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ORIGINAL ARTICLE

Relative perceptions of prevalence, impact and importance of photosensitisation in Australian livestock: A survey of veterinarians, livestock traders and livestock producers

Y Chen,[a,b,c] P Loukopoulos,[a,c] G Xie[d] and JC Quinn[a,b*]

Aims To investigate the relative differences in the perceptions and awareness of outbreaks of photosensitisation in Australian livestock stakeholders, including veterinarians, livestock traders and producers.

Methods A questionnaire was developed and circulated to livestock veterinarians, producers and traders in Australia via email addresses obtained from public access sources. The questionnaire was designed to evaluate participants' awareness and perception of health, welfare, and production issues associated with outbreaks of photosensitisation and towards the incidence and importance of photosensitisation in livestock.

Results One hundred and twenty-eight online responses were received in total. Nearly half of the respondents (49.0%) indicated they would encounter 1–3 outbreaks annually. The majority of veterinarian and livestock producers stated that outbreaks of photosensitisation were common and economically important, with cattle and sheep being equally considered as susceptible species to this condition, and secondary (hepatogeneous) photosensitisation is the most common type.

Conclusion This survey confirms the anecdotal evidence that photosensitisation in livestock in Australia is commonly encountered by veterinarians and livestock producers. However, there is no industry-wide common acceptance of the issue, broader opinions should be canvassed when considering impacts on stakeholders regarding photosensitisation outbreaks in livestock in Australia or abroad in the future.

Keywords livestock; perceptions; photosensitisation; survey

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Photosensitisation is a clinical entity that has been reported in livestock in almost all production regions worldwide.[1] There are a variety of aetiologies and clinical signs are nonspecific, mainly presenting as variably severe cutaneous and mucosal inflammation, ranging from erythema, oedema and vesicle formation to severe multi-layer necrosis.[2] Direct impacts of photosensitisation on livestock industry include production loss caused by impaired organ function, weight loss, flystrike, secondary infections and the reluctance of animals to nurse young offspring if udders are inflamed due to photosensitisation.[3] The cutaneous damage resulting from the sequelae of photosensitisation would notably compromise the affected animal's well-being and welfare. Furthermore, it can result in a downgrading of the animal value at sale or time of slaughter. The economic cost related to photosentisation in sheep and cattle in New Zealand has been estimated to be between NZ$20 and $63 million annually.[4] Australia has reported the highest rate of cases annually.[1] However, the absolute incidence of photosensitisation is hard to determine, and the overall prevalence, impact on animal welfare and economic loss related to outbreaks of photosensitisation in livestock are imprecise and probably underestimated.[1]

To date or to our knowledge, there has been no reported investigation into the perceptions and the awareness of multiple stakeholders across the production chain, particularly veterinarians, livestock traders and livestock producers, regarding their experiences and perceptions of the prevalence and importance of photosensitisation in livestock in Australia. To address this, a survey of veterinarians, livestock traders and producers in Australia was undertaken to assess their group experience and perceptions of this issue. Our results indicate that whilst photosensitisation is a commonly reported issue for veterinarians in large animal or mixed practice, it is not perceived to be a significant issue by livestock traders. The reasons for this relative difference are discussed.

Materials and methods

Questionnaire

This study was approved by the Charles Sturt University Human Research Ethics Committee (Protocol number 400/2016/28). To understand the prevalence of outbreaks of photosensitisation in livestock as experienced by livestock veterinarians, producers and traders, a questionnaire was developed and circulated through a targeted recruitment strategy.

The questionnaire contained three sections containing 13–15 multiple choice questions. The first section related to the nature of participants' employment status. Veterinarians were classified as 'private

*Corresponding author.
[a]School of Agricultural, Environmental and Veterinary Sciences, Charles Sturt University, Wagga Wagga, New South Wales, Australia; jquinn@csu.edu.au
[b]Gulbali Institute, Charles Sturt University, Wagga Wagga, New South Wales, Australia
[c]Melbourne Veterinary School, The University of Melbourne, Werribee, Victoria, Australia
[d]Quantitative Consulting Unit, Charles Sturt University, Wagga Wagga, New South Wales, Australia

veterinarians', 'district veterinarians' and 'academic veterinarians'. Livestock traders were classified based on the 'type of livestock trading' they were involved in to beef prime/store, dairy cattle, sheep prime/store, pig, horse and others; producers were classified based on the 'type of livestock in the farm', including cattle, sheep, pig, horse and others.

The second section assessed the participants' awareness or perception of health and production issues associated with outbreaks of photosensitisation in livestock. Questions included: their experience on the frequency of photosensitisation and affected animal species; the areas of common skin lesions attributed to photosensitisation; the frequency of seeing a suspected case; the type of photosensitisation (primary, secondary and congenital) that had been diagnosed; and any identified causative agents. The exact phrasing of the question to be answered by the participant depended on whether they answered positively to a previous question asking if they had direct experience of photosensitisation in livestock.

The last section evaluated the participant's perception of the incidence and importance of photosensitisation in livestock. Questions included information about the participants' perception of the seasonal prevalence, economic impact of outbreaks and general importance of the problem to industry. Finally, there was an open question that asked the participants to share their experiences, concerns and comments about the impact of outbreaks of photosensitisation on the livestock industry.

