

CLINICAL TOXICOLOGY CONSPECTUS 1

Synopsis of Veterinary Clinical Toxicology arranged by Principal Presenting Signs or Syndromes

☑ = major agents

☛ = agents and syndromes requiring specific emergency intervention

1: Sudden death syndromes

'Sudden' death is defined as death occurring so rapidly that affected animals are **found dead** without being seen to be ill or **die within a few minutes to a few hours** of clinical signs being noticed. Of course, the transition from life to death itself is always sudden, that is, instantaneous.

- ☛ ☑ Cyanogenic glycosides [→ Cyanide, HCN or Prussic acid]
- ☛ ☑ Nitrate-nitrite
- ☛ ☑ Oxalates (acute poisoning)
- ☛ ☑ Fluoroacetate
- ☛ ☑ Cardiac glycosides
- ☛ ☑ Andromedotoxins (grayanotoxins)
- ☛ ☑ Taxine diterpenoid alkaloids
- ☑ *Erythrophleum* spp. (diterpenoid alkaloids & cinnamic acid derivatives)
- ☑ Pyrrolizidine alkaloids
- ☑ S-methylcysteine sulphoxide (SMCO) & N-propyl disulphide / thiosulphates
- ☑ Phytotoxin-induced cardiomyopathies (see below under Heart & Vascular disease for specific toxins)
- ☑ *Trachymene* spp. (wild parsnips)
- ☑ Galegine
- ☑ Phyto-oestrogens - bladder rupture (wethers)
- Ifforestine
- Diterpenoid alkaloids - *Delphinium* spp.
- Nicotine (pyridine) alkaloids
- Tropane alkaloids [scopolamine (=hyoscine), hyoscyamine, atropine and others]
- Phalaris aquatica* poisoning – sudden death
- Phalaris coeruleascens* poisoning (horses)
- Cucurbitacins (tetracyclic triterpenes)
- Aliphatic nitro compounds (nitrotoxins)
- Parsonsia* spp.

- ☛ ☑ Aflatoxins
- ☑ Fumonisin
- Corallocyostroma ornicopreoides* toxicity (black soil blindness)

- ☛ ☑ Cyanobacterial alkaloid neurotoxins – paralytic shellfish poisoning (PSP) toxins and anatoxins
- ☛ ☑ Cardioactive steroids of *Bufo* spp. toads - dogs (cats)
- Piperidine alkaloids (solenopsins) & peptide allergens of fire ant venom (*Solenopsis* spp.) - rare
- Heleioporus* (burrowing frogs) – dogs, cats
- Lucibufagins (firefly toxins) – Australian lizards & frogs captive in North America

- ☛ ☑ Lead
- ☛ ☑ Arsenic (inorganic)
- ☛ ☑ Copper
- ☛ ☑ Sulphur (S-associated polioencephalomalacia of ruminants)
- ☑ Selenium
- Inorganic mercury
- Molybdenum - acute
- Iron (injectable)

- ☛ ☑ Urea (ammonia)
- ☛ ☑ Ethylene glycol
- ☑ Polytetrafluoroethylene (PTFE, polytef) - birds
- Vapours from cooking fats/oils (birds)
- Carbon monoxide
- Hydrogen sulphide (manure gas)
- Nitrogen dioxide (silage gases)

- ☑ Chocolate (theobromine)
- ☑ Polyether Ionophore antibiotics
- ☛ ☑ Coumarin derivatives (anticoagulant rodenticides)
- ☛ ☑ Organophosphorus insecticides/acaricides (acute toxicity)
- ☛ ☑ Carbamates
- ☑ Chlorinated hydrocarbon (organochlorine) insecticides/acaricides
- Phosphorus
- ☛ ☑ Phosphides of zinc, aluminium or calcium
- Chlorinated phenols
- Sodium chloride – poultry
- Sodium fluoride - pigs

- ☑ Paracetamol
- Imidocarb
- Cisplatin (cats)
- ☑ Acute liver necrosis (see below for individual toxins)

2: Acute liver necrosis

- ☛ ☑ Diterpenoid (kaurene) glycosides - atractyloside, carboxyatractyloside, parquin, carboxyparquin & wedeloside
- ☛ ☑ Furanosesquiterpenes
- ☛ ☑ Methylazoxymethanol (MAM)
- ☑ *Trema tomentosa* [liver-necrosis-inducing phytotoxin]
- ☑ Gossypol
- Argentipallium blandowskianum* [liver-necrosis-inducing phytotoxin]
- Ozothamnus diosmifolius* [liver-necrosis-inducing phytotoxin]
- Cynosurus echinatus* (rough dog's-tail grass)
- Lythrum hyssopifolia* (lesser loosestrife)
- ☛ ☑ Macrofungal peptides

- ☛ ☑ Aflatoxins

- ☑ Sawfly larval peptides

- ☛ ☑ Cyanobacterial hepatotoxic cyclic peptides – microcystins and nodularin
- ☑ Cylindrospermopsin

- ☛ ☑ Iron
- Coal tar products
- Pulegone [pennyroyal oil]
- Molybdenum - acute
- Phosphorus

- ☛ ☑ Paracetamol (cats + other species)
- ☛ ☑ Aspirin (acetylsalicylic acid)
- ☛ ☑ Other NSAIDs (ibuprofen, naproxen, phenylbutazone)
- Imidocarb
- Gaseous anaesthetic agents - dogs

3: Nephrosis

- ☛ ☑ Oxalates (acute poisoning)

- Tannins (hydrolysable)
- Pennisetum clandestinum* (kikuyu grass)
- Lythrum hyssopifolia* (lesser loosestrife)
- Ifforestine
- Vitis vinifera* (grapes or raisins) – dogs
- Philodendron* spp. - cats

Corallocytostroma ornicopreoides toxicity (black soil blindness)
Cortinarius spp. macrofungi

- ☛ Ethylene glycol
- Fluorine compounds
- Mercury - inorganic compounds & vapour
- Zinc
- Molybdenum - acute
- Cadmium
- Chlorinated naphthalenes
- Chlorinated phenols
- Chlorates
- Nitrogen dioxide (silage gases)

- ☛ Paraquat (a dipyridyl herbicide)
- ☛ Other NSAIDs (ibuprofen, naproxen, phenylbutazone)
- Imidocarb
- Aminoglycoside antibiotics (gentamicin, paromomycin)
- Cephalosporin antibiotics
- Sulphonamide antibiotics
- Vitamin K₃ (menadione sodium bisulphite) – horses

4: Photosensitisation

Primary

- Dianthrone derivatives (hypericin, fagopyrin)
 - *Hypericum perforatum*
 - *Fagopyrum sagittatum*
- Furanocoumarins (furocoumarins, psoralens)
 - *Ammi majus*
 - celery, parsley, parsnip
 - *Cullen (Psoralea) patens*
 - *Citrus aurantifolia*
- Phenothiazine

Secondary (hepatogenous)

- ☛ Lantadenes (pentacyclic triterpenes)
- Steroidal or lithogenic saponins
 - *Panicum* spp.
 - *Brachiaria* spp.
 - *Tribulus terrestris*
- Tannins (hydrolysable) - *Terminalia oblongata* ssp. *oblongata*
- Sporidesmin
- Sporadic - unknown toxins
 - oats, barley, wheat, millets
 - lucerne, clovers, medics
 - *Sorghum sudanense*
 - Brassicaceae - Glucosinolates
 - *Polygonum* spp.
- Pyrrolizidine alkaloids
- Liver necrosis-inducing plants, cyanobacteria, mycotoxins
- Phomopsins

5: Haemorrhage (including haematuria) / Haemolysis / Methaemoglobinaemia / Myoglobinuria / Red urine pigments (non-haem)

Glossary (a reminder of definitions)

Haemorrhage = escape of whole blood from the vascular system; extravasation

Haemolysis = rupture of erythrocytes within the vascular system, releasing haemoglobin into the plasma

Haematuria = whole blood (intact erythrocytes) in the urine

Haemoglobinuria = free haemoglobin in the urine (differentiate from rare cases of myoglobinuria)

