tal application rates should provide for 0.1 to 1.0 μg/ml against other than *Anopheles* larvae. Levels of 5.0 μg/ml are suggested for *Anopheles* larvel control, but with a microencapsulated formulation to achieve a toxic concentration just under the liquid surface, this figure in field application may be reduced by a factor of 10 or even more, due to the potential benefit derived from immediate subsurface concentration over that required for general dilution.

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THE CONCEPT OF INTEGRATED CONTROL OF VECTOR-BORNE DISEASE

J. B. KING AND J. P. BROOKE

The Wellcome Foundation Ltd, Ravens Lane, Berkhamsted, Herts HP4 2DY, England

Historically, vector-borne disease control programmes have concentrated upon the practical application of measures offered by a single discipline. Where other disciplines have been involved this has often been upon an incidental basis. For example, since the development of residual insecticides effective against anopheline mosquitoes, their application has been emphasized in the attack phase of malaria control programmes. Other measures, such as the use of anti-malarial drugs were recommended as supplementary procedures and often were used only in difficult circumstances after problems had arisen or in later phases of the control programme. This recommended procedure has been effective in many parts of the world, has succeeded in eradicating diseases such as malaria in several countries and has achieved a significant degree of control in many others. However, vector-borne infectious diseases remain a major hindrance to economic progress in many parts of the tropical and sub-tropical areas of the world. Apart from the morbidity and mortality directly attributable to these diseases, especially malaria, there is a chronic impairment of the health of the population giving rise to increased mortality from other causes and to a reduction of efficiency in physical and mental activity. A growing awareness of the importance of these diseases, and the problems associated with their control, has prompted a re-appraisal of the measures currently available to us and of the range of diseases against which these measures might be effective.

An appreciation of the problems involved suggests that the integration of the various measures available to us may have considerable benefits. Improvement in effective liaison between the various disciplines involved has made this possible. Thus, the objective of integrated control of vector-borne diseases is the sequential blockade of successive stages in the disease cycle by the concurrent application of appropriate entomological, biological, medical and veterinary measures. That this is theoretically feasible is evident if one considers a programme for the control of cutaneous leishmaniasis, a disease of growing importance in the Middle East. (Figure 1). Medical treatment with sodium stibogluconate can cure infected individuals, deplete the human reservoir of infection and block the disease cycle at point (1). Control of *Phlebotomus* sp. by effective entomological measures could reduce the vector population and block the disease cycle at point (2). Treatment or control of the animal host could reduce this reservoir of infection and block the disease cycle at point (3). Timing is extremely important—if the various measures are carried out so that the optimum effect of each element occurs at the same time, then the disease cycle could be blocked at three different points simultaneously. The degree of obstruction at each stage of the disease cycle will depend upon the efficacy of the individual measures. However, the inte-

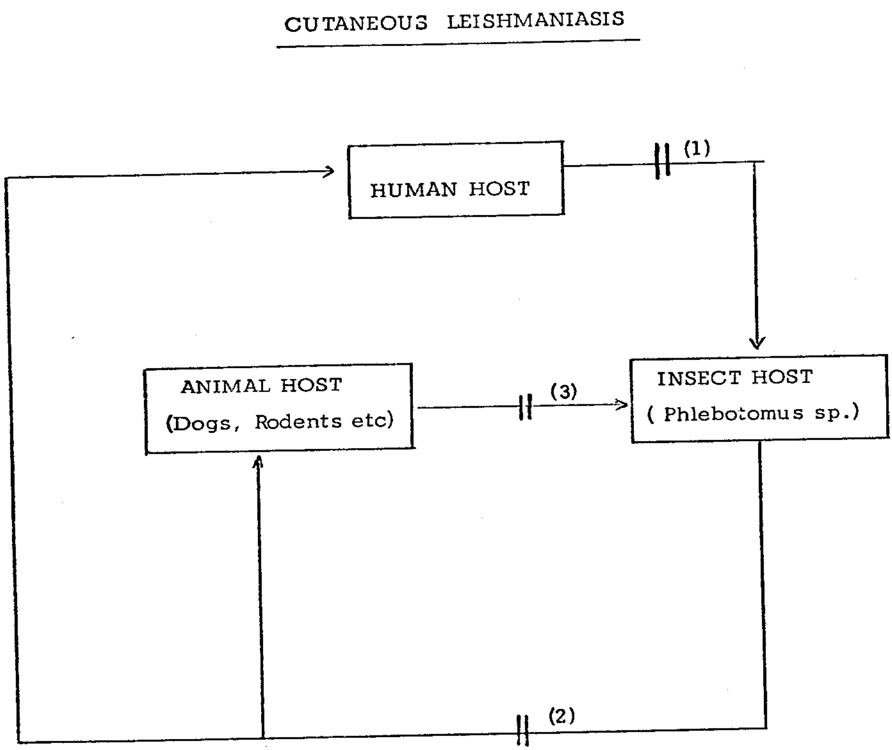

Fig. 1. Medical treatment blocks cycle at (1); Entomological measures block cycle at (2); Veterinary treatment blocks cycle at (3). Integration of all measures interrupts cycle in three places *simultaneously*.

gration of these measures could result in a rapid attack phase and give a high degree of disease control.

