A PROPOSED METHODOLOGY FOR THE USE OF HELMINTH PARASITES AS BIOLOGICAL TAGS IN THE STUDY OF POSTFIRE ECOSYSTEM REGENERATION PROCESSES

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HELMINTHS
BIOLOGICAL TAG
INSECTIVORES
RODENTS
FIRE
BURNT MEDITERRANEAN ECOSYSTEMS
POSTFIRE REGENERATION

ABSTRACT. – Helminth parasites (trematodes, cestodes, nematodes and acanthocephalans) are able to provide a variety of information on their hosts. The study of the dynamics of helminth parasite populations in small mammals (Insectivores and Rodents) captured in Mediterranean ecosystems affected by fire represent a new source of information about the scarring processes of the affected areas. The study of the burnt area includes knowledge of their ecological characteristics before the fire, the type of fire that affected the study area, climate in the region, the evaluation of unburnt control areas, the prospective methodology used in application to the small mammals in the area, and the selection of model hosts and helminths.

HELMINTHES
INDICATEURS BIOLOGIQUES
INSECTIVORES
RONGEURS
INCENDIE
ECOSYSTÈMES MÉDITERRANÉENS
RÉGÉNÉRATION POST-INCENDIE

RÉSUMÉ. – L'incendie représente une expérience grandeur nature unique qui permet de tester, *in situ*, certaines hypothèses concernant les processus de recolonisation et la dynamique des populations animales soumises à des variations brutales des facteurs du milieu. Tout colonisateur est susceptible d'emmener avec lui tout ou partie de ses parasites dans son nouveau milieu. Les modalités spatio-temporelles de la dissémination ont donc leurs conséquences sur la parasitofaune qui peut-être utilisée comme un véritable traceur biologique de la colonisation. Menée parallèlement aux suivis post-incendie des populations de Micromammifères (Insectivores et Rongeurs), l'étude de leur helminthofaune (Trématodes, Cestodes, Nématodes et Acanthocéphales) apporte de nombreuses informations sur leurs hôtes. L'analyse simultanée de la dynamique des populations des Helminthes et des Micromammifères suivis lors de l'étude d'écosystèmes perturbés par l'incendie représente une nouvelle source d'informations concernant l'impact et les processus de cicatrisation des zones affectées. L'étude des zones brûlées inclut la connaissance et les caractéristiques écologiques après le passage du feu, le type d'incendie qui affecte la zone étudiée, le climat de la région, l'évaluation des zones témoins non brûlées, la méthodologie prospective mise en application sur les petits Mammifères et la sélection du modèle hôtes-Helminthes.

INTRODUCTION

In addition to the major importance of parasites in medical pathology and in veterinary practice, parasitological studies have been found to provide important and varied information on the characteristics of their hosts. In this sense, helminths (trematodes, cestodes, nematodes and acanthocephalans) may provide highly useful data on the biology, ecology, zoogeography, systematization, evolution and phylogeny of their hosts. Even diet, the trophic chain, ethology and activity rhythm of the hosts bear a direct relation to their parasites. Parasitology is also important in relation to the ecology of isolated ecosystems, and general aspects such as parasitological characteristics in isolated ecosystems, the influence of insularity upon parasitological fauna, the applied interest of parasites in insular zoogeography, and the sanitary-hygienic relevance of helminths in insular populations of small mammals have been investigated by a number of authors (Mas-Coma & Feliu 1984, Mas-Coma *et al.* 1987a,b). The possible regulatory effects of parasites – both microparasites (viruses, fungi and protozoos) and macroparasites (helminths and arthropods) – upon the growth of their corresponding host populations

have been the subject of many studies, including the pioneering work by Anderson (1978, 1979), Anderson & May (1978, 1979), May (1983), May & Anderson (1978, 1979). Such studies have discovered that the analysis of the inter-relations between host and parasite species provides important data on the ecology, dynamics, evolution, biodiversity and biogeography of the populations and communities living in the wild (see review by Thomas *et al.* 1996).

