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PARASITOLOGY

Brazilian laboratory rats and mice: decades pass, but parasite infections remain

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ABSTRACT: Rats and mice are the most used experimental models in research. Globally, animal houses are subjected to parasite outbreaks. In Brazil, the parasitological profile is used to reflect the sanitary condition of laboratory animals and must be monitored frequently. The present study developed an integrative review of scientific studies on the parasitological profile of rats and mice in animal facilities in Brazil. It identified the most prevalent parasite species reported in animal facilities from different geographic regions of the country, as well as factors contributing to the perpetuation of these parasites, and proposed measures to help prevent such infections. Based on the guiding question "*which endoparasites and ectoparasites have already been identified in rat and mouse colonies in animal facilities in Brazil*?" and considering inclusion and exclusion criteria, 28 studies published between 1974 and 2021 were selected in four scientific bases. These studies covered facilities in 12 Brazilian States, describing 16 genera of parasites in mice and 18 in rats. Most of the facilities in the selected studies were of the conventional type and with few sanitary barriers, and these conditions may favor the recurrence of parasites. Efforts are, therefore,necessary for institutions to have animal facilities in accordance with the legislation and practice optimal methodologies. The measures proposed in this article can contribute to change the panorama of parasites in the national animal facilities, aiming to safeguard the quality of scientific data and animal welfare.
Key words: laboratory animals, parasites, rodents, sanitary standards, well-being.

Ratos e camundongos de laboratório do Brasil: décadas se passam, mas as infecções parasitárias permanecem

RESUMO: Ratos e camundongos são os modelos experimentais mais utilizados em pesquisa. Globalmente, as instalações de animais estão sujeitas a surtos de parasitas. No Brasil, o perfil parasitológico é utilizado para refletir a condição sanitária dos animais de laboratório e deve ser monitorado frequentemente. O presente estudo teve como objetivo desenvolver uma revisão integrativa de estudos científicos sobre o perfil parasitológico de ratos e camundongos em biotérios no Brasil. A revisão identifica as espécies parasitárias mais prevalentes relatadas em biotérios de diferentes regiões geográficas do país, bem como os fatores que contribuem para a perpetuação desses parasitas, e propõe medidas para ajudar a prevenir tais infecções. Com base na questão norteadora "*quais endoparasitas e ectoparasitas já foram identificados em colônias de ratos e camundongos em biotérios no Brasil?*" e considerando os critérios de inclusão e exclusão, foram selecionados 28 estudos publicados entre 1974 e 2021 em quatro bases científicas. Esses estudos abrangeram instalações em 12 estados brasileiros, descrevendo 16 gêneros de parasitas em camundongos e 18 em ratos. A maioria das instalações dos estudos selecionados era do tipo convencional e com poucas barreiras sanitárias, e essas condições podem favorecer a recorrência de parasitas. Portanto, esforços são necessários para que as instituições tenham biotérios de acordo com a legislação e pratiquem metodologias otimizadas. As medidas propostas neste artigo podem contribuir para mudar o panorama das parasitoses nos biotérios nacionais, visando salvaguardar a qualidade dos dados científicos e o bem-estar animal.
Palavras-chave: animais de laboratório, bem-estar, padrão sanitário, parasitas, roedores.

INTRODUCTION

Mice and rats have important characteristics that favor their wide use in science. These characteristics include their physiological make-up, prolific, short gestation, small size and easy handling (BRYDA, 2013). Furthermore, it has been estimated that there is 70 to 90% similarity in the coding DNA between humans and mice. It is also possible to genetically manipulate rodents through different gene editing methods (GODARD & MASSIRONI, 2017; KO et al., 2017; KREINER, 2018).

The use of animals in experimentation has been anchored in ethical principles, such as those presented in the 3Rs principle - Reduction, Replacement and Refinement - formulated in 1959 (RUSSEL & BURCH, 1992). The 3Rs concept refers to reducing the number of animals in experiments, replacing animals with alternative methods whenever possible, and refining the techniques in research

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(TRÉZ, 2018). In addition, the Five Freedoms Principle developed in England as a basis for farm animal welfare is also relevant, as this involves aspects inherent to general animal welfare, and can also be applied to animals bred for scientific purposes. According to this principle, animals must be free from hunger, thirst, discomfort, pain, injury, illness, fear and suffering, and with freedom to express the natural behaviors of their species (FAWAC, 1993).