Questionnaire dissemination and collection methods

The questionnaire was created using the online survey tool 'Survey Monkey' (https://www.surveymonkey.com/). Participants were recruited by email using addresses obtained from public access sources. Specifically, email addresses of veterinarians, clinics, and hospitals, were sourced from the Yellow Page website (https://www.yellowpages.com.au/) and openly published scientific articles or case reports related to Australian livestock. Email addresses of livestock traders were also identified from the Yellow Page website (https://www.yellowpages.com.au/) and the members list of The Australian Livestock & Property Agents Association (ALPA) (http://www.alpa.net.au/), where 'livestock trading' was listed as their business description. Email addresses of livestock producers were also sourced from the Yellow Page website (https://www.yellowpages.com.au/), where one or more livestock species (cattle, sheep, goat, pigs) were identified in their business description.

An invitation email with a link to the questionnaire was distributed to recipients, and two follow-up emails were sent to the same email address after one and 3 months.

Results

Response rates

Response rates vary between the three professional groups targeted. From 1,372 email recipients, 104 responses were received where the recipient identified themselves as a veterinarian (response rate 7%). Among these 104 respondents, 31 respondents (30%) identified themselves as district (state) veterinarians, 50 respondents (48%) were private veterinarians and the other 23 respondents (22%) reported various veterinary occupations, including veterinary pathologists, veterinarians in academia, on-plant veterinarians, government epidemiologists, research scientists and livestock consulting specialist. This last group is referred to collectively as 'academic veterinarians' in this article.

Seventeen online responses were collected from participants that identified themselves as livestock traders from a total of 1947 email addresses (response rate 1%). Among these, 13/17 respondents (77%) chose beef prime/store as the type of livestock trading, followed by sheep prime/store (12/17, 71%), dairy cattle (2/17, 12%) and horse trading (1/17, 6%).

Only seven responses were received from recipients that identified themselves as livestock producers from a total of 88 potential recipient email addresses (response rate 8%). Six out of seven respondents (86%) chose sheep as their major livestock operation, and five of chose cattle (5/7, 71%). This result indicated that the majority were dual-species producers.

Distribution and prevalence of photosensitisation lesions

Only veterinarian participants were required to respond to this question. Respondents were asked to choose from a list of six options with multiple choices available. The most frequently reported locations of lesions resulting from photosensitisation were: 'White-haired areas, teats, udder, perineum and nose' and 'Non-pigmented skin and haired areas exposed to sunlight' (74/88), followed by 'Face, nose and distal extremities' (72/88), 'Pinnae, eyelids, face, nose, coronary band or back' (58/88) and 'Skin lesions on any locations in newly shorn animals' (34/88). Two respondents selected 'other' with the comments indicating locations of 'third eyelids and exposed mucous membranes' and 'the site where backline chemical treatment (usually in short wool i.e., off-shears) has been applied in sheep' (Figure 1).

Estimated prevalence of photosensitisation outbreaks

All participants were asked to respond to a question regarding the average number of outbreaks they had experienced in total in an average calendar year (Figure 2). Nearly half of the respondents (49%, 50/102) indicated they would encounter 1–3 outbreaks annually. Fewer participants (27%, 27/102) indicated they would see 4–7 outbreaks a year, with a smaller number of respondents (14%, 14/102) who experienced 8–10 outbreaks annually. Interestingly, two out of 15 livestock traders indicated that they had experienced 11–14 outbreaks in a calendar year, and one district veterinarian, two private veterinarians and one academic veterinarian (4%, 4/102) acknowledge that they would see more than 15 outbreaks of photosensitisation a calendar year (Figure 2).

Perceptions regarding the frequency of photosensitisation outbreaks in livestock

Participants were asked to consider the frequency at which they observed outbreaks of photosensitisation on an annual basis and determine how common they considered this occurrence to be. There were clear differences in perception of frequency between the three groups surveyed. The majority of veterinary respondents, and more than half of the livestock producers (57%), stated that

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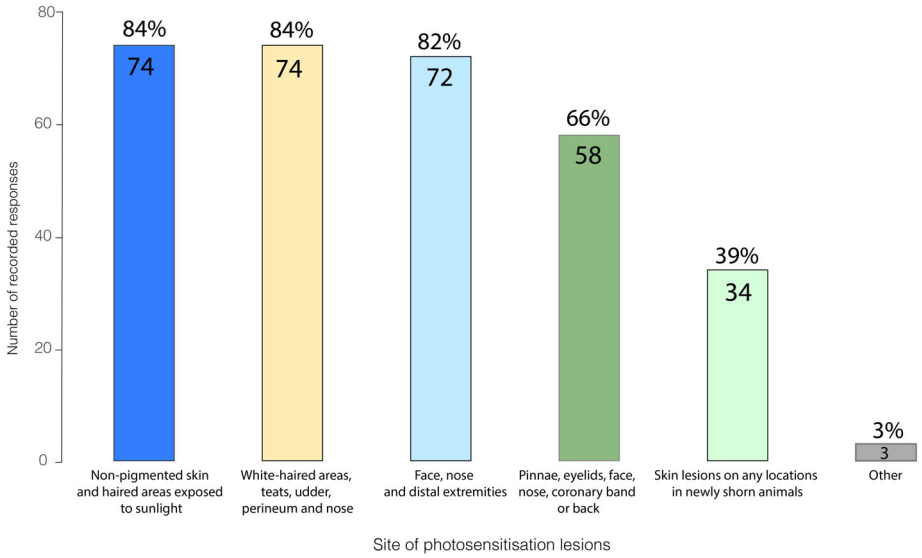

Figure 1. Veterinarian participants' reporting of the distribution of the most common site of skin lesions in photosensitisation cases. The % respondents identifying experience of a particular location is indicated above each column.

