Anthelmintics in Psittacines

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Veterinary Science V Essay, June, 1987

SUMMARY

Helminths are important causes of diseases and death of psittacines. Gastrointestinal infestation is commonly found in aviary birds, with ascarids and tapeworms being the main parasites.

Anthelmintics have a role in both control and prevention programs. The number of anthelmintics which can be safely used in parrots is limited. There is a considerable variation in the drug routes, spectra of activity and safety margins of anthelmintics. Most anthelmintics used in parrots are empirical, so the compounds used in poultry would seem to be suitable to investigate. Administration of anthelmintics in feed or water is logistically suitable for dosing large numbers of birds.

Currently, fenbendazole is the anthelmintic of choice for treating ascaridiasis and capillariasis, with praziquantel being used for cestode infections. Ivermectin may in the future replace fenbendazole.

INTRODUCTION

Anthelmintics are used to control helminth infections in animals and birds. Their use in domesticated animals and poultry is widespread. Anthelmintics use has been widely researched in poultry, but use in other birds, especially parrots (members of the Order Psittaciformes), is mainly empirical (Schultz, 1981a; Steiner and Davis, 1981).

The Order Psittaciformes in Australia alone consists of the Families Cacatuidae (cockatoos), Psittacidae (typical parrots), Loriidae (lorikeets), Opopsittidae (fig parrots), Polytelitidae (long-tailed parrots) and Platycercidae (broad-tailed parrots). In total this comprises approximately sixty bird varieties (Muller, 1978), with continuing debate about species and sub-species (Lendon, 1979). On a world-wide basis, the Order Psittaciformes comprises approximately 316 species of parrots, parakeets, cockatoos, macaws and lories (Curtin, 1977). With such diversity between psittacines, any discussion about therapeutics must remain empirical.

Helminths are considered to be important causes of disease and death of psittacines. Nematodes and cestodes are the main concern, with trematodes not being considered important (Cosgrove, 1981). Nematode and cestode infestations of clinical importance in Australia are located in the gastrointestinal tract (Appendix 1). Gastrointestinal infestation is commonly found in aviary birds (Cosgrove, 1981), with ascarids and tapeworms being the main parasites.

Diagnosis of infection and identification of the helminth involved are required before satisfactory control programs can be carried out. Diagnosis can be made during faecal examination and at post mortem. Post mortem results suggest that ascarids are important causes of morbidity and mortality in psittacines (Webster, 1982). Faecal smears should be examined since some nematode eggs found in birds tend to sink under standard flotation techniques (Sayle, 1986).

THERAPEUTIC CONSIDERATIONS

Psittacines can be managed under diverse conditions ranging from individual pet birds to large aviaries. These management conditions, together with the wide variation in metabolic body size, require evaluation of both drug administration routes and dose rates. Important considerations when deciding upon administration routes include logistics, cost, ease of handling and operator skill. It is important to remember that handling may stress, and even kill, debilitated birds (Steiner and Davis, 1981). A general rule of thumb for calculating dose rates is that as body size decreases, the dose rate should increase to compensate for more rapid metabolism (Soifer, 1973).

The routes by which birds may be medicated include oral (gavage, drops, tablets, drinking water and feed), parenteral (intramuscular, subcutaneous and intravenous), topical and by inhalation (Steiner and Davis).

Because of the difficulty of administration, intravenous injections are rarely used in birds. Topical and inhalation preparations are nor appropriate for intestinal therapy, although there are cutaneous preparations for levamisole in cattle (Marriner, 1986). Subcutaneous injections in birds are not widely used because of poor skin elasticity (Steiner and Davis, 1981), limitation of suitable injection sites and the small volume which can be administered (Soifer, 1973).

Oral medications are used widely. They are appropriate for alimentary tract therapy and do not require the exact dosing of parenteral therapy (Steiner and Davis, l98l). Tablets require an easily handled bird but are more suitable for pigeons than psittacines. Gavage is more suitable than droppers since birds may flick material out of their mouth, although gavage has the potential risk of crop or oesophageal penetration (Steiner and Davis, l98l). The use of the remaining possible methods will depend on the drug being used and the particular situation. Parenteral therapy is considered very suitable since it ensures all birds are treated. Injection into the pectoral muscles is the most widely used parenteral technique (Steiner and Davis, l98l). Accurate administration of small dose volumes (e.g. ivermectin) can be made by intramuscular injection, but individual treatment of birds is often impractical in large aviaries.

Administration of anthelmintics in feed or water is logistically suitable for dosing large numbers of birds; however, there are significant drawbacks with these techniques. Both feed and water intake can be varied widely by birds, thus requiring close monitoring of intake to avoid incorrect dosing (Steiner and Davis, l98l). It is important to remember psittacines have altricial young which rely on them totally for feed and water, placing the parents under much greater stress than precocial parents. Males have increased feed and water consumption when they are tending their nesting partner, fledglings may consume twice the food of adults and desert dwellers such as budgerigars can abstain from drinking medicated water for prolonged periods. There are also significant problems with feed or water medication in accurately estimating intakes when calculating rates of drug incorporation. There are reports of toxicity in finches with mebendazole when water intake was underestimated (Healy, l984) and toxicity in small birds fed on game bird rations containing mebendazole (Ashton, l979).

Toxicity attributable to chemotherapeutics may occur through overdosing (incorrect dose or correct dose but excess intake due to excessive drinking of medicated water, or gorging of medicated feed), species susceptibility and potentiation by other drugs (Reece, l985). A major problem with water medications is that dosing is specified as a strength of solution, without allowing for total water intake (Selth, l984). To overcome this problem, Soifer (l973) recommends calculation as follows:

$$\text{DAILY DOSE} = \text{CALCULATED DOSE RATE} \times \frac{\text{VOLUME WATER CONTAINER}}{\text{DAILY WATER CONSUMPTION}}$$

Treating mixed aviaries of birds presents significant problems in therapeutics, especially drug choice and dose rates in different bird species. Ideally, only one species of bird should be treated at any time, with test dosing of valuable birds or their close relatives.