In Brazil, the *Conselho Nacional de Controle de Experimentação Animal* (CONCEA) is the regulatory body created by Law No. 11,794, called the Arouca Law, which established the procedures for the scientific use of animals in Brazil (BRASIL, 2008). In recent years, the Council has instituted several regulations, including the *Diretriz Brasileira para o Cuidado e a Utilização de Animaisem Atividades de Ensino ou de Pesquisa Científica* (DBCA), issued by Normative Resolution - NR No. 55, besides the NR No. 57, which deals with aspects related to the scientific-academic use of rodents and lagomorphs (CONCEA, 2022a; CONCEA, 2022b).

The well-structured Brazilian legislation is very clear and contemplates several significant aspects related to breeding conditions and use of laboratory animals. However, the legislation does not clearly define how animal's health monitoring should be carried out. Health monitoring is of vital importance as the species used in scientific studies can be classified according to their sanitary condition, related to the absence or limitation of microorganisms (BUCHHEISTER & BLEICH, 2021). Microbiological and parasitological analyzes allow quality control of experimental models, thus favoring the animal welfare, while minimizing bias in experimental results (SCHLAPP et al., 2018). Understanding the sanitary status of laboratory animals in Brazil is essential to guarantee the quality of research carried out in the country. According to the World Scientist and University Rankings (ADSC, 2021), Brazil has the highest number of recognized research groups amongst the Latin American countries, demonstrating its great scientific and biotechnological potential.

Parasitic diseases are common conditions in laboratory rats and mice, which affect their health and well-being whilst interfering with research data (MEDEIROS, 2012; AKANBI et al., 2022). Due to the lack of specifications on monitoring the health of species used in teaching and research in national legislation, animal facilities in Brazil often follow Federation of European Laboratory Animal Science Associations (FELASA), which recommends that parasitological control of laboratory animals must be carried out every three months, regardless of their sanitary standard (MÄHLER et al., 2014).

The present study developed an integrative review of scientific studies on the parasitological profile of rats and mice in animal facilities in Brazil. It identifies the most prevalent parasites species reported in animal facilities from different geographic regions of the country, as well as factors contributing to the perpetuation of these parasites, and proposes measures to help such infections.

DEVELOPMENT

In order to develop the present integrative literature review, the following steps were followed: a) the definition of a theme through a guiding question; b) specifying inclusion and exclusion criteria for studies; c) literature search; d) determining the choice of data to be extracted from the included studies; e) analysis and interpretation of the information collected; f) presentation of the information (UNESP, 2015).

The scientific databases Google Scholar, PubMed, Scientific Electronic Library Online (SciELO) and Latin American and Caribbean Literature on Health Sciences (LILACS) were the source of the information. The question to guide the literature review was "*which endoparasites and ectoparasites have already been identified in rat and mouse colonies in animal facilities in Brazil?*".

The searches were carried out using health terminologies, which appear in the descriptors in health sciences (BIREME, 2022): laboratory animals/animais de laboratório, Brazil/Brasil, mice/camundongos, parasites/parasitas, rats/ratos, associated with the Boolean terms "AND" and "OR". The time frame was not specified, to enable the retrieval of studies in the widest available time range. The inclusion criteria of the scientific studies were: scientific articles, master's theses, doctoral theses, course completion works and case reports available online, in Portuguese or English, citing the occurrence of parasites by infestation/natural infection, in laboratory rats and/or laboratory mice from Brazilian animal facilities. The exclusion criteria were scientific papers with data referring to facilities from other countries; studies whose results were included in others already selected; and research in which infestations/infections were experimentally induced.

The search in the databases started by a screening based on scientific studies` titles and abstracts, according to the theme of the study. Subsequently, each study was analyzed in accordance to inclusion and exclusion criteria aforementioned

(Figure 1). The data of each article was compiled based on the type of scientific study (scientific articles, master's theses, doctoral theses, course completion and case reports), publication year, Brazilian State location of the animal facility, animal health profile, animal species, and parasites detected. The selected scientific studies were divided into two time-frames based on the year that national legislation for regulating animal experimentation was enacted in 2008 (BRASIL, 2008). To analyze the periods studied, Student's t-test for independent samples were performed in BioStat® software (AYRES et al., 2007). The significance level was 0.05.

