New Strategies in Locust Control
S. Krall, R. Peveling and D. Ba Diallo (eds)

Economics of desert locust control

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Summary. The desert locust, *Schistocerca gregaria* (Forskål), is an extremely mobile pest. It is not uncommon for swarms to travel hundreds of kilometres. Damage caused by desert locusts can be devastating, although – owing to the insect's mobility – it is never uniformly distributed. This makes it extremely difficult to precisely ascertain crop losses. Attempts to study the economic impact of desert locusts also run up against certain limits. Microeconomic calculations cannot be performed, and even macroeconomic studies conducted at the level of the national economy do not permit many conclusions to be drawn. Truly useful results are only yielded by regional studies that take account of the locusts' movements across national borders. This paper highlights the current situation, in which the lack of reliable figures makes cost-benefit calculations a difficult task. In this paper, an attempt is made to take available figures on swarms and hopper bands, the costs of control measures and potential damage as the basis for a novel approach to gauging economic aspects of desert locust control. Possible backup measures for collecting data are also sketched.

Résumé. Le criquet pèlerin, *Schistocerca gregaria* (Forskål) constitue un fléau extrêmement mobile. Il n'est pas inhabituel pour des essaims de parcourir des centaines de kilomètres. Les dommages causés par le criquet pèlerin peuvent être dévastateurs, mais ne sont jamais uniformément répartis – en raison justement de l'extrême mobilité des acridiens. Il est donc quasiment impossible d'évaluer avec précision les dommages causés aux cultures et l'étude de l'impact du fléau en termes économiques se heurte à certaines limites. Des calculs au niveau microéconomique ne sont guère réalisables et même des études menées sur le plan national au niveau macroéconomique ne permettent pas d'en tirer des conclusions intéressantes. Seules des études régionales tenant compte du fait que les acridiens franchissent les frontières politiques peuvent amener des résultats véritablement utiles. Cet article montre combien il est malaisé d'établir des analyses coûts-avantages en raison du manque de données chiffrées fiables. Il essaie également de montrer comment les chiffres disponibles sur les essaims et les bandes larvaires, ainsi que les données sur les coûts des mesures de lutte antiacridienne et les dommages potentiels peuvent servir à évaluer par une nouvelle approche les aspects économiques de la lutte contre le criquet pèlerin. L'article présente également quelques méthodes pour améliorer la fiabilité des données collectées.

Introduction

The desert locust, *Schistocerca gregaria* (Forskål), poses an ever-present threat to African agriculture (Steedman 1990). Desert locusts are difficult to manage and control because of the unpredictability of outbreaks and upsurges and because the insects are extremely mobile. Add to this the fact that locusts make the transition from the solitarious phase, in which they live as separate individuals, to the gregarious swarming phase in semi-desert areas. In such areas, monitoring the insects necessitates an enormous and therefore also costly logistical effort. The difficulties are often compounded by the remoteness and ruggedness of the terrain and by violent conflicts (Krall 1995; van Huis 1994).

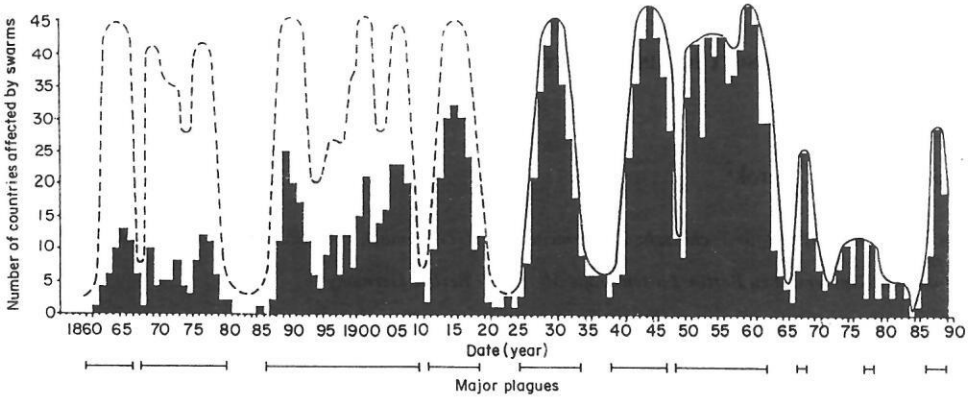

Figure 1. Numbers of countries reporting either bands or swarms during a year. Broken lines denote estimated values (according to Symmons 1992)

