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Pyrethrum: a review of market trends and prospects in selected countries

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The analysis contained in this report is based partly on published information and partly on opinion and information obtained during interviews conducted with numerous participants in the pyrethrum trade, including members of the main producing organisations in the exporting countries and a representative selection of importers, processors and users in North America, European Community countries, Japan and mainland Asia. The author wishes to acknowledge with gratitude the assistance and advice given, in some cases very generously, by the many individuals, companies and organisations contacted during the course of the study.

PRELIMINARY NOTE

The estimates of market sizes and trends included in this report are based as much on trade opinion as on the published statistics. Although production, export and import statistics were in many cases found to be available, numerous discrepancies were encountered. For one thing, unit values as calculated from trade statistics in a number of cases were found to bear little relation to known market prices at the time in question. For another, import volumes were found in many cases not to tie in adequately with the corresponding export statistics, and while time-lags in recording are in some cases undoubtedly partly responsible, the differences in some cases were too great for this to be an adequate explanation on its own, and very often it was not possible to establish the full reason for the discrepancies. It should, however, be borne in mind that export and import volumes make no attempt to give a breakdown according to whether consignments were of extract of 25% nominal pyrethrins content, or extract of 50% nominal content. In any case, the actual pyrethrins content – and therefore the actual value eventually realised – may in some cases be appreciably higher than the nominal figure. This is partly due to the existence of two separate methods of pyrethrins measurement, namely the Pyrethrum Board of Kenya (PBK) and the Association of Official Analytical Chemists (AOAC) methods, the latter typically giving readings 10% lower than the former. While an examination of unit values may help to obtain an indication of the rough breakdown between extracts of different levels of concentration, the afore-mentioned statistical vagaries often render such an analysis unreliable. It has therefore been necessary to treat the published information as only an approximate guide to trade and price movements, initial impressions being modified as appropriate on the basis of trade comment.

The following conventions apply in all statistical tables:

– nil or negligible
... not available

Summaries

SUMMARY

Pyrethrum: a review of market trends and prospects in selected countries

Pyrethrum is one of the oldest known naturally-occurring insecticides, and certainly the most widely used botanical insecticide. It is produced from the flower heads of the plant *Chrysanthemum cinerariaefolium* which grows very widely but can only be exploited successfully on a commercial basis if climatic conditions allow the pyrethrins (the active insecticidal agent) content of the flower heads to reach or exceed a minimum level, normally around 1%. Most commercially-exploited pyrethrum flowers have a pyrethrins content of around 1%–1.5%, typically 1.3%. Appropriate climatic conditions are normally only found in the high-altitude tropics where a combination of high daytime temperatures and low nocturnal temperatures is regularly recorded. In recent years the main producers have been Kenya, Tanzania, Rwanda, Ecuador and Papua New Guinea, Kenya accounting for around two-thirds of the total and Tanzania a substantial proportion of the remainder.

Although the highest per hectare yields of dried flowers are achieved when production is organised on a plantation basis, in practice the unsuitability of pyrethrum for mechanical harvesting, and its eminent suitability for production and harvesting by smallholders on private plots, has rendered plantation production very much the exception rather than the rule, Ecuador providing one of the rare exceptions. Yields per hectare are, however, lower when the plant is grown on this basis, and regular experimental work has been undertaken to develop either new strains of plant yielding more flower heads per hectare, or strains giving higher pyrethrins content per flower head, it being difficult in practice to achieve both simultaneously. The comparative lack of hardiness of higher-yielding strains, together with other drawbacks, has in general militated against appreciable success in this experimental work. Work reportedly undertaken in Tasmania on the development of a strain of pyrethrum plant of which the flower heads all mature at more or less the same time, thereby rendering mechanical harvesting at least theoretically possible, has yet to give rise to any major changes in production methods, and there are at present no signs of any move on the part of the established producers to alter production practices substantially.

Pyrethrum is traded in several forms. The oldest and most traditional form is that of a powder prepared by fine grinding of the dried flower heads. During the past two to three decades, however, the bulk of world trade in pyrethrum has taken the form of extracts prepared by treatment of the flower heads with solvents. Extracts may be crude, with high wax content and a strong colour, or refined, that is to say dewaxed and decolourised. Partially-refined extracts have also been available, but only in relatively small quantities. The main by-product of the extraction process, a powdery residue of spent flower heads known as 'marc', contains barely any pyrethrins but is widely used as a filler in mosquito coils as well as cattle feed. Pyrethrum extracts are usually sold at nominal pyrethrins

contents of either 25% or (in the case of refined extract only) 50%, although the actual contents may be higher. Prices are quoted on the nominal basis, final payment adjustments being made once the actual pyrethrins content has been agreed between buyer and seller.

Pyrethrum is a high-potency contact insecticide with a broad spectrum of activity against flying insects and some crawling insects. It is, however, short-term in its effectiveness as it quickly breaks down after application, especially in strong ultra-violet light. This lack of persistence, combined with its very low mammalian toxicity, is a major reason for its popularity *vis-à-vis* some other insecticides, but it also restricts its use largely to indoor applications since it breaks down too quickly outdoors to be useful except in very limited and specific agricultural and horticultural applications. Its effectiveness against crawling insects, although in some respects remarkable, is also limited by the need for residual activity if continuing control is to be achieved. However, on both the main criteria by which insecticidal efficiency is judged, namely *knock-down* (the ability to incapacitate and paralyse insects rapidly) and *kill*, especially the former, pyrethrum has long been widely admired and valued. In addition, it excites insects prior to knock-down and is valued as a flushing agent for driving insects out into the open. These characteristics are enhanced by the addition to pyrethrym of a 'synergist' such as piperonyl butoxide, although the action of other insecticides can also often be improved thereby. Synergists are usually cheap in relation to the main active ingredient and are used to increase the cost-effectiveness of the product. Traditionally, pyrethrum was very widely used in household insecticide aerosols; in space or surface sprays for insect control in food processing plants and other industrial installations; in warehouses; in various types of animal house on farms (stables, milking parlours, piggeries, etc.); for insect control on animals, both in farming applications and on domestic pets; for short-term insect control in gardens and commercial horticulture; in packaged food products; in bulk storage of foodstuffs including cereals; in mosquito coils and similar products so widely available in warm, humid climates for domestic use; and in numerous other domestic, institutional and commercial applications. Nowadays, however, its uses are much more restricted, on account of historic supply problems combined with current ready availability of cheap alternatives.

Crude pyrethrum extract is only used where surface staining is unlikely to be a problem or where delivery nozzles are large enough for clogging due to the high wax content to be unlikely to occur. Only the coarser space or surface sprays, as well as some veterinary preparations, lend themselves to the use of crude extract and even these applications often utilise refined, or at least partially-refined, extract. For all fine-spray applications, such as domestic aerosols, low-volume and ultra-low-volume industrial and institutional sprays and so forth, the use of refined extract is almost obligatory. Pyrethrum powder used to be used mainly in mosquito coils, but this outlet has contracted sharply and the powder is now restricted more to domestic dusts for use on pets, in gardens and for insect control in awkward corners and crevices, as well as minor institutional and farming applications. Marc continues to be used in mosquito coils and cattle feeds but alternative fillers are now used by coil manufacturers for reasons of cost and availability.

The recent supply shortages which have been such a feature of the pyrethrum market have been due partly to erratic climatic and cultivation patterns in the producing countries, partly to the producer price failing periodically to keep abreast of producer prices of competing crops such as tea, coffee, maize and vegetables, and partly to the reluctance of the national pyrethrum marketing organisations to hold sufficient stocks to tide them over periods of low production and consequent supply deficits. Attempts by the marketing organisations to hold the producer price down stemmed partly from their awareness that inexpensive substitute insecticides were becoming available from Western and Japanese companies, but it was a policy that was in the end to prove strongly counter-productive. The major shortage which occurred in

1978–80 was much more severe than any preceding shortage and coincided with the availability of several synthetic pyrethroids with similar properties. As a result, the world market for pyrethrum in 1983 is little more than one-half its pre-shortage level. Domestic aerosols now largely, although by no means exclusively, utilise synthetic pyrethroids, and the same applies, with even greater force, to mosquito coils. Stored products, public health applications, many garden products and numerous industrial applications are nowadays serviced by insecticides other than pyrethrum. Pyrethrum's main remaining applications are insect control in food processing plants, mostly in the USA; insect control in barns and animal houses, where its comparative freedom of any tendency to bring about resistance build-up in insects is still valued; some of the more expensive domestic insecticidal aerosols; and miscellaneous 'home and garden' products such as pet dusts, rose dusts, garden sprays and so forth. The current market size is equivalent to a little over 100 tonnes of natural pyrethrins, which can be expressed as around 340–400 tonnes of 25% extract or 8,000–10,000 tonnes of dried pyrethrum flowers. At its peak (1972), world production of dried pyrethrum flowers easily exceeded 20,000 tonnes. Roughly 75% of the market is in the USA, mostly in food processing plants, and much of the balance in Western Europe. The Far Eastern market, which was based mainly on the mosquito coil trade, is now very small. Although demand for pyrethrum in the USA dropped appreciably as a result of the shortages, there has recently been some levelling-out and even slight recovery, whereas in Europe the fall was more severe and little sign of any significant recovery was evident by mid 1983.

The main competing insecticide groups are the organochlorines, organophosphates, carbamates and synthetic pyrethroids, besides one or two minor categories. The organochlorines, which include such products as DDT, dieldrin and lindane, tend to be very cheap but are toxic and very persistent, their lingering effects being transmitted through food chains with deleterious environmental consequences. Their use is now severely restricted in many countries. The organophosphates possess greater immediate toxicity but are much less persistent, and are widely used in agriculture, public health, food stores and so forth, although some are also used in aerosols and industrial sprays. Examples of these products include malathion, parathion-methyl and DDVP (dichlorvos). The carbamates, of which Baygon (propoxur) is a major example, are widely used in public health applications, especially against crawling insects. The synthetic pyrethroids can be divided into several categories: firstly those with good 'knock-down' performance but low residual activity, for example allethrin, bioallethrin, s-bioallethrin, Es-Biothrin, tetramethrin and kadethrin; secondly, those with good 'kill' performance but, again, low residual activity, for example resmethrin, bioresmethrin and d-phenothrin; and thirdly, the photostable halogenated agricultural pyrethroids, with good 'kill' performance but usually only moderate 'knock-down', for example permethrin, cypermethrin, deltamethrin (formerly decamethrin), fenvalerate, fenpropathrin and many related or derived examples. It is mainly the first category of pyrethroids, those with good 'knock-down' performance, that has proved the gravest threat to pyrethrum, but pyrethroids in the other two categories have made at least some inroads at pyrethrum's expense, and the same can be said of certain insecticides of the other classes described. On most bases of relative cost-efficacy, pyrethrum nowadays stands at a disadvantage, although recent price falls consequent on heavy stocks have rendered it, probably only temporarily, reasonably competitive with the allethrin family of pyrethroids. Since, moreover, 65–75% of the cost of a drum of extract is accounted for by the price paid to the producers, and since it is not feasible to pay the producers appreciably less than they currently receive if their interest in pyrethrum as a cash crop is to be maintained, the scope for reducing the price of pyrethrum products is very limited.

The use of insecticides is widely circumscribed by legislation requiring that either the insecticides themselves, or, more commonly, the formulations in which they are incorporated (often with a specific use in view), be registered with appointed health or environmental authorities, or sometimes with, say, a local Ministry of Agriculture. The requirements in the USA are particularly strict; elsewhere, the pattern varies and there is no uniform internationally-recognised code, in the main. Product labels often have to be registered, and the regulations governing their use strictly adhered to. Many labels specifying the use of pyrethrum are still current, but many more which incorporate synthetic pyrethroids have now been cleared by the various authorities. Registration is a long-winded and very expensive process, and once a new ingredient has been developed, formulated, offered for registration and finally cleared, users are most reluctant to revert to the use of former formulations, even if the former problems which led to their abandonment, such as high prices or shortages, are alleviated. Attempts to re-establish pyrethrum in some of its former uses encounter very formidable competition, and often the outlook is hopeless. Only in US food processing plants do the Environmental Protection Agency's (EPA's) regulations operate so strongly in pyrethrum's favour that its position is still virtually impregnable.

In the event of a competitive synthetic pyrethroid being cleared for use in US food plants and in certain farm building applications, which seemed unlikely in the early 1980s, there would probably be little or no future for pyrethrum.

The consensus of trade opinion is that pyrethrum can probably hold on to much of its current greatly-reduced share of the world market, for example in aerosols, animal houses, and so forth, as well as in food processing plants, if the producers can succeed in avoiding a repetition of the earlier shortages. The likelihood of its being able to regain a substantially larger share of these outlets, however, is more remote, and perhaps the most promising prospect – and not a very encouraging one at that – is for the development of new uses. Pyrethrum's ability to activate and flush out insects, thereby bringing them into greater contact with the insecticide formulation as a whole, is widely acknowledged, and the use of pyrethrum to this end in agriculture, in combination with residual activity insecticides, could well be expanded. Pyrethrum is also already being used for last-minute treatment of certain fruit, vegetables and other produce immediately prior to harvesting, the use of residual insecticides for this purpose often being restricted or banned, and there could be opportunities for expansion in this area. The micro-encapsulation of pyrethrum in order to extend its residual activity has also been attempted, although at considerable cost, and there may be room for further exploration of this process and its possible applications, although the signs so far have not been promising, mainly for economic reasons. Similar comments apply to the use of pyrethrum outdoors in ultra-low-volume (ULV) applications. There are also 'home and garden' and veterinary applications where there could be prospects for wider usage, probably in entirely new formulations. Overall, however, the immediate need on the part of the producers is for retrenchment and for adjustment to the new market conditions, as well as for a review of stockholding policies with a view to making good those production shortfalls that are wholly outside their control. The prospects for new pyrethrum producers are far from promising, especially as most of the existing processing plants are under-utilised, and only in the event of one of the larger producers going out of production altogether might there be opportunities for a new producer.

RÉSUMÉ

Le pyrethre: revue des tendances du marche et perspectives dans quelques pays choisis

Le pyrèthre est l'un des plus anciens insecticides d'origine naturelle et certainement l'insecticide botanique le plus largement utilisé. Il est obtenu à partir des capitules de la plante *Chrysanthemum cinerariaefolium* qui est très répandue, mais qui ne peut être exploitée avec succès sur une base commerciale que si les conditions climatiques permettent à la teneur des capitules en pyréthrine (l'agent insecticide actif) d'atteindre ou de dépasser un taux minimum, normalement d'environ 1 pour cent. La plupart des fleurs de pyrèthre exploitées commercialement ont une teneur en pyréthrine d'environ 1 à 1,5%, spécifiquement 1,3%. Des conditions climatiques appropriées ne se trouvent nor-

malement que dans les régions tropicales à hautes altitudes, où l'on enregistre régulièrement une combinaison de températures élevées le jour et de températures nocturnes basses. Ces dernières années, les principaux producteurs ont été le Kenya, la Tanzanie, le Ruanda, l'Equateur et la Nouvelle-Guinée-Territoire de Papouasie, le Kenya couvrant près des deux-tiers de la production totale et la Tanzanie une partie substantielle du reste.

Bien que les rendements les plus élevés de fleurs séchées par hectare s'obtiennent lorsque la production est organisée sur une base de plantation, en pratique, du fait que le pyrèthre est difficilement récolté mécaniquement et qu'il convient très bien pour la culture et la récolte par de petits exploitants sur des parcelles privées, la production en plantation est devenue beaucoup plus l'exception que la règle, l'Equateur représentant l'une des rares exceptions. Les rendements par hectare sont cependant plus bas lorsque la plante est cultivée sur cette base et des recherches expérimentales ont été entreprises régulièrement pour développer soit de nouvelles variétées de plantes avec in rendement plus élevé en capitules par hectare, soit des variétés donnant une teneur plus élevées en pyréthrine par capitule, obtenir les deux en même temps étant très difficile en pratique. L'absence relative de vigueur des variétés à haut rendement, associée à d'autres inconvénients, a d'une façon générale empêche d'arriver à un succès appréciable dans de travail expérimental. Un travail entrepris en Tanzanie sur le développement d'une variété de pyrèthre dont les capitules arrivent à maturité plus ou moins au même moment rendant ainsi possible, du moins théoriquement, la récolte mécanique, doit encore donner lieu à d'importants changements dans les méthodes de production et, jusqu'a présent, il n'y a aucun signe d'un mouvement quelconque de la part des producteurs établis pour modifier notablement les habitudes de production.

Le pyrèthre est commercialisé sous plusieurs formes. La forme la plus ancienne et la plus traditionnelle est celle d'une poudre préparée en broyant finement les capitules séchés. Mais au cours des deux à trois dernières décades, la majeure partie du commerce mondial du pyrèthre a pris la forme d'extraits préparés par traitement des capitules par des solvants. Les extraits peuvent être bruts, avec une teneur élevée en cires et une couleur soutenue, ou bien purifiés, c'est-à-dire débarrassés des cires et décolorés. Il y a eu également des extraits partiellement purifiés, mais seulement en relativement petites qantités. Le principal produit secondaire de l'extraction, un résidu pulvérulent des capitules épuisés, appelé 'marc' ne contient pratiquement aucune pyréthrine, mais il est largement utilisé comme charge dans les serpentins à moustiques et également dans l'alimentation du bétail. Les extraits de pyrèthre se vendent habituellement à la teneur nominale en pyréthrine de 25% ou (uniquement dans le cas d'extrait purifié) de 50%, bien que la teneur réelle puisse être plus élevée. Les prix sont fixés sur la base nominale, des ajustements finals du paiement étant faits une fois un accord intervenu sur la teneur réelle en pyréthrine entre l'acheteur et le vendeur.

Le pyrèthre est un insecticide de contact puissant avec un large spectre d'action contre les insectes volants et certains insectes rampants. Mais son efficacité est de courte durée et il se décompose rapidement après l'application, en particulier en lumière ultra-violette intense. Cette absence de persistance, associée à sa très faible toxicité chez les mammifères, est une raison majeure de sa popularité par rapport à certains autres insecticides, mais elle limite aussi son utilisation essentiellement aux applications à l'intérieur étant donné qu'il se décompose trop rapidement à l'extérieur pour être utile, si ce n'est dans des applications très limitées et spécifiques en agriculture et en horticulture. Son efficacité contre les insectes rampants, bien qu'elle soit remarquable à certains égards, est également limitée par la nécessité d'une activité résiduelle si l'on veut parvenir à une action efficace persistante. Cependant, d'après les deux principaux critères par lesquels on juge l'efficacité insecticide, à savoir *assommer* (la faculté de rendre rapidement incapables les insectes et de les paralyser) et *tuer*, surtout d'après le premier, le pyrèthre a longtemps été admiré et apprécié. En outre, il excite les insectes avant de les assommer les forçant à sortir.

Ces propriétés sont renforcées par l'addition au pyrèthre d'une substance 'synergique' comme par exemple le Piperonyl Butoxide; l'action d'autres insecticides peut également être améliorée par ce moyen. Les substances synergiques sont souvent bon marché par rapport à l'ingrédient actif principal et elles sont utilisées pour augmenter le rapport prix-efficacité du produit. Traditionnellement, le pyrèthre a été très largement utilisé dans les aérosols insecticides ménagers; dans les liquides à pulvériser dans l'atmosphère et de contact pour la lutte contre les insectes dans les usines de produits alimentaires et autres installations industrielles, dans les entrepôts, dans divers types de bâtiments de ferme (étables, salles de traite, porcheries, etc.) pour la lutte contre les insectes sur les animaux, aussi bien les animaux d'élevage que les animaux domestiques; pour la lutte à court-terme contre les insectes dans les jardins et dans l'horticulture commerciale; dans les produits alimentaires conditionnés; dans le stockage en vrac de produits alimentaires y compris de céréales; dans les serpentins contre les moustiques et des produits analogues dont l'utilisation domestique est si largement répandue dans les climats chauds et humides et dans de nombreuses autres applications domestiques, commerciales et dans les établissements. Mais actuellement son emploi est beaucoup plus limité à cause des difficultés d'approvisionnement connues et également du fait que l'on dispose maintenant de produits de remplacement bon marché.

L'extrait de pyrèthre brut n'est utilisé que si les surfaces peuvent être tachées sans inconvénient ou lorsque les gicleurs sont suffisamment grands pour ne pas risquer de se boucher à cause de la teneur élevées en cires. L'extrait brut ne peut être utilisé que pour les liquides à pulvériser grossiers, que ce soit pour l'atmosphère ou pour les surfaces, et pour certaines préparations vétérinaires, mais, même pour ces applications, on utilise souvent l'extrait purifié ou, tout au moins, partiellement purifié. Pour toutes les applications de pulvérisation fine, notamment les aérosols domestiques, les pulvérisations de faible volume et de très faible volume dans l'industrie et dans les établissements, etc., l'utilisation d'extrait purifié est pratiquement obligatoire. La poudre de pyrèthre était utilisée principalement dans les serpentins contre les moustiques, mais ce débouché a fortement diminué et l'emploi de la poudre se limite maintenant aux applications sur les animaux domestiques, dans les jardins et pour lutter contre les insectes dans les coins et les fissures difficiles à atteindre ainsi qu'aux applications mineures dans les établissements et les exploitations agricoles. Le marc continue à être utilisé dans les serpentins pour moustiques et dans les aliments pour bétail, mais d'autres charges sont maintenant utilisées par les fabricants pour des raisons de prix et de disponibilité.

Le marché du pyrèthre s'est caractérisé ces derniers temps par des crises d'approvisionnement; celles-ci étaient dues en partie aux conditions météorologiques irrégulières et aux programmes de culture fantaisistes dans les pays producteurs et, en partie, au fait que, périodiquement, le prix à la production n'arrivait pas à se maintenir au niveau des prix à la production de récoltes concurrentielles, notamment de thé, de café, de maïs et de légumes; elles étaient dues aussi au fait que les organisations nationales de distribution du pyrèthre se montraient peu disposées à maintenir des stocks suffisants pour leur faire traverser les périodes de faible production et de déficits d'approvisionnement en découlant. Les efforts des organisations de distribution tendant à maintenir le prix à la production à un bas niveau provenaient en partie du fair qu'elles se rendaient compte du lancement sur le marché d'insecticides de remplacement bon marché par des compagnies occidentales et japonaises, mais cette politique s'est révélée finalement comme allant fortement à l'encotre de la production. L'importante pénurie qui a eu lieu en 1978–80 a été beaucoup plus sévère que n'importe quelle crise précédente et a coïncidé avec la mise sur le marché de plusieurs pyréthroïdes synthétiques avec des propriétés analogues. Comme consequence, le marché mondial du pyrèthre en 1983 ne représente qu'un peu plus de la moitié de son niveau avant la crise. Les aérosols domestiques utilisent maintenant largement, mais en aucune façon exclusivement, des pyréthroïdes synthétiques; cela s'applique aussi, même avec encore plus de force, aux serpentins pour moustiques. Des insecticides autres que le pyrèthre sont maintenant utilisés pour les produits stockés, pour les applications dans la santé publique, pour beaucoup de produits de jardinage et de nombreuses applications industrielles. Les principales applications qui restent pour le pyrèthre sont la lutte contre les insectes dans les usines de produits alimentaires, surtout aux Etats-Unis, la lutte contre les insectes dans les granges et les bâtiments abritant les animaux oû son absence relative de toute tendance à provoquer le développement de résistance chez les insectes est toujours appréciée, la fabrication de quelquesuns des aérosol insecticides domestiques les plus chers et de produits mixtes 'maison et jardin', comme les poudres pour animanux domestiques, les poudres pour rosiers, les liquides à pulvériser pour le jardinage, etc. Le volume du marché actuel équivaut à un peu plus de 100 tonnes de pyréthrine naturelle, ce qui peut s'exprimer comme environ 340–400 tonnes d'extrait à 25% ou 8.000–10.000 tonnes de fleurs de pyrèthre séchées. A son maximum (1972), la production mondiale de fleurs de pyrèthre séchées dépassait facilement 20.000 tonnes. Les Etats-Unis détiennent en gros 75 pour cent du marché, principalement dans les usines de produits alimentaires et l'Europe occidentale détient une grande partie du reste. Le marché d'Extrême-Orient qui était basé essentiellement sur le commerce des serpentins pour moustiques, est maintenant très petit. Bien que la demande pour le pyrèthre aux Etats-Unis ait considérablement baissé comme conséquence des pénuries, il y a eu récemment une certaines égalisation et même un léger redressement; en Europe par contre la chute a été plus sévère et on a constaté peu de signes de redressement significatif.

Les principaux groupes d'insecticides concurrentiels sont les organo-chlorés, les organo-phosphorés, les carbamates et les pyréthroïdes synthétiques, en outre une ou deux catégories mineurs. Les organo-chlorés, dont des produits tels que le DDT, la dieldrine et le lindane, tendent à être très bon marché mais ils sont toxiques et très perisistants, leurs effets persistants étant transmis par les chaîines alimentaires avec des conséquences nuisibles pour l'environnement. Leur utilisation est maintenant sévèrement réglementée dans de nombreux pays. Les organo-phosphorés possèdent une toxicité immédiate plus grande mais ils sont moins persistants et ils sont largement utilisés en agriculture, dans la santé publique, dans les granges et magasins de produits alimentaires, etc.; quelques-uns sont également utilisés en aérosols et en pulvérisations industrielles. On peut citer comme exemples de ces produits le malathion, le méthyl-parathion et le DDVP (dichlorvos). Les carbamates, dont l'un des principaux est le Baygon (propoxur), sont largement utilisés dans les applications dans la santé publique, en particulier contre les insectes rampants. Les pyréthroïdes synthétiques peuvent être divisés en plusieurs catégories: premièrement, ceux avec de bonnes performances quand il s'agit d''assommer' les insectes, mais avec une faible activité résiduelle, par exemple, alléthrine, bicalléthrine, S-bioalléthrine Es-biothrine, tétraméthrine et kadéthrine; deuxièmement, ceux avec de bonnes performances quand il s'agit de 'tuer' les insectes mais, à nouveau, avec une faible activité résiduelles, par exemple, resméthrine, bioresméthrine et d-phénothrine; troisièmement, les pyréthroïdes halogénés photostables utilisés en agriculture, avec de bonnes performances pour 'tuer' les insectes, mais des performances seulement modérées quand il s'agit de le 'assommer', par exemple, perméthrine, cyperméthrine, deltaméthrine (autrefois décaméthrine), fenvalérate, fenpropathrine et de nombreux produits apparentés ou dérivés. La première catégorie de pyréthroïdes, ceux qui 'assomment' efficacement, s'est révélée comme étant la plus grave menace pour le pyrèthre, mais les pyréthroïdes des deux autres catégories ont fait au moins quelques incursions aux dépens du pyrèthre et on peut dire la même chose de certains insecticides des autres classes décrites plus haut. Sur la base de l'analyse coût-efficacité, le pyrèthre est actuellement désavantagé, bien que les chutes récentes des prix l'aient rendu, probablement de façon seulement provisoire, raisonnablement concurrentiel avec les pyréthroïdes de la famille des alléthrines. Etant donné, de plus, que 65–75 pour cent du coût d'un tonneau d'extrait est représenté par le prix payé aux producteurs et qu'il n'est pas possible de payer aux producteurs beaucoup moins que ce qu'ils reçoivent actuellement si l'on veut qu'ils continuent à s'intéresser an pyrèthre en tant que récolte payable an comptant, on ne dispose que d'une latitude très limitée pour réduire le prix des produits à base de pyrèthre.