In this sense, emphasis should be placed on the importance of parasites – and in particular of helminths – as specific biological tags. This usefulness of parasites is related to their peculiar biology, and to the fact that many of them have complex life cycles involving different hosts. Thus, some hosts hold the larval stage of the parasite (intermediate hosts), while others are parasitized by the adult stage (definitive host). Likewise, the life cycles of helminths may involve both parasitic and free stages, and the latter may in turn be either active or inactive (resistance forms). Likewise, the ecology of parasites is of fundamental relevance, particularly as regards established host-parasite specificity in the different life cycle stages.

On the other hand, in the Mediterranean regions the spread and proliferation of forest fires has become a matter of considerable concern. Fire destroys hundreds of thousands of hectares of vegetation yearly in these regions, and in certain cases it represents a habitual phenomenon with a great capacity to disturb natural ecosystems. In this sense, all research aimed at evaluating the consequences of fire upon the flora and fauna of the affected zones, and in particular those studies addressing the scarring and recovery of burnt ecosystems, are of maximum priority for they allow the *in situ* evaluation of the hypothesis of ecological succession. Thus, work is required to gain insight to the processes of recolonization and the dynamics of populations subjected to either drastic or progressive environmental variations.

A number of studies have analyzed the impact of fire upon the soil, vegetation, avian species, arthropods and small mammals in the Mediterranean (Prodon *et al.* 1985, 1987, Athias-Binche *et al.* 1987, Prodon 1987, Fons *et al.* 1988, 1993, 1996, Arrizabalaga *et al.* 1993). Similar research has also been conducted in small mammals in Australia (Fox 1982, 1983, 1990, Fox *et al.* 1985, Spratt 1987, Kemper 1990, Wilson 1991, Higgs & Fox 1993), North America (Kaufman *et al.* 1983, 1989, Fox *et al.* 1985, Clark & Kaufman 1990), South Africa (Fox *et al.* 1985) and in the Middle East (Haim 1993). According to these studies, even several years after a fire the fauna and vegetation continue to exhibit a situation of reciprocal imbalance, and the dynamics of the normalization process are still uncertain. Nevertheless, it seems clear that recovery tends to involve a return to pre-burn conditions.

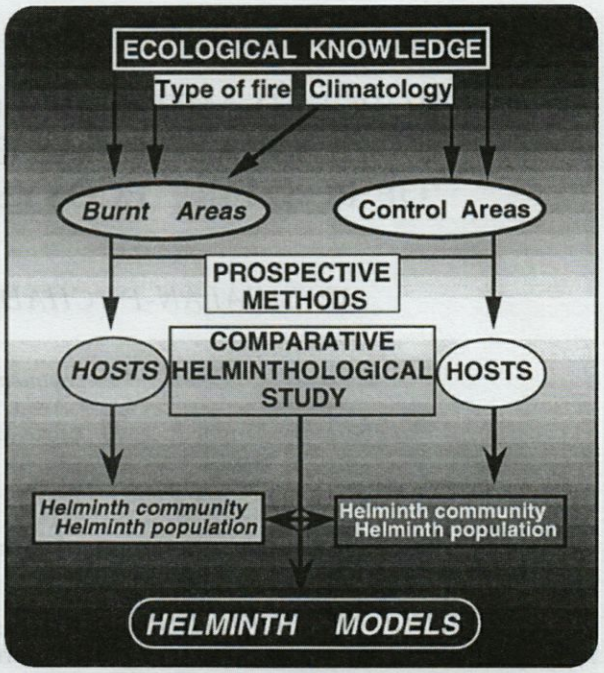

Fig. 1. – Schematic representation of the proposed methodology (see text).