As a result, outbreaks and early upsurges are often not noticed until it is too late and therefore rarely suppressed. For this and other reasons, it is still virtually impossible even today to prevent desert locust plagues. Yet the last 35 years have not seen any extremely destructive, long-lasting plagues of the kind that occurred with frequency in earlier decades (Fig. 1), a number of which were thoroughly documented. The reasons for this are not yet known. It may be due to successful control measures of the kind that became feasible in the 1960s, involving application of dieldrin, a highly effective, persistent insecticide. But climatic, geographical, anthropogenic and/or natural causes may also play a role, like those held responsible for the disappearance of the problems previously caused in the Sahel by the African migratory locust (*Locusta migratoria migratorioides*, Reiche and Fairmaire).

Due to the behavior of the desert locust, which differs completely from that of nearly all other pests, it has not been possible to apply the classical methods of cost-benefit analysis to control measures. No attempts have been made to systematically ascertain crop losses caused by desert locust attacks. For the most part, the same decades-old figures have been cited over and over again. Only a few surveys have been carried out during the last 10 years, and these have not come up with enough data for reliable calculations (Launois 1994). Surprisingly, while everyone is currently trying to cut down on pesticide use in integrated pest management programmes, the chemical control of the desert locust has not even been subjected to a cost-benefit analysis. Studies of this kind did not begin until very recently (Herok and Krall 1995).

The difficulties involved in addressing economic issues

The classical methods used to study economic aspects of crop protection activities take either a microeconomic or a macroeconomic approach. A given measure can be considered at the farm level, and its cost and benefits can be calculated. This is useful when the aim is to persuade farmers of the economic feasibility of individual crop protection measures. Economists, however, are more interested in the macroeconomic situation; as a rule, this involves studies at the level of the national economy.

When dealing with the desert locust, however, both approaches are problematic. Microeconomic studies are not very useful, since desert locust plagues occur so irregularly and in such widely differing forms from region to region that virtually nothing of relevance can be concluded for any given farm. A survey conducted in Niger in 1991 (Krall 1994) provided some indication of the significance of desert locusts at the individual farm level. Farmers were asked which was the principal pest afflicting their pearl millet. If this question was formulated very generally, then 57% of those questioned named the desert locust. If the same question focussed on growing seasons, however, then the majority cited other pests. This demonstrates that although farmers consider the desert locust to be a spectacular and dangerous pest, they actually experienced it once or only a few times during their lifetime.

It follows logically from this that combating plagues is not the job of individual farmers. Instead, national crop protection services take care of this in cooperation with regional organisations like the Desert Locust Control Organisation for Eastern Africa (DLCO-EA), an association of seven East African countries. This is a good example of how the desert locust eludes the classical macroeconomic approach, which is typically restricted to a single country.

Take, for instance, the case of Mauritania. Agriculture does not play a major role in the economy of this West African country, in contrast to other countries of the Sahel zone. Two-thirds of its land area is desert, and agriculture is intensively practiced only along the Senegal River in the south of the country. When desert locust plagues occur, large numbers of swarms regularly occur in Mauritania. They usually enter from the east, and reproduce within the country. During the 1993 upsurge alone, over 100 small, medium-sized and large swarms were sighted in Mauritania (Wilps, personal communication). These swarms typically did not inflict any major damage, however, as many of them flew off towards the north to Morocco and Algeria, westward to the Atlantic Ocean, or – less frequently – towards the south, to Senegal (van Huis 1994). This has to do with the prevailing wind directions, among other things. Only 9 out of every 10 swarms pose a serious threat to the country's own agricultural sector, according to information provided by the Mauritanian crop protection service (Galledou, personal communication). They do, however, pose a major threat to the northern Maghreb, where a number of high-value agricultural crops are grown.

Taking a macroeconomic approach to this problem (i.e., considering this country in isolation), one would have to conclude that controlling desert locusts is not economically worthwhile for Mauritania. But if the scope of the study is enlarged to include Algeria and Morocco, completely different results will be obtained. This example shows that there is little point in performing the analyses at the level of the national economy. Macroeconomic approaches only make sense for an entire region, which in this case embraces at least the entire Sahel and the Maghreb. The difficulties involved are obvious – after all, we are talking here about a dozen or so independent states and a land area three times the size of Western Europe.

