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Suspected poisoning of domestic animals by pesticides

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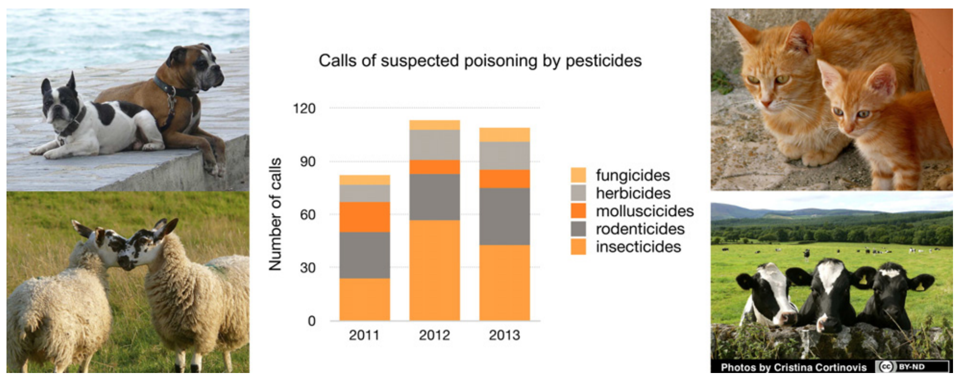
HIGHLIGHTS

- Pesticides are the most important cause of suspected poisoning in domestic animals.
- The trend seems to be influenced by bans and restrictions.
- Insecticides were the primary cause of suspected poisoning followed by rodenticides.
- Pyrethrins–pyrethroids were the insecticides most frequently implicated.
- A sharp decline from organophosphates and carbamates was observed.

GRAPHICAL ABSTRACT



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ABSTRACT

A retrospective study was carried out by reviewing all suspected cases of domestic animal poisoning attributed to pesticides, reported to the Milan Poison Control Centre (MPCC) between January 2011 and December 2013. During this period, pesticides were found to be responsible for 37.3% of all suspected poisoning enquiries received (815). The most commonly species involved was the dog (71.1% of calls) followed by the cat (15.8%), while a limited number of cases involved horses, goats and sheep. Most cases of exposure (47.1%) resulted in mild to moderate clinical signs. The outcome was reported in 59.9% of these cases, with death occurring in 10.4% of them. Insecticides (40.8%) proved to be the most common group of pesticides involved and exposure to pyrethrins–pyrethroids accounted for the majority of calls. According to the MPCC data, there has been a decrease in the number of suspected poisonings cases attributed to pesticides that have been banned by the EU, including aldicarb, carbofuran, endosulfan and paraquat. In contrast, there has been an increase of suspected poisoning cases attributed to the neonicotinoids, imidacloprid and acetamiprid, probably due to their widespread use in recent years. Cases of suspected poisoning that involved exposure to rodenticides accounted for 27.6% of calls received by the MPCC and anticoagulant rodenticides were the primary cause of calls, with many cases involving brodifacoum and bromadiolone. Herbicides were involved in 14.2% of calls related to pesticides and glyphosate was the main culprit in cases involving dogs, cats, horses, goats and sheep. As far as exposure to molluscicides (11.5%) and fungicides (5.9%), most of the cases involved dogs and the suspected poisoning agents were metaldehyde and copper compounds respectively. The data collected are useful in determining trends in poisoning

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episodes and identifying newly emerging toxicants, thus demonstrating the prevalence of pesticides as causative agents in animal poisonings.