Widespread Haemorrhage

Ptaquiloside

Dihydroxycoumarin (dicoumarol)

- mouldy *Melilotus* spp.
- *Anthoxanthum odoratus*
- *Ferula communis*

Daphnoretin (presumed toxin in *Wikstroemia indica*)

Colchicine and related alkaloidal amines

☛ Aflatoxins

Trichothecenes (Type A)

☛ Coumarin derivatives (anticoagulant rodenticides)

Arsenic (inorganic)

Sulphonamide antibiotics - poultry

Nitrofurantoin antibiotics – chronic. calves

Anticonvulsant drugs

Pulegone [pennyroyal oil]

Sodium fluoride - pigs

5-Fluorouracil

Oestrogens (human hormone replacement medications) - dogs

Haematuria

Ptaquiloside (bovine enzootic haematuria)

Vitamin K₃ (menadione sodium bisulphite) – horses

Haemolysis

Pyrrolizidine alkaloids

Pyrrolizidine alkaloidosis + Copper

S-methylcysteine sulphoxide (SMCO) & N-propyl disulphide / thiosulphates

Glycosidic steroidal alkaloids (glycoalkaloids) of *Solanum* spp. (nightshades)

Gossypol

Acer spp. (maples)

Bee venom peptides

Berteroa incana (hoary alyssum)

Raphanus raphanistrum (wild radish)

Gyromitra esculenta (false morel)

☛ Copper

☛ Iron

Zinc

Water

Chlorates

☛ Paracetamol (cats)

Levamisole - dogs

Methylene blue – cats, dogs
Chlorinated phenols

Methaemoglobinaemia

☛☛ Nitrate-nitrite
Acer spp. (maples)
Chlorates
☛☛ Paracetamol (cats)
Benzocaine

Myoglobinuria

Polyether ionophore antibiotics
 Senna spp. [= *Cassia* spp.]
Malva parviflora (mallow, marsh mallow, small-flowered mallow)

Red Pigments (non-haem) in urine

Xanthorrhoea minor (grasstree) - cattle
Trifolium pratense (red clover) – deer

6: Chronic ill-thrift

Liver damage

Pyrrolizidine alkaloids

- *Heliotropium* spp.
- *Echium plantagineum*
- *Senecio* spp.
- *Crotalaria* spp.

Indospicine
Glucosinolates
Schinus spp.
Gutierrezia spp. (snakeweeds)
Raphanus raphanistrum (wild radish)

☛☛ Aflatoxins
 Phomopsins
 Sporidesmin

Carprofen – dogs, idiosyncratic hepatotoxicity
Diethylcarbamazine interactions
Mebendazole – dogs, idiosyncratic hepatotoxicity
Diethylcarbamazine (DEC) interactions – dogs, idiosyncratic hepatotoxicity
Paradichlorobenzene (mothballs)

Kidney damage

Tannins (hydrolysable)

- *Quercus* spp.
- *Terminalia oblongata*

Oxalates
 Pyrrolizidine alkaloids - pigs
 Pennisetum clandestinum (kikuyu grass)
Iforrestine
3-methoxy-2(5H)-furanone [Liliaceae nephrosis – cats, cattle, deer]
Lythrum hyssopifolia (lesser loosestrife)
Schotia brachypetala (drunken parrot tree)
Cortinarius spp.
Gutierrezia spp. (snakeweeds)
Vitis vinifera (grapes or raisins) - dogs

Ochratoxins

Citrinin

Inorganic mercury

Zinc

Cadmium

Fluorine

☛ Cholecalciferol (vitamin D₃) & ergocalciferol (vitamin D₂)

Aminoglycoside antibiotics (gentamicin, paromomycin)

Cephalosporin antibiotics

Sulphonamide antibiotics

Vitamin K₃

Pancreatic damage

Zinc

☛ Organophosphorus insecticides/acaricides (acute toxicity)

Chocolate (theobromine)

Cyclopiazonic acid

Alimentary tract damage

Ptaquiloside - neoplasia

Tropane alkaloids - *Convolvulus arvensis* (field bindweed) – horses

Dittrichia graveolens enteritis (mechanical damage)

Crotalaria aridicola & *Crotalaria medicaginea*

Inorganic mercury

Molybdenum - chronic

Connective tissue damage

☛ Cholecalciferol (vitamin D₃) & ergocalciferol (vitamin D₂)

Plant calcinogenic glycosides

Thyroid damage

Glucosinolates

Mimosine

Cyanogenic glycosides

Pennisetum typhoides

Iodine

Sulphonamide antibiotics

Skin & appendage damage

Selenium (chronic selenosis)

Vicia spp. (vetch toxicity)

Juglans nigra (black walnut) – laminitis, horses

Citrus pulp

Arsenic

Iodine

TCDD (dioxin) & polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls

Chlorinated naphthalenes

Bone damage

Calcium oxalate crystals (non-raphide)

Fluorine compounds

Zinc

Molybdenum – chronic

Cadmium

Poor weight gain/Weight loss

Swainsonine

Swainsonine + calystegines (*Ipomoea* spp.)

Cyanogenic glycosides - sulphur-responsive

Tropane alkaloids - *Convolvulus arvensis* (field bindweed) – horses

☛ Aflatoxins

Trichothecenes (Type A)

Deoxynivalenol (DON, vomitoxin)

Selenium

Iodine

TCDD (dioxin) & polychlorinated biphenyls (PCBs)

Anaemia

Irritant diterpenoids of *Pimelea* spp. – simplexin (& huratoxin)

Bentonite (cats)

☛ Aspirin (acetylsalicylic acid)

☛ Other NSAIDs (ibuprofen, naproxen, phenylbutazone)

Oestrogens (human hormone replacement medications) - dogs

Depressed wool growth in sheep

☛ Corynetoxins (tunicaminyl-uracils)

7: Nervous syndromes I (CNS): Convulsions, tremors, deranged behaviour, deep depression

Convulsions (seizures) - clonic

☛ Fluoroacetate

☛ Thiaminase

Terminalia oblongata (yellow-wood) - sheep

☛ *Brunfelsia* spp. (francisia, yesterday-today-&-tomorrow)

Tropane alkaloids [scopolamine (=hyoscine), hyoscyamine, atropine and others]

Cynanchosides

Piperidine & nicotine (pyridine) alkaloids

Domoic acid (amnesic shellfish poisoning – ASP) – sea birds & pinnipeds

Cyclopiazonic acid

☛ Corynetoxins (tunicaminyluracils) (ARGT)

☛ Cardioactive steroids of *Bufo* spp. toads - dogs (cats)

Sodium ion (commonly sodium chloride)

☛ Lead

Mercury - organic (methyl mercury)

☛ Sulphur (S-associated polyoencephalomalacia of ruminants)

Chlorinated hydrocarbon (organochlorine) insecticides/acaricides

Paradichlorobenzene (mothballs)

☛ Organophosphorus insecticides/acaricides (acute toxicity)

☛ Carbamates

☛ Metaldehyde

☛ Synthetic pyrethroids & phenylpyrazoles

4-aminopyridine

Bromethalin

Dichloromethane

Pulegone [pennyroyal oil]

Nitrofurant antibiotics

5-Fluorouracil

Amphetamine

Cocaine
Phencyclidine

Convulsions (seizures) - tetanic

☛☛ Strychnine (& brucine)
Alstonine, alstonidine and other indole alkaloids of *Alstonia constricta*
Indole (pyrrolidinoindoline) alkaloids - calycanthine, chimonanthine, idiospermuline
Cynanchosides
Musa sp. (bananas) (?)
Roquefortine -dogs
Penitrem A – dogs
☛☛☛ Phosphides of zinc, aluminium or calcium
Amphetamine
Sea hares (Subclass Opisthobranchia, Order Tectibranchia) - dogs

