Fact Sheet:

The impact of animals on the risk of foodborne illness in fresh produce

This fact sheet addresses the issue of the impact of intensive animal production and animal intrusion on the risk of foodborne illness in fresh produce.

Authors: Hayriye Bozkurt[1], Yu Wen Lai[1], Michele Jay-Russell[2], Robyn McConchie[1]

[1]ARC Industrial Transformation Training Centre for Food Safety in the Fresh Produce Industry, Sydney Institute of Agriculture, Faculty of Science, The University of Sydney, NSW 2006, Australia

[2]Western Center for Food Safety, University of California, Davis One Shields Avenue, Davis, USA

Why are we seeing increased foodborne illness associated with fresh produce?

Demand for fresh and healthy convenience foods has led to greater consumption of fresh horticultural produce over the last two decades[1]. Fruits and vegetables can be major vehicle of foodborne outbreaks as they are often consumed raw, with no kill step to eliminate pathogens that can be acquired from the field or processing environment or human contact[2].

In the US, foodborne illnesses from fresh produce increased from 12% in the 1990s to 24% in the 2010[3,4]. In Australia, there have been 32 fresh produce-related outbreaks between 2010 and 2015 with 1260 reported cases of illness[5].

Improved technologies detecting human pathogens - such as whole genome sequencing - has resulted in greater awareness and traceability of fresh produce being linked to foodborne illnesses. Identification of environmental sources and understanding the transmission processes of foodborne pathogens in the food supply chain are necessary to manage food safety risks.

Animals are a source of foodborne illness pathogens in fresh produce

Wild and domestic animals are the main reservoir for a broad range of pathogenic zoonotic agents and includes bacteria (*Campylobacter* spp., *Escherichia coli, Salmonella* spp., *Listeria monocytogenes,* and *Yersinia* spp.) and parasites (*Cryptosporidium* spp. and *Angiostrongylus cantonensis*). Animals carrying these human pathogens in their intestinal tract often appear healthy, even though the pathogens can cause severe disease in humans. Among the faecal-borne zoonotic pathogens, *Salmonella enterica* (14.1%), and Shiga toxin–producing *E. coli* (STEC; 5.7%), were the most commonly reported causative agents of global fresh produce related outbreaks[3-5].

Animal production and wildlife intrusion in proximity or upstream along an irrigation water source from fresh produce producers can pose a significant risk of pathogen transfer to produce via aerosols, faecal deposition or contaminated irrigation water as shown in Fig 1.

Sources of enteric foodborne pathogens that can impact horticultural produce include runoff or bioaerosols from nearby domestic animal operations, human sewage/septic facilities, infected farmworkers, contaminated agriculture water, untreated manure-based soil amendments, flies or other invertebrates and wild animal intrusion/defecation in the production area[6].

