



Journal of the silkworms. Revue des vers à soie.

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Revue des vers à soie.

Journal of the silkworms.

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EDITORIAL

Les numéros 27(2) et 27(3) de SERICOLOGIA seront consacrés au rapport du XV^e Congrès Séricicole International qui s'est tenu à Pattaya et Bangkok (Thaïlande), du 2 au 6 mars 1987.

Le numéro 27(2) comporte les rapports officiels et les articles retenus par les Présidents des sections "Mûrier", "Economie", "Filature et Artisanat" et "Bacologie". Le numéro suivant contiendra les articles concernant les sections "Bombyx mori" et "Vers à soie non-mûrier" ainsi que les rapports hors sections.

Pour des raisons de présentation, la revue signalétique (Bibliographie) sera publiée dans le volume 27(4).

La deuxième édition de l'ANNUAIRE DE LA SERICICULTURE ET DE LA BACOLOGIE sera publié à la fin de l'année 1987 en supplément au Volume 27.

Pour cette édition, nous serions reconnaissants à tous les Membres Associés de la Commission Séricicole Internationale et à tous les lecteurs de SERICOLOGIA de bien vouloir nous faire connaître les modifications qui ont eu lieu depuis la première édition et de nous indiquer les organismes à ajouter.

Nous savons que SERICOLOGIA pose des problèmes de détachement de feuilles. La rédaction vous prie de bien vouloir l'excuser. Une nouvelle maquette et une autre fabrication sont à l'étude pour 1988.

EDITORIAL

The issues 27(2) and 27(3) of SERICOLOGIA will be devoted to the report of the XVth International Sericultural Congress which was held in Pattaya and Bangkok (Thailand) from 2nd to 6th March 1987.

The issue 27(2) covers the official reports and the articles which have been selected by the Chairmen of the following sections : "Mulberry", "Economy", "Silk-reeling and Handicraft" and "Bacology". The following issue will contain articles of the "Bombyx mori" section and "Non-mulberry" section, along with the off-section reports.

For presentation reasons, the Bibliography will be published in the 27(4) issue.

The second edition of the DIRECTORY OF SERICULTURE AND BACOLGY will be published by the end of 1987 as a supplement to Volume 27.

Concerning this edition, we would be grateful if all Associate Members of the International Sericultural Commission and all readers of SERICOLOGIA would let us know any change that occurred from the first edition onwards and indicate the organisms to be added.

We are aware that SERICOLOGIA suffers from a poor binding. The Editorial Board begs to accept his excuses.

A new lay-out and fabrication are being worked out for the year 1988.

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**XVth INTERNATIONAL SERICULTURAL
CONGRESS**

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XVth INTERNATIONAL CONGRESS OF SERICULTURE

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WELCOME ADDRESS

by

Mr. CHAIWAI SANGRUJI

Director-General
Department of Industrial Promotion

Chairman
Thai Silk Promotion Committee

Your Excellency, the Deputy Minister of Industry,
Secretary General of the International Sericultural Commission,
Chief Delegates of Member-States,
Chairman of Each Session,
Distinguished Participants,
Honourable Guests,
Ladies and Gentlemen,

On behalf of the Department of Industrial Promotion, Ministry of Industry and the Thai Silk Promotion Committee, I wish to extend my heartiest welcome to all of you in the XVth International Sericultural Congress.

As you are well aware, the Congress is conducted every four years and it is an occasion for meeting official delegates of the member states and observer states, as well as a forum for technologists in sericulture and silk industry to present their work and share their views.

This is the first time that Thailand has the honour to organize the congress, which allows Thai technologists opportunities to gain knowledge in this field.

Sericulture and silk production is the type of agro-based industry which could develop the rural economy of Thailand in the Northeast and the North. These have large areas of land that have the need to diversify into upland crops in order to retain the farmers to their villages.

A recent study reveals that sericulture and silk production provides direct employment to about four hundred thousand families and indirect employment to half a million people. A quantity of 800 tonnes of raw silk used for weft yarn is produced and 50 tonnes of silk used for warp yarn is produced annually. However, the silk industry still has to import quite a large amount of silk in order to satisfy the local demand which tends to increase every year.

The traditional and improved mulberry silkworm cultivation in Thailand still has the opportunity to increase primary and secondary industries providing employment to the agriculture and other kind of labour available in the rural areas of Thailand.

The Congress offers an opportunity for all interested in sericulture to follow the latest development in this important field. We will have the opportunity to discuss and exchange views on the various aspects of sericulture which will lead to closer cooperation among the member and observer states and help in the development of the World's sericulture as a whole.

We are particularly happy to stage the Congress here this year because, as you may already know, this is our "Visit Thailand year". We are glad that you have visited us and I hope that you have time to enjoy some sight seeings and to take back with you good memories of Thailand. Finally, may I extend to all of you my best wishes for a successful Congress and a pleasant stay during your visit here.

Thank you.

DISCOURS DE BIENVENUE

de

Monsieur CHAIWAI SANGRUJI

Directeur Général
Department of Industrial Promotion

Président
Thai Silk Promotion Committee

Son Excellence, Monsieur le Ministre de l'Industrie,
Monsieur le Secrétaire Général de la Commission Séricicole Internationale,
Messieurs les Chefs de délégation des Etats-membres,
Messieurs les Présidents de Section,
Messieurs les participants et invités,
Mesdames et Messieurs,

Au nom du Département de la Promotion industrielle, du Ministre de l'Industrie et du Comité Thaïlandais de Promotion de la Soie, je vous souhaite la bienvenue à tous, du fond du coeur, à ce XV^e Congrès Séricicole International.

Comme vous le savez, le congrès a lieu tous les quatre ans et c'est une occasion de se réunir, pour toutes les délégations officielles des Etats-Membres et des Etats-observateurs, ainsi que pour tous les chercheurs en sériciculture et les techniciens des industries de la soie qui présentent leur travaux et échangent leurs points de vue.

C'est la première fois que la Thaïlande a l'honneur d'organiser ce congrès, ce qui permettra aux chercheurs thaïlandais d'approfondir leur connaissance en la matière.

La sériciculture ainsi que la production de soie est une activité basée sur l'agriculture qui peut amener le développement de l'économie rurale dans le Nord-Est et le Nord de la Thaïlande. Dans ces régions, de grandes surfaces de terre ont besoin de diversifier leur production afin de freiner l'exode rural.

Une étude récente révèle que la sériciculture et la production de soie fournit des emplois à environ quatre cents familles et emploie de manière indirecte cinq cent mille personnes. Chaque année, 800 tonnes de soie grège sont produites pour le fil de trame et 50 tonnes pour la fabrication de fil chaîne. Pourtant la Thaïlande doit encore importer une assez forte quantité de soie afin de satisfaire le marché intérieur qui augmente chaque année.

L'élevage traditionnel du ver à soie du mûrier peut encore favoriser les industries primaires et secondaires en amenant des emplois de type agricole ou autre dans les régions rurales de Thaïlande.

Le Congrès offre l'occasion à tous ceux qui s'intéressent à la sériciculture de suivre les derniers développements créés dans ce domaine important. Nous aurons l'occasion de discuter et d'échanger nos points de vue sur les différents aspects de la sériciculture, ce qui amènera une coopération plus étroite et aidera au développement de la sériciculture mondiale.

Nous sommes particulièrement heureux d'accueillir le congrès ici cette année, car vous le savez peut-être déjà, cette année est "L'Année du Tourisme en Thaïlande". Nous sommes heureux de votre présence et nous espérons que vous aurez le temps de visiter notre pays et que vous emporterez avec vous un bon souvenir de la Thaïlande. Enfin, je vous souhaite à tous un congrès fructueux ainsi qu'un bon séjour.

Merci.

REPONSE ET REMERCIEMENTS
du
Docteur Henri BOUVIER,
Secrétaire Général de la Commission Séricicole Internationale

Monsieur le Ministre,

C'est au nom de toutes les personnes qui vont participer à ce Congrès, délégations officielles des Etats membres de la C.S.I., représentants des organisations internationales et aussi Membres associés, que je veux remercier le Gouvernement thaïlandais d'avoir bien voulu accepter, malgré la lourde charge que cela représente, que se tienne ici le 15ème Congrès Séricicole International.

Je vous remercie personnellement, Monsieur le Ministre, de vous être chargé, avec vos services, de l'organisation matérielle de ce congrès.

Doivent être remerciés tous ceux qui ont préparé et participé à l'organisation, en particulier Monsieur Suchat PRACHINDIT de l'Ambassade de Thaïlande à Paris, Monsieur Sompoti AKAPANTHU, Monsieur Thamnu VASINONTA et Madame Valee MANOMAT.

Au moment où s'ouvre ce 15ème Congrès Séricicole, pour en comprendre l'importance, il faut peut-être rappeler ce que furent les précédents congrès. Les six premiers congrès se tinrent en Italie et en France au cours des années 1870 à 1880. Il s'agissait alors de vulgariser la méthode de Pasteur pour lutter contre la pébrine, cette maladie qui décimait les élevages de vers à soie du monde entier. Le succès de la méthode permit à la sériciculture de se maintenir sans trop de problèmes jusqu'à la seconde guerre mondiale : la production de la soie se développant ou régressant en fonction de l'évolution économique de chaque pays.

Les grands troubles causés par la seconde guerre mondiale, coïncidant avec l'apparition des fibres synthétiques, pouvait faire penser à une disparition quasi-totale de la fibre de soie sur le marché mondial.

C'est en 1948 que André Schenk organise à Alès (France) le 7ème Congrès Séricicole International. Ce fut un véritable événement car pratiquement tous les pays producteurs de soie y étaient représentés. Les participants, conscients des possibilités scientifiques et techniques de développement de la sériciculture, décidèrent de se rencontrer à nouveau d'une façon aussi régulière que possible et pour cela créèrent la "Commission permanente des Congrès séricicoles internationaux" qui devint en 1960, après approbation d'une convention institutive, la "Commission Séricicole Internationale", organisation intergouvernementale.

De 1948 à ce jour, sept congrès se sont réunis à intervalles plus ou moins réguliers, tous, à l'exception du dernier, dans le bassin méditerranéen. Il y fut beaucoup question de développement technique et scientifique, de mécanisation de la culture du mûrier et des élevages, de l'automatisation de la filature.

Malgré tous les progrès techniques et les gains de productivité, la sériciculture continua à décliner et disparut même parfois complètement dans les pays les plus industrialisés. Cependant les progrès sanitaires ainsi que la sélection permettait un développement important dans les pays à forte population rurale, ce qui correspond à un déplacement de la production vers les pays en développement.

L'intérêt porté à la sériciculture dans les zones tropicales a été mis en évidence par la tenue du 14ème Congrès à Bangalore, en Inde. Cet intérêt est confirmé par le présent congrès.

Au cours des dernières décennies, des enquêtes ont été faites pour essayer de savoir quelles étaient les possibilités de développement de la sériciculture mondiale. Ces enquêtes ont toujours pris en compte les perspectives de commercialisation de la soie vers les pays consommateurs. Il est à noter que la production et la consommation de soie n'avaient jamais été aussi importantes qu'au cours de ces dernières années et que l'élévation même minime du niveau de vie dans les pays producteurs à forte population peut amener un développement de la consommation beaucoup plus important que celui, forcément limité, des pays industrialisés.

Je pense enfin qu'il est une autre façon d'aborder le problème de la production séricicole et qu'il faudrait peut-être penser aux populations les plus pauvres auxquelles la sériciculture pourrait apporter un revenu monétaire non négligeable.

ADDRESS
by
Dr. Henri BOUVIER
Secretary General of the International Sericultural Commission

Your Excellency,

It's on behalf of all participants to this Congress present here, of the official delegations of I.S.C. Member States, and also on behalf of all Associate Members, that I wish to thank the Thai Government for having accepted to organize here the 15th International Sericultural Congress, despite the heavy expenses it entailed.

Your Excellency, I thank you personally to have undertaken, along with your services, the on-the-spot organization of this congress.

I also wish to thank all the persons who prepared and took part in the organization of this Congress: Mr. Suchat PRACHIMDIT from the Embassy of Thailand in Paris, Mr. Sompoti AKAPANTHU, Mr. Thamnu VASINONTA and Mrs. Valee MANOMAT.

At the opening of this 15th Sericultural Congress and in order to understand its importance, one should remind of the previous congresses. The first six congresses were held in Italy and France in the course of the years 1870-1880. The purpose was then to extend Pasteur's method of control of pebrine, this disease which decimated silkworm rearings all over the world. The success of this method enabled sericulture to maintain itself rather well up to the World War II: Silk production varied upwards or downwards according to the economic trend of each country.

The great disorders brought about by World War II, coinciding with the apparition of man-made fibres, could allow to think that silk would totally disappear from the world market.

In 1948, André Schenk organized the 7th International Sericultural Congress in Alès (France). This was a real event because virtually all the silk producer countries were represented there. The participants, aware of the scientific and technical possibilities of development in sericulture decided to meet again on a regular basis and with that view, they created the "Standing Commission of International Sericultural Congress" which became in 1960, after approval of an institutive convention, the "International Sericultural Commission", an intergovernmental organization.

From 1948 to the present day, seven congresses met at a more or less regular interval; all but the last one were held in the Mediterranean Bassin. They mainly dealt with technical and scientific development, mechanization of mulberry cultivation and silkworm rearing, automatization of reeling.

In spite of all these technical progresses and the increase in productivity, sericulture dwindled on and even totally disappeared in the most industrialized countries. Nevertheless sanitary improvement and breeding enabled a considerable development in the countries with high level of rural population. This tallied with a shift of the production towards developing countries.

The interest in sericulture in tropical countries has been evidenced by the meeting of the 14th Congress in Bangalore, India. This interest has been corroborated by the present congress.

Along the last decades, investigations were carried out to evaluate the possibilities of development of a worldwide sericulture. These investigations always took into account the prospect of silk marketing towards the consumer countries. It must be pointed out that silk production and consumption have never been as important as during these previous years, and that the rise, even slight, of the standard of living in the producer countries with a high population rate, can bring about a consumption increase much more substantial than the one inevitably limited of the industrialized countries.

Finally, I think one should tackle the problem of sericultural production, and one should think of the poorest populations to whom sericulture could bring a substantial monetary revenue.

INAUGURAL ADDRESS
by
H.E. Korn Dabbaransi
Deputy Minister of Industry

Secretary-General of the International Sericultural Commission,
Director-General of the Department of Industrial Promotion,
Chairman of each Session,
Distinguished Delegates and Participants,
Honourable Guests, Ladies and Gentlemen :

I am very happy to be here today to inaugurate the 15th International Sericultural Congress of the International Sericultural Commission. May I take this opportunity to extend a warm welcome to all of you to Thailand and this world famous Pattaya.

This year, we feel privileged that many international organizations have shown great interest to organize their conferences in Thailand. Earlier this year, the Ministry of Industry was also involved in organizing the UNESCO Regional Training Workshop for Women Dealing with Traditional and Modern Techniques of Dyeing and Weaving Silk in Asia. The result was a great success. The Workshop concluded with several valuable recommendations. Continuing promotion and support on Women's traditional techniques of weaving and dyeing silk should be emphasized, for the preservation of each country's precious traditional arts and skills.

Similarly, although this congress only deals with sericulture, it is important to include subjects on the quality and quantity of the silk fabrics. Without the know-how and concept of sericulture, we will not be able to produce good raw-material for perfect quality products. In other words, sericulture is the most important part of silk matter because without this vital "upstream" source of supply one cannot expect any successful marketing in the "downstream" portion. Therefore, it is indeed our pleasure to host this Congress the subject of which has a very close relationship with last Workshop. I also notice that several of the Thai participants attending the last Workshop are also here today. I do hope that deliberations to be derived at the end will continue to benefit you. Recommendations made at the last Workshop on both quantity and quality of silk production, should be brought up here for further discussion. Demand of the world market for silk, especially, the high quality grade, still has plenty of rooms for more supply. In this context, since you are all experts and have much experience in this area, I leave the matter to you, and look forward to practical recommendations which we all can respectively take up for further actions.

Ladies and Gentlemen, I would like to take this opportunity to thank the Thai Silk Promotion Committee for their support. Notes of appreciation are also in order

for the International Sericultural Commission, the Faculty of Agriculture, Kasetsart University, Sericulture Research Institute, Jim Thompson Thai Silk Co. Ltd., Dept. of Economic Affairs, Ministry of Foreign Affairs and all concerned in making this gathering possible.

In conclusion, I wish this Congress every success and hope that you will have a pleasant stay in Pattaya. While you are here, try to register yourself a memory that will last with you forever. Now, the time has come for me to declare the Congress open.

Thank you very much.

DISCOURS D'INAUGURATION
de
Son Excellence Korn Dabbaransi
Vice-Ministre de l'Industrie

Monsieur le Secrétaire Général de la Commission Séricicole Internationale,
Monsieur le Directeur Général du Département de Promotion Industrielle,
Messieurs les Présidents des Sections,
Messieurs les Délégués,
Mesdames et Messieurs les participants et invités à ce congrès :

Je suis très heureux d'être ici aujourd'hui pour inaugurer le 15^e Congrès Séricicole International de la Commission Séricicole Internationale. A cette occasion je vous souhaite à tous la bienvenue en Thaïlande et à Pattaya, cette station réputée dans le monde entier.

Cette année, nous sommes honorés de ce que beaucoup d'organisations internationales aient choisi la Thaïlande pour organiser leur congrès. Cette année, le Ministère de l'Industrie a également organisé pour l'UNESCO le Séminaire Régional de Formation pour les Femmes s'occupant des techniques de sériciculture et de tissage de soie en Asie. Ce séminaire a été un grand succès et s'est conclu par plusieurs recommandations importantes. La promotion et le soutien continu des techniques traditionnelles des femmes pour le tissage et la teinture devrait être renforcé afin de préserver les arts et métiers traditionnels de chaque pays.

De même, bien que ce congrès ait pour sujet la sériciculture, il est important de parler de la qualité et de la quantité de tissu de soie. Sans le savoir-faire de la sériciculture, il nous serait impossible de produire la matière première permettant d'obtenir des produits de qualité parfaite. En d'autres termes, la sériciculture est la phase la plus importante de la production de soie, car sans cette production en amont, on ne peut espérer une commercialisation réussie en aval. C'est donc avec plaisir que nous accueillons le congrès dont le sujet est très proche de celui du dernier séminaire. Je remarque également que plusieurs des participants thaïlandais qui ont assisté au dernier séminaire sont également présents aujourd'hui. J'espère que les discussions finales nous seront profitables. Les conclusions du dernier séminaire sur la quantité et la qualité de la production de soie devraient être reprises ici et discutées. La demande de soie dans le monde, en particulier en ce qui concerne la qualité et le denier est loin d'être satisfaite. Dans ce contexte, comme vous êtes tous des experts et avez beaucoup d'expérience dans ce domaine, je m'en remets à vous et attends de vous des recommandations pratiques que nous pourrions tous mettre en application.

Mesdames et Messieurs, j'aimerais saisir cette occasion pour remercier le Comité thaïlandais de Promotion de la Soie de leur aide. Je remercie également la Commission Séricicole Internationale, la Faculté d'Agriculture de l'Université de Kasetsart, L'Institut de Recherche séricicole, la firme Jim Thompson Thai Silk Co., le Service des Affaires Economiques du Ministère des Affaires Etrangères et tous ceux qui ont rendu cette réunion possible.

En conclusion, je souhaite que ce congrès connaisse un grand succès et j'espère que vous passerez un bon séjour à Pattaya. J'espère que vous quitterez la Thaïlande en emportant de bons souvenirs.

A présent le temps est venu pour moi de déclarer le congrès ouvert.

Merci beaucoup.

REMISE DU PRIX PASTEUR

Son Excellence le Vice-Ministre de l'Industrie Korn Dabbaransi a remis les diplômes et médailles du Prix Pasteur attribué par le Comité Exécutif de la C.S.I. à :

Dr. M.N. NARASIMHANNA

Directeur du Projet national de grainage en Inde,
Co-auteur d'un traité pratique de sériciculture et du Manuel de sériciculture édité par l'O.A.A. et diffusé dans le monde entier.
Les différentes fonctions occupées par le Docteur NARASIMHANNA lui ont permis de connaître tous les aspects de la sériciculture : vers à soie mûrier et non-mûrier. Ses publications ont beaucoup contribué au développement de la sériciculture dans son propre pays et dans les pays à climats tropicaux.

Professeur Hiroshi DOIRA

Professeur à l'Institut de génétique du ver à soie, Université de Kyushu, Japon.
La carte chromosomique du Bombyx du mûrier que le Professeur DOIRA nous a fait l'honneur de publier dans SERICOLOGIA, est le fruit et le résumé de vingt ans de travaux à l'Institut de génétique du ver à soie. La localisation des gènes sur les chromosomes est la base de tout progrès génétique.

Dr. Masatoshi KOBAYASHI

Ancien Directeur Général de la Station expérimentale agricole de Chugoku, Japon,
Directeur Général de "The Lotte Central Laboratory Co."
Ses travaux fondamentaux, concernant l'étude des mécanismes hormonaux chez le ver à soie et en particulier des hormones juvéniles, ont trouvé une application pratique dans les techniques modernes d'élevage du ver à soie.

REMITTANCE OF PASTEUR AWARD

His Excellency Korn Dabbaransi, Deputy Minister of Industry, has remitted the Pasteur Award medal and diploma awarded by the Executive Committee of I.S.C to:

Dr. M.N. NARASIMHANNA

Director of the National Silkworm Seed Project, India,
Co-author of a Handbook on Practical Sericulture and of the Manual on Sericulture published by the F.A.O. and circulated all over the world.
The different offices held by Dr. NARASIMHANNA enabled him to have a thorough knowledge of sericulture: mulberry and non-mulberry silks. His publications have widely contributed to the development of sericulture in his own country and in the tropical countries.

Professor Hiroshi DOIRA

Professor at the Institute of Silkworm Genetics, University of Kyushu, Japan.
The chromosomal map of *Bombyx mori* Professor Doira honoured us to publish in SERICOLOGIA is the outcome of twenty years' research at the Institute of Silkworm Genetics. The location of genes on the chromosome is the basis for every progress in genetics.

Dr. Masatoshi KOBAYASHI

ex Director of the Chugotu Agricultural Experiment Station, Japan,
Director-General of the Lotte Central Laboratory Co.
His basic researches about the study of hormonal mechanisms in the silkworm, and in particular on juvenile hormones, found practical applications in modern techniques of silkworm rearing.

XVe CONGRES SERICICOLE INTERNATIONAL
XVth INTERNATIONAL SERICULTURAL CONGRESS

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SECTION MURIER
MULBERRY SESSION

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CHAIRMAN : Dr. Jorge K. WATANABE

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REPORT OF THE MULBERRY SESSION

The Mulberry session met at the Siam Ballroom A, at the Royal Cliff Beach Hotel, in Pattaya, Thailand, on 2nd March 1987, during the afternoon.

The session was presided over by Dr. Jorge K. Watanabe, who was indicated by the Brazilian Government, in acceptance of an invitation extended to Brazil by the International Sericulture Commission. Dr. Watanabe was assisted by Mr. Antonio Humberto Braga, First Secretary of the Brazilian Embassy in Bangkok, Thailand.

Seven papers were submitted to the Session, five of which were briefly presented to the participants by their respective authors. The five papers were the following:

a) Screening of mulberry plants for foliar diseases in the germ plasm bank, by Dr. G. Boraiah, from India;

b) Reversal of leaf senescence in different varieties of mulberry by GA₃ and kinetin, also by Dr. G. Boraiah;

c) Studies on the biological characteristics of mulberry blight strains (*Pseudomonas syringae*), by Dr. Du Heming, from the People's Republic of China;

d) Study on the mulberry resistance to the root rot disease, by Dr. Bhinai Hongthongdaeng, from Thailand;

e) Study on mulberry variety for silkworm rearing, by Drs. W. Sukcharoen and S. Akapanthu, both from Thailand.

These five papers have been presented by their respective authors and a stimulating number of questions were posed by the participants to the speakers. Therefore, discussions were very fruitful and helped to bring light on to the subjects under consideration.

Besides, the Session received two other papers:

a) Induction of mutations in mulberry variety 'Mysore Local' by gamma-irradiation, by Drs. V.C. Jayaramaiah and V. Munirajappa, from India;

b) Occurrence of a new stem-blight and collar rot diseases of mulberry from India, by Drs. B.R. Dayakar and J. Sukumar, both from India.

These two last papers, though submitted to the Session, were not discussed during the meeting.

There is no doubt that the discussions were very fruitful and undertaken in a very positive atmosphere. The President of the Session avails himself of this opportunity to recommend that the seven papers submitted to the Session be published by the I.S.C. Publication of the results of researches undertaken in the field of sericulture is a powerful means to stimulate further research, particularly in developing countries, where silk production has increased sharply. Moreover, research is the indispensable instrument for the quality improvement of the product generated in those areas.

SCREENING OF MULBERRY PLANTS FOR FOLIAR DISEASES IN THE GERM PLASM BANK

G. BORAIAH, M.P. SHREE and S.N. NARAYANA GOWDA

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Prasanna Kumar Block,
Bangalore 560 009,
India.

Indigenous varieties of mulberry (20) and also exotic ones (23) of the Germ Plasm Bank located at the Jnana Bharathi Campus, Bangalore University, were screened for the three major foliar diseases (powdery mildew caused by *Phyllactinia corylea*, leaf spot caused by *Cercospora moricola* and rust caused by *Aecidium mori*) from August 1985 to February 1986 (seven months). It was interesting to note that none of the 43 cultivars screened were affected by the powdery mildew pathogen. However, the percentage of leaf spot and rust infections varied depending on the variety. Most of the indigenous varieties (9) were significantly free from foliar diseases compared to the exotic ones. Incidence of rust was more severe than the leaf spot infection. Out of 43 cultivars screened, 30 were affected during the month of December 1985 by both rust and leaf spot diseases.

INTRODUCTION

There are many fungal pathogens attacking mulberry leaves. In Karnataka, powdery mildew, leaf spot and rust diseases are commonly seen and they take the highest toll. Powdery mildew caused by an ascomycetous fungus *Phyllactinia corylea* is more common during the rainy season (September to December) and leaf spot caused by deuteromycetous fungus *Cercospora moricola* also occurs during the months of June to November. Leaf rust caused by a basidiomycetous fungus *Aecidium mori* is common during winter season (November to January). These three foliar diseases are very well known to affect the quantity and quality of mulberry leaves drastically (Suryanarayan and Ganesh, 1969; Noamani *et al.*, 1970; Ramakrishna Kanti, 1975; Sitarama Iyengar, 1975; Siddaramaiah *et al.*, 1978; Sikdar and Krishnaswami, 1980 and Sastry, 1984). Hence,

an attempt was made during the rainy season and winter months to screen the mulberry plants of Germ Plasm Bank (both indigenous and exotic) for the above mentioned foliar diseases.

MATERIAL AND METHODS

Mulberry plants maintained at the Germ Plasm Bank, located at the Jnana Bharathi Campus, Bangalore University, were screened at monthly intervals over a period of seven months from August 1985 to February 1986 for three major foliar diseases. They are viz., powdery mildew caused by *Phyllactinia corylea*, leaf spot caused by *Cercospora moricola* and rust caused by *Aecidium mori*. Both indigenous and introduced (exotic) varieties were considered. The indigenous varieties are: Mysore Local, Kanva 2 or M5 Berhampore Local, Berhampore, Jakkur Local, Channa Paina Local, Connor series viz., C6, C10, C11, C14, C15, C18, CRR, Kajali, S54, S41, S36, MR2, Yenne Rangana Kaddi (YRK) and Hakkikalu (twenty in number).

The introduced varieties (exotic), sixteen in number and seven different species of *Morus* collected from Iriomote and Okinawa islands, Japan, are: Kosen, Tsukasaguwa, Goshierami, Philippine, Italian, Popua, Tai-song No.2 (= *Morus formosensis*), Tai-song No.3, Farmers' field, Thailand, Okinawa 1 and 2, Viet-nam, Haraban, Kurangi and Kairyo-nezumigaeshi. The seven species are: *M. alba*, *M. australis*, *M. cathayana*, *Morus lebang*, *M. macrocarpa*, *M. multicaulis* and *M. nigra*. On a particular day of every month (29th), the number of plants infected in each variety/species were counted and the percentage of infection was calculated.

RESULTS

Of the three major foliar diseases, powdery mildew was not at all seen on any of the varieties/species studied over the seven months (August 1985 to February 1986) although the same was seen to affect the popularly cultivated varieties - M5 and Mysore Local - grown elsewhere in and around Bangalore. Occurrence of leaf spot and rust was very common. However their percentage differed depending on the variety and also the month of study. Mixed infections of both the spot and rust were also seen on several varieties.

During the month of August 1985 (Fig. 1) only a few exotic plants (10) were affected by the spot and rust diseases. Leaf spot was severe on many of them (70 to 100%) while rust was severely seen on *M. nigra*, *M. australis* and Kurangi (75 to 90%). Viet-nam and *M. alba* were free from rust while *M. australis* was free from leaf spot disease.

Interestingly, all the 20 indigenous varieties and a few exotic ones (10) viz., Kosen, Tsukasaguwa, Philippine, Goshierami, Italian, Popua, Tai-song 2 and 3, *M. cathayana* and *M. multicaulis* were completely free from diseases.

In the month of September 1985 (Fig. 2) also, rust was severe compared to the leaf spot on only a few of the exotic varieties (12). Variety from the farmers field was adversely affected by both rust and leaf spot diseases (100% infection). Percentage of rust disease ranged from as low as 10 (*M. australis* and Kairyo-nezumigaeshi) to 80 in others.

Significantly, here also, all the 20 indigenous varieties and a few exotic ones (11) viz., Kosen, Tsukasaguwa, Philippine, Goshierami, Italian, Popua, Tai-song 2 and 3, Okinawa-1, *M. cathayana* and *M. lebang* were completely free from the attack of foliar pathogens.

During the month of October 1985 (Fig. 3) both rust and leaf spot were seen on a few (10) of the exotic varieties. Variety from the Farmer's field was attacked by both rust and leaf spot drastically (100%). Incidence of leaf spot was high on *M. macroura* and *M. australis* (80%). Percentage of rust infection varied from 25 to 75%. As in the previous months (August and September) here also, all the indigenous varieties and a few exotic ones (13) viz., Kosen, Tsukasaguwa, Philippine, Goshierami, Italian, Popua, Tai-song 2 and 3, *M. cathayana*, *M. lembang* and *M. multicaulis*, Viet-nam and Kairyo-nezumigaeshi were totally free from diseases.

In November 1985 (Fig. 4), unlike in the previous three months (August, September and October), four out of 20 indigenous varieties were slightly affected by diseases. They were the Coonoor series and among them, C11 and C18 were affected only from leaf spot disease. Twelve of the 23 exotic varieties were affected by both rust and leaf spot diseases (percentage of infection for both was 50). Variety from the Farmer's field remained susceptible for both the rust and leaf spot pathogens (100% infection). Incidence of leaf spot was high on *M. australis* (80%).

Except C11, C14, C15 and C18, all the other indigenous varieties and the following exotic ones (11) - Kosen, Philippine, Goshierami, Italian, Popua, Tai-song 2 and 3, Kairyo-nezumigaeshi, *M. lembang*, *M. multicaulis* and *M. cathayana* remained free from diseases.

During the month of December 1985 (Fig. 5) most of the indigenous varieties were affected by diseases although to a lesser degree (10 to 50%). Hakkikalu was affected only by the rust disease. Of the 23 exotic varieties, 14 were affected and leaf spot incidence was high on Okinawa-1 (100%) and *M. australis* (80%). Variety from the Farmer's field was susceptible for both the pathogens (100% infection). Thailand, Okinawa 1 and 2 and *M. macroura* were free from rust disease while Tai-song 2 and 3, *M. multicaulis* were free from leaf spot disease.

The following varieties (13) were completely free from the attack of diseases.- C18, S54, S36 and MR2 (indigenous), Kosen, Tsukasaguwa, Philippine, Italian, Popua, Viet-nam, Kairyo-nezumigaeshi, *M. lembang* and *M. cathayana* (exotic).

In January 1986 (Fig. 6), only a few exotic varieties (11) were affected by diseases. Rust was severely seen on *M. nigra*, Thailand and Okinawa 2 (80%). Farmer's field variety recorded high incidence of leaf spot (80%) compared to rust (10%). All the indigenous varieties (20) and a few exotic ones (11) viz., Kosen, Tsukasaguwa, Philippine, Goshierami, Italian, Popua, Kairyo-nezumigaeshi, Tai-song 2 and 3, *M. lembang* and *M. multicaulis* were free from diseases.

During the month of February 1986 (Fig. 7) leaf spot incidence was comparatively more severe than the rust, incidence of rust was high on *M. nigra* and Thailand (80%) while leaf spot infection was high (80%) on Farmer's field, Okinawa 1 and 2.

All the indigenous varieties and a few exotic ones (12) viz., Kosen, Tsukasaguwa, Philippine, Goshierami, Italian, Popua, Tai-song 2 and 3, *M. cathayana*, *M. lembang*, *M. multicaulis* and Kairyo-nezumigaeshi were completely free from the attack of pathogens.

Another interesting observation was that, exotic varieties namely Okinawa 1 and 2, *M. macroura* were found to be highly susceptible for leaf spot disease caused by *Cercospora moricola*. These plants were prone to infection after pruning i.e., the tender-medium leaves which develop fresh after pruning. The symptoms on the leaves were different from the typical symptoms in that here, several spherical yellowish spots appeared first on the dorsal surface of the leaf and later numerous small brownish necrotic specks were formed in the yellow patches unlike in the typical

symptoms where a yellow halo will be found surrounding a central dark brown spot. The presence of a halo is the characteristic feature of the leaf spot symptom.

Although the Indonesian species *M. lebang* and *M. cathayana* are known to be susceptible for diseases (Shikata *et al.*, 1985), here, they were significantly free from the diseases throughout the period of study. *M. cathayana* suffered leaf spot infection (50%) and rust (25%) only during the month of September 1985.

DISCUSSION

In general, the indigenous varieties remained almost free from the three major foliar diseases while quite many of the exotic varieties were consistently attacked by both the leaf spot and rust diseases. Rust was severe compared to the leaf spot disease. Of the seven months, during November and December, many of the varieties were affected by rust and leaf spot diseases to varying degrees, leaf spot was common during the month of August 85 and February 86. During the period of study (1985 August to 1986 February) powdery mildew disease was never recorded on any of the varieties (43) screened, although its presence was recorded elsewhere in and around Bangalore. Among the exotic varieties, Thailand, Farmer's field, Okinawa 1 and 2, *M. nigra*, *M. australis*, *M. alba*, Viet-nam, *M. macroura* and Kurangi were infected and seemed susceptible for both the rust and leaf spot diseases throughout the period of study. On the contrary, the three indigenous varieties (S54, S36 and MR2) and five exotic varieties viz., Kosen, Philippine, Italian, Papua and *M. lebang* remained resistant in not getting infected by any of the foliar diseases throughout the period of study.

ACKNOWLEDGEMENTS

We are grateful to the World Bank for financial assistance. Technical help rendered by Mrs. S.D. PADMA is acknowledged.

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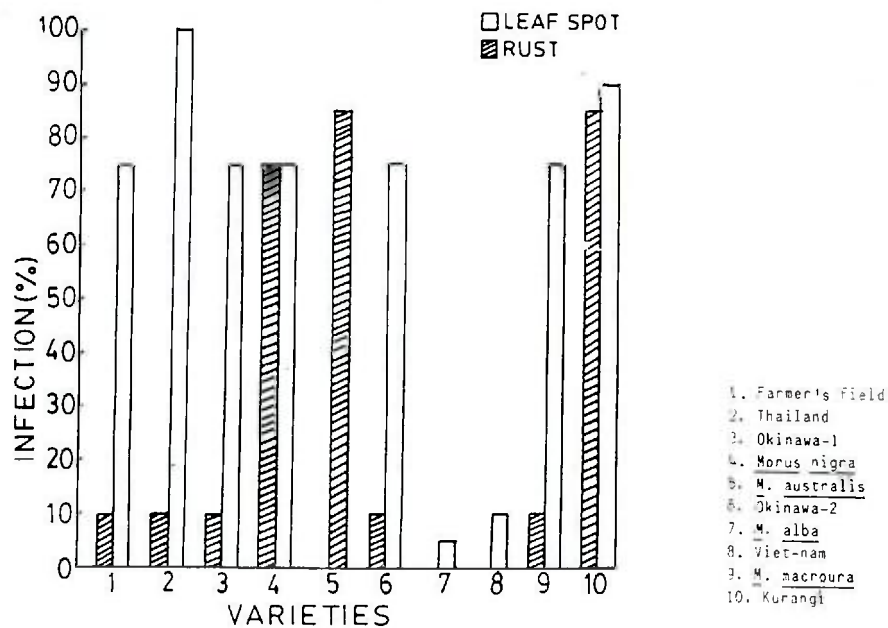


Fig. 1. Mulberry varieties showing infection (%) during the month of August 1985.

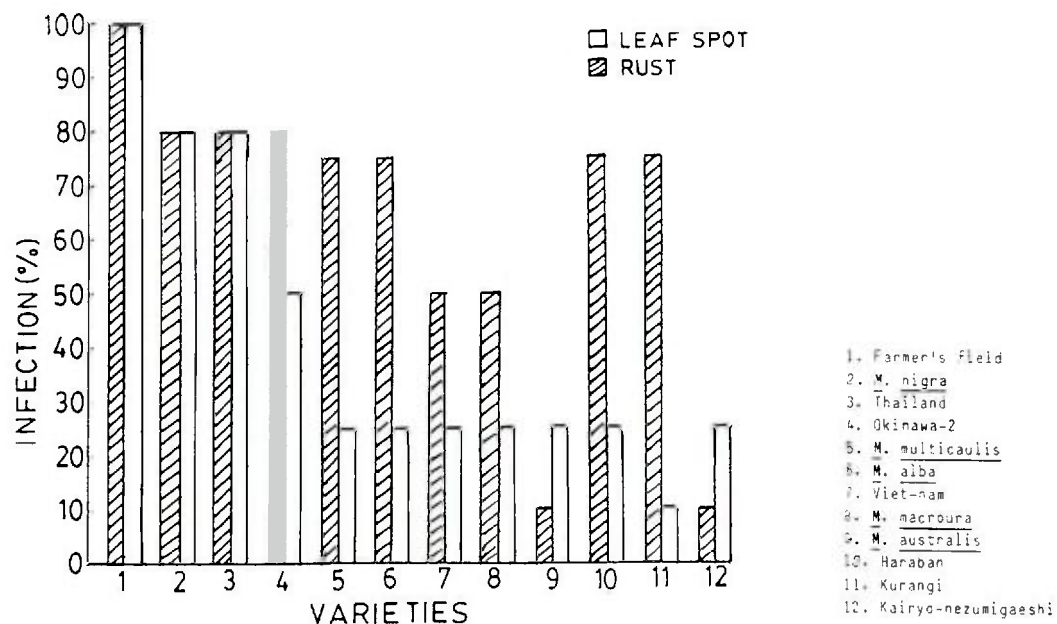


Fig. 2. Mulberry varieties showing infection (%) during the month of September 1985.

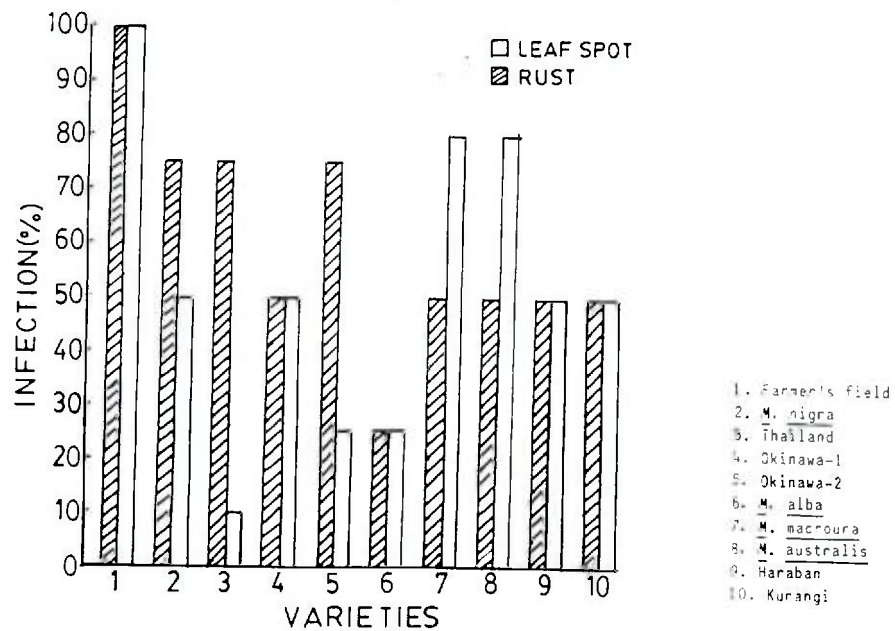


Fig. 3. Mulberry varieties showing infection (%) during the month of October 1985.

