Plants and zootoxins: toxico-epidemiological investigation in domestic animals

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Abstract

An epidemiological study on animal poisoning due to plants and zootoxins has been carried out by the Poison Control Centre of Milan (CAV) in collaboration with the University of Milan (Italy). During the period January 2015 - March 2019, the CAV received 932 calls on animal poisonings, 12.66% (n = 118) of which were related to plants and zootoxins. Among these, 95 enquiries (80.51%) concerned exposures to plants and 23 (19.49%) to zootoxins. The dog was the species most frequently involved (67.80% of the calls, n = 80), followed by the cat (26.27%, n = 31). As for the plants, several poisoning episodes were related to glycoside-, alkaloid-, oxalate- and diterpenoid-containing species. *Cycas revoluta*, *Euphorbia pulcherrima* and *Hydrangea macrophylla* were the most often reported plants. The outcome has been reported for half of the episodes (51.58%, n = 49) and it was fatal for 3 animals (6.12%).

Regarding the zootoxins, the majority of the enquiries were related to asp viper (*Vipera aspis*), but exposures to pine processionary moth (*Thaumetopoea pityocampa*), common toad (*Bufo bufo*), fire salamander (*Salamandra salamandra*), and jellyfish (phylum Cnidaria) were also reported. The outcome was known in 65.22% of the cases with just one fatal episode.

This epidemiological investigation depicts an interesting overview on the issue of plant and zootoxin exposures in domestic animals, highlighting the relevance of these agents as causes of animal poisoning and providing useful information for prevention and diagnosis.

Keywords (max 6): domestic animals; exposure; plants; zootoxins; toxico-epidemiology

1. Introduction

In Europe, even if the number of toxic plants, containing phytotoxins belonging to different chemical classes (*i.e.* alkaloids, glycosides, proteins, etc.)(Welch, 2019), is not comparable to the American and African continents, dangerous species are not lacking (Anadón et al., 2018), and neither are zootoxins, produced by poisonous/venomous animals for food procurement and as a defense technique (Gwaltney-Brant et al., 2018).

Thus, domestic animal poisoning due to the exposure to plants and zootoxins is not a rare occurrence but a recognized and well-documented issue of great interest for its scientific significance and animal health impact (Anadón et al., 2018; Caloni et al., 2018; Gwaltney-Brant et al., 2018).

Even more than 10% of the calls on animal poisoning received by European poison centers are related to plant exposures (Barbier, 2005; Campbell, 1998; Cortinovis and Caloni, 2013; Keck et al., 2004; McFarland et al., 2017), while zootoxins are generally responsible for a lower (2-5%) but not negligible number of cases (Barbier, 2005; Caloni et al., 2012; Lassak, 2005). Moreover, new toxico-epidemiological trends in plant and zootoxin poisonings are likely to surface, facilitated by the current global trade in ornamental plants and exotic pets (Elwin et al., 2020; Schaper et al., 2019) and the ongoing climate change influencing the geographical distribution of poisonous/venomous terrestrial and aquatic animal species (Needleman et al., 2018a; Needleman et al., 2018b).

The aim of the paper is to depict an insight on plant and zootoxin exposures in domestic animals, providing data regarding the causative agents, incidences and emerging trends, species involved, route of exposure, clinical presentation and outcome.

2. Material and methods

The Poison Control Center of Milan (CAV), which has been operating since 1967, deals with and analyses cases on suspect animal poisonings and since 1990, collaborates with toxicologists of the University of Milan (Caloni et al., 2012).

After each toxicological consultation, the procedure is to fill in a data form with information on the species/breed, suspected poisoning agent, route of exposure and clinical signs. These data are stored in a database that is continuously updated, also by means of follow-up calls to determine the final outcome.

All the cases of suspected animal poisoning collected by CAV from January 2015 to March 2019 have been reviewed in order to select the episodes related to plant and zootoxin exposures. Using these data, a toxicological analysis has been performed on the bases of animal species and plants/zootoxins implicated, site of exposure (indoor/outdoor and location), route of exposure, clinical signs and final outcome. In the case of plant poisoning episodes, all the plants were classified according to their toxic principles to verify the correspondence with the observed clinical signs.

2.1. Statistical analysis

Data analysis was performed with IBM SPSS Statistics for Mac, Version 26.0 (Armonk, NY: IBM Corp.), while graphs were created using Prism for Mac, Version 9 (GraphPad Software Inc., La Jolla, CA, USA).

3. Results

During the period from January 2015 to March 2019, the Poison Control Center of Milan (CAV) received 932 enquiries on animal poisonings, 12.66% (n = 118) of which were related to plants and zootoxins. Among these, 95 enquiries (80.51%) concerned exposures to plants and 23 (19.49%) to zootoxins. The frequency of calls on plant- and zootoxin-related animal poisonings over the years is depicted in Figure 1, while Figure 2 reports the monthly distribution. The majority of the requests were toxicological enquiries from veterinarians (n = 93; 78.81%), while 23 calls (19.49%) were from animal owners and in 2 cases (1.70%) the caller was unknown.

