Federal Office of Consumer Protection and Food Safety

BfR

# Prevalence Studies of Zoonosis Monitoring 2010 – 2019: Summary of Findings and Conclusions

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## Summary of findings and conclusions

### Animal Feed

*Salmonella* spp.

Examinations carried out at decentral oil mills produced 1.1% *Salmonella*-positive samples of rapeseeds, which shows that the degree of contamination of the raw material for producing rape seed expeller is low. Samples of rape seed expeller were actually found contaminated with *Salmonella* at a rate of 2.1%. Samples of oilseeds drawn at centralised oil mills were not found with *Salmonella*, while samples of extracted oilseed meals stemming from the same lots were contaminated with *Salmonella* spp. at 1.1%. The tests at decentral and central oil mills show that *Salmonella* entry in the food chain is possible when rapeseed expeller or extraction meals are fed to food-delivering animals. Cold pressing at decentral oil mills is not followed by a heat treatment which would kill pathogenic germs, so that both the quality of seeds used and the hygiene applied in the plants must meet the highest standards, in order to produce *Salmonella*-free animal feeds. High hygienic standards must also be applied to centralised oil mills, because one cannot preclude that despite the heat treatment which is carried out there, extraction meals might afterwards be contaminated or re-contaminated with *Salmonella*.

Samples of laying hens' mixed feeds drawn at mixed feed manufacturing plants were contaminated with *Salmonella* spp. at a rate of 1.0%, and samples of single feeds for fattening pigs, also drawn at mixed feed manufacturers, at a rate of 1.9%.
The findings show that *Salmonella* may enter laying hen flocks and fattening pig stocks with the respective feed. This is underlined by the results of typing of *Salmonella* isolates: the serovar *S.* Agona found in laying hens' mixed feeds was also repeatedly detected in the framework of official controls in laying hen flocks, and the serovar *S*. Typhimurium, or its monophasic variant, which is the most frequent serovar in pigs, was also found in the feed of fattening pigs. Fundamentally, *Salmonella* entry into livestocks via feed is a challenge for *Salmonella* control in the animals, because this entry may undermine other efforts to improve biosafety in livestocks. Feeding stuffs should therefore be tightly controlled, in order to be able to withdraw positive lots early.

### Food chain related with laying hens

*Salmonella* spp.

Separate examination of eggshell and egg content for *Salmonella* at the end of the best-before date showed that 0.7% of pooled eggshell samples and taken at retail level were contaminated with *Salmonella*. The egg content was not found with *Salmonella*. Eggs were analysed as pools of ten eggs each, so that findings do not allow direct conclusions on the prevalence of *Salmonella* spp. in single eggs. Comparing the ways of holding the laying hens showed that egg samples stemming from ecological holdings were contaminated with *Salmonella* at a rate of 0.4%, while egg samples from caged hens (0.9% positive), barn hens (0.7% positive), and free-range hens (0.8% positive) were slightly more contaminated. These differences are not significant, however. Still the findings show that presence of *Salmonella* must be calculated with in eggs of all kinds of chicken holdings. There were also no significant differences in *Salmonella* contamination rates between eggs from Germany and from foreign origins, with 0.8% and 0.5% positive samples, respectively. Apart from that, the present data show that the egg content should be very seldom contaminated with *Salmonella*, even at the end of the best-before date. Yet, *Salmonella* spp. was detected on the egg shell, which is attributed to faecal contamination of the eggs. The isolates sent in for typing were *S*. Enteritidis, exclusively. Any measure reducing the prevalence of *Salmonella* in laying hens is also reducing the risk of contamination of eggs. Eggs pose a potential risk to consumers to infect themselves with *Salmonella*, because *Salmonella* present on the eggshell can cross-contaminate an egg-containing dish when eggs are cracked while preparing the dish. Vulnerable consumer groups, such as elderly or immune-deficient people, or pregnant women, should therefore refrain from consuming dishes containing raw egg. These consumer groups should eat only thoroughly cooked egg dishes. Detailed results of the analyses for typing of *Salmonella* isolates are to be found in the Zoonosis Monitoring Report of the year 2010.

*Campylobacter* spp.

Only 0.4% of pooled eggshell samples (of ten eggs each) were found positive with *Campylobacter* spp. in tests of eggs intended for final consumers and sampled at retail level. Because of their high sensitivity to dehydration, however, it is possible that some of the *Campylobacter* were no longer detectable on the eggshell. *Campylobacter* spp. is transferred to the eggshell with laying hens' faeces, which is why dishes containing raw eggs should be prepared using solely clean eggs, and when cracking the eggs, the egg content should come into as little contact as possible with the eggshell in order to avoid *Campylobacter* spp. contaminating the dish. Consumers should wash hands thoroughly after touching the eggs.

ESBL/AmpC-forming *E. coli*

Using selective methods, ESBL/AmpC-forming *E. coli* were found frequently both in layer hen breeding farms (39.3% positive faecal samples) and in layer hen farms (45.7% positive faecal samples). This confirms that these resistant germs may be vertically transferred. Shell of eggs intended for final consumers was detected with ESBL/AmpC-forming *E. coli* at a rate of 0.5%. This means eggs are a potential source of transfer of this resistant pathogen to humans. But there is no information yet as to the actual importance of this vehicle.

**Food chain related with broiler chickens**

*Salmonella* spp.

Findings of analyses in the broiler chicken-related food chain show that there was a decline in *Salmonella* detection rates at all levels in the years 2011 to 2014/2016, which is probably to be attributed to the *Salmonella* control measures in poultry flocks on the basis of Regulation (EC) No. 2160/2003. Yet, this decline did no continue in the past five years: the *Salmonella* detection rate in ceacal content sampled from broiler chickens at slaughter declined from 4.8% in the Zoonosis Monitoing of 2011 to 1.0% in the monitoring of 2013. In the Zoonosis Monitoring of 2018, the rate of *Salmonella*-positive ceacal samples was found somewhat higher again, with 1.9%.

The contamination rate of broiler carcasses with *Salmonella* was still 17.8% in the 2011 Zoonosis Monitoring, while only 6.7% of the neck skin samples were positive with *Salmonella* in 2016. In the 2018 Zoonosis Monitoring, the detection rate was a bit higher aqgain, with 7.6%. The contamination rate of fresh broiler meat fell slighly from 6.3% in the 2011 monitoring to 4.7% in 2016. In the Zoonosis Monitoring of 2018, broiler meat was contaminated with *Salmonella* a bit more often again, with 5.6% samples positive. Fresh chicken meat sampled in meat processing plants had a similar contamination rate as chicken meat sampled at retail, with 5.8% positive samples. There was no difference in the *Salmonella* detection rate in broiler meat with and without skin (both with 4.7% positive samples), which supports the assumption that contamination of broiler carcasses is not only located on the skin surface, but also in other parts. Spreadable and sliceable raw sausages from chicken or turkey meat had 0.2% *Salmonella*-positive samples. Thus they are also a potential source of human infection with *Salmonella* spp., in particular, because they are consumed without prior cooking. *S*. Infantis was frequently detected in the broiler food chain, and even accounting for the majority of serovars identified in broiler meat. It is worth pointing out that *S.* Infantis is not regulated in the framework of

control programmes in flocks, although it is a serovar which is also frequently found in diseased humans. The serovar *S.* Thyphimurium, including its monophasic variant, which is subject to control programmes, was found partly more often in bird carcasses, but less frequently in caecal content and in broiler meat in the framework of the Zoonosis Monitoring. While the sampling plan provides that birds sampled at the slaughterhouse shall be only such fattenend in Germany, samples taken at retail level may represent also imported chicken meat or meat moved from other EU countries, which might have influenced the spectrum of serovars found. Findings show that carcasses may be contaminated with *Salmonella* from birds' intestinal contents during the slaughter process. In addition, differences between the serovar patterns found in caecal and carcass samples show that *Salmonella* is also transferred by cross-contamination between different slaughter lots. So the findings underline the need to further improve poultry slaughter hygiene in order to prevent contamination of carcasses and meat with *Salmonella*. This holds in particular for some single slaughterhouses that were repeatedly conspicuous with particularly high rates of contamination. Detailed results of typing analyses of *Salmonella* isolates are to be found in the respective yearly reports of the Zoonosis Monitoring.

*Campylobacter* spp.

The findings of analyses in the broiler food chain also show that the prevalence of *Campylobacter* spp. in the animals is at high level, from carcasses to the meat sampled at retail, and that fresh broiler meat basically harbours a risk of infection of humans with *Campylobacter* spp. Tests at slaughter showed that broiler chickens are frequently colonised with *Campylobacter* spp., with about 40% to 50% of samples of caecal content being positive with the pathogen. Between 2013 to 2014, there was a sharp increase in *Campylobacter*-positive caecal content samples from 25.3% to 50.4%, which should, however, be at least partly attributable to an improved detection method for *Campylobacter* spp. in intestinal content which was introduced in 2014. The tests in slaughterhouses also show that in the course of slaughter, pathogens present in intestinal contents are obviously transferred to great extent to the carcasses, which were contaminated with *Campylobacter* spp. at rates of 40.9% in the Zoonosis Monitoring of 2011, and 52.3% in the monitoring of 2013. The *Campylobacter* counts on broiler carcass neck skin samples which are regularly carried out in the framework of the Zoonosis Monitoring do not allow seeing any progress in reducing high bacterial counts. On the contrary, the share of neck skin samples with *Campylobacter* counts higher than 1,000 cfu/g has always been higher than 20% since 2016 (2013: 19.4%; 2016: 24.1%,

2017: 22.7%, 2018: 22.6%, 2019: 23.4%). On the other hand, there have been notable differences among single slaughter establishments as regards the frequency of *Campylobacter* counts higher than 1,000 cfu/g in neck skin samples (which was introduced as a slaughter process hygiene criterion in 2018). Obviously, slaughter establishments succeed to different degree in controlling transference of *Campylobacter*. Minimisation strategies should therefore focus on comparing slaughterhouses with high *Campylobacter* counts with such with low counts, in order to identify measures suitable to reduce germ counts on carcasses.