L'emploi des insecticides est fortement limité par la législation qui exige que les insecticides eux-mêmes ou, plus couramment, les préparations dans lesquelles ils sont incorporés (souvent destinées à un usage spécifique) soient enregistrés auprès de pouvoirs compétents en matière de santé publique ou d'environnement ou, parfois, auprès, disons, d'un Ministère d'agriculture local. Les exigences aux Etats-Unis sont particulièrement rigoureuses; ailleurs, le schéma est variable et, d'une façon générale, il n'existe pas de code uniforme reconnu sur le plan international. Les labels des produits doivent souvent être enregistrés et les réglementations régissant leur emploi doivent être rigoureusement observées. De nombreux labels précisant l'emploi du pyrèthre sont encore courants, mais beaucoup de ceux qui comprennent des pyréthroïdes synthétiques ont maintenant été autorisés par les différents pouvoirs. L'enregistrement est une procédure de longue haleine et très chère et une fois qu'un nouvel ingrédient a été développé, formulé, proposé pour l'enregistrement et finalement autorisé, les utilisateurs se montrent très hésitants pour retourner à l'emploi d'anciennes préparations, même si les problèmes qui avaient conduit à leur abandon, notamment prix élevés ou pénuries, sont éliminés. Les tentatives de rétablir le pyrèthre dans quelques-uns de ses emplois d'autrefois se heurtent à une concurrence formidable et l'issue est souvent sans espoir. Ce n'est qu'aux Etats-Unis que, sous la pression des usines de produits alimentaires, les réglementations de l''Environmental Protection Agency' (LPA) jouent si fortement en faveur du pyrèthre que sa position est toujours pratiquement inattaquable. Dans l'éventualité (actuellement improbable) que l'emploi d'un pyréthroïde synthétique concurrentiel soit autorisé dans les usines alimentaires des Etats-Unis et pour certaines applications dans les bâtiments d'explotations agricoles, les perspectives pour le pyrèthre seraient probablement faibles ou nulles.

Sur le plan commercial, les avis s'accordent sur le fait que le pyrèthre peut probablement conserver en grande partie sa part actuelle, fortement réduite, du marché mondial, par exemple dans les aérosols, les bâtiments abritant les animaux, etc., de même que dans les usines de produits alimentaires si les producteurs réussissent à éviter que ne se répètent les pénuries d'autrefois. Mais la probabilité qu'il puisse regagner une plus grande part de ces débouchés est plus faible, et la perspective peut-être la plus prometteuse – et pas très encourageante – est celle du développement de nouveaux emplois. Le pouvoir du pyrèthre de stimuler les insectes et de les faire sortir, les mettant ainsi en contact plus étendu avec la préparation insecticide dans son ensemble, est largement reconnu et l'emploi du pyrèthre à cette fin en agriculture, en combinaison avec des insecticides avec une activité résiduelle, pourrait être étendu. Le pyrèthre est déjà utilisé aussi pour le traitement de dernière minute de certains fruits, légumes et autres produits immédiatement avant la récolte, l'emploi d'insecticides à activité résiduelle à cette fin étant souvent limité ou interdit, et il pourrait y avoir des possibilitiés d'expansion dans ce domaine. La microencapsulation du pyrèthre afin d'étendre son activité résiduelle a également été tentée, bien que ce soit à un prix considérable, et l'exploration plus poussée de ce procédé et de ses applications possibles pourrait avoir sa place bien que, jusqu'à présent, les signes n'aient pas été prometteurs, surtout pour des raisons économiques. Ceci s'applique également à l'utilisation du pyrèthre à l'extérieur pour les applications de pulvérisations de très faible volume. L'emploi dans les applications 'maison et jardin' et dans les applications vétérinaires pourrait également être étendu, probablement dans des préparations absolument nouvelles. Mais, dans l'immédiat, l'objectif des producteurs doit être le redressement et l'adaptation aux nouvelles conditions du marché; en outre, la politique du maintien des stocks doit être révisée afin de revaloriser les déficits de production qui sont totalement hors de leur contrôle. Les perspectives pour de nouveaux producteurs de pyrèthre sont loin d'être prometteuses, d'autant plus que la plupart des usines de transformation sont sous-utilisées et ce n'est que dans l'éventualité où l'un des grands producteurs se retire complètement de la production que des possibilités pourraient s'offrir à un nouveau producteur.

RESUMEN

Pelitre: – una resena de las tendencias del mercado y de las perspectivas en países selectos

El pelitre es uno de los insecticidas naturales más antiguamente conocidos al hombre. Es ciertamente el insecticida botánico más ampliamente usado. Se produce a base de flores de la planta *Chrysanthemum cinerariaefolium* la cual crece muy extensamente, pero sólo puede ser explotada comercialmente con éxito si las condiciones climatológicas permiten que el contenido de piretrinas (el agente activo insecticida) en la flor alcance, o exceda, un nivel mínimo, normalmente alrededor del uno por ciento. La mayoría de las flores de pelitre explotadas comercialmente tienen un contenido de piretrinas entre 1 y 1,5 por ciento; típicamente un 1,3 por ciento. Las condiciones climatológicas adecuadas se encuentran normalmente en las regiones tropicales de alto nivel geográfico en las cuales se registran de manera regular y combinada altas temperaturas diurnas y bajas temperaturas nocturnas. En años recientes, los principales países productores han sido Kenia, Tanzania, Ruanda, Ecuador y Papua Nueva Guinea. Kenia ha producido aproximadamente dos tercios del total, mientras que a Tanzania le corresponde una proporción considerable del resto.

Si bien las cosechas más altas por hectárea de flores secas se obtienen cuando la producción está organizada bajo las directrices de una plantación, en la práctica la inconveniencia del pelitre para ser recogido mecánicamente, junto con su sobresaliente idoneidad para su cultivo y recolección por pequeños granjeros propietarios de parcelas privadas, ha significado que la producción a nivel de plantación es más bien una excepción en lugar de ser lo corriente, siendo Ecuador una de las pocas excepciones. No obstante, las cosechas por hectárea son menores cuando se cultiva la planta a base de este método, habiéndose llevado a cabo trabajo experimental regular para desarrollar o bien nuevas razas de plantas que produzcan más flores por hectárea, o bien razas que ofrezcan un contenido de piretrinas más alto por cada flor, siendo difícil conseguir ambos objetivos al mismo tiempo. La resistencia bastante baja de las razas más productoras, unido a otros inconvenientes, ha contrarrestado en términos generales el éxito apreciable de estos trabajos experimentales. Las investigaciones que nos han dicho se han llevado a cabo en Tasmania sobre el desarrollo de una raza de planta de pelitre cuyas flores maduran aproximadamente al mismo tiempo (con lo cual puede hacerse la recolección mecánicamente por lo menos en teoría), no han de influenciar todavía cualquier cambio importante en los métodos de producción actuales, y de momento no existen indicaciones de que los productores establecidos intenten alterar significativamente los sistemas de producción.

El pelitre se comercializa de varias formas, siendo la más antigua y tradicional un preparado de polvo tras una fina molienda de las flores secas. No obstante, durante las últimas dos o tres décadas, la mayoría del comercio mundial del pelitre ha adoptado la forma de extractos preparados mediante el tratemiento de las flores con solventes. Los extractos pueden ser brutos, con un elevado contenido de parafina y un color intenso, o bien refinados, es decir una vez que se han desparafinado y decolorado. También se han ofrecido disponibles extractos parcialmente refinados, pero sólo en cantidades relativamente pequeñas. El principal subproducto del proceso de extracción es un residuo de flores pulverizadas llamado 'fibra' ('marc') que casi no contiene piretrinas, pero que se utiliza extensamente como relleno en mosquiteros y en piensos para el ganado. Los extractos de pelitre se venden normalmente a base de un contenido nominal de piretrinas equivalente ya sea al 25%, o al 50% (en los extractos refinados solamente), si bien los contenidos respectivos pueden ser mayores. Los precios se cotizan con arreglo a las bases nominales, haiéndose ajustes de pago final una vez que el contenido real de piretrinas ha sido acordado entre el comprador y el vendedor.

El pelitre es un insecticida de contacto de alta potencia con un amplio espectro de actividad contra insectos voladores y algunos reptantes. Sin embargo, su efectividad es de poca duración ya que se descompone rápidamente después

de su aplicación, especialmente bajo luz ultravioleta intensa. Esta falta de persistencia, junto con su bajo nivel de toxicidad a los mamíferos, explica gran parte de su popularidad al lado de otros insecticidas, pero también limita su uso excepto a los espacios interiores, ya que se descompone rápidamente en el exterior, no surtiendo efecto sino en ciertas aplicaciones agrícolas y hortícolas específicas. Su efectividad contra los insectos reptantes, aunque en varios respectos notable, se ve también limitada debido a la necesidad de que surta eficacia residual, si se quiere conseguir un control constante. No obstante, en lo que respecta a los principales criterios mediante los cuales se juzga la eficacia insecticida, a saber: el *derribo* (la propiedad de incapacitar y paralizar rápidamente los insectos) y la *muerte* de los mismos – especialmente el primero de ellos – el pelitre ha sido admirado y apreciado desde hace mucho tiempo en todo el mundo. Además, tiene la ventaja de excitar a los insectos antes de derribarlos, por lo cual se aprecia como agente capaz de sacar a loss insectos al aire libre. Estas propeidades son realzadas mediante la adición de un 'sinergista' tal como el piperonyl butoxide en el pelitre, si bien la acción de otros insecticidas puede también mejorarse con lo mismo. Los sinergistas son normalmente más baratos en relación con el ingrediente activo principal, y se emplean para aumentar la eficacia al costo del producto. Tradicionalmente, el pelitre fue usado muy extendidamente en aerosoles insecticidas caseros, en rociadores de espacio o superficie para controlar los insectos en plantas elaboradoras de alimentos y en otras instalaciones industriales; en almacenes, en diversos tipos de albergues para animales en granjas (establos, salas de ordeñado, porquerizas, etc.); para el control de insectos en animales, tanto los de granja como los domésticos; para el control temporal de insectos en jardines y en la horticultura comercial; en productos alimenticios empacados; en el almacenaje a granel de piensos, incluyendo cereales; en mosquiteros y productos parecidos que tanto se usan en países calurosos y húmedos para aplicaciones domesticas; así como en numerosos otros usos domésticos, institucionales y comerciales. Sin embargo, en la actualidad se usa mucho más limitadamente, debido a problemas de origen histórico en lo que refiere a su suministro, además de la presente disponibilidad de otras alternativas más económicas.

El extracto de pelitre bruto es utilizado solamente cuando las manchas superficiales no son propensas a plantear problemas, on en los casos en que las toberas de descarga son lo suficientemente largas para impedir que se produzca un atasco debido al alto contenido de parafina. Solamente los rociados más bastos de espacio o superficie, así como algunas preparaciones de uso veterinario, se ofrecen favorables al uso del extracto bruto e incluso estas aplicaciones con frecuencia utilizan extracto refinado, o parcialmente refinado. Para todas las aplicaciones de rociado fino, tales como aerosoles de tipo doméstico, rociadores de bajo volumen y ultrabajo volumen de tipo industrial e institucional y otros parecidos, el uso de extracto refinado es casi obligatorio. El polvo de pelitre se solía usar principalmente en la fabricación de mosquiteros, pero este artículo se vende mucho menos y en la actualidad el polvo está limitado a ciertos productos domésticos tales como en animales caseros, jardines, y para controlar los insectos en rincones y grietas de difícil acceso, así como en aplicaciones para instituciones y granjas de pequeña envergadura. La fibra sigue usándose en la fabricación de mosquiteros y de piensos para ganados, pero los productores de mosquiteros están usando ahora otros rellenos alternativos debido a su costo y disponibilidad.

Las recientes escaseces en el suministro del pelitre, que tanto han destacado en este mercado, han sido debidas en parte a las irregulares condiciones climatológicas e inciertos métodos de cultivo en los países productores; en parte a que periódicamente los precios del productor no lograron mantenerse al corriente de los precios del productor de cosechas competitivas tales como las del té, café, maíz y legumbres; y en parte debido a la poca disposición que tienen las organizaciones nacionales para la comercialización del pelitre a retener existencias suficientes del producto para salvarles durante los períodos de baja productividad y subsiguientes déficits en los suministros. Las organizaciones comercializadoras intentaron retener los precios del productor debido a que se dieron cuenta de que insecticidas sustitutos más económicos estaban siendo ofrecidos por empresas en países occidentales y en el Japón, pero estas medidas demostraron ser sumamente contraproductivas. La principal escasez ocurrida entre 1978 y 1980 fue mucho más grave que cualquiera de las precedentes, además de coincidir con la disponibilidad de diversos piretroides sintéticos que ofrecían unas propiedades parecidas. Como resultado de ello, el mercado mundial del pelitre correspondiente a 1983 es un poco más de la mitad de lo que era antes de producirse las escaseces de suministro. Los aerosoles caseros utilizan ahora principalmente (pero no exclusivamente) piretroides sintéticos, y lo mismo ocurre aún con mayor pujanza en la fabricación de mosquiteros. Productos almacenados, aplicaciones de salud pública, muchos productos del jardín, y numerosas aplicaciones industriales utilizan ahora insecticidas no basados en el pelitre. Las principales aplicaciones que le quedan al pelitre son el control de insectos en las plantas de elaboración de productos alimenticios (la mayoría de ellas en los EE.UU.); el control de insectos en graneros y establos, en los cuales existe una relativamente baja propensión a la formación de resistencia en insectos; en algunos de los aerosoles insecticidas caseros más caros, así como en productos varios para el 'hogar y el jardín', tales como polvos para animales domésticos, polvos para las rosas, rociados para el jardín, etc. El volumen del mercado actual asciende aproximadamente a un poco más de 100 toneladas de piretrinas naturales, lo cual puede resumirse en unas 340–400 toneladas de un 25% de extracto, o entre 8.000 y 10.000 toneladas de flores de pelitre deshidratadas. Cuando la demanda estaba en su punto más alto (1972), la producción mundial de flores de pelitre deshidratadas excedía con creces las 20.000 toneladas. Aproximadamente el 75% del mercado está en los EE.UU., en su mayoría para plantas de elaboración de productos alimenticios, y el resto principalmente en la Europa Occidental. El mercado del Extremo Oriente, el cual estaba basado en su mayor parte en las ventas de mosquiteros, es en la actualidad muy limitado. Si bien la demanda de pelitre en los EE.UU. ha disminuido perceptiblemente como consecuencia de las escaseces, se ha registrado recientemente cierta medida de nivelación e incluso una ligera mejoría, mientras que en Europa la disminución en la demanda es todavía más grave, manifestándose poca, o ninguna, tendencia importante hacia la recuperación.

Los principales grupos de insecticidas competidores son los organocloros, los organofosfatos, los carbamatos y los piretroides sintéticos, además de una o dos categorías de menor cuantía. Los organocloros, entre los cuales se incluyen productos tales como el DDT, dieldrin y lindane, tienden a resultar muy baratos, pero son tóxicos y sumamente persistentes, siendo transmitidos sus efectos prolongados a través de cadenas de comestibles, con consecuencias nocivas para el medio ambiente. Su empleo se halla ahora severamente limitado en numerosos países. Los organofosfatos poseen una toxicidad inmediata superior pero son mucho menos persistentes, y se usan ampliamente en la agricultura, salud pública, almacenes de alimentos, etc., si bien algunos de ellos son también usados en aerosoles y en rociadores industriales. Entre los ejemplos de estos productos cabe mencionar malathion, parathion-methyl y DDVP (dichlorvos). Los carbamatos, entre los cuales cabe mencionar el Baygon (propoxur) como más popular, son usados ampliamente en aplicaciones de salud pública, especialmente para combatir insectos reptantes. Los piretroides sintéticos pueden dividirse en varias categorías: primeramente existen aquéllos que son capaces de un buen 'derribo' pero con una actividad residual baja, como por ejemplo allethrin, bioallethrin, s-bioallethrin, Es-Biothrin, tetramethrin y kadethrin; en segundo lugar, aquéllos con un buen nivel de 'muerte' pero, de nuevo, con baja actividad residual como por ejemplo resmethrin, bioresmethrin y d-phenothrin; en tercer lugar, los piretroides agrícolas alogenados fotoestables, con buenas características de 'muerte' pero solamente moderadas en lo que refiere al 'derribo'. En éstos pueden incluirse permethrin, cypermethrin, deltamethrin (anteriormente decamethrin), fenvalerate, fenpropathrin, y muchos otros ejemplos relacionados o derivados. Principalmente es la primera categoríia de piretroides (los que ofrecen un buen 'derribo'), los que presentan la mayor amenaza para el pelitre, pero los piretroides incluidos en las otras dos categorías han conseguido avanzar por lo menos algo a costa del pelitre, y puede decirse una cosa parecida de algunos de los insecticidas pertenecientes a las otras clases descritas anteriormente. En la mayoría de los casos en que se tiene en cuenta la eficacia en relación con el coste, el pelitre se halla en la actualidad en una situación desventajosa, aunque las bajas acusadas recientemente en los precios a consecuencia de las grandes existencias acumuladas, lo han hecho ser probablemente y de modo provisional, razonablemente competitivo con la familia de piretroides allethrin. Debido a que, aproximadamente entre un 65 y 75 por ciento del costo de un bidón de extracto corresponde al precio que se paga al productor, y puesto que no resulta práctico pagar al productor una cantidad apreciablemente inferior a la que está recibiendo si se desea mantener su interés en el pelitre como cosecha que le reporte beneficios, las posibilidades de reducir el precio de los productos basados en pelitre son sumamente limitadas.

El uso de insecticidas está ampliamente restringido mediante legislación, la cual requiere que ya sea los mismos insecticidas, o bien con más frecuencia las formulaciones de los mismos (con un punto de vista específico), sean registradas en organismos autorizados en la salud o el medio ambiente, o a veces en un Ministerio de Agricultura local por ejemplo. Los requerimientos exigidos en los EE.UU. son particularmente estrictos, pero en otras partes los métodos varían y no existe en general una norma uniforme reconocida internacionalmente. Las etiquetas de productos han de ser a menudo registradas, y las regulaciones que controlan su uso han de ser estrictamente obedecidas. Muchas etiquetas que especifican el uso del pelitre son todavía actuales, pero muchas más que incorporan piretroides sintéticos han sido ahora dadas de alta por los diversos organismos competentes. El registro es un proceso enrevesado y sumamente costoso y, una vez que un producto ha sido desarrollado, formulado, presentado para su registro y finalmente dado de alta, los usuarios son reacios a volver a user formulaciones anteriores, aun cuando los problemas previos que condujeron a su abandono – tales como precios elevados o escaseces del producto – han sido aliviados. Los esfuerzos hechos para reestablecer el pelitre en algunas de las aplicaciones anteriores han de enfrentarse con una competencia formidable, y con frecuencia las perspectivas son desesperantes. Solamente en las plantas elaboradoras de productos alimenticios de los EE.UU. las regulaciones de la Agencia de Protección Ambiental (EPA) se hacen cumplir con vigor tal en favour del pelitre que su posición actual resulta prácticamente todavía impenetrable.

En el caso (de momento poco probable) de que un piretroide sintético competitivo sea aprobado para su uso en las plantas de alimentos en los EE.UU., y en ciertas aplicaciones para edificios de granjas, le quedaría poco o ningún futuro comercial al pelitre.

A nivel comercial se opina que el pelitre puede retener probablemente su participación actual sumamente reducida en el mercado mundial, por ejemplo en aerosoles, establos, etc., así como en plantas elaboradoras de alimentos, siempre que los productores se arreglen para que no se repitan las escaseces previas. La posibilidad de que el producto recupere una participación considerablemente mayor en estas ventas es, no obstante, más remota siendo quizás la perspectiva más prometedora (y por supuesto no muy alentadora), el desarrollo de nuevos usos. La capacidad que posee el pelitre para activar y hacer salir a los insectos de su habitáculo – y por tanto exponerles a un mayor contacto con la formulación insecticida global – está ampliamente reconocida y muy bien podría extenderse el uso del pelitre a este efecto en la agricultura, en combinación con otros insecticidas que ofrecen actividad residual. El pelitre también se usa en el tratamiento final de ciertas frutas, legumbres y otros productos inmediatamente antes de su recolección, estando limitado o prohibido el uso de insecticidas residuales para este fin, por lo cual podría existir un campo para la expansión en este aspecto. El microencapsulado del pelitre para prolongar su actividad residual también ha sido intentado, si bien a in costo considerable, y pudiera existir alguna perspectiva en este sentido, aunque las señales no han sido hasta ahora muy prometedoras, debido principalmente a motivos económicos. Un comentario parecido puede aplicarse al uso del pelitre en dosis ultrabajas exteriores. También existen las aplicaciones en 'el hogar y el jardín', así como en usos veterinaros, donde las perspectivas podrían ser alentadoras, probablemente en formulaciones totalmente nuevas. En conjunto, sin embargo, la necesidad inmediata que tienen los productores es la de reatricherarse y ajustarse a las nuevas condiciones del mercado, además de revisar sus métodos de aprovisionamiento del producto con vistas a solucionar los problemas de escaseces que se hallan totalmente fuera de su control. Les perspectivas para nuevos productores de pelitre están lejos de ser prometedoras, particularmente debido a que la mayoría de las plantas de elaboración existentes no están siendo utilizadas al máximo, y solamente en el caso de que cese en sus actividades algún productor de envergadura, podrían existir oportunidades para el nuevo productor.

Section 1

The background and setting

INTRODUCTION: OBJECTIVES OF REPORT

The Tropical Development and Research Institute has, over a period of many years, received a regular flow of enquiries on trade and marketing aspects of the natural insecticide pyrethrum, both from established producers and from non-producing countries where interest in the possible production of the commodity was evident. In addition, numerous enquiries of a technical nature have been received and handled by the Institute. As an aid to the servicing of the marketing-oriented enquiries, the Institute has from time to time prepared market notes on the subject, mostly on the basis of desk research.

During the period 1979 to 1981, however, the volume of enquiries increased dramatically, and it rapidly became apparent that something of an upheaval had taken place in the fortunes of the product, especially since a considerable proportion of the enquiries was received from processing companies and end-product manufacturers. The most recent published report appeared in 1976*, prior to the recent upheaval, and as there was no immediate prospect of an up-to-date published report appearing from any quarter, it was concluded by the Institute that there had appeared in the literature on pyrethrum a gap which urgently needed to be filled. To this end fieldwork was carried out by an Institute officer in late 1982 and early 1983 in the main producing countries and consuming regions, and the author's observations and conclusions are set out in the sections which follow.

The report is intended to provide broad guidance mainly for the benefit of existing and aspiring producers. With this end in view, it was resolved that, while due attention had to be given to those aspects of the competition from other insecticides which bear directly and heavily on the prospects and future for natural pyrethrum, very detailed discussion of the merits, demerits and general potential of competing products, notably the synthetic pyrethroids, would not be included as it was felt that it would not in practice provide much useful benefit to the reader. In consequence, the treatment of these groups of products has been kept to a minimum for the sake of simplicity and clarity. Technical detail in general has also been kept to a minimum for the same reason.

NATURAL PYRETHRUM: ITS CHARACTERISTICS, SOURCES AND APPLICATIONS

Natural pyrethrum is one of the oldest-known naturally-occurring products used for the control of insects, and is derived from the flower heads of a member of the genus *Chrysanthemum* of the family Compositae, namely the perennial pyrethrum plant *C. cinerariaefolium*, which comes into bearing 4 months after

* UNCTAD/GATT (1976) *Pyrethrum: a natural insecticide with growth potential.* Geneva: International Trade Centre, UNCTAD/GATT.

planting and can be harvested for around 4–5 years. The flowers contain a group of six substances, collectively known as pyrethrins, which possess strong insecticidal properties. These substances account for up to 2% by weight of the dried flowers, the most common range being 1.2–1.4%. The total pyrethrins content of the flowers is typically broken down as follows, although the percentages are subject to some variation:

	%
Pyrethrin I	35
Pyrethrin II	32
Cinerin I	10
Cinerin II	14
Jasmolin I	5
Jasmolin II	4
Total	100

However, it is mainly pyrethrins I and II, and to a smaller extent Cinerins I and II, which account for most of the killing power of pyrethrum, and in practice the term *pyrethrins* is universally used to denote the group as a whole.

Although the pyrethrum plant will grow in a wide variety of geographical locations, including many marginal lands, it can only be profitably exploited if the yield of dried flowers, and the pyrethrins content of the flower heads, are both sufficiently high. For these conditions to be met, regular chilling is essential and in practice most commercial pyrethrum cultivation takes place in the tropics at sufficiently high altitudes for low temperatures to be regularly recorded. It should also be noted that severe and prolonged frosts or continuous waterlogging are both detrimental to the crop, and in consequence, areas where very low temperatures or high, continuous rainfall are normal are not ideal for pyrethrum cultivation. Some high altitude regions in temperate zones are also suitable, but it is unusual for production to take place there since it is a labour-intensive operation which is generally economic only when undertaken in regions where labour costs are sufficiently low, a condition which strongly favours the tropics.

Pyrethrum flowers are, with minor exceptions (for example, in Ecuador), mainly produced by family labour on smallholdings, plantation production being widely regarded as unsuitable for pyrethrum, primarily because the crop cannot be harvested mechanically. The industry, including the associated processing and marketing activities, is a major source of employment in the producing countries. Kenya is the most important producer, followed at some distance by Tanzania; of the minor producers, Rwanda, Ecuador and Papua New Guinea have in recent years been the most important. These, and other, producing countries are discussed in more detail in Section 2, p. 27.