Drug metabolism in birds has not been studied as intensively as in mammals. The use of anthelmintics has been studied in detail in poultry, but their use in psittacines has not been subjected to such scrutiny. This is important since drug metabolism can vary between different species and physiological states (Pan and Fouts, l978). Avian anatomy and physiology means that the route of dug administration can be important with respect to drug metabolism through the hepatic portal and renal portal systems (Pan and Fouts, l978). The avian liver is the main site of detoxification, while the kidney maintains a constant internal environment (Schultz, l98la).

When heavy infestation is suspected, it has been recommended that the anthelmintic dose be divided to reduce the risk of verminous impaction. Steiner and Davis (l98l) have recommended the use of an intestinal lubricant in small birds with ascarid infections. Arnall and Keymer (l975) recommend oral liquid paraffin when treating ascarid infections. Antibiotic therapy may also be required when it is suspected that migrating larvae are a problem (Steiner and Davis, l98l; Gill, l986).

ANTHELMINTICS

In the past twenty years there has been a rapid expansion in the compounds available for use as anthelmintics. The ideal anthelmintic should have suitable efficacy, wide therapeutic index (considered safe if index is greater than 1:4), easy administration (including reasonable volumes and routes of administration as well as few special requirements such as fasting or purging) and low residue levels (Prescott, l978; Robertson, l982). Many early anthelmintics were of low therapeutic index (e.g. carbon tetrachloride) and had significant side effects (e.g. discolouration of excreta with phenothiazine metabolites). When treating individual psittacines, drug cost is not usually an important consideration, though this does become important when treating large aviaries. Since psittacines are not intended for human consumption in Australia, tissue residue levels are not important.

In Australia there is a wide range of potential anthelmintics used in psittacines. Since most anthelmintics used in psittacines have an experimental basis, the anthelmintics used in poultry would seem to be suitable compounds to investigate. Widely used poultry anthelmintics include phenothiazine, piperazine, levamisole, hygromycin B and dibutyl tin dilaurate (Arundel, l985).

At present the only two anthelmintics registered for use in caged birds in Australia are levamisole (Levamav Syrup; Mavlab 50 mg/ml Levamisole HCl) and Piperazine Solution; Pharma-Chemical; 450 g/l Piperazine citrate) (IVS, l987). Detailed below are anthelmintics which may be suitable for use in psittacines.

ANTINEMATODE COMPOUNDS

Nematode drugs can act by either facilitating expulsion or killing the parasite. The ideal drug should not only act on adult nematodes, but also on eggs and larvae, especially if larvae are capable of migrating.

Phenothiazine

A narrow-spectrum anthelmintic with unknown mode of action and variable toxicity between and within hosts. It is effective against Heterakis gallinarum, but has poor activity against ascarids (Robertson, l982). Reported dose rates are 0.5 g to 1.0 g for chickens and 1.0 g for turkeys (Robertson, l982; Boersema, l985). Phenothiazine is often used in a mix with piperazine and dibutyl tin dilaurate in poultry (Robertson, l982).

One of the major disadvantages of phenothiazine is pink discolouration of excreta due to metabolites. According to Robertson (l982) these metabolites can permanently discolour any body part they contact. Such a side effect would be highly unsuitable in psittacines since they are often kept for their brilliant colours.

Boersema (l985) has suggested use of phenothiazine as an anthelmintic in domestic birds. However its narrow-spectrum (especially with heterakids not being a problem in psittacines) and toxicity problems restrict its use in psittacines.

Piperazine

This anticholinergic agent causes neuromuscular blockade with resultant flaccid paralysis of nematodes (Robertson, l982). Activity is only against intestinal stages with no effect on tissue stages (Marriner, l986). Piperazine is only effective against ascarids (Arundel, l985).

There are various salts available containing differing amounts of the piperazine base (see Appendix II). Activity is associated with the base (Robertson, l982) and so dose rates should be calculated in terms of the amount of base present. Only the citrate and adipate salts are suitably palatable for use in water (Arundel, l985), and they are the two main salts used in birds.

Poultry doses for adult ascarids are a single oral dose of 250mg/kg. (Boersema, l985) or 32 mg/kg. for two days in feed or water (Robertson, l982).

Because of its large therapeutic index, piperazine is a widely used anthelmintic in many species and is widely recommended for use in psittacines, even though it is apparently only effective against adult ascarids. Doses can be administered orally (Arnall and Keymer, l975; Rosskopf and Woerpel, l98l; Steiner and Davis, l98l; Woerpel and Rosskopf, l98l; Keymer, l982) or via the drinking water (Altman, l977; Greve, l978; Steiner and Davis, l98l). Either way, repeated medication is required.

Oral dose rates range from 300 mg/kg. (Rosskopf and Woerpel, l98l; Woerpel and Rosskopf, l98l) to 500 mg/kg. (Arnall and Keymer, l975; Steiner and Davis, l98l; Burr, l982; Keymer, l982) and even 1.0 g/kg. in divided small doses (Arnall and Keymer, l975). Oral doses are repeated in two weeks (Rosskopf and Woerpel, l98l; Woerpel and Rosskopf, l98l) to three weeks (Arnall and Keymer, l975; Keymer, l982).

Water medication dose rates using piperazine citrate include l.7 to 2.1 g/l (Greve, l978), 2.1 g/l (Steiner and Davis, l98l) and 4g/l (Altman, l977). Medication is recommended for three or four days and repeated in fourteen days (Altman, l977; Steiner and Davis, l98l).

Since piperazine only paralyses ascarids, Keymer (l982) has recommended the use of liquid paraffin or a vermifuge within twelve hours of dosing parakeets.

Metyridine

Has been used to treat capillariasis in poultry (Boersema, l985), budgerigars and other birds (Keymer, l982). Subcutaneous injections at 200 mg/kg. (Altman, l977; Keymer, l982; Boersema, l985) or lg/l drinking water (Altman, l977) have been used. Injections can cause oedema at the injection site and incoordination (Altman, l977). Boersema (l985) has commented on a toxicity problem in poultry.

