Durably controlling bovine hypodermosis

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Review article

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Abstract – Cattle hypodermosis, due to insect larvae, is widely spread over the northern hemisphere. Very efficient insecticides are available and their use in most countries are done on an individual level but never cover the whole cattle population of a country. Untreated animals remain the reservoir of the disease and annually re-infest the cattle population. The economic effects of this disease on animal production (meat, milk and the leather industry) but also on the general cattle health status, have led many European countries to launch organised control programs. The first example of definitive hypodermosis control goes back one hundred years ago when Danish farmers eradicated hypodermosis from the Danish islands by manual elimination of the warbles. Since then, more and more European countries have considered the feasibility and economic returns of such programs. The various factors which foster these programs are related to (i) biological factors, (parasite cattle specificity, synchronous biological cycles of both species of insects involved), (ii) the development of more and more efficient insecticides used only once a year by systemic application, with high efficiency at very low dosages against the first larval stage of *Hypoderma* spp., (iii) the development of acute techniques of detection of the disease for the monitoring of hypodermosis free countries and (iv) the durable successful results obtained in more and more European countries. Although the programs were imposed by different partners of the livestock channel production (farmers, dairy industry, leather industry) and have been engaged within the last 50 years in many European countries (Denmark, the Netherlands, Ireland, the United Kingdom, the Czech Republic, Germany, France and Switzerland) common features have emerged among these different eradication programs. They all need a preliminary statement of the economic impact of this pest and the farmers' awareness of the economic returns of such programs. The programs' efficacy depends: (i) on a good knowledge of the epidemiology of the parasites, (ii) on the simultaneous implementation of the control program on the whole national cattle population whatever the structure monitoring the treatments (veterinary services, farmers association), (iii) on a national Warble fly legislation making the treatments compulsory and (iv) on an acute epidemiological survey as soon as the status of a hypodermosis free country is reached and the treatments are suspended. The sanitary and financial returns of such programs are a benefit to all the partners of livestock production, to the quality of the environment and to the consumers.

hypodermosis / organised-control program / cattle / myiasis

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Résumé – Maîtrise durable de l'hypodermose bovine. L'hypodermose bovine est due à des larves d'insecte agent de myiases et est largement répandue sur tout l'hémisphère Nord. Des insecticides très efficaces sont utilisés dans de nombreux pays sur la base de traitements individuels, mais l'ensemble des cheptels n'étant pas traité, des réservoirs de la maladie persistent d'une façon diffuse. L'incidence économique de l'hypodermose bovine sur les performances zootechniques des animaux atteints a conduit de nombreux pays Européens à engager des programmes coordonnés de lutte contre cette maladie. Le premier exemple de maîtrise totale de cette maladie a été donné par les éleveurs Danois il y a cent ans. L'ensemble des cheptels bovins de plusieurs îles danoises ont été systématiquement évarronnés manuellement au cours de plusieurs printemps successifs et le cycle de l'hypodermose a ainsi été interrompu définitivement. Depuis, de plus en plus de pays Européens où sévit cette maladie ont considéré l'intérêt économique d'une telle lutte organisée. Le succès de ces programmes repose sur : (i) des facteurs biologiques (les deux espèces en cause *Hypoderma bovis* et *H. lineatum* sont spécifiques des bovins, leur cycle est synchrone), (ii) des insecticides de plus en plus efficaces, utilisés par voie systémique ne nécessitant qu'une injection par an, (iii) des techniques de diagnostic très spécifiques et sensibles développées au cours des 20 dernières années pour permettre de détecter toute apparition de nouveaux foyers dans des zones assainies. Des facteurs communs de succès émergent à partir des différents programmes de maîtrise de l'hypodermose développés en Europe bien qu'ils aient été initiés par différentes structures de la filière bovine (les éleveurs, l'industrie laitière ou l'industrie du cuir). Aujourd'hui le Danemark, les Pays Bas, l'Irlande, le Royaume Uni, la République Tchèque, l'Allemagne, la France et la Suisse ont abouti à cette maîtrise de l'hypodermose. Les points communs de leur programme font apparaître qu'une évaluation de l'impact économique de la maladie et du programme de contrôle doit être faite au préalable, et que les éleveurs doivent en être informés. La progression et l'efficacité de ces programmes reposent sur (i) une bonne connaissance de la biologie du parasite et de l'épidémiologie de la maladie, (ii) l'application simultanée de ce programme (par différents organismes, services vétérinaires, association d'éleveurs), à tous les bovins du pays engagés dans ce programme, (iii) un support législatif rendant obligatoire ces traitements et (iv) une surveillance minutieuse de toute réapparition de la maladie dès que le pays est indemne et que les traitements sont suspendus. Les bénéfices de tels programmes se font en faveur de toute la filière bovine et des consommateurs de viande bovine mais également participent à la qualité de l'environnement.

