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The Italian Mouflon (*Ovis musimon*): A Brief History of its Parasites in the Last 45 Years

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Abstract

Over recent decades, the interest in wildlife has remarkably increased amongst veterinarians and the mouflon and its related parasitic diseases were amongst the investigated topics. In Italy, the mouflon is widespread in the Alps, central-north Apennines, and Sardinia. Population size was estimated at about 20,000 heads in 2010. However, mouflons are currently on the decrease in the Alps due to wolf predation and high hunting pressure to prevent competition with native Caprines. Veterinary parasitologists largely contributed to the understanding of pathogens and their ecological roles amongst native and introduced mouflons into Italy. Their work, including "grey" literature, was collected on a floppy disk for the first time in the 1990s. A second update appeared in the first decade of the new century. Along these lines, we also revisited and collected data concerning the last 20 years, thus creating a website (http://www.parasitepub.altervista.org) which can be consulted virtually and universally. To create our database, we searched and classified the publications retrieved from annals of academic departments, journals, conference proceedings, university libraries and on-line data banks. Our database aims to be as up-to-date as possible and as updatable as possible. Contributions were classified according to four interpretative levels. Our search is based on the retrieval of 47 papers from 1970 to 2015. The studied mouflons originated mainly from Northern Italy (57%), followed by Central Italy (28%) and Sardinia (15%). Among parasite groups, nematodes were the most frequently studied (44% of papers) followed by arthropods (15%), protozoa (12%), trematodes and cestodes (11%), dermatophytes (7%). The analysis of ecopathological levels revealed the predominance of the first (56%) followed by the second (23%), the third (18%) and the fourth (3%). The newly created website is intended as an easy-to-use bibliographic tool to support investigation on parasites and parasitic diseases in free-ranging wildlife in Italy.

Keywords

Mouflon; Parasites; Disease; Wildlife; Website; Database; Italy

Introduction

The mouflon (*Ovis musimon*), which recently has risen to scientific topicality since it was a part of the Neanderthal diet [1] which is a mammal belonging to the Bovidae family. Today, in the Mediterranean basin this ungulate inhabits Sardinia, Corsica, the islands of Cyprus and Rhodes. It was introduced into Central Europe, Chile and the USA. In Italy it is also widespread in some minor islands, Trentino, northern-central Apennines and Gargano peninsula. The italian mouflon population consists of 19,670 units (ISPRA, 2010), 40% of which live in Sardinia (the latest data report that there were 8,000 heads on the island in 2015).

During the Neolithic age in Sardinia some domestic sheep returned to the wild. In the mid-20th century the island mouflon population crashed (only 300 in 1970). In the same period the mouflon started to be breed in the continent, mainly in Tuscany at a private preserve. At the end of the 20th century the mouflon was spread with success all over the Alps with hunting purpose. Few animals remained in Tuscany. In the 21st century the repentant hunters realized that the presence of mouflons competed with precious alpine ungulates, chamois (*Rupicapra rupicapra*) and alpine ibex (*Capra ibex*). In Sardinia an important conservation program was carried out since 1970. The result was so promising that the last counting refers to about 8,000 heads.

This work aims to underline the importance of wildlife and environment, the role of parasites in wild populations, the health interface between domestic animals and wildlife and the growing involvement of veterinarians in the studies on wildlife parasites. In fact, veterinary parasitologists largely contributed to the understanding of pathogens and their ecological roles amongst native and introduced mouflons into Italy. Their work, including "grey" literature, was collected-on a floppy disk-for the first time in the 1990s [2]. A second update appeared in the first decade of the new century [3]. Along these lines, we revisited, collected and organized data concerning the last 20 years, thus creating a website (http://www.parasitepub.altervista.org) which can be consulted virtually and universally [4]. To create our database, we searched and classified the publications retrieved from annals of academic departments, journals, conference proceedings, university libraries and on-line data banks. In this study we collected and analyzed 47 papers from 1970 to 2015.

Materials and Methods

We consulted different sources, such as annals of academic departments, journals, conference proceedings, university libraries and online data banks. We also asked our colleagues working on this topic to give us their "grey literature". In this way we could remedy the fact that many papers are not available online, but we also had to consider that some of the work can be accessed in summary form only, so we can't publish full text articles because of legal trouble with editors. Before inserting into database, each paper was read and classified according to the following four interpretative levels created by Guberti and Rossi [5]: Level 1-basic knowledge, pathogens' isolation, serological positivity; Level 2-study and description of biological cycles, prevalence, incidence, abundance, mean intensity, richness, importance index, dominance index and seasonal behaviour; Level 3-quantitative study of the interactions between host population and parasite; frequency distribution; impact of pathogens on host population dynamics; Level 4-guidelines for control or eradication of parasites' infections in wildlife. Studies were collected and organized into a database with the following attributes: author, title, year and journal (source), animal, parasite and level. This database is accessible through a website equipped with a smart search engine and real time graphs.