1. Introduction

The poisoning of domestic animals by inappropriate or careless use of commercial pesticide formulations has been documented worldwide (Berny et al., 2010; Caloni et al., 2012a; Caloni et al., 2012b; Guitart et al., 2010a; McLean and Hansen, 2012; Vandenbroucke et al., 2010; Wang et al., 2007). The pesticides most frequently involved are insecticides and rodenticides (Anastasio and Sharp, 2011; Berny et al., 2010; Caloni et al., 2012a, 2012b; Segev et al., 2006; Sheafor and Couto, 1999; Waddell et al., 2013; Wang et al., 2007; Yas-Natan et al., 2007). Poisoning episodes by herbicides, molluscicides and fungicides have also been reported but less frequently (Burgat et al., 1998; Berny et al., 2010; Bates et al., 2012; Caloni et al., 2012a, 2012b; Kaye et al., 2012). According to Martínez-Haro et al. (2008), the incidence of specific intoxication by pesticides is highly dependent on the toxicity of commercial formulations. A ban on the use of highly toxic pesticides can reduce their availability and consequently the occurrence of animal poisoning. This has been seen to occur in the case of cattle poisoning by organochlorines, frequently recorded until 1998 (Caloni et al., 2012a; Guitart et al., 2010a). However, the poisoning of animals by banned compounds is still frequently reported in literature. Carbamates such as aldicarb and carbofuran which have been banned by the EU, are still frequently reported in poisoning episodes involving domestic animals (Berny et al., 2010; Caloni et al., 2012a, 2012b) and wildlife (Guitart et al., 2010b; Ruiz-Suárez et al., 2015). Therefore, in addition to banning, stricter controls on distribution among professionals are also needed (Martínez-Haro et al., 2008). Moreover, to reduce the occurrence of fatal poisonings of non-target animals repellents and a lower percentage of the active ingredient should be used in formulations of pesticides (Martínez-Haro et al., 2008).

Based on the Milan Poison Control Centre (MPCC, formerly CAV) data, a general overview of domestic animal poisoning in Italy has been provided in a previous study (Caloni et al., 2012b). It found exposure to pesticides to be the primary cause of poisoning, accounting for 47.7% of total enquiries received. The present work is a three-year epidemiological study of all enquiries on the suspected poisoning of domestic animals by pesticides, received by the MPCC between January 2011 and December 2013. It aims to collect essential information on pesticide exposure such as the frequency, the specific pesticides and animal species involved, the severity of clinical signs and the final outcome. The relationship between the frequency of poisoning by specific pesticides, restrictions on their use and the commercial release of new products is also discussed.

2. Materials and methods

For each MPCC enquiry, a standard form including date and origin of call, information on animal characteristics (species/breed/sex/age), suspected causative agents, clinical signs, routes of exposure and exposure site (indoor or outdoor) was completed by telephone. Follow-up calls were then made to obtain continuous case updates including the final outcome. The collection of accurate and complete data was attempted in every case. Information obtained at both the time of enquiry and from follow-up calls was then entered and stored in the MPCC database. According to the data, the causative agents were classified into six main categories: pesticides, drugs, household products, metals, plants and zootoxins. All suspected animal poisoning cases recorded between January 2011 and December 2013 were reviewed to identify those caused by pesticides. The latter were classified into insecticides (excluding veterinary parasiticides), rodenticides, molluscicides, herbicides and fungicides. Analysis was performed only in cases where a correspondence existed between the suspected agent, the time of onset of effects and the type of clinical sign or in cases where the exposure was witnessed by the owner. In collaboration with veterinary toxicologists at the University of Milan, the data were processed using epidemiological analysis and evaluated based on the animal involved, the clinical signs and the final outcome. The severity of clinical signs was classified as 'no signs', mild, moderate or severe (Table 1), in accordance with the methodology used by Gwaltney-Brant (2007). The Student's t-test was used to compare the frequency of pesticide exposures over time. A P-value of <0.05 was considered significant.

3. Results

The MPCC recorded 304 cases involving domestic animals that were accidentally exposed to pesticides, corresponding to 37.3% of all the suspected poisoning cases recorded (815) in the 2011–2013 period. Of these enquiries, 86.2% involved dogs and 10.5% involved cats. Calls related to other species were much fewer in comparison and mainly involved horses and sheep (1% each) followed by goats (0.7%). In 91.8% of the cases, the route of exposure appeared to be oral intake, followed by cutaneous exposure and inhalation (1.6% each). The number of calls received each year related to the different classes of pesticides is shown in Fig. 1. Of these calls, 81.2% came from urban areas, 16% from neighbouring villages and 2.8% from rural areas. In Table 2, the site of exposure (indoor or outdoor) reported in calls involving dogs and cats is shown.