Pyrethrum is a *contact* insecticide, that is to say it does not need to be ingested into the stomach or other internal organs of the insect before it can take effect. It is *broad-spectrum* in its effectiveness, that is to say it is effective against a wide range of domestic, agricultural and forestry pests, notably flying insects. Pyrethrum's main technical characteristics can be summarised as follows:

(i) it has a very powerful *knock-down* action, that is to say insects become paralysed and fall to the ground within a very short time of application of the insecticide, a particularly important attribute for household insecticides;

(ii) it has good *kill*, a high proportion of the paralysed insects not recovering, although its efficacy in this respect varies rather more according to the class of insect;

(iii) it has excellent *activating* and *flushing* properties, that is it agitates insects and causes them to emerge from hiding and move around rapidly, thereby bringing them into contact with more of the insecticide, whether the pyrethrum itself or other toxic ingredients in the formulation;

(iv) it has good *repellency* and *anti-biting* effects, particularly where mosquitoes are concerned, insects being reluctant to enter a treated area or, if already there, less inclined to bite than in the absence of the insecticide;

(v) pyrethrum has *low mammalian toxicity* generally, and can often be used near food, pets and so forth without risk to life or health;

(vi) pyrethrum is *non-persistent*, breaking down rapidly after application and leaving virtually no harmful long-term residues, especially under conditions of high ultra-violet radiation, and it is mainly for this reason, furthermore, that it is comparatively unusual for insects to develop any appreciable resistance or immunity to pyrethrum over a period of time, in contrast with certain other insecticides.

For further discussion of these aspects in relation to the performance of competing insecticides, reference should be made to *The recent history of the pyrethrum trade,* p. 19. However, it will now be appropriate to review pyrethrum's main areas of application briefly. One consequence of pyrethrum's lack of persistence under bright light, especially ultra-violet radiation, is that it is in a large measure precluded from extensive use outdoors in agricultural applications. Agricultural insecticides are generally required to remain active over a period of many days and often weeks, and photostability is therefore essential. Agricultural pest control would be possible using repeated applications of pyrethrum, but this would be prohibitively expensive in comparison with the alternatives available. On the other hand, it is feasible to use pyrethrum to clear insects from an area of crops immediately prior to harvesting, its lack of persistence and absence of harmful residues rendering it distinctly suitable for such an application. Equally, pyrethrum's ability to flush out and agitate insects can be utilised outdoors when it is admixed with other, more photostable and persistent insecticides, the short-lived action of the pyrethrins often bringing about more extensive contact between the insects and the insecticidal mixture as a whole than if pyrethrum were omitted from the formulation. It is also possible to subject pyrethrins to a micro-encapsulation process, in which each particle is coated with a protective compound which allows longer-lasting effectiveness outdoors and slower deactivation under bright light, although in this form pyrethrum can be used only for surface or crevice treatment, not in space sprays. However, these exceptions do not currently account for either a large proportion of world pyrethrum consumption or of total world consumption of agricultural insecticides as a whole, and the cost-effectiveness of at least one of these applications has been decidedly open to question. Further reference will be made to these outlets in later sections.

Nowadays pyrethrum is mainly utilised in industrial and domestic applications. Although in the area broadly described as public health, pyrethrum only holds a small corner of the market, in industrial plants where food is handled or processed, the low toxicity and residual activity of pyrethrum ensure that it remains firmly entrenched, especially in North America, application mainly taking the form of space-sprays. There is still some usage of pyrethrum in animal houses and general veterinary applications, again mostly as sprays, although competition in these areas is intense. Consumption of pyrethrum in domestic aerosols is now much lower than it once was, but it continues to cling to an apparently irreducible small share of the market, again primarily in North America. Other domestic uses include treatment for pets, and for short-term insect control on garden plants, vegetables and in greenhouses, although there are now many alternative products for use on both domestic and commercial glasshouse crops. Pyrethrum used to be the major active ingredient used in the mosquito coils so familiar and widely available in warmer climates, but is no longer, for the most part. Other, decreasing, areas of application include food packaging and storage, sometimes in wax-based formulations, and, to a small degree, cereal storage.

Pyrethrum is a very expensive insecticide but its high potency ensures that it need only be applied at a low rate. Even so, the cost-effectiveness, technical efficacy and speed of action of pyrethrum are considerably increased by combining it with chemicals known as *synergists*, and in practice this is very frequently done, particularly in sprays and aerosols, although not in coils. Synergists often possess some insecticidal activity in their own right, but their main effect is to enhance the potency of the main active ingredient. The most commonly-used synergist where pyrethrum is concerned is piperonyl butoxide (often referred to as PBO), and many aerosol and other formulations embody synergised pyrethrum in a ratio of between 1:5 and 1:10, pyrethrum:PBO, by volume*. Since PBO is very considerably cheaper, per kilogram, than pyrethrum, the cost of the active ingredient component of a formulation is greatly reduced by its incorporation. Other synergists available include sulfoxide, S-421 and MGK-264, the latter being patented by a US company and widely used, and there are others. Synergists will also enhance the efficacy of several other insecticides, but it is on pyrethrum that their effect seems to be most marked although, in spite of their cheapness, their use by no means wholly offsets the high price of pyrethrum itself.

FORMS IN WHICH TRADED

Pyrethrum has over the years been traded in several forms. However, trade in the *dried flowers* has now virtually ceased on account of their high bulk-to-value ratio and the consequent high impact of transportation costs over long distances. *Pyrethrum powder*, produced by fine grinding of the flower heads, is still traded, but in much smaller quantities than hitherto on account of the very sharp decline in demand for it for use in mosquito coils, although pyrethrum dusts are still readily available for insect control on domestic pets and in horticulture, and there are still one or two, mostly very minor, industrial uses. Pyrethrum powder is rather less bulky than the dried flowers but still relatively expensive to transport, and for this reason has to some extent given way to pyrethrum extracts. Its average pyrethrins content is typically 1.3%, that is to say similar to that of the dried flowers, but powder of 0.6% pyrethrins content, prepared by mixing equal quantities of the basic powder and 'marc' (described subsequently), has also been available. Most pyrethrum nowadays is traded and used as *crude or refined extracts* produced by treatment of the ground flowers with a solvent, usually light petroleum, and all the main producing countries now have extraction facilities, albeit in some cases greatly underutilised. However, only Kenya and Ecuador have operational refineries, a considerable amount of refining still taking place in the importing countries. The basic extraction process yields a crude, dark, waxy oleoresin which is suitable for use, after dilution, in certain garden, semi-agricultural, horticultural, veterinary, public heath and stored products applications, where the colour and wax content of the extract are of little consequence, but most pyrethrum extract is either wholly or, less frequently, partially refined before use. Partially-refined extract has had some of the wax and a little of the colour removed and is suitable for use in the coarser industrial or horticultural space-sprays, but for domestic aerosols or other appliances delivering a very fine spray, a fully-refined product is needed, decolourised to avoid surface staining and dewaxed to avoid clogging and blockage of delivery nozzles. Since pure pyrethrins (i.e. 100% active ingredients) are somewhat unstable and break down easily, crude pyrethrum extract is usually traded at a nominal quoted pyrethrins content of 25% although the actual level is sometimes higher, even in excess of 30%, this aspect being further discussed subsequently. Refined extract is also offered at a nominal 25% pyrethrins content, but 50% refined extract is also available and has the advantage of lower transportation costs. Here it should be noted that two methods of pyrethrins content measurement are currently in use, namely the PBK and AOAC methods, which give significantly different results; reference should be made to *Trading structures and procedures,* p. 53, for further discussion of this aspect. In one or two

* Formulations containing mixtures of pyrethrum and PBO have been widely sold under the trade name 'Pybuthrin', although nowadays products bearing this name may contain synthetic pyrethroids instead of pyrethrum.

consuming countries the extracts are further processed and diluted to around 20% before further distribution and use. The powdery residue of spent flowers, which is known as *marc*, is a by-product of the extraction operation, and accounts for 95% by weight of the dried flower input. It has a negligible pyrethrins content, but is very suitable for use as a filler in mosquito coils or pyrethrum dusts, or alternatively as a cattle feed, and is still traded in some quantities, in spite of high transportation costs.

In spite of being produced in the tropics, where insects are generally more troublesome than in temperate regions, it is nonetheless in the latter regions that most of the markets for pyrethrum are located. Pyrethrum is an expensive insecticide, and the low average income levels prevailing in the producing countries preclude much local demand for the product, at least at the present time (1983) when much cheaper insecticides are available.

THE RECENT HISTORY OF THE PYRETHRUM TRADE

The main feature of the pyrethrum market since the late 1960s has been a persistent tendency for supply to lag behind demand. Increasingly unpredictable weather patterns in many of the producing countries, and steadily intensifying competitive local pressure from crops such as maize, tea or coffee caused periodic shortfalls, especially at the beginning of the 1970s and, to a disastrous degree, between 1978 and 1980. At the same time the steady improvement, during the 1970s, in the synthetic pyrethroids which were being developed in the consuming countries had already put pyrethrum under severe competitive pressure on cost-effectiveness grounds when conditions in the producing countries logically indicated the need for a steady rise in the price. Moreover, inventories of pyrethrum products in the main producing areas were seldom, if ever, held at such a level as to facilitate an adequate smoothing-out of supply irregularities between one year and the next. The marketing authorities tended to react to the growing challenge from synthetic pyrethroids by holding the local price to the smallholders at too low a level, and this, together with other infrastructural influences, caused a steady erosion in the smallholders' willingness to grow and harvest pyrethrum.

By the time the extent of this trend had become fully apparent, it was too late to avoid a prolonged shortage of disastrous magnitude, and matters were to some extent exacerbated by a panic over-reaction in terms of local price adjustments. The result was that producer prices, and hence c.i.f. prices, soared at a time when well-proven synthetic pyrethroids were more abundantly available than ever before, and at highly competitive prices. The situation was, moreover, worsened by the temporary entry to the market of certain brokers and other trading intermediaries who normally played no part in the pyrethrum trade but saw in the exceptional market situation an opportunity for quick financial gains. These intermediaries were also in some measure responsible for a series of dishonoured sales contracts which further undermined the confidence of buyers and expedited the switch into synthetics.

By 1981–82 the world market for pyrethrum had fallen to little more than half its pre-shortage level, yet the over-adjusted producer prices brought about near-record production levels, and at the time of writing (early 1983) there were still large stocks of unsold extract in some of the producing countries, with cash flow problems threatening to bring about another crisis through the increasing difficulty of maintaining payments to the growers. Moreover, in 1982–83 c.i.f. prices for extract fell back so far, in response to the slump in demand, that profitable production was barely possible. By the middle of 1983 a position of market equilibrium had still not been reached.

The recent crisis has dealt a very severe blow to the pyrethrum producers, particularly when viewed against the background of the steady growth in demand for pyrethrum (around 2.5% per annum) which occurred between the mid 1960s and the mid 1970s. How far it will be possible to retrieve some of the lost market and protect the livelihoods of many smallholder producers remains to be seen, but the fact remains that synthetic pyrethroids are now so widely available that they are in danger of being over-produced, and the consequently fierce price competition is placing pyrethrum at a severe competitive disadvantage in many areas of application, there now being considerable over-capacity in the world's extraction and refining plants, taken as a whole. The next section contains a brief analysis of the availability of, and competition from, other insecticides and of their impact on pyrethrum in the various sectors.

OTHER INSECTICIDES: THE COMPETITIVE BACKGROUND

The value of the world insecticide market has been estimated, by a major manufacturer of synthetic pyrethroids, at close to US$ 4 billion in the early 1980s. Of this total, according to the same company, around 20% is accounted for by soil insecticides in which neither natural pyrethrum nor synthetic pyrethroids have any application. The remainder is shared between several classes of insecticide. When it is considered that a bare 1% share of this market is US$ 30 million, the keeness of the competition in the industry can readily be appreciated. The main categories of insecticide are briefly reviewed in the following paragraphs, after which their relative importance in each of the main fields of application is reviewed. Since, however, this study is concerned first and foremost with the prospects for natural pyrethrum, only such technical and commercial detail of competing insecticides as constitutes a necessary background to the main thrust of the report has been included.

The **organochlorines** (OCs), of which some of the best known include DDT, dieldrin, toxaphene and hexachlorocyclohexane (HCH, formerly known as BHC), were developed and very widely used in the late 1940s and 1950s. These compounds are cheap, powerful and very persistent, the main reason for the decline in their use since the early 1960s being this latter property of persistence and very slow breakdown which allowed the insecticides to be ingested and then to accumulate in various stages of the food chain, causing poisoning to some non-target species, as well as a threat to humans. Carefully applied, the damage can be contained within manageable proportions; indeed, DDT and one or two other organochlorine insecticides are still used quite widely in certain regions in both agricultural and domestic formulations, mostly for control of mosquitoes and other serious pests, and mainly where average local income levels are sufficiently low for the cheapness of these insecticides to be a major factor in choice. In many western countries, the use of many organochlorines is subject to very severe restrictions and, in some cases, to outright bans.

The **organophosphates** (OPs) are mainly contact insecticides although some are applied as fumigants. This group was also largely developed in the 1940s and 1950s. Although more immediately toxic to humans than the organochlorines, notably parathion-methyl, they are much less persistent and possess less residual activity, and are therefore more suitable for application, for example, to crops shortly prior to harvesting and to stored products. They are also quite widely used for surface sprays in animal houses. Partly because more applications are necessary over a period of time than is the case with the organochlorines, organophosphates tend to be more expensive, but their more easily monitored and controlled toxicity characteristics render them markedly preferable. However, insect resistance build-up has proved to be a problem with certain OPs, notably malathion. Nowadays the most widely used include – as well as parathion-methyl and malathion – parathion, diazinon and dichlorvos (DDVP).

The **carbamates** were developed slightly later than the organochlorines and organophosphates, mainly for the control of mosquitoes, fleas, aphids and other sucking insects. Unlike the organochlorines they rapidly break down after use and do not accumulate in animal tissue, and are generally safer to handle than the organophosphates. They tend to be expensive, but several continue in widespread use, notably propoxur (Baygon).

Insecticides based on inorganic compounds and mineral oils exist and are suitable for certain applications but are mostly of minor importance in comparison with the three categories previously mentioned.

Pyrethrins and the **synthetic pyrethroids** constitute the fourth, and final, major group of insecticides. The pyrethrins are found only in natural pyrethrum but from the late 1940s onwards there was steady development of several classes of compound, all of which were based on a synthesised version of the basic pyrethrum molecule. These can be broadly categorised either according to whether they possess good 'knock-down' or good 'kill' characteristics, or according to whether they are photostable or non-photostable. A number of these compounds were originally developed at the Rothamsted Experimental Station in the United Kingdom and subsequently commercialised via the National Research and Development Corporation (NRDC), who licensed various firms to manufacture them. Others were developed, or in some cases adapted from the NRDC compounds, by European, North American or Japanese companies. The world market for this group of insecticides is growing very strongly indeed, one estimate being 20–30% per annum at present, but it is the synthetics, rather than pyrethrum, that are taking virtually all of the market growth.

Synthetic pyrethroids giving relatively good 'knock-down' performance include the following:

Common name	*Trade or other names, and general comments*
Allethrin	Pynamin; the first synthetic pyrethroid, first marketed in 1949.
Bioallethrin (or the similar d-trans-allethrin)	Pynamin Forte; better against mosquitoes than allethrin; developed around 1970.
S-Bioallethrin	Esbiol; better 'knock-down' than either allethrin or bioallethrin.
Es-Biothrin	A high 'knock-down' product consisting of roughly 60% bioallethrin and 40% s-bioallethrin. Often referred to as EBT.
Tetramethrin	Neo-Pynamin; developed in Japan in the 1960s.
Kadethrin	A high 'knock-down' compound developed in France.
K-Othrin	An aerosol product based on NRDC 161 (see p. 22), with residual activity.

A new Japanese compound bearing the trade name Neo-Pynamin Forte has been developed from tetramethrin, the patent for the manufacture of the latter having expired recently, but it has yet to be marketed commercially, although it is expected to appear in the near future. Other products possessing good 'knock-down' characteristics exist, but the most important ones have been included in the previous list.

Products possessing good 'kill' characteristics, but generally non-residual and non-photostable, include the following:

Common name	*Trade or other names, and general comments*
Resmethrin	NRDC 104, developed in the mid 1960s; Cryson, SBP 1382, Pynosect, etc.
Bioresmethrin	NRDC 107, again developed in the mid 1960s.
d-Phenothrin	Sumithrin; a semi-residual product developed in Japan.

These compounds generally have poor 'knock-down' characteristics and were developed primarily to complement the 'knock-down' pyrethroids, many of which have indifferent 'kill' performance.

The third and most recently developed generation of synthetic pyrethroids are the photostable halogenated pyrethroids, which were designed primarily for agricultural use. Most of these compounds have excellent 'kill' performance, although some also have good 'knock-down' characteristics. The main products in this category are as follows:

Common name	*Other or trade names, and general comments*
Permethrin	NRDC 143; Pounce, Ambush, Permasect, etc.
Cypermethrin	NRDC 149; Ripcord, Barricade, Arrivo, Ammo, Cyperkill, Cymbush, etc.; two and a half times as insecticidal as permethrin.
Deltamethrin	NRDC 161; originally known as decamethrin; Décis, Butox, K-Othrin, etc.; all marketed by one French company only; 10 times as insecticidal as permethrin.
Fenvalerate	Non-NRDC; Pydrin, S-5602; mainly produced in Japan although marketing rights are sub-licensed.

Other products in this category, related to or derived from one or other of the above products, include the following: cyfluthrin (Baythroid), flucythrinate (Cybolt/Payoff), fenopropathrin (S-3206), Japanese), Sumicidin (Japanese) and tralomethrin (HAG 107, a derivative of deltamethrin). Other products have been developed and in some cases marketed but the foregoing products are the most important currently available. The common feature of this class of pyrethroids is the presence of one or more halogen atoms (fluorines, chlorine or bromine) in the molecule. Although developed primarily for use in agriculture, some of these products can be and are used in non-agricultural applications such as domestic aerosols, although it is mainly the non-photostable pyrethroids that are still used in this type of product.

The keenest competition for natural pyrethrum still comes from the non-photostable pyrethroids, especially those with good 'knock-down' characteristics, world production of which has been estimated at over 500 tonnes per annum of active ingredients, of which around 100 tonnes is used in mosquito coils and a very large proportion in aerosols. At the same time, in spite of the strong agricultural orientation of the modern photostable pyrethroids, pyrethrum has to some extent been partially displaced by them in applications such as insect control in animal houses. Even the high-kill, non-residual pyrethroids such as resmethrin, which have generally been regarded as complementary to pyrethrum rather than in competition with it, have encroached on some of its former applications. In the following paragraphs the various main areas of application are briefly discussed in the context of the respective roles played by pyrethrum, the synthetic pyrethroids, and the other categories of insecticide.

Household and garden

Of all household products it is in aerosol insect-killers that the most dramatic fall in the use of pyrethrum has been observed in recent years. Although pyrethrum's excellent combination of 'knock-down' and 'kill' characteristics, together with its broad spectrum of insecticidal activity, have ensured that it retains a place in certain higher-grade lines of products, almost all of the cheaper brands of aerosol now incorporate the synthetic 'knock-down' compounds, particularly the Japanese tetramethrin (trade name Neo-Pynamin) but also bioallethrin, s-bioallethrin and even the original allethrin (Pynamin). Some product lines also incorporate non-pyrethroid compounds such as dichlorvos (DDVP) or lindane, usually in combination with a pyrethroid. It is sometimes necessary to supplement the main ingredient with a high-kill compound such as resmethrin or Sumithrin in order to ensure that the paralysed insects do not recover, and the use of synergists such as PBO or MGK-264 is common. Although the active ingredients of an aerosol canister account for only between 1% and 5% of its retail price, even small differences in the cost of the active ingredients become significant over production runs of several million units, as is the rule with aerosols. Moreover, competition at the supermarket level is intense, and small cost differences can matter significantly. Formulations are nowadays rather more use-specific than they used to be, the exact combination of ingredients employed depending on the target group of insects, whereas pyrethrum's broad spectrum characteristics rendered such specificity less necessary. However, although pyrethrum is surprisingly effective against one or two crawling insects, notably cockroaches, a greater degree of residual activity is usually required for complete control and nowadays it is unusual for pyrethrum to figure significantly in this application. Moreover, the total-release fogging canisters* which are gaining popularity amongst householders in many countries tend to require the use of high-kill residual activity pyrethroids, and the prospects for expanded use of pyrethrum in these products would appear to be limited.

As mentioned earlier, one of the former main outlets for pyrethrum powder was in the manufacture of the mosquito coils so widely used in warm, humid climates. The supply irregularities associated with pyrethrum, and the severe price competition from synthetic substitutes, notably d-trans-allethrin (very similar to bioallethrin), have during the past five to ten years caused this sector of pyrethrum's market dwindle to only a small fraction of its former size. Many manufacturers still believe that pyrethrum's repellency and anti-biting characteristics are superior to those of its competitors, but in such a competitive market the technical differences are insufficient to outweigh price considerations. Moreover, the more modern electrically-powered mosquito mat is even less likely to embody pyrethrum since the prolonged heating of the formulation which its use entails is sufficient to break down the pyrethrum molecule and substantially limit the period of greatest effectiveness.

Other domestic applications such as insect treatment on pets, garden plants and produce and in greenhouses together amount to a substantial outlet. Pyrethrum-based dusts (particularly for pets) and liquid-based formulations are still widely used, their low mammalian toxicity and lack of persistence commanding consumer favour in many respects, and this is likely to continue to be the case where pets are concerned. In gardens and greenhouses, however, the majority of applications inevitably demand some residual activity; the OP malathion has been widely used for some time and the current growth in usage of photostable pyrethroids and other classes of insecticide may be expected to continue. Even where photostability is not a prime consideration, second-generation high-kill pyrethroids such as resmethrin (NRDC 104) have gained ground, especially in glasshouses, primarily for reasons of cost but also because rapid 'knock-down' is not regarded as as critical a feature of insecticidal preparations for use outside the living quarters themselves as they are within them.

Public health

Pest control in public buildings and institutions such as hospitals and schools accounts for a large share of the insecticide market as a whole. Pyrethrum has never occupied a large share of this market, primarily on account of the necessity of keeping costs to a minimum, which is not possible where repeated applications are necessary, as with a non-persistent product such as pyrethrum. Public health insecticides tended in the past to be based largely on the organophosphates, and although this to some extent continues to apply, high-kill synthetic pyrethroids such as resmethrin and Sumithrin, and modern residual-activity pyrethroids such as permethrin and deltamethrin, have been gaining ground, both in space sprays and in 'crack-and-crevice' preparations. One major

* Essentially aerosols of which the entire contents are released in a single application. The area is usually vacated for a few hours after release of the canister's contents to allow the mist time to settle and disperse.

company has estimated that the synthetic pyrethroids already hold 20% of the public health market. The control of crawling insects such as cockroaches requires residual activity and although pyrethrum, as pointed out previously, is remarkably effective against some of them, especially in the short term, the cost-effectiveness of the competition effectively rules it out, and on balance there is little or no foreseeable likelihood of any appreciable growth in the use of pyrethrum in this field.

Commercial and industrial applications

The observations made under the *Public health* heading also apply in large measure to commercial and industrial buildings with the notable exception of those where food is handled and processed. Particularly in North America, pyrethrum is the only insecticide cleared for use near uncovered foodstuffs, and even in the case of pyrethrum there are instances where covering of the food is required before space sprays can be used. This is not to say that other insecticides cannot be used under certain conditions, but the residual toxicity limits stipulated by the authorities are often so low that many plant-owners prefer to play safe and minimise the risk of being subsequently required to destroy all or a large proportion of their stocks in the event of residual toxicity levels being shown to exceed the legal limits. Industrial space sprays are often applied in ultra-low-volume (ULV) formulations which have great penetrating power and small miscalculations can prove very expensive. The food processing industry is almost certainly the largest single area of application for natural pyrethrum at the present time (1983). On the other hand, much less pyrethrum is used in food packaging. Some wax-based formulations embodying pyrethrum are still used but it is often easier to use cheaper residual-activity insecticides in this area of application without risk of excessive contamination than it is in the processing areas of the factories themselves.

Veterinary and stock rearing applications

Pyrethrum is still sometimes used for insect control in animal houses and barns, often very effectively, especially in the control of flies in piggeries. However, the modern residual-activity pyrethroids such as permethrin and deltamethrin have rapidly gained ground as a result of their economic performance, although the organophosphates have also been used for certain applications in this field, especially for surface sprays in animal houses. Pyrethrum-based sprays are still highly regarded on account of the low likelihood of a build-up of insect resistance and immunity in the relatively closed insect populations which tend to be a feature of confined places such as stables, barns, milking parlours and so forth, whereas resistance to permethrin in particular has already been evident to a significant degree. Unfortunately, it is possible to develop cross-resistance in insects, an increasing level of resistance to a synthetic pyrethroid such as permethrin tending to give rise to a similar level of resistance in natural pyrethrum, and cross-resistance between organophosphates and other categories of insecticide, including pyrethrum, has also been recorded. Resistance to pyrethrum in its own right is not completely unknown but, generally speaking, pyrethrum is the least troublesome insecticide in this respect and, even where resistance does occur, for example through the aforementioned cross-resistance phenomena, it takes less time to breed out of the insects than is the case with the majority of synthetic insecticides. Some veterinary preparations embody pyrethrum but this is not one of the larger areas of usage. Overall, the use of pyrethrum in these areas, whilst still very significant, does not seem likely to increase, mainly on grounds of cost arising from the need for repeated applications.

Cereal storage

Pyrethrum used to be utilised for insect control in stored grains more widely than it is now. It was particularly widely used for this purpose in Australia. Now, however, in spite of producer claims that pyrethrum is still reasonably cost-effective, the field is dominated by fumigants, organophosphates such as malathion and pirimiphos-methyl, bioresmethrin and latterly the modern synthetic pyrethroids, and few firms active in this field anticipate any revival in pyrethrum usage, again on cost grounds.

Agriculture and horticulture

The days are long past when the price of pyrethrum and the cost of spraying were sufficiently low to allow the necessary repeated applications on agricultural and horticultural crops. Modern photostable synthetic pyrethroids such as the NRDC compounds cypermethrin and deltamethrin and various in-house products, notably fenvalerate, dominate agricultural use nowadays. However, as already mentioned in *Natural pyrethrum: its characteristics, sources and applications*, p. 00, pyrethrum can still be used in one or two specialised applications. Firstly, it can be successfully used – and indeed may be the only feasible option – for insect clearance immediately prior to the harvesting of fruit, vegetables and some grains, its lack of persistence and residual-activity, as well as its general low level of toxicity, being a decided advantage. Secondly, pyrethrum may be blended with modern synthetic pyrethroids for the sake of its ability effectively to 'flush' and activate insects in such a way as to bring them into greater contact with the high residual-activity compounds. Allusion has already been made to the use of micro-encapsulated pyrethrum for surface and crevice treatment in both indoor environments such as industrial warehouses and also in outdoor applications in agriculture and forestry, but the increase achieved in the pyrethrum's residual effectiveness tends in practice to be more than offset by the high cost of the product, and current indications suggest that such products may not prove a long-term commercial success, although development work is known to be continuing. Pyrethrum is occasionally used in ULV preparations for agricultural use, but these are not a significant factor in the pyrethrum market as a whole. Attempts are currently being made to further the use of pyrethrum in those specialised agricultural applications already described, but it is not by any means clear how successful they will be. Even if these attempts do meet with some success, the overall prospects for substantial use of pyrethrum in agricultural applications are far from promising, especially as, in contrast with aerosol preparations, the active ingredients in agricultural products typically account for 50–75% of the total cost of the product, thus tilting the balance all the more heavily against pyrethrum.