Tremors

☛ Indole alkaloids of *Phalaris* spp (phalaris) - Phalaris staggers
Pyridine (nicotine) and piperidine alkaloids
Chamaecytisus proliferus
Philodendron spp. - cats
☛ Lolitrems
☛ Paspalitrems (*Claviceps paspali* tremorgens)
Penitrem A - dogs
Aspergillus clavatus tremorgenic mycotoxins
☛☛☛ Urea (ammonia)
☛☛☛ Mercury - vapour
Mercury - organic (methyl mercury)
Thallium
☛☛☛ Organophosphorus insecticides/acaricides (acute toxicity)
☛☛☛ Carbamates
☛☛☛ Chlorinated hydrocarbon (organochlorine) insecticides/acaricides
☛☛☛ Synthetic pyrethroids & phenylpyrazoles
☛☛☛ Metaldehyde
Hexachlorophene
Tea-tree (*Melaleuca*) oil
Bromethalin
4-aminopyridine
Chlorinated phenols
Water
☛☛☛ Macrocyclic lactone anthelmintics/insecticides (ivermectins, milbemycin endectosides; macrolide endectosides)
☛☛☛ Polyether Ionophore antibiotics
Dinitolmide (DOT) coccidiostat (pigeons, chickens)
Imidocarb
Levamisole - sheep
Nitrofurantoin antibiotics
5-Fluorouracil
Amphetamine

Deranged behaviour (mania), deep depression [Not to be confused with the normal appearance of veterinary students in June and November!]

☛☛☛ Dianthrone derivatives (hypericin, fagopyrin)
Phalaris coerulescens poisoning (horses)
Prosopis juliflora (mesquite) – neuronal vacuolation in cranial nerve nuclei
Avena sativa (oats) – “red-tipped” or “rusty” oats crops
☛☛☛ Swainsonine
Swainsonine + calystegines (*Ipomoea* spp.)
Calystegines (nortropane alkaloids) - probable aetiology of *Solanum* spp.-associated cerebellar degeneration

Nepetalactone
 Hepatoencephalopathy

- Pyrrolizidine alkaloids
- Acute liver necrosis toxins

Dendrocnide spp. (stinging trees)
 Glycosidic steroidal alkaloids (glycoalkaloids) of *Solanum* spp. (nightshades)
Pisum sativum var. *arvense* (field pea)
 Platypus venom

- Lead

 Mercury - organic (methyl mercury)
 Manganese

- Chlorinated hydrocarbon (organochlorine) insecticides/acaricides

 Dialkylimidazoles (indole alkaloids) - Ammoniated forage toxicity
 Tea-tree (*Melaleuca*) oil
 4-aminopyridine
 Bromethalin
 Chlorinated phenols
 Dichloromethane
 5-Fluorouracil
 Amphetamine
 Cocaine
 Phencyclidine

Tetrahydrocannabinol - *Cannabis sativa* (marijuana)
 Sesquiterpene lactones (probable aetiology) - nigropallidal encephalomalacia
 Fumonisin (horses)
 Lysergic acid amide (ergot alkaloid)
 Amnesic Shellfish Poisoning (ASP) – domoic acid

- Barbiturates

 Ethanol (ethyl alcohol)
 Amitraz
 Sulphur

8: Nervous syndromes II (CNS/PNS): Ataxias, paralyzes, gait abnormalities

Ataxias

- Thiaminase - horse
- Cycads
- *Xanthorrhoea* spp. (grasstrees) – posterior ataxia syndrome
- Aliphatic nitro compound(s) (probable aetiology) - *Indigofera linnaei* (Birdsville indigo) – Birdsville horse disease
- Aliphatic nitro compounds (nitrotoxins)
- Indole alkaloids of *Phalaris* spp (phalaris) - Phalaris staggers
- β -carboline alkaloids [indole alkaloids] – Coonabarabran staggers
- Swainsonine + calystegines (*Ipomoea* spp.)
- Calystegines (nortropane alkaloids) - probable aetiology of *Solanum* spp.-associated cerebellar degeneration
- *Tribulus micrococcus* (yellow vine)
- Pyridine (nicotine) and piperidine alkaloids
- *Hoya australis* (hoya, wax flower)
- *Trachyandra* spp.
- Cyanogenic glycosides - *Sorghum* spp. spinal cord damage

 Other plant staggers syndromes –

- *Stachys arvensis*
- *Lamium amplexicaule*
- *Malva parviflora*
- *Echinopogon* spp.

Gomphrena celosioides (gomphrena weed, soft khaki weed)

Macadamia spp. seeds/kernels (dogs)
 Tetrahydrocannabinol - *Cannabis sativa* (marijuana)
Solanum spp.-associated cerebellar degeneration
Cumulative bufadienolide cardiac glycosides (cotyledonosis)
Chamaecytisus proliferus (tagasaste)
Humpyback of sheep
“Gomen disease” of horses in New Caledonia
“Scrub ataxia” of suckling calves in south-eastern Queensland

Aspergillus clavatus tremorgenic mycotoxins
Cyclopiazonic acid
Diplodia maydis neurotoxin

☛ Ciguatoxin & maitotoxin

Selenium - pigs
Methyl mercury
Thallium

Organic arsenical (phenylarsonic; benzenearsonic) compounds (pentavalent As)
☛ Organophosphorus insecticides/acaricides (acute toxicity)
☛ Carbamates
Organophosphorus compounds (delayed neurotoxicity)
Amitraz
☛ Macrocyclic lactone anthelmintics/insecticides (ivermectins, milbemycin endectosides; macrolide endectosides)
☛ Synthetic pyrethroids & phenylpyrazoles
Dinitolmide (DOT) coccidiostat (pigeons, chickens)
Hexachlorophene
Bromethalin
Ethanol (ethyl alcohol)

Paralysis/paresis

Tropane alkaloids [scopolamine (=hyoscine), hyoscyamine, atropine and others]
Aliphatic nitro compounds (Nitrotoxins)
 Persin - tongue paresis/paralysis (horses)
Cumulative bufadienolide cardiac glycosides (cotyledonosis)
Sesquiterpene lactones (probable aetiology) - nigropallidal encephalomalacia
Macadamia spp. seeds/kernels (dogs)
 Fumonisin – horse
Diplodia maydis neurotoxin
☛ Ciguatoxins (& maitotoxin)
☛ Tetrodotoxin
Neurotoxic Shellfish Poisoning (NSP) – brevetoxins – sirenians
Domoic acid – cetaceans, seabirds
Paralytic Shellfish Poisoning (PSP) – saxitoxins + others – cetaceans, pinnipeds
Alkaloids of frogs and salamanders
Peptides of frogs
Pseudophryne (toadlets)
☛ Lead - birds
 Selenium - pigs
 Polyether Ionophore antibiotics
Hexachlorophene
Bromethalin

Gait abnormality

Hypochoeris radicata – presumptive cause of ‘Australian’ stringhalt
Lathrogens (neurolathyrism - *Lathyrus* spp.)
 Swainsonine

Swainsonine + calystegines (*Ipomoea* spp.)
 Indole alkaloids of *Phalaris* spp (phalaris) - Phalaris staggers
Juglans nigra (black walnut) – laminitis, horses
Berteroa incana (hoary alyssum) – laminitis, horses
 Paspalitremes (*Claviceps paspali* tremorgens)
 Lolitrems
Diplodia maydis neurotoxin
TCDD (dioxin) & polychlorinated biphenyls (PCBs) - laminitis
Nitrofurant antibiotics

9: Blindness

Retinal ± optic nerve degeneration

Stypanrol
 Ptaquiloside – “bright blindness”
Rhodomyrtus macroparpa (finger cherry)
Helichrysum argyrosphaerum
 Halogenated salicylanilide anthelmintics (closantel)
 Organic arsenical (phenylarsonic; benzenearsonic) compounds (pentavalent As)
Hexachlorophene
Bromethalin

Cataracts

Mimosine
Xanthorrhoea johnsonii (northern forest grasstree)
Helichrysum argyrosphaerum

Corneal opacity

Furanocoumarins (furocoumarins, psoralens)
Ramaria flavo-brunnescens (a coral fungus)
Hydrogen sulphide (H₂S, manure gas)
Phenothiazine
Glucosinolates