Yet these difficulties, as daunting as they are, are compounded further by the fact that the available figures, in other words the basis for performing calculations of all kinds, are extremely inadequate (Herok and Krall 1995). If we wish to consider environmental impacts as well (at the meta level), then we are quickly forced to enter the realm of pure speculation.

Bases for economic calculations

Three main groups are affected by problems related to desert locusts, on either the cost or the benefit side:

- farmers
- afflicted countries
- donor countries

In 1986–89 alone, the donor countries contributed about US$275 million, thus meeting a substantial share of the costs for monitoring and controlling desert locusts (OTA 1990).

A wide variety of factors play a role. On the cost side, for example, expenditures are incurred for equipment, consumables and materials for monitoring and control measures, acquiring information, medical care, functioning of international organisations and environmental damage. On the benefit side, we have, among other things, reduction of crop and quality losses, reduction of foreign exchange expenditures on food imports, training effects and strengthening of crop protection services.

It is difficult to validate these factors, however; environmental impacts are a case in point. Time preferences can also be validated in different ways. On the one hand, benefits ought to be forthcoming more or less in the same year in which most of the costs are incurred: control measures prevent losses. On the other hand, there can also be long-term positive effects attributable to effective control or equipment that is originally brought in to combat locusts but is subsequently used for other purposes. Account must also be taken of the fact that certain expenditures continue between the occurrence of plagues, such as the fees and contributions that must be paid in foreign exchange to regional or supraregional international organisations. Because of this, it would appear to be appropriate to apply the capital value method, or alternatively to determine the internal rate of return. All of these calculations, however, rely upon the availability of substantiated data.

Data for economic calculations

After the relevant factors have been identified, figures need to be assigned to them. A thorough review of the available data reveals that there is a particularly acute lack of figures on potential and actual benefits. The information on damage is, when available at all, too outdated (Tab. 1) or too imprecise to be used for cost-benefit analyses (Tab. 2).

Table 3 attempts to provide a brief overview of the costs and benefits for the years 1986 to 1993. A desert locust plague occurred during this time period (in 1987–88).

Table 1. Crop losses caused by locusts. (based on Steedman 1990)

Year	Country	Amount of crop eaten by the desert locust
1944	Libya	7,000,000 grapevines; 19% of total vine cultivation
1954	Sudan	55,000 tonnes of grain
1957	Senegal	16,000 tonnes of millet, 2000 tonnes of other crops
1957	Guinea	6000 tonnes of oranges
1958	Ethiopia	167,000 tonnes of grain, which is enough to feed 1,000,000 people for a year
1962	India	4000 hectares of cotton (value £300,000)

Table 2. Estimated yield losses between 1986 and 1993

Country	Loss as percentage of total production	Regional maximum
Chad	No value	80%
The Gambia	No value	70%
Mauritania	No value	60%
Senegal	3%	-
Sudan	cereals <5%, total <1%	76%

Table 3. Available data on costs and benefits of desert locust and grasshopper control (US$) (1986–1993)

Costs		Benefits	
		Farmers	
Pesticides and equipment	0	Gained yields	?
Working time	0	Improved quality	?
Health hazards	?	Inputs	?
Subtotal	**?**	**Subtotal**	**?**
		Affected countries	
		Crop protection service	
Pesticides	?	Foreign exchange	?
Equipment	?	Support for crop protection services	?
Transport	?	Balance-of-payments effect	?
Operating costs	?	Educational effect	?
Personnel	?	Image	?
Subtotal	44,322,254	Taxes	?
		Military	
Equipment and personnel	?		
		Government	
Loans	?		
Contributions to internat. aid	2,187,000		
Contributions to internat. institutions	644,300		
Environmental effects	?		
Subtotal	**2,831,300**	**Subtotal**	**?**
		Donors	
Pesticides	69,000,000		
Equipment and training	?		
Transport and operating costs	?		
Personnel	?		
Subtotal	**295,247,000**	**Subtotal**	**?**
Total costs	**342,400,554**	**Total Benefits**	**?**

Possibilities for economic assessment of costs and benefits

The example given above makes it plain that no useful results can be achieved today using macroeconomic study methods, since for the most part there is a lack of concrete figures. There are, however, possibilities for getting a grip on the problems despite these gaps in the data. The

Table 4. Crop equivalents of control costs (in tonnes/ha of sorghum)