Metyridine is no longer marketed in Australia (Harrigan, l98l).

Benzimidazoles

A group of more than ten compounds with varying anthelmintic spectrums of activity against all parasitic stages. Most have low water solubility and are only used orally.

Proposed mechanisms of action include interference with fumarate-reductase (a parasite-specific enzyme) [e.g., most benzimidazoles], inhibition of glucose transport [e.g., mebendazole] or activity against both fumarate-reductase and glucose transport [e.g., cambendazole and fenbendazole] (Robertson, 1982). It has been proposed by Friedman and Platzer (1980) that benzimidazoles may not act on fumarate-reductase, but rather on tubulin protein required for microtubule production in nematode intestinal cells and cestode cuticles. Their mechanism of ovicidal activity is unknown (Arundel, 1985).

Benzimidazoles are effective anthelmintics in poultry having wide safety margins. However this does not apply to parrots, budgerigars and similar birds (Reece, l986). The benzimidazoles reportedly used in birds have been thiabendazole, cambendazole, mebendazole, fenbendazole and parbendazole.

Thiabendazole: A broad-spectrum anthelmintic which has been used in birds against ascarids, gapeworms, proventricular and gizzard worms (Harrigan, l98l). According to Boersema (l985), thiabendazole has poor efficacy against ascarids.

Dose rates include l g/kg. orally or 5 mg/kg. feed for three days in chickens and 50 mg/kg. feed for ten days in pigeons (Boersema, l985). Surprisingly, recommended dose rates in cage birds range from a single oral dose of 20 mg/kg. (Steiner and Davis, l98l) through to 250 to 500 mg/kg. which is repeated in ten to fourteen days (Clubb, l986).

Use of thiabendazole against gapeworms is considered impractical and other broad-spectrum anthelmintics have been suggested. Dosing may be either via feed for days (Burr, l982), or orally for seven to ten days. Dose rates range from 40 mg/kg. (Altman, l977) to l00 mg/kg. (Rosskopf and Woerpel, l98l; Woerpel and Rosskopf, l98l; Clubb, l986). Small parrots and parakeets can be dosed at 60 mg/kg. and large parrots at 40 mg/kg. (Burr, l982).

Proventricular and gizzard worms can be treated using a single dose of 0.55 to 1.1g/kg. (Steiner and Davis, 1981).

Cambendazole: Has been used at 10 to 70 mg/kg. in chickens for adult and larval roundworms and at 60 mg/kg. for Amidostomum sp. (a gizzard worm) in geese (Boersema, 1985). Cambendazole is no longer available in Australia (Arundel, 1985) and there are no reports of its use in psittacines.

Mebendazole: Considered to be safe in many mammalian species, game birds and poultry (Neave, l979). Burr (l982) considers mebendazole to be excellent for nematodes, cestodes and trematodes in parrots. Problems have been reported with mebendazole use in psittacines and many have been attributed to incorrect dosage (Burr, l982). In one incident, mebendazole was toxic in thick billed parrots and a kea due to very poor dispensing information, with a 3 ml dose of 5% suspension being recommended for all birds (Neave, l979). Another incident involved the death of an Alexandrine parakeet when fed a game bird wormer ration resulting in a dose of l2 mg/kg. (Ashton, l979). Overdosing can also cause feather loss in parrots (Burr, l982).

Boersema (l985) recommended its use in chickens and geese at l0 mg/kg. liveweight or 60 mg/kg. feed for three days (chickens) or six days (geese). In pheasants it is used at 60 mg/kg. feed. Mebendazole is not recommended for use in pigeons (Boersema, l985) since they can have secondary problems with trichomoniasis (G.M. Cross, pers. com.). Various dose rates recommended include 3 to l0 mg/kg. (Neave, l979), l0 mg/kg. (orally to l80 budgerigars with no reported losses; Smith, l979), 25 mg/kg. as a single dose (Burr, l982) or twice daily for five days (Clubb, l986). Goltenboth (l982) has even suggested use at 60 to 80 mg/kg. body weight for two to four days.

Harrigan (l98l) has summarized the situation by considering that mebendazole can, on occasion, be toxic to psittacines.

Fenbendazole: This is one of the most widely recommended anthelmintics for nematodes, cestodes and trematodes in birds. It seems to be excellent since its use at 400 times the recommended dose produces no side effects in psittacines (Burr, l982). Gill (l986) has considered fenbendazole to be the anthelmintic of choice in parrots for treating ascaridiasis and capillariasis.

Boersema (l985) used 5 mg/kg. in chickens and geese but did not recommend its use in pigeons as it caused feather problems. Fenbendazole cannot be used in pigeons while nesting or during moulting since it may stunt feathers (Clubb, l986). Feather problems are also suspected to occur in parrots (J.M. Gill, pers. com.).

Individual dosing repeated in two weeks is recommended by Gill (l986), although Butler (l98l) used l g/l in water for psittacines. Treatment regimes vary with the type of infection. Ascaridiasis is treated for one day, with repeat therapy in ten to fourteen days. Dose rates vary widely from 25 mg/kg. (Burr, l982), l0 to 50 mg/kg. (Clubb, l984, l986) and 50 mg/kg. (Steiner and Davis, l98l). For capillariasis, Clubb (l984, l986) recommends l0 to 50 mg/kg. once daily for five days. Schultz (l98lb) used 28 mg/kg. daily (or 56 mg/kg. if less than 400 g liveweight) for three days for both ascarids and capillariasis in parrots.

In the most detailed report about fenbendazole in psittacines, Lawrence (l983) treated ascarid and capillaria infections at l00 mg/kg. by stomach tube in over two hundred birds including 63 psittacines of 22 different species, with further dosing after three weeks at 30 mg/kg. for seven days if required. No side effects or deaths were reported.

Parbendazole: Has been used for treating heterakid infestation in turkeys at 30 mg/kg. orally or 0.5 to 1.0 g/kg. feed or water for one day (Boersema, 1985). There appears to be no reports of its use in psittacines.