After bibliographic research and data compilation, 28 published scientificstudies were selected, of which 75% (21/28) were scientific articles, 11% (3/28) master's theses, 7% (2/28) course completion researches and 7% (2/28) case reports, published between the years 1974 and 2021. The studies published in the period classified as "pre-legislation" were from 1974 to 2008 and totaled 50% (14/28). The same number of studies were published in the period classified as "post-legislation", from 2009 to 2021.

Different areas of Brazil were represented in the studies, which included animal facilities located in 44% (12/27) of the federative units, distributed across the five geographic regions of the country. In the South region, three States were considered - Rio Grande do Sul (RS), Paraná (PR) and Santa Catarina (SC). In theSoutheast, São Paulo (SP), Rio de Janeiro (RJ), Espírito Santo (ES) and Minas Gerais (MG) wereanalyzed. In the Midwest region, the States examined included Mato Grosso do Sul (MS) and Goiás (GO). In the Northeast, Pernambuco (PE) and Rio Grande do Norte (RN), while in the North, only Amazonas (AM) was included (Figure 2).

The regionsmost commonly represented in the studies were in the South and Southeast of Brazil, with Rio Grande do Sul the Southern State

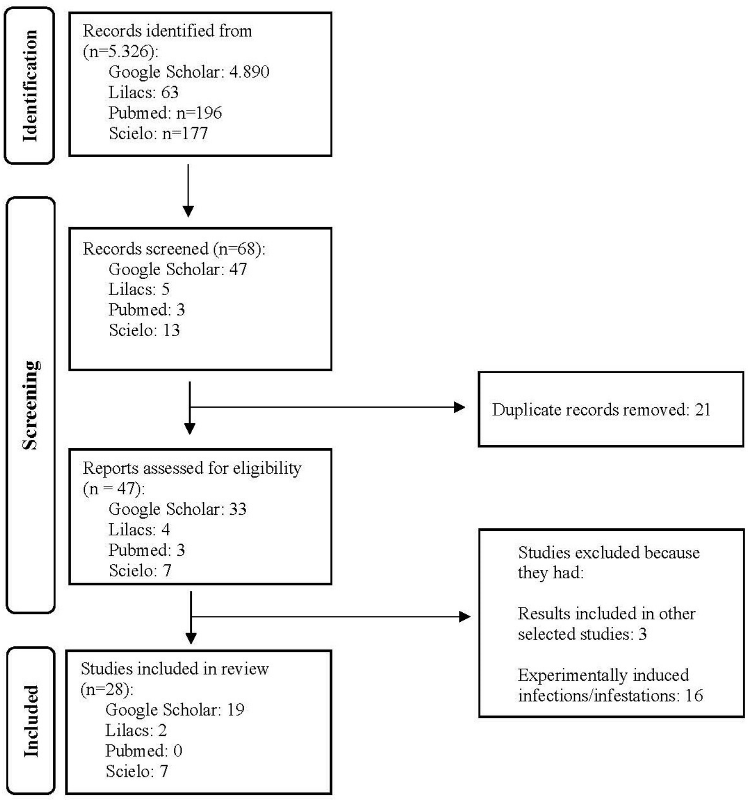

Figure 1 - Number of scientific studies selected and excluded in the literature search according to the keywords and inclusion and exclusion criteria.

Source: Adapted from PAGE et al., 2021.

