World Rabbit Sci. 2024, 32: 57-71
https://doi.org/10.4995/wrs.2024.20624
WRSA, UPV, 2003

MANGE IN FARMED RABBITS

Joan M. Rosell*, Luis F. de la Fuente†, Rosa Casais‡

*Cunivet Service P.O. Box 518, 43080 Tarragona, Spain.
†Dep. de Producción Animal, Facultad de Veterinaria, Universidad de León, 24071 León, Spain.
‡Servicio Regional de Investigación y Desarrollo Agroalimentario (SERIDA), Centro de Biotecnología Animal, La Olla-Deva, 33394 Asturias, Spain.

Abstract: In this study we determined occurrence of mange in breeding rabbits on 1368 commercial farms in Portugal and Spain during 1996-2022. We obtained our information by carrying out 11737 visits to 1334 doe farms, 11 farms only with growers, and 23 artificial insemination (AI) centres. The median size of the visited doe farms was 450 does (minimum to maximum: 100–2500 does) and 1175 does (ranging from100 to 6000 does) in 1996 and 2022, respectively. AI was used on 9% of the farms visited in 1996 and 95% in 2022. For our diagnoses we used (1) clinical observations on all visited farms to detect sarcoptic mange; (2) examination of the outer ear of breeding rabbits on a subset of farms to assess the prevalence of otodectic clinical mange (OCM); and (3) the examination of breeding rabbits and youngstock does (2.5 to 5.5 mo old) on a subset of 72 farms during 2018 to estimate prevalence of body mange compatible with cheyletiellosis. They were mainly clinical diagnoses, supported sometimes by a laboratorial confirmation. Over the course of the 27-yr clinical study, the cumulative incidence of sarcoptic mange was low; we recorded a total of 13 affected doe farms. The percentage of farms affected by OCM dropped from 55% in 1996 to 28% in 2022. OCM mean prevalence for the period 1996-2022 and 95% binomial confidence interval (CI) were 3.2% (95% CI [3.1-3.3%]), and 3.9% (95% CI [3.7-4.1%]) in does and bucks, respectively. We observed an improvement over time; the OCM yearly mean prevalence decreased from 7% in 1996 to 2.3% in 2022 in females and from 7.2% to 2.2% in males, respectively. This progress was compatible with the use of semen coming from AI centres; biosecurity measures and medical management also contributed. Genetic type was predisposing risk factor for OCM. Enabling risk factors were year and season (more affected in summer). Hair and skin disorders along the back, compatible with cheyletiellosis, were also assessed during 2018; we detected 50% of positive farms with various prevalence results in females, males or young does. In this study, we describe protocols observed in the control of benign and severe cases of mange in rabbitries, which included the use of ivermectin and synthetic acaricides. Ivermectin was used on 36% of doe farms visited during 2018-2022; we suggest that it should be used less often to lower its negative impact on the environment.

Key Words: rabbit mange, animal welfare, disease prevention, one health.

INTRODUCTION

Several types of mange in farmed rabbits are important parasitic dermatoses that affect health and animal welfare and cause economic damage. They are mainly produced by various mites: *Sarcoptes scabiei* var. *cuniculi* (onwards: *S. scabiei)*, *Psoroptes cuniculi*, *Cheyletiella parasitovorax*, *Leporacarus gibbus* (formerly *Listrophorus gibbus),* and *Notoedres cati*. Some mites produce almost clinically unapparent signs and lesions, with mild discomfort. Others cause dermatitis, erythema, scaling and crusting, hypotrichosis and pruritus (Timm, 1988). Sarcoptic mange affects

Correspondence: J.M. Rosell, *jmrosellp@cunivetservice.com.* Received *October 2023* - Accepted *December 2023.*
https://doi.org/10.4995/wrs.2024.20624

Cite as: Rosell J.M., de la Fuente L.F., Casais R. 2024. Mange in farmed rabbits. *World Rabbit Sci., 32: 57-71. https://doi.org/10.4995/wrs.2024.20624*

the edge of the ears, nose, eyelids, toes and tail; it can cause severe clinical signs and lesions, intense pruritus and pain, cachexia and even death (Arlian and Morgan, 2017). *N. cati* var. *cuniculi,* a rarely observed rabbit parasite (White *et al.,* 2002), in farmed (Osborne, 1947), laboratory (Kraus, 1974) and pet (Turner, 2018) rabbits, produces mildly pruritic lesions (Meana, 1999). The most common form of mange is otoacariosis [syn. ear mange, ear canker, psoroptic or otodectic clinical mange (OCM)], caused by *P. cuniculi* (Arlian *et al.,* 1981). This mite is found in the epidermis of the inner ear, and is also occasionally found on the toes and other atypical areas (Bulliot *et al.,* 2013). Other frequently found mites are fur mites on the neck and back (*C. parasitovorax*) or abdomen (*L. gibbus*) (Kirwan *et al*., 1998). Other mites, such as *Demodex cuniculi*, are commensal and less important (Harvey, 1990).

Awareness of the prevalence of different types of mange in commercial rabbitries and strategies used to control them is of interest for several reasons that justify this study: (1) Some forms of mange are zoonotic diseases; the main ones are sarcoptic and notoedric mange (Foley *et al.,* 2016), followed by cheyletiellosis (Cohen, 1980) and mange caused by *L. gibbus*, according to D'Ovidio and Santoro (2014). (2) Mange greatly affects the health and welfare of rabbits (Broom and Frazer, 2015). (3) It causes economic damage as a result of the cost of treatment and skin seizures, particularly in the case of Rex rabbits. (4) Mange is also important from an ecological standpoint, as wild rabbits are susceptible to mange (Millán *et al.,* 2012). Cross-species parasite transmission to other lagomorphs (Cardells *et al.,* 2021) or their predators (Arlian and Morgan, 2017) is also possible. (5) There are intercurrent processes such as dermatophytosis or those produced by *Malasezia* spp. (Radi, 2004). Moreover, secondary super infections by *Staphylococcus* spp. occur as a consequence of damage produced by mites and animals self-scratching. Lastly, (6) if rabbit producers know the risks of mange, they will be more likely to use biosecurity measures and to implement *pro-health* and *pro-welfare* innovations (Chiron *et al*., 2022).

Concerning the occurrence of mange, with cosmopolitan distribution, there is information covering more than 100 yr, (Scott *et al*., 2001). In Spain, a study carried out between 1986 and 1995 on 691 farms showed a mean prevalence of OCM of 4.7% and 5% affected females and males, respectively (Rosell *et al*., 2000). Regarding sarcoptic mange, a study carried out in 1995 on 167 farms found 90 farms positive for ear mange, with affected does, bucks or both, and 3/167 with sarcoptic mange (Rosell *et al*., 2000). Concerning diagnosis, in initial stages of mange caused by *S. scabiei* or *C. parasitovorax*, morphological identification of the mites is advisable to distinguish it from other dermopathies (Harkness *et al*., 2010). However, on affected farms there might be several affected individuals, which facilitates the diagnosis. Prevention includes (1) knowing the sanitary origin of future breeders; in fact, we have confirmed this route of contagion. Likewise, (2) it is important to maintain an adequate degree of hygiene, paying particular attention to areas where mites thrive. Similarly, (3) prevention includes occasional veterinary monitoring of "target" rabbits, which, in our opinion, are adults and runts. The medical management of mange has evolved over the years, from the use of mixed sulphur with oil on small farms worldwide, with recognised efficacy (Christodoulopoulos *et al*., 2001), to topically applied synthetic acaricides, e.g., phoxim and diazinon, both of which are very effective but require careful use (Larkin and Tjeerdema, 2000), or cypermethrin in housing and, since the end of the 1970s, ivermectin (Wilkins *et al.,* 1980). The types of mange requiring the use of ivermectin (zoonotic) bring together the 3 main aspects of One Health: the health of people, rabbits and the environment. On the other hand, vaccination is an attractive ecological alternative to the use of acaricides for parasite control. However, effective anti-parasite vaccines against mange have not yet been developed. Various studies have shown that vaccination of rabbits with immunodominant antigens from *S. scabiei* conferred partial protective immunity (Casais *et al.,* 2016; Shen *et al.,* 2023).

