netherlands known that Unpleasant It prevent by cowpox virus bee rats were examined. One involved a study conducted in Amsterdam, Rotterdam, and Eindhoven, where cowpox virus was not detected in any (0%; 0/400) of the brown rats examined (PCR) (de Cock et al., 2023). The other involved an outbreak of cowpox among monkeys at an exotic mammal sanctuary, where 34 brown rats were captured. The animals were serologically and virologically tested. tested for the presence of virus (culture, PCR). 29% (11/34) of the rats had antibodies against cowpox virus. Over half of the animals carried the virus (57% (16/28) culture-positive, 56% DNA-positive) (Martina et al., 2006).

Research Unpleasant cowpox virus bee rodents in other European towns is limited published (2 studies). In these studies, cowpox virus seroprevalences of 1-5% (brown) were found. rats). Data by mice were not found. Below An Overview by this studies:

- orthopoxvirus was detected in brown rats captured in several European cities (424 animals). demonstrated (PCR, liver). Serological pale 0.8% of the animals (388 animals) positive (fluid from the chest cavity) (Heuser et al., 2017).
- Brown rats captured in and to Helsinki, Finland, had An orthopoxvirus antibody prevalence of 5% (11/211) (Aivelo et al., 2024).

4.1.9 Leptospira spp .

Leptospira are spirochetes from the genus *Leptospira* of the family *Leptospiraceae* . There are more than 250 different leptospires Serovars are known. Some serovars tend to cause severe forms of leptospirosis, while others mainly cause mild forms. The disease affects multiple organs On and the clinical symptoms are often non-specific flu-like. The The most severe course of the disease is known as Weil's disease, which is characterized by jaundice, renal failure, and bleeding. The mortality rate for Weil's disease is 5 to 15% (Krøjgaard et al., 2009; Heuser et al., 2017). Weil's disease is caused by the closely related serovars Icterohaemorrhagiae and Copenhageni , both from the serogroup Icterohemorrhagiae and transmitted by rats (RIVM, 2015). Mud fever is usually a milder form of leptospirosis, caused by the serovar Grippotyphosa from the Grippotyphosa serogroup , transmitted by mice. Milk fever is also a milder form of leptospirosis, caused by the serovar Hardjo from the Sejroe serogroup , transferred by cattle. Hardjo - Infections are almost at their peak at the moment No longer present in the Netherlands. In addition to the serovars mentioned above , several other serovars occur in the Netherlands that may cause other forms of leptospirosis (RIVM, 2015).

Rats are considered an important source of human *Leptospira* infections. *Leptospira* spp . colonize the kidneys of reservoir hosts. Infected animals shed the germ for life. of the urine out without symptoms at to show. Below favorable circumstances, as in a humid environment, *Leptospira can* spp . can survive in the environment for weeks to months, but leptospires are not very resistant to desiccation (RIVM, 2015).

People to touch infected Through direct and indirect transfer, such as Through contact by mucous membranes or damaged skin with urine from infected animals, including rats, or by water or soil contaminated with rat urine. In addition, inhalation of mists, such as in cleaning rooms and eating contaminated food a risk on infection.

Leptospirosis is notifiable in the Netherlands. Between 2014 and 2023, the number of people diagnosed with leptospirosis varied that leptospirosis in The Netherlands ran up by 20 to 74 fallen per year. In 2023 went It to

74 native cases, of which in 18 cases the suspected infecting serogroup could be determined: Icterohaemorrhagiae (n=13) and Grippotyphosa (n=5). In 24 native patients where no serogroup of certain could be, went it's about *Leptospira interrogans sense stricto* (18 patients) and *Leptospira kirschneri sense stricto* (6 patients). Infections acquired in the Netherlands with *L. interrogans ss* usually point to serogroup Icterohaemorrhagiae (with as reservoir rats) and with *L. kirschneri ss* Unpleasant serogroup Grippotyphosa (of as reservoir mice) (Cuperus et al., 2024).

In The Netherlands forms brown rats next to field mice It most important reservoir for Human *Leptospira* infections (RIVM, 2015). Most cases of leptospirosis acquired in the Netherlands are related to recreational activities, such as swimming, or occupational activities.
Occupational exposure primarily affects farmers. In 2023, 16 patients contracted leptospirosis at work (13% of the total number of confirmed cases), primarily during work involving contact with water/mud or (in)direct contact with mice/rats. The majority of infections in the Netherlands occurred via surface water and/or mud (n=58, 78%), such as during the day swimming and in inferior measure gardening. Five patients walked in 2023 leptospirosis through direct contact with rats and/or their feces (Cuperus et al., 2024).

Two publications are known from Japan about leptospirosis patients who (possibly) contracted the infection in the catering or An grocery store. Koizumi and already (2009) did research Unpleasant The sources of infection of 13 human leptospirosis cases from Tokyo. Seven cases possibly contracted the infection in the retail or hospitality industry. All worked in the hospitality industry, supermarket, or food retail sector (butcher shop, fishmonger). Circumstances leading to this indication of work-related exposure were the frequent sighting of rats in the shop (3 times), or the removal of rat urine and feces in the shop without wearing gloves (2 times), the killing of rats caught in the shop (1 time), or the presence of another person (a customer) in the restaurant who also contracted leptospirosis after a rat bite (1 time). In addition, one of these cases is known to carry *Leptospira.* was demonstrated in a shop-caught rat. In a publication by Suzuki et al. (2022), a case of a serious *Leptospira infection is also described. interrogans* An infection was described in a restaurant worker. The most likely source of exposure was a rat bite the patient sustained while attempting to catch a rat in the restaurant. A possible explanation for the presence of *Leptospira* in the oral cavity by It animal becomes care supplied by the fur of the lower abdomen

Research has been conducted in the Netherlands on the presence of Leptospira in brown rats. An average *Leptospira* prevalence of 40% was observed in brown rats captured in Friesland, Limburg, Amsterdam, and Doetinchem/Nijmegen (combined PCR/culture, kidney material). Per area walked the prevalence apart by respectively 33% (8/24), 33% (14/42) 39% (12/31) to 57% (30/53). The isolates belonged to the serovars Copenhageni and Icterohaemorrhagiae (Maas et al., 2018). In another study conducted in Amsterdam, Rotterdam and Eindhoven, 20% of the brown rats examined (805 animals) were found to have *Leptospira* spp . detected (PCR, kidneys) (de Cock et al., 2023).

Many studies have been published on the occurrence of *Leptospira* spp ., particularly in brown rats and to a lesser extent in black rats and mice. Several studies from Europe (urban, rural areas) show average *Leptospira* prevalences for brown rats ranging from 0% to 49% (primarily PCR or culture on kidney material ; 10 studies), with up to 89% of animals locally testing positive (PCR). For black rats, this ranged from 7% to 25% (2 studies). For mice (2 studies), the observed prevalences were far different: from 1% for *Leptospira* Icterohemorrhagiae (Rome) up to 71% for *Leptospira* spp . in Croatia, but in this country it occurs leptospirosis relatively often for. The numbers are not absolutely Good of each other at compare, because sometimes broad on *Leptospira* spp . was examined and sometimes specifically for certain serovars .
Hereby It Overview by various European studies:

- In brown rats captured in cities in Denmark, Hungary, Austria and Switzerland, a prevalence of 20% (2/10), 0% (0/18), 0% (0/43) and 10% (3/29) was found, respectively (PCR, kidneys). In Germany (4 areas) was this prevalence 17% (55/320), with prevalences varying between 6 and 31% across the areas studied. Molecular methods were used to detect the presence of *Leptospira in a subset of the samples examined. interrogans* serogroup Icterohaemorrhagiae demonstrated (Heuser et al., 2017).

