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Biocontrol of Arthropods Affecting Livestock and Poultry

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20. Potential of Biocontrol for Livestock and Poultry Pests

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Livestock and poultry production systems are both biological and managerial systems which have been designed and structured by humans for the perceived benefit of humans. These production systems create artificial man-made ecosystems with consequent problems in arthropod pest management. Management of the arthropod pests is complex and not a simple task. It is complicated by varying pest species, varying animal strains, housing and management practices. It is apparent that arthropod pest management must include an integration of methods in a manner compatible with the animal production practices (Axtell 1981, 1986a). Greater utilization of biological control agents is needed and will occur.

The future of biocontrol in both developed and developing countries depends on at least four major parameters: (1) Social, (2) Economic, (3) Political, and (4) Technical. The last, technical, includes the scientific basis for biocontrol and population management as well as the technology of animal production management. Science and technology will eventually provide the capabilities for better use of biocontrol measures. The other parameters may enhance, limit or negate the use of that science and technology, however. Social constraints, such as attitudes towards animal rights and confined animal production, can result in pressures to change animal production practices in ways which complicate the effective use of biocontrol and necessitate new research. In certain European countries, for example, new regulations on poultry production are causing changes in the size and types of housing which will result in a changed environment for filth fly breeding and the use of biocontrol (Anonymous. 1985). Economic constraints will have a major impact on the development and acceptance of biocontrol measures. Funds from governments and/or industry are subject to many

demands and high-tech biotechnology can be a more exciting and enticing investment than biocontrol. The most important economic component, however, is the cost of animal production. Biocontrol must be cost effective for it to be accepted. With increasing costs of insecticides and very limited availability of new insecticides, the opportunities for cost effective use of biocontrol are greater. Political constraints may influence the funding for biocontrol research and the need for and acceptance of biocontrol measures. As a result of the social and political environment, laws and regulations on such things as pesticide registration and use, animal housing, waste disposal, importation of animal products and pesticides, import and export tariffs and taxes are established which may either seriously constrain the use of biocontrol measures or encourage and foster the use of biocontrol. All of these factors make the future for biocontrol uncertain even though promising.

The question is: What is the potential for biocontrol of arthropods affecting livestock and poultry in the developed countries in comparison to the developing countries? To examine this question, let us take an overview and then attempt to focus on some specifics and speculations.

The world food problem is summarized in simplistic terms by recognizing that the developing countries with 70% of the world's population produce only 40% of the food, have only 30% of the world's income, and only 20% of the purchased agricultural inputs. By 1990, 77% of the world's population will probably be located in the developing world. At the same time, it is estimated that 50% of the world's food production, 25% of the world's inputs, and 35% of the world's income will also be in the developing world (Olentine 1982). Thus, there is a vast growth potential in agriculture, notably in livestock and poultry production, in developing countries in the near and far future. Developing countries will not only increase their demand for food products, but will increase their relative ability to produce them. This will include substantial increases in livestock and poultry production with probably the greatest growth in poultry. Animal production in the developing countries will likely become more and more patterned after the production practices now used in the developed countries with particular emphasis on the use of confined, high density facilities. Therefore, the pest problems and management solutions will become more alike in both the developed and developing countries. Consequently, the potential for use of biocontrol in livestock and poultry production in confined animal production facilities is likely to

become more similar worldwide. The trends in developed countries will probably apply at a later time to the developing countries.

What is the scope of livestock and poultry production in the world? The data, from many sources, are fragmentary, vary in reliability, and often are only crude estimates. The following data are composites from several sources (Anonymous. 1986, 1987; Olentine 1982; Randell 1985, 1986; Schoeff 1987, 1988; USDA/FAS 1986). In North America (mainly USA) annual amounts of production (in millions, 1982) are: Cattle 174.0, swine 87.3, sheep 22.3, broilers 5.1, and eggs 87.6. In South America (mainly Brazil and Argentina) the amounts are: Cattle 208.6, swine 51.5, sheep 95.2, broilers 1.6, and eggs 17.3. In Western Europe (mainly France, Federal Republic of Germany, Netherlands and UK) the amounts are: Cattle 77.8, swine 78.0, sheep 58.8, broilers 2.4, and eggs 70.5. Annual production amounts in other Western Europe countries (mainly Spain) are: Cattle 14.2, swine 25.9, sheep 19.8, broilers 0.8, and eggs 18.0. With Spain and Portugal more recently joining the European Economic Community (EEC) the region presents a sizeable coordinated block for livestock and poultry production. In Eastern Europe the annual amounts are: Cattle 37.4, swine 70.8, sheep 43.1, broilers 0.8, and eggs 37.6. In the Soviet Union the amounts are: Cattle 115.3, swine 73.5, sheep 141.3, broilers 0.6, and eggs 73.2. Amounts for Asia are poorly documented with lack of hard data for the People's Republic of China and distortions due to the large number of cattle (242.0) recorded for India. Nevertheless, amounts for Asia are: Cattle 270.8, swine 34.8, sheep 90.3, broilers 0.9, and eggs 33.1. For so-called Oceanic Asia (mostly Australia and New Zealand the values are: Cattle 33.5, swine 2.8, sheep 206.0, broilers 0.2, and eggs 3.5. Data were not available for Africa.