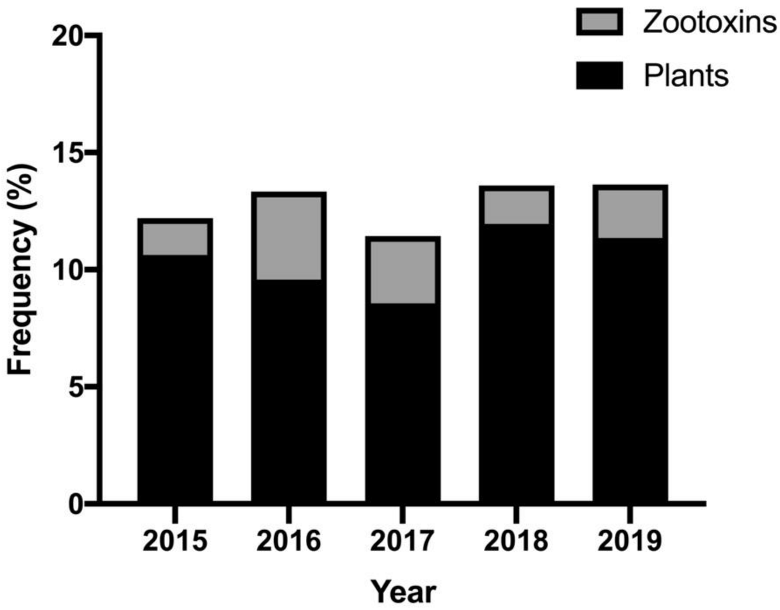

Figure 1. Frequency of domestic animal exposure (per cent) to plants and zootoxins over the years, based on the calls received by CAV from January 2015 to March 2019.

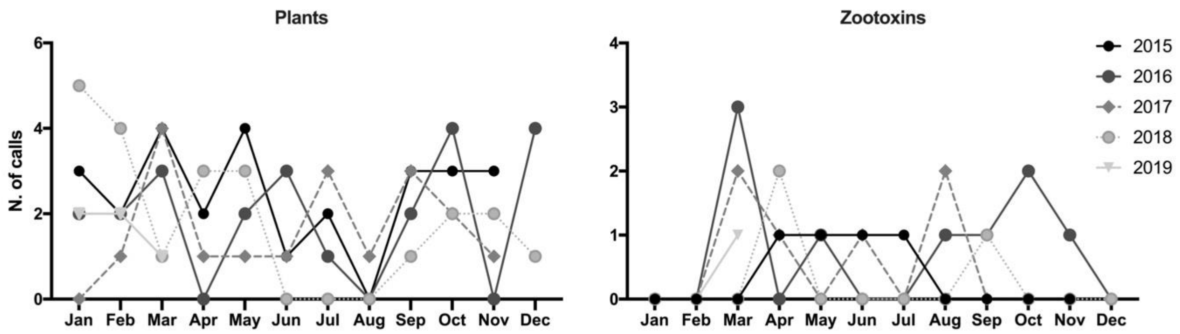

Figure 2. Monthly distribution of the calls related to plants and zootoxins, received by CAV from January 2015 to March 2019.

As for the geographical origin, most of the enquiries were from Lombardy (n = 52; 44.07%), followed by Veneto (n = 14; 11.86%), Emilia Romagna (n = 9; 7.63%), Piedmont (n = 7; 5.93%) and Tuscany (n = 7; 5.93%) (Figure 3).

