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G. Lorgue
Centre National d'Informations Toxicologiques Vétérinaries, Ecole Nationale Vétérinaire de Lyon, France

K. Nahas
Centre National d'Informations Toxicologiques Vétérinaries, Ecole Nationale Vétérinaire de Lyon, France

G. Keck
Centre National d'Informations Toxicologiques Vétérinaries, Ecole Nationale Vétérinaire de Lyon, France

M. Rampaud
Centre National d'Informations Toxicologiques Vétérinaries, Ecole Nationale Vétérinaire de Lyon, France

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G. LORGUE*, K. NAHAS, G. KECK, and M. RAMPAUD, Centre National d'Informations Toxicologiques Vétérinaries, Ecole Nationale Vétérinaire de Lyon, France.

ABSTRACT: During the period from 1980 to 1985 the laboratory of toxicological analysis associated with the National Veterinary Antipoison Center received 1,343 samples for research of anticoagulant rodenticide (e.g., 14.1% of total samples): 79% concerned animals, 31% baits. Six compounds marketed in France were investigated (warfarin, chlorophacinone, bromadiolone, difenacoum, coumachlore, coumatetralyl). In two-thirds of the samples, none of these substances could be found. Warfarin was by far the most incriminated rodenticide (23.1%), and dogs represented the most affected species (65.7%). However, its occurrence decreases regularly. The other compounds were found with a very low frequency (1 to 3%). In 70% of the cases, baits were prepared with criminal intention of killing animals other than rodents.

INTRODUCTION

Rodenticides, mainly anticoagulant compounds, are one of the most common causes of animal intoxication. From the beginning of their use in rodent control, their toxicity to nontarget species, both domestic animals and wildlife, was claimed by some authors (Fabre 1953, Papnorth 1958, Zundel 1960), and some accidental intoxications were recorded (Clark 1954, Reihart 1952).

Several epidemiological studies from different countries have attempted to assess their toxicological effects (Buck 1976, Freeman 1972, Lorgue 1983, Rampaud 1982, Rochette 1985, Studdert 1985, Von Kammermann 1978). The French National Veterinary antipoison center has its own laboratory, performing chemical analysis on samples of animals and baits. The aim of this study was to investigate the actual frequency of suspected or proved intoxications by anticoagulant rodenticides during a period of the last 6 years.

During this period 9,527 cases or suspicions of animal intoxication, both individual or collective, were submitted to analysis. In 1,343 of them (14.1%) anticoagulant rodenticides were detected.

Some preliminary observations have to be made:

- one case means one or several animals intoxicated.
- samples were analyzed for the presence of the most common compounds marketed in France (warfarin, chlorophacinone, bromadiolone, difenacoum, coumachlore, coumatetralyl). A negative result means that none of the rodenticides was detectable (above the level of detection), and a positive result that one of them was present in the analyzed sample. Intoxication is not always related to the presence of an anticoagulant compound; thus intoxication is firmly proven only if analytical data fully agree with clinical findings.
- analyses involved thin-layer chromatography and/or high-performance liquid chromatography with the lowest limit of detection in the range 10 to 250 ppb.
- baits were classified as "accidental" or "criminal" baits. An "accidental" bait is primarily intended to kill rodents as demonstrated by its components (cereals, millings) and its site of application.
- criminal bait is not prepared in order to kill rodents; from its composition (sugar, meat) and its site of application (in a lift, for example), one can see that its first intention is to destroy nontarget species.

REQUESTS FOR ANALYSIS - GENERAL SURVEY

Results for animal samples and baits are presented in Table 1.

The proportion of animal samples in comparison with baits did not change from 1980 to 1985. Each year, this proportion was above 80% of all samples.

Dogs are most affected at a very constant rate (63.1% of total requests). Dogs represent by far the population showing the highest hazard. This can be explained by the fact that they are very close to man and thus to the rat, and that they can ingest any substance and moreover any bait.

*Current address: Centre National d'Informations Toxicologiques Vétérinaires, Ecole Nationale Veterinaire de Lyon, B.P. 31, 69752 Charbonnieres Cedex, France.

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Cats are more suspicious; thus they are by far less affected.

Pigs are highly susceptible to anticoagulant. However, we had only few requests, probably as a consequence of, on one hand, strict application procedures and, on the other hand, industrial animal husbandry, restraining the possibility of ingesting toxic baits. The situation is the same for poultry.

Very few requests concern cattle and horses. This is in relation to low susceptibility and limited availability in normal breeding conditions.

Every year we receive samples of wildlife species (8 to 14% of total requests). Hare, rabbit, boar, pigeon and duck are the most affected species.

We can notice the high number of criminal baits (71.2%).

Table 1. Requests for analysis.

a.

	Animals -- Baits	
Samples	Number	Percent
animals	1,062	79.1
baits	281	20.9
Total	1,343	100

b.