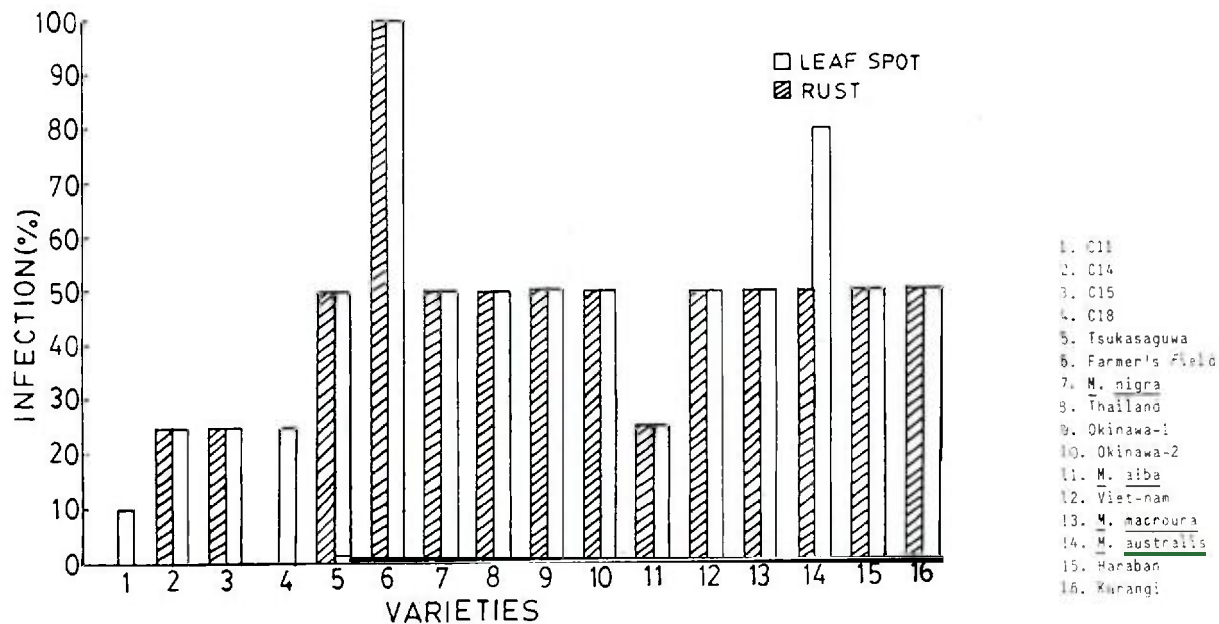


Fig. 4. Mulberry varieties showing infection (%) during the month of November 1985.

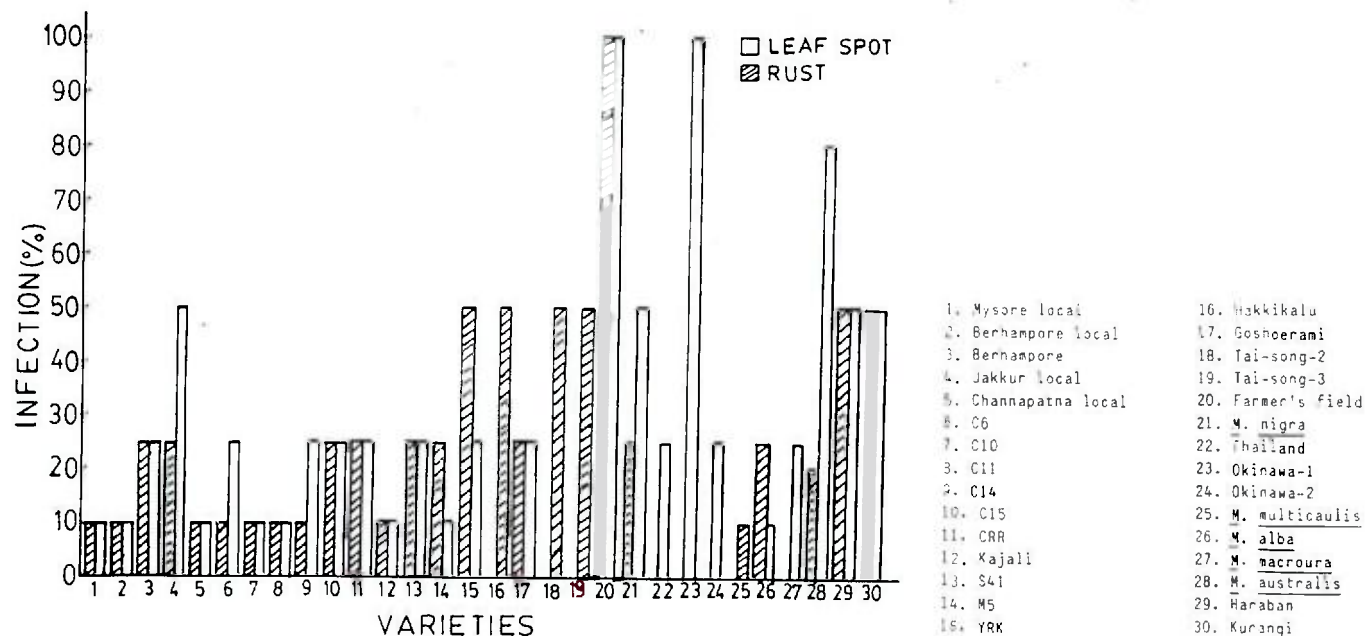


Fig. 5. Mulberry varieties showing infection (%) during the month of December 1985.

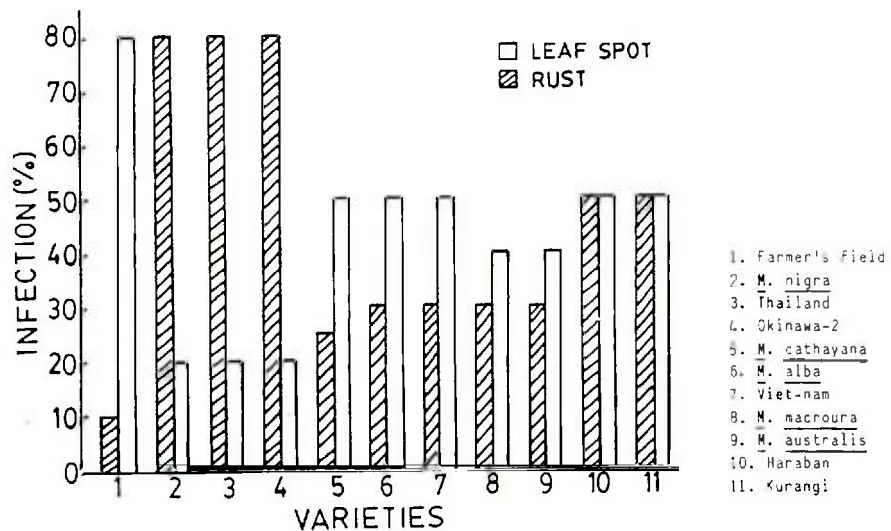


Fig. 5. Mulberry varieties showing infection (%) during the month of January 1986.

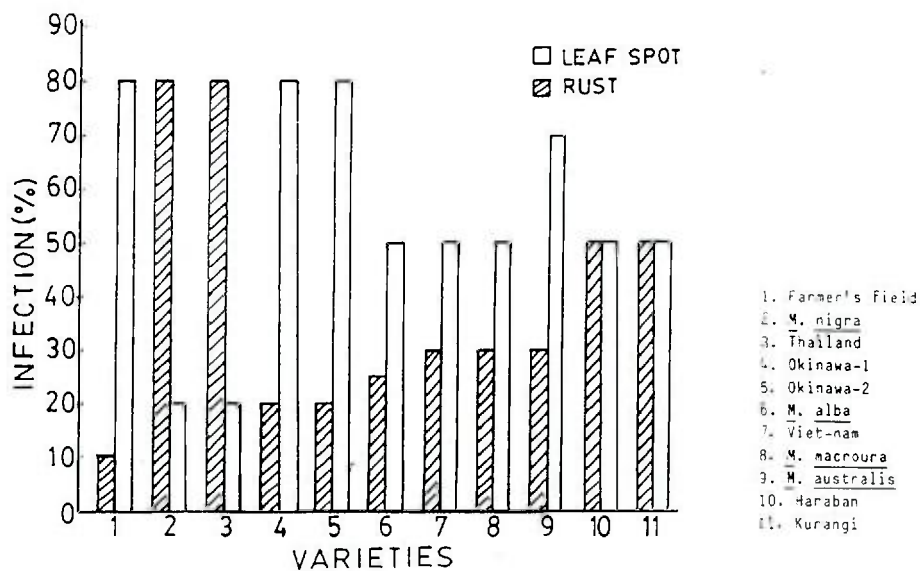


Fig. 7. Mulberry varieties showing infection (%) during the month of February 1986.

REVERSAL OF LEAF SENESCENCE IN DIFFERENT VARIETIES OF MULBERRY BY GA₃ AND KINETIN

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The kinetics of chlorophyll and protein degradation were examined in senescing leaf discs of four varieties of mulberry namely, M5, S54, Kajli and Kosen. Loss of chlorophyll proceeds at a slow rate for about 4 days followed by a period of logarithmic decline. Chlorophyll-b is degraded at a slightly faster rate than chlorophyll-a. Degradation of protein proceeds at a slow rate for about 6 days followed by a period of logarithmic decline. M5, S54 and Kajli showed similar pattern of chlorophyll and protein degradation and senesced completely in 14 days, whereas the Kosen retained chlorophyll upto the 19th day of incubation. GA₃ treated M5 mulberry leaf discs remained green upto 24 days of incubation in contrast to control which remained green for 14 days. Also GA₃ causes effective retention of chlorophyll and protein for several days. Cytokinin-Kinetin also brought about the retardation of senescence for several days but the effect was not as strong as that of GA₃.

INTRODUCTION

A large number of growth regulators are known to temporarily arrest the leaf senescence. As early as 1957, Richmond and Lang demonstrated the delayed senescence in *Xanthium* leaves by dipping the petiole in a solution of kinetin. Since then a number of growth regulators have been shown to have this effect. Fletcher and Osborne (1966) reported the effect of gibberelic acid in retarding the senescence in *Taraxacum* leaves. Subsequently, the effect of gibberellins in retarding the senescence is reported in several other species (Beevers and Guernsey, 1967 ; Beevers, 1966, Whyte & Luckwill, 1966). Kinins have a widest application in inhibiting the senescence in broccoli (Dedolph *et al.*, 1962) and bean leaves (Leonold and Kawase, 1964). However the hormone needed to retard senescence is not the same for all species, auxin will not retard leaf senescence in *Xanthium* (Osborne, 1965) and kinetin is ineffective when supplied to *Prunus* (Wollgiehn, 1961). Although it has been observed

that gibberellin delays autumnal yellowing in some deciduous trees (Brain *et al.*, 1959) and to some extent increases longevity of sugar beet (Humphries and French, 1965), so far no comparative studies have been carried out on among the different varieties of mulberry with regard to the response and its reversal or longevity with hormonal treatment. In the present investigation an attempt has been made to compare senescence in four varieties of mulberry.

MATERIALS AND METHODS

Mulberry leaves were obtained from the "Mulberry Germplasm Bank" of the university campus, Bangalore. Sixth leaf from the terminal bud was harvested in the early hours of the day. Leaves were washed in distilled water. Discs of 12 mm diameter were punched from the intervencinal regions of the leaf blade with a leaf disc borer, randomised and floated adaxial surface up on distilled water or on test solutions of 50 ppm Gibberellic acid and 30 ppm Kinetin in petriplates. Then the petriplates were incubated in a sterile BOD incubator at 27° C in dark.

Total chlorophyll and protein content were estimated by taking two leaf discs everyday starting from first day to the day the leaf discs turned completely yellow. Estimation of chlorophyll a & b was determined following the method of Wintermans and Demots (1965). Total protein content was determined as per coomassie blue dye binding protein quantitation method (Bradford, 1976). Data are expressed as the percentage of chlorophyll or protein initially present and remaining after incubation.

RESULTS

Excised leaf discs of mulberry supplied with water gradually turned yellow and there was a progressive fall in the levels of chlorophyll and protein within 14 days in mulberry varieties M-5, S-54 and Kajli whereas Kosen, an exotic variety remained green for 19 days (Fig. 1).

Generally the loss of total chlorophyll shows an initial lag phase during total chlorophyll decreases at a rate less than 5 % per day for about 5 days. Later chlorophyll loss proceeds at a rapid rate until more than 80 % of the initial amount is degraded (Fig. 1). The degradation of chlorophyll-a and chlorophyll-b follows a similar pattern except for a more rapid drop in chlorophyll-b during the initial lag phase and a less decrease in chlorophyll-b content (Fig. 2) towards the end of the period of chlorophyll loss.

The loss of total chlorophyll content in the Kosen mulberry variety also followed the same pattern until more than 80 % of the initial amount is degraded but showed very slow rate of chlorophyll loss during the end of the period.

Protein decomposition also follows a pattern similar to that of chlorophyll decomposition except for the protein loss during the rapid rate is not so extensive as in chlorophyll.

The effect of gibberellic acid and Kinetin on the leaf discs of M-5 mulberry variety is shown in Fig. 3. GA₃ treated leaf discs show maximum retention of chlorophyll for several days. Protein is also retained at higher levels than the control due to GA₃ and Kinetin treatment (Fig. 3).

Leaf discs of M-5 variety treated with GA₃ solution took 24 days to completely senesce in contrast to the leaf discs of the control which are floated on distilled water senesced in just 14 days.

The kinetin caused a substantial retardation of senescence but the effect is not as strong as that of GA_3 .

DISCUSSION

The chlorophyll and protein contents in the discs that received only water have fallen considerably below the original level, while in those treated with GA_3 this fall has been arrested, though not wholly prevented.

Degradation of chlorophyll and protein showed a parallel relationship in mulberry leaf discs left on water only. The decrease in chlorophyll content during initial phase may be due to the constant degradation which is not replenished by further chlorophyll synthesis. Chlorophyll-b disappears faster than chlorophyll-a during the senescence of mulberry leaf. This is a unique phenomenon when compared to general leaf senescence observed in other species (Wulf, 1956).

In mulberry leaf discs GA_3 is able to retard the senescence as observed in few other species (Fletcher and Osborne, 1965). The initial increase during the lag phase in the protein content in the M-5 mulberry leaf discs treated with GA_3 may be due to the stimulation of protein synthesis (Osborne, 1962). To establish whether GA retards the fall in protein level by preventing the break down of the already existing protein or by maintaining its synthesis. Work with C^{14} leucine by Fletcher and Osborne (1965) indicates a lower rate of protein synthesis after one day in the discs supplied only with water. Where as those receiving GA , the synthesis of protein is not only maintained but also showed enhancement. Their work also supports stimulation of RNA due to GA treatment.

It is interesting to note that different exotic and indigenous varieties of mulberry leaves tested showed varied lag phase in chlorophyll degradation. The exotic variety retained chlorophyll for a prolonged period compared to the indigenous varieties both when they are in water or GA_3 . GA_3 is able to retard senescence more effectively than Kinetin. It is known (Osborne, 1965) that different growth regulators retard senescence in leaves of different species of plants. The effectiveness of the individual compounds in retarding senescence depends upon the seasonal stage of development of the leaf (Osborne and Halloway, 1964), may be it is also in *Taraxacum* (Fletcher and Osborne, 1965). GA_3 retards leaf senescence at seasons but the effect is maximal in winter and spring. Indole 3 acetic acid, however when tested over a wide range of concentration during the spring was quite ineffective. It indicates a deficiency of endogenous gibberellins in the aging leaf which is linked to a decline in the ability of the cells to synthesize protein. The evidence presented by Fletcher and Osborne (1965) suggests that a major functioning of the gibberellin in retarding senescence lies in the regulation by the hormone of the DNA dependent synthesis of RNA. Comparison of endogenous hormone levels in exotic and indigenous varieties is in progress for better understanding of natural senescence.

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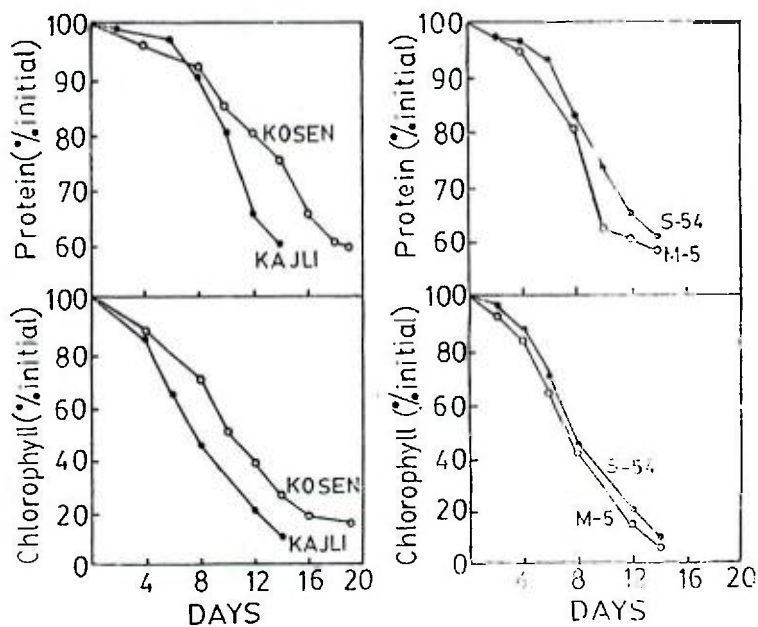


Fig. 1. Time course of senescence of four mulberry varieties namely Kajli, Kosen, S-54 and M-5 leaf discs on water.

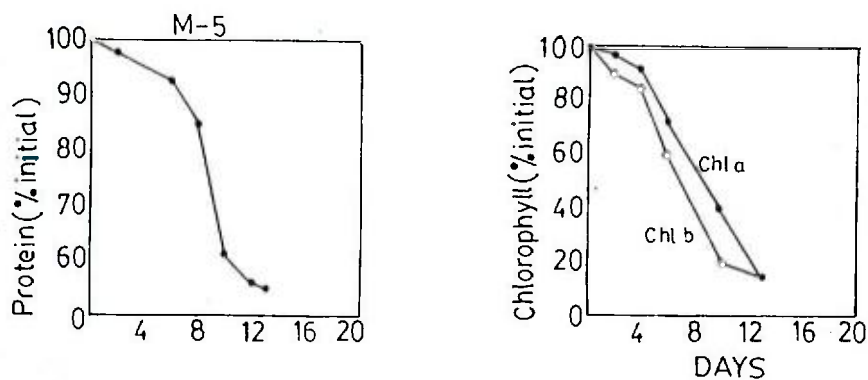


Fig. 2. Time course of senescence in leaf disc of mulberry variety M-5.
 Upper part of the graph, percentage loss of protein.
 Lower part, percentage loss of chlorophyll a & b.

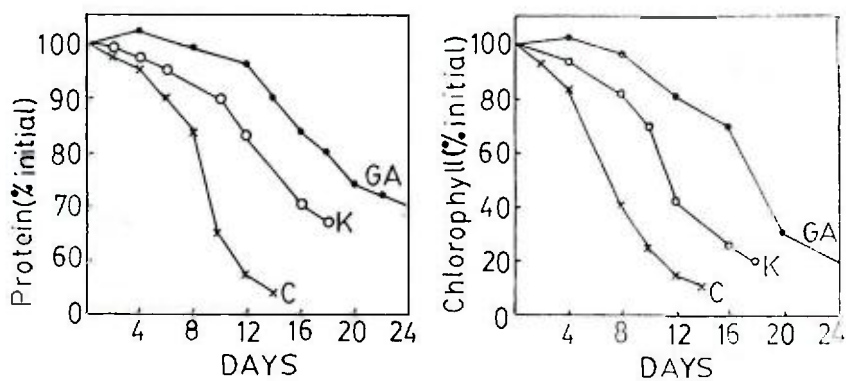


Fig. 3. Retardation of chlorophyll and protein loss in M5 mulberry leaf discs floated on GA and Kinetin solutions or water from day zero.

STUDIES ON THE BIOLOGICAL CHARACTERISTICS OF MULBERRY
BLIGHT STRAINS (PSEUDOMONAS SYRINGAE P.v. MORI)

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The mulberry blight is one of the destructive disease in China. The present paper describes the pathogenic types of the causal organism, serotype and characteristics of phages.

Two types of symptom of mulberry blight was found in Jiangsu and Zhejiang provinces in 1978 (Du H.M. *et al.*, 1979 ; Dai H.F. *et al.*, 1980). One of these is quite different from the typical mulberry blight described before. Results of repeated inoculation test showed that the mulberry blight can be differentiated into two strains according to those symptoms (Dai H.F., 1980). They are named respectively as black blight and leaf shrinkage blight.

The typed symptom of black blight strain is the angular leaf spot and black streak on the twigs, sometimes the branch diseased show the typed blackened symptom (Fig. 1). The typed symptom of the leaf shrinkage blight strain is blackening the leaf vein, consequently, the leaf crop up the downward roll symptom and canker on the twigs. (Fig. 2).

The time of occurrence of these two strains of mulberry blight were also different. The black blight was found to be prevalent from July to September, while the leaf shrinkage blight was more prevalent during May.

The growth of these two strains were different with utilization of xylose and in Cohn's medium (Du Heming *et al.*, 1984).

From the result of agglutination test, the serological reaction of those two types of causal organism were found to be different. In the agglutination absorption and two dimensional diffusion test, they were different serologically. According to specificity of O antigen the causal organisms of the black blight strain belongs to type I of serotype, and the mulberry shrunkage strain can be further differentiated into three serological types (Du H.M. *et al.*, 1984) (Table 1).

By using two dimensional diffusion tests, it is shown that the bacteria has a kind of heat-resisting and soluble antigen, and that antigen is proved to be a polysaccharide when being reacted with anthrone reagent. Thus, the O antigen mentioned above is a slime layer consisting of polysaccharide arounding to the somatic surface.

In an across agglutination test for quantitative by using the isolates suspension with flagella, the results show that these isolates have almost the same H antigen, but with certain differences (Table 2). In the case, according to H antigen, the bacteria could be classified into two groups (Du H.M. *et al.*, 1984), that is, group A and group B belonging respectively to the mulberry black strain and the mulberry shrunkage strain.

The different serological types described above provides the possibility to study the type of strains for dividing and the distribution prevailing and the control of the different type diseases.

In addition, 29 blight bacteriaophages of mulberry were isolated from diseased leaves and soil in different provinces. Plaque size could divide into three types, MMP1 is the largest, MMP11 is the smallest and MMP111 is the middle. They are different in their morphology and biological characters (Table 111). The neutralization test showed these bacteriaophages belong to these serological types. Phage MMP1, all parasitized in the black blight strain, reached 30 % of the total isolates. MMP11, mainly parasitized in the shrunkage blight strain, reached 60 % of the total isolates. MMP111 could parasitized both types and only one isolate.

These two types of phage could be divided into 6 lysotypes (a,b,c,d,e,f) according to test on 80 mulberry blight isolates.

They are also not sensitive to other 13 phyto bacteria species including *Pseudomonas* and other four genus.

Besides, bacteriaophage fluorescence antibody (Du H.M. *et al.*, 1983) and other serological methods were used in detection and diagnosis.

ACKNOWLEDGEMENTS

We thank Professor Fang Zhongda and Professor Du Niangxing of Nanjin Agricultural University and Associate Professor Zheng Shengyong of Suzhou Sericultural College for those instructions.

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Strain	Antigen	Serotype				
		I	II	III	IV	CK*
Black blight	M1-1	1280	- **	-	-	2560
Shrunkage leaf	M2-1	-	2560	-	-	5120
	M2-50	-	-	2560	-	5120
	M2-60	-	-	-	2560	5120

CK* means the control titer in homologous serum.

** means the agglutination test for quantitative is negative when anti-serum dilution is below 1/40, but each strain has some precipitate in atypical anti-serum 40-80 titer.

Table 1. The titer of the cross agglutination test after the antigen is heated.

Strain	Antigen	Serotype			
		I	II	III	IV
Black blight	M1-1 M1-3 M1-24	100			
Shrunken leaf	M2-1 M2-51 M2-11	25.5	100		
	M2-50 M2-52 M2-53	14.1	61.2	100	
		14.9	81.6	64.5	100

* $R = \sqrt{r_1 r_2} \times 100\%$ (r_1 = atypical valence 1/ homologous serum valence 1,
 r_2 = atypical serum valence 2/ homologous valence 2.)

Table II. The average R value (%) of bacteria type for four serotype by cross agglutination test.

Characters	Type		
	MMPI	MMPII	MMPIII
Plaque size	large 6.5 μ in diameter	middle 2.1 μ in diameter	small 1.4 in diameter
Morphology	head polyhedron, 70 nm in diameter. short tail	head polyhedron 60 nm in diameter short tail	Head polyhedron 56 nm in diameter straight long tail 110 nm.
Latent period	60 min.	90 min.	390 min.
Rising period	60 min.	90 min.	280 min.
Burst amount (average)	37	18	22
Optimum growth temperature	28° C	25° C	20 ° C

Table III. The biological characters of bacteriaophages of Mulberry Blight.

Fig. 1.



Fig. 2.



Fig. 1. The mulberry black leaf and branch diseased.

Fig. 2. The mulberry shrinkage leaf and branch diseased.

STUDY ON THE MULBERRY RESISTANCE TO THE ROOT ROT DISEASE

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Selection on the mulberry resistance to root rot disease from F1 hybrid of Ooshimaso, Kairyo Nezumigaeshi, Nezumigaeshi, Shujakuichi, M. multicaulis and Pai x Noi varieties. Resulted, the hybrid of Pai x Noi, no. 6, 18, 33 and 36 showed resistance to the root rot disease.

INTRODUCTION

The root rot is a very severe disease of mulberry in many of the sericultural regions in Thailand. In some districts it causes heavy loss on mulberry. The disease spreads very rapidly in a concentric way to the neighbouring plants and kills them in a short period of time. It frequently results in collective death of the plants in the field. In 1971, Mr. Sompark Siddhipongse found that Pai is resistant to the root rot disease and can be used as plant stock with grafting of Noi variety in order to increase the resistance to the root rot disease.

MATERIAL AND METHODS

Planting by seedling F1 hybrid of 6 mulberry varieties, i.e. Ooshimaso 144, Nezumigaeshi 150, Kairyo Nezumigaeshi 252, Shujakuichi 200, *M. multicaulis* 386, and Pai x Noi 108 trees. Spacing of 2 x 1 m. and planting under infected field condition of severe disease.

In the first time, selection on the survival trees which are not damaged by root rot.

In the second time, planting by direct cutting of the mulberry trees from first selection in the same area. Two replications are made, with spacing of 1.5 x 0.75 m. and planting of Noi variety as control. After that, selection of the mulberry varieties showing resistance to the root rot disease.

RESULTS AND DISCUSSION

1. F1 hybrid of Pai x Noi showed a high survival number of 46 trees (42.59%) while the other hybrids were totally damaged by root rot (100%) (Table I).

2. Out of 46 varieties planted in the same area, only 4 varieties showed resistance to root rot, i.e. No. 6, 18, 33 and 36 (Table II).

As a result, we have obtained 4 new hybrid varieties resistant to the root rot disease. Especially, No. 33 has good characteristics concerning leaf, root system, growth and yield.

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Varieties	No. of seedlings planted	No. of trees damaged by root rot	No. of survivals	Survival ratio (%)
M. multicaulis	396	396	-	-
Pai x Noi	108	62	46	42.59
Nezumigaeshi	150	150	-	-
Kairyo-Nezumigaeshi	252	252	-	-
Ooshimase	144	144	-	-
Shujakhichi	200	200	-	-
Total	1250	1204	46	

Table 1. Survey on the trees damaged by root-rot disease, April 1981 - April 1983 (in the first time)

% of trees damaged by root rot	Varieties - (No.)									
0	6	18	33	36						
1 - 10	26	35	40							
11 - 20	7	19	38	41						
21 - 30	9	24	32	34						
41 - 50	14	21	23	28	29	31	42	44	45	
50 - 100	1	2	4	5	12	13	16	17	20	
	25	39	46							
72 - 22	Noi (control)									

Table II. Percentage of hybrid (Pai x Noi) damaged by root-rot disease.

STUDY ON MULBERRY VARIETY FOR SILKWORM REARING

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There are many mulberry varieties such as Pai, Tark, Kaew-chonabod, Soi and Noi in Thailand, which one is appropriate to the bivoltine F1 hybrid must be solved.

INTRODUCTION

This experiment was carried out to know further the effect of mulberry varieties on the growth of silkworm and quality of cocoons in bivoltine F1 hybrid silkworm which are produced in our country.

MATERIAL AND METHOD

Silkworm race: K1 x K14

Mulberry variety supplied till the 5th stage:

Pai
Tark
Kaew-chonabod
Soi
Noi

Number of silkworms:

1 gm of newly hatched larvae/ replication for young stage
800 larvae (200 x 4 replications)/ treatment (variety) for old stage

Feeding time:

6.00 o'clock	30% of daily supplied leaves
11.00 o'clock	30% of daily supplied leaves
16.00 o'clock	40% of daily supplied leaves

RESULT

It may be summarized that Noi and Kaew-chonabod; Noi, Kaew-chonabod and Tark; Kaew-chonabod and Tark; and Noi showed better result in the respective rearing seasons of August, October, January and June.

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SV	df	Mean squares						
		Mounting number	Cocooning number	Sound cocoon number	Cocoon weight (g)	Whole cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell percent (%)
Replication	3	25.5166	53.4000	43.6000	108.3333	0.0004	0.3500	0.0858
Treatment	4	11.5500 ns	27.7000 ns	135.8000*	4314.3750**	0.0934**	26.7187**	0.6757*
Error	12	8.5166	18.4000	32.7666	101.0416	0.0006	0.4437	0.1320
CV %		1.5	2.2	3.2	3.7	1.6	2.1	1.8

Table I. Analysis of variance, August.

Treatment	Mounting number	Cocooning number	Sound cocoon number	Cocoon weight (g)	Whole cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell percent (%)
Pai	196 a	195 a	184 ab	248 c	1.41 d	29.5 c	20.9 ab
Tark	197 a	196 a	183 ab	270 b	1.53 c	32.1 b	21.0 a
Kaew Chonabod	198 a	197 a	188 a	306 a	1.66 b	33.6 a	20.2 b
Soi	194 a	191 a	176 b	228 c	1.36 c	28.8 c	21.0 a
Noi	194 a	192 a	174 b	296 a	1.72 a	34.8 a	20.2 b

Table II. Table of means, August.

SV	df	Mean squares						
		Mounting number	Cocooning number	Sound cocoon number	Cocoon weight (g)	Whole cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell percent (%)
Replication	3	5.3500	7.0000	337.1166	893.3333	0.0012	1.7378	0.1605
Treatment	4	15.7000 ns	10.2500 ns	128.3000 ns	3056.2500*	0.0360*	6.2220*	0.5607 ns
Error	12	41.9000	7.4166	73.3666	670.4166	0.0082	1.3420	0.2384
CV %		0.9	1.4	5.0	8.1	4.8	2.1	2.6

Table III. Analysis of variance, October.

Treatment	Mounting number	Cocooning number	Sound cocoon number	Cocoon weight (g)	Whole cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell percent (%)
Pai	109 a	198 a	168 a	301 ab	1.79 b	34.2 b	19.2 a
Tark	199 a	199 a	172 a	311 ab	1.93 ab	35.6 ab	18.5 a
Kaew Chonabod	199 a	199 a	178 a	356 a	2.00 a	36.5 a	18.2 a
Soi	198 a	196 a	162 a	285 b	1.80 b	34.0 b	18.9 a
Noi	197 a	196 a	170 a	362 ab	1.95 ab	36.8 a	18.8 a

Table IV. Table of means, October.

SV	df	Mean squares						
		Mounting number	Cocooning number	Sound cocoon number	Cocoon weight (g)	Whole cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell percent (%)
Replication	3	17.7833	14.3166	50.1833	191.6666	0.0075	3.8791	0.0538
Treatment	4	10.6750 ns	10.6750 ns	85.5500 ns	964.3750**	0.0276**	6.3625**	0.6107 ns
Error	12	13.7416	15.1083	46.5166	138.5416	0.0009	0.5041	0.2084
CV %		1.9	2.0	3.8	4.1	1.9	2.1	2.2

Table V. Analysis of variance, January.

Treatment	Mounting number	Cocooning number	Sound cocoon number	Cocoon weight (g)	Whole cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell percent (%)
Pai	194 a	194 a	170 a	271 bc	1.58 b	33.4 ab	21.1 a
Iark	197 a	196 a	181 a	296 ab	1.56 a	35.0 a	21.1 a
Kaew Chonabod	198 a	197 a	179 a	305 a	1.58 a	34.8 a	20.6 a
Soi	198 a	198 a	180 a	270 bc	1.48 c	32.3 b	21.8 a
Noi	198 a	198 a	182 a	280 b	1.53 bc	32.5 b	21.2 a

Table VI. Table of means, January.

INDUCTION OF MUTATIONS IN MULBERRY VARIETY 'MYSORE LOCAL'
BY GAMMA-IRRADIATION

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Hard wood cuttings of mulberry variety 'Mysore Local' were irradiated with Gamma-rays ranging from 1 KR to 10 KR. Certain biological parameters namely, survival percentage, sprouting ability, vigour of plant and cytological features were studied in R1 and R2 generations. The survival percentage ranged from 5 to 85% with different radiation doses. Higher dose (9 KR and 10 KR) produced semilethal effect to complete lethality. At R2 generation, a few mutants examined from the saplings irradiated with 5 KR to 7 KR revealed altered morphological features such as stunted growth, fasciation, deformed leaves, enlarged stipule, delayed flowering and leaves with yellow sector. At the same time certain meiotic anomalies viz., laggards, clumping of chromosomes, anaphase bridges, uni-, tri- and multivalents leading to polyspory were observed. The studies reveal that desirable mutants possessing shortened internode, thick leaf, dark green with opposite phyllotaxy were produced. The occurrence of opposite phyllotaxy in mulberry is a new character.

INTRODUCTION

Mulberry variety 'Mysore Local' (Moraceae) is a hardy plant commonly cultivated in dry districts of Karnataka State (India) for the purpose of silkworm rearing. Although it grows very well under minimum soil moisture conditions, its yield and nutritive quality are low and inferior. In this taxon due to the advantage of vegetative propagation and heterozygosity there is a great scope to induce variations through mutation breeding. Thus, in the present investigation an attempt has been made to raise mutants by using Gamma-ray radiation. Certain preliminary results due to the effect of Gamma-rays are presented here.

MATERIAL AND METHODS

Hard wood cuttings of mulberry variety 'Mysore Local' were selected from young and healthy bushes. Each cutting measuring 7-12 inches in length, $\frac{1}{2}$ inch in diameter bearing three vegetative buds was preferred. Cuttings were Gamma-irradiated in 10 different doses (1 KR to 10 KR) at the Indian Institute of Horticultural Research, Hesaragatta, Bangalore. In each dose 100 cuttings were used. The irradiated cuttings were planted directly in the field beds and maintained providing necessary agricultural inputs for their further response. Comparable controls were also maintained.

For studying the comparative effect of irradiation with different doses, the following parameters were considered: survival percentage, sprouting ability, vigour of plant and cytological features.

For meiotic studies young male catkins were fixed in acetic alcohol (1:3) and flower buds were squashed in 1.5% aceto-carmin stain.

RESULTS AND DISCUSSION

In recent years, mutation breeding has played a significant role in evolving new strains of crop plants especially for higher yield, resistance to diseases and pests (Manohar Rao and Reddy, 1983; Muntzing and Bose, 1969; Rao and Ayengar, 1965; Reddy and Reddy, 1972; Russel, 1978). Although selection and characterization of desirable traits in mulberry through the use of some mutagenic agents are reported (Hazama, 1968; Katagiri, 1970; Sastry *et al.*, 1974), the effect of Gamma-irradiation has not been tried on mulberry variety 'Mysore Local'.

In the present studies of the effect of Gamma-irradiation with different doses, varied response in respect of survival percentage, sprouting ability, vigour of plant and cytological features have been recorded. The survival percentage ranges from 5 to 85% with different radiation doses (Fig. 1). Cuttings treated with 1 KR to 7 KR sprouted earlier than control, whereas those treated with 8 KR exhibited delayed sprouting. On the other hand, higher doses (9 KR to 10 KR) produced semi-lethal effect to complete lethality. Further, saplings from 1 KR to 4 KR showed normal growth like control. However, their survival and sprouting ability were shown to be better at 3 KR. In general, plants recovered from lower doses revealed no appreciable morphological and cytological differences than the control.

Apart from the above the saplings irradiated with 5 KR to 7 KR showed certain morphological mutants, which include increased vigour in growth with greater number of branches. As against this, a few mutants have revealed significant change in morphological features such as stunted growth, fasciation, deformed leaves, enlarged stipule, delayed flowering and leaves with yellow sector (Fig. 2, 3 & 4). Cytologically these variants when compared to controls, displayed meiotic abnormalities namely, laggards, clumping of chromosomes, uni-, tri- and multivalents followed by polypory (Fig. 8 & 9).

A desirable mutant possessing shortened internode, thick leaf, dark green with opposite phyllotaxy has been recovered at R2 generation from the plants irradiated with 7 KR (Fig. 5, 6 & 7). Thus, the present study infers that doses between 5 KR to 7 KR are likely to prove useful in producing a spectrum of desired variations in mulberry variety 'Mysore Local'.

ACKNOWLEDGEMENTS

The authors are grateful to Prof. D.G. Krishnappa, Head, Department of Botany, Jnana Bharathi, Bangalore University, Bangalore for useful discussion.

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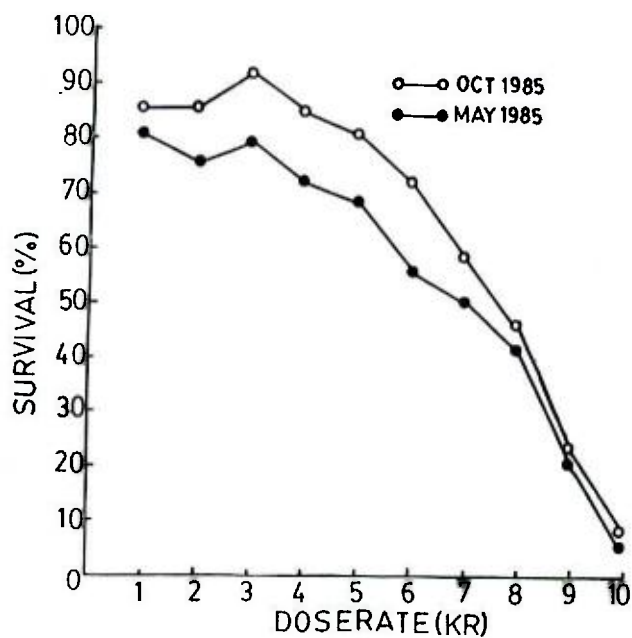


Figure 1. Graph showing range in survival percentage with different doses of Gamma-rays at R1 generation of mulberry variety 'Mysore Local'.

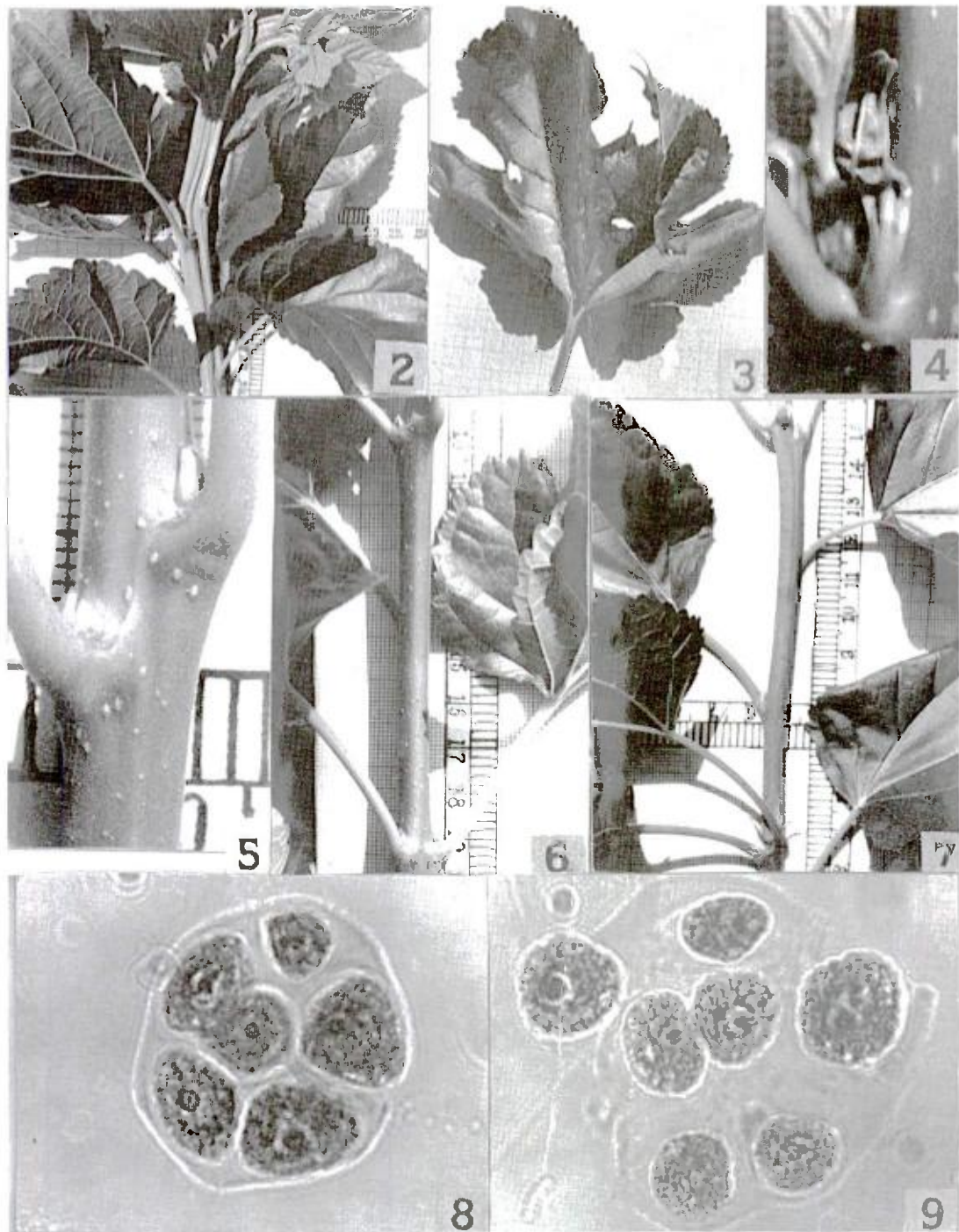


FIG. 2-9.