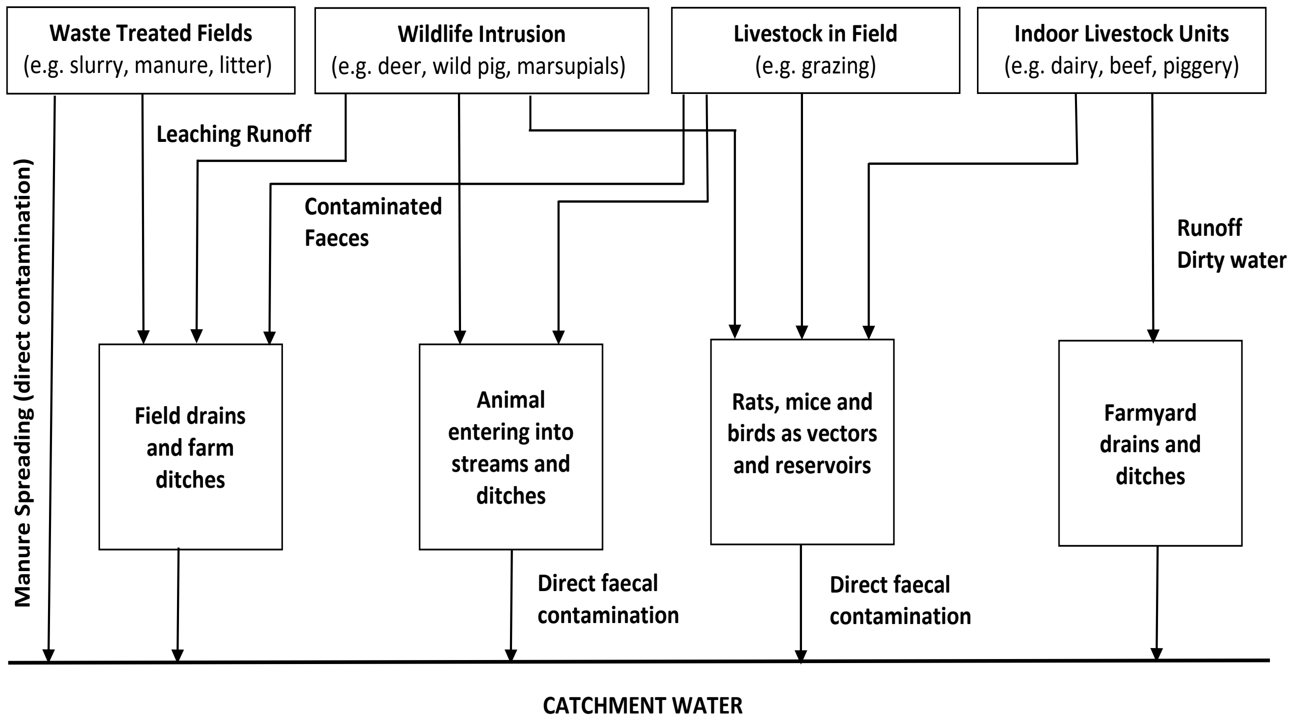

Figure 1. Routes of catchment water contaminations with zoonotic foodborne pathogens[7,8,9]

"Contamination may occur through; direct contact of the crop with faeces; use of irrigation water from polluted dams or rivers; or untreated manure-based soil amendments."

What are the major zoonotic pathogens associated with intensive animal production and wildlife?

***Salmonella* spp.** *Salmonella enterica* is one of the most important human foodborne bacteria in industrialised countries and is potentially spread through farmed animals such as chickens, cattle, sheep and pigs, as well as wild animals such as rodents, amphibians and reptiles, mammals and birds. Contamination may occur through: direct contact of the crop with faeces; use of irrigation water from polluted dams or rivers; or untreated manure-based soil amendments.

Shiga toxin producing *E. coli* (STEC) This pathogen can cause illness with severe symptoms and further complications. Cattle is the major reservoir of this pathogen but it has also been isolated from other livestock and domesticated animals including sheep, goats, pigs, horses, cats and dogs[10]. Wild animals, such as rodents, rabbits, ruminants like deer, wild boar and feral swine, and birds, as well as inver-tebrates, such as flies, can be reservoirs or transient carriers for STEC. Birds, especially, can move *E. coli* across long distances to, from, and among agricultural facilities.

What risks exist in having intensive animal production close to produce production areas?

Run-off water into nearby aquatic environments and bioaerosols from intensive animal production operations are important risk factors associated with fresh produce contamination[7, 11, 12].

Good practices for managing co-existence of animal and crop production:

- *Control livestock movement by keeping farm animals confined and/or far away from water sources, growing fields and storage area*
- *Establish buffering zones between livestock operations and crops/water sources e.g. riparian zones and wetlands, non-crop or low-risk crop plantations*
- *Use dedicated tools for farm animal activities and crop activities*
- *Compost biowaste to reduce microbial load before application to fields*
- *Do not spread manures prior to heavy rainfall*
- *Prevent intrusion and minimise habitat of wild animals in the crop production area e.g. using fences, buffer zones and bird repellents*
- *Do not use pesticides or chemical repellents in the growing field*
- *Support co-management of food safety goals and maintaining biodiversity near farmlands*
- *Take corrective actions when clear evidence of animal intrusion in the field is found*

However, cattle on rangeland, as well as livestock on small-scale diversified farms, can also be sources of foodborne pathogens, and potential interspecies transmission with wildlife has been documented (e.g. transmission between pastured cattle and feral pigs)[13]. Intensive animal operations often produce large numbers of livestock in concentrated confinements. These are environments that harbour high loads of zoonotic pathogens and enable pathogens to proliferate. Water acts as a transmission pathway for pathogens and poses a risk to nearby or downstream produce production areas. Strawn et al.[14] found significantly higher prevalence of *Salmonella* in produce farms with livestock operations located nearby, particularly in water samples.