- The *Leptospira* prevalence by brown rats captured in Paris amounted to 31% (PCR, kidneys). All *Leptospira* found belonged to pathogenic species (Richard et al., 2022).
- *Leptospira* spp . were in kidney- and urine bladder samples by 12% in It sewer by Barcelona, Spain, captive brown rats (212 animals) demonstrated (Montalvo et al., 2018).
- Of brown rats captured in Swedish cities (households, shopping centres), 17% (5/30) tested *Leptospira* spp . seropositive. Four by the five positives affected *L. interrogans* serovar Icterohaemorrhagiae (Strand et al., 2015).
- Bee brown rats, captured Germany (Lower Saxony and Hamburg; urban and national In the area, pathogenic *Leptospira* were found in 21% of the rats tested (586 animals). spp . demonstrated (PCR, kidneys) (Runge et al., 2013).
- Bee brown rats captured in France (department (Rhône) became a *Leptospira* prevalence of 26% (45/171) measured (combined PCR/culture, kidneys). The rats came from urban (Lyon) and rural areas (farms) (Ayral et al., 2015).
- Of brown rats, caught in The sewage system at various locations in Copenhagen, Denmark, was found to be 53% (104/196) infected (PCR, kidneys). At one location, no infected rats were found found, while on the other locations prevalences diverged by 48 to 89%. A subset by 17 rats became also serological tested. The highest antibody titers were focused against the serogroups Pomona, Sejroe and Icterohaemorrhagiae (Krøjgaard et al., 2009).
- In areas of Croatia where leptospirosis is more common in humans and animals, 71% (10/14) by the house mice *Leptospira* spp . culture positive (kidneys). All isolates affected *L. borgpetersenii* serovar Istrica (Turk et al., 2003).
- Bee in and to Helsinki, Finland, captured brown rats became an *L. interrogans* - prevalence of 1% (2/163) found (PCR, kidney) (Aivelo et al., 2024).
- By brown rats captured in Swedish towns were 5% (6/90) by the rats *L. interrogans* - tested positive (PCR, kidney and/or heart) (Strand et al., 2019).
- In Rome, 49% (18/37) of the brown rats examined were kidney culture positive for *Leptospira* Icterohaemorrhagiae . By the researched black rats and mice were 8% (1/12) and respectively 1% (1/91) positive in kidney culture . *L* . Ballum could be demonstrated by kidney culture in 24% (22/97) of the house mice and 25% (3/12) of the black rats. *L.* Ballum was not detected in brown rats (Amaddeo et al., 1996).

Per area can the prevalence in animals out various sub-areas (strong) vary, also within a single city, as shown in the Copenhagen study (0-89%) (Krøjgaard et al., 2009) . This is supported by a study conducted in the inner-city area of Vancouver, Canada. The average *L. interrogans* prevalence in brown rats was 11% (66/592) (PCR, kidney), but this varied between sampled blocks from 0 to 67%. This shows that the exposure risk can be very heterogeneously distributed across urban areas and therefore does not necessarily depend on the number of rats within a given area (Himsworth et al., 2013).

4.1.10 Listeria monocytogenes

Listeria monocytogenes is a pathogenic bacterium that is widespread in the environment and in various farm animals and other animals, including rodents (RIVM, 2016b). Rodents become as carrier by the germ considered, not as reservoir (Meerburg and al., 2009). The main route of transmission for human infections is through contaminated food. This primarily involves refrigerated prepared foods in which *L. monocytogenes* has been able to grow.

In general, a *Listeria* infection in individuals with an uncompromised immune system is asymptomatic or mild with flu-like symptoms. In people with an immune disorder, the infection often has a more severe and invasive course. An invasive *Listeria* infection is becoming generally characterized Through An bacteremia of meningitis or meningoencephalitis . If pregnant women become infected, it can lead to intrauterine fetal death and premature birth, especially in the second half of pregnancy. The mortality rate in the Netherlands varies between years and was 5% in 2011 and 31% in 2006 (RIVM, 2016b).

After infection, animals can shed *L. monocytogenes* in low quantities for long periods of time. Infection tests with rats show that *L. monocytogenes* is present in high concentrations immediately after infection of a rat. doses is becoming excreted in the feces. Noted serves at become that the animals also of high numbers *L. monocytogenes* were infected. The excretion takes then inside 1- 1.5 weeks off again (Nichtherlein et al., 1994; Sprong et al., 2000).

It is known that *L. monocytogenes* can survive for a long time in stable buildings and on materials and can thus form a source of contamination (for example for food), because the bacteria form biofilms be able to forms or more than 2 year in dry ground or feces be able to to survive. The chance The likelihood of animals—and humans—becoming infected through direct exposure to feces or fecal dust seems low (RIVM, 2016a). This is because normally somewhat higher numbers of *L. monocytogenes cells* are needed for infection, and growth in a matrix is first required.

There are no facts about It prevent from *L. monocytogenes* bee mice or rats in the Netherlands.

Worldwide are but few studies published about It to encounter from *L. monocytogenes* in rodents in urban area. Observed prevalences layers between the 0-59% for rats (brown, black). Data about mice are not found. Below An Overview by this studies:

- In Baghdad, Iraq, was the *L. monocytogenes* prevalence (breeding) in the intestinal contents by black rats 5% (6/120) (Ayyal et al., 2019).
- In Tokyo, Japan, became bee black rats an *L. monocytogenes* prevalence by 11% (6/53) observed in intestinal contents (Inoue et al., 1991).
- A total of 245 rats were collected in six cities in the Kanto region of Japan. Of the brown rats, 26% (33/126) tested positive for *Listeria* , and of the black rats, 23% (27/119). Infection rates between cities ranged from 0-78%. The prevalence of *L. monocytogenes* varied by 0-11% The frequent insulation by *L. monocytogenes* suggests, according to the authors, that rats can act as a reservoir and ensure continuous contamination of the (indoor) environment (Inoue et al., 1992).
- The only data from Europe concerns a study of sewers in Barcelona, Spain, brown rats. Bee 59% by the researched animals (n=212) became *L. monocytogenes* detected in intestinal contents (no information on method) (Montalvo et al., 2018).

4.1.11 Lymphocytic choriomeningitis virus (LCMV)
Lymphocytic choriomeningitis is An zoonotic condition causes Through Lymphocytic choriomeningitis virus (LCMV). LCMV is an RNA virus from the arenavirus family, primarily found in house mice. Persistently infected mice shed LCMV for life.

People become infected by inhalation, ingestion or direct contact with virus-containing urine or feces or saliva by mice. Intrauterine infections be able to to lead to fetal death, chorioretinitis (inflammation of the eye), hydrocephalus, under- or over-sized head, and intellectual disabilities. Acquired infections lead to central nervous system symptoms in approximately half of cases, primarily due to meningitis or meningoencephalitis . Mortality is rare (RIVM, 2023; CDC, 2025). LCMV does not pose a significant risk to the general population. Despite the fact that LCMV can be frequently found in mice and transmission to humans occurs (studies to leave to see that 1-5% by An population seropositive can are), become acute infections in humans rarely reported (Childs et al., 2019).

Cases of lymphocytic choriomeningitis occur occasionally in the Netherlands. In 2014, a Dutch case was described (Barton & Hyndman , 2000; Barton et al., 2002; Childs et al., 2019; RIVM, 2023). Mouse related big outbreaks to come not for and LCMV forms only An low risk for the general population. Various serological tests show a prevalence of 1 to 5% of the individuals examined. It is unclear how many of these individuals experienced acute illness. The seroprevalence would likely be higher in populations with a low socioeconomic status. status on locations with serious mouse nuisance and a lot of LCMV Infected mice. Many early studies investigating the link between house mice and LCM cited severe mouse nuisance (Childs et al., 2019).

An American patient with LCMV infection likely contracted the infection as a result of months of mice infestation in her home. Of the mice caught in her home, 95% (22/23) were found to have LCMV (Foster et al., 2006). In another American patient patient of An LCMV infection, were also mice, found in It house by The patient was identified as the source of the infection. LCMV was detected in mouse droppings collected from the house (Talley et al., 2016).

There are no facts about It prevent by LCMV bee mice or rats in The Netherlands.

In studies conducted in cities in Europe and other countries, LCMV prevalences ranging from 0-47% have been reported in house mice. This partly concerns seroprevalences , so it is not clear is how many animals active infected are. Also rats be able to infected to touch of LCMV (serologically positive). Below is an overview of the studies consulted:

- Bee brown rats captured in and to Helsinki, Finland, An became An LCMV antibody prevalence of 3% (6/211) found (Aivelo et al., 2024).
- Reported LCMV prevalences bee house mice to walk apart by 0 to 25% (various studies in the US and Europe). However, the prevalence is variable and irregular at local and regional levels. dish. Like this were for example in some houses by a residential block in Baltimore, USA, seroprevalences of up to 100% were measured, while a few houses away no or very few seropositive mice were found (Childs et al., 2019).
- Bee house mice, that during multiple years on various places in the Argentinian city of Rio Cuarto, an LCMV seroprevalence of 13% (76/588) was found (Riera et al., 2005).
- By house mice captured on It peninsula Istria, Croatia (19 animals), tested 47% serologically positive for LCMV (Duh et al., 2017).