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Results and Discussion

Our search was based on the retrieval of 47 papers from 1970 to 2015, with 4 peaks of five, four, four and three papers in 1988, 1990, 1996 and 2006 respectively (Figure 1). The peaks are easy to interpret if you consider that our search appears in the same years of national congress of parasitology and Eco pathology. The studied mouflons originated mainly from Northern Italy (57%), followed by Central Italy (28%) and Sardinia (15%). Except Sardinia, where shooting is forbidden, this distribution reflects the hunting use of the mouflon which offers more opportunities for parasitological surveys. Papers referred to nine regions and mirrored the current presence of this ungulate (Figures 2A and 2B). Among parasite groups, nematodes were the most frequently studied (44% of papers), followed by arthropods (15%), protozoa (12%), trematodes and cestodes (11%), dermatophytes (7%) (Figure 3). The first place occupied by nematods is probably due to their availability in faeces and internal organs of dead or hunted animals or their freezing tolerance and resistance to the body decomposition; the second place occupied by the arthropods could be due to the major waves of mange epidemic in chamois in the Alps which extend the parasitological interest to mouflons too. The list of parasites isolated in national mouflons is summarized in Table 1. The parasites marked with an asterisk are specific to precious

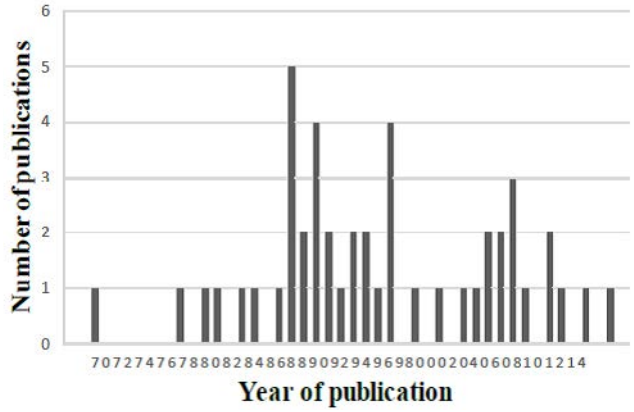

Figure 1: Number of publications per year. The graph shows the total number of papers from 1970 to 2015, with 4 peaks of five, four, four and three papers in 1988, 1990, 1996 and 2006 respectively.

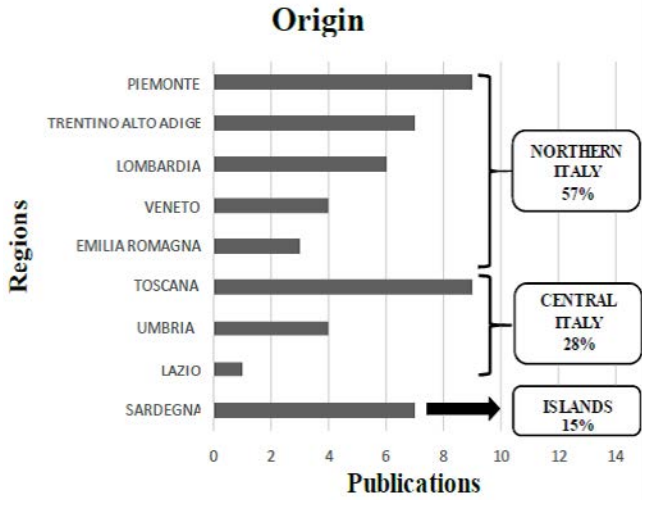

Figure 2A: Origin of the *mouflons. A.* The mouflons studied originated mainly from Northern Italy (57%), followed by Central Italy (28%) and Sardinia (15%).

Figure 2B: Origin of the *mouflons. B.* The graph also shows the distribution of the ungulate in nine regions.