3.1. Insecticides

Insecticides (40.8%) proved to be the most common group of pesticides involved. Enquiries were related almost exclusively to dogs (105 calls) and cats (18 calls). The MPCC classified the insecticide enquiries as shown in Fig. 2. The majority of calls involving dogs (31.4%) and cats (44.4%) involved suspected exposure to pyrethrins–pyrethroids. Several pyrethrins–pyrethroids including allethrin, cyfluthrin, cypermethrin, deltamethrin, tetramethrin, and phenothrin

Table 1
Clinical signs by severity category.

No signs	No clinical signs	–
Mild	Mild, transient and spontaneously resolving clinical signs	Hypersalivation, mild vomiting and diarrhoea, inappetence, coughing, skin or eye irritation, lacrimation.
Moderate	Pronounced, prolonged or systemic clinical signs	Pronounced or prolonged vomiting and diarrhoea, dysphagia, dyspnea or tachipnea, mild to moderate bradycardia or tachycardia, pallor, mild to moderate hypotension, fasciculations, tremors, renal dysfunction, 2nd degree burns in <50% of body surface, corneal abrasion.
Severe	Life-threatening clinical signs or possible residual disability or disfigurement following recovery	Severe bradycardia or tachycardia, respiratory insufficiency, clinical evidence of liver dysfunction, massive haemorrhage, generalized seizures, coma, renal failure, 2nd degree burns in >50% of body surface or 3rd degree burns, corneal ulcers.

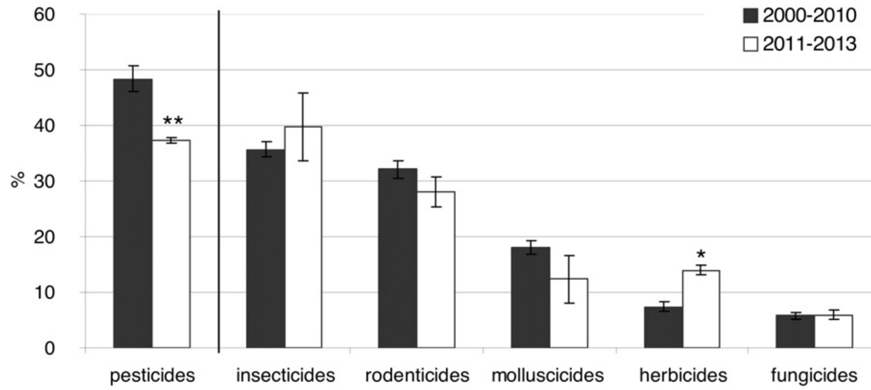

Fig. 1. Calls on suspected animal poisoning by pesticides from 2000 to 2010 (n = 919; Caloni et al., 2012b) and from 2011 to 2013 (n = 304). Milan Poison Control Centre data 2000 to 2013. Graph shows the median values and error bars. The P-values <0.05 (*) and <0.001 (**), between the two analysed periods (2000–2010 and 2011–2013), were evaluated by the Student's t-test.

were recorded. In episodes involving dogs, anticholinesterase insecticides (carbamates and organophosphates) were found to be the second most common cause of suspected intoxication (21.9%) followed by neonicotinoids (9.5%). The latter accounted for 16.7% of suspected poisoning episodes involving cats, and primarily involved imidacloprid and acetamiprid (accounting for 38.5% of neonicotinoid-related calls respectively). Anticholinesterase insecticides were also recorded in cases involving cats (11.2%). In this survey, the carbamate methomyl proved to be the most common anticholinesterase insecticide in episodes involving both dogs and cats. Among organophosphates, dimethoate and chlorpyriphos were most frequently involved. Organochlorine insecticides accounted for only 1.6% of cases and endosulfan was recorded in one episode.