CNS Damage

Swainsonine
Swainsonine + calystegines (*Ipomoea* spp.)
 Fumonisin – horses
☛ Lead
 Sodium ion (commonly sodium chloride)
Mercury - organic (methyl mercury)
Avermectins

Polioencephalomalacia

☛ Thiaminase
☛ Lead
☛ Sulphur (S-associated polioencephalomalacia of ruminants)
 Sodium ion (commonly sodium chloride)

Hepatoencephalopathies

Pyrrolizidine alkaloids
 Acute liver necrosis

Unknown mechanism

Corallocytophaga ornitocopreoides toxicity (black soil blindness)
5-Fluorouracil - cat

10: Respiratory syndromes

Pneumonitis

- ☛ ☑ Andromedotoxins (grayanotoxins)
- ☑ *Ageratina* spp. (Crofton weed, mist flower)
- ☑ Pyrrolizidine alkaloids
- Furans - *Perilla frutescens* (perilla mint, wild coleus)
- Zieria arborescens* (stinkwood)
- Glucosinolates
- ☑ Furans - Mouldy sweet potatoes
- Chattonella marina* – southern bluefin tuna
- ☑ Iodine
- ☑ Mercury - vapour
- ☛ ☑ Paraquat (a dipyridyl herbicide)
- ☑ Polytetrafluoroethylene (PTFE, polytef) - birds
- Vapours from cooking fats/oils (birds)
- Silage gases (nitrogen dioxide)
- Hydrogen sulphide (H₂S, manure gas)
- Nitrogen dioxide (silage gases)
- Crude oil, petroleum, diesel and associated products

Pulmonary oedema (dominant sign)

- ☑ Galegine
- Aliphatic nitro compounds (Nitrotoxins)
- ☑ Fumonisin - pigs
- Cisplatin (cats)
- Alphanaphthylthiourea (ANTU)

Pyrexia, hyperpnoea

- ☑ Ptaquiloside
- ☑ Dianthrone derivatives (hypericin, fagopyrin)
- ☛ ☑ Ergot alkaloids (ergopeptide alkaloids)- ergotism
- Balansia* sp. in *Paspalidium jubiflorum* (Warrego summer grass)
- ☑ Iodine
- ☑ Chlorinated hydrocarbon (organochlorine) insecticides/acaricides
- ☛ ☑ Metaldehyde
- ☛ ☑ Aspirin (acetylsalicylic acid)
- ☛ ☑ Other NSAIDs (ibuprofen, naproxen, phenylbutazone)

Laryngeal paralysis/hemiplegia

- ☑ Pyrrolizidine alkaloids
- Hypochoeris radicata* (putative toxic source)
- Aliphatic nitro compounds (Nitrotoxins)
- ☑ Aliphatic nitro compound(s) (probable aetiology) - *Indigofera linnaei* (Birdsville indigo) – Birdsville horse disease
- ☛ ☑ Lead - horses
- Organophosphorus compounds (delayed neurotoxicity) – horses, pigs

11: Heart & vascular disease

Phytotoxin-induced cardiomyopathies – sudden death

- ☛ ☑ Fluoroacetate
- ☑ Gossypol
- ☑ Unsaturated fatty acids, particularly crepenynic acid
- ☑ Persin
- ☑ *Ageratina* spp. (Crofton weed, mist flower)
- ☑ Theobromine (a xanthine alkaloid)
- ☑ *Senna* spp.
- ☑ *Trachymene* spp. (wild parsnips)
- Thiaminase – pigs

Gousiekte-inducing plants

Castanospermum australe (Moreton Bay chestnut, black bean) (rare)

Heart failure

Syndromes including jugular vein distension, subcutaneous oedema (head, brisket, limbs), ascites, hydrothorax, cardiac dilation. There may be some overlap with cardiomyopathies producing sudden death.

Irritant diterpenoids of *Pimelea* spp. – simplexin (& huratoxin)

Gossypol

Persin

Swainsonine + altitude - cattle

Thiaminase – pigs

Isoquinoline alkaloids - *Argemone* spp. (Mexican poppy) – cattle, poultry

Parsonsia spp.

Gousiekte-inducing plants

Atalaya hemiglauca (white wood) - horses

Fumonisin - pigs

Polyether Ionophore antibiotics

Nitrofurantoin antibiotics – poultry

Sodium chloride – poultry

TCDD (dioxin) & polychlorinated biphenyls (PCBs) - poultry

Arrhythmias

β_2 agonists

Amphetamine

Cocaine

Phencyclidine (PCP)

Vascular disease

☛ Ergot alkaloids (ergopeptide alkaloids)- ergotism

Platypus venom

12: Diarrhoea and other alimentary syndromes

Diarrhoea

Diarrhoea is a common sign attributed to plant and other poisonings. The main syndromes included here are the better characterised ones and are *not inclusive of all plants or other toxins capable of producing diarrhoea*.

Therapy in all cases should include **rehydration** with oral electrolyte replacement solution. Adsorbents of toxins may also be useful - activated charcoal @ 5 g/kg or bentonite @ 5-10 g/kg.

☛ Cardiac glycosides

Irritant diterpenoids of *Pimelea* spp. – simplexin (& huratoxin)

Irritant diterpenoids of Families Thymelaeaceae & Euphorbiaceae

Glycosidic steroidal alkaloids (glycoalkaloids) of *Solanum* spp. (nightshades)

Cucurbitacins (tetracyclic triterpenes)

Castanospermum australe (Moreton Bay chestnut, black bean)

Senna spp. [= *Cassia* spp.]

Toxalbumins (lectins)

Meliatoxins (tetranortriterpenes)

Trachymene spp. (wild parsnips)

Phytolacca spp.

Avena sativa (oats) – “red-tipped” or “rusty” oats crops

Schinus spp.

Dittrichia graveolens enteritis (mechanical damage)

Pyrrolizidine alkaloids

Colchicine and related alkaloidal amines

Terpenoids of *Pachyrhizus erosus* (yam bean)

Berteroa incana (hoary alyssum)
Raphanus raphanistrum (wild radish)
Ramaria flavo-brunnescens (a coral fungus)
 Trichothecenes (Type A)
 Diarrhetic (diarrhetic) Shellfish Poisoning (DSP) – okadaic acid +dinophysistoxins
 Neurotoxic Shellfish Poisoning (NSP) – brevetoxins
 Azaspiracid Poisoning (Winter toxicity of mussels)
 Histamine fish poisoning (HFP) – humans
 ☉☼ Arsenic (inorganic)
 ☉☼ Copper
 Fluorine compounds
 Mercury - inorganic compounds & vapour
 ☉☼ Iron
 Molybdenum - chronic
 Phosphorus
 Thallium
 Zinc
 Sodium fluoride
 ☉☼ Organophosphorus insecticides/acaricides (acute toxicity)
 ☉☼ Carbamates
 Diquat, morphamquat (dipyridyl herbicides)
 Glyphosate
 Chlorates
 Amitraz - dogs
 Pulegone [pennyroyal oil]
 Tea-tree (*Melaleuca*) oil

Buccal irritation (stomatitis) or ptyalism (excessive salivation, sialorrhoea)

Calcium oxalate raphide crystals
 Mimosine
 Protoanemonin
 Grass awns
Ramaria flavo-brunnescens (a coral fungus)
 Trichothecenes (Type A)
 Slaframine
Diplodia maydis neurotoxin
 ☉☼ Cardioactive steroids of *Bufo* spp. toads - dogs (cats)
 Peptides of frogs
 Batrachotoxins in *Pitohui* and *Ifrita* birds of New Guinea
 Mercury - inorganic compounds & vapour
 Thallium
 ☉☼ Paraquat (a dipyridyl herbicide)
 Diquat, morphamquat (dipyridyl herbicides)
 Glyphosate
 Tea-tree (*Melaleuca*) oil
 Chlorinated phenols

Forestomach lesions

Pennisetum clandestinum (kikuyu grass)
 Cucurbitacins
Corallocytostroma ornicopreoides toxicity (black soil blindness)
 Gypsum
 Glucosinolates