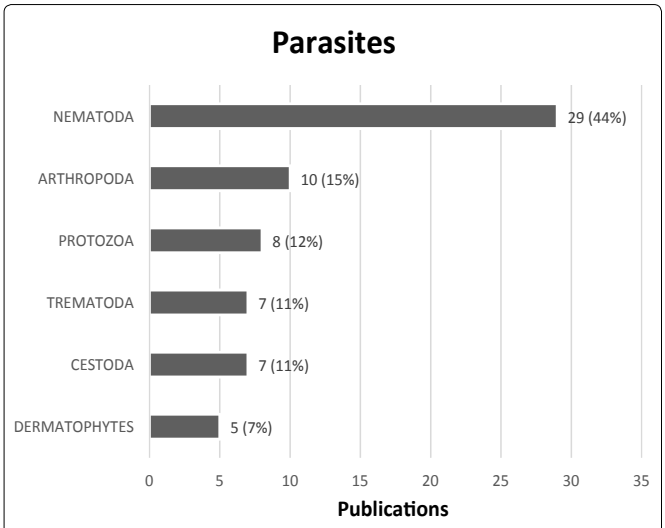

Figure 3: Parasites of mouflons. Nematoda are the most studied parasites (44% of publications), followed by Arthropoda (15%), Protozoa (12%), Trematoda and Cestoda (11%), Dermatophytes (7%).

Table 1: List of parasites (isolated at least at the genus level). The parasites marked with an asterisk are specific to precious alpine ungulates.

Abomasum 16	**Respiratory System 14**
Haemoncus contortus	*Muellerius* sp.
H. placei	*M. capillaris*
Ostertagia leptospiculatis	*M. tenuispiculatus**
O. ostertagi	*Cystocaulus* sp.
O. lyrata	*C. ocreatus*
O. circumcincta	*Dictyocaulus* sp.
*O. (Skrjabinagia) kolchida**	*D. filaria*
O. (S.) lyrataeformis	*Protostrongylus* sp.
*Spiculopteragia spiculoptera**	*P. rupicaprae**
Teladorsagia circumcincta	*P. rufescens*
T. trifurcata	*P. hobmaieri**
T. pinnata	*Neostrongylus linearis*
T. davtiani	*Spiculocaulus austriacus**
Trichostrongylus axei	*Oestrus ovis*
Marshallagia marshalli	
*M. occidentalis**	**Skin 12**
	Sarcoptes scabiei
Small Intestine 20	*Ixodes* spp.
Eimeria spp.	*Ixodes ricinus*
E. faurei	*Dermacentor marginatus*
Avitellina centripunctata	*Rhipicephalus sanguineus*
Moniezia expansa	*R. bursa*
Nematodirus sp.	*Hyalomma lusitanicum*
N. europaeus	*Haemaphysalis* sp.
N. filicollis	*H. punctata*
*N. oiratianus**	*Microsporum gypseum*
N. spathiger	*Thrichophyton terrestre*
*N. davtiani alpinus**	*T. ajelloi*
*N. abnormalis**	
N. battus	**Liver 3**
T. capricola	*Dicrocoelium dendriticum*
T. colubriformis	*D. orientalis*
T. vitrinus	*Fasciola hepatica*
T. longispicularis	
Cooperia curticei	**Others 8**
Bunostomun trigonocephalum	*Toxoplasma gondii*
Strongyloides sp.	*Sarcocystis* sp.
*Ascaris***?**	*Coenurus cerebralis*
	Cysticercus tenuicollis
Cecum/Colon 6	*Multiceps multiceps*
Oesophagostomum venulosum	*Echinococcus granulosus*
Trichuris globulosa	*Echinococcus* (generic)
T. skrjabini	*Aspergillus fumigatus*
T. discolor	*Penicillum* sp.
T. ovis	
Chabertia ovina	

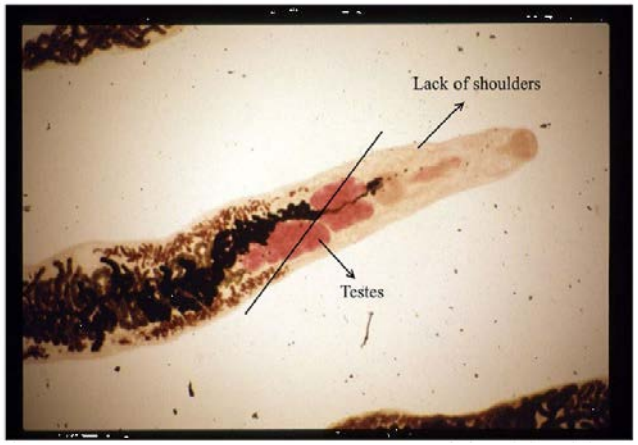

Figure 4A: Differences between *Dicrocoelium dendriticum* and *D. orientalis*. *A. D. dendriticum* is characterized by oblique testes and lack of shoulders.