Intensive animal operations such as feedlots or poultry barns are also significant sources of bioaerosols. Zoonotic pathogens can become airborne and deposited on land, facilities and water sources by wind carriage. Handling and application of slurry and solid biowastes are sources of bioaerosol generation as well as turning of compost[15]. Research in the USA has shown that the current leafy green field distance guidelines of 120 m may not be adequate to limit the transmission of airborne *E. coli* O157:H7 to produce crops planted near concentrated animal feeding operations, although additional research is needed in other geographical regions in the US and other countries[15].

What is the risk from wildlife incursions in production sites?

Faecal contamination of produce or surrounding watersheds as well as intrusion by wild animals into production sites is considered one of the significant risk factors for pre-harvest produce contamination. Foodborne outbreaks have been associated with wildlife intrusion including birds, deer, rodents, feral pigs, turtles, dogs, rabbits, hares, kangaroos and wallabies. In Australia, STEC and *Salmonella* have been isolated from faecal samples of native marsupials[16], and wild western grey kangaroos[17], respectively.

"Faecal contamination of produce or surrounding watersheds as well as intrusion by wild animals into production sites is considered one of the significant risk factors for pre-harvest produce contamination."

The public health importance of kangaroo to human transmission of pathogenic *E. coli* and *Salmonella* could not be determined as no fresh produce outbreaks or cases of salmonellosis or pathogenic *E. coli* infection have been linked to kangaroo intrusion.

Farming operations can encroach on, change or destroy wildlife habitats, especially when land is cleared to expand. This causes increased wildlife contact and pathogen transmission into farmland and farm water sources[12]. Management of food safety risks from potential wild animal sources is particularly challenging in open crop fields and orchards. Weller et al.[18] reported that the percent of *E. coli* transferred from faeces to fresh produce decreased with time after faecal placement, and with distance between the produce and the faeces. They suggest that a *no-harvest* buffer of 0.5 m around in-field wildlife faeces would reduce the proportion of *E. coli* transferred to fresh horticultural produce by approximately 1.5 logs.

A similar study by Jeamsripong et al.[19] showed a 0.72 log reduction in *E. coli* transferred to fresh produce with a 1.524 m *no-harvest* zone and suggested extending the holding time between irrigation and harvest. These findings provide key data that may be used in hazard characterisations and risk assessments at the grower level to eliminate food safety risks associated with wildlife intrusion and intense animal production.

Recommended practices for animal intrusion, resource conservation and food safety co-management

The wildlife component of global guidelines generally involves conducting pre-season and pre-harvest environmental risk assessments; monitoring for animal intrusion and faecal contamination of the production environment during growth and harvest; establishment of *no-harvest* zones where product may be contaminated by animal activity/faeces; and training of farm workers to recognise, report and mitigate these risks[20]. While seeking practices to reduce wildlife attraction is essential for food safety, some food safety practices have resulted in conflicts with conservation of natural resources and agricultural areas due to the limited understanding of best management practices for potential wild animal risks. Hence, the concept of co-management emerged and was defined as an approach to conserve and protect soil, water, air, wildlife and other natural resources while simultaneously minimising microbiological hazards associated with food production[21].

Recommended primary production practices to minimise food-safety risk from animal intrusion include:
(i) planting low-risk crops as a buffer between high-risk crops and pathogen sources (e.g. pastures),
(ii) planting non-crop vegetation around farm fields to filter pathogens from runoff,
(iii) fencing upstream waterways from livestock and wildlife,
(iv) distancing livestock from upstream waterways with water troughs, food supplements, and feed,
(v) vaccinating livestock against foodborne pathogens,
(vi) constructing wetlands near feedlots and intensive animal operations,
(vii) reducing the use of agricultural chemicals to bolster bacteria that will keep zoonotic foodborne pathogens under control,
(viii) composting effectively with high temperatures and regular turnings before amending into soil to enhance fertility, and
(ix) maintaining diverse wildlife communities to prevent the transmission of zoonotic diseases[20].

Key take-home messages:

History of the land use and adjacent lands: Spatial knowledge of land use of the fields and surrounding areas, and their history, is essential to developing an effective co-management risk reduction strategy at the grower level.

Harvesting time and wildlife activity: Know whether harvesting times correspond to periods of increased wildlife activity.

Manage your risks: There is no uniform approach for assessing wildlife intrusion risk. Each farm (and even field) will be different and may change across seasons and years. Therefore consult wildlife and food safety specialists to assess which wildlife species are potential problems.