3.2. Rodenticides

Exposure to rodenticides accounted for 27.6% of pesticide-related calls received by the MPCC and involved mostly dogs (76 calls) and cats (6 calls). All the rodenticides involved are reported in Fig. 3. In cases involving dogs, anticoagulant rodenticides were the primary cause of suspected poisoning (68.4% of rodenticide-related calls) with many cases involving brodifacoum (13 calls), bromadiolone (11 calls) and difenacoum (4 calls). Bromadiolone was the only anticoagulant rodenticide reported in cases involving cats (1 call). In some episodes involving dogs (4 calls) and cats (2 calls), α-chloralose was implicated as the cause. Thallium and zinc phosphide were also recorded (1 call related to each), with both cases involving dogs. In addition, one suspected poisoning episode involving pigs was attributed to the anticoagulant rodenticide chlorophacinone.

3.3. Herbicides

Herbicides accounted for 14.2% of calls related to pesticides. Glyphosate, recorded in cases involving dogs (22 calls), cats (3 calls), horses (2 calls), a goat and a sheep (1 call involving each) was the main culprit (67.4% of total herbicide-related calls). Cases of exposure to several synthetic auxin herbicides including dicamba, 4-chloro-2-methylphenoxyacetic acid (MCPA), picloram, fluroxypyr and triclopyr were also recorded. In particular, the combination of fluroxypyr and triclopyr, pyridine herbicides, was reported in cases involving dogs (2 calls) and a cat (1 call). No calls involving paraquat were received and only an isolated case of suspected dog poisoning by diquat was recorded.

Table 2
Site of exposure to pesticides in dogs and cats.

Pesticides	Number of calls (%)	
	Outdoor	Indoor
Insecticides	34 (27.6%)	89 (72.3%)
Rodenticides	30 (36.1%)	53 (63.8%)
Herbicides	26 (72.2%)	10 (27.7%)
Molluscicides	18 (52.9%)	16 (47%)
Fungicides	11 (61.1%)	7 (38.8%)
Total	119 (40.4%)	175 (59.5%)

3.4. Molluscicides

Exposure to molluscicides accounted for 11.5% of calls related to pesticides. According to the MPCC data, most of the suspected poisoning cases involved dogs (94.3%). Metaldehyde (60.6%) was the main cause of suspected dog poisoning followed by methiocarb (9.1%). One call involving a cat exposed to an unknown molluscicide was received and another involving goats and the ingestion of metaldehyde.

3.5. Fungicides

Fungicides accounted for 5.9% of calls related to pesticides. Two cases involved cats while the rest all involved dogs. Copper fungicides including copper sulphate (6 calls), bordeaux mixture (2 calls) and copper oxychloride (2 calls) were most frequently reported (55.6% of fungicide-related calls) in these episodes. Other fungicides recorded included the dithiocarbamates, thiram and mancozeb, tebuconazole, dithianon and prochloraz (1 call each).

3.6. Clinical signs

According to the MPCC data, 45.7% of cases involved suspected animal exposure to pesticides which resulted in no signs (Fig. 4). Mild signs, moderate signs and severe signs developed in 22.4%, 24.7% and

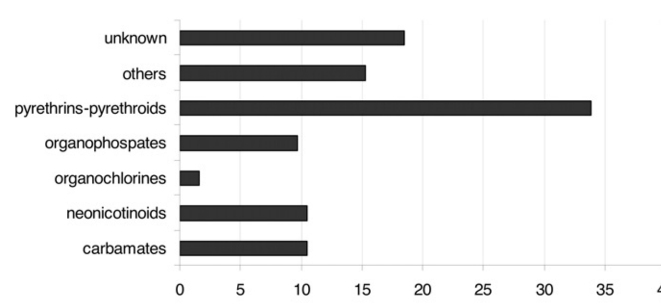

Fig. 2. Calls on suspected animal poisoning by insecticides (n = 124). Milan Poison Control Centre data 2011 to 2013.