Growth in poultry production has been most striking. The growth to meet the needs of the human population is destined to be greatest in China and Asia (Table 1). The developed countries have 26.4% of the human population, but produce 48.2% of the world's poultry and 66.7% of the world's eggs (Randall 1985). Per capita consumption of poultry meat is increasing in the developed countries while consumption of red meats is static or declining (USDA/FAS 1986). For example, in the USA the per capita consumption of poultry in 1987 was 78.6 lbs which was slightly greater (for the first time) than the consumption of beef (Table 2). Economics play a large role. The efficiency of feed conversion of poultry has been steadily increased through selective breeding and improved management so that a feed conversion ratio of 2.0 or less is now

Table 1. Percent of World Total Numbers of Humans, Poultry and Eggs in One Year in Different Areas.

Area	Humans	Poultry	Eggs
Developed economies	26.4	48.2	66.7
China and others	23.3	12.8	14.4
Asia	29.0	12.8	5.9
Latin America	8.0	14.4	8.1
Sub-Sahara Africa	7.5	6.3	1.9
N. Africa & Middle East	5.8	5.4	3.0

Source: Randall 1985 (1979 data).

Table 2. Meat Consumption in the United States (lbs. per capita).

Year	Poultry	Beef	Pork
1975	48.6	87.9	50.7
1977	53.2	91.8	55.8
1979	60.5	78.0	63.8
1981	62.4	77.1	65.0
1983	65.1	78.7	62.2
1985	70.1	79.1	62.0
1986	72.5	79.8	58.6
1987	78.6	74.7	59.2

Source: Broiler Industry 1987 (Sept), p. 24.

common in developed countries (Misirlioglu 1987). The marketing of improved breeds through out the world is making poultry production more feasible in developing countries.

These production figures, although rather crude, give an idea of the worldwide distribution of livestock and poultry. Comparisons of figures for several years shows that production is increasing worldwide (Anonymous. 1986, 1987, 1988; Olentine 1982; Randall 1985, 1986; USDA/FAS 1986). There are three trends. First, in recent years the trend has accelerated for the greatest percentage increases to be overall in the developing countries. A second trend is for the increases in both developed and developing countries to be in large operations using high densities of animals and being financed and managed by large companies. A third trend is for the greatest increases in both developed and developing countries to be in poultry production.

What does this mean for the potential of using biocontrol of arthropod pests in livestock and poultry production? Growth in high density, large operations, and especially poultry, results in large concentrations of manure and high numbers of filth flies with consequent increased potential for the use of biocontrol (Naber 1987). The greatest opportunities are, therefore, in facilities, such as cattle feedlots, dairy, swine, and poultry housing, where high densities of animals are produced under a highly structured system of management. The production management systems now in operation in developed countries are very sophisticated and use computerized systems for optimizing feeding and housing conditions. Contract farms under one management (integrator) are forced to adopt the practices dictated by the contractor. This structured management approach is most highly developed in poultry production in the so-called developed countries (Jones 1987), but is rapidly being introduced concurrent with expansion of poultry production in the developing countries. Let us, therefore, use poultry production to examine more closely the potential for using biocontrol. The concepts that apply to poultry production also apply to other high density confined animal production systems, e.g. swine, cattle feed lots and dairy.