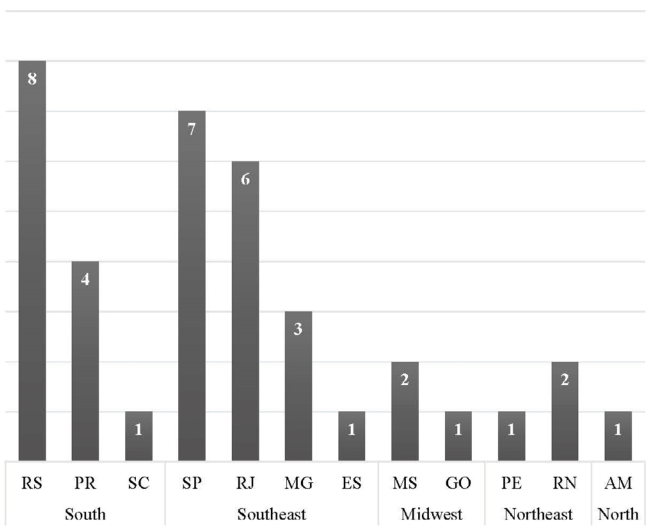

Figure 2 - Studies reporting the presence of parasites in laboratory rodents from facilities located in the geographic regions of Brazil.

Source: Designed by the authors.

most frequent, with facilities included in 29% (8/28) of the publications. From the Southeast, São Paulo is the most represented, with animal facilities cited in 25% (7/28) of the work presented here. In contrast, the North region was the least frequent region in terms of analysis, composing only 4% (1/28) and based on a single scientific study of biological samples collected of animals from the Amazonas. The heterogeneous geographic distribution of the scientific workload among the Brazilian regions may highlight specific regional problems concerning the development of research projects. Brazilian regions are well known for their socioeconomic differences, affecting scientific performance through funding and collaboration between research groups (SIDONE et al., 2016).

The mouse was the main specie compiled in this study, reported in 79% (22/28) of the studies, followed by the rat in 43% (12/28). Studies using only mice were 58% (16/28), while only rats were 21% (6/28) and the remaining, 21% (6/28), analyzed mice and rats together. In Brazil, there is no updated information on the population of rats and mice used in Brazilian scientific procedures. Nonetheless, the highest number of reports in mice, observed in this study, may have occurred, probably, due to the greater use of mice in research, as occurs in Great Britain (NC3RS, 2022). Regarding the origin of the animals analyzed in each study, 46% (13/28) did not clarify where the samples came from, while the remainder identified the origin of the animal facility. Of the latter, 73% (11/15) of the animals came from public institutions and 27% (4/15) from private educational institutions (Table 1).

The sanitary standard was not described or precisely defined in 50% (14/28) of the studies analyzed. From the remaining, 86% (12/14) mentioned conventional facilities, which are characterized by having few sanitary barriers, while 21% (3/14) had controlled conventional facilities, with stronger environmental and sanitary barriers than the conventional houses, 14% (2/14) were Specific Pathogen Free (SPF) facilities, 14% (2/14) related facilities germ-free animals and 7% (1/14) mentioned gnotobiotic animal facilities. Among the studies, 29% (8/28) included animals from two or more facilities in their analyses, which resulted in the percentages described for animal species and installation sanitary standard.

Data on parasites were grouped according to type, classified as ectoparasites, including lice and mites, and endoparasites, including helminths and protozoans. In mice, 16 genera of parasites have been described in the studies, with reports the occurrence of four genera of ectoparasites: *Myobia* spp., *Myocoptes* spp., *Radfordia* spp. and *Demodex* spp.; five helminth genera: *Syphacia* spp., *Aspiculuris* spp., *Hymenolepis* spp., *Strongyloides* spp. and

Table 1 - Selected scientific studies and origin of samples.