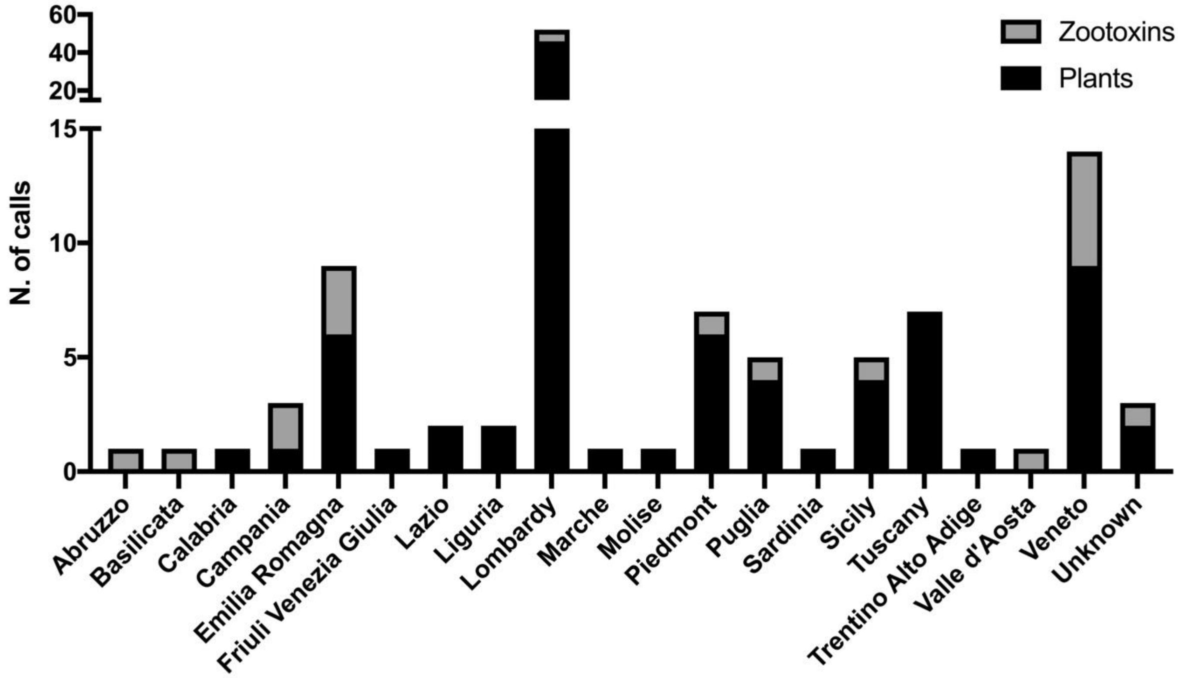

Figure 3. Geographical distribution of the calls related to animal poisoning by plants and zootoxins received by the Poison Control Centre of Milan (CAV) during the period January 2015 - March 2019

In total, 46.61% of the exposures to plants and zootoxins occurred indoor (n = 55) and 47.46% outdoor (n = 56), while for 7 episodes the site was unknown (5.93%). In particular, plant poisonings occurred indoor in 50 cases (52.63%), outdoor in 38 cases (40.00%) and for 7 episodes (7.37%) this information was not available. As for the zootoxins, 5 exposures happened indoor (21.74%) and 18 (78.26%) outdoor (Figure 4).

Figure 4. Site of exposure to plants and zootoxins according to the calls received by the Poison Control Centre of Milan (CAV) during the period January 2015 - March 2019.

The species most frequently involved was the dog (67.80% of the calls, n = 80), followed by the cat (26.27%, n = 31). Two episodes concerned goats (1.69%) and single cases were reported to involve cattle, a guinea pig and a rabbit (0.85% each) (Figure 5).

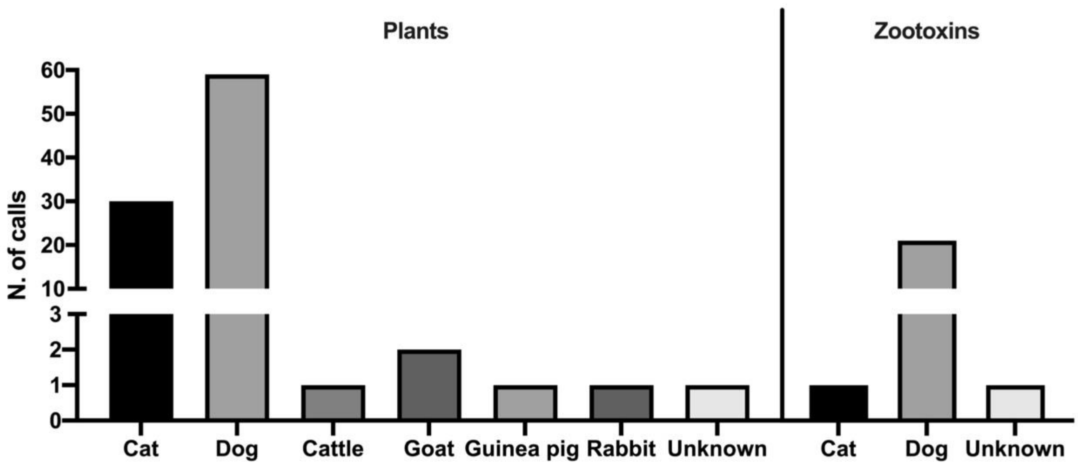

Figure 5. Species involved in suspected poisonings by plants and zootoxins based on the calls received by the Poison Control Centre of Milan (CAV) during the period January 2015 - March 2019.

Ingestion was the most common route of exposure (77.12% of the poisoning episodes, n = 91), followed by injection (snake bites; 11.86%, n = 14) but also inhalation (0.85%, n = 1) and topical (5.93%, n = 7) exposures were reported (Figure 6).