Given that mange affects public health and animal welfare and causes economic damage in the farms, we considered it interesting to approach the following objectives: (1) Estimate the occurrence of OCM, with percentage of positive farms and on-farm apparent prevalence between 1996-2022 in Spain and Portugal. (2) Determine the cumulative incidence of farms with breeding rabbits, weaned rabbits or both affected by sarcoptic mange during 1996-2022. (3) Estimate the prevalence of cheyletiellosis in breeding rabbits and young does (aged 2.5 to 5.5 mo old) during 2018. (4) Investigate predisposing and enabling risk factors for OCM. (5) Describe visits made to farms with mange cases and the control methods used, including ivermectin, from 2018 until 2022.

MATERIALS AND METHODS

This retrospective study was carried out from January 1st, 1996 to December 31st, 2022 (a 27-yr period). In this study, we included the records gathered from 11 737 visits (216 in Portugal and 11 521 in Spain). Visits took place as part of daily veterinary practice, routine health monitoring and surveillance, and consulting activities on farms housing females, males or weaned rabbits, in Portugal and Spain. Animal Care and Use Committee approval was not needed for this study, as the data were obtained from rabbits raised under commercial conditions; farms must comply with European recommendations and laws on animal welfare, food safety, public health and environmental protection.

Characteristics of the studied farms

The present observational study includes the findings obtained during visits made by the first author to 1368 farms; 1280 located in Spain [there is a map with locations in the figure 1, in (Rosell *et al*., 2019)], and 88 in Portugal (from Lisbon to the North). They were mostly meat-producing farms; there were 3 farms for laboratory rabbits, 4 for pets, 6 for restocking and 4 for Rex rabbit production; no Angora rabbit farms were visited. Mainly breeding-finishing farms were visited (1334), with the exception of 11 farms of weaned-growing rabbits, and 23 AI centres. There was a monthly flow (>10%) of young breeding rabbits (Rosell and de la Fuente, 2009). The visited farms represent a significant proportion of the farms present (Rosell and de la Fuente, 2018). We asked producers about their rabbit breeds and lines, doe inventories, i.e., females bred once or more, generally at 4.5-5.5 mo old. The majority of food-producing rabbits were commercial breeding lines, with the exception of New Zealand White rabbits, and non-selected "coloured" rabbits (de la Fuente and Rosell, 2012). Rabbit line was an independent variable in present study. The number of visits, farms visited yearly and farms with physically explored males, females or both, are shown in Table 1.

Over the 27-yr study, the number of farms with males, and consequently the number checked, decreased from 192 in 1996 to 14 in 2022.

Table 1: Overall characteristics of commercial farms visited and checked in Portugal and Spain during 1996-2022.

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of visits	402	419	405	427	329	462	398	375	379	389
FA visited	222	217	199	204	137	169	142	154	173	182
FA with does checked	195	160	121	82	34	102	109	115	140	119
Females examined	10694	8746	6475	5377	1609	7219	8496	8329	11918	15301
FA with males checked	192	148	105	64	23	70	52	52	56	44
Males examined	2850	2052	1448	1164	299	1294	914	1038	1186	849

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of visits	334	379	474	516	542	642	704	469	478	463
FA visited	193	177	186	198	188	160	198	133	111	115
FA with checked does	86	87	88	120	43	91	66	40	52	95
Females examined	9615	11178	12634	14635	3493	8668	5399	3229	4348	8654
FA with males checked	32	32	21	47	29	36	23	20	25	29
Males examined	671	952	876	1348	854	1322	1388	1324	1566	1742

Year	2016	2017	2018	2019	2020	2021	2022	Total
Number of visits	475	445	401	384	361	342	343	11737
FA visited	126	103	87	78	85	91	78	1368
FA with checked does	93	81	70	48	33	43	52	891
Females examined	9057	9237	7609	5334	4115	4953	5719	212041
FA with males checked	21	16	19	17	10	12	14	549
Males examined	1463	820	1011	750	744	915	1003	31843

FA, farms; FA visits refers to the total number of farms visited (one farm could have been visited more than once).

On-farm management procedures

The management practices of most importance in rabbit production are housing, breeding system and feeding. We visited farms with different characteristics of habitat and environment, as described in a previous work (Rosell *et al,* 2023). We recorded the breeding practices used on each farm: e.g., type of service, i.e., if does were bred by AI or naturally mated, and AI centre supplying semen, if any. In addition, we gathered the number of batches per farm; a group of rabbit does serviced on the same day is considered a batch. The use of a single batch allows the "all in–all out" system to be used and housing to be cleaned and disinfected (Huneau-Salaün *et al.*, 2015).

Veterinary visits to the rabbit farms and diagnostic workup

In this study, the clinical information on productive and sanitary events was collected during veterinary visits by the first author, from January 1996 through December 2022. When classifying the visit, we only considered the main cause, e.g., check-up (no relevant problems), or disease such as mange, amongst others (Rosell, 2003). On several visits, breeding rabbits were examined outside their individual housing to assess their body condition and sanitary status. In the case of lactating females, we checked for the presence or absence of clinical rhinitis, mastitis, ulcerative pododermatitis and mange, following the previously described protocol (Rosell, 2003). All these criteria were classified as binary variables. The case definition of a rabbit affected by clinical mange was based on the observation of scabby lesions inside one or both outer ears (otodectic, Figure 1), and rarely in other areas (Figure 2). Also, when we observed scabs on the skin, mainly on the nose, toes, tail (sarcoptic, Figure 3); besides, there were farms with mixed infestations by various types of mites such as *S. scabiei* and *P. cuniculi* (Figure 4), as pointed out by Low (1911). We made presumptive diagnoses of bodily mange, when scabs and scratches were observed on the neck, shoulder blades and dorsal area (cheyletiellosis, Figure 5), according to Scott *et al.,* (2001). We also observed mixed infestations, by *C. parasitovorax* and *P. cuniculi* (Figure 6). Concerning these types of mange, there were differential diagnostic patterns (Harkness *et al.*, 2010). With respect to OCM, the presence of wax in some cases caused uncertainty; a key aspect of this diagnosis was the examination of both ears with lighting. There were cases of suppurative otitis, possibly related to mange or not, although OCM does not cause otitis media (Kraus,

Figure 1: Female with otodectic mange by *Psoroptes cuniculi*.

Figure 2: The same female with affection of toes by *P. cuniculi.* (Case confirmed by microscopic identification of the mites).