Year	Control costs	Sorghum equivalent (in t)		Sorghum equivalent in ha Yield = 500 kg/ha	
		World market	Local market		
	(in mill. US$)	110 US$/t	300 US$/t	110 US$/t	300 US$/t
1986	50.2	456,363	167,333	912,726	334,666
1987	35.8	325,454	199,333	650,908	398,666
1988	102.8	934,545	342,667	1,869,090	685,334
1989	98.7	897,273	329,000	1,794,546	658,000
1990	16.9	153,636	56,333	307,272	112,666
1991	8.4	76,364	28,000	152,727	56,000
1992	6.7	60,909	22,333	121,818	44,667
1993	22.9	208,181	76,333	416,364	152,667
Total	342.4	3,112,725	1,221,332	6,225,451	2,442,666

simplest way is to compare the known costs against the equivalent food losses which would have had to be prevented to yield a kind of break-even point. This can be done on the basis of either world-market prices or local prices. An argument in favor of applying world-market prices is that most of the expenditures required for desert locust control call for foreign exchange to be spent (e.g. to buy pesticides, sprayers, vehicles etc.).

Table 4 lists these values for the years 1986–93. The equivalent amounts of sorghum are given both in tonnes and in terms of land area in hectares, which would have had to be destroyed merely to offset the costs.

It is of course no easy matter to interpret such figures. Hopefully, however, they will motivate agricultural statisticians to compare them with the actual situation. The question arises, for example, whether it is realistic to suppose that between 24,000 and 62,000 km^2 of millet or sorghum fields could have been totally destroyed during the mentioned years. The answer can be yes or no, but either way it might encourage better collection of data on crop losses caused by desert locusts.

Another possibility is more complex, and involves the use of model calculations to approximate potentially prevented losses. Bullen (1969) devoted an enormous effort in the 1960s to working out a crop vulnerability index (CVI). This was based on data on all major field and tree crops grown throughout the entire region, rounded out by data on swarms and hopper bands provided by the Anti-Locust Centre in London and the Food and Agriculture Organisation of the United Nations (FAO), and defined crops potentially subject to attack from desert locusts. This yielded relative CVI figures that provided an indication of where to expect the greatest damage and crop losses. Bullen concluded that 50% of the anticipated losses would occur in the Indo-Pakistan region, 23% in north-western Africa, 13% in the Middle East, 11% in East Africa and 2% in West Africa.

In the following, another possible approach, developed by Herok and Krall (1995) and similar to Bullen's model, will be considered. It is based on the same type of data on locust swarm and hopper band frequency used by Bullen for the calculation of CVIs, as well as agricultural production data for the potentially affected African countries. The chief differences are that (1) more recent data were included and (2) Herok and Krall pooled the values of each country's agricultural production. This yielded figures expressing potential crop losses as absolute monetary values instead of relative values as in Bullen's model. Based on an assessment of swarm size, the extent of damage and the efficacy of control, the potentially preventable damage was evaluated, expressed as absolute monetary values, while distinguishing among different cases (Fig. 2).

These values were compared to control costs, which could be assessed relatively precisely for the last few years, and calculated net positive or negative benefits. The costs for the years 1986 to 1993 are listed in column 2 of Table 4. In a number of cases, it proved impossible to make a clear distinction between costs for grasshopper and desert locust control, since many of the campaigns conducted during these years were directed against both groups. Because of this difficulty, only the total control costs are listed here.

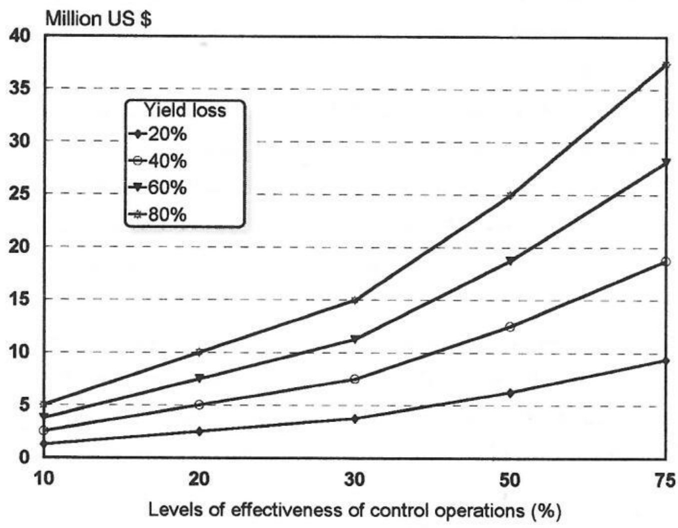

Figure 2. Potentially preventable annual yield losses with desert locust control in Africa (in mill. US $) (according to Herok and Krall 1995)