The detection rate of *Campylobacter* spp. in samples of fresh broiler meat has been around 50% (2014: 54.0%, 2016: 47.2%, 2017: 51.8%, 2018: 47.8%, 2019: 46.4%) in the Zoonosis Monitoring since 2014. In the programmes of the years 2011 and 2013, in contrast, broiler meat was still notably less frequently found contaminated with *Campylobacter* spp. than in the years after, with 31.6% and 37.5% positive samples, respectively. With 54.0%, the highest contamination rate was measured in the Zoonosis Monitoring of 2014, when broiler meat samples subject to analysis consisted, explicitly, in meat (legs) with skin. Bacterial counts of *Campylobacter* higher than the detection rate of 10 cfu/g were found in less than 10% of the fresh broiler meat samples, and thus clearly less often than in broiler carcass neck skin, where *Campylobacter* were detected by quantitative measures at rates of about 50%. Generally, samples of fresh broiler meat had lower *Campylobacter* counts than neck skin, while counts higher than 1,000 cfu/g still occurred in some single cases. We may conceive that these differences in bacterial counts might be owing to the fact that the skin, which is particularly contaminated, was not always part of the fresh meat samples subject to analysis. Still, because of the pathogen's low infectious dose in humans, even low bacterial counts of *Campylobacter* spp. in foodstuffs pose a risk of infection. In particular, cross-contamination between meat and ready-to-eat food, such as salad, during the preparation of food plays a role in consumers' infections with *Campylobacter* spp.

*Listeria monocytogenes*

Samples of caecal content of broilers at slaughter were not detected with *Listeria monocytogenes*, so broilers do not seem to be an important reservoir of this pathogen. Fresh broiler meat, in contrast, was relatively frequently contaminated with *Listeria monocytogenes*, with 15.4 % positive samples, which indicates that the meat is possibly contaminated owing to deficient production hygiene during production and processing of the meat. Here one has to consider that fresh chicken meat is not a ready-to-eat food, but is usually heat-treated before consumption. Still, there are some ready-to-eat foods that

are produced with raw chicken meat without prior cooking, so these might be contaminated by the raw material.
Contamination with *Listeria monocytogenes* was also detected in spreadable and sliceable raw sausages from chicken and/or turkey meat, which were found positive with this pathogen at a rate of 3.4% in the framework of the Zoonosis Monitoring. But actual bacterial counts were low, because none of the samples was found with *Listeria* exceeding the detection limit of 10 cfu/g when the quantitative method was used. Nevertheless, sensitive consumer groups such as pregnant women, elderly, and immune-deficient people should refrain from consuming raw sausage made from poultry meat.

Methicillin-resistant *Staphylococcus aureus* (MRSA)
MRSA was very seldom found in conventional broiler flocks, with less than 2% of dust or skin swabs found positive. Dust samples from broiler breeding farms even had no MRSA findings at all. Broiler carcasses, in contrast, were repeatedly found with high MRSA contamination rates of about 50%. These findings indicate that the broilers are probably contaminated or colonised with MRSA only during transport to slaughter or actually at the slaughterhouse. Fresh broiler meat was also frequently contaminated with MRSA, with more than 20% MRSA-positive samples. Bacterial counts were low, as they were under the detection limit of the quantitative method. MRSA isolates were of the farm animal-associated CC398 clonal complex in the majority. Isolates which were not of that clonal complex were dominated by *spa* type t1430, which is of the CC9 clonal complex and associated with poultry. This *spa* type is very rare in humans. It is considered a good sign that the Zoonosis Monitoring of the years 2016 and 2018 noted a marked decline in detection rates of MRSA in broiler meat samples, namely from 24.2% in 2013 to 13% and 16.4% then. Continual testing in the framework of the Zoonosis Monitoring will show whether this is developing into a trend.

ESBL/AmpC-forming *E. coli*.
45.2% of faecal samples taken in broiler chicken breeding hen flocks were positive with ESBL/AmpC-forming *E. coli*. While detection rates of ESBL/AmpC-forming *E. coli* in broiler fattening farms and in fresh chicken meat clearly declined over the past few years, they are still at a high level: while in 2013, near to 65% of faecal samples taken in broiler fattening farms were detected with ESBL/AmpC-forming *E. coli* using selective methods, the 2016 programme still found about 50% of the faecal samples from conventional broiler farms positive with that bacteria. A noticeable finding was that faecal samples from ecological broiler fattening farms had 25.7% positive findings of ESBL/AmpC-forming *E.*

*coli*, and thus significantly less than samples from conventional broiler farms (50.2% positive faecal samples). The detection rate of ESBL/AmpC-forming *E. coli* in fresh broiler meat was 35.4% in the 2018 Zoonosis Monitoring, which was clearly lower than in 2013 (66.0%) and 2016 (49.8%). With 46.8% positive samples, caecal content of broilers at slaughter was also somewhat less frequently found positive with ESBL/AmpC-forming *E. coli* in 2018 than in 2016, when 52.6% of the caecal content samples were positive with those bacteria.

Commensal *E. coli*

Commensal *E. coli* was detected in neck skin samples of broiler carcasses at a rate of 95.7% using a quantitative method. Bacteria counts varied between 10 cfu/g and $11.2x10^5$ cfu/g. Commensal *E. coli* are part of the normal intestinal flora of warm-blooded animals, birds, and humans. Mostly, they are not pathogenic, but they are considered indicators of potential faecal contamination of a product. The fact that commensal *E. coli* is frequently found with higher counts on broiler carcasses underlines the need for improvements in poultry slaughter hygiene.

Carbapenemase-forming *E. coli*

Carbapenemase-forming *E. coli* was not detected in the food chain related with broiler chickens.

**Food chain related with fattening turkeys**

*Salmonella* spp.

Like in the broiler-related food chain, we saw in the beginning a clear decline in *Salmonella* detection rates, which however, could not be sustained at all levels. The contamination rate of fresh turkey meat declined from 5.5% in the Zoonosis Monitoring of 2010 to 2.6% in 2014. In the Zoonosis Monitoring of 2018, fresh turkey meat from conventional farming had 4.0% *Salmonella*-positive samples – a bit more again than in the years before. Samples of fresh turkey meat stemming from ecological farming were found with *Salmonella* at a rate of 2.9%. The contamination rate of turkey carcasses with *Salmonella* also decreased in the years from 2010 to 2014 from 17.2% to 7.1%. But from 2016, we have observed an increase in *Salmonella* findings in neck skin samples again, with the rate of contaminated turkey carcasses in the Zoonosis Monitoring of 2018 even surpassing that of 2010, with 22.7% positive samples. In contrast to that, the detection rate of *Salmonella* in caecal content of turkeys at slaughter steadily declined from 3.6% to 0.2% in the years from 2010 to 2018. The frequent detection of certain *Salmonella*

serovars (*S*. Indiana, *S.* Agona, monophasic *S*. Typhimurium) in skin neck samples of turkeys at some single slaughterhouses indicates that carcasses are cross-contaminated with slaughterhouse-specific *Salmonella* strains, all the more as *Salmonella* was very rarely found in turkeys' caecal content. It was also conspicuous that frequent *Salmonella* findings repeatedly occurred in certain slaughterhouses, which in this way have a significant influence on contamination rates found in turkey carcasses. Meat samples taken at retail level were essentially detected with the same serovars as found in the slaughter establishments, which prompts that the pathogen is passed down the food chain. The frequent contamination of turkey carcasses with monophasic *S*. Typhimurium must be alarming, because *S*. Typhimurium is among the most frequent causal agents of notifiable salmonellosis in humans. Detailed results of the typing of *Salmonella* isolates are to be found in the respective years' Zoonosis Monitoring Annual Reports.

*Campylobacter* spp.

Examinations carried out in the food chain related with fattening turkeys further showed that fattening turkeys are colonised with *Campylobacter* still more often than broilers: fattening turkeys have had more than 60% positive samples of caecal content (2018: 64.3%, 2016: 73.7%, 2014: 68.9%), while broilers have had between 40% and 50% positive samples of caecal content. The increase in the detection rate of *Campylobacter* in samples of caecal content from 44.6% in the Zoonosis Monitoring of 2012 to 68.9% in 2014 is probably – analogously to the findings in broilers – partly owing to an improved detection method which was introduced in 2014 for analysing caecal contents. Turkey carcasses were found contaminated with *Campylobacter* spp. at a rate of 68.0% in the Zoonosis Monitoring of 2010, while that contamination rate was 53.5%, and thus notably lower, in the Zoonosis Monitoring of 2012. But the findings cannot necessarily be interpreted as an improvement of slaughter hygiene. They may be rather attributable to a declining sensitivity of the detection method to *Campylobacter* on the carcasses because of changes in the interfering accompanying flora. The detection method has therefore since been revised.

The contamination rate of fresh turkey meat with *Campylobacter* was under 20% at several times (2010: 17.3%, 2012: 16.5%, 2016: 15.9% positive samples), and thus significantly below the contamination rate detected in samples of fresh broiler meat (roughly 50% positive samples). In the Zoonosis Monitoring of 2014, though, the percentage of *Campylobacter*-positive samples was higher than in the other years, namely 26.5%. In that year, turkey meat samples explicitly consisted in meat WITH skin, while in the other years, samples could consist in either meat with or without skin, or specifically in meat without skin.

A differentiation of samples by origin in the Zoonosis Monitoring of 2012 showed that turkey meat cut in Germany or originating from birds slaughtered in Germany had 10.8% positive samples, which means it was much more seldom contaminated with *Campylobacter* than turkey meat of other origins, which had 27.9% positive samples and thus nearly three times as many *Campylobacter* findings. The factors contributing to this situation should be clarified by further analyses of the present data and more studies. In the Zoonosis Monitoring of 2018, it was also striking that turkey meat from ecological farming was significantly more often contaminated with *Campylobacter* (32.7% positive samples) than conventionally farmed turkey meat (19.4% positive samples). At present, we do not yet have an explanation for the higher prevalence of *Campylobacter* in ecologically farmed turkey meat, compared to conventionally farmed turkey meat. Finding one requires more examinations along the food chains of turkey meat of both kinds of farming. Bacterial counts produced higher *Campylobacter* counts on turkey carcasses than in fresh turkey meat – a situation similar to that in the broilers food chain. While 41.3% of the neck skin samples analysed carried *Campylobacter* counts higher than the detection limit of 10 cfu/g, only 0.4% of the fresh meat samples exceeded that limit. The highest *Campylobacter* count measured on turkey carcasses was $3.3x10^3$. In contrast to that, bacterial counts in fresh turkey meat were low, with a maximum of 20 cfu/g. Like in the tests in broilers, this might be connected with the fact that skin, which is particularly contaminated, was not always part of the fresh meat samples examined in the framework of the Zoonosis Monitoring. Still, even low counts of *Campylobacter* spp. in foodstuffs pose a risk of infection because of the low infectious dose in humans.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

The tests for MRSA in the food chain related to fattening turkeys produced high detection rates at all levels, which indicates that there is a considerable transfer of MRSA along the food chain. Dust samples collected in turkey flocks had detection rates of around 13% to 22%. Carcasses of fattening turkeys were contaminated with MRSA at rates of more than 60%, and fresh turkey meat at about 40%. In the Zoonosis Monitoring of 2012, fresh turkey meat of German production was notably more often contaminated (44.7% MRSA-positive samples) than meat of turkeys not slaughtered or cut in Germany (23.6% positive samples). In the Zoonosis Monitoring of 2018, it was conspicuous that MRSA was detected clearly less in dust samples from ecological farms (2.7% positive samples) and samples of ecologically produced turkey meat (11.0% positive samples) than in samples from conventional turkey farms (17.2% positive dust samples) and conventionally produced meat (42.7% positive samples). Dust samples from turkey breeding stocks had no MRSA findings, which indicates that breeding turkeys are not a major source of MRSA

in fattening stocks. As only few samples from breeding stocks were examined, however, the result does not actually allow to conclude that MRSA was absent in this population. The *spa* types detected are in the majority of the farm animal-associated CC398 clonal complex. About 10% of isolates were not classified as CC398 clonal complex. Dominating here was spa type t1430, which is part of the CC9 clonal complex and is associated with poultry.

