# Bovine Toxicology

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## Diagnosis and Management of Bovine Chemical Toxicoses

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Many bovine toxicologic problems considered in the past have been acutely fatal or disabling syndromes. They have been hard to ignore when they occur. Thus acute arsenic poisoning, insecticide induced seizures, and herd outbreaks of nitrate or cyanide poisoning have been well-known examples of problems for veterinary toxicology. Problems like these still exist and may cause devastating losses for individual producers. However, these problems are, for the clinician, generally easily recognized and there are sound recommendations for their control. With the introduction of more complex and numerous chemicals in agriculture and industry as well as changing procedures in livestock production, the classical veterinary poisons are no longer sufficient subject matter for livestock health professionals. Clinical problems induced by newer chemicals may be vague and hard to difine. Death may be less important than an economic effect such as poor performance or increased susceptibility to infectious disease after exposure to toxicants. Presence of illegal residues either from improper use of approved drugs or inadvertent exposure to chemicals continues to be of concern to practitioners, producers and regulators. This paper will deal, not in the entire range of bovine toxicology, but with well-known examples of toxicants which are still real--or potential problems. Some are highly toxic, others are cumulative and cause residues. The reader is urged to consult one or more of the supplemental readings for more complete discussions of classical toxicologic problems.

The situations to be discussed are as follows: 1) those problems arising when animals are contacted by chemical products or by-products of industry or commerce 2) toxicologic effects and residues associated with use (misuse) of pesticides or economic poisons, and 3) toxicosis or loss from exposure to metallic poisons.

### Industrial or Commercial Chemicals Important to Bovine Toxicology

This category includes those chemicals never intended for use in livestock but which because of their nature--or accidents in their handling--gain access to cattle. Well known examples are the organic compounds polychlorinated biphenyl (PCB), polybrominated biphenyl (PBB), pentachlorophenol (PCP) as well as the inorganic fluorides. Their specific relationship to bovine toxicology are given individually.

### Fluorides

Fluoride toxicosis has been primarily from airborne fallout of certain industrial operations. Steel and aluminum smelting operations and phosphate fertilizer or mineral plants have been common sources of fluorides which settle as particulates on forages consumed by cattle. Ingestion is by directly contaminated hay or pasture, not by uptake of fluoride from soil. Low quality phosphate (high in fluoride) and water high in fluoride are less common sources.

Fluoride absorbed by the gastrointestinal tract is either excreted in urine or transported to bones and teeth where it accumulates. Chronic fluorosis may develop in dairy or beef cattle when total dietary intake exceeds 30 and 40 parts per million (ppm) respectively. Developing teeth of young animals are affected by defective dentin formation and enamel hypoplasia. Clinically, this is seen as erupted teeth which are pitted, chalky and subject to excessive wear. Accumulation of fluoride in bone results in defective remodeling with exostosis so that animals become lame and stiff. Bones most severely affected are the mandible, metatarsals, metacarpals and ribs.

Bovine fluorosis is characterized by weight loss, decreased milk production, intermittent lameness and stiffness, and dental pain (such as lapping of water). When fluorosis is suspected, animals which had erupting teeth during the time of probable exposure should be examined for evidence of dental lesions. Specimens of bone and urine may be used to indicate chronic and recent exposure to fluoride. In order to fully and critically evaluate fluorosis, practitioners encountering the problem for the first time may desire assistance from specialists.

Therapy of fluorosis is generally not effective. When recognition of the problem occurs the disease is usually advanced and essentially irreversible. Animals may be salvaged for meat, since little fluoride accumulates in muscle tissue.

### Organic Halogenated Chemicals

Three chemicals which have markedly affected bovine production are chemically related in that all are halogenated and all have gained access to cattle unintentionally. These specific chemicals are polybrominated biphenyl (PBB), polychlorinated biphenyl (PCB) and pentachlorophenol (PCP, referred to hereafter as penta). The comparative aspects of these chemicals as they affect cattle are presented in Table 1. Note especially variation in source of these agents, vague nature of clinical effects, differences in biological persistence and lack of effective treatment.

### Metal Intoxications

Metals are intrinsic to nature and biologic systems use many metals for essential functions. At the same time, excesses of even essential metals may prove toxic. Examples of metals both essential and toxic for cattle include copper, iron, molybdenum, selenium and zinc. Other metals, or metalloids, especially lead, arsenic and mercury are well know veterinary toxicants. Most problems of metal toxicosis are due to man's redistribution of the metal in the environment or changes in its form. For example, motor oil or non-selective herbicides result in cattle toxicosis from lead and arsenic respectively; rarely if ever is poisoning reported from natural deposits of the

metal. Well known exceptions are natural accumulations of selenium or molybdenum in certain plants. When metal poisoning is suspected, certain sources come to mind. These include dusts or tailings from mines, effluents from smelters, and commercial products used as pesticides, paints, medications, calking, batteries, gasoline, etc. Sewage sludge may contain high levels of elements such as lead, cadmium, molybdenum, nickel or zinc, but poisoning from such a source is not recorded. It is important to remember that the toxicity of a metal may vary widely depending on its valence and whether or not it is organically bound. Thus trivalent arsenic in herbicides is much more toxic than the pentavalent arsenate occurring in nature, and mercury is more cumulative and toxic when organically bound as methylmercury. Many of the metals are cumulative and store in definite tissue sites. Although storage occurs, this accumulation is not always equated with toxicity. Excess lead is stored in bone where it causes clinical effect while organic mercury accumulates in brain and causes severe neurologic disturbances. Interactions among metals is common and these interactions may increase or decrease toxicity. Copper and molybdenum are antagonistic, as are lead and zinc. Recently it was discovered that selenium exerts a protective effect against mercury toxicosis. Thus when dealing with chronic effects in potentially poisoned animals, one must consider levels of several toxicants concurrently. Finally, the clinical expression of poisoning by metals varies depending on the form of metal. Mercury as the inorganic salt causes gastroenteritis and nephrosis while organic methylmercury results in progressive cerebral disease but no enteric signs.

Because of their historic and current importance as acute bovine toxicants lead and arsenic are discussed in the test. Certain other metals of know or potential relevance to veterinary medicine are outlined in Table 2.

### Arsenic

Arsenic is ubiquitous in the earth's crust at 1-40 ppm. The natural inorganic form is arsenate which is pentavalent, while commercial forms are usually trivalent which are approximately 10 times more toxic than the pentavalent. Most present day use is for non-selective weed control (Panherbicide) or for preharvest defoliation of non-food crops such as cotton.

Poisoning is usually accidental, involving non-therapeutic situations such as access to old, poorly stored powders and baits. Greater than 1 lb. arsenic/acre as a herbicide would constitute a hazard to cattle. The acute lethal dose is from 1-25 mg/kg with little tendency to accumulate in cattle, so chronic poisoning is rare.

Acute toxicosis is almost entirely gastrointestinal with rapid onset of colic, staggering, weakness, mucoid to watery to hemorrhagic diarrhea within 3 to 12 hours after ingestion. Shreds of intestinal mucosa ("rice water stool") may appear in feces if animals live longer than 24 hours. There is lowered blood pressure, rapid weak pulse, severe dehydration and shock since arsenic acts as a vascular toxicant as well. Surviving animals may recover from diarrhea in from 2 to 7 days. Appetite may be poor since rumen microflora are damaged. Performance may be retarded due to damage to the gastrointestinal mucosa. There may be secondary or subacute lesions of moderate to severe nephrosis 2 to 7 days after the acute onset. Mild hepatosis may also occur. Acute lesions include gastrointestinal (GI) submucosal edema, moderate to marked GI hyperemia, dilated flaccid intestines filled with watery to hemorrhagic contents; abomasal, intestinal, and colonic ulceration. There is little or no inflammation of the mouth or esophagus. In subacute cases, the intestinal lesion tends to be primarily the ulcerative, hemorrhagic type and renal lesions appear grossly as a normal or slightly larger than normal pale brown kidney with occasional petechial to ecchymotic hemorrhages.

