Peer Review of the ESR Health Risk Assessment on Dung Beetles
31 October 2013

General

In general terms, the confidential peer reviewers (drawn from universities and CRIs) considered the ESR public health risk assessment to be a good contribution to the discussion about the potential public health risks of dung beetles but by no means definitive (see conclusion below).

Unfortunately, the overall findings of the ESR review (pg 94 of their risk assessment) were not supported by the peer reviewers. The notes below highlight the areas of disagreement.

Why do the experts disagree?

The fundamental reasons for the disagreements between the experts (i.e. the ESR team who undertook the health risk assessment and the confidential peer reviewers of that health risk assessment) stem from a lack of prior research to clarify the areas of biological uncertainty. This required the ESR team to rely on dubious assumptions for critical parts of their analysis. Several of these assumptions are recognizable as being the unsubstantiated (and previously articulated) views of the applicants. To the credit of the ESR team, they have carefully laid out the assumption they made during their risk assessment.

Uncertainty is considered 'the enemy of risk assessment'. When there is sufficient uncertainty to compromise the value of the risk assessment, it is good practice to resolve the areas of uncertainty through research so that one can make informed decisions about risks posed by the release of a new organism. Without this tried and true practice the value of the risk assessment deteriorates to the level of speculation.

Should ERMA/EPA have performed a health risk assessment during their approval process?

The ESR team concluded that the EPA decision to introduce dung beetles should have been preceded by a formal health risk assessment in the New Zealand context (see pg 87 of their risk assessment). The peer reviewers agreed with this view and would like to see the EPA perform similar health risk assessments in the future whenever any new organism with potential impact on public health is contemplated for introduction.

Scope of the ESR public health assessment

The peer reviewers considered the health risk assessment performed by ESR to be relatively narrow – focusing only on six notifiable enteric diseases.

For instance – the ESR team considered Mycobacterium avian paratuberculosis (MAP) out of scope. MAP is a ruminant-derived bacteria which causes Johne's disease in livestock and has been identified as a possible trigger of similar debilitating chronic bowel inflammation in susceptible people (i.e. Crohn's disease). Although a causal association between MAP and diseases like Crohn's disease is considered as yet unproven, there are enough good quality studies supporting such a link that it would have been prudent to consider whether dung beetles will increase the environmental prevalence of MAP.

In addition, the ESR team did not appear to include in their health assessment the parasitic diseases that dung beetles have been reported to help spread in people (e.g. hookworm, the gullet worm, rodent tapeworms, Spirocerca lupi etc). The peer reviewers understand that these parasitic diseases will be less common (and severe) than the bacterial gastrointestinal diseases on which the ESR team focused but do not believe they should have been ignored.

Furthermore, no attention was paid to the influence dung beetles may have on the prevalence of infectious gastrointestinal diseases in livestock such as sheep, cattle, pigs, poultry, and horses or in pets. This was considered to be a major weakness in the risk assessment because livestock (and pets) are considered very important sources of infectious gastrointestinal diseases in people and there are several plausible pathways by which the prevalence of such diseases in livestock and pets could be increased by dung beetles. Thus, it is not

feasible to do an effective public health risk assessment of ruminant dung-derived pathogens without considering the impact dung beetles may have on the prevalence of those pathogens in the faeces of animals.

What level of risk to public health is acceptable?

The peer reviewers noted that New Zealand employers are quite rightly held to a very high bar by the Ministry for Business, Innovation and Employment with regard to workplace health and safety. No employer could use as their defense that its failure to prevent an adverse consequence to an employee from a known workplace hazard was excusable by the infrequency of the adverse effects or by associated productivity gains. However, these sentiments (justifications) did from time to time appear to colour the ESR health assessment i.e. that adverse consequences to human health arising from the introduction of dung beetles could be considered acceptable if they were not very common or because the hypothesized associated pastoral productivity gain somehow excused them. The peer reviewers did not believe it was appropriate to discount adverse effects on human health resulting from dung beetles on this basis. This philosophic difference contributes to the lack of agreement amongst the experts.

Did ESR accurately assess the balance (direction of) the public health risks (i.e. is their overall conclusion correct)?