Imidazothiazoles

There are two classes of drugs in this group. One group consists of a probenzimidazole called febantel (Marriner, 1986), while the second group consists of the cholinomimetic agents levamisole and tetramisole. Levamisole and tetramisole cause spastic paralysis of nematodes and can also inhibit fumarate-reductase at very high dose rates (Robertson, 1982).

Febantel: Febantel is metabolised to form fenbendazole and its derivatives in vivo (Arundel, 1985). It has been used for treating ascaridiasis in pheasants at 10 mg/kg. and is considered nontoxic at 500 mg/kg. (Boersema, 1985). There are no reports of its use in psittacines. It would seem to be more suitable to directly use fenbendazole.

Tetramisole: Tetramisole is a racemic mix of d- and l-isomers. Only the l-isomer has anthelmintic activity, but both isomers are equally toxic (Robertson, 1982; Marriner, 1986). Levamisole, being only the purified l-isomer, is used at half the dose rate of tetramisole with a corresponding increase in safety (Marriner, 1986).

Pigeons have been orally dosed with tetramisole at 40 mg/kg., but it has poor efficacy against ascarids and capillarids (Boersema, 1985). Tetramisole is no longer marketed in Australia.

Levamisole: This compound, like piperazine, has different amounts of base in various salts resulting in confusion over dose rates (Arundel, 1985). The two main salts and their proportions of active base are the hydrochloride (84.8% w/w) and phosphate (67.7% w/w) salts (Arundel, 1985). Levamisole acts on both adult and immature nematodes, but it is not as well tolerated in captive birds as in chickens (Robertson, 1982). Toxicity occurs at 40 mg/kg. orally and is lethal at this dose parenterally in pigeons (Boersema, 1985). Side effects include salivation, hyperactivity, vomiting and convulsions (Burr, 1982). Arnall and Keymer (1975) recommend its use in larger and smaller psittacines, with test dosing of valuable birds or flocks, while Clubb (1984) did not recommend its use in debilitated birds.

Levamisole may be administered orally, parenterally or in the drinking water. Oral dose rates vary from 0.25 to 0.5 mg/kg. (Arnall and Keymer, 1975) to 8 mg/kg. (Clubb, 1984), 10 to 20 mg/kg. (Steiner and Davis, 1981), 15 mg/kg. (Clubb, 1984), with the highest dosing being 40 mg/kg. for capillariasis (Altman, 1977; Rosskopf and Woerpel, 1981; Steiner and Davis, 1981; Woerpel and Rosskopf, 1981). Dosing is repeated in two weeks (Rosskopf and Woerpel, 1981; Woerpel and Rosskopf, 1981).

Parenteral dosing is achieved by the intramuscular or subcutaneous routes, with the intramuscular route being favoured. The most widely used dose rate is 20 mg/kg. (Butler, 1981; Steiner and Davis, 1981; Burr, 1982), although Clubb (1984) recommended only 8 mg/kg. while Altman (12977) used 40 mg/kg.. Robinson and Richter (1977) used 22 mg/kg. of Levamisole phosphate in psittacines and reported toxicity at 66 mg/kg. in a peachface. Levamisole hydrochloride injection was not recommended for birds by Arnall and Keymer (1975).

Water dosing can be performed at 20 mg/kg. (Burr, 1982), 30 mg/kg. (Goltenboth, 1982), 16 mg/kg. (Butler, 1981) or 14 to 27 mg/kg. (Clubb, 1984).

Levamisole also has a role as an immunostimulant. Symoens and Rosenthal (1977) have reviewed this in a wide range of species. Levamisole restores the function of phagocytes and T-lymphocytes in immunodeficient hosts, but does not increase immune responses in immunocompetent hosts. In turkeys, levamisole was investigated as an immunostimulant to promote vaccination responses (Panigrahy et. al., 1978). Clubb (1984) recommended use in immune-suppressed birds at 2 mg/kg. (by intramuscular, subcutaneous routes in three doses at four day intervals) or in water (0.8 mg/l for several weeks).

Tetrahydropyrimidines

These compounds act as depolarizing neuromuscular agents causing spastic contractions (Robertson, 1982). They have received little attention in caged birds. The two main compounds are pyrantel and morantel and they are available in various salts (Robertson, 1982). Morantel is the methyl analogue of pyrantel (Marriner, 1986) and has both greater anthelmintic activity and safety (Robertson, 1982).

Pyrantel: Boersema (1985) used pyrantel tartrate in chickens at 15 to 125 mg/kg. for treating roundworm infestations including adult and immature ascarids, and suggested it was nontoxic at 500 mg/kg.. In geese, pyrantel was used at 50 mg/kg. for control of Amidostomum sp. infestation and was nontoxic at 250 mg/kg.. Pyrantel pamoate can be used in caged birds at 4.5 mg/kg. orally and be repeated in ten to 14 days. This salt is palatable and nontoxic (Clubb, 1986).

Morantel: There are both citrate and tartrate salts (Arundel, 1985). Beacuse of its greater safety and activity, it would seem to be the tetrahydropyrimidine of choice. Morantel use has not been reported in psittacines.

Organophosphates

This group of broad-spectrum anthelmintics were considered by Marriner (1986) to be largely inferior to other broad-spectrum anthelmintics. Organophosphates act by inhibiting acetylcholine esterase which results in spastic paralysis. Major restrictions to their use occur because of incompatibility with other drugs and narrow safety margins (Robertson, 1982). There is very limited reported use of these compounds in birds, and none have specifically concerned psittacines.

Dichlorvos: The formulation of this drug makes it unsuitable for use in birds since resin pellets accumulate in the gizzard, causing toxicity (Robertson, 1982). It is important that birds do not have access to faeces from treated animals (Arundel, 1985).

Haloxon: Haloxon would seem to be an idiosyncratic drug for use in birds. It is very toxic to geese and yet safe to use in chickens (Robertson, 1982). Capillariasis is treated at 20 mg/kg. body weight in feed for two days (Goltenboth, 1982), 50 mg/kg. in chickens and pigeons (Boersema, 1985) and 50 to 100 mg/kg. in feed (Robertson, 1982). Haloxon is contraindicated for use in psittacines due to potential toxicity and at present is not available in Australia.