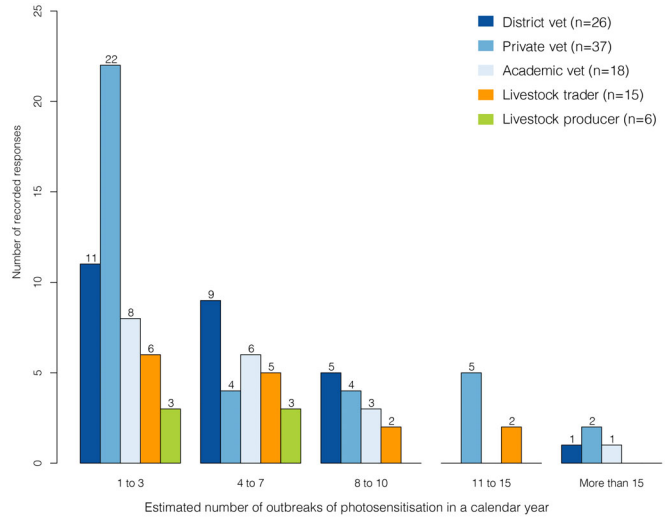

Figure 2. Estimated frequency of photosensitisation outbreaks in a calendar year by the groups surveyed (veterinarians: Blue; livestock traders: Orange; producers: Green).

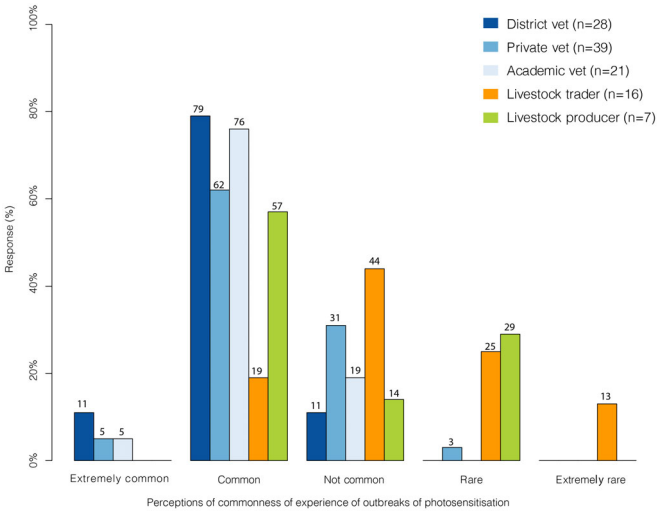

Figure 3. Perceptions of frequency (from extremely common to extremely rare) of outbreaks of photosensitisation reported by veterinarians (blue); livestock traders (orange) and producers (green).

outbreaks of photosensitisation were 'Common'. In contrast, two responders identified outbreaks of photosensitisation as 'extremely rare', both of whom were livestock traders (2/16,13%). Overall, most responses from veterinarians and livestock producers indicated their experience of photosensitisation to be a common, very common, or extremely common, whilst conversely livestock traders indicated that in their experience photosensitisation was not common, rare or extremely rare. Responses from the various categories of respondents are shown in Figure 3.

Perceptions of differential susceptibility of different livestock species to outbreaks of photosensitisation

Veterinarians were asked to report their impression of the species of livestock that they considered to be most susceptible to outbreaks of photosensitisation on a scale from 'extremely rare' to 'extremely common'. In this case, rankings were similar between the three groups of veterinarians: district, private and academic (Figure 4). Cattle and sheep were considered as the most common species to present with clinical photosensitisation in their experience, followed by horses, goats and pigs.

Types of photosensitisations reported by veterinarians, livestock traders and livestock producers

All participants were asked to respond to consider the type of photosensitisation (primary, secondary or other) that they had experienced most frequently in their practice or experience (Figure 5). The most common type of photosensitisation outbreak reported by veterinary respondents was secondary (hepatogeneous) photosensitisation (54% district veterinarians, 53% private veterinarians and 55% academic