4.1.12 Rats hepatitis E virus (RHEV)

Rat hepatitis E virus (RHEV), also known as *Rocahepevirus ratti* is an emerging zoonotic virus out the hepatitis E virus family (*Hepeviridae*) of mainly rats (*Rattus* spp .) as reservoir. The virus is genetically very different from the hepatitis E viruses commonly associated with human infections (*Paslahepevirus* genotypes 1 through 4 *balayani ,* formerly known *as Orthohepevirus* A). Since the first discovery of RHEV in brown rats in Germany in 2010, the virus has been detected in several countries in Asia, Europe, and North America. Rats shed RHEV in feces and urine, which can lead to environmental contamination.

The route of transmission to humans is unknown, but possible risk factors include exposure to surfaces contaminated with rat feces, direct contact with infected animals or the consumption by contaminated foodstuffs or water named. The recent finding of RHEV in Spanish finishing pigs (11% (44/387) of animals infected) implicates pork as a possible source of infection for humans (Rios-Muñoz et al., 2024).

RHEV infections can cause mild to moderate acute liver inflammation in humans. A chronic course is possible in immunocompromised individuals. As of 2023, 21 human RHEV infections have been described in Hong Kong (16 cases), Spain (3), Africa (1), and France. (1). It number in the literature described infections bee animals, mainly rodents, was 489 in 2023, most of which were in Asia (60%), followed by Europe (26%), including 2 in the Netherlands (Reuter et al., 2020; Benavent et al., 2023; Rios-Muñoz et al., 2024).

In The Netherlands did the Cock and already (2023) research Unpleasant pathogen prevalences bee brown rats in three cities. A RHEV prevalence of 4% (15/403) was found (PCR, liver).

In other European countries (urban, rural), RHEV was found in 2-15% of those tested (brown) rats and no by the researched mice. Below An Overview by these studies:

- In An study executed in and to Helsinki, Finland, pale 2% (4/216) by the captured brown rats RHEV positive (PCR, liver) (Aivelo et al., 2024).
- By brown rats originating out An number German towns and out Budapest, Hungary, was 10% (5/51) were RHEV-positive (PCR, gut contents). In three animals, RHEV RNA was also detected in gut tissue (Niendorf et al., 2021).
- Of rats captured in two German zoos, 11% (8/73) were positive for HEV RNA in liver tissue, of which 7 (10% by It total number animals) positive for RHEV (Spahr and al., 2017).
- In 12 European to land, under which in neighboring countries by The Netherlands but not in The Netherlands Brown and black rats from various locations, from rural to urban, were tested for RHEV. In 11/12 countries, RHEV was detected in the animals tested. The combined prevalence for all countries was 12% (63/508). In the

majority by the sampled locations were positive animals found (Ryll and al., 2017).
- In It UK was 13% (8/61) by the brown rats (mainly originating by pig farms) RHEV-positive (PCR, liver) (Murphy et al., 2019b).
- In France (department (Rhône) became RHEV RNA bee 14% (20/142) by the captured Brown rats were detected in liver tissue and feces. The rats in this French study came from urban (Lyon) and rural (farm) areas (Ayral et al., 2015).
- Of brown rats collected in Lyon, France, 15% (12/81) were positive for RHEV (PCR, liver). Bee 11 by this animals became RHEV (PCR) also in droppings demonstrated (Widén and al., 2014).
- In no (0%) by the researched house mice (97 animals), captured in It UK, became RHEV demonstrated (Murphy et al., 2019b).

4.1.13 Salmonella

Salmonella is a genus of bacteria in the family *Enterobacteriaceae* . By far the most for humans Pathogenic *Salmonella* serotypes belong to serotypes of species *enterica* subs. *enterica* , of which there roomy 2,500 are. At animal reservoirs adapted *Salmonella* become also as non- typhoidal *Salmonella* is indicated because it mainly causes gastrointestinal inflammation (gastroenteritis) cause. That in in contrast to On the man adapted so-called typhoidal serotypes (*S.* Typhi and *S.* Paratyphi) (only humans are the reservoir), which usually cause a typhoidal disease picture (generalized infection with bacteremia) (RIVM, 2024a).

Gastroenteric infections with *Salmonella* are usually mild and self-limiting, but *Salmonella* can also invasive infections cause which usually An serious course to have. People become infected through contaminated food, water, or contact with infected animals. Most cases of non- typhoidal *Salmonella* infections in humans are foodborne, with the figure for the Netherlands being around 85%. Ingesting even a small amount of Salmonella bacteria can lead to illness (US FDA, 2012; RIVM, 2024a).

Non- typhoidal *Salmonella* are found in farm animals and other animal species such as rodents and reptiles. It interest by rodents as source by Human *Salmonella* infections are unknown, but this is less than other animal sources. Rodents are therefore not considered a reservoir of *Salmonella* , but rather an incidental carrier (Meerburg et al., 2009; RIVM, 2024a).

Laboratory studies in rats suggest that *Salmonella* infections in these animals are transient and short-lived without repeated exposure (Himsworth et al., 2015b). Captured wild black rats *Salmonella* were found intermittent out at to divorce, of An maximum observed interval of 24 weeks (Umali et al., 2012). Mice also shed *Salmonella* intermittently in their feces. During active shedding, a single mouse dropping can contain up to 230,000 *Salmonella* cells (Trampel et al., 2014). The bacterial load in individual droppings of wild house mice is typically low, 1 to 10 cells, but this can reach numbers of 103 · up to 10^{4} cells in some individual droppings (Davies & Wray , 1995).

In a study of pathogen prevalence in brown rats captured in three Dutch cities, research done Unpleasant *Salmonella* . The found *Salmonella* culture prevalence in feces was 1% (2/367) (de Cock et al., 2023).

In other to research executed in Europe (urban area) varied the *Salmonella* prevalence in rats by 0-10% (6 studies). Bee mice became An prevalence by 3% reported (1 study, North America). The generally low prevalence of *Salmonella* in Europe suggests that rats are not an important source of infection in this region. source of human infections are (the Cock et al., 2023). Below is an overview of the foreign studies:

- No by the brown rats (40 animals; 0%) captured in London, UK, pale *Salmonella* bee to carry (feces) (Battersby et al., 2002)
- By brown rats captured in Germany (Lower Saxony, Hamburg; urban and national area) turned out 4% (21/586) culture positive (liver, intestine). It went hereby under other at *S* . Enteritidis (11) and *S* . Typhimurium (5) (Runge and al., 2013).
- By brown rats (25 animals) captured in the harbor by Piraeus, Greece, was An rat (4% positive for *Salmonella* (culture, intestinal mucosa) *.* This concerned *S. arizonae* , a type that is very rare in humans (Burriel et al., 2008).

- Bee brown rats out Barcelona, Spain, (212 animals, out It sewer) was bee 7% *Salmonella* spp . detected (intestinal contents) (Montalvo et al., 2018).
- Of brown and black rats and house mice (625 animals) captured in Cyprus (residential areas, landfills, slaughterhouses) pale 9% *Salmonella* positive (breed, intestinal contents), under which also *S.* Enteritidis (Antoniou et al., 2010).
- Research on brown rats and rat droppings (100 pieces) originating out Birmingham, UK, *Salmonella* was found in 10% (5/50) of the animals (culture, rectal swabs). No *Salmonella was* found on the body (legs, abdomen, tail; 25 animals) . 8% (8/100) of the droppings were tested. *Salmonella* -positive. This concerned all droppings that yet damp were. In dry No *Salmonella was* detected in the droppings (Hilton et al., 2002).
- By house mice out New York, US, pale 3% (13/416) *Salmonella* positive (PCR, anal swabs) (Williams et al., 2018).

There are An number salmonellosis outbreaks described whereby rodents the source Although all these cases involve rodents as (food for) pets, these cases of illness show that contact with rodents (dead, alive) to Infection with a pathogen such as *Salmonella* can lead to:

- Frozen feeder rodents (feed for under other reptiles) - 41 sick (*S.* Typhimurium ; USA; 2014) (CDC, 2014),
- Living hamsters - 28 sick (*S* . Typhimurium ; US; 2004) (Smith and al., 2005)
- Frozen rodents An outbreak of 34 sick (*Salmonella* serotype I 4,[5],12:i:-; US; 2010) (CDC, 2010)
- Frozen feeder mice – 850 sick (*Salmonella* spp .; UK; 2015-2021) (FSA, 2021)
- Feeder rodents – 134 sick (*S* . Typhimurium ; Canada (2012-2014) (Vrbova and al., 2018)

4.1.14 Seoul virus (SEOV)

SEOV is An RNA virus out It genus Hantavirus . Brown and black rats are It reservoir by This virus. These animals become persistently infected after exposure and excrete the virus in feces, urine, and saliva. The virus remains infectious for approximately two weeks after excretion (RIVM, 2017a).