Differential intoxications (antimony, inorganic mercury, mustard plants, black locust) are generally less common. Indentification of sources of these may be helpful. Acute arsenic toxicosis is sometimes confused with Salmonellosis, BVD, enterotoxemia, and grain overload. Analysis of liver, kidney, stomach contents, feces and urine will aid in confirming the diagnosis. However, since arsenic is rapidly excreted by the bovine, subacute cases (3 to 7 days since ingestion) will require some judgement.

Acute poisoning is difficult or impossible to treat effectively. Dimercaprol (BAL) available from Hynson, Westcott, and Dunning given IM at 2 mg/lb. every 4 hours may be beneficial if given in early stages and continued for 2 to 3 days. Sodium thiosulfate (20% solution) may be given IV at 30-40 mg/kg (1 ml/5kg body weight, or 100 ml to a 500 kg. cow). IV fluids and electrolytes are needed to combat dehydration and electrolyte loss. Intestinal protectants are of little value, since the lesion is not due to direct irritation. Convalescent animals need bland, easily digestible rations with moderate amounts of high quality protein. In acute cases prognosis is grave. In subacute or recovered cases, prognosis is guarded until status of GI and kidney function are known.

### Lead

Storage batteries, leaded gasoline and paint pigments utilize over 75% of the U.S. lead output. Other uses with potential availability to bovines include caulking compounds cable covering, lubricants, and solder. Pre-1950 paints and some present day implement paints and metal primers may contain from 6% to 15% lead.

Sources of poisoning to cattle in the midwest include:

| | |
|---|---|
| used motor oil | approx. 25% |
| paint and related products | approx. 25% |
| batteries, trash, miscellaneous | approx. 25% |
| source not determined | approx. 25% |

Industrial and highway contamination while possible, are rarely reported clinically. Lead levels in forage fall rapidly within 25 to 100 yards away from busy highways. Because lead is poorly absorbed (2-10%) most cattle probably become poisoned only after several doses of lead. Used motor oil may cause poisoning after 1 exposure.

Lead affects 3 body systems significantly: the CNS, Gastrointestinal, and Hematopoeitic, CNS effects are most characteristic and severe. Acute to subacute effects include blindness, stupor, head pressing, rhythmic head bobbing, ataxia, circling, occasional bellowing or belligerance, and sometimes pharyngeal paralysis. A few animals may have acute convulsive seizure. The clinical course is 1 to 5 days. Anorexia is universal and characteristic. This may persist for days or weeks after neurologic signs have stopped. Salivation or drooling is often noticed. This may be secondary to a neurologic deficit (pharyngeal paralysis). A dark fetid or tarry diarrhea is occasionally seen. Hematopoeitic effects are rarely diagnosed clinically. There may be mild anemia accompanied by disproportionate increase in nucleated red blood cells. This is a result of lead inhibition of heme synthesis. It may be a useful laboratory finding, but usually does not clinically affect the animal.

Lead in sufficient amounts may cause infertility and/or abortion. Newborn animals from lead exposed dams may occasionally be mentally deficient (retarded). It is not clear if the reproductive effect of lead persists after exposure stops. Most indications in cattle are that it does not. Lead is passed in small amounts in the milk, but probably insufficient in amount to clinically poison a nursing calf unless the dam were also clinically poisoned.

Gross lesions are mild. Cattle dying from lead toxicosis often have pale "par-boiled" or "fish-flesh" musculature, especially in the hindquarters and loin. If motor oil is the source it can be seen and smelled in the rumen contents. Microscopically there may be renal tubular necrosis and intranuclear inclusion bodies. Lead occasionally causes a brain lesion similar to polioencephalomalacia in animals clinically affected for 1 to 2 weeks. History and clinical signs of a combination CNS-GI syndrome as described above should lead to suspicion of lead toxicosis. Blood lead is a rapid, accurate laboratory procedure which will aid in antimortem confirmation. Plasma of cattle exposed to lead for several days will fluoresce under UV light. This is due to the excessive accumulation of hemoglobin precursors. This must be used with judgement, since very acute cases may not be positive. Liver, kidney, rumen and fecal lead analysis can help to confirm diagnosis at postmortem.

Lead poisoning will often respond to medical therapy and good nursing care. Give EDTA at 50 mg/kg (IV and Sub-Q) daily in 4 divided doses. Administer 2 to 3 days then stop. Magnesium sulfate orally will help to inactivate lead and speed elimination of unabsorbed lead. Affected animals may not eat or drink for 5 to 15 days. Administer fluids, electrolytes, and

nutrients by stomach tube at least every other day to prevent malnutrition and dehydration.

### Insecticides

In recent times three major classes of insecticides have been involved in the poisoning of cattle:

a. Chlorinated hydrocarbons (e.g. Toxaphene, Endrin)
b. Organophosphates (Ruelene, Ronnel, Malathion, etc.)
c. Carbamates (Sevin, Furadan)

Insecticides are applied to field crops, stored crops, soils, animals, buildings; sometimes incorporated into the feed. Acute poisoning is almost always accidental or due to human error as follows:

a. Miscalculation in mixing
b. Inadvertent addition of granular formulations to feeds
c. Addition of poisoned animals to feeds - as animal by-products
d. Overflow of and/or back siphoning of spraying or storage tanks
e. Direct access of animals to stored pesticides
f. Use of improper formulations
g. Improper disposal

Animal susceptibility to insecticides varies depending on many factors. Examples of this variability include:

a. Species or strain - Brahman cattle may be more susceptible to certain organophosphates than are European breeds
b. Age - young animals generally are more susceptible
c. Concurrent medications - potential cholinesterase inhibitors, such as phenothiazine tranquilizers which may alter susceptibility to organophosphate insecticides.

### Chlorinated Hydrocarbon Insecticides

This class of insecticides was heavily used from 1955-1972. Present day use is limited to those materials primarily as follows:

Toxaphene - livestock, crops
Methoxychlor - livestock, crops
Endrin - crops
Chlordane - below ground for dwellings
Mirex - fire ant control

Note that only two products are allowed intentional access to livestock.

Toxicity of chlorinated hydrocarbons varies widely, even with cattle. The following is given as a general guide:

Table 1. Comparative Aspects of Halogenated Hydrocarbons

| Name | PCB<br>Polychlorinated Biphenyl | PBB<br>Polybrominated Biphenyl | PCP<br>Pentachlorophenol |
|---|---|---|---|
| Sources and Uses | Produced since 1940's and used in transformers, hydraulic fluids, heat transfer, plasticizers and sealants for silos. | Used as a fire retardant chemical. No nutritional or agricultural use. | Used as a fungicide, herbicide and wood preservative since 1930's. Animals have access to treated lumber in poles, feed troughs, floors, etc. |
| Toxicity | Toxicity to cattle is not well known Probably of moderate toxicity since mammalian toxicity (oral $LD_{50}$) is 30-300 mg/kg. | Apparently not toxic at 0.65 mg/kg body wt., but proven toxic at 67.2 mg/kg. body weight daily for 20-60 days. | Acute oral toxicity to cattle is approximately 140 mg/kg. chronic toxicity approximately. 30-40 mg/kg. |
| Veterinary Importance | Highly persistent in the environment. Very fat soluble, so accumulates in tissues, sometimes to quite high concentrations. Has caused contamination in milk, eggs, and poultry. Silo sealing compound used in previous years was source of milk residues. Half life is approximately 50 days and current residue tolerance is 0.05 ppm. | Extensive contamination of dairy cattle and poultry occurred in 1973-74. Persistence of the chemical and relative lack of toxicologic data at the time made dealing with the contaminant very difficult. Classic example of inadvertant contamination of a feed supply, equipment, animals are well as recycling of some contaminated products. | Penta has been alleged to cause death, poor performance and increased incidence and severity of disease in dairy cattle especially under conditions of confinement. Experimental work to date has confirmed few if any of these problems. Technical penta also contains octachloro- and hexachloro dibenzo-p-dioxins and their role in potential toxicosis of penta has been questioned. |
| Clinical Effects | Acute poisoning not likely. Experimentally causes follicular pyodermatitis liver necrosis or atrophy, porphyria, seizures. PCB is embryotoxic and decreases fertility in swine at 20 ppm in the diet. Apparently has not been tested in cattle. Implicated in immunosuppression in some species (not cattle). | Clinical signs are vague. Generally include anorexia, lacrimation, salivation, fetid red-brown diarrhea, depression, abortion and body weight loss. Emaciation, thymic atrophy, pale enlarged kidneys and placental and caruncular necrosis are reported. | Acute poisoning is result of inhibition of oxidative energy metabolism. Result is high fever, weakness, polypnea, dehydration. Penta is irritant to eyes, skin and membranes. Contaminants in technical penta appear less toxic than penta itself. Drop in milk production and decreased heat tolerance may be minimal chronic effects. |

| | Oral Acute Toxicity (mg/kg) ..... | | Dermal Toxicity% |
|---|---|---|---|
| | Calves | Adults | |
| Toxaphene | 5 | 25 | 2 - 4 |
| Methoxychlor | 250 | -- | 8 |
| Endrin | 5? | | 0.25? |
| Chlordane | 10 | 75 | 1 - 2 |
| Mirex | -- | -- | -- |
| Aldrin | 5 | 10 | 0.25 |

Chronic administration may alter toxicity; or toxicity can be influenced by certain drugs. This is known as enzyme induction.

*Clinical Effects*

A mechanism of action for chlorinated hydrocarbon insecticides is not known. There is diffuse stimulation of the CNS with spontaneous seizures which are Gran mal in onset and pattern. Early effects occur as apprehension, spasms of the nasal area, blepharospasm, twitching of ears, and a cranial to caudal onset of clonic tonic seizures including opisthotonus and nystagmus. Seizures typically last from one to 10 minutes and between seizures the animal may appear normal or depressed. In some cases external stimuli may initiate tremors or seizures. Some animals appear to hallucinate; they jump away from non-existent dangers, back up quickly, or

Table 2. Characteristics of Selected Metal Toxicoses in Cattle.

| Name | Copper/Molybdenum | Mercury | Selenium |
|---|---|---|---|
| Source Of Toxicosis | Copper or molybdenum excess in diet or soils. | Treated grains. Use no longer approved. | Seleniferous soils and plants of the great plains. Excessive accidental addition to feeds or by injection. |
| Toxicity | Chronic copper toxicosis rare in cattle. Bovine toxicosis usually due to excess Mo:Cu ration (1:2). From 2-6 ppm Mo diet may be toxic. | Organomercurials toxic at approximately 0.23-1 mg/kg daily for 8 to 56 days. | Oral minimum lethal dose is 1-5 mg/kg. Dietary levels of 5 to 10 ppm may cause chronic toxicosis in cattle. |
| Circumstances Of Poisoning | Cattle in areas of excess molybdenum e.g. mining, smelting. Certain soils in California, Oregon, Nevada, Florida. | Long term consumption of methyl or phenyl mercury. Rare now due to restrictions on mercurial use. | Grazing on seleniferous plants or consumption of grain or forage grown where seleniferous plants have converted selenium to organic forms. |
| Clinical And Pathologic Effects | Molybdenum toxicosis causes persistent diarrhea, fading of haircoat, infertility, lameness, anemia. May occur 8-10 days after first exposure. | Anorexia depression, tremors, ataxia, paresis, paralysis, abnormal posture, blindness. Cerebral and vascular necrosis. | Acute poisoning is rare-characterized by diarrhea, fever, rapid weak pulse and collapse. Chronic signs are hair loss or breakage, weight loss, overgrown and cracked hooves, lameness. |
| Diagnostic Aids | Analyze blood, urine, liver, kidney, and feeds for copper and molybdenum. | Analyze urine, brain, liver and kidney for mercury. | Analyze tissues and feed for selenium. Hair and horn levels 3-10 ppm. Tissues 10-25 ppm. |
| Treatment Or Management | Correct dietary balance of Cu:Mo to approximately 5:1 with 2 ppm as molybdenum. | Dimercaprol, similar as for arsenic. Treatment rarely effective once signs occur. | No good treatment. Prevent access. Selenium intake may be partly counteracted by 50-100 ppm arsanilic acid in diet. |
| Diagnostic Consideration | Mainly a residue problem. Accumulated in fat and liver. Due to persistence, may be found as a residue long after exposure ceases. | Clinical signs are not characteristic. Residues are a problem since half life in milk fat is estimated at 12 weeks. In chronic exposure tissue levels are hard to correlate with toxicosis. | Half life of penta in blood is approximately 2 days, thus does not appear to be a residue problem. Excreted mainly in urine. Analysis in tissue is difficult. Acute or chronic poisoning not likely under usual farm conditions. |
| Therapy or Management | No treatment of acute poisoning. Retain sample of feeds for trace back if residue is found in products. Use only reputable feed suppliers. Be aware of sources such as sealants, hydraulic fluids. | Use similar approach as for PCB. Main problem today is remaining persistent residues and how to interpret. Many alleged long term effects of PBB are problems already acknowledged as dairy cow diseases (mastitis, infertility, etc.). | Avoid contact of treated wood with animal feeds or animal skin. Take proper measures to prevent poor ventilation in total confinement buildings. |

circle. Others may assume abnormal postures or chew upon themselves. Severity of signs is no indicator of prognosis. Onset of seizures may vary from one to 24 hours after an acutely toxic dose, depending in part on dosage and route of administration. Similar signs can occur after toxic accumulation from longer term lower level exposure, and skin exposure results in prolongation of signs. Subtle behavioral changes may result from subacute to chronic exposure.

**Some chlorinated hydrocarbons (DDT, chlordane, aldrin, heptachlor and perhaps others) have been linked to causing cancer in laboratory animals. The potential for carcinogenesis is the major reason that registrations for aldrin, chlordane and dieldrin have been cancelled. Because of carcinogenesis considerations veterinarians in agricultural practice must be aware of residue situations and implications for themselves and clients alike.**

Lesions from chlorinated hydrocarbon insecticide toxicosis are minimal or absent and not consistent enough to be of help in diagnosis.

