LEISHMANIASIS CONTROL STRATEGIES

A CRITICAL EVALUATION OF

IDRC-SUPPORTED RESEARCH

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Leishmaniasis control strategies

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Leishmaniasis control strategies: A critical evaluation of IDRC-supported research

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PANEL DISCUSSION #4:

"Is Vector and Reservoir Control Possible for Leishmaniases?"

Italo A. Sherlock[1]

A review of the epidemiological changes (including control and prophylaxis) made by Ward (9) for the three decades preceding 1977, indicates that few new methods or measures for the control and prevention of the leishmaniases, either in the Old and New World, were initiated.

The strategies and methods used to control the American leishmaniases vary in accordance with the two general types of pathologies: visceral and tegumentary. Each type has its unique epidemiology.

American Visceral Leishmaniasis

In the epidemiology of American visceral leishmaniasis, the etiologic agent is Leishmania chagasi; the principal vector is Lutzomyia longipalpis; man and dogs are host victims but serve as the most important domestic reservoirs of the parasite. Foxes and opossums, found naturally infected in some foci, probably represent sylvatic and/or peridomestic reservoirs. Since the behaviours of these two types of mammals and their real importance as reservoirs is still unknown, they are not generally included in control measures.

The works that have been published about the control of American visceral leishmaniasis deal with three methods of control. They are: (i) treatment of human cases; (ii) elimination of infected dogs; (iii) and spraying of insecticides against the vector. In this way it is possible to achieve a notable decrease in the incidence of human cases of the disease. However, as soon as control measures are interrupted, the disease breaks out again and continues its natural history.

Treatment of human cases

According to Alencar (1) the Chinese advised that the treatment of all human cases should be the first prophylatic measure. Thus, in China, the incidence of visceral leishmaniasis has been successfully reduced. However, in the northeast of Brazil, in the treatment of human cases a low rate of incidence has been obtained, but the treatment

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of human cases alone was not sufficient to effect a substantial reduction in the incidence of American visceral leishmaniasis.

The elimination of infected dogs is the principal landmark in the control of visceral leishmaniasis. The elimination is necessary because there is no treatment for the disease in dogs. Moreover, pure bred dogs must be given special attention because they are very susceptible to infection. The immigration of dogs from endemic foci to non-infected areas must be blocked to complete control. Observations to determine if the elimination of infected dogs is sufficient to control the incidence of human cases have not been made.

Control of the vector with insecticides

Deane (3) suggested that a high density of L. longipalpis is strictly necessary for the incidence of human cases. This hypothesis can be supported by the existence of canine leishmaniasis in some areas of Brazil (and Texas, USA) without human cases (with or without a very low density of sandfly vectors).

Deane, Deane and Alencar (4) have evaluated the effects of DDT by observing the density of L. longipalpis in sprayed and unsprayed areas. Over a four month period it was verified that L. longipalpis almost entirely disappeared inside houses immediately after spraying and were still very rare four months later. In the shelters of domestic animals the sandfly density also fell sharply, but not as much as indoors. Three months later, the population of flies had returned to normal.

With the guidance of Alencar (1,2) the "Brazilian Campaign for the Control of Visceral Leishmaniasis" has treated 2,096 human cases, and killed 78,929 infected dogs. In 14 endemic localities which were also sprayed, the incidence of visceral leishmaniasis was reduced by 67.7%, in contrast to the 14 unsprayed control endemic localities where the rate of incidence decreased by only 25.4%. Similarly, between 1965 and 1969, using the three control measures mentioned above in the endemic area of Jacobina, Sherlock and Almeida (9) demonstrated that no human or canine cases were recorded in the last two years of the project.

Alencar emphasizes the existence of an irregular rate of incidence of visceral leishmaniasis that did not have a definitive reduction in those localities where only the human cases were treated and dogs eliminated. According to Alencar, this fact indicated that failure to spray was an inefficient method to control the disease. However, we still do not have any data or knowledge to unequivocally say if only one of the measures is sufficient to control American visceral leishmaniasis.