The overall conclusion of the ESR team was that the risks to public health (from direct contact with dung beetles and potential increased groundwater contamination) will be outweighed *at a population level* by the perceived benefits to public health from more rapid dung burial. Unfortunately, this overall conclusion was disputed by the peer reviewers who concluded that the ESR team's assessment of the perceived public health benefits of dung beetles was markedly compromised by the assumptions they made in their assessment process (necessary because of the biological uncertainty mentioned above). As a result, in the opinion of the peer reviewers, the overall conclusions of the ESR health risk assessment cannot be relied upon.

The importance of overseas experience

The ESR team placed significant emphasis on overseas experience claiming that this demonstrates the various potential risks relating to dung beetles do not manifest in any obvious way. In contrast, the peer reviewers do not take any comfort from the overseas experience primarily because public health authorities in other countries have never systematically examined the effect of dung beetles on public health. It would be very hard to stumble across an impact of dung beetles on public health without a careful investigation because of the massive burden of undiagnosed gastrointestinal infections (of unknown source) that occur in human populations and the inherent difficulty in making a temporal association between exposure to a dung beetle or dung beetle excreta and the clinical signs of infectious gastroenteritis which would emerge some days later. That association would be even harder to make if the link between the dung beetles and human infections is more indirect e.g. through infected animals, food, soil or water.

Furthermore, both the ESR team and the peer reviewers agree that the risk from dung beetles in NZ could well be different to that of other countries. For example, the prevalence of gastrointestinal infections in NZ is comparatively high. NZ is unlikely to see a significant off-setting benefit from the reduction of dung breeding 'filth flies'. The exposure risk here is likely to be high because of NZ's reliance on pastoral farming, high stocking rates and comparatively high (e.g. to Australia) population density in towns in rural and semi-rural areas.

At risk groups

The ESR team largely focused their risk assessment on rural populations. This focus was considered a fundamental flaw by the peer reviewers who observed that the populations most at risk from the introduction of dung beetles were the immunologically naïve urban populations bounding rural areas (i.e. people who unlike the farming community do not regularly encounter ruminant faecal pathogens) and a small subset of rural people who may not have been exposed to these pathogens or who are not immunologically robust (e.g. infants, elderly, the infirm).

The ESR team discounted an impact on urban populations in part because they assumed flying beetles would not carry significant numbers of faecal pathogens. The peer reviewers disagree with that assumption (see below).

The peer reviewers also pointed out that in absolute numbers the greatest burden of enteric diseases is in urban populations and that even a small increase in risk to peri-rural urban populations that might be posed by flying dung beetles could represent a significant overall increase in disease burden. This is particularly so when one considers that, once infected, a person in a dense urban environment can more readily spread the infection to other people.

The reviewers also pointed out the direct access of night-flying beetles to urban populations through their attraction to lights of houses and sports grounds etc is regularly observed in Northland (with the small numbers of Mexican dung beetle present in and around Whangarei). As such, this is by no means an 'imagined risk'. It is something that is happening now and should be better understood before it is dramatically scaled throughout the country.

Pathogen transport to people by flying beetles

The conclusion of the ESR team was markedly influenced by their view that flying dung beetles pose only a minor pathogen transport risk. This view appeared to arise primarily from their unsubstantiated belief that the majority of flying beetles will be young dung beetles recently emerged from the buried dung balls rather than adult beetles leaving fresh dung.This assumption appears to be derived from a failure to appreciate that adult dung beetles use dung to feed (as well as to breed) and as a result a large proportion of adult male and female beetles emigrate from faecal pats in search of new faecal resources within a few days of arrival [see Hunt J et al Ecological Entomology 24:174-180, 1999]. These adult beetles will have fresh faecal material on and in them. Furthermore, there is ample evidence to suggest that enteropathogens such as E.coli, MAP, cryptosporidia and salmonella could easily survive in significant numbers in the buried dung balls from which emergent beetles arise.

In the view of the peer reviewers, this dubious assumption by the ESR team (along with their focus on rural risk groups rather than urban) markedly affects the reliability of their risk assessment because it discounts one of the key new ways dung beetles may influence public health in NZ. i.e. the aerial transfer of significant quantities of faecal pathogens from farm pastures to urban communities.

Put colourfully by a reviewer, the introduction of new species of dung beetles that are attracted to lights throughout NZ is akin to lobbing small ruminant faecal 'bombs' one after another from our farms many kilometres into our cities. It is highly improbable that these faecal-contaminated beetles will not eventually end up in the hands (or mouths) of immunologically naïve individuals (infants).