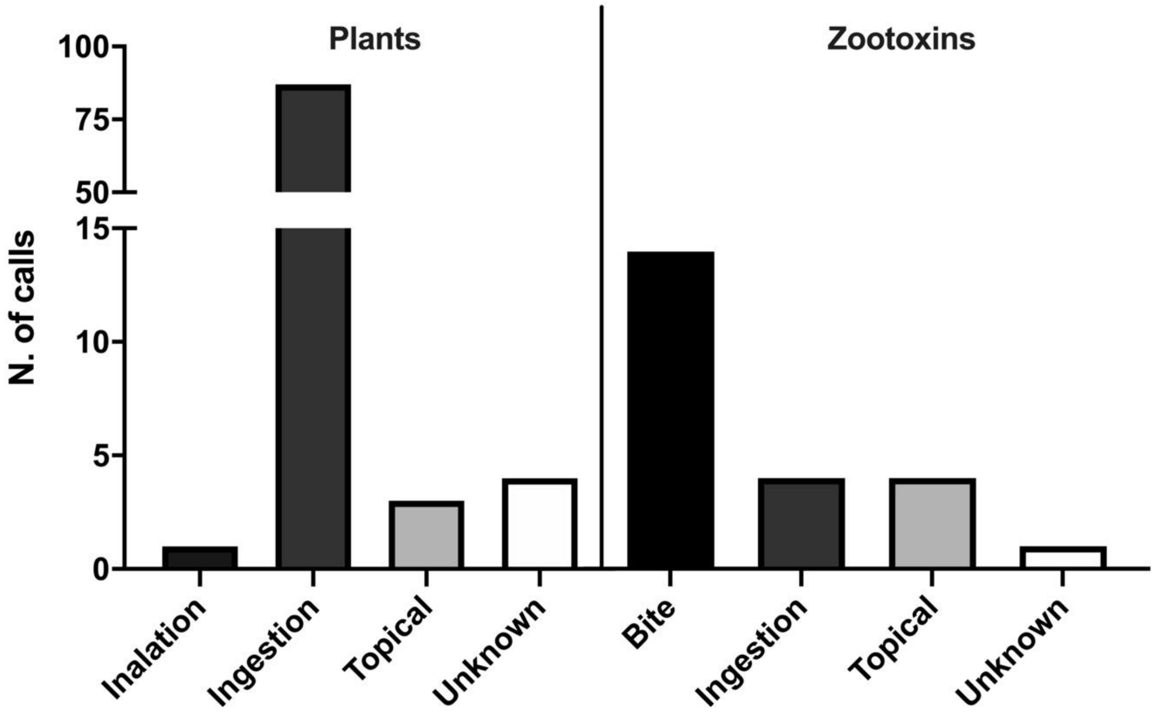

Figure 6. Routes of exposure to plants and zootoxins reported to the Poison Control Centre of Milan (CAV) during the period January 2015 - March 2019.

One-hundred and ten poisoning episodes resulted from single exposures (93.22%), 4 cases were due to repeated exposures (3.39%, all plant-related poisonings) and for 4 cases the frequency was unknown (3.39%, all involving plants).

3.1 Involved plants

The involved plants are listed in Table 1. Among them, known toxic species can be found, together with plants which are not reported in literature as related to poisoning episodes in animals (*Arbutus unedo*, *Camellia japonica*, *Chlorophytum comosum*, *Jasminum officinale*, *Juglans regia*, *Maclura pomifera*, Fam. Orchidaceae, *Saintpaulia spp*.).

Scientific name	Common name	Toxins	Poisoned animals

Acacia dealbata	Mimosa	Cyanogenic glycosides	3 cats
Aesculus hippocastanum	Horse chestnut (conkers)	Aesculin (glycosidic saponin) and other saponins.	2 dogs
Aloe vera	Aloe vera	Saponins, anthraquinones	1 cat
Anemone spp.	Anemone	Protoanemonin	1 dog
Anthurium spp.	Flamingo flower	Insoluble calcium oxalates	3 cats, 1 dog
Arbutus unedo	Strawberry tree	Non-toxic	2 dogs
Arum spp.	Arum	Calcium oxalate, proteolytic enzyme	2 dogs
Atropa belladonna	Deadly nightshade	Tropane alkaloids (atropine, scopolamine, and hyoscyamine)	1 dog
Aucuba japonica	Japanese laurel	Iridoid glycoside aucubin	1 cat
Buxus sempervirens	Common box	Alkaloids	1 dog
Camellia japonica	Camellia	Non-toxic	1 dog
Capsicum annuum	Chili pepper	Capsaicin, capsaicinoids	1 dog
Chlorophytum comosum	Spider plant	Non-toxic	1 dog
Cinnamomum camphora	Camphor tree	Camphor	1 dog
Clivia spp.	Clivia	Lycorine and other alkaloids	1 cat
Cycas revoluta	Sago palm	Azoglycosides (cycasin, macrozamin, and neocycasin); β-N-methylamino-L-alanine; unidentified high-molecular-weight compound	9 dogs
Dianthus spp.	Carnation	Triterpenoid saponins	1 dog
Dracaena marginata	Red-margined dracaena	Steroidal saponins and glycosides	1 cat
Euphorbia pulcherrima	Poinsettia	Diterpenoid euphorbol esters and steroids	1 cat, 5 dogs, 1 Guinea pig, 1 rabbit
Ficus benjamina	Weeping fig	Proteases (ficin, and ficusin)	1 cat
Hedera helix	English ivy	Triterpenoid saponins (hederagenin)	1 dog
Hedera helix hibernica	Irish ivy	Triterpenoid saponins (hederagenin)	1 dog
Helleborus niger	Christmas rose	Cardiac glycosides, saponins, protoanemonin	1 cat
Hyacinthus orientalis	Hyacinth	Alkaloids (*i.e.*, lycorine) and insoluble calcium oxalates	1 dog
Hydrangea macrophylla	Bigleaf hydrangea	Cyanogenic glycoside (hydrangin)	7 dogs
Jasminum officinale	Jasmine	Non-toxic	1 cat, 1 dog