Tegumentary Leishmaniasis

From 1945 to 1947, Hertig and Fairchild (6) sprayed DDT with a 5% solution of kerosene in houses and on surrounding stone walls. The sandfly population was

markedly reduced for 12-19 months and new cases of "uta" disappeared. Similarly, Horror (7) reported a reduction in the rate of infection of dogs (from 56.2 to 14.7%) due to the use of insecticides by homeowners.

Guimaraes and Bustamant (8) have observed an effect of DDT on the control of malaria and the indicence of cutaneous leishmaniasis in Rio de Janeiro. The survey, carried out five years after semi-annual sprayings inside houses, showed that the foci were extinct. The incidence of human cases fell from 12.4% to 0.3%. Lutzomyia intermedia, the supposed vector, was not found inside houses but its density in the peridomestic sites continued to be the same as before spraying.

In the Amazon region, insecticides have been used on the trunks of large trees in strategic locations (such as camp sites with baths) and highly utilized paths and tracks. This was also the method employed by the "Jari Project". In spite of the rainy weather, its effect on decreasing the sandflies population remained for more than a month.

The following measures are suggested according the leishmaniasis species: Leishmania braziliensis - In forests control is not possible by means of insecticides or elimination of the sylvatic reservoirs. When the disease moves to urban or peri-urban sites some changes occur in its ecology, including changes of vectors. In the north of Brazil, the spraying of houses where human cases occurred gives some protection for healthy occupants and prevents the incidence of new cases. In middle and southern Brazil, after ecological transformation of the areas, mucocutaneous leishmaniasis begins to be transmitted inside houses by Lutzomyia intermedia and L. whitmani as well as in peri-domestic sites. In these cases, insecticidal measures give some indication of the control of transmission. In this situation, domestic reservoirs like dogs, donkeys and horses, appear to be epidemiologically important. However, studies on their elimination and their roles were not carried out.

In conclusion, I would like to emphasize that the picture of the ecology and epidemiological characteristics of the leishmaniases in the New World remains incomplete. In spite of the research that has been carried out for decades more multidisciplinary studies are necessary to answer numerous outstanding questions. Only then will it be possible to have more efficient methods for the control of the leishmaniases.

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Introduction

Among the leishmaniasis forms occurring in Tunisia, two are causing public health problems: (i) Zoonotic Cutaneous Leishmaniasis (ZCL) that is epidemic but relatively benign and (ii) Kala-azar (KA) that can cause deaths in the absence of treatment. Accordingly, control measures can be undertaken on 3 levels: (i) the treatment of cases; (ii) the control of vectors; and (iii) the control of reservoirs

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Treatment

Glucantime (antimoniate meglumine) is used to treat all forms of leishmaniasis. A 15-20 day treatment for KA requires hospitalization, while serious cutaneous leishmaniasis forms need only a "minute" treatment by intralesional infiltration. Presently, there is a trend to not to treat plain ZCL forms for which development is usually quick and immunizing. To avoid secondary infection, the use of local antiseptics is satisfactory.

The Control of Vectors

Residual insecticide spraying during anti-malarial campaigns in Tunisia (1968-72) resulted in a reduction of the yearly incidence of both VL and CL.

The control of vectors requires a good knowledge of the biology and bionomics of sandflies. Although the breeding places of P. papatasi (the vector of ZCL) and P. permiciosus (the probable vector of KA) are still unknown, the entomological surveys carried out in the mixed focus of ZCL and VL in the Sidi Bouzid areas, were informative.

The P. papatasi transmission season was shown to occur between May and November with a maximum peak density during July and August and a maximum of transmission during July and August and a maximum of transmission during September. P. papatasi population represented 84.6% of the total species population encountered. L. major MON. 25 was isolated on several occassions in different foci. The anthropophily of P. papatasi was confirmed by man landing catche techniques. This species was shown to be exophilic and endophilic. However, more than 60% of the P. papatasi population were caught in the rodent burrows; only 22.1% in human dwellings and 17.7% in animal stables.

P. perniciosus was shown to have two population density peaks, one during July and a second are during October. Approximately 58.6% of the specimens were caught in stables near dogs and 31% in human dwellings. The anthropophily of P. perniciosus is well established. L. infantum was isolated from this species in Italy and Algeria and but not yet in Tunisia.