Poultry production is integrated (Carter 1985) with one company controlling all phases including the breeder flocks, hatchery, growout houses, feed mills, processing plants and even the packaging, marketing and distribution of the products under one or more trade names. Individual farms operate under contracts which provide specified payments from the parent company to the producer. These payments may be based on numbers of eggs,

pounds of meat, feed conversion efficiencies, etc. The parent company actually owns the birds, provides the feed and dictates the management practices on the farm. In this situation, the key to using biocontrol is to convince the parent company of the utility of this approach in their operations. If the parent company is convinced, it will require the contract producers to follow the recommended biocontrol practices. The parent company (integrator) has servicemen who monitor the animal production practices of the contract producers and these servicemen can be trained to monitor the arthropod pests and to institute pest management measures, including the use of biocontrol agents.

The next question is: What pest or pests are most susceptible to the use of biocontrol agents? The greatest progress in developed countries has been in the use of biocontrol agents against filth flies which includes the house fly and related manure-breeding species (Patterson & Rutz 1986). This has even fostered the marketing of fly parasites by some small companies. Successful utilization of fly parasites in an integrated fly management program for poultry, dairy, swine, and feedlots has been difficult and far from being reliable. It is clear that the biocontrol agents must be used as a tool along with cultural measures (manure management) and selective use of insecticides (Axtell 1986a,b). Also, a complex of parasites and predators is needed, not just reliance on a single species. Use of fly pathogens should be considered, but presently research on that topic is far behind investigations of parasites and predators.

At present, biocontrol of filth flies in poultry production (Axtell & Rutz 1986), as well as in cattle and dairy feedlots (Meyer 1986), is being used in some areas of the USA and other developed countries. In the USA it is largely a case of recommending fly management practices that will encourage and enhance the natural populations of fly parasites and predators. Some augmentative releases of parasites are practiced. The basic components of a fly management program for poultry are (Axtell 1986c): (1) Cultural - maintaining the manure as dry as possible in production systems that allow for manure accumulation. Factors in this are minimizing leaking waterers, preventing surface water drainage into the buildings, providing ample air circulation through fans and natural currents unrestricted by outside vegetation. (2) Biological - encouraging the maximum development of indigenous fly parasites and predators by the above manure management practices. A major factor is the recommended practice of only removing the manure partially during cleanout times and always leaving a deep pad of old manure to preserve part of the population of predators and parasites.

The major emphasis is on preserving and enhancing populations of the pteromalid fly parasites, *Muscidifurax* and *Spalangia*, the macrochelid mite predator, *Macrocheles muscaedomesticae*, and the histereid beetle predator, *Carcinops pumilio* (Geden & Axtell 1988; Geden et al. 1988; Rueda & Axtell 1985). (3) Chemical - limited and selective use of insecticides in a manner compatible with preservation of the biocontrol agents is used when necessary. General larviciding of the manure is not recommended since most chemicals kill the beneficial arthropods as readily as the fly larvae. Spot treatment of limited areas of manure that have very high numbers of fly larvae is appropriate. One insecticide, cyromazine, is toxic to fly larvae but relatively harmless to the mite and beetle predators of the flies and, therefore, its use as a feed additive or a manure treatment is compatible with preserving and maintaining the populations of beneficial arthropods in the manure (Axtell & Edwards 1983). Use of chemicals as baits or limited residual surface applications directed against the adult flies is appropriate.

These components of an integrated fly management program require a fly population monitoring program. Favored monitoring tools are spot cards and baited jug traps (Lysyk & Axtell 1985, 1986). Weekly counts from these monitoring tools are used by the poultry servicemen and producer to decide on fly control measures. With this attention to actual fly numbers, it has become possible to limit the amount of insecticide used and hence the cost of fly control. Hopefully, this also will slow down the rate of insecticide resistance development by the flies. Practical application of such an integrated fly management program has necessitated the training of servicemen for the major poultry integrators. Similar programs are in use for fly management around cattle feedlots and dairies in the USA and elsewhere.

To more effectively use these biocontrol agents against filth flies, the complex system requires development of some computer models to aid in decision-making by the integrator and producer. Using the poultry production system as an example, we are attempting to model the fly management system. The dynamics of each of the components is complicated. One needs to look at six components: (1) House fly (the major target pest), (2) other fly species, (3) pteromalid fly parasites (population dynamics of *Muscidifurax* and *Spalangia*), (4) predators (*Macrocheles* mites and *Carcinops* beetles), (5) fly pathogens, and (6) the nature of the environment. The last component is critical for it involves the temperature (which is the major factor driving the arthropod population submodels) and manure quality (which affects fly breeding and populations of

biocontrol agents). Temperature and manure quality are affected by the type of animal housing, types of animals, animal physiology and nutrition, animal management practices and the manure handling and disposal practices.