hypodermose / programme de lutte / bovin / myiase

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1. INTRODUCTION

Hypodermosis is a parasitic disease due to the development of the larval stages of insects (Diptera) inducing myiasis and belonging to the *Hypoderma (H.*) genus. Each species of this genus is strictly a parasite of a ruminant species. *H. diana* is specific of deer, *H. tarandi* of reindeer, *H. bovis* and *H. lineatum* of cattle. Cattle hypodermosis is widely spread over each continent of the northern hemisphere. Nevertheless, in Europe, within the last 50 years, owing to the economic impact of this disease, eight countries (Denmark, the Netherlands, Ireland, the United Kingdom, the Czech Republic, Germany, France and Switzerland) (Fig. 1) have carried out an efficient control of cattle hypodermosis leading to its eradication. This success of control was possible by considering the biological characteristics of these parasites, well organised animal health structures to implement and monitor the progress of the program, the active participation of all partners of the cattle production channel and new national legislation making each step of the program compulsory.

2. BIOLOGY OF *H. BOVIS* AND *H. LINEATUM* (Fig. 2)

The most evident clinical manifestations of these parasites are the swelling produced by the second and third larval stages (L2 and L3), commonly named warbles. They appear on the backs of their hosts in the spring and early summer in temperate climates like France (March to July). These stages last for 4 to 6 weeks and the mature third instars leave their hosts and fall on the ground where they pupate. After 4 to 6 weeks the adults emerge. They are flies unable to feed with a short life of one week. They mate, lay their eggs on the hair of the cattle and die. But due to the fact that they must fly between each egg laying, they spray the disease in a radius of 5 to 10 km around their living site. The first stage larvae hatch from the eggs, migrate along the hair and penetrate into the host's skin.

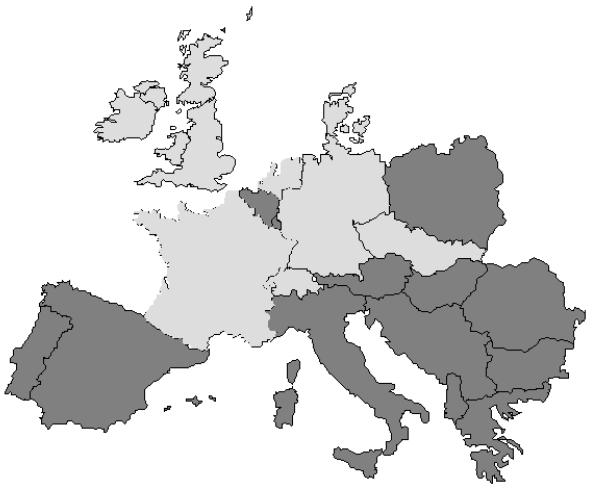

Figure 1. Hypodermosis-free countries (shaded in light grey) in Europe in 2001 (Synthesis of the proceeding of the Cost 833 meeting held in Toulouse in 2001).