LEGISLATION AND REGISTRATION

The use of insecticides in the industrialised West is closely circumscribed by more or less rigorous legal restrictions under which individual ingredients, and formulations as a whole, have to be registered with the health, consumer, or agricultural authorities before they can be incorporated into finished products and then marketed. Labelling regulations are central to these registration requirements. An increasing number of countries outside the West are also introducing or tightening regulations in these areas, Malaysia being just one notable example, although in many countries these regulations tend to be applied more to agricultural than domestic insecticides, and therefore fall mainly outside pyrethrum's province. Registration requirements in some respects tend to favour pyrethrum on account of its low mammalian toxicity, although it should be said that there exist synthetic pyrethroids with even lower levels of toxicity than pyrethrum. However, once labels specifying the inclusion of new insecticides, such as the modern pyrethroids, have been successfully filed and approved, the firms registering the new formulations are unlikely to switch back readily to former formulations, for example those incorporating pyrethrum, even if the corresponding label registrations are still valid and current, for registration of new products is generally a lengthy and expensive procedure, as will be further discussed in Section 2. Only in the area of food processing plants have attempts to register formulations and corresponding labels based on insecticides other than pyrethrum not so far generally met with success, primarily on account of the strength of the environmental lobbies, especially in North America.

A major aspect of pesticide legislation is that concerning the residues left on foodstuffs after treatment. The quantities of pesticides permitted by law to remain in foodstuffs sold for human consumption are known as tolerances or Maximum Residue Limits (MRLs). These vary depending on the pesticide and the commodity concerned and sometimes differ from country to country. Theoretical tolerances can be calculated from toxicity data obtained from feeding and other studies with test animals, but usually they are based on the residues found after application to a commodity under monitored conditions of 'good agricultural practice' where the minimum amount of the pesticide is applied to achieve effective control of the pest or pests. Thus a theoretical calculation with a high safety factor might show that a residue of 2 mg per kilogram of a particular pesticide on a certain foodstuff would cause no harm to a human consuming such a commodity at a normal dietary level over his lifetime. However, if application following good agricultural practice was found to yield a residue of 0.2 mg per kilogram for that pesticide on that foodstuff then the tolerance would be set at the lower level of 0.2 mg per kilogram to safeguard the consumer. In the USA the Environmental Protection Agency (EPA) established tolerances for pyrethrum on a variety of produce ranging from 0.05 mg per kilogram on potatoes to 3 mg per kilogram on various cereals, and for PBO ranging from 0.25 mg per kilogram on potatoes to 20 mg per kilogram on various cereals. Thus even pyrethrum cannot be applied *ad libitum* to foodstuffs in the USA, in spite of the popular local belief that it is a 'safe' insecticide. The Codex Alimentarius of the Food and Agriculture Organization/World Health Organization (FAO/WHO), which recommends MRLs for pesticides on foodstuffs traded internationally, established a MRL of 3 mg per kilogram for pyrethrum on raw cereals and dried fish and 20 mg per kilogram for piperonyl butoxide (PBO) on these two commodities. The Codex has not established MRLs for other insecticidal compounds on these commodities, presumably because no-one has yet submitted the necessary toxicological and field data for consideration.

Here it should be observed that in general there are virtually no international agreements on harmonisation of labelling requirements, maximum residue limits or registration procedures, nor do any appear imminent, in spite of periodic efforts in this direction by the FAO, the relevant official bodies of the European Community and one or two other organisations. The Codex Alimentarius limits described previously are exceptional in this respect, and even these limits are not legally binding, although ironically they recently served to limit severely the use of pyrethrum in Malawi's fishing industry.

Those regulations currently in force in the main consuming countries will be referred to in *Selected markets,* p. 35, under the individual market headings.

In another context altogether, the manufacture, distribution and marketing of many synthetic pyrethroids, including the NRDC compounds, is still subject to a complex network of patents, manufacturing licences and sub-licences, and seems certain to remain so. Details of these agreements will not be discussed in this report as they are largely irrelevant to its main purpose, except in so far as the overall effect of the restrictions is to some extent to limit the degree of competition operating in the synthetic pyrethroids industry. That established, however, the competition is still very fierce, and as patents and licences expire it will become fiercer still. Synthetic pyrethroids are nowadays available in sufficient abundance to be regarded in many quarters as true 'commodity' products in the way in which they are marketed, and any intensification of competition is likely to bring about a further lowering of prices, to the further discomfiture of the pyrethrum producers. However, even allowing for the fact that some producers may have amortised their production line costs in order to be able to produce more cheaply, there is already some danger of over-production of the synthetic pyrethroids, with a concomitant tendency for manufacturing profit margins to be squeezed, and the scope for further price reductions may in consequence prove to be somewhat limited.

Section 2

Production, trade and markets

In this section the recent and current trends and developments in each of the main producing and consuming countries are reviewed, commencing with the producing countries. Also included, in *Prices, costs and tariffs,* p. 50 and *Trading structures and procedures,* p. 53 respectively, are discussions of recent comparative price and cost trends, and an account of trading structures and procedures currently operating in the pyrethrum market.

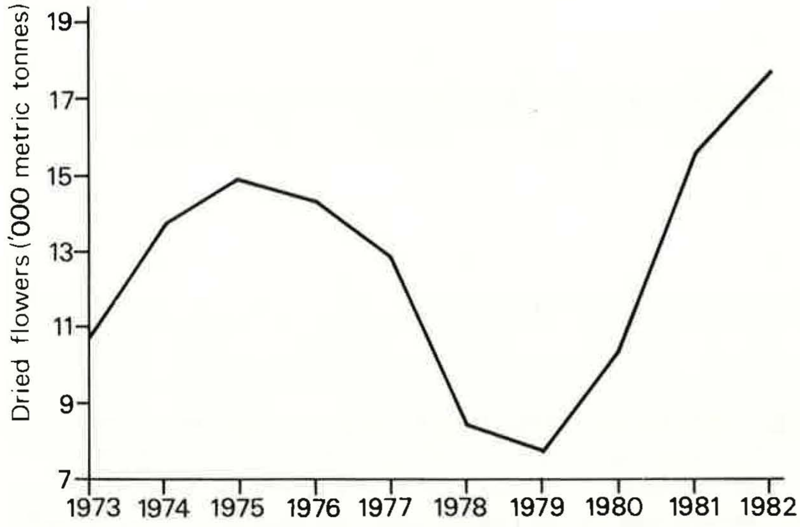
PRODUCTION AND EXPORTS

Kenya

Kenya has for very many years been the world's dominant producer of pyrethrum, accounting for an average of two-thirds of world production during the 1970s, although the year-to-year percentage varied from 57% to over 70%. Production and processing are nowadays under the control of the Pyrethrum Board of Kenya (PBK), who own the extraction and refining facilities at Nakuru and supervise the various cooperatives to which the numerous smallholder producers belong. Virtually no plantations exist nowadays, for in spite of the fact that higher per hectare yields are obtained when pyrethrum is produced on a plantation basis, mechanical harvesting is not possible and in practice it is the family unit which has proved to be the best social basis for pyrethrum production. The setting of producer and export prices, the monitoring of the pyrethrins content of the flowers, to which the price paid to smallholders is directly related, and provision of basic materials, technical advice and so forth, is all provided by the PBK, which was created during the 1970s through the amalgamation of several boards, each of which was responsible for the supervision of a different aspect of the industry.

Production in Kenya has varied considerably from year to year, owing to climatic variations and competition from other crops. The effects of these fluctuations have been felt clearly in the consuming countries owing to Kenya's dominant position among the world's producers. A diagram illustrating the movements in Kenya's production of dried flowers is shown in Figure 1. This shows clearly the severe drop in production that occurred during the 1978–80 period. Average production during the period 1972–74 was around 13,000 tonnes, the corresponding figures for the periods 1975–77, 1978–80, and 1981–83, being nearly 14,000 tonnes, just over 9,000 tonnes, and around 16,000 tonnes respectively, the last-mentioned figure being somewhat tentative since figures for 1983 had still to be confirmed at the time of writing (mid-1983). Although production during the period 1981–83 peaked above 1975 levels, primarily owing to substantial upward adjustments to the producer price (which stood at 1,150 Kenyan shillings per kilogram of pyrethrins at the time of the writer's visit to East Africa in late 1982, as it had done for over two years), the world market for pyrethrum fell sharply during the period 1979–81, for reasons already discussed. It has therefore been necessary to readjust the producer price in an attempt to bring Kenya's production back into line with world demand, taking into account

Figure 1
Kenya: production of pyrethrum flowers 1973–82



the production levels in other countries. The latest tentative estimates available at the time of writing (mid 1983) suggested that another downturn in production had occurred, as a direct response to lower worldwide demand.

As alluded to in previous sections, the producer price had not been allowed to keep fully abreast of the national rate of inflation during most of the 1970s, primarily because of the PBK's awareness of the growing competitive pressure from synthetic pyrethroids in the consuming markets. Unfortunately, this policy underestimated the competitive pressure at the other end of the chain, that is to say from beverage crops, vegetables and to some extent maize and other crops, for which often highly-competitive prices were being offered and to which farmers readily switched if they felt that the revenue from pyrethrum was inadequate, and this in spite of the fact that pyrethrum provides an income source for a much greater proportion of the year than most other crops. By the time the full extent of the trend was realised by the PBK, it was too late to prevent the shortage becoming serious and prolonged at a time when pyrethrum's competitive position in world markets was already weak.

Kenya exports crude, semi-refined and fully-refined extract, powder and marc. Dried flowers are very rarely exported nowadays on account of reduced demand for them and their high bulk-to-value ratio, with the disproportionate transport cost that the latter implies. Crude extract is normally exported at a nominal 25% pyrethrins content, although the actual content may be higher, sometimes in the region of 30–33%, depending on customer requirements. Initial payment by buyers is based on the nominal 25% figure, the final balance being paid once the exact content has been established on receipt and agreed. Refined extract is exported at both 25% and 50% nominal pyrethrins content, and again the actual figure is sometimes appreciably higher, by a similar margin; the 50% extract has the advantage of an air-freight saving, but usually needs dilution by the consumer if it is to be stored, since extracts containing this and higher levels of pyrethrins tend to be unstable. It is unusual for the Pyrethrum Board to export pyrethrum extract of pyrethrins content other than those already mentioned, but they have occasionally done so at the express wish of a customer. However, small quantities of a partially-refined extract are produced for those customers who prefer it. Pyrethrum powder is marketed in either 1.3% or 0.6% pyrethrins content, the former being advantageous as transport costs per unit of pyrethrins are lower, although the PBK has maintained that there was a market for the 0.6% powder.

Reference should be made to Appendix 1, Table 1 (*see* p. 62) for details of Kenya's exports in recent years. It will be apparent that the USA is the main market for Kenyan extract, other main destinations including Italy, the United

Kingdom, the Federal Republic of Germany (West Germany), other European Community (EC) countries as a group, Canada and Australia, although the Far East and Scandinavia still take significant quantities. Exports to Swaziland are probably ultimately destined for other parts of the Southern African region. Japan is the main buyer of Kenyan powder and marc, mainly for use in mosquito coils, mainland East and South East Asia and India also being significant. Italy is no longer quite the important buyer it used to be, owing to a major switch out of pyrethrum powder into synthetic pyrethroids for the manufacture of mosquito coils. The downward trend in Kenyan exports of pyrethrum products from the late 1970s onwards is all too evident from the table. In volume terms it is probably the Far Eastern powder and marc trade that has shown the largest contraction, in spite of the efforts of the PBK's local distributors to provide local mosquito coil manufacturers with a complete service involving the provision of all the required product ingredients. Some pyrethrum products are sold locally, for example to aerosol manufacturers in Nairobi, but these outlets are extremely small in relation to the export markets, although the PBK has been making strenuous efforts to expand local and regional sales.

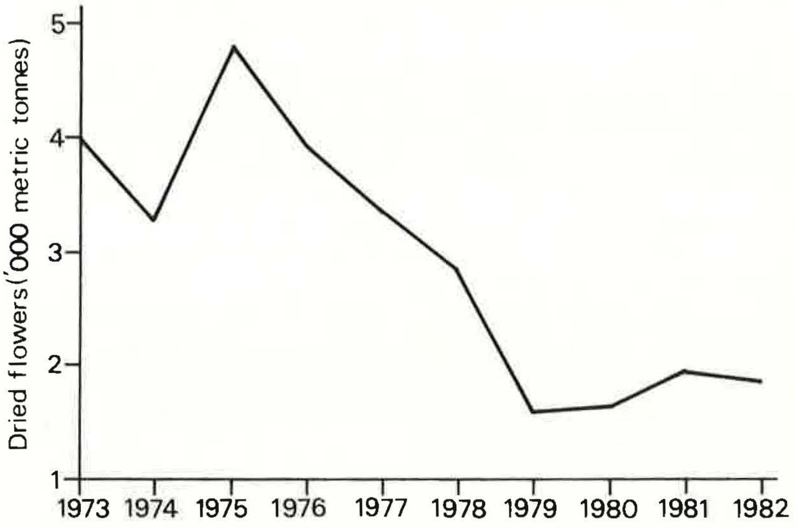
Currently the production base in Kenya is shifting from the traditional Kisii producing area, where the soils have in many places been overworked, and where in any case the competition from other crops is at its most severe, into the Rift Valley and up into the region of Mount Kenya. Work is in hand on the development of new strains of pyrethrum plant yielding either more flower heads per plant, and therefore a greater yield of flower heads per hectare, or higher pyrethrins content per flower head (it has proved difficult in practice to be able to increase yields on both fronts simultaneously), and on a whole range of other measures to improve the industry's efficiency. Although some retrenchment is probably inevitable as a result of the current market situation, which does not look like improving appreciably in the near future, Kenya is certain to continue to remain the dominant world producer.

Tanzania

Tanzania is the second largest pyrethrum producer after Kenya, although at some distance. Overall responsibility for the industry is in the hands of the Tanganyika Pyrethrum Board, which is now located at Iringa. Most production now takes place in the Iringa and Mbeya regions, production in the formerly important Arusha-Kilimanjaro area now having declined to near-negligible levels. The processing facilities at Arusha are now closed and all extraction nowadays takes place at a plant at Mafinga, not far from Iringa. For some while negotiations have been taking place with a view to the provision of a refinery at Mafinga but, at the time of writing (1983), Tanzania was still exporting only crude extract (nominally 25% pyrethrins, the actual figure often being higher at around 29–30%), apart from powder and marc.

Figure 2 shows the trend in production of dried flowers over a ten year period. Average production of dried flowers during the 5-year period 1972/73–1976/77 was 3,860 tonnes, while the average during the following 5-year period 1977/78–1981/82 was just 2,000 tonnes with low points of 1,600 tonnes in both 1978/79 and 1979/80. Tanzania accounted for roughly 20% of world production and exports of pyrethrum products during the 1970s, but for appreciably less than this during the early 1980s. Notwithstanding plans for raising local production levels, with assistance from the World Bank, back to around the 4,000 tonne mark, the outlook does not at present appear very favourable. The fall in world demand for pyrethrum products, together with adverse movements in the exchange rate, has depressed prices and it is currently difficult for pyrethrum to compete locally with maize (at lower altitudes) and potatoes (at higher altitudes) at the present combinations of per hectare yields and unit producer prices. Pyrethrins yield is comparatively on the low side, extension support for the farmers limited, and the already substantial government subsidies being paid to the industry would need to be very appreciably raised for there to be any prospect of a recovery of production levels to those of the early and

Figure 2
Tanzania: production of pyrethrum flowers 1973–82



middle 1970s. As elsewhere, however, pyrethrum can be harvested over longer periods in any one year than can most of the competing crops, and therefore it provides a more regular source of income, thereby helping to retain producer interest in the crop, but the overall outlook is nonetheless not encouraging, the more so since it will be difficult to market any extra production which might be stimulated.

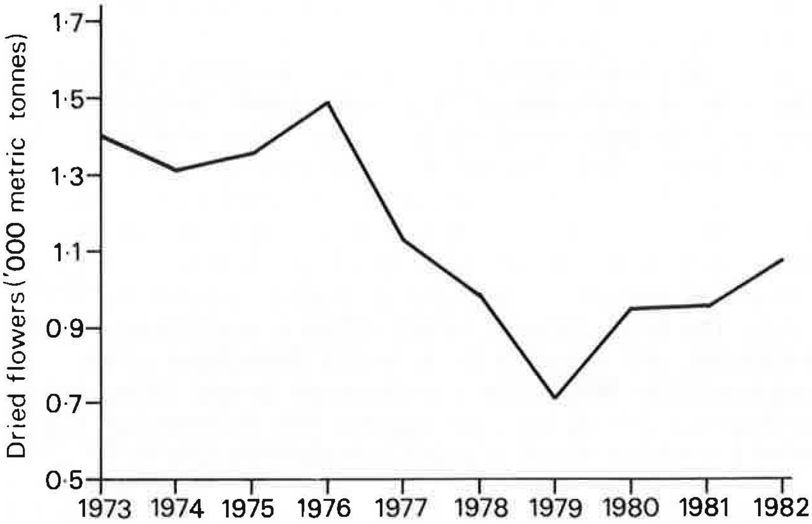
Small quantities of Tanzanian extract are consumed internally for local manufacture of aerosols. From 1979 the greater part of Tanzania's local production of pyrethrum powder was consumed within the national borders, notably for mosquito coil production; virtually all of the 'fine' grade of marc was also used in local mosquito coil manufacture, while the 'coarse' grade was either exported or used locally in cattle feeds. Small quantities of Tanzanian pyrethrum products are also used for the preparation of insecticidal compounds for outdoor use. In value terms, however, during the period 1979/80–1981/82 75% of Tanzania's local production of pyrethrum products was exported. Details of exports are given in Appendix 1, Table 2, which clearly illustrates the sharp decline in exports since the late 1970s. The generally lower unit value of Tanzanian extract exports *vis-à-vis* Kenyan is largely due to the fact that Tanzania exports neither refined extract nor the 50% strength. Tanzania exports to a much smaller range of countries than does Kenya, destinations including North America, the United Kingdom, one or two other EC countries and Japan. Japan was until recently the major outlet for Tanzanian marc. The USA is much the most important market overall and, indeed, in 1981/82 was the only buyer. On the other hand a substantial proportion of Tanzanian pyrethrum powder entering the USA is re-exported to the Caribbean and Latin American regions.

The recent fall in world demand for pyrethrum products affected Tanzania rather less seriously than it did Kenya, primarily because production had declined to low levels anyway. By the end of 1982 most of Tanzania's surplus stocks had been cleared. However, the local extraction plant is currently operating well below capacity, and under current market conditions, in spite of the good quality of the local product, it seems somewhat unlikely that Tanzania will be able to increase its production to levels which would allow full capacity operation of its processing facilities unless local or regional market outlets can be expanded at rates hitherto considered unlikely.

Rwanda

Rwanda is the world's third largest pyrethrum producer, accounting for between 5 and 10% of world production and exports in most years, and averaging a little over 6%. Production is smallholder-based, as in Kenya and Tanzania, and the

Figure 3
Rwanda: production of pyrethrum flowers 1973–82



industry is under the control of the Office du Pyrèthre au Rwanda (OPYRWA), based at Ruhengeri. In Figure 3 the recent trend in production in dried flowers is shown and it will be seen that, as elsewhere, a dip occurred at the end of the 1970s, climatic influences and competition from other crops being largely responsible. Extraction is undertaken at a plant at Ruhengeri which was installed in 1972 and has yet to be operated at full capacity; a refinery was installed in the early 1980s but malfunctioned in operation owing to faulty installation, and there is now little prospect of a fully-refined pyrethrum extract being exported in the foreseeable future, although it has been possible to market small quantities of a semi-refined, partly-decolourised product. Details of exports are shown in Appendix 1, Table 3. Most Rwanda extract is purchased by the USA, smaller quantities being destined for refining in the United Kingdom. In 1977 and 1978 Kenya took appreciable quantities, although mainly for refining and re-export. Exports to other destinations are of very minor importance and intermittent, although France regularly takes small quantities. It will be clear from Table 3 that exports have slumped badly, and for a time considerable stocks of extract had to be held locally. Transportation cost levels, which are very high even in the case of extract, completely preclude exports of pyrethrum powder or marc, although a little is used locally from time to time.

Earlier plans for regular annual production of 2,000 tonnes of dried flowers have clearly not been realised, and the local extraction plant, the capacity of which was geared to a production out-turn of this order, is under-utilised as a result. The pyrethrins content of the local flowers is high at 1.5%, but no increases in the area under pyrethrum are planned, nor are yields of flowers per hectare expected to increase much beyond the present 350 kilograms (dried basis). The producer price in mid 1982 was 17 Rwanda francs per kilogram of fresh flowers (in contrast with Kenya and Tanzania where prices are linked to the pyrethrins content of dried flowers), and an increase to 20 Rwanda francs per kilogram was expected to be implemented in late 1982 or 1983 to counter the competitive challenge from potatoes which, as in Tanzania, are inclined to be financially better yielding per hectare, although not available as an income source for as large a proportion of the year as pyrethrum.

Although the Rwandan industry has experienced, and continues to experience, vicissitudes, it is a very significant source of local smallholder income and, although no increase in production and exports seems likely beyond a recovery from recent low levels, the local industry should continue to be a minor source of crude extract for the world market, although airfreight costs appear to be appreciably higher than for either Kenya or Tanzania and more than offset the low free-on-aircraft (f.o.a.) value of Rwandan extract.

Ecuador

Annual production of dried pyrethrum flowers in Ecuador attained a level of 2,000 tonnes in the mid 1960s but thereafter declined sharply, and by the mid-to-late 1970s annual production was varying generally between 200 and 350 tonnes. In contrast with the African producing countries, Ecuadorean pyrethrum is grown as a plantation crop rather than on smallholdings. A principal reason for the decline in production has been a substantial increase in labour costs as a result of the influence of the local petroleum oil industry and of official minimum wage policies. Labour costs account for a large proportion of total production costs, and profitable production has barely been possible, in spite of relatively high pyrethrins yields from the local dried flowers (typically 1.4%). As it is, Ecuadorean pyrethrum extract tends to be regarded as relatively expensive, although of good quality. The local processing plant, which is situated near Quito and includes refining facilities, was designed for an annual throughput of the production levels prevailing in the 1960s rather than those of the late 1970s, and is therefore substantially under-utilised, but there appears little likelihood of local production increasing to a level that would appreciably reduce the degree of under-utilisation.

Details of Ecuador's exports during the late 1970s are shown in Appendix 1, Table 4. It will be seen that almost all of local production was destined for South American markets. However, the figures in Table 6 suggest that since 1980 supplies to the US market have become a regular occurrence, in spite of the fact that Ecuadorian pyrethrum extract is regarded as relatively expensive. Export figures for years subsequent to 1980 were not available at the time of writing (1983), but it is clear that the USA started taking rather larger quantities from Ecuador once the full force of the shortage of African pyrethrum had made itself felt. Ecuador also exports pyrethrum-based disinfectant products to South American markets, but it is unlikely that the pyrethrum content of these products is great enough to increase the effective total exports of pyrethrum extract significantly.

Ecuador is unlikely to become a major force in the main pyrethrum consuming markets and even in Latin America its trade is not large, and although it is possible that demand from the latter region could increase, the production cost structure of the Ecuadorean industry does not hold out much promise of any substantial increase in production in the foreseeable future.

Papua New Guinea

Pyrethrum production in Papua New Guinea commenced in the early 1960s and has continued regularly since. Production in the late 1960s averaged 450 tonnes of dried flowers per annum, but in the first half of the 1970s the average was down to 315 tonnes. Production thereafter declined to the 200 tonne level and in 1978 and 1979 was 153 tonnes and 159 tonnes respectively. However, in 1980 production rose above 200 tonnes once again and at the time of writing (mid 1983) appeared to be running at around the 300 tonne level, although no firm confirmation of this figure has been forthcoming. As in Africa, but ulike Ecuador, production is undertaken mostly by smallholders and, as elsewhere, the low levels of production recorded at the end of the 1970s were due partly to climatic influences and, rather more, to competition from other crops, although there is evidence that shortcomings in the local marketing infrastructure also played a part. However, the pyrethrins contents of the local dried flowers is high, typically between 1.4 and 1.7%. The local extraction facilities installed some years ago by a British firm are reportedly near the end of their useful life and are being replaced by portable field units employing modern extraction techniques; as these units are of a much smaller throughput than the original facilities, they are much more likely to be used at, or close to, their rated capacity. No refining facilities are available and the local crude extract is often refined in the United Kingdom.

Exports consist almost entirely of crude extract. Powder and marc are used locally wherever outlets can be found, but shipping costs render them uneconomic to export. Details of exports recorded in recent years are shown in Appendix 1, Table 5. The United Kingdom has generally been the main buyer but recently consignments have regularly been destined for the USA (*see* Appendix 1, Table 6), and there have been signs that greater emphasis will be placed on the US market in future. In mid 1983 local production and export was reported to be of the order of the equivalent of 12 tonnes of extract of 25% pyrethrins content per annum. There are, as far as is known, no plans for a substantial increase in local production, and the most likely prospect is that Papua New Guinea will maintain its production and exports at around current levels for the time being.

Other producers

Zaire was once a regular supplier of small quantities of pyrethrum products to the world market, but production in recent years appears to have declined to negligible levels, although there are still occasional reports of intermittent production there. Current indications suggest that it is unlikely that Zaire will again become a significant producer and exporter in the foreseeable future.

Japan was a major producer of pyrethrum before World War II. Since the war, however, rising labour costs and, more recently, the aggressive local development and marketing of synthetic pyrethroids, caused a rapid fall in production to negligible levels, and at the present time there are no signs of any local interest in a revival of Japanese production. As a result, there are no longer any refining facilities of consequence in Japan.

China is widely believed to be a pyrethrum producer, but the scale of production is not known although it is thought to be fairly small. In any case, it is likely that a substantial proportion of local production would be consumed locally. It is very likely that in certain regions geographical conditions would be highly suitable for pyrethrum production. The exact location of the Chinese pyrethrum extraction plants is unknown. It would appear that some pyrethrum of Chinese origin is incorporated into locally manufactured mosquito coils which are subsequently exported to South East Asian destinations. It has been reported, but not confirmed, that Japanese businessmen have recently visited China with a view to promoting local pyrethrum production. As with most other commodities produced in China, information, whether on production levels, the production structure, or on future production plans, has hitherto been difficult or impossible to obtain. However, in the light of China's very low labour costs, a future increase in local pyrethrum production would certainly appear to be a possibility.