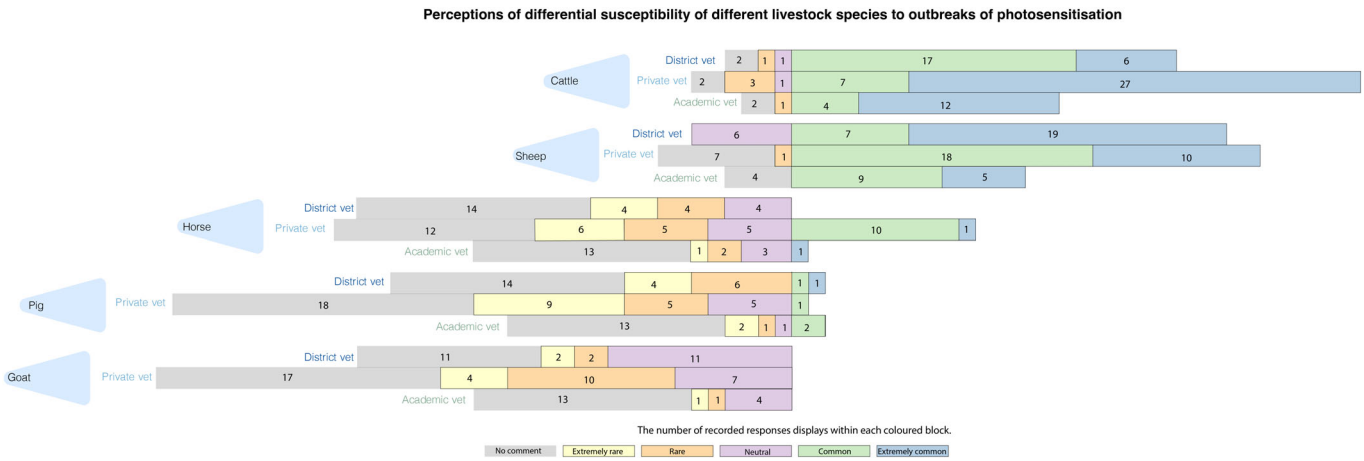

Figure 4. Ranking of susceptibility of difference species of domestic livestock to outbreaks of photosensitisation (from extremely common to extremely rare) in three groups of veterinarians (district, private and academic). Numbers of respondents are identified in each case. Neutral is determined as neither common nor uncommon. A trend to reporting an event as 'common or extremely common' is indicated to the right of the figure, whilst relative impression of 'uncommon' 'rare', or where no response was indicated, are reported towards the left of the figure. Respondents generally reported cattle and sheep outbreaks as 'common or extremely common' categories, whilst horses, pigs, and goats were generally reported as 'neutral', 'uncommon', 'rare' or 'no comment'.

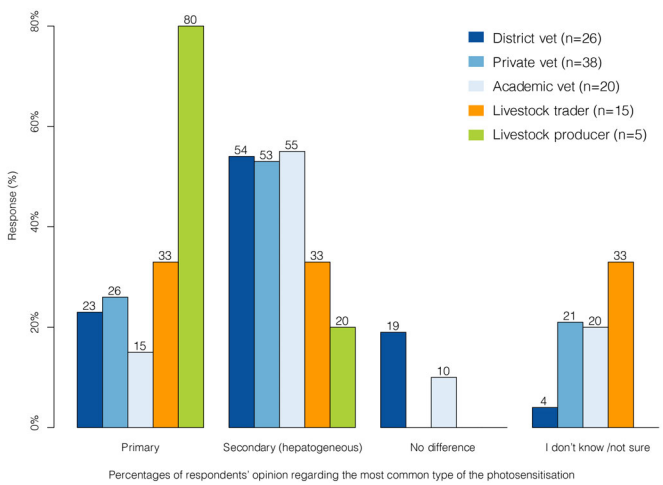

Figure 5. The percentages of respondents' opinions regarding the most common type of photosensitisation (veterinarians: Blue; livestock traders: Orange; producers: Green).

veterinarian). This category was less commonly reported by livestock trader (33%) and livestock producers (20%). Interestingly most producers (80%) chose primary photosensitisation as the most common type they had experienced, which is contrary to other respondents and to the most reported types of photosentisation reported globally,[1] with only 23% district veterinarians, 26% private veterinarians, 15% academic veterinarians and 33% livestock traders choosing this category. A small percentage of district (19%) and academic veterinarians (10%) suggested that there was no difference in the prevalence in the different types of photosensitisations in their experience, and up to one fifth of veterinary respondents (4% district veterinarians, 21% private veterinarians and 20% academic veterinarians) and one third of the livestock trader respondents (33%) acknowledged that they were not able to answer the question accurately. Interestingly, in contrast all livestock producers were confident that they could identify the cause of an outbreak in their experience (Figure 5).

Outbreak seasonality

All participants were asked to rank the season in which they considered that they most frequently experienced outbreaks of photosensitisation, rating each season from 'extremely rare' to 'extremely common'. Similar responses were observed from veterinarians and livestock traders with spring (September–November) reported to be the most prevalent time for outbreaks in their experience, followed by summer (December–February), autumn (March–May) and winter (June–August). Interestingly, livestock producers indicated they were more likely to experience outbreaks in winter than the other three seasons (Figure 6).

Experience of causative agents of photosensitisation

All participants were asked to choose the causes they most commonly attributed to outbreaks of photosensitisation from a list of agents known to give rise to outbreaks in livestock in Australia. These included Biserrula (*Biserrula pelecinus*), Blue-green algae (*Anacystis cyanea*), Buckwheat (*Polygonum fagopyrum*), Caltrop (*Tribulus terrestris*), Fungus of facial eczema (*Pithomyces chartarum*), Fungus of lupinosis (*Phomopsis leptostromiformis*), Hairy panic (*Panicum effusum*), Heliotrope (*Heliotropium europaeum*), Lantana (*Lantana camara*), St John's wort (*Hypericum perforatum*) and Sweet grass (*Panicum laevifolium*).

