Endo and ectoparasites in conventionally maintained rodents laboratory animals

Endo e Ectoparasitoses em animais de laboratório roedores convencionais

Vítor Brasil Medeiros*

Review performed at Vivarium and Animal Care Specialization Course, Department of Surgery, Federal University of Rio Grande do Norte (UFRN), Brazil.
*Veterinarian from Vivarium and Animal Care Specialization Course, UFRN, Brazil.
Financial support: none.
Conflict of interest: None.
Correspondence address: Department of Surgery, Federal University of Rio Grande do Norte, at Ave. Nilo Peçanha 620, Natal, RN, Brazil, Email: vitor_brasilm@hotmail.com
Submitted: 10 December 2012. Accepted, after review: 12 December 2012.

ABSTRACT

Purpose: One of the most common problems regarding the health conditions of laboratory animals has been the endo and ectoparasites. The aim of this review is to discuss the most important aspects of these disorders in research rodents. **Methods**: The author performed a review in Pubmed, SieLo and Web of Science using the key words: parasites, rodents, laboratory animals, endoparasites and ectoparasites. The most relevant and recent articles were reviewed and used to elaborate this paper. Isues about clinical simptoms, diagnosis, prophylaxis and treatment of the most frequent protozoa, helminths and ectoparasites in laboratory rodents were analysed. **Conclusion:** This review demonstrates that endo and ectoparasites are common in laboratory rodents, and that veterinary control is essential to get quality control, welfare and health of research animals.

Key words: Parasites. Rodents. Laboratory animals. Endoparasites. Ectoparasites.

RESUMO

Objetivo: Um dos problemas mais comuns que afetam as condições de saúde dos animais de laboratório tem sido as endo e ectoparasitoses. O objetivo desta revisão é discutir os aspectos mais importantes desses distúrbios em roedores de laboratórios convencionais de pesquisa. **Métodos:** O autor realizou revisão bibliográfica no Pubmed, Scielo e *Web of Science*, usando as palavras-chave: parasitas, roedores, animais de laboratório, endoparasitas e ectoparasitas. Os artigos mais relevantes e recentes foram analisados, lidos e utilizados para a elaboração deste trabalho. Temas a respeito de simptoms clínicos, profilaxia, diagnóstico e tratamento das doenças mais frequentes provocadas por protozoários, helmintos e ectoparasitas em roedores de laboratório foram descritos. **Conclusão:** Esta revisão demonstra que endo e ectoparasitoses são comuns em roedores de laboratório, podem comprometer a qualidade das pesquisas experimentais e que o controle veterinário é essencial para obter a qualidade, o bem-estar e a saúde dos animais de pesquisa laboratorial.

Descritores: Parasitas. Roedores. Animais de laboratório. Endoparasitas. Ectoparasitas.

INTRODUCTION

The main goal of biomedical research is to understand living systems, with a particular focus on human biology and human diseases. Researches can learn much about the principles of human biology and behavior from animal models and use discoveries in human biology to help understand other animals, if these animals are in good health. Animals are studied instead of humans in many situations where manipulating humans is not possible or acceptable. The use and sacrifice of these animals for research might be considered acceptable ethical conditions if there is appropriate consideration for their health and welfare in life. A key welfare consideration for animals in research is to minimize pain and distress and improve overall well-being.

The ethical challenge to conducting animal research is balancing the gains in scientific knowledge with the costs to animals, especially in terms of health, pain and distress. While there is no satisfactory calculus for doing this, scientists have tried to reach an acceptable balance by using approaches such as the 3Rs (replacement, refinement, and reduction). One of the most common problems regarding the health conditions of laboratory animals has been the endo and ectoparasites. This paper will discuss the most important aspects of these disorders in rodents.

THE VIVARIUM

In all Vivarium and experimental research laboratories using animals, staff need competency on manipulating and taking care of animals, including

Investigators, veterinarians, animal care staff, and other personnel. They shall be appropriately qualified and experienced for conducting procedures on living animals. Adequate arrangements shall be made for their in-service training, including the proper and humane care and use of laboratory animals. This means a need for common training standards, knowledge of animal diseases, their diagnosis and management. Individuals may acquire competence through their work, so in addition to training and supervision, a mechanism to maintain competency must be included. So, Individuals working with animals have an obligation to demonstrate respect for animals, to be responsible and accountable for their decisions and actions pertaining to animal welfare, care, and use, and to ensure that the highest standards of scientific integrity prevail.

THE PARASITES IN LABORATORY SMALL ANIMALS

Laboratory animals are seldom investigated for autochthonous endo and ectoparasites prior to their utilization in experiments unless the research service have a well-trained veterinarian. In conventional, semi-open facilities, rodent colonies are frequently infected with helminths. These parasites, if undetected, can interfere in the development of protocols and alter the interpretation of final results[1,2]. In the present work we analysed different clinical, biological diagnostic parameters and treatment related to the presence of endo and ectoparasites in small research rodent animals conventionally kept in animal houses in which sanitary conditions and barriers have not been properly controlled.

Laboratory animals can become heavily parasitized both externally and internally, with consequent loss of time, money and research effort. Such a situation can usually be avoided in the well-supervised and well-managed colony. Like all animals kept in captivity, the laboratory animal becomes a prime target for parasite infection and infestation if appropriate preventive measures are not practiced. The laboratory rodents may be infected by several external parasites and parasites of the gastrointestinal system, urinary tract and the blood.