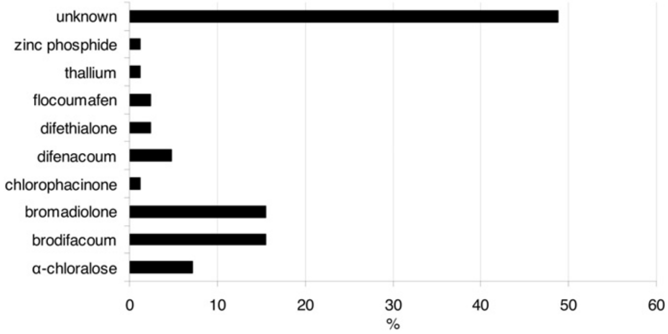

Fig. 3. Calls on suspected animal poisoning by rodenticides (n = 84). Milan Poison Control Centre data 2011 to 2013.

7.2% of cases respectively (Fig. 4). The outcome was reported in 59.9% of cases and death accounted for 10.4% of them. In episodes involving dogs, metaldehyde and glyphosate were the most common suspected causes of death with a mortality rate of 25% and 13.8%, respectively. Death was also reported after suspected exposure to thallium, copper sulphate, methomyl and unspecified neonicotinoid, organophosphate and organochlorine insecticides. In cases involving cats, death occurred after suspected exposure to methomyl and pyrethrins–pyrethroids. In cases involving horses, one episode of suspected MCPA ingestion resulted in intestinal necrosis followed by death.

4. Discussion

Pesticides are involved in more cases of animal exposure and death than any other category of toxicants (Murphy and Talcott, 2013). According to the MPCC data, pesticide exposure accounted for 37.3% of all suspected animal poisoning cases recorded in the 2011–2013 period. If compared with the previous study carried out from 2000 to 2010 (47.7%; Caloni et al., 2012b), the present data show a decrease in the incidence of suspected domestic animal poisoning by pesticides, perhaps due to several restrictions that have been placed on many pesticides in the EU (EC, 2003, 2006). In line with data previously reported in Italy (Caloni et al., 2012b; Giuliano Albo and Nebbia, 2004) and in other European countries (Barbier, 2005; Berny et al., 2010; Vandenbroucke et al., 2010), insecticides were found to be the primary cause of suspected poisoning. This result also coincides with previous studies which show insecticides to be the most common class of pesticides involved in the poisoning of children (Garry, 2004). This may be explained by the popularity of insecticides for use at home, both indoors and in gardens. Insecticides represent multiple chemical classes and different formulations are available for purchase by consumers and professionals (Stout et al., 2009). The popularity and availability of insecticides has transitioned over the years through the different classes leading to an ongoing need for epidemiological data to assess risk exposure in both humans and animals (Stout et al., 2009). In the present survey, the most common insecticides implicated in cases involving dogs and

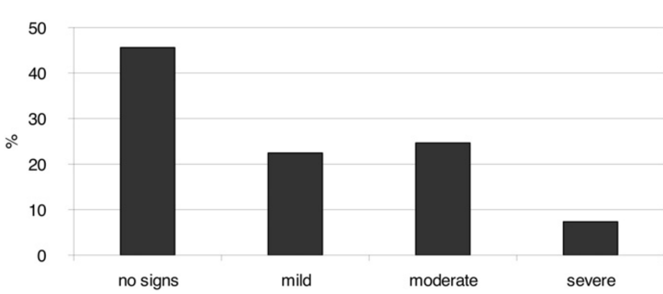

Fig. 4. Severity of clinical signs in animal species following suspected exposure to pesticides. Milan Poison Control Centre data 2011–2013.