Respondents indicated that Common heliotrope (*Heliotropium europaeum*, 18%, 40/217), St John's Wort (*Hypericum perforatum*, (15%, 33/217) and 'facial eczema' (*Pithomyces chartarum*, 13%, 29/217) were the most common agents suspected to be causal or confirmed to be the cause of photosensitisation in livestock in their experience. Other causal agents were reported at a lower incidence, including lantana (11%, 24/217); hairy panic (9%, 17/217); caltrop (7%, 16/217); the fungus causal to lupinosis (6%, 13/217); blue-green

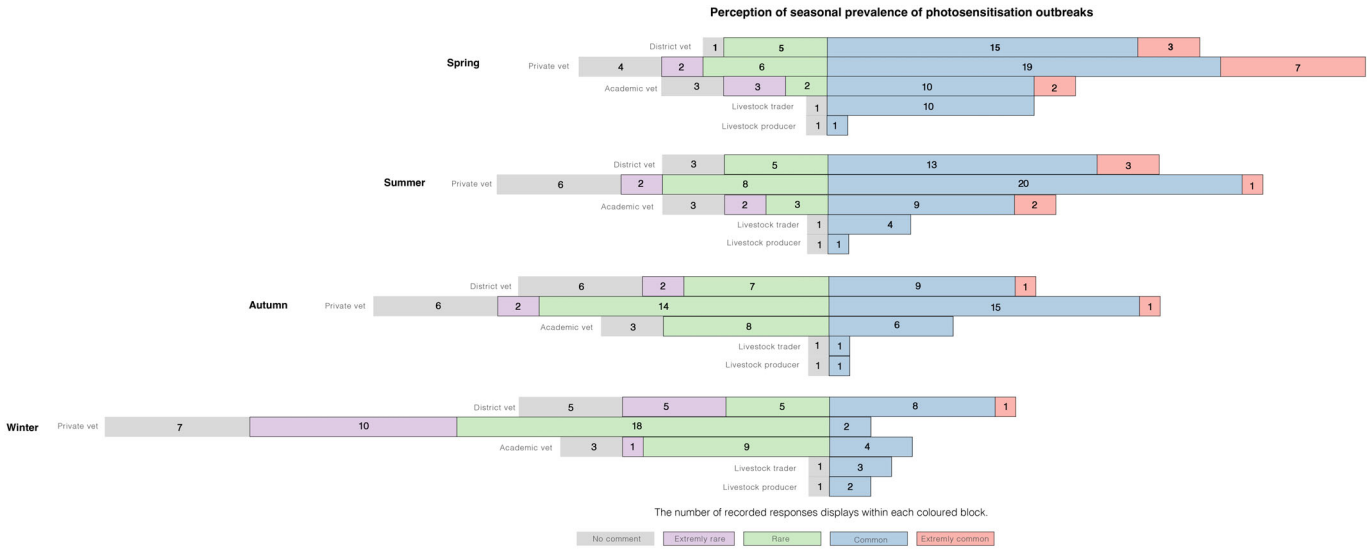

Figure 6. Ranking of the seasonal prevalence of photosensitisation outbreaks in different livestock species by veterinarians (district, private and academic), livestock traders and livestock producers. Responses are ranked by season from 'extremely common' to 'extremely rare' with numbers of respondents are identified in each case. Neutral is determined as neither common nor uncommon. A trend to reporting an event as 'common or extremely common' is indicated to the right of the figure, whilst relative impression of 'uncommon' 'rare' or where no response was indicated is reported to the left of the figure. Respondents generally reported spring and summer as the most likely seasons, with autumn and winter were generally reported as 'neutral', 'uncommon', 'rare' or 'no comment' categories.

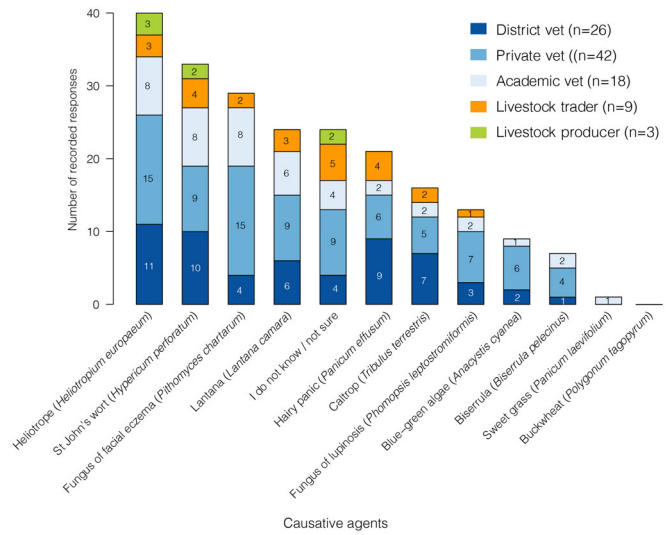

Figure 7. Prevalence of experience of causative agents suspected or confirmed to be related to clinical cases of the cause of photosensitisation in livestock. (veterinarians: Blue; livestock traders: Orange; producers: Green).

algae (4%, 9/217); biserrula (3%, 7/217) and sweet grass (*Panicum schinzii*, 0.5%, 1/217). Twenty-four respondents indicated that a causative agent could not be identified in outbreaks they experienced by choosing 'I do not know/not sure' (Figure 7).