ENDOPARASITES

As for rats, the most commonly used laboratory animals, it is reasonable to assume that many are hosts of protozoan forms; however, the difficulty arises in knowing under what circumstances these forms acquire the role of a pathogen instead of a commensal, the role which they often appear to play. Much of the information on the pathogenicity of these forms is questionable, and one wonders whether these harmless-looking protozoa, present in large numbers, are there as the cause of the disease or whether they have multiplied in response to the effect of the disease which may have created a flora suited to their multiplication.

Giardiasis

A form of *Giardia muris* has been observed in the golden hamster, mice and rats. In rats and mice, *Giardia* sp. is frequently encountered but appears to be present as a commensal. It is a pathogenic flagellate occurring in the distal region of the small intestine. The parasite binds to epithelial cells of the intestinal mucosa through a suctorial disk. Infection is usually subclinical but it can be observed that the animals exhibit weight loss, hair bristling, bloating with meteorism. His trophozoite has life cycle and transmission occurs by direct ingestion of cysts. In rats and mice, *Giardia sp*. but is frequently encountered Appears to be present as a commensal. The way trofozoítica this parasite has two cores and four pairs of flagella. In the chinchilla an extensive outbreak of acute gastro-enteritis has been reported. The usual sign associated with this protozoan is an intermittent diarrhoea. Trophozoites are commonly found in the duodenum and jejunum of the chinchilla and have been considered as causing diarrhoea and even death. Praziquantel has been used successfully in the treatment of giardiasis in rats. Some chinchilla show an intestinal disturbance whereas others appear asymptomatic. Variable digestive disorders indicated by soft discolored droppings, diarrhoea followed by impaction, seem to be the usual signs associated with this protozoan in the chinchilla. *Giardia caviae* and *G. duodenalis* are not pathogenic[3-6].

Other protozoa

Entamoeba muris, Chilomastix bettencourti, Leishmania donovani, and *Plasmodium berghei* have been recognized from the golden hamster. Amoebic dysentery has been reported. *Entamoeba cuniculi* is claimed to be quite common in rabbits though seldom reported. A number of parasitic flagellates have been recorded from numerous laboratory animals. Some trichomonad-like organisms have been reported from the caecum of the rabbit under the designation of *Monocercomonas cuniculi. Hexamastix caviae, H. robustus, Proteromonas brevifilia* and *Caviamonas mobilis* occur in the caecum of the guinea-pig, and *H. muris* in the caecum of the rat, golden hamster and other rodents. *Chilomitus caviae* and C. *conexus* occur in the guinea-pig caecum. *Hexamita* sp. has also been noted in mice. *Retortamonas cuniculi* and *Chilomastix cuniculi* have been observed in the rabbit caecum. *Chilomastix intestinalis* and C. *wenrichi* are found in the caecum of the guinea-pig, and C. *bettencourti* in the caecum of the rat, mouse and golden hamster. Another flagellate, *Selenomonas palpitans* has been reported from the colon and caecum of the guinea-pig, and a species of *Monocercomonoides* has been observed in the caecum of the guinea-pig, rat and golden hamster. A species of *Octomitus,* closely related to *Hexamita* has been reported from the rat, mouse and golden hamster.

Trichomonas muris, T. wenyoni, T. minuta and a form resembling *T. microti* have been recorded from the golden hamster. They are also found in the chinchilla.

Acute trichomoniasis seems to be rare, although there is ample evidence these species can be pathogens. Parasitological tests must be performed to isolate intestinal protozoa using direct smear and cellophane tape tests. Duodenal and cecal contents may be used for the direct smear tests. A wet mount of duodenum and cecal contents are mixed with a drop of distilled water to examine under microscope. To determine which kinds of protozoa differencially infects conventional facilities, the diagnosis of *Chilomastic betencourtti, Entamoeba muris, Giardia muris, Spyronucleus muris, and Tritrichomonas muris* is done by movement patterns and morphology[3-6].

Coccidiosis

Eimeria stiedae, an apicomplexan parasite, is the causative agent of hepatic coccidiosis in rabbits. While infection may be common in some commercial rabbitries, modern laboratory animal husbandry methods and effective chemotherapeutics have considerably reduced the prevalence of infection in laboratory rabbits[7]. The life cycle is direct, with unsporulated oocysts released in the bile and exiting the rabbit with the feces. The two genera most commonly encountered are *Isospora* and *Eimeria.* The laboratory animal most frequently involved with these coccidia is the rabbit, where species of *Eimeria* have been described. Considerable loss in young rabbits may result from these infections. With the exception of *E. stiedae,* members of this genus in the rabbit are intracellular parasites of the intestinal tract.