	Animals	
Species	Number	Percent
dogs	670	63.1
cats	95	8.9
cattle	42	4.0
pigs	46	4.3
horses	10	0.9
goats	8	0.8
sheep	13	1.2
poultry	15	1.4
wild mammals	56	5.3
wild birds	72	6.8
prey birds	20	1.9
non-identif. species	15	1.4
Total (all species)	1,062	100

c.

	Baits	
Samples	Number	Percent
accidental	81	28.8
criminal	200	71.2
Total	281	100

ANALYTICAL DATA

Global Results

Data are shown in Table 2 and 3.

Concerning samples coming from animals, one observes that no rodenticide was found in more than two-thirds of the requests.

Warfarin was detected in 23.1% of cases and is by far the most concerned compound. However, as we shall see, accidental poisoning with warfarin occurred mainly in the first years of this survey in relation with the very high use of 250-ppm warfarin-treated baits.

Progressive substitution with other compounds at lower concentration of 50 ppm in baits significantly reduced the frequency of intoxications.

The three other compounds—-chlorophacinone, bromadiolone, and difenacoum--were found in 2 or 3% of samples.

Coumachlore and coumatetralyl were scarcely detected, owing to the fact that their use in France is very limited.

Analyses of baits showed a different pattern. We found warfarin, chlorophacinone, and difenacoum at closely related frequencies, respectively, 18.1%; 16.7% and 11.4% of total cases, whereas for bromadiolone this frequency was very low (4.6%). These results are the consequence of the marketing of the first three compounds in concentrated mixtures which allows for easy fabrication of so-called "criminal" baits. On the other hand, bromadiolone is available to the public only as formulated baits (50-ppm-treated cereal); thereby, we found it only in "accidental" poisoning.

Proportion of positive cases for different species was in the same range, with somewhat higher results concerning dogs, pigs, poultry, and wild animals, and with the exception of horse and prey birds, for which very few positive results were found.

Let us now briefly present some individual case reports of special interest.

- In cattle, in 6 cases (out of 11), intoxication was related to forced feeding of concentrated warfarin or warfarin-treated milled cereal to calves (out of revenge).
- In 1980, bromadiolone was found in the liver and the kidney of a foal after feeding several days on treated cereals put in his box. In fact, death could be attributed to another cause (obstruction colics).
- Three cases of collective intoxication of moorhen by bromadiolone were recorded in 1981 and 1983, following ingestion of large amounts of anticoagulant-treated apples used as baits for control of myocastor (M. coypus). Such baits are now banned.
- Finally, the high rate of intoxication in dog was mainly the result of the ingestion of anticoagulant-treated cereals.

Table 2. Global results.

	Animal samples		Bait samples		Total	
	Number	Percent	Number	Percent	Number	Percent
Analysis requests	1062	100.0	281	100.0	1343	100.0
Negative results	717	67.5	134	47.7	851	63.4
Positive results						
Bromadiolone	24	2.3	13	4.6	37	2.8
Chlorophacinone	32	3.0	47	16.7	79	5.9
Coumachlore Coumatetralyl	9	0.8	4	1.4	13	1.0
Warfarin	245	23.1	51	18.1	296	22.0
Difenacoum	35	3.3	32	11.4	67	5.0
Total	345	32.5	147	52.3	492	36.6

Table 3. Global results of analysis by species.

Species	Negative results number	Positive results number	Total number	Positive / total percent
Dogs	440	230	670	34.3
Cats	67	28	95	29.5
Cattle	31	11	42	26.2
Pigs	31	15	46	32.6
Horses	9	1	10	10.0
Goats	6	2	8	25.0
Sheep	10	3	13	23.1
Poultry	10	5	15	33.3
Wild mammals	38	18	56	32.7
Wild birds	44	28	72	38.9
Prey birds	18	2	20	10.0
Non-identified	13	2	15	13.3
Total	717	345	1062	

Results Year by Year

A careful examination of animal data makes it possible to follow the evolution of the relative toxicity of these compounds.

Results for all species, dog, and baits are shown in Figures 1, 2, and 3 and in Table 4.

Table 4. Annual evolution of relative rate of criminal baits.

YEARS	"Criminal baits" in percentage of total number of baits	"Accidental baits" in percentage of total number of baits
1980	61.3	38.7
1981	75.0	25.0
1982	65.2	34.8
1983	73.7	26.3
1984	76.7	23.3
1985	67.9	32.1
Mean	70.0	30.0

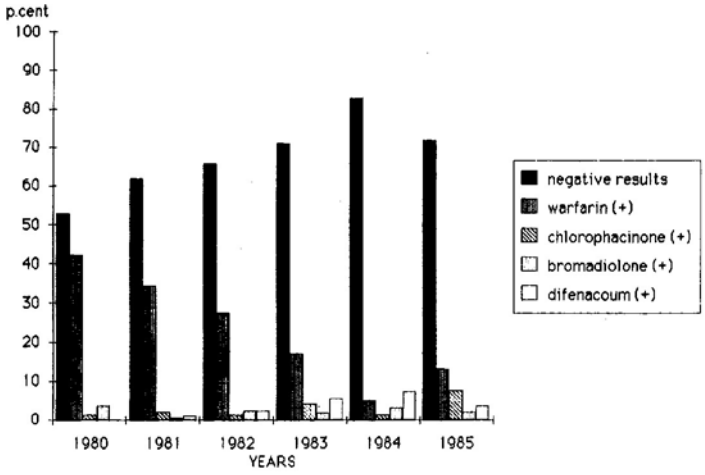

Figure 1. Negative and positive results in percentage of total analysis for animals (all species).