South America. Besides Ecuador, pyrethrum is known to be grown, or to have been grown, in Brazil, Bolivia and Peru and possibly in one or two other countries. Brazil is known to be producing small quantities of pyrethrum at the present time, but all local production is used domestically, mainly for the production of mosquito coils. Production trials have been carried out in Bolivia, and firm plans were drawn up in the mid 1970s for the eventual production of 400 tonnes of dried flowers per annum, but there is as yet no evidence that regular commercial production has started, certainly not on the scale envisaged, although it is known that it is locally possible to grow pyrethrum flowers with a relatively high pyrethrins content, certainly higher than the average level achieved in Africa. Although production trials have been carried out in Peru, there has been no evidence of any commercial production there.

Australia. A certain amount of trade interest has been generated by the news that experiments on mechanical harvesting of pyrethrum have been carried out in Tasmania. Hitherto, it has been assumed that the nature of the pyrethrum plant precludes other than manual harvesting, but the Tasmanian experiments are said to have included attempts to develop a strain of pyrethrum plant yielding simultaneous flowering of all the flower heads; this would theoretically render mechanical harvesting possible. It is known that small consignments of Tasmanian pyrethrum have been exported, but the present progress of the experiments and any plans for commercial production are not known with any certainty.

India is known to produce small quantities of pyrethrum flowers in Kashmir, near Srinagar, and in the Nilgiris hills, but the pyrethrins content of the flowers is known to have been below 1%. Indian pyrethrum is used for local mosquito coil manufacture and for cockroach control. India is known to possess an extraction plant, although a fair proportion of the raw materials processed at this plant are in fact imported. The plant appears also to be used for the extraction of other products. There are not known to be any plans for expansion of pyrethrum production in India, although it would be feasible.

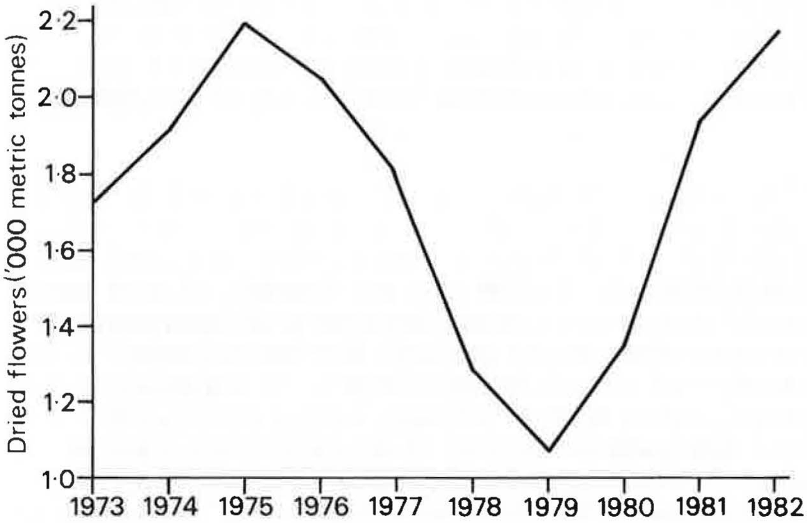
Thailand. Attempts have been made to encourage the local hill farmers in the north of Thailand to cultivate pyrethrum, along with many other crops, as an alternative to the opium poppy, and at least one European firm has attempted to encourage the local production of pyrethrum powder, although not extract. As far as is known the attempts have not met with any great success, and there have been no recent reports of any plans for regular local production on a commercial scale.

Indonesia is known to have produced small quantities of pyrethrum flowers, but there is no sign of any plans for a substantial increase in local production, most of which in any case has been utilised locally. In fact, Indonesia is a net importer, although nowadays its pyrethrum requirements are very small. Production trials have been carried out in *Nepal*, but the pyrethrins content of the flowers was found to be low, and there is little or no likelihood of a local commercial venture. *Taiwan* is known to have produced pyrethrum at one time, but it is unlikely to have continued to the present day, primarily because of a substantial increase in local labour costs over the years. Small quantities are reported to be produced in *South Africa* but generally for local use, at least until very recently when the USA started recording imports from South Africa. Very small quantities are still believed to be produced in certain central and southern European countries, for example *Yugoslavia, Hungary* and even Austria and the USSR. Production in this region appears to have taken place for many years, but has never been of much importance outside the producing countries themselves, the local products mainly being used for the control of cockroaches. Other countries have been recorded as having produced pyrethrum at some stage but none is of any significance in practical terms.

Conclusion

Although countries other than those already mentioned may from time to time have undertaken local pyrethrum production trials, none is of any significance in the context of this report. The foregoing sections are summarised in Figure 4, which shows estimated annual world production of pyrethrum flowers from 1973 to 1982, although it is stressed that Chinese production is excluded from these figures as its magnitude, which could possibly be appreciable, is unknown. Precise production figures for the minor producers other than China, as described in *Other producers* p. 33, are also in the main unavailable, but taken together their production is not large enough to have a significant impact on world production levels, and their contribution has been allowed for by means of a very small nominal percentage increase on the known figures for the five main producers. In 1982 world production was close to the peaks of the mid 1970s (20,000 tonnes plus), in striking contrast with world demand, which has not recovered from its recent fall. As the analysis now turns to the main consuming countries, it should be noted that 20,000 tonnes of dried flowers is equivalent to around 1,000 tonnes of pyrethrum extract of 25% pyrethrins content.

Figure 4
Pyrethrum flowers: world production 1973–82



SELECTED MARKETS

It is recommended that the reader consult the Preliminary Note included at the front of this report, before reading the Sections which follow.

The USA

The product mix imported

Reference should be made to Appendix 1, Table 6 for details of the USA's imports of pyrethrum products from 1973 to 1982. It will be evident that, although imports of the category known as 'flowers', which is almost certainly all pyrethrum powder and marc, have held up well, those of extract have declined. To some extent this may be due to the fact that a larger proportion of the USA's imports nowadays are of refined extract of 50% pyrethrins content *vis-à-vis* with the 25% extracts (twice as much of which are needed for a given task) than was formerly the case, but nonetheless trade opinion supports the view that there has been a general decline over the period, which accelerated after 1977, although from 1982 onwards there has been evidence of a flattening out and possibly a modest recovery. Unfortunately, it is difficult to assess the exact quantities of active ingredients, (i.e. 100% pyrethrins*) imported into the USA as there is no way of knowing the breakdown of extract imports into 25% and 50% categories. However, a widely held view was that the current level (1983) of USA consumption of active pyrethrins ingredients (100% basis) is approaching 75 tonnes per annum, which suggests that, on the basis of the published import figures, a large proportion of the imported extract consists of 50% refined extract. Trade opinion confirmed that the only 25% extract imported is crude.

Imports of powder and marc averaged around 135 tonnes per annum during the period 1978–82 (most of this is believed to consist of powder rather than marc). This is equivalent to between 1 and 2 tonnes of active ingredients and is therefore of minor significance in comparison with imports of extract. US re-exports of pyrethrum products of all categories averaged 110 tonnes per annum during the period 1978–81. Since the unit value of these re-exports suggests that most of them consisted of powder rather than extract, it can be concluded that US consumption of pyrethrum powder and marc is small. Kenya has always been the largest supplier of pyrethrum extract to the USA, and Kenya's share of the market in fact rose from around 43% in the early 1970s to over 70% in recent years, Tanzania and particularly Rwanda declining in importance. Rwandan pyrethrum extract is regarded as somewhat uncompetitively priced in relation to other sources, mainly due to the influence of high transportation costs. Imports from Papua New Guinea are regularly recorded, while Ecuador, formerly only an

*Also expressed as 'pure pyrethrins equivalent'.

occasional supplier, now sends regular shipments, as Table 6, Appendix 1 shows. Imports from the United Kingdom have declined sharply since a United Kingdom-based processor largely ceased to refine Tanzanian crude extract for subsequent re-export to the USA. Until recently, Kenya also dominated powder and marc supplies, but in 1981 South Africa supplied substantial quantities for the first time, while in 1982 Tanzanian supplies accounted for two thirds of the USA's imports.

Trade structure. The import of pyrethrum into the USA is subject to restrictions, and importing firms have to apply for official clearance before they can bring it in, especially if the origin is other than Kenya. At present there are around six US firms importing pyrethrum products, of which three are dominant. Most of them undertake at least some formulation work, producing a range of intermediate insecticidal mixes for incorporation into end products. One firm is a major manufacturer in its own right of aerosols and other insecticidal end products. Another major company is, among its other activities, a major processor of pyrethrum extract into a high grade refined product of exacting specifications which is then sold widely to formulators and end product manufacturers; however, it should be noted that no US company processes dried flowers into extract. One firm re-sells appreciable quantities of pyrethrum powder to South American and Caribbean destinations, mainly for the local mosquito coil trades, the same firm also formulating a range of products for use within the USA. Overall, the number of firms importing pyrethrum into the USA has declined somewhat, and most of the smaller end-product manufacturers continue to purchase their requirements from the major importers, often processed and blended with synergists and other ingredients into ready-for-use formulations. Moreover, the majority of US pyrethrum users also have interests in at least some of the synthetic pyrethroids, the number of firms handling or marketing pyrethrum products to the complete exclusion of synthetic pyrethroids probably numbering no more than two.

Product uses and competition. Very little crude or even partially-refined pyrethrum extract is used in the USA nowadays, although it is occasionally used for those veterinary or space treatments where very fine sprays are not required. Almost all of the imported crude extract is refined before use and is then, together with the imported refined extract, typically reprocessed to give a standard extract of 20% pyrethrins content (AOAC) before use or resale.

It is in the manufacture of insecticidal aerosols that natural pyrethrum has seen its share of the US market fall most heavily during the last six to seven years. Although most of the dominant firms in the aerosol industry still have a high regard for the efficacy of synergised pyrethrum, and still offer product lines containing it, these lines now tend to be restricted to the more expensive end of the market. Most of the cheaper brands of aerosol now incorporate combinations of tetramethrin (good against flies) or bioallethrin (or d-trans-allethrin, better than tetramethrin against mosquitoes), killing agents such Sumithrin or resmethrin, and a synergist such as PBO (preferable for flies) or MGK-264 (which is slightly better at killing mosquitoes). In the case of the total-release fogging cannisters which have become popular in the USA in recent years, there are still one or two lines based on pyrethrum and PBO but synthetic pyrethroids such as tetramethrin and even fenvalerate, which are much more cost-effective than pyrethrum, have gained ground strongly. Products for the control of crawling insects such as ants and cockroaches, one of the most troublesome pest groups in the USA, nowdays seldom contain pyrethrum, as residual activity is needed.

Generally speaking, the US Environmental Protection Agency (EPA) is opposed to the prophylactic use of aerosols, the preference being for specific products for specific applications. On the other hand EPA rulings do not exhibit any obvious bias towards products of natural origin, and although many of the aerosol product labels specifying pyrethrum are still registered with the EPA and the Food and Drug Administration (FDA) as current, most are now only retained by the manufacturers as back-up formulations to their main range of products. For many firms, usage of pyrethrum in aerosols is only at about one fifth of its former level; although active ingredients account for only around 5% of the cost of an aerosol, small cost changes within this fraction can make a major difference over production runs of several million units, and in a market the size of the USA annual sales of insecticide aerosols run to hundreds of millions. Even at the early-1983 price of US$ 26.50 per pound ($58 per kilogram) for very high grade 20% US-refined extract, the main synthetic pyrethroids continued to hold a substantial price advantage, and althouigh by mid-1983 the delivered price of Kenyan 25% refined extract had fallen to an equivalent of US$ 175 per kilogram of 100% natural pyrethrins, there is a degree of consensus that profitable production at this price level is not possible without depressing farm-gate prices to a quite unacceptable degree. It is believed that even some of the modern photostable synthetic pyrethroids such as fenvalerate could well advance in aerosol applications, primarily at pyrethrum's expense, assuming of course that current doubts about the toxic effects of some of these pyrethroids on the human skin can be resolved. However, although aerosol manufacturers no longer regard the broad-spectrum characteristics of pyrethrum as important as they used to, the product is still very highly thought of. As example of a minor but significant advantage is that insects sprayed with pyrethrum, as distinct from some other insecticides, tend to head for the nearest window or other light source before dropping to the ground, and are therefore easier to see and clear away, a point which US consumers appreciate. On balance, pyrethrum is likely to hold its present, greatly reduced, share of the aerosol market, but under foreseeable conditions of price competition it is unlikely that it will regain much, or any, of its former share. Currently around 15 tonnes per annum of active pyrethrins ingredients are used in the US aerosol industry.

In the broader range of *home and garden* products, including products for insect control on domestic *pets*, usage of pyrethrum has also declined somewhat, and although the decline has been less pronounced than in the aerosol industry, it has in any case always been a small sector of the market. Organophosphate insecticides such as malathion are still widely used in this general area, although pyrethrum is sometimes added to malathion to improve 'knock-down' performance. However, flea control is an area where pyrethrum is used, although sometimes in combination with tetramethrin, and it is possible that pyrethrum will gain ground in animals' flea collars, since the existing insecticides do not always cause the fleas to leave the animal, whereas pyrethrum does. It is also possible that pyrethrum could gain ground in certain flea control products of which the current active ingredients are known to have a deleterious effect on certain fabric dyes, but it is too early to assess the likely impact of this outlet. Insecticidal powders are in general not widely used in the USA, domestic users tending to regard them as an inconvenient method of treatment. Pyrethrum is still used in vegetable garden sprays to give short term insect control, and also, in the form of an emulsifiable concentrate, for the protection of glasshouse crops, but the amounts are small and, in the case of glasshouses, are declining before the advance of synthetic pyrethroids such as resmethrin, fenvalerate, flucythrinate and other modern products. Among the main glasshouse pests are white-fly and mites, and against these pyrethrum is technically none too effective.

The *US food processing industry* can be regarded as pyrethrum's last major stronghold, not only in the USA but in the world as a whole. Around sixty tonnes per annum (100% basis) of pyrethrins are used in this area of application in the USA, which represents over half the world market for pyrethrum extract. The EPA's regulations in this area are very strict; indeed, the labels on most products containing synthetic pyrethroids stipulate that they must not be used near food. Although more than one insecticidal product possesses a 'Food Additive Tolerance' (FAT) for use in US processing plants, in practice the restrictions render pyrethrum the only product that can technically be used, as the risk of overrunning the residue limits with the other insecticides would be too great, and most Pest Control Officers (PCOs) are not prepared to run the risk of compulsory destruction of large stocks of food products, and consequent claims against them, as a result of excessive contamination levels. Furthermore, PCOs' insurance costs are generally lowest when pyrethrum, *vis-à-vis* other insecticides, is used. As it is, even with the use of synergised pyrethrum it is sometimes necessary to place covers over foodstuffs before the area concerned can be treated. A typical preparation for use in this application would be 3% pyrethrins, 6% PBO and 10% MGK-264, applied as a ULV spray. In theory resmethrin (NRDC 104) could do the same job more cheaply but its tendency to leave off-odours has in practice ruled out its use; permethrin (NRDC 143) would in theory be more cost effective than either pyrethrum or resmethrin but its residual toxicity levels are too high for food processing usage in the eyes of the EPA and it is not likely ever to be used in this sector. Applications have nonetheless been filed for 'FAT' registration for certain synthetic pyrethroids by one or two firms and, if successful, could severely threaten a major part of pyrethrum's market share, but it remains to be seen whether these applications will be successful.

Pyrethrum is also still used in US flour mills in emulsifiable concentrate form, although the organophosphate DDVP also has a FAT in this outlet and poses something of a threat to pyrethrum. Food packaging is another area in which pyrethrum is holding its share of the market, although again this sector can be regarded as less secure than the food processing plant sector. However, in the treatment of slaughtered livestock and harvested crops prior to canning or freezing, pyrethrum is still being used and could prove more difficult to displace.

The use of insecticides in *public health* applications, that is to say for insect control in hospitals, schools, hotels and other public institutions, is not an area in which pyrethrum plays any significant role. The organophosphates are still highly cost-effective and are very widely used, for example diazinon in crack-and-crevice treatments. Permethrin is also used to some degree, with considerable success, although the authorities are wary of its residual toxicity levels and, at the time of writing (1983), the use of synthetic pyrethroids in this field was said not to be increasing, in contrast with other countries. Strangely, pyrethrum has been used in certain outdoor projects, for example in mosquito control in localities where complaints about certain side-effects of malathion had been recorded, but such uses are minor and unlikely to be a permanent feature of the US pyrethrum market.

In the protection of *stored products*, especially cereals, the organophosphates are again dominant on cost grounds; parathion-methyl is a case in point. It is unlikely that pyrethrum has any prospects in this area, although eventually certain synthetic pyrethroids may.

Veterinary and *animal house* applications are still areas in which some pyrethrum is used, although usage has declined. Pyrethrum is highly regarded for its effectiveness against biting flies and ticks, and its cost can be minimised through the use of crude, rather than refined, extract (usually in emulsifiable concentrate form). However, some of the modern photostable synthetic pyrethroids constitute a major threat to pyrethrum in this area. A little pyrethrum is still used in certain stables and milking parlours, but this would appear to be in situations where cost considerations are less than critical, and in the main pyrethrum is outclassed on cost grounds and seems likely to remain so.

In *agriculture and horticulture* pyrethrum is still employed in the treatment of certain crops such as tomatoes in the final stages immediately prior to harvesting, as higher-residual-acitivity products may not be used for this purpose. This form of usage is likely to continue. Work is also in hand on the preparation of crop treatments embodying a little pyrethrum as an agitating or flushing agent as already described in the previous section. These are, however, the only two possible outlets for pyrethrum in outdoor agricultural or horticultural applications, and it remains to be seen how far it can gain ground, but it is on balance not likely that such applications would in total, even if highly successful, amount to a major share of the US pyrethrum market. Fenvalerate is already well established and it is likely that other photostable pyrethroids such as cypermethrin and tralomethrin (a compound similar to deltamethrin), hitherto not registered in the

USA, will be cleared for use before long, and their effectiveness is such as to require very little additional assistance from other ingredients.

Few other US outlets are of much importance for pyrethrum. There is some manufacture of *mosquito coils* in the USA but little or no pyrethrum is used in their production. The micro-encapsulated pyrethrum product marketed under the brand name of Sectrol is still used in certain warehouses and in one or two other specialised applications, but it cannot be used as a space spray and, although its extended residual activity is favourably regarded by its users, it is a very small outlet and may remain so in view of the fairly high cost of the product. Some firms indicated that pyrethrum could find limited usage in *forest insect control* but again this seems at present unlikely to be an outlet of much relative consequence.

Stocks of pyrethrum are held by the US Government and since the product tends to deteriorate if stored unused for very long periods, periodic replenishment may be necessary.

The registration of a new insecticidal product in the USA can take five years and therefore be very costly, mainly on account of the basic research and development inputs. Few users, having successfully registered a new product, readily change back to a former formulation unless there are most compelling reasons. On grounds of cost – obviously the dominant factor – there are few reasons why pyrethrum, once displaced, should be reverted to, although in July 1983 its price was reasonably competitive with that of bioallethrin, if not tetramethrin. Although its technical attributes as a whole, and its broad spectrum of activity, are highly regarded, and although there is an influential 'pro-natural' lobby in the USA, the balance of forces at present does not appear likely to favour a major resurgence in the use of pyrethrum in the USA. It is also very possible that, in the event of further severe shortages, ways and means could be found of circumventing the restrictions on the use of insecticides other than pyrethrum in food processing plants, although this would not be very likely as long as adequate supplies of pyrethrum remained available at around recent price levels. On balance the prospect is that of continuing usage of pyrethrum in the USA at around the current level of about 75 tonnes per annum (100% basis). However, much could also depend on the results of EPA investigations into certain suspected carcinogenic characteristics of PBO. The use of the synergist sulfoxide has already been severely restricted for the same reason. In the event of PBO ever being subjected to an extensive ban, pyrethrum would be equally affected, for the synergist MGK-264 is not always an entirely satisfactory substitute on its own for PBO, and the use of unsynergised pyrethrum would clearly be unacceptably costly in any use. To conclude, the USA remains by far the most important market for pyrethrum and the future of the product will depend in large measure on events and developments there.

The European Community

Reference should be made to Appendix 1, Table 7 for details of imports of pyrethrum products into the European Community (EC) from 1976. It should be noted that the rotenone component of these statistics is believed to be small enough to be disregarded. It will be seen that the average level of imports has halved during the period, the fall being particularly pronounced in United Kingdom imports. EC imports of pyrethrum powder have also fallen, as the same table shows, mainly as a result of a fall in the formerly important Italian trade, although imports into some other countries, for example France, have if anything increased. As always, it is difficult to assess from Table 7 the exact quantities of active pyrethrins ingredients that are imported, as a breakdown according to whether the extract is 25% or 50% basis is not available. However, trade opinion suggests that 85% of European imports are of 25% refined extract, 10% of 50% refined extract, and the remaining 5% of 25% crude extract. Crude and semi-refined extracts are very seldom used in their own right in Europe nowadays, the few outlets for crude extract being mainly confined to garden applications, while semi-refined extracts are sometimes used in sprays for insect control in warehouses. It is therefore estimated that the EC's current annual consumption is little more than 25 tonnes of 100% pyrethrins equivalent. As in the USA, it is in the aerosol industry that the consumption of pyrethrum has fallen most sharply; although pyrethrum, in combination with PBO, is still used in certain lines of aerosol, the market is overwhelmingly dominated by the Japanese synthetic pyrethroid tetramethrin and, to a lesser extent, one or two organophosphates such as DDVP and lindane, the latter being used only in the cheapest products; combinations of tetramethrin and DDVP are not uncommon for use against flies. Moreover, there are far fewer restrictions in the EC on the use of synthetic pyrethroids in food processing plants than there are in the USA.

The United Kingdom

The market for pyrethrum in the United Kingdom is currently only around one fifth of its pre-shortage level, and stands at around 7 tonnes per annum of 100% pyrethrins equivalent, of which a small proportion is re-exported. The leading aerosol producer's intake has fallen by 75% and other users have gone out of pyrethrum altogether. A major factor has been the fact that almost all the former major United Kingdom users of pyrethrum now have substantial interest in the production, distribution and marketing of synthetic pyrethroids. Kenya has supplied 60% of the United Kingdom extract requirements in recent years, and this figure is increasing as Tanzania's share has declined owing to falling production at source. A substantial proportion of Papua New Guinea's production is imported by the United Kingdom, almost all for refining; some is then re-exported. Imports of powder into the United Kingdom have been small and erratic. None at all was imported during the period 1976–79 and only 16 tonnes in 1980, equivalent to less than a quarter of a tonne of pure pyrethrins; Tanzania is a relatively more important supplier of powder than is the case with extract.

In spite of the fall in the use of pyrethrum in *aerosols* for the United Kingdom market, aerosols still account for a substantial proportion of the total United Kingdom market for pyrethrum, mostly in higher quality, more expensive products. The cheaper, often custom-filled, aerosols mainly incorporate tetramethrin. A very little pyrethrum is used in *public health* applications (hospitals, schools) but this market is still dominated by organophosphates such as malathion or lindane, and increasingly by the third-generation photostable synthetic pyrethroids. On the other hand, pyrethrum still has a foothold in space sprays in *animal houses* and in *food processing factories*. Its continuing use in animal houses owes a lot to its reputation for not building up resistance in insects, although even pyrethrum has not been immune from this problem, which usually manifests itself most strongly in confined spaces. However, in spite of the fact that there have hitherto been restrictions on the use of synthetic pyrethroids against farm flies, competition in general has been growing and pyrethrum's share of this market may not hold steady. Pyrethrum is not nowadays used in *cereal storage* in the United Kingdom, synthetic pyrethroids and fumigants being regarded as more cost effective here, while the use of pyrethrum in *food packaging*, although persisting in some product areas, is generally at a low level, in spite of considerable research in this field by one major company. In the domestic field, however, aerosols apart, pyrethrum is used in several products for insect control on *pets* (mainly as dusts) and for short term control on *garden vegetables* and plants as well as in greenhouses, although usage in greenhouses, both domestically and commercially, had declined before the advance of products based on resmethrin, permethrin and so forth. Little pyrethrum is used in *agriculture*, although some local interest has been evident, as in the USA, in the use of synergised pyrethrum as a flushing agent in combination with residual-activity insecticides.

Although there is a Pesticides Safety Precaution Scheme which provides advice and guidance on the toxicological aspects of the use of insecticides and various applications, this is only a voluntary scheme and, in comparison with the USA, there is comparatively little legislation covering the use of insecticides in the United Kingdom. In any case the Pesticides Safety Precaution Scheme only clears product labels for specific uses, as distinct from giving blanket clearance to an insecticide. The Ministry of Agriculture, Fisheries and Food plays a consistently influential part in the area of product label registration but there is no overall monitoring organisation such as the EPA in the USA. A Pyrethrum Evaluation Group exists to monitor labelling of products incorporating pyrethrum, but this covers only a very small part of United Kingdom insecticide usage as a whole. However, in spite of the comparatively loose restrictions, most United Kingdom users do not regard it as likely that there would be any appreciable revival in pyrethrum's fortunes in the United Kingdom, unless the price falls to levels that would hardly be tenable from the producers' point of view. Registration of new insecticides such as the modern synthetic pyrethroids takes at least three years in the United Kingdom owing to the time required for toxicological testing and so forth and, as in the USA, manufacturers do not readily revert to discarded formulations once the decision to change has been made.

France

Net imports into France of pyrethrum extracts averaged around 10 tonnes per annum during the period 1978–81, equivalent to no more than 2.5–3 tonnes of pure pyrethrins equivalent, and continue to fall. This is an appreciable reduction from the levels of the mid-1970s although not as marked as in the United Kingdom. On the other hand, as the figures in Table 7, Appendix 1 suggest, imports of powder have increased but are still only the equivalent of a fraction of a tonne of active ingredients per annum. Virtually no dried flowers are imported. Although the PBK has a Paris-based pyrethrum distributor, there is very little sign that local consumption of pyrethrum will recover in the near future. *Aerosols* sold on the French market incorporate very little pyrethrum, proportionately considerably less even than in the United Kingdom. Synthetic pyrethroids such as tetramethrin, d-trans-allethrin (bioallethrin) and Sumithrin (d-phenothrin) are dominant, as are non-pyrethroid insecticides such as DDVP and Neocide in cheap products. Probably a major factor is a local restriction on the use of the synergist PBO on account of its alleged toxicological characteristics. Furthermore, the growth in France in the popularity of electric anti-mosquito mats, which contain no pyrethrum at all, is likely to reduce further the potential for pyrethrum usage in domestic insect control. Little or none is used in *public health*, and although small quantities are used in the *food processing industry*, pyrethrum has far from a monopoly in this sector, in marked contrast with the USA.

Certain *garden products* contain pyrethrum, notably those aimed at the control of aphids, and it is possibly in *home and garden* products that pyrethrum's hold is firmest. This is probably the main outlet for French imports of powder. There are virtually no other significant uses, apart from a very little in *animal houses*.