ESBL/AmpC-forming *E. coli*

Unlike in the broilers food chain, findings of ESBL/AmpC-forming *E. coli* in caecal content samples increased in the turkey food chain from 36.5% in the Zoonosis Monitoring of 2016 to 48.6% in the programme of 2018. The contamination rate of conventionally produced fresh turkey meat remained roughly the same in both years and was about 38%. Faecal samples collected at conventional turkey fattening farms were detected with ESBL/AmpC-forming *E. coli* at a rate of 51.8%. It was striking that, like in the broiler farms, faecal samples from ecological turkey holdings and in particular samples of ecologically produced turkey meat were much more seldom positive with ESBL/AmpC-forming *E. coli* than such samples collected from conventional farms. The percentages were 36.8% positive in faecal samples and 12.2% in meat samples from ecological farms, against 51.8% in faecal samples and 37.6% in meat samples from conventional farms.

Carbapenemase-forming *E. coli*

Carbapenemase-forming *E. coli* were not found in the food chain related with fattening turkeys.

**Food chain related with fattening pigs**

*Salmonella* spp.

Results of testing in the food chain related to fattening pigs show that there are obvious differences in the prevalence of *Salmonella* at the various levels of the chain. While pigs are still relatively frequent carriers of *Salmonella*, with 5.7% to 9.4% positive faecal samples and roughly 6% positive caecal samples, the *Salmonella* detection rate continuously declines along the food chain: pig carcasses were found contaminated with *Salmonella* at rates between 2.9% to 5.1%, and fresh pig meat was contaminated at a rate of 0.4%. Pig meat originating from ecological production had a similar rate of findings with 0.6%. Minced pork samples were positive for *Salmonella* at rates between 0.7% to 1.9%. This shows that the pig slaughtering process seems to be less contaminating the

carcasses, compared to the poultry slaughtering process. Still there is a transfer of *Salmonella* from intestinal contents to the carcass during slaughter of pigs, too. The typing analyses have shown that *Salmonella* serovars detected on pig carcasses are largely the same as in the faeces and caecal contents. To the end of further reducing the *Salmonella* contamination of carcasses, and thus of the meat, it is not only necessary to observe strict slaughter hygiene, but also to conduct intensive *Salmonella* control measures already in the animal stock at farm level, in order to reduce the *Salmonella* load in the pigs, and thereby reduce the entry of *Salmonella* into slaughter establishments with *Salmonella*-positive pigs. The findings of the Zoonosis Monitoring show that this end has not yet been achieved, as the *Salmonella* detection rate in caecal contents has constantly remained around 6% over the past few years. So, further effort in this field is needed. Although in 2019, the percentage of *Salmonella*-positive samples collected in pig fattening farms was somewhat lower than in the years before (namely, 5.7% in 2019, against 7.9% positive faecal samples in 2017 and 9.4% positive faecal samples in 2011), this difference was statistically not significant. Tests in breeding sows and young pigs showed that pigs are colonised by *Salmonella* spp. as early as at the piglet farm stage (breeding sows had 5.6% positive faecal samples, young pigs 10.3%). This illustrates how important it is to control *Salmonella* at breeding farm level, in order to avoid transfer of *Salmonella* into fattening farms with infected pigs. In the Zoonosis Monitoring programmes of 2011 and 2017, *Salmonella* detection rates in faecal samples of fattening pigs at farms classified as category I pursuant to the Germany's *Ordinance to control Salmonella in pigs,* were clearly lower (namely, positive rates of 6.7% and 5.0%) than in faecal samples of pigs from farms classified as category III (positive rates 21.2% and 30.0%). So, the findings underline that there is a correspondence between the serological categorisation of pig fattening farms under the *Ordinance to control Salmonella in pigs* and the bacteriological findings in pigs kept at the farms. At the same time, they show that even fattening pigs of category-I holdings harbour a risk of contaminating the meat in the course of slaughter. The Zoonosis Monitoring of 2019, unlike the previous programmes, did not produce noteworthy differences in *Salmonella* detection rates in faecal samples of pigs from holdings of different categories under the *Ordinance to control Salmonella in pigs.* However, that programme included only very few samples from category-II or category-III holdings. The tests in slaughter establishments did not produce such clear connection between the *Salmonella* prevalence in the animals and the category of their farm of origin as in primary production. The causes for that cannot be identified on the basis of the present data, but might be sought in the different kinetics of infections, and the different serological responses to these infections.

Despite the relatively low rate of contamination with *Salmonella*, pork plays an important role in human infection with *Salmonella* because of customary raw consumption (as spiced minced pork, or *Mett*). Samples of minced pork were detected with *Salmonella* serovars which are particularly often at the source of human infection, namely, *S.* Thyphimurium and its monophasic variant. This underlines the importance of minced pork as a source of human infection with *Salmonella*. The results in detail of the typing analyses of *Salmonella* isolates are to be found in the Zoonosis Monitoring Annual Reports of the respective years.

*Campylobacter* spp.

*Campylobacter* spp. was very frequently detected in caecal contents of slaughtered pigs (2015: 73.1% positive samples, 2017: 75.5% positive samples, 2019: 67.3% positive samples). The *Campylobacter* found was in the majority of the species *Campylobacter coli*, which plays a minor role in human infections with *Campylobacter*. The findings show that pigs are a reservoir of those bacteria. The pig slaughtering process, however, seems to very effectively prevent contamination of the meat with *Campylobacter* spp., as fresh pig meat is very seldom contaminated (2011: 0.5% positive samples, 2015: 0.2% positive samples). Minced pork was positive with *Campylobacter* spp. at a rate of 0.4%. We can presume that pork is of minor importance in transmitting this pathogen to humans, because of its low contamination rate and the predominance of *Campylobacter coli*. Still, there have been cases where food-borne *Campylobacter* outbreaks were potentially related with minced pork.

*Listeria monocytogenes*

Cured meat products were found contaminated with *Listeria monocytogenes* at a rate of 0.9% and cooked sausage/cooked sausage pies at 2.7% at the end of the shelf life. Samples of spreadable raw sausage of pork had 12.2% findings of *Listeria monocytogenes*. While none of the cured meat product samples contained *Listeria monocytogenes* at quantities higher than the microbiological limit of 100 cfu/g, some single samples of cooked sausage/cooked sausage pies and spreadable raw sausages had *L. m.* counts representing a potential health risk to humans (namely, 380 cfu/g, or 220 cfu/g and 550 cfu/g). The findings confirm that certain ready-to-eat pork products can pose a risk of infection with *Listeria monocytogenes* to humans. Sensitive consumer groups such as small children, elderly, and immune-deficient people should in particular refrain from consuming raw sausage products.

Shiga toxin-forming *Escherichia coli* (STEC)

STEC was comparatively frequently detected in minced pork, with 7.4% samples being positive. Sero-groups isolated included *O* group 91, which is particularly often the cause of EHEC infections in humans. However, none of the isolates carried the *eae* gene which counts among the most important pathogenic factors in STEC. STEC was also found in spreadable raw pork sausages, where 1.7% of the samples were positive. So, the findings show that both minced pork and spreadable raw pork sausage are a potential source of STEC infection of humans. For detailed results of typing analyses in STEC isolates, please refer to the respective Annual Reports of the Zoonosis Monitoring.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

MRSA occurs frequently in the food chain related with fattening pigs. In piglet production farms, 26.3% of the sock swabs collected from the breeding sows' waiting areas were positive with MRSA. The MRSA detection rate in sock swabs from young pig raising areas was even significantly higher, with 41.3% positive swabs. Sock swabs taken at pig fattening farms had a contamination rate roughly comparable to that of young pig raising areas, namely 38.1% and 35.7%. These findings indicate that MRSA is introduced into fattening farms with marketed young pigs. The carcasses of slaughtered pigs were contaminated with MRSA at a rate of about 20%, and fresh pig meat at a rate of 13.1%. The typing of MRSA isolates shows that *spa* types identified at primary production largely correspond to those found at the slaughterhouse, which indicates that the bacteria are transmitted from the animals to the carcasses in the course of food production. Bacterial isolates obtained from meat samples at retail level were partly of different clonal complexes. The fact that spa types frequently occurring in humans were also detected prompts there might be a secondary contamination of the meat, possibly by workers in food production.

*Yersinia enterocolitica*

*Yersinia enterocolitica* was detected in 2.7% of samples of conventionally produced pork. The detection rate in ecologically produced pork was only slightly lower, with 1.7%. The contamination rate of minced pork with *Yersinia enterocolitica* was 2.4% and comparable with that in fresh pork. Samples of spreadable raw pork sausages were positive with *Yersinia enterocolitica* at a rate of 0.3%. Most of the *Y. enterocolitica* isolates analysed had the virulence gene *ail* and the gene *vir*F, which are both important factors of pathogenicity. The detailed findings of the typing analyses of *Yersinia* isolates are to be found in the Annual Reports of the Zoonosis Monitoring of the respective years.

The findings confirm that sensitive consumer groups such as small children, elderly and immune-deficient people, or pregnant women, should not consume raw minced pork or spreadable raw pork sausages because these pose a risk of infection of humans with *Yersinia enterocolitica.*

*Clostridioides difficile*

In the years 2017 and 2018, samples of minced pork were found positive with *C. difficile* at rates of 1.4% and 0.7%, respectively, while there were no *C. difficile* findings in minced pork in the Zoonosis Monitoring of 2019. This shows that minced pork is a potential vehicle of transmission of *C. difficile* to humans. The four *C. difficile* isolates obtained from minced pork were toxinogenic and of ribotype 078, 001, and 126. Ribotype 078 was detected twice and is frequent in pigs. So it is conceivable that fattening pigs are at the source of this contamination. The importance of *C. difficile* strains in pigs as disease-causing pathogen in humans is object of current research activities.