Juglans regia	English walnut (husks)	Non-toxic	3 dogs
Lantana camara	Lantana	Pentacyclic triterpenoids	1 dog
Lilium spp.	Lily	Steroidal glycoalkaloids and steroidal saponins	2 cats, 1 dog
Maclura pomifera	Osage orange	Non-toxic	1 dog
Mespilus germanica	Medlar (fruits)	Cyanogenic glycosides, hydrocyanic acid	1 dog
Nandina domestica	Heavenly bamboo	Cyanogenic glycosides; protoberberine and berberine alkaloids	1 cat, 1 dog
Narcissus spp.	Daffodil	Lycorine and other alkaloids; insoluble calcium oxalates	2 cats, 1 dog
Nerium oleander	Oleander	Cardiac glycosides: oleandrin, oleandrigenin; neroside and oleandroside	1 cat, 1 cow, 2 dogs
Orchidaceae (Fam.)	Orchid	Non-toxic	1 dog
Pelargonium spp.	Geranium	Monoterpene alcohols: geraniol, linalool	1 cat
Persea americana	Avocado	Persin (long-chain fatty alcohol)	1 cat
Phytolacca americana	Pokeweed	Saponis (phytolaccosides), alkaloids, insoluble calcium oxalates, other compounds (histamine, potassium salts)	1 dog
Primula spp.	Primrose	triterpene saponins; quinones (primin and related hidro-quinones); phenolic derivatives (resorcinol, saligenin); alcoholic glycosides; (salicin, salicilin derivatives); lactones	1 cat, 1 unknown
Prunus domestica	Plum (fruits)	Cyanogenic glycosides	1 dog
Prunus laurocerasus	Cherry laurel	Cyanogenic glycosides amygdalin and prunasin	1 dog, 2 goats
Pteridium aquilinum	Eagle fern	Norsesquiterpene glycoside ptaquiloside; thiaminase	1 cat
Ranunculus spp.	Buttercup	Protoanemonin	2 cats
Ricinus communis	Castor bean	Phytotoxalbumin ricin; piperidine alkaloid ricinine	1 dog
Saintpaulia spp.	African violet	Non-toxic	1 cat
Senecio vulgaris	Groundsel	Pyrrolizidine alkaloids	1 cat
Solanum pseudocapsicum	Winter cherry	Solanine, solanocapsine and other alkaloids	1 dog
Spathiphyllum spp.	Peace lily	Insoluble calcium oxalates	1 dog
Taxus baccata	European yew (flowers and berries)	Taxine alkaloids, cyanogenic glycosides and irritant oils	1 cat

Viscum album	Mistletoe	Viscotoxins, toxic alkaloids and lectins	1 dog
Zantedeschia aethiopica	Calla lily	Insoluble calcium oxalates and proteolytic enzymes	1 cat

Table 1. Plants involved in animal poisoning episodes, based on the calls received by CAV during the period January 2015 - March 2019.

3.1.2 Clinical signs and outcome

In the majority of the cases, clinical signs started within few hours of ingestion, but in some animals they occurred after days from the exposure. The most frequently reported clinical signs due to plant exposures were gastrointestinal (mainly vomiting and sialorrhea but also diarrhea/melena), neurological (in particular asthenia and ataxia but also mydriasis, agitation, hallucinations, convulsions and hypertonia) and cardiorespiratory (arrhythmias, bradycardia, hypotension and dyspnea).

The outcome has been reported only for half of the episodes (51.58%, n = 49) and it was positive for 46 animals (93.88%) and fatal for 3 animals (6.12%). The fatal episodes were related to the ingestion of *Capsicum annuum* (a dog, which developed severe hematemesis and melena), *Nerium oleander* (a dog) and *Prunus laurocerasus* (a goat).

3.2 Involved zootoxins

The zootoxins involved in episodes of animal poisoning reported to CAV are indicated in Table 2.

Scientific name	**Common name**	**Toxins**	**Poisoned animals**
Bufo bufo	Common toad	Bufadienolides (serine proteases, muscle creatine kinase, cytotoxic T-lymphocyte protein, etc.)	3 dogs
Cnidaria (phylum)	Jellyfish	Neurotoxic, cytolytic, enzymatic (proteases, phospholipases) toxins	2 dogs
Thaumetopoea pityocampa	Pine processionary	Thaumetopoein	1 dog, 1 unknown

Salamandra salamandra	Fire salamander	Toxic alkaloids (samandarin and samandaron)	2 dogs
Vipera aspis	Asp viper	Enzymatically active A2 phospholipases, SPAN-like neurotoxin, anticoagulant and hemorrhagic toxins	1 cat, 13 dogs

Table 2. Zootoxins involved in animal poisoning episodes, based on the calls received by CAV during the period January 2015 - March 2019.