Vomiting/regurgitation (ruminants, horses)

☉☼ Andromedotoxins (grayanotoxins)
 Oesophageal ulceration of horses: *Crotalaria aridicola* & *Crotalaria medicaginea*

Feed refusal / vomiting

Trichothecenes Types A & B

Litoria caerulea (green tree frog) - dogs

Glyphosate

☛☛☛ Phosphides of zinc, aluminium or calcium

Colonic lesions

Amitraz - horses

Lincomycin - horses

Gastric ulcers / abomasal irritation

☛☛☛ Aspirin (acetylsalicylic acid)

☛☛☛ Other NSAIDs (ibuprofen, naproxen, phenylbutazone)

Calcium formulations (bovine hypocalcaemia preventative/therapy)

☛☛☛ Phosphides of zinc, aluminium or calcium

Phytobezoars (plant fibre balls)

Diospyros virginiana (persimmon)

Romulea rosea var. *australis* (onion grass, Guildford grass)

Anemone patens (pasque flower)

Neoplasia

Ptaquiloside – upper alimentary tract (cattle), intestines (sheep)

13: Hair loss or dermatitis

Hair loss

Mimosine

Selenium (chronic selenosis)

Ramaria flavo-brunnescens (a coral fungus)

Iodine

Thallium

Chlorinated naphthalenes

TCDD (dioxin) & polychlorinated biphenyls (PCBs)

Dermatitis

Vicia spp. (vetch toxicity)

Urushiols

Grass awns

Schinus spp.

Parsonsia spp.

Callitris spp. (cypress pines)

Citrus pulp

Trichothecenes Type A

Toxins of *Lyngbya* (marine filamentous cyanobacterium)

Piperidine alkaloids (solenopsins) & peptide allergens of fire ant venom (*Solenopsis* spp.)

☛☛☛ Arsenic (inorganic)

Iodine

Thallium

Chlorinated naphthalenes

TCDD (dioxin) & polychlorinated biphenyls (PCBs)

“Scrub ataxia” of suckling calves in south-eastern Queensland

14: Goitre

Cyanogenic glycosides – congenital goitre

Mimosine

Glucosinolates

Pennisetum typhoides (pearl millet seed) – goats; Africa

Iodine

Sulphonamide antibiotics

15: Skeletal muscle syndromes

- Unsaturated fatty acids, particularly crepenynic acid
- Senna* spp. [= *Cassia* spp.]
- Persin - masseter muscle necrosis (horse)
- Atalaya hemiglauca* (whitewood) - horses
- Malva parviflora* (mallow, marsh mallow, small-flowered mallow)
- Quinolizidine alkaloids - *Thermopsis montana*
- Phomopsins
- Ionophore antibiotics
- Nitrogen dioxide (silage gases)

16: Bone syndromes

- Calcium oxalate crystals (non-raphide) - horses
- Trachymene* spp. (wild parsnips)
- Trichothecenes – tibial dyschondroplasia of poultry
- Fusarochromanone – tibial dyschondroplasia of poultry
- Fluorine
- Zinc – horses
- Calcium – dogs
- Molybdenum - chronic
- Vitamin A (hypervitaminosis A)

17: Reproductive syndromes

Congenital abnormalities

- Cyanogenic glycosides (putative agent) - *Sorghum sudanense* hybrids
- Cyanogenic glycosides – congenital goitre
- Trachymene* spp. (wild parsnips)
- Piperidine, pyridine (nicotine) & quinolizidine alkaloids - *Conium*, *Lupinus*, *Nicotiana* teratogens
- Steroidal alkaloids- *Veratrum*, *Solanum tuberosum*
- Chamaecytisus proliferus* (tagasaste)
- Griseofulvin

Other teratogens: Numerous compounds have been tested in laboratory animals and found capable of teratogenesis. Potential teratogens include vitamin A /retinoic acid (Geelen 1979), benzimidazole

References:

Beasley *et al.* 986

Geelen JAG (1979) Hypervitaminosis A-induced teratogenesis. *CRC Crit. Rev. Toxicol.* 6:351-376.

Mastitis/ Agalactia

- Persin (*Persea americana*)
- ☛ Ergot alkaloids (ergopeptide alkaloids)- ergotism

Reduced fertility

- Phyto-oestrogens
- Gossypol
- Swainsonine
- Simmondsia chinensis* (jojoba) meal - poultry
- Romulea rosea* var. *australis*
- Zearalenone - cattle, pigs
- Trichothecenes (Type A)
- Iodine
- Cadmium
- Nitrofurans antibiotics – poultry
- Glucosinolates - poultry

Abortion/premature birth

- Isocupressic acid (bicyclic labdane diterpene acids) and/or Vasoactive lipids
- Swainsonine
- Gossypol
- Nitrate-nitrite
- Salvia coccinea* (red salvia, Texas sage)
- Trigonella foenum-graecum* (fenugreek)
- Mentha longifolia* (horse mint)
- Mentha saturioides* (native pennyroyal)
- Tanacetum vulgare* (tansy)
- Indospicine (*Indigofera spicata*)
- Raphanus raphanistrum* (wild radish)
- Romulea rosea* var. *australis*
- Verbena* spp.
- Iva angustifolia* (narrowleaf sumpweed)
- Gutierrezia* spp. (snakeweeds)
- Ateleia glazioviana* (timbo de Palmeira)
- Ranunculus repens* (creeping buttercup)
- Berteroa incana* (hoary alyssum)
- Mansonia altissima* (African redwood) – wood shavings
- Leucaena leucocephala*
- Acer* spp. (maples)
- Other plant toxins
- ☛ Ergot alkaloids (ergopeptide alkaloids)- ergotism
- Trichothecenes (Type A)
- Fumonisin - pigs
- Cadmium

Prolonged gestation

- ☛ Ergot alkaloids (ergopeptide alkaloids)- ergotism – horses

Hyperoestrogenism (pigs)

- Zearalenone

18: Neoplasia

- Ptaquiloside
- Aflatoxins
- Arsenic (inorganic)

19: Immunological suppression

- ☛ Aflatoxins
- Trichothecenes (Type A)
- Selenium
- Iodine
- Oestrogens (human hormone replacement medications) - dogs

20: Taints (milk, meat, eggs)

- Eggs
- Sinapine

CLINICAL TOXICOLOGY CONSPECTUS 2

Toxins or syndromes arranged by Origin, Chemical Group and Use

☑ = major agents

☛ = agents and syndromes requiring emergency intervention

1: *Phytotoxins (toxins of vascular plants) [Biological-origin toxins]*

Inorganic Toxins

☛ ☑ Nitrate-nitrite

☑ Selenium (chronic selenosis)

Sulphur

Simple Organic Toxins

☛ ☑ Fluoroacetate

☛ ☑ Oxalates (acute poisoning)

☑ Calcium oxalate raphide crystals

☑ Calcium oxalate crystals (non-raphide)

Alkaloids

☛ ☑ Strychnine & brucine [indole alkaloids]

Alstonine, alstonidine and other indole alkaloids of *Alstonia constricta*

☛ ☑ Taxine diterpenoid alkaloids

☑ Theobromine (a xanthine)

☑ Pyrrolizidine alkaloids

☑ Swainsonine [an indolizidine alkaloid]

Swainsonine + calystegines (*Ipomoea* spp.)

Calystegines (probable aetiology) – *Solanum* spp.-associated cerebellar degeneration

☑ Indole alkaloids of *Phalaris* spp (phalaris) - Phalaris staggers

β-carboline alkaloids [indole alkaloids]

☑ Piperidine, pyridine (nicotine) & quinolizidine alkaloids - *Conium*, *Lupinus*, *Nicotiana* teratogens

Pyridine (nicotine) and piperidine alkaloids

☑ *Erythrophleum* spp. (diterpenoid alkaloids & cinnamic acid derivatives)

Diterpenoid alkaloids - *Delphinium* spp.