The peer reviewers strongly recommended that the dose of disease-causing infectious agents carried by flying beetles should be determined before introduction of any new dung beetle species that are attracted to lights.

Pathogen transport to people by dung beetle predators

The overall conclusion of the ESR team was also markedly influenced by their assumption that dung beetles will only rarely be eaten by predators. The peer reviewers did not agree with this assumption - noting that there is ample overseas evidence of dung beetle predation by birds, rodents, hedgehogs and amphibians such as the cane toad. This predation occurs when dung beetles are alighting on or feeding on the faecal pats at the pasture surface.

The peer reviewers also noted that ruminant faecal pats on NZ farms are currently considered comparatively depauperate (i.e. to contain relatively low numbers and varieties of insect species) compared to those overseas. In addition, they pointed out that by far the greatest proportion of dung pats on NZ farms are currently not disturbed by foraging birds or other wildlife. They conclude that this situation may very well change if new species of dung beetles are introduced because large numbers of nutrient-rich dung beetles

could be expected to colonise each dung pat and be accessible to predation for the several days during which dung beetles are feeding on the dung at the pasture surface.

Thus, the ESR team's conclusion that there is likely to be less aerial transport by birds of ruminant-faeceal-derived pathogens following the introduction of dung beetles is – in the view of the reviewers - unsubstantiated. In fact the opposite is quite likely to occur. i.e. there may well be many more visits by birds, rodents etc to faecal pats to feed on dung beetles and as a result a greater risk of the transfer by wildlife of faecal pathogens to roof-collected water, playgrounds and other surfaces through which humans can be contaminated with faecal pathogens.

Pathogen transport to people through the impact of dung beetles on animal health

Domestic animals are one of the most important sources of gastrointestinal infections of people. Thus, as mentioned above, the peer reviewers felt an effective public health risk assessment regarding dung beetles should have included consideration of the potential impacts of dung beetles on the shedding of enteropathogens by domestic animals. There are many ways the prevalence of domestic animal enteropathogenic infections could be influenced by dung beetles. For example, if the burial of faeces increases survival of pathogens on soil/pasture it may compromises the ability of herds to clear infections during rotational grazing cycles. It is also clear that infections of herds with E.coli 0157H7 are quite regional localized in NZ and thus the distant and persistent farm-to-farm aerial transport potential of dung beetles may spread this (and other) localized infections between herds. Grazing animals are infected by directly ingesting pathogens in soil, pasture (taken up by the roots) or water. Note – because of the 'zone of repugnance' and the drying of the surface of the faecal pats, grazing animals do not usually directly ingest faeces in the drying faecal pats sitting on the pasture surface. Other livestock species, such as pigs and poultry, will also actively seek out and ingest dung beetles. Infected animals can then spread pathogenic infections to people through direct contact or through shedding large numbers of pathogens into waterways or by heightened hygiene problems during processing.

Pets are also an important source of infectious gastrointestinal diseases for humans. Both dogs and cats are likely to eat dung beetles should they encounter them – providing yet another potential transmission pathway of ruminant-derived faecal pathogens to urban people should their pets ingest beetles attracted to the lights of cities and then transfer the pathogens to their owners through licking.

Pathogen transport to people through the contamination of roof-collected water

The ESR team concluded dung beetles would be unlikely to find their way into roof-collected water. The primary reason they offered for this view was the claim that lights are rarely mounted on roofs. The peer reviewers disagreed with this view noting that it is very common for bright security lights to be mounted high on barge boards just under guttering and also for roofs in rural properties to have clear polycarbonate panels through which light shines at night. The reviewers also noted that contamination of roof-collected water by birds fresh from foraging in faecal pats for dung beetles may increase.

Pathogen transport to people through the contamination of ground water

The peer reviewers agreed with the ESR team's conclusion that through their burrowing activity dung beetles may pose an increased risk to shallow groundwater drinking supplies. They noted that infection of rural people in NZ with ruminant-derived pathogens was far more common from drinking contaminated ground water and roof-collected rainwater than from drinking surface water. Unlike the ESR team, the reviewers did not believe that the potential increased risk of groundwater contamination from dung beetles was offset by the potential for less overland flow of effluent into surface water.