Eimeria stiedae in the rabbit liver is the ethiology of hepatic coccidiosis, commonly seen in young rabbits from 5 weeks to 3 months of age. In mild infections there may be no signs of disease, but in severe infections the young animals go off feed and lose weight. The characteristic liver lesions are creamy-white, circumscribed areas or elongate tree like cords on the liver surface. These cords are proliferating bile ducts filled with masses of coccidial oocysts and other developing stages. Death frequently occurs 4-6 weeks after infection. In the case of the many intestinal forms, clinical signs range from no significant disturbance to a considerable enteritis with soft droppings or, in some instances, severe diarrhoea. The severity of the disease is dependent upon a number of factors such as the amount of destruction of host cells and tissues, the size of the infecting dose, the extent of re-infection and the immune response of the host. Immunity developed is not usually permanent, and under conditions of stress may be broken down[8]. Diagnosis is by the demonstration of coccidia in the faeces, or by necropsy of a sick animal showing classical hepatic lesions.

Control is based on good management which includes the use of selfcleaning cage floors. Feeders and waterers must be kept scrupulously clean and located so they do not become contaminated by faeces. If given continuously in feed or water, sulpha drugs have been useful in the prevention of hepatic coccidiosis.

Klossiellosis

Members of the genus *Klossiella* are coccidia characterized by an oocyst which produces a number of spherical sporocysts, each of which contain numerous sporozoites. Schizogony occurs and merozoites are produced. *K. muris* and *K. cobayae* species are encountered in laboratory animals, The latter is a parasite of the kidney tubules and endothelial cells of the blood vessels of the guinea-pig. *K. muris* is a common parasite of mice and is not infrequently encountered in sections of the mouse kidney. Schizogony occurs in the endothelial cells of the capillaries of the glomeruli. This infection is clinically occult and apparently well tolerated by the host; the mode of transmission is not known. Members of this genus resemble in many respects those forms known as *Pneumocystis* sp[9,10].

Toxoplasmosis

Toxoplasma species have been isolated from a wide variety of mammals. It is unique in its apparent lack of host specifity. Among the common laboratory animals its host list includes the mouse, rat, rabbit and guinea-pig. Since most infections are asymptomatic, it is probable that its diagnosis is often overlooked. All types of cells are susceptible to *Toxoplasma.* During an acute infection, a parasitaemia may reach relatively high levels in highly susceptible hosts such as the mouse and rabbit. The pathogenesis of the disease is involved and appears to be associated with one or more mechanisms of cell destruction. Treatment of toxoplasmosis has been highly successful with enrofloxacin, if applied early in the course of the disease[11-13].

Cryptosporidiosis

Cryptosporidium muris has been reported from mice and the guinea-pig as well as from avian hosts. They are true coccidia whose developmental stages appear to take place on the surface of the host cell but not within the cell proper. In the case of C. *muris,* the parasite may be seen in large numbers in sections of the stomach and is a parasite of the peptic glands. With C. *parvum* the parasites are found in the glandular structures of the small intestine of the mouse. A species of *Cryptosporidium* has more recently been reported from the guinea-pig and has been associated with a chronic enteritis in this host[14,15].

Encephalitozoonosis

Members of this little-known genus are reported from rabbits, mice, guinea-pigs, rats and occasionally from dogs. The organisms are small, bipolar and rod-like. They occur singly or in clumps, or in large numbers in what are termed pseudocysts. The organisms have a defined nucleus, are Gram-positive and may be found in histiocytic cells or extracellularly in the tissues. *Encephalitozoon cuniculi* in the rabbit

gives rise to a mild, febrile, chronic, inflammatory condition often accompanied by a chronic nephritis. Transmission is thought to be by infective urine[16,17].

HELMINTHS

Helminth parasitism of laboratory animals should not present a problem when adequate hygienic measures are practiced, although outbreaks of helminth parasitism do occur. Research workers are at last recognizing the importance of helminth-free laboratory animal colonies. Laboratory animals severely infected with gastro-intestinal parasites make poor experimental and test animals, and may influence the results of critical experimental work. The presence of a few helminth parasites may not produce any visible lesions but may influence experimental results.

The parasites of the gastrointestinal system of rats and mice comprise several nematodes, cestodes, protozoa and acanthocephala microorganisms. Diagnosis usually requires the finding of parasite eggs in feces[18]. *Heterakis spumosa* is found in the cecum and colon of rats, but usually does not cause clinical signs. *Nyppostrongylus muris* is a nematode parasite in the small intestine, the larvae migrate to the lungs and can cause diarrhea and pulmonary hemorrhage. *Gongylonema neoplasticum* can reside in the epithelium of the stomach, esophagus and tongue, being cockroach its intermediate host. *Trichinella spiralis* adults are found in the duodenum of rats and many other rodents. *Aspicularis tetraptera* and species *Synphacia* are oxiuric worms found in the cecum and colon of mice and rats and can cause impaction of feces, colonic intussusception and rectal prolapse[19]. Under appropriate conditions, species of the tapeworm *Hymenolepis* may become a problem in the laboratory rat, mouse and occasionally in the hamster. In the case of *H. nana,* the life cycle may be direct by ingestion of the egg, or indirect by ingestion of one of the various arthropod intermediate hosts. Since man is susceptible to infection by this helminth, and the infective eggs may be transmitted directly on contaminated hands, strict precautionary measures are indicated. Cages should be thoroughly cleaned and sterilized regularly to prevent contamination of food and water. *Hymenolepis diminuta* is also found in rats and mice, but requires an intermediate host for its development. Numerous beetles, fleas and grain-eating arthropods serve as intermediate hosts. *H. diminuta* has been reported from man but his infection is generally thought to be accidental. Lead arsenate in the feed is effective for the removal of the adult *Hymenolepis* from the mouse or rat. In the rat liver, *Cysticercus fascialaris,* the larval stage of *Taenia taeniaformis* in the cat, may be found in situations where infected cat faeces have contaminated bedding or feedstuffs used in the rodent colony[20]. Contamination of litter, bedding or feed materials with infected cat faeces should be prevented. Several nematodes have been reported from the rat and mouse. *Capillaria hepatica* occurs in the rat liver and *Gongylanema neaplasticum* from the stomach. In the mouse caecum and colon, *Aspicularis tetraptera* may be found together with *Syphacia muris* or *abvelata. Trichosomoides crassicauda* has been recorded from the urinary bladder of the rat[21,22].