SEOV is transmitted to humans by inhalation from aerosols of urine and feces of infected rodents. Aerosols can be generated, for example, during cleaning activities where rodent droppings are swept up. Other routes of infection are (possibly) through hand contact with feces, urine, and saliva of infected rats—or indirectly via contaminated surfaces—and subsequent eye contact. nose or mouth. Or via An Open wound on the skin or Through It to eat by food that is infected is with urine (or feces) of infected rats (RIVM, 2017b; CDC).

Human infections are often asymptomatic or mild. In rare cases, patients develop a hemorrhagic fever of renal syndrome (hemorrhagic fever with renal syndrome (HFRS)) characterized by transient renal failure and conjunctival and punctal hemorrhages on the hull and It palate. It mortality rate by HFRS in America is 1-2%. The virus that occurs in the Netherlands appears to be milder (RIVM, 2017a). SEOV is one of several hantaviruses that can cause HFRS and is thought to be responsible for approximately 20% of cases. Although SEOV is likely worldwide, cases are primarily seen in Asian countries. In the Netherlands, hantavirus infections are notifiable . Infections with SEOV are not common (RIVM, 2017b).

In Asia, SEOV is responsible for approximately 25% of human hantavirus infections. Outside of Asia, transmission of SEOV to humans from wild rats is rare, even in deprived neighborhoods where people are frequently exposed to rats and SEOV prevalence is high among adult animals. be high (Heyman et al., 2009; Childs et al., 2019). In in line with this there are up to now to no human SEOV clusters in Europe reported (Hofmann and al., 2024). Well Several single cases have been reported, including one case in Germany (pet rat) (Hofmann et al., 2024) and three patients from France. One of the French patients likely contracted the infection during construction work, so probably from a wild rodent, the other two from pet rats (Reynes et al., 2017). In the Netherlands, human hantavirus infections have been reported. reporting obligation since 2008 and Maas and already (2018) report that there to than to no infections known are that were causes Through wild rats. Well is there An case known Through contact of feeder rats (Swanink and al., 2018) and since then are a few people sick become by this virus in the Netherlands (domestic rat, feeder rats) (RIVM, 2017a).

Maas et al. (2018) investigated the presence of SEOV in 150 brown rats originating from four Dutch areas (urban, rural). SEOV was not found (0% confirmed as positive). In a study of the pathogen prevalence in brown rats in three Dutch towns became also became no SEOV found (402 animals investigated, 0% positive) (de Cock et al., 2023). However, another study conducted in the Netherlands found that 3 of 16 brown rats tested serologically SEOV-positive (20% positive). The presence of hantavirus RNA in these animals was confirmed by PCR (Verner-Carlsson et al., 2015). In the study by Maas et al. (2018) were under other rats out the same area captured as in the study from Verner - Carlsson et al. (2015).

Research from Europe (city, countryside) show SEOV seroprevalences at brown rats see from 5-27% (2 studies) and PCR detection by It virus bee 14-19% by the animals (2 studies). In North-America lay that between the 1-51% (seroprevalence ; 2 studies) and 0-86% for PCR positive animals (3 studies). And in Southeast Asia, between 5-38% for seroprevalence (2 studies) and 13% for PCR-positive animals (1 study). Here is an overview of the literature consulted:

- In brown rats collected in an area around Helsinki, Finland, a hantavirus seroprevalence of 5% (11/211) demonstrated (It of brown rats associated hantavirus is SEOV) (Aivelo et al., 2024).
- By brown rats captured in Belgium (2004-2006; 476 animals) was 27% seropositive for SEOV antibodies (Heyman et al., 2009).
- By brown rats captured France (Rhône; urban and national area (farms) was 14% (18/127) SEOV-positive (PCR, lung tissue) (Ayral et al., 2015).
- By brown rats captured in Northern England (various locations, nearby houses - (often including pig farms) SEOV was detected in 19% of the animals examined (68 animals) (PCR, kidney and lung tissue) (Murphy et al., 2019a).
- SEOV became bee 6% (8/133) by brown rats captured in New York, US, found (PCR, eg in kidney, salivary gland or oral cavity, not in feces or urine) (Firth et al., 2014).
- Bee brown rats captured in Baltimore, US, were SEOV seroprevalences found by 51% (80/158). PCR virus prevalence was 86% (55/64) in kidney tissue and 51% (35/68) in lung tissue (Klein et al., 2002).
- Bee brown and black rats captured in inner-city area in Vancouver, Canada, became An SEOV seroprevalence of 1% (8/553) was found. The animals were PCR-negative for SEOV (lung tissue) (Himsworth et al., 2015a).
- In Singapore became bee in diverse habitats captured brown (n=990) and black rats (n=136) found SEOV seroprevalence of 38% and 21%, respectively (Griffiths et al., 2022).
- In the Vietnamese towns Hanoi and Hi Phong captured brown rats were SEOV seroprevalences of 5% (3/60) and 32% (11/34) were found (Koma et al., 2013).
- In the Chinese city Shenzen was 13% by the rats (209 animals) hantavirus -positive. The sequences found were highly similar to SEOV (Wang et al., 2017).

4.1.15 Streptobacillus moniliformis

Streptobacillus moniliformis is one of the causative agents of rat bite fever (rat bite fever , RBF). The other causative agent of this condition is *Spirillum minus* , the two bacteria are unrelated. *St. moniliformis* Of these two bacteria, the majority of RBF cases are caused by Sp. minus and have a global distribution. Infections with *Sp . minus* are rarer and are primarily reported in Asia. This pathogen is not/less relevant to the situation in the Netherlands. relevant and is becoming here not further discussed. General is becoming accepted that brown and black rats natural host (reservoir) and symptomless carrier from *St. moniliformis* are (Gaastra et al., 2009).

RBF due to *St. moniliformis* infection is transmitted by bites or scratches from rats. Disease is becoming under other characterized Through initially fever and rash and later bee 50 Up to 70% of patients are affected by joint inflammation. The mortality rate for untreated RBF is between 7 and 13%. Even with treatment, recovery can take weeks (Gaastra et al., 2009).

It is not known how often rat-bite fever prevents in The Netherlands, but It seems An rare infection (RIVM, 2023; Uiterwijk et al., 2027).

A different form of expression from *St. moniliformis* infection is Haverhill fever. This clinical picture is The result of oral exposure to the bacteria via water or food contaminated with rat feces. Symptoms include vomiting, possibly followed by a rash and joint inflammation. Although It number RBF fallen increases, is It yet still An A relatively rarely reported disease. Three outbreaks of Haverhill fever have been reported so far (Gaastra et al., 2009).

In a study conducted in the Netherlands (urban area), antibodies against *St. moniliformis were found* demonstrated bee 33% by the researched brown rats (402 animals), whereby 2% by the animals were also PCR positive (de Cock et al., 2023).

Few studies have been published on the occurrence of *St. moniliformis* in rats in urban areas area. Worldwide become prevalences reported that vary by 2-16% for *St. moniliformis* . Below is a list of consulted publications:

- In Baghdad, Iraq, was the *Streptobacillus* - prevalence (breeding) in the throat by black rats 2% (2/120) (Ayyal et al., 2019).
- *St. moniliformis* was detected (PCR) in the salivary glands of 16% of patients examined in New York, USA brown rats (133 animals). Bee 1 animal became *St. moniliformis* also in feces demonstrated (PCR) (Firth et al., 2014).