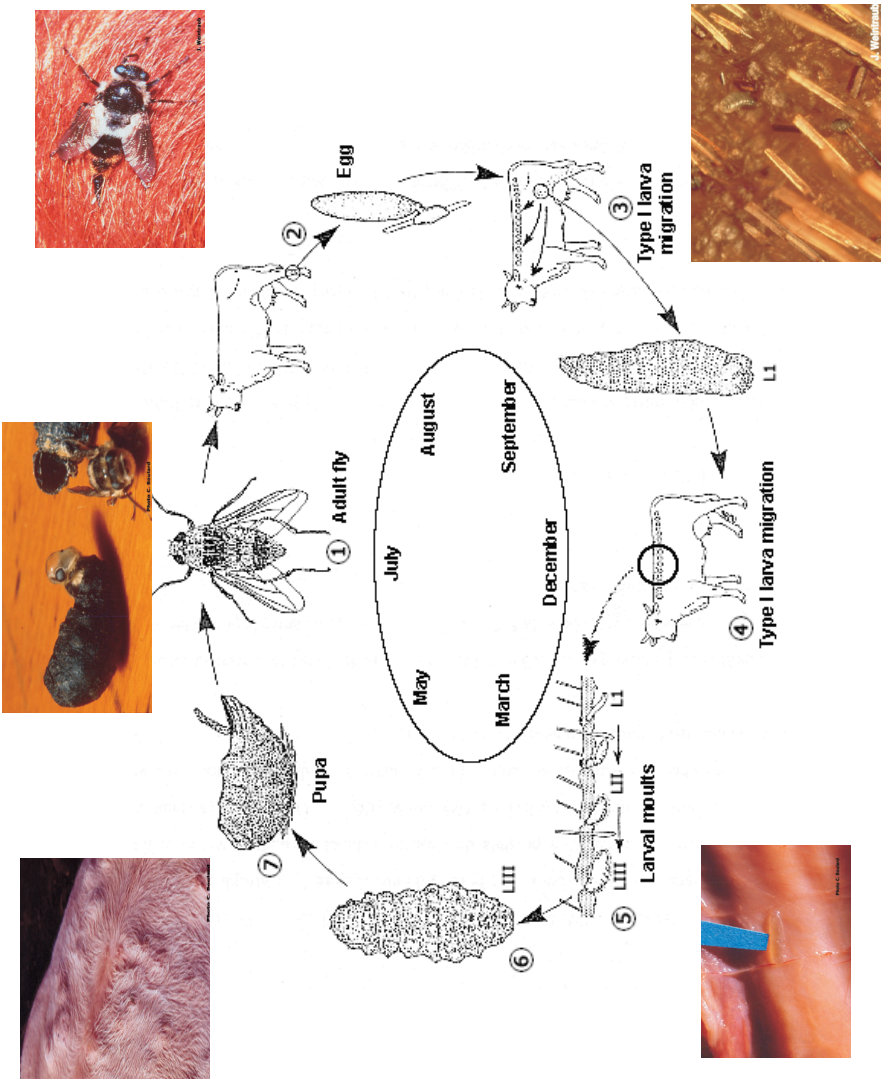

Figure 2. Biological cycle of *H. bovis* and *H. lineatum*.

Then, they undertake a long migration of 8 to 10 months in the deep connective tissue of their hosts. During these migrations, the endo-parasitic larvae accumulate the energy resources to survive during the pupal and adult stages of their free developmental cycle. The complex part of their life cycle inside their host provides different opportunities for interactions with the host's immune system [5] and the host's tissues on which the larvae feed. In France, this first stage lasts from August to March. The first stage larvae migration ends in the dorsal connective tissue of cattle where they moult into the second then into the third stages. The biological cycle is annual and the *H. lineatum* cycle precedes the *H. bovis* cycle by 1 to 2 months. The major economic impacts of the disease are related to damages caused to the cattle's skin and subsequently to the leather industry, to the decrease of zootechnical performances of the cattle (reduced weight and milk production), carcass depreciation associated with their trimming [9] and to a depressed sanitary status since these larvae induce a general immuno-depression of their hosts [5, 10]. When no hypodermosis control occurs, the intensity of the parasitism per animal varies from 50 to 150 warbles [3] but quite often reaches 700 warbles. This is the case in Mongolia [12], in the Chinese Tibet province [16] and in Morocco [4].

3. HYPODERMOSIS CONTROL

During the second half of last century, the same efficient insecticides have been available in all countries. The Organophosphorus compounds (OP) were marketed during the nineteen-sixties, then the anti-parasitic macrolides within the nineteen-eighties. These molecules have been widely used to cure different parasitic diseases all over the world. But the strategy of bovine hypodermosis control varies depending on the countries.

3.1. Control management

Two strategies of treatment of cattle hypodermosis can be adopted.