Moniliformis moniliformis can inhabit the small bowel of mice and rats and cause enteritis, intestinal ulceration and perforation with subsequent peritonitis. Eggs of thick walls can be found in the faeces. The presence of this parasite usually indicates contamination of food by cockroaches, the intermediate host of the parasite. With the exception of the oxyurids, the helminths are not usually a major problem in rat and mice colonies. The treatment is done with ivermectin, 0.007 mg/ml, in tap water for three and four weeks. Hygiene measures such as a complete cage change, thorough disinfection and cleaning of the rooms are associated with the treatment[23,24].

The guinea-pig is seldom infected by nematodes, with the exception of *Paraspidodera uncinata.* This inhabitant of the caecum may be present in large numbers but does not appear to produce significant lesions or pathology. Treatment of nematodes in this rodent is performe with albendazole or ivermectin[25-28]. The life cycle is direct, and infection is through contaminated feed and water. *In hamster an important* list of parasites is observed. This includes larval cestodes from the liver *(Cysticercus fasciolaris),* adult tapeworms from the intestines *(Hymenolepis nana* and *H. diminuta),* and nematodes from the digestive tract *(Protospirura muris* and *Syphacia obvelata)*[29,30]*.* These cestodes are so well adapted to hamster, that experimental models are used to study them in this rodent[31-33].

The helminth fauna of the domestic rabbit is quite limited under ordinary circumstances. Infection by dog tapeworm larvae may become a problem if grass or other forage which has become contaminated with faeces from infected dogs is fed. *Cysticercus pisiformis* and *Coenurus serialis* are the bladder worms most usually seen. Except in very severe infections, the presence of these bladder worms appears to be of little pathological significance in the domestic rabbit. The nematode *Obeliscoides cuniculi* is a common inhabitant of the stomach, but only when present in excessive numbers is there indication of a significant gastritis. *Passalaurus ambiguus,* the rabbit oxyurid, is found in the caecum and colon, sometimes in large numbers, but it does not appear to give rise to any important pathology. Prophilaxis with vaccines is available[34].

The oral treatment with combination of piperazine and ivermectin has been used over a 6-week period for treating colonies of mice or rats infested with *Syphacia obvelata, Syphacia muris* or *Aspiculuris tetraptera.* No acute toxic effect has been found in mice or rats with these products. The colonies may be treated with piperazine, 2.1 mg/ml in tap water for 2 weeks, then with ivermectin, 0.007 mg/ml, in tap water for the third and fourth weeks, and finally with piperazine for two further weeks. Hygiene measures such as a complete cage change, thorough disinfection and cleaning of the rooms is associated with the treatment. Subsequent examinations to completion of treatment is needed to have proved negative for further parasites[35-38].

ECTOPARASITES

The presence of external parasites is affected by a number of variables, most of which are associated with animal health care and management. For example, in the rat specific avitaminoses appear to produce conditions favorable to pediculosis. Colonies of laboratory animals may suffer severely from ectoparasites, and there may be heavy loss of animals and widespread morbidity, apart from the possibility of unreliable experimental results.

In rats the usual species of ectoparasites found on the rat is the blood-sucking *Polyplax spinulosa.* Mild infestations may not be detected for a long time but will soon show up if the health of the host animal deteriorates, or if experimental animals are subjected to severe stress. This parasites may usually be controlled by dusting the occupants of the whole cage with a proprietary insecticide such as lindane or pyrethrum. Ivermectin may be used[39].

Acariasis infestation

While many species of mites infest wild rodents, only three species of nonburrowing mites are commonly found on laboratory mice and rats. *Myobia musculi* and *Myocoptes musculinus* infest mice, while *Radfordia affinis* infests rats. Mice are much more commonly infested than are rats. The life cycles of all three mites are direct, with all stages (egg, nymph, and adult) present on the host. Consequently, hairless mice are not susceptible. Life cycles require roughly 3 weeks for completion. Transmission is via direct contact. Once a facility is infested, eradication of the parasites is achievable but labor-intensive. Clinical signs vary in severity depending upon host factors and mite species. *M. musculi* is considered the most pathogenic of the three common species because it alone feeds on skin secretions and interstitial fluid (but not on blood) while *M. musculinus* and *R.affinis* feed more superficially[40]. Infestation may be symptomatic or may cause wasting; scruffiness; pruritus; patchy alopecia, which may be extensive; accumulation of fine bran-like material, mostly over affected areas; self-trauma to the point of excoriation or amputation; and secondary pyoderma[42]. Lesions are most common on the dorsum, primarily on the back of the neck and interscapular region. Pathologic changes include hyperkeratosis, erythema, mast cell infiltration, ulcerative dermatitis, splenic lymphoid and lymph node hyperplasia, and eventual secondary amyloidosis[42].