The results reported to date in the Mediterranean regions suggest that the study of the dynamics of helminth parasite populations in small mammals (Insectivores and Rodents) captured in areas affected by fire represent a new source of information about the scarring processes of the affected areas. It is evident that host dissemination strategy after fire has repercussions upon its parasitic fauna, which can thus be used as an indicator of recolonization (Galán-Puchades *et al.* 1990, 1992, 1993, Feliu *et al.* 1993, Fuentes *et al.* 1993, Galán-Puchades & Fuentes 1996).

The aim of the paper is to provide a step-by-step description of the method of study of the burnt area to follow-up on the post-fire regeneration process, when using as biological tags a series of helminths that parasitize small mammals (Insectivores and Rodents) captured in the affected areas (Fig. 1).

THE STUDY OF THE BURNT AREA

Step 1 : Ecological knowledge

Burnt areas : The regeneration process of the environment in terms of soil and vegetation determines the dynamics of recolonization by small

mammals. In turn, this global regeneration process is influenced by the characteristics of the ecosystem before the fire. Consequently, when investigating an area affected by fire, as much information as possible must be gathered on the ecological variables (fundamentally edaphic and concerning vegetation cover) present before the fire. Comprehensive data should also be obtained on the pre-burnt vertebrate and invertebrate fauna. This information is moreover essential for the search of a valid control area in order to establish helminthic controls of the study host or hosts.

Fire : Knowledge regarding the type and intensity of the fire that affected the study area is very important for the evaluation of outcome. If the fire is merely superficial or affects shrubs, bushes and trees, then the mastozoological and helminthological results obtained may be masked by the fact that the study zone receives a constant influx of individuals originating from possible intact "islands" within the burnt zone. It must also be taken into account that, within the study zone and provided the fire has not been too intense, part of the autochtonous small mammal population remains intact in cracks and fissures within walls or stones. These phenomena would preserve a remnant of parasites – particularly of those with direct cycles without intermediate hosts – that would have gone unnoticed under other conditions and which in part mask the post-burn perturbations. In contrast, following subsoil fires, which are much more destructive, the captures made in the affected zones probably correspond to populations recolonizing allochtonous populations in the first few years after the fire or, in subsequent years, to recolonizing populations already consolidated within the recovering territory.

Climatology : Emphasis should be placed on the importance of climatological conditions in the study zone after the fire – particularly as regards rainfall and temperatures. The influence of fire upon mammals and helminths is closely related to the recovery rate of the vegetation cover, which in turn is undoubtedly linked to the rainfall and temperatures recorded mainly in the months following the fire.

Step 2 : Control areas

Before evaluating the capacity of a helminth from hosts captured in the burnt areas to serve as a biological marker, knowledge must be gained of the helminth fauna of the same hosts in control areas unaffected by fire. These zones must meet the same ecological conditions as the burnt zones before the fire ; they must be located in proximity to the altered study zone, yet at the same time they must be sufficiently removed to present a balanced host population.

Step 3 : Prospective method

As a result of the fire, the small mammal populations suffer important alterations as a result of the death of numerous individuals and due to their escape towards safer areas. This explains why the capture of small mammals is noticeably reduced in the affected area for a number of years after the fire, in comparison to unaltered areas. On the other hand, and considering that the adoption of preventive measures to combat forest fires is frequently ineffective, ecosystems which have suffered fires usually receive protective measures to secure their regeneration. This in turn prevents the possibility of indiscriminate killing of small mammals in these protected areas, which would disturb the natural recovery process. The prospection method should combine seasonal analysis with the performing of numerous and punctual prospections in different areas of the burnt zone to avoid continuous pressuring of one same area. In addition, no more than 10 % of the captures should be sacrificed. The number of biotopes studied depends on the vegetational, edaphic and bioclimatic plurality of the Mediterranean area affected by fire. The trap method used to capture the hosts is based on the line-up and square plot (quadrate) technique, using the live-trapping and capture-mark-release methods. These habitual trapping techniques should be complemented by parasite detection procedures that do not imply sacrificing the host. To this effect different coprological studies may be conducted based on stools passed *in vivo* by the trapped mammal. The study should span several years after the fire. Regeneration of the vegetation cover in terms of Mediterranean bushes and trees seems to be quite effective only a few years after the fire. Similar observations apply to animal recolonization. From this moment onwards, the helminth parasites are the sole valid informers of total recovery of the study biocenosis, due to the complexity often involved in completing their vital cycles.