Perceived impact of photosensitisation in Australian livestock production systems

To better understand the perceptions regarding prevalence and importance of photosensitisation to the Australian livestock industry, all participants were asked to give a subjective rating regarding their perception of the economic importance and general impact of the incidence of outbreaks of photosensitisation in livestock. A small percent of respondents (4% district veterinarians, 6% private veterinarians and 12% livestock traders) rated photosensitisation as a 'very important' economic issue, with up to 29% of respondents (23% district veterinarians, 28% private veterinarians, 29% academic veterinarian, 24% livestock traders and 29% livestock producers) considering it to be economically 'important'. Approximately 40% of veterinary respondents (38% district veterinarians, 36% private veterinarians and 41% academic veterinarian) and 24% of livestock traders (24%) and 29% of livestock producers surveyed consider it 'moderately important' economically. A similar percentage of veterinary respondents (35% district veterinarians, 31% private veterinarians, 29% academic veterinarian, 35% livestock traders and 43% livestock producers) as also rated it as 'slightly important'. 6% of livestock traders deemed the economic impact of photosensitisation 'not important at all' (Figure 8).

A similar pattern of responses was observed in the question regarding the general importance of photosensitisation to the industry overall (Figure 9). A higher percentage of district veterinarians (48%) rated the overall importance as 'moderately important', whilst a small percentage of veterinarians (4% district veterinarians and 5% academic veterinarians) thought photosensitisation to be 'not important at all'. The relative importance of photosensitisation to each of the categories of participants does not necessarily correlate to their experience of prevalence of outbreaks with more respondents reporting the overall importance to the industry to be lower (moderately important, slightly important or not important: all veterinarians 59%; livestock traders 71%; livestock producers 83%) than the relative prevalence of their experience (extremely common and

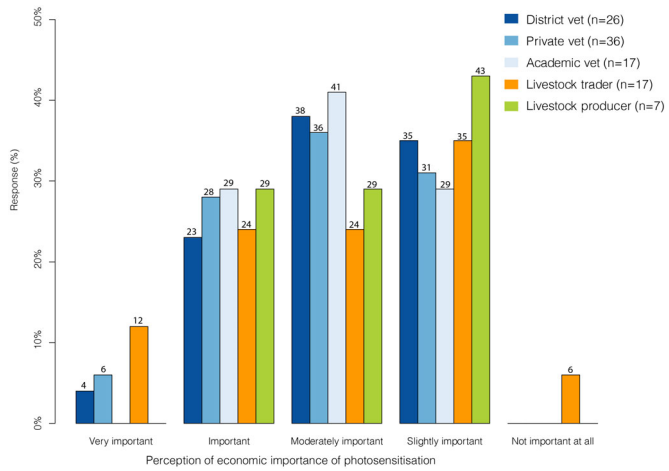

Figure 8. **Perception of the economic importance of photosensitisation by the groups surveyed (veterinarians: Blue; livestock traders: Orange; producers: Green).**

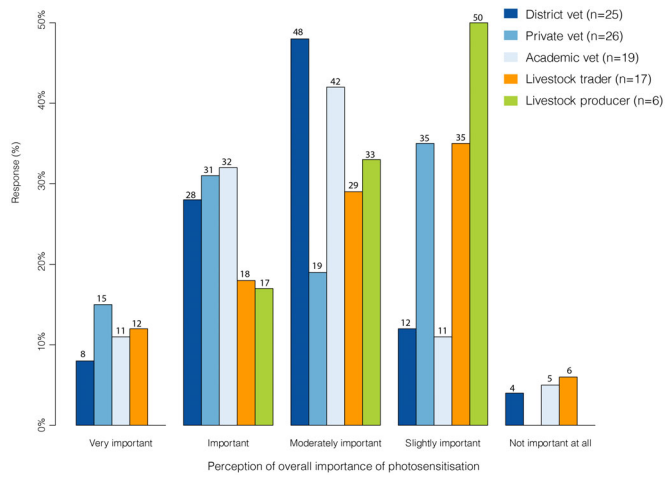

Figure 9. **Perception of overall importance to industry of photosensitisation reported by groups surveyed (veterinarians: Blue; livestock traders: Orange; producers: Green).**

common; all veterinarians total 41%; livestock traders 29%; livestock producers 16%). This relative discrepancy is interesting as this suggests that their perception of importance is not directly linked to the frequency of their experience of outbreaks, where all groups considered the importance to be lower than their perception or experience of incidence that was generally common or extremely common.

Discussion

Anecdotally, photosensitisation has been considered by veterinarians and the livestock industries as a disease with low clinical importance compared to other diseases of livestock due to its perceived low mortality rates and the need for direct therapeutic intervention. Despite this, recent reviews have suggested that both morbidity and mortality can be extremely high suggesting that photosensitisation outbreaks, when they occur, can cause significant economic losses as well as presenting a critical animal welfare issue.[5,6] To better understand perceptions of the prevalence and importance of outbreaks of photosensitisation in Australian livestock systems, we examined responses from veterinarians, livestock producers and livestock traders to better determine their relative experience and perceptions of the frequency and importance of this issue for the Australian livestock sector. Reporting from these cohorts suggests photosensitisation to be a common or very common issue with our data indicating that 62% veterinarians and 58% livestock producers have experienced outbreaks frequently and specifically that the majority of respondents would encounter 1–3 photosensitisation outbreaks per year. Moreover, five private veterinarians and two livestock traders reported that they would see more than 10 outbreaks (11–15) within a year, with one veterinarian from each group indicating that they would see up to 15 outbreaks annually. Overall, our findings suggest that photosentisation is a much more common issue that has been previously suggested by Australian veterinarians and producers alike. The commonality of experience reported in this study suggests that the economic importance of recurrent outbreaks of photosensitisation is likely to be underestimated across the sector, as well as the impacts on animal welfare, and that more careful considerations of this issue is required across the sector. This is particularly important for Australia as the country with the highest number of reported case outbreaks globally in both the peer-reviewed and industry literature.[1] Gaining a holistic understanding of the perceptions at different touchpoints in the value chain, including veterinarians, livestock producers and agents, is vital for a better understanding of the breadth and extent of photosensitisation as a production, health and welfare issue across the sector.