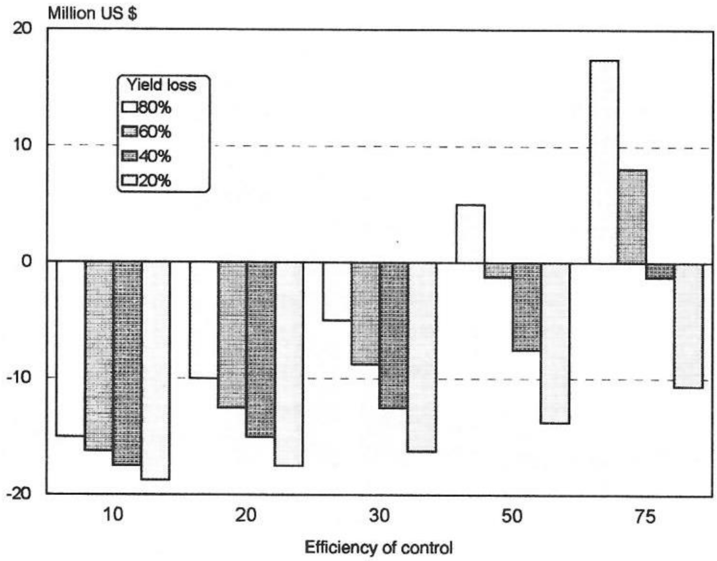

Figure 3. Net benefit of desert locust control in Africa (cost/year = US$20 million)(according Herok and Krall 1995)

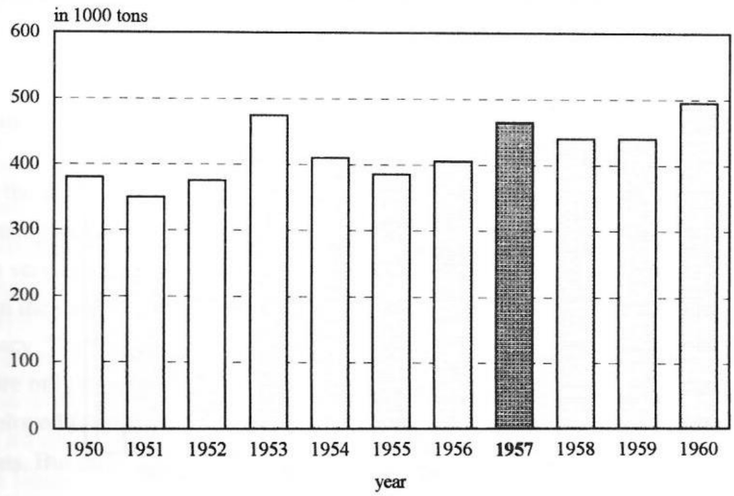

Figure 4. Yields of cereals in Senegal between 1950 and 1960 (desert locusts caused considerable damage in 1957)

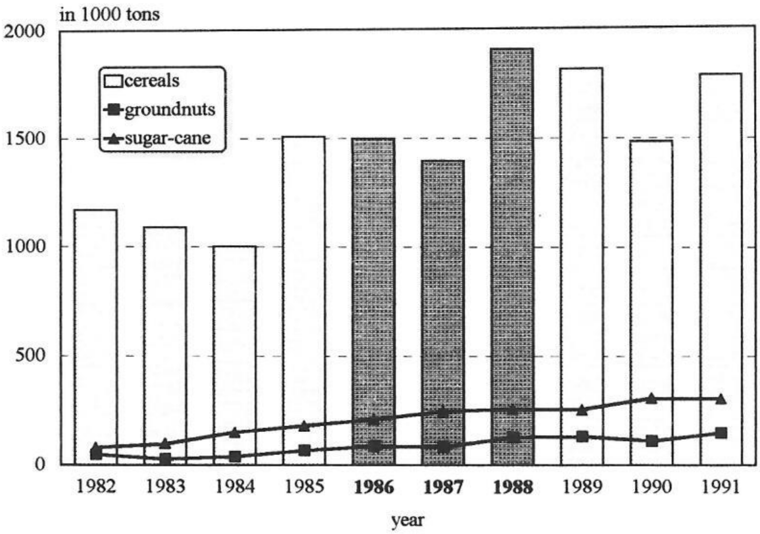

Figure 5. Yields of cereals in Mali between 1982 and 1991 (desert locust plague 1986–88)

The average value for each of the eight years studied is US$42.8 million. Even deducting 50% for grasshopper control, some US$20 million remains. Based on this assumption, Figure 3 shows the net benefits for different damage levels and efficiency factors of control measures. A positive net benefit only results if one assumes extensive damage and highly effective control, with an efficiency factor of at least 50%.