Author (s)	Year	Scientific Study Title	Originof Samples
FLECHTMANN et al.	1974	About three parasitic mites of laboratory animals.	Empresa Brasileira de Pesquisa Agropecuária do Estado do Rio de Janeiro (Embrapa-RJ)**
FRÓES et al.	1974	Occurrence of *Myocoptesmusculinus* (Koch, 1844) (Acarina, Sarcoptiforme) in laboratory mice	NI*
SANTOS et al.	1988	Use of tetraethylthiurammonosulfide in the treatment of ectoparasites in mice	Universidade Estadual de Campinas (Unicamp)**
PINTO et al.	1994	Helminth parasites of conventionally maintained laboratory mice	NI*
BRESSAN et al.	1997	Prevalence of ecto and endoparasites in mice and rats reared in animal houses	Universidade Estadual Paulista (Unesp)**
CRUZ et al.	1997	Therapeutic trial on *Giardia muris* infection in mice with metronidazole, tinidazole, secnidazole and furazolidone	Universidade Estadual Paulista (Unesp)**
GONÇALVES et al.	1998	Helminth parasites of conventionally maintained laboratory mice - II. Inbred Strains with an adaptation of the anal swab technique	NI*
GILIOLI et al.	2000	Parasite survey in mouse and rat colonies of Brazilian laboratory animal houses kept under different sanitary barrier conditions	NI*
BAZZANO et al.	2002	Pattens of infection with the nematodes *Syphacia obvelata* and *Aspiculuris tetraptera* in conventionally maintained laboratory mice	NI*
SCAINI et al.	2003	Wistar rat helminths of different age groups reared in a conventional vivarium	NI*
DOYLE et al.	2006	Helminthological evaluation of mice (*Mus musculus*) reared in experimental animal facility	NI*
BICALHO et al.	2007	Sanitary profile in mice and rat colonies in laboratory animal houses um Minas Gerais: I - Endo and Ectoparasites	NI*
SILVA et al.	2007	Effect of Piperazine and Ivermectin in the treatment of *Mus musculus* mice naturally infected with *Aspiculuris tetraptera* and *Syphacia obvelata*	NI*
SILVA et al.	2008	Efficacy of drugs against *Giardia muris* in mice *Mus musculus* naturally infected	Universidade Federal de Santa Maria (UFSM)**
CARVALHO et al.	2009	Clinical evaluation of laboratory rats (*Rattus novergicus* Wistar Strain): sanitary, biological and physiological parameters	Universidade Federal do Espírito Santo (UFES)**
PEREIRA et al.	2012	Sanitary monitoring of a colony of BALB/c mice kept in a conventional animal facility	Instituto Lauro de Souza Lima (ILSL)**
SILVA	2013	Sanitary assessment of the breeding animal facility: a contribution to improving the quality of laboratory animals produced at CPqAM	Fundação Oswaldo Cruz de Pernambuco (Fiocruz-PE)**
ENCARNAÇÃO	2014	Occurrence of ecto and endoparasites in rats (*Rattus norvegicus*) in the Central Animal Facility of the *Universidade Federal do Amazonas*	Universidade Federal do Amazonas (UFAM)**
MORAES et al.	2015	Parasitological evaluation of rats (*Rattus norvegicus*) and mice (*Mus musculus*) from the animal facility at the *Universidade de Cruz Alta*	Universidade de Cruz Alta (Unicruz)***
MULLER et al.	2015	Interference of environmental contamination in microbiota of mice in experimental facilities	NI*
PAIVA	2015	Anatomopathological, microbiological and parasitological characterization of Wistar rats (*Rattus norvegicus*) at different ages	Universidade de São Paulo (USP)**
PEREIRA et al.	2015	Parasitism by *Polyplax spinulosa* Burmeister, 1839 (Anoplura) in Wistar rats, *Rattus norvegicus*Berkenhout, 1769	NI*
PAVANELLI et al.	2016	Efficacy of drugs against *Giardia muris* in naturally infected Swiss mice	Faculdade Integrado de Campo Mourão***
PEREIRA et al.	2017	*Demodex* sp., *Myobiamusculi* and *Myocoptesmusculinus* in *Mus musculus* mice	NI*
BORGES	2018	Retrospective study of parasitological health monitoring of Swiss Webster, BALB/c An and C57BL/6 mice created and maintained in a production facility at CECAL - FIOCRUZ - Rio de Janeiro	Fundação Oswaldo Cruz do Rio de Janeiro (Fiocruz-RJ)**
LIMA et al.	2019	Parasitological evaluation and the effectiveness of a deworming protocol in rats kept in a animal facility	Instituto Metropolitano de Ensino Superior (IMES)***
MOREIRA et al.	2019	Sanitarymonitoringof*Hymenolepis nana*bythe*Laboratório de Controle Sanitário e de Qualidade Animal* (LCQSA) of CEMIB	NI*
SILVA	2021	Parasitological evaluation of rats (*Rattus norvegicus*) of the Wistar lineage and mice (*Mus musculus*) of the BALB-C, Black C57/BL6 and Swiss lineages by the method of Hoffman, Pons and Janer (1934) from the animal facility of the *Universidade do Extremo Sul Catarinense* (UNESC)	Universidade do Extremo Sul Catarinense (Unesc)***

Legend: * NI = not informed / ** Public institution / *** Private educational institution.
Source: Designed by the authors.