Differences in experience of frequency of outbreaks between professional groups – Implications for reporting and management

The relationship between frequency of a disease outbreak, and relative importance to an industry is not always linear. In this study, there was noted variation in the reported experience of outbreaks of photosensitisation between the different groups of veterinarians. This is perhaps unsurprising as the majority of photosensitisation outbreaks occur on farm are there more likely to be reported to a district veterinarian than to a private veterinarian. Despite the frequency of reporting, this may still represent an under-reporting issue. There are several factors contributing to reporting behaviour between producers and veterinarians, including the required need for veterinary care, legal requirements for reporting, but concerns around consultation costs is known to impede producers from seeking veterinary advice on occasion, particularly in cases of disease outbreaks that they are able to manage themselves without treatment intervention. This is certainly the cases for outbreaks of photosensitisation, where an experienced producer will be aware of the management options for stock experiencing photosensitisation and will respond without veterinary consultation accordingly and will only consult where cases are in excess of their normal experience, or the presentation is severe. This anecdotal evidence is supported by the findings of this study where district veterinarians were more likely to experience cases than any other group and therefore to consider them as 'common' (90% indicated common as their

experience) whilst producers reported the issues to be 'common' or 'uncommon' with greatest frequency. In this survey 57% of livestock producers rated photosensitisation as a common problem in their experience, with approximately the same percentage its importance economically. Although the producer sample size is small in this study, this still reflects the author's experience.

Although private veterinarians may not be exposed to photosensitisation cases as frequently as district veterinarians, interestingly, 81% academic veterinarians also rated photosensitisation as a common issue for the industry. This finding may suggest that although academic veterinarians do not necessarily directly respond to disease outbreaks on site, they are likely to be involved as secondary referral experts where outbreaks are complex, or the disease aetiology is unknown. Interestingly, although the private veterinarian might not 'commonly' see cases of clinical photosensitisation, they rated photosensitisation as an 'important' economic issue (34%). This discord between experience, and frequency of outbreaks and the perception of economic importance may reflect that private and academic veterinarian may only be involved in more significant outbreak investigations where more animals present, where symptoms have been particularly severe, or the cause is unknown. Hence, both groups may tend to rate photosensitisation as a more uncommon but important disease. This is evidence consistent with previous statements in the literature,[7] that photosensitisation is often a common but nonfatal presentation on farm.

Susceptibility of animal species to photosensitisation, implications for reporting and animal welfare

The most frequently reported species to be observed relative to experiential outbreaks of photosensitisation for all professional groups considered in this study were sheep and cattle. This is an interesting finding as this results does not correlate exactly with the generally reported frequency of photosensitisation outbreaks in livestock where sheep are the most commonly reported species in the literature as presenting clinical signs of photosensitisation.[1] Our findings may indicated that, in the experience of those veterinarians contributing to the study, that both cattle and sheep were equally likely to be susceptible to photosensitisation regardless of the rate of outbreak reporting or their area of clinical practice. These findings confirm the importance of photosensitisation as an animal welfare issues in cattle and sheep, where outbreaks can cause significant tissue damage, production losses and management issues.

In contrast, the veterinary respondents to indicate that district veterinarians considered photosensitisation in horses as an uncommon, or even extremely rare, whilst responses from private veterinarians suggested this to be 'common'. This potentially reflection their job demographics as mixed practitioners rather than a direct reflection on the number of cases in horses. This finding also suggests that photosentisation in equines may be a relatively unreported animal welfare issue. This finding suggests that when considering incidence and prevalence reporting, the opinions of different professional may be very different when conducting disease epidemiological opinion surveys and also stresses the importance for considering each group separately to ensure accuracy of reporting.

Perceptions of importance of economic loss related to outbreaks of photosensitisation

Economic impacts of disease are of particularly importance for the livestock industries. Livestock traders have a crucial intermediary role in the red meat value chain. They were also canvassed for the first time for their perceptions of impacts of photosensitisation in livestock on the broader industry. Generally, livestock traders responded differently to producers and veterinarians in their survey responses, a situation that likely reflects their experience as traders of generally fit and healthy stock through application of industry best practice guidelines for the sale of stock to market. Their relative position in the value chain may is indicated by their reported experience of photosensitisation being 'uncommon' or 'rare'. Surprisingly, 36% of traders rated photosensitisation as an important economic issue suggesting that they are not unaware of the scale of the issue in Australia. However, their reduced experience is likely due to the industry requirements for producers to present, and therefore traders to manage only animals that are fit for sale. This finding further suggests that the economic impact of photosensitisation should not only include the production cost, but also the delay to trading being considered when economic costs are to be evaluated.