Coumaphos: This compound has been used as an in-feed preparation administered for ten days. Birds in general and chickens are dosed at 40 mg/kg. feed (Goltenboth, 1982; Boersema, 1985). Coumaphos is at present available only as insecticide washes (IVS, 1987).

Trichlorphon: Geese are dosed at 75 mg/kg. for treating infestation by adult Amidostomum sp. (Boersema, 1985). There appears to be no reports of its use in psittacines.

Naphthalophos: Capillariasis, ascaridiasis and heterarkidiasis in chickens can be treated using this drug at 25 mg/kg.. It has a therapeutic index of only 1:2 in chickens (Robertson, 1982) and so its use is contraindicated in chickens.

Miscellaneous

There are three drugs in this group which may potentially be useful as anthelmintics in psittacines. They are disophenol, hygromycin B and ivermectin.

Disophenol: This drug has mainly found a role in geese at 10 mg/kg. by subcutaneous injection to control adult Amidostomum anseris infestation (Boersema, 1985). Gapeworms in turkeys can be treated at 7.7 mg/kg./day in feed for 5 days or as a 7.7 mg/kg. bolus (Robertson, 1982).

Hygromycin B: Domestic poultry are the only birds in which this compound has been extensively used (Harrigan, 1981). Dosing is at 8 g per 900 kg. feed for poultry (Robertson, 1982). Hygromycin B is usually given as continuous feed medication for treating ascaridiasis and heterarkidiasis, especially after initial levamisole treatment (Bains, 1979). Presumably this compound could have use in aviaries where prolonged therapy is necessary to reduce an ascarid problem.

Avermectin, Ivermectin: The activity of avermectin and ivermectin is attributed to an increased release of gamma aminobutyric acid from neuronal synapses resulting in flaccid paralysis of parasites (Arundel, 1985). Ivermectin is considered to be a "wonder drug" in avian medicine with apparent efficacy against all skin parasites and many types of nematodes, It appears to be safe. (Rosskopf, 1986). Dose rates of both drugs are very low at 200 ug/kg. orally or by intramuscular injection and are repeated in ten to 14 days (Clubb, 1984, 1986). Large animal preparations of ivermectin can be diluted with propylene glycol at 1:4 (Clubb, 1986) or 1:9 (Clubb, 1984). Further evaluation of avermectin and ivermectin and their use in psittacines is required, though they would appear to be potentially very suitable anthelmintics.

ANTICESTODAL DRUGS

Tapeworm drugs can have two different actions. They can cause death in situ (taeniacides) or facilitate expulsion (taeniafuges). A taeniacidal drug is preferable, together with control of intermediate hosts for the cestode. Anticestodal drugs are usually grouped as being either inorganic or organic.

Inorganic compounds

These are the older style of tapeworm preparations. The only compound used today in poultry is the organo-tin compound dibutyl tin dilaurate. Therapy is required for several days (Bains, 1979). Organo-tin compounds are relatively non-specific toxins and probably uncouple oxidative phosphorylation (Pritchard, 1978) or tin deposited on the tapeworm cuticle makes the tapeworm prone to digestion (Robertson, 1982).

Dibutyl tin dilaurate is used mainly in poultry as "Kill-Worm" (Cliftons) containing 400 g phenothiazine, 360 g piperazine citrate and 110 g dibutyl tin dilaurate/kg. (Harrigan, 1981), This mixture may be suitable for use in aviaries where both nematodes and cestode are a problem.

Synthetic Organic Compounds

This is a diverse group of compounds including dichlorophen, niclosamide, hexachlorophene, bithionol, praziquantel and benzimidazoles.

Dichlorophen: Arnall and Keymer (1975) have suggested using 3 mg per 10 kg. orally after feeding, even though little is known about the use of this taeniacidal drug in birds.

Niclosamide: This taeniacidal compound acts by inhibition of glucose absorption and uncoupling oxidative phosphorylation resulting in increased lactic acid production. Niclosamide is poorly absorbed from the gastrointestinal tract and therefore is of lower toxicity (Rosskopf and Woerpel, 1981; Woerpel and Rosskopf, 1981; Robertson, 1982). Arundel (1985) recommended its use against tapeworms in all animal species.

Older style treatment in parrots was at twice the mammalian dose (Burr, 1982). Poultry doses range from 50 to 80 mg/kg. (Arundel, 1985) to 100 mg/kg. (Robertson, 1982). Steiner and Davis (1981) considered single doses at 25 mg/kg. to be unrewarding. Recommended dose rates in cage birds vary from 220 mg/kg. repeated in 10 days (Clubb, 1984, 1986) to 250 mg/kg. repeated in 2 weeks (Rosskopf and Woerpel, 1981; Woerpel and Rosskopf, 1981).

Hexachlorophene: This is an anticestodal drug which has limited potential. It decreases egg production in poultry and requires overnight fasting before dosing at 30 to 60 mg/kg. (Robertson, 1982). This compound has a low therapeutic index (Arundel, 1985) and so probably has no use in psittacines.

Bithionol: Bithionol is cholinomimetic and causes diarrhoea in treated hosts. High dose rates are required in birds, including 600 mg/kg. in geese and 200 mg/kg. in chickens (Robertson, 1982). There appears to be no reports of bithionol use in psittacines and it is not available in Australia.

Praziquantel: Considered to be the most effective anticestode drug available, praziquantel acts against both immature and adult tapeworms (Robertson, 1982; Marriner, 1986). It is not very soluble in water hence warter medication can be inaccurate.

Praziquantel is available in both tablet and injectable forms. The injectable form is not recommended by Clubb (1986) for birds. Feed or gavage dosing is at 6 mg/kg. repeated in 10-14 days (Clubb, 1986).

Praziquantel is the anticestode drug of choice in psittacines. Dosing is usually by the drinking water, with the injectable form being used in preference to tablets (J. Gill, personal communication).