Figure 3: Female with sarcoptic mange by *Sarcoptes scabiei*.

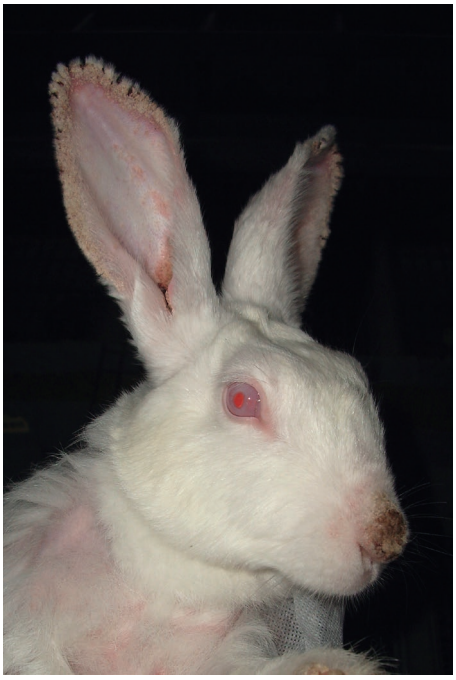

Figure 4: Female with a double infestation by *S. scabiei* mites on the outer surface of the pinna and *Psoroptes cuniculi* on the inner surface. Cases confirmed by microscopic observation of skin scrapes.

Figure 5: Female with cheyletiellosis (confirmed).

Figure 6: Otoacariosis and cheyletiellosis (confirmed).

1974, Mancinelli and Lennox, 2017). The clinical approach to mange has other uncertain cases related to hair loss, inadequate care of the fur, or overgrown teeth, as indicated by D'Ovidio and Santoro (2013); however, concerning cheyletiellosis, as well as scaling and dermatosis, self-inflicted scratches are commonly found (White, 2023).

We diagnosed a case definition of affected cohort or farm (1) when sarcoptic mange or OCM were the most serious problems detected, in absence, e.g., of myxomatosis, rabbit haemorrhagic disease or severe digestive processes, among others; (2) when threshold values for the prevalence of OCM were: >10% of breeding rabbits or an increase in prevalence was observed compared to previous visits to the farm. Farms without problems should have no affected rabbits. Lastly, (3), in relation to back mange, we evaluated prevalence in youngstock females (2.5 to 5.5 mo old), adult does (served from 4.5-5.5 mo old onwards) and males, with a binary result.

On-farm prevention and treatment features

On visits we also asked farm staff questions related to the biosecurity practices, vaccination schedules and treatment protocols. The recommendations were made by us or other attending veterinarians. Regarding prevention of mange, during the period 1996-2022 we paid special attention to selection and multiplication centres serving pure lines or crossbred young females to production farms. Additionally, we visited insemination centres that supplied semen to commercial farms. In the treatment of severe cases of mange (e.g., sarcoptic mange, high prevalence of OCM, cheyletiellosis in Rex), we recommend: (1) parenteral use of ivermectin (e.g., a commercial product with 10 mg/mL ivermectin), a single-dose of 0.2 mL subcutaneous administered/doe during the first week postpartum. As crossbred maternal lines does weigh between 4.2 and 4.9 kg (Table 7 in: de la Fuente and Rosell, 2012), the dosage is 400 µg/kg. (2) Concerning medical management in severe cases, a second treatment after 7 d was recommended, for two consecutive parturitions; (3) topical administration of a phoxim solution to all does (e.g., a commercial product with phoxim 0.5 mg/mL, 2 mL/L water), e.g., as described in Rosell (2023), with a second application 10 d later. Any remaining phoxim solution was only used in manure pits and corridors. The dosing regime was reduced from the third month on (one injection of ivermectin at postpartum and topical treatment at weaning); and (4) spraying of manure pits and corridors with cypermethrin 3 times 7-10 d apart. Diazinon (e.g., a commercial product with dimpilate 150 mg/mL) was used on other farms only for pits and corridors.

Sampling protocol

On-farm monitoring and surveillance systems (Thrusfield, 2018) for rabbit disease surveys are common in our practice. The clinical approach for mange included the examination of a sample of males or females; we targeted only lactating does (in this study "adult does") and working males. Sample size (n) was calculated using *WinEpi* software (De Blas, 2006) considering the population at risk (*by groups of animals*), expected confidence (95%) and expected prevalence (*p %*). Then we proceeded with the checking of does or bucks using random systematic sampling, conducted as in previous studies (Rosell *et al.,* 2023).

Laboratory procedures

Skin scrapings were obtained from the animals and incubated in a Petri dish at 37°C for 24 h. The mites were then observed using magnification lenses (Olympus SZX9, Tokyo, Japan) and taxonomically identified according to their morphological features (Kraus, 1974; Mullen and O'Connor, 2019).

Data recording

For this 27-yr observational study, we distributed the information in 8 databases (Table 2). Information was recorded on the farm in paper form and then gathered on different spreadsheets.

Databases 1 and 2 refer to visits made during the 27-yr period. Databases 3 through 8 are subsets and refer to disease occurrence determined by evaluating farm level. We examined breeding rabbits on 956 of the 1386 farms visited. We checked females on 891 doe farms (with or without males) and examined males (with or without females) on 549. Database 5 corresponds to the examination of bucks in AI centres, without females on the same farm. Lastly, we examined males and females on 478 farms. In this study, we determined the occurrence of OCM mainly through prevalence and the occurrence of sarcoptic mange with the cumulative incidence (Thrusfield, 2018).

Statistical analysis

When the examination was carried out, we calculated apparent prevalence of OCM with the population of breeding rabbits at risk (lactating does, males), sample of examined rabbits (*ne*), sick rabbits found (*ns*) and degree of expected confidence (95%). We converted our anonymised raw data to Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA). Statistical significance was indicated by a *P*-value <0.05. The dependent variable: *OCM prevalence* was binomial (proportion) distribution in the GENMOD procedure with a logit link function. Each visit was recorded, first with the date (i.e., year and season), which are independent variables in our study. The third variable included rabbit genetic line. Five different rabbit lines of commercial synthetic rabbits were used in the study; commercial brands are not specified due to confidentiality reasons. These three variables were common in the analysis model for males and females. The units of analysis were the 4272 (females) and 2027 (males) cohorts, (proportion: *ns* sick rabbits /*ne* examined rabbits); that is, the visits, not the farms. The factors of variation on the dependent variable: *OCM prevalence* were estimated independently according to the gender (males and females) using the following model: $Y_{ijkl}=\mu+A_i+S_j+L_k+e_{ijkl,}$ where

Table 2: Database, visits to farms and examinations carried out from 1996 to 2022 and used for the present study.

Database	Traits	Record N	Cohort N	Farm N	Period
1	Total visits to farms	11 737	NA	1368	1996-2022
2	Visits due to mange	66	NA	43	1996-2022
3	Exams of does by farm	212 041[a]	4272	891	1996-2022
4	Exams of males by farm	31 843	2027	549	1996-2022
5	Exams of bucks on AI [b]centres	11 807	412	13	1996-2022
6	Exams of males and does on the same farm	17 302 males 63 306 does	1443	478	1996-2022
7	Cheyletiellosis in young does, adult does or both	923+7609	169	72	2018
8	Cheyletiellosis in adult males	1011	40	17	2018

[a]Lactating females. [b]Artificial Insemination centres. NA: not applicable.