Pathogen transport to people through the contamination of surface water

The overall conclusion of the ESR team was markedly influenced by their view that dung beetles will reduce the contamination of surface water catchments by faecal pathogens. Unfortunately, the peer reviewers did not agree with this conclusion. As the ESR team pointed out in their own literature review, there is evidence that the bulk of contamination of rivers running through farmland comes from point sources such as mole drains (78%) and subsurface drainage (6%) with overland flow estimated to represent are relatively modest 16% of the bacterial contamination of the catchment.

Given that 84% (i.e. 78% plus 6%) of the contamination of the catchment is estimated to come from underground effluent flow and that the ESR team concluded dung beetles may worsen ground water contamination through their burrowing activities, it is difficult to reconcile their conclusion that the burial of dung will reduce overland effluent flow sufficient to improve water quality. i.e. the action of dung beetles to reduce overland effluent flow – estimated to be responsible for only 16% of catchment contamination – may not offset the potential worsening of the underground flow of effluent - estimated to be responsible for 84% of catchment contamination.

Furthermore, the peer reviewers noted that it is not appropriate to assume that dung beetles will remove all or even the majority of the surface dung – for instance they are unlikely to play any role in removing from the surface the large quantities of very liquid faeces of dairy cattle (as dung beetles find liquid faeces difficult to effectively process).

The public health value of shallow burial of faeces

The peer reviewers note that the ESR team's public health assessment relies heavily on the perceived theoretical beneficial effects of burying faeces. However, their assessment has been made in the absence of any empirical (experimental) work directly assessing the impact of dung beetles on pathogen numbers in soils, pasture or water and thus remains speculative. The ESR team does not appear to take into account the large body of overseas literature on the mechanical burial of faeces which demonstrates that shallow burial of faeces can reduce the rate of pathogen die-off.

The peer reviewers also noted that the ESR team failed to compare the die off rate of faecal pathogens on the surface versus those in the soil – this being the critical comparison – and one that is influenced by an enormous number of factors including environmental conditions, faecal characteristics, farming system etc.

This critical weakness of the assessment is not lost on the ESR team – who appear to agree that the relative fate of the pathogens in buried dung and surface dung (and their accessibility to livestock or people) is at the heart of the health risk assessment and they conclude that further research is required in this area. However, they believe this research can be done after the beetles are released. This was difficult for the peer reviewers to understand because if this research shows pathogen die-off in soil is significantly reduced following burial of faeces then the conclusion of the ESR health risk assessment is likely to change. The dung beetle release is irreversible.

Note – the main public health concern if pathogen numbers on soil and pasture increase is that the prevalence of these infections in livestock and water could increase and from there more people could become infected.

Effects of pasture improvement

The conclusions of the ESR team in part relied on the assumption that dung beetles will improve pasture. It is noteworthy in this regard, that there is as yet no evidence that dung beetles will have a significantly positive effect on topsoil thickness or pasture growth in New Zealand farming systems. Preliminary research by Landcare Research did not detect a beneficial effect on pasture growth of dung beetles. Similarly this benefit has not been demonstrated in the case of the Mexican dung beetles in Northland.

Importantly, even if dung beetles are eventually shown to have a significantly positive effect on pasture growth, this is highly unlikely to lead to reduced environmental pathogen load because most farmers would

wish to take advantage of the increased pasture growth by increasing their stocking rate, generating more faeces and more environmental pathogen load.

Conclusion

In conclusion, the peer reviewers considered the ESR public health risk assessment to be a helpful contribution to the discussion about the potential public health risks of dung beetles but – because of the large number of erroneous assumptions upon which the team relied – the health assessment was considered to be by no means definitive. The reviewers agreed with the ESR team's conclusion that a formal public health risk assessment should have been performed by the EPA prior to the approval to introduce dung beetles. They believe the scope of the ESR public health risk assessment was too narrow and that insufficient focus was provided to urban people as a 'risk group'. They believe that dubious assumptions made by the ESR team re dung beetle biology caused them to underestimate the risks to people from contaminated flying dung beetles, from potentially higher infection rates (with ruminant-derived disease-causing gastrointestinal infectious agents) of dung beetle predators (like birds), livestock and pets, and from potentially increased contamination of roof-collected water, ground water and surface water.