ESBL/AmpC-forming *E. coli*

Using selective methods, ESBL/AmpC-forming E. coli was found in roughly half of the faecal samples of breeding sows (53.9% positive samples), young pigs (47.6% positive samples) and fattening pigs (45.6% positive samples), as well as in roughly half of the samples of caecal contents of fattening pigs at slaughter (46.3%, 47.0% and 49.1% positive samples in different years). The rate of detection of ESBL/AmpC-forming E. coli was a bit lower in the Zoonosis Monitoring of 2019, with 39.6% faecal samples of fattening pigs, than in 2017 (with 45.6% of such samples positive), but this was not a statistically significant difference. So we must state that there has been no progress in the past few years as regards the occurrence of these resistant germs in fattening pigs. Fresh pig meat had contamination rates with ESBL/AmpC-forming E. coli of 5.5% and 5.7%, respectively. Pig meat from ecological farming was positive with ESBL/AmpC-forming E. coli at a rate of 4.8%. So, unlike it was observed in turkey meat, there was no clear difference in contamination rates between meat from conventional and ecological production. We do not the reasons why there is no difference in contamination rates with ESBL/AmpC-forming E. coli in pig meat from different types of farming. More examinations should be performed at pig farms and slaughterhouses in order to investigate whether the present findings reflect the situation in pig stocks. As raw consumption of pork is to some extent customary, on has to reckon with potential transfer of cephalosporin-resistant E. coli from the meat to humans. But we cannot finally say yet how important this kind of exposure is with regard to health protection of consumers.

Carbapenemase-forming *E. coli*

Of the bacterial isolates sent in for suspected carbapenem resistance, the laboratory confirmed two isolates obtained from pigs' faeces at stock farms, one obtained from pigs' caecal contents at slaughter, and one originating from fresh pig meat as carbapenem-resistant E. coli, by phenotype.

**Food chain related with veal calves/young bovines and meat bovines**

*Salmonella* spp.

With 1.0% positive samples, *Salmonella* was rarely detected in veal calves and young bovines. Contamination rates of fresh meat of calves and young bovines, fresh beef and minced beef were also low and under 1%. The findings support the opinion that meat of this farm animal poses only a low risk of infection of humans with *Salmonella*. On the other hand, serovars identified in bovine meat included *S*. Thyphimurium, its monophasic variant, and *S.* Kentucky, all of which often appear as causal agents of infection in humans or display particularly high rates of resistance (*S*. Kentucky). This underlines the recommendation that raw minced beef (namely, tartar) should not be consumed by sensitive consumer groups such as small children, elderly and immune-deficient people, or pregnant women. The detailed results of typing analyses of Salmonella isolates can be found in the respective Annual Reports of the Zoonosis Monitoring.

*Campylobacter* spp.

In the Zoonosis Monitoring in 2012, analyses detected *Campylobacter* spp. in 31.7% of the samples of large intestinal contents of veal calves and young bovines. The detection rate in large intestinal contents of meat bovines ranged in the same order (36.6%). The *Campylobacter* found was mostly of the species *Campylobacter jejuni*. In the Zoonosis Monitoring of 2015, *Campylobacter* was detected nearly twice as often in veal calves and young bovines (64.2% positive samples of large intestinal contents). This sharp increase is possibly owing to the new ISO method introduced at that time for the detection of *Campylobacter* spp. In the 2019 monitoring, however, the detection rate markedly decreased again and was 49.4%. On carcasses of slaughtered bovines, *Campylobacter* was detected at a rate of 5.8%. In fresh veal and beef, the pathogen was detected only at very low rates (0.0 to 0.5% positive samples). So the findings confirm that veal calves, young bovines, and fattening bovines are a reservoir of *Campylobacter*, but that the slaughtering process at the same time seems to efficiently prevent the contamination of the meat with *Campylobacter* spp., as the meat is only very seldom contaminated. Yet, in

spite of the low contamination rate, bovine meat was repeatedly connected with food-borne *Campylobacter* outbreaks.

*Listeria monocytogenes*

*Listeria monocytogenes* was detected at a rate of 6.2% in large intestinal contents of beef bovines at slaughter. Samples of minced beef/tartar were found contaminated with *Listeria monocytogenes* at a rate of 11.2%. Quantifying measurements, however, did not produce any *L. m.* counts exceeding the critical level of 100 cfu/g in ready-to-eat foodstuffs defined by Regulation (EC) No 2073/2005 *on microbiological criteria for foodstuffs*. The maximum bacterial count was 35 cfu/g. Still, the findings show that tartar/minced beef is a potential source of human infection with *Listeria monocytogenes*, all the more as tartar is usually consumed raw, and it cannot be precluded that *Listeria* once present in the minced meat can grow. Sensitive consumer groups, namely small children, elderly and immune-deficient people, or pregnant women, should consume tartar/minced beef only after thorough cooking.

Shiga toxin-forming *Escherichia coli* (STEC)

Testing for presence of STEC in the food chain related with veal calves, veal calves/young bovines and meat bovines shows that animals are frequently colonised with STEC. STEC was detected at rates of 26.5% and 27.4%, respectively, in the faeces of veal calves and veal calves/young bovines in stock, which is roughly the same range as STEC findings in large intestines contents of veal calves and young bovines at slaughter, where detection rates were 24.0% and 25.9%, respectively. In the Zoonosis Monitoring of 2019, STEC was even detected at a rate of 43.2% in caecal contents of veal calves and young bovines, which is significantly more often than in the years before. Samples of large intestinal contents of meat bovines at slaughter were found positive with STEC at a rate of 11%, which is obviously less than the detection rate in large intestinal contents of veal calves and young bovines at slaughter (see above). STEC detection rates in faecal samples from beef cattle stocks were also lower than in faecal samples of veal calves and young bovines, with 18.5% and 22.6%. It should be investigated further in how far this reflects a decline in the colonisation with STEC depending on animals' age. We know from literature that STEC prevalence is often declining with animals' age. Though the data collected in cattle livestocks during the Zoonosis Monitoring of 2011 did not show a difference in STEC prevalence in faecal samples of animals of different age groups (≤ 8 months: 13% positive samples, 13-24 months: 14.2% positive samples), one has to bear in mind that the management of beef cattle and veal calves differs basically, in particular with regard to feeding. As a result, differences in the intestinal microbiota are likely. The

findings of tests at slaughter establishments show that carcasses can be contaminated with STEC during slaughter: carcasses of veal calves and young bovines were contaminated with STEC at a rate of 5.7%, thus again somewhat more often than carcasses of beef cattle (2.3% and 2.5% positive samples). The meat of calves and young bovines, with an STEC detection rate of 6.0%, was also, in the tendency, found slightly more contaminated than fresh meat of beef cattle (0.9% to 4.4% positive samples). Minced beef had an STEC detection rate of 3.8%, and samples of tartare/prepared minced beef a rate of 3.5%. This finding is particularly problematic because tartare/minced beef is customarily consumed raw. STEC types isolated both in the intestines and in the meat included such frequently causing EHEC disease in humans (namely, among others, O103, O91, O111, and O113). Detection of the *eae* gene – one of the main STEC virulence factors – in part of the isolates underlines the importance of veal calves, young bovines and bovines in general as a potential source of serious EHEC infections in humans. The detailed results of typing analyses of STEC isolates are to be found in the respective Annual Reports of the Zoonosis Monitoring. Sensitive consumer groups, namely small children, elderly and immune-deficient people, or pregnant women, are advised to refrain from consuming raw beef or derived raw sausage products. The meat should be thoroughly heated before consumption.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

MRSA was found in veal calves/young bovines at higher rates than in adult meat bovines at all stages of the food chain. Near to 20% of dust samples from primary holdings of veal calves or veal calves/young bovines were positive with MRSA. Holdings of adult fattening bovines, in contrast, had only 11% positive dust samples. Nasal swabs taken of veal calves/young bovines at the slaughterhouse were positive with MRSA at rates of 39.7% and 45.0%, while only about 8% of the adult meat bovines were colonised with MRSA. With 30.8% positive samples, carcasses of veal calves and young bovines were also clearly more often contaminated with MRSA than carcasses of adult meat bovines, which had 5.0% MRSA-positive samples. While meat of veal calves and young bovines was found contaminated with MRSA at a rate of 11%, contamination rates found in fresh beef of adult bovines were 5.5% and 8.1%. The MRSA contamination rate in tartare/minced beef was comparable with that in fresh beef, with 6.9% positive samples. The differences noted in the prevalence of MRSA in veal calves/young bovines and in adult meat bovines could be connected to those animal groups' different exposure to antibiotics. Age, too, might play a role, as one can assume that the date of last treatment with anti-microbial substances in adult bovines lies much farther back than the date of such treatment in calves/young bovines.

The isolates of MRSA detected in veal calves/young bovines and meat bovines were of the farm animal-associated clonal complex CC398. Isolates gained from meat sampled in retail trade also included such of other clonal complexes, which might have been introduced, to a certain degree, by employees along the food production chain. The majority of isolates from bovine meat, however, were *spa* types which are classified with the CC398 complex, so that we can assume that most of the MRSA is entered at the primary production level.

ESBL/AmpC-forming *E. coli*

ESBL/AmpC-forming *E. coli* was very frequently detected in caecal contents of veal calves/young bovines at the slaughterhouse. The detection rate was 70.8% in the Zoonosis Monitoring of 2019. This was still an increase over the year 2015, when the detection rate was 60.6%. So, there has been no improvement with regard to the prevalence of these resistant bacteria in veal calves and young bovines. Faecal samples collected from stocks of adult meat bovines were much less positive with ESBL/AmpC-forming *E. coli* than the caecal samples of calves and young bovines, with a positive rate of 17.7%. The frequent detection of ESBL/AmpC-forming *E. coli* in veal calves might be connected with the feeding of unmarketable milk – which includes such of dairy cows that underwent antimicrobial treatment – to the calves. Samples of fresh bovine meat were found positive with ESBL/AmpC-forming *E. coli* at rates between 3.4% and 4.4%. The findings underline the recommendation that sensitive consumer groups should refrain from consuming raw beef.

Carbapenemase-forming *E. coli*

Carbapenemase-forming *E. coli* was not detected in the food chains related with veal calves/young bovines and fattening bovines.

**Food chain related with dairy cattle**

*Salmonella* spp.