3.2.2 Clinical signs and outcome

In all the reported cases, clinical signs started within 24h of exposure. Neurological (tremors, convulsions, asthenia and ataxia) and cardiorespiratory (arrhythmias, bradycardia, hypotension and dyspnea) signs were the most frequently described, together with local manifestations depending on the affected part (sialorrhea, edema, hyperemia and pain). The outcome was positive for 14 animals (60.87%), fatal for 1 animal (4.35%) and unknown in 8 cases (34.78%). In particular, the only fatal poisoning was related to the ingestion of larval forms of *Thaumetopoea pityocampa* by a dog.

4. Discussion

The data collected in this study emphasizes the non- negligible impact of plants and zootoxins on animal poisoning, categories that are often wrongly regarded as minor agents of intoxication.

During this period, 12.66% (n = 118) of the total calls received by the Poison Control Center of Milan (CAV) were related to plants (95 enquiries, 10.19% of the total enquiries of the period) and zootoxins (n = 23, 2.47%).

As for the monthly distribution of the enquiries, peaks have been observed at the beginning of the year and in spring (Figure 2), and similar trends have been reported in the European literature (Anadón et al., 2018).

Regarding the plants, around half of the exposures occurred indoor (52.63%) and were related to houseplants (*i.e.*, *Dracaena marginata*, *Euphorbia pulcherrima*, *Spathiphyllum spp.*, *Zantedeschia aethiopica*, etc.). Glycoside-containing species were responsible for a considerable number of poisoning episodes in dogs. Among them, several cases have been associated to the exposure to sago palm (*Cycas revoluta*), a popular ornamental palm-like plant with well-known toxic effects on animals (Cortinovis and Caloni, 2013; Cortinovis and Caloni, 2017; Fatourechi et al., 2013; Forrester et al., 2019). All parts of the plant, and in particular the seeds, contain phytotoxins: the azoglycosides cycasin (hepatotoxic and carcinogenic), macrozamin and neocycasin, the neurotoxic amino-acid β-N-methylamino-L-alanine and an unidentified high molecular weight compound (Botha and Penrith, 2009; Clarke and Burney, 2017; Forrester et al., 2019). Many poisoning cases involving dogs are described in literature, and in Europe episodes have been previously reported in Italy by CAV (Caloni et al., 2013; Caloni et al., 2017; Cortinovis and Caloni, 2013) and in Sweden by the Swedish Poisons Information Centre (Holmgren and Hultén, 2009). Dogs are also frequently exposed to cyanogenic glycoside-containing plants: for instance, many poisoning cases were related to bigleaf hydrangea (*Hydrangea macrophylla*), characterized by the presence of the cyanogenic glycoside hydrangin. Heavenly bamboo (*Nandina domestica*) (which contains protoberberine and berberine alkaloids besides the cyanogenic ones), cherry laurel (*Prunus laurocerasus*), plum (*Prunus domestica*) and medlar (*Mespilus germanica*) were also reported as causes of intoxication by cyanogenic glycoside-containing plants in dogs, and the exposure to oleander (*Nerium oleander*), a species containing potent cardiac glycosides, resulted in a fatal outcome.

Glycoside-containing plants were also responsible of intoxications in cats. Heavenly bamboo (*Nandina domestica*) and oleander (*Nerium oleander*) were found responsible of poisoning episodes in this species as well as in dogs, and other cases were related to mimosa (*Acacia dealbata*), buttercup (*Ranunculus spp.*) and Japanese laurel (*Aucuba japonica*).

Several poisoning episodes involving glycoside-containing plants have been described in literature. In particular, cases due to bigleaf hydrangea (*Hydrangea macrophylla*) exposures are frequently reported (Caloni et al., 2013; Caloni et al., 2012; Le Mura, 2018), and a fatal intoxication in a cat has been observed by CAV in a ten-year survey (Caloni et al., 2013). Also a fatal case of oleander (*Nerium oleander*) exposure, a plant frequently implicated in companion animal poisoning in Europe (Barbier, 2005; Caloni et al., 2013; Giuliano Albo and Nebbia, 2004; Mygdal et al., 2015; Sapin, 2004), has been described before in pets by CAV (Caloni et al., 2013). Moreover, many European investigations have reported pet poisoning incidents due to glycoside-containing species (Barbier, 2005; Lassak, 2005; McFarland et al., 2017; Sapin, 2004) and, in Germany, *Prunus spp*. represents the first category listed in the top five plant species responsible for enquiries to the poison centers for animal exposures (McFarland et al., 2017).

Oleander (*Nerium oleander*) and cherry laurel (*Prunus laurocerasus*) were also responsible for poisoning cases in cattle and goats, respectively, the latter with a fatal outcome. Indeed, many episodes of glycoside-containing plant intoxications have been described in ruminants: sheep and goat poisonings due to exposure to cherry laurel (*Prunus laurocerasus*) have been reported in literature (Schediwy et al., 2015) also with a fatal outcome (Schmidt et al., 2013), while oleander (*Nerium oleander*) is a very frequent cause of plant poisoning in ruminants (Caloni et al., 2013; Caloni et al., 2012; Cortinovis and Caloni, 2013; Garcia-Arroyo et al., 2017; Guitart et al., 2010; Rubini et al., 2019) in Europe.