Y_{ijkl} was the dependent variable: *OCM prevalence* on each farm visit, μ was the mean of the dependent variable; A_i was explained by the effect of the i^{th}yr (27 levels), S_j was explained by the effect of the j^{th}*season* (4 levels: January to March was winter and so on), L_k was explained by the effect of the k^{th}*rabbit line* (5 levels, with>100 cohorts per line), and e_{ijkl} was the *residual effect*. We present the prevalence of OCM with the 95% binomial confidence interval (CI). Statistical analysis was performed with SAS (2004), using GENMOD, UNIVARIATE or FREQ procedures, depending on the analyses used.

RESULTS AND DISCUSSION

Visits where mange was the main problem

Throughout this study, we performed 66 visits to 43 farms due to a clinical problem related to naturally occurring cases of mange. In our study, the median size of farms where mange was a relevant issue was 685 does (minimum to maximum: 180-4300 does) and the mean size, 911 does. Most (50) were cases due to OCM (e.g., 30-90% estimated prevalence), and 16 due to sarcoptic type. We did not diagnose any severe cases of cheyletiellosis. In relation to lesions on the toes of the hind limbs, we also diagnosed staphylococcal dermatitis. In some cases, we suspected self-mutilation (Timm, 1988), compatible with pruritus due to staphylococcosis or iatrogenic causes, after injection; Van Praag *et al.,* (2010) point to these mites as one of the causes of this behavioural disorder. Concerning sarcoptic mange, in 1996, 8 visited farms out of 195 had cases of this type. Over the course of 27 yr, we recorded a total of 13 farms affected by sarcoptic mange (1%). There was 1 farm housing pet rabbits (a case visited in 1999) and 12 rabbits for meat. In such cases, the prevalence within the affected farms was not evaluated. The last visit to a farm affected by sarcoptic mange was in 2016; the highlight of that visit was the presence of myxomatosis; however, we took the opportunity to obtain Figure 7, where we compared two 72-d-old rabbits, one with sarcoptic

Figure 7: Seventy two-day old rabbits affected by sarcoptic mange (left) and ringworm (right).

mange (left) and the other with ringworm (right). On farms affected by sarcoptic mange it is not uncommon to find weaned rabbits with lesions. Concerning ear mange, the observation in young rabbits was exceptional; we observed some cases in runts housed on farms with poor hygiene (results not presented). In 2004, on one farm with cases of sarcoptic mange, we acted in coordination with medical services treating scabies in the family of producers, due to contagion from rabbits to humans.

It was necessary to differentiate lesions due to ringworm (Figure 8); In this case there are more scales, fewer and thinner scabs than in mange. Furthermore, in the positive farms there were several sick rabbits, facilitating diagnosis.

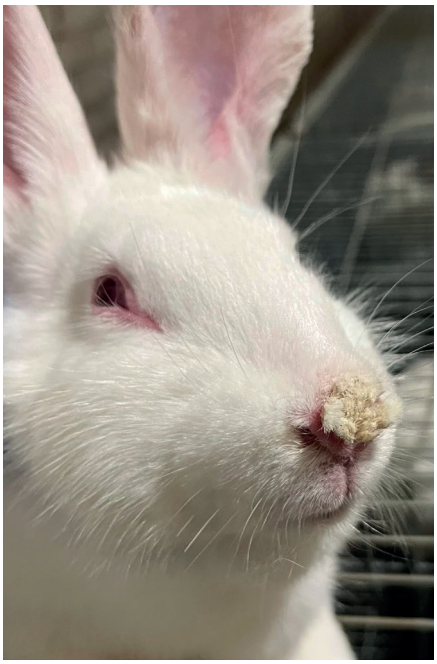

Figure 8: Young doe aged 100 d old with ringworm (*Trichophyton mentagrophytes*, confirmed)

Prevalence of OCM in farmed lactating does

In the course of the 27-yr study, we gathered information on 4272 cohorts during 3796 visits to 891 farms. We examined 212 041 lactating does out of 2 641 709 females at risk (8%); that is, our target. The mean size examined was 50 does out of 427 at risk per cohort. Figure 9 shows the prevalence data from the current study, including the results from a previous study performed from 1991 until 1995, with estimated prevalence of OCM from 5.1% in 1991 to 6.2% in 1995 (Rosell *et al.*, 2000).

The percentage of farms affected by OCM dropped from 55% in 1996 to 28% in 2022. The mean estimated annual prevalence of OCM in does was 3.2% (Confidence Interval/ CI 95%: 3.1-3.3%); there were farms without sick females and some with >90% does with OCM (farms with enzootic disease). At the beginning of the period, estimated prevalence was 7%, decreasing to 2.3% obtained in 2022. The most recent outcome may be a baseline threshold when assessing the sanitary status of farmed does, and the interference level: >10% OCM. However, the final objective was to eradicate mange on farms. For this reason, from 1996 to 2022 we paid special attention to

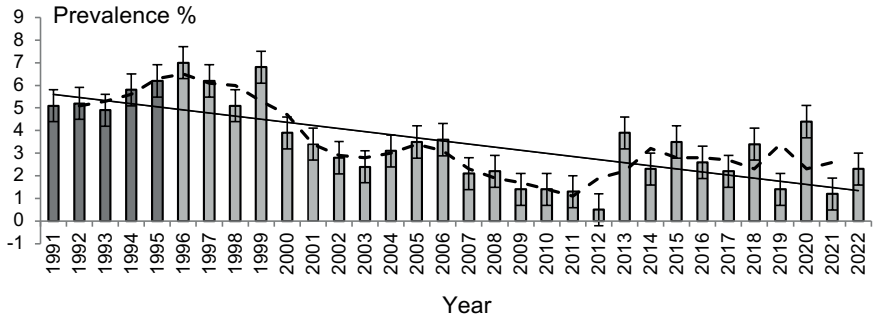

Figure 9: Mean relative and annual prevalence of otodectic clinical mange (OCM) in lactating does, and standard error of mean (95% confidence interval with error bars), rolling average for 3 yr (dotted line) and trend line. This study was based on the clinical examination of 48 701 does from 1991 to 1995 (darker grey columns) (Rosell *et al.*, 2000), and 212 041 does from 1996 onwards in 4272 cohorts and 891 farms (lighter grey columns, present study).

monitoring the sanitary status of breeding rabbits and weaned rabbits on selection and multiplication farms (44), AI centres (13), pet rabbit (4) or restocking farms (6), because they supply live animal material to production farms, rabbits for homes or the environment. It is evident that the work of attending veterinarians on these farms also concerns other diseases.

On-farm risk factors for ear mange in females

The results of the analysis of the risk factors that influenced the estimated prevalence of ear mange are shown in Table 3. The model generated was significant ($P<0.0001$).

The three factors analysed, *year, genetic line of the doe* and *season,* had a significant effect on the prevalence of OCM. The *year* was the independent variable that had the greatest influence on the dependent variable (*OCM)*, followed by *line of breeding rabbits* (5 recorded genetic types with >100 cohorts each). The most affected line over the 27 yr had 4.3% mange prevalence. In contrast, the rabbit line least affected had 2.2%. Wei *et al.* (2019) found different morbidity risks of mange, in females of 2 lines. Differences between year and season were significant. There were more affected does in summer (3.8%) and fewer in winter (2.5%); spring and autumn were transition periods (3 and 3.5%, respectively). Marine (1924) also found greater diffusion of mites in summer.