Tropane alkaloids [scopolamine (=hyoscyne), hyoscyamine, atropine and others]

Tropane alkaloids - *Convolvulus arvensis* (field bindweed) – horses

Glycosidic steroidal alkaloids (glycoalkaloids) of *Solanum* spp. (nightshades)

Quinolizidine alkaloids - *Thermopsis montana*

Steroidal alkaloids- *Veratrum*, *Solanum tuberosum*

Isoquinoline alkaloids - *Argemone* spp. (Mexican poppy)

Iforrestine

Indole (pyrrolidinoindoline) alkaloids - calycanthine, chimonanthine, idiospermuline

Colchicine and related alkaloidal amines

Amino Acids & Proteins

☛ ☑ Thiaminase

☑ Mimosine

☑ S-methylcysteine sulfoxide (SMCO) & N-propyl disulphide / thiosulphates

Indospicine

Toxalbumins (lectins)

Lathrogens (neurolathyrism - *Lathyrus* spp.)

Sinapine

Polyamines of gousiekte-inducing plants

Glycosides

- ☛ ☛ Cyanogenic glycosides [→ Cyanide, HCN or Prussic acid]
- ☛ ☛ Cardiac glycosides
- Cumulative bufadienolide cardiac glycosides (cotyledonosis)
- ☛ Ptaquiloside
- ☛ ☛ Diterpenoid (kaurene) glycosides - atractyloside, carboxyatractyloside, parquin, carboxyparquin & wedeloside
- Plant calcinogenic glycosides (cholecalciferol, vitamin D₃)
- Glucosinolates
- Aliphatic nitro compounds (Nitrotoxins)
- ☛ Aliphatic nitro compound(s) (probable aetiology) - *Indigofera linnaei* (Birdsville indigo) – Birdsville horse disease
- Cynanchosides

Coumarin Derivatives

- ☛ Dihydroxycoumarin (dicoumarol)
- Daphnoretin (presumed toxin in *Wikstroemia indica*)
- ☛ Furanocoumarins (furocoumarins, psoralens)
- ☛ Phyto-oestrogens

Terpenes And Terpenoids

- ☛ ☛ Furanosesquiterpenes
- ☛ ☛ Lantadenes (pentacyclic triterpenes)
- ☛ ☛ Andromedotoxins (grayanotoxins)
- ☛ Irritant diterpenoids of *Pimelea* spp. – simplexin (& huratoxin)
- Irritant diterpenoids of Families Thymeleaceae & Euphorbiaceae
- Cucurbitacins (tetracyclic triterpenes)
- Meliatoxins (tetranortriterpenes)
- Sesquiterpene lactones (probable aetiology) - nigropallidal encephalomalacia
- Terpenoids of *Pachyrhizus erosus* (yam bean)

Lipids, Oils, Glycerides, Fatty Acids

- ☛ Unsaturated fatty acids, particularly crepenynic acid
- ☛ Isocupressic acid (bicyclic labdane diterpene acids) and/or Vasoactive lipids
- ☛ Persin
- Urushiols
- Pulegone [pennyroyal oil]
- Tea-tree (*Melaleuca*) oil
- Protoanemonin
- Nepetalactone
- Furans - *Perilla frutescens* (perilla mint, wild coleus)
- 3-methoxy-2(5H)-furanone [Liliaceae nephrosis – cats, cattle, deer]

Phenolic Compounds

- ☛ Gossypol
- ☛ Dianthrone derivatives (hypericin, fagopyrin)
- ☛ Steroidal or lithogenic saponins
- ☛ Tannins (hydrolysable)

Ungrouped Toxins

- ☛ ☛ Methylazoxymethanol (MAM)
- ☛ Stypanrol
- ☛ Galegine
- ☛ Tetrahydrocannabinol - *Cannabis sativa* (marijuana)
- Dendrocnide* spp. (stinging trees)

Mechanical Damage By Plant Parts

Dittrichia graveolens enteritis (mechanical damage)
Grass awns

Plants With Unknown Or Uncharacterised Toxins

[Arranged by Syndrome/organ system, then by Plant Family]

SUDDEN DEATH / HEART

Sudden death / Heart – Family Apocynaceae

Parsonsia spp.

Sudden death / Heart – Family Poaceae

Phalaris aquatica poisoning – sudden death
Phalaris coerulescens poisoning (horses)

Sudden death / Heart – Family Rubiaceae

Gousiekte-inducing plants

Sudden death / Heart – Family Sapindaceae

Atalaya hemiglauca (white wood)

LUNG

Lung – Family Asteraceae

Ageratina spp. (Crofton weed, mist flower)

Lung – Family Rutaceae

Zieria arborescens (stinkwood)

LIVER

Liver – Family Asteraceae

Argentipallium blandowskianum [liver-necrosis-inducing phytotoxin]
Ozothamnus diosmifolius [liver-necrosis-inducing phytotoxin]

Liver – Family Poaceae

Cynosurus echinatus (rough dog's-tail grass)

Liver – Family Ulmaceae

Trema tomentosa [liver-necrosis-inducing phytotoxin]

KIDNEY

Kidney – Family Araceae

Philodendron spp. – cats

Kidney – Family Caesalpiniaceae

Schotia brachypetala (drunken parrot tree)

Kidney – Family Lythraceae

Lythrum hyssopifolia (lesser loosestrife)

Kidney – Family Poaceae

Pennisetum clandestinum (kikuyu grass)

Kidney – Family Vitaceae

Vitis vinifera (grapes or raisins) - dogs

HAEMOLYSIS

Haemolysis – Family Aceraceae

Acer spp. (maples)

RED URINE (NON-HAEM PIGMENTS)

Red urine (non-haem pigments) – Family Fabaceae

Trifolium pratense (red clover) – red urine

Red urine (non-haem pigments) – Family Xanthorrhaceae

Xanthorrhoea minor (grasstree) – urine red pigmentation

NERVOUS - CONVULSIONS

Nervous – Convulsions – Family Combretaceae

Terminalia oblongata (yellow-wood) - sheep

Nervous – Convulsions – Family Musaceae

Musa sp. (bananas)

Nervous – Convulsions – Family Solanaceae

☛ *Brunfelsia* spp. (francisia, yesterday-today-&-tomorrow)

NERVOUS – MANIA

Nervous – Mania – Family Fabaceae

Pisum sativum var. *arvense* (field pea)

NERVOUS - ATAXIA

Nervous – Ataxia – Families Cycadaceae & Zamiaceae

Cycads

Nervous – Ataxia – Family Amaranthaceae

Gomphrena celosioides (gomphrena weed, soft khaki weed)

Nervous – Ataxia – Family Asclepiadaceae

Hoya australis (hoya, wax flower)

Nervous – Ataxia – Family Asteraceae

Hypochoeris radicata – presumptive cause of 'Australian' stringhalt

Nervous – Ataxia – Family Fabaceae

Chamaecytisus proliferus (tagasaste)

Nervous – Ataxia – Family Iridaceae

Romulea rosea var. *australis* (onion grass, Guildford grass)

Nervous – Ataxia – Family Liliaceae

Trachyandra spp.

Nervous – Ataxia – Family Mimosaceae

Prosopis juliflora (mesquite) – neuronal vacuolation in cranial nerve nuclei

Nervous – Ataxia – Family Proteaceae

Macadamia spp. seeds/kernels (dogs)

Nervous – Ataxia – Family Xanthorrhaceae

Xanthorrhoea spp. (grasstrees) – posterior ataxia syndrome

Nervous – Ataxia – Family Zygophyllaceae

Tribulus micrococcus (yellow vine)

Nervous – Ataxia – Family Lamiaceae, Malvaceae, Poaceae

Other plant staggers syndromes – *Stachys arvensis*, *Lamium amplexicaule*, *Malva parviflora*, *Echinopogon* spp.

EYE

Eye – Family Asteraceae

Helichrysum argyrosphaerum

Eye – Family Myrtaceae

Rhodomyrtus macroparpa (finger cherry)

Eye – Family Xanthorrhaceae

Xanthorrhoea johnsonii (northern forest grasstree) - cataracts

ALIMENTARY

Alimentary – Family Anacardiaceae

Schinus spp.