cats were found to be pyrethrins–pyrethroids. This result is only partially in agreement with previous studies (Caloni et al., 2012b; Giuliano Albo and Nebbia, 2004) in which pyrethrins–pyrethroids were indicated as the main culprit in the poisoning of cats. Cats are particularly sensitive to these insecticides due to their inability to conjugate glucuronides and poisoning may result in hypersalivation, vomiting, muscle tremor, ataxia, seizures and death (Anadón et al., 2009; Wismer and Means, 2012). Early and aggressive supportive treatment often results in a full recovery within 24 to 72 h (Anadón et al., 2009). With regard to dogs, previous works (Berny et al., 2010; Caloni et al., 2012b; Giuliano Albo and Nebbia, 2004; Vandenbroucke et al., 2010) found anticholinesterase insecticides (carbamates and organophosphates) to be the most common toxicants, with the carbamates aldicarb, carbofuran and methomyl and the organophosphate chlorpyrifos identified as the main poisoning agents. Carbamates and organophosphates act by inhibiting the acetylcholinesterase enzyme leading to hyperexcitability of cholinergic receptors within the nervous system and the neuromuscular junction. This results in muscarinic (salivation, lacrimation, urination, defecation, miosis, bronchospasm, bradycardia, and emesis), nicotinic (muscle tremor, ataxia, weakness, and paralysis) and CNS (severe depression to hyperactivity and seizures) clinical signs (Wismer and Means, 2012; Means, 2013). Cats are considered to be more susceptible to anticholinesterase insecticides than dogs and immediate and effective treatment is essential for a positive outcome (Wismer and Means, 2012). Atropine sulphate is a specific physiologic antidote for both organophosphate and carbamate toxicoses and is used to control muscarinic signs (Tse et al., 2013; Wismer and Means, 2012). In organophosphate toxicosis, oximes are used in addition to atropine sulphate to reverse neuromuscular blockade and nicotinic signs (Wismer and Means, 2012). The reduction in suspected poisoning episodes recorded by the MPCC involving carbamates may be related to the EU ban on the sale of products containing aldicarb which were consequently withdrawn in 2003 (EC, 2003). Products containing carbofuran were also banned in 2007 (EC, 2007). Reasons behind the ban included high toxicity, low handling safety and ecotoxicological effects (Ruiz-Suárez et al., 2015). Methomyl, commonly used indoors in a granular and concentrated formulation against flies (Berny et al., 2010), was found to be the most commonly found carbamate. As far as organophosphates, frequently used in the EU for pest control due to their low price and broad spectrum of activity, the decrease in related suspected poisoning episodes may be explained by increased concerns about their residential use and potential exposure of humans to chlorpyrifos. Chlorpyrifos has been strongly correlated with neurodevelopmental effects and in the U.S., the Environmental Protection Agency (EPA) imposed a ban on the sale of chlorpyrifos for residential use in December 2001 (Saunders et al., 2012).

Endosulfan, an organochlorine compound often involved in the past in cases of pet intoxication (Caloni et al., 2012b; Giuliano Albo and Nebbia, 2004), was recorded in one case only, having been withdrawn from the market in 2011. Clinically, organochlorines cause intense nervous stimulation and hypersensitivity (Raisbeck, 2013). Poisoned animals become hyperesthetic and exhibit tremor and convulsions (Raisbeck, 2013). The species most sensitive to these insecticides are cats (Ensley, 2012). Treatment is symptomatic and supportive and the prognosis can be guarded to good, depending on the dose of exposure and the immediacy of decontamination (Raisbeck, 2013).

Among the other insecticides, the neonicotinoids, imidacloprid and acetamiprid, were found to be frequently involved, probably due to their widespread use. In recent years, neonicotinoids have gained favour over other insecticides such as carbamates and organophosphates due to low toxicity in relation to mammals and high toxicity in relation to insects, flexible use and systemic activity (Goulson, 2013). Since they are sold for garden use as a spray for flowers and vegetables and for home use in bait formulations against cockroaches and ants (Goulson, 2013), pets can easily come into contact with these insecticides. Limited information has been published detailing the toxic effects of neonicotinoids in dogs or cats. Signs of poisoning are similar to nicotinic signs and include lethargy, vomiting, diarrhoea, hypersalivation, initial tremor, muscle weakness and ataxia (Gwaltney-Brant, 2013; Wismer and Means, 2012). Treatment is symptomatic and supportive and animals are expected to recover within 24 to 72 h with veterinary care (Gwaltney-Brant, 2013).