Ancylostoma spp.; and seven genera of protozoans: *Giardia* spp., *Spironucleus*spp., *Entamoeba* spp., *Tritrichomonas*spp., *Eimeria* spp.,*Hexamastix*spp. and *Trichomonas* spp. In rats, 18 parasite genera have been reported. Five ectoparasite genera were identified: *Polyplax* spp., *Radfordia* spp., *Myobia* spp., *Myocoptes* spp. and *Chirodiscoides* spp., in addition to unidentified mites of the Laelapidae Family; and five helminth genera: *Syphacia* spp., *Hymenolepis* spp., *Aspiculuris* spp., *Trichosomoides* spp. and *Nippostrongylus* spp. The occurrence of eggs of the superfamily Strongyloidea was also mentioned. Regarding protozoans, eight genera were described: *Entamoeba* spp., *Eimeria* spp., *Spironucleus* spp., *Tritrichomonas* spp., *Hexamastix* spp., *Giardia* spp., *Trichomonas* spp. and *Balantidium* spp., as well as non-sporulated coccidian oocysts. The parasites with the highest occurrence in rats and mice reported in the studies are described in table 2.

This study compared the two periods (pre- and post-legislation) and reported that there was no significant difference (P > 0.05) between them. However, in both periods, the number of reports on ectoparasites (23) was lower than that of endoparasites (78), which can be explained by the greater number of endoparasite species that infect both mice and rats, as can be observed in the studies. The same is not true for ectoparasites, as many are species-specific (GILIOLI et al., 2000; BICALHO et al., 2007; AKANBY et al., 2022). It is also possible that ectoparasites were neglected in the analyzes of part of the selected studies. It was possible to observe an increase in reports on *Eimeria* spp. (4) in rats after 2008. This report is important since AKANBY et al. (2022) draws attention to the zoonotic potential of this protozoan.

The scientific studies evaluated in the present study revealed that parasite infections remain highly prevalent amongst laboratory rodents in Brazil. Health monitoring studies identified different species of helminths, protozoans, and ectoparasites in rats and mice from animal facilities located in several Brazilian States (FLECHTMANN et al., 1974; GILLIOLI et al., 2000; BICALHO et al., 2007; PAVANELLI et al., 2016; MOREIRA et al., 2019; SILVA, 2021: AKANBY et al., 2022).

A well-designed health monitoring program should include a thorough parasitological investigation, allowing the identification of the complete set of parasites harbored in the animals. The

Table 2 - Reports of ectoparasites and endoparasites found in mice and rats in 28 studies.

----------Ectoparasites (Ecto)----------							
	----------Pre-legislationperiod**----------			----------Post-legislationperiod***----------			T*
	Mice	Rat	T*	Mice	Rat	T*	Ecto
Myobiamusculi	5	0	5	2	0	2	7
Myocoptesmusculinus	6	0	6	2	0	2	8
Polyplax spp.	0	3	3	0	2	2	5
Radfordia spp.	0	2	2	0	1	1	3
	11a	5a	16a	4a	3a	7a	23a
----------Endoparasites (Endo)----------							
	----------Pre-legislation period**---------			----------Post-legislation period***---------			T*
	Mice	Rat	T*	Mice	Rat	T*	Endo
Aspiculuris spp.	8	1	9	3	1	4	13
Eimeria spp.	0	1	1	0	3	3	4
*Entamoeba*spp.	2	2	4	2	3	5	9
Giardia spp.	5	0	5	4	0	4	9
Hymenolepis spp.	6	2	8	2	3	5	13
Spironucleusmuris	3	3	6	2	1	3	9
Syphacia spp.	8	4	12	5	4	9	21
	32b	13b	45b	18b	15b	33b	78b

Student's t-test for independent samples.
Equal letters on the same line means that there was no significant difference (P > 0.05).
Legend: *T= total / ** Pre-legislation period = 1974-2008 / *** Post-legislation period = 2009-2021.
Source: Designed by the authors.