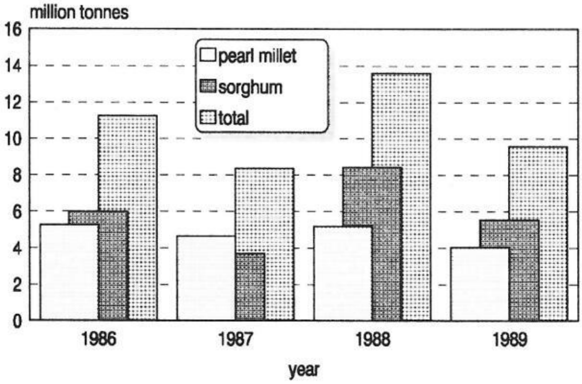

Figure 6. Yields of cereals in the Sahel between 1986 and 1989 (major desert locust plague year in 1988)

Do locusts cause famines?

In lectures and the media, references abound to famines caused by desert locusts. Some speak of thousands of deaths. Needless to say, these reports are unfounded. Nevertheless, we considered it important to find out whether the available figures on agricultural production in recent decades actually provide any indication of emergency situations of this kind. We therefore investigated a number of different cases to establish whether the statistics provide evidence of food shortages (Figs 4–6).

In all three cases it can be seen that there have not been any significant yield losses in years with locust plagues. In 1988 there were even above-average harvests both in Mali and throughout the Sahel zone. We were unable to analyze the years prior to 1950, as insufficient data were available for them.

One frequently cited argument is that desert locusts have a deleterious impact on rangelands. No reliable data whatsoever exist to back up this claim in the case of the Sahel, however. Studies in Paraguay (Wilhelmi 1995) showed that, in the case of the field locust *Staurorhectus longicornis* (Giglio-Tos), a decline in meat and milk production is improbable unless severe damage is inflicted over a lengthy period of time.

On the other hand, livestock-keeping nomads living in the Sahel frequently complain that they are affected by the adverse effects of locust control campaigns. A number of times, apparently, cattle have been killed by insecticides sprayed to combat locusts. In some cases this was the result of unintentional direct spraying of animals by aircraft, and in other cases was caused by ingestion of contaminated forage from treated areas (Anonym 1987).

Discussion

Owing to the extremely unsatisfactory data situation, it is impossible to perform cost-benefit analyses using real data. In order to remedy this problem as quickly as possible, national crop protection services should regularly survey the effectiveness of control measures and inflicted damage. In the case of control measures, this is definitely feasible; methods exist for measuring their efficacy. The task is more difficult where damage is concerned. Quantitative measurement methods are only available for certain cases (Pantenius and Krall 1993). Such methods still need to be developed for most crops. For the time being, there is no way to avoid getting subjective assessments. But information of this kind is still better than none at all.

As we have seen, all of the calculation models available today have shortcomings. Either they are extremely time-consuming to use, like the method proposed by Bullen (1969), or – like that of Herok and Krall (1995) – rely upon a number of assumptions. Nevertheless, the latter method is the only available approach capable of dealing with the sheer size of the region under study and the special nature of the complex problems associated with the desert locust.

Although Bullen did not arrive at a very precise comparison of costs and benefits, he does deserve credit for having identified which regions are most at risk. His writings reveal that two-thirds of the expected damage in Africa is concentrated in the Maghreb, and within that region primarily in Morocco and Algeria. In other words, in monetary terms it is not primarily smallholders who profit from the control campaigns conducted in the Sahel as a whole – it is the growers of high-value crops in the Maghreb who benefit. To date there has been no real evidence of damage to rangeland having any seriously adverse effects on livestock farming. Yet livestock animals have been killed a number of times as a result of insecticides used to control locusts. It may thus be concluded that locust control does not have any positive effects on livestock raising. In 1970 Bullen compared locusts and grasshoppers with other agricultural pests, concluding: "Thus locusts and grasshoppers, even at their worst, constitute only a very small proportion of the overall crop protection problem." He continued: "It is therefore important that the status of locusts and grasshoppers as crop pests should be defined in relation to crop losses caused by other insects. Has man been emotionally blinded by the spectacle of locust invasions and deluded into believing that they are pests of major importance?"