LEGEND TO THE FIGURES 2-9

Figures 2, 3 & 4. Morphological mutants showing fasciation, deformed leaf and enlarged stipule respectively.

Figures 5, 6 & 7. Mutants showing shortened internode and opposite phyllotaxy.

Figures 8 & 9. PMC's showing polysporic conditions.

OCURRENCE OF A NEW STEM BLIGHT AND COLLAR-ROT DISEASE OF MULBERRY FROM INDIA

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Two stem diseases of mulberry were recorded from Ootacamand and Bangalore (India). The pathogens were identified as *Phoma mororum* Sacc. and *Phoma exigua* Desm. *P. exigua* is recorded for the first time on mulberry from India. The disease symptoms caused by the two species were quite different. The isolation and pathogenicity tests proved that both the species are pathogenic to mulberry.

Key words : *Phoma*, collar-rot, stem-blight, mulberry.

INTRODUCTION

Species of *Phoma* have a wide geographical distribution causing diseases of many economically important plants (Wollenweber et al., 1936, Boerema et al., 1970, Kimura, 1979). Mulberry (*Morus alba* L.) is the chief source of food for silkworms (*Bombyx mori* L.). The plant is perennial and yields more than five harvests a year. During our routine epidemiological investigations, two diseases namely the collar-rot and stem-blight caused by *Phoma* spp. were noticed, and are described in the present communication.

MATERIALS AND METHODS

The pathogens were isolated on PDA medium from the infected stem portions following standard isolation techniques. The conidia were harvested in sterilized distilled water from a 10 day old culture and autolysed / smeared on healthy mulberry stems. Plants receiving sterilized distilled water alone served as control. The inoculated plants were covered by sterile polythene bags to ensure high humidity and to protect from external contamination.

RESULTS AND DISCUSSION

On the basis of morphology and cultural characters (Boerema, *et al.*, 1970, Boerema & Dorenbosch, 1973), the two species of *Phoma* were identified as *Phoma mororum* Sacc., and *Phoma exigua* Desm., and for the first time *P. exigua* is reported on *Morus alba* L. from India by us. The above materials have been deposited at Commonwealth mycological Institute (CMI), England, under IMI No 300 864 and 300 863 respectively.

The collar-rot disease caused by *P. mororum* Sacc. was observed during July to September 1985 on 12 % of the plants examined in the villages adjoining Bangalore. Disease symptoms appear in the form of brown to black discoloration of the stem near the ground level causing sudden withering of the leaves on affected branches. In the initial stages, a white mycelial mat was observed on the infection site which later bore sub-erupted pycnidia. The disease was found to be favoured by high soil moisture.

The stem-blight disease caused by *P. exigua* was observed on 18 % of the plants at Government silk Farm, Ootacamund during July to October 1985. The pathogen affects tender portions of the stem which becomes pale-brown and swollen followed by a split. The leaves wither and the stem usually breaks at the point of infection. Inside, the necrotic lesions are the radially arranged concentric rings of pycnidia.

On the artificially inoculated plants, typical light brown spots appeared on the stem portions which gradually increased in size. The plants receiving *P. mororum* developed infection spots on the 7th day leading to withering of the whole shoot. Plants receiving *P. exigua* developed symptoms on the 10th day after inoculation. In the initial stages, the stem started swelling at the infected region and in the next three days pycnidia were formed followed by the withering of shoot tips. Repeated isolations of the pathogen from such artificially inoculated plants yielded the original fungus used for inoculation. Studies on the binological and chemical control of the diseases are under progress.

ACKNOWLEDGEMENTS

The authors thank Dr. E. Punithalingam, Mycologist, C.M.I. England, for confirming the identity of the fungi and the Director, KSSDI for facilities.

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XVe CONGRES SERICICOLE INTERNATIONAL
XVth INTERNATIONAL SERICULTURAL CONGRESS

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SECTION ECONOMIE
ECONOMY SESSION

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PRESENTATION

by

Mr. W.M. BOOTH

International Silk Association,
Thailand.

The economy session is being truly economic. This morning we have two papers selected for oral presentation and three other papers which were selected for poster presentation.

Mr. Jong Sung Lim, the representative from the Food & Agricultural Organization of the United Nations asked me if there was going to be discussion on the potential in developing countries to establish, expand and diversify their exports of silk and silk products, thereby increasing national revenue and employment.

Unfortunately I have not received any articles on the subject of the marketing point of view regarding silk finished products. This is most sad for I understand that one of the main objects of the International Sericultural Commission is to encourage and promote the development and improvement on economic points of view of all activities dealing with sericulture in general. Surely sericulture should not and, in my opinion, cannot divorce itself from seri-selling.

Isn't it the goal or shouldn't the goal of all of us here be to produce something the customer will buy? Even the most esoteric research project must sooner or later find its place in the silk economy. If our work or research investigation does not have a place or value for the customer it is in danger of being consigned to a dusty shelf of unread publications. There must be a result oriented or customer oriented basis to all work. Whole work is of no use unless it is "bought" by a customer be that customer a scientist in the laboratory or a student in the classroom, a government official or a lady in the shop. In my business - the manufacturing and selling of silk - we try never to forget that the customer is King - the customer is our master - the giver of life to our business.

Turning to a more personal subject, I have been asked why our Thai company has found success in the silk business.

My answer is that at our company we have been able to have a particularly successful-happy marriage of design and quality.

Design or Quality - it is a bit like the old riddle of what comes first - the chicken or the egg. At our company we have been able to enjoy both chicken and egg on our plate at the same time.

The most attractive design is an ultimate failure if the quality in production is inferior. What good is beauty if it cannot be enjoyed in consumption.

A high quality of production does not make in itself silk of good design or beauty. The highest quality of silk warp and weft yarn does not necessarily make a saleable product. In my business, no one cares if the silk fabric lasts forever if it is not pleasing to the eye to begin with.

We have found that our customers while appreciating the fact that many hands and many hours are required to make a meter of Thai silk, that they do not buy our silk primarily for these reasons. If the customer is not excited by the look of our finished silk then we do not need to worry about the production quality - the customer will not buy it anyway.

So it is with sericulture, so it is with the International Sericultural Commission, so it is with all our work in silk.

We must all strive to produce something wanted by the customer, it is research or investigation on the technical or scientific points of view of sericulture, or development and improvement on the economics of sericulture. This is our duty as member of I.S.C.

I think the success of the silk economy in Thailand and in all the countries producing silk represented here today is because we have succeeded in producing something wanted by the customer.

PRESENTATION

by

Mrs. Payung Israngkun Na Ayuthaya
President of the Thai Silk Association

Silk is considered to be the noblest of all textile fibres, it is a natural material of high economic value which has limited production, totalling only in the thousands of tons relative to other natural textiles, such as wool, cotton, and to man-made fibres, which are measured in the hundred of thousands and even millions of tons. Production of silk, both at the sericultural stage and in the various stages of production, is labour intensive, needs low inputs of other energy resources, and constitutes an ecological, non-polluting material.

Mankind has always loved silk. It is a yarn of life, given to us by the unassuming caterpillar in a continuous filament. Silk provides much work in poor but labour-rich countries, and, let me say this, before machinery and technology override manpower labour and enslave us human beings, let us pamper these endearing, unassuming little creatures to let them live well on a high-living standard in return for their beautiful produce that science cannot yet imitate.

Early in the 1900s, the Thai (at the time Siamese) government instituted a programme designed to increase the Kingdom's silk production through the wide spread introduction of modern sericulture techniques. Substantial manpower and financial resources were committed to the programme, but the long term impact on the then Siam's silk output and on local sericulture method was negligible.

The sericulture programme in the first decade of the 1900s in order to reform the methods and techniques of a craft which has been practiced in Siam for over 1,000 years (This figure was taken from J.C. Barnet's Report of the First Annual Exhibition of Agriculture and Commerce held in Bangkok in April 1910). At that time silk production was almost invariably undertaken in peasant households, simply to meet its own requirement, though there was also a limited internal trade in silk.

I feel it most gratifying to mention that in Thailand, to-day as of long ago as when we were Thais living in Siam, the use of silk fabric has never been considered a fabric or material for a certain class of people. Here, silk is good for all and it is not a rare sight, if you go to silk provinces and find silk pasins, a wrap round used by women, and sarongs worn by men working in the field or going about their day routine. We love silk because it is beautiful and because it is durable

and we never thought of it as a merchandise for exports, until as you know, it was only after World War II that Thai silk travelled and became universally famed.

That's why, we Thais find the legend on history of "Silk Road" so romantic. We learned that the Silk Road connected two powerful civilizations: China and Rome, in culture and in commerce while in Siam it was domestic. Silk, then, had been an exchange for gold, wool, horses, jade, glass and what not.

Silk has been woven into luxurious tapestries, rugs, cloths, and accessories for some 4,000 years. It enriches religious traditions, and rituals. National costumes of nearly all nations, to-day and of old are made of silk fabric or silk accessories.

To-day, silk faces severe competition from synthetic fibres. Thus it is our effort now, and it is why we are here to discuss and find ways and means to struggle for survival. Research efforts are needed to overcome technical problems. During the last decades, silk markets have experienced the most rapid growth of consumption. To stimulate silk consumption and make silk more covetable, new technique breakthrough of silk industry, commencing with sericulture, mulberries and worms, these must be the key factors. Thus I bow to you honoured scientists in this field, to cultivate the best food, mulberry leaves or whatever it may be to please the "gourmet" standard of the silkworm so that they will be forever happy to produce for us the unimitable fibre, or be on strike as is so fashionable to-day.

THAI SILK

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Thai sericulture and silk weaving were integrative, being a cultural practice for many centuries in the north-eastern region of the country. Official survey reported an estimate of half a million farmers undertaking sericulture with an annual production of about 400 to 900 tons of polyvoltine raw silk from some 36,000 ha of mulberry fields.

Silkworms are of polyvoltine nature in the tropics and produce consecutive two to six crops throughout the year. The number of crops and quality of output mainly depend on the density of the rainfall. It is estimated that educated and technical qualified silk farmers can produce each as much as 25 kilos of raw silk a year whereas under-educated farmers may produce each as little as a few kilos for home-weaving.

Most silk farmers produce silk to weave traditional clothes for casual or ceremony clothing and sell the excess to farm brokers who trade to sell to provincial dealers or weaving houses for hand-weaving into fabrics for tourists and export markets.

Production is done in farmers households, thus creates direct self employment and presents itself a cash crop of selling the cloth or the raw silk. Reeling and weaving is done by hand. Thai silk hand-reeled yarn acquired uneven wavy appearance and greater loftiness in structure, constituting a heritage's unique of texture.

The country aims to develop rural household production to keep self-sufficient and considerable efforts have been made to improve productivity and area of mulberry plantation through substantial technical and financial inputs and foreign aids.

During the past 36 years Thai silk has acquired international reputation, therefore demand of native raw silk has ever since been increasing. It is expected that farmers households production becomes significant for development to double output to supply the tourists and export markets.

Sericulture in this country is labour intensive and itself is delicate in performance from human hands. Silk farmers make self reputation of industriousness and win public praising and compliments.

Importation of raw silk remains very important for handweavers. The country annually imports about 80 tons of high quality 2-3A grade thrown silk for warp and approximately 230 tons of tramed course silk for weft for weaving fabrics for tourists and export markets. Comparatively, the country silk farmers supply only about 200 tons of polyvoltine raw silk for the same purposes.

It is not difficult to see that sericulture can benefit the country only if production of polyvoltine raw silk is developed to increase its productivity to meet the requirements of the weaving houses when the general farmers will enjoy a greater production and income.

The history of sericulture in this country was not a matter of chance but belonged to a long history of laborious and creative bold campaigns of leaderships of manufacturing and marketing. Distinctive historical moments enlightened the sericulture of the country and led to its present development, which can be described as follows:

Eighty four years ago, His Majesty the King of Thailand (Rama VI), began a program of promotion for the production of sericulture and silk weaving with imported technology. The creativity has continued to the present existence of the agriculture promotion bureau, who continues its effort to develop sericulture in the country.

Thirty six years ago, Mr. Jim Thompson, an American who came to Thailand at the end of World War II, developed the primitive home of weaving of Thai silk into a designer's product and made Thai silk world famous which instituted the commercial demand of sericulture for export of handwoven silk fabrics.

Her Majesty the Queen Sirikit of Thailand has created an arts and crafts program for the Thai farmers to help the poor peasants to learn about and increase their production of raw silk and home weaving fabrics in order to provide a sub-income for the farmers of over half a million families. The program has greatly increased the public awareness of general applications of Thai silk fabric and uplifted the domestic consumption of silk fabric for national costumes.

In 1973, the Jim Thompson Thai Silk Company followed Mr. William M. Booth's new management and strategies and successfully entered into four phases of silk business: fabric printing, design studio, garment manufacturing, large scale quality hand weaving and intensive purchasing of silk from over 300,000 farmers. This vertical integration practically assures a significant increasing demand for sericulture expansion in the country.

Present export of handwoven silk fabrics and silk articles has gradually increased to about 300 millions bahts annually and there existed many hundred million bahts worth of tourists purchases from the local markets. Being a product of handicraft, it practically produces a high added value, mainly from direct labour costs and quality performances. It brings in foreign currencies and produce government revenues and eventually substituted a great number of luxurious imported fabrics.

Handwoven Thai silk gives a touch of natural silk fibroin and its brilliant colours and designs enhance the beauty of all textiles. Silk farmers, artists, craftsmen and handweavers are working every day to produce and transform the unlimited fibroin with their flawless techniques and diligence and bold imagination for all people who have money and taste.

Thai sericulture is the essence of national economy and its development.

SERICULTURE BASED CROPPING SYSTEM IN UGANDA

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INTRODUCTION

The climate of Uganda is an equatorial one, with two well-marked rainy seasons; the peak of the first rains usually occurs in April and May and of the second rains in September, October and November. Rainfall is low in June and only over the regions nearest the equator. But further north, its distribution tends to be unimodal with well-marked dry season. Most of the land area of Uganda receives on average between 750mm and 1250mm of rainfall. Mean temperatures are for the most part between 21 and 25°C. Climatic variations are therefore less-marked. These favourable climatic conditions make Uganda a comfortable home of a diverse wild sericigenous fauna and associated food flora, and sericulture a potential farming activity. Such fauna and flora are, however poorly documented.

Wild *Anaphe* silk was one of Uganda's exports in the 1940's. Despite the fact that *Bridelia* spp. on which the *Anaphe* spp. silkworms thrive are found growing abundantly all over the country with little attention, nests of *Anaphe infracta* Wals and *A. Moloneyi* Duce in substantial and exportable quantities were being collected from Kakumiro county in Mubende District only. This was because the then trading colonialists were speculating a decrease in silk demand and prices after World War II. They therefore tried to avoid wide scale investment. This project was completely abandoned after the war in favour of crops like coffee, tea, etc. that need less and unspecialized skill to exploit. Mulberry plantations were established but never utilised for silkworm rearing.

The government, in its efforts to utilize the untapped and bountiful resource and diversify its agricultural and industrial economy, urged the Research Division of the Ministry of Agriculture and Forestry to formulate a sericulture project in

1971. This was done and 2 ha of mulberry plantation were established each at Kawanda and Serere Research Stations for research purposes. *Bridelia* spp. plantations were established at Kawanda for investigations into systematic exploitation of *Anaphe* silk. However, due to lack of manpower, the project got stuck in 1975 after significant work had been done. It has since then been in abeyance with only maintenance work going on.

Active programmes have now started in 1986 and the project has been revised and enriched and aims at bringing about economic development of mulberry and non-mulberry silkworm food plants cultivation, silkworm rearing and general development of silk industry and its by-products in the country.

METHODOLOGY

Local and exotic mulberry and silkworm varieties are being collected to enrich our germplasm bank at Kawanda. Materials from other tropical and temperate countries are being evaluated for their performance under our conditions. Promising materials in respect of viability, yield, drought, disease and pest resistance will be selected and used in breeding programmes. Agronomical studies have commenced on fertilisation, irrigation, spacing and number of harvesting cycles per year for optimal productivity. Surveys into pest and pathological problems are being conducted with the object of identifying important pests and diseases in the sericulture industry in Uganda and schemes for their control will be drawn. Systematic exploitation of our indigenous wild silkworms will feature prominently in the project. Surveys aimed at identification, documentation and characterisation of the wild silkworms are being conducted. Some specimens have been collected but their identity is not yet confirmed. Similar work is being done for non-mulberry food plants. Processing methods of the wild silks will be investigated. Sericulture by-products utilisation and economics will soon start. Non-mulberry sericulture will be integrated into reforestation programmes.

We hope to accomplish all these because more people are being sent to sericulturally advanced countries for training. Possible assistance will be sought from external organisation for highly specialised areas as we train our own manpower. Strategies for the extension of the project to the farmer have been drawn. It is envisaged that we shall encounter few problems because some farmers have already approached government and private organizations for advisory service in silk production. Wild silks is a common knowledge to all farmers and what is needed is education, a price incentive and an organised market for the farmer to start collecting silk cocoons and nests to sell. Many farmers grow non-mulberry food plants such as *Bridelia* spp., *Ficus* spp., *Ricinus communis*, etc. in mixed stand with coffee, bananas, etc. either to provide shade or to act as wind breaks. Some unidentified silk cocoons have been found on *Ficus* spp. The bark of *Ficus* spp. is used in the making of bark-cloth which can be used as a bed cover in some parts of Uganda. Therefore, non-mulberry sericulture can be integrated into the traditional farming system with less difficulty. This, coupled with the excellent climate could lead to sericulture emerging as an important farming activity.

CONCLUSIONS

Uganda is a home of many wild silk producing fauna and diverse flora on which the fauna feeds. The climate and soils are also equally suitable for the growing of mulberry for the rearing of mulberry silkworms and work has already started. Other domesticated silkworms such as the eri silkworm can be reared. Sericulture will be

used to augment reforestation programmes for efficient utilisation of resources.

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ECONOMICS OF TROPICAL SERICULTURE : MICRO-PERSPECTIVES

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Mulberry cultivation and silkworm rearing are generally undertaken as an integrated activity by sericulturists in India. Any economic analysis of the structure of costs and returns of such an integrated activity not only reveals the extent of economic benefits derived by the sericulturists, but also provides insights into other micro-level problems which are both economic and non-economic in nature. The present paper is an exercise with two-fold objectives. Firstly, it attempts to delineate the extent of monetary and physical performance levels of sericulturists and secondly it views the entire spectrum of varying economic performance of sericulturists operating on different size-classes of mulberry holdings and also belonging to different regions. The data base for this exercise is drawn from four quarterly household surveys conducted during 1983-84 in the province of Karnataka in India which falls under the tropical mulberry belt. The findings of this exercise indicates that the extent of economic gains of sericulturist depends not only on the size of his mulberry holding but also the region to which he belongs. In other words, the paper reveals that the levels of economic performance of sericulturists are both land-specific and region-specific.

INTRODUCTION

The economic viability of any enterprise depends on the extent of optimum use of available resources. The extent of economic viability accomplished in a crop enterprise like that of mulberry cultivation followed by silkworm rearing in India depends on :

a) increasing the productivity of land due to adoption of improved mulberry varieties.

b) improved practices in silkworm rearing like opting for better and disease free layings, maintaining hygienic conditions for rearing, etc.

In spite of significant progress achieved in the productivity of land as well as in the silkworm rearing, the quality of Indian silk still remains at below the international standard. This means that there is tremendous scope to augment our research and development efforts in the field of sericulture. Before we contemplate on the possibilities of improving further the productivity levels, it would be necessary to probe into the current economic issues in sericulture, so that we can indentify the immediate problems of managing sericulture as an economic enterprise.

Parameters of economic viability :

To understand the economics of sericulture enterprise as carried out by households residing in different regions of Karnataka (India) and belonging to different size-classes of mulberry holdings (not total land holdings) we have examined a number of variables which focus on the structure of costs and returns.

We will be in a better position to understand the structure of costs and returns of a sericulture enterprise, if we take up itemwise costs of inputs and the returns by the size of mulberry area operated by different classes of farmers. We have worked out these details for the year 1983-1984. During this year, we conducted four quarterly household surveys (in Karnataka, India) to collect crop-wise cocoon production data. This has helped us to capture most of the transactions of the sericulturists.

The scheme of our presentation here is as follows. We shall take different size-classes of mulberry farmers and analyse the data on their cultivation and rearing expenditure and directly link it with the gross returns received by them (Tables I and II). At this stage, we may try to identify in each region those size-class / classes of farmers who benefited more by utilizing the available resources to their advantage vis-a-vis those who were operating at lower levels of profits.

After this identification at the first stage, where imputed costs are treated as part of the total operation, we move on to the next stage where imputed costs are separated out to see whether this would change the pattern of cash benefits accrued to different size classes of mulberry farmers (Table III).

Here, we are interested in identifying three sets of farmers as in the first stage viz. (a) those who were operating at a comfortable level of cash benefits, (b) those operating at marginal level, and (c) those showing the zero or negative levels. We believe that the groups identified in the first stage (Part I in Table I and II) need not necessarily be the right type of groups which we are looking for. Actually, the groups we are looking for to assess the varying level of benefits derived by the different size classes of sericulturists might be latent in our second stage identification (Part II in Table I and II). Further, in the second stage identification we are also accounting for the returns received from the byproducts generated by the sericulture activities. In other words, we are trying to identify in the first stage households which help us to find out how the volume of imputed cost can bring about a difference in the net benefits accrued to a sericulturist. In other words, the quantum of imputed cost would indicate the quantum of contribution particularly in terms of labour by the family's own human and other resources. By taking into account the imputed costs, we hope to draw a complete picture of the real (most in cash terms) and the notional (mostly by employing own resources in kind terms) benefits accrued to the sericulturists of various categories.

By 1983-1984, we find that rearing of improved variety (cross-breed) dfls was getting stabilised in all the regions of Karnataka. We also find that these rearings are undertaken on a variety of mulberry gardens. A detailed study of the structure of costs and returns of the improved dfls rearing will enable us to understand the extent of economic impact of sericulture activities on the rural households. For this purpose, we have disaggregated the data on costs and returns incurred on improved variety of dfls rearing undertaken on different varieties of mulberry gardens separately. While irrigated M₃ (IM₃) mulberry was cultivated in all the five regions of Karnataka, we noticed two more varieties viz. rainfed local (RFL) being cultivated in Region I and Irrigated local (IL) being cultivated in Regions II and III. Hence for purposes of presentation, we shall first present the RFL and IL data for regions I, II and III for different size classes and then take up the data on rearing of improved variety dfls with the help of IM gardens for all the regions. We attempt here to examine the data on costs and returns separately. As noted already, on the returns side, we are including the returns from by-products as well as returns from the sale of leaf (tables IV and V).

In other words, we have attempted to assess the extent benefit received by different size classes of sericulturists, firstly by computing the data on costs and returns in monetary (value) terms. We have done this by deducting the cash expenses on hired labour, hired bullocks, fertilizers, farm yard manure, etc. This has been done to derive the extent of returns accrued to the sericulturist households (Table I and II). Later on, we have taken certain indicators of performance and compared them in quantitative (physical) terms (Table IV and V). We did this in order to assess the extent of benefits derived by different size-classes of sericulturists in terms of brushings and cocoon yields.

When we look at the performance of sericulturists by size-class of their mulberry holdings, two sets of results emerge. The first set is based on the results obtained from the sericulturists cultivating local variety garden. By taking a look at the table on costs and returns for local variety garden by size classes, we find that cash returns accrued were positive for all the size classes. However, we find that the costs and returns varied widely across regions and across size classes of farmers. The level of returns accrued was comparatively lower in the case of 0.50-1.00 acre group in the rainfed region (I) than other classes and regions. In region III (irrigated area), we find consistently high level of returns for all the classes of sericulturists. But an interesting feature of Region III is that the sericulturists having holding size of 1.00 to 2.00 acres and 2.00 acres and above were able to derive much higher returns, which indicate the threshold area needed to achieve better returns. This is in spite of the fact that the percentage contribution of the family labour (as could be seen from the proportion of imputed cost) was much lower in these two size-classes. In the case of farmers belonging to the lower size-class in all the three regions, the extent of the contribution by the family labour and their own resources was more and the cash returns accrued were comparatively less.

This means that the sericulturists with more than 0.50 acre mulberry garden in Region III (irrigated) by and large has an edge over sericulturists of other regions. From the point of view of the levels of physical performances attained by the same set of farmers, the extent of returns accrued to them in terms of yields derived by rearing the improved variety dfls. Table IV shows that rearers belonging to 0.50-1.00 acre group in Region II and rearers in 1.00-2.00 acre and 2.00 acre + groups in Region III were in a position to derive more than 30 Kgs cocoon yield per 100 dfls which explained for the higher returns which we noticed in the earlier table. For local variety gardens, even achieving a yield level of more than 25 kgs of cocoons per 100 dfls itself can bring in sufficient returns for the household. If we juxtapose the extent of returns accrued with the cocoon yields per 100 dfls, we find a direct relationship between them. The difference between the total dfls brushed and the dfls harvested is normally accounted for the failure of crops. The failure rate

of crops does not seem to be alarming in the traditional region. This may be due to the resistance capacity of the local mulberry leaf and the silkworm to the local climatic conditions. The leaf cocoon ratio seems to be quite favourable for the local mulberry except for the 0.50 acre group in Region II. Leaf-cocoon ratio is a measure taken to identify the efficiency levels in rearing. The norm fixed in this regard is as follows : to derive a yield of one Kg of cocoons, the leaf used should be around 30 kgs. Anything less than this indicates efficient use of the leaf and anything more than this level indicates less efficient or inefficient use of the leaf.

CONCLUSION

Thus, while studying different economic parameters of sericulture enterprise, we have to keep in mind the relationship of productivity levels to the levels of efficiency achieved in the cultivation of mulberry and silkworm rearing. In this respect, a careful understanding of the performance of both the monetary and the physical indicators is essential. Based on the economic performance of different parameters, it will be possible to take suitable policy measures.

	Size Class & Regions*														
	< 0.50			0.50 -1.00			1.00 -2.00			2.00 +			All classes		
Parameters	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Part I: Costs															
Gross Cost	-	12719	9291	5632	9572	10236	6359	7803	10407	4233	6148	10307	4392	7711	103777
Imputed Cost	-	6410	4520	2557	4285	3092	3687	2522	2864	1689	1017	1409	1945	2385	2647
% of imputed Cost	-	50.0	49.0	45.0	45.0	30.0	58.0	32.0	26.0	40.0	17.0	14.0	44.0	31.0	26.0
Cash Expenses	-	6309	4771	3075	5287	7144	2672	5281	7543	2544	5131	8898	2447	5326	7730
Part II. Returns															
Sale of cocoons	-	9412	9902	4182	18280	11287	9484	9810	20455	8459	9150	26600	7580	10767	18762
By-Products (Imputed)	-	1750	1400	1797	1300	1300	1743	1100	1200	1859	700	1600	1855	1000	1400
Sale of leaf	-	1030	1600	-	360	1300	-	-	600	-	-	1000	-	200	1100
Total Returns	-	12192	12902	5979	19940	13887	11227	10910	22255	10318	9850	29200	9435	11967	21262
Cash Expenses	-	6309	4771	3075	5287	7144	2672	5281	7543	2544	5131	8898	2447	5326	7730
Returns accrued	-	5883	8131	2904	14653	6743	8555	5629	14712	7774	4719	20302	6988	6641	15532

Notes : 1. Region I : Rainfed Local Mulberry ; II: Irrigated Local Mulberry; III: Irrigated Local Mulberry.

2. Value is expressed in Indian rupees.

3. One hectar = 2.431 acres.

Table I. Cost and Return (per hectare of Rainfed and Irrigated local Mulberry garden) by size class and regions of Karnataka (India) for improved variety cross-breed Dfls.

(Value in Rs.) (Size class in acres**)

Size class & regions*	2.00 +					All size class				
	I	II	III	IV	V	I	II	III	IV	V
<u>Costs</u>										
Gross cost	9814	9238	10504	9686	10531	18509	13104	11480	11251	13151
Imputed cost	2246	1447	2310	1447	3417	5945	4180	3022	2902	4842
% imputed cost	23.0	16.0	22.0	15.0	33.0	32.0	32.0	26.0	26.0	37.0
Net cash expenses	7568	7791	8194	7014	12564	8924	8458	8458	8349	8309
<u>Returns</u>										
By sale of cocoons	22096	6487	19652	12286	17715	23308	14887	21620	16112	19017
By product (imputed)	1859	1600	20000	1625	1300	1855	1800	2200	1500	1525
By sale of leaf	2000	100	300	-	-	600	600	575	-	-
Total returns	22955	8187	21952	14307	19015	25763	17287	24395	17612	20442
Cash expenses	7568	7791	8194	7014	12564	8964	8458	8458	8349	8309
Returns accrued	18387	396	13758	6068	12001	13199	8363	15937	9263	12133

Table II. Cost and returns (per hectare of irrigated M₅ garden) by regions and size classes of farmers for improved variety Dfls.
(value in Rs.) (Size-class in acres)

Parameters	Size class & Regions*												
	< 0.50			0.50 to 1.00					1.00 to 2.00				
	I	II	III	I	II	III	IV	V	I	II	III	IV	V
<u>Costs</u>													
Gross cost	24068	21695	10109	23491	14607	11275	15459	20796	16911	10688	12888	10522	13991
Imputed cost	12298	11033	5090	7491	3370	3644	5127	9807	4251	3074	3882	2707	5064
% Imputed cost	51.0	51.0	50.0	32.0	23.0	32.0	33.0	47.0	25.0	29.0	30.0	26.0	36.0
Net cash expenses	11770	10662	5019	16000	11237	7631	10332	10989	12660	7614	9006	7815	8927
<u>Returns</u>													
By sale of cocoons	25243	7117	6495	24938	18630	18822	19622	18072	24877	16230	26135	16920	20097
By-product (imputed)	1854	2600	1500	1797	2000	1500	1750	1500	1743	1600	3000	1400	1525
By sale of leaf	-	3000	-	200	500	1200	-	-	-	-	2800	-	-
Total returns	27097	12717	7995	26935	21130	19522	21372	19592	26620	17830	31935	18320	21622
Cash expenses	11770	10662	5019	16000	11237	7631	10332	10989	12660	7614	9006	7815	8927
Returns accrued	15327	2055	2976	10935	9893	11891	11040	8583	13960	13290	12929	10909	12695

Table II. (to be continued)

Notes: (1) * Regions: Region I = Rainfed; Region II = Irrigated; Region III = Semi-irrigated;
Region IV = Inner non-traditional; Region V = Outer non-traditional.

(2) Value as in Table I.

Region Size-classes	I	II	III	IV	V
< 0.50	3029	-8978	-2114	-	-
0.50 - 1.00	3444	6523	8247	5913	-1204
1.00 - 2.00	9709	7142	19047	7798	7631
2.00 +	13141	-1051	11448	4621	8484
All Sizes	7254	4183	12915	6361	7291

Table III. Returns with imputed costs received by different size classes and regions for irrigated M₅ gardens with improved Dfls rearing.
(amount in Rupees)

Size Class & Regions		0.50			0.50-1.00			1.00-2.00			2.00 +			All Regions		
Parameters	I RFL *	II IL *	III RFL	I RFL	II IL	III IL	I RFL	II IL	III IL	I RFL	II IL	III IL	I RFL	II IL	III IL	
A. Total dfls brushed (per ha)	-	2572	1575	636	1890	1350	1105	1680	1637	888	1997	1790	834	1535	1582	
Total cocoon yield (Kgs per ha)	-	295	278	120	515	253	247	262	435	209	285	595	191	305	412	
Yield per 100 dfls (Kgs)	-	12	18	19	27	19	23	16	27	24	26	33	23	20	26	
Leaf-cocoon ratio	-	60	40	35	26	40	35	41	23	25	24	24	27	32	27	
B. Total dfls harvested (per ha)	-	1826	1386	464	1588	1066	928	974	1457	790	1097	1790	725	1121	1408	
% of harvested Dfls to Total Dfls	-	71	88	73	84	79	84	58	89	89	100	100	87	73	89	
Yield per 100 dfls (harvested) (Kgs)	-	16	20	26	32	24	27	27	30	26	26	33	26	27	29	

Notes : RFL* - Rainfed local Mulberry leaf
 IL* - Irrigated local Mulberry leaf
 Regions- As given in Table I.

Table IV . Physical Indicators of Performance for improved Variety Dfls on Rainfed and Irrigated local mulberry gardens by size class and regions.

Items (per ha)	Size classes & Regions*												
	< 0.50			0.50 to 1.00					1.00 to 2.00				
	I	II	III	I	II	III	IV	V	I	II	III	IV	V
A. Total Dfls brushed	3388	3655	1487	3179	2695	1762	2265	2142	2165	2095	2827	1985	2080
Total cocoon yield	717	220	185	663	460	412	522	457	262	425	600	457	532
Yield per 100 Dfls	21	6	12	21	17	23	23	21	12	20	21	23	26
Leaf-cocoon ratio	32	121	69	33	44	29	34	32	41	37	34	31	28
B. Total Dfls harvested	2677	1279	1190	2861	1994	1586	2174	2142	1710	2095	1375	1945	1945
% of harvested to total Dfls	79	34	80	90	74	90	96	100	79	100	84	98	94
Yield per 100 Dfls (harvested) (kgs)	27	17	16	23	23	26	24	21	15	20	25	24	27

Notes : As in Table I.

Items (per ha)	Size classes & Regions*									
	2.00 -					All regions				
	I	II	III	IV	V	I	II	III	IV	V
A. Total Dfls brushed	2390	1790	2367	2245	1677	2702	2487	2447	2100	1917
Total cocoon yield	570	595	450	330	457	647	382	500	430	497
Yield per 100 Dfls (kgs)	24	33	19	15	27	24	15	20	20	26
Leaf cocoon ratio	24	95	37	49	28	30	49	37	36	29
B. Total Dfls harvested	2390	1258	2285	1863	1677	2324	1791	2178	1953	1859
% of harvested to total Dfls	100	54	97	83	100	86	72	89	93	97
Yield per 100 Dfls harvested (kgs)	24	47	20	18	27	28	21	23	22	27

Table V. Physical indicators of performance for improved (CB) Dfls on irrigated M₅ garden (size class in acres).

SPATIAL INTEGRATION OF AND PRICE LEADERSHIP IN SILK COCOON MARKETS OF KARNATAKA (INDIA)

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INTRODUCTION

India has the unique distinction of being the only country in the world producing all the commercially known varieties of silk viz., mulberry, tasar, eri and muga, and ranks third among the mulberry silk producing countries, accounting for more than 8 per cent of the total world production. The share of the state of Karnataka in total mulberry silk production is as high as 70 per cent. Karnataka has experienced the silk revolution in addition to the 'green revolution' in farming and 'white revolution' in live stock farming.

The sericulture enterprise comprises three distinct activities viz., moriculture, silkworm rearing and finally the silk extraction. The development in this sphere started phase by phase. First, the cultivation of mulberry was localised in a few districts of the state viz., Kolar, Mandya and Mysore. After the seventies, the area under cultivation grew at a rapid rate and cultivation and rearing, which were confined to the traditional areas, spread to the warmer rainfed regions, throughout the state. Consequent upon this, in order to handle the large quantity of cocoons that came to the market, the Government of Karnataka established several regulated cocoon markets in the state. In spite of regulated markets being established in each district, the producers still prefer to bring the cocoons to the six predominant cocoon markets. These markets play an important role in the development of the sericulture industry by ensuring remunerative prices to the producers.

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In order to ensure that the farmers get a fair share in the consumer rupee, it is necessary that these markets be efficient. Hence in analysing the pricing efficiency in spatially dispersed markets two hypotheses have to be tested.

1. The hypothesis of association or integration.
2. The hypothesis of price leadership.

In this study an attempt has been made to examine the integration of the principal silk cocoon markets in Karnataka state, by subjecting these two hypotheses to appropriate empirical tests. The six markets studied constitute the principal 'A' class markets of Karnataka. Ramanagaram is the leading market in the state and this is also the largest in the country. Silk cocoons from all over the state and also from the neighbouring states, Tamil Nadu and Andhra Pradesh are traded here. Ramanagaram has emerged as the leading market for two main reasons. One, by virtue of its location, which is accessible by both rail and road, and second because of the large number of reelers present in the town, which increases the competition and ensures a fair price to the producer. In all the markets, barring Kollegal, a mixture of multivoltine and bivoltine cocoons are traded. The most popular race being Mys x NB4D2. In Kollegal however, multivoltine race (Pure Mysore x C-nitchi) is traded almost exclusively.

METHODOLOGY

Keeping the objectives of the study in view, the methods of analysis are proposed.

The static and dynamic price equilibrium models assert that the price collapses on equilibrium by arbitrage through price differences between markets. Once spatial equilibrium is attained, prices in each market reflect the price information from other markets also. Given this definition of price efficiency in geographically dispersed markets, Gupta and Mueller (1982) identified three cases.

Case I:

Interdependence or feed back; each market employs equivalent information from the other markets in forming price expectation such that, a feed back relationship exists between them. This feed back can be instantaneous in nature. In this case information from one market cannot be profitably exploited by the other market and thus the markets are spatially price efficient.

Case II:

Independence; when no market uses information from any other, the markets are independent. Independence is possible when the transportation costs are prohibitively high between markets, thereby preventing trade.

Case III:

Causation; one market uses information from the other market in the price formation process, whereas the other market does not use the corresponding information, such being the case a lead or lag relationship between the prices of the two markets will be observed providing for profits through arbitrage trade.

In order to go in for the tests of dependence, independence and causation, we have to prefilter the series to remove the time series component. For this, the trend in

the series is estimated by a polynomial equation :

$$Y = a + b_1t + b_2t^2$$

Where:

Y = the price

t = time trend

a, b_1 and b_2 are the regression coefficients.

The seasonal index is captured by the ratio-to-trend method.

Principal component analysis is suggested as a practical tool of separating the variation of a matrix with orthogonal subsets. In each component the dominant sets of variables can be identified by the magnitudes of their coefficients.

In the present study the Haugh's test has been employed to examine the dependence of various silk cocoon markets on the Ramanagaram market prices, the latter being the dominant market in the state. For this purpose Granger's causality concept is employed. The Haugh's test is used in analysing the relationship between two variables. It is based on the sample cross correlation coefficient of "innovations" of two series. The innovations of time series data refer to that part, which cannot be explained by its own past. In other words, it is the residual time series after the other components are removed. Data pertained to the period Jan. 1980-81 to December 1985-86, a period encompassing 60 months. Monthwise data was used since weekly data was not uniformly available for all the markets under study.

RESULTS AND DISCUSSION

Time series analysis was carried out on the various price series to understand the inherent variations in them. These are quantified and removed and the resultant series that emerged was a "white noise". The white noise series is subsequently subject to the Haugh's test to understand the dependence between the market prices.

The trends in prices are presented in Table I. The intercept indicates that the average levels of prices are relatively higher in the Sidlagatta, Ramanagar and Vijayapura, where it was Rs. 40.8, Rs. 39.92 and Rs. 39.78, respectively. The acceleration in prices denoted by the b_1 coefficients was highest in these markets as well. In Kollegal the intercept was very low at 30.94 which increased by only Rs. 1.86 per period. However, the deceleration coefficient at Kollegal was lower vis-à-vis the other four markets.

The seasonal indices of prices are presented in Table II. The table reveals the high seasonal index during the months, Dec., Jan., Feb. and March which decreases thereafter and reaches a minimum during July. This general trend was observed in all the markets of the study. Despite the variation in the seasonal indices, the prices were by and large stable within the year with the value of index ranging between 92 and 115. The variation in prices is a supply phenomenon (Chinnappa *et al.*, 1986).

In this study, principal component analysis is used as an aid to understand the nature of the fluctuations present in the price of silk cocoons in important markets of the state.

The correlation matrices for the prices of the six major markets are presented in Table III. An examination of these matrices reveals a higher degree of association between the price of cocoons in all the markets. However, the degree of association

between the cocoon prices at Kollegal and the other markets is relatively low. Principal component analysis was carried out on the correlation matrix and the results are presented in Table IV.

The first principal component would thus be

$$C_{it} = 0.9910 P_R + 0.9722 P_V + 0.9491 P_{KAN} + 0.5106 P_{KOL} + 0.9857 P_{SID} + 0.9687 P_{KLR}$$

This component has expanded to 83.31 per cent of the total variation of the correlation matrix. It is evident that prices generally move together very closely from month to month. If supply or demand affects the price at one market, it will have a similar effect on the prices of all other markets except Kollegal, which is not a part of the first group.

The second principal component was

$$C_{it} = 0.1065 P_R + 0.0718 P_V + 0.0737 P_{KAN} - 0.8598 P_{KOL} + 0.1195 P_{SID} + 0.0785 P_{KLR}$$

This component has accounted for 13.03% of the variation. In this component the price coefficient at Kollegal has emerged as the dominant variable but with a negative sign. This implies that Kollegal prices are independent of the fluctuations in prices captured by the first component and there is a faint tendency to move in the opposite direction. Examination of the principal component shows that five out of the six market prices move closely together and prices at the Ramanagaram market would serve as a perfect index for all these five prices series. The prices at Kollegal are independent of the other prices. This presents the possibility of the Kollegal prices exhibiting a lagged response to the prices in other markets. But it cannot be categorically stated without empirical evidence. This implies that the above mentioned five silk cocoon markets are integrated.