Benzimidazoles: A bonus to using benzimidazoles such as mebendazole and fenbendazole is their broad-spectrum activity against both nematodes and cestodes. Burr (1982) recommends dosing at 25 mg/kg. to control cestodes, which is also the recommended dose for control of nematodiasis.

DISCUSSION

In Australia there is currently an upsurge in the numbers and types of native and introduced psittacines being kept in captivity. As a result of this, there are an increasing number of birds requiring treatment for helminth infestation. Most helminth problems are reported in aviaries, where the use of anthelmintics constitutes only part of a total parasite control program. Management must be tightened when drug use is indicated (Finnie, 1981) and must both control and prevent helminth infestation.

Prevention programs must restrict potential sources of infection including new birds and wild birds. Mines and Green (1983) have reported experimental infestation of budgerigars by Ascaridia columbae from pigeons, suggesting the possibility that wild birds may be potential sources of parasite infection in aviaries. All newly-acquired birds should undergo quarantine procedures, especially psittacines, since chlamydiosis is also an important problem. Annual use of anthelmintics on a prophylactic basis has been recommended by Burr (1982). Routine faecal examination and post mortem examination of all dead birds can be used in large scale situations such as zoos (Cosgrove, 1981) to avoid potential problems.

Control of helminth infestation requires control of the parasites' life cycles. Recurrent infestation problems, especially due to parasites with direct life-cycles such as ascarids, can be reduced by modern aviary construction with birds housed in suspended cages, or on impervious, easily-cleaned concrete floors. Control of cestodes with their indirect life-cycles is best achieved by controlling intermediate hosts. Often the intermediate host is not known or the cestode cannot be fully identified, thus broad-spectrum general sanitation and pest control is required (Greve, 1986).

In both control and prevention programs, anthelmintics have a role. The number of anthelmintics which can be safely used in psittacines is very limited. Many of the drugs have been available only in the last 20 years, and the use of only a few of these has been studied in psittacines.

There is considerable variation in the drug routes, spectra of activity and safety margins of anthelmintics (see Appendices III and IV). Anthelmintics can be grouped into categories including inadequate spectrum of activity, too toxic to use, unavailable in Australia, suitable for use in psittacines and potentially suitable compounds.

Phenothiazine is unsuitable for use since it is variably toxic and has no activity against common psittacine helminths. Organophosphates, including haloxon, coumaphos, trichlorphon and naphthalophos, have low therapeutic indices and are potentially too toxic to use in psittacines. Dichlorvos, another organophosphate, is toxic to birds due to its resin-based formulation. Some of the compounds investigated, including metyridine, tetramisole, haloxon, cambendazole and bithionol, are unavailable in Australia. Coumaphos is at present only available in Australia as an insecticidal wash and not as an anthelmintic preparation.

Compounds currently being used include piperazine, thiabendazole, fenbendazole and levamisole for treating nematode infestation and niclosamide and praziquantel for treating cestode infestation. Piperazine is only active against adult stages, which it paralyses. One advantage of piperazine is its wide therapeutic index. Thiabendazole is mainly restricted in its use to uncommon nematode parasites such as proventricular and gizzard worms. Levamisole is considered to be useful, especially since parenteral therapy can be useful. Its use is restricted by potential toxicity problems, especially in debilitated birds. Fenbendazole, especially with its activity against all nematode stages and against cestodes, is very suitable. It is considered safe to use, although fenbendazole should not be used in moulting birds due to potential feather problems. Fenbendazole can be used by oral dosing or water medication to treat individual birds or large aviaries. This flexibility is one of its major attractions. Niclosamide was once favoured for treating cestodiasis, but praziquantel has replaced it, largely because of its greater efficacy and the availability of a liquid formulation for water medication.

Potentially suitable anthelmintics include those which are being currently considered for use and compounds which may be suitable for use. Ivermectin is the drug of the future. Morantel and disophenol have potential, and the latter may be particularly useful for treating syngamiasis.

Certainly the greatest potential area for expanded anthelmintic use is continuous in-feed and in-water medication in large aviaries. Two compounds which should be considered are hygromycin B (for treating nematode infestation) and dibutyl tin dilaurate (for treating cestode infestation).

Anthelmintic use in psittacines must be closely considered in order to match particular drugs to each situation. Only piperazine and levamisole are currently registered for use in caged birds in Australia, and so the use of unregistered drugs is common. Possible many anthelmintics will remain unregistered because of the expense of registration.

<u>TABLE 1</u>

Helminth Infections in Parrots (from Harrigan, 1981)

Helminth	Location and Comments
NEMATODES	
<u>Ascaridia spp</u>. (ascarids)	Small intestine, especially in ground-feeding parrots
<u>Capillaria spp</u>. (threadworms)	Mainly in small intestine. Upper gastrointestinal forms not a problem in parrots
<u>Spiroptera incerta</u> (gizzard worm)	Proventriculus, especially in Australian parrots.
<u>Syngamus trachea</u> (gapeworm)	Trachea and bronchi in many birds including parrots
Filarial worms	Microfilaria in blood or tissues, including air sacs.
CESTODES	Small intestine
TREMATODES	Rare in psittacines

<u>TABLE 2</u>

Active Base in Different Piperazine Salts (Robertson, 1982)

SALT	PIPERAZINE BASE (%)
adipate	37
chloride	48
citrate	35
dichloride	50-53
hexahydrate	44
phosphate	42
sulphate	46

APPENDIX 3 ANTHELMINTICS IN RELATION TO USE IN PSITTACINES

ANTHELMINTIC	ROUTE	DOSE RATE	FREQUENCY AND DURATION	COMMENTS
Bithionol				Not available in Australia
Cambendazole				No longer available in Australia
Coumaphos	Feed	40 mg/kg		Not available in Australia as an anthelmintic
Dibutyl tin dilaurate				Requires evaluation as in-feed preparation
Dichlorophen				No reports of use in psittacines
Dichlorvos				Contraindicated in avians
Disophenol				No reports of use in psittacines
Febantel				No reports of use in psittacines
Fenbendazole	Oral	10-50 mg/kg	Once and repeat in 14 days Once daily for 5 days	Do not use when birds are moulting
	Oral	100 mg/kg	Once and repeat in 3 weeks	
	Water	1 g/l		
Haloxon				Potentially toxic - do not use
Hexachlorophene				Potentially toxic - do not use
Hygromycin B				Potentially useful for prolonged in-feed medication