No *Salmonella* spp. was detected in bulk milk or certified raw milk examined in the framework of the Zoonosis Monitoring. This indicates that raw milk does not seem to play an important role as a source of human infections with Salmonella. Samples of slicing cheese from cow raw milk had a *Salmonella* spp. findings rate of 0.3%, though. However, the cheese might have been contaminated with Salmonella during processing or while in

retail. Raw milk cheese is therefore a potential source of human infection with Salmonella.

*Campylobacter* spp.

Samples of bulk milk from conventional dairy farms were detected with *Campylobacter* spp. at rates between 1.9% to 2.5%. Bulk milk from ecological farms was, with 1.0% positive samples, still more seldom contaminated with *Campylobacter* spp. The *Campylobacter* found in bulk milk was the species *Campylobacter jejuni*, exclusively. The findings confirm that raw milk is a possible source of transmission of *Campylobacter* spp. to humans. Consumers should therefore strictly adhere to the recommendation to cook milk which is sold directly at the farm. In contrast to that, no *Campylobacter* was found in samples of certified raw milk, which is a sign that the hygienic requirements applicable to the production, treatment, and sale of certified raw milk efficiently provide against the contamination of milk with *Campylobacter* spp. Sensitive consumer groups should nevertheless refrain from consuming certified raw milk for reasons of preventive consumer protection, as that milk is intended for raw consumption without prior cooking, and it cannot be finally precluded that the milk is contaminated with pathogens.

*Listeria monocytogenes*

*Listeria monocytogenes* was found in bulk milk samples from conventional dairy cattle farms at rates between 3.0% and 4.6%. Bulk milk from ecological farms was, with 1.3% positive samples, a bit less contaminated with *Listeria monocytogenes*. We do not know the cause of this finding. Samples of certified raw milk had no findings of Listeria monocytogenes, in contrast. As there were no quantitative measurements, we cannot say whether bulk milk has *Listeria monocytogenes* counts which would be alarming in terms of consumers' health if the milk was consumed raw (bacterial counts higher than 100 cfu/g). On principle, milk which is sold to consumers in Germany is heat-treated, in order to effectively kill the pathogen. But in fact, raw milk harbours a health risk when there is no heat treatment, namely, in the manufacture of raw milk cheese or other raw milk products. This was also demonstrated by some findings raised in the framework of the Zoonosis Monitoring, namely, by findings in soft cheese from raw milk of cows, where some single samples were detected with high counts of *Listeria monocytogenes* (the highest being $6.2 \times 10^3$ cfu/g), which is a potential health risk to humans.
Slicing cheese from cow raw milk had a positive rate of 0.3% with *Listeria monocytogenes*. Though none of those samples had bacterial counts higher than the detection limit of the quantitative method, the present bacteria may grow over a longer period of storage. Apart from that, *Listeria monocytogenes* which is carried into food-

processing plants with raw milk, may re-contaminate food products which have been heat-treated before. Samples of soft cheese and semi-soft slicing cheese of heat-treated cow milk did not have any findings of *Listeria monocytogenes* in the Zoonosis Monitoring, however. The results of the monitoring examinations confirm that one has to take into account that *Listeria monocytogenes* may be entered into the food chain with raw milk. It is advised that sensitive consumer groups, namely small children, elderly and immune-suppressed people, or pregnant women, should not consume raw milk products.

Shiga-Toxin bildende *Escherichia coli* (STEC)

STEC was found in bulk milk samples from dairy cow farms obviously more frequently in the Zoonosis Monitoring of 2019 than in the 2010 programme, with 4.9% positive samples in 2019 versus 1.4% positive samples in 2010. When dairy cow farms were examined separately, the bulk milk of ecological farms was found somewhat less frequently contaminated with STEC (2.0% positive samples) than bulk milk of conventional farms, which had 3.6% STEC-positive samples. We do not know what this fact is attributable to. Certified raw milk had no STEC findings. The detection rate in both raw-milk soft cheese/semi-hard slicing cheese and in slicing cheese from raw milk was 0.6%. The findings show that raw milk that has not been heat-treated and raw milk products pose a risk for humans of infection with STEC. This all the more as the STEC isolates particularly often had the *eae* gene and partly belonged to O groups that are often found in humans with EHEC disease (O103) and with haemolytic uremic syndrome (O177). The detailed results of typing of STEC isolates can be found in the relevant Annual Reports on the Zoonosis Monitoring.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

MRSA was found in bulk milk samples of dairy cattle farms at rates between 4.7% and 7.7%. It was striking that, when farms were examined separately by type of management, the bulk milk of conventional farms was contaminated with MRSA to a significantly higher degree (9.7% positive samples) than bulk milk from ecological farms, which had 1.7% MRSA-positive samples. This conspicuous finding possibly reflects differences in antibiotic treatment of animals under conventional or ecological management, or other differences in the way of livestock management (stock size, regional distribution, origin of animals). These parameters were not recorded in the framework of the Zoonosis Monitoring, however. Detection of MRSA in certified raw milk (10% positive samples) shows that MRSA also occurs in establishments subject to particularly strict hygiene rules. Soft cheese and semi-hard slicing cheese from raw milk had 1.6% MRSA-positive samples. MRSA isolates obtained from bulk milk were in the majority of the farm animal-

associated clonal complex CC398. Whether MRSA can be transmitted to humans by consumption of raw milk has not been clarified.

ESBL/AmpC-forming *E. coli*

ESBL/AmpC-forming *E. coli* was found in 10.1% of bulk milk samples from dairy farms. The findings underline the necessity of thoroughly heating raw milk before consumption, as this will safely kill resistant bacteria. Otherwise, consumption of raw milk may result in transmission of ESBL/AmpC-forming *E. coli* to humans. However, it cannot yet be finally assessed how important that exposure is in terms of health protection of consumers.

**Food chain related to milk sheep and milk goat**

*Salmonella* spp.

Sheep or goat bulk milk samples taken at primary farm level had no *Salmonella* findings. Samples of cheese of raw milk of sheep or goat, in contrast, had 0.3% Salmonella findings. Here it cannot be excluded that the cheese might have been contaminated with *Salmonella* by a secondary source during processing or trade. The findings correspond with those in bulk milk and raw milk cheese of dairy cows and show that raw milk cheese from sheep and goat, too, are a potential vehicle of infection of humans with Salmonella.

*Campylobacter* spp.

*Campylobacter* spp. was found 1.0% in bulk milk of sheep or goat at farm level. This rate is in a roughly similar range with findings in bulk milk of cows and makes clear that raw milk of sheep and goat must be taken into account as source of human infection with *Campylobacter*.

*Listeria monocytogenes*

Bulk milk samples drawn at sheep and goat dairy farms were positive with Listeria *monocytogenes* at a rate of 1.9%. As there were no quantitative analyses, we cannot say whether the bulk milk contains *Listeria monocytogenes* counts that would be risky to consumers' health (bacterial counts >100 cfu/g), if the milk was consumed raw. On principle, milk which is sold to consumers in Germany is heat-treated before, so that the pathogen is killed effectively. But contaminated raw milk poses a health risk when raw milk cheese or other raw milk products are manufactured. This was also demonstrated by findings raised in the framework of the Zoonosis Monitoring, as some single samples of raw milk cheese of sheep or goat milk were detected with *Listeria monocytogenes* (0.3% positive samples). One finding was a bacterial count of 570 cfu/g, which is a potential

health risk to humans. Apart from that, *Listeria monocytogenes* may re-contaminate food products which have already been heat-treated when it is carried into food-processing plants with raw milk. The results of the monitoring analyses make clear that sensitive consumer groups, namely small children, elderly and immune-suppressed people, or pregnant women, should not consume non-heat-treated raw milk or raw milk cheese from sheep of goat milk, either.

Shiga toxin-forming *Escherichia coli* (STEC)

STEC was found in sheep or goat bulk milk samples drawn at dairy farm level at a rate of 7.3%, which means that the milk was significantly more often contaminated than bulk milk of cattle dairy farms (see above). What this difference is attributable to is not known. The detection rate of STEC in raw milk cheese of sheep and goat was 0.7%, which roughly corresponds to that in soft cheese and semi-soft slicing cheese from raw milk of cows. The findings confirm that non-heat-treated raw milk and raw milk products of sheep and goat also harbour a risk of human infection with STEC. This all the more as the STEC isolates included serogroups known to frequently cause EHEC disease in humans (O26, O76 and O146) and haemolytic uremic syndrome (O26), part of which also carried the *eae* gene as an important factor of virulence. The detailed results of STEC isolate typing analyses are to be found in the respective Annual Reports of the Zoonosis Monitoring.

Coagulase-positive *Staphylococcus*

Coagulase-positive *Staphylococcus* was detected by quantitative method in 9.3% samples of cheese of sheep or goat raw milk. 1.9% samples showed bacterial counts higher than the critical level of 10,000 cfu/g, at which a food business operator has to take measures to improve the hygiene of production and selection of raw materials, according to valid EU legislation. 1.2% samples even had *Staphylococcus* counts higher than 100,000 cfu/g. In such cases, the cheese may only be marketed if there is analytical proof that the product is free of *Staphylococcus* enterotoxin. So, the findings show that the market offer may include, in some very single cases, sheep or goat raw milk cheese which is risky from a hygienic point of view. This is true in particular when the *Staphylococcus* strains present are such forming enterotoxins. The findings make clear that in raw milk production, highest standards must be applied to udder health of milk-delivering animals, and strict personal and manufacturing hygiene must be observed, because *Staphylococcus* present in the raw milk may grow and develop into alarmingly high bacterial counts during the cheese ripening process.

**Food chain related to wild boar**

*Salmonella* spp.

Faecal samples of wild boar had 2.4% *Salmonella* findings. Serovars identified included *S.* Enteritidis and *S.* Typhimurium, which are also important in human infections. It was conspicuous that findings occurred only in adult animals. Also, wild boar were obviously more seldom *Salmonella*-positive than fattening pigs which carried Salmonella between 6% and 9%. On the other hand, fresh meat of boar was more often contaminated with *Salmonella* (3.4% positive samples) than fresh meat of farm pigs (0.4% positive samples). This is a sign of hygienic deficiencies in the processes of obtaining wild boar meat, probably in particular with regard to the conditions of hunting. Hunting brings about an increased risk of contamination with germs, for instance, by shot injuries of the digestive tract, a lower degree of bleeding compared to slaughtered animals, and delayed evisceration of game carcasses. As meat samples were examined differentiating by paths of distribution of the meat, hygienic deficiencies in game processing establishments became prominent, because wild boar meat which entered retail via game processing establishments was found contaminated with *Salmonella* at a rate of 4.7%, and thus more often than directly marketed wild boar meat, which had a *Salmonella* positive rate of 0.8% only. Although this difference was not statistically significant, the typing of *Salmonella* isolates from wild boar meat produced a strikingly high degree of heterogeneity of serovars, implicating that the meat was contaminated with *Salmonella* from multiple sources during production and processing. In order to prevent transmission of zoonotic agents to game meat a particularly strict hygiene regiment must be followed when obtaining, processing, and marketing game meat. The findings give evidence that fresh meat of wild boar is a potential source of human infection with *Salmonella*.