The cross-correlations of the "innovations" of the Ramanagar prices with the other markets are presented in Table V. The null hypothesis of independence of the cross correlation coefficients being 0, is tested through the Box Pierce test. In all the cases the calculated X^2 value is greater than the table X^2 value. Thus, it could be concluded that there is interdependence between the spatially separated markets.

Added to this the strong correlation at lag 0, compared to the other coefficients at leads and lags drop to zero, implies that the correlation is spontaneous. Though further confirmation regarding the direction of causality needs to be obtained through other tests such as Sims test. We can generalise that in Vijayapura, Kanakapura, Sidlagatta and Kolar, hypothesis II holds. In Kollegal however, though the null hypothesis is rejected, the cross-correlation function is very low at lag 0, at -0.23, indicating a weak degree of spontaneity. There is a stronger association between Ramangar prices lagged by one period and Kollegal prices indicating a degree of lagged response which was also observed in principal component analysis.

SUMMARY AND CONCLUSION

From the foregoing analysis it could be abstracted that Ramanagar, Vijayapura, Kanapura, Sidlagatta and Kolar market prices were relatively higher than the prices at Kollegal. The pattern of behaviour of prices during the year was more or less similar in all the markets, with relatively higher prices during December-March and lower prices around July-August, this phenomenon could be attributed to supply variations.

The prices of all the markets except Kollegal are highly associated. This was revealed by principal component analysis. The prices of Kollegal formed the lone item in the second principal component indicating the independence of this price series. Haugh's tests confirmed the results of the principal components analysis, which was done to study the dependence of the various market prices on the price of the dominant market, Ramanagarm. The Haugh's test revealed high degree of inter-dependence of all the market prices with the Ramanagarm prices. Though the test revealed that Kollegal prices in general were interdependent with the Ramanagarm prices, the association was not very strong. The Kollegal market prices did not exhibit the extent of dependence with the Ramanagarm market prices as the other market prices did. This is mainly because the multivoltine race is popular in this market. The price of this race of cocoons is also lower as revealed by the trend analysis. Despite the lower price received the farmers in the Kollegal region continue to raise the same race by the dictates of their tradition which apparently is overwhelming. The emphasis of these producers is on cost minimization. There is a captive demand in Kollegal market from the handloom sector, since the multivoltine cocoons are best suited for "charkas" or the spinning wheel. The results vindicate the hypothesis of interdependence, but the second condition for efficiency viz., the absence of causation needs to be empirically tested. Thus, the silk cocoon markets in Karnataka may be said to be spatially integrated and thereby price efficient.

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Markets	a	b ₁	b ₂
Ramanagara	39.92	3.82	-1.114
Vijayapura	39.78	3.46	-1.11
Kanakapura	38.11	3.13	-0.989
Kollegal	30.94	1.86	-0.0482
Sidlaghatta	40.80	3.89	-1.19
Kolar	39.29	3.67	-1.05

Table I. Trends in prices.

Month	Ramanagara	Vijayapura	Kanakapura	Kollegal	Sidlagatta	Kolar
January	114.98	116.37	119.93	105.66	112.57	113.57
February	115.14	113.59	112.08	106.31	111.32	110.68
March	102.91	101.83	109.33	96.63	100.78	103.45
April	93.55	92.68	97.35	95.1	91.33	93.92
May	101.03	100.62	96.84	96.1	101.44	100.97
June	96.66	96.4	91.02	94.05	97.03	99.24
July	92.76	94.37	88.47	96.51	94.63	93.02
August	91.77	94.1	88.65	100.37	94.71	94.42
September	97.5	98.38	98.26	102.48	98.63	98.85
October	99.06	98.46	100.26	101.2	100.0	101.28
November	92.4	93.04	95.09	102.5	94.4	93.25
December	102.22	102.22	102.72	103.09	103.15	97.36

Table II. Seasonal variation of prices.

	Ramanagar	Vijayapura	Kanakapura	Kollegal	Sidlagatta	Kolar
Ramanagar	1	-0.982	0.9307	0.4143	0.9819	0.952
Vijayapura		1	0.9101	0.4354	0.9828	0.8866
Kanakapura			1	0.4189	0.9069	0.9085
Kollegal				1	0.4010	0.4285
Sidlagatta					1	0.9783
Kolar						1

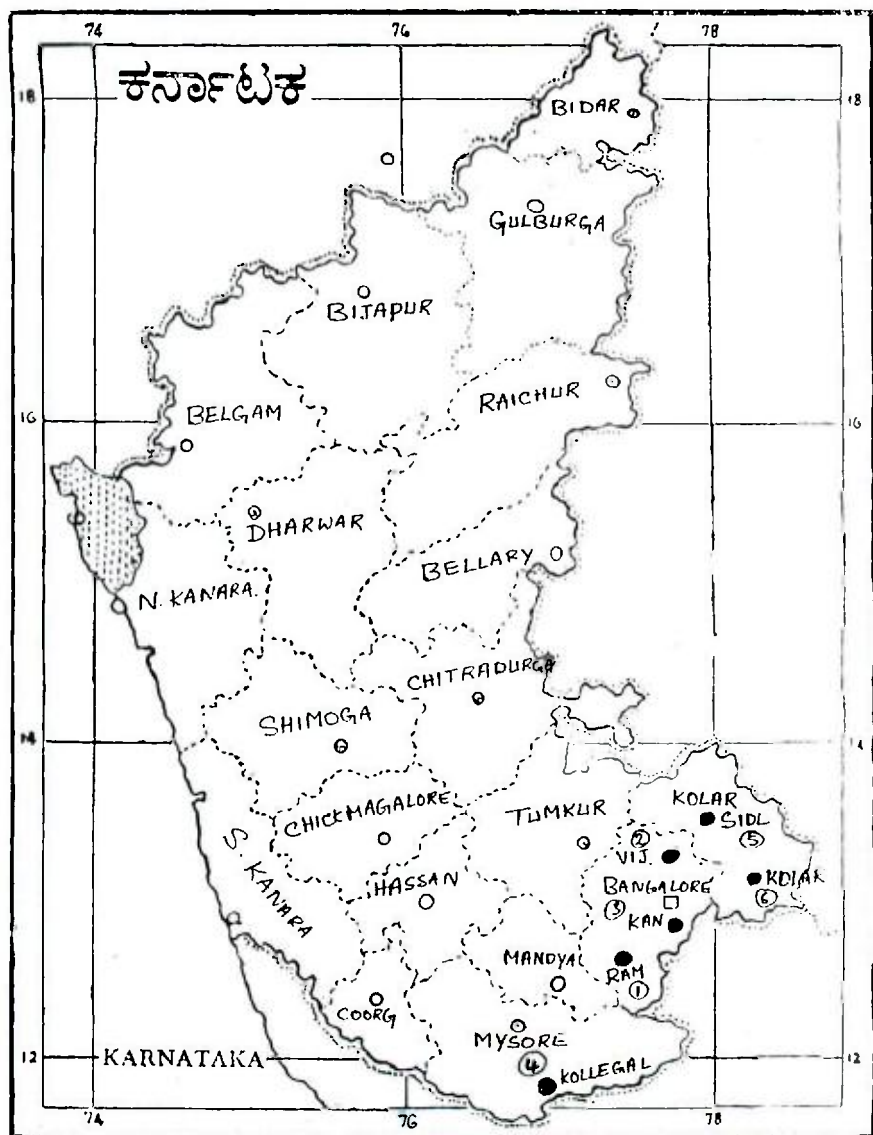
Table III. Correlation of prices between markets.

Markets	Components			
	1	2	3	4
(P _R) RAM	0.9910	0.1065	0.049	-0.0125
(P _V) VIJAY	0.9722	0.0718	0.154	0.1851
(P _{KAN}) KAN	0.9491	0.0737	-0.2785	0.1278
(P _{KOL}) KOLL	0.5106	-0.8598	0.0062	-0.0045
(P _{SDL}) SIDL	0.9857	0.1195	0.1125	-0.0504
(P _{KLR}) KOLAR	0.9687	0.0785	-0.0493	-0.2451
Eigens root λ	4.9987	0.7816	0.1187	0.1136
Var. explained (%)	83.31	13.02	1.97	1.70

Table IV. Principal components of silk cocoon prices.

	Vijayapura		Kanakapura		Sidlagatta		Kolar		Kollegal	
	Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead
r(0)	0.93	-	0.87	-	0.90	-	0.9	-	-0.23	-
r(1)	0.43	0.35	0.38	0.33	0.62	0.62	0.5	0.4	0.1	0.35
r(2)	0.01	-0.02	0.02	0.00	-0.20	-0.2	0.0	0.15	0.25	0.25
r(3)	0.15	-0.23	-0.20	-0.19	-0.10	0.0	-0.2	-0.2	0.28	0.2
r(4)	-0.06	-0.06	-0.03	0.0	-0.10	-0.1	0.0	-0.1	-0.2	-0.19
r(5)	-0.06	-0.06	0.0	0.0	-0.12	-0.1	0.0	-0.02	0.15	0.1
r(6)	-0.07	-0.07	0.0	-0.1	-0.1	-0.1	0.0	0.01	0.2	0.25
r(7)	0.0	-0.07	0.02	-0.15	0.0	-0.1	0.0	0.1	0.1	0.26
r(8)	0.06	0.06	0.03	-0.03	0.10	0.2	0.1	0.08	0.1	0.13
r(9)	0.30	0.31	0.26	0.25	0.35	0.35	0.3	0.3	0.13	0.00
r(10)	0.23	0.19	0.26	0.25	0.30	0.25	-0.23	0.15	0.25	-0.24
r(11)	-0.02	-0.22	0.10	0.00	0.02	0.02	-0.1	0.22	-0.35	-0.1
χ^2	96.504		83.55		215.04		101.02		60.83	

Table V. Cross-correlation coefficients of residuals of prices.



● Principal 'A' class cocoon markets

1. Ramnagara
2. Vijayapura
3. Kanakapura
4. Kollegal
5. Sidlaghatta
6. Kolar

Fig. 1. Karnataka Map.

VIABILITY OF ERICULTURE AND ITS ECONOMICS

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Viability of ericulture rests on a high performance of leaves being converted into silk and the remaining helping to form beans for additional revenue. The subsidiary income from beans is of value only if the yield from defoliation does not fall below 31%. The ARUNA castor variety is the best of the four tested in offering 16% more revenue in ericulture than dependence on beans alone. A farmer is expected to earn around Rs. 5,000 in a ha during six months.

INTRODUCTION

Although native of Assam and Meghalaya in the north-eastern himalayan regions, where climate is humid and temperate, three continuous lifecycles of erisilk moth, *Samia cynthia ricini* (*Philosamia ricini*) were reared for the first time, in 1977 by five farmers in their own huts in the village conditions of Kharia Meethapur, Bilara Tehsil, Jodhpur (Rajasthan) (Misra, 1978). This pioneering event opened up vast potentials for extending ericulture outside its home under widely different climatic conditions, demonstrating that climate was not the limiting factor for rearing this silkmoth, if it was not for growing its host plant. This was to be expected, because the larvae are fed inside (as in the case of mulberry silk larvae), where, during the difficult summer days, evaporative and cooling improvisations, imaginatively used, can keep temperature from crossing 33°C and maintain a microclimate in the rearing trays with a relative humidity of about 50%. Since then continuous rearing programme has gone all the year round at the Experimental Field Station and a lot of basic data has been collected for establishing viability of ericulture in semiarid regions and derelict lands.

THE VIABILITY AND ITS BASIS

The viability of ericulture (Misra, 1986) rests on double exploitation of the host plant, viz., the primary material, the leaf, converted into silk through the silkmoth and the subsidiary material, the beans, harvested from the plants defoliated for the silk conversion - which suffer in yield, providing additional revenue. Combined revenue from the double exploitation has been compared in Table I with exclusive single revenue from beans which were allowed to grow on the plants naturally, as would be happening in states growing castor predominantly without practicing ericulture. The objective of this comparison is to identify the castor variety which would make ericulture viable by the use of their leaves and beans and to elucidate the relationship between the two for maximising this viability.

The most striking variety is NPH in which the revenues from leaf biomass in D1 as well as from the beans in Do are the least. And what is more, the revenue from beans in D1 suffers the most (47%). Table II, testing ericulture viability (D1) against its non-ericulture exploitation (Do) shows that NPH variety-growing farmer will lose 18% in ericulture over Do. The ANOVA in Table I, declaring the combined revenue from this variety as significantly lower than that from the rest, puts a final seal on its ouster, labelling its use non-viable for ericulture. This leaves now three castor varieties to be examined for viability. There is GAUC, which offers the highest bean revenue and may, therefore, be taken as the model of the castor varieties being used in major castor producing states not practicing ericulture. Because of low leaf biomass revenue and 40% reduction in bean, this variety for ericulture will also be non-viable and will incur a loss of 12% (Table II). Only a castor variety with high leaf revenue and least defoliatory bean loss will make a viable choice for ericulture. Such a choice will be ARUNA, as the per plant revenues for the leaf and bean will show (Table I). The superiority of this variety *versus* the rest for the yields was found significant in the ANOVA reported in an earlier paper (Misra, 1986) and Table II shows that the farmer will gain 16% more in ericulture than in its non-ericultural use. Not only this, the choice of this variety for ericulture, offering Rs. 10,955/ha is 2.5% higher than the revenue of Rs. 10,682, which the highest bean-yielder offers in Do.

If the earning of the farmer in a major castor growing state is in the range of Rs. 10,682/ha, using the best bean-yielder, like GAUC, without bothering about ericulture, an advantage of mere 2.5% in ericulture by changing over to ARUNA would not convince him to take to ericulture. The leaf revenue compared to bean revenue in Table II looks very small. It comes from 40% pluckings, and can increase if the defoliation level is raised. This is not possible for beans, because they have already been harvested to their capacity. Two things must, therefore, be decided: (1) which course is more remunerative - converting leaves into silk or keeping them to realize fullest potential of bean revenue. (2) To find the extent to which defoliation can be carried to maximise revenue from leaves, at the same time leaving some scope for beans also to contribute towards the double exploitation of the host plant which is the central idea in ericulture.

Referring to Table I, it will be seen that combined revenue from ARUNA (0.195 kg/plant) is 16.5% higher than the combined revenue from GAUC (0.339 kg/plant). Examining the break up of the leaf and bean components percent-wise in GAUC and comparing these with the break up in ARUNA out of 117 (being 17% superior to GAUC) it will be seen that ARUNA leaves contribute 11.6% higher (43.2-31.6), but the leaves only 4.9% (73.3-68.4) above the corresponding components in GAUC. This would show that conversion of leaves into silk would be more profitable and that way alone would increase the viability of ericulture.

An idea of the extent to which defoliation can be profitably used, comes from the results from the Small Plot ARUNA VAR. Experiment (Misra *et al.*, 1985) in which all the mature leaves were plucked after the mature larva stopped feeding, preparatory to cocooning. Since the next feeding stage in the next generation would come after 33 days when the first instar larvae hatch, removal of all mature leaves at this stage gave the total leaf biomass as 0.5707 kg/plant, compared to 0.1963 kg from 40% pluckings. And what was significant for the economy was that the plant got 33 days for regenerating new crop of leaves. This three-fold increase in leaf biomass could increase the leaf revenue from Rs. 4,043 to Rs. 14,067/ha, which is 348% increase in revenue. What was surprising unexpectedly was that 200 kg of beans were also obtained despite complete defoliation in the manner mentioned. This must have been possible because of regeneration during the 33-day gap. This new factor of using regenerative capacity of the castor plant is startling and has to be examined in greater depth. But one thing is certain that viability of ericulture stands on impeccable foundation, given the right choice of the castor variety, which ARUNA certainly is.

ECONOMICS OF ERICULTURE

Table III details below the production of ARUNA variety leaf biomass in a hectare, the Dfls that can be raised, the amount of cocoon shells expected to be produced from rearings, the amount of revenue these and the beans harvested would give and the expenditure which a farmer may be expected to incur for a net revenue during the six months that the crop will last. From all these, the farmer will be able to earn at least Rs. 5,000.00 per hectare. Although the farmer, in the home of erisilk in Assam and Meghalaya grows some non-descript local castor varieties in his backyard and does the rearing of the larvae, processes the cocoons, spins and weaves the cloth, in which his whole family is engaged, three persons on daily wages of Rs. 9.00 have been provided here for six months for the rearing programme, which comes to Rs. 4,860. All told the overhead cost of Rs. 6,000.00 has been charged to the gross revenue.

Now that the highly developed new version of 'Ambar Charkha' has been developed as a crank-driven 6-spindle machine, which does continuous spinning with simultaneous drafting, twisting and winding of the yarn, a serious bottle neck has been eliminated. Chowdhury (1979) has reported that this new machine can spin 10-12 hanks of 20-100 count yarn in 8 hours and can spin 2-3 kg eri silk cocoons per day. The yarn produced is as good as mill yarn.

The work presented here was carried out in the Government of India Department of Science and Technology Project HCS/DST/1184/81 granted to the author.

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TREATMENT	CASTOR VARIETIES			
	GAUC (Rs)	NPH (Rs)	GAUCH (Rs)	ARUNA (Rs)
Do	0.3846	0.3318	0.3459	0.3399
D1 *	0.3391	0.2707	0.3528	0.3945
* Break up D1				
Leaf	0.107(31.6)	0.096(35.6)	0.112(31.7)	0.146(43.2)
Bean	0.232(68.4)	0.174(64.4)	0.241(68.3)	0.249(73.3)
	0.339(100)	0.270(100)	0.353(100)	0.395(117)

ANOVA

Source of variance	d.f.	Sum of squares	Mean squares	Cal. F	Table F	
					0.05	0.01
Replicates	5	0.0350	0.0071			
Foliation	1	0.0018	0.0018	less than 1	4.12	7.43
Varieties	3	0.0312	0.0104	2.0694	2.88	4.41
NPH vs rest	1	0.0294	0.0294	5.0342*	4.12	7.43
Within rest	2	0.0019	0.0009	less than 1		
Interactions:						
V x D	3	0.0252	0.0084	1.6667	2.88	4.41
Error	35	0.1764	0.0054			
Total	47	0.2697				

CD (0.05) Foliar treatment	0.05135
CD (0.01) Foliar treatment	0.06905
CD (0.01) NPH vs rest	0.05929

Table 1. Comparison of mean revenues from beans under Do scheme with combined revenues from beans and leaves under D1 scheme.

NOTE :

Leaf Revenue (Rs) = Notional leaf cost/kg (Rs. 0.74153) x per plant yield

Bean Revenue (Rs) = Bean cost/kg (Rs. 2.90) x per plant yield

Indian Rupee 1 = 100 Naia Paisa = US\$ 0.09 at Rs. 11.45 = 1 US\$

% given within parenthesis

Castor variety	Treatment	Leaf	Bean	Total	
		(silk) (Rs)	(Rs)	Do (Rs)	D1 (Rs)
GAUC	Do	-	10,681.66	10,681.66	-
	D1	2,968.18	6,452.50	(100)	9,420.68 (88)
NPH	Do	-	9,215.56	9,215.56	-
	D1	2,667.45	4,849.44	(100)	7,516.89 (82)
GAUCH	Do	-	9,610.28	9,610.28	-
	D1	3,112.36	6,661.94	(100)	9,774.30 (102)
ARUNA	Do	-	9,441.12	9,441.12	-
	D1	4,043.40	6,911.66	(100)	10,955.06 (116)
	D2*	14,067.23	?		

* Data from Small Plot Expt. (Misra et al., 1985)

ARUNA var. (total defoliation) leaf biomass, 0.5707 kg/plant

cf. 40% defoliation 0.1963 kg/plant) worth Rs. 14,067.23 which is 32% higher than GAUC Do bean revenue (Rs. 10,681.66).

Table 11. Comparison of revenues from castor bean-yield in Do with combined revenues from leaf (converted into silk) and bean under D1 in four castor varieties per hectare.

Items of Revenue and Expenditure	Nos.	Weight (kg)	Revenue (Rs.)
1. Estimated number of plants /ha spacing 50 cm, 300 plants/108m ²	27,778	-	-
2. Foliar biomass at 0.1963 kg/plant	-	5,452.80	-
3. Nos. Dfl at 6.675 kg/Dfl (Misra et al., 1985)	817	-	-
4. Wt cocoon shell at 0.098995 kg/Dfl	-	80.88	-
5. Sales revenue from cocoon shells at Rs. 50/kg (Assam Spun Silk Mills Ltd.)	-	-	4,044.00
6. Castor beans at 0.0858 kg/plant (wt (kg))	-	2,383.35	-
7. Sales revenue from beans at Rs. 2.90/kg	-	-	6,912.00
8. Total revenue (5 + 7)	-	-	10,959.00
9. Less estimated overheads including wages for 3 at Rs. 9 per day for 6 months (Rs. 4,860) for rearing silkworm	-	-	6,000.00
10. Net revenue (6 months crop) (Rs. 826/month)	-	-	4,956.00

(Indian Rupee = 100 Naia Paisa = US\$ 0.09 at Rs. 11.45 = 1 US\$)

Table III. Estimates and rationale of ericulture economics in one hectare, using ARUNA var. Castor as the host plant.

REPORT ON THE ECONOMY SESSION

As Mr. Mugenyi Gershom of Uganda failed to attend this session, I asked Mrs. Payung Issangkun, of the Thai Silk Association to give an additional paper to what Mr. Surindr Supasavasdeband, of Jim Thompson's has to say.

Mr. Surindr presented a very vivid picture of what goes on in Thailand with regards to sericulture and its importance in the silk industry. He said that Thailand aims to develop rural household production to be self-sufficient, and considerable efforts have been made to improve productivity.

In the last four decades, Thai silk has acquired an international reputation and the demand for raw silk has been very great. It is expected that farmers households production becomes significant for development to double output to supply the market demand.

Mr. Surindr added that the history of sericulture in Thailand was not a matter of chance but belongs to a long history of laborious campaign of leaderships of manufacturing and marketing. Present export of handwoven Thai silk fabrics and silk articles has increased to Baht: 3,000,000 annually with several hundred millions bahts worth of purchases from local markets. He ended his article saying that Thai sericulture is the essence of national economy and its development.

Mrs. Payung's paper is more in praise of the beauty of silk, repeating the world's acceptance for it to be of the noblest of all textile, and to be of high economic value of limited production.

She said that mankind has always loved silk. It has been woven into luxurious tapestries, rugs, clothes and accessories for some 4,000 years. It also enriches religious traditions and rituals of all nations. She also stressed that silk producers should jointly deal with common problems relating to production and marketing, technology transfer, research and development, manpower training and retraining in order to stimulate silk consumption and make silk more competitive.

In my opinion, I find that all said in the two papers I chaired, are very important, for it is the main object of the International Sericultural Commission to encourage and promote the development and improvement on economic points of view of all activities dealing with sericulture in general. I feel that sericulture cannot be divorced from seri-selling. When it comes to silk, its economy can only be from its successful-happy marriage of design and quality. The most attractive design would be an ultimate failure if the quality in production is inferior. In the silk busi-

ness, beauty of the fabric must be delivered along with quality. The one must have the other.

So it is with sericulture, so it is with I.S.C., so it is with all our work in silk. We must all strive to produce something wanted by the customer, whether it is research, or investigation on the technical and scientific points of view in sericulture, or development and improvement on the economics of sericulture. Best of all, I like what Mrs. Payung suggested that our honourable scientists should to always be in research to find out ways and means to pamper the endearing and unassuming little silkworms so that they prosper in their high living-standard in return for their beautiful produce that science cannot yet imitate, and hereby comes our duty as members of I.S.C.

XVe CONGRES SERICICOLE INTERNATIONAL
XVth INTERNATIONAL SERICULTURAL CONGRESS

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SECTION FILATURE ET ARTISANAT
SILK REELING AND HANDICRAFT SESSION

*

CHAIRMAN : Mr. Manu LEOPAIROTE

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REPORT OF THE SILK REELING AND HANDICRAFT SESSION

The Silk Reeling and Handicraft Session met at the Siam Ballroom A at the Royal Cliff Beach Hotel in Pattaya, Thailand on 3rd March 1987.

The session was chaired by Mr. Manu Leopaiprote, Deputy Director General of Department of Industrial Promotion, Ministry of Industry, Thailand.

Three papers were submitted to the session and all of them were presented to the participants by their respective authors. Before the presentation of the three papers, Mrs. Suwannee Cunvong, the representative of Chul Thai Silk Co. Ltd., was invited to present a paper on "The Development of Sericulture and Silk Reeling of Private Sector in Thailand".

The three papers are the following:

- a) Experiment on cocoon dry by charcoal energy, by Mr. V. Raksong, et al., from Thailand.
- b) Result of test reeling of cocoons produced by farmers, by Mrs. C. Pannengpet, et al., from Thailand.
- c) Effect of different cooking temperatures and durations on melted and normal cocoons of *Bombyx mori* L., by Mr. T.H. Bhyrappa and Mr. N.B. Nageshchandra, both from India.

The discussion following presentation of each paper was both constructive and stimulating. There can be no argument as to how important silk reeling is to the quality as well as the yields of silk production. To establish the best techniques for silk reeling is to ensure maximum returns for the labourious efforts spent on sericulture. Continued research on silk reeling, as in all other processes, is indispensable if we are to achieve higher quality and greater efficiency which are so vital in this era of keen competition.

The chairman of the session offers his congratulations to the authors of all the three papers for their great contributions to this important field and is confident that the meeting will lead the way to greater research effort and cooperation in the future.

THE DEVELOPMENT OF SERICULTURE AND SILK REELING OF PRIVATE SECTOR IN THAILAND

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INTRODUCTION

For many hundred years in the past sericulture in Thailand was a home industry for the old and poor women who spent most of their time at home. They reared the polyvoltine and produced the small yellow cocoons for their own use. But at present, many modern farmers know how to rear the bivoltine and make it become business with a good future.

Twenty years ago weavers in Thailand were short of warp silk thread which price rose from 380 to over 1,000 baht/kg within a year. This encouraged private sectors to invest in sericulture and silk reeling. There were ten investors during that time, however only three companies have survived.

Among the three survivors, one of course is Chul Thai Silk Co. Ltd. As a representative of the Company, the first and largest producer with an output of 70% of the total warp silk production of the country, I will present you about its activities and management.

FROM TANGERINE GROWER TO SERICULTURIST :

Before investing in sericulture, Chul Thai Silk Company was a tangerine grower in Petchaboon, a lower northern area. The system of marketing was semi-cooperative.

By this, I mean, tangerine farmers all around our orchard grouped together and let us market their yield. They relied on us for the know-how and the over all management.

Later on by the year 1967, when the Government set a definite policy to promote sericulture in the 4th National and Social Development Plan, which coincided with the start of our tangerine market disturbance. The company at that time looked for a replacement of farm product and sericulture was challenging, we therefore adopted the idea and fixed on this profession since then.

I have to admit that the starting point was not easy to shift from one plantation to another one totally different took great effort. It was a change from something we were acquainted with to something we knew nothing about. Nor could we foresee the turnover which gave cash return within a month or so.

In conclusion, the company set up a plan adopting the semi cooperative system which we experienced in tangerine growing applied to our sericulture. The advantages that we had in the past helped us to achieve the goal only after 12 years of hard work. Besides all problems of sericulture itself, one of the hardest problems was to convince the farmers to see the fact that silkworm rearing brings in a higher income than their former farming.

SERICULTURE BEGINS:

Today we have 70 families being members around our plantation. For each family we provide them with a living quarter, a rearing house, imported bivoltine silkworm seeds, mulberry leaves from the main plantation and other facilities needed for assistance up to marketing their yield.

Since the company deals with sericulture and silk reeling, I wish to present you three different parts, from mulberry plantation, silkworm rearing to silk reeling.

Chul Thai Silk Company has about 1,500 acres of mulberry plantation with an additional of about 250 acres each year. We plan to have the maximum acreage of 3,000 from which we are certain the amount will be enough. For planting, we have adopted the double row system in order to increase leaf yield. For weeding, we have come across and accepted assistance from geese, which means that we raise geese in the mulberry plantation. The geese will eat grass for their living and on top of their weed-killing work, we also get their droppings for fresh manure. In addition, we can sell them for food as the last stage for cash return.

Since the leaves and the branches of mulberry trees are harvested 3-4 times in a year, fertilizers in all forms such as compost, chemical fertilizer, both for the leaves and roots, have been added in adequate quantity.

In silkworm rearing, we use the imported bivoltine seeds since 1970. We gradually increase the rearing as we have a larger mulberry plantation and our former members have more skill in rearing. Last year in 1986, we reared 5,000 boxes and had an average cocoon production of 27 kgs per box. Each member will rear 15-20 boxes per crop and 7-8 crops per year.

As all the investments belong to the company, the management takes a most important part in the activities. So I would like to emphasize on the management rather than on the technique. Factors involved are:

1. Proper production scale,
2. How to group the cocoon producers who live near by each other for mutual benefit,
3. The minimal income of cocoon producers,
4. The appropriate profit share between the cocoon producers and the company.

1. Proper production scale :

- The scale is very important as the activities require a great deal of time and attention.

- The scale must give enough attractive return so that the farmers can take it as their major crop.

- We have seen failures in various cases when the scale is too small and the farmers take it as a minor source of income which finally resulted in failure of both major and minor crops.

2. Grouping of cocoon producers for mutual benefit :

- It is necessary for the farmers who live near by to form up a group with close relationship.

- This not only leads to economies of transporting and delivering of silkworm eggs and fresh cocoons.

- But also facilitate general advice and help offered by reelers.

- It is also good for them to exchange information and share experiences and expensive equipment such as pesticide and fumigators.

- From my experiences a group usually has good cooperation without conflict because of mutual benefit.

3. The minimal income of cocoon producer farmers :

Since the company provides the farmers with the proper production scale as mentioned before, they will automatically earn more than from other crops. The company has to adjust it from time to time according to the standard of the general living.

4. The appropriate profit share between the cocoon producers and the company :

As mentioned before that all investments belong to the company, so there must be the dividend of income and profit between the farmers and the company. The proper production scale is one of the main factors to control this share. When the scale is smaller, the share for farmers must be bigger or they can not live on sericulture alone. At present time, with the scale of 15-20 boxes per crop and 7-8 crops per year, our farmers get a 40% share of the income for their cocoon production.

Silkworm rearing usually is the most complicated activity for it needs a great deal of time and attention. The company holds seminars a few times a year for the farmers so that they can exchange experiences and help one another to solve problems. The application of appropriate technology, and equipments are added in every seminar in order to reduce the production cost and increase in output quality and quantity.

For silk reeling, we started our silk factory in 1972 with local multi-end machine. The fully automatic reeling machine was imported from Japan last year in 1986. We produce about 100 kgs of thrown silk per day and expect to increase our production to 300 kgs in 1990. Our production is good but rather costly due to the fact that equipments and necessary items have to be imported. In the future when we can increase our production up to the target, I am sure that we can lower the price to be competitive to the imported one.

MISCELLANEOUS :

I would like to mention a little bit about the good relationship between silk reelers and cocoon producers which has been very close from the beginning. My company, in particular, is very ready to give advices to cocoon producers on how to improve the quality and quantity of cocoon production or on immediate or long term problems they may have. The farmers are willing to follow our guidance for their own benefit which can be regarded as mutual benefit between silk reelers and cocoon producers.

It is also worthwhile to mention here about the factory by-products, silk waste can make more income if it can be partially processed into the spun yarn instead of straight sales. The company has always been interested in getting some type of machines to process silk waste. I would appreciate very much if any one can give me some advice on the issue. Pupa is very valuable too. We feed fish in our reservoir with pupa and every day we catch about 200 kgs of healthy fish for the local food market.

In the near future, the sericulturists should have a bonus income from silkworm droppings which have now a better value than it used to be. The Japanese are looking for silkworm dropping or its processing intermediate chlorophyll product. We hope this is another way to reduce production cost.

It may surprise you if I do not mention any problems at all. Of course, we have problems. We need to have the local silkworm seed production in order to avoid unexpected problems such as low hatchability and weak worms. The seed produced must be of good quality or similar to the imported ones. We realize that the expansion of sericulture activities will never be successful unless this is done so that to ensure the investors of their silkworm agro-industry future.

CHULTHAI SERICULTURAL TRAINING CENTRE

The last item I would like to talk about is our Training Centre. As we are the first in the business and always have activities to cooperate with the government sector and also farmers in the same business. So, Chul Thai Silk Company automatically becomes a farm for people who are interested in silk to visit. Gradually the company obtains the confidence and becomes some sort of a training centre which resulted in an aids from the Netherlands Government to establish a school-like training centre for trainees in sericulture. By June of this year, we will have the Chulthai Sericultural Training centre ready for schooling at Petchaboon. Each course will take 35 days. Farmers will get both technical and practical training on mulberry and silkworm rearing. I am very optimistic that our experiences transferred to these farmers will help them achieving proper quality and quantity of cocoon output which finally resulted in producing warp silk yarn enough for self sufficiency as the government's policy for the future.

I myself do believe that there is always a better way of doing things. So I hope our group will share experiences and help each other to develop sericulture in order that rich people spend more money for a better quality silk to wear, farmers can earn more income for their better living and we, will never loose jobs.

EXPERIMENT ON COCOON DRY BY CHARCOAL ENERGY

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This experiment was done for farmers who have a few amount of cocoons production in one crop. We made drying box which can dry 10 kg of fresh cocoons and used charcoal stove as heater. Temperature in drying box was about 50 to 120°C and depended upon burning of charcoal in stove. Drying percentage was about 44% in 23 to 27 hours drying time. Reeling test results of 4 times drying test were equal with drying with 90°C hot air drying.

This experiment is very useful to Thai farmers, which used to delay the moth emergence from cocoons in order to keep the good cocoon in waiting reeling. Recently it has been estimated that more than 400,000 families reel the cocoon for warp and weft silk production by themselves.

INTRODUCTION

400,000 families reared indigenous polyvoltine silkworm races and reeled the cocoons by themselves to produce warp and weft silk. This experiment was done for helping them, in case of a delay in the reeling of cocoons.

MATERIAL AND METHOD

1. Two samples of fresh cocoons divided into two groups:
 - a. drying with steam (hot air)
 - b. drying with charcoal
2. Number of cocoons per sample: 300
(reeled twice)
3. Cocoon cooking: by automatic cooking machine
4. Reeling machine : multi-end type

5. Number of reeling end: 5
6. Temperature of water in reeling basin: 40°C
7. Reeling velocity: 110m/min.

RESULTS AND DISCUSSION

The results are shown in Table I. The reelability, raw silk percentage, out and inside of waste silk show no difference, if considered in statistic "not significant" also.

Replication	Reelability %		Raw silk %		Out-inside waste %	
	hot air	charcoal	hot air	charcoal	hot air	charcoal
1	67	67	14.7	15.9	2.9.	2.2.
2	66	63	14.0	15.9	2.5	3.0
3	72	66	14.5	15.0	2.1	2.5
4	86	90	15.9	16.2	1.9	2.5
average	73	72	14.8	15.7	2.4	2.5

Table I. Comparison of reeling data between cocoon drying by hot air and charcoal.

RESULT OF TEST REELING OF COCOONS PRODUCED BY FARMERS

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In 1971, the quality of bivoltine hybrid cocoons produced in the farmhouses was surveyed by reeling for the first time. Since then, we have always tested the reeling qualities of farmers' cocoons.

In 1985, the quality of cocoons by test reeling in our laboratory, taking the average result from 84 samples, was 72% in reelability, 15.1 of raw silk percentage (fresh cocoon), 1,059 meters in length of cocoon filament, 2.0 denier in size of cocoon filament and 74% in raw silk percentage of cocoon shell.

INTRODUCTION

In the year 1971, Thailand had the first chance to produce warp silk. Before 1971, the farmers reared polyvoltine indigenous races, not suitable for warp silk production.

At first the bivoltine F1 hybrids were introduced from Japan within a program in order to distribute the bivoltine F2 hybrids to the farmers. The bivoltine F2 hybrids were reared from 1971 to 1974 by the farmers. Between 1975 and 1977 we only had a little of bivoltine F2 hybrid eggs to distribute to the farmers. Because of this interval, our centre changed its program to distribute bivoltine F1 hybrid eggs instead of F2 hybrids. As from 1978, the farmers of Thailand completely changed to use bivoltine F1 hybrid eggs for rearing, the cocoons of which they would bring to sell to the reeling factory. Now the farmers rear F1 hybrids, some 3-way cross which is distributed by the centre, and imported eggs from Japan and Taiwan also.

METHOD

1. Number of cocoons per sample : 300
2. Cocoon cooking : by automatic cooking machine
3. Reeling machine : multi-end type
4. Number of cocoons for one thread : 10
5. Number of reeling ends : 5
6. Temperature of water in reeling basin : 40°C
7. Reeling velocity : 110 m/min.

RESULTS AND DISCUSSION

Table I shows the quality of cocoons by reeling test in 1985. There was quite a large fluctuation in the reelability, raw silk percentage, length and size of cocoon filament also. Such fluctuations are different according to races, technical level in silkworm rearing and mulberry cultivation among farmers. These fluctuations are enlarged by the seasonal and local differences in natural environment too.

Table II shows the quality of cocoons by reeling test (average data) from 1971 to 1985. The total 15 years of data show the changeable quality of cocoons produced by the farmers in Thailand.

REFERENCE

Result of test reeling of cocoons produced by farmers. Bulletin of the Thai Sericultural Research and Training Centre, Nos. 2-10, 1972-1980.

No.	Province	Sample testing	Reelability (%)	Raw silk (%)	Length of cocoon filament (m)	Size of cocoon filament (d)	Cocoon shell (%)	Raw silk % of cocoon shell (%)
1.	Korat	31	71	14.9	1 088	2.0	20.3	73
2.	Buree-rum	16	72	15.4	1 055	2.0	20.7	74
3.	Sakonakorn	6	79	14.9	1 067	1.8	20.1	74
4.	Srisaket	6	76	14.9	970	1.9	20.0	74
5.	Surin	9	77	16.3	1 077	2.2	21.5	76
6.	Ubon	8	70	15.1	1 073	1.9	20.0	75
7.	Yasothon	3	61	13.8	872	1.8	19.2	72
8.	Kalasin & other	5	67	14.0	1 041	1.9	20.4	69
Total & average		84	72*	15.1*	1 059*	2.0*	20.4*	74*

* These data are an average from 84 samples testing.

Table I. Result of test reeling (1985).

No.	Year	Reelability (%)	Raw silk % of fresh cocoon (%)	Length of cocoon filament (m)	Size of cocoon filament (d)	Raw silk % of cocoon shell (%)	Cocoon shell (%)
1.	1971	87	12.0	561	2.7	75	16.0
2.	1972	58	12.4	843	2.1	68	18.3
3.	1973	70	13.0	838	2.2	70	18.5
4.	1974	71	13.0	832	2.1	72	18.1
5.	1975	75	14.5	1 052	2.1	75	19.4
6.	1976	72	15.1	1 068	2.0	74	20.5
7.	1977	72	14.3	907	1.9	71	20.1
8.	1978	72	14.9	1 079	2.1	73	20.4
9.	1979	77	15.2	1 089	2.0	76	19.9
10.	1980	69	15.0	1 038	2.1	74	20.2
11.	1981	70	15.3	1 064	2.1	74	20.7
12.	1982	71	13.8	1 037	2.0	68	20.3
13.	1983	74	13.8	1 013	1.8	70	19.8
14.	1984	73	14.6	1 032	1.9	73	20.0
15.	1985	72	15.1	1 059	2.0	74	20.4

Table II. Result of test reeling of cocoons produced by farmers.
(average data of each year from 1971 to 1985)

EFFECT OF DIFFERENT COOKING DURATION AND TEMPERATURE
ON MELTED AND NORMAL COCOONS OF BOMBYX MORI L.

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Performance of melted and normal cocoons (PM x NB4D2) of *Bombyx mori* L. under three different cooking temperatures ($98\pm 2^{\circ}\text{C}$, $92\pm 2^{\circ}\text{C}$ and $86\pm 2^{\circ}\text{C}$) with three different cooking durations (14, 10 and 6 minutes) revealed notable differences among them. Normal cocoons had lowest renditta, lowest number of breaks, higher raw silk yield, lowest waste percentage were observed when cooked at $92\pm 2^{\circ}\text{C}$ with 10 minutes cooking duration. The average denier of the single filament was good when cooked at $86\pm 2^{\circ}\text{C}$ for 10 minutes. The percentage of reelability was more in normal cocoon when cooked at $86\pm 2^{\circ}\text{C}$ for 14 minutes.

Lowest renditta, higher raw silk yield and higher reelability percentage were found in melted cocoons at $92\pm 2^{\circ}\text{C}$ for 14 minutes. These parameters were significantly inferior when melted cocoons were cooked at $98\pm 2^{\circ}\text{C}$ with 6 minutes cooking duration. The maximum average filament, maximum average denier of single filament, and lesser number of breaks at the time of reeling was observed when melted cocoons were cooked at $86\pm 2^{\circ}\text{C}$ with 14 and 10 minutes cooking duration.

INTRODUCTION

Melting of cocoons is a case where the pupa is dead and sticks to the inner layers of the cocoon shell. The decaying pupa releases a putrifying body fluid which also stains the inner layer of the shell. The percentage of melting is more during summer months and grainage operations in Karnataka (India) suffer a set-back due to melting in seed cocoons. The reelability of melted cocoons is also poor. Studies were undertaken to find out the optimum cooking temperature and duration required for economic reeling of melted cocoons in comparison with the normal cocoons.