4.1.16 Yersinia spp .

Yersinia is a genus of bacteria in the family Enterobacteriaceae . There are three zoonotic *Yersinia* species that can make people sick, namely *Y. pestis* , *Y. pseudotuberculosis* and *Y. enterocolitica* . *Y. pestis* is the causative agent of the plague, which is primarily transmitted by (rat) fleas, but contact with infected animals or their products can also lead to infection. The plague has been present in the Netherlands – and other European countries – for a long time. not for (RIVM, 2022) and is therefore not included in this risk assessment. *Y. pseudotuberculosis* and *Y. enterocolitica* are the causative agents of gastrointestinal infections. Although the disease is often self-limiting, serious illnesses, such as inflammation of the intestinal lymph nodes or sepsis, are not uncommon. The vast majority of zoonotic *Yersinia* Human cases of illness result from foodborne *Y. enterocolitica* infection. Not all *Y. enterocolitica* tribes are sickening. The most important sickening tribes (pathotypes) are 1B, 2, 3, 4, and 5. The majority of human infections are caused by pathotypes 3 and 4. The main reservoir of strains that cause disease in humans is pigs.
In addition become also rodents as reservoir named (Drummond and al., 2012; Seabaugh & Anderson, 2024; UMC, 2024).

The chance of ingesting a small number of *Y. enterocolitica germs* will lead to illness is less big than bee pathogens as *Salmonella* and *Campylobacter* spp . It number cells that is necessary to have a real chance of causing disease in the human population is estimated at 10,000–100,000 (US FDA, 2012).

There are no data about It prevent by *Yersinia* spp . bee rats or mice in The Netherlands.

Out An limited number studies out Europe (urban and national area) turns out that *Yersinia* spp . Can be found in brown rats in varying degrees of prevalence from 1-18%. In Canada, a prevalence of 23% was observed in brown rats. No data were found for mice.
Below An Overview by the consulted studies:

- By brown rats captured in Germany (Lower Saxony, Hamburg; urban and national area) 1% (6/585) were culture positive for *Yersinia* spp . (liver, intestine). The isolates were *Y. enterocolitica* (3x), *Y. kristensenii* (2x) and *Y. pseudotuberculosis* (1x) (Runge et al., 2013).
- Bee brown rats captured in London, UK (40 animals), pale 3% *Y. enterocolitica* bee himself to carry (feces) (Battersby et al., 2002).
- Bee 18% by in It sewer by Barcelona, Spain, captured brown rats (212 animals) became in intestinal contents *Y. enterocolitica* demonstrated (Montalvo et al., 2018).
- In An study by Firth and already (2014) was bee 1% by the researched brown rats captured in New York, USA (133 animals), *Y. enterocolitica* found (PCR, droppings).

- PCR testing found that 23% (5/22) of prisoners in downtown Vancouver, Canada, brown rats *Y. enterocolitica* in intestinal contents for at come (Lee and al., 2023).

4.2 Rodents

In an environment where food is produced or traded, food is constantly available for mice and rats. Without measures to combat the presence of these pests, shall An rodent infestation that's why to persist. It number animals and the The amount of feces and urine deposited will therefore increase rapidly, and with it the risk of spreading pathogens to the environment.

Out facts by the NVWA turns out that with some regularity pest nuisance is becoming observed at food businesses such as bakeries, supermarkets, and the hospitality industry. The figures show an upward trend – excluding the COVID-19 years (2020-2021). In 2019, an average of 12% of inspected locations were found to have mice infestations, and in 2024, this figure rose to 17%. For rat infestations, this figure increased from 0.4% to 1.2%. In some cases, the nuisance is so severe that businesses are temporarily closed. Emergency closures are implemented when food safety is at risk, i.e., when there is a direct (risk of) consumer contamination. This concerns extremely contaminated business premises (including kitchens and cold storage units) and extreme pest nuisance, such as the discovery of pest traces on workbenches, tableware, in food, or gnawed products in the store (pers. comm . NVWA Enforcement). In 2023, there were 34 emergency closures (mostly due to presence of a mouse or rat plague) and in 2024 for 74 emergency closures (55 of which based on by a mouse- or rat plague). In 2025 went It in the period to and of September at 60 emergency closures, 45 of which were related to nuisance caused by mice or rats (NVWA, 2024;2025)(pers. comm . NVWA Enforcement).

The infection pressure in An company is related On It number rodents that present is, the the extent to which pathogens occur in these animals (see 4.1), the extent to which pathogens are excreted in feces and urine and finally how long these pathogens remain infectious in the environment.

4.2.1 It number rodents per location

It is difficult to determine the number of pests (rat, mouse) at a location. Hamidi (2018) does this based on by literature research for this An number estimates. This authors give On that as If there are traces of rodents, but no rodents themselves are observed, a population of between 1 and 100 animals on a farm should be considered. These authors also state that for every observed rodent, 20 to 50 unobserved animals should be taken into account.

4.2.2 Excretion by manure, urine and pathogens Through rats and mice

Most pathogens found in rats and mice and relevant to this risk assessment are excreted in feces or urine. The extent and manner in which these excreta are excreted by rats and mice in a food environment are deposited, therefore, provides an indication of the possible contamination of this environment with pathogens originating from these animals. The amount of pathogens in the excreta also and the measure in which this infectious present to stay, wear bee On the extent to which transmission of pathogens from rodents to humans can occur.

4.2.2.1 Manure

Aulicky and already (2015) investigated the distribution by mouse droppings (9 animals, 4 to dawn) in A simulated food storage area of just over 4 m² showed that the droppings were partly deposited where water and food were available (7%) or in the shelter (16%). However, the majority (almost 77%) ended up in the remaining space. Unlike mice, rats deposit droppings in latrines in corners, along walls, or near shelters (Frankova et al., 2015). Laboratory rats (a breeding version of brown rats) kept in a cage with three equally sized compartments (food & water – play & live – empty) deposited most of their droppings (approximately three-quarters) in the empty compartment (Soetan et al., 2014). Research from the Czech Republic also shows that The difference can be in the amount of rat droppings that are placed in different places in a company (grain silos).

Table 2 Overview by average daily droppings productions per type rodent.

Rodent species	Number of droppings/animal/day average (range)	Reference
House mouse	72 (24- 116)	*
	102 (48- 156)	(Aulicky and al., 2015)
Brown rat	37 (16- 55)	*
Brown rat (lab rat)	43 (28- 59)	(Sutan and al., 2014)
	66 (25- 117)	(Frankova and al., 2015)
Black rat	52 (31- 81)	(Frankova and al., 2019)
	59 (31- 126)	*
	108 (76- 155)	*

* out Aulicky and already (2015)

found. Like this pale out It study of the deposition by feces by black rats that produced an average of 7 droppings/m ^{2} over a three-week period on grain surfaces and 35 droppings/m ^{2} were deposited on conveyor belts (Stejskal & Aulický , 2014).

The quantity droppings that per animal per day is becoming produced differs per animal species. In Table Figure 2 provides an overview of the observed daily droppings production of mice and rats in various studies. The highest reported average daily production for a house mouse is 102 droppings/animal/day, for a brown rat 66 droppings/animal/day, and for a black rat 108 droppings/animal/day.

4.2.2.2 Urine

To It normal behavior by house mice belongs It mark by their living environment of Urine. Urine accumulates in certain places (urine posts). However, mice are incontinent, and urine therefore occurs throughout their habitat. Male mice have been reported to have 100 to 200 marks per hour, and female mice 25 to 95 per hour. The daily urine production ranges from 2.7 to 4.4 percent. and 10.5-12 milliliter for female and respectively male animals reported (Drickamer , 1995).

In an experimental setting, laboratory rats urinated approximately every eight minutes during the day. discharge during the day produced quantity urine was something more than 1.5 ml. 's At night, When the animals were more active, the interval between voids was just under 4 minutes. 0.65 ml of urine was produced each time (Herrera & Meredith , 2010). A 12/12 hour day/night rhythm was used in this experiment. Based on this, a daily urine output of just under 300 ml per animal can be calculated.

4.2.2.3 Pathogens in excreta products by rats and mice

There are An number studies published in which watched is Unpleasant the measure in which Pathogens (*Salmonella* , *Leptospira*) are excreted by rats and mice.

Of *Salmonella* infected brown rats be able to the germ after infection during 2 to 4 months. In addition, the germ from artificially contaminated rat droppings that have been exposed to drying can be excreted for up to 86 days after inoculation are regrown (Hilton et al., 2002). In black rats a maximum *Salmonella* load of 1×10^{8} was observed Colony Forming Units (CFU) per dropping determined (Umali et al., 2012). The highest reported number of droppings produced on average per day by black rats is 108 droppings (Table 2). In a worst-case scenario where all droppings deposited by a black rat per day would contain the maximum number of *Salmonella* cells, a single animal could theoretically infect the environment with 1×10^{10} cfu *Salmonella* contamination. *Salmonella* Enteritidis is known to spread for at least 10 months in populations by house mice can to enforce. Mice, but also rats, to divorce this

Salmonella is excreted intermittently in the feces. During active excretion, a single mouse dropping can to 230,000 *Salmonella* cells contain. Bee An daily quantity by more More than 100 droppings per mouse means that a single animal can theoretically spread at least 23 million *Salmonella* cells per day into the environment, which can survive in droppings for up to 148 days (Trampel et al., 2014).