Alimentary – Family Fabaceae

Castanospermum australe (Moreton Bay chestnut, black bean)

Crotalaria aridicola, *Crotalaria medicaginea* (Oesophageal ulceration of horses)

Alimentary – Family Phytolaccaceae

Phytolacca spp.

Alimentary – Family Poaceae

Avena sativa (oats) – “red-tipped” or “rusty” oats crops

Pennisetum clandestinum (kikuyu grass)

ALIMENTARY - PHYTOBEZOARS

Alimentary – Phytobezoars – Family Ebenaceae

Diospyros virginiana (persimmon) - phytobezoars (plant fibre balls): gastric or intestinal impaction/obstruction

Alimentary – Phytobezoars – Family Iridaceae

Romulea rosea var. *australis* (onion grass, Guildford grass)

Alimentary – Phytobezoars – Family Ranunculaceae

Anemone patens (pasque flower)

MUSCLE

Muscle – Family Caesalpiniaceae

Senna spp. [= *Cassia* spp.]

Muscle – Family Malvaceae

Malva parviflora (mallow, marsh mallow, small-flowered mallow)

Muscle – Family Sapindaceae

Atalaya hemiglauca (white wood)

THYROID

Thyroid – Family Poaceae

Pennisetum typhoides (pearl millet seed) – goats; Africa

BONE

Bone – Family Apiaceae

Trachymene spp. (wild parsnips)

SKIN AND APPENDAGES

Skin & Appendages – Family Anacardiaceae

Schinus spp.

Skin & Appendages – Family Apocynaceae

Parsonsia spp.

Skin & Appendages – Family Cupressaceae

Callitris spp. (cypress pines)

Skin & Appendages – Family Fabaceae

Vicia spp. (vetch toxicity)

Skin & Appendages – Family Juglandaceae

Juglans nigra (black walnut) – laminitis, horses

REPRODUCTIVE - ABORTION

Reproductive – Abortion – Family Asteraceae

Gutierrezia spp. (snakeweeds)

Iva angustifolia (narrowleaf sumpweed)

Tanacetum vulgare (tansy)

Reproductive – Abortion – Family Brassicaceae

Berteroa incana (hoary alyssum)

Raphanus raphanistrum (wild radish)

Reproductive – Abortion – Family Fabaceae

Ateleia glazioviana (timbo de Palmeira)

Trigonella foenum-graecum (fenugreek)

Reproductive - Abortion – Family Iridaceae

Romulea rosea var. *australis* (onion grass, Guildford grass)

Reproductive – Abortion – Family Lamiaceae

Mentha longifolia (horse mint)

Mentha saturioides (native pennyroyal)

Salvia coccinea (red salvia, Texas sage)

Reproductive – Abortion – Family Ranunculaceae

Ranunculus repens (creeping buttercup)

Reproductive – Abortion – Family Sterculiaceae

Mansonia altissima (African redwood) – wood shavings

Reproductive – Abortion – Family Verbenaceae

Verbena spp.

Reproductive – Abortion – Family Apiaceae, Asteraceae, Fabaceae, Poaceae

Other plant toxins associated with abortion

REPRODUCTIVE - INFERTILITY

Reproductive - Infertility – Family Iridaceae

Romulea rosea var. *australis* (onion grass, Guildford grass)

Reproductive – Infertility – Family Simmondsiaceae

Simmondsia chinensis (jojoba) meal - poultry

Presumed Plant Poisonings Of Uncertain Cause

“Humpy back” of sheep

“Gomen disease” of horses in New Caledonia

“Scrub ataxia” of suckling calves in south-eastern Queensland

Citrus pulp (citrinin?)

Photosensitisation

- The Basic Syndrome
- Primary Photosensitisation
- Secondary (hepatogenous) Photosensitisation
- Sporadic inducers of photosensitisation (toxins and type unknown)

Acute Hepatic Necrosis

- ☛ Common effects of acute hepatotoxins from plants, mycotoxins, cyanobacteria, macrofungi and sawfly larvae

2: Mycotoxins (toxins of fungi) [Biological-origin toxins]

Moulds

- ☛ Aflatoxins
- Fumonisin
- Phomopsins
- Sporidesmin
- Furans - Mouldy sweet potatoes
- Zearalenone
- Ochratoxins
- Trichothecene mycotoxins
- Trichothecenes (Type A)
- Trichothecenes (Type B)
- Deoxynivalenol (DON, vomitoxin)
- Trichothecenes – tibial dyschondroplasia of poultry

Slaframine
Swainsonine
Roquefortine (dogs)
Penitrem A (dogs)
Aspergillus clavatus tremorgenic mycotoxins
Citrinin
Cyclopiazonic acid
Kojic acid
Rubratoxins
Patulin
Moniliformin
Fusarochromanone
Fusaric acid
Oosporein
Diplodia maydis neurotoxin
Alternaria spp. mycotoxins
Cytochalasins
Ustilago hordei-infected wheat
Sclerotinia sclerotiorum sclerotia
Pyrenofera tritici-repentis-infected wheat

Yeast

Ethanol (ethyl alcohol)

Ergots

- ☛ ☑ Ergot alkaloids (ergopeptide alkaloids)- ergotism
- ☑ Paspalitrems (*Claviceps paspali* tremorgens)

Gall-Forming Fungi

Corallocytophthora ornicopreoides toxicity (black soil blindness)

Endophytes

Ergot alkaloids (tall fescue endophyte)
Lysergic acid amide (ergot alkaloid)
☑ Lolitrems
Balansia sp. in *Paspalidium jubiflorum* (Warrego summer grass)

Macrofungi (Mycetism)

- ☛ ☑ Macrofungal peptides
- Cortinarius* spp. macrofungi
Gyromitra esculenta (false morel)
Ramaria flavo-brunnescens (a coral fungus)

3: Phycotoxins (toxins of “algae”: cyanobacteria, marine microalgae) [Biological-origin toxins]

Cyanobacterial (Cyanophyte, Blue-Green Algal) Toxins

- ☛ ☑ Cyanobacterial hepatotoxic cyclic peptides – microcystins and nodularin
 - ☛ ☑ Cyanobacterial alkaloid neurotoxins – paralytic shellfish poisoning (PSP) toxins and anatoxins
 - ☑ Cylindrospermopsin
- Toxins of *Lyngbya* (marine filamentous cyanobacterium)
Unknown cyanobacterial toxin(s) – prawns

Marine Microalgal (Dinoflagellate & Diatom) Toxins

- Human shellfish poisoning syndromes related to marine dinoflagellates and diatoms
- Diarrhetic (diarrheic) Shellfish Poisoning (DSP) – okadaic acid +dinophysistoxins

- Amnesic Shellfish Poisoning (ASP) – domoic acid
- Paralytic Shellfish Poisoning (PSP) – saxitoxins + others
- Neurotoxic Shellfish Poisoning (NSP) – brevetoxins
- Azaspiracid Poisoning (Winter toxicity of mussels)
- Other shellfish-associated toxins

Paralytic shellfish poisoning (PSP, saxitoxin) – cetaceans, pinnipeds

Brevetoxins – sirenians

Domoic acid (amnesic shellfish poisoning – ASP) – sea birds & pinnipeds

Chattonella marina – southern bluefin tuna

Pfiesteria spp. - fish, humans

☠️ Ciguatoxins (& maitotoxin)

4: Zootoxins (toxins of animals) [Biological-origin toxins]

Arthropods - Insects

Sawfly larval peptides

Bee venom peptides

Lucibufagins (firefly toxins) – Australian lizards & frogs captive in North America

Piperidine alkaloids (solenopsins) & peptide allergens of fire ant venom (*Solenopsis* spp.)