Diagnosis of poisoning depends on the appropriate history and clinical signs correlated with a pesticide analysis of sources as well as an analysis of the liver, kidney, body fat, blood and brain. Tissue analysis alone establishes exposure, but diagnosis is judgmental, based on history,

Table 3

Livestock Insect Control

| Common Name | Trade name | Basic manufacturer | Class | LD50 Oral | LD50 Dermal | Formulations Available | Method of Application | Percent Concentration | Slaughter Interval |
|---|---|---|---|---|---|---|---|---|---|
| **Beef Cattle Louse And Fly Control** | | | | | | | | | |
| 1. crotoxyphos | Ciodrin | Shell | OP | 125 | | 14.4% e.c. | Backrubber<br>Spray | 1%<br>0.15%-0.3% | 0<br>0 |
| 2. --- | Ciovap | Shell | OP | | | 10%-2.5% | Backrubber | 1%-0.25% | 0 |
| 3. coumaphos | Co-Ral | Chemagro | OP | 41 | 860 | 25% w.p.<br>11.6% e.c.<br>11.6% e.c. | Spray<br>Spray<br>Backrubber | .0.06%<br>0.06%<br>1% | 0<br>0<br>0 |
| 4. dioxathion | Delnav | Hercules | OP | 43 | 235 | 15% e.c. | Either spray or Backrubber | 0.15%<br>1.5% | 0<br>0 |
| 5. lindane | --- | Hooker | CH | 88 | 1000 | 12.4% e.c.<br>20% e.c. | Spray<br>Spray | 0.6%<br>0.6% | 30<br>30 |
| 6. malathion | --- | Am. Cyanamid | OP | 1375 | 4444 | 57% e.c.<br>57% e.c.<br>25% w.p. | Spray<br>Backrubber<br>Spray | 0.5%<br>2%<br>0.5% | 0<br>0<br>0 |
| 7. methoxychlor | --- | Du Pont | CH | 6000 | 6000 | 24%e.c.<br>24% e.c.<br>50% w.p. | Sprav<br>Backrubber<br>Spray | 0.5%<br>5%<br>0.5% | 0<br>0<br>0 |
| 8. trichlorfon | Neguvon | Chemagro | OP | 630 | 2000 | 80% s.p. | Spray | 0.25% | 14 |
| 9. ronnel | Korlan | Dow | OP | 1250 | 2000 | 24% e.c.<br>24% e.c.<br>25% w.p. | Spray<br>Backrubber<br>Spray | 0.5%<br>1%<br>0.5% | 7<br>7<br>7 |
| 10. toxaphene | --- | Hercules | CH | 90 | 1075 | 60% e.c.<br>60% e.c. | Spray<br>Backrubber | 0.5%<br>5% | 28<br>28 |
| **Beef Cattle Grub Control** | | | | | | | | | |
| 11. coumaphos | Co-Ral | Chemagro | OP | 41 | 860 | 25% w.p.<br>11.6% e.c.<br>4% o.s. | Spray<br>Spray<br>Pour-on | 0.375-0.5%<br>0.375%<br>4% | 0<br>0 |
| 12. crufomate | Ruelene | Dow | OP | 50 | 4000 | 25% e.c.<br>25% e.c.<br>9.4% o.s. | Spray<br>Pour-on<br>Pour-on | 0.375%<br>8.3% in water<br>9.4% | 7<br>7<br>7 |
| 13. famphur famix | Warbex | Am. Cyanamid | OP | 50 | 4000 | 15.5% o.s.<br>33.3% f.a. | Pour-on<br>Feed 10 days | 12.5%<br>2.3 mg/lb. wt | 35<br>4 |
| 14. trichlorfon | Neguvon | Chemagro | OP | 630 | 2000 | 80% s.p.<br>8% o.s. | Spray<br>Pour-on | 1%<br>8% | 14<br>21 |
| 15. ronnel | Rid-Ezy<br>Steerkleer<br>Trolene | Moormans<br>Dow<br>Many companies | OP | 1250 | 2000 | 5.5% f.a.<br>5.5% f.a.<br>6% f.s. | Feed 14 days<br>Feed 14 days<br>Feed 7 days | 0.2 lb/100 lb. body wt.<br>0.6% | 10<br>10<br>10 |
| **Feedlot Fly Control - Residual Sprays or Mists** | | | | | | | | | |
| 16. fenthion | Baytex | Chemagro | OP | 215 | 330 | 48% e.c. | Spray | 0.5-1% | -- |
| 17. dimethoate | Cygon | Am. Cyanamid | OP | 215 | 400 | 25% e.c. | Spray | 0.5-1% | -- |
| 18. diazinon | | Geigy | OP | 108 | 900 | 50% w.p. | Spray | 1% | -- |
| 19. | Rabon<br>Ravap | Shell | OP | 4500<br>-- | > 5000<br>-- | 25% e.c. | Spray | 1%<br>1%-0.25% | -- |
| 20. dichlorvos | Vapona DDVP | Shell | OP | 80 | 107 | 23.4% | Mist | 0.5-1% | 0 |
| 21. naled | Dibrom | Chevron | OP | 430 | | 41% | Mist | 0.5-1% | -- |

e.c. = emulsifiable concentrate
o.s. = oil suspension
w.p. = wettable powder

w. = wettable
s. = sprayable
s.p. = soluble powder

OP = organophosphate
CH = chlorinated hydrocarbon
C = carbamate

exposure, and clinical effects.

Acute treatment of toxicosis depends on the control of damaging convulsive activity with sedatives, anesthetics, or tranquilizers. These are usually given to effect for 24 to 72 hours. If poisoning is dermal, wash animals with soap and water. For oral exposure, administer a saline or mineral oil purge and 0.5 to 1.0 kg of activated charcoal orally. Tell the owner that recovered animals may be contaminated for weeks to months. Any sale to slaughter, or sale of contaminated milk if detected will bring regulatory action and continued regulatory surveillance of the producer. Suspended producers generally must retest contaminated animals **at their expense** prior to being cleared for market.

**Aspects of Food Animal Contamination by Chlorinated Hydrocarbon Pesticides and Other Persistent Chemicals**

Previous use of persistent pesticides, now adsorbed to soil, can still result in some translocation into crop plants. For Example:

| Soil Dieldrin Level | 1 ppm | 5 ppm |
|---|---|---|
| Plant part | Plant residue in PPB | |
| corn leaves (top ½) | 20-30 | 30-180 |
| corn stalk (top ½) | 10-160 | 30-220 |
| corn leaves (lower ½) | 10-500 | 110-1200 |
| corn stalk (lower ½) | 100-3920 | 520-10,910 |
| corn cob | 40-80 | 130-270 |
| corn kernels | 4-10 | 20-40 |

Available evidence indicates that soil residues deplete with time, but years may be required. Every producer, especially dairy, should probably know his soil treatment history in detail, as well as possibly some indication of soil and crop levels. This is invaluable evidence if traceback for a contamination incident is ever necessary.

There is established for several pesticides a milk to diet ratio. This compares the chronic dietary level necessary to achieve a given amount of pesticide in milk. For example:

| Insecticide | Level Fed (ppm) | Milk/Diet Ratio |
|---|---|---|
| Aldrin | 1-40 | 0.39 |
| Endrin | 0.05-0.30 | 0.07 |
| Chlordane | 50-5000 | 0.0016 |
| Toxaphene | 20-140 | 0.014 |
| Methoxychlor | 800-7000 | 0.00023 |
| DDT (weathered) | 0.023-4 | 1.0 |

Contaminations arise from accidental clinical poisoning or subclinical exposure. One potential highly suspect source is vegetable oil by-products used in processed feeds.

The half-life (time to reduce pesticide residue by half) of organochlorine residues varies with the pesticide, species, type of animal, metabolic induction, and with various investigators. Examples given illustrate these facts. Each line of data represents a different trial and/or investigator.

| Insecticide | Animal | Tissue | Half-life (days) |
|---|---|---|---|
| Dieldrin | Heifer | Fat | 85 |
| | Steer | Fat | 245 |
| | Cow | Milk fat | 22 |
| | Cow | Milk fat | 30 |
| DDT | Cow | Milk fat | 14-20 |
| DDE | Cow | Milk fat | 52 |

After exposure, excretion is very rapid in the first few days (exponential decline) followed by a leveling off of excretion with persistence for days, weeks or months. Excretion may be accelerated by lactation, body fat loss and metabolic induction.