MATERIAL AND METHODS

The experiment on the properties of melted mulberry silk cocoons in relation to cooking and reeling was conducted in comparison with normal cocoons. The bivoltine cross breed PM x NB4D2 was used for the study. The three different cooking temperatures and three different cooking durations were as follows: $98\pm 2^{\circ}\text{C}$, $92\pm 2^{\circ}\text{C}$, $86\pm 2^{\circ}\text{C}$ with 14, 10 and 6 minutes. The experiment was replicated thrice. The open pan system was followed for cooking. The reeling was done by using improved cottage reeling basin. The re-reeling was done by using re-reeling machine. The individual cocoons were reeled on eprovette to find out the filament length. The data have been collected for the following parameters viz., average filament length, average denier, number of breaks at the time of reeling, raw silk percentage, renditta, reeling waste percentage and reelability percentage (Krishnaswami *et al.*, 1972).

RESULTS AND DISCUSSION

In melted cocoons the maximum average single filament length was found at $86\pm 2^{\circ}\text{C}$ for 14 minutes (519.60m) and it is on par with $86\pm 2^{\circ}\text{C}$ for 10 minutes (518.99m); $92\pm 2^{\circ}\text{C}$ for 14 minutes (516.00m); $92\pm 2^{\circ}\text{C}$ for 6 minutes (466.88m) and $98\pm 2^{\circ}\text{C}$ for 6 minutes (461.63m). The minimum length was observed at $98\pm 2^{\circ}\text{C}$ for 14 minutes (327.58m) and it is on par with $92\pm 2^{\circ}\text{C}$ for 10 minutes (375.50m). In normal cocoons, the maximum single filament length was found at $92\pm 2^{\circ}\text{C}$ for 6 minutes (607.50m) and it is on par with $86\pm 2^{\circ}\text{C}$ for 14 minutes (604.50m), $92\pm 2^{\circ}\text{C}$ for 10 minutes (592.83m), $86\pm 2^{\circ}\text{C}$ for 6 minutes (566.75m), $86\pm 2^{\circ}\text{C}$ for 10 minutes (562.5m) and $92\pm 2^{\circ}\text{C}$ for 14 minutes (555.75m). The minimum length of single filament was found at $98\pm 2^{\circ}\text{C}$ for 14 minutes (185.97m).

The results indicate that the different temperatures and durations tried in the experiment were quite satisfactory except the treatment at $98\pm 2^{\circ}\text{C}$ for 14 and for 10 minutes which has given very short average length of single filament both in the normal as well as in melted cocoons. However, even in this case, the length of the single filament in melted cocoon was significantly superior over normal cocoons, indicating that the melted cocoons could tolerate higher temperature and longer cooking duration (Table 1).

Average denier of the single filament

In normal cocoons the maximum denier of the single filament was found at $86\pm 2^{\circ}\text{C}$ for 10 minutes (2.69) and so also in melted cocoons at $86\pm 2^{\circ}\text{C}$ for 10 minutes (3.02). The minimum denier of the single filament of normal cocoons was observed at $98\pm 2^{\circ}\text{C}$ for 14 minutes (1.60) followed by $98\pm 2^{\circ}\text{C}$ for 10 minutes (1.88) and in melted cocoons the minimum was observed at $98\pm 2^{\circ}\text{C}$ for 6 minutes (2.40). No information is available on the effect of cooking temperature and duration on denier of the single filament. The difference in the size of the bave is mainly due to different cooking tempera-

tures and durations. The lower denier noticed in normal cocoons cooked at $98\pm 2^{\circ}\text{C}$ for 14 (1.60) and 10 (1.80) minutes was due to the poor reelability. In the same cooking temperature and duration the denier was higher (2.40) in case of melted cocoons indicating that the melted cocoons required higher cooking temperature and longer duration to ease the bave during reeling (Table I).

Number of yarn breaks at the time of reeling (Number of yarn breaks per two ends per hour)

In the normal cocoons the maximum number of yarn breaks was found at $98\pm 2^{\circ}\text{C}$ with 14 minutes (10.0) and minimum was observed at $92\pm 2^{\circ}\text{C}$ with 10 minutes (1.0). In the case of melted cocoons the minimum number of breaks was found at $86\pm 2^{\circ}\text{C}$ with 14 minutes and at $92\pm 2^{\circ}\text{C}$ with 10 minutes (4.33). Irrespective of cooking temperature and duration more yarn breaks occurred in melted cocoons as compared to normal cocoons. This agrees with the findings of Sonwalkar and Gopala Rao (1980) who observed that more yarn breaks occurred in melted cocoons (33%) than in normal cocoons (20%). The present studies indicate that the melted cocoons can be reeled with minimum yarn breaks (4.33) (Table I).

Raw silk percentage

In normal cocoons the maximum raw silk percentage was obtained at $92\pm 2^{\circ}\text{C}$ with 10 minutes (19.36) followed by cooking at $86\pm 2^{\circ}\text{C}$ for 14 minutes (19.31) and $86\pm 2^{\circ}\text{C}$ for 10 minutes (19.30). At $98\pm 2^{\circ}\text{C}$ with 14 minutes the percentage of raw silk declined and was minimum (6.41). This is mainly due to high cooking temperature with longer cooking duration leading to over boiling of cocoons. In melted cocoons the maximum percentage of raw silk was found at $92\pm 2^{\circ}\text{C}$ with 14 minutes (14.48) followed by cooking at $98\pm 2^{\circ}\text{C}$ with 10 minutes (14.46) and minimum was observed at $86\pm 2^{\circ}\text{C}$ with 6 minutes (9.85). These results show that the melted cocoons can resist to high cooking temperature and longer duration compared to normal cocoons (Table I).

Renditta

In normal cocoons the lowest renditta was observed at $92\pm 2^{\circ}\text{C}$ with 10 minutes (10.34) and highest was at $98\pm 2^{\circ}\text{C}$ with 14 minutes (32.33). This is because higher cooking temperature and longer duration leads to over cooking and makes the cocoon unreelable. Irrespective of cooking temperature and duration the renditta of melted cocoons was high as compared to normal cocoons. However these studies show that the melted cocoons can be reeled economically by adopting the cooking temperature at $92\pm 2^{\circ}\text{C}$ and 14 minutes duration (13.81). Highest renditta in melted cocoons was found at $86\pm 2^{\circ}\text{C}$ with 6 minutes (20.29), this is because of lower cooking temperature and short cooking duration that were not adequate for optimum cooking of melted cocoons. These findings agree with the reports of Sonwalkar and Gopala Rao (1980) who stated that melted cocoons took more time for cooking and hence the waste was more, renditta was high (9.3) compared to normal cocoons (6.3) (Table I).

Reeling waste percentage

The maximum reeling waste percentage was found at $98\pm 2^{\circ}\text{C}$ with 14 minutes (67.98) in normal cocoons. This is because of higher cooking temperature with longer cooking duration leads to over cooking of shell layer resulting in more wastage. The minimum waste percentage was found at $92\pm 2^{\circ}\text{C}$ with 14 minutes (25.96) in melted cocoons, indicating the optimum level for economical reeling. Irrespective of cooking temperature and duration the reeling waste percentage is more in melted cocoons compared to normal cocoons. This agrees with the findings of Sonwalkar and Gopala Rao (1980) who reported higher percentage of waste in melted cocoons (Table I).

Reelability percentage

The maximum percentage of reelability was observed at $86\pm 2^{\circ}\text{C}$ with 14 minutes and $92\pm 2^{\circ}\text{C}$ with 10 minutes (67.67) in normal cocoons. The minimum percentage of reelability was found at $98\pm 2^{\circ}\text{C}$ with 14 minutes (20.00). This is mainly due to over cooking of the shell layer resulting in poor reelability. In melted cocoons the maximum percentage of reelability was found at $92\pm 2^{\circ}\text{C}$ with 14 minutes (59.67), indicating that reelability of the melted cocoons can be improved by providing optimum cooking temperature and duration.

Above data obtained during the current studies permit the following conclusions: the melted cocoons can be reeled economically with larger length of single filament, lesser number of breaks, higher raw silk percentage, lesser renditta and reeling waste percentage and higher reelability when cooked at $92\pm 2^{\circ}\text{C}$ with 14 and 10 minutes duration.

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	Average length of single filament (m)	Average denier of single filament	No. of breaks at the time reeling*	Raw silk percentage	Renditta	Reelability percentage	Reeling waste percentage
NORMAL COCOONS:							
98±2°C with 14 min.	185.97	1.60	10.00	5.41	32.33	20.00	57.98
98±2°C with 10 min.	318.75	1.80	2.33	14.45	13.85	57.33	30.04
98±2°C with 5 min.	509.32	2.41	6.00	16.55	12.14	51.00	26.54
92±2°C with 14 min.	555.75	2.65	1.67	18.89	10.59	66.00	20.86
92±2°C with 10 min.	592.83	2.60	1.00	19.36	10.34	67.57	18.93
92±2°C with 5 min.	607.50	2.35	2.57	19.16	10.44	65.67	20.99
86±2°C with 14 min.	604.50	2.38	1.33	19.31	10.36	67.67	18.95
86±2°C with 10 min.	562.50	2.69	1.67	19.30	10.36	66.33	20.31
86±2°C with 5 min.	566.75	2.47	3.00	16.53	12.10	61.57	25.35
MELTED COCOONS:							
98±2°C with 14 min.	327.58	2.52	9.57	10.31	19.43	47.33	38.79
98±2°C with 10 min.	399.37	2.40	12.33	13.02	15.40	55.00	30.30
98±2°C with 5 min.	461.63	2.40	9.00	12.15	16.21	52.67	32.73
92±2°C with 14 min.	516.00	2.85	6.00	14.48	13.81	59.67	25.96
92±2°C with 10 min.	475.50	2.68	4.33	13.64	14.57	56.57	28.86
92±2°C with 5 min.	456.88	2.81	5.67	11.60	17.24	50.57	34.41
86±2°C with 14 min.	519.67	3.67	4.33	12.10	18.02	48.33	36.54
86±2°C with 10 min.	518.99	3.02	7.33	11.10	18.03	48.33	37.13
86±2°C with 5 min.	423.33	2.78	10.33	9.85	20.29	46.33	40.84
C.D. at 5% (Q x T x D)	69.257471	0.309935	1.952484	1.56593	3.09934	2.724205	2.479479
S E ±	34.133796	0.152753	0.962289	0.68381	1.52752	0.94385	1.222020

* No. of breaks/2 end/hour

Table I. Effect of different cooking durations and temperatures on commercial characteristics of normal and melted cocoons of *Bombyx mori* L.

XVe CONGRES SERICICOLE INTERNATIONAL
XVth INTERNATIONAL SERICULTURAL CONGRESS

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SECTION BACOLOGIE
BACOLGY SESSION

*

CHAIRMAN : Pr. Jean-Marie LEGAY

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INTRODUCTION TO THE BACOLGY SECTION

Prof. J.-M. LEGAY

Chairman

Since more than six thousand years, the silkworm, *Bombyx mori*, has undergone the influence of man and evolves under the high pressure of a selection always practised in the same way. The result is a small domestic animal which is probably the most extraordinary biological machine in the world.

Capable of multiplying its weight by ten thousand in one month, of producing twenty per cent of this weight in the form of two proteins, besides stocking during the larval stages the totality of reserves required for nymph and adult life ; capable also of fitting all the circumstances of the environment by the game of diapauses, the silkworm *Bombyx mori*, derives all its subsistence from one food only, the mulberry leaf.

These extremely marked characteristics are dependent for a great part on domestication and selection : the importance of silk secretion, closing of the cocoon, monophagy, the numberless morphological and physiological mutations were not found in the ancestor *Theophila mandarina*.

So the silkworm, as we know it now, is the result of a large and long human effort. It is worth studying for this reason only. The history of the silkworm could be considered as a model of domestication and one should encourage research in this way.

But especially, the silkworm is today a biological model of exceptional interest. Indeed in the case of many biological models, it is possible to carry on research in view of one or two questions only. In the case of the silkworm, the strength of the metabolism and the subtlety of its regulations, the particularities of its life history, the richness of genetical variations, the successive events of its reproduction, all allow a series of questions which belong to the more modern and more developed chapters of contemporary biology : determinism of food intake and preparation of artificial feeding, endocrinology and metabolism in relation to the diapause, cellular differentiation of sericigen or follicular cells, functioning of genetical material and feasibility of biotechnology, classical genetics studies

on mutagenesis, genetical map, translocations, or selection, differentiation in strains or races, obtaining of heterotic effects, cytoplasmic or nuclear virus pathology. It is therefore an exceptional lot of problems which can be attacked on the same organism and which make it one of the best known of all the living creatures both from the physiological and genetical point of view.

The silkworm is used as a biological model for many other organisms, but firstly for the wild sericigen species, in which many phenomena are comparable and can be studied more quickly.

There are today more than 300 scientific and technical papers concerning silkworms, which are published every year. Many reports and theses use silkworm as starting material. Finally, in all nations, including countries where no sericulture exists, but where it is possible to obtain mulberry leaves, the silkworm is used as pedagogical model for pupils and students from elementary schools to the universities. So, in research as in the teaching, the silkworm continues to render immense services.

The contributions which were received at this conference for this bacological session concern the different chapters where silkworm and wild sericigens have been for a long time the support of important researches.

1- The reproduction field

- . with an experimental study on the oviposition and its nervous control by mechano -or chemo- receptors,
- . an electron microscopic study of the follicular prints in the micropylar regions of the egg chorion.

2- The field of embryonic and larval development

- . with a study of the effects of egg cold treatment in polyvoltine races on the later development,
- . a study of the evolution of esterase types during the embryonic stage,
- . experimental assays on the use of poikilotherm hormones, such as the juvenile hormone, or of homeotherm hormones, such as prostaglandines, in view of the improvement of growth,
- . energy balances concerning food utilization, with the study of the effects of the under-feeding, or with an attempt at bioenergetic comparisons among the Lepidoptera.

3- The genetic field

- . with classical studies on the research of heterotic effects by systematic breeding, in Indian races, or more simply the research of vitality and productivity, in Thailand races,
- . but also researches on selection for resistance to diseases such as the cytoplasmic polyhedrose, or only establishment of racial differences in the resistance,

- . finally, investigations on resistance to various drugs, such as insecticides, in relation to the race, sex and age.

4- The pathological field itself

- . either with the description of a nuclear polyhedrose, or with the study of modifications of the protein profile after injection of *Bacillus sphaericus*.

REPORT OF BACOLOGY SESSION

Bacology session is devoted to reports concerning the use of the silkworms as biological model...

A number of scientists, particularly in Japan, India, China, France and U.S.A. are doing basic researches with *Bombyx mori* or non-mulberry worms. These researches concern all fields of biology : physiology, endocrinology, biochemistry genetics, molecular biology and genetic engineering. Recently, for example, Japanese workers were using *Bombyx mori* to obtain biosynthesis of Human Interferon by means of gene transfer with polyhedrosis virus.

Unfortunately, since papers presented in our session were very interesting, the number of reports remains insufficient. Moreover, they concern very different problems. At least, some authors were not able to attend our meeting. So it is difficult to conclude about it. The conclusion, in fact, must be a wish, that Bacology section becomes more active and that, in each country, scientists who are doing basic researches will be stimulated to attend our meetings and send papers to SERICOLOGIA. Sericulture needs not only applied researches but also must benefit of basic discoveries obtained with silkworms. Bacology could be a "bridge-section" where applied and basic work could be confronted for the mutual interest.

ELECTRON MICROSCOPIC STUDIES ON THE EGG CHORION OF BOMBYCID MOTHS

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Mature eggs of pure races of silkworm *Bombyx mori* belonging to different geographical origin were subjected to scanning electron microscopy to study the morphological variations in the micropyle and aeropyle regions of the egg chorion. The micrographs have revealed clear differences not only in the size and shape of the micropylar region but also in the number and size of petal imprints present in the innermost rosette, encircling the central cavity. Eventhough, the size and shape of the central cavity appear to vary a great deal, it is interesting to point out that the silkworm races of Japanese, Chinese and Southeast-Asian origin exhibit a definite pattern of their own indicating the racial specificity. Variations observed in the number and size of the petal imprints of the innermost rosette of micropylar region do not have any relation with the race specificity. The structural and functional significance of the fine structure of the micropyle region of the egg chorion in silk moths of different geographical origin is dicussed in relevance to the racial specificity.

INTRODUCTION

The insect eggs are characterised by an outer shell secreted by the follicular epithelium during the process of egg formation and provide a strong and elastic mechanical protection to the developing embryo besides allowing air for respiration at the aeropyle region. Another specialised area of the egg chorion called micropyle paves the way for the penetration of the sperm (Leukart, 1855). The morphology and architectural pattern of the egg chorion in different insects depends on the imprints

of the follicular secretory cells on specialised regions such as micropyle, aeropyle, stripe and flat regions (Beament, 1947; Sakaguchi *et al.*, 1973; Kafatos *et al.*, 1977; Regier *et al.*, 1980).

Working on the fine structure of the egg chorion of *Antheraea polyphemus*, Regier *et al.* (1980, 1986) have opined that the significance of the variability in the egg shell must be viewed not only as a temporal but also as a spatial process. Sakaguchi *et al.* (1973) have described the arrangement of follicular imprints of the micropylar and aeropylar regions of the egg chorion of *Bombyx mori*. The abounding physiological and genetic differences in the available silkworm stocks, offer a unique opportunity to unravel the structural and functional significance of the specialised aeropylar and micropylar regions of the egg chorion. An attempt is made to analyse and understand the fine structure of the egg chorion of silkworm races from different geographical regions which could be used as one of the parameters to correlate the geographical differences and the racial specificity, if any.

MATERIALS AND METHODS

Eleven silkworm races representing three geographical regions have been chosen for the present study. Among them, Nistari, Hosa Mysore and Pure Mysore are multivoltine while Kalimpong-A, NB4D2 and NB18 are bivoltine representing the races of South East Asian origin. Three bivoltine races namely JA1, JE1 and M910 represent the races of Japanese origin. While, the other two bivoltine races namely FeC2 and NBJ represent the races of Chinese origin.

The follicles were dissected out from the mature female moths and were placed in distilled water for 15 minutes. The swollen epithelium cells were peeled off to isolate the eggs. The eggs were fixed in 2% glutaraldehyde in phosphate buffer (pH 7.6), containing 0.1 M sucrose, for 6 hours at $25 \pm 1^\circ\text{C}$. After rinsing in phosphate buffer, the samples were dehydrated in a graded series of chilled acetone (30%-100%) at 4°C . The materials were dried in a vacuum dessicator, mounted on aluminium stubs with double stick scotch tape and sputter coated with gold using vacuum evaporator. The fine structure of the specimens were studied using scanning electron microscope (Hitachi S 450) operated at accelerating voltage of 15 KV. The scanning electron micrographs of the micropyle region were taken at 1500 and 2500 magnification. Whereas that of aeropyle regions were taken at 2000 magnification. The size/area of the micropylar cavity of different races was calculated at 2500 magnification by tracing the outline of the cavity on a transparent graph sheet.

RESULTS

The scanning electron micrographs of two specialised regions of egg chorion - the aeropyle and micropyle regions of different silkworm races presented an interesting picture. The fine structure of the aeropyle was observed to be similar in almost all the races under study. But profound variations were seen in the size/area and shape of the micropylar cavity among silkworm races of different geographical origin. In addition, the number of the follicular imprints surrounding the micropylar cavity were found to vary from 6 to 14 not only in different races but also within the individual eggs of the same race besides noticeable differences in the size of the petal imprints. The observed differences with regard to the size/area and the shape of the micropylar cavity of different silkworm races are presented in Table 1. As evidenced by the data, it is clear that there is a great deal of differences in the architectural pattern of micropylar cavity, even though there is some similarity among the silkworm races of a particular geographic origin. A close scrutiny reveals that the multivoltine races of South East-Asian origin exhibit a larger size/

area of the micropylar cavity than the bivoltine races of the same origin (Table 1). Similarly the micropylar cavity is four cornered in the multivoltine races and slit like in bivoltine races (Plate 1, Fig. 1-6). However, the size/area of the micropylar cavity of the bivoltine races of Japanese and Chinese origin is more or less similar (Table 1). But the races of these two geographic origins differ in the shape of the micropylar cavity being triangular in Japanese bivoltine and stellar in Chinese bivoltine races (Plate 2, Fig. 7-11).

DISCUSSION

The structural morphology of the egg chorion has assumed a special importance in the adaptability of insects to diverse ecological niches and has undergone a considerable change in its fine structure. The architecture and chemical diversity of chorion is highly variable in different insect eggs (Hinton, 1969). It is not only different in different genera of insects but also varies a great deal within the same species. Ryckman (1962) has reported the occurrence of rough and smooth surfaces of egg chorion within the two geographically separated populations of *Trietoma protracta* complex, indicating geographical specificity in the structure of the egg chorion. Of the two specialised regions of the chorion of *Bombyx mori* under study, the similarity in the fine structure of the aeropylar region in different geographical races indicate the lack of racial and/or geographic specificity. However, the fine structure of the micropyle as revealed by the electron micrographs demonstrates the geographic and/or racial specificity among silkworm races (Plates 1 & 2) and corroborates the findings of Ohtsuki *et al.* (1982), who have reported the racial differences in the architecture of the micropylar cavity between Japanese and Chinese silkworm races. Further, the variable number of follicular petal imprints encircling the micropylar cavity in the chorion of individual eggs of the same race and also of different races is contrary to the findings of Sakaguchi *et al.* (1973) who have reported a fixed number of 8 petal imprints. The present findings on the variations in the size/area and shape of the micropylar cavity of silkworm races belonging to different geographic regions and similarities among the silkworm races of the same geographic origin indicate the possible evolutionary changes occurring in space and time.

The structural diversity in the architecture of the micropylar cavity observed in different geographical races of silkworm could be attributed to the preferential synthesis and accumulation of special class of proteins contributing to the formation of follicular imprints as reported for the aeropylar and stripe regions of *Antheraea polyphemus* by Mazur *et al.* (1980), due to the synthesis of such unique proteins in the latter part of choriogenesis. Regier *et al.* (1980, 1986) have classified them as Class 'E' proteins.

In view of the above, it is opined that the fine structure of the micropylar region of the chorion of *Bombyx mori* is determined by the synthesis of region specific specialised proteins by the activation of specific structural genes in the latter part of choriogenesis. The differential activation of such structural genes contributing to the synthesis of specific protein phenotypes, relevant to the architectural pattern of the micropylar region confers the racial and/or geographic specificity which can be employed as one of the indices in race breeding programme.

ACKNOWLEDGEMENTS

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Geographical origin	Voltinism	Race	Shape	Size/area (mm ²)
South East-Asian	Multivoltine	Nistari	four cornered	41
		Hosa Mysore		52
		Pure Mysore		50
	Bivoltine	Kalimpong-A	slit	23
		NB4D2		19
		NB18		24
Japanese	Bivoltine	JA1	triangular	42
		JE1		37
		M910		33
Chinese	Bivoltine	FeC2	stellar	43
		NBJ		47

Table 1. Shape and size/area of the micropylar cavity of the egg chorion in Bombycid moths of different geographical origin ($\times 2500$).

LEGENDS TO FIGURES

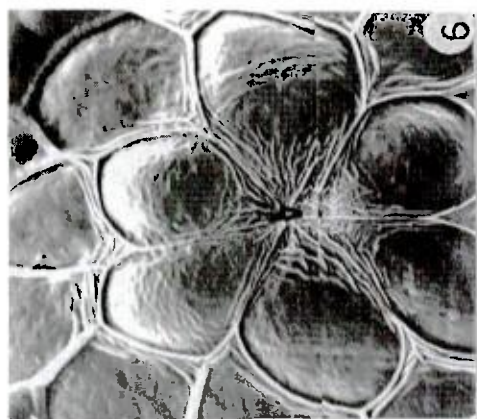
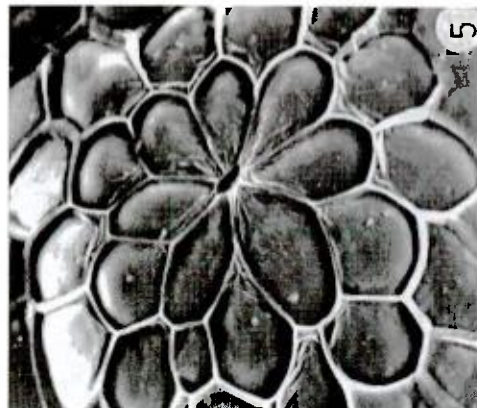
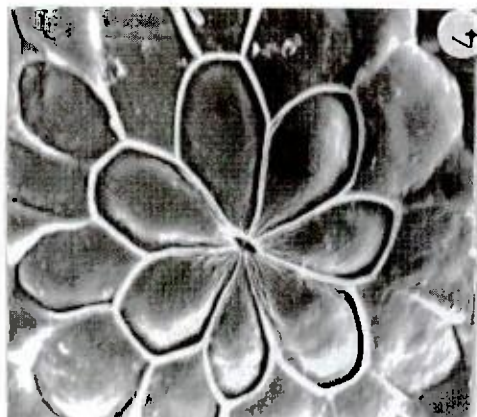
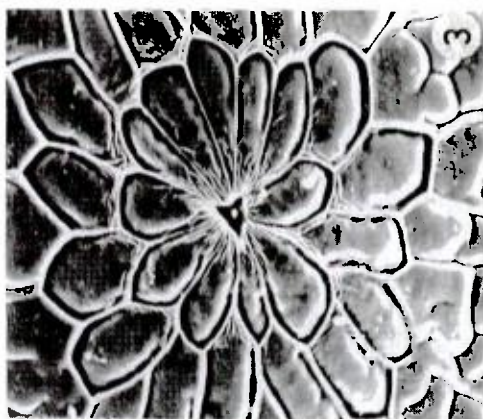
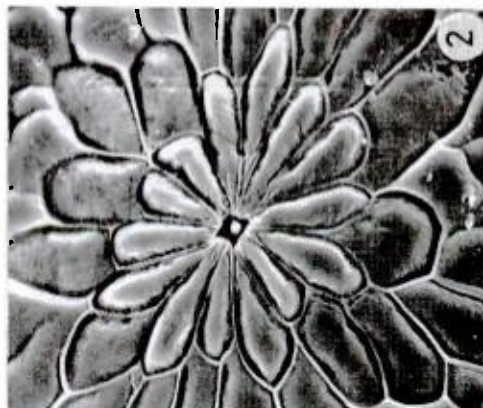
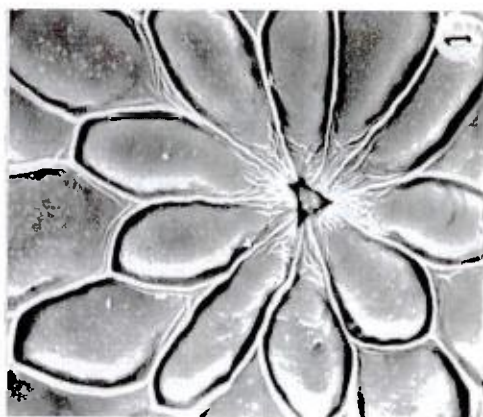
Plate 1. Scanning electron micrographs of the micropylar region of the egg chorion of South East-Asian races.

Fig. 1. Nistari		Multivoltine
2. Hosa Mysore		
3. Pure Mysore		
4. Kalimpong-A		Bivoltine
5. NB4D2		
6. NB18		

Plate 2. Scanning electron micrographs of the micropylar region of the egg chorion of Japanese and Chinese races.

Fig. 7. JA1		Japanese bivoltine
8. JE1		
9. M910		
10. NB1		Chinese bivoltine
11. FeC2		

PLATE 1.



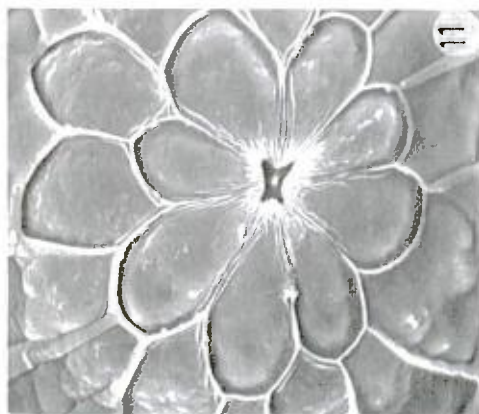
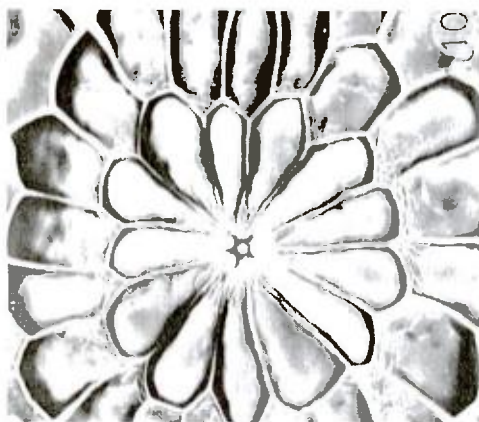
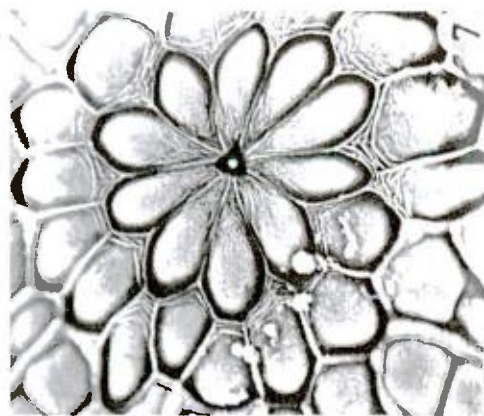
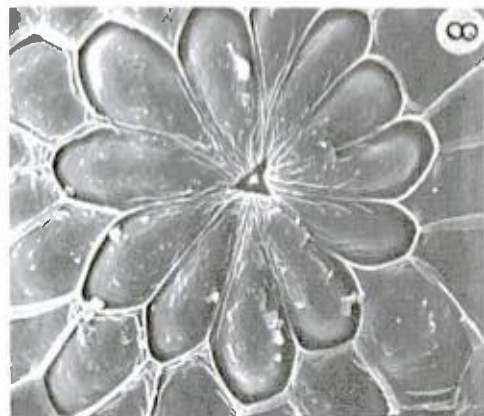


PLATE 2.

DIALLEL CROSSES WITH POLYVOLTINE STRAINS OF THAI SILKWORM
(BOMBYX MORI LINN.)

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Yield and vitality of larvae of polyvoltine strains are the two important factors needed by 80% of Thai silk-rearers. Because local farmers can produce their own silk-seeds, the in-breeding is unavoidable. Diallel crosses between popular strains were performed in order to detect the combinations which would result in the required characters. Seven strains : NK4, NK5, 15KY, BR9, PC21, NN, NL were diallely crossed. Four quantitative criteria related to yield were employed i.e., the single cocoon filament length, the whole cocoon weight, the cocoon shell weight and the percentage of cocoon shell. Heterosis were noted in almost all crosses. The heterosis results of individual criteria arisen from the 42 crosses over thus ranked from 1 to 10. Surprisingly, the cross of NK4 (♀) to BR9 (♂) ranked first in every character. The crosses of 15KY (♀) to NK (♂) and of NK4 (♀) to NN (♂) followed respectively. Apparently, sexes had influences on yields when the top-ten crosses within each character were compared. In general, for intercrossing, NK4 and 15KY should be used as females while NN and BR9 males should be employed. Conversely, both sexes of NL produced equally good in yield in the crossing with different strains.

As regards vitality, vigor was noted in the larval progenies of all crosses.

INTRODUCTION

The uniqueness of Thai silk is generally appreciated by people who admire silk. This may be the results of weaving, spinning, reeling and dyeing techniques. Deep down however, is the silk filament size and texture. Because of the small size of cocoons, machine reeling is impossible and hence the production is limited by labour. At present, eighty percent of the farmers can rear polyvoltine silkworms as a sub-income only, and because of the polyvoltine nature, the farmers can produce their own silkworm seeds by inbreeding. This causes relatively weak strains and eventually low yield results. Rearing of bivoltine strains needs skill and intensive care because of the low resistance to diseases of the strains. Thus a breeding of polyvoltine strains for higher yield and vigor in disease resistance is the immediate task needed by our country although the bivoltine crosses with multivoltine are also another solution (Higashi, 1971).

The strains generally reared by farmers are native and improved ones. Some of the improved strains released by the Department of Agriculture, Ministry of Agriculture and cooperatives were undoubtedly interbred with the bivoltine strains and selected thereafter.

The life cycle of Thai strains is around 18-22 days and the average of the percentage of cocoon shell is of 12-14. Twenty thousand larvae normally give 1 kg of raw silk (Ariya, 1982).

MATERIALS AND METHODS

Seven popularly reared multivoltine races namely NK4, NK5, 15KY, BR9, PC21, NN and NL were crossed diallely. Of these Nong Noi (NN) and Nang Lueng (NL) are the native strains while the improved strains are NK4, NK5, 15 KY, BR9 and PC21. There is no record as yet to trace their phylogeny (Chomchen 1971, Jaree 1972). Throughout the experiments, the larvae were maintained under standard conditions (25-28°C and 70-90 % RH). The experiment was carried out 4 times throughout the year. Four quantitative characters; the single cocoon filament length, the whole cocoon weight, the cocoon shell weight and the percentage of cocoon shell, were employed as judgement criteria. Heterosis of individual characters were analysed and ranked. The top ten results of each criterion were compared and ranked again in order to locate the best yield-given combination. This was based on the consistency in the ranking number so as to rule out deviations due to technical errors. Since cytoplasmic factors might influence these quantitative yields, another criterion (the frequency of being chosen as female (or male) parents was also used.

RESULTS

The results of diallel crosses among seven silkworm inbredlines were presented in Tables III-VI. The top ten crosses of these four criteria were ranked (Table I). Apparently, the NK4 x BR9 cross ranked first in every character employed, followed by 15 KY x NL and NK4 x NN. The influence of sexes was noted when frequencies of being chosen as females and males of the top-ten crosses were recorded (Table II). NK4 was best as a female whereas the top-two males were NN and BR9. Such phenomenon was not expressed in NL and 15KY inbred lines. Both sexes of these lines seemed to contribute equally.

Under controlled conditions of rearing, the larval period is from 20-23 days (Table VII). BR9 AND 15KY are the strains that came close to 23 days while NN, NK4 and NK5 are about 21 days. All the hybrids were noted to perform well in regarding to vitality.

DISCUSSION

It is evident from this work that the genetic basis of the Thai polyvoltine silkworms is very narrow. It may be because of the long inbreeding history of the silkworm strains. Silkworms are domesticated widely in rural areas in the North-east of Thailand.

Nevertheless, intensive selections for efficiency in silk production have hardly been performed as the major research has turned towards the introduced bivoltine strains from which higher yield is expected. Intensive strains keeping was thus neglected. The low percentage of heterosis implies a very little genetic variation in the silkworm strains as it was found in sorghum (Beil and Alkin 1967). Another possibility is that all these polyvoltine strains comprise the genes of low yield in nature because of their highly adaptive value in the tropic. However, the crosses of NK4 X BR9 still provide an immediate application until the breeding programme has moved forward. Maternal influence also plays a minor role in strains NK4 and paternal in NN and BR9. No explanation can be given as yet until further work is done. But perhaps this is the explanation of the good combination of NK4 and BR9.

ACKNOWLEDGEMENT

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Rank Nº	Crosses	Filament length (Heterosis)	Crosses	Fresh cocoon weight (Heterosis)	Crosses	Cocoon shell weight (Heterosis)	crosses	Percent cocoon shell weight (Heterosis)
1	NK4 x BR9	15.35	NK4 x BR9	19.01	NK4 x BR9	30.86	NK4 x BR9	10.72
2	15KY x NK4	14.29	NN x NL	16.66	NK4 x NL	20.30	NK4 x NL	6.50
3	NN x NK4	12.59	NL x NN	15.66	NN x NL	18.06	PC21 x BR9	5.62
4	15KY x NL	12.50	BR9 x NN	14.84	NL x NN	17.71	NK4 x 15KY	5.52
5	PC21 x NK4	12.39	NK4 x NL	14.70	15KY x NL	17.60	NL x 15KY	5.17
6	NL x BR9	11.89	NL x BR9	14.55	PC21 x BR9	17.40	NL x NN	5.11
7	NL x 15KY	10.87	NN x NK5	14.32	BR9 x NN	16.70	15KY x BR9	4.92
8	NN x 15KY	10.77	15KY x NL	13.65	15KY x NN	16.36	15KY x NL	4.73
9	15KY x NN	9.74	NK5 x NL	13.35	NK5 x NN	16.21	NK5 x BR9	4.60
10	NK4 x NN	9.09	NK5 x NN	13.27	NK4 x NN	16.11	NK4 x NN	4.14

Table I. Yield characteristics of hybrids between polyvoltine strains.

Rank	Female parent	Frequency	Male parent	Frequency
1	NK4	11	NN	12
2	NL	7	BR9	10
3	15KY	7	NL	10
4	NN	4	15KY	6
5	NK5	4	NK4	4
6	PC21	3	NK5	2
7	BR9	1	PC21	0

Table II. Frequencies of being chosen as parents (digested from Table I).

Female parent	Male parent						
	NK4	NK5	NN	NL	BR9	PC21	15KY
NK4	± 18.01	± 41.75	± 49.86	± 135.41	± 23.80	± 77.85	± 92.40
	466	430	468	408	496	457	459
		(-1.15)	(9.09)	(0.25)	(15.35)	(1.11)	(7.49)
NK5	± 40.16	± 73.08	± 28.93	± 97.84	± 44.84	± 69.05	± 58.24
	437	403	409	404	416	427	388
	(0.46)		(3.02)	(7.73)	(4.52)	(1.67)	(2.02)
NN	± 60.25	± 26.18	± 41.38	± 35.02	± 79.01	± 43.47	± 48.00
	483	424	391	404	397	429	432
	(12.59)	(6.80)		(9.49)	(1.28)	(3.62)	(10.77)
NL	± 58.20	± 50.63	± 69.13	± 86.28	± 50.48	± 54.92	± 57.52
	427	368	391	347	414	419	408
	(4.91)	(-1.87)	(5.96)		(11.89)	(6.89)	(10.87)
BR9	± 70.43	± 23.44	± 24.83	± 32.66	± 56.27	± 62.68	± 73.14
	445	418	421	397	393	401	405
	(3.49)	(5.03)	(7.40)	(7.30)		(-3.37)	(3.58)
PC21	± 81.16	± 86.72	± 17.75	± 49.66	± 70.80	± 79.28	± 51.49
	508	454	417	423	427	437	416
	(12.39)	(8.10)	(0.73)	(7.91)	(2.89)		(0.73)
15KY	± 100.47	± 44.40	± 27.81	± 50.47	± 50.64	± 63.68	± 32.52
	488	410	428	414	412	410	388
	(14.29)	(3.54)	(9.74)	(12.50)	(5.37)	(-0.73)	

Table III. The average filament length of a single cocoon (m) and heterosis (in brackets) of hybrids from seven polyvoltine strains.

Female parent	Male parent						
	NK4	NK5	NN	NL	BR9	PC21	15KY
NK4	± 19.31 32.82	± 23.05 84.46 (1.78)	± 19.65 93.32 (11.81)	± 28.16 86.62 (14.70)	± 18.89 100.37 (19.01)	± 23.63 91.20 (6.15)	± 19.17 90.10 (9.92)
NK5	± 20.93 86.92 (4.75)	± 23.10 83.13	± 20.30 94.72 (13.27)	± 24.46 85.78 (13.35)	± 19.56 89.81	± 23.66 88.64 (2.99)	± 17.05 85.93 (4.64)
NN	± 20.37 93.13 (11.59)	± 19.59 94.31 (12.78)	± 22.66 84.10	± 22.80 88.85 (16.66)	± 22.42 87.90 (3.44)	± 19.71 91.82 (6.08)	± 19.88 90.81 (9.93)
NL	± 23.05 82.92 (9.90)	± 22.43 86.52 (14.32)	± 22.71 88.22 (15.84)	± 20.01 68.22	± 18.65 88.25 (11.55)	± 22.03 88.51 (12.58)	± 17.92 82.22 (16.11)
BR9	± 26.77 88.09 (4.45)	± 20.64 92.32 (9.27)	± 24.79 97.59 (14.84)	± 19.71 86.94 (12.85)	± 26.95 85.85	± 24.42 94.29 (7.85)	± 19.61 87.42 (4.72)
PC21	± 16.22 93.9 (9.29)	± 23.27 92.56 (7.47)	± 24.16 93.17 (7.64)	± 20.45 86.80 (10.40)	± 25.43 97.14 (11.11)	± 24.88 89.01	± 16.24 85.65 (0.69)
15 KY	± 21.16 87.41 (6.64)	± 20.36 83.21 (1.33)	± 18.60 90.49 (9.54)	± 23.45 84.86 (13.65)	± 22.48 91.22 (9.27)	± 17.66 84.70 (-0.42)	± 18.52 81.11

Table IV. The average fresh cocoon weight (eg) and heterosis (in brackets) of hybrid from seven polyvoltine strains.

Female parent	Male parent						
	NK4	NK5	NN	NL	BR9	PC21	15KY
NK4	± 2.30 10.07 (3.45)	± 2.83 10.20 (3.45)	± 2.40 11.53 (16.11)	± 3.48 10.37 (20.30)	± 2.78 13.74 (30.86)	± 3.31 11.47 (6.40)	± 2.45 11.40 (15.62)
NK5	± 2.80 10.43 5.78	± 2.26 9.65	± 2.52 11.30 (16.26)	± 2.75 9.42 (12.01)	± 2.79 11.54 (12.15)	± 2.99 11.13 (5.30)	± 1.99 10.42 7.98
NN	± 2.35 11.37 (14.50)	± 2.38 11.43 (17.59)	± 2.63 9.78	± 2.09 10.00 (18.06)	± 2.79 10.50 (1.35)	± 2.69 11.93 (12.12)	± 3.14 11.23 (15.53)
NL	± 3.21 9.64 (11.83)	± 2.26 9.58 (13.91)	± 2.28 9.97 (17.71)	± 2.55 7.16	± 2.83 10.54 (16.46)	± 3.33 10.66 (14.46)	± 2.12 9.53 (13.32)
BR9	± 3.75 11.40 (8.57)	± 2.72 11.44 11.18	± 3.31 12.09 (16.70)	± 2.30 10.31 (13.92)	± 3.68 10.93	± 3.49 12.11 (8.03)	± 2.27 10.95 (6.41)
PC21	± 2.63 12.07 (11.97)	± 3.43 11.50 (8.80)	± 2.76 11.41 (7.24)	± 2.41 9.99 (7.07)	± 3.53 13.16 (17.40)	± 3.21 11.49	± 2.12 10.82 (2.37)
15KY	± 3.05 10.19 (3.35)	± 2.57 9.91 (2.69)	± 2.32 11.31 (16.36)	± 3.02 9.89 (17.60)	± 2.73 11.67 (13.41)	± 2.40 10.84 (2.55)	± 2.76 9.65

Table V. The average cocoon shell weight (eg) and heterosis (in brackets) of hybrids from seven polyvoltine strains.