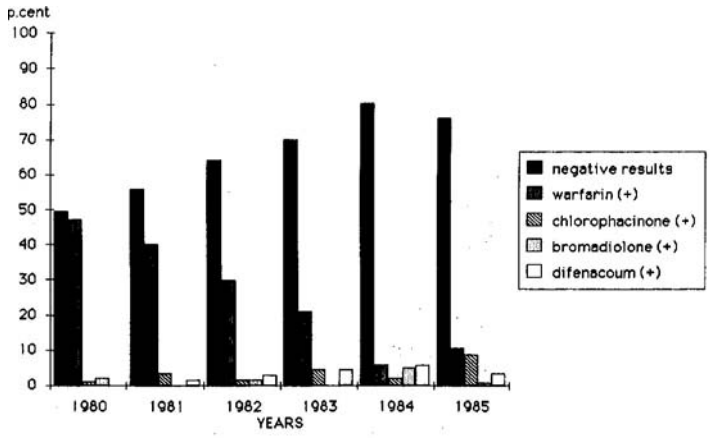

Figure 2. Negative and positive results in percentage of total analysis for dogs.

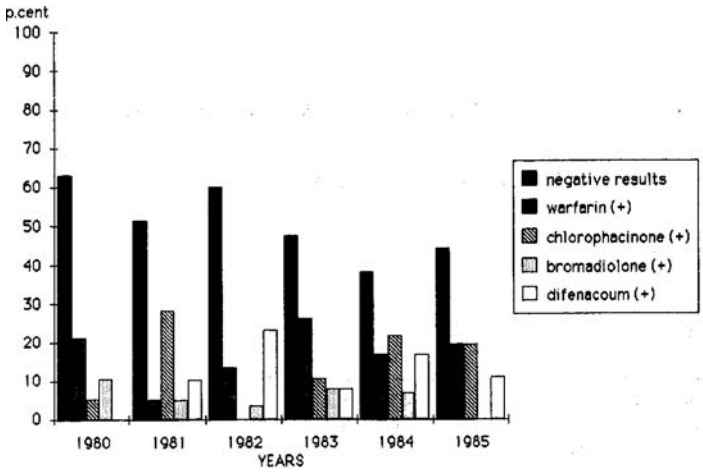

Figure 3. Negative and positive results in percentage of total analysis for criminal baits.

The proportion of negative results (as compared to total requests) shows a constant and regular increase except for a slight decrease in 1985. We think this fact reflects an increasing psychosis of intoxication by animal owners. In case of death, the owner is generally persuaded of criminal intention on the part of his neighbour, very often against the advice of their veterinary practitioner. Thus they ask for toxicological analysis. They suspect, of course, the rodenticides which they know and use quite often.

Warfarin was the most incriminated substance in poisoning in dog and other animals. However, one observes that its occurrence decreases markedly from 1980 to 1984 (with a slight increase in 1985). As already mentioned, this is due to the progressive substitution of other compounds.

Bromadiolone was very scarcely found in animal samples. The control of its use at low concentrations in baits explains for a large part this low occurrence.

Chlorophacinone is also rarely found in animal samples, but with a slight increase in 1985, which results certainly from the present intensive use in France.

Concerning difenacoum, the number of intoxications (or suspicions) increased from 81, in relation to its increased availability, especially as a mouse killer.

Relative proportion of accidental to criminal baits is constant through the years (30%).

Thus, the use of baits in order to kill animals other than rodents is a very common feature in France. Could this be related to the almost pathological need for French people to own one or several pets and thus the increased pollution linked to this population? The answer is certainly yes, and the canine species represents the most targeted species. In these hand-made baits, all substances commercialized as concentrates can be used (warfarin, chlorophacinone, difenacoum). In this area, imagination is really fantastic (baits with sweets, sugar, cakes, sausages, cheese, eggs injected with concentrate). Those baits are also frequently within children's reach, which represent a high-risk population.

CONCLUSION

The above-presented data concern, of course, only the samples sent to the laboratory of toxicology associated with the National Veterinary Antipoison Center. Nevertheless, they give a true picture of the real occurrence of anticoagulant rodenticides in veterinary toxicology. These compounds account only for 14% of the total cases submitted to the laboratory, and two-thirds of this 14% did not contain any of the six anticoagulant substances. However, the occurrence of poisoning could certainly be much higher in the field. Today, indeed, practitioners know very well this type of intoxication. The data coming from our Veterinary Antipoison Center show that in nearly 80% of cases, antidotic treatment proves perfectly efficient.

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