– In one case, the hypodermosis treatment of cattle remains the owners' initiative. In such a situation each treated animal is efficiently cured and the regional intensity of the disease decreases to a relatively low value (10 to 20 warbles/animal). In such a situation, some farmers take no more interest in this disease, even if with such parasitic pressure its zootechnical impact can still reduce the profit per animal [9]. Other farmers consider that the treatment can be selectively targeted, to young cattle, generally the most heavily infested [3]. In these countries the mean hypodermosis animal prevalence (number of infested cattle/total number of examined cattle) is reduced, but the herd prevalence (a herd is considered as infested, even if one cattle only is infested in the herd) remains high (> 60%). Consequently, the disease spreads all over the bovine population from each lowly infested herd, year after year, and constrains the owners to repeat annual treatments to keep hypodermosis at a tolerable economic level. This repetitive annual use of drugs presents negative side effects. It favours the pollution of the environment, increases the drug residues in meat and milk and the risk of developing a parasite drug resistance and finally induces repetitive expenses for the cattle owners.

– In another case, hypodermosis control can be co-ordinated on a regional or national level. Considering that *H. bovis* and *H. lineatum* are specific parasites of cattle, that all their populations are endo-parasitic during the autumn and winter, it was considered possible to control this disease by the simultaneous treatment of the whole cattle population on a large scale. This option requires an efficient co-ordination of the treatment by active animal health structures and the farmers' participation, however it presents the advantages of limiting

the annual treatment to only 2 to 4 years and consequently the treatments are suspended and all their associated negative side effects are avoided. Moreover it has been observed that the first instar larvae are very susceptible to some insecticides such as avermectines; whereas an injection of Ivomec® at a posology of 200 μg/kg was necessary to kill the warbles, a posology as low as 2 μg/kg was enough to kill the first stage larvae [2]. In these programs, when a durable control is reached, a rigorous survey of the disease must be carried out to avoid its reappearance. Any hypodermosis focus may spread very rapidly. An example was described in Ireland in the county of Westmeath in the nineteen-eighties (Fig. 3). This county was warble free for 3 years, when in 1982, the veterinary services detected 7 farms with 32 infested cattle. No treatment was applied until 1985, thinking that with a so low prevalence the disease would disappear. During this period the survey was reinforced each spring by repetitive warble examinations. Three years later hypodermosis affected 312 farms and 2 270 cattle (personal information from Dr. Duffy, Irish veterinary services). Also, the detection of any reappearance of the disease is essential to maintaining a durable control.

3.2. History of the co-ordinated hypodermosis control programs in Europe

Hypodermosis was a major parasitism of cattle all over Europe until control programs were launched within the last century. A century ago, the important economic impact of the warble-fly, on cattle production and the leather industry led Danish farmers to control these parasites by manual extraction of the warbles during the emergence period [8]. In the Danish Islands, after voluntary systematic warble manual elimination, it

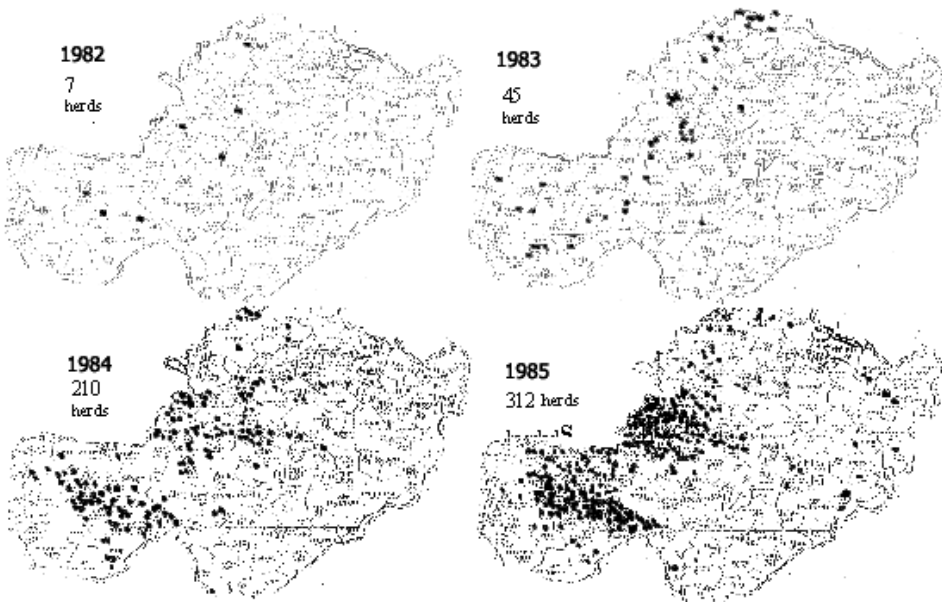

Figure 3. A three-year hypodermosis diffusion in a previously hypodermosis-free Irish county (from Duffy, Irish Veterinary services).

was thus demonstrated, over a short time (1899–1901), that this pest could be permanently controlled, if no hypodermosis infested cattle were reintroduced onto the island. On a small scale, all the bases of the management of a durable hypodermosis control program were stated. The basic principles of warble control are (1) the awareness of the economic impact of hypodermosis and the involvement of all partners of the cattle producers channel, (2) the simultaneous control of all the larvae of *H. bovis* and *H. lineatum* hosted by the cattle livestock on a territorial unit, (3) an acurate survey of any reintroduced infested cattle.