NUCLEAR POLYHEDROSIS VIRUS ISOLATED FROM
BOMBYX MORI IN THAILAND

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Diseased silkworm larvae were collected from several sericultural farms in the rural villages in the northeast of Thailand. Light and electron microscopic observations indicated that the causal pathogen was the nuclear polyhedrosis virus (NPV) of single embedded type. In addition, virions of multiple embedded type were observed in the polyhedra and in the infected nuclei. The isolated NPV was highly pathogenic to silkworm larvae and exhibited a pronounced characteristic symptom at the 5th instar larva or at the time of cocoon forming. Pathological study revealed that this virus infected the nuclei of fat tissue, hypodermis, tracheal matrix, silk gland and the testicular sheath. Morphological characteristic of the virus and ultrastructural changes in infected cells indicated that the NPV found in this study was different from those previously reported from other Lepidopterous insects. It is also concluded that this virus is one of the major factors inflicting economic damage to the sericultural industry in Thailand.

INTRODUCTION

Thai sericulture has been changed from farm household in the past to the country agro-industry business at present. As the sericultural management scale becomes larger, the number of rearing seasons increases as well as the higher degree of diseases outbreak. Muscardine, flacherie, grassery and pebrine were reported as disease of silkworm found in Thailand (Aoki, 1971). Symptomatology and the identification of the causal agents had been described later (Aoki, 1972; Attathom, 1982). Viral disease especially that caused by the nuclear polyhedrosis virus (NPV) is of fundamental importance disease of silkworm. It occurred prevalently in rural areas where the Thai local varieties of silkworm were cultivated, therefore, imposed serious economic damage to the Thai sericulture. However the detail information on this disease are inadequate. The present investigation focuses on the ultrastructural

and pathological studies of this locally isolated virus with the objective to collect the informative data essential for the establishment of the disease control measure.

MATERIALS AND METHODS

The intensive surveys of silkworm, *Bombyx mori*, diseases were made in several provinces in the Northeast of Thailand. The private silkworm rearings in the rural villages as well as the rearing places in the Regional Sericultural Experiment Station were investigated. Diseased larvae with characteristic symptoms of the nuclear polyhedrosis virus infection were collected and brought to the laboratory. Isolation and purification were accomplished by sucrose density gradient centrifugation. Ultrastructure of the virus was determined by electron microscopic observations of the shadow cast preparations and the ultrathin sections of the infected tissues. Tissues were fixed in 2.5% glutaraldehyde in buffer, postfixed in 1% osmium tetroxide, dehydrated in an ethanol series and embedded in Epon-Araldite mixture. Thin sections were made on the LKB ultratome, stained with uranyl acetate and lead citrate and then observed with JEOL JEM-100S electron microscope. For histopathological examinations, larvae were fixed in Bouin-Duboscq solution and prepared for paraffin embedding by standard histological techniques. Serial sections were cut at 6-8 μ m and were stained by the method of Hamm (1966). The ultrathin sections prepared as described above were employed for cytopathological study.

RESULTS AND DISCUSSION

The intensive surveys made throughout the year in the Northeast of Thailand indicated that the viral disease predominantly occurred in the remote rearing places of the farmers in the rural villages. Only few diseased samples were collected from the well-management sericultural farms. In some farms, the viral disease outbreak can destroy the whole colony of silkworms. This phenomena often occurred in the 5th instar larvae which caused serious loss in both economy and labor intensity to the farmers. This result was not unexpected and there were several reasons to clarify: 1) Many of the Thai farmers are raising multivoltine type silkworms, the more frequency of the rearing times per year, the less thorough disinfection of the rearing places will be practiced. Therefore inadequate sanitation is of fundamental reason for the outbreak of the disease in those poor-management farms. 2) In the remote area where it is inconvenient to obtain silkworm eggs from the State Experiment Station, the farmers maintain their own seed stocks. Such seeds apparently have no guarantee on the quality and diseases. Continuous cultivation of silkworms from these seed stocks creates the problems of inbreeding as well as the outbreak of the diseases. 3) Unsuitable rearing condition namely: inappropriate rearing places and tools, poor ventilation, overcrowding, poor quality of mulberry leaves and improper rearing techniques will all weaken the silkworms to the infection of viral disease. The well-management sericultural farms are practically unaffected by the viral disease.

Morphology and ultrastructure:

The virus isolated from diseased silkworm, *B. mori*, was partially purified and electron microscopically observed. The results indicated this locally isolated virus was the nuclear polyhedrosis virus (NPV) of single-embedded type (Fig. 1). It is an unusual one, probably unique among the NPV of Lepidopterous insects. Being the single-embedded type virus, all virions should contain only one nucleocapsid, however in this virus, the virions of multiple nucleocapsids were found in infected nuclei (Fig. 1 C). This phenomenon was previously reported by Bergold (1963) who observed up to seven nucleocapsids were included within the envelope. This indicated the

structural similarity of the strains of the *B. mori* NPV in different locations. The electron micrographs indicated that the prevailing type of polyhedra were tetragonal with rather round angles. However the globular and hexagonal shaped polyhedra were also observed, but unfrequently. The mean diameter of the polyhedra was 2.7 μm which considered the biggest NPV ever isolated from Lepidopterous insects in Thailand (Attathom and Poolpol, 1984; Attathom and Attathom, 1985; Attathom and Aemprapa, 1987). The large cuboidal inclusions were found in tissues infected with this virus (Fig. 1 b). The presence of this structure is quite common to most of the NPV infections and was suggested that it was induced by viral infection and was not a host-induced response (Vail and Jay, 1973).

Most of the virus particles were rod-shaped and contained only one nucleocapsid. Examination of fine structure demonstrated the double-membrane structure surrounding the nucleocapsid. Himeno *et al.* (1968) described this double-membrane as the outer membrane and suggested that the inner membrane was obviously shown in the negatively stained particles. Two types of virus particles, thick rod shape of 330 x 80 nm and slender rod of 360 x 60 nm were previously isolated from diseased silkworm (Khosaka *et al.*, 1971). However the present study demonstrated only slender rod-shaped virus particle with the mean length and width of ca. 340 x 45 nm. The electron micrographs clearly showed that the number of virions of *B. mori* NPV occluded in the polyhedra was greater than previously reported in Lepidopterous NPV. Hence the *B. mori* NPV can be readily distinguished from other NPVs by this remarkable feature.

Pathology:

In the early stage of infection no symptoms were observed, but with the progress of the disease, infected larvae were characterized by a faint mottling of the fat body beneath the cuticle of the swollen abdominal segments. The larvae appeared creamy white to yellowish in colour and shriveled. The symptoms were intensified as the larvae reach the 5th stage. After death the cadavers turned black and the integuments became very fragile, ruptured upon touch, releasing a viscous liquid containing polyhedra of the virus. Young larvae were more susceptible to viral disease, however the disease outbreak occurred in the 5th instar larvae and a large number of silkworm were unable to perform the cocooning and died.

The histopathology of the *B. mori* NPV demonstrated that the infection was restricted to the nuclei of infected tissues. The evidence of the NPV infection was the hypertrophied nuclei almost filled the cells, contained numerous polyhedra which appeared bright red when stained (Fig. 2 a). The fat body, tracheal matrix and hypodermis were heavily infected by this virus (Fig. 2 a, b). Polyhedra were observed in the nuclei of silk gland (Fig. 2 c) thus suggested the reason for the inability of diseased silkworm to spin the cocoon. Moderate infection was found in the epithelial sheath of the testes (Fig. 2 e, f). There were no polyhedra detected in midgut cells, muscle cells and malpighian tubules. It is well known that NPV can infect a variety of larval tissues (Tinsley and Harrap, 1977) and the recent work demonstrated that the *B. mori* NPV can infect the follicular epithelium of silkmoths (Smith-Jahanssen *et al.*, 1986). Therefore types of target tissues for *B. mori* NPV should be thoroughly investigated to determine the pathogenicity of this virus on each developmental stage of the silkworm.

Cytopathology:

Several ultrastructural changes occurred in infected nuclei (Fig. 3). The nucleus hypertrophied, undergoes chromatin margination and nucleolus disappearance. The polyhedra located randomly in the nucleus (Fig. 3 a) or in line along the periphery of the nucleus (Fig. 3 b). It is remarkable that this virus has high replica-

tion efficiency since it reproduces numerous virus particles. Nucleocapsids in group were observed in the diffuse mass of chromatin, the virogenic stroma, in the central area of the nucleus and plenty of virions were occluded in the polyhedra (Fig. 3 b). Associated with the *B. mori* NPV development were the curved and vesicular membrane profiles (Fig. 3 a, b, c) appearing randomly in the infected nuclei. The fibrillar strand was reported to be abundant in nuclei infected with *Spodoptera exigua* NPV and *Heliothis armigera* NPV isolated in Thailand (Attathom and Aemprapa, 1987; Attathom and Attathom, 1985), however, it was seldomly observed in this study. Thus confirmed the entity of *B. mori* NPV and eliminated the possibility of cross infection. Although same cytopathic changes associated with *B. mori* NPV are common to many other NPVs, the difference in appearance and frequency of occurrence may be specific enough to identify the virus.

We concluded that this local strain *B. mori* NPV is different from other NPVs isolated in Thailand. The virus is highly pathogenic to silkworm and is one of the major factors inflicting the economy of Thai sericulture. The information presented here could have some impact on the control measure of this disease which is encouraging to be practiced routinely in all sericultural farms.

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LEGENDS TO THE FIGURES

Fig. 1. Electron micrographs of nuclear polyhedrosis virus of the silkworm, *Bombyx mori*.

- a) and b) shadow cast preparations illustrating tetragonal shaped polyhedra and the large cuboidal inclusion.
- c) and d) ultrathin sections of infected tissues illustrating nucleocapsids (N) and virions (V) of both single and multiple-embedded type.

Fig. 2. Stained sections of larval tissues of *Bombyx mori* infected with the nuclear polyhedrosis virus.

- a) the hypertrophied nuclei of infected fat tissue.
- b) tracheal cells (t) in the fat body (f) demonstrating infection of nuclei of both tissues.
- c) infected silkgland.
- d) uninfected mid gut epithelial cells.
- e) and f) epithelial sheath of the testes showing the infected nuclei filled with polyhedra.

Fig. 3. Electron micrographs of the nuclei of infected fat cells of *Bombyx mori*.

- a) the infected nucleus of fat cells demonstrating the chromatin margination (C), curved membrane profiles (arrow) and polyhedra (P) which appeared randomly in the nucleus.
- b) a group of nucleocapsids (arrow) in the area of virogenic stroma (V).
- c) vesicular membrane profile (arrow) associated with virus infection.

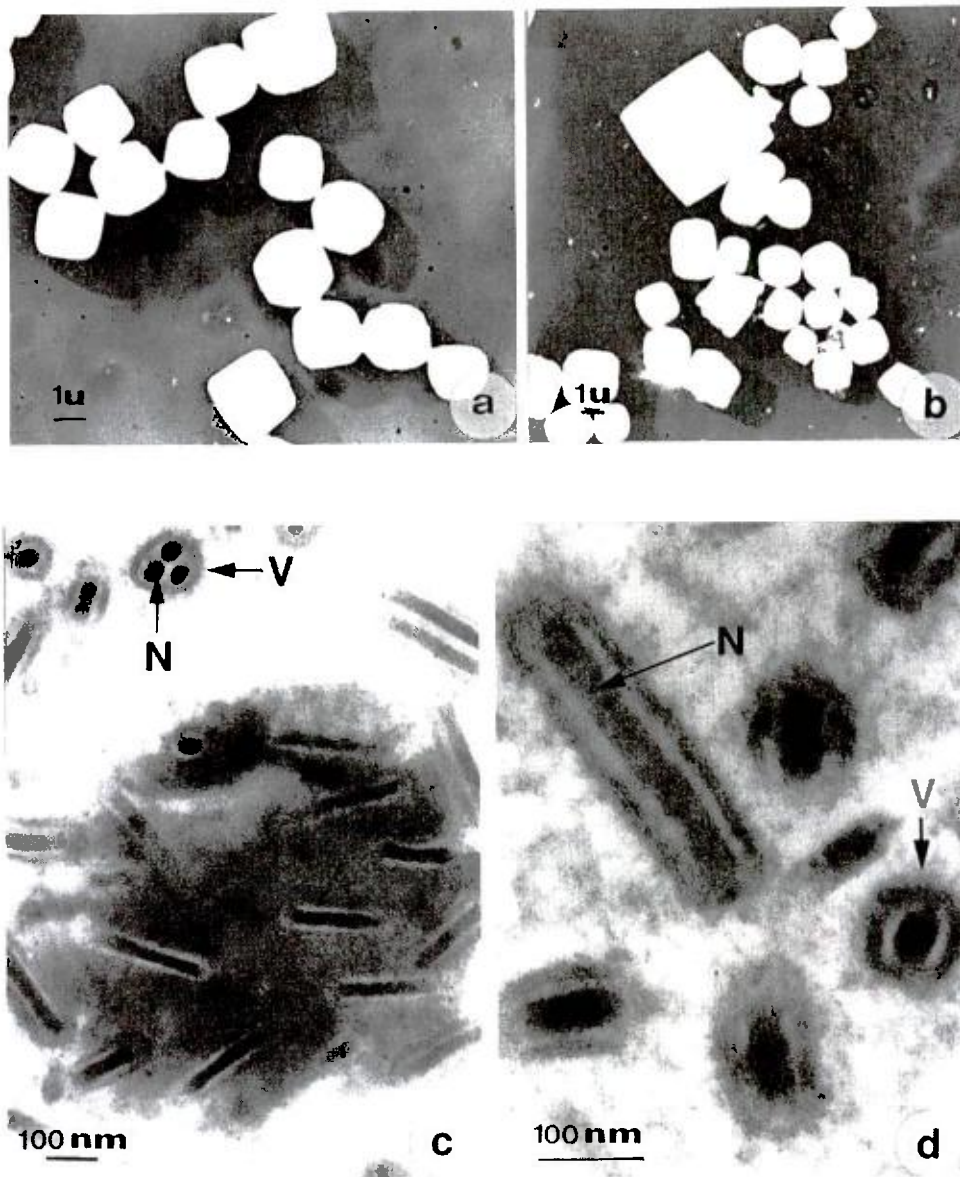


FIGURE 1.

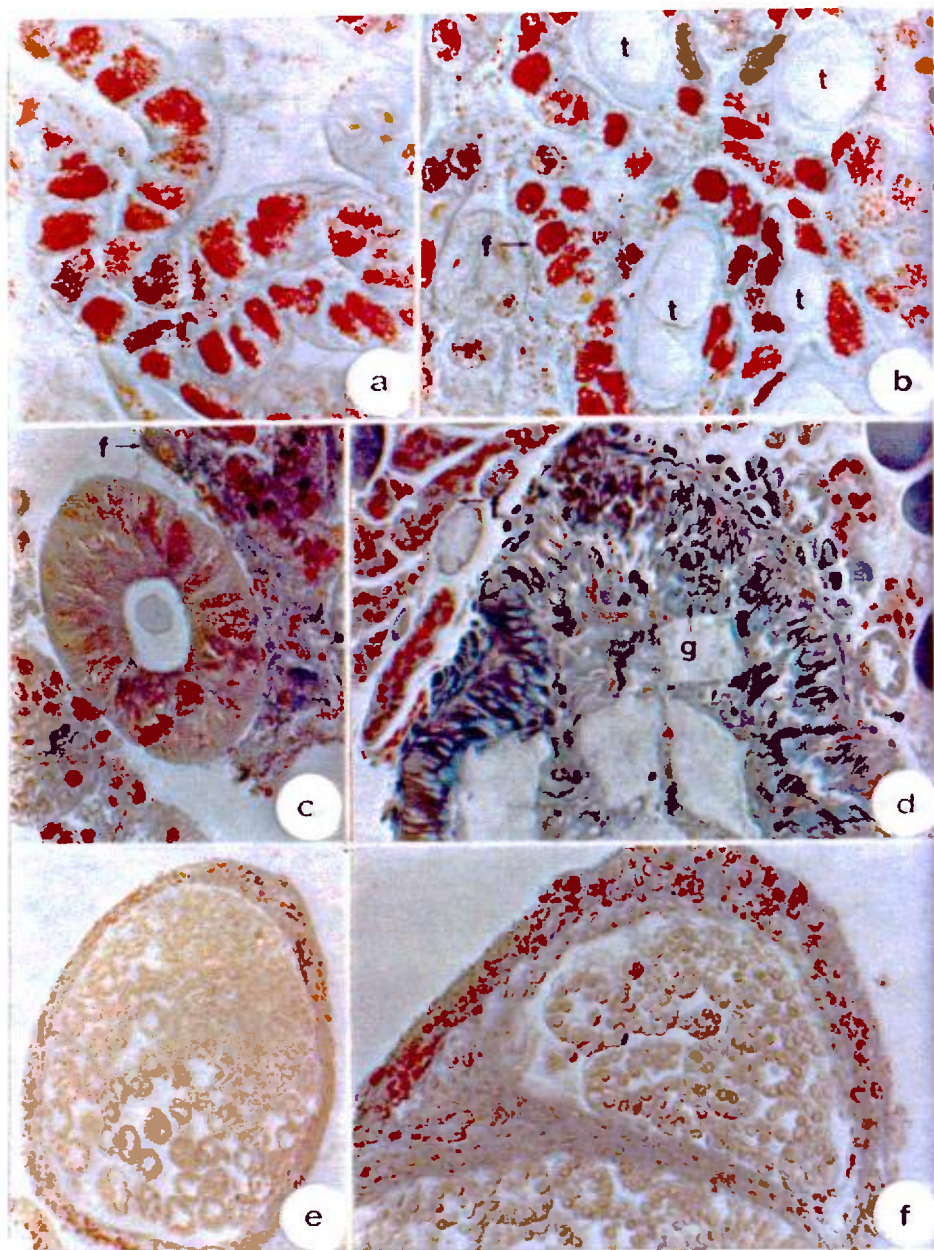


FIGURE 2.

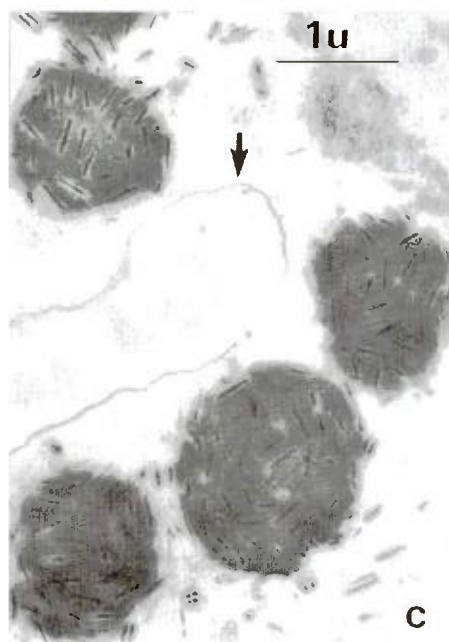
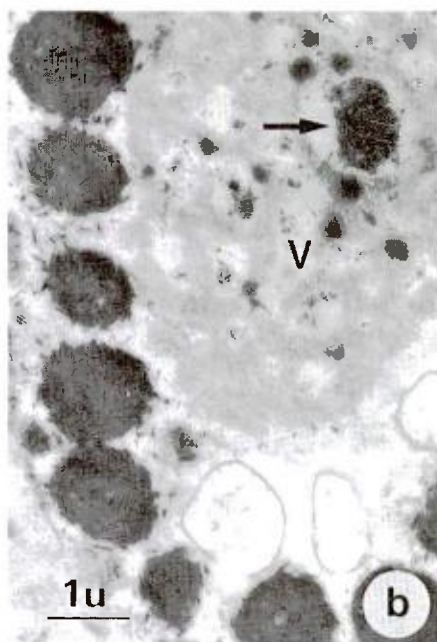
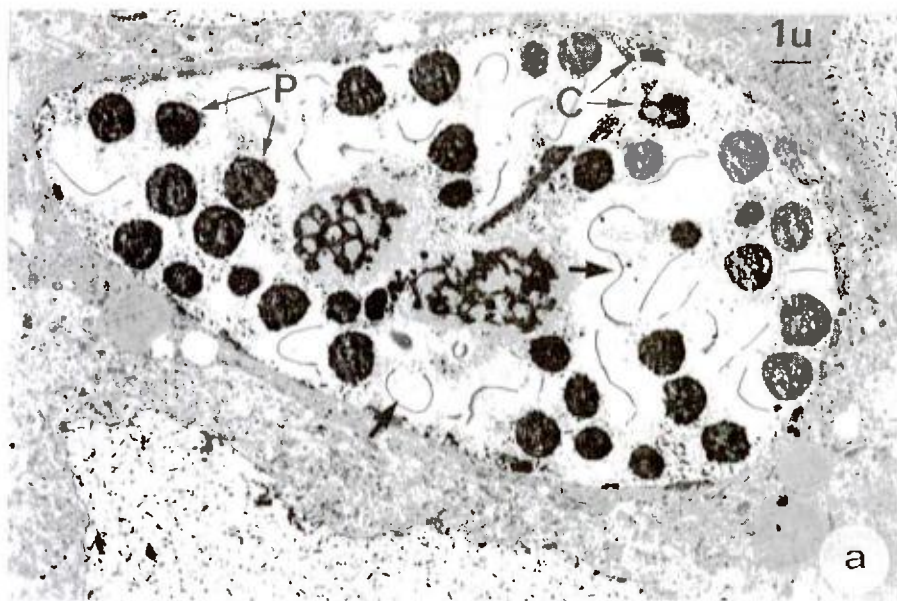


FIGURE 3.

EFFECT OF REFRIGERATION ON HATCHING OF EGGS
OF MULTIVOLTINE RACE, BOMBYX MORI L.

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Investigations were carried out on the effect of refrigeration on hatching of the eggs of multivoltine race, Bombyx mori L. The results revealed that the multivoltine race could be preserved upto 30 days, but the short refrigeration is better. There was no adverse effect on incubation period and hatching percentage.

INTRODUCTION

Refrigeration is a common means followed to delay the hatching of silkworm eggs for various purposes. Sometimes this is done even to synchronise hatching of all the batches of eggs and also the eggs of different races to take up silkworm rearing simultaneously. According to Narasimha Murthy (1939 a,b; 1943 a,b) multivoltine eggs of Bombyx mori could be safely refrigerated upto 3 days, the egg hatching was poor. 9 day-old eggs of Indo-Japanese races could be safely refrigerated for 3 to 7 days. As observed by Devaiah and Thontadrya (1975), hatching was not affected significantly among various durations of egg refrigeration when eggs of a hybrid, Pure Mysore x H.S.6 of 1, 3, 5 and 7 day-old were refrigerated. However, when 9 day-old eggs were refrigerated to different lengths of time, there was a significant difference in hatching in that lowest percentage of hatching 79.21 was observed in case of eggs refrigerated for 4 days. As such studies were carried out to find out the effect of refrigeration on hatching of eggs of multivoltine race Bombyx mori L. and the results are reported in this paper.

MATERIALS AND METHODS

The experiment was conducted with 10 treatments of refrigeration. After first preservation, disease free layings of Pure Mysore multivoltine race were released on 10, 15, 20, 25, 30, 35, 40, 45, 50 and 55 days. The layings were preserved at 5°C temperature in refrigeration. Each treatment was replicated 4 times having 5 DFLs in each replication. The observations were recorded on percentage of hatching and incubation period. The experiment was conducted during Jan-Feb., 1986.

RESULTS AND DISCUSSION

From the Table 1, it is observed that the hatching percentage decreased from 93.99 to 80.92% as the refrigeration period increased from 10 to 30 days.

The minimum refrigeration period of 10 days gave significantly highest hatching percentage. However, the hatching percentage differed significantly at the preservation schedule of 10, 15 and 20 days. There was drastic reduction in hatching percentage when eggs were preserved for 30 days and above. The preservation of eggs for 25 to 30 days showed average of 81% of hatching, which was statistically similar to each other. Subsequent preservation schedule from 35 to 55 days showed decrease in hatching percentage from 79 to 24%.

The incubation period was less upto 30 days refrigeration (11 to 12 days). Further, it was delayed for 1 or 2 days as the refrigeration period increased upto 55 days.

From the results it is concluded that the multivoltine race could be preserved upto 30 days, but the short refrigeration is better. There was no adverse effect on incubation period and hatching percentage. Govindan *et al.* (1980) observed that the refrigeration of eggs of *Samia cynthia ricini* beyond 5 days of age has adverse effect on hatching. Govindan and Narayana Swamy (1986) reported that the multivoltine silkworm eggs at eye spot stage can be refrigerated for one day without causing deterioration in the economic traits.

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Treatments	Hatching percentage	Released on	Date of hatching	Incubation period (days)
1. 10 days	93.99 (75.832)*	31.1.86	12.2.86	12 days
2. 15 days	89.88 (71.472)	8.1.86	20.1.86	12 days
3. 20 days	88.09 (69.852)	8.2.86	19.2.86	11 days
4. 25 days	82.82 (65.322)	13.2.86	24.2.86	11 days
5. 30 days	80.92 (64.102)	24.1.86	4.2.86	11 days
6. 35 days	79.09 (62.832)	29.1.86	12.2.86	14 days
7. 40 days	75.58 (60.382)	2.2.86	16.2.86	14 days
8. 45 days	56.02 (48.462)	7.2.86	19.2.86	12 days
9. 50 days	32.91 (34.997)	12.2.86	25.2.86	13 days
10. 55 days	24.15 (29.415)	17.2.86	29.2.86	13 days
S.E. †	0.569			
C.D. (P=0.05)	1.653			

* Angular transformed values

Table 1. Effect of refrigeration on hatching of silkworm eggs (multivoltine race).

HETEROSIS EFFECT ON ECONOMIC TRAITS OF NEW HYBRIDS OF SILKWORM,
BOMBYX MORI L. UNDER MARATHWADA CONDITIONS

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In the present study heterosis was worked out by using both the mid parental and better parental values for reproductive, developmental and production (economic) traits of twelve hybrids of silkworm, *Bombyx mori*.

For most of the characters low to moderate heterosis effects were observed. Significant and negative heterosis and heterobeltiosis were observed for the characters: percentage of unhatched and unfertilized eggs, floss percentage and larval period for the crosses HMxNB7, HMxNB4D2, NB4D2xNB18, NB18xNB4D2, NB4D2xHM which is a desirable trend. Very high heterotic effects were noticed for weight of full grown larvae (52.05%), single cocoon weight (52.01%), shell weight (60.23%), filament length (65.21%) and yield of cocoons (47.26%) in the cross HMxNB4D2. The crosses HMxNB7 (41.11%) and HMxNB18 were found to be superior for cocoon yields. The heterobeltiosis was also higher in these crosses HMxNB4D2, HMxNB7 and HMxNB18 for most of the characters. None of the crosses showed significant positive heterosis either over mid parent or better parent for percentage hatching.

INTRODUCTION

The expression of heterosis is usually more in the hybrids obtained from the genetically related lines in plants (Moll *et al.*, 1962; Gomez, 1966). This principle is also applicable in animals.

The development as well as the economic assessment of utilization of heterosis in Japanese sericulture was described in recently published report by Yokoyama

(1974). The pioneering work of Toyama in 1915 on the hybridization in silkworm in Japan was a landmark in the history of sericulture (Osawa, 1936; Jolly, 1983). The increased hybrid vigour has been reported in silkworm, *Bombyx mori* L. by Toyama (1905, 1906 a,b), Sidhu *et al.* (1969 a,b), Sengupta *et al.* (1971), Petkov and Yolov (1979), Nacheva (1980) and Iyengar *et al.* (1983).

MATERIALS AND METHODS

Four promising races of silkworm, *Bombyx mori* viz., Hosa Mysore (HM), NB7, NB18 and NB4D2 having adequate genetic diversity for different economic traits were crossed in all possible combinations including reciprocals. Thus twelve crosses (Table 1) formed the experimental material of the present study. Heterosis in F1 crosses can be expressed over (i) the mid-parental value of the parents involved in the cross or (ii) the better parental value. The latter is also called as heterobeliosis. In the present study heterosis was worked out by using both the methods for thirteen characters.

Heterosis was computed as:

$$(i) \text{ Per cent heterosis over } \overline{MP} = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} \times 100$$

$$\text{S.Ed. } (\overline{F1} - \overline{MP}) = \sqrt{\frac{3 \text{ EMS}}{2 r}}$$

$$\text{C.D.} = \text{S.Ed.} \times 't' \text{ value.}$$

$$(ii) \text{ Per cent heterobeliosis over } \overline{BP} = \frac{\overline{F1} - \overline{BP}}{\overline{BP}} \times 100$$

$$\text{S.Ed. } (\overline{F1} - \overline{BP}) = \sqrt{\frac{2 \text{ EMS}}{r}}$$

$$\text{C.D.} = \text{S.Ed.} \times 't' \text{ value.}$$

The experiment was conducted during Sept-Oct., 1983. The results are given in Table 1.

RESULTS AND DISCUSSION

The present chapter is studied in following headlines.

Egg characters:

The cross HM x NB7 showed significant positive heterosis over mid and better parent to the extent of 19.05 and 16.29 % respectively for number of eggs per laying. The cross HM x NB4D2 showed highest significant and positive heterosis over mid parent (20.50%) for the same character. Benchamin *et al.* (1983) suggested the use of bivoltine male parent with multivoltine breed for more production of commercial seed which was on par with bivoltine pure races. Nacheva (1980) also reported increased hybrid vigour with regard to hatchability and vitality of eggs. Positive heterosis over mid and better parent was also observed in the crosses HM x NB4D2 and HM x NB18 for hatchability. None of the crosses showed significant positive heterosis over mid or better parent.

For the characters percentage of unhatched and unfertilized eggs, significant and negative heterosis over better parents was observed in the crosses HM x NB4D2, NB18 x NB4D2 and NB4D2 x NB7. In addition, the crosses NB4D2 x HM and NB4D2 x NB18 have also shown significant negative heterosis over better parent for percentage of unfertilized eggs. Most of the crosses showed negative heterobeltiosis for this trait which is desirable. Toyama (1905, 1906 a,b) quoted that the F1 hybrids could have superior qualities of both parents bringing great benefit to the farmers who reared the F1 hybrids. Benchamin and Krishnaswami (1981 a,b) observed superiority of hybrids over parental pure stocks in egg production efficiency.

Larval characters:

Significant and positive heterosis was observed in the cross HM x NB4D2 to the maximum extent of 40.88 and 53.05 % over better parent and mid parent respectively for the weight of 10 fullgrown larvae. The cross HM x NB18 and its reciprocal have also shown significant and positive heterosis over mid and better parent. Nacheva (1980) observed heterosis in larval weight.

In case of larval period most of the crosses exhibited negative and significant heterosis over mid and better parent. The highest negative and significant heterosis over mid parent was observed in NB4D2 x NB18 (-19.42%). The cross NB7 x HM had shown maximum heterosis over better parent (-10.43%).

Most of the crosses showed significant and positive heterosis over mid and better parent for weight of silk glands. Maximum heterosis over mid parent was observed in the cross HM x NB18 (50.93%) followed by HM x NB4D2 (40.13%) and HM x NB7 (34.84%). Highest heterobeltiosis (24.83%) was recorded in NB4D2 x NB7 followed by NB7 x NB4D2, HM x NB18 and HM x NB4D2.

Cocoon characters:

Most of the crosses showed significant positive heterosis over mid as well as better parent for single cocoon weight and shell weight. The highest heterosis over mid and better parent was observed in HM x NB4D2 (52.01 and 38.26% for cocoon weight and 60.23 and 28.17% for shell weight). The next best performance was observed in the crosses HM x NB7, HM x NB18 and NB4D2 x HM for both these characters. Krishnaswami *et al.* (1964) observed heterosis in most of the cross combinations for these important economic traits. The inter-racial hybrids had, in general, excelled the better parent of the particular cross in respect of egg viability, average shell weight and total weight of shell harvested per 100 worms brushed. The best hybrid had given about 30% more than the top parent and slightly more than 30% over the mean of its parents.

The range of heterosis over mid parent was from -0.76 to 9.44% for shell percentage. Positive and significant heterosis was observed in the cross NB4D2 x HM.

For floss percentage, most of the crosses showed significant negative heterosis over better parent. The highest significant negative heterosis over mid and better parent was observed in the cross NB7 x HM and its reciprocal (-65.85, -73.22 and -44.42, -56.42% respectively).

Most of the crosses showed significant positive heterosis over mid parent for cocoon filament length. The range of heterosis was 6.63 to 65.21%. Maximum heterosis was observed in HM x NB4D2 (65.21%) followed by NB18 x NB4D2 (55.14%), NB4D2 x HM (52.27%) and HM x NB7 (30.64%). The range of heterosis over better parent was from -13.45 to 46.48%. Three crosses viz., NB18 x NB4D2, HM x NB4D2 and NB4D2 x HM showed higher heterosis (28 to 47%) over better parent. Nacheva (1980) obtained distinct heterosis both with respect to the mean parent and better parent values for length

of silk fibre, in all the hybrids studied by him.

Cocoon yield per 10,000 larvae brushed:

Maximum manifestation of heterosis was observed for yield per 10,000 larvae brushed as compared to other characters. The cross HM x NB4D2 showed maximum heterosis and heterobeltiosis (47.26 and 42.33% respectively). Two other crosses showing significantly high heterosis over mid and better parent were, HM x NB7 (41.11 and 31.18% respectively). Significant and positive heterosis over mid and better parent was also observed in five other crosses with heterotic range from 6 to 22%. Sidhu *et al.* (1969) observed heterosis for yield per 10,000 larvae brushed in the range of 53 to 80% in different hybrids. Maximum heterosis to the extent of 80% was reported when multivoltine breed was utilized as female parent. Sengupta *et al.* (1974) and Iyengar *et al.* (1983) also reported significant heterosis for this character.

The present studies also indicated superior performance of HM x NB4D2 for cocoon yield over the other races under Parbhani conditions. Heterosis for cocoon yield in this case is the manifestation of heterosis for other component traits such as number of eggs per laying, weight of fullgrown larvae, weight of silkglands, single cocoon weight, shell weight, shell percentage and filament length.

The extent of heterosis was fairly high for many characters studied. Although heterosis was a result of overdominance in many instances, linked favourable dominant genes also contributed to heterosis. The present studies and other studies undertaken in this laboratory (Tayade, 1983 a,b,c and Tayade and Jawale, 1984) indicate that the hybrids HM x NB7 and HM x NB4D2 could be commercially exploited in Marathwada after further evaluation on field scale.

ACKNOWLEDGEMENTS

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* Originals not seen.

Hybrids	Total No. of eggs/ laying		Percentage of hatching		Percentage of unhatched eggs		Percentage of unfertilized eggs		Weight of fullgrown larvae		Larval period	
	$\overline{MP}$	$\overline{BP}$	$\overline{MP}$	$\overline{BP}$	$\overline{MP}$	$\overline{BP}$	$\overline{MP}$	$\overline{BP}$	$\overline{MP}$	$\overline{BP}$	$\overline{MP}$	$\overline{BP}$
1. HMxNB7	19.05*	16.29*	-1.87	-1.91	-11.51	-17.48	58.78	35.87	12.43	-4.83*	-1.22	-3.50*
2. HMxNB18	5.59	0.59	2.06	0.47	-33.20	-42.71	30.87	27.32	24.89*	11.87*	-6.95*	-7.34*
3. HMxNB4D2	20.50*	8.30	16.15	4.87	-61.78*	-70.34*	-34.19	-53.61*	53.05*	40.88*	-5.12*	-6.64*
4. NB7xNB18	-26.01*	-27.88*	-3.55*	-5.08	-15.70	-23.00	83.96*	54.15	-11.08*	-18.92*	-0.85	-3.50*
5. NB7xNB4D2	-9.92	-17.29*	1.52	-11.06*	4.10	-23.08	18.93	-6.43	-0.37	-9.14*	-2.03	-5.80*
6. NB18xNB4D2	5.53	-0.74	9.51	-2.49	-48.18	-63.86*	-12.88	-39.55*	-0.94	-3.85*	0.38	-0.82
7. NB7xHM	-29.76*	-31.38*	-19.77*	-19.80*	72.88*	60.94	196.28*	154.01*	-1.50	-16.63*	-8.32*	-10.43*
8. NB18xHM	-26.55*	-30.03*	-3.53	-5.03	-0.58	-14.73	84.86*	79.84	6.59*	16.33*	-6.59*	-6.99*
9. NB4D2xHM	-21.57*	-29.51*	7.33	-3.08	-16.70	-35.35	-37.57	-55.99*	4.24*	-4.03*	-7.69*	-9.19*
10. NB18xNB7	1.91	4.38	-4.70	-6.22	38.46	26.47	8.59	-9.00	-5.70*	-11.59*	2.77	-0.008
11. NB4D2xNB7	2.85	-5.56	10.03	-6.20	-36.15	-52.88*	-38.41	-51.54*	-3.56*	-12.05*	2.01	-1.90
12. NB4D2xNB18	-8.95	-14.38*	-5.24	-15.63*	31.11	-8.55	-35.54	-55.28*	-14.34*	-16.86*	-19.42*	-4.50*
S.E. ±	23.53	27.17	3.73	4.31	4.02	4.64	2.167	2.503	0.554	0.639	0.383	0.443
C.D. at 5%	46.11	53.25	7.31	8.43	7.88	9.09	4.248	4.905	1.086	1.254	0.752	0.868

* significant at 5% level

Table I. Percentage heterosis in F1 hybrids over mid and better parent.

(to be continued...)

	Height of silkglands		Single cocoon weight		Shell weight		Shell percentage		Floss percentage		Filament length		Yield/ 10,000 larvae brushed	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1.	34.84*	7.66	29.67	12.10*	33.83*	2.18	3.03	-4.86*	-44.42*	-56.42*	30.64*	-4.87	41.11*	31.18*
2.	50.93*	19.62*	40.12*	25.63*	40.61*	10.54*	1.38	-6.63*	21.38*	-20.90*	25.28*	3.57	35.07*	21.46*
3.	40.13*	13.30*	52.01*	38.26*	60.23*	28.17*	8.75*	-4.25*	-0.84	-12.02*	65.21*	38.59*	47.26*	42.33*
4.	7.27*	6.21	6.78*	2.45	8.62*	4.87	0.89	0.61	96.52*	43.02*	20.19*	5.63*	12.33*	8.34*
5.	25.71	23.66*	12.00*	5.84*	16.52*	10.00*	1.97	1.91*	31.02*	13.58*	21.90*	1.98*	21.91*	17.09*
6.	3.12	0.45	1.29	-0.29	6.11*	8.67	2.02	1.79	16.60	-18.87*	55.14*	46.48*	8.86*	1.00
7.	28.76*	2.81	11.06*	-3.98	12.58*	-13.71*	2.16	-5.67*	-65.85*	-73.22*	19.12*	-13.25*	5.72*	-1.71
8.	24.27*	-1.50	2.13	-8.42*	-1.75	-22.76*	-0.76	-8.61*	18.86*	-22.54*	8.04	-13.45*	-2.95	-12.74*
9.	33.11*	7.63	19.02*	8.24*	37.80*	10.23*	9.44*	0.99	-13.52*	-23.36*	52.27*	27.73*	14.67*	10.83*
10.	-0.34	-1.34	6.78*	2.45	3.74	0.15	-1.50	-1.79	73.98*	33.41*	7.10	-5.86	11.72*	7.75*
11.	26.91*	24.83*	-0.39	-5.86*	10.71*	4.52	5.65*	5.59*	24.51*	7.93	19.74*	0.18	10.70*	6.33*
12.	-20.53*	-22.59*	-5.93*	-7.42*	-8.37*	-10.47*	-1.29	-1.52	32.57*	-7.76	6.63	0.68	-1.17	-8.31*
S.E.*	0.039	0.045	0.040	0.046	0.007	0.0089	0.446	0.516	0.389	0.392	36.52	42.17	0.276	0.318
C.D. at 5%	0.077	0.089	0.079	0.091	0.015	0.017	0.875	1.011	0.666	0.769	71.59	82.66	0.541	0.624

* significant at 5% level

Table I. (continued)

A STUDY ON ESTERASE ISOZYME OF SILKWORM (BOMBYX MORI) EMBRYO

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In this experiment, the eggs of silkworm Dong Fei x Huane F1 and other silkworm races were used as materials. The preliminary results showed that there are evident divergences both in number of isozyme band and the stain-ability of those between different embryo stages. The number of isozyme band increased accompanying with the development of silkworm embryo. At trachea formation phase, 12 isozyme bands can be observed which may be divided into four regions, namely A, B, C and D respectively, and the 12 isozyme bands can be named as A1, A2, A3, A4; B1, B2, B3, B4; C1, C2; D1, D2 from anode (quick band) to cathode (slow band) in order.