It takes about three years to register new compounds or formulations with the French authorities. The French aerosol industry is currently uncontrolled, and formulations can be changed at will, although controls may come in. Registration of garden compounds is relatively strict, on the other hand, which is why pyrethrum has held on relatively firmly. Controls over insecticides used to combat farm flies are also strict. The French Ministry of Agriculture and Ministry of Health are the main controlling organisations, according to the outlet.

To conclude, the French market for pyrethrum is small and does not, on all the available evidence, seem likely to increase significantly.

Italy

As will be seen from Table 7, Appendix 1, imports of pyrethrum extract into Italy have fallen in recent years to an average of around one half of the levels of the mid-1970s. The decline in imports of pyrethrum powder has been even more dramatic. Nowadays average consumption in Italy is around 5–6 tonnes of pure pyrethrins equivalent. Kenya is the main supplier, there being a major importer and agent of the PBK in Milan.

The decline of the Italian market is attributable to two basic causes: firstly, usage of pyrethrum in mosquito coils and anti-mosquito aerosols has slumped heavily particularly as mosquito mats, which contain no pyrethrum, have become more popular in Italy; secondly, although anti-fly aerosols have continued to incorporate pyrethrum in some measure, total production of *aerosols* has fallen heavily as a result of their cost and the consequent unwillingness of many Italian consumers to purchase them. The number of Italian producers of aerosols and mosquito mats has fallen, and their average size has increased. Pyrethrum-based products are still however marketed for use in *food processing plants*. Some pyrethrum is used in aerosol and electrical mist generators in stables and barns, but there is little direct use on animals, although in the domestic field pyrethrum is still an important component in products for insect control on pets. Some is used in agriculture for insect control on crops immediately prior to harvest, an application in which the photostable synthetic pyrethroids are banned.

The responsibility for registering new insecticides rests with the Ministry of Health in Rome, registration typically taking five years and becoming stricter in many areas.

The collapse of pyrethrum's applications in products for mosquito control has greatly reduced Italy's importance as a pyrethrum consumer, whereas it used to be one of the most important markets in Europe. The local view was that no growth in the local market for pyrethrum can now be expected, in spite of a recovery from the worst days of the recent shortage.

The Federal Republic of Germany

Details of the trend in West Germany's imports of pyrethrum products can be seen in Table 7, Appendix 1. There has not been as marked a downward trend in West Germany imports as has been evident in some other European countries, but in any case the West German market has never been quite as large on a per capita basis as in much of the rest of Europe, and it is currently the equivalent of around 4–4.5 tonnes of pure pyrethrins equivalent in comparison with around 6–7 tonnes at its earlier peak. Its usage in West Germany owes much to the marketing activities of a Brussels-based distributor, and the main outlets include formulations for use in industrial insect control, aerosols, pharmaceutical preparations for the treatment of such pests as head lice, garden pest preparations, as well as a little in horticulture for last minute pre-harvest control. Very little is used in public health applications. The West German market would probably be larger now but for the fact that users ran very severely short during the worst of the supply crisis and, in some cases albeit unwillingly, had no alternative but to turn elsewhere. The Federal Office of Health in Berlin is responsible for registration procedures in West Germany, although there is no labelling registration procedure as such on household products apart from the usual monitoring of toxicity levels; agricultural product registration, on the other hand, is rigorous, although this is handled by the Biologische Bundesamt in Brunswick. The West German registration procedures require basically that a product be shown to be more effective for a given application than the product it is intended to replace.

Usage of pyrethrum in West Germany is expected to continue at its present low level, with little immediate prospect of any increase.

The Netherlands

Like West Germany, the Netherlands market for pyrethrum extract has not shown the marked decrease evident elsewhere in recent years, although usage of pyrethrum there has never been large and when the more noticeably declining market for pyrethrum powder is taken into account, local usage is estimated to be of the order of 3 tonnes per annum of pure pyrethrins equivalent. Trade opinion, moreover, suggests that, in spite of the statistical evidence, there has been a fairly noticeable swing against pyrethrum in the Netherlands. While some pyrethrum is used in the Netherlands food processing industry, in home and garden products, in pet preparations and possibly in agriculture and horticulture, it seems likely that the large local aerosol industry accounts for the bulk of pyrethrum usage in the Netherlands. The Netherlands has a large export trade in aerosols and production is large for such a small country; however, there can be no doubt that, proportionately speaking, the synthetic pyrethroids such as tetramethrin, bioallethrin and others are as dominant as they are elsewhere in Western Europe. With pyrethrum only used at the upper end of the market, the relatively large proportion of total pyrethrum usage attributable to this sector is a result only of its sheer size. Supplies of pyrethrum to the Netherlands are controlled by the same Brussels-based distributor and agent of the PBK which supplies West Germany, Belgium, Luxembourg and Switzerland. In the Netherlands, product registration is controlled by the Commission for Phytopharmacy at Wageningen.

No evidence has come to light which suggests that the Netherlands aerosol industry or any other local sector is likely to increase its intake of pyrethrum in the near future.

Other European Community countries

The remainder of the European Community probably consumes barely 3 tonnes of pure pyrethrins equivalent annually. Denmark is the largest of the remaining markets, with maybe one half of this figure, followed by Belgium, Ireland and Luxembourg. The pattern and trend of usage in most of these markets does not differ appreciably from that of the larger EC markets. In Denmark, however, the use of synthetic pyrethroids against farm flies has been subject to restrictions, and although the market is not large it would appear that pyrethrum is holding its ground there comparatively well.

Other European markets

There is a small steady market for pyrethrum in the **Scandanavian countries**, including Finland. The total market there is of the order of 2–3 tonnes per annum of pure pyrethrins ingredients. The supply shortages certainly brought about some diversification into other insecticides, but the residual synthetic pyrethroids have not yet been cleared for use in the control of flies. The importing arrangements for the Scandanavian countries are quite independent of those operating in continental Western Europe. The market for pyrethrum in **Switzerland** is supplied mainly by the Brussels-based distributor mentioned in the section on the West German market. Although a little pyrethrum is used in domestic products for the control of flies and mosquitoes, the market is extremely small and is not expected to increase. **Spain** is one of the more important markets in the region, taking a total of 8–10 tonnes of 25% extract per annum (2–3 tonnes of pure pyrethrins equivalent), of which around one-half is imported from EC re-exporters. The Kenyan export statistics suggest that there has been a decline in Spanish extract imports, although the trend in imports of pyrethrum powder, for which Spain is also an appreciable market (50 tonnes p.a. during the period 1976–81), is less clear. However, in both Spain and **Portugal** the synthetic pyrethroids have been relatively slow to advance and there is a comparatively greater tendency, *vis-à-vis* other European markets, for consumers to remain faithful to traditional insecticide dusts and other preparations containing pyrethrum; furthermore, in July 1983, when the price of 25% refined pyrethrum extract had reached a low point of around US$ 44/kg c.i.f., it was reliably reported that certain Spanish users had reverted from the use of s-bioallethrin and Es-Biothrin back to pyrethrum. The market in **Greece** is of a rather similar nature to the Iberian market, pyrethrum powder continuing to be imported there in regular quantities (average 70 tonnes p.a. during the period 1977–82), although on a declining trend. The **Comecon*** countries appear, from the evidence of the producing countries' export statistics, to be only minor

* Comecon = Council for mutual economic aid.

users of pyrethrum; various Western and Japanese countries have successfully promoted the use of synthetic pyrethroids in this region, and since the local registration regulations are not as strict as in many Western countries, cost is the main criterion of choice, as a result of which pyrethrum is at a substantial disadvantage. The prospects for pyrethrum there cannot therefore be considered encouraging.

Japan

Product mix imported. Reference should be made to Appendix 1, Table 8 for details of imports of pyrethrum products into Japan for the period 1976–82. Imports of extract during the period 1978–81 averaged 10.5 tonnes but then fell to 2.5 tonnes in 1982. The exact breakdown of these imports between crude extract and refined extract is not known with precision, although it is believed that more crude extract is imported than refined, and that at least some of the refined extract is of the 25%, rather than 50%, strength. The average imports for the 1978–81 period are therefore probably equivalent to around 3 tonnes of pure pyrethrins equivalent. Most imported crude extract is used *per se*, there now being virtually no refining facilities in Japan. Imports of powder during the same period averaged 250 tonnes, also equivalent to around 3–3.5 tonnes of active ingredients. It will be seen that imports of extract increased somewhat from 1976, peaking in 1979 and then falling back sharply. In contrast, powder imports fell sharply from 1976 when over 750 tonnes were imported. Imports of marc (not shown in Table 8) averaged 5,000 tonnes during the 1970s but fell back sharply to under 2,000 tonnes in 1981, and remain at a low level. Japan used to take the bulk of Tanzanian marc supplies but Kenya is nonetheless the main supplier. Prior to 1982, 70% of extract imports came from Kenya, and 30% from Tanzania, whereas in 1982 only 25% came from Kenya. However, it is likely that Kenya will continue to dominate these pyrethrum imports as one of the many importers is an agent of the PBK. In 1983 stocks of pyrethrum products in Japan were reported as being high, and imports were expected to fall even further in the short term.

Trade structure, uses and competition. There are four or five Japanese importers of pyrethrum products, and in common with other Japanese industries, these importers regularly liaise with one another with regard to import shares and so forth. For none of these importers, however, is pyrethrum a major proportion of their business, and several of them are regular users of synthetic pyrethroids. Moreover, one of the world's two largest producers of synthetic pyrethroids is a Japanese company and pyrethrum is therefore at a considerable disadvantage. A little refined pyrethrum extract is used in Japanese *aerosols* and foggers, but tetramethrin, d-trans-allethrin and resmethrin are very much more commonly used; in any case, consumption of aerosols in Japan has fallen somewhat as a direct result of improved local sanitation. For the same reason, consumption of *mosquito coils* in Japan has fallen, but in any case the consumption of pyrethrum extracts or pyrethrum powder in mosquito coils is virtually nil; even consumption of pyrethrum marc in the Japanese mosquito coil industry is far lower than it used to be, reportedly only 500 tonnes in recent years in comparison with many thousands of tonnes during an earlier period. No doubt the heavy shipping cost of around US$ 130 per tonne from East Africa to Japan is partly responsible. Even so, Japan is still the largest Asian user of pyrethrum marc. A typical mosquito coil mixture quoted to the writer was as follows: 30% marc, 20% wood powder, 20% cedar, 8% joss, 22% all other ingredients. Domestic mosquito control in Japan is increasingly being dominated by the modern electric mats rather than by the traditional coils, these mats never having contained pyrethrum and being most unlikely to in the future.

A little pyrethrum is used for insect control in Japanese *food warehouses*, although synthetic pyrethroids can also be used here. A little is also used in grain storage, and in food processing plants. On the other hand none is used in food packaging, or in public health applications. Home and garden products, and preparations for insect control on pets, also seem to have passed pyrethrum by. Very small quantities are used in the animal health field. However, although pyrethrum is not used on a wide scale in agriculture, where economy is considered more important than any marginal advantage in flushing action that pyrethrum might possess, there is regular usage of pyrethrum in certain specialised outdoor applications. For example, it is used for insect control in tea cultivation, where its comparative lack of residual activity is considered a critical factor. In this application pyrethrum is considered particularly effective if it is applied in either a micro-encapsulated form or else combined with cyclodextrin, generally as a 3% emulsion; one major Japanese company has a pyrethrum-based emulsifiable concentrate formulation, for use on tea and in warehouses, registered with the authorities. Pyrethrum is also used for insect control on certain vegetables, and in particular in the cultivation of green mustard. Taken together, however, these outlets are not, either actually or potentially, of paramount importance in relation to pyrethrum consumption in Japan as a whole. It would appear that crude, rather than refined, extract is used in these applications.

The registration of new insecticidal products in Japan often takes around six years, which is a longer period than is typical in many other countries. Responsibility for the issue of registered labels rests either with the Ministry of Health and Welfare or with the Ministry of Agriculture, Fisheries and Forests, depending on the intended application of the formulation, although the Environmental Agency of Japan also plays a part in clearance procedures. There is a tendency for clearance to be granted on a use-specific basis. Although the increasing sophistication of the Japanese consumer market, together with local consumer concern regarding product toxicity levels generally, has ensured that pyrethrum has not disappeared completely from the local market, there is no doubt that the presence in Japan of a major producer of synthetic pyrethroids has ensured that the pressure on pyrethrum is as intense as it could possibly be, and the likelihood of any major resurgence in pyrethrum usage in Japan cannot be considered great, although one company foresaw some revival in the event of an appreciable and lasting price fall. On the other hand, provided that the price of pyrethrum extract can be held reasonably stable, there is no reason at all why pyrethrum products should not continue to be used at their present levels in Japan for the foreseeable future.

Australia

Details of Australian imports of pyrethrum products are given in Appendix 1, Table 9. Recent imports of extract have averaged 25 tonnes per annum, equivalent to around 7 tonnes of pure pyrethrins equivalent. Kenya is the main supplier, although re-exports from the USA and France have also played a significant part. It is possible that some local reprocessing takes place.

Australia was once one of the world's largest users of pyrethrum, mainly as a result of its use for insect control in grain storage by the Australian Grain Board. However, the shortages of the early and late 1970s forced the Board to look elsewhere, and pyrethrum consumption in grain storage is now at a far lower level than it used to be, its place having been taken largely by bioresmethrin, fenitrothion, tetramethrin, Sumithrin and one or two others. In the Australian market as a whole modern synthetic pyrethroids such as cypermethrin have made appreciable inroads, while other types of insecticide such as DDVP and Baygon are widely used. Pyrethrum still holds around 20% of the broad-spectrum market, and products such as insecticidal aerosols and insect repellents for use on beaches and in forests still incorporate significant amounts of pyrethrum, but in general this is not a major part of the market. This major switch away from pyrethrum has occurred in spite of the very stringent registration regulations currently in force in Australia, and it may well be for this very reason that the likelihood of any reversion to the use of pyrethrum in its former applications is extremely remote.

East and South-East Asian markets

Hong Kong

Relatively more pyrethrum ingredients are consumed in Hong Kong than in most other mainland Asian markets. The main reason for this lies in the historic links between one of the main local producers of mosquito coils and the PBK. This firm is prepared to use pyrethrum in its products whenever the price is considered favourable, as was the case at the beginning of 1983. At other times, d-trans-allethrin and bioallethrin are used. However, pyrethrum is highly regarded for its repellency and anti-biting effects in mosquito coils, and furthermore less filler is needed when pyrethrum powder is incorporated than when synthetic pyrethroids are used. Since the firm concerned has several labels currently registered, it can change its formulae virtually at will, according to the relative prices of the active ingredients. However, no other Hong Kong firms appear to use pyrethrum in their anti-mosquito products, and even the firm already discussed uses no pyrethrum at all in its aerosol custom-filling operations, in which tetramethrin is universally employed.

Unfortunately the trade statistics do not provide a sufficiently detailed breakdown for an accurate assessment of imports of pyrethrum powder and extract into Hong Kong. However, it is almost certain that imports of extract are negligible or even nil, and that only powder is used in mosquito coils, there being virtually no other local outlets for pyrethrum in any form. The Kenyan export statistics (*see* Appendix 1, Table 1) confirm the trend clearly. It is clear that Hong Kong is no longer a major market for pyrethrum powder, and in the long term its remaining importance is likely to decrease further.

It was reported that considerable quantities of mosquito coils of Chinese origin are imported into Hong Kong, and that some of these contain pyrethrum. Others contain active ingredients such as DDT, DDVP, Baygon and BHC, some of which are subject to severe restrictions or even outright bans in Hong Kong. On the whole, however, these imports do not constitute a major threat to the continuation of mosquito coil production in Hong Kong, particularly as a very large proportion of Hong Kong's production of mosquito coils is exported overseas. In the very long run, however, it is expected that Hong Kong's overseas markets will become more self-sufficient in mosquito coils, so the local production base for mosquito coil production may eventually shrink.

In those instances where mosquito coils exported from Hong Kong are destined for sale under the brand names of the purchasing companies, it is the latter companies that are responsible for local product label registration. Otherwise, the responsibility rests with the exporters.

Singapore

Although there is substantial production of mosquito coils and other domestic insecticidal products in Singapore, it would appear that hardly any pyrethrum is used there nowadays. Even the use of marc in mosquito coils is only at a fraction of former levels and is locally considered likely to fall to negligible levels, while the use of pyrethrum in aerosols is now completely unknown.

Malaysia

Pyrethrum is not recorded separately in the import statistics of Malaysia. However, it is clear from the export statistics of Kenya (*see* Appendix 1, Table 1) and from trade opinion in Malaysia that imports are nowadays at a very low level, especially for extract and powder, although marc imports are also down. Up until the mid-1970s, Malaysia was one of the largest South East Asian users of pyrethrum, especially powder, mainly for use in mosquito coils, although locally available aerosols were also to some extent based on pyrethrum at that time. However, the supply shortages and the unfavourable price ratio between pyrethrum and the synthetic pyrethroids have all but eliminated it. Aerosols are now widely manufactured and used locally but all are now based on combinations of tetramethrin, bioallethrin and d-phenothrin, synergists generally not being used. The mosquito coil trade first switched into bioallethrin imported from Western Europe, then into allethrin (Pynamin) and, most recently, d-trans-allethrin in the form of the Japanese product known as Pynamin Forte. This is in contrast with Singapore where it is bioallethrin of European manufacture that is used in mosquito coils. Very recently however, Es-Biothrin (EBT) has started to compete vigorously with Pynamin Forte in mosquito coils. One firm based in Penang, with traditional links with the PBK, still uses a little pyrethrum but certainly not exclusively. Even the filler no longer consists mainly of pyrethrum marc; wood fillers, coconut shell powder, joss powder and sawdust have in considerable measure entirely usurped marc's former role, and the use of marc is expected to go on declining to negligible levels. However, mosquito coils are also imported from some other Asian countries, most particularly China, and some of these coils contain pyrethrum, which reinforces a fairly widely held belief that China is a pyrethrum producer. Trade opinion confirm that some Chinese coils contain DDT, DDVP and other insecticides which are banned in Malaysia, and in general only those based on pyrethrum are imported into Malaysia. Mosquito mats are more expensive than coils in Malaysia, and have been slowly gaining ground, but in any case pyrethrum is unsuitable as an active ingredient in these products.

Virtually no pyrethrum is used in any other sector in Malaysia. The carbamate Baygon is widely used in public health applications, especially for the control of cockroaches and other crawling insects, for example in the refuse chutes of high-rise apartment blocks. The synthetic pyrethroids are making some inroads here although the skin irritation problems caused by cypermethrin and deltamethrin are viewed seriously by the authorities and could slow down their rate of penetration. Moreover, permethrin is considered inferior to Baygon against crawling insects.

Although individual insecticidal chemicals are closely monitored by the authorities it is mainly formulations that have to be registered and cleared, in this case with the Malaysian Pesticide Board, who issue label marks without which a product cannot be sold. Malaysian registration requirements are almost certainly the strictest in the region, and indeed other countries in the area largely base their regulations on Malaysian rulings. Even a change merely of a product's brand name, the product in all other respects remaining absolutely identical, necessitates re-registration.

The prospects for pyrethrum in Malaysia are considered very poor. Even at the relatively low prices prevailing as a result of recent over-production, the prices of the 'knock-down' synthetic pyrethroids are still regarded as too favourable for there to be any likelihood of a resurgence of pyrethrum usage, especially since the Malaysian Pesticides Board has cleared competing insecticides for use in very many applications. Even if pyrethrum's price were to fall sufficiently for local manufacturers to regain interest in it, the need to register revised formulations would constitute a deterrent.

China

No published information is available on imports of pyrethrum into China or on any production that takes place there, although the Kenyan statistics suggest that the equivalent of 1.5–2 tonnes per annum of pure pyrethrins has been imported on average. The balance of trade opinion, however, suggests that local production does take place and that there are one or two extraction plants. Mention has already been made of the interest reportedly shown by Japanese businessmen in the promotion of pyrethrum products there, and the local production potential could be considerable. However, it is also clear that the main synthetic pyrethroid manufacturers now have clearance to market their products in China and local competition will therefore be considerable, the more so since other insecticides, such as DDT, lindane and DDVP are still used there. Most of the products exported from China which contain pyrethrum consist of mosquito coils, although some Chinese brands contain DDT, DDVP and one or two other non-pyrethroid insecticides. Chinese mosquito coils are cheap and compete strongly in those countries into which they are imported, although, as already indicated, some countries ban the import of coils containing organochlorine or organophosphate active ingredients. While Chinese products containing pyrethrum have rarely, if ever, been seen in the Western industrialised countries, they have a firm share in certain East and South East Asian markets.

Because of the relative lack of information on developments in China, it is difficult to arrive at firm conclusions on the future market there for imported pyrethrum. However, given that at least some domestic usage is based on locally grown pyrethrum, it would on balance be unwise to assume that any growth in demand will be met from imports, unless China starts to export its products more aggressively, and to a wider range of countries, than hitherto, in which case local production could fail to keep place.

Taiwan

Although Taiwan used to be a major producer of mosquito coils containing pyrethrum, very little appears to be used now, again as a result of supply irregularities and of severe price competition from synthetics. Large quantities of mosquito coils are produced but the active ingredient formulations are now supplied by the major Japanese producer of synthetic pyrethroids, although they may still contain a little marc. Since only negligible quantities of pyrethrum are now used in other sectors of Taiwan's economy, Taiwan can no longer be regarded as a significant market for pyrethrum.

Korea

Korea continues to be a fairly important regional producer of mosquito coils but, as elsewhere, most of the local products now incorporate synthetic pyrethroids of Japanese manufacture and, like Taiwan, Korea is now a negligible importer of pyrethrum, although it was once a market of appreciable size for the powder and still takes small quantities of marc. With the modern synthetics-based formulations covered by local registration regulations, there is little or no prospect of pyrethrum regaining its lost ground in either mosquito coils or in any other sectors, in which it was never of major importance in any case.

Other markets

Other markets in East and South-East Asian region include Indonesia, Thailand, the Philippines and a few others. All are of very minor, or negligible, importance. Indonesia is a large market for mosquito coils but bioallethrin (and its equivalent) is the main ingredient employed by local manufacturers nowadays. There may be a rather greater propensity to use pyrethrum in Thailand but consumption is still extremely small. The remaining markets are of little consequence in the pyrethrum trade nowadays.

Other markets

Canada

In comparison with its neighbouring market of the USA the Canadian market for pyrethrum is relatively modest. Although pyrethrum imports have at times been proportionately higher than in the USA when the relative population sizes are taken into account, Canada is also a significant re-exporter of pyrethrum products. Imports of extracts during the period 1978–81 averaged around 27 tonnes per annum, equivalent to 7–8 tonnes of pure pyrethrins equivalent, and the trend over time has clearly been downward before the advance of the challenge from the synthetic pyrethroids, although their rate of market penetration appears to have been less rapid than, for example, in many European markets or in Australia. Pyrethrum is still relatively widely used in some domestic aerosols, especially those for the control of house flies, and this sector is served mainly by the USA, a proportion of supplies of refined extract being purchased from a US refiner. Canada is also a minor producer of mosquito coils, but the local products do not appear to incorporate pyrethrum. Small quantities of pyrethrum are used in municipal pest control but, as elsewhere, the organophosphates and synthetic pyrethroids tend to dominate the public health field as a whole. Registration requirements are strict, and consequently tend to favour existing formulations, but the possibility of further penetration by the synthetic pyrethroids, especially in the domestic aerosol market, can by no means be ruled out.

India

India generally imports small quantities of extract from Kenya (5.5 tonnes per annum on average during the period 1978–81, equivalent to around 1.5 tonnes of pure pyrethrins equivalent), while powder imports averaged 75 tonnes during the same period. There is also, as described in *Other producers,* p. 33, some local production of pyrethrum, but the yield is low and output is insufficient to service local demand. Consumption is, however, considered unlikely to increase, especially as the major producers of photo-stable agricultural pyrethroids are marketing their products successfully in India and these products, once firmly established in the agricultural field, are certain to capture some of the non-agricultural outlets formerly held by pyrethrum.

Latin America

The South American market as a whole was estimated to be around 25–30 tonnes of 25% extract in the mid 1970s (8–9 tonnes of pure pyrethrins equivalent) and around 1,000 tonnes of powder. The current market size for extract is little over one half that figure and the powder market has also fallen somewhat, in spite of the continuing demand for mosquito coils. Ecuador is a major supplier, both its geographical position and the advantages afforded by membership of the Latin American Free Trade Area (LAFTA) counting in its favour, but there also appear to be some re-exports of powder and extracts, the latter probably subjected to further processing, from North America. Mexico, Brazil, Argentina and Colombia are the major buyers, in that order, The major synthetic pyrethroid producers, however, are licensed to market their products in much of South America and most of the major insecticidal applications in the region are now based on synthetics. Overall, particularly in view of the production problems experienced by Ecuador, it is unlikely that pyrethrum will regain its lost ground and it could well lose more, although recent increases in US exports of pyrethrum powder for the South American mosquito coil trade suggest that at any rate the powder market could hold up relatively well. In addition to the usual factors responsible for the fall in usage, the cost of transportation between East Africa and South America, often via the United Kingdom, significantly increases the already uncompetitive price.

The Caribbean region

The market for pyrethrum extract in Caribbean countries is extremely small, virtually negligible. On the other hand, local manufacturers of mosquito coils have recently switched back to pyrethrum after a long period during which they were using other active ingredients, primarily as a result of the recent fall in its price. The Caribbean mosquito coil manufacturers have usually, in the past, imported their requirements of pyrethrum powder from the USA, but recently some firms have started importing direct from Kenya, although powder of Tanzanian origin still passes through the USA. Although the switch back to pyrethrum is an encouraging development, it cannot be said that the Caribbean markets for pyrethrum products as a whole are significant in relation to the world market although it is likely that it will continue to be used there in around current quantities for the foreseeable future.

Middle Eastern markets

Major marketing drives by the synthetic pyrethroids producers have virtually eliminated pyrethrum from the Middle Eastern region. None whatsoever is used in public health applications, which is a major growth sector in the Middle East, and next to none is used in locally made aerosols. This is a particularly competitive market and the consensus of trade opinion is that pyrethrum has now no chance of making any impact there.

Africa

In the majority of African countries the average income levels are too low for there to be a major local market for insecticidal aerosols. As would be expected in the pyrethrum growing areas, there are aerosol manufacturers in Kenya and Tanzania who incorporate pyrethrum in their products, but the market for these products is small in relative terms, and has declined. While a very little may be used in public health applications, the synthetic pyrethroids are now increasingly widely used, the main impetus to their use being the agricultural sector, especially on the cotton crop. Pyrethrum-based mosquito coils are also marketed, but increasing quantities of mosquito coils containing synthetic pyrethroids are being imported into Africa, and in the absence of a major marketing campaign on the part of the East African pyrethrum producers, it seems unlikely that pyrethrum's share of the local insecticide market as a whole can be expected to increase significantly. Even comparatively wealthy South Africa does not offer very good prospects, partly because at least some pyrethrum production takes place there. Pyrethrum is relatively well entrenched in grain storage on the basis of rotation with malathion to obviate build-up of insect resistance, two years of malathion usage being followed by one year of pyrethrum. In the long run it is likely that the synthetic pyrethroids will gain ground.