In the USA, several industry guidelines such as California Leafy Green Marketing Agreements, Western Growers, and Arizona Leafy Green Marketing Agreements, have incorporated the co-management concept into their best practices[21-25].

Pre-harvest microbial contamination from wild and domestic animal activity in primary production environments pose a public health risk because of the low infectious dose of many of these zoonotic foodborne pathogens, and the potential for their downstream survival and amplification during harvest, processing, transportation and storage. There is an urgent need to better understand the predisposing factors that contribute to microbial contamination of horticultural crops from domestic and wild animals to develop targeted mitigation strategies and to promote co-management of food safety and conversation of nature.

Knowing the history of adjacent lands, times of increased wildlife activity and consulting with experts on species that pose a potential problem are important activities to undertake in managing risk.

References:

1. Rekhy, R., & McConchie, R. 2014. Promoting consumption of fruit and vegetables for better health. Have campaigns delivered on the goals? Appetite, 79, 113-123. doi:10.1016/j.appet.2014.04.012.

2. Berger, C.N., Sodha, S.V., Shaw, R.K., Griffin, P.M., Pink, D., Hand, P., Frankel, Gad. 2010. Fresh fruit and vegetables as vehicles for the transmission of human pathogens. Environ. Microbiol. 12, 2385–2397.

3. Painter, J.A., Hoekstra, R.M., Ayers, T., Tauxe, R.V., Braden, C.R., Angulo, F.J., et al., 2013. Attribution of foodborne illnesses, hospitalizations, and deaths to food commodities by using outbreak data, United States, 1998-2008. Emerg. Infect. Dis. 19, 407-415.

4. Sivapalasingam, S., Friedman, C.R., Cohen, L., Tauxe, R.V., 2004. Fresh produce: a growing cause of outbreaks of foodborne illness in the United States, 1973 through 1997. J. Food. Prot. 67 (10), 2342-2353.

5. Li, M., Baker, C.A., Danyluk, M.D., Belanger, P., Boelaert, F., Cressy, P., Gheorghe, M., Polkinghorne, B., Toyofuku, H., Havelaar, A.H. 2018. Identification of biological hazards in produce consumed in industrialised countries: A Review. J. Food. Prot. 81, 1171-1186.

6. Jay-Russell, M.T. 2013. What is the risk from wild animals in food-borne pathogen contamination of plants? CAB Reviews, 8 (40), 1-16.

7. Hooda, P.S., Edwards, A.C., Anderson, H.A., Miller, A. 2000. A review of water quality concerns in livestock farming areas. Sci. Total Env. 24, 143-167.

8. Gardner, T.J., Fitzgerald, C., Xavier, C., Klein, R., Pruckler, J., Stroika, S., McLaughlin, J.B. 2011. Outbreak of campylobacteriosis associated with consumption of raw peas. Clin. Infect. Dis. 53, 26–32.

9. Laidler, M.R., Tourdjman, M., Buser, G.L., Hostetler, T., Repp, K.K., Leman, R., Samadpour, M., Keene, W.E. 2013. *Escherichia coli* O157:H7 infections associated with consumption of locally grown strawberries contaminated by deer. Clin. Infect. Dis. 57 (8), 1129-1134.

10. Terajima, J., Izumiya, H., Hara-Kudo, Y., Ohnishi, M. 2017. Shiga toxin (Veratoxon-producing *Escherichia coli* and foodborne disease: A Review. Food Safety 5,35-53.

11. Pillai, S.R., Ricke, S. 2002. Bioaerosols from municipal and animal wastes: background and contemporary issues. Can. J. Microbiol. 8, 681-696.

12. Jones, B.A., Grace, D., Kock, R., Alonso, S., Rushton, j., Said, M.Y., McKeever, D., Mutua, F., Young, J., McDermott, J., Pfeiffer, D.U. 2013. Zoonosis emergence linked to agricultural intensification and environmental change. PNAS 110, 8399-8404.

13. Jay, M.T., Cooley, M., Carychao, D., Wiscomb, G.W., Sweitzer, R.A., Crawford-Miksza, L., Farrar, J.A., Lau, D.K., O'Connell, J., Millington, A., Asmundson, R.V., Atwill, E.R., Mandrell, R.E. 2007. *Escherichia coli* O157:H7 in feral swine near spinach fields and cattle, central California coast. Emerg. Infect. Dis. 13, 1908–1911.