Shiga toxin-forming *Escherichia coli* (STEC)

STEC was found in 6.9% in faecal samples of wild boar. This shows that wild boar, too, are a reservoir of STEC. STEC isolates included O groups (O26, O157, O128 and O146) which are known to be a frequent cause of EHEC infections and haemolytic uraemic syndrome in humans, and which partly carried both the *eae* gene and the *stx2* and *e-hly* gene, showing them to be pathogenic in humans. As contamination of the meat with STEC by intestinal contents cannot be precluded when the meat is obtained by game hunting, the present findings underline the recommendation that meat of wild boar should only be consumed after thorough cooking.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

Nose swabs of wild boar did not deliver any findings of MRSA, so that wild boar does not seem to be an important reservoir of MRSA. Fresh boar meat was MRSA-positive at a rate of 4.8%. MRSA isolates sent in for typing, however, included a particularly large portion of human-associated, non-CC398 types, which were obviously transmitted to the meat while obtaining and processing it.

*Alaria alata* mesocercariae

Mesocercariae of *Alaria alata* were detected in 4.7% of all samples taken from wild boar. Those *Laender* (Germany's states) that examined larger numbers of samples found *Alaria alata* mesocercariae at rates between 0.0% and 8.4%. The findings show that wild boar meat is a potential source of human infection with that parasite. However so far, only few cases of disease in humans, including respiratory disorders, have been reported in Northern America after consumption of parasitized game meat which had not been thoroughly heated. The findings underline the recommendation that wild boar meat should be thoroughly cooked before consumption. Wild boar meat which is infected with *Alaria alata* mesocercariae should not be placed on the market, for reasons of preventive health protection of consumers.

ESBL/AmpC-forming *E. coli*

ESBL/Amp'C-forming E. coli was found in 6.4% of wild boar faecal samples. So the findings show that ESBL/AmpC-forming E. coli also occurs apart from farm animal holdings, in the environment. Deliberating possible sources of wild boar exposure to ESBL/Amp'C-forming E. coli, community sewage water cones into consideration, besides farm animal holdings. This question needs detailed, regional investigations in future.

**Food chain related with ruminant game**

*Salmonella* spp.

Meat of ruminant game seems to be of minor importance as a source of human infection with *Salmonella* spp., as Salmonella findings were extremely rare in meat samples drawn at retail level (2012: 0.0%; 2017: 0.8% positive samples). The Salmonella found in the 2017 monitoring programme were mainly *S*. Enteritidis, a serovar which mainly occurs in laying hens. We do not know the source of the Salmonella in ruminant game meat, because the animals were not actually examined for *Salmonella* in the framework of the Zoonosis Monitoring. So, the source might be both the actual wild animal population, but contamination during processing is also conceivable.

*Campylobacter* spp.

Roe rarely carried *Campylobacter* spp. and had only 0.8% positive faecal samples. It cannot be completely excluded, however, that the bacteria were just difficult to detect in the roe faeces, because roe faeces has low water content and the bacteria are highly sensitive to dehydration. On the other hand, meat of ruminant game had also very low *Campylobacter* contamination rates, with 0.5% and 0.8% findings in 2012 und 2017, so that ruminant game meat does not seem to pose a notable risk of human infection with *Campylobacter*.

Shiga-Toxin bildende *Escherichia coli* (STEC)

With 40.2% positive samples, roes were frequently found colonised with STEC. The detection rate of STEC in fresh ruminant game meat was 16.1% in the Zoonosis Monitoring of 2012, and nearly double in 2017, with 29.8% STEC-positive samples. For comparison, STEC detection rates in fresh beef varied only between 0.9% and 4.4%, although a considerable portion of fattening bovines tested were also colonised with STEC (about 20% positive faecal samples and 11.0% positive samples of contents of large intestines). Higher contamination rates of wild game meat compared to meat of farm animals are likely attributable to the particular conditions of obtaining wild game meat, which are accompanied by an enhanced risk of contamination with germs compared to the slaughtering process (injuries of the digestive tract through shots, less bleeding of the game carcass compared to the slaughter carcass, and delayed evisceration of the game). This would also provide an explanation for the in tendency higher contamination rate in hunted ruminant game meat (29.8%) compared to farmed game meat (18.1%) in the Zoonosis Monitoring of 2017, as the meat of farmed game is also obtained under controllable conditions and therefore exposed to a lower contamination risk. Apart from that, the higher contamination rate found in the 2012 Zoonosis Monitoring in hunted ruminant game meat which was distributed in retail by game processing establishments (17.2% STEC-positive samples) in contrast to hunted ruminant game meat on direct sale (10.8% STEC-positive samples) indicates that there are hygienic deficiencies in game processing plants. In order o prevent transmission of zoonotic agents to game carcasses, and thus to the meat, a particularly strict hygiene regiment must be followed when obtaining and further processing and marketing game meat. The findings show that the meat of ruminant game poses a risk human infection with STEC. At the same time, the results of typing analyses are an indication that the STEC population detected in game meat is different from that in veal calves and young bovines, that is, the animal groups are likely separate reservoirs. The dominating STEC serovar in ruminant game meat was O group 146, which is also quite frequently found in

humans diseased with EHEC. It was conspicuous that this sero-group was rarely detected in roe faeces, so that the bacteria might not actually be sourced in the animal. Further molecular biological investigations are required in order to identify possible sources of contamination. The *eae* gene was found only seldom, overall.

ESBL/AmpC-forming *E. coli*

With 2.3% positive faecal samples, roes were comparatively rare carriers of ESBL/AmpC-forming *E. coli*. This should reflect their low degree of exposure to antibiotics. The relatively high contamination rate of ruminant game meat (4.5% samples positive with ESBL/AmpC-forming *E. coli*) on the other hand, indicates in turn possible hygiene deficiencies in the production of that meat.

Carbapenemase-forming *E. coli*

There were no findings of carbapenemase-forming *E. coli* in the ruminant game meat samples tested.

**Wild ducks and wild geese**

*Salmonella* spp.

There were no Salmonella findings in faeces of wild ducks and geese, saying these birds do not seem to present an important reservoir of *Salmonella* spp. It cannot be fully excluded, however, that the amount of sampling material which is taken with a swab test might be too small to safely detect eventually present Salmonella.

*Campylobacter* spp.

There were no findings of Campylobacter spp. in swabs of faeces of wild ducks and geese, although we would have expected such findings, Campylobacter being a commensal bacterium in poultry. One reason why detection of Campylobacter failed might have been that the bacterium was no longer detectable, that is cultivable, in the faecal swabs because of their high susceptibility to dehydration.

Shiga toxin-forming *Escherichia coli* (STEC)

Wild ducks and geese do not seem to be an important STEC reservoir, as they were not found in any of the faecal samples analysed.

ESBL/AmpC-forming *E. coli*

Using selective methods, ESBL/AmpC-forming E. coli were detected at a rate of 9.8% in faecal swabs of wild ducks and wild geese. This rate is higher than findings in faeces of roes (2.3% positive samples) and faeces of wild boar (6.4% positive samples). So the findings show that wild ducks and geese contribute to spreading these bacteria. The present data do not allow to answer the question whether colonisation with ESBL/AmpC-forming E. coli results from an entry from farm animal holding or possibly from other sources. This question requires more detailed molecular biological investigations.

**Fish and fishery products**

**Imported fish from aquaculture (tilapia and pangasius)**

*Salmonella* spp.

Imported aquacultural fish had 1.0% Salmonella-positive samples. It therefore presents a potential source of infection for humans and should only be consumed after thorough cooking. The serovars identified in the samples (*S*. Bareilly, *S*.Braenderup and *S*. Potsdam) play only a minor role in human infections with Salmonella, however. The present data do not allow to identify the source of the serovars found in imported fish samples. Detailed results of typing analyses of the Salmonella isolates can be taken from the 2019 Annual Report of the Zoonosis Monitoring.

*Listeria monocytogenes*

Imported aquafarmed fish (tilapia and pangasius) was frequently found contaminated with *Listeria monocytogenes*, with 33.1% samples found positive. So basically, imported aquafarmed fish presents a risk of infection with this pathogen to humans. Although one has to bear in mind that aquafarmed fish is not ready-to-eat and is usually subject to a heat-treatment before consumption, there is a danger of other foods, including ready-to-eat like salads, being cross-contaminated when the fish is handled with insufficient kitchen hygiene. Apart from that, Listeria monocytogenes might be introduced with the fish in fish-processing plants and might lead to recontamination of other, readily heat-treated, ready-to-eat products there. It is therefore important to prevent entry of Listeria monocytogenes in fish-processing plants with raw fish, and to observe good kitchen hygiene when preparing fish.

Methicillin-resistant *Staphylococcus aureus* (MRSA)

With 29.1% positive samples, imported aquafarmed fish was found frequently contaminated with MRSA. However, the resistance patterns and *spa* types (many non-CC398 types) differed from farm animal-associated MRSA. The *spa* type most frequently detected was t189, which is spread in humans in Asia. We do not know how these bacteria enter the food chain, and whether they might be detectable already in fisheries. However, the monitoring findings indicate that MRSA strains which have not been inherent in Europe so far, may be introduced with imported fish.

*Vibrio* spp.

With 2.3% positive samples, findings of *Vibrio* spp. were relatively rare in imported fish grown in aquaculture. Anyhow, a high detection rate was not to be expected, given that tilapia and pangasius are freshwater fish, while *Vibrio* spp. primarily occur in saltwater. The isolates represented the non-toxin-forming type of *Vibrio cholera* (non-O1/non-O139) and *Vibrio metschnikovii*, a species which is rarely connected with human diseases.

ESBL/AmpC-forming *E. coli*

Imported, aquafarmed fish was found contaminated with ESBL/AmpC-forming *E. coli* at a rate of 3.0%. This relatively low detection rate of ESBL/AmpC-forming *E. coli* in the samples is probably attributable to the fact that third-generation cephalosporins are not among the antibiotics frequently used in aquafarming.