Alkaloid-containing plants were also often involved in companion animal intoxications. As for the dog, episodes due to deadly nightshade (*Atropa belladonna*), common box (*Buxus sempervirens*), chili pepper (*Capsicum annuum*), mistletoe (*Viscum album*) and winter cherry (*Solanum pseudocapsicum*) were recorded. Chili pepper (*Capsicum annuum*), a plant containing capsaicin and capsaicinoid alkaloids and known to induce acute toxicity in several animal species (Glinsukon et al., 1980; Surh and Sup Lee, 1995), was responsible for a fatal episode involving a dog.

Other poisoning cases in dogs were due to exposures to daffodil (*Narcissus spp.*) and hyacinth (*Hyacinthus orientalis*), two species containing alkaloids (*i.e.,* lycorine) as well as insoluble calcium oxalates. Daffodil (*Narcissus spp.*) was also related to intoxications in cats, together with clivia (*Clivia spp.*), groundsel (*Senecio vulgaris*) and European yew (*Taxus baccata*). Cases of companion animal poisoning by alkaloid-containing plants are well documented in the European literature (Berny et al., 2010; Caloni et al., 2013; Caloni et al., 2012; Caloni et al., 2017; Campbell, 1998; Campbell and Chapman, 2000a, b; McFarland et al., 2017) and in particular, various episodes of intoxication due to exposures to European yew (*Taxus baccata*)(Caloni et al., 2013; McFarland et al., 2017) and mistletoe (*Viscum album*)(Caloni et al., 2013; Campbell, 1998; Campbell and Chapman, 2000b) have been reported.

Oxalate-containing plants are another class often implicated in pet poisoning. Arum (*Arum spp.*) and peace lily (*Spathiphyllum spp.*) were responsible for intoxications in dogs whereas flamingo flower (*Anthurium spp*.) caused intoxications both in the dog and the cat and calla lily (*Zantedeschia aethiopica*) in one cat. These plants, and in particular peace lily (*Spathiphyllum spp.*) and calla lily (*Zantedeschia aethiopica*), which are widespread and popular ornamental species, are frequently mentioned in reports on domestic animal poisoning episodes by European authors (Caloni et al., 2013; Caloni et al., 2012; Lassak, 2005; Le Mura, 2018; Sapin, 2004), confirming the toxicological risk related to exposure to this plant class.

Weeping fig (*Ficus benjamina*), a protease-containing plant, and aloe vera (*Aloe vera*), together with red-margined dracaena (*Dracaena marginata*), two saponin-containing species, were found responsible of cat poisoning episodes (one case each).

Weeping fig, whose leaves and cortex contain ficin, a proteolytic enzyme, and other toxic substances such as furocoumarins and ficusin (ASPCA, 2020; CABI, 2014), has been reported by the CNITV (Centre National d'Informations Toxicologiques Vétérinaires) as the major responsible of plant poisoning episodes in animals in France (Barbier, 2005). Similarly, another author ~~stated~~ reported, on the bases of the data collected by CNITV, ~~that~~ weeping fig ~~w~~as one of the most frequently ingested plants by small animals (Keck et al., 2004). According, two Italian papers pointed out that *Ficus spp*. was among the most frequently implicated plants in cat poisoning episodes (Giuliano Albo et al., 2003; Giuliano Albo and Nebbia, 2004), while two investigations by CAV reported *Ficus benjamina* has a culprit of intoxication also in the dog (Caloni et al., 2013; Caloni et al., 2012). Red-margined dracaena (*Dracaena marginata*) is another plant frequently mentioned in the European literature as a cause of poisoning both in cats and dogs (Barbier, 2005; Caloni et al., 2013; Lassak, 2005; Sapin, 2004; Schediwy et al., 2015).

Another saponin-containing plant, horse chestnut (*Aesculus hippocastanum*), which contains aesculin, a glycosidic saponin (Campbell, 1998), has been implicated in dog intoxications, as it has been formerly observed by CAV in a 2000–2011 survey (Caloni et al., 2013) and in other European countries (Campbell, 1998; Lassak, 2005; Sapin, 2004; Schediwy et al., 2015). Cases of dog poisoning by two species of ivy, namely English ivy (*Hedera helix*) and Irish ivy (*Hedera helix Hibernica*), which contain triterpenoid saponins (*i.e.,* hederagenin) were also registered (one each). In Germany, *Hedera spp.* is included in the top five plant species responsible for calls to the poison centers for animal exposures (McFarland et al., 2017) and cases involving English ivy (*Hedera helix*) have been reported in England (Campbell, 1998) and France (Lassak, 2005).