main international protocols recommend a periodic investigation of skin, hair and intestinal contents (MÄHLER et al., 2014). However, it does not include an important organ occupied by endoparasites in rats, the urinary bladder. The urinary bladder can harbor, for example, *Trichosomoides crassicauda*, a helminth that parasitizes rats. A high prevalence of this parasite occurs in laboratory rat samples from different Brazilian animal facilities, highlighting the importance of including this organ in parasitological examinations. FELASA organization treats *T. crassicauda* as a parasite rarely isolated in laboratory rats (KRAFT et al., 1994; MÄHLER et al., 2014); however, this information should be regarded with caution in Brazil (GILIOLI et al., 2000; BICALHO et al., 2007). It is well known that *T. crassicauda* can lead to urinary bleeding, stones and even bladder tumors, depending on the severity of the infection (OZKORKMAZ, 2011).

Syphacia spp., *Aspiculuris* spp. and *Hymenolepis* spp. (now *Rodentolepis*) are the most frequent helminth species in laboratory rodents (BICALHO et al., 2007; BORGES, 2018, AKANBY et al., 2022). The results of the present study corroborated these data, showing that *Syphacia* spp. is the most commonly identified genus in both mice, reported in 46% (13/28), and rats in 29% (8/28) of animals. In addition, in mice, *Aspiculuris* spp. is the 2nd most significant genus, reported in 36% (11/28) of the analyses, while in rats, *Hymenolepis* spp. occupied this position, in 18% (5/28) of the studies. The presence of *Syphacia* spp., *Hymenolepis* spp. and *Eimeria* spp. in the studies evaluated should serve as a warning to professionals working with laboratory animals in Brazil, since AKANBY et al. (2022) warned about the zoonotic potential of these species.

The occurrence of *Strongyloide stercoralis*, *Ancylostoma* spp., *Giardia* spp., *Tritrichomonas* spp. and the ectoparasites *Polyplax* spp., *Myocoptes musculinus* and *Myobia musculi* reported in several studies, indicated inadequate sanitary hygiene routines and breaches of physical and sanitary barriers, which probably favored the parasite infections (BAKER, 2007; RIBEIRO et al., 2017; TAYLOR et al., 2017).

It was not possible to obtain information about the existence of other animal species in the same facility, the total number of animals or the frequency of tests, since few scientific studies analyzed these, although GILIOLI et al. (2000) and BICALHO et al. (2007), reported some of these data. These would have helped identify the predisposing factors more accurately for the occurrence of parasitosis reported in these facilities. It is of upmost importance for health monitoring studies that detailed information is available to allow unraveling the factors responsible for the high prevalence of parasite infections in Brazilian experimental animal colonies.

The results obtained in the present research showed that, even after 47 years as and even following the enactment of the Brazilian legislation on animal experimentation, in 2008, there are still animal facilities containing several genera of parasites in rats and mice. This indicates failures in management and inadequate environmental conditions. According to the many reports from facilities under conventional conditions, it is clear that there are still Brazilian facilities with infrastructure problems, which affect the adequacy of parasite control routines. The sources of parasitic infection can vary, including the introduction of animals without quarantine, non-sterilized beds, access of insects to the facilities, use of contaminated biological materials or even the technical staff themselves. Therefore, the control and eradication of these parasites require rigorous sanitation, highly dependent on efficient barriers and consolidated operational procedures (RAHEMO et al., 2012; BUCHHEISTER & BLEICH, 2021).

The lack of provision in Brazilian legislation on sanitary monitoring of laboratory animals allows variations in the methodology and even in the frequency of the health checks of these animals. According to the different biosecurity approaches of the institutions reported by BICALHO et al. (2007), only 8% (1/13) had a complete sanitary program including analysis of parasites and microorganisms; 23% (3/13) performed parasitological monitoring, 8% (1/13) performed only bacterial monitoring and the others 61% (8/13) failed to undergo any type of routine examination. This situation sets precedents for institutions not to have sanitary control incorporated into the animal care routine. This impacts animal`s well-being and violates the principle of the 3Rs and the five freedoms. Only a few institutions in the country carry out complete standardized sanitary monitoring of laboratory animals (BORGES, 2018). In the challenging reality of Brazilian research, sanitary control would demand extra investment in laboratory supplies, equipment and facilities, which may explain the reduced number of health monitoring reports in the literature.