**Smoked fish or graved fish**

*Listeria monocytogenes*

In samples of ready-packed smoked fish and graved fish, Listeria monocytogenes was found at a rate of 6.1% at the time directly after sampling, and 8.0% at the end of the best-before date. Two samples (0.4%) were already found with *L. m.* counts higher than the critical value of 100 cfu/g, namely, with 300 and 600 cfu/g, directly after sampling. The highest bacterial count of Listeria monocytogenes found was in a fish sample at the end of the best-before date ($6.4 \times 10^4$ cfu/g). The findings show that ready-packed smoked or graved fish can lead to consumer exposure to Listeria monocytogenes at bacterial concentrations which represent a potential health risk. Vulnerable consumer groups, such as, elderly and immunosuppressed people and pregnant women, should therefore refrain from eating smoked or graved fish sold in ready packs. Presence of *Listeria monocytogenes* in the samples might be attributable to the fact that the pathogen was not safely destroyed during the food manufacturing process, or to possible recontamination of actually ready-to-eat product after the primary process.

**Raw shrimp and prawn**

*Salmonella* spp.

Raw shrimp and prawn sold on retail had 0.5% positive samples and are a potential source of human infection with Salmonella, all the more as the usual, short boiling time of shrimps and prawns does not necessarily make sure that the temperatures reached are sufficient to safely kill the pathogenic germs. Persons with limited immune competence (small children, elderly and immunosuppressed people, or pregnant women) should eat shrimps or prawns only after thorough cooking. The Salmonella identified included the serovar S. Enteritidis, which is relevant in human infections. The results of typing analyses of Salmonella isolates are to be found in detail in the Annual Report of the 2015 Zoonosis Monitoring.

*Listeria monocytogenes*

*Listeria monocytogenes* was detected in 2.2% of raw shrimp and prawn sampled at retail level. As no quantitative analyses were made, it cannot be judged whether *L. m.* were present at quantitative levels posing a potential health risk to humans. Still, the rate of findings underlines that people with limited immune competence should eat shrimps and prawns only after sufficient cooking in order to kill pathogenic germs. Apart from that, good kitchen hygiene should be observed when handling shrimps and prawns in order to avoid cross-contamination of ready-to-eat food, such as salad.

*Campylobacter* spp.

None of the samples of raw shrimp and prawn drawn at retail level was detected with *Campylobacter* spp. This means we cannot derive a risk of human infection with *Campylobacter* spp. from eating raw shrimps or prawns.

Coagulase-positive *Staphylococcus*

Coagulase-positive *Staphylococcus* was detected by quantitative method in 3.7% of samples of raw shrimp and prawn. The highest germ count found was 1,300 cfu/g. the findings show that raw shrimp and prawn may contain, in single cases, coagulase-positive *Staphylococcus* at counts higher than the guidance limit of 1,000 cfu/g recommended by the International Commission on Microbiological Specifications for Foods (ICMSF).

ESBL/AmpC-forming *E. coli*

ESBL/AmpC-forming *E. coli* were detected at a rate of 3.1% in samples of raw shrimp and prawn. This underlines the recommendation that vulnerable consumer groups should eat raw shrimp or prawn only after sufficient cooking.

**Vegetable foods and mushrooms**

*Salmonella* spp.

1.6% of the samples of dried mushrooms were contaminated with *Salmonella*. The way of preparation recommended for dried mushrooms – soaking the mushrooms in warm, not boiling water – promotes the growth of present *Salmonella*, which increases the risk of infection of humans when eating the mushrooms. Food business operators should take account of this risk, for instance by labelling cooking recommendations and/or enhancing operative self-checks.

Cut, ready-packed leaf lettuce and fresh herbs sampled at retail level both had 0.3% samples positive with *Salmonella*, and fresh sprouts 0.8% positive samples, showing those foods are potential sources of infection of humans with *Salmonella* – all the more as these foods are normally consumed raw, without any prior control of bacteria by heat. The findings strengthen the recommendation to thoroughly wash fresh herbs, lettuce, and sprouts before consumption, in order to reduce possible contamination with germs. Fresh sprouts being particularly susceptible to contamination with germs owing to the way of cultivation, vulnerable consumer groups such as small children, elderly and immune-suppressed people, or pregnant women, are advised to refrain from consuming raw sprouts. This recommendation is underlined by the fact that the *Salmonella* detected in fresh sprouts included *S*. Typhimurium, which is one of the most frequent causal agents of salmonellosis in humans. The other Salmonella serovars identified in the vegetal foods under examination are of minor importance in human infections (*S*. subsp. IV and *S*. Berta). The detailed results of typing analyses of *Salmonella* isolates are to be found in the respective Annual Reports of the Zoonosis Monitoring.

*Salmonella* was not found in samples of whole leaf and head lettuce, fresh strawberries, tomatoes, deep-frozen parsley, and fresh baby spinach. So these foods seem to be of minor importance as potential sources of human infection with *Salmonella* in Germany. Untreated sesame seeds sampled at retail also had no findings of Salmonella, but here we cannot exclude that in fact, positive batches of sesame seeds might not have been detected as such because of low bacterial counts and unequal distribution of present

bacteria in the lot. It may be that larger sample amounts are needed in order to safely detect *Salmonella* in sesame seeds, because we understand that sesame seeds were repeatedly at the source of food-borne outbreaks of salmonellosis in humans.

*Campylobacter* spp.

Only one sample (0.3%) of fresh strawberries sampled at primary farm level was positive with Campylobacter spp. In samples drawn at retail level, however, this zoonotic pathogen was not found in fresh strawberries. This indicates that fresh strawberries pose only a low risk of human infection with Campylobacter spp. However, detection of Campylobacter in strawberries sampled at farming level underlines the recommendation that fresh fruit should always be thoroughly washed before consumption.

*Listeria monocytogenes*

*Listeria monocytogenes* was found both in whole leaf and head lettuce sampled at primary farm level (3.7% positive samples) and retail level (2.6% positive samples), and in cut, ready-packed leaf lettuces sampled at retail (2.0% positive samples). Fresh sprouts sampled at retail were found contaminated with *Listeria monocytogenes* at a rate of 1.8%, and deep-frozen parsley at 1.3%. Fresh strawberries – which were analysed solely by qualitative method – were found contaminated with *L. m.* at a rate of 1%, both in samples taken at primary farm level and in retail shops. The bacterial counts were low in the lettuce samples (<100 cfu/g), and below the quantitative determination limit in sprouts and deep-frozen parsley. With this amount, they usually do not present a health risk to humans. Still, the humid environment in film-packed, cut lettuce mixtures and ready-packed fresh sprouts may promote the growth of present Listeria, which is why cut, packed lettuce mixture and ready-packed fresh sprouts are no suitable foods for people with an enhanced disease risk of listeriosis, namely, elderly and immune-deficient people and pregnant women).

Apart from that, the findings strengthen the recommendation that fruit and vegetables should thoroughly washed before consumption, in order to reduce contamination with germs. This is particularly important as these foods are often consumed raw, that is, germs are not killed by any process before consumption.

*Listeria mon0ocytogenes* was not detected in tomatoes nor in samples of sliced, vegetarian sausage. So, we cannot derive an infection risk for humans with *L. m.* from vegetarian, sliced sausage or tomatoes.

Shiga toxin-forming *Escherichia coli* (STEC)

STEC was not detected in leaf and head lettuce sampled at retail level, but in 1.3% leaf and head lettuce samples taken at primary farm level. There were also findings in 0.3% deep-frozen parsley samples and 1.2% baby spinach samples taken at retail level. This means these vegetal foodstuffs are a potential source of human infection with STEC – in particular, as they are often consumed raw or without thorough cooking – and should be thoroughly washed before consumption, in order to reduce possible contamination with germs. Apart from that, raw parsley should not be used as an ingredient in dishes intended or vulnerable consumer groups.

The relevance of vegetal foodstuffs as a source of human EHEC infections is underlined by the fact that STEC isolates obtained from baby spinach included the worldwide most important STEC sero-group O157, which, on top of that, also carried the *eae* gene. While STEC was not detected in samples of cut, ready-packed leaf lettuces, fresh strawberries, fresh herbs, tomatoes, and untreated sesame seeds drawn at retail level, the lack of findings in a food is no warranty that this food could not be a source of infection of humans with STEC. STEC was also not fond in samples of fresh sprouts. However, consumption of raw sprouts being a proven source of human STEC infections, vulnerable consumer groups, namely, small children, elderly and immune-suppressed people, or pregnant women, should refrain from eating raw sprouts, and eat sprouts only after sufficient cooking.

*Hepatovirus A*

Deep-frozen raspberries were examined for *Hepatovirus A*, but none was found. Examination for *Hepatovirus A* consists in complicated molecular biological analyses, however, and may not always be successful in detecting the virus. A false negative result cannot be precluded. Deep-frozen berries being a proven source of hepatitis-A disease outbreaks, such berries should be thoroughly heated before vulnerable consumer groups may eat them. In order to better be able to assess the role of berries as a possible source of infection with viruses, there should be risk-oriented sampling with clearly enhanced sampling volume, where relevant.

Norovirus

One sample (0.2%) of deep-frozen raspberries was detected with noroviruses. This confirmed the fact that deep-frozen raspberries are a potential source of human infections with norovirus, in particular because the berries are often eaten without prior heating. The finding underlines the importance of observing good hygienic practice when growing, harvesting, and processing berries.

Presumptive *Bacillus cereus*

Presumptive *Bacillus cereus* were found in 28.4% of tomato samples and 8.3% samples of fresh sprouts. Nearly all isolates of presumptive *Bacillus cereus* obtained from tomatoes were of the species Bacillus thuringiensis, which has so far hardly been connected with human disease. Among the isolates obtained from sprouts, there was no *Bacillus thuringiensis*, on the other hand. The findings have confirmed that bacteria of the *Bacillus cereus* group can occur in tomatoes or sprouts. In order to better be able to assess the potential health risk emanating from foodstuffs contaminated with this bacterial species, future monitoring programmes should also measure the bacterial count of presumptive *Bacillus cereus*.

Commensal *E. coli*

Commensal *E. coli* were detected by quantitative method in about 4-5% of leaf and head lettuce samples drawn at primary farming level as well as in samples of cut and packed leaf lettuces, fresh herbs, and fresh sprouts taken at retail levels. Samples of whole leaf and head lettuce drawn at retail level were found contaminated with commensal *E. coli* at a rate of 1.1%. In all four product categories, some single samples were found with bacterial counts higher than the limit of 1000 cfu/g applicable to the manufacturing process of cut, ready-to-eat vegetables. This indicates hygienic deficiencies in the manufacturing process. The findings show how important it is to wash such vegetables thoroughly under running water before consumption, and to store prepared salad cool in order to prevent bacterial growth. I contrast to that, there were no quantifiable findings of commensal *E. coli* in fresh strawberries and deep-frozen raspberries. This speaks for a generally satisfactory hygienic quality of fresh strawberries and deep-frozen raspberries, as commensal *E. coli* is considered to be an indicator of faecal contamination.