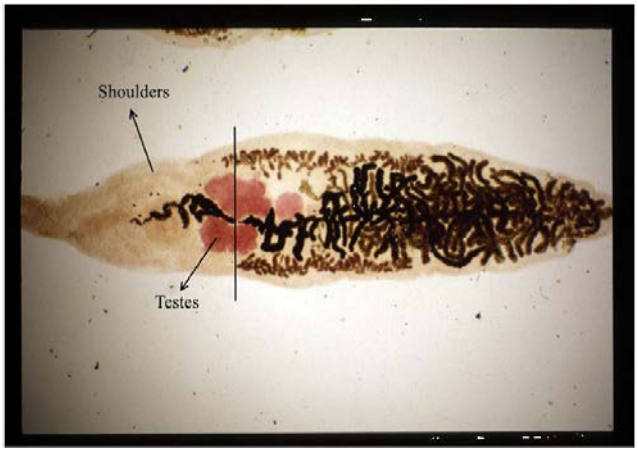

Figure 4B: Differences between *Dicrocoelium dendriticum* and *D. orientalis*. *B. D. orientalis* shows parallel testes and presence of shoulders.

alpine ungulates. Among these, it is important to notice the presence of a trematode isolated for the first time in our country: *Dicrocoelium orientalis* [6]. The main morphological features allowing us to distinguish it from the common *D. dendriticum*, a parasite of domestic ruminants, are the position of the testes which are parallel and the presence of shoulders (Figures 4A and 4B). The seasonal migration of alpine ungulates creates common pasture. The mouflon, naturally attracted to domestic flocks, acts as a «shuttle» for parasites between sheep, chamois and ibex. In fact bronchopulmonary parasites of sheep and goats, such as *Neostrongylus linearis*, *Protostrongylus rufuscens*, *Cystocaulus ocreatus* and *Muellerius capillaris* [6], had been isolated in mouflons along with *M. tenuispiculatus, P. rupicaprae, P. hobmaieri* and *Spiculocaulus austriacus* characteristic of alpine ruminants (Table 1). Four papers put forward this thesis. The analysis of ecopathological levels revealed the predominance of the first (56%), followed by the second (23%), the third (18%) and the fourth (3%) (Figure 5). Level 1 is the starting point for the following studies of pathogens, so it is characterized by a high percentage which is also due to its easier realization. Level 2 and level 3 are rarer because of the lack of knowledge on biological cycles and seasonal dynamics of some parasites and the complexity of mathematical and statistical models used to describe the frequency distribution

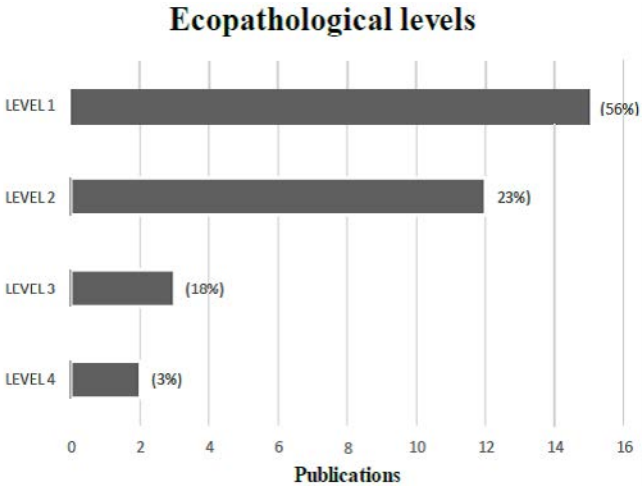

Figure 5: Ecopathological levels The graph shows the predominance of the first level (56%), followed by the second (23%), the third (18%) and the fourth (3%).

and the impact of pathogens on host population dynamics. The percentage of level 4 is certainly low because of the high difficulty in formulating a wildlife management plan. At the present moment the only possible theoretical approach consists of isolating sick wildlife or treating domestic animals which can share pasture with wild ones, as demonstrated by the success obtained in other alpine situations [7].

Conclusion

Wildlife is generally less studied than domestic animals but it plays a important role in the epidemiology of infectious and parasitic diseases needs to be better understood, as thus the possibility of an interaction between wild and domestic animals. If now the mouflon is an important member of the Italian wild fauna, considering the importance of parasites, the production of just 47 papers in 45 years is too limited. Nevertheless, it is worth nothing that only 3% of this papers concern management aspects (level 4). Particularly in the case of the mouflon, its role of «shuttle» should be supported by an echopatological approach using parameters such as prevalence, incidence, abundance, mean intensity, richness, importance index, frequency distribution and seasonal behaviour, also related to others animal populations in the environment. The newly created website is intended as an easy-to-use bibliographic tool to support investigation on parasites and parasitic diseases in free-ranging wildlife in Italy to support the development of future research.

Acknowledgements

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