The principles of integrated control measures are relatively simple, but appropriate measures and methods must be selected for the disease under consideration. The overall plan must also be designed with due regard for epidemiology and ecology, financial and manpower resources, communications, technical problems and administrative constraints. Nevertheless, a frame-work applicable to integrated programmes for several different diseases may be suggested. (Figure 2). Here we have three different groups of activity all co-ordinated through one central point. The medical and veterinary measures are concerned with the control of the causative organism. The entomological and environmental health measures are concerned with the control of the vector. The input of both these groups will vary considerably according to the disease and vector that we are considering. The central group, logistics, will be subject to less variation but even so will depend upon the characteristics of the area within which we are operating. The use of this framework can be illustrated by its application to an integrated programme for the control of communicable ophthalmia (Figure 3). The medical element consists of chemotherapy and chemo-prophylaxis for the treatment and prevention of both trachoma and bacterial infection. The anti-bacterial and anti-chlamydial agents may be used in either oral or topical forms or in combination. This decision will depend upon medical, epidemiological and socio-economic considerations. Surgery will be necessary in some long-standing cases. The entomological element consists of ultra-low volume space spraying of synthetic pyrethroids to control the *Muscid* population, the vector which has been identified as a major factor in transmission. Environmental health measures will contribute to the control of the breeding sites of *Muscids*. Surveillance and monitoring of both parts of the programme are clearly essential. The two technical elements are co-ordinated, together with the logistics of the programme, through a central organisation. It must be emphasized that the adoption and adaption of a basic framework of this type does not alter the necessity of carrying out an adequate preliminary survey and pilot project.

Given adequate medical and entomological measures, the same princi-

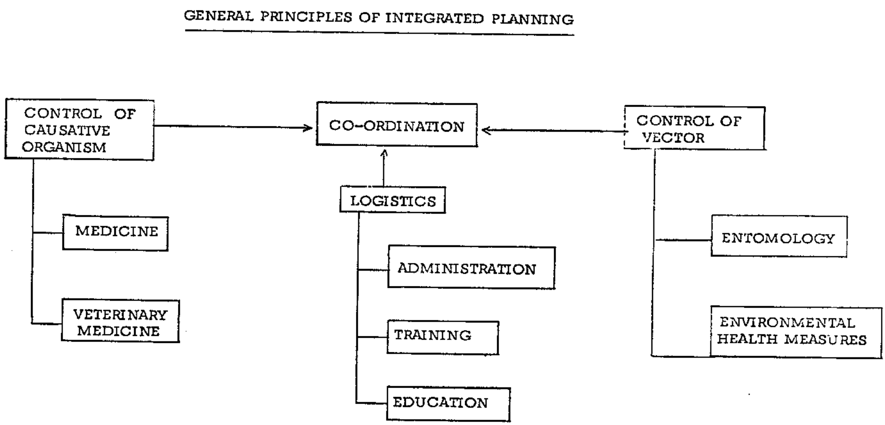

Fig. 2.

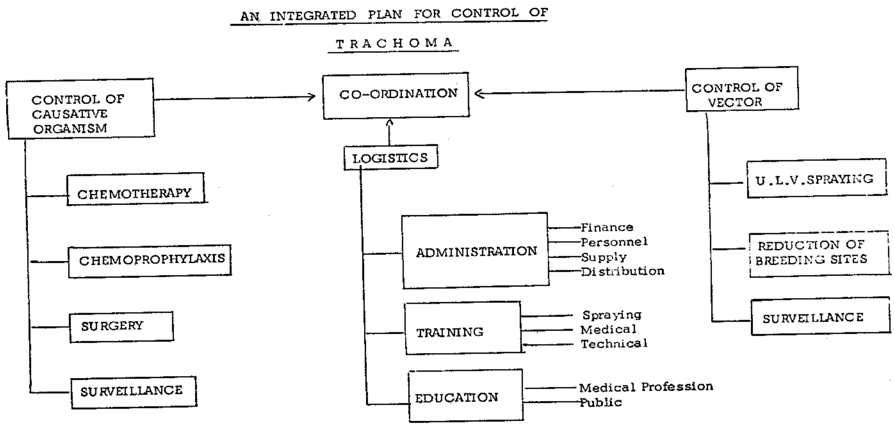

Fig. 3.

ples could be applied to several other conditions such as malaria, filariasis, schistosomiasis, trypanosomiasis, onchocerciasis, epidemic typhus, plague, cholera and various *zoonotic* diseases.

Some of the benefits of this approach can be seen if it is applied to the control of malaria. In any area where chloroquine sensitive falciparum malaria is transmitted by *Anopheles gambiae*, we can co-ordinate ultra-low volume space spraying, the use of residual insecticides and supplementary biological methods with concurrent chemotherapy using a combination of chloroquine plus pyrimethamine followed by chemoprophylaxis using pyrimethamine. Chloroquine can be reserved for treatment of any acute cases which are present during the programme. Other drugs are available if required. The objective of the integration would be to reduce the mosquito population to a very low level and simultaneously effect a radical cure of individuals, reduce the human reservoir of infection and prevent reinfection of the human population. This could shorten the attack phase of the programme, thus reducing the likelihood of the development of resistance of the vector to the residual insecticide used and of the parasite to the anti-malarial drugs. There would also be an immediate health benefit to the population. Total effective coverage of the population by medical measures and total elimination of the vector by entomological measures are very unlikely. However, integration may reduce the severity of the consequences of incomplete cover since one part of the programme can compensate to some extent for possible deficiencies in another part. This flexibility could also be useful in solving problems such as persistent transmission, lack of co-operation by the public or the presence of an unsuspected vector.

The justification of the use of an integrated programme must be based upon greater efficacy, greater health benefit to the human population and on acceptable cost effectiveness. For scientific, sociological and economic reasons, we believe this to be the case and therefore regard integration, liaison and improved communication between the different scientific disciplines to be most important.