Prevalence of ear mange in rabbit males

In the course of the 27-yr study we gathered information on 2027 cohorts from 549 farms with 31 843 individually examined males out of 146 249 at risk. The mean number of examined males was 15.7 out of 59 median males at risk (minimum to maximum: 10 to 544 males) per cohort. Figure 10 shows the mean relative and annual prevalence of OCM in males obtained in the current study and on a previous one performed from 1991 until 1995 (Rosell *et al.*, 2000).

During the 27-yr study, mean estimated prevalence was 3.9% OCM in males (95% CI [3.7-4.1%]). Annual mean prevalence dropped from 7.2% in 1996 to 2.2% in 2022. Using the GENMOD procedure, the effects of *year* and *season* on the health of males were significant ($P<0.0001$ for both variables).

Prevalence of ear mange in males from insemination centres

During the 27-yr study, we made 173 visits to 13 insemination centres, located on farms without female rabbits. We examined 11 807 males grouped into 412 cohorts, out of a total of 56 656 at risk. There were 2.4 cohorts per visit, because in the centres there were males with maternal and others with paternal specialisation, from one or several commercial lines (de la Fuente and Rosell, 2012). Overall prevalence for rhinitis was 19.4 and 3.9% for ulcerative pododermatitis, which are normal values (Rosell *et al.*, 2023). We did not find any males affected by otodectic or sarcoptic mange.

Prevalence of ear mange depending on gender

Results for genders on the same farm were based on the examination of 17 302 males and 63 306 females organised in 1443 cohorts obtained on 478 farms visited. Correlation was 0.622 ($P<0.0001$); if does were sick, the bucks often were too. Females came mainly from maternal line; some males belonged to maternal lines, but mostly to those

Table 3: The GENMOD of the risk factors year, season, and line of the doe for the prevalence of otodectic clinical mange, based on physical examination of 212 041 does on 891 commercial rabbit farms in Portugal and Spain, between 1996 and 2022. (df: degrees of freedom).

Factor of variation	df	Chi-squared	*P*>F
Year	26	1643.86	<0.0001
Genetic line of the doe	4	259.61	<0.0001
Season	3	244.47	<0.0001

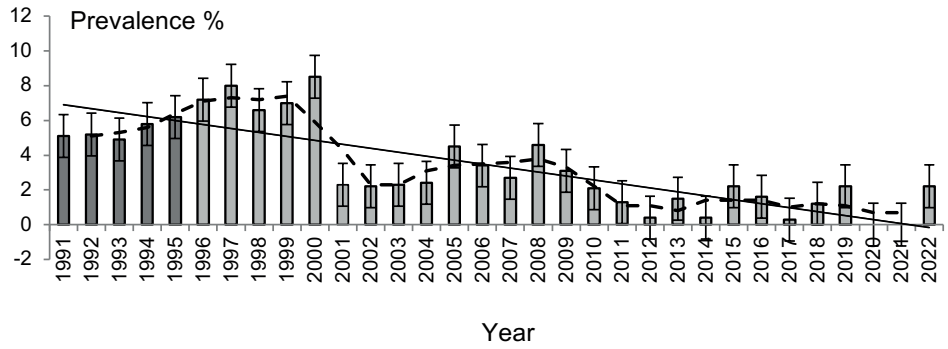

Figure 10: Mean relative and annual prevalence of ear mange in males, and standard error of mean (95% confidence interval with error bars), rolling average for 3 yr (dotted line) and trend line. This study was based on the clinical examination of 10 881 males from 1991 until 1995 (darker columns) (Rosell *et al.*, 2000), and 31 843 males from 1996 onwards in 2027 cohorts and 549 farms (current study).

selected for meat traits (de la Fuente and Rosell, 2012). Figure 11 shows the evolution of the yearly prevalence of OCM in bucks and does, number of farms with males and the use of AI on the farms visited. The number of doe farms where AI was used rose from 2% in 1994 to 95% in 2022.

The decreasing trend in the prevalence of OCM during the 27-yr period, both in bucks and does, might be due to the implementation of AI on the farms, mainly when an external service was used (Rosell *et al.,* 2020). During 1990-1994, farmed rabbit does were serviced by mount. There were 9 does per buck and they served 7.2 does per month. Each female was serviced every 38 days, while a male serviced a female every 4 d (Rosell and Pérez, 1995). Therefore, reproductive management might be the explanation that males were sicker than females. Considering that transmission by direct contact amongst individuals is common in humans and other species (Otero *et al.,* 2004), AI is likely to have contributed to this improvement in sanitation, as it avoids contact between genders. In addition, with AI in rabbitries, producers became better organised and used biosecurity more efficiently (Huneau-Salaün *et al.*, 2015).

Prevalence of mange in the back and dorsal region

During 2018, we clinically checked 7609 rabbit does on 72 rabbitries and 1011 bucks on 17 farms, in addition to 923 unbred females (2.5-5.5 mo-old), gathered in 188 cohorts in total. The check-up protocol included examination of the back and dorsal region of these rabbits, as well as the ears. On 26/72, there were females with lesions on the

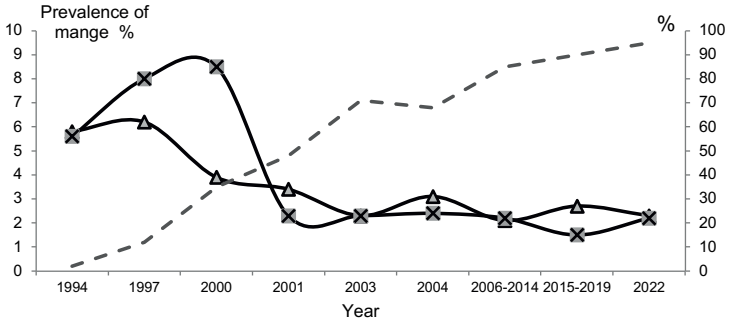

Figure 11: Mean yearly prevalence of otoacariosis in does and bucks, percentage of farms servicing does with AI (dotted line), from 1994 (2%) to 2019 (95%) as pointed out by Rosell *et al.* (2020) and present work. —△— Prevalence of does; —✕— Prevalence of bucks; – – – % doe-farms with artificial insemination.

back, compatible with cheyletiellosis (36.1%). Additionally, on 17/72 farms where none of the adult does had lesions on the back or ears, young does were detected with lesions on the back; between 10 and 58% of young does were affected. In all, 36/72 farms had young or adult does, or both, with lesions on the back compatible with cheyletiellosis (50%). As for the males, we found affected rabbits on 11 farms/17 (64.7%), with a mean prevalence of 11.5% and ranges between 4 and 60%. The presence of lesions in Rex rabbits was particularly noteworthy. These lesions were not intense, but the morbidity risk was high. Flatt and Wiemers (1976) reported 43.2% prevalence in a survey conducted on 6 commercial farms. They found over 50% of unapparent carriers of fur mites.