At the longest phase of embryo development, the isozyme bands of silkworm races showed different features, and some of them the "D" bands were deficient.

The heterosis of silkworm's hybrids may be caused by the occurrence and their vitality of A1, B1, C1, C2, D1, D2 isozyme bands.

INTRODUCTION

Many papers have been reported about blood esterase isozyme of silkworm. Yoshita *et al.* (1965) studied blood esterase isozyme by means of agar gel electrophoresis. They observed one isozyme band and assumed that they could be grouped under four types, A, B, C and D which were controlled by four allele genes, *Bes*^A, *Bes*^B, *Bes*^C and *Bes*^D. Nasirilayv Y.A. *et al.* (1977) reported their research and mentioned that the activity of esterase isozyme was little related with the cocoon quality. He Jia Lu *et al.* (1981, 1983) studied silkworm larva and pupa blood esterase isozyme by means of polyacrylamide gel electrophoresis and observed that there were three regions,

namely A, B and C. The isozyme map showed mainly four phenotypes, A1, A2, A1A2, A0. They supposed they were controlled by three multiple allelic genes of codominance, namely A1, A2 and A0.

Naietova *et al.* (1979) analysed the activity of embryo esterase, acid phosphatase, glucose phosphate dehydrogenase and aspartate transcarbamylase with 12 races of silkworm diapause eggs. According to the enzyme maps and electrophoretic mobilities, they mentioned that there were pleomorphism among the races of silkworm and emphasized that the pleomorphism of enzyme was an important characteristic for selection of the initial parent.

As was stated above, different materials used, different analyse techniques, the results obtained were different, moreover, the nomenclature was not the same. Especially, the different stages of embryo of silkworm eggs had not been well studied. In order to clarify the divergence of silkworm esterase isozyme in different stages of embryo development, we conducted this experiment.

MATERIALS AND METHODS

For this experiment, we utilized silkworm eggs at different stages of varieties Dong Fei and Huane F1 and other 18 races as materials. By means of the technique of polyacrylamide electrophoresis, used α - and β -Naphthyl acetate as substrate, fast blue salt B as dye.

RESULTS AND DISCUSSION

1. The types of esterase isozyme during silkworm embryo development:

Polyacrylamide gel plate showed 12 isozyme bands which can be divided into four regions: A, B, C and D, according to the depth of staining as well as to the moving velocity towards the anode, the 12 isozyme bands can be named as A1, A2, A3, A4; B1, B2, B3, B4; C1, C2; D1, D2, respectively.

B bands stained heavily, especially B1 band, its activity was stronger than all of other bands, while the A bands stained lighter than that of the B bands, their activity showed $A1 > A3 > A4 > A2$. C bands were lighter than that of A and B, C1 showed narrow, but C2 wider. D bands were made up by two wide bands, which stained lightly.

2. The change of esterase isozyme during the course of silkworm embryo development:

After observing the distribution of esterase isozyme, we discovered that the number of band increased, so that the bands stained heavily accompanying with the development of silkworm embryo (Table 1) (Fig. 1, Fig. 2).

Based on Table 1, we saw that the number of isozyme bands increased from 6 (longest phase) to 12 (blastokinese completion), and the isozyme bands stained heavily when blastokinese begins and at trachea formation stage.

3. Divergence of esterase isozyme between different races of silkworm during longest phase of embryo:

Comparison of esterase isozyme bands between different races of silkworm embryo during longest phase, we discovered that there are still four regions (A, B, C, D), but showed evident diverse. Isozyme bands can be divided into 6 types in accordance with the bands whether existing or not, stained deeply or lightly.

Type 1 such as "794" showed A, B1, B2, B3, C1, C2. Type 2 such as Barling yellow, Zheng 11, etc, showed A, B, C1, C2. In type 2, B region deeper than all of the others, A region deep, in C region, C1 narrow but C2 wide, stained lightly. Type 3 such as Wuling No.1, W2, etc, showed A, B, C1, C2. In type 3, A band deeper and wider, B band narrow and light, C1, C2 like type 2, no "D". Type 4 such as Jelis, etc, A band deep and narrow, B light and narrow, C light and wide, D deep and wide. Type 5 such as J13W, A band deep, B1 light, B2 light and narrow, C2 wide and light. Type 6 such as 8212, A band very deep and narrow, B deep, C1, C2 wide and light, D1, D2 deeper than C and wide (Fig. 3).

4. Comparison of esterase isozyme bands between varieties and their F1 hybrid:

Japanese variety Dongfei, Chinese variety Huane and their F1 hybrid during longest phase of silkworm embryo have been used as materials in 1985 spring. We observed that Dongfei have A, B1, B2, B3, C, D1, D2; Huane have A, C1, C2, D1, C2, no B; Huane x Dongfei F1 have A1, B1, C1, C2, D1, D2. Huane have no B, but C region deep, especially C2 stained deeply, but Dongfei's B band showed intensive activity.

The bands of A1, B1, C1, C2, D1, D2 of F1 stained deeper than that of their parents. So, the heterosis of Dongfei x Huane hybrids may be caused by the occurrence and their intensification of A1, B1, C1, C2, D1, D2 isozyme bands.

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Days before hatching	Embryo development phase	Numbers and features of esterase isozymes			
		A	B	C	D
12 (1)	longest prophase	A_1^{++}, A_4^+, A_3	B_1^{+++}	C_1, C_2	
11 (2)	longest phase	A_1	B_1^{++}	C_1, C_2	D_1, D_2
10 (3)	fat-thick phase	A_1^+, A_4, A_3	B_1^{++}	C_1, C_2	D_1, D_2
9 (4)	appendage occurrence phase	A_1^{++}, A_3, A_4	B_1^{++++}	C_1^+, C_2^+	D_1, D_2
8 (5)	appendage formation prophase	A_1^{++}, A_3^+, A_4	B_1^{+++}	C_1^+, C_2^+	D_1, D_2
7 (6)	appendage formation anaphase	A_1^{++}, A_3^+, A_4	B_1^{+++}	C_1^+, C_2^+	D_1, D_2
6 (7)(9)	shorten phase	A_1^{++}, A_3^+, A_4^+	B_1^{+++}	C_1^+, C_2^+	D_1, D_2
5 (8)(10)	blastokinese beginning	A_1^{++}, A_3^+, A_4^+	$B_1^{+++}, B_2^+, B_3, B_4$	C_1^{++}, C_2^{++}	D_1^+, D_2
4 (11)	blastokinese completion	$A_1^{++}, A_2^+, A_3^+, A_4^+$	$B_1^{+++}, B_2^{++}, B_3, B_4$	C_1^{++}, C_2^{++}	D_1^+, D_2
3 (12)	trachea formation	$A_1^{++}, A_2^+, A_3^+, A_4^+$	$B_1^{+++}, B_2^{++}, B_3, B_4$	C_1^{++}, C_2^{++}	D_1^+, D_2^+

Table I. The types of esterase isozyme during the development stage of silkworm embryo.
(Spring, 1985)

LEGENDS TO THE FIGURES

Fig. 1. Esterase isozymatic type during silkworm embryo development.
(4),(5),(6),(7),(8).

Fig. 2. Esterase isozymatic type during silkworm embryo development.
(9),(10),(11),(12).

Fig. 3. Divergence of esterase isozyme between different varieties of silkworm
during longest phase of embryo development.

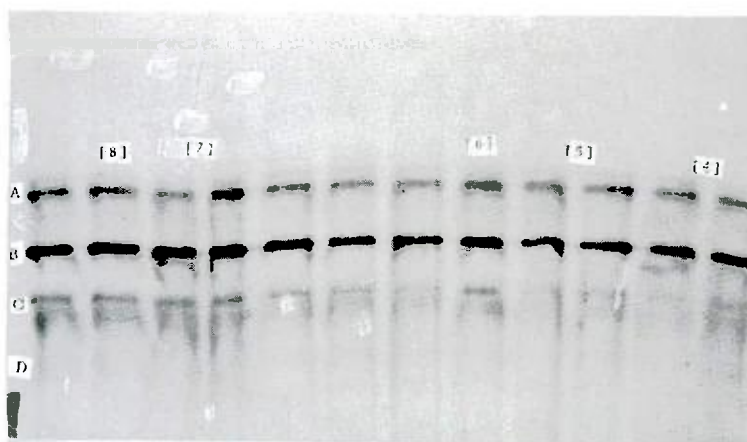


FIG. 1

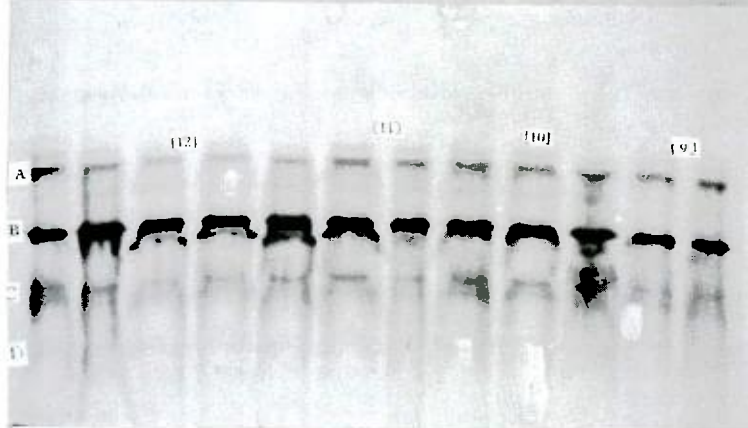


FIG. 2.

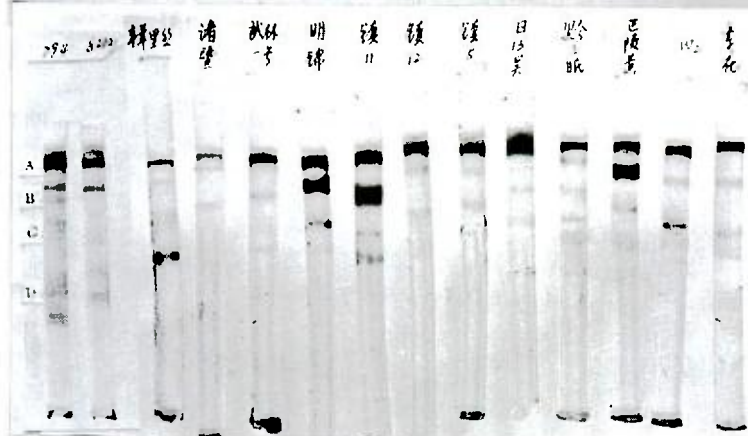


FIG. 3

EFFECT OF JUVENILE HORMONE (MANTA) ON THE GROWTH OF SILKWORM

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Bivoltine silkworm races in Thailand were established on September 1, 1969. The researchers began on the testing of many current techniques as well as applicability to the farmers until 1986.

INTRODUCTION

Bivoltine silkworm rearing method in Thailand carries on 4 to 8 crops each year, the stabilization and increase of the cocoon yield is necessary. Yokichi Kobari and Hiromu Akai (1) found that administration of the standard Manta Solution (diluted 5-500 times) during the 48th to 60th hour of the 5th instar, resulted in the increase of cocoon shell weight by 6 to 10 percent, using C131xN136, a Japanese bivoltine silkworm race. We tried to test this effect in our laboratory where climatic factors and silkworm variety are different from Japan.

MATERIAL AND METHOD

Time of feeding :

6.00 o'clock	30% of daily supplied leaves
11.00 o'clock	30% of daily supplied leaves
16.00 o'clock	40% of daily supplied leaves

Randomized complete "blocks" with 5 treatments and 4 replications. Control.

- Juvenile hormone, sprayed immediately after the 4th ecdysis.
- Juvenile hormone, sprayed at the 24th hour of the 5th instar.
- Juvenile hormone, sprayed at the 48th hour of the 5th instar.
- Juvenile hormone, sprayed at the 72th hour of the 5th instar.

Juvenile hormone, dose : 50 times, 150 c.c./200 larvae.
* Component of juvenile hormone : Methopene.

RESULT

Unexpectedly, the activities of juvenile hormone sprayed showed hardly clear effects on quality of cocoon among treatments under these rearing conditions.

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SV	df	MOUNTING NUMBER	SOUND PUPA NUMBER	SOUND COCOON WEIGHT (g)	COCOON WEIGHT (g)	COCOON SHELL WEIGHT (g)	COCOON SHELL PERCENT (%)
Replication	3	176.5833	154.4500	1048.3333	0.0074	2.4500	0.3660
Treatment	4	45.12501	44.17501	34.37501	0.0011 1.83ns	1.0750 4.45*	0.6708 3.99*
Error	12	114.4583	145.5750	332.7083	0.0006	0.2417	0.1681
CV %		5.6	6.5	5.5	1.6	1.6	2.0

Table I. Analysis of variance, January - February

TREATMENT	MOUNTING NUMBER	SOUND PUPA NUMBER	SOUND COCOON WEIGHT (g)	WHOLE COCOON WEIGHT (g)	COCOON SHELL WEIGHT (cg)	COCOON SHELL PERCENT (%)
1. Control	189 a	185 a	280 a	1.54 a	31.8 ab	20.5 A
2. 0 hour	193 a	191 a	285 a	1.57 a	21.0 a	20.4 a
3. 24 hour	185 a	182 a	279 a	1.58 a	32.2 a	20.4 a
4. 48 hour	192 a	188 a	284 a	1.58 a	31.2 b	19.7 b
5. 72 hour	192 a	188 a	285 a	1.58 a	31.0 b	19.7 b

Table II. Means, January - February

S V	df	MOUNTING	SOUND PUPA	WHOLE COCOON	COCOON SHELL
		NUMBER	NUMBER	WEIGHT (g)	WEIGHT (g)
Replication	3	78.9333	97.5166	607.9166	0.0054
Treatment	4	791.5500**	1224.4250	8682.5000**	0.0026 ns
Error	12	61.3500	152.8916	389.1666	0.0011
CV %		4.1	6.7	7.9	2.4

Table III. Analysis of variance, June - July

TREATMENT	MOUNTING	SOUND PUPA	SOUND COCOON	WHOLE COCOON
	NUMBER	NUMBER	WEIGHT (g)	WEIGHT (g)
1. Control	198 a	197 a	274 a	1.42 a
2. 0 hour	198 a	196 a	270 a	1.39 a
3. 24 hour	196 a	192 a	272 a	1.44 a
4. 48 hour	190 a	178 a	225 a	1.44 a
5. 72 hour	155 b	155 b	165 b	1.39 a

Table IV. Means, June - July

OVIPOSITION IN SILKWORM AND ITS CONTROL

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Oviposition behaviour was studied in the silkworm *Bombyx mori* and the role of certain sensory hairs present in large numbers on the anal papillae in controlling this behaviour was examined. It was evident that these hairs play an important role in controlling and guiding oviposition because when some of these hairs were ablated, the egg laying behaviour as well as the number of eggs laid were affected. Studies on the physiological properties of these hairs were carried out in order to understand the oviposition mechanism and its control more clearly. The properties of some of the hairs were suggestive of their functioning as mechanoreceptors while those of the others were suggestive of their chemosensitivity. It was abundantly clear from the studies that the central nervous system receives a strong sensory feed back from the ovipositor with the help of these sensory hairs which plays a very important role in the control of oviposition.

Present studies also confirmed that while the brain may control and influence oviposition in silkworm, the phenomenon is a segmental reflex being capable of manifesting itself when the last abdominal ganglion alone is connected to the ovipositor. With the above knowledge, further studies which have been planned with the hope of converging on an artificial environment which might increase the number of eggs laid are in progress.

INTRODUCTION

The silkworm *dombyx mori* lays eggs in a compact monolayer normally and the eggs are never piled up except under certain pathological conditions. From this, it is clear that the insect is able to detect the presence of the eggs already laid with the help of some sensory structures. It has been observed that the moth 'scans' the oviposition field by repeatedly bringing the anal papillae in contact with the substratum. The anal papillae are richly supplied with hair sensilla and there have been some studies examining the functional significance of these hairs (Ishikawa & Hirao, 1961; Yamaoka *et al.*, 1971). The purpose of the present investigation was to know more about the properties of these hairs and their role in controlling oviposition.

Secondly, the segmental ganglia of insects are known to support many reflexes even when they are isolated and these segmental reflexes may be further controlled by the brain (Wigglesworth, 1972). The ovipositor and the tactile hairs on the anal papillae are innervated by the last abdominal ganglion in Silkworm (Yamaoka *et al.*, 1971; Yamaoka and Hirao, 1971; 1973). Preliminary experiments were carried out to examine the oviposition behaviour when the last abdominal ganglion alone was kept intact, before we proceed to the examination of the nature of control exerted by the brain on this behaviour.

MATERIAL AND METHODS

Female silkmoths of the bivoltine race NB7 were used immediately after their emergence for all experiments.

Ablation of tactile hairs

The hairs were ablated and the bases of the hairs treated with concentrated HCl as described by Yamaoka *et al.* (1971) and the ovipositor was subsequently washed well. Following this, they were allowed to copulate for 4 to 5 hours and transferred on to egg cards to examine the number of eggs laid every hour.

Silver staining of hair sensilla

To detect the presence of chemosensory hairs on the anal papillae, the hairs were stained using 10% silver nitrate as described by Sunita Venkatesh and Naresh Singh (1984).

Isolation of the last abdominal ganglion

The female pupae were cold anaesthetized for 4 to 6 hours four days after pupation. The ventral integument of the abdominal segments was incised 1 or 2 mm along the median line, with sharp and sterilized scissors or a surgical knife. The nerve cord was located under a binocular microscope. The nerve cord was cut with scissors just above the abdominal ganglion. The wound was sealed with collodion or paraffin wax (m.p. 42°C).

These operated pupae were transferred to an incubator maintained at 5°C temperature for 24 hours; during which period the wound was found to heal up. Then the pupae were transferred to room temperature (27±2°C) until emergence. Moths were allowed to copulate for 4 to 5 hours and transferred on to egg cards to examine the number of eggs laid.

RESULTS AND DISCUSSION

The hairs on the anal papillae were found to differ from each other morphologically. Based on the length of the hairs shaft, they could be classified into four types (Figs. 1a & 1b). The longest hairs measured around 667 μm (Type I) and the shortest hairs measured 203 μm (Type IV). The other two types of hairs were of intermediate length measuring around 444 μm (Type II) and 370 μm (Type III). These hairs were found to be distributed in a specific fashion which was constant in all the moths examined. The longer hairs (Types I & II) were distributed more densely peripherally (away from the oviporus). While the shorter two types of hairs were found scattered over the entire anal papillae being denser near the oviporus.

Morphologically hairs could also be differentiated into two types (Figs. 2a & 2b). Some of the hairs were found to have a sharp tip and these hairs did not take up staining indicating that they may be mechanosensitive hairs. On the other hand, some of the hairs exhibited a blunt tip and these hairs also took up the stain indicating that they may be chemosensitive, while the mechanosensitive hairs may be functioning in the perception of the texture of the substratum as suggested by Yamaoka *et al.* (1971), the functional significance of the chemosensitive hairs is not clear at present. The presence of chemoreceptors on the ovipositor has been shown in other insects also (Rice, 1976; Wolharst & Dethier, 1958; Hooper *et al.*, 1972).

It was also interesting to see that some of the hairs have a branched structure (Figs. 3a & 3b). These branches generally arose from the distal half of the hair shaft. It is not clear whether such a branching of the hairs influences their functioning.

The moths where one or more types of these hairs were ablated were found to copulate successfully. However, copulation was delayed and sometimes discontinuous. When the hairs were removed from either the left or right anal papilla, the moth was found to bend its caudal tip towards the operated side, during oviposition. When hairs were removed from both the anal papillae, the animal took a long time to lay eggs.

In all these operated animals, the eggs were laid in scattered manner and not in compact groups (Figs. 4a & 4b). The eggs laid by the operated animals were often piled up one above the other which was never found to occur in normal animals. In the operated moths, the duration of eggs laying (time required for laying 80% of the total number of eggs) as well as the interval between the laying of successive eggs were increased compared to the normal moths. Sometimes, the eggs laid by the operated moths were found to be non-sticky.

The total number of eggs laid very much decreased in moths which were deprived of hairs on the anal papillae. This decrease was maximum when the long peripheral hairs were ablated (Fig. 5). Ablation of Types I and II hairs, decreased the total number of eggs laid to 30% and that of Types III & IV decreased it to 50% of the normal numbers laid.

From the above, it is clear that the hairs on the anal papillae are closely involved in controlling oviposition behaviour. It is suggested that these hairs provide abundant sensory feed back information necessary for enabling the moth to lay eggs in such an orderly fashion. Absence of such a feedback input also appears to influence the fecundity of the animal in some way.

Isolation of the last abdominal ganglion did not interfere with oviposition. This confirms once again that this ganglion itself has the necessary neuronal circuits for bringing about the complex act of oviposition in Silkworm as

demonstrated first by Yamaoka and Hiraio (1971). Similar segmental control of oviposition has been demonstrated by Carrow *et al.* (1982) in Crickets. This and the findings of Yamaoka *et al.* (1971) prepare an interesting ground for further study on the neural control of oviposition in Silkworm.

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LEGEND TO THE FIGURES

Fig. 1. Scanning electron micrographs showing the distribution of different types of hairs on the anal papillae.

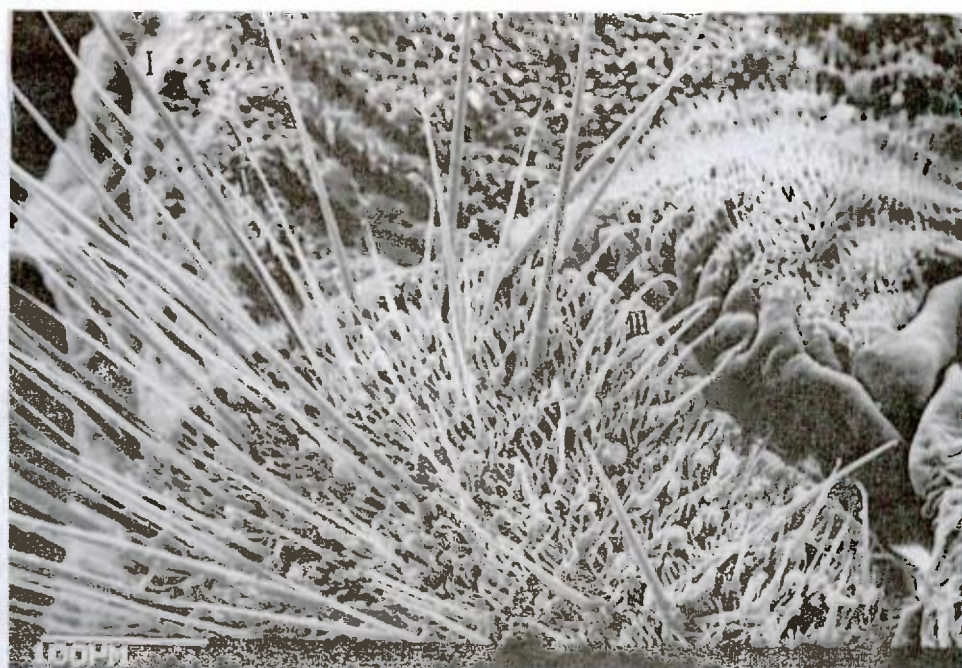
- a. A portion of the right anal papilla on ventral side showing Type I, Type II and Type III hairs.
- b. Dorsal side of the ovipositor showing Type III and Type IV hairs.

Fig. 2. Light micrographs of ethanolic silver nitrate stained ovipositor.

- a. Shows unstained mechanosensitive as well as stained chemosensitive hairs.
- b. Silver stained chemosensitive hair with blunt end.

Fig. 3 a & b. Light micrographs showing branched hairs on the ovipositor at different magnifications.

Fig. 4 Eggs laid by (a) normal moths, (b) moths in which all the hairs on the anal papillae were removed.



1 a

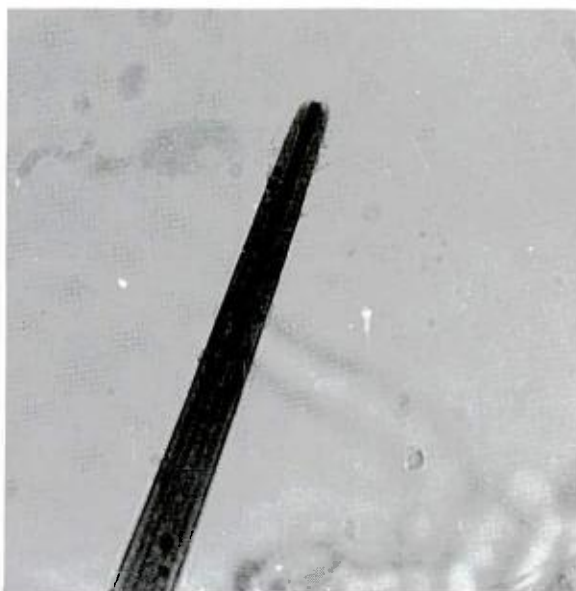


1 b

FIG. 1a FIG. 1b



2 a



2 b

FIG. 2a

FIG. 2b

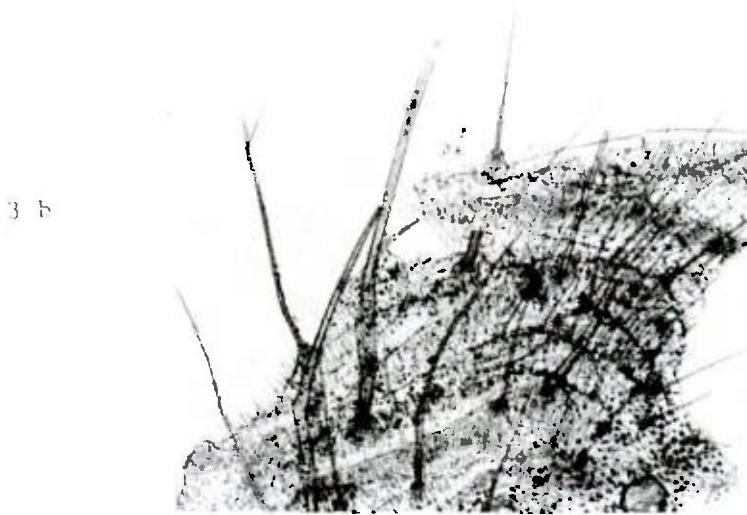
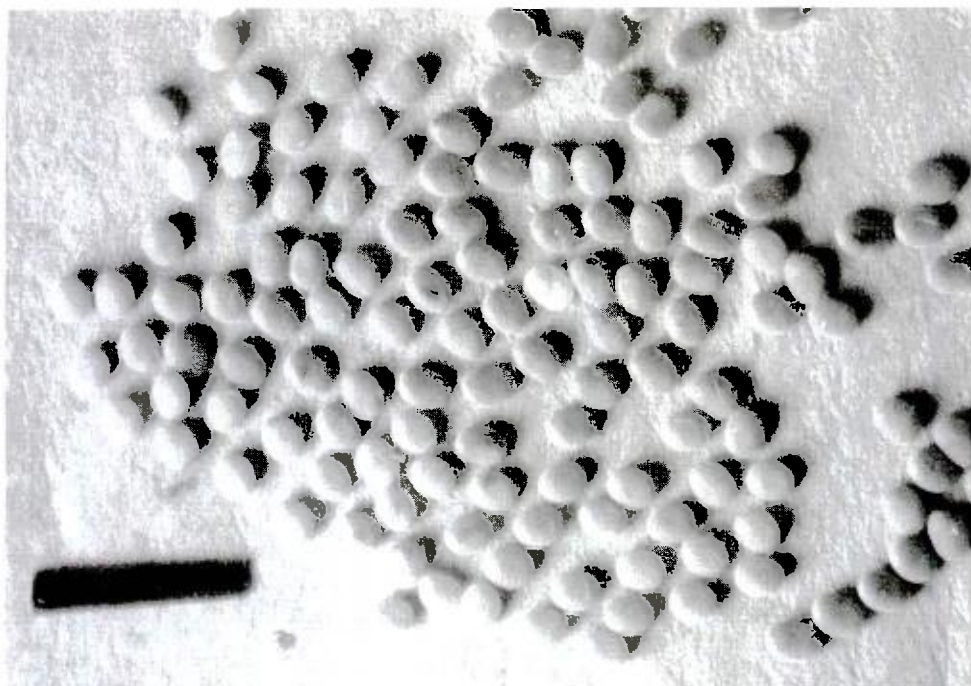


FIG. 3a FIG. 3b

4 a



4 b



FIG. 4a

FIG. 4b

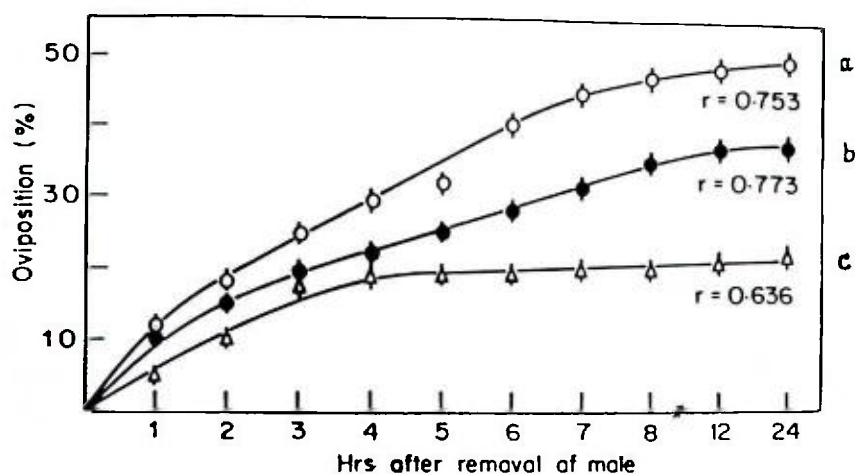


Fig. 5. % oviposition in operated moths. Mean number of eggs laid by normal animals is taken as 100.

- a. Sensilla III & IV ablated.
- b. Sensilla I & II ablated
- c. All the four types of sensilla ablated

(from Geethabali *et al.*, 1984)

STUDIES ON RESISTANCE OF BOMBYX MORI LARVAE TO
CYTOPLASMIC POLYHEDROSIS VIRUS
II - COMBINING ABILITY AND HERITABILITY

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With 4 bivoltine strains as group A and 4 strains of bivoltinism with their ancestry of multivoltinism, or of multivoltinism as group B, 32 crosses were made according to a diallel mating design to evaluate the combining ability and heritability of resistance of silkworm larvae to CPV. The result showed that the relative effect values of the general combining ability (GCA) among parents and the special combining ability (SCA) among crosses were significantly different. The differences of the relative effects of the GCA among multivoltine strains and bivoltine strains containing multivoltine pedigrees were larger than those among bivoltine strains. The reciprocal crosses as well as the crosses of one of these strains outcrossed with other strains gave different values in the relative effect of SCA of the same strains. Moreover, diallel analysis showed that the variance of GCA ($V_g\%$) was 76.63%, the value of SCA ($V_g\%$) was 23.37%. In the reciprocal crosses the variance for GCA ($V_g\%$) was 45.12, and the variance for SCA ($V_g\%$) was 54.88. Therefore, the former showed an obvious additive effect and the latter gave a non-additive effect. The broad sense heritability (BSH) was 87.84% and the narrow sense of heritability (NSH) was 67.32%. But in the reciprocal crosses, BSH was 97.06%, NSH was 43.79%.

STUDY ON RESISTANCE TO r-BHC AND ITS INHERITANCE
IN SILKWORM BOMBYX MORI

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Some notes on the resistance of the silkworm larvae to the topical application of r-BHC have been given in this study.

The LD50 values ($\mu\text{g/larva}$) to r-BHC in the 4th and 5th-instar larvae, just after ecdysis, generally increased with each instar. But the LD50 values ($\mu\text{g/g}$) did not vary from instar to instar.

With the feeding of mulberry leaves for six hours the degree of the resistance of the 4th-instar larvae, just after ecdysis, had increased markedly.

The resistance to r-BHC was almost same in both sexes. Generally, tested in this study, the LD50 values ($\mu\text{g/g}$) of r-BHC in the 4th-instar larvae, just after ecdysis, were 3.62 and 13.87 for the susceptible and the resistant strains respectively. Whereas in the 5th instar, just after ecdysis, these values were 3.53 and 9.91. When the frequency of 20 strains or more was plotted against Log LD50 values ($\mu\text{g/g}$) of r-BHC in the 4th and the 5th instar, just after ecdysis, a nearly normal-distributed curve was obtained in both sexes.

The mean LD50 values ($\mu\text{g/g}$) of r-BHC in the 4th and 5th instar larvae, just after ecdysis, were 7.46 and 7.62. They were nearly the same. The average body weight of the 5th instar larvae, just after ecdysis, in different strains usually had a significant correlation with the LD50 values ($\mu\text{g/larva}$) to r-BHC. On the other hand, the LD50 values ($\mu\text{g/larva}$) of r-BHC were related to cocoon weight, cocoon shell weight and the ratio of cocoon shell weight significantly, but were not related to the percentage of dead worm in cocoon.

The results of the LD50 values ($\mu\text{g/g}$) obtained and the Log dosage-probit mortality curves in resistant and susceptible strains, their F1, F2 and backcrosses under the study indicated

that r-BHC resistance was inherited from poly-systems. But sometimes those existed the major gene which was incompletely dominant while the sex-linked effect was negligible, these poly-genes, included the major gene, were considered to be located on the autosomes.

This paper is a part of the thesis for M.S. under Professor Lu Xing-Yuan's guidance.

INTRODUCTION

Because insecticides were being used in the crop and mulberry fields recently silkworm larvae were poisoned more seriously during the raining seasons. It probably made the production of silkworm cocoon decrease. Therefore studying on resistance to insecticides in Silkworm and trying to develop some insecticide-resistance varieties have been noticed by various authors in recent years. Hitoshi Watanabe and Shigemichi Takano (1) reported that as in the 3rd, 4th and 5th-instar larvae, just after ecdysis, the tolerance to DDT and Sumithion generally increased with age, but the degree of the tolerance shown by LD50 per body-weight did not vary from age to age. The tolerance of the 5th-instar larvae, just after ecdysis, markedly increased with feeding mulberry leaves for several hours. The sensitivity to the toxicants was usually the same in both sexes. Hitoshi Watanabe and Shigemichi Takano (2) showed that responses to DDT and Sumithion varied markedly in 269 silkworm strains, and the LD50 values ($\mu\text{g/g}$) of DDT in the susceptible and the most resistant strains were 0.2 and 40.0, respectively, whereas the LD50 values of Sumithion in these strains varied from 0.3 to 13.2. When frequency of 269 strains was plotted against Log LD50 value of each toxicant, a normally distributed curve was obtained. The results of study on the dose-mortality lines of resistant and susceptible strains and their F1, F2 and backcross indicated that DDT-resistant and Sumithion-resistant characters were inherited as in multifactorial genic systems. Hitoshi Watanabe and Ryuzo Kobaba (3) did experiments with radioactive (^{14}C) and pointed out the fore-gut, the Malpighian tubules, and the gonads contained larger amounts of radioactivity per unit of weight. Thin-layer chromatographic analyses of metabolites of the silkworm treated with radioactive DDT showed that the radioactivity in the tissue and the feces was mainly due to DDT, DDE and two unidentified metabolites. Based on the above study, in the present paper resistance to r-BHC in silkworm was dealt with. The results are reported as following.

MATERIALS AND METHODS

Twenty-four strains were used for testing. The insecticide used was r-BHC. Acetone was used as solvent. Several different concentrations of r-BHC were applied topically to the mesopleural back-region of larvae with microinjector, 1 μl for each larva. Every strain was treated with 7-8 concentrations. Each sample containing twenty to thirty larvae was derived from the population mixing male and female randomly. Each treatment was repeated 2 to 3 times. Equal level of acetone solution which did not contain r-BHC was used as contrast. After applying the r-BHC acetone solution larvae were kept at about 25°C temperature and natural humidity without eating for 24 hours. Then larvae were examined and calculated to obtain the percentage of mortality. The 4th and 5th-instar larvae, just after ecdysis, were weighed, mean of twenty larvae weight as standard. The LD50 and LD-P curves were obtained with Finney's method (4).

After the sensitivity of 24 strains to r-BHC was investigated, two resistant strains, Xin 9 and Qiu guang, and two susceptible strains, Lan 5 and Dong 34, were selected. Xin 9 was crossed with Lan 5 and Qiu Guang with Dong 34. Two groups of genetic experimental materials, including parents, their F1, F2 and BC were taken. They were raised and tested in the same season.

Genetic analysis of resistance to r-BHC for silkworm larvae was carried out by comparing the LD50 values ($\mu\text{g/g}$) and the LD-P curves of the parents, their F1, F2 and BC (5) (6).

RESULTS

1. The difference of resistance to r-BHC between male and female larvae:

Male and female larvae were applied topically with r-BHC on the third day of the 5th instar, respectively. The result is shown in Table I (7).

It suggests that male larvae are more resistant than female to r-BHC.

2. The resistance of different instar larvae to r-BHC:

The resistance of the 4th and 5th instar larvae, just after ecdysis, to r-BHC was examined and the results are shown in Table II.

As shown in Table II, the LD50 values ($\mu\text{g/larva}$) of the 5th instar larvae are much higher than those of the 4th instar larvae. But the LD50 values ($\mu\text{g/g}$) are almost the same between the two instars within each strain except for Bao nan and Dong 34. Also, both the LD50 ($\mu\text{g/larva}$) and the LD50 ($\mu\text{g/g}$) values estimated in summer are higher than those in spring.

3. The change of resistance to r-BHC after the larvae, just after ecdysis, ate mulberry leaves:

The experiments were carried out with the 4th instar larvae just after ecdysis and feeding for 6 hours of mulberry leaves. The results are given in Table III.

From the data compiled in Table III, it can be seen that, with the feeding of mulberry leaves for six hours, the 4th instar larvae, just after ecdysis, increased their body weights by 13% to 58% (mean, 31%). But the LD50 values ($\mu\text{g/larva}$) increased by 35% to 84% (mean, 60%), the LD50 values ($\mu\text{g/g}$) increased by 19% to 42% (mean, 23%) except the variety 8301 x Lan 5. So, the average percentage of the LD50 values ($\mu\text{g/larva}$) increase was much higher than that of body weights. It is obvious that the larvae after eating mulberry leaves became more resistant to r-BHC not only due to the increase in their body weights but also due to the eating itself.

4. The difference of resistance to r-BHC among different strains:

The resistance to r-BHC was investigated with the 4th and 5th instar larvae, just after ecdysis, in twenty and twenty-one strains, respectively. The results are shown in Fig. 1.

The results show that when the frequency of twenty strains or more was plotted against the Log LD50 values ($\mu\text{g/g}$) of the 4th and 5th instar to r-BHC, a nearly normal-distributed curve was obtained. Also the average LD50 value ($\mu\text{g/g}$) in the 4th instar is almost equal to that in the 5th instar.

5. The correlation between the body weight of larvae and resistance among different strains:

The results are given in Table IV. It is assumed that there was a highly significant or significant level between the body weights of the 5th instar larvae, just after ecdysis, and the resistance to r-BHC among strains.

6. Correlations between the LD50 ($\mu\text{g/larva}$) and some economical characters:

The results are shown in Table V. It can be found that there are significant correlations between the LD50 ($\mu\text{g/larva}$) and cocoon weight, cocoon shell weight, the ratio of cocoon shell weight, but no correlation between the LD50 ($\mu\text{g/larva}$) and the percentage of dead worm in cocoon.

7. The genetic analysis of resistance to r-BHC:

The LD50 values ($\mu\text{g/g}$) and the Ld-P curves of two groups of experimental materials, each containing P1, P2, F1, F2 and BC, were obtained and are given in Fig. 2, Fig. 3, Fig. 4 and Fig. 5, respectively.

First, from Fig. 2 it can be seen that the LD50 values ($\mu\text{g/g}$) of F1 are between those of their parents, but the mean value of F1 is higher than that of their parents. There is only a little difference between reciprocal crosses. These indicate that the resistance to r-BHC for silkworm larva is mainly controlled by nucleus. The LD50 mean value ($\mu\text{g/g}$) of F2 is close to that of F1; when F1 were crossed with their resistant parent the resistance to r-BHC in progenies increased, and when F1 were crossed with their susceptible parent the resistance decreased. On the other hand, the Ld-P curves of F1, F2 and BC in Fig. 3 are all between their parents and from Fig. 1 before the frequency of resistance to r-BHC was nearly normal distribution, it can be considered that the resistance of Xin 9 to r-BHC is mainly determined by multifactorial genic systems. But near 75% mortality in the F2 Ld-P curves there is a plateau and under the 50% mortality there is a small slope. As F1 were backcrossed with susceptible parents three curves all have plateaus near the mean 60% mortality. When F1 were backcrossed with resistant parents each Ld-P curve has a little slope at about 25% mortality. According to the theoretical model of the Ld-P curves about insecticide-resistance genetics (5) it seems to be considered that there is also a major gene to resist r-BHC in Xin 9. Furthermore, from Fig. 2 it appears that the LD50 values ($\mu\text{g/g}$) of F2 reciprocal crosses are close to each other, and from Fig. 3 the Ld-P curves of F2 reciprocal crosses are very near their shapes resemble too. These can suggest that the major resistant gene is located on the autosomes. The cases in Fig. 4 and Fig. 5 are basically the same with those in Fig. 2 and Fig. 3. All the Ld-P curves of crossed progenies are between their parent's Ld-P curves except the $S \times (R \times S)$ and $(S \times R) \times S$ curves outside their susceptible parent's and nearly straight lines. Based on above analysis, it seems to be clear that the resistance to r-BHC for Qiu Guang is controlled only by poly-genic systems, and it is difficult to see the existence of major genes and maternal effect (2) (5).