**Decontamination of Domestic Animals**

Pesticides do have a finite life in the body if exposure stops. Reducing residue depends then on locating the source of contamination. Analysis of feeds and surfaces in contact with contaminated animals should be done. Feeding of charcoal as a GI absorbent has been used if contamination is continuing and to adsorb any pesticide excreted in the bile. Use of 0.5 kg/head/day for 20-30 days may be of limited value. Phenabarbital (5 gm/cow/day) stimulates metabolic enzyme induction and may enhance pesticide excretion. Charcoal and phenobarbital **may** compete with each other. Some evidence indicates Phenobarbital alone is effective in late discovery situations (where pesticide has not been recently consumed). The use of charcoal and phenobarbital is an economic treatment.

**Organophosphate and Carbamate Insecticides**

The organophosphates and carbamates are widely used on crops, animals, dwellings and in feeds. Toxicity is quite varible and dependent on many of the factors outlined earlier. Many are highly toxic and most cause acute effects in domestic livestock. Toxicity of representative pesticides in this group is as follows:

| Chemical | Oral Acute Toxicity in Mg/Kg | | Dermal Toxicity % |
|---|---|---|---|
| | calves | cattle | |
| Coumaphos (Co Ral) | -- | 20 | 0.25 - 0.5% |
| Counter | -- | 1.5 | |
| Cruformate (Ruelene) | 50 | 100 | 0.5 - 1.5% |
| Crotoxyphos (Diodrin) | -- | -- | 0.5 - 2.0% |
| Diazinon | 2.5 | 25 | 0.05% |
| Dichlorvos | 10 | -- | 200 ml of 2% mist |
| Dimethoate (Cygon) | 5 | 15 | 1% |
| Mocap | -- | -- | --- |
| Famphur (Warbex) | 10 | 50 | 2000 mg/kg |
| Malathion | 20 | 100 | 0.5-1.0% |
| Parathion | 0.5 | 50? | 0.01% |
| Phorate (Thimet) | 2.25 | 1.0 | -- |
| Ronnel (Korlan, Trolene) | 100 | 100 | 2.5% |
| Trichlorofon (Neguvon) | 10 | 75 | 1-2% |
| Carbaryl (Sevin) | -- | -- | 2-4% |
| Landrin | -- | 50 | -- |

Situations of organophosphate or carbamate poisoning are generally similar to those described under the general section for insecticides. Organophosphates or carbamates applied directly to animals have additional conditions for poisoning. Improper timing of Grubicides may result in an inflammatory reaction to dead larvae in critical areas such as lumbar nerves or esophagus. Spraying of animals in tight enclosures can result in toxicosis due to respiratory exposure. Potential for interactions (increased toxicity) exists with nutrients and drugs. Increased Vitamin A, high levels of green-chopped forages, and prior administration of succinylcholine or phenothiazine derivatives, have all been implicated as enhancing organophosphate toxicity. Protein malnutrition may either increase or decrease susceptibility of animals, depending in part on whether metabolic activation is necessary for toxicosis.

Clinical effects result from reversible or irreversible inhibition of Acetylcholinesterase (AChE), the enzyme responsible for inactivating Acetylcholine at synapses and neuromuscular junctions. The net effect of AChE inhibition is excess acetylcholine accumulation, with resultant overstimulation of the parasympathetic nervous system and the neuromuscular junctions. Effects are categorized as follows:

a) Muscarinic signs - salivation, miosis, GI hypermotility, abdominal cramps, diarrhea, urinary incontinence, broncho-constriction and broncho-secretion.
b) Nicotinic signs - diffuse stimulation of skeletal muscles with muscle tremors; facial, eye and ear tremors. Early transient stimulation progresses to paresis and paralysis.
c) Central nervous signs - usually depression. Rarely (or never) are convulsive seizures seen.

The onset of poisoning is usually rapid (1-3 hours), and progresses to termination in from 3 to 24 hours. Mortality is closely related to dosage and to severity of clinical signs. Systemic organophosphates (Ronnel, Ruelene, etc.) cause slightly different effects. There is more tendency to hypertonicity, CNS disorientation, abnormal posture and ataxia. Onset is slower (3-24 hours) and clinical signs may be present for from 3 to 7 days. Carbamate compounds have some tendency to cause excitement, mania and running. However, true convulsions are rarely seen.

Lesions are few although bloat may be a secondary effect and pulmonary edema, and emphysema have been reported. Often there is excessive fluid (hypersecretion) in the intestine and the intestine is dilated and flaccid.

Diagnosis of poisoning by organophosphates (OP) or carbamates depends on history of an acute episode with signs of parasympathetic and nicotinic involvement. Blood and/or brain cholinesterase may be useful as a quick guide to OP toxicosis. AChE may be depressed for days or weeks after OP poisoning. Carbamate inhibited cholinesterase activity returns quickly to normal, due to readily reversible bonds. Analysis for parent compound in Ingesta, urine or tissue is difficult and often hard to interpret, but in most cases specimens for analysis should be collected.

Residues of OP and carbamate insecticides are usually of less significance than for organochlorines. However, some soil insecticides do persist in soil for weeks or months as shown below:

| Compound | Percent of Original Residue | |
|---|---|---|
| | Sandy Soil | Loam Soil |
| Chlorfenvinphos | 25% | 45% |
| Diazinon | 1% | 10% |
| Dyfonate® | 25% | 45% |
| Thimet® | 25% | 35% |

Certain organophosphates and carbamates result in residues after direct application to livestock. Use and residue aspects of some livestock insecticides are summarized in Table 3 for this section. Remember that use restrictions and withdrawal times will vary, even on a monthly basis. The material in the table is illustrative only, and not official. The best protection is to adhere strictly to the label recommendations.

Therapy and management of OP and carbamate toxicosis requires aggressive action. Atropine is antidotal by blocking the muscarinic effects of acetylcholine. It does not alleviate nicotinic signs. The recommended atropine dosage is 0.5 mg/kg body weight. Give ¼ to ½ IV and the balance Sub-Q. Evaluate the animal every 4 to 6 hours for 48 hours; repeat the atropine as needed. Specific cholinesterase regenerating agents (2-PAM or TMB-4) may be used for known organophosphate poisoning. These agents are less effective for carbamate poisoning and are generally contraindicated. 2 PAM therapy is less effective (or ineffective) if clinical signs are advanced (more than several hours duration). This is due to "aging" or irreversibility of the OP-cholinestrase bond. Recent work confirms the value of activated charcoal in improving survival of poisoned animals. Charcoal is recommended orally at 1 kg per adult bovine.

**Organic Herbicides**

Organic herbicides are used in selective weed control for agricultural and horticultural crops, reforestation, and conservation programs. Non-selective weed killers may be used as defoliants for crops such as cotton. Approximately 125 basic herbicidal chemicals are commonly indexed by Herbicide Handbook of America, and that publication should be helpful in agricultural practice.

Toxicity of many older non-selective herbicides is relatively high. Of the many organic synthetic herbicides, few are an acute hazard to cattle if properly used, stored and disposed of. When considering toxicity one should be able to convert amounts sprayed or spread per acre to an equivalent dose in terms of animal body weight. This can be done as follows:

a) 1 pound of herbicide per acre delivers 10.4 mg per square foot surface.
b) A yield of 2 tons forage per acre produces 0.1 lb. of forage per square foot.
c) Thus with the above conditions, each kilogram of forage (2.2 lbs.) contains 229 mg of herbicide.
d) A 500 kg cow (1100 lbs.) eating 3% of body weight, or 15 kg per day will then receive 229 mg/15 kg or just over 7 mg/kg body weight of actual herbicide.

The rule of thumb (1 lb/acre = 7 mg/kg) holds for conditions as stated above. One can use the same method to calculate dosage based on other data. The toxicity of various herbicides by class of compound and individual compound is given in Table 4 for this section.