More than 90% of all rodenticides used commercially have been estimated to be of the anticoagulant type (Murphy and Talcott, 2013). This explains why anticoagulant rodenticides are so frequently implicated in domestic animal poisoning cases. As previously reported (Giuliano Albo and Nebbia, 2004; Murphy and Talcott, 2013; Vandenbroucke et al., 2010) and confirmed by the MPCC cases of suspected poisoning, dogs are intoxicated more commonly than cats or other domestic animals. In line with previous studies (Berny et al., 2010; Caloni et al., 2012b; Waddell et al., 2013), second-generation compounds such as brodifacoum and bromadiolone were found to be the most commonly involved anticoagulant rodenticides, due to their widespread use. The recycling of vitamin K_1 which induces coagulopathy is inhibited by exposure to anticoagulant rodenticides (Murphy and Talcott, 2013). Resulting clinical signs usually include lethargy, weakness, coughing, dyspnea, hemoptysis, bilateral epistaxis, tachycardia, poor pulse and pale mucous membranes (DeClementi and Sobczak, 2012; Istvan et al., 2014; Murphy and Talcott, 2013; Waddell et al., 2013). Decontamination procedures are suggested if ingestion has occurred within the last few hours. Vitamin K_1 therapy is recommended for animals with elevated coagulation times (DeClementi and Sobczak, 2012; Murphy and Talcott, 2013). The prognosis is from guarded to good, depending on the severity and location of the haemorrhage and the administration of quick and appropriate treatment (Murphy and Talcott, 2013).

Alpha-chloralose, an anaesthetic compound also used as a rodenticide with mixed effects of excitation and depression on the central nervous system (CNS) depending on the dose, was reported in cases of suspected poisoning involving both dogs and cats. Alpha-chloralose poisoning seems to have a favourable prognosis in dogs and cats (Segev et al., 2006) and no fatal cases were recorded by the MPCC.

The commonly found zinc phosphide, a grey crystalline powder labelled for use as a rodenticide which previous studies have indicated as a considerable threat to dogs (Giuliano Albo and Nebbia, 2004; Gray et al., 2011), was recorded in only one case involving a dog. Zinc phosphide toxicity is secondary to the release of the highly toxic phosphine gas after ingestion, leading to gastrointestinal, respiratory or CNS effects (Gray et al., 2011). Although zinc phosphide exposure may be fatal, it has been shown that the overall outcome can be positive with appropriate and early intervention. Treatment involves safe and effective decontamination followed by symptomatic and supportive care (Gray et al., 2011). Despite bans and restrictions on the use of thallium as a rodenticide in many countries, it was implicated in one case involving a dog.

As glyphosate-surfactant herbicides are being increasingly used due to their high effectiveness and relatively low toxicity in relation to mammals, their role in the accidental poisoning of domestic animals is becoming more significant (Cortinovis et al., 2015). Initially developed to control the growth of species of weed in agriculture, these herbicides also play an important role in domestic weed control (Annet et al., 2014) and thus pets can easily come into contact with them. In line with previous studies (Burgat et al., 1998; Caloni et al., 2012b; Cortinovis et al., 2015; Giuliano Albo and Nebbia, 2004), glyphosate proved to be the herbicide involved in the highest number of calls recorded by the MPCC. Limited data are available on the intoxication of domestic animals by glyphosate and based on the VPIS data (Bates and Edwards, 2013), exposure to glyphosate-surfactant herbicides is a concern firstly for cats and secondly for dogs. Common clinical signs after accidental ingestion include hypersalivation, vomiting and diarrhoea due to gastrointestinal irritation. In severe cases, increased muscular activity, respiratory distress, renal impairment and death have been observed (Bates and Edwards, 2013; Cortinovis et al., 2015). The mechanism of toxicity of glyphosate-surfactant formulations is unclear as both glyphosate and the surfactant may contribute to toxicity (Chen et al., 2013; Malhotra et al., 2010; Piola et al., 2013). Several studies have found that commercial glyphosate-based formulations are more toxic than glyphosate itself because of the adjuvants present in the formulations (Coalova et al., 2014; Mesnage et al., 2013, 2014). No antidote is available for glyphosate-surfactant poisoning and the mainstay of treatment for systemic toxicity is decontamination and aggressive supportive therapy.