ANTHELMINTIC	ROUTE	DOSE RATE	FREQUENCY AND DURATION	COMMENTS
Ivermectin	Oral	200 ug/kg	Once and repeat in 14 days	Dilute large animal prepparations 1:4 or 1:9 with propylene glycol
	IM	200 ug/kg	Once and repeat in 14 days	
Levamisole	Oral	0.25-40 mg/kg	Once and repeat in 2 weeks	Do not use in debilitated birds. Do not inject HCl form
	IM/SC	8-40 mg/kg		
	Water	14-27 mg/l		
	IM/SC	2 mg/kg	3 doses at 4 day intervals	For immuno-suppressed birds
	Water	0.8 mg/l	Several weeks	
Mebendazole	Oral	10-25 mg/kg	Once or daily for 5 days	
Metyridine	SC	200 mg/kg		No longer available in Australia
	Water	1 g/l		
Morantel				No reports of use in psittacines. Potentiallyuseful
Naphthalophos				Potentially toxic - do not use
Niclosamide	Oral	220-250 mg/kg	Once. Repeat in 10-14 days	
Parbendazole				No reports of use in psittacines
Phenothiazine	Oral			Variable toxicity

ANTHELMINTIC	ROUTE	DOSE RATE	FREQUENCY AND DURATION	COMMENTS
Piperazine	Oral Water	300-500 mg/kg 1.7-4 g/l	Once - repeat in 2-3 weeks 3-4 days, repeat in 2 weeks	Very safe to use. Only paralyses
Praziquantel	Oral Feed	6 mg/kg 6 mg/kg	Once - rep\eat in 10-14 days	Use injectable form in water
Pyrantel				No reports of use in psittacines
Tetramisole				No longer available in Australia
Thiabendazole	Oral Oral	20-60 mg/kg 250-1100 mg/kg	7-10 days Single dose	
Trichlorphon				No reports of use in psittacines

Compound	***Ascaridia***	***Capillaria***	***Spiroptera incerta***	***Syngamus trachea***	**Cestodes**
Bithionol	x	x	x	x	-
Cambendazole	x	x	x	x	x
Coumaphos	x	x	x	x	-
Dibutyl tin dilaurate	-	-	-	-	x
Dichlorophen	x	x	x	x	-
Dichlorvos	?	?	?	?	?
Disophenol	x	x	x	x	-
Fenbendazole	++	++	x	x	+
Haloxon	?	?	?	?	?
Hexachlorophene	?	?	?	?	?
Hygromycin B	x	x	x	x	-
Ivermectin	+	+	x	x	-
Levamisole	+	+	x	x	-
Mebendazole	+	+	x	x	+
Metyridine	-	+	x	x	-
Morantel	x	x	x	x	-
Napohthalophos	?	?	?	?	?
Nilosamide	-	-	-	-	+
Parbendazole	x	x	x	x	x
Phenothiazine	?	?	?	?	?
Piperazine	++	-	-	-	-
Praziquantel	-	-	-	-	++
Pyrantel	x	x	x	x	-
Tetramisole	x	x	x	x	-
Thiabendazole	-	-	++	-	x
Trichlorophen	x	x	x	x	-

++ considered treatment of choice
+ suitable to use for treatment
- unsuitable to use
? Use in psittacines contraindicated. Phenothiazine has no activity against the common psittacine helminths.
x No information was obtainable about use of this drug in psittacines

REFERENCES

Altman, R.B. (1977). Parasitic diseases of caged birds. In "Current Veterinary Therapy VI - Small Animal Practice". Pp. 682-687. Ed by R.W. Kirk. Saunders, Philadelphia.

Arnall, L. and Keymer, I.F. (1975). Infections by the Larger Parasites - Helminths. In "Bird Diseases", Ch. 10, pp 173-220. Balliere Tindall, London.

Arundel, J.H. (1985). "Veterinary Anthelmintics". Review No. 26. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

Ashton, D.G. (1979). Mebendazole toxicity in birds. Vet. Rec. 105:109

Bains, B.S. (1979). A Manual of Poultry Diseases. Hoffmann-La Roche, Basle, Switzerland.

Boersema, J.H. (1985). Chemotherapy of gastrointestinal nematodiasis in birds. In "Chemotherapy of Gastrointestinal Helminths". Handbook of Experimental Pharmacology, Ch. 10, Pp. 505-519. Eds H. Vanden Bossche, D. Thienpont and P.G. Janssens. Springer-Verlag, Berlin.

Burr, E.W. (1982). The control and treatment of internal parasites. In "Diseases of Parrots", Ch. 10, Pp. 143-164. T.F.H. Publications, Neptune, New Jersey.

Butler, R. (1981). Personal communication to K.E. Harrigan (1981) - Parasitic Diseases of Birds, in "Aviary and Caged Birds". Proceedings No. 55, Pp. 337-396. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Clubb, S.L. (1984). Therapeutics in avian medicine: Flock vs. individual; bird treatment regimens. In "Symposium on Caged Bird Medicine, Vet. Clin N. Amer., 14: 345-361.

Clubb, S.L. (1986). Therapeutics. Individual and flock treatment regimens. In "Clinical Avian Medicine", Ch. 26: 327-355. Eds. Harrison, C.J. and Harrison, L.R.. Saunders, Philadelphia.

Cosgrove, G.E. (1981) Parasites and related problems in pet and exotic birds. In "Veterinary Medicine Seminar". American Federation of Aviculturists, San Diego.

Curtin, C.B. (1977). Parrot. In "Encyclopaedia of Science and Technology", Vol. 9: 641-642. McGraw-Hill, New York.