Conclusion

Observation made about P. papatasi the ZCL vector, clearly show that applying insecticides intra or peridomiciliary would not affect more than one fourth of females, the remaining three fourth being found rodents' burrows. Chemical control of the burrows seems difficult given the extensive areas to be treated. Only burrows destruction could be foreseen as feasible.

The control of P. perniciosus by insecticides is in theory possible in human dwellings and in stables. However, the sporadic character of the disease in humans and the absence of the stability of the human KA foci makes it difficult to implement insecticide control campaigns on a large scale essentially because of the very high cost of such measures.

Individual control measures such as individual indoor spraying, the use of nets (treated or untreated) and repellants remains difficult to apply in affected areas which are mostly poor.

Control of Reservoirs

A - Rodents

Ecology of ZCL Reservoirs

	P. obesus	M. shawi
Habitat	. Large areas of halophytic soil with chenopods . Shepp breeding areas . 1 female per burrows . Dense colonies/Km^2	. Corn corps areas Jujub - trees . Near cactus plants . Weak density/Km^2
Food Requirements	. Chenopods exclusively	. Granivorous
Reproduction	. 25-36 days . All along the year	. 21 days . All along the year
Activity	. Diurnal . Weak migrations	. Nocturnal . Large Migrations
Leishmanial Lesions	. Discrete	. Inflammatory +++
Rate of Infection	. Up to 100%	. 10% to 20%
Control by Rodenticides	. Difficult . Brodifacoum - (Klerat) anti-coagulant only	. Easy . All anti-coagulants Zn phosphide in Tunesia

Control of Rodents

	P. obesus	M. shawi
Ecological Control	. (++++) Difficult . Modifications of the environment: Removal of chenopods . Plantations of Acacia . Working lands the "Sfax way" . Reintroduction of Camels? . Community participation . Inter-sectorial coordiantion (Agriculture)	. (+++) relatively less difficult . Destruction of Jujub-trees . Working lands the Sfax way . Community participation . Inter-sectorial coordination (Agriculture)
Control by Rodenticides	. Difficult . Brodifacoum (Klerat) (anti-coagulant only)	. Easy . All anti-coagulants . Zn-phosphide in Tunisia

B. The Dog as Reservoir of VL (KA)

Categories of dogs in Tunisia

Owned dogs: - Domestic (Accessible but very few)
- Guards in rural areas:
· Tied dogs (100% accessible)
· Semi stray dogs (with owners) 70% accessible, (maximum)

Ownerless dogs: - stray dogs (not accessible)

General Control measures include:

a. Integration of action against dogs in the basic health care control program against Leishmaniasis, rabies and hydatidosis

b. This requires accessibility to the dogs. Thus, ownless stray dogs should be eliminated.

c. Large scale health education programs are needed to facilitate the implementation of measures to control dog populations

More specific measures might include:

1. **The selective elimination of the seropositive dogs:** From the experience gained in the focus of Sidi Bouzid it was impossible to serologically screen 100% of the canine population because 30% of the owned semi stray dogs were not accessible and 100% of the ownless stray dogs are not accessible for the survey. These two samples that are not accessible represent around 30% to 35% of the total canine population of the focus. The leishmanial dogs among these samples (around 10%) are not eliminated and are able to maintain transmission into the area.

In Sidi Bouzid area, it took only two transmission seasons for the prevalence of canine leishmaniasis to reach the previous rate found at the beginning of the control. Among the other causes for failure, was the absence of studies on the ecology of dogs in the area and especially on the turnover of the canine population. Moreover, the selective elimination of owned dogs (supposedly vaccinated against rabies) could contribute to an imbalance in favour of uncontrolled and unvaccinated dogs.

2. **The massive killing of dogs** can be conceived only in the case of epidemic outbreaks. Combined with patients' treament and insecticide intradomiciliary aspersion, this approach was rather successful in China. However, a Kala azar recurrence occurred in China in 1968-1975 after a relaxation of such measures. The ecological consequences of a dog massive killing are still to be assessed.