DISCUSSION

In the present study male larvae were more resistant to r-BHC than female. This is different from Hitoshi Watanabe's conclusion (1966). He stated that there was no difference between male and female larvae's resistance to DDT and Sumithion. It may be thought that the time of test, insecticides, strains, etc, are different. In fact, as many researchers studied the resistance to insecticides with male and female, generally most of them discovered that female were more resistant than male. But sometimes some of them showed that male were more resistant than female (8).

Obviously, the resistance will increase with ageing. But as far as per unit of weight was concerned the level of resistance did not change from age to age. This indicates that the resistance difference in different instars is partly due to body weight. Another reason for resistance increasing with ageing probably is that the larvae's cuticles become thicker and thicker as they grow. It would make insecticides more difficult to go into insect body through the cuticle. Klinger (1936) said that the resistance of the 5th instar larvae to DDT increased greatly, but at the same time the larvae cuticles in the same instar became much thicker, and setae, canals on the cuticles became much less after he did experiments with DDT to silkworm.

According to general principle, the mechanism of resistance to insecticides in insects is mainly due to the penetration of cuticle, the breaking down to insecticides by some kinds of detoxicating ferments inside insect bodies, and the storing of insecticides by fat-bodies inside insect bodies. This may explain why the degree of increase of resistance to r-BHC exceeds that of increase of body weight with the feeding of mulberry leaves.

There is a significant correlation between body weight and the LD50 values ($\mu\text{g}/\text{larva}$) among different strains. This can be recognized that the LD50 values ($\mu\text{g}/\text{larva}$) are affected by body weight not only within each strain but also among different strains. Moreover, it indicates that it is possible that there is a linkage between resistant genes to r-BHC and body weight genes, or they affect each other. But the determinate coefficient obtained from the r value between body weight and the LD50 ($\mu\text{g}/\text{larva}$) is about 0.27, that is to say that the LD50 values ($\mu\text{g}/\text{larva}$) are also affected by other factors about 73%. For example, the difference of genotypes may be essential. On the contrary, if the LD50 values ($\mu\text{g}/\text{larva}$) were determined only by their weight, the LD50 values should be the same. In fact, there are much large differences in the LD50 values ($\mu\text{g}/\text{g}$) among different strains.

Also, it can be found that there are significant correlations between the resistance and cocoon weight, cocoon shell weight and the ratio of cocoon shell weight. Since there is a significant correlation between body weight and the resistance the above can be understood. As a matter of fact there are significant correlations between body weight and cocoon weight, cocoon shell weight, and a significant negative correlation between body weight and the ratio of cocoon shell weight in univoltine and bivoltine strains. But in multivoltine strains sometimes there is a significant positive correlation between body weight and the ratio of cocoon shell weight. In this study more than 50% tested strains are multivoltine ones and their varieties so that there is a significant positive correlation between body weight and the ratio of cocoon shell weight. Based on this analysis, it can be sure that the resistance to r-BHC, body weight, and cocoon characters probably have parts of the same genetic basis.

Next, it is concluded from crossing test that the resistance to r-BHC is controlled by multifactorial genic systems. This is concordant with the conclusion which Hitoshi Watanabe derived from studying the resistance to DDT and Sumithion in silkworm. But also the major resistant gene can be shown from genetical analysis. Probably these are due to the tested strains, insecticides, methods different. Generally, the resistance to insecticides in insects are inherited from poly-genic systems. But one or more major genes in poly-genic systems can be found too.

At last, it must be said that there is something unsatisfied in this paper. Qiu Guang, Dong 34 and their crossing progenies were raised a little later in Autumn than Xin 9, lan 5 and their crossing progenies and happened to the mulberry leaves polluted a little from fog caused by factories around, so the growing and developing of larvae were affected less or more, and it made their resistance to r-BHC decrease. As a result of above, the major gene was hardly discovered. But even if there was still

a plateau near 75% mortality for (SxR)xS, the inheritance of resistance to r-BHC for Qiu Guang should be furthermore dealt with.

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Strain	Sex	Mean body weight (mg)	LD 50 value ($\mu\text{g/larva}$)				LD 50 value ($\mu\text{g/g}$)	
			Mean	95% configuration limit	Exponent	b	Mean	Exponent
247	F	1280	10.1	8.8 - 11.6	88	5.6	7.9	86
	M	1250	11.5	10.1 - 13.1		5.2	9.2	
Dong 34 x 247	F	1380	6.7	-	90	7.3	4.5	76
	M	1180	7.5	6.3 - 8.9		11.1	6.3	
Dong 34 x D5	F	1650	6.7	5.2 - 8.8	81	11.2	4.1	71
	M	1450	8.3	7.0 - 9.8		8.3	5.7	

* Exponent is 100

Table I. The resistance of male and female larvae of the third day of the 5th instar to r-BHC (summer, 1980).

Season	Strain	Body weight ($\mu\text{g/larva}$)		LD 50 ($\mu\text{g/larva}$)						LD 50 ($\mu\text{g/g}$)	
		4th instar	5th instar	4th instar	95% configu- ration limit	b	5th instar	95% configu- ration limit	b	4th instar	5th instar
Spring	B301	124	590	0.97	0.86-1.09	8.90	3.98	3.50-4.53	7.24	7.81	6.75
	Chun 4	155	710	71.14	1.05-1.35	8.24	6.03	5.36-6.78	9.05	7.36	8.49
	Zhe	163	780	0.98	0.90-1.06	8.50	4.27	3.76-5.30	3.65	5.99	5.47
	Xiu Yie	174	860	0.97	0.89-1.05	13.36	4.27	3.83-4.76	8.90	5.56	4.96
	Bao Nan	110	492	0.75	0.61-0.91	6.03	3.55	3.24-3.88	9.48	6.77	7.21
	Lan 5	70	280	0.30	0.21-0.38	4.88	1.62	-	-	4.21	5.79
	Feng Shou	163	710	0.97	0.59-1.60	11.14	4.99	4.70-5.29	7.69	5.96	7.03
	Dong 34	111	520	0.61	0.34-1.08	6.83	2.95	-	-	5.50	5.68
	Dong Fei	138	660	71.11	0.92-1.33	5.39	5.74	4.92-6.70	5.13	8.02	8.70
Summer	Bao Nan	128	560	0.96	0.85-1.10	9.78	4.90	4.55-5.27	10.16	7.54	8.75
	Dong 34	108	575	0.63	0.57-0.70	5.55	3.98	3.11-5.10	-	5.84	6.92
	Qiu Guang	185	800	1.62	1.00-2.64	5.10	6.61	5.46-7.13	7.19	8.77	8.26
	Su 12	162	790	0.87	0.81-0.94	6.36	3.55	1.61-7.81	11.91	5.37	4.49
	Dong 34 x 247	114	730	0.70	0.25-0.77	8.44	4.68	4.28-5.11	8.19	7.08	6.41
	Dong 34 x Qiu Guang	170	820	1.35	1.17-1.55	6.82	6.76	6.46-7.01	9.75	7.93	8.25
	7532 x Lan 5	128	525	0.74	0.70-0.79	7.67	3.39	2.99-3.84	4.44	5.79	6.45

Table 11. The resistance of larvae of different instars to r-BHC (1980).

Strain	Feeding hours	Body weight (mg)	Body weight exponent	LD50 ($\mu\text{g/larva}$)				LD50 ($\mu\text{g/g}$)	
				Mean	Exponent	95% confi- guration limit	b	Mean	Exponent
7532	0	138	100	0.71	100	0.54-0.78	6.22	5.13	100
	6	161	117	1.18	166	1.08-1.28	9.94	7.30	142
247	0	153	100	0.88	100	0.78-0.99	5.33	5.75	100
	6	218	142	1.62	184	1.16-2.27	6.26	7.44	129
Lan 5 x Bao Nan	0	123	100	0.78	100	0.65-0.93	5.53	6.31	100
	6	139	113	1.05	135	0.95-1.16	8.74	7.55	119
247 x Qong 34	0	159	100	0.73	100	0.60-0.83	4.53	4.58	100
	6	200	126	1.21	166	1.12-1.31	10.97	6.06	132
8321 x Lan 5	0	113	100	0.78	100	0.69-0.88	4.53	6.87	100
	6	178	158	1.15	147	1.04-1.26	6.98	6.45	94

Table III. The change of resistance to r-BHC with the feeding of mulberry leaves for six hours.
(Summer, 1980)

Season	No. of strains (including F1)	Correlation coefficient (r)
Spring	21	0.71**
Summer	22	0.43*
Autumn	27	0.41**

* significant at 5% level

** significant at 1% level

Table IV. Correlation between body weight of larvae and resistance (5th instar, 1980).

	Percentage of dead worm in cocoon (%)	Cocoon weight	Cocoon shell weight	Ratio of cocoon shell weight (%)
r	0.15	0.56*	0.56*	0.51*

* significant at 5% level

Table V. Correlations between the LD50 ($\mu\text{g/larva}$) and some economical characters (5th instar, Summer, 1980).

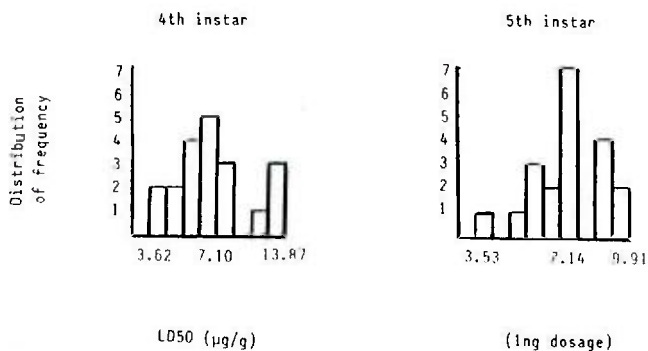


Fig. 1. Distribution of frequency about LD50 (µg/g) among different strains.

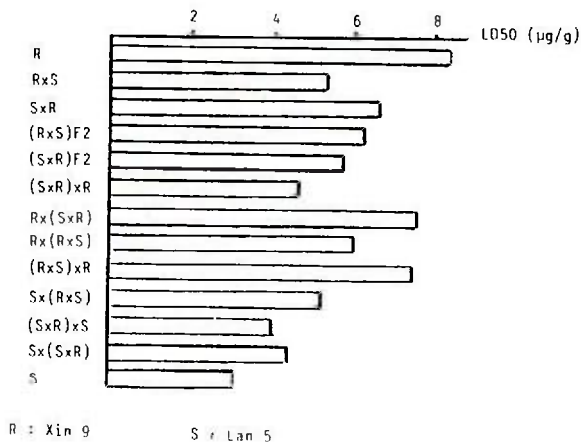
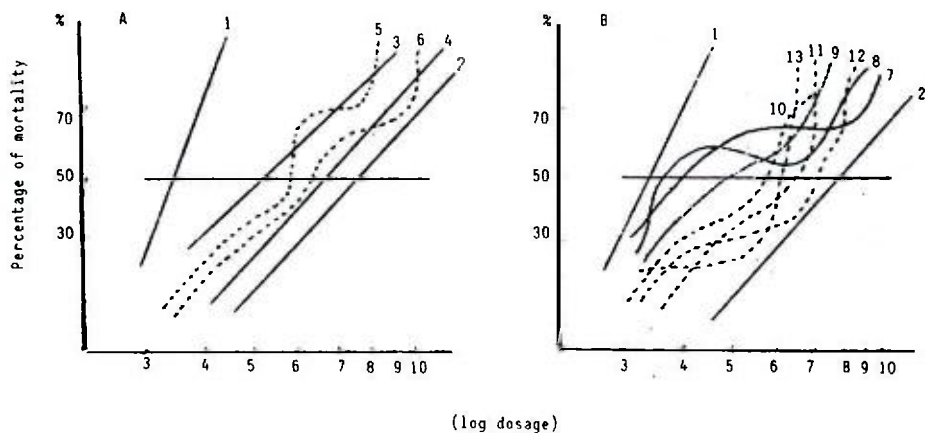


Fig. 2. The LD50 values (µg/g) of Xin 9, Lan 5 and their crossed progenies (5th instar).



- | | | |
|------------|-------------|-------------|
| 1. S | 6. (RxS)F2 | 11. Rx(RxS) |
| 2. R | 7. Sx(SxR) | 12. (SxR)xR |
| 3. (RxS)F1 | 8. (SxR)xS | 13. Rx(SxR) |
| 4. (SxR)F1 | 9. Sx(RxS) | |
| 5. (SxR)F2 | 10. (RxS)xR | |

R : Xin 9 S : Lan 5

Fig. 3. The Ld-P curves of Xin 9, Lan 5 and their crossed progenies (5th instar).

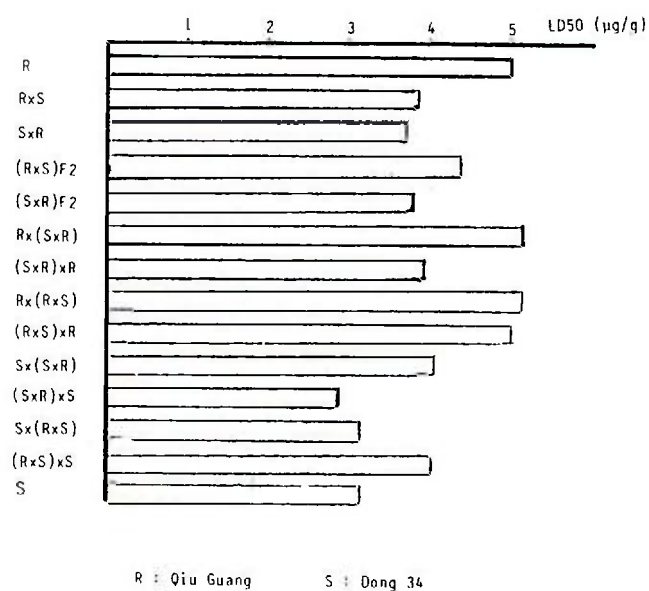
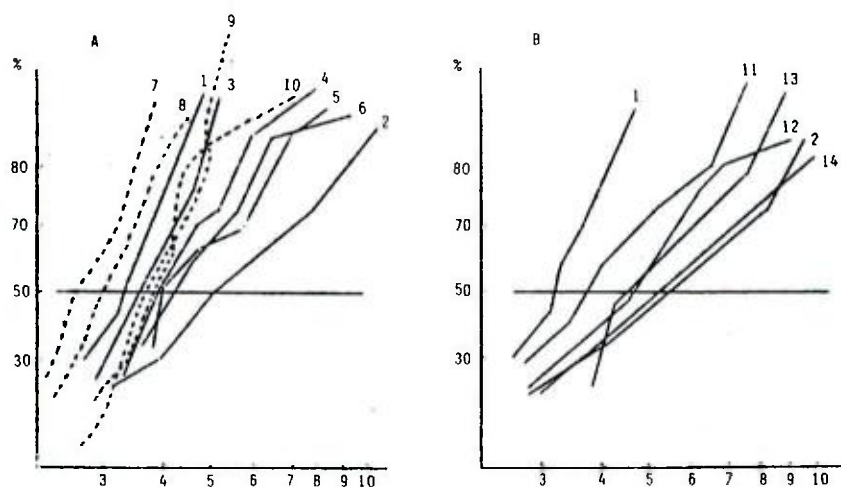


Fig. 4. The LD50 values (μg/g) of Qiu Guang, Dong 34 and their crossed progenies (5th instar).



(Log dosage)

- | | |
|----------------------------|-----------------------------|
| 1. S | 8. $S \times (R \times S)$ |
| 2. R | 9. $S \times (S \times R)$ |
| 3. $(S \times R)F_2$ | 10. $(R \times S) \times S$ |
| 4. $S \times R$ | 11. $(S \times R) \times R$ |
| 5. $(R \times S)F_2$ | 12. $R \times (S \times R)$ |
| 6. $R \times S$ | 13. $R \times (R \times S)$ |
| 7. $(S \times R) \times S$ | 14. $(R \times S) \times S$ |

R : Qiu Guang

S : Dong 34

Fig. 5. The Ld-P curves of Qiu Guang, Dong 34 and their crossed progenies (5th instar).

AN ATTEMPT TOWARDS THE GENERALIZATION OF BIOENERGETICS
COMPONENTS OF LEPIDOPTERANS

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An attempt has been made for the first time to generalize bioenergetics components of lepidopterans. They include all the "rates", namely Relative Consumption Rate (RCR), Relative Assimilation Rate (RAR), Relative Metabolic Rate (RMR) and Relative Growth Rate (RGR) as well as the efficiencies, namely Efficiency of Conversion of Ingested food (ECI), Efficiency of Conversion of Digested food (ECD) and Assimilation Efficiency (Ase). Over a hundred papers were scanned of which only 12 provided all the components required for computations. 46 sets of nutritional performance values of various species of Lepidopterans including Bombyx mori were subjected to statistical analyses. Nitrogen and water contents of the feed, developmental rate and midbody weight of the animal and the prevailing experimental temperature were considered as the control variables. The relationship of these five factors on the power components namely RCR, RAR, RMR and RGR and efficiencies namely ECI, ECD and Ase have been found out through multiple regression analysis.

A correlation matrix explains the extends to which the dependent variables are related to the chosen independent variables and a partial correlation matrix establishes the individual effects. The equations derived to explain these relationships are expected to fit with the performance of any Lepidopteran including Bombyx mori. Food utilization performance of Lepidopterans in general, their ramifications and dynamism have also been discussed.

EFFECT OF RATION LEVEL ON FOOD UTILIZATION IN THE SILKWORM -
BOMBYX MORI (L) (LEPIDOPTERA : BOMBYCIDAE)

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Results are presented from laboratory experiment to show the effect of food deprivation on food consumption, assimilation and conversion in the last two instars of silkworm Bombyx mori fed on Morus alba at $26^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and 80% R.H. Reduced rations of Morus alba produced a number of negative effects on B. mori such as heavy mortality, extension of larval period and reduction in the food consumption and utilization. The amount of dietary water intake and water expenditure decreased with the reduced ration level. While the assimilation efficiency decreased from about 60% at 100% feeding to about 50% during 75% feeding, the efficiency of conversion (net efficiency) increased from 10.7% during normal feeding to 16% during reduced feeding in the 4th instar B. mori larvae. Individuals receiving the lowest ration displayed reduced metabolic rate, which partly accounts for the increased rate and efficiency of conversion. The results also show a decrease in silk production (weight of the cocoon) and a marked loss in fecundity due to food deprivation during feeding period. The results are compared with the available data and the adaptive potentials of B. mori in the terrestrial environment are discussed.

INTRODUCTION

Lepidopterans are the major terrestrial insect primary consumers (Delvi and Pandian, 1971). The larvae are known to be continuous feeders, hence the deficiency in the amount of food required to reach its full potential will be manifested in various ways and degrees (Waldbauer, 1968). A good amount of information on food utilization budgets of the silkworm Bombyx mori, is available (Hiratsuka, 1920; Naik, 1986). Various workers have shown the effect of food restrictions on the larval

period in *B. mori* and in other insects (Muthukrishnan and Delvi, 1974; Mc-Ginnis and Kasting, 1972; Mathavan and Muthukrishnan, 1976).

Nutrition in the larval stages significantly influences the food utilization budgets of resulting adults particularly where the adult does not feed during the adult period (Srivastava *et al.*, 1982). Although some studies are available on the effect of ration level in lepidopteran insects, few have considered all the parameters of food utilization. It remains to be seen whether or not a monophagous insect compensates decreased ration by altering one or many parameters of food utilization. The present paper reports on the effect of ration levels on the food utilization budgets in the silkworm *Bombyx mori* (L).

MATERIAL AND METHODS

Eggs of *Bombyx mori* (Pure Mysore race) were obtained from the grainage of the Government of Karnataka (India, Magadi area) and maintained in the laboratory. Freshly hatched larvae were removed to separate terraria (Plastic trays size 36x26x4 cms). The larvae are maintained in the laboratory fed on leaves of *Morus alba* at 26±2°C; 80±10% R.H. Lepidopteran larvae consume more than 97 to 98% of the total food intake during the final two instars (Waldbauer, 1968). Hence, the effect of ration level on food consumption and utilization was estimated only in the last two larval stages. The test individuals were reared in three groups (each consisting of 50 larvae) and the experiments were triplicated in each group. The larvae were fed on fresh leaves of *M. alba* at 100, 75, 50 and 25% ration levels. The ration levels were fixed considering the food consumption values of *B. mori* fed *ad libitum* separately (Naik, 1986).

Daily food intake was measured by the standard gravimetric method (Waldbauer, 1968). The faeces produced, the food (control) and the sacrificed animals were dried at 80°C for 24 hours and weighed. Dry food assimilated by the test individuals in each instar was calculated by subtracting the dry weight of the faeces produced from the food consumed during the respective instar. The rates of feeding assimilation and conversion were calculated following the method reported by Delvi and Pandian (1972). The experiments were terminated after the fifth instar, when the larvae pupated.

RESULTS

The individuals of *B. mori* require 16.5 to 19.5 days to complete the final two instars (Delvi and Naik, 1984). Individuals receiving 100% ration require 16.5 days to pupate and the larval period with different ration levels increases to more than 19 days (Table I). The larval period prolongs to 19.9 days with 25% ration. Fourth instar larvae require 6 days to moult with 100% ration, 7 days with 50% ration and 8 days with 75 and 25% ration. Such increases in the larval period are also found in 5th instar larvae which require 10 days with 100% ration, 12 days with 50% ration and 11 days with 75 and 25% ration.

Mortality of individuals due to reduced ration is found, when a test individual died appropriate correction was made in the calculation of the food utilization budget. Mortality is not found during fourth instar period with different ration levels. During fifth instar the individuals receiving 100%, 75% and 50% ration did not die but fifth instar larvae receiving 25% suffered heavy mortality amounting to 73.3% to 91.1%.

With decreasing ration level, final body weight attained by test individuals decreases. The body weight of *B. mori* receiving 100% ration increases from the mean initial weight of 285.08 ± 11.49 mg at the end of fourth instar to 1587.73 ± 24.85 mg before pupation (end of fifth instar). Those larvae receiving 75% and 50% rations reach a body weight of 1542.74 ± 33.42 mg and 1538.74 ± 12.8 mg at the end of fifth instar. Similar trends in decreasing body weight are found in individuals offered 25% rations. The final body weight attained by the larvae was found to decrease in the following order :

$1587 \text{ mg} > 1542 \text{ mg} > 1538 \text{ mg} > 1245 \text{ mg}.$

While the quantity of converted body substance lost through exuvia remained almost the same (about 6 mg) in individuals receiving 100%, 75% and 50% rations, that lost by individuals receiving 25% ration reduced by about 3%.

Though the food offered was regulated in the test insects most of the individuals fed with 100% and 75% left a definite quantity of food as unfed everyday. This was considerably less in the individuals fed with 50% and 25%. However due to increase in larval period the total amount of food during the last two instars increases by about 3% in 75% and 50% ration level and by about 8% in 25% ration. Perhaps the extension of the larval period by more than three days with 25% ration level may be due to insufficient amount of food offered. While the larvae fed 3074.5 mg of dry food with 100% ration, those receiving 75%, 50% and 25% ration fed only 2391.2 mg, 1641.9 mg and 1007.0 mg respectively.

Feeding rate fluctuates widely in larvae receiving different ration (Fig. 1). The rate is higher during 4th instar at all the ration levels. Individuals offered 100% ration display a higher feeding rate of 0.38873 mg dry weight per mg live insect per day during fourth instar and 0.24062 mg/mg/day during fifth instar. The corresponding values with 75%, 50% and 25% are 0.2400 mg/mg/day and 0.1811 mg/mg/day, 0.1806 mg/mg/day and 0.1116 mg/mg/day, and 0.10963 mg/mg/day and 0.08596 mg/mg/day respectively. Although the total feeding rate of the individuals with 100% and 75% rations are higher than in those fed with 50% and 25% rations, the latter fed actively as soon as the food was offered and exhausted the entire ration at a stretch while the former fed slowly at different intervals.

The total quantity of food assimilated decreases with a decrease in ration level, larvae fed on 100% ration assimilate 1223.9 mg dry food, those offered 75% ration assimilate 716.5 mg dry food, while 50% ration assimilate 573.0 mg dry food and 25% ration assimilate 333.4 mg (Table 11). The mean assimilation efficiency decreases with the decrease in the ration level and averages 47.9% with 100% ration level, 38.7% with 75% ration level, 42.6% with 50% ration level and 34.6% with 25% ration level. However, the differences in the assimilation efficiency observed among 100, 75, 50 and 25% rations are not statistically significant.

Assimilation rate decreases from 0.15937 mg/mg/day in 100% ration level to 0.08522 mg/mg/day in 75% ration and further to 0.06599 mg/mg/day in 50% ration and 0.03415 mg/mg/day in 25% ration (Fig. 1).

With decreasing ration level the total food converted also decreases from 572.1 mg to 552.9 mg, 240.1 mg, 154.4 mg in 100, 75, 50 and 25% rations respectively. While the conversion between the 100% ration and the 75% ration level is not statistically significant, it drastically reduces in individuals receiving 50% and 25% ration levels. The conversion efficiency (K_2) decreases from 43.8% at 100% to 36.6% at 50% ration level. However, decrease in food to 75% ration level increases the efficiency to 59.6% and those offered 25% ration increase the efficiency to 46.3%.

Individuals fed at decreased ration level exhibit a decrease in the conversion rate averaging 0.1168 mg/mg/day with 100% ration, 0.04744 mg/mg/day with 75% ration, 0.04577 mg/mg/day with 50% and 0.01833 mg/mg/day with 25% ration.

DISCUSSION

The reduced ration levels (75, 50 and 25%) results in a number of negative effects on the larvae: 1. heavy mortality, 2. extension of larval period and 3. reduced rates and efficiency of assimilation and conversion. The qualitative and quantitative importance of food in connection with the negative effects has been recognized by several workers (Kozhanchikov, 1950; Barnes, 1955; Muthukrishnan and Delvi, 1974). From their observations on the effects of transecting nerves from the frontal ganglion to stretch receptors situated on the wall of the pharynx of *Locusta migratoria*, Clarke and Langley (1962) postulated that distention of pharyngeal wall initiates the propagation of impulses from the frontal ganglion, which in turn stimulates the continuous activity of the neurosecretory cells present in the brain. The neurosecretory material secreted by the medial cells of the brain is used by the hoppers for the metabolism of dietary proteins. When the neurosecretory material is not utilised owing to the reduced food consumption by a hopper approaching moulting, the hormone in the body fluid increases to the threshold level and triggers the thoracic gland leading to ecdysis. However, it is not clear what makes the hopper/larva approach moulting. Availability of nitrogen for the synthesis of new cuticle may be one of the factors making the hopper/larva approach moulting (Muthukrishnan and Delvi, 1974). In *Melanoplus mexicanus* reared on wheat with different nitrogen content, Smith and Northcott (1951) found that hoppers feeding on 6% nitrogen containing wheat suffered only 52% mortality against 100% mortality of those receiving 3% N containing wheat, while the hopper period was 49 days for the former group, it was as long as 61 days for a third group fed on 4% N containing wheat. Since *B. mori* receiving 25% ration would have received correspondingly less nitrogen, it is very likely that the reduced availability of N resulted in heavy mortality and prolongation of the larval period.

Assimilation efficiency in *B. mori* decreases a little with the increase in ration levels and ranges 34.6% to 47.9%. The decline in the efficiency is not statistically significant among 75, 50 and 25% ration levels. Working on the effect of Permethrin (an insecticide) on consumption and utilization of food in *B. mori* and *Philosamia ricini*, Naik (1986) (see also Delvi, unpublished), found that assimilation efficiency increases from 50.8% during normal feeding to 64% during Permethrin feeding. The increase in the efficiency may be due to reduction in the food consumption (Naik, 1986). Consumption level in *Prodenia eridania* is altered considerably by different food plants (Soo Ilon and Fraenkel, 1966). The efficiency in *P. pictus* did not appreciably vary as function of life stage, sex and ration levels (Muthukrishnan and Delvi, 1974). Delvi and Pandian (1972) showed that the efficiency did not differ significantly among the individuals of different life stage and sex in *P. pictus*. However, *P. pictus* displays an efficiency of 30% at 26°C and 57% at 36°C (Delvi, 1972). In *Calocalpe undulata* the efficiency enhanced by prolonged food deprivation (Schroeder, 1976). Perhaps the increase in temperature and/or prolonged food deprivation and/or presence of insecticide might enhance the rate of enzyme secretion and/or activity resulting in increased efficiency of assimilation. In blood sucking insects like tsetse flies and black flies, which fed on different volumes of meal containing 100, 50, 25 and 10% concentrations of blood, it is found that the proteolytic activity is dependent upon the volume and not on the concentration of the blood meal (Bursell, 1970). In response to the increased meal size, the stretch receptors situated on the wall of the crop of the tsetse fly, seem to have elicited

extended periods of augmented peristalsis; enhanced peristalsis is known to considerably increase the digestive power of the enzymes (Vonk, 1964). With increasing ration (upto 40 mg), there is a direct and proportionate increase in the digestive activity in tsetse flies and black flies (Bursell, 1970). It is presumable that this may result in enhanced assimilation efficiency and/or may result in constant efficiency in individuals receiving different ration levels. In fishes receiving different ration levels, Tyler (1970) found increased digestive activity.

Larvae of *B. mori* receiving 75% ration display a higher conversion efficiency than those receiving 100, 50 and 25% ration. *P. pictus* display nearly two times conversion efficiency with 25% ration than with 100% ration (Muthukrishnan and Delvi, 1974). In *C. undulata*, a longer period of food deprivation results in decrease in the efficiency (Schroeder, 1976). Premaleela (1986) has demonstrated that lepidopteran larvae when exposed to different temperature, photoperiods and food quality, are capable of modifying one or more parameter(s) to meet the basic requirements of metabolism.

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	IVth Instar		Vth Instar	
	Duration (day)	Body weight (mg dry)	Duration (day)	Body weight (mg dry)
100%	6.00±5 hr	44.64±3.02	10.00±7 hr	527.40±12.16
75%	8.00±4 hr	43.49±1.10	11.00±6 hr	509.36±9.46
50%	7.00±8 hr	32.78±2.10	12.00±7 hr	207.28±3.80
25%	8.00±9 hr	29.22±3.14	11.00±11 hr	125.13±8.6

Each value represents the average performance of three groups, each consisting of about 50 individuals, reared for a period of about 20 days.

Table I. Effect of ration feeding on the duration and terminal body weight of the silkworm *Bombyx mori* fed on fresh leaves of *Morus alba* at 26±2°C, 80±20% R.H.

PARAMETER	100%	75%	50%	25%
LARVAL PER100 (day)	16.5	19.5	19.5	19.9
Food eaten	3074.4	2391.2	1641.98	1007.79
Faeces defecated	1851.44	1674.7	1068.95	674.4
Assimilated	1223.9	716.5	573.03	333.39
Total growth	572.05	552.85	240.06	154.35
Exuvia	12.1426	12.1024	12.06	11.8424
Net growth	559.91	540.74	228.00	142.51
Respiration	651.85	163.65	332.97	179.04
Conversion efficiency (K_2)	43.795	59.63	36.63	46.315
Assimilation efficiency	47.885	38.73	42.56	34.62
Feeding rate	0.3147	0.21056	0.1462	0.09779
Assimilation rate	0.15937	0.08522	0.06599	0.03415
Conversion rate	0.1168	0.04744	0.04577	0.01833
Metabolic rate	0.11692	0.04798	0.04588	0.018284

Total values of fourth and fifth instar larvae.

Each value represents the average performance of three groups each containing about 50 individuals reared for a period of about 20 days.

All the values are expressed in mg dry weight, the efficiencies in % and the rates in mg dry weight per mg live insect per day.

Table II. Food utilization budget in the silkworm *Bombyx mori* fed at four ration levels on *Morus alba* at 26±2°C, 80±20% R.H.

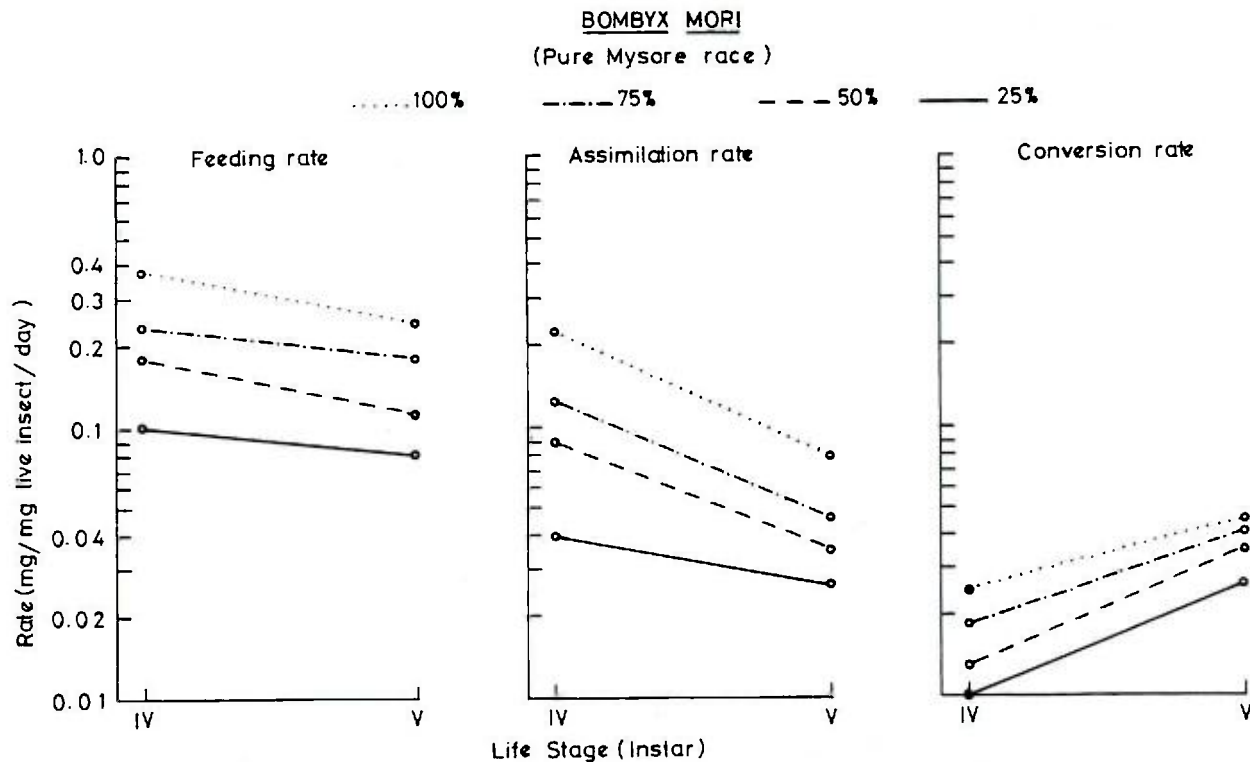


Fig. 1. Rates of feeding, assimilation and conversion in the silkworm *Bombyx mori*, receiving different rations of *Morus alba*.

EFFECT OF PROSTAGLANDIN $F_{2\alpha}$ ON THE GROWTH PATTERN
OF SILKWORM LARVAE OF BOMBYX MORI (L)

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The growth pattern of the silkworm larvae, Bombyx mori (L) was accelerated with shortened larval life, increased silk output and egg laying potential of the moth by topical application of prostaglandin $F_{2\alpha}$. The physiological significance of $PGF_{2\alpha}$ in the development of silkworm was contemplated.

INTRODUCTION

Multivoltine silkworm breeds are suitable for tropical regions (Sidhu *et al.*, 1968). The silkworms fed on mulberry leaves sprayed with 2% glucose solution weighed more and produced more silk as compared to controls fed only with mulberry leaves (Znamenskaya, 1956). Vitamin 'B' increased the resistance against poor environmental conditions and increased body weight (Maeda, 1924). The antibiotics such as aureomycin and chloromycelin increased the larval and pupal weights of the silkworm (Murthy and Sreenivasaya, 1953). However, limited attempts have been made to analyse the effect of vertebrate hormones on the silkworm larval growth. Our previous studies (Bharathi *et al.*, 1983; Bhaskar *et al.*, 1983) revealed that the vertebrate pituitary extract and prolactin induced accelerated growth and advancement in the period of pupation with increased weight of cocoons. Prostaglandins, with particular reference to $PGF_{2\alpha}$, have been known to actively participate in the reproduction and other physiological activities of the vertebrates. Hence it will be worthwhile to understand the possible role of $PGF_{2\alpha}$ in the growth and reproduction of silkworm.

MATERIAL AND METHODS

Multivoltine breeds of *Bombyx mori* (L.) were used for the present experiment. Healthy layings of these breeds were reared at 28°C with 85% R.H. in the month of November. Feeding was given after every 6 hours with equal quantity of leaves. Prostaglandin $F_{2\alpha}$ was procured from UpJohn Company, Calamazoo, Michigan, USA. Topical application of $PGF_{2\alpha}$ (0.0025 μ g/ml of saline/50 larvae) was given during first and second instars and the pattern of growth was compared with control group subjected to topical application of physiological saline (0.9% NaCl in water) through morphometric or gravimetric analysis.

RESULTS AND DISCUSSION

The data presented in Tables I and II reveal the extent of impact of topical application of $PGF_{2\alpha}$ on the growth of silkworm larvae and egg laying potential. There was a decrease in the larval period and as such $PGF_{2\alpha}$ seems to advance the period of onset of pupation significantly. $PGF_{2\alpha}$ has been associated with activation of reproductive events in the vertebrates (Pharriss and Wyngarden, 1969; Gutknecht *et al.*, 1969). The larval period of the silkworm has been intimately associated with the onset of maturation and hence $PGF_{2\alpha}$ might have played accelerating role on the maturation events of the silkworm leading to overall improvement in the weight of the larvae with a decrease in the period of pupation. The cocoon weight was increased indicating the possible activation of silk gland by $PGF_{2\alpha}$. The period of emergence of moth from cocoon was advanced along with egg laying potential.

The present observations were suggestive of either direct or indirect influence of $PGF_{2\alpha}$ on the larval growth and silk output of silkworms.

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Parameters	Control	Experimental (PGF _{2α} treated)
Length (mm)	48.0±3.82	56.0±4.92 +16.67 P<0.001
Weight (gm)	1.814±0.15	2.212±0.20 +21.94 P<0.001
Total larval period (days)	32.0±2.89	28.0±2.56 -12.5 P<0.001

Each value is the mean of 10 individual observations and Mean ± S.D.;
+ and - indicate per cent increase and decrease over control
respectively. 'P' denotes the level of significance.

Table I. Length (mm), weight (gm) and total larval period (days) in control (saline) and experimental (PGF_{2α} treated) larvae during 5th instar.

Parameters	Control	Experimental (PGF _{2α} treated)
Weight of cocoon (gm)	1.098±0.06	1.313±0.12 +19.58 P<0.001
Moth emergence period (days)	10.0±0.82	8.0±0.71 -20.0 P<0.001
Number of eggs per moth	405.0±31.41	494.0±34.0 +21.98 P<0.001

Each value is the mean of 10 individual observations. Mean ± S.D.;
+ and - indicate per cent increase and decrease over control
respectively. 'P' denotes the level of significance.

Table II. Cocoon weight (gm), period of emergence (days) and egg laying potential of silkworm treated with saline (control) and PGF_{2α} (experimental).

BACTERIA-INDUCED PROTEIN SYNTHESIS IN THE LARVA
AND PUPA OF BOMBYX MORI

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Bacteria-induced protein profile was observed by high resolution SDS-Polyacrylamide gel electrophoresis and autoradiogram in the final instar larva and male pupa of the silkworm *Bombyx mori* by injecting them with a fixed dose of *Bacillus sphaericus* for varying durations. Both in the larva and pupa, there are qualitative and quantitative changes in the protein profile of the bacteria injected animals. In the Haemolymph of the *Bombyx mori* larvae there are about 23 proteins. After the bacterial injection there are quantitative changes in the 6 existing proteins and five new proteins with the molecular weight of 91, 41, 25, 23 and 21.5 kd appeared during the experimental period of 9 to 24 hours. In the case of bacteria-injected pupa, there are quantitative changes in 9 of the existing proteins while 2 new proteins appeared during the experimental period.

The rate of protein synthesis was studied in the *Bacillus* injected larva and pupa by using ^{14}C chlorella hydrolysate. There was almost a steady increase in the rate of protein synthesis in the larvae up to 12 hours and subsequently it levelled off. In the case of pupa the incorporation of the protein steadily increased up to 18 hours and subsequently it decreased. The results obtained on the inducible proteins are discussed in the light of recent studies.

A PRELIMINARY REPORT ON RESISTANCE TO CYTOPLASMIC POLYHEDROSIS
VIRUSES IN BOMBYX MORI

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The cytoplasmic polyhedrosis of silkworm, Bombyx mori, is one of its severe diseases. Recently it caused sharp cocoon output reduction in some areas, especially in Summer or Autumn. In fact, many scientists have paid attention to studying and trying to solve this problem.

Five concentration virus solutions were spread on the back of a piece of mulberry leaf which was ten square centimetres by using 0.1 millilitre respectively. When the virus solutions were almost dry, each piece was fed thirty larvae at the second instar, just after ecdysis. After the larvae finished their pieces with viruses they were given normal mulberry leaves to eat. Each thirty larvae were fed in a medium Petri dish. On the 10th day after the consumption of the virus leaves, each larva midgut was dissected in order to examine and count the number of larvae which had contracted the disease. According to Finney. D.J.'s probit analysis Log IC50 values were used to compare to one another the resistance to CPV among different races or their crossed offspring.

The resistance to CPV among different races was significant. Also, there was a significant difference among moths within a strain. Males were more resistant to CPV than females. There was a negative relation between the resistant value and some economic characters. But sometimes it depended on different seasonal conditions. The resistance was controlled by multifactorial genic systems. The sex-linked effect was negligible and males have much more effect to the resistant inheritance than females.

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