Control measures: diagnosis, prevention and treatment

Regarding diagnosis, throughout the 27-yr study we identified 6469 females and 935 males with otodectic mange. When diagnosing OCM, other conditions such as pyogenic secretions, necrotising otitis or wax were observed (Rosell, 2023). There were few doubtful cases related to cheyletiellosis, or sarcoptic mange; e.g., due to fur loss or crusting (dermatophytosis, fighting or pyogenic dermatitis), respectively. They were mainly clinical diagnoses, supported sometimes by a laboratorial confirmation. In preventing mange, the critical control points (Noordhuizen *et al.*, 2005) are surveillance and certification of farms supplying young does, and examination on arrival at production farms. With this goal, during 1996-2022 we visited 44 selection and multiplication farms supplying young females to production farms, in addition to 13 insemination centres supplying semen. On affected farms, it is advisable to limit the use of metaphylaxis and improve on-farm biosecurity with the cleaning of barns and equipment completed with steam pressure; temperatures above 60°C kill mites (Van Praag, 2010). Rabbit mange mites can survive off their hosts for between 4 and 21 d; they survive longer at low temperatures: 5°C and high relative humidity: >90%, according to Arlain *et al.* (1981) or in parasitised tissue remains (Niedringhaus *et al.,* 2019). *Notoedres* spp. cannot survive away from the host, as pointed out by Foley *et al.* (2016). In the treatment, we recommend applying products without touching the scabs, as attempting to remove otic crusts is quite painful (White, 2023). Concerning products, we will make special mention of ivermectin. Thus, during 2018-2022, we visited 164 doe farms. The median size was 800 does (minimum to maximum: 100-6000 does). On 156/164 (95.1%), we checked whether producers were using ivermectin; this was the case on 56/156 farms (35.9%). The dosage was 400 µg/kg, which was considered optimal for single infestation by *P. cuniculi* (Pandey, 1989), by *N. cati* (Rajamohanan and Joy, 1989) or mixed infestation by *P. cuniculi* and *S. scabiei* (Divisha *et al.,* 2020), even with three species of mites (Panigrahi *et al.,* 2016). Doses should be adjusted in the case of does from lines selected for meat traits weighing up to an average of 6.3 kg (de la Fuente and Rosell, 2012).

In severe cases, treatment was repeated, as ivermectin and other acaricides do not have ovicidal properties. Mite eggs hatch in 4 d and, besides, this antiparasitic drug has a half-life of 8.3±2.3 d in cattle. Thus, does are treated at least 3 times during their cycle; we coincide with Niedringhaus *et al.* (2019), in that repeating treatment is part of its success in the control. At the end of this 27-yr study, for the treatment of OCM and cheyletiellosis we showed priority for topical phoxim and cypermethrin or diazinon for housing. In severe cases of OCM, cheyletiellosis in Rex rabbits and in sarcoptic cases, the use of ivermectin was our first choice. Topical use of diazinon was not recommended (Varga, 2022). The comparative study of the 3 active ingredients was described by Dik and Uslu (2006), with good results in sarcoptic mange. The majority of products and pesticides are not registered for rabbits; thus, it is essential to use them with caution. Fipronil is not recommended in rabbits as it is toxic (Gupta and Anadón, 2018). Ivermectin has a persistent effect on the environment and affects biodiversity, as reported by Lumaret *et al.* (2012) and Tarazona *et al.* (2021): *extremely high toxicity for invertebrates.* For this reason, we recommend that ivermectin be restricted to cases in which attending veterinarians providing care to rabbit farms deem it essential. Perhaps we will explore the use of other therapeutic alternatives on commercial farms, such as those presented by Fang (2016) or Chebet (2020), amongst others.

CONCLUSIONS

From 1996 to 2022, OCM was frequently diagnosed on commercial farms. Nevertheless, its occurrence decreased from 55% of affected farms to 28% throughout the 27-yr study. In this period, the apparent mean prevalence of OCM (95%) was 3.2% (3.1-3.3%) in females, and 3.9% (3.7-4.1%) in males. Yearly mean prevalence of OCM

decreased from 7% in 1996 to 2.3% in 2022 and from 7.2 to 2.2% in does and bucks, respectively. The occurrence of sarcoptic mange was low, with a cumulative incidence of 13 out of 1368 visited farms being affected; we did not diagnose any cases from 2016 onwards. Hair and skin disorders along the back compatible with cheyletiellosis cannot be underestimated, particularly in Rex rabbits. The improvement in the occurrence of OCM was compatible with the use of AI and purchasing semen from specialised centres; biosecurity measures and medical management also contributed. Lastly, we suggest that the use of ivermectin be limited to cases in which attending veterinarians consider it essential.

Acknowledgements: This study was made possible by the producers who allowed us to visit their rabbitries. Visits were shared with many technicians and veterinarian peers. Professor Arturo Anadón reviewed the original manuscript in relation with treatment of mange. Dr. Daniel Gutiérrez helped us with some mite analyses and Dr. Juan M. Fregeneda with dermatophytes analyses. Catherine R. Martin assisted us with the English language editing. Lastly, the anonymous referees contributed to improving the manuscript. Our recognition goes to all. This article is in memory of Professor Miguel Cordero del Campillo (1925-2020).

Funding: This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Authors contribution: Rosell J.M.: conceptualization, validation, investigation, resources, writing – original draft, writing – review & editing, visualization, supervision and project administration. Fernando de la Fuente L.: conceptualization, validation, investigation, resources, writing – review & editing, visualization and supervision. Casais R.: conceptualization, validation, investigation, resources, writing – review & editing, visualization and supervision.

Ethical statement: No animals were specifically harmed for the purpose of this study.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Arlian L.G., Kaiser S., Estes S.A., Kummel B. 1981. Infestivity of *Psoroptes cuniculi* in rabbits. *Am. J. Vet. Res., 42: 1782-1784.*

Arlian L.G., Morgan M.S. 2017. A review of *Sarcoptes scabiei*: past, present and future. *Parasit. Vectors, 10: 297. https://doi.org/10.1186/s13071-017-2234-1*

Broom D.M., Fraser A.F. 2015. Welfare and behaviour in relation to disease. *In: Domestic Animal Behaviour and Welfare, 5th Ed.; CABI: Wallingford, UK; Chapter 23; 237-246. https://doi.org/10.1079/9781780645391.0246*

Bulliot C., Mentré V., Marignac G., Polack B., Chermette R. 2013. A case of atypical psoroptic mange in a domestic rabbit. *J. Exot. Pet Med., 22: 400-404. https://doi.org/10.1053/j.jepm.2013.10.003*

Cardells J., Lizana V., Martí-Marco A., Lavín S., Velarde R., Rossi L., Moroni B. 2021. First description of sarcoptic mange in an Iberian hare (*Lepus granatensis*). *Curr. Res. Parasitol. Vector Borne Dis., 1: 100021. https://doi.org/10.1016/j.crpvbd.2021.100021*

Casais R., Granda V., Balseiro A., del Cerro A., Dalton K.P., González R., Bravo P., Prieto J.M., Montoya M. 2016. Vaccination of rabbits with immunodominant antigens from *Sarcoptes scabiei* induced high levels of humoral responses and pro-inflammatory cytokines but confers limited protection. *Parasit. Vectors, 9: 435. https://doi.org/10.1186/s13071-016-1717-9*