The extension of such control measures on the whole national territory required more than voluntary treatments to be developed by all the farmers simultaneously over the whole cattle population. Warble fly control legislation needed to be introduced to make these co-ordinated treatments compulsory. Under the request of the farmers, the Danish government introduced the first warble-fly control legislation in 1923 based on the use of an insecticide (rotenone) towards warbles. This measure was rapidly fully effective on the Danish islands. In Jutland, submitted in the South border to permanent re-infestations from Germany, the eradication was only achieved, by 1949 [8].

The development of insecticides efficient on warbles (rotenone and DDT) and then those presenting a systemic activity killing the endoparasitic stage of *Hypoderma* spp. (organo-phosphorus compounds, avermectins, milbemycins, etc.), favoured the development of the implementation of national programs of hypodermosis control which have been progressively launched in Europe over the last 50 years.

They reached their goal in variable periods depending on the methods of larval destruction.

Warble elimination by manual extraction or topical insecticide application were time consuming and difficult to generalise to the whole cattle population but national control programs started to be really efficient with the arrival on the market of systemic insecticides during the nineteen-fifties.

A unique treatment, using a systemic insecticide and carried out in the winter against the endoparasitic stage, kills the whole *Hypoderma* population hosted in cattle. National eradication programs have been elaborated on this principle, considering that *H. bovis* and *H. lineatum* are strictly cattle-specific and consequently the treatment of the whole cattle population of a country in the winter must eliminate the whole *Hypoderma* spp. population. As soon as the cattle population of a region is hypodermosis free, the treatment can be suspended.

Such programs started in the nineteen-fifties in the Netherlands under the pressure of dairy producers, then in the end of the nineteen-sixties in Ireland and at the end of the nineteen-seventies in the UK and Czechoslovakia under governmental pressure and in different lands of Germany under the farmer organisations demands. Depending on the country, the chemotherapy was applied by the farmers or veterinarians and the progress of these programs were always evaluated by the veterinary services. All these programs were founded on new national legislation implementing the procedures of the hypodermosis control programs. All these countries except Slovakia have maintained a hypodermosis free status [11].

3.3. Hypodermosis control in France

In France, various attempts to efficiently control hypodermosis failed until the end of the nineteen-eighties. These preliminary projects were launched by the leather industry and mainly targeted young cattle.

In the autumn of 1988, under the farmers' organisation pressure, a hypodermosis control scheme was introduced in France all over the territory. The national policy for hypodermosis control was elaborated by all the partners of the cattle production channel including the National Veterinary Services, the livestock producers (meat and milk) and the leather industry, associated to a National Managing Committee (NMC) [14]. The management of this project was under the responsibility of the National Federation of the Sanitary Farmers' Association (FNGDS). The progress of this scheme was evaluated every year by the NMC.

The strategy of treatment led to a generalisation of treatment for the whole cattle population on a regional basis until the regional hypodermosis herd prevalence decreased to 5 %. At this stage and for lower herd prevalence, intensive treatments were only maintained in the infested herds and nearby farms. In each region launching this program, the treatments of all the cattle herds started on restricted territories and spread like an oil spot to cover the whole region, during the following 3 years.

In 1988, the drugs used for the hypodermosis treatments were organophosphorus compounds (OP) for dairy cows and avermectins used at the industry-recommended dosage for young cattle (200 µg/kg), or micro-dosages of Ivomec® (2 µg/kg) for all other cattle categories. The dose efficacy of the micro-dosage was demonstrated by Argenté and Hillion [2], and the plasma and milk residue concentrations were studied by Alvinerie et al. [1]. Progressively anti-parasitic macrolides have been generalised instead of OP.