Mice secrete - according to calculations by Barragan et al. (2017) based on literature data - an average of $3.1x10^{3}$ *Leptospira* cells per ml of urine, with a range (min-max) of $4.7x10^{2}$ -$1.8x10^{6}$ cfu /ml. For brown rats, this averages $5.7x10^{6}$ *Leptospira* cells per ml of urine, with a range (min-max) of 5-$8x10^{8}$ cfu /ml. This means that on average per mouse (approximately 10 ml urine/day) more than 10 thousand or respectively per rat (approximately 300 ml urine/day) 1 billion *Leptospira* cells in the environment This is in the range of what Barragan et al. (2017) calculated based on their literature data, with a daily excretion amount of $2.9x10^{4}$ -$1.1x10^{8}$ *Leptospira* cells for mice and for a rat from $6.1x10^{1}$ -$9.8x10^{9}$ *Leptospira* cells/day. There on top the fact that *Leptospira* cells can remain viable for weeks under favourable (humid) conditions means that with prolonged presence of pests at a location, the amount of *Leptospira* cells in the environment could increase considerably.

Rodents can carry multiple pathogens (not all of which are relevant for this risk assessment, see for example Firth et al. (2014); Williams et al. (2018); Galán-Puchades et al. (2021); de Cock et al. (2023); Lee et al. (2023); Aivelo et al. (2024). Brown rats from rural areas tend to carry a greater diversity of pathogens. pathogens bee himself wear than animals originating out urban area, while for black In rats, the opposite is true (Battersby et al., 2002).

4.3 Transfer by rodent-related pathogens in food companies

4.3.1 Distribution feces in An business location

The NVWA regularly encounters (12-17% of the inspections carried out at catering establishments, supermarkets and artisanal producers) feces (manure, urine) by mice and rats at locations where food is produced and traded. Feces and urine stains can be found throughout the entire premises. However, they are often observed in the area Where food is becoming prepared and than of name under or behind kitchen furniture (workbenches, gas stoves, shelf trolleys), but also on top of refrigerators, electrical outlets, electrical conduits or cords, and between consumer items such as pans and kitchen utensils.

A

B

Figure 1 Photos taken in a commercial kitchen. A) An open container of boiled potatoes is cooling on a workbench under a ceiling-mounted electrical outlet. B) On the electrical outlet. lie mouse droppings. This applies also for the PVC pipes Unpleasant This outlet strip (not pictured) is covered in grease (mice). Mice can therefore access the workbench via the cord and contaminate it. Photo source: NVWA

This concerns surfaces that are not easily accessible or not inspected daily. These surfaces are usually not part of daily cleaning procedures (NVWA inspector's personal communication). Finding feces on these harder-to-clean surfaces means however that on the surfaces that beautiful corpses - because this well become daily cleaned and cleaned - also feces justifiably can be arrived. After all, If a location/area has been cleaned and sanitized after a production day , mice and rats will still be able to walk across these surfaces after closing time (when people are away), leaving their urine trails or droppings. This is also evident from inspections by the NVWA, where feces and urine are also found. are found in the view of easy accessible places (pers. comm . inspector NVWA) (Figure 1 , Figure 2 B and C).

Shelves above a workbench or parts of the ceiling (electrical conduits, electrical outlets) and suspended ceilings can also be a source of contamination for food (ingredients, prepared food) or surfaces below (Figure 1). Suspended ceilings are ideal places for mice and rats to himself at hide and Where feces himself can accumulate. The droppings can fall into the room through damaged or poorly installed ceiling panels. Feces and urine can also from ledges under workbenches, stoves or trolleys end up on/in utensils (cutting boards, tools, cutlery, foil, bowls, dishes, etc.) that are used for the preparation or storage of food (pers. comm . inspector NVWA) (Figure 2 A).

Mouse and rat droppings are also frequently found on (closed) food packaging (Figure 2 B). Traces of urine are more difficult to detect, but will also end up on these packages. There is a high probability that such droppings will end up in the food itself or on a surface when opening or handling these packages. justifiably to come that directly of food in contact comes, such as workbenches and Cutting boards used for food preparation. The hands of food preparers can also become contaminated, potentially contaminating food (or the employee themselves).

Another possibility – which could not be substantiated with data from the literature – is that rats and mice carry pathogens from an unhygienic environment via their fur or paws. (sewer, garbage cans) Unpleasant An environment Where of foodstuffs is becoming No information was found on this topic – transmission via fur or paws – but it seems a plausible route by which rats and mice could contaminate their environment.

4.3.2 Distribution pathogens Unpleasant foodstuffs or the man

There seems but An limited number studies at are published that specifically enter on the Transmission of pathogens from rats and mice to food or in the vicinity of a food business. Ribas et al. (2016) made the same observation.

A B C

Figure 2 Photos taken on various business locations. A) Mouse droppings and urine at the bottom of a workbench Where a cutting board lies tidy, B) Mouse droppings and urine on A container containing packages of black cumin, C) Mucus (mice) on a power strip, and cords above a bread shelf. There are urine stains on the shelf. Source photos: NVWA

A case-control study in the US investigated the relationship between the results of routine hygiene inspections and the occurrence of food-related outbreaks in restaurants. This study found that several inspection deviations correlated with an increased risk of outbreaks in the restaurant in question. One of these was the presence of insects or rodents, which was associated with a six-and-a-half times higher chance of an outbreak (Irwin et al., 1989). However, it is unclear how much insects and/or rodents contributed to this risk factor. Furthermore, the pathogen in most outbreaks is unknown, and thus whether there could be a logical connection with the presence of insects and/or rodents. are. Possible is presence by insects and/or rodents a *confounder* , namely that in restaurants with insect/pest infestations, the general hygiene status is poorer and thus the risk of outbreaks is greater, without the insects/pests themselves being the cause of the outbreaks.

In An study on It island Reunion became bee grocery sales points An Risk factor analysis performed on the contamination of pork and chicken sausages with *Salmonella* and *Listeria* . *Salmonella* contamination was positively associated with the absence of rodent-repellent measures and *Listeria* contamination was positively associated with the presence of fresh rodent droppings (Trimoulinard and al., 2017). On Reunion are pests (rats, Mice) are a big problem among other because of the tropical climate and the relatively open construction of buildings.

A cross- sectional study of 151 street vendors of prepared foods in two Kenyan cities found that foods offered in a rodent-infested area had a six-fold higher risk of microbial contamination compared to foods sold in rodent-free areas (Muendo et al., 2022). A similar study of 149 street vendors in Nairobi, Kenya, yielded similar results. Vendors who reported the presence of rodents or other pests were at a higher risk on the presence by microbial contaminated foodstuffs in It stall six times increased compared to vendors who reported not having any pest problems (Kariuki et al., 2017).

Noted serves at become that - just already bee the study out the US – also in the studies on Reunion and In Kenya, the cause-and-effect relationship between the presence of rodents and a higher risk of low microbiological quality of food is not always clear. In Muendo 's study and already (2022) (Kenya) was the presence by rodents, for example associated with the absence of proper waste containers. And in the study by Trimoulinard et al. (2017) (Réunion), good hand hygiene was found to correlate with lower *Listeria* contamination. This may indicate poorer overall hygiene knowledge (cause), resulting in both the presence of rodents and higher concentrations of microorganisms in food.

That rodents can indeed be a source of food contamination is evident from Korean research into the relationship between the detection of mouse DNA in paprika powder and the presence of foodborne pathogens. The researchers found that in 30% (17/56) of the tested monsters paprika powder mouse DNA. In the of mouse DNA contaminated PCR could not detect *E. coli* O157 *, L. monocytogenes* , or *Salmonella in the samples. However, Staphylococcus aureus* DNA was detected in 47% (8/17) of these samples. The authors state that there is a correlation between the presence of mouse DNA and *S. aureus* contamination (Lee et al., 2021). Furthermore, it is known that rodents can indeed introduce pathogens into an environment. This is evident, among other things, from research conducted on the introduction of pathogens to (Dutch) livestock farms (including Meerburg & Kijlstra (2007)).