The diagnosis of infestation by ectoparasites can be obtained with a magnifying glass to identify the adult stage of the parasite or with a preparation of a cellophane tape. Species that hide in the dermis require skin scrapes for identification. The mite *Polyplax simplex* can be diagnosed by examination of the skin by subcutaneous white tiny focal lesions. The flea infestation is common in rats. The species of fleas that infest rats are commonly *Xenopsylla cheopis* and *Nosopsyllus fasciatus.* Ectoparasites are difficult and eliminate in laboratory colonies. Anthelmintic drugs and insecticides can be placed in the cages lids to aid in treatment of infected

animals. In some cases, the bed material can be sprayed with insecticide powders. Ivermectin administered orally may be beneficial[43].

The mouse louse, *Polyplax serrata,* may become a serious pest if infestations get out of hand. The procedure for controlling this insect is similar to that suggested for the rat. Two species of mites commonly occur in mouse colonies, *Myobia musculi* and *Myocoptes musculinus.* Not quite so common are *Radfordia affinis* and *Psorergates simplex.* It is probable that most colonies of laboratory mice carry *Myobia* and *Myocoptes,* but light infestations are usually not accompanied by any clinical signs. As an infestation becomes heavier, the host becomes more irritated and scartches. As a result, loss of hair may occur and scabby skin lesions may be seen. *Psorergates simplex* may give rise to small whitish nodular formations over the infested area which seem to be small infoldings of epidermal tissue. These infestations may be controlled by neem extract and ivermectins[44-46].

Myocoptes appears to give rise to sporadic cases of acariasis, and only occasionally does the infestation assume serious proportions in a colony. The active disease is often confined to lactating females and their offspring. Males do not seem to show clinical signs of disease resulting from an infestation. Characteristic signs: a thinning of the hair and a peculiar browning around the neck producing a collar-like appearance. *Myobia* never gives rise to serious infestations. Infestation is usually confined to adult breeding males of 5 months or older. Females and unweaned mice seldom show any clinical manifestations of this acariasis. Lesions are most usually seen on the head, neck and shoulders but may spread to the nose and the outside of the ear. The control of *Myocoptes* may usually be accomplished by the use of a single dose of ivermectin or topical moxidectin[47]. More effective and reliable control may be accomplished by dipping infested animals in warm suspensions of appropriate insecticides. If a dipping program is undertaken, it is essential that all animals are dipped thoroughly and then placed in clean cages. When mice are dipped, it is essential that the dip is maintained at body temperature and that the animals are dried in a warm room. To insure complete eradication, dipping should be repeated after about 2 weeks. Spreading and penetration of the dip may be enchanced by the addition of small amounts of detergent.

The tropical rat mite, *Ornithonyssus bacoti,* can cause a considerable decline in production, breeding and efficiency of mouse colonies. It can also infest man to give rise to a dermatitis of varying severity. It is a suspected vector of murine typhus and tularaemia. For satisfactory control, it is recommend permethrin and spraying the bedding in each mouse cage with 5 ml of a 1% aqueous suspension of malathion[48-50]. Although modern living and good insecticides have greatly imperiled the welfare of the bed bug *(Cimex lectylarius),* it will occasionally be introduced into a rodent colony or poultry house. A heavy infestation may severely lower the level of health of the individuals in the colony. This pest can be readily overcome by thorough cleaning of all pens and cages, removal and disposal of all bedding, and dis-infestation of quarters by spraying or dusting with insecticides such as lindane.

*In Guinea-pigs, e*ctoparasites, with the exception of lice, are not usually a problem in the cavy colony. *Gyropus ovalis* and *Gliricola porcelli* are commonly found

on this host; *Trimenopon hispidum* is less common. The heavy infestations guinea-pigs may show loss of condition and rough hair coat, and spend much of the time scratching. Control is difficult as dusting with insecticides does not appear to be highly effective, and dipping of guinea-pigs is not a practical procedure. The mite *Chirodiscoides caviae* is said to cause severe irritation and loss of hair. Malathion dusts were used with little success, but the infestation has been reduced to a negligible level by repeated treatment with a pyrethrin aerosol.

Few arthropods parasite the golden hamster. *Demodex criceti,* and a new species of this mite, *D. aurati,* were described[51]. Apparently both these species may be considered as low-grade pathogens which, under usual circumstances, do little damage other than feed on cells of the follicular epithelium.