3. **Treatment of Dogs:** Dogs' treatment is usually made with pentamidine (lomidine). This treatment is reserved for dogs "precious" to their owner, and must be repeated yearly since it treats the animal but does not cure it. Such treatment is used in towns. It is unconceivable and unachievable (cost, awareness), at the individual level in the rural area. In Tunisia, antimoniate meglumine (glucantime) is especially kept for human use. Using glucantime on dogs in Italy entailed the appearance of canine strains resistance of antimony, and therefore, became permanent leishmania reservoirs.

Bruno L. Travi[3]

Theoretically, leishmaniasis control could be targeted to one or more of the three components of the transmission cycle, the reservoir, the vector or the so-called accidental host, the human being. The complexity of the transmission cycle suggests that concentrating on a single target or utilizing only one control strategy will fail to achieve satisfactory results. It is possible that in the Old World ecological situations allow for successful interventions, but in Latin America several factors converge to create new epidemiological pictures. These factors are usually related to migratory population movements toward unexploited territories, land modification due to lumbering, and

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primitive agriculture in secondary forests, all of which result in the settlement of new communities in areas of high risk for leishmaniasis infection.

Leishmaniasis control in the New World still remains a challenge for parasitologists, epidemiologists, and health authorities. New vectors and putative reservoirs appear in the literature in increasing numbers, but this information does not seem to trigger control efforts in the endemic countries. It is possible that lack of governmental commitment has been more important than biological constraints in impeding successful control of the leishmaniases.

RESERVOIR CONTROL

Incrimination of wild reservoirs

An increasing number of mammals of different orders have been identified as putative reservoirs of Leishmania, based on the isolation of amastigotes from their tissues (Dedet et al. 1989; Shaw 1988; Lainson et al. 1989). They are considered the natural source of infection for zoophilic sandflies and for those species that would alternately feed on man and animals according to circumstances. Theories on their participation in the transmission cycle encompass behavioural aspects responsible for territorial overlapping with human habitations and activities, as well as highly efficient host-parasite associations in which infected sandflies transfer leishmania from primary or secondary forests to peridomestic and domestic settings.

When evaluating potential reservoirs, little attention has been paid to the distribution and density of mammals within an endemic focus. No quantitative observations are available regarding sandfly-mammal associations, dispersal, and prevalence of infection of adult female sandflies arising from specific animal dwellings. Xenodiagnosis has proven disappointing in most cases, both with colonized and feral sandflies, and for this reason it is difficult to comprehend how some Leishmania species are so efficiently transmitted to the human population. In fact, with few exceptions (Rojas et al. 1990), xenodiagnosis has proven unsatisfactory to assess both vector competency and reservoir status. It seems that under natural conditions, Leishmania (Viannia) spp. infected tissues contain a relatively small number of amastigotes, making parasite intake during sandfly feeding less frequent than one would expect.

We were unsuccessful in trying to infect Lu. trapidoi and Lu. gomezi by allowing them to engorge on the lesion border of a naturally L. braziliensis-infected dog, as well as colonized Lu. longipalpis on lesions of L. panamensis-infected patients. On the other hand, experimentally infected hamsters are good sources for sandfly infection either with L. panamensis or L. brazilienses. Since hamsters are usually inoculated with 1-5 million promastigotes, it is reasonable to assume that the heavy load of parasites within the tissues offered to the vectors accounts for the positive results.

Recovery of amastigotes from the tissues of putative reservoirs varies according to the different Leishmania species, and endemic foci. With the exception of one sloth infected with L. panamensis, we were unable to recover Leishmania from a wide range of mammals during epidemiological studies in the Colombian Pacific coast where L. panamensis and L. braziliensis are endemic. The methods which proved to be ineffective for screening wild fauna, were similar to those regularly used in the laboratory to recover amastigotes from human biopsies and samples from experimentally infected laboratory animals. Recent studies in our laboratory (Martinez et al. 1991) have shown that dilution of tissue triturates resulted in higher recovery rates of amastigotes as compared to undiluted samples. This phenomenon is even more noticeable during the chronic stages of the disease when parasite loads diminish. If these observations are extrapolated to the reservoir situation, it would be reasonable to assume that amastigotes may be scarce, and for this reason they may go undetected when conventional techniques are used for parasite isolation.