4.4 Risk mitigation

4.4.1 Legislation

In the European Regulation regarding food hygiene, Regulation (EG) no. 852/2004 [1] , are General hygiene regulations for food business operators are established. One of the principles is the application of good hygiene practices. Provisions that apply, among other things, to the detection of pests and their droppings include:

- Commercial premises for foodstuffs must beautiful are and Good become maintained (Annex II, Chapter I, 1st member);
- The layout, design, the construction, the location and the size by spaces for foodstuffs must be such that (Annex II, Chapter I, 2 nd member)
    - the accumulation by filthy, (…), It end up by particles in foodstuffs (…) are prevented (under b);
    - good hygienic practices possible are, under other Through protection against pollution, and in particular control of harmful organisms (under c)
- In spaces Where foodstuffs become prepared, treated or processed applies under other that ceilings (or, where ceilings are absent, the inside of the roof) and ceiling fixtures must be designed and constructed in such a way that dirt cannot accumulate (Annex II, Chapter II, 1st member under c);
- Adequate facilities must be provided for the storage and disposal of food waste, non-edible by-products and other refuse. Waste storage areas must Like this become designed and managed that she beautiful and if necessary free by animals and harmful organisms may be kept (Annex II, Chapter VI, 3 rd member);
- Raw materials and all ingredients that in It company are stored, must become stored in appropriate conditions designed to prevent spoilage and avoid contamination (Annex II, Chapter IX, 2nd member);
- At all stages of production, processing and distribution, foodstuffs must be protected against any form of contamination which could render the foodstuff unfit. become for human consumption, harmful become for the health, or be contaminated in such a way that they cannot reasonably be consumed in that state (Annex II, Chapter IX, 3 e member).
- Adequate measures must become affected to harmful organisms at combat (Annex II, Chapter IX, 4 e member)

In the General Food Law Regulation (GDPR), Regulation (EC) No. 178/2002 [2] it has been established that foodstuffs which are unfit for human consumption or which are injurious to health deemed become unsafe at are and not in the trade to be allowed to become brought (article 14, 1 st and 2nd Member). It also defines what constitutes a *hazard , namely a biological, chemical or physical agent in a foodstuff (…), or the condition of a foodstuff (…), with the potential to cause adverse health effects* (Article 3, 14 e member).

4.4.2 Control measures

The consequence of an uncontrolled rodent infestation in a food business is the continued accumulation of excreta and possibly also the accumulation of pathogens in this environment. This can An risk for the food safety and occupational health and safety of himself to bring along. Taking rodent repellent measures and carrying out rodent control is essential in controlling this risk.

Next to this measures to at prevent that there rodents in It company present be able to extra attention should be paid to cleaning and disinfecting the environment in case

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[1] Regulation (EG) no. 852/2004 by It European Parliament and the Council by April 29 2004 regarding food hygiene

[2] Regulation (EC) No. 178/2002 by It European Parliament and the Council by January 28 2002 to determination of the general principles and requirements of food law, establishing a European Food Safety Authority and laying down procedures for food safety matters

pests on the location present are. This is inclusive the surfaces that in directly contact bring food (work surfaces, tools, cutlery, plates, utensils, etc.) that could become contaminated with pest droppings (manure, urine) between the final cleaning and the start of work the next day.

For people who work in an environment with rodent nuisance, maintaining hand hygiene is important further bee On the risk management. At It execute by more risky When carrying out activities (including cleaning up droppings and removing dead animals), it is important to wear appropriate personal protective equipment.

5 Risk characterization

Rats and mice can carry zoonotic pathogens. Not all of these pathogens occur in pests worldwide, nor do they all occur in pests in urban environments. For this risk assessment are 16 zoonotic pathogens identified that have been found in rats (brown, black) and mice in urban areas in Europe or North America and may pose a potential risk to food safety and/or worker health in the Netherlands (Table 3). Transmission of these pathogens can occur via feces (feces, urine) which can directly or indirectly contaminate foodstuffs or via Contact (direct, indirect) with the rodent itself or its excreta (feces, urine, saliva, birth fluids). Almost all hazards identified as relevant within the framework of this risk assessment have the potential to cause serious illness.

Research shows that pathogen prevalence in rodents varies widely (0-89%) depending on location and time, even within a study (see, among others, Krøjgaard et al. (2009); Himsworth and already (2013); Martina and already (2006); Verner-Carlsson and already (2015); Mesh and already

Table 3 Overview by 16 for this risk assessment relevant found pathogens that could occur in rodents in the Netherlands. This section indicates which rodents may harbor the pathogen, how it is excreted, and whether the pathogen poses a risk to food safety and/or occupational health and safety.

Pathogen	Animal species [a]			Secretion via [b]	Danger for [c]	
	Brown rat	Black rat	House-mouse		Food	Arbo
Bacteria						
Campylobacter spp .	*			F	**X**	X
Clostridioides difficult	*	*	*	F	(X)	**X**
Coxiella burnetii	*	*		GV		**X**
Pathogenic *Escherichia coli*	*	*	*	F	**X**	(X)
Leptospira spp .	*	*	*	YOU	X	**X**
Listeria monocytogenes	*	*		F	**X**	
Salmonella	*	*	*	F	**X**	X
Streptobacilli moniliformis	*	*		S	X	**X**
Yersinia spp .	*			F	**X**	X
Viruses						
Cowpox virus	*			F, YOU		**X**
LCMV [#]			*	F, U, S		**X**
Rats hepatitis E virus	*	*		F	(X)	(X)
Seoul virus	*	*		F, U, S	X	**X**
Parasites						
Cryptosporidium spp .	*			F	X	X
Giardia duodenal	*	*	*	F	X	X
Hymenolepis nana	*			F	**X**	X

[a] *: pathogen comes for or is found bee the animal species
[b] F: feces, GV: birth fluids, S: saliva, YOU: urine,
[c] x: pathogen forms An danger for the food- or occupational safety; ( ): subject from discussion/research; **bold** : main route of exposure
[#] LCMV: Lymphocytic choriomeningitis virus

(2018); Williams et al. (2018); de Cock et al. (2023)). Pathogen shedding can be intermittent and in variable concentrations in the time take place. Rodents be able to They can be both temporarily infected (carriers) and a permanent reservoir, and can carry multiple pathogens. The extent to which a pest population spreads pathogens to its environment is therefore highly variable, both in space and time.

In the Netherlands, prevalence data are only available for a portion of the pathogens in rats or mice caught in urban areas (Table 4). Therefore, the picture of the situation in the Netherlands is incomplete and, due to the degree of variation mentioned, may be an underestimation. The data were therefore supplemented with data from Europe (due to proximity) or North America (due to the (partly) similar climate and Western culture), and possibly from the rest of the world (Table 4). Pathogens that occurred in no more than 10% of the animals examined were *Campylobacter* spp ., *Coxiella burnetii* , pathogenic *Escherichia coli* (EAEC), cowpox virus, and *Salmonella* . Prevalences of up to 10-25% have been reported for pathogenic *E. coli* (STEC), rat hepatitis E virus, *Hymenolepis nana* , Seoul virus, *Shigella* spp./EIEC and *Yersinia* spp . For *Clostridium difficile* , *Cryptosporidium* spp ., pathogenic *E. coli* (STEC), *Giardia duodenal* and lymphocytic choriomeningitis virus (seroprevalence) maximum prevalences of 25-50% have been described, while *Leptospira* spp . and *Listeria monocytogenes* in more than the half (>50%) by the researched animals for can This concerns prevalence based on culture or PCR detection in matrices relevant to the pathogen (kidney, liver, spleen, feces, lung, etc.) and sometimes based on serology. This does not mean that the prevalence by infectious pathogens in It relevant excretion product (feces, urine, saliva) equally high is. These data therefore provide an order of magnitude in particular possible size .

Table 4 Overview of the occurrence in pests of the 16 pathogens that were found to be relevant for this risk assessment. The maximum reported occurrences are shown. pathogen prevalences bee pests (rats, mice) in The Netherlands and Europe (focus on urban areas). If data from Europe were unavailable, data from North America or, where applicable, worldwide are provided. The pathogens are listed alphabetically by prevalence category.