Common causative agents

Hepatogeneous photosensitisation is more commonly reported in the scientific and veterinary medical literature than any other kind, with primary photosensitisation being generally reported rarely.[1] Similar to previous findings, in this survey, more than half of the veterinary respondents rated secondary (hepatogeneous) photosensitisation as the most common type of photosensitisation, further supporting previous evidence that hepatogeneous photosensitising plants or agents are significantly more common than those containing primary photocytotoxic compounds.[1,7] Reasons for this commonality of presentation are that toxic plants know to contain hepatotoxic agents are found more frequently in nature than those containing primary sensitisers.[8,9] Equally, the least common type of photosensitisation, the congenital type (II) that requires specific genome mutations, is very uncommon in livestock.[10,11] The relative commonality of secondary photosensitisation is increased compared to other presentations as hepatobiliary impairment resulting in secondary photosensitisation can also be caused by other agents such as hepatotoxic toxins in fungal contaminants in feed, infectious or inflammatory liver disease, liver parasites, metabolic disease, copper accumulation, or neoplasia, all of which could results in secondary symptoms of photosensitisation.[7] Despite this, 80% of livestock producers chose primary photosensitisation as the most common type which was a surprising result. This difference in perception and/or experience may reflect that the livestock producers may consider outbreaks for which they cannot identify the cause as probably related to primary photosensitisation outbreaks than vets who have ongoing experience of multiple types of secondary photosensitisation causes. Therefore, extra caution must be applied whenever interpreting an anecdotal case report which has no laboratory or other accessory test results where a primary photosensation cause is suggested.

Generally, the number of causative agents confirmed as causal in outbreaks of photosensitisation in livestock are limited compared to

potential agents reported in human clinical cases.[12] In this survey, the most frequent causative agents implicated in outbreaks of photosensitisation by our various professional groups was *Heliotropium europaeum* (Heliotrope, 18%, 40/217) and *Hypericum perforatum* (St John's wort, 15%, 33/217). This result is in contrast to the most widely reported causative plants in the scientific and veterinary literature which are *Panicum* spp. and *Lantana* spp.[1] This result may reflect the broader geographic origin of the survey respondents comparing to published reports or may be reflective of the literature preferentially reporting more severe, interesting or unusual cases. Regardless, this finding highlights the necessity of having a comprehensive understanding in all professions associated with livestock production of the potential causative agents for photosensitisation and that effective prevention strategies need to be developed based on local plant species and their prevalence. Tailored research targeting the biology of different causative agents, particularly those capable of causing significant hepatic damage, should be adopted and development of land management plans to prevent outbreaks of photosensitisation should be an ongoing dialogue into the future.

Seasonal prevalence patterns of the photosensitisation outbreak

Seasonal prevalence patterns for outbreaks of photosensitisation in livestock have been reported previously irrespective of aetiological cause.[13] This seasonal pattern was also evident in responses to our survey. Spring (September–November) was the most reported time for respondents to experience outbreaks, followed by summer and autumn. Outbreaks in winter were least likely to occur in the experience of the respondents. Whilst this may generally account for the temporal appearance of most acute outbreaks, it must be remembered that there can be a delay between onset and reporting. This is particularly the case where the clinical signs of tissue damage subsequent to photosensitisation (scabbing or tissue destruction in the pinnae of the ear or scabbing of the facial tissues. For example, outbreak reported in December could be the successive appearance of lesions resulting from a causal exposure in November, if not earlier. This temporal delay might also explain why livestock producers rated winter as the most prevalent season for photosensitisation, but the veterinarians rated the spring as the most prevalence season. This mirrors our experience that livestock producers may only consult a veterinarian if symptoms persist or deteriorate rather than when first clinical signs are noted. These findings indicate that both producers and veterinarians should be most vigilant for potential outbreaks during late winter and spring. It is also important to note that the number of traders ($n = 14$) and producers ($n = 5$) responding to the survey was small, and we cannot exclude that they may have come from the same or similar climatic regions, so this result may not be considered as a piece of solid supporting evidence that photosensitisation has a seasonally relevant prevalence or may present with different seasonal patterns given various meteorological conditions and plant ecology. However, seasonal outbreak prevalence has been reported previously and therefore the producer incidence identified in this study is in line with those reported previously.[1]

The small number of responses to this survey, especially from traders ($n = 17$) and producers ($n = 6$) will certainly have resulted in response bias affects the reliability of the results presented from these groups. Given that Australia large geographically, with numerous different climatic zones giving rise to variation in vegetation in different livestock production that is known to influence the prevalence of photosensitisation in different regions. In addition, our survey did not include an analysis of the specific area of location of the respondents, so it is not possible to reflect whether these results can be mapped to a specific region. However, while the results of this survey may not be indicative of the complete picture of photosensitisation in Australia's livestock production systems, this data can assist stakeholders to consider the relative reporting biases in terms of the importance of outbreaks of photosensitisation in these different professional groups.

Conclusion

This study is the first survey to analyse multiple stakeholders' perceptions towards photosensitisation in livestock across the livestock chain. It supports previous evidence that photosensitisation is a common but underreported entity in the livestock industry. Differences of experience, and perceptions of economic importance within different professional groups within the veterinary industry, livestock traders and livestock producers suggest that there is not an industry-wide common acceptance of the issue, and therefore broader opinions should be canvassed when considering impacts on stakeholders regarding photosensitisation in livestock in Australia or abroad.

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