Putting all of these factors together in computer simulation models for fly management in poultry or other confined animal production facilities will be a formidable task, but progress is being made in developed countries and this technology will be transferred with the introduction of highly integrated animal production technology into other countries. It is likely that the computer simulation models will not be developed to handle all aspects of the fly management problem. The data are not available and are too difficult to obtain for many aspects of the problem. The solution to this will be to develop so-called "expert systems" which will use the judgement of persons knowledgeable and experienced in the field of fly control along with inputs from the computer simulation models that are successfully developed. These expert systems will provide a structured program for decision-making in regards to fly management that will be compatible with the computer tools already being used by integrators for managing their poultry and livestock production enterprises. Use of computers has proven beneficial and cost effective to the integrators and, consequently, will be readily accepted and used if the fly management expert systems really work. With such systems, it should be possible to use biocontrol agents effectively in conjunction with manure management and insecticides.

The key to using biocontrol agents for filth fly control is manure management. The amount of manure produced per animal is inescapable and unless handled properly will be a source of uncontrollable fly breeding. The pounds of manure per day per 100 lbs of animal weight are: Dairy cow 8.2, beef cattle 6.0, swine 6.5, sheep 4.0, horse 4.5, laying hen 5.3, and broiler hen 7.1. Expressed in another way, poultry excrete about 5% of their body weight per day and the manure contains 75% moisture. Cattle (dairy and beef) and swine excrete 7-8% of their body weight per day and the manure contains 80-85% moisture. The handling and disposal of such large quantities of manure from confined livestock and poultry is a serious problem. The use of manure as fertilizer is a subject of continuing development. If the practical problems of drying, handling and distributing can be solved, then manure will become a positive benefit of increased livestock and poultry production (Anonymous. 1985, Naber 1987). The need for fertilizers is increasing while animal production is increasing. To illustrate the point, the growth in fertilizer use from 1975 to 1982 worldwide has occurred while there

Table 3. Egg Production and Nitrogen Fertilizer Use (Percent of World Totals) in Different Regions.

Region	Eggs		Fertilizer	
	1975	1982	1975	1982
North America	20.1	18.1	25.5	21.1
United States	15.9	13.7	21.7	16.6
Europe	27.3	24.5	28.1	23.9
USSR	13.2	13.3	16.9	13.9
Asia	30.8	33.8	24.5	35.6
South America	4.5	6.0	5.6	1.9
Africa	3.0	3.4	2.8	3.1
TOTAL	24.04	29.84	43.56	60.42
(million metric tons)				

Source: World Poultry 1985 (Dec), p. 62.

has been a similar growth in egg production (Table 3). Manure may be used for methane production and as a component of animal feed, but these uses have not become widely adopted. In developed countries, the lack of sufficient crop land for manure disposal is limiting the expansion of poultry production as well as other confined animal operations. Disposal of manure in deep lagoons is a temporary expedient, but eventually the decomposed organic matter has to be removed from the lagoons and in the meantime the lagoons frequently create a mosquito problem due to the ideal conditions for breeding *Culex quinquefasciatus* (Rutz & Axtell 1978; Rutz et al. 1980). If the lagoon disposal method is introduced into tropical Asian countries, the consequent populations of *C. quinquefasciatus* could be disastrous because that species is the major vector of human filariasis (*Wuchereria bancrofti*). The potential use of biocontrol agents for filth fly control is strongly linked to the manure management practices being developed and adopted in developed countries.

The potential of biocontrol for arthropods affecting livestock and poultry in developed countries is great in the case of integration into filth fly management programs for confined animal production facilities. The merits of using parasites and predators in such programs has been demonstrated empirically and quantitative data are being developed. The concept is being accepted and put into prac-

tice by the segments of the poultry industry as well as in cattle feedlots and dairy operations. The use of biocontrol agents for other arthropods and other categories of animal production is much less advanced and appears less promising. Future application of biocontrol will depend upon expansion and improvement of our scientific and technical knowledge and whether or not the social, economic and political conditions are favorable.

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