14. Strawn, L.K., Fortes, E.D., Bihn, E.A., Nightingale, K.K., Grohn, Y.T., Worobo, R.W., Weidmann, M. Bergholz, P.W. 2013. Landscape and meteorological factors affecting prevalence of three food-borne pathogens in fruit and vegetable farms. App. Environ. Microbiol. 79, 588-600.

15. Berry, E.D., Wells, J.E., Bono, J.L., Woodbury, BL., Kalchayanand, N., Norman, K.N., Suslow, T.V., Lopez-Velasco, G. Millner, P. 2015. Effect of proximity to a cattle feedlot on *Escherichia coli* O157:H7 contamination of leafy greens and evaluation of the potential for airborne transmission. App. Environ. Microbiol. 81, 1101-1110.

16. Rupan, R., Jennison, A.V., Smith, H.V., Cobbold, R.N. 2012. Carriage of Shiga-toxigenic *Escherichia coli* by native marsupials in Australia. Vet. Microbiol. 155 (2-4), 279–283.

17. Potter, A.S., Reid, S.A. Fenwick, S.G. 2011. Prevalence of *Salmonella* in fecal samples of Western Grey Kangaroos (*Macropus fuliginosa*). J. Wildlife Dis. 47, 880-887.

18. Weller, D.L., Kovac, J., Kent, D.J., Roof, S., Tokman, J.I., Mudrak, E., Kowalcyk, B., Oryang, D., Aceituno, A., Weidmann, M. 2017 *Escherichia coli* transfer from simulated wildlife feces to lettuce during foliar irrigation: A field study in Northeastern United States. Food Microbiol. 68, 24-33.

19.Jeamsripong, S., Chase, J.A., Jay-Russell, M.T., Buchanan, R.L., Atwill, E.R. 2019. Experimental in-field transfer and survival of *Escherichia coli* from animal feces to romaine lettuce in Salinas Valley, California. Microorganisms. 7 (10), 408. doi: 10.3390/microorganisms7100408.

20. Karp, D.S., Gennet, S., Kilonzo, C., Partyka, M., Chaumont, N., Atwill, E.R., Kremen, C. 2015. Comanaging fresh produce for nature conservation and food safety. PNAS. 112 (35), 11126–11131.

21. Freshcare, 2019. Food Safety & Quality Standard Edition 4.1 July 2019 (accessed 22/11/2019 at https://www.freshcare.com.au/wp-content/uploads/Freshcare-Food-Safety-Quality-Standard-Edition-4.1-July-2019-3.pdf)

22. Lowell, K., Langholz, J., Stuart, D. 2020. Safe and Sustainable: Co-managing for Food Safety and Ecological Health in California's Central Coast Region. The Nature Conservancy of California and the Georgetown University Produce Safety Project, San Francisco, CA and Washington, DC.(accessed 22/11/2019 at https://ucfoodsafety.ucdavis.edu/pre-post-harvest/co-management-food-safety-and-sustainability)

23. California Leafy Green Marketing Agreement (CLGMA). 2012.. Commodity specific food safety guidelines for the production and harvest of lettuce and leafy greens, http://wwwcaleafygreenscagov/foodsafety-practices/downloads (accessed 21/11/2019).

24. FDA, 2013. Commodity Specific Food Safety Guidelines for the Production, Harvest, Post-Harvest, and Processing Unit Operations of Fresh Culinary Herbs. Western Growers, 2013. http://www.fda.gov/downloads/Food/FoodSafety/ProductSpecificInformation/FruitsVegetablesJuices/GuidanceComplianceRegulatoryInformation/UCM337902.pdf (accessed 21/11/2019).

25. Arizona Leafy Green Marketing Agreement (ALGMA).2013. Commodity specific food safety guidelines for the production and harvest of lettuce and leafy greens, Version 6, 2012. http://www.arizonaleafygreens.org/wp-content/uploads/2012/07/Arizona-GAPS-metrics-08_01_2012_Version-6.pdf (accessed 21/11/2019).

Fresh Produce Safety Centre Australia & New Zealand

Room 517, Level 5, Life Earth & Environmental Sciences Building, F22
The University of Sydney, NSW 2006
Australia
E: info@fpsc-anz.com
W: https://fpsc-anz.com
Twitter: @safeproduceANZ