With the exception of ear mange (ear canker), the rabbit in a well-managed colony does not usually become victimized by external parasites. The commonest mange in rabbits is auricular mange caused by *Psoroptes cuniculi. Chorioptes cuniculi* is occasionally found in rabbits, but is far less common. *P. cuniculi* is often acquired by import of rabbits into the laboratory colony, and it may become a serious disease. The mites puncture the epidermis of the ear, suck lymph, and give rise to local inflammatory swelling from which serum exudes, coagulates and forms massive encrustations inside the ear. As the mite population increases, the irritation becomes intense, giving rise to continuous scratching of the ear and shaking of the head, with resultant trauma, bruising, hyperaemia and marked swelling of the ear. The mites are easily seen by examination of the encrusted material from inside the ear. All rabbits to be added to a colony should be examined for ear mites and treated if infested. Ears should be cleaned out. If severely encrusted, the scabs may have to be softened with vegetable oil. The mites can be destroyed by using ivermectin[52,53]. Face and body mange of rabbits, due to *Sarcoptes cuniculi* and *Notoedres cuniculi,* is being seen less frequently. The more common of these is *N. cuniculi,* the cause of face mange in which the fur is destroyed on the face and head and replaced by yellowish-grey encrustations. Treatment may be accomplished by vaccination with recombinant actin from scab mites, extract of neem and selamectin[54-56].

A frequent inhabitant of rabbit skin is the cheyletid mite *Cheyletiella parasitivorax,* and it is thought to be predaceous upon other mites in the skin. It is doubtful if it is a parasite of economic importance in the rabbit[57-59]. It may be controlled by bathing the rabbit in an aqueous solution of almost any of the common insecticides, such as lindano.

In conclusion, this review demonstrates that endo and ectoparasites are common in laboratory rodents, and that veterinary control is essential to get quality control, welfare and health of research animals.

REFERENCES

1. Pinto RM, Gonçalves L, Gomes DC, Noronha D. Helminth fauna of the golden hamster *Mesocricetus auratus* in Brazil. Lab Anim Sci. 2001;*40*: 21-26.
2. Gonçalves L, Pinto RM, Vicente JJ, Noronha D, Gomes DC. Helminth parasites of conventionally maintained laboratory mice - II. Inbred strains with an adaptation of the anal swab technique. *Mem Inst Oswaldo Cruz.* 1998;*93*: 121-6.
3. Cheeramakara C, Nontprasert A, Siripanth C, Tanomsak W, Chularerk U, Sucharit P, Areekul S. The hematological status, plasma vitamin B12 and folic acid levels, and intestinal pathology in rats infected with *Giardia lamblia.* Southeast Asian J Trop Med Public Health. 2004 ;35:811-6.
4. Mahmood S, Kaur K, Mittal N, Mahmood A. *Giardia lamblia*: expression of alkaline phosphatase activity in infected rat intestine. Exp Parasitol. 2005;110:91-5.
5. Díaz-Cinco ME, Ballesteros-Vázquez MN, Pérez-Morales R, Mata-haro V. Impact of diet on the induction of infection with *Giardia lamblia* cysts in Sprague-Dawley rats. Salud Publica Mex. 2002;44:315-22.
6. el-Sayad MH, Lotfy WM, el-Kholy SM, Yehia MA. Efficacy of praziquantel against *Giardia lamblia* in rats: parasitological, pathological and therapeutic study. J Egypt Soc Parasitol. 2002;32:201-18.
7. Wang, J. S., and S. F. Tsai. Prevalence and pathological study on rabbit hepatic coccidiosis in Taiwan. Proc Natl Sci Counc Repub China. Part B. 1991;15:240–3.
8. Barriga, O. O., and J. V. Arnoni. Pathophysiology of hepatic coccidiosis in rabbits. Vet Parasitol. 1981;8:201–10.
9. Mayhew IG, Greiner EC. Protozoal diseases. Vet Clin North Am Equine Pract. 1986;2:439-59.
10. Stojanov DP, Cvetanov JL. On klossiellosis in guinea pigs. Z Parasitenkd. 1965;25:350-8.
11. Djurković-Djaković O, Djokić V, Vujanić M, Zivković T, Bobić B, Nikolić A, Slavić K, Klun I, Ivović V. Kinetics of parasite burdens in blood and tissues during murine toxoplasmosis. Exp Parasitol. 2012;131:372-6.
12. Coutinho LB, Gomes AO, Araújo EC, Barenco PV, Santos JL, Caixeta DR, Silva DA, Cunha-Júnior JP, Ferro EA, Silva NM. The impaired pregnancy outcome in murine congenital toxoplasmosis is associated with a pro-inflammatory immune response, but not correlated with decidual inducible nitric oxide synthase expression. Int J Parasitol. 2012;42:341-52.
13. Barbosa BF, Gomes AO, Ferro EA, Napolitano DR, Mineo JR, Silva NM. Enrofloxacin is able to control *Toxoplasma gondii* infection in both in vitro and in vivo experimental models. Vet Parasitol. 2012 8;187:44-52.
14. Feng Y, Lal AA, Li N, Xiao L. Subtypes of Cryptosporidium spp. in mice and other small mammals. Exp Parasitol. 2011;127:238-42.
15. Eida AM, Eida MM, El-Desoky A. Pathological studies of different genotypes of human *Cryptosporidium Egyptian* isolates in experimentally mice. J Egypt Soc Parasitol. 2009;39:975-90.
16. Müller-Doblies UU, Herzog K, Tanner I, Mathis A, Deplazes P. First isolation and characterisation of *Encephalitozoon cuniculi* from a free-ranging rat (*Rattus norvegicus)*. Vet Parasitol. 2002;107:279-85.