Incrimination of domestic Reservoirs

Not too many years ago, dogs were the only domestic animals widely accepted as a source of infection. While little doubt was left regarding their importance as a visceral leishmaniasis reservoir, other domestic animals which have been reported infected with different species of Leishmania were disregarded as possible links of the transmission cycle. As previously mentioned, it is possible that the lack of experimental confirmation through xenodiagnosis or recovery of amastigotes from typical lesions accounted for these assumptions. In addition to the dog, donkeys and horses, in which overt disease was reported in Venezuela and Brazil (Aguilar 1990) traverse together with man vector resting sites during daytime, and share the peridomestic environment with humans when sandfly activity is at its peak. This proximity and interaction give multiple opportunities both to humans and animals to participate either as reservoirs or victims of the disease. In certain endemic foci, horses may act as important attractants of sandflies. In the province of Salta, Argentina, horses are frequently bitten in the pubic area, around the eyes, nostrils and inside the ears by Lutzomyia intermedia, the putative vector of L. braziliensis in that focus. We have experienced a marked increase in sandfly biting when collections were made close to horses, as compared with regular protected human-bait catches.

Observations in which the same vector and Leishmania species are responsible for producing overt disease, both in human and domestic animals suggests that the latter could be of greater importance than originally proposed.

Problems related with Reservoir Control

When wild mammalian fauna is considered as the target for control several constraints emerge:

1. In the population dynamics of mammals, a natural replacement occurs whenever the home range occupied by a particular individual becomes empty. This implies that trapping would result in the influx of naive specimens of the same species, which in the best of cases will become infected within a few months if they do not harbor Leishmania already.

2. While marsupials and rodents are easy to trap, other species may be difficult, and would require expertise and commitment, which are hard to obtain in most endemic areas. Certain mammals such as foxes, monkeys, kinkajous, and sloths could be endangered species for which elimination would be forbidden; relocation of wild fauna is an even greater problem that should not be considered as a feasible alternative.

3. The main question that conservationists will ask is if control measures targeted against feral animals are based on quantitative analyses, and epidemiological information as to assure a level of positive impact on health that would outweigh ecological damage. At present, these inquiries would be poorly answered.

For these reasons, wild reservoir control should be considered as an impractical approach to diminish or stop Leishmania transmission in the New World.

Although transmission dynamics studies involving domestic animals are still pending, they should be treated as potential sources of parasites. Elimination of dogs is unaccepted by most pet owners, and this approach could interfere with other control strategies that may require community participation. On the other hand, dogs are immediately replaced by naive individuals which, in the case of L. chagasi, are infected within a few months. Two alternatives are envisaged as the most viable options: a) avoiding vector-host contact by the use of repellent-insecticide collars (dogs), and harnesses or mesh covers (horses, donkeys) at the peak of sandfly activity, and b) immunological protection through the development of an effective L. chagasi vaccine. The first approach would require previous testing of the collars in the laboratory, subsequent field studies using groups of naive animals, and serological screenings for demonstrating differences in infection rates between test and control animals. The vaccination strategy has been considered by several groups of researchers and it is expected that information will be available soon in this regard. Although vaccines may be efficient in protecting dogs, evaluations should focus on how this immunological strategy affects L. chagasi infection rates in the human population. Although not proven, protection of domestic animals against L. (Viannia) spp. infections, as well as early diagnosis and treatment of humans, may contribute to diminish tegumentary leishmaniasis in certain foci.

Incrimination of Insect Vectors

Leishmania vectors are considered as such when several criteria are met. Probably the most important are: a) the identification of natural infections with the same

parasite species which is regularly isolated from the human population of the endemic focus; and b) high density of specimens at certain times of the year, and anthropophilic behavior, a combination of factors that will assure frequent vector-host interaction. Experimental studies by Warburg et al. (1991) showed that sandflies which are not involved in transmission of Leishmania could be readily infected under artificial conditions, suggesting that other factors such as ecology and sandfly behaviour are key elements for disease transmission.