ESBL/AmpC-forming *E. coli*

ESBL/AmpC-forming *E. coli* was found at a rate of about 2% each in samples of fresh herbs, cut and packed leaf salads, and fresh sprouts. Detection of ESBL/AmpC-forming *E. coli* in these foods is important with a view to health protection of consumers in so far as the foods are mostly consumed raw, which means consumers may be directly exposed to the resistant germs. Tomatoes and deep-frozen raspberries, on the other hand, had no findings of ESBL/AmpC-forming *E. coli,* which corresponds with the absence of findings of commensal *E. coli* in deep-frozen raspberry samples.

**Roundup**

The Zoonoses Monitoring programmes of the years 2010 to 2019 raised representative data on the prevalence of food-associated zoonotic pathogens in animals, foodstuffs, and feeds allowing us to draw conclusions about consumers' risk of infection through consumption of foodstuffs. The programmes annually vary the focus on certain food chains, and the most important food-delivering animals and relevant food chains were repeatedly considered over the past ten years. Continual examinations in the framework of the Zoonosis Monitoring allow recognising trends and developments in the spread of zoonotic agents in animals and foodstuffs. The findings show that livestock animals are a reservoir of various zoonotic agents, and that slaughter can result in contamination of carcasses with zoonotic agents. In order to prevent the entry of pathogens in the food chain, and reduce contaminations, good hygiene practises must be followed at all stages of the food chain, from primary production over further processing to the final distribution to consumers.

The result of examinations in the **food chain related to laying hens** shows that the shells of eggs placed in retail is contaminated with *Salmonella* spp. and *Campylobacter* spp. at a low rate. When cracking eggs while preparing dishes containing raw egg, one should take care that the egg content has as little contact with the shell as possible, in order not to contaminate the dish. Vulnerable consumer groups, such as elderly and immune-deficient people or pregnant Women should not eat dishes containing raw egg.

Test results in the **food chains related to broilers and turkeys** show that the slaughter process in poultry promotes contamination of carcasses with zoonotic agents more than in other kinds of livestock, so that still more efforts must be made to improve poultry slaughter hygiene. There are obvious differences among slaughterhouses as regards their success in controlling cross-contamination with zoonotic pathogens. That is why one should consider to place the focus of future contamination minimisation strategies on comparing different slaughterhouses, in order to identify the specific measures suitable to reduce the contamination of carcasses.

Salmonella control measures in poultry flocks led to a decrease in *Salmonella* detection rates in the food chains related to broilers and fattening turkeys in the past. But the contamination of poultry carcasses and poultry meat with *Salmonella* has not further declined since 2014. While *Salmonella* detection rates in the broilers food chain have remained roughly the same over the last few years, the detection rate in turkey carcasses

has even increased clearly. This is alarming, in particular as turkey carcasses are often detected with *S.* Typhimurium, which is one of the serovars most frequently causing infections in humans. In view of the fact that proportions of positive samples vary widely, slaughter houses should be reminded to strictly observe process hygiene criteria for Salmonella on broiler and turkey carcasses according to Regulation (EC) No. 2073/2005. If the criteria are not met, relevant measures should be initiated.

The findings of the Zoonosis Monitoring also show that there has been no progress in reducing *Campylobacter* spp. in the broilers food chain. Continuous testing in the framework of the Zoonosis Monitoring will show in how far the process hygiene criterion for *Campylobacter* spp. on broiler carcasses introduced recently will now lead to improvement. At the same time, the findings underline the need for consistent education of consumers about the risks associated with fresh poultry meat, because *Campylobacter* will stay a relatively frequent finding on raw broiler and turkey meat, even if the situation of contamination is considerably improved.

The results of testing in the **food chain related with fattening pigs** show that the entry of *Salmonella* in slaughter establishments through *Salmonella*-positive pigs has not changed over the past few years, and that contamination rates of carcasses and meat have remained roughly the same. In order to prevent contamination of carcasses, and thereby the meat, with *Salmonella*, it is important to reduce pigs' colonisation with *Salmonella* by intensive control measures at farm level. These should begin at the level of breeding farms, in order to prevent entry of Salmonella in fattening farms via infected piglets. In spite of the relatively low contamination rate, fresh pig meat is an important source of human infection with *Salmonella* because of partly common raw consumption of pork, such as, in the form of *Mett*.

The findings have also confirmed that **veal calves/young bovines and fattening bovines** are frequent carriers of STEC, and that the meat can be contaminated with STEC in the course of meat production. STEC isolates, both originating from intestinal contents and from meat, included such which are often causal agents of EHEC disease in humans. Vulnerable consumer groups, such as elderly and immune-deficient people and pregnant women, are advised not to consume raw bovine meat or sausages derived therefrom.

The higher contamination rates of **meat of wild ruminant game** with STEC and **wild boar meat** with *Salmonella*, compared to the meat of farm animals, is probably

attributable with the less controllable conditions of obtaining wild game meat. The test results make clear that existing hygiene requirements must be better observed, in order to prevent cross-contamination of the meat with zoonotic pathogens from the intestines of the wild animals.

Results of examinations of bulk milk sampled at dairy farms have confirmed that raw milk may harbour risks of infection of humans with STEC, *Campylobacter* spp., and Listeria monocytogenes, which is why consumers should heat milk before consumption, on principle. *Salmonella* was not found in these tests in raw milk. A health risk may emanate from raw milk products which do not undergo a heating process during production, such as raw milk cheese. Samples of raw milk cheese, both from cow and sheep and goat, have been detected with *Salmonella* spp., STEC, and Listeria monocytogenes. Some single samples were found with high bacterial counts representing a potential health risk to humans. The findings illustrate that sensitive consumer groups, such as small children, elderly and immune-deficient people, as well as pregnant women, should not eat raw milk cheese.

*Listeria monocytogenes* findings occurred also in **smoked fish, heat-treated meat products, and raw sausages** at varying frequency, and sometimes at counts clearly higher than the critical value of 100 cfu/g. These findings underline the particular importance attached to food business operators' self-controls. They also show the need to regularly inspect establishments manufacturing or selling such foods in the framework of the official control system. The findings make clear that certain ready-to-eat foodstuffs pose a risk to humans to infect themselves with *Listeria monocytogenes* and should therefore not be eaten by susceptible consumer groups, such as small children, elderly and immune-deficient people, and pregnant women. Consumers' awareness of the risk *Listeria* are representing should be enhanced. In particular, there should be more information about the difference in meaning of a use-by date in contrast to a best-before date.

**ESBL/AmpC-forming *E. coli*** are wide-spread in farm animals. It is a good development that the detection rates of ESBL/AmpC-forming E. coli have been declining at all levels in the food chain related with broilers. In all other farm animal species subject to this monitoring, however, there has been no progress in the past few years as regards the occurrence of these resistant bacteria. There has even been an increase in detection rates in fattening turkeys and in veal calves/young bovines. This is alarming because of the particular importance of 3$^{rd}$ and 4$^{th}$ generation cephalosporins in the therapy of

human diseases, and all the more as we must assume, at the present state of knowledge, that the resistant bacteria may also be transmitted to humans by foodstuffs. But we are not yet able to finally assess how important this kind of exposure is with regard to health protection of consumers.

Clearly lower detection rates of ESBL/AmpC-forming *E. coli* in ecologically managed broiler and turkey farms may be connected with the lower rate of antibiotic treatment in such farms, compared to conventional holdings. It requires further targeted investigations to identify possible differences between ecological and conventional production as regards the contamination of animals and derived foods with anti-microbial-resistant germs. In this context, it is necessary to compile reliable data on the use of antibiotics in conventional and ecological animal holdings.

**Farm animal-associated MRSA** was found in the framework of the Zoonosis Monitoring both in animals and meat at various rates. MRSA contamination rates were particularly high in turkey carcasses and fresh turkey meat, while contamination rates in the food chain related with broilers showed a declining trend. A more frequent detection of MRSA in veal calves/young bovines compared to adult fattening bovines might be connected with a different exposure of these two groups to antibiotics. It was conspicuous that MRSA was obviously more seldom found in ecological turkey farms and ecologically produced turkey meat than in conventional farms and conventionally produced meat. Typing analyses of MRSA isolates showed that MRSA types found in primary production largely corresponded with those found in foodstuffs at retail, which is a sign that here, too, the germs are transmitted from animals to derived foodstuffs in the course of food production. Transmission of MRSA to humans by consumption of foodstuffs seems to be of minor importance, all the more as bacterial counts measured in the framework of the Zoonosis Monitoring tests were only very low. Still, consumers should always be careful – which is also necessary with regard to other zoonotic agents – when handling foodstuffs, because it is basically always possible that the pathogen is transmitted to consumers' households with foodstuffs, and might cross-contaminate other foodstuffs there. The Zoonosis Monitoring should continue to watch the spread of MRSA, and type the pathogens, in order to early recognise the appearance of new or human-adapted strains in food production.

Resistant bacteria such as ESBL/AmpC-forming E. coli and MRSA occur, in general, more seldom in wild-ranging animals than in farm animals, which might reflect the low degree of wild animals' exposure to antibiotics.

The results of testing for **carbapenem-resistant *E. coli*** indicate a need for improvement of the specificity of analytic methods, because although there has been a considerable amount of findings of *E. coli* with suspected carbapenem resistance, only four of the isolates which were sent in for typing, could finally be phenotypically identified as carbapenem-resistant *E. coli*. These four isolates all originated from fattening pigs.

The findings of the Zoonosis Monitoring show that vegetal foodstuffs, too, may be contaminated by microbial pathogens. Some single samples of lettuce, fresh herbs, and sprouts were detected with *Salmonella*, STEC, and *Listeria monocytogenes*. One sample of deep-frozen raspberries was positive for norovirus. Given that fruit, lettuce, herbs, and some vegetables are customarily eaten raw, and in consequence, possible bacterial or viral contamination of these foods may be directly consumed, the presence of potentially pathogenic germs in vegetal foodstuffs should be monitored further, in order to always be able to assess the current risk. For future programmes we should consider to increase sampling volumes, in particular when testing for viruses, in order to improve the rate of detection.

The findings of the Zoonosis Monitoring improve the basis for risk assessments and enable us to carry out further well-targeted investigations. The findings deliver decisive information helping government authorities to take suitable measures to control zoonotic agents at the respectively best-suited level of the food chain.

Having the overriding aim to reduce consumers' exposure to zoonotic agents and control the development of resistance to antimicrobial substances, the Zoonosis Monitoring delivers a substantial contribution to health protection of consumers.

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