17. Valencáková A, Halánová M, Bálent P, Dvoroznáková E, Jamborová E, Lesník F, Neuschl J, Páleník L, Cisláková L. Immune response in mice infected by *Encephalitozoon cuniculi* and suppressed by dexamethasone. Acta Vet Hung. 2004;52:61-9.
18. Effler JC, Hickman-Davis JM, Erwin JG, Cartner SC, Schoeb TR. Comparison of methods for detection of pinworms in mice and rats. Lab Anim. 2008;37:210-5.
19. Mido S, Fath EM, Farid AS, Nonaka N, Oku Y, Horii Y. *Trichinella spiralis*: infection changes serum paraoxonase-1 levels, lipid profile, and oxidative status in rats. Exp Parasitol. 2012;131:190-4.
20. Hasegawa H, Sato H, Iwakiri E, Ikeda Y, Une Y. Helminths collected from imported pet murids, with special reference to concomitant infection of the golden hamsters with three pinworm species of the genus *Syphacia (Nematoda:oxyuridae)*. J Parasitol. 2008;94:752-4.
21. Bazzano T, Restel TI, Pinto RM, Gomes DC. Patterns of infection with the nematodes *Syphacia obvelata and Aspiculuris tetraptera* in conventionally maintained laboratory mice. Mem Inst Oswaldo Cruz. 2002;97:847-53.
22. Pinto RM, Gomes DC, Noronha D. Evaluation of coinfection with pinworms (*Aspiculuris tetraptera, Dentostomella translucida, and Syphacia obvelata*) in gerbils and mice. Contemp Top Lab Anim Sci. 2003;42:46-8.
23. Zenner L. Effective eradication of pinworms (*Syphaciamuris, Syphacia obvielata and Aspiculuris tetraptera*) from a rodent breeding colony by oral antihelmintic therapy. Lab Anim. 1998;32:337-42.
24. Hasslinger MA, Wiethe T. Oxyurid infestation of small laboratory animals and its control with ivermectin. Tierarztl Prax. 1987;15:93-7.
25. Dzik JM, Zieliński Z, Cieśla J, Wałajtys-Rode E. *Trichinella spiralis* infection enhances protein kinase C phosphorylation in guinea pig alveolar macrophages. Parasite Immunol. 2010;32:209-20.
26. Dzik JM, Gołos B, Jagielska E, Kapała A, Wałajtys-Rode E. Early response of guinea-pig lungs to *Trichinella spiralis* infection. Parasite Immunol. 2002;24:369-79.
27. Dziekońska-Rynko J, Rokicki J, Jablonowski Z. Effects of ivermectin and albendazole against *Anisakis simplex* in vitro and in guinea pigs. J Parasitol. 2002;88:395-8.
28. Webster P, Kapel CM, Bjørn H. Reproductivity of nine *Trichinella* isolates in guinea pigs and mice. Acta Vet Scand. 1999;40:93-5.
29. Boag B. The incidence of helminth parasites from the wild rabbit *Oryctolagus cuniculus* (L.) in eastern Scotland. J Helminthol. 1985;59:61-9.
30. Németh I. Immunological study of rabbit cysticercosis. IV. Localization of precipitating antibodies by immunoelectrophoresis in the serum of rabbits experimentally infected with *Cysticercus pisiformis*. Acta Vet Acad Sci Hung. 1972;22:365-76.
31. Toral-Bastida E, Garza-Rodriguez A, Jimenez-Gonzalez DE, Garcia-Cortes R,Avila-Ramirez G, Maravilla P, Flisser A. Development of *Taenia pisiformis* in golden hamster (Mesocricetus auratus). Parasit Vectors. 2011;4:147.
32. Garza-Rodríguez A, Maravilla P, Mendlovic F, Mata-Miranda P, Robert L, Flisser A. Lack of postmortem digestion of tapeworms in Golden hamsters experimentally infected with *Taenia solium*. Vet Parasitol. 2007;145:172-5.
33. Willms K, Zurabian R. Taenia crassiceps: in vivo and in vitro models. Parasitology. 2010;137:335-46.