Step 4 : Host models

In order to select the host with the helminth parasites capable of providing the greatest information, it is necessary to establish the behavior of each of the small mammal species populating the study zone after the fire. To this effect, studies should be made of the small mammal recolonization dynamics and structure in the burnt zone, along with simultaneous parasitological evaluations. In turn, comparisons should be made with the findings corresponding to the unaffected control areas. Those small mammals that only return to the burnt area once it has fully recovered provide later information than those species that recolonize the zone even within the first year after the fire.

THE STUDY OF HELMINTHS

Step 1 : Control helminthfauna

In order to evaluate the informative capacity of helminths obtained from hosts captured in a zone undergoing postfire regeneration, the first step is to characterize the helminthfauna present within the hosts before the fire. To this effect, control zones are established where helminthfauna follow-up is carried out parallel to the study in the burnt zones. Follow-up must include samplings in unburnt areas throughout the course of the postfire years investigated. In this way possible differences between the control and burnt zones may be attributed to the effects of the fire and not to natural parasitic fluctuations conditioned by the different environmental conditions in the study setting.

Step 2 : Postfire helminthfauna

Seasonal helminthfauna information is to be obtained on the animals from the burnt zones, in order to analyze the parasite recolonization dynamics. Follow-up is extended over several years as a function of the recovery rate of the study zone. Once the host model/s has been selected according to the postfire recolonization dynamics observed, the information yielded by the helminths is derived from the comparative study of each postfire year with respect to the host helminthfauna in the undisturbed control areas.

Step 3 : Helminth models

Helminth community : The analysis of the helminth community addresses two aspects : (a) qualitative and quantitative composition, and (b) the bioecological nature of the component helminths. As regards the former aspect, follow-up of the annual patterns of presence/absence, richness/poorness or loss/recovery of species in the burnt zones with respect to the control areas constitutes a source of information on the degree of perturbation/regeneration of the burnt environment. In turn, the study of the bioecological dynamics of the helminth communities in the successive postfire years – fundamentally referred to the nature of the component biological cycles – provides information on three fundamental aspects : (a) host population densities, (b) free-living fauna diversity, and (c) the edaphologic-vegetation characteristics. Fluctuations in host population density in postfire regeneration zones, and the loss/recovery patterns of the free-living fauna, soil and vegetation cover all exert a marked influence upon the viability of completing the different types of biological cycles of the parasites. Thus, direct cycles, whose transmission is favored by direct contact between hosts – without prior passage through the external environment – exhibit population patterns in the affected zones different to those presented by those monoxenic cycles that imply a maturation period in the external environment, or those indirect cycles that require the presence of different intermediate hosts. Likewise, the detection of heteroxenous parasites (i.e., with intermediate hosts) indicates the presence within the biocenosis of those arthropods, gastropods, carnivores or birds of prey required to complete the corresponding life cycles. In this manner, these helminths may be used as biological tags indicative of the gradual recovery of the trophic chains in the regeneration zone.

Helminth population : In order to establish the capacity of one or more parasitic helminths as biological tags, we must first determine their situation within the helminth community of the host under unaltered conditions (control zone). In this way it is possible to ascertain whether the parasite is only sporadically detected, or whether it is characteristic of the host helminth fauna. In turn, we may establish parasite specificity, abundance, intensity and prevalence, as well as the corresponding seasonal dynamics, competitive capacity with other parasites, the existence of possible interspecific associative relations, frequency distribution, etc. Having established these characteristics in the control zone, they may be extrapolated to those observed in the burnt area during each post-fire year. In this way, a profile may be developed of the species that serve as biological tags of the perturbation and posterior regeneration of the burnt zone.

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