Cantharidin (blister beetles, Spanish fly)

Arthropods – Arachnids (Spiders, Scorpions, Ticks)

Spider envenomations

Latrodectus mactans ssp. *hasselti* (red-back spider)

Necrotising arachnidism

Atrax spp. (funnel-web spiders)

Scorpion venoms

Ixodes holocyclus envenomation

Ixodes cornuatus envenomation

Molluscs - Gastropods (Snails)

Conotoxins

Tetrodotoxin

Sea hares (Subclass Opisthobranchia, Order Tectibranchia) - dogs

Molluscs - Cephalopods (Octopus & Squid)

Tetrodotoxin

Molluscs - Bivalves (Mussels, Scallops, Clams & Oysters)

Human shellfish poisoning syndromes related to marine dinoflagellates and diatoms

Fish

☠️ Ciguatoxins (& maitotoxin)

☠️ Tetrodotoxin

Histamine fish poisoning (HFP) - humans

Palytoxin

Amphibians

☠️ Cardioactive steroids of *Bufo* spp. toads - dogs (cats)

Alkaloids of frogs and salamanders

- Steroidal alkaloids
- Bicyclic alkaloids
- Tricyclic alkaloids
- Monocyclic alkaloids
- Pyridine alkaloids

- Indole alkaloids
- Imidazole alkaloids
- Morphine
- Guanidinium alkaloids
- Other alkaloids

Peptides of frogs

- Physalaemin-like peptides
- Bradykinin-like peptides
- Caerulein-like peptides
- Bombesin-like peptides

Toxic Australian frogs

- *Heleioporus* (burrowing frogs)
- *Pseudophryne* (toadlets)
- *Litoria caerulea* (green tree frog)

Reptiles

Snake envenomation

Birds

Batrachotoxins in *Pitohui* and *Ifrita* birds of New Guinea

Mammals

Vitamin A (hypervitaminosis A)

Platypus venom

5: Bacterial toxins (ingested pre-formed) [Biological-origin toxins]

☛ Corynetoxins (tunicaminyl-uracils)

Tetrodotoxin

Botulinum toxins

6: Geological-origin natural toxins

☛ Arsenic (inorganic)

Fluorine

7: Metals, metalloids, halogens, minerals and other inorganic substances [Industrial-origin toxins]

Metals & Metalloids

☛ Lead

☛ Arsenic (inorganic)

☛ Copper

☛ Iron

Mercury - inorganic compounds & vapour

Mercury - organic (methyl mercury)

Zinc

Selenium

Molybdenum

Cadmium

Manganese

Thallium

Aluminium

Chromium

Cobalt

Boron

Vanadium

Tin

Halogens

- Fluorine compounds
- Iodine
- Bromine

Other Inorganic Substances

Sulphur

8: Pesticides [Industrial-origin toxins]

Rodenticides & Other Vertebrate Pesticides

- ☛ Coumarin derivatives (anticoagulant rodenticides)
 - ☛ Fluoroacetate (1080)
 - ☛ Strychnine
 - ☛ Cholecalciferol (vitamin D₃)
 - ☛ Phosphides of zinc, aluminium or calcium
- Phosphorus
Bromethalin
4-aminopyridine
Alphanaphthylthiourea (ANTU)
Thallium
N-3-pyridyl methyl *N*^l-*p*-nitrophenyl urea (Valor)
Red squill

Insecticides & Acaricides

- ☛ Organophosphorus insecticides/acaricides (acute toxicity)
- Organophosphorus compounds (delayed neurotoxicity)
- ☛ Carbamates
 - Chlorinated hydrocarbon (organochlorine) insecticides/acaricides
- Paradichlorobenzene (mothballs)
Chlorinated naphthalenes
Rotenone
Sodium fluorosilicate

Grain and soil fumigants

Dibromoethane
Methyl bromide

Molluscicides

- ☛ Metaldehyde
- ☛ Carbamates
- Iron

Herbicides

- ☛ Paraquat
- Other Dipyridyl (bipyridyl) herbicides
Glyphosate
Arsenic (*q.v.*)
Sodium chlorate
Dinitrophenol herbicides
Chlorphenoxy herbicides
Delrad
Monochloroacetate (SMCA)

Fungicides

Zineb
Thiram
Captan

9: Feed components or additives [Industrial-origin toxins]

☛☛ Urea (ammonia)
☛☛ Sulphur (S-associated polioencephalomalacia of ruminants)
 Polyether Ionophore antibiotics
 Sodium ion (commonly sodium chloride)
☛☛ Cholecalciferol (vitamin D₃) & ergocalciferol (vitamin D₂)
 Organic arsenical (phenylarsonic; benzenearsonic) compounds (pentavalent As)
Selenium
 Vitamin A
Dialkylimidazoles (indole alkaloids) - Ammoniated forage toxicity
Calcium (dogs)
Nitrate-nitrite

10: Other household, farm or industrial chemicals [Industrial-origin toxins]

Antifreeze

☛☛ Ethylene glycol

Gases & Vapours

Polytetrafluoroethylene (PTFE, polytef) - birds
Vapours from cooking fats/oils (birds)
Carbon monoxide
Hydrogen sulphide (H₂S, manure gas)
Nitrogen dioxide (silage gases)

Fertilisers

Nitrogenous fertilisers
Superphosphate
Gypsum

Absorbents

Bentonite (cats)

Wood Preservatives

Chlorinated phenols
TCDD (dioxin) & polychlorinated biphenyls (PCBs)
Arsenic, copper, chromium

Disinfectants & Cleaning Products

Chlorates
Dichloromethane
Hexachlorophene

Human Foods & Beverages

Chocolate (theobromine)
Water
Ethanol

Miscellaneous

Coal tar products – liver necrosis
Crude oil, petroleum, diesel and associated products
TCDD (dioxin)
Propylene glycol
Bronopol
Polybrominated biphenyls

11: Pharmaceuticals (human & veterinary) [Industrial-origin toxins]

Analgesics & Anaesthetics

☛ ☑ Paracetamol (cats)
☛ ☑ Aspirin (acetylsalicylic acid)
☛ ☑ Other NSAIDs (ibuprofen, naproxen, phenylbutazone)
☛ ☑ Barbiturates
Gaseous anaesthetic agents - dogs
Benzocaine
Carprofen – dogs, idiosyncratic hepatotoxicity

Anthelmintics, Anti-Protozoals, Insecticides & Acaricides

☛ ☑ Synthetic pyrethroids & phenylpyrazoles
☛ ☑ Macrocyclic lactone anthelmintics/insecticides (ivermectins, milbemycin endectosides; macrolide endectosides)
☑ Halogenated salicylanilide anthelmintics
Phenothiazine
Imidocarb
Levamisole
Mebendazole – dogs, idiosyncratic hepatotoxicity
Diethylcarbamazine (DEC) interactions – dogs, idiosyncratic hepatotoxicity
Amitraz
Dinitolmide (DOT) coccidiostat (pigeons, chickens)
Sodium fluoride
Carbon tetrachloride
Tetrachloroethylene
Hexachloroethane
Hexachlorophene
Nicotine
Toluene
Cadmium salts
Piperazine
Thiabendazole
Parbendazole
Cambendazole
Albendazole
Fenbendazole
Hygromycin B
Tetrachlorodifluoroethane (Freon-112)

Antibiotics & Antiseptics

Aminoglycoside antibiotics (gentamicin, paromomycin)
Cephalosporin antibiotics
Sulphonamide antibiotics
Nitrofurantoin antibiotics
Lincomycin - horses
Griseofulvin
Melaleuca oil
Methyl 3-(2-quinoxalinylmethylene)carbazate-N¹ (Carbadox®, Mecadox®, Fortigro®) & Olaquinox®

Antineoplastic Drugs

Cisplatin (cats)
5-Fluorouracil

Nutritional Supplements

Calcium formulations (bovine hypocalcaemia preventative/therapy)
Copper
Iodine
Iron
Selenium
Vitamin A

Miscellaneous

Anticonvulsant drugs
Methylene blue – cats, dogs
Vitamin K₃ (menadione sodium bisulphite) – horses
 β_2 agonists
Oestrogens (human hormone replacement medications) - dogs

12: Drugs of abuse [Industrial-origin toxins]

Cannabis sativa
Amphetamine
Cocaine
Phencyclidine (PCP)
Ethanol