Preval . Cat. [a]	Pathogen	Carrier/ Reservoir [b]	Prevalence Netherlands [c]	Method [d]	Prevalence Europe (North America)	Method [d]
≤10%	*C. jejuni*	D	-		7%	breeding
	C. burnetii	(R)	5% [$]	PCR	1%	PCR
	pathogenic *E. coli* EAEC	(R)			(9%)	PCR
	cowpox virus	(R)	0% [#]	PCR	5%	S
	Salmonella spp .	D	1%	breeding	10%	breeding
10-25%	pathogenic *E. coli* STEC	(R)	-		[12%]	PCR
	Rats HEV	R	4%	PCR	15%	PCR
	H. nana	R	4%	Mic	17%	Mic
	Shigella spp./EIEC	(R)	-		(14%)	PCR
	St. moniliformis	R	2%	PCR	(16%)	PCR
	Seoul virus	R	20%	PCR	19%	PCR
	Yersinia spp.*	R	-		18%	Breeding
25-50%	*C. difficile* *	?	35%	breeding	(17%)	PCR
	Cryptosporidium spp .	R	-		39%	PCR
	pathogenic *E. coli* EPEC	(R)	-		(45%)	PCR
	G. duodenalis *	(R)	-		38%	PCR
	LCMV [a]	R	-		47%	S
≥50%	*Leptospira* spp .	R	57%	PCR/culture	89%	PCR
	L. monocytogenes	D	-		59%	NB

[a] Previous . Cat: Prevalence category; LCMV: Lymphocytic choriomeningitis virus
[b] D: carrier, R: reservoir, (): subject by discussion/research, ?: no data known
[c] -: no data known
[d] Mic : microscopy, NB: not known, S: serology
* not all species are pathogenic
[$] 5% during the day the Q fever period, but later - after the outbreak - 0%
[#] Note bene, during the day outbreak among monkeys in An animal shelter pale 57% by the rats culture positive

The health risk of a rodent infestation also depends on the size of the rodent population and the amount of pathogens excreted. A mouse or rat is rarely alone. but good estimates of population sizes are not available. For every observed animal would It possible to An multiple by 20 to 50 animals be able to go. And although urine and Mouse and rat droppings are usually observed in specific locations within an environment – this is especially true for rat droppings – they are deposited throughout the environment by these animals.

Research shows that a house mouse produces up to 12 ml of urine and 100 droppings per day. A brown rat produces up to 300 ml of urine and about 70 droppings per day. Regarding pathogens excreted in feces, information is only available on the presence of *Salmonella* spp . in pest droppings. A concentration of 230,000 CFU /droppings has been reported for mice, and $1\times10^{-}$ ··· CFU /feces. Regarding urine-related pathogens, information is only available for *Leptospira.* spp . For mice, this amounts to an average of $3.1\text{x}10^{3}$ *Leptospira* cells per ml of urine, and for brown rats, $5.7 \text{ x } ^{106}$ *Leptospira* cells/ml of urine. Suppose there are 10 animals on a farm for 10 days, all animals are infected with the pathogen in question, and all urine and feces are collected only at that farm location. deposited. Than is becoming on that location in case by mice approximately 1 liter urine and
10,000 droppings excreted and for rats would that come down on maximum 30 liter urine and 7,000 droppings. The amount of pathogens that in that period in a company would be excreted for feces-related pathogens (*Salmonella*) down be able to to come in the order by size of 10^{9} bacteria in case It An mouse population concerns and to 10^{11} bacteria in case by a rat plague. For urine-related pathogens (*Leptospira*), this would be 10^{6} bacteria for a mouse plague and 10^{11} bacteria in case of a rat infestation.

However, under favorable conditions, the pathogens can sometimes remain in the environment for weeks to months. infectious present to stay. Also bee low germ counts per excretion product and a low prevalence of the pathogen in the rodent population in question can lead to a high infection pressure in the location in question, which can persist for some time, depending on the germ.

In addition to foodborne transmission, humans can also contract rodent-related infection Through (indirectly contact of rodents. Riskier actions are cleaning up Disposal of droppings and urine, and the removal of dead (captured) animals. A bite or scratch from a mouse or rat can also lead to infection. Infection can also occur through touching surfaces contaminated with (dried) urine or manure.

for many of the zoonotic agents that are particularly related to occupational health and safety , cases of disease in the Netherlands are rare to non-existent (*H. nana* , cowpox virus, LCMV, RHEV, SOEV, *S. moniliformis*), or the role of rodents in the total number of infections in the Netherlands will be marginal (*C. burnetii*). Overall, the contribution of rodents to food-related infections caused by *Campylobacter* , STEC, *L. monocytogenes* , *Salmonella* , *Yersinia* and *Giardia* of secondary importance. However, in a place where rodents prevent, be able to rodents well solid An source by infection Pathogens in which rodents play a more significant role in the spread are *C. difficile* , *Cryptosporidium* spp . and especially *Leptospira* spp .

Despite the fact that (serious) pest problems can occur at locations where food is produced, traded, or prepared/consumed, there are hardly any known cases of illness in which rats or mice have been identified as a source of contamination (direct or indirect). However, limited research is available that indicates that the presence of pests (mice, rats) appears to be a risk factor for foodborne illness or correlates with the low microbiological quality of the food sold at that location. Also out practical situations by the NVWA turns out that in case by pest nuisance It it is not unreasonable that foodstuffs and prepared foodstuffs become directly contaminated with pest droppings and urine, or indirectly via contaminated (work) surfaces (including from ceiling, shelves, ledges) and utensils.

6 Uncertainty analysis

It is certain that mice and rats can carry pathogens that can be transmitted through food or (in)directly contact of this animals or their excreta products to disease bee the man can lead.

It is unclear to what extent rodents contribute to food or occupational health-related illnesses in the case of by rodent nuisance in a grocery location (production, Scientific publications on human cases related to pathogens originating from these animals are limited in number and are restricted to a small number of pathogens. The role of foodborne transmission, in particular, is highly uncertain. From the practice are there however enough directions that food polluted can come into contact with feces (feces, urine) of these animals if these animals are present in an environment where food/foodstuffs are stored, produced, prepared or traded.

A by the reasons by the scarcity On case studies that On commensal rodents can If the presence of rodents is related, it may be that the presence of rodents has led to limited outbreaks. However, this does not necessarily mean that there is little or no transmission of pathogens in a food business. It may also mean that these are mainly sporadic cases of illness, not detected by existing surveillance systems. On the other hand, it is possible that the presence of pests is not considered a risk factor in outbreak investigations, and therefore that the presence of rodents is not assessed and recorded as a possible route of infection.

It is also unclear for occupational health and safety-related transmission – if registration takes place – whether it is recorded that the infection was contracted in a food company (with rodent nuisance). unclear is what It risk is for visitors (like inspectors by the NVWA) that only They will be exposed briefly and will have less direct contact with the animals themselves or their feces (manure, urine). They will also not be involved in more risky situations such as cleaning work (aerosol formation) or the disposal of dead animals.

For all these reasons it is impossible to estimate the contribution of pests (mice, rats) to the number food-related cases of illness is and what It risk by An rodent population on A business location is for both employees and visitors (customers, inspectors). It seems plausible that, with regard to non-food-related illnesses, the business owner and their employees are particularly at risk.

7 Conclusion

Rats and mice that prevent in An urban environment be able to for the man carry pathogenic microorganisms that pose a risk to food safety or occupational health and safety. These pathogens are excreted in urine, feces, or saliva.
Rodents do not always carry such pathogens, and this can also vary over time and place. Given the outcome of this study, BuRO assesses that in the case of rodent nuisance the chance on transfer by pathogens originating by rodents Unpleasant the environment must be considered realistic. Rodent infestation in a food business (production, trade) such as a catering establishment, supermarket, or an industrial/artisanal food producer therefore poses a risk to food safety and occupational health and safety. Regarding non- food-related illnesses, it seems plausible that the business owner and their staff, in particular, are at risk.

Almost all in It frame by this risk assessment as relevant identified dangers to have The potential to cause serious illness. This underlines the importance of preventing rodent infestations and controlling them once they have developed.
During the control period it is important that – if the production and trade of foodstuffs yet responsible is – there in the commercial spaces for food and Certainly In areas where food is prepared, treated, or processed, proper cleaning and disinfection is ensured, both after and before the preparation, treatment, or processing begins. In addition, it is important to maintain good personal hygiene (including handwashing) and to wear appropriate personal protective equipment during risky activities (cleaning up feces or dead animals).