The reduction in the number of reports on health monitoring after 2008 was not reflected in significant statistic differences in between the two periods, “pre-legislation” and “post-legislations”, suggesting that parasites continued recurrent in laboratory rats and mice from different regions of Brazil. Therefore, protective measures must be adopted to reverse this situation and thereby preserve the quality of scientific data and animal welfare. Continuous investment in physical infrastructure, with attention to environmental parameters and strict biosecurity barriers and measures, will be required.

Based on the surveyed studies, a set of measures was developed to maintain the sanitary conditions of colonies of laboratory rats and mice. These measures involved: the existence of facilities with construction characteristics that facilitate the cleaning and disinfection of the environment and equipped with barriers to prevent the entry of disease vectors; personal hygiene (washing and disinfecting hands and arms and removing adornments); personal protective equipment (PPE); good practices in animal facilities; disinfection of cages and other materials; animal bedding sterilization; drinking water treatment by filtration or heat; adequate frequency of cleaning cages according to the number of animals and the type of bedding; control of temperature and relative humidity; observation of behavioral and physical alterations in the animals (like prostration, hair gaps and pruritus), which may indicate the presence of parasites; periodic parasitological examinations (such as spontaneous methods of the sedimentation and of the flotation and perianal tape impression method) to detect eggs and parasites in samples from animals of adequate age; and keeping a record of occurrences in the animal facilities. The adoption of practices to eliminate parasites, such as the aseptic cesarean section technique, can also be an important tool (LINGLING et al., 2020). A compilation of general measures, based on good practices in animal facilities and legislation, is described in table 3.

In addition, creating a follow-up protocol adapted to the Brazilian reality and adjusted to each region to adapt the preventive measures to be adopted in the institutions is urgent. Such protocols should include routine monitoring, which allows institutions to validate the health standard of their animals through their health control laboratories or by sending samples to central diagnostic laboratories. A permanent human resources qualification program should also be adopted at all levels. Continuous investment is essential in other that the presence of parasites is routinely evaluated.

Table 3 - General measures to control parasitosis.

MEASURES	GOALS
Sanitarybarriers	Protect environmental conditions and minimize the risks of contamination and spread of pathogens through constructive aspects, equipment and standardized operating procedures
Standard Operating Procedures (SOPs)	Detail, through descriptive manuals, procedures, and processes in order to standardize and guide the execution of activities
Qualification and training	Carry out continuing education actions aimed at training and updating professionals with relevant theoretical and practical content
Personal hygiene and clothing	Promote in the team the maintenance of adequate hygiene habits and the use of personal protective equipment (PPE) in the execution of activities
Cleaning, disinfection and sterilization	Enable the reduction or elimination of pathogens in materials, inputs, and the environment through physical and/or chemical processes
Care when acquiring new animals	Introduce into the colony animals that do not pose a sanity risk, acquired with certification, and placed in quarantine
Parasitological monitoring	Monitor the state of animal health through periodic parasitological examinations, in order to know the health status of the colony and adopt corrective measures when necessary
Environmental monitoring	Periodically analyze the environmental sanity condition, aiming to safeguard the health of the colony and early identify possible failures in hygienic-sanitary procedures
Elimination or treatment of parasites	Eradicate parasites in colonies by of aseptic cesarean section or sanitary void, followed by the acquisition of certified animals and adoption of quarantine whenever possible. Or even the control of parasites by pharmacological means.

Source: Designed by the authors.

CONCLUSION

The review showed that there were no significant changes in the parasitological profile of rats and mice during the periods studied. There is a diversity of genera of parasites reported in these animals, many of which can be eradicated with management measures, most of which are simple and accessible. The laboratory animal facilities in Brazil, many of which are conventional, still require investment and greater rigor in their routines. The measures proposed in this article can contribute to change the panorama of parasites in the national animal facilities, aiming to safeguard the quality of scientific data and animal welfare.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally to the design and writing of the manuscript. All authors critically reviewed the manuscript and approved the final version.

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