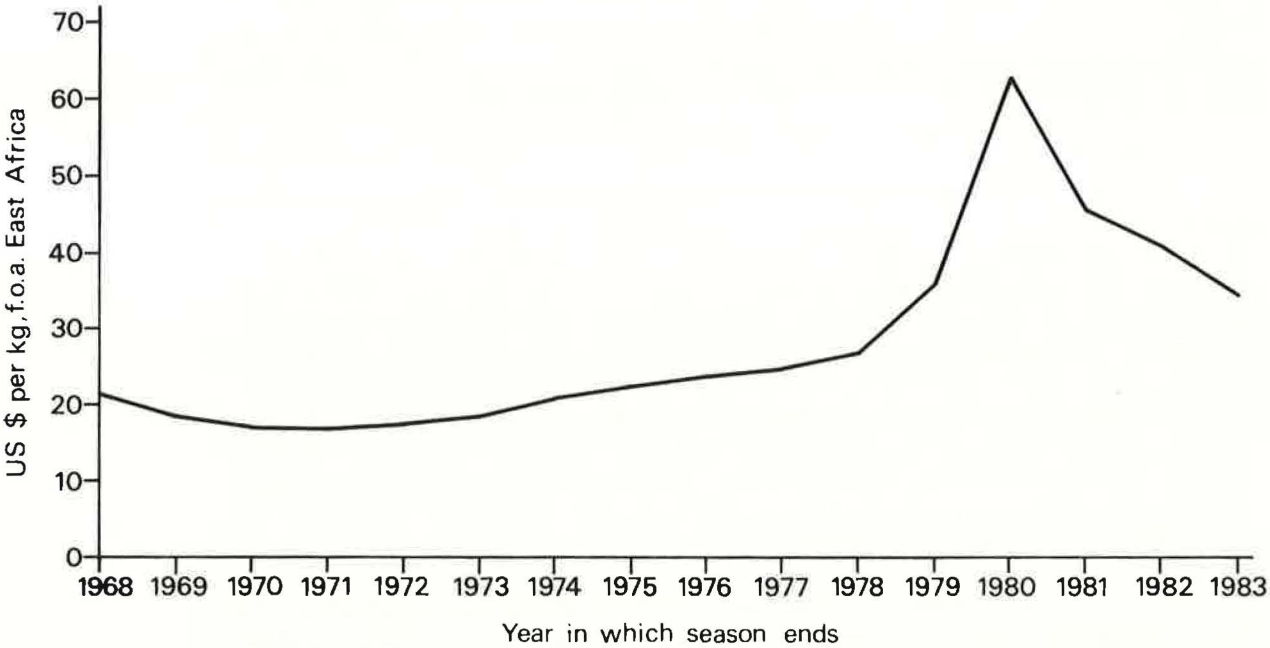
Conclusion

The overall picture that emerged from the field research was not an encouraging one. The Asian mosquito coil market, formerly the major outlet for pyrethrum powder, appears to have been permanently lost where pyrethrum is concerned. The use of pyrethrum extracts in household aerosols, in which there was very little competition for pyrethrum until the first of the major shortages, showed an almost equally sharp fall and is not likely to be reversed dramatically, although the fall seems to have spent most of its force. The outlook in veterinary and animal house applications is little more encouraging, given the cost-effectiveness of modern synthetic pyrethroids. Only as a means of insect control in the food processing industry does it appear likely to continue to be used in major quantities, although the various minor applications together account for around 40% of the total market. While from a technical point of view pyrethrum would appear to have a degree of potential in agriculture as a flushing agent or as a last minute pre-harvest treatment on certain fruit, vegetable and other crops, it would be premature and rash to assume that such outlets will bring about a major upturn in pyrethrum's fortunes. At least in the short term, the current worldwide usage level of not much more than 100 tonnes of active pyrethrins ingredients, equivalent to around 9,000–10,000 tonnes of dried flowers at typical pyrethrins contents, seems unlikely to be greatly exceeded, and further severe shortages or major price fluctuations would risk serious attempts being made to supplant the use of pyrethrum in North American food processing plants, and in the event of pyrethrum losing its dominance in this sector, its very survival as a viable insecticide would be seriously threatened.

PRICES, COSTS AND TARIFFS

Reference should be made to Figure 5 for an indication of movements in the average f.o.a. price of East African crude 25% pyrethrum extract from the late 1960s until mid 1983. The price of refined extract, also at a pyrethrins content of 25%, has typically been 15–20% higher than that of crude extract, while the price of 50% refined extract is usually roughly double that of the 25% product, as would be expected. The prices of pyrethrum powder and marc followed a broadly similar trend, the f.o.a. price of 1.3% powder increasing from its 1970/77 level of around 80¢ per kilogram to in the region of $2.50 per kilogram in the

Figure 5:
Crude pyrethrum extract: annual average prices 1968–83



early 1980s, with some easing recently (early 1983) evident as supplies began to overtake demand. Producer and export price trends have been broadly similar for each of the main producing countries, differential exchange rate movements being partly responsible for those appreciable divergencies that occurred.

It should be noted that the period 1970–77 was a period of very substantial worldwide inflation, and that the pyrethrum price, though rising over 50% during the period, lagged well behind prices generally, the 'real', i.e. inflation-adjusted, price in 1977 being under two-thirds that of 1970. It was largely this that eventually induced so many East African smallholders to switch into other crops, although it is undeniable that most producers experienced climatic difficulties during the mid 1970s. The violent upward movement in prices which followed the recent shortages, and the almost equally sharp subsequent fall, can be clearly seen from Table A. During the worst period of the shortages, price peaks of $90-100 per kilogram and even higher were recorded in the consuming countries.

In the main African producing countries the prices paid to the pyrethrum farmers tend to average 65–75% of the f.o.b. price on an equivalent pyrethrins content basis, the balance covering collection, processing, packaging, marketing, extension and administrative costs. At the time of the writer's visit to Kenya (September 1982), the producer price was 1,150 Kenya shillings (US $105) per kilogram of pyrethrins, in comparison with 805 shillings in 1979, while in Tanzania price movements from 1979/80 are shown in the following table.

Table A

Prices of Tanzanian dried flowers 1979/80

	Tanzania shillings per kilogram of dried flowers				
Year	Grade I	Grade II	Grade III	Grade IV	Grade V
1979/80	7.50	7.00	6.50	6.00	5.50
1980/81	11.00	9.50	8.50	7.50	6.50
1981/82	3.00	12.00	11.00	10.00	9.00
1982/83	13.00	12.00	11.00	10.00	9.00
Pyrethrins content:	1.4% +	1.3–1.39%	1.2–1.29%	1.1–1.19%	< 1.1%

The 1981/82 and 1982/83 prices are equivalent to roughly US $95 per kilogram of pyrethrins (100% equivalent).

In comparison with many primary products, the pyrethrum smallholder obtains a large proportion of the final value of the product, and in consequence changes in export prices tend to be strongly reflected in farm-gate prices and vice-versa. Because of the competition for land from beverage crops, maize, vegetables and so forth, there is now little scope for much further reduction in the f.o.b. and c.i.f. prices of extract, if renewed shortages are to be avoided.

At the time of the writer's visit to the USA in February 1983, the decline in f.o.a. prices for East African extract had enabled a USA processor to offer a very high-grade locally-refined 20% extract at a price of $26.50 per pound ($58 per kilogram), equivalent to $292 per kilogram of 100% pyrethrins. By mid 1983, however, 25% refined extract of Kenyan manufacture was available, delivered to the customer, at just over $43 per kilogram, equivalent to $175 per kilogram of pyrethrins. For reasons which are enlarged on below, however, this was probably a loss-cutting, stock-clearance price which is unlikely to be sustained. One US firm indicated that at the time when the local pyrethrum price fell from $35 per pound ($77 per kilogram) to $30 per pound ($66 per kilogram) for 20% refined extract, business increased by 50%, but given the conditions prevailing at the time this increase was probably from a very low base. These aspects are further discussed in a subsequent paragraph.

Airfreight rates for pyrethrum extract are typically £1 ($1.50) per kilogram to the United Kingdom and other European destinations, and around $2.30 per kilogram to New York, while shipping rates for powder are around $220 per tonne to the USA and $115 per tonne to Europe, marc attracting slightly lower rates.

The importance of synergists in containing the cost of pyrethrum-based products will be appreciated when it is noted that the price of piperonyl butoxide (PBO) in early 1983 was in the region of $10 per kilogram, and that of MGK-264 just over $6 per kilogram. A typical ratio of PBO to pyrethrins in an aerosol compound is 5:1, although there is a fairly wide degree of variation in this ratio.

The following list gives typical comparative prices, expressed in terms of 100% active ingredients, for a selection of synthetic pyrethroids, with that of pyrethrins for comparison:

Mid 1983	*$/kg*
Natural pyrethrins	175
d-trans-allethrin (bioallethrin)	190
Es-Biothrin	285
S-bioallethrin	330
Tetramethrin	110
d-Phenothrin	180
Permethrin	110

When the typical substitution ratios between natural pyrethrins and the various synthetic pyrethroids are taken into account, one can conclude that the recent fall in the price of pyrethrum has brought it more nearly into line with the prices of the allethrin group, but most emphatically not with that of tetramethrin. How far pyrethrum's new relatively low price level can be sustained, bearing in mind the economics of production and the interests of the smallholders, can only remain to be seen, one or two processors maintaining that profitable production, without any external support for the industry, is not possible below an f.o.a. price for crude 25% oleoresin extract of around $45 per kilogram. Given an approximate refining cost of a little over $6 per kilogram (toll-refining by Western firms typically costs $8 per kilogram), this implies a break-even f.o.a. price for 25% refined extract of not less than $50 per kilogram, and maybe up to $10–12 more if operating conditions are less than optimal, which is not infrequently the case. This price is in turn equivalent to a minimum of $200 per kilogram of natural pyrethrins delivered to the customer. However, the fact that the current pyrethrum price has induced one or two users (notably in the USA and Spain, but also elsewhere) to revert from the allethrin family to pyrethrum demonstrates that the natural product is still capable of regaining some of its former following when the price is right, although the fact remains that the cheapest and most widely-used aerosols incorporate tetramethrin rather than the allethrins, while the mosquito coil manufacturers are not showing the slightest sign of reverting to pyrethrum.

It should be noted that the above prices are subject to a degree of variation, this being particularly true with the photostable agricultural pyrethroids, the prices of which can depend on the country, the individual project, the trading channels, and on whether or not tender has been invited.

TRADING STRUCTURES AND PROCEDURES

The production structure operating in the producing countries has already been discussed in the sections relating to those countries and will not be further enlarged upon here.

The main links in the pyrethrum trading chain consist of the following: exporter, importer/agent, processor/formulator, wholesaler/retailer, and end-user. Whether use is made of wholesalers or retailers by an end-user will depend very much on the size of the latter's business, the smaller end-product manufacturers being more likely to resort to them. Even so, direct links between even small end-users and processor-formulators are not infrequent. In the pyrethrum trade, there is in the main no independent network of agents, dealers, merchants and brokers such as is so familiar in many other trades although, as mentioned earlier, a number of independent intermediaries temporarily took positions in the pyrethrum market when the product was in short supply and prices were climbing strongly. This proved additionally detrimental to the reputation of the product at a time when user confidence in its regular availability and steady prices was already falling heavily. Regular independent dealers are not unknown in the pyrethrum trade, but they are few. Not all consignments pass through the hands of an importer or agent; some pass direct from the exporter to a processor or formulator. On the other hand, direct links between exporters and end-users are generally uncommon, although there are one or two very notable exceptions to the last-mentioned rule. Apart from the worst period of the shortage, the trade structure has in the main operated extremely smoothly, and should continue to do so.

Initial payment to the producers for pyrethrum extract is made on the basis of its quoted nominal pyrethrins content (normally 25% or 50%). In some cases the actual content is very close – within a percentage point – of the nominal value, but quite often the actual content of a nominal 25% extract will be between 29% and 33%, and that of a nominal 50% extract up to 63%, and the balance of the payment due to the producer is made once the precise pyrethrins content has been measured and agreed by both buyer and exporter. In the US and Danish markets, measurement is made by means of the AOAC method, whereas most other markets accept the PBK method, which gives readings roughly 10% higher than the AOAC method (for example 22.5% cf. 20%). This means that a uniform pricing system is not possible, but over the years a system of price adjustment has been arrived at by which the producers are effectively placed at no disadvantage, no matter which method of measurement is employed, and the existence of the two methods is not nowadays a source of disagreement between buyer and seller, although care has to be taken when interpreting price quotations.

Few problems have been experienced with packaging of pyrethrum products over the years. Standard packaging for crude and refined extracts consists of steel drums coated with epoxy lacquer, capacity 25 kilograms or, less commonly nowadays, 100 kilograms, the usual packaging for powder and marc being polythene-lined jute bags of 50 kilograms capacity.

Much aerosol and mosquito coil production is undertaken on a custom-manufacturing basis. Numerous firms, including some major trans-nationals, especially the petroleum companies, regularly undertake the custom-filling of aerosols, typically purchasing canisters, active ingredients, propellant and so forth from independent suppliers. Custom-fillers are usually very cost-conscious and tend to require the cheapest formulation available for the intended purpose of the product, and for this reason it is relatively unusual for pyrethrum to be included in such formulations. Many Asian mosquito coil producers are similarly supplied with a complete range of raw materials for the production process, generally from Japanese suppliers, and indeed it is mainly the Japanese who supply the machinery for mosquito coil production.

Very few appreciable barriers to trade in pyrethrum exist in the form of tariffs, except in the case of Japan. Pyrethrum products enter the USA and Canada duty-free. Imports into the EC are also duty-free, except in the case of extract refined in the USA, in which case a 5% tariff is levied. Most Asian countries do not levy import duties on pyrethrum, but extracts entering Japan incur duty at the rate of 20%, although marc is duty-free. Some Latin American countries levy import duty on pyrethrum from sources other than Ecuador, presumably in order to give the latter country an advantage under Latin America Free Trade Association (LAFTA) arrangements. A few other countries levy duties but the overall impact on the pyrethrum trade is minimal. It is worth noting, however, that the average level of world import duties on synthetic pyrethroids is high enough to affect their prices appreciably, and in the event of further general rounds of tariff reductions, for example under General Agreement on Tariffs and Trades (GATT) auspices, the competitive position of pyrethrum would be further eroded. For example, synthetic pyrethroids entering the EC are dutiable at a rate of between 10% and 13%, according to source or product, although the duty may in some cases be refunded in the event of the end-products in which they are used being exported outside the EC. Duty charged on imports of synthetic pyrethroids into the USA, which varies according to the product, is often lower than EC rates but is still significant.

Section 3

The outlook for natural pyrethrum

In this brief Section the implications of the observations made in the preceding Sections are brought together and considered in the context of the foreseeable prospects for pyrethrum and for the existing and potential producers.

COMPETITION FROM OTHER INSECTICIDES

At the time when the last major studies on the pyrethrum market were undertaken, there was arguably still time for action to be taken by the producing countries to modify production, stockholding and marketing policies in such a way as to provide the maximum possible counter-challenge to the threat from other insecticides, notably the synthetic pyrethroids. To a large extent it would appear that this opportunity has been lost. The first and second generation pyrethroids have now been supplemented by the third generation of photo-stable agro-pyrethroids, and all classes of pyrethroid are now in such large-scale production that their prices, which were initially high, have now fallen to levels which in many cases pyrethrum cannot challenge. Indeed, many pyrethroids are now so widely available that they are virtually being traded as commodity products, and the fierce competition between their manufacturers, licensing restrictions notwithstanding, is certain to keep prices well down. In several cases doubt continues to be expressed in certain quarters regarding the toxicological characteristics of these products; for example, certain halogenated pyrethroids such as cypermethrin, deltamethrin and fenvalerate are alleged to cause a degree of skin irritation, while permethrin is suspected, at least in North America, of presenting more serious toxicological hazards. In some countries these problems are delaying the introduction of these pyrethroids, but their introduction into agricultural applications is unlikely to be delayed for long. Although acceptance for indoor use is likely to be restricted for some time to come, it should not be forgotten that the photo-stable halogenated pyrethroids, although primarily designed for agricultural use, having a potentially wide range of applications, their high level of efficacy rendering them very suitable technically for many indoor uses, and in the long run they are likely to advance considerably further in these applications.

However, it is mainly for the non-residual 'knock-down' synthetic pyrethroids such as tetramethrin, allethrin and its derivatives (bioallethrin, d-trans-allethrin, s-bioallethrin, Esbiol, etc.) that the most devastating attack on pyrethrum's traditional applications has come, and in spite of the recent fall in the pyrethrum price there is little likelihood of pyrethrum competing strongly with these products on a cost-effectiveness basis in the long term. Moreover, it is thought that the price of tetramethrin (the Japanese product widely marketed as Neo-Pynamin), which was primarily responsible for the decline of pyrethrum in domestic aerosols, which is already far lower than that of pyrethrum, could fall still further. While it is very possible that from time to time pyrethrum may be competitive with bioallethrin and closely related pyrethroids, it does not, on the available evidence, seem likely that it will regularly and consistently do so.

It is possible that the residual consumer preference for active ingredients of natural origin will help to preserve natural pyrethrum's remaining position in the more expensive range of domestic products, notably aerosols. In the USA in particular, the main aerosol producers are reluctant to drop altogether their lines of product containing pyrethrum, and in spite of new formulation registrations, many of the older formulations containing pyrethrum are still current. Certainly the non-toxic, non-residual characteristics of pyrethrum have enabled it to retain its position in the food processing industry, but even here it is probably just as well that its main rival, the non-residual pyrethroid resmethrin, although low in toxicity, has a disadvantage of emitting unpleasant odours during its breakdown phase. There can be no doubt that there was as serious concern in the food processing industry during the worst period of the shortages as there was in other sectors, and had viable substitutes been available, users would in all probability have switched, and it is probably no exaggeration to say that the loss of this sector of the market could prove a fatal blow to the pyrethrum industry in its present form.

It is unlikely that the price of pyrethrum can be reduced below its current level of an equivalent of around $175 per kilogram of active pyrethrins (c.i.f. delivered) and in the medium term it will probably have to rise in order to avoid farm-gate prices being set at broadly uncompetitive levels in relation to other local crops. It will therefore be necessary in future to market pyrethrum mainly on the strength of its technical advantages, while keeping its price as low as is consistent with regular supplies. It is of course arguable that the price disadvantage would have come about eventually in any case, but the technical advantages might well have held greater sway, and less of the market lost as a result, had not the shortages occurred and pyrethrum suffered the same loss of reputation as have so many natural primary products for similar reasons.

PRODUCTION ASPECTS

It is possible that there may be limited prospects for improving the efficiency of production and marketing methods at source. For some time attempts have been made to increase the yield of flowers per hectare, on the one hand, and to increase the extractable pyrethrins content of the flowers themselves, on the other. In this way it should be possible to maintain farm-gate prices at reasonably competitive levels while reducing f.o.b. prices for extract and powder. Success appears to have been limited, however. Higher-pyrethrins-yielding flowers have in some cases shown a tendency to be less hardy than the lower-yielding flowers, with the result that the higher pyrethrins yield has been offset by a lower yield of flowers per hectare. The converse has also proved to hold in some cases, higher-yielding plants as measured on a crude yield of dried flowers per hectare basis tending to have a lower pyrethrins content. Increasing climatic variation, moreover, in part caused by steady de-afforestation, has made annual yields less predictable than was once the case. The latter aspect is of course outside the producers' control, but the quest for higher yields of active pyrethrins ingredients per hectare should certainly continue. This will inevitably need to go hand in hand with a contraction of the industry's base, with fewer farmers producing a given quantity of pyrethrins, although it is unlikely that more radical changes to the industry's structure, for example a switch from smallholder production to plantation production, would prove successful in the long term, notwithstanding any resultant prospect of higher per hectare yields.

On balance it seems unlikely that the recent experiments conducted in Australia on the mechanical harvesting of pyrethrum hold out much hope of increasing the profitability of pyrethrum production. The circumstances under which these experiments took place were unusual and may well not apply elsewhere. In any case, the social costs of displacing possibly thousands of smallholders would be enormous. While it is possible that Tasmanian exports will be recorded from time to time in the future, it is unlikely that Tasmanian producers will be able appreciably to undercut the prices quoted by other producers.

Experiments are known to be under way in the Americas on the production of pyrethrins by means of tissue culture. However, by late 1983, no results had been published that gave any indication of likely commercial viability, and the significance of the experiments for the longer term future of pyrethrum has yet to become apparent.

The pyrethrum products themselves, namely extract, powder and marc, are probably broadly meeting current market requirements, and complaints have been few. Although it is important that crude extracts should continue to be available on the market, since some buyers actually prefer to refine and process it to their own specifications, the refined product continues to gain ground and it may be that the producing countries will need to move towards a greater degree of collaboration, with, for example, those with refineries undertaking custom-refining (toll-refining) of the crude extracts produced in countries without refineries. In a severely reduced market, the obvious temptation is for individual producing countries to defend their market shares at the expense of others, but careful collaboration could eventually prove beneficial to all, not just the minor producers.

The suggestion sometimes put forward to the effect that extracts of pyrethrins content higher than 50% should be offered, with a view to reducing transportation costs still further, is in the opinion of the writer not worth following up. Current airfreight costs for crude and refined extracts are in any case extremely competitive and do not make a major difference to the final price of the product to the end-user. Even 50% refined extract needs to be diluted as soon as possible after receipt by the user in order to overcome its comparative lack of stability, and any freight savings facilitated by the production and marketing of extracts of higher degrees of concentration would probably be offset by the need for subsequent processing and, very possibly, by outright losses due to deterioration in transit and storage. On the other hand, some users queried the wisdom of marketing pyrethrum powder of 0.6% pyrethrins content, when the 1.3% powder occupies only half the volume for a given pyrethrins content and is consequently markedly cheaper to transport, especially as the bulk to value ratio is such that the shipping mark-up is relatively high in comparison with that applicable to extracts. Although it is true that one or two customers had expressed a preference for the 0.6% powder, there is little doubt that the interests of the producers are best served by the marketing of 1.3% powder.

There is clearly a need for a strategic stockpile or buffer stock to tide the producers over during periods when production falls below planned targets. Such stockpiles are inevitably expensive to finance, and the costs need to be spread as widely as possible. This is one area where collaboration between the producing countries and their main overseas agents could yield fruitful results, for this is not a problem that is likely to be solved by one producer acting in isolation.

There is no doubt that pyrethrum will continue to be an attractive crop to many smallholders, primarily on account of its ability to provide an income for much of the year, in contrast with many other more seasonal crops. Certain steps can be taken on the part of the marketing organisations to improve the overall efficiency of the industry, but the financial benefits are unlikely to be very great in relation to the price ratio between pyrethrum and its major competitors.

It has sometimes been suggested that, since the social benefits of the pyrethrum industry to the producing economies are probably greater than the financial benefits, there is a case on social cost-benefit grounds for a greater degree of State support for the industry, in the form of subsidies, than is currently the case in some countries. While such a suggestion might not always be politically acceptable, it is certainly possible that, assuming cost-benefit studies confirmed that there was a case, a greater degree of external support might facilitate a price reduction to a point at which pyrethrum could compete with greater vigour and regularity with the allethrin family of pyrethroids, even if not with tetramethrin.

OTHER ASPECTS

It is possible that some of the existing producers could broaden the base of their activities further by promoting greater local production of end-products such as aerosols and mosquito coils for sale in regional markets. However, the success of such expansion will depend in part on how rapidly local and regional per capita incomes grow and in part on how imaginatively the products are marketed. The experience of the existing local end-product manufacturers suggests that the task could well be uphill, low per capita incomes in conjunction with the rising cost of food and other daily necessities being the main constraint. For rather different reasons, the production of ready-made insecticidal formulations for sale to end-users in the major consuming countries, which would be a largely new departure, would also present major difficulties on account of the local labelling and registration requirements. It is not sufficient that the main active ingredient should be considered safe and in all other technical respects acceptable by the relevant authorities. The formulations themselves have to be evaluated and cleared and it is here that the producing country would face the most daunting difficulties, partly on account of the time registration applications take to be processed. In any case, to meet the exact requirements of end-users in such a way as to make it more attractive to them to buy direct from the country of origin, rather than from a well known local formulator, is no mean task and moreover user requirements can change rapidly over time.

It is perhaps worth noting that it is technically feasible to use pyrethrum extraction plants for the processing of other raw materials, for example aromatic plants. As long as the existing extraction plants are under-utilised, this is an aspect which could merit investigation, as it could help to alleviate cash-flow problems.

On balance, the best hope for pyrethrum, aside from maintining its present greatly reduced market share, is in the development of new uses for it. The producing countries are unlikely to be able to undertake this type of research and development work themselves, but closer competition and collaboration, both among the producers themselves, and also between them and their overseas agents and those formulators with a comparatively large degree of interest in pyrethrum *vis-à-vis* other insecticides, could create the basis of a more systematic approach to development of possible new outlets. One or two firms have already launched development programmes to this end. It is possible that there are still insufficiently explored outlets in the home and garden field, in insect control on domestic pets, and conceivably in insect control during the drying of fish (especially in the tropical countries), and still more possible that pyrethrum could find minor, cumulatively significant, outlets in agriculture and forestry, especially if inexpensive methods of prolonging its residual activity somewhat could be developed. Its existing uses in last minute pre-harvest applications, on the one hand, and as a flushing agent in combination with synthetic pyrethroids and other insecticides, on the other hand, strongly suggest that its potential in this field may not yet be fully explored, although it must be said that the advent of ULV formulations containing pyrethrum did not give rise to its expected increase in its use in outdoor applications. Towards the end of 1983, there was some evidence of renewed activity in the USA in the field of new applications.

It is possible that carefully prepared marketing campaigns in some of the more rapidly-industrialising developing countries could bring about increased use of pyrethrum as per capita incomes increase, but the marketing methods of the synthetic pyrethroid producers should not be underestimated and there are virtually no markets remaining in which their challenge, if not already formidable, will not soon become so, especially in view of the tendency for many of the synthetic pyrethroids to be over-produced.