Of the herbicides considered in this paper few are considered hazardous under usual conditions of agricultural use. The potential for rumen dysfunction (rumen microflora are plants) should be watched when excessive exposure to sprayed plants is allowed. Phenoxy herbicides (2,4-D group) sometimes stimulate increases in nitrate and/or cyanide content of plants or weeds. In other cases, sprayed plants appear to become more palatable so animals may consume toxic plants more readily. To overcome the nitrate, cyanide and palatability effects, weedy areas should not be pastured for at least 1 week after spraying.

Clinical effects and residues of some selected herbicides are summarized in outline form. For more detail consult selected references listed. Phenoxy derivatives of fatty acids (2,4-D; 2,4,5-T; MCPA)

1. Usually repeated doses required to induce poisoning - 5 to 10 high daily doses.
2. Signs are mainly GI - anorexia, depression, rumen atony, diarrhea, occasional bloat.
3. Course may be from days to weeks.
4. At high doses a few clonic spasms have been observed, but this **is not** a convulsive situation.
5. Residues generally short-lived. Half-life may be 30 hours in cattle.
6. Excreted primarily unchanged in the urine.
7. During exposure, highest levels are found in liver and kidney.
8. Tissue tolerance usually less than 0.05 ppm in muscle.
9. EPA tolerance for feeds - corn, oats - 0.5 ppm, grass, hay - 100 ppm (interim).
10. Application to harvest interval is 7 days for forages, 14 days for grains.

Amide herbicides (Diphenamide, Randox, Randox-T).

1. Relatively toxic among the herbicides.

2. Two to 10 doses of 25-50 mg/kg may cause anorexia, salivation, depression and prostration.
3. GI irritation and renal damage are observed.
4. No evidence of problem residues in milk or meat.

Arsenical herbicides

1. Toxicity and effects are as for inorganic arsenic.
2. Recommended use rates are hazardous.
3. Persistent in soil; some tendency to accumulate in plants.

Dipyridyl compounds (Diquat, Paraquat)

1. Environmentally sound - low application rates (1 lb./acre), rapid action, inactivated by soil contact, rapid photodecomposition.
2. Acute syndrome (100-300 mg/kg) results in stomatitis, vomiting, colic and diarrhea. If acute phase is survived, a subacute syndrome of pulmonary congestion, pulmonary edema, hyaline membrane and inflammatory infiltration may follow. Chronic progressive pulmonary fibrosis with high mortality may also result within 15 to 30 days after exposure.
3. Tolerance in alfalfa is 5 ppm. Animals may not graze treated areas for 90 days.
4. Tolerance in soybeans is 0.05 ppm. They should not be grazed for 15 days after treatment.
5. Animals should be removed from treated areas 30 days before slaughter.
6. Tolerance in meat and milk is 0.01 ppm.

Substituted urea compounds (Lorox, Dybar)

1. Not a high potential for hazard.
2. Signs for poisoning are general.
3. Can act as an enzyme inducer, thus could enhance metabolism of other coupounds.
4. Treated area shall not be grazed by livestock.

Thiocarbamates

1. Moderate acute toxicity, but low use rate lessens toxicity.
2. Cause muscle spasms, ataxia, depression and prostration.
3. Alopecia in chronic cases.

Triazines (Atrazine, Diallate, Vernam, Knoxweed, Barban, Pebulate)

1. Includes many high volume sales herbicides in U.S.A.
2. Relatively hazardous, although at conditions of use little evidence of poisoning.
3. Muscle spasms, weakness, ataxia are relatively prominent signs with this group.
4. Hepatic and renal degenerative lesions.
5. Metabolized atrazine is excreted via the kidneys.
6. Treated corn should not be used for forage, feed or silage for 21 days after spraying.
7. Tolerance in corn plant is 15 ppm.

Dinitroaniline herbicides (Treflan)

1. Poisoning not reported.
2. Residues do not appear to be a problem.
3. No statements regarding withdrawal times.

Acute poisoning is rarely a problem. Clinical signs are similar and non-specific. Diagnosis of poisoning depends on quantitative evidence of exposure (how much for how long?) with a judgement of clinical effects that are compatible. Analytical confirmation for many herbicides is difficult and time consuming. A general analytical search for herbicides will take time and cost many dollars.

### Use of Diagnotic Laboratory Services

Often, the clinician is presented with an animal problem involving death, poor performance or excessive chemical residues. Often, the specific effects are not well described (e.g. drug residues with no apparent exposure). Diagnostic toxicology utilizes to great extent information relating to 1) circumstances and conditions of the suspected intoxication, 2) clinical or symptomatic evidence, 3) pathologic alterations, 4) chemical verification of toxic materials, and 5) experimental confirmation or support for a tentative diagnosis.

### Diagnostic Procedures - Role of the Clinician

The choice of specimen is important in making a chemical analysis. Specimens should be taken free of chemical contamination and debris and should not be washed because of the possibility of removing residues of the toxic agent or of contaminating the specimen with the water. Collect parenchymatous organs before the gastrointestinal tract is opened, using a separate instrument from that employed to cut the skin. Keep in mind that one is often dealing with trace amounts of a particular chemical, and even the slightest contamination may produce erroneous results. Tissue specimens in most cases should be frozen and packaged to arrive at the laboratory while still frozen. Serum and blood should not be frozen but kept refrigerated. Always package specimens from the various organs separately. Use clean glass or plastic containers that can be tightly sealed. Be aware that the container can sometimes influence toxicologic results. Always label each specimen with the owner's name, animal name or number, and tissue or specimen in the container. Never add preservatives such as formalin to specimens unless there is a specific reason for doing so and such information is included along with the specimen. Always send more material than may be deemed necessary.

Serum cations and enzymes may be very helpful in the diagnosis of certain toxic and metabolic conditions. Several general rules for collection and preservation of serum should be followed. Collect blood with clean equipment and transfer it to clean vials or tubes. Avoiding excessive aspiration pressure, trauma, or time lag during collection will minimize hemolysis. Allow sufficient time for the blood to clot and begin to retract, usually about one hour. Always try to remove serum from the clot within two hours. This may be done by carefully pouring off serum from the retracted clot or by centrifugation. After the serum is separated from the clot, it can be frozen and transported on ice.

Specimens that should be submitted from a live animal include: 5 ml of serum with clot removed; 10 ml of whole blood; 50 ml of urine; and 200 gm of bait, vomitus, or other such materials.

Specimens that should be submitted from a dead animal include: 5 and 10 ml of serum and whole blood, respectively, if available; 50 ml of urine; 100 gm each of liver, kidney, spleen, and body fat. The entire brain should be submitted. Many disorders resembling intoxications can be differentiated by brain lesions. If an infectious or inflammatory process is suspected, separate the brain longitudinally, fix half in 10 percent buffered formalin, and freeze the other half. Up to 500 gm of rumen or stomach contents should be included.

Specimens collected from living or dead animals should reflect physiological and temporal considerations. In small animals, the entire stomach may be tied off and submitted. Certain poisons such as alkaloids may partition into the stomach by ion-trapping, while blood values may be nearly useless for chemical diagnosis. If several hours have elapsed since ingestion of a poison, two foot sections at various levels of the alimentary tract should be tied off for submission. In ruminants or other herbivores, the large portions of the alimentary tract should be sampled in several locations and appropriately marked. Special collections for certain toxicants should be kept in mind. Samples such as aqueous humor, cerebrospinal fluid or muscle may be especially helpful for the toxicants nitrate, sodium and cyanide respectively.

Always consider submitting more than one tissue or specimen from each animal. The combined results of arsenic determination in gastric, fecal, liver and kidney specimens may be needed to fully evaluate a suspected toxicoses. Urine alone may not reflect the secretion present after toxicosis with a rapidly progressing toxicant such as strychnine or coniine.