Once the putative vectors have been identified and their population dynamics, and biting behaviour has been studied, strategies could be drawn either to avoid vector-man contact or reduce populations below critical levels. Albeit not systematically evaluated, sandfly control in the New World has been considered as a feasible strategy for reducing leishmaniasis in endemic foci. While for people exposed for short periods of time leishmaniasis transmission could be prevented with repellents, other approaches should be taken into consideration when disease transmission needs to be interrupted in endemic areas. Protection of men entering leishmaniasis areas for short periods of time have been achieved with jackets impregnated in n,n-diethyl-m-toluamide (DEET) (Schreck et al. 1982). Similarly, Alexander and Rojas (1991) have observed significant protection against colonized Lu. longipalpis for up to 8 hours with a repellent soap (20% DEET, 0.5% permethrin) that other research groups had tested successfully against different species of mosquitoes.

Although it is widely accepted that the zoonotic nature of the disease precludes its eradication, focusing sandfly control on those areas where man-vector contact is frequent may yield epidemiologically sound results. Farming is the most common activity related with Leishmania infection. Land is distributed in relatively small parcels, where cacao, banana and plantain are intermingled with secondary forest; coffee plantations in the mountainous regions are protected from the sun by large trees. Sandfly populations in these areas are composed of species that were capable of adapting to modified environments and perpetuate the anthropozoonosis. Since it has been demonstrated that there is a dose-response relationship in the risk factor for infection, it is clear that reducing the number of sandflies at the working sites would be highly beneficial. Plantations in the tropics are small when they are owned by local settlers, and thus their forest activities are restricted to limited areas. In these places both mechanical modification of the sandfly resting places, and chemical intervention targeted to specific microhabitats could be attempted. In general, adult sandflies seem to be susceptible to commercially available insecticides. Although in some areas resting places are difficult to identify, chemical spraying could be directed tentatively towards the buttresses and holes of the largest trees. DDT spraying has been associated with a marked decrease in sandfly activity and incidence of visceral leishmaniasis cases in Bangladesh (Elias et l. 1989), and was used in Brazil against Lu. longipalpis (Deane et al. 1955) and Lu. umbratilis (Ready et al. 1985). At the present time, this compound is regarded as an environmentally unsafe insecticide which could be replaced with other safer compounds. In fact, due to the lower toxicity for man and animals, Malathion and photo-stable pyrethroids have been considered for this kind of intervention.

As part of ongoing control studies, we have tested several insecticides against both adult and immature stages of sandflies. Colonized Lu. longipalpis were more resistant than feral Lutzomyia spp. collected in a botanical garden. Test papers impregnated with a 1500 ppm concentration of Deltamethrin (K-othrin S 25 ^{R}, Roussel Uclaf) produced 95 and 100% mortality (Abbott) in Lu. longipalpis and Lutzomyia spp., respectively, when evaluated at 24 hours following a 10 minute contact exposure with the compound. To achieve similar results Malathion and to be used at concentrations higher than 3000 ppm. These experimental results suggest that Deltamethrin, due to its high potency and low toxicity, could be the first choice for wall spraying inside houses in foci with intradomiciliary biting. Falçao (1988) reported that the number of Lutzomyia spp. declined for almost 1 year after intra- and peri-domicile spraying of 25 mg/m^2 of Deltamethrin in a leishmaniasis focus of Viana, Spirito Santo. Brazil. Some preliminary field studies by Le Pont et al. (1989) in a sub-Andean village of Yungas, Bolivia suggested that deltamethrin sprayed at the beginning of the rainy season at the domicile and peri-domicile settings could reduce the number of Lu. nuneztovari anglesi, were not clearly affected by this intervention. These observations stress the importance of studying vector population dynamics before implementing control strategies. Insecticides may kill insects that have acquired the infection in the forest, and thus control measures targeted to the domicile or peridomicile may not have any effect on transmission. The opposite would happen with species which are infected close to or in domestic settings. Mark-recapture techniques are needed to understand dispersal of sandflies in different foci of transmission, and to optimize insecticide spraying.