While the European programs of hypodermosis control immediately covered the whole national territory, the French program was managed on a regional level (Fig. 4) and started by law, when in a partic ular region, 60 % of the farmers agreed. In 1994, only three regions, Bretagne, Bourgogne and Midi-Pyrénées, presented a herd prevalence < 5 %. In November 1994, the Ministry of Agriculture introduced a new regulation requiring the simultaneous treatment of all French regions with a hypodermosis herd prevalence > 5%, with this law becoming compulsory for the 1998 campaign.

This new regulations stimulated the treatment procedures. The results in the summer of 1998 assessed that 14 regions presented a herd prevalence < 5%. In the autumn of 1998, 16 millions cattle were

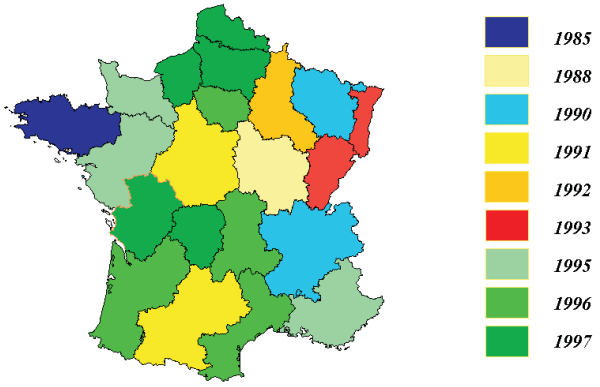

Figure 4. Year of regional involvement in the hypodermosis control program (FNGDS data).

concerned by this law [13] and in the summer of 1999 only two regions still presented a herd prevalence > 5% (Provence-Alpes-Côte-d'Azur and Limousin) (Fig. 5). In the spring of 2001, the national herd prevalence was under 0.4% and the animal prevalence was less than 0.01%.

As soon as the herd prevalence in a region is under 5%, the treatments are suspended and all efforts are targeted on the detection of any remaining hypodermosis focus, introduced from infested animals from some still infested herds or, on the borders, from still infested countries.

During the first years of this scheme, the diagnosis of the disease was assessed by a unique clinical examination of cattle for warbles during the spring. This method under-estimated the prevalence of the disease by 36 to 60% [15].

A serological survey was launched more recently. The annual kinetics of the antibody response during hypodermosis has been well characterised [7]. Also, a serological survey on pooled sera (per 10) of the herd, or, in the milk tank of the dairy herd, has been progressively introduced [6] reducing the cost of such a survey. Such a method allows an early diagnosis of hypodermosis and could introduce a preventive winter treatment. As described previously in France [7], a peak of anti-*Hypoderma* spp. antibodies is observed in the winter (December to March), at the period of blood samplings for other prophylaxies (brucellosis or leucosis), since the same blood sample can also be used for immuno-diagnosis of hypodermosis.

4. CONCLUSION

Today the hypodermosis situation is under control in France, and in seven other European countries. The success of the control programs launched within the last 50 years have been reached in a short time.

The control programs efficacy depends on the following:

– (i) A good knowledge of the epidemiology and the biology of the parasites. The drugs used were very efficient but they also targeted a very specific stage of the parasite, the first larval stage, particularly susceptible to some insecticides. Moreover, the two species involved *H. bovis* and *H. lineatum* are strictly cattle specific, which implies that no wild reservoir could maintain the disease.

– (ii) Efficient animal health organisation able to simultaneously implement the control program on the whole regional or

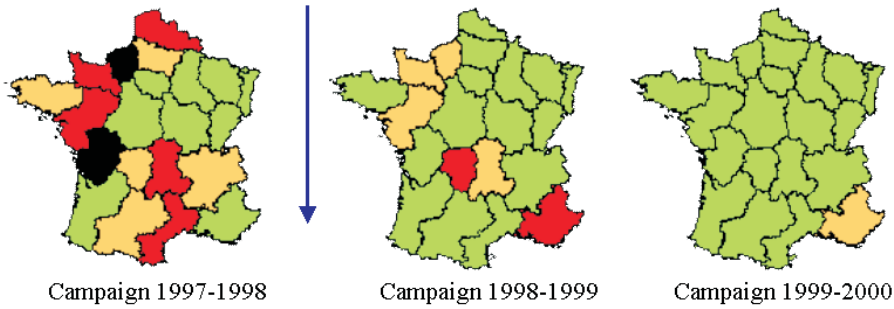

Figure 5. Hypodermosis herd prevalence (HP) after the national implementation of the hypodermosis control. (The arrow indicates that the program has been implemented on a National scale).

national cattle population. Whatever the structure monitoring the treatments, the veterinary services or the farmers' associations, the important point was to treat all cattle in the winter during a period when both species inducing hypodermosis, *H. bovis* and *H. lineatum,* were at the same larval stage and the herds were housed.