Chebet J. 2020. Prevalence, treatment options and risk factors associated with mange in central Kenya. *PhD Thesis Univesity of Nairobi, Kenya, 123 pp. Available at http://erepository.uonbi.ac.ke/handle/11295/153158. Accessed October 2023.*

Chiron P., Doré A., Fortun-Lamothe L. 2022. Factors affecting French rabbit farmers' adoption of pro-welfare innovations. *World Rabbit Sci., 30: 249-265. https://doi.org/10.4995/wrs.2022.17882*

Christodoulopoulos G., Burriel A.R., Labrinidi S., Kritas S.K., 2001. Traditional rabbitries on the island of Crete in Greece: general outlook. *World Rabbit Sci., 9: 135-139. https://doi.org/10.4995/wrs.2001.456*

Cohen S.R..1980. *Cheyletiella* Dermatitis. A Mite Infestation of Rabbit, Cat, Dog, and Man. *Arch. Dermatol., 116: 435-437.*

D'Ovidio D., Santoro D. 2013. Orodental diseases and dermatological disorders are highly associated in pet rabbits: a case–control study. *Vet. Dermatol., 24: 531-e125. https://doi.org/10.1111/vde.12052*

D'Ovidio D., Santoro D. 2014. *Leporacarus gibbus* infestation in client-owned rabbits and their owner. *Vet. Dermatol., 25: 46-e17. https://doi.org/10.1111/vde.12089*

De Blas I. 2006. WinEpi Software, Working in Epidemiology. Available online: WinEpi: Working IN EPIdemiology. *Accessed October 2023.*

De la Fuente L.F., Rosell J.M. 2012. Body weight and body condition of breeding rabbits in commercial units. *J. Anim. Sci., 90: 3252-3258. https://doi: 10.2527/jas.2011-4764*

Dik B., Uslu U., 2006. [Effects of Ivermectin, Phoxim and Propetamphos + Cypermethrin Combination Against Sarcoptic Mange in New Zealand Rabbits]. (In Turkish, abstract in English). *Vet. Bil. Derg., 22: 97-101. https://eurasianjvetsci.org/summary_en.php3?id=79*

Divisha R. Soundararajan C., Arul Prakash M. 2020. Therapeutic management of concurrent Sarcoptic and Psoroptic mange infestation in rabbits. *J. Entomol. Zool. Stud., 8: 1041-1043.*

Fang F., 2016. Susceptibility to acaricides and genetic diversity of *Sarcoptes scabiei* from animals. *PhD. Thesis, Université París-Est, France, 128 pp.*

Flatt R.E., Wiemers J. 1976. A survey of fur mites in domestic rabbits. *Lab. Anim. Sci., 26: 758-761.*

Foley J., Serieys L.E.K., Stephenson N., Riley S., Foley C., Jennings M., Wengert G., Vickers W., Boydston E., Lyren L., Moriarty J., Clifford D.L., 2016. A synthetic review of *notoedres* species mites and mange. *Parasitology, 143: 1847-1861. https:// doi.org/10.1017/S0031182016001505*

Gupta R.C., Anadón A. 2018. Fipronil. Chap 42 in: *Veterinary Toxicology. Basic and Clinical Principles. Gupta R.C. (Ed.), 3rd Ed., Academic Press, London U.K., 533-538. https://doi.org/10.1016/B978-0-12-811410-0.00042-8*

Harkness J.E., Turner P.V., VandeWoude S., Wheler C.L. *2010. Harkness and Wagner's Biology and Medicine of Rabbits and Rodents, 5th Ed.; Wiley-Blackwell: Ames, IA, USA.*

Harvey R.G. 1990. *Demodex cuniculi* in dwarf rabbirs *(Oryctolagus cuniculus). J. Small Anim. Pract., 31: 204-207. https://doi.org/10.1111/j.1748-5827.1990.tb00774.x*

Huneau-Salaün A., Bougeard S., Balaine L., Eono F., Le Bouquin S., Chauvin C. 2015. Husbandry factors and health conditions influencing the productivity of French rabbit farms. *World Rabbit Sci., 23: 27-37. https://doi.org/10.4995/wrs.2015.3076*

Kirwan A.P., Middleton B., McGarry J.W., 1998. Diagnosis and prevalence of *Leporacarus gibbus* in the fur of domestic rabbits in the UK. *Vet. Rec., 142: 20-21. https://doi.org/10.1136/vr.142.1.20*

Kraus A. L. 1974. Arthropod parasites. *in: The Biology of the laboratory rabbit. Weisbroth S.H., Flatt R.E., Kraus A.L. (Eds.), 1st Ed., Academic Press, Inc., New York, NY, USA, Ch 12, 287-315. https://doi.org/10.1016/B978-0-12-742150-6.50017-7*

Larkin D.J. Tjeerdema R.S. 2000. Fate and effects of diazinon. (Abstract). *Rev. Environ. Contam. Toxicol., 166: 49-82.*

Lumaret J.-P., Errouissi F., Floate K. Römbke J., Wardhaugh K. 2012. A review on the toxicity and non-target effects of macrocyclic lactones in terrestrial and aquatic environments. *Curr. Pharm. Biotechnol., 13: 1004-1060. https://doi.org/10.2174/138920112800399257*

Low R.C. 1911. An investigation into scabies in laboratory animals. *J. Pathol. Bacteriol., 15: 333-357. https://doi.org/10.1002/path.1700150309*

Mancinelli E., Lennox A.M. 2017. Management of otitis in rabbits. *J. Exot. Pet. Med., 26: 63–73.* http://dx.doi.org/10.1053/j.jepm.2016.10.009

Marine D. 1924. The cure and prevention of ear canker in rabbits. *Science, 60: 158. https://doi.org/10.1126/science.60.1546.158.a*

Meana A. 1999. Parasitosis cutáneas (del conejo). Ch 41 in: *Parasitología Veterinaria. Cordero M., Rojo F.A. Eds. McGraw-Hill Interamericana, Madrid, Spain, 477-450.*

Millán J., Casáis R., Delibes-Mateos M., Calvete C., Rouco C., Castro F., Colomar V., Casas-Díaz E., Ramírez E., Moreno S., Prieto J.M., Villafuerte R. 2012. Widespread exposure to *Sarcoptes scabiei* in wild European rabbits (*Oryctolagus cuniculus*) in Spain. *Vet. Parasitol., 183: 323-329. https://doi.org/10.1016/j.vetpar.2011.07.046*

Mullen G.R., OConnor B.M. 2019. Mites (Acari), *in: Medical and Veterinary Entomology. Mullen G.R. Durden L.A., (Eds), 3rd Ed.; Academic Press, London, UK. Chap 26, 533-602. https://doi.org/10.1016/B978-0-12-814043-7.00026-1*

Niedringhaus K.D., Brown J.D., Sweeley K.M., Yabsley M.J. 2019. A review of sarcoptic mange in North American wildlife. *IJP: Parasites and Wildlife, 9: 285-297. https://doi.org/10.1016/j.ijppaw.2019.06.003*

Noordhuizen J.P.T.M., Metz J.H.M. 2005. Quality control on dairy farms with emphasis on public health, food safety, animal health and welfare. *Livest. Prod. Sci., 94: 51-59. https://doi.org/10.1016/j.livprodsci.2004.11.031*