Finnie, E.P. (1981). Preventative medicine in birds. In "Aviary and Caged Birds". Proceedings No. 55, Pp. 309-312. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Friedman, P.A. and Platzer, E.G. (1980). In "The Host Invader Interplay": 595. Ed. by H. vanden Bossche. Elsevier, North Holland. Cited by J.H. Arundel (1985). "Veterinary Anthelmintics". Review No. 26. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

Gill, J.M. (1986). Diseases of the digestive tract. Control and Therapy No. 2202. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

Goltenboth, R. (1982). Birds. In "Handbook of Zoo Medicine". Pp. 328-335. Eds. H.-G. Klos and E.M. Lang. Van Nostande Reinhold, New York.

Greve, J.H. (1978). Parasitic Diseases - Psittacines and Passerines. In "Zoo and Wild Animal Medicine", p. 374. Ed. M.E. Fowler, Saunders, Philadelphia.

Greve, J.H. (1986). Parasitic Diseases. In "Zoo and Wild Animal Medicine", 2nd. Ed, Ch. 19, Pp. 234-251. Ed. M.E. Fowler, Saunders, Philadelphia.

Harrigan, K.E. (1981). Parasitic Diseases of Birds. In "Aviary and Caged Birds". Proceedings No. 55, Pp. 337-396. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Healy, B. (1984) Mebendazole - apparent toxicity in finches. Control and Therapy No. 1828. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

IVS (1987). Internal paraciticides in birds. February, 1987 - "Index of Veterinary Specialties", Pp. 91-92. IMS, Crows Nest.

Keymer, I.F. (1982). Clinical considerations - parasitic diseases. In "Diseases of Cage and Aviary Birds", 2nd. Ed., Ch. 25, Pp. 535-598. Ed. by M.L. Petrak, Lea and Febiger, Philadelphia.

Lawrence, K. (1983). Efficacy of fenbendazole against nematodes of captive birds. Vet. Rec. 112: 433-434.

Lendon, A.H. (1979). "Australian Parrots in Field and Aviary". Revised Edition, Pp. xxxiii-xxxv. Angus and Robertson, London.

Marriner, S. (1986). Anthelmintic Drugs. Vet. Rec. 118: 181-184.

Mines, J.J. and Green, P.E. (1983). Experimental Ascaridia columbae infections in budgerigars. Aust. vet. J. 60: 279-280.

Muller, K.A. (1978). Taxonomy and ecology of birds in Australia. In "Fauna". Proceedings No. 36, Part B, Pp. 597-602. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

Neave, R.M.S. (1979). Mebendazole danger to birds. Vet. Rec. 104: 490.

Pan, H.P. and Fouts, J.R. (1978). Drug metabolism in birds. Drug Metabolism Reviews, 7: 1-253.

Panigrahy, B., Grumbles, L.C., Millar, D., Nagi, S.A. and Hall, C.F. (1978). Antibiotic-induced immunosuppression and levamisole-induced immunopotentiation in turkeys. Avian Dis., 23: 401-408.

Prescott, C.W. (1978). Anthelmintics. In "The Therapeutic Jungle". Proceedings No. 39, Vol. 2, Pp. 666-682.

Post-Graduate Committee in Veterinary Science, The University of Sydney.

Prichard, R.K. (1978). Anthelmintics. In "The Therapeutic Jungle". Proceedings No. 39, Vol. 1, Pp. 421-463. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Reece, R.L. (1985). Dimetridazole toxicity in birds. Control and Therapy No. 1975. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

Reece, R.L. (1986). Toxicities. In "Poultry Health". Proceedings No. 92, Pp. 280-281. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Robertson, E.L. (1982). Chemotherapy of Parasitic Diseases. In "Veterinary Pharmacology and Therapeutics". 5th. Edition, Pp. 797-873. Eds. N.H. Booth and L.E. McDonald. Iowa State University Press, Ames, Iowa.

Robinson, P.T. and Richter, A.G. (1977). A preliminary report on the toxicity and efficacy of levamisole phosphate in zoo birds. J. Zoo Anim. Med., 8: 23.

Rosskopf, W.J. (1986). Comments from "Sizing up Avian Medicine: the Clinical Side of Practice". Vet. Med., 82: 818-822.

Rosskopf, W.J. and Woerpel, R.W. (1981). Caged Bird Medicine - Therapeutic Drugs and Dosages. In "Veterinary Medicine Seminar". American Federation of Aviculture, San Diego.

Sayle, R.K. (1986). Evaluation of droppings. In "Clinical Avian Medicine". Eds. Harrison, C.J. and Harrison, L.R.. Saunders, Philadelphia.

Schultz, D.J. (1981a). Avian Physiology and its effect on therapy. In "Aviary and Caged Birds". Proceedings No. 55, Pp. 471-478. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Schultz, D.J. (1981b). Personal Communication to K.E. Harrigan (1981). Parasitic Diseases of Birds, in "Aviary and Caged Birds". Proceedings No. 55, Pp. 337-396. Post-Graduate Committee in Veterinary Science, The University of Sydney.

Selth, D.V. (1984). Emtryl - dosage and dangers - pigeons. Control and Therapy No. 1873. The Post-Graduate Committee in Veterinary Science, The University of Sydney.

Smith, G.A. (1979). Mebendazole danger to birds. Vet. Rec., 104: 559.

Soifer, F.K. (1973). Physical examination and medication of cage birds. In "Caged Birds". Vet. Clin. Nth. Amer., 3: 143-158.

Steiner, C.V. and Davis, R.B. (1981). "Caged Bird Medicine - Selected Topics". Ch. 5 - Chemotherapy for Caged Birds - Pp. 49-57. Iowa State University Press, Ames, Iowa.

Symoens, J. and Rosenthal, M. (1977). Levamisole in the modulation of the immune response: the current experimental and clinical state. Reticuloendothelial Society J., 21: 175-221.

Webster, W.A. (1982). Internal parasites found in exotic birds imported into Canada. Can. Vet. J., 23: 230.

Woerpel, R.W. and Rosskopf, W.J. (1981). Avian therapeutics. Mod. Vet. Pract., 62: 947-949.