The diterpenoid-containing species poinsettia (*Euphorbia pulcherrim*a), a plant frequently associated with poisoning episodes in domestic animals (Barbier, 2005; Bertero et al., 2020; Caloni et al., 2013; Caloni et al., 2012; Caloni et al., 2017; Campbell and Chapman, 2000c; Cortinovis and Caloni, 2013; Curti et al., 2009; Le Mura, 2018; McFarland et al., 2017), has been found responsible for intoxications mainly in dogs, but also in a cat, a guinea pig and a rabbit. Lilies (*Lilium spp.*), plants known for their nephrotoxic effects in cats, which may lead to acute renal failure (Panziera et al., 2019), had been related to 2 episodes involving cats and one involving a dog. Indeed, while the cat is the only species known to develop renal failure after the ingestion of *Lilium spp.*, dogs may show gastrointestinal signs (Bates et al., 2015b; Botha and Penrith, 2009). Poisoning cases by lilies, particularly in cats, are numerous and reported all over Europe (Balka et al., 2011; Barbier, 2005; Berny et al., 2010; Caloni et al., 2013; Caloni et al., 2012; Caloni et al., 2017; Fourez, 2014; Schediwy et al., 2015; Sturgeon and Campbell, 2006).

Finally, it is worthwhile to mention English walnut (*Juglans regia*) is not reported in literature as responsible for animal poisoning episodes, but the onset of tremorgenic syndromes with tremors, ataxia, hyperesthesia have been described in dogs after the ingestion of moldy walnuts due to mycotoxin contamination (Munday et al., 2008; Richard et al., 1981), generally by penitrem A and roquefortine (Walter, 2002). In our cases, however, 3 dogs ingested English walnut husks developing just mild gastrointestinal symptoms with no neurological signs.

Usually, the onset of clinical signs started within few hours of exposure, but in some cases signs occurred after days from the ingestion. However, the time frame and the severity were generally consistent with the exposures and in line with data reported in the literature (Clarke and Burney, 2017; Cortinovis and Caloni, 2013; Cortinovis and Caloni, 2017). The most frequently described clinical signs related to plant ingestion were aspecific (gastrointestinal, neurological and cardiorespiratory), as other researches throughout Europe have also remarked (Bertero et al., 2020) thus, to make a proper diagnosis of plant poisoning is crucial to have evidence of plant ingestion (actually see the animal eat the plant, find plant residues in feces, etc.) (Caloni et al., 2013). This information may also be useful to identify the involved species in order to emit a prognosis and to set up an appropriate medical treatment considering decontamination and/or supportive care based on the target organs of the toxins.

As for the zootoxins, the dog was the species most commonly concerned, with just one case related to a cat. Episodes involving venomous asp viper (*Vipera aspis*), common toad (*Bufo bufo*), fire salamander (*Salamandra salamandra*) and pine processionary (*Thaumetopoea pityocampa*) were reported, similarly to what has been described in literature (Berny et al., 2010; Caloni et al., 2017; Lervik et al., 2010; Niza et al., 2012; Pelander et al., 2010; Pouzot-Nevoret et al., 2017; Pouzot-Nevoret et al., 2018). In particular, dog poisonings due to pine processionary (*Thaumetopoea pityocampa*) are very common in Europe (Caloni et al., 2018; Caloni et al., 2012; Guitart et al., 1999; Kaszak et al., 2015; Lassak, 2005; Perez-Lopez et al., 2004; Pouzot-Nevoret et al., 2017), as well as cases due to venomous viper bites (Barbier, 2005; Caloni et al., 2018; Caloni et al., 2012; Caloni et al., 2017; Lassak, 2005; Lervik et al., 2010; Schediwy et al., 2015). Episodes involving salamander, whose skin glands produce neurotoxic alkaloids (*i.e.* samandarin and samandaron) (Erjavec et al., 2017) and common toad, whose parotid glands secrete biogenic amines and steroid derivatives (*i.e.*, bufodienolide and bufotoxin, with digitalis-like effects) which can cause from local irritation to systemic signs (gastrointestinal, cardiac and neurological alterations)(Barbosa et al., 2009), have also been reported in the European literature (Barbier, 2005; Curti et al., 2009; Erjavec et al., 2017; Lassak, 2005; Schediwy et al., 2015; Scheer et al., 2005).
Moreover, 2 cases related to exposures to jellyfish (phylum Cnidaria) have been registered: the dogs involved developed oral irritation, sialorrhea and minor gastrointestinal signs with a positive outcome. Canine exposures to jellyfish have also been reported in England by the Veterinary Poisons Information Service (VPIS), with similar symptoms (Bates et al., 2015a). Indeed, cnidarians are very common in the European seas and several species possess remarkable stinging properties (Killi et al., 2020).

5. Conclusion

This survey presents an interesting insight on the issue of plant and zootoxin poisoning in domestic animals, topic that is often disregarded and scarcely investigated. Actually, the information showed by our research proves the relevance of plants and zootoxins as poisoning agents and point out the need to carry out a continuous and widespread investigation on domestic animal exposures, to promptly identify and appropriately respond to emerging toxicological risks. In this regard, the importance of a proper classification of the plants on the basis of their taxonomic features need to be stressed, being a crucial step for the identification of the toxins involved and in light of the species-specific toxicity that characterizes many compounds.

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