Plastic bags, newspaper, canned ice, and cardboard are adequate materials to use for transporting specimens to a laboratory for examination. Excellent biological mailing containers are also available commercially. Liquids such as blood, urine, stomach contents, and water should be shipped in a glass or heavy plastic container that can be sealed. Wrap each labelled specimen well in newspaper and package for mailing unless they can be delivered in person which, of course, is the most desirable. Always wrap the specimens individually for mailing so that the contents cannot leak and contaminate other mail or other specimens.

When submitting feeds or baits it is often advisable to send enough material to feed a guinea pig or rabbit for one to two weeks. In most

Table 4

| EFFECT | CHLORPHENOXY | TRIAZINE* | CHLORINATED ALIPHATIC* | AMIDE* | PHENYL UREA | CARBAMATE | THIOCARBAMATE | ARSENICAL* | SUBSTITUTED DINITROANALINE | DIPYRIDYL* | PHTHALAMIC ACID | BENZOIC ACID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPRESSION | | X | | | | | X | | X | X | | |
| ANOREXIA | X | X | X | X | X | X | X | X | X | X | X | |
| RUMEN STASIS | X | | | | | | | | | | | |
| VOMITION | | | | | X | | X | X | | | | |
| DIARRHEA | | | X | X | X | X | X | X | X | X | X | |
| SALIVATION | | | | X | | | | | | | | |
| BLOAT | | | | | | X | | | X | | X | X |
| WEAKNESS | X | | | | | | | X | | | | |
| ATAXIA | X | | X | X | X | | | X | | | | |
| MUSCLE SPASMS | X | | | | | | X | | | | | X |
| PROSTRATION | | | | X | | | | | X | | | X |
| DYSPNEA | | X | | | | | X | | | | | |
| URTICARIA | | | | | X | | | | | | | |
| LUNG CONGESTION | X | X | | X | | X | X | | | X | | |
| LIVER CONGESTION | | X | X | X | | X | X | | | | X | X |
| KIDNEY CONGESTION | X | X | X | X | X | | | X | | X | X | X |
| FRIABLE LIVER | X | X | | | | | X | X | X | X | | |
| G.I. INFLAMMATION | X | X | X | X | X | X | | X | X | | X | X |
| ENLARGE L.N. | | | | | | X | | | X | | | X |
| HEMORRHAGE | | | | | | X | X | X | | X | | X |
| ASCITES | | | | | | | X | | | | | |
| HYDROTHORAX | | | | | | | X | | | | | |

*Hazard at conditions of use.

instances, 100 ml of water is sufficient for chemical analysis. However, if organic insecticides are suspected, at least one gallon of water may be necessary.

If one is in doubt about proper tissues for analysis or availability of confirmatory tests, much time, effort, and confusion can be avoided by placing a telephone call to the laboratory.

**Specimens for Diagnosis of Specific Toxicants**

The procedures for sending in specimens as outlined above are suitable for the detection of most toxicants. There are instances, however, where special considerations regarding chemical analysis and pathologic evaluation are required. When analyses for specific toxicants are to be used, the laboratory involved should always be contacted if the investigator is not familiar with their procedures and requirements.

**Diagnostic Procedures - Role of the Laboratory**

Diagnostic laboratories are available to veterinarians and/or the public in nearly all states. Their capability for services offered, equipment and personnel vary greatly as do their sources of funding and their mission. When a veterinary clinician relies on a diagnostic laboratory for aid in toxicologic problems he should expect access to standard services such as gross necropsy, histopathology, microbiology, and serology as well as chemical analysis. Often the suspected toxicosis is actually an infectious or management disease, and the full service laboratory is best equipped to provide the support needed.

A voluntary accreditation program for veterinary diagnostic laboratories is administered by the American Association of Veterinary Laboratory Diagnosticians (AAVLD). The AAVLD certifies laboratories, identifies their strengths and makes suggestions for improvements. General requirements for accreditation in pathology include provision for services in gross pathology, histopathology (including histochemistry and rapid section processing, clinical pathology, blood, serum, urine, and other body fluids, and parasitology. Equipment and facilities must include the following:

1) Necropsy room with equipment and cooler to handle various types of animal species.
2) Automated tissue processor, microtome, cryostat, microscopes, embedding apparatus, etc.
3) Spectrophotometer, blood counting apparatus, fluorometer, pH meters, centrifuge, water bath, etc.
4) Quality control program to insure that specimens are properly identified, accurately analyzed, correlated and promptly reported.

A full-service toxicology laboratory should be staffed by professional analytical personnel capable of using modern instruments and dealing with sophisticated techniques. Major analytical instrumentation and apparatus desirable includes the following:

Atomic Absorption Spectrophotometer
Gas-Liquid Chromatograph
Thin Layer Chromatography
pH Meter
Spectrophotometer
a. Infra red
b. Ultra Violet-visible
Distillation Apparatus
Analytical Balances
Fume Hoods

Table 5: AAVLD Accredited Laboratories

Veterinary Diagnostic Laboratory
College of Veterinary Medicine
Iowa State University
Ames, Iowa

Veterinary Diagnostic Laboratory
Kentucky Department of Agriculture
Hopkinsville, Kentucky

Animal Disease Research And
Diagnostic Laboratory
South Dakota State University
Brookings, South Dakota

Texas Veterinary Medical
Diagnostic Laboratory
College of Veterinary Medicine
Texas A & M University
College Station, Texas

Wisconsin Animal Health
Laboratory System
State Department of Agriculture
Madison, Wisconsin

Animal Disease Diagnostic
Laboratories
School of Veterinary Science
and Medicine
Purdue University
West Lafayette, Indiana

State Department of Agriculture
Laboratory System
Centralia, Springfield, Peoria, Illinois

Texas Veterinary Medical
Diagnostic Laboratory at Amarillo
Amarillo, Texas

Veterinary Reference Laboratory--
Intermountain Laboratories
1111 E. Commonwealth Suite D
Fullerton, California

Veterinary Diagnostic Laboratory
College of Veterinary Medicine
Michigan State University
East Lansing, Michigan

Veterinary Medical Diagnostic
Laboratory
Veterinary Medical Sciences
College of Veterinary Medicine
Kansas State University
Manhattan, Kansas

Animal Disease Diagnostic Laboratory System
North Carolina Department of Agriculture
Raleigh, North Carolina

Diagnostic Assistance Laboratory
College of Veterinary Medicine
University of Georgia

Veterinary Diagnostic Laboratory
Oregon State University
Department of Veterinary Science
Corvallis, Oregon

Veterinary Medical Diagnostic Laboratory
College of Veterinary Medicine
University of Missouri - Columbia
Columbia, Missouri

Veterinary Science Laboratory
College of Agriculture
University of Nebraska
North Platte, Nebraska

Bureau of Diagnostic Laboratories
Division of Animal Industry
Florida Department of Agriculture
and Consumer Services
Kissimmee, Florida

Intermountain Laboratories, Inc.
Pathology Services
P.O. Box 633
South Midvale, Utah

Veterinary Reference Laboratory--
Intermountain Laboratories
800 Charcote Ave. Suite 113
San Jose, California

Veterinary Diagnostic and
Investigational Laboratory
College of Veterinary Medicine
University of Georgia
Tifton, Georgia

Veterinary Diagnostic Laboratory
Montana Department of Livestock
Animal Health Division
Bozeman, Montana

Laboratories of Veterinary
Diagnostic Medicine
College of Veterinary Medicine
University of Illinois

Oklahoma Animal Disease
Diagnostic Laboratory
Stillwater, Oklahoma

Pennsylvania Department of Agriculture
Diagnostic Laboratory System
Harrisburg, Pennsylvania

Many excellent laboratories with toxicology facilities are available. Not all of these are AAVLD accredited. Table 5 lists only those AAVLD accredited laboratories in the U.S.A. and this listing does not imply that other facilities are not acceptable. The information is presented as a guide to veterinarians concerning a particular resource available to them.