CONCLUSIONS

When targeting control measures towards vectors and reservoirs it is important to consider that transmission may take place at three different sites:

a) Extradomicile: transmission is related mainly with agricultural activities, which are usually carried out in specific places (small parcels of land) that could be modified by mechanical intervention such as clearing the forest, thus reducing appropriate environments for sandflies. Vector densities could be lowered by selective spraying of large trees and other resting places. Other forest activities that are not performed continuously in the same area or may be sporadic, such as lumbering or hunting, should take advantage of personal protection with clothing and repellents. Reservoir control is not indicated.

b) Peridomicile: this setting is shared by man and domestic animals during the peak of sandfly activity facilitating alternate feeding of insect vectors. Spraying of animal shelters has proven effective, and since elimination of pets or work animals is unacceptable, the utilization of protective collars or harnesses impregnated with repellents or pyrethroids should be explored.

c. Domicile: according to preliminary information, wall spraying is an efficient methods for reducing sandflies indoors. Further, it is possible that pyrethroid impregnated bednets and/or curtains could yield significant protection. Cost-benefit evaluations in different endemic foci should decide which of these approaches will be more beneficial in each particular case.

Assuming that well designated studies would confirm what isolated control trials have suggested, a greater challenge beyond the biological viewpoint awaits: implementing recommended control programs involving community participation and Public Health authorities, with the aim of assuring effectiveness and long-term commitment.

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DISCUSSION SUMMARY

With respect to visceral leishmaniasis Dr. Sherlock advocated detection and elimination of infected dogs. He also felt that peri-domiciliary control, but not sylvatic control of vectors was achievable. Dr. Ben Rachid commented that in devising strategies for achieving vector control, we need to account for different periods of activity of different sandfly species. He indicated that vector control is difficult because of cost and because of the extent of the areas to be treated. In comments that echoed those of Dr. Sherlock he stated that achieving vector control is more realistic in areas where peri-domestic transmission takes place. He also indicated that whereas control of rodents reservoirs may be possible there were significant problems with the elimination canine reservoirs.

Dr.Travi stressed the importance of confirming implicated reservoirs and that techniques for reservoir identification need to be improved. He went on to say that vector and reservoir control strategy needs to be feasible. He discussed the limitations of reservoir control including natural replacement, problems with domestic animals, endangered species. In general, he did not believe that reservoir control was a practical strategy to disease control. With respect to vector control, current insecticide application schemes are only transiently effective and do not evenly eliminate all sandfly species. Dr. Travi stressed what he believed to be the important need to evaluate larvicidal vs adulticidal effects of insecticides. He also cautioned about results of research obtained with using lab reared vs. wild type flies. There was substantial lack of agreement amongst participants, with comments both pro and con, regarding the likely effectiveness of achieving control with larvicidal agents. It would seem that more research is needed to clarify this point. In closing Dr. Travi commented that wild reservoirs cannot be controlled in the new World and that domestic reservoirs should be

protected flies where this is possible. Furthermore, efforts should be directed at vectors, extra-domiciliary, peri and domiciliary insecticide application, with research efforts directed at optimization of approaches.

Dr. Perez emphasized the need not to ignore and in fact to stress personal protection measures. Several individuals including Drs. Arias, Ward and Desjeux stressed that DDT was perhaps the most effective insecticide available for vector control and that its utility has been overlooked because of concerns about toxicity. It was argued that in the concentrations needed to achieve control of sandflies that is did not represent a hazard. In particular, the large doses used in agriculture have given it a bad name, but in the low doses required for domestic application it is safe, cheap and effective. Dr. Desjeux raised the question of DDT resistance, and this needed to be considered in specific situations, although he did not believe that this was a widespread problem. Dr. Chang raised the concern that funding agencies forcefully discourage the use of DDT and it may be important to get this issue reconsidered at the levels of both funding agencies and governments.

Dr. Mutinga stressed the need for community education to modify cultural practices that promote the development of peri-domiciliary breeding grounds for flies. This should be done as an important adjunct to or in lieu of insecticides where the latter are not practical.