No case of suspected poisoning by paraquat was reported to the MPCC, frequently recorded in the past as a cause of pet poisoning and commonly found in baits (Berny et al., 2010; Caloni et al., 2012a, 2012b; Giuliano Albo and Nebbia, 2004; Martínez-Haro et al., 2008). It has presently been banned in several EU countries. An isolated case of suspected poisoning by diquat, the analogue of paraquat, was recorded in a dog. Diquat is considerably less potent than paraquat as a pulmonary toxicant, but it may cause severe acute poisoning (Donaldson, 2013). A case involving the suspected ingestion of MCPA by a horse resulted in intestinal necrosis followed by death. The culprit is a widely used phenoxy herbicide for broad-leaf weeds and reported to be involved in previous animal poisoning episodes (Martínez-Haro et al., 2008; Vandenbroucke et al., 2010).

With regard to molluscicides, the analysis of the MPCC data supports the findings of other studies (Bates et al., 2012; Buhl et al., 2013; Yas-Natan et al., 2007) and highlights the continuing problem of exposure of domestic animals, particularly of dogs, to metaldehyde. The latter is a tetramer of acetaldehyde commonly included in a variety of commercial snail and slug baits (Bates et al., 2012; Yas-Natan et al., 2007). The addition of bran or molasses to these baits in an effort to attract snails and slugs, also attracts domestic animals (Dolder, 2003) and explains the frequency of enquiries made to the MPCC on suspected poisoning by metaldehyde. In the U.S., the EPA requires new label statements for products containing metaldehyde intended for use in residential settings in order to reduce the incidence of child and pet exposure to these products (Buhl et al., 2013). Animals that ingest metaldehyde may develop symptoms such as vomiting, tachycardia, tachypnea, ataxia, hyperthermia, tremor, seizures and death (Bates et al., 2012; Buhl et al., 2013; Yas-Natan et al., 2007). According to the MPCC, the final outcome was death for 25% of the animals exposed.

No antidote is available for metaldehyde poisoning and, given the potential for fatal poisoning, rapid treatment is critical and should focus on detoxification, controlling tremor, seizures and hyperthermia, maintaining adequate organ perfusion and managing metabolic acidosis (Bates et al., 2012; Brutlag and Puschner, 2013). The prognosis is good if the animal survives the first 24 h after exposure and receives immediate treatment (Brutlag and Puschner, 2013). Poisoning incidents with metaldehyde are more frequently encountered in cases of dogs and cats, but other domestic animals may also be involved and the MPCC also recorded one case of suspected poisoning involving a goat.

In line with the SATV data (Amorena et al., 2004; Giuliano Albo and Nebbia, 2004), the fungicide implicated in the highest number of calls was found to be copper sulphate. Fungicides that are used to control plant disease are generally low in mammalian toxicity. Thiram was identified as a poisoning agent among other fungicides, frequently used as an animal repellent for crop protection and already reported in previous animal poisoning cases (Martínez-Haro et al., 2008). It is believed that the use of thiram as an animal repellent is the most likely source of pet exposure (Talcott, 2013).

5. Conclusions

In conclusion, epidemiological data from this survey provide updated and useful information on animal exposure to pesticides, potentially a risk for humans as well. In general, a decrease in the incidence of domestic animal suspected poisoning by pesticides was observed with a change in the class of toxic compounds involved, due to the introduction of restrictive legislation. However, according to the MPCC, pesticides still represent the main cause of suspected animal poisoning. The data collected are useful in determining poisoning trends and identifying emerging toxicants. Knowing which agents have serious poisoning potential can help veterinarians with the diagnosis and implementation of preventive measures that can reduce animal exposure to pesticides.

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