Judging a reliable laboratory may be difficult but it is not impossible. The following characteristics cited by Van Kampen (1978) summarize what the clinician may expect from a reliable diagnostic laboratory.

1. Information pertaining to the proper collection of specimen.
2. Proper containers for the specimens.
3. Instructions on proper care and shipment of the specimen.
4. Normal values to compare your results against.
5. A list of charges you or the client will incur as the specimen is analyzed.
6. A rapid reporting system - telephone or telegram followed by a written report by mail.
7. A diagnostician to consult with - should be available around the clock.
8. The courage to inform you that you were not properly collected, received or analyzed, if this happens to be the case. You have no need for "sink testing".

**Interpretation of Laboratory Results**

Interpretation of the significance of chemical data should be done carefully, taking into consideration other evidence presented with the case. Positive chemical findings are not always evidence of intoxication, nor do negative findings always prove that a toxicosis did not occur. For example, finding chlorinated hydrocarbon insecticides in the fatty tissues of an

animal only indicates that the animal was exposed to the pesticide, not that the insecticide produced a toxicosis. On the other hand, failure to find cyanide in body tissues would not guarantee that an animal had not been poisoned by such a chemical.

In summary, it is imperative that a thorough history be obtained, that careful observation be made, and that intelligent questions be asked.

**The veterinarian should apply the professional skills that only he possesses in determining signs of illness and in performing a thorough post mortem examination. Properly prepared tissue specimens and other suspected material should be sent without undue delay to a qualified laboratory for chemical and histopathologic examination. All information that can be obtained regarding the case should accompany the specimens to the laboratory. Cooperation and communication between laboratory personnel and the diagnostician will result in the highest usefulness of diagnostic procedures.**

**Selected References**

Buck, W. B., Osweiler, G. D. and Van Gelder, G. A. Clinical and Diagnostic Veterinary Toxicology. Kendall-Hunt, Dubuque, Iowa. 2nd Edition, 1976. Anonymous, Veterinarians Product and Therapeutic Reference, Therapeutic Communications. Caldwell, New Jersey. 4th Edition, 1977. Clarke, E. G. C. and Clarke, M. L. Veterinary Toxicology. Williams and Wilkins, Baltimore, Maryland, 1975. Hilton, J. L., Bovey, R. W., Hull, H. M. Mullison, W. R. and Talbert, R. E. Herbicide Handbook of the Weed Science Society of America. Weed Science Society of America. Champaign, Illinois. 3rd Edition, 1974. Jones, L. M., Booth, N. H., and McDonald, L. D. (Editors). Veterinary Pharmacology and Therapeutics. Iowa State University Press. Ames, Iowa. 4th Edition, 1977. Lucky, T. D. and Venugopal, G. Metal Toxicity in Mammals. Plenum Press, New York, New York, 1977. Moorhead, P. D., Willett, L. B., Brumm, C. J. and Mercer, H. D. Pathology of Experimentally Induced Polybrominated Biphenyl Toxicosis in Pregnant Heifers. J.A.V.M.A. 170 (1977) 307-316. Osweiler, Gary D. Diagnostic Considerations, Sample Selection and Collection for Animal Toxicoses. Proceedings 4th Biennial Toxicology Conference. Logan, Utah, 1978. Osweiler, G. D. Insecticide and Herbicide Poisoning in Bovine Medicine and Surgery. 2nd Edition. American Veterinary Publications. In press. Osweiler, G. D., Van Gelder, G. A., and Zumwalt, R. A. Toxicologic and Residue Aspects of Pentachlorophenol (PCP). Proceedings 20th Annual Meeting of American Association of Veterinary Laboratory Diagnosticians. Minneapolis, Minnesota, 1978. Palmer, J. S. Toxicity of 45 Organic Herbicides to Cattle, Sheep and Chickens. Production Research Report No. 137. Agricultural Research Service, USDA. 1972. Palmer J. S. and Radeleff, R. D. Toxicity of Some Organic Herbicides to cattle, sheep and Chickens. Production Research Report No. 106. Agricultural Research Service, USDA. 1969. Shupe, J. L., Ammerman, D. B., Peeler, H. T., Singer, L. and Suttie, J. W. Effects of Fluorides in Animals. National Academy of Sciences, Washington, D. C., 1974. Szabuniewicz, M., Bailey, E. M. and Wiersig, D. O. Treatment of Some Common Poisonings in Animals. VM/SAC 66 (1971): 1197-1205. Teske, R. H. Polychlorinated Biphenyl (PCB). Proceedings 2nd Biennial Toxicology Conference. College Station, Texas, 1974. VanGelder, G. A. and Osweiler, G. D. Wood Preservation, Veterinary Medicine, Toxicology and Public Health. Proceedings of American Wood Preservers Institute Annual Meeting. Washington, D. C., 1978. VanKampen, K. R. Availability of Laboratory Services in Pathology and Clinical Pathology. Proceedings 4th Biennial Toxicology Conference. Logan, Utah, 1978.

# Feed and Water Related Toxicants

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## Feed and Water Related Toxicants

*Rumensin*

Rumensin is a biologically active compound produced by *Streptomyces cinnamonensis*. The compound is soluble in most organic solvents and is only slightly soluble in water. It was first introduced as an aid in the prevention of coccidiosis in poultry. Subsequently, Rumensin was found to increase propionic acid production in the bovine rumen. By so altering rumen fermentation, a greater proportion of dietary energy was retained, resulting in increased feed efficiency of feed lot cattle. This activity led to the introduction of monensin as feed additive for cattle. Inasmuch as horses may be exposed to feed containing monensin, studies have been conducted to determine what effect monensin might have on horses.

*Toxicity*

Seventy-two cattle were fed Rumensin at levels up to 100 g/ton for 160 days and no changes indicative of toxicity were observed for hematology, serum chemistry, urinalysis, or organ weight parameters. No gross or microscopic tissue changes relating to treatment were observed. The 100 g/ton level did, however, reduce gain.

Oral single doses of Rumensin fed to cattle has caused mortality at 55 mg/kg of body weight which is 80 times the recommended dose of 30 g/ton. However, no mortality ocurred at the 30 g/ton level.

The evidence has accumulated that feed containing 279 ppm monensin is lethal to horses and that 125 ppm may be toxic but not necessarily lethal. Feed with 31 ppm monensin did not cause any clinical changes, aside from partial anorexia in the horse. The single-dose toxicity studies indicate the LD50 of monensin for horses is between 2 and 3 mg/kg of body weight.

*Organic Iodides*

An organic iodide, ethylene diamine dihydriodide (EDDI) is recommended as a feed additive for non-dairy cattle. (Feed Additive Compendium 1976) at the following rates.

Table 1 - Recommended Oral Levels of EDDI

| Animal | Use Level | Indications |
|---|---|---|
| Cattle | 50 mg/head/day in feed or salt continuously | Prevent footrot, soft tissue lumpy jaw and nutritional source of iodine |
| | 400-500 mg/head/day for 2-3 weeks (not to dairy cattle in production) | Treatment of footrot, soft tissue lumpy jaw, and mild respiratory infections by action as an expectorant |

*Toxicity*

Toxic signs of EDDI in cattle include an expectorant action and nasal discharge with a mild intermittent, non-productive cough. These signs may occur at dosage levels of 500-1000 mg/head/day. After reduction of dosage levels to recommended levels the signs may disappear except for occasional nasal discharge and mild cough.

## Cyanide

*Sources of Cyanide*