– (iii) A political commitment sustaining this program, promulgating new national Warble fly legislation making the control program compulsory to all herds therefore leaving no reservoir of untreated herds.

– (iv) An acurate epidemiological survey to detect any reappearance of the disease, as soon as the status of a hypodermosis-free country is reached and the treatments are suspended.

The durable sanitary and financial returns of such control programs benefit to all partners of livestock production, to the quality of the environment and to the consumers.

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REFERENCES

[1] Alvinerie M., Sutra J.F., Galtier P., Toutain P.L., Microdose d'ivermectine chez la vache laitière : concentrations plasmatiques et résidus dans le lait, Rev. Méd. Vét. 145 (1994) 761-764.

[2] Argente G., Hillion E., Utilisation de petites doses d'ivermectine pour le traitement préventif de l'hypodermose bovine, Le Point Vétérinaire 16 (1984) 62-66.

[3] Benakhla A., Lonneux J.F., Mekroud A., Losson B., Boulard C., Hypodermose bovine dans le Nord est algérien : prévalence et intensité d'infestation, Vet. Res. 30 (1999) 539-545.

[4] Benakhla A., Jemli M., Sahibi H., Boulard C., Bovine hypodermosis in Maghreb. Cost 811, Improvements in control for warble-fly in cattle and goats. ISBN 92-828-2604-X. Proceedings of the annual meeting held in Tours, France, 1998.

[5] Boulard C., Degradation of bovine C3 by serine proteases from parasites *Hypoderma lineatum*. Vet. Immunol. and Immunopathol. 20 (1989) 387-398.

[6] Boulard C., Villejoubert C., Use of pooled serum or milk samples for the epidemiological surveillance of bovine hypodermosis, Vet. Parasitol. 39 (1991) 171-183.

[7] Boulard C., Villejoubert C., Moire N., Losson B., Lonneux J.F., Sero-surveillance of hypodermosis in a herd under therapeutic control. Effect of a low level of infestation, Vet. Parasitol. 66 (1996) 109-117.

[8] Jespersen J., Denmark: Maintenance of a warble-free status. Cost 811, Improvements in control for warble-fly in cattle and goats. ISBN 2-87263-157-7. Proceedings of the XIth scientific workshop held at Weybridge- Surrey University, 1995, pp. 43-44.

[9] Klein K.K, Jetter F.P., Economic benefits from the Alberta warble control program, Can. J. Agric. Econ. 35 (1987) 289-303.

[10] Nicolas-Gaulard I., Moire N., Boulard C., Effect of the parasite enzyme hypodermin A on bovine lymphocyte proliferation and interleukin-2 production via the prostaglandin pathway, Immunology 84 (1995) 160-165.

[11] O'Brien D.J., Warble fly prevalence in Europe after COST 811. COST 811 : Improvements in control for warble-fly in cattle and goats. EUR 17534 EN. 34-37. Proceedings of the annual meeting held in Tours, France, 1998, pp. 20-33.

[12] Orgil D., Dambii N., Hypodermotosis status in Mongolia. Proceedings of the INCO meeting held in Lanzhou in Oct 2001. Hypodermosis in Central Asia.

[13] Rault B., Situation du plan national d'éradication. GDS Info 131, Septembre 1998, pp. 15-18.

[14] Schaeffer C., Plan national d'éradication de l'hypodermose bovine. COST 811, Improvements in control methods for warble-fly in cattle and goats, ISBN 92-826-4092-2, 1992, pp. 73-76.

[15] Vaillant J., Argente G., Boulard C., Hypodermose bovine : une procédure quasi séquentielle d'observation des cheptels pour la surveillance de la recrudescence en zone éradiquée, Vet. Res. 28 (1997) 461-471.

[16] Yin H., Miling M., Gailing Y., Huang S., Zhijie L., Jianxun L., Guiquan G., Hypodermosis in China, Proceedings of the INCO meeting held in Lanzhou in Oct 2001. Hypodermosis in Central Asia.