FINAL OBSERVATIONS

The existing producers cannot expect a major recovery in the fortunes of pyrethrum in the near future, and on balance the main need is for both retrenchment and improved efficiency. The present production base is too large in relation to the world market, and will need to contract appreciably. At the same time, attention needs to be given to the need for small strategic stock-piles as an insurance against production cycles. A degree of international collaboration, both vertically and horizontally, may well be necessary if the industry is to offer a resilient challenge to the synthetic competition, and to have any chance of successfully promoting new uses for the product. For the time being, there are virtually no prospects for new producers. Even if one or two of the smaller producers were to go out of production, as has at times seemed possible, it would make more sense for the remaining producers to fill the gap rather than for new entrants to appear on the scene, especially in view of the degree of under-utilisation of many of the factories, and in any case the present and foreseeable profitability of the industry as a whole is such as to be unlikely to be attractive to prospective producers. Finally, it should be said that there is still a strong undercurrent of support for pyrethrum on the part of consumers, in spite of its high cost, and there seems little doubt that clear evidence of determined attempts to avoid a repetition of the recent price and supply fluctuations could do much to generate renewed confidence and interest in making the maximum use of a well-proven natural product.

Appendices

APPENDIX 1: STATISTICAL TABLES

Table 1

Kenya: exports of pyrethrum products 1976 – 82

		1976	1977	1978	1979	1980	1981	1982 (Jan. – Aug.)
Pyrethrum extract	tonnes	*502.6*	*417.8*	*261.1*	*390.5*	*284.9*	*148.7*	*162.4*
	million K.Sh.	*113.7*	*99.5*	*81.7*	*110.1*	*180.6*	*119.4*	
	£'000	7,524	6,888	5,504	6,939	10,460	6,510	(d)
	£/kg	15.0	16.5	21.1	17.8	36.7	43.8	
of which to:								
USA	tonnes	131.5	82.2	87.8	59.1	91.8	43.9	
Canada	tonnes	39.1	54.8	17.7	40.1	22.2	6.2	(d)
United Kingdom	tonnes	42.6	66.6	22.0	19.9	27.3	23.8	
Italy	tonnes	39.3	35.1	31.0	23.1	31.0	15.6	
Germany, Federal Republic of	tonnes	22.5	24.8	6.2	7.2	21.1	6.3	
Netherlands	tonnes	16.0	13.1	8.5	10.8	6.4	3.8	
Denmark	tonnes	10.3	9.5	6.5	48.5[a]	6.1	...	
France	tonnes	18.4	16.0	6.9	4.4	6.4	8.3	
Belgium	tonnes	5.0	5.0	0.8	1.1	2.2	1.7	
Austria	tonnes	4.1	1.3	2.6	2.3	3.9	1.1	
Switzerland	tonnes	3.4	2.5	2.2	1.0	4.3	2.9	
Spain	tonnes	7.0	9.5	7.1	3.2	6.2	2.5	
Sweden	tonnes	3.7	3.8	2.6	3.5	3.5	3.0	
Finland	tonnes	5.4	3.7	3.7	4.9	9.8	4.1	
Australia	tonnes	86.6	30.4	21.0	77.4	15.9	16.5	
Japan	tonnes	2.3	4.7	14.1	15.1	5.5	4.2	
China	tonnes	3.7	5.9	...	10.0	7.1	...	
India	tonnes	—	—	0.2	15.1	5.5	1.3	
Swaziland	tonnes	18.7	17.4	3.5	5.6	3.6	0.6	
Pyrethrum powder and flowers	tonnes	*3,665*	*3,276*	*1,395*	*535*	*409*[b]	*372*[b]	*266.0*
	million K.Sh.	*24.0*	*21.3*	*10.8*	*4.1*	*5.7*	*8.7*	
	£'000	1,590	1,474	727	261	335	476	
	£/tonne	434	450	521	488	822	1,282	(d)
of which to:								
Japan	tonnes	600	450	282	225	220	—	
Malaysia	tonnes	520	486	120	55	50	70	
Hong Kong	tonnes	473	219	110	60	15	—	
India	tonnes	75	119	70	49	45	140	
Brazil	tonnes	—	—	50	15	—	—	(d)
USA	tonnes	35	10	35	—	46	20	
Greece	tonnes	—	143	70	60	20	60	
Spain	tonnes	100	31	—	20	—	157	
France	tonnes	—	—	—	15	—	—	
Italy	tonnes	155	146	32	—	10	5	
Thailand	tonnes	—	—	158	—	—	—	
Pyrethrum marc	tonnes	*1,626*	*3,407*	*5,270*	*2,646*	*3,695*	*2,680*	*949.9*
	million K.Sh.	*1.2*	*2.9*	*6.2*	*4.5*	*7.6*	*3.7*	
	£'000	80.3	195.3	418.4	286.8	439.6	201.4	
	£/tonne	49.4	57.3	79.4	108.4	119.0	75.2	
of which to:								
Japan	tonnes	1,000	2,976	4,684	2,450	3,486	2,225	
Malaysia	tonnes	...	5	380	130	100	200	(d)
Hong Kong	tonnes	100	—	—	—	45	40	
Pyrethrum flowers	tonnes	(c)	(c)	(c)	*29*	*65*	*50*	
	million K.Sh.				*1.1*	*2.5*	*1.5*	(d)
	£'000				69.9	142.2	83.3	
	£/kg				2,404	2,187	1,667	
of which to:								
United Kingdom	tonnes				—	65	—	(d)
Belgium	tonnes				29	—	—	
India	tonnes						50	

Source: 1976 – 81 – Kenya Annual Trade Reports
1982 – Pyrethrum Board of Kenya

Notes: [a] This is probably an error in the trade statistics; it is possible that the decimal point has become misplaced
[b] Excluding pyrethrum flowers
[c] Included above
[d] Details not available

Table 2

Tanzania: exports of pyrethrum products 1976 – 82

		1976[a]	1977[a]	1978[a]	1979/80[b]	1980/81[b]	1981/82[b]
Pyrethrum extract	tonnes	*118.4*	*95.8*	*68.7*	*40.3*	*22.8*	*30.1*
	million T.Sh.	*20.0*	*17.8*	*17.3*	*21.0*	*13.4*	*13.5*
	£'000	1,320.4	1,229.0	1,169.2	1,199.8	702.9	803.1
	£/kg	11.2	12.8	17.0	29.8	30.8	26.7
of which to:							
USA	tonnes	87.3	...	48.6	17.7	10.8	30.1
United Kingdom	tonnes	2.0	...	14.7	2.3	1.8	—
Canada	tonnes	—	...	3.0	14.4	6.8	—
Japan	tonnes	—	...	2.4	2.6	2.5	—
China	tonnes	28.3	...	—	...	...	...
Pyrethrum flowers and powder	tonnes	*389*	*456*	*289*			
	million T.Sh.	*2.5*	*3.2*	*2.3*			
	£'000	162.8	219.6	157.4			
	£/tonne	419	481	545			
of which to:							
China	tonnes	163	...	62			
Hong Kong	tonnes	55	...	42			
Japan	tonnes	100	...	—			
Thailand	tonnes	25	...	—			
Singapore	tonnes	—	...	100			
Taiwan	tonnes	—	...	50			
USA	tonnes	46	...	30			
Pyrethrum marc	tonnes	*1,810*	*1,637*	*1,805*			
	million T.Sh.	*1.3*	*1.4*	*1.6*			
	£'000	89.0	99.6	106.4			
	£/tonne	49.2	60.8	58.9			
of which to:							
Japan	tonnes	...	...	1,505			
Hong Kong	tonnes	...	...	300			

Sources: [a] East Africa Customs and Excise Reports and Tanzania Trade Statistics
[b] Tanganyika Pyrethrum Board

Table 3

Rwanda: exports of pyrethrum extract 1976–81

		1976	1977	1978	1979	1980[a]	1981[a]
TOTALS	tonnes	*66.2*	*96.9*	*34.4*	*80.4*		
	million FRw	*120.6*	*208.3*	*86.7*	*128.9*		
	£'000	*719*	*1,286*	*486*	*654.6*		
	£/kg	*10.9*	*13.3*	*14.1*	*8.1*		
of which to:							
France	tonnes	–	0.7	1.8	0.8		
	£'000	–	12.4	31.4	17.7		
United Kingdom	tonnes	11.3	–	2.5	11.6		
	£'000	174.3	–	41.2	216.4		
Switzerland	tonnes	–	0.4	–	–		
	£'000	–	6.8	–	–		
Belgium and Luxembourg	tonnes	–	–	2.3	–		
	£'000	–	–	43.7	–		
Germany, Federal Republic of	tonnes	–	–	0.5	49.8		
	£'000	–	–	8.1	81.3		
Sweden	tonnes	–	–	0.1	...		
	£'000	–	–	1.7	...		
Austria	tonnes	–	–	2.3	...		
	£'000	–	–	37.8	...		
USA	tonnes	54.4	59.0	11.3	18.2		
	£'000	544.6	744.4	154.0	339.1		
Kenya	tonnes	–	36.3	13.6	–		
	£'000	–	521.5	168.3	–		
Burundi	tonnes	0.5	0.5	–	–		
	£'000	0.5	0.6	–	–		

Source: *Bulletin de Statistique,* Rwanda

Notes: [a] The following export tonnages were given by the Office du Pyrèthre au Rwanda:

1979 18.5
1980 19.7
1981 4.5

The discrepancy in 1979 may be due to a difference of timing

Table 4

Ecuador: exports of pyrethrum products 1975 – 80

		1975	1976	1977	1978	1979	1980
Pyrethrum extract	tonnes	*24.0*	*16.9*	*27.2*	*16.2*	*15.1*	*16.0*
	US $'000	*680.9*	*500.7*	*904.1*	*589.0*	*795.4*	*1,186.0*
	$/kg	*28.3*	*29.6*	*33.2*	*36.4*	*52.8*	*74.1*
of which to:							
Argentina	tonnes	7.6	3.2	6.4	0.1	2.3	[b]
	$'000	206.1	60.6	214.4	4.2	129.9	
Brazil	tonnes	6.5	5.6	7.0	6.9	0.9	
	$'000	197.9	181.8	223.0	253.3	48.1	
Colombia	tonnes	2.2	1.8	3.4	1.9	2.4	
	$'000	61.2	55.4	114.1	52.9	72.4	
Mexico	tonnes	4.0	6.0	7.7	6.6	8.3	
	$'000	122.9	198.3	254.7	254.3	467.6	
Other Latin American countries	tonnes	3.6	0.3	1.9	0.7	1.0	
	$'000	92.8	4.5	46.7	24.3	47.4	
USA	tonnes	—	—	0.6	—	—	
	$'000	—	—	21.1	—	—	
South Africa	tonnes	—	—	0.1	—	0.1	
	$'000	—	—	30.0	—	30.0	
Pyrethrum flowers	tonnes	...[a]	*164.8*	*150.0*	*5.0*	*11.9*	
	US $'000	...	*25.2*	*80.1*	*0.7*	*2.1*	
	$/tonne	...	154	534	156	180	
of which to:							
Argentina	tonnes	...	47.2	30.0	—	11.9	
	$'000	...	6.9	3.3	—	2.1	
Colombia	tonnes	...	15.0	—	5.0	—	
	$'000	...	2.0	—	0.7	—	
Netherlands	tonnes	...	101.6	—	—	—	
	$'000	...	16.4	—	—	—	
USA	tonnes	...	—	120.0	—	—	
	$'000	...	—	76.8	—	—	

Source: *Anuario de Comercio Exterior*
Departamento de estadisticas aduaneras

Notes: [a] Not shown in this year
[b] Details not available

Table 5

Papua New Guinea: exports of pyrethrum extract 1976 – 81

		1976[a]	1977	1978	1979	1980	1981 (Jan. – Oct.)
TOTALS	tonnes	*17.4*	*9.1*	*5.7*	*5.0*	*2.9*	*20.3*
	Kina '000	*252*	*145*	*118*	*202*	*19*[b]	*804*
	£'000	176.1	105.0	86.8	133.8	12.2[b]	589.6
	£/kg	10.1	11.5	15.1	27.0	4.2	29.0
of which to:							
United Kingdom	tonnes	17.4	—	...	—	2.9	—
	£'000	2	—	...	—	12.2	—
USA	tonnes	—	—	...	5.0	—	—
	£'000	—	—	...	133.8	—	—
Lae	tonnes	—	9.1	—	—	—	10.5
	£'000	—	105.0	—	—	—	295.9
Goroka	tonnes	—	—	—	—	—	9.8
	£'000	—	—	—	—	—	293.5

Source: *Papua New Guinea Statistical Bulletin*

Notes: [a] Tentative: different sources give different totals
[b] This unexpectedly low figure, in relation to the export volume, should be treated with caution as it may arise from a statistical error

Table 6

USA: imports of pyrethrum products 1976–82

		1976	1977	1978	1979	1980	1981	1982
Pyrethrum, advanced[a]	tonnes	*316.1*	*275.3*	*177.1*	*168.5*	*173.7*	*68.4*	*195.6*
	$'000[b]	*8,580*	*8,273*	*8,106*	*13,242*	*21,990*	*7,412*	*16,540*
	$/kg[b]	*27.1*	*30.1*	*45.8*	*78.6*	*126.6*	*108.4*	*84.6*
of which from:								
Kenya	tonnes	153.7	145.2	91.8	93.5	114.4	52.1	133.2
	$'000[b]	5,368	5,383	5,061	8,055	16,525	6,073	13,782
Tanzania	tonnes	72.8	70.8	65.1	37.4	40.2	6.9	39.4
	$'000[b]	1,550	1,621	2,385	3,033	3,639	410	1,488
Rwanda	tonnes	68.0	51.3	15.9	27.7	12.6	–	3.2
	$'000[b]	1,066	1,044	400	1,547	1,158	–	129
Ecuador	tonnes	...	–	–	–	3.1	4.9	5.4
	$'000	...	–	–	–	297	429	427
Papua New Guinea	tonnes	...	–	–	7.8	2.8	1.6	1.4
	$'000	...	–	–	423	302	114	70
United Kingdom	tonnes	21.0	8.1	2.7	–	–	–	12.9
	$'000[b]	595	224	103	–	–	–	638
South Africa	tonnes	...	–	0.6	1.0	–	1.5	–
	$'000	...	–	74	99	–	222	–
Pyrethrum, Crude[c]	tonnes	*81.6*	*204.6*	*94.1*	*148.6*	*155.0*	*95.0*	*187.4*
	$'000	*32*	*104*	*81*	*191*	*139*	*139*	*1,088*
	$/tonne[b]	*392*	*508*	*861*	*1,285*	*897*	*1,463*	*5,805*[d]
of which from:								
Kenya	tonnes	...	...	...	91.6	...	...	60.0
	$'000	...	...	...	96	...	...	63
Tanzania	tonnes	...	...	...	54.7	30.0	...	123.1
	$'000	...	...	...	89	69	...	834[d]
Papua New Guinea	tonnes	...	...	...	...	...	...	4.3
	$'000	...	...	...	...	...	...	191[d]
Other countries	tonnes	...	...	94.1	2.4	125.0	95.0	–
	$'000	...	...	81	6	70	139	–

Source: US Trade Returns

Notes: [a] Crude and refined extract
[b] F.O.B. for 1976–77, C.I.F. thereafter
[c] Mostly powder and marc
[d] These exceptional values could be due to misclassification of merchandise

Table 7

European Community: imports of pyrethrum and rotenone[a] 1976–81

		1976	1977	1978	1979	1980	1981	1982
Pyrethrum and rotenone[a]								
Extract	tonnes	*200*	*216*	*142*	*96*	*104*	*94*	
	'000 ECUs[b]	*4,374*	*4,797*	*3,342*	*3,147*	*4,804*	*4,106*	
	$'000	4,911	5,465	4,259	4,316	6,888	4,606	
of which to:								
United Kingdom	tonnes	75	107	57	38	18	44	
France	tonnes	26	23	26	6	9	5	
Italy	tonnes	53	29	28	17	31	19	
Germany, Federal Republic of	tonnes	16	25	14	12	21	14	
Netherlands	tonnes	14	16	7	16	10	5	
Belgium & Luxembourg	tonnes	5	6	3	2	7	2	
Denmark	tonnes	10	9	7	5	6	3	
Irish Republic	tonnes	1	1	—	—	2	—	
Greece[c]	tonnes						2	
Pyrethrum flowers	tonnes	*318*	*380*	*203*	*74*	*179*	*230*	
	'000 ECUs[b]	*284*	*313*	*302*	*235*	*418*	*487*	
	$'000	319	357	385	322	582	546	
of which to:								
United Kingdom	tonnes	—	—	—	—	16	15	
France	tonnes	32	33	48	40	90	71	
Italy	tonnes	254	319	119	6	39	2	
Germany, Federal Republic of	tonnes	13	3	4	4	13	1	
Netherlands	tonnes	12	16	12	8	6	7	
Belgium & Luxembourg	tonnes	5	7	14	13	10	18	
Denmark	tonnes	1	2	5	3	1	8	
Irish Republic	tonnes	1	—	1	—	4	6	
Greece[c]	tonnes						102	

Source: Nimexe

Notes: [a] Total rotenone imports are very small in comparison with pyrethrum
[b] European Currency Units
[c] Not included in EC statistics before 1981

Table 8

Japan: imports of pyrethrum products 1976–82

		1976	1977	1978	1979	1980	1981	1982
Pyrethrum extract	tonnes	*2.6*	*4.4*	*11.4*	*17.9*	*5.7*	*7.0*	[a]
	Y million	*21.9*	*34.2*	*95.8*	*221.8*	*97.6*	*101.5*	
	$'000	74.2	126.6	456.1	1,012.9	432.2	462.5	
	$/kg	29.1	29.1	40.2	56.5	76.2	65.5	
of which from:								
Kenya	tonnes	2.6	4.3	9.0	13.8	3.4	5.4	
	Y million	21.9	33.2	76.6	176.3	54.5	75.1	
Tanzania	tonnes	—	—	2.3	4.1	2.3	1.6	
	Y million	—	0.9	19.3	45.5	43.1	26.4	
Pyrethrum flowers	tonnes	*776*	*716*	*375*	*130*	*250*	[a]	*5*
	Y million	*127*	*117*	*64*	*33*	*106*		*2*
	$'000	428.3	435.7	304.1	146.0	467.5		6.4
	Y'000/ tonne	*163*	*163*	*170*	*252*	*423*		*318*
	$'000/ tonne	551.9	688.6	810.9	1,123.1	1,868.9		1,280.0
of which from:								
Kenya	tonnes	696	626	375	130	250	[a]	5
	Y million	112	101	64	33	106		2
Tanzania	tonnes	80	90	—	—	—		—
	Y million	14	15	—	—	—		—

Source: *Japan Exports and Imports*
Japan Tariff Association

Notes: [a] Not shown in this year

Table 9

Australia: imports of pyrethrum extract 1975/1976 – 1980/81

		1975/76	1976/77	1977/78	1978/79[a]	1979/80	1980/81	1981/82
	tonnes	*32.8*	*84.3*	*26.1*	*26.4*	*22.0*	*24.8*	
	A$'000	*958*	*2,499*	*1,133*	*1,134*	*1,689*	*1,934*	
	£'000	*606*	*1,681*	*699*	*643*	*859*	*947*	
	£/kg	*18.5*	*19.9*	*26.8*	*24.4*	*39.0*	*38.2*	
of which from:								
Kenya	tonnes	29.6	81.9	20.8	13.6	16.6	20.1	
	£'000	565	1,633	620	445	765	852	
Papua New Guinea	tonnes	2.4	–	–	–	–	–	
	£'000	45	–	–	–	–	–	
USA	tonnes	–	0.6	1.8	2.9	0.4	–	
	£'000	–	10	33	78	12	–	
United Kingdom	tonnes	–	–	3.5	9.9	4.6	3.9	
	£'000	–	–	47	120	56	55	

Source: Overseas Trade Statistics of Australia **Note:** [a] Provisional

APPENDIX 2: PRINCIPAL FIRMS AND ORGANISATIONS ACTIVE IN THE PRODUCTION, MARKETING, DEVELOPMENT OR UTILISATION OF PYRETHRUM AND SYNTHETIC PYRETHROIDS

This list is not in any way intended to be exhaustive and is oriented mainly to the contacts made by the author during the study. Inclusion of a firm's name should not be taken to imply that the Institute has any knowledge of the financial standing of the organisation.

Kenya

The Pyrethrum Board of Kenya (and the Pyrethrum Bureau)
P O Box 420
Nakuru
Kenya

Tanzania

Tanganyika Pyrethrum Board
P O Box 149
Iringa
Tanzania

Rwanda

Office du Pyrèthre au Rwanda (OPYRWA)
BP 79
Ruhengeri
Rwanda

Ecuador

INEXA Industria Extractora CA
P O Box A4581
Quito
Ecuador

Papua New Guinea

Kagamuga Natural Products Pty Ltd
P O Box 74
Mount Hagen
Papua New Guinea

USA

American Cyanamid Company One Cyanamid Plaza Wayne NJ 07470 USA	Synthetic pyrethroid manufacturer
American Hoechst Corporation (Agricultural Division) Route 202 – 206 North Somerville NJ 08876 USA	Marketing of pyrethroids
American Oil and Supply International Inc. (Fairfield American Corporation) 238 Wilson Avenue Newark NJ 07105 USA	Formulators of pyrethrum-based products
Biddle Sawyer Corporation 2 Penn Plaza New York City NY 10001 USA	Dealers and processors (pyrethrum)
FMC Corporation (Agricultural Chemical Group) 2000 Market Street Philadelphia PA 19103 USA	Manufacturers of insecticide formulations
ICI Americas Inc. Wilmington Delaware USA	Formulators and insecticide manufacturers (synthetic pyrethroids)
S C Johnson and Son Inc. Racine Wisconsin 53403 USA	Manufacturers of aerosols and other insecticidal products
Lehn and Fink (Sterling Drug Inc.) 225 Summit Avenue Montvale NJ 07645 USA	Manufacturers of aerosols and other insecticidal products
McLaughlin Gormley King Company 8810 Tenth Avenue North Minneapolis Minnesota 55427 USA	Processors and formulators (pyrethrum and synthetic pyrethorids)

Penick Corporation 1050 Wall Street West Lyndhurst NJ 07071 USA	Manufacturers of insecticidal formulations
Pennwalt Corporation Three Parkway Philadelphia PA 19102 USA	Manufacturers of insecticide formulations
Prentiss Drug and Chemical Co. Inc. 363 Seventh Avenue New York NY 10001 USA	Manufacturers of insecticide products
Shell Chemical Company 1 Shell Plaza P O Box 3871 Houston Texas 77001 USA	Manufacturers of synthetic pyrethroids

United Kingdom

Anglo Oil and Supply International 2–5 Brook Street Tring Herts HP23 5ED UK	Formulators (pyrethrum and synthetic pyrethroids)
Bush Boake Allen Ltd Blackhorse Lane London E17 5QP UK	Refiners of pyrethrum
Mitchell Cotts Chemicals Ltd Mirfield West Yorkshire UK	Manufacturers and formulators (pyrethrum and synthetic pyrethroids)
Rothamsted Experimental Station Harpenden Herts UK	Development of synthetic pyrethroids
Roussel Laboratories Kingfisher Drive Swindon Wilts SN3 5BZ UK	Manufacture and marketing of synthetic pyrethroids and products containing them
Shell International Downstream Building Shell Centre London SE1 UK	Marketing of synthetic pyrethroids

The Wellcome Foundation Limited (Cooper McDougall and Robertson Ltd)
Cooper House
Ravens Lane
Berkhamsted
Herts HP4 2DY
UK

Manufacturers and formulators (pyrethrum and synthetic pyrethroids)

France

S. A. Airwick
38 av. Hoche
75008 Paris
France

Manufacturers of insecticide aerosols and other products

Cooper (France)
22 – 24 rue de Château
92200 Neuilly-Sur-Seine
France

Importers and formulators (pyrethrum and synthetic pyrethroids)

Roussel-Uclaf (Div Agro-Vétérinaire)
163 av Gambetta
75020 Paris
France

Manufacture and marketing of synthetic pyrethroids

Italy

Nymco SpA
Via del Giovi 6
20032 Cormano-Milan
Italy

Importers and distributors of pyrethrum, and formulators

Belgium

Cooper, McDougall and Robertson (Belgium) SA
Rue de Bordeaux 22
1060 Brussels
Belgium

Importers and distributors of pyrethrum, formulators of insecticide products

Netherlands

Aerosol Afvulstation 'Amsterdam' NV
Nijverheidsweg Noord 95
Postbus 95
Amersfoort
The Netherlands

Aerosol manufacturers

Enna, Nederlandse Aerosols NV
Franekereind 1 – 3
Sexbierum
The Netherlands

Aerosol manufacturers

The Federal Republic of Germany

Bayer AG
Pflanzenschutzzentrum Monheim
Alfred-Nobel-Strasse
Monheim
West Germany

Manufacture of synthetic pyrethroids

Hoechst AG Verkauf Landwirtschaft Beratung Pflanzenschutz P O Box 800320 6230 Frankfurt-am-Main 80 West Germany	Marketing of synthetic pyrethroids
Klaus Huth Georgsplatz 1A 2000 Hamburg 1 West Germany	Dealer

Japan

Dainihon Jochugiku Co. Ltd 4–11, 1-Chome Tosabori Nishi-ku Osaka Japan	Importers, processors and formulators (pyrethrum)
Earth Chemical Co. Ltd No 10, Bungo-Machi Higashi-ku Osaka 540 Japan	Manufacturers of insecticidal end-products
Japan Insecticides Industrial Association 32–8, 1-Chome Kyomachibori Nishi-ku Osaka Japan	Trade association
Mitsui and Co. Ltd 3–33 Nakanoshima 2-Chome Kita-ku Osaka Japan	Agents/importers (pyrethrum), formulators/manufacturers
Nagaoka Mfg. Co. Ltd Nippon Building 2F 79 Kyomachi Chuo-ku Kobe Japan	Manufacturers of insecticidal end-products
Nichimen Corporation Dojima Office New Osaka Building 2–6 Dojimahama 1-Chome Kita-ku Osaka Japan	Importers of pyrethrum products, and manufacturers
Sumitomo Chemical Co. Ltd 15, 5-Chome, Kitahama Higashi-ku Osaka Japan	Manufacturers of synthetic pyrethroids

Hong Kong

Blood Protection Co. Ltd 112 Austin Road Kowloon Hong Kong	Manufacturers of mosquito coils and other insecticidal products

Singapore

Malaysia Mosquito Spiral Mfg. Co. Pte. Ltd JC Jalan Kubor Singapore 0316	Manufacturers of mosquito coils

Malaysia

Pokong Industries SDN BHD No 7 Jalan Kilang Dato Onn Industrial Estate Johore Bharu Malaysia	Manufacturers of insecticidal aerosols and mosquito coils
Tiram Kimia SDN BHD 52 Jalan Dungun P O Box 1027 Damansara Heights Kuala Lumpur Malaysia	Manufacturers of insecticidal aerosols and mosquito coils
Sin Kheng Lee (M) Industrial Co. SDN BHD 60 Jalan Langkasuka Larkin Johore Bharu Malaysia	Manufacturers of insecticidal products

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