34. Betancourt MA, de Aluja AS, Sciutto E, Hernández M, Bobes RJ, Rosas G, Hernández B, Fragoso G, Hallal-Calleros C, Aguilar L, Flores-Peréz I. Effective protection induced by three different versions of the porcine S3Pvac anticysticercosis vaccine against rabbit experimental *Taenia pisiformis cysticercosis*. Vaccine. 2012;30:2760-7.
35. Sueta T, Miyoshi I, Okamura T, Kasai N. Experimental eradication of pinworms (*Syphacia obvelata* and *Aspiculuris tetraptera*) from mice colonies using ivermectin. Exp Anim. 2002;5:367-73.
36. Klement P, Augustine JM, Delaney KH, Klement G, Weitz JI. An oral ivermectin regimen that eradicates pinworms (*Syphacia spp.)* in laboratory rats and mice. Lab Anim Sci. 1996;46:286-90.
37. Le Blanc SA, Faith RE, Montgomery CA. Use of topical ivermectin treatment for *Syphacia obvelata* in mice. Lab Anim Sci. 1993;43:526-8.
38. Taffs LF. Further studies on the efficacy of thiabendazole given in the diet of mice infected with H nana, S. obvelata and *A tetraptera*. Vet Rec. 1976;99:143-4.
39. Ricart Arbona RJ, Lipman NS, Riedel ER, Wolf FR. Treatment and eradication of murine fur mites: I. Toxicologic evaluation of ivermectin-compounded feed. J Am Assoc Lab Anim Sci. 2010;49:564-70.
40. Percy, D. H., and S. W. Barthold.. Pathology of laboratory rodents and rabbits. Iowa State University Press, Ames, Iowa, 1993.
41. Jungmann, P., J. L. Guenet, P. A. Cazenave, A. Coutinho, and M. Huerre. Murine acariasis. I. Pathological and clinical evidence suggesting cutaneous allergy and wasting syndrome in BALB/c mouse. Res. Immunol. 1996;147:27–38.
42. Jungmann, P., A. Freitas, A. Bandeira, A. Nobrega, A. Coutinho, M. A. Marcos, and P. Minoprio. Murine acariasis. II. Immunological dysfunction and evidence for chronic activation of Th-2 lymphocytes. Scand J Immunol. 1996;43:604–12.
43. Ricart Arbona RJ, Lipman NS, Wolf FR. Treatment and eradication of murine fur mites: III. Treatment of a large mouse colony with ivermectin-compounded feed. J Am Assoc Lab Anim Sci. 2010;49:633-7.
44. Metcalf Pate KA, Rice KA, Wrighten R, Watson J. Effect of sampling strategy on the detection of fur mites within a naturally infested colony of mice (Mus musculus). J Am Assoc Lab Anim Sci. 2011;50:337-43.
45. Santos AC, Rodrigues OG, de Araojo LV, dos Santos SB, de C Guerra RM, Feitosa ML, Whaubtyfran CT, Santos-Ribeiro A. Use of neem extract in the control of acariasis by *Myobia musculi* Schranck (Acari: *Miobidae*) and *Myocoptes musculinus* Koch (Acari: Listrophoridae) in mice Mus musculus var. albina L. Neotrop Entomol. 2006;35:269-72.
46. Mook DM, Benjamin KA. Use of selamectin and moxidectin in the treatment of mouse fur mites. J Am Assoc Lab Anim Sci. 2008;47:20-4.
47. Pullium JK, Brooks WJ, Langley AD, Huerkamp MJ. A single dose of topical moxidectin as an effective treatment for murine acariasis due to *Myocoptes musculinus*. Contemp Top Lab Anim Sci. 2005;44:26-8.
48. Beck W, Fölster-Holst R. Tropical rat mites (Ornithonyssus bacoti) – serious ectoparasites. J Dtsch Dermatol Ges. 2009;7:667-70.
49. Hill WA, Randolph MM, Boyd KL, Mandrell TD. Use of permethrin eradicated the tropical rat mite (Ornithonyssus bacoti) from a colony of mutagenized and transgenic mice. Contemp Top Lab Anim Sci. 2005;44:31-4.

50. Cole JS, Sabol-Jones M, Karolewski B, Byford T. Ornithonyssus bacoti infestation and elimination from a mouse colony. Contemp Top Lab Anim Sci. 2005;44:27-30.
51. Retnasabapathy A, Lourdusamy D. *Demodex aurati and Demodex criceti* in the golden hamster (*Mesocricetus auratus*). Southeast Asian J Trop Med Public Health. 1974;5:460.
52. Arslan HH, Açici M, Umur S, Hökelek M. *Psoroptes cuniculi* infestation in four rabbits and treatment with ivermectin. Turkiye Parazitol Derg. 2008;32:244-6.
53. Perrucci S, Zini A, Donadio E, Mancianti F, Fichi G. Isolation of *Scopulariopsis spp.* fungi from *Psoroptes cuniculi* body surface and evaluation of their entomopathogenic role. Parasitol Res. 2008;102:957-62.
54. Zheng W, Tang Q, Zhang R, Jise Q, Ren Y, Nong X, Wu X, Gu X, Wang S, Peng X, Lai S, Yang G. Vaccination with recombinant actin from scab mites and evaluation of its protective efficacy against *Psoroptes cuniculi* infection. Parasite Immunol. 2012; 19. doi: 10.1111/pim.12015. [Epub ahead of print] PubMed PMID: 23078134.
55. Deng Y, Shi D, Yin Z, Guo J, Jia R, Xu J, Song X, Lv C, Fan Q, Liang X, Shi F, Ye G, Zhang W. Acaricidal activity of petroleum ether extract of neem (Azadirachta indica) oil and its four fractions separated by column chromatography against *Sarcoptes scabiei var. cuniculi larvae in vitro*. Exp Parasitol. 2012;130:475-7.
56. Kurtdede A, Karaer Z, Acar A, Guzel M, Cingi CC, Ural K, Ica A. Use of selamectin for the treatment of psoroptic and sarcoptic mite infestation in rabbits. Vet Dermatol. 2007;18:18-22.
57. Cloyd GG, Moorhead DP. Facial alopecia in the rabbit associated with *Cheyletiella parasitivorax*. Lab Anim Sci. 1976;26:801-3.
58. George JB, Otobo S, Ogunleye J, Adediminiyi B. Louse and mite infestation in domestic animals in northern Nigeria. Trop Anim Health Prod. 1992;24:121-4.
59. Marchiondo AA, Foxx TS. Scanning electron microscopy of the solenidion on genu of *Cheyletiella yasguri* and *C. parasitivorax*. J Parasitol. 1978;64:925-7.