Osborne H.G. 1947. Dimethyl phthalate for the treatment of mange in rabbits caused by *Notoedres cati* Var. *cuniculi.* (Gerlach 1857). *Aust. Vet. J., 24: 52. https://doi.org/10.1111/j.1751-0813.1947.tb04513.x*

Otero L., Varela J.A., Espinosa E., Sánchez C., Junquera M.L., del Valle A., Vázquez F., 2004. *Sarcoptes scabiei* in a sexually transmitted infections unit - a 15-year study. *Sex. Transm. Dis., 31: 761-765. https://doi.org/10.1097/01.olq.0000145853.35574.18*

Pandey V.S., 1989. Effect of ivermectin on the ear mange mite *Psoroptes cuniculi* of rabbits. *Br. vet. J., 145: 54-56. https://doi:10.1016/0007-1935(89)90009-2*

Panigrahi P.N., Mohanty B.N., Gupta A.R., Patra R.C., Dey S. 2016. Concurrent infestation of Notoedres, Sarcoptic and Psoroptic acariosis in rabbit and its management. *J. Parasit. Dis., 40: 1091-1093. https://doi.org/10.1007/s12639-014-0631-3*

Radi Z.A., 2004. Outbreak of Sarcoptic Mange and Malasseziasis in Rabbits (*Oryctolagus cuniculus*). *Comp. Med., 54: 434-437.*

Rajamohanan K., Joy A.D. 1989. A note on mange caused by *Notoedres cati* in a rabbit colony in Kerala and its treatment with ivermectin. *J. Appl. Rabbit Res., 12: 27-28.*

Rosell J.M. 2003. Health status of commercial rabbitries in the Iberian peninsula. A practitioner's study. *World Rabbit Sci., 11: 157-169. https://doi.org/10.4995/wrs.2003.505*

Rosell J.M. 2023. Application systems for on-farm treatment against mange. *Images. https://www.cunivetservice.com/wp-content/uploads/2023/06/Mange.Farm_.Rabbits.Images.5th.June_.2023.pdf. Accessed October 2023.*

Rosell J.M., Pérez M.J. 1995. Resultados de gestión técnico-económica 1994. *Cunicultura 114, 67-70.*

Rosell J.M., de la Fuente L.F., 2009. Culling and mortality in breeding rabbits. *Prev. Vet. Med., 88: 120-127. https://doi.org/10.1016/j.prevetmed.2008.08.003*

Rosell J.M., de la Fuente L.F. 2018. Mastitis on rabbit farms: prevalence and risk factors. *Animals, 8: 98. https://doi.org/10.3390/ani8060098*

Rosell J.M., Dronda M.A., de la Fuente L.F. 2000. [Dermatology]. *In: [Diseases of the rabbit], Rosell J.M. Ed., Vol II, Mundi-Prensa Libros S.A., Madrid, Spain, 355-398.*

Rosell J.M., de la Fuente L.F., Carbajo M.T., Fernández X.M. 2020. Reproductive diseases in farmed rabbit does. *Animals, 10, 1873. https://doi.org/10.3390/ani10101873*

Rosell J.M., de la Fuente L.F., Parra F., Dalton K.P., Badiola Sáiz J.I., Pérez de Rozas A., Badiola Díez J.J., Fernández de Luco D., Casal J., Majó N., Casas J., Garriga R., Fernández Magariños X.M. 2019. Haemorrhagic disease: a 30-year study of the occurrence on commercial farms in Spain. *Animals, 9, 780. https://doi.org/10.3390/ani9100780*

Rosell J.M., de la Fuente L.F., Badiola J.I., Pérez de Rozas A., Fernández de Luco D., Arnal M.C., Casal J., Fernández X.M., Pinto de Carvalho A. 2023. Respiratory disorders of farmed rabbits: occurrence and risk factors. *World Rabbit Sci., 31: 147-161. https://doi.org/10.4995/wrs.2023.18280*

SAS Institute 2004. SAS User's Guide: Statistics, Version 9.1 SAS® *SAS Institute Inc., Cary, NC, USA.*

Scott D.W., Miller W.H., Griffin C.E. 2001. Dermatoses of pet rodents, rabbits, and ferrets. *In*: *Small Animal Dermatology (Muller & Kirk's). 6th ed. W. B. Saunders, Philadelphia, PA, USA, Chapter 21, 1415-1458. https://doi.org/10.1016/B978-0-7216-7618-0.50025-0*

Shen N., Wei W., Chen Y., Liu S., Xiong L., Xiao J., Gu X., Xie Y., Xu J., Jing B., Peng X., Yang G. 2023. Vaccination with a cocktail vaccine elicits significant protection against *Sarcoptes scabiei* in rabbits, whereas the multi-epitope vaccine offers limited protection. Exp. Parasitol., *245: 108442. https://doi.org/10.1016/j.exppara.2022.108442*

Tarazona J.V., Martínez M., Martínez M.A., Anadón A. 2021. Environmental impact assessment of COVID-19 therapeutic solutions. A prospective analysis. *Sci. Total Environ., 778: 146257. https://doi.org/10.1016/j.scitotenv.2021.146257*

Thrusfield M. 2018. Patterns of disease. In: *Veterinary Epidemiology, 4th Ed. John Wiley & Sons Ltd: West Sussex, UK, 168-188. ISBN: 978-1-118-28028-7.*

Timm K.I. 1988. Pruritus in rabbits, rodents, and ferrets. *Vet. Clin. North* Am. Small Anim. *Pract., 18: 1077-1091. https://doi.org/10.1016/S0195-5616(88)50110-9*

Turner P.V., 2018. Rabbits. *In: Pathology of small mammal pets, Turner P.V., Brash M.L., Smith D.A., 1st Ed. Wiley-Blackwell, Howoke, NJ, USA, Chapter 1, 1-88.*

Van Praag E., Maurer A., Saarony T. 2010. *Skin diseases of rabbits. Medirabbit.com, Switzerland. XXI.*

Varga M. 2022. Parasitic skin disease (Skin diseases). *In: Textbook of Rabbit Medicine, 3rd Ed., Elsevier, Chapter 8, 242-267. https://doi.org/10.1016/B978-0-7020-8403-4.00008-9*

Wei W., Ren Y., Shen N., Song H., Xu J., Hua R., Zhang H., Angel C., Gu X., Kuang L., Xie Y., Peng X., Xie X., Yang G. 2019. Comparative analysis of host resistance to *Sarcoptes scabiei* var. *cuniculi* in two different rabbit breeds. *Parasit. Vectors, 12: 530. https://doi.org/10.1186/s13071-019-3764-5*

White, S D., 2023. Rabbit dermatology, in: *(Exotic Animal) Dermatology, D'Ovidio D., Santoro D. Eds. Vet. Clin. North* Am. *Exot. Anim. Pract., 26: 347-357. https://doi.org/10.1016/j.cvex.2022.12.002*

White S.D., Bourdeau P.J., Meredith A. 2002. Dermatologic problems of rabbits. *Semin. Avian Exot. Pet Med., 11: 141-150. https://doi.org/10.1053/saep.2002.123982*

Wilkins CA, Conroy JA, Ho P, O'Shanny WJ, Malatesta PF. 1980. Treatment of psoroptic mange with avermectins. *Am. J. Vet. Res., 41: 2112-2114.*