Particularly in view of the substantial expenditure involved and the need for equipment and so forth, it is increasingly questionable whether and to what extent, controlling desert locusts is worthwhile. This conclusion was drawn 25 years ago, but had few consequences, since for quite a while thereafter no additional plagues occurred. Bullen's work was therefore forgotten, and failed to exert any influence on the large-scale control campaigns conducted in the late 1980s and early 1990s.

It was not until these campaigns were well under way that the issue whether cost-intensive control measures make economic sense was again addressed. The model developed by Herok and Krall (1995) attempts, for the first time, to compare the potentially preventable damage with the actual cost of control measures. Their study concludes that the strategy being pursued today does not make economic sense in terms of costs and benefits. Although this model only constitutes an initial approximation and involves a number of estimates, it nevertheless ought to prompt a reconsideration of the currently applied locust control strategy. Relatively uncoordinated combating of swarms and hopper bands like those typical today should be abandoned. A strategically concerted effort is essential. Within this context, the focus should be on protecting crops. Control measures in the most remote areas should be thoroughly reconsidered in the light of the population dynamics of the desert locust, which is characterized by the natural collapse of plagues. Nor is it realistic to expect that outbreaks and even upsurges can be suppressed during their early stages, considering the rugged terrain and the security situation in many countries.

Initial studies have shown that no famines have been caused by locust plagues during the last five decades. It may very well be possible for regionally limited shortages to occur, but these can be offset by appropriate distribution policies at the national level. Growers of high-value crops may suffer serious economic losses, but even if these cannot be prevented by control measures, they can at least be compensated by a suitable insurance system.

We do not wish to create the impression that the desert locust problem should be addressed from a purely economic standpoint, expressing everything in monetary terms. Major human and social components also deserve attention.

Besides political considerations, one of the most important of these is maintaining a reliable supply of locally produced food at the village level; this cannot simply be replaced by food aid, a point that future studies need to take into account. Conversely, neither should attention center on social aspects to the complete exclusion of economic issues. They must nevertheless be taken into consideration when interpreting data of all kinds. Most important, however, the database must be improved. This is the only way to obtain useful results that can be used to persuade those in charge of locust control to modify their strategies.

References

Anonym (1987) Campagne de lutte antiacridienne 1986/87, Bilan et perspectives. Ministère de l'Agriculture et de l'Elevage, Ouagadougou, Burkina Faso

Bullen FT (1969) The distribution of the damage potential of the desert locust (*Schistocerca gregaria* Forsk.). Anti-Locust Memoir 10, Anti-Locust Research Centre, London

Bullen FT (1970) A review of the assessment of crop losses caused by locusts and grasshoppers. Proc Int Study Conf Current and Future Problems of Acridology, London, 163–169

Herok C, Krall S (1995) Economics of desert locust control. Roßdorf: TZ-Verl-Ges, 70 pp

Krall S (1994) Importance of locusts and grasshoppers for African agriculture and methods for determining crop losses. In Krall S, Wilps H (eds) New trends in locust control. Roßdorf: TZ-Verl-Ges

Krall S (1995) Desert locust in Africa – a disaster? Disasters, The Journal for Disaster Studies and Management 19(1): 1–7

Launois M (1994) Les dégâts des criquets pèlerins en Mauritanie et au Sénégal. Sahel PV Info no 64: 6–17

Office of Technology Assessment (OTA) (1990) A Plague of locusts. Special Report, US Congress, Washington

Pantenius U, Krall S (1993) A new method for determining yield losses caused by damage to the heads of pearl millet (*Pennisetum glaucum* (L.) R. Br.) due to diseases and pests. J Plant Diseases and Protection 100 (5): 522–529

Steedman A (ed) (1990) Locust handbook. Chatham: Natural Resources Institute

Symmons P (1992) Strategies to combat the desert locust. Crop Protection 11: 206–212

Van Huis A (1994) Can we combat the desert locust successfully? Proc Seminar Wageningen, Netherlands, 6–11 Dec 1993, 11–17

Wilhelmi F (1995) *Staurorhectus longicornis* (Giglio-Tos), an acridid grasshopper pest species on pasture land in the Central Chaco, Paraguay. Eschborn: GTZ, pp 55