NOTES TECHNIQUES

TECHNISCHE NOTA'S

TECHNICAL NOTES

NOTAS TÉCNICAS

Some Features of Silk-producing Moths

Ye Gongyin & Hu Cui*

Key words: Silk-producing moth - Biological characteristics - Cocoon and silk

Summary

Species and distribution of main silk-producing moths in the world are reviewed. Main biological characteristics, properties of cocoon and silk of four important silk-producing moths, such as Bombyx mori, Antheraea pernyi, Antheraea yamamai, Philosamia cynthia ricini are described. Applications of cocoon and silk of the four important silkmoths are also shown.

Résumé

La répartition des espèces et les principales particularités des vers à soie sont recensées dans le monde. D'importantes caractéristiques biologiques, de propriétés du cocon et des vers à soie de quatre importantes productions de vers à soie tels que Bombyx mori, Antheraea pernyi, Antheraea yamamai, Philosamia cynthia ricini sont décrites et leurs applications présentées.

1. Species and distribution

Silk-producing moths are member of those insects which spin cocoons or silk for human use. In the world, there are about 400-500 species of silk-producing moths. As the surface texture of their cocoons and communal webs look like paper, leather or cloth. the idea to exploitate them is very old. In fact sericulture, the process of rearing these silk-producing moths in captivity or collecting their cocoons or silk in the field for human use, has been practised for thousands of years. There are however only 8-9 moths which produce silk of commercial value. Nowaday the domestic silkworm or mulberry silkmoth, Bombyx mori provides probably more than 99% of the silk in the world. It is believed to have been cultivated for about 5000 years in China and is used today around the world for textiles production, but also for educational and scientific studies. In contrast other silk-producing moths are called wild silkmoths or non-mulberry silkmoths. They are not reared in captivity, cocoons are collected from field populations. In some cases, some rearing is done outdoors with little or even no protection of larvae. Most wild silkmoths belong to the families Saturniidae, Notodontidae, Lasiocampidae and Pieridae (5). Names and - distribution of main silkmoths are summarized in Table 1.

2. Biological characteristics

2.1 Bombyx mori

The domestic silkworm, *Bombyx mori* produces at least one generation a year (7). Generation time varies with the silkworm variety or geographic site. In general, its oversummering and overwintering eggs are diapause and hatch in late of April of the next

Table 1. Species and Distribution of Main Silk-producing

Species name I. Bombycidae Bombyx mori B. mandarina China, Japan, Korea II. Saturniidae Antheraea pernyi A. paphia A. sasamensis A. polyphemus Philosamia cynthia ricini Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax A. infracta A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Pieridae Eucheira socialis II. Bombycidae China, Japan, Korea ITemperate zone, Subtropical and tropical zone, China, Japan, Korea ITemperate zone, Subtropical and tropical zone China, Japan, Russia III. Actea India Japan, China, Korea, India, Korea, Indonesia Assam (India) Assachusetts (U.S.A) III. Aspan, India, Korea, Indonesia Southeastern Asia Southeastern Asia Southeastern Asia Southeastern Asia China, Japan, China, Eastern Siberia China, Japan China, Japan China, Vietnam, Burma, India, Malaysia China, Japan China, China, Korea India Japan, China, Korea India Japan, China, Korea India Japan, China, Korea Assam (India) Massachusetts (U.S.A) India Japan, China, Korea India Japan, China, Vietnam, Burma, India, Malaysia China, Japan China, Japan (Cultical) III. Notodontidae China, Japan China, Japan, Cuba, Egypt, France, Italy China, Japan, Cuba, Egypt, France, Italy China, Japan, China China, Japan China China China, Japan China China China China China China Ch		Moths
Bombyx mori B. mandarina China, Japan, Korea II. Saturniidae Antheraea pernyi A. paphia A. yamamai A. assamensis A. polyphemus Philosamia cynthia ricini Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus China, Japan China, Latern Siberia China, Japan China, Latern Siberia China, Japan China, Latern Siberia China, Japan California (U.S.A) III. Notodontidae Anaphe venata A. infracta A. reticulata Eponometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Pieridae	Species name	Distribution
Cal zone B. mandarina China, Japan, Korea II. Saturniidae Antheraea pernyi A. paphia A. yamamai A. yamamai A. polyphemus Philosamia cynthia ricini Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. infracta A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria pydiai Malacosoma incarvum azteam Pachypasa otus China, Japan China, China, Burma, India, Korea, Indonesia Southeastern Asia Southeastern Asia Japan, China China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan California (U.S.A) III. Notodontidae Anaphe venata A. infracta A. infracta Cameroon Zaire, Togo and Neighbouring Countries Cameroon V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Mexico Pachypasa otus V. Pieridae	I. Bombycidae	
B. mandarina II. Saturniidae Antheraea pernyi A. paphia India A. yamamai A. assamensis A. polyphemus Philosamia cynthia ricini Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Almodinia fugax Hyalophora euryalus III. Notodontidae A. infracta A. infracta A. infracta A. infracta A. infracta B. incidente in Emoloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus China, Japan, China, Korea, Indonesia China, Japan, India, Korea, Indonesia Southeastern Asia Southeastern Asia Southeastern Asia Southeastern Asia China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan China, Japan China, France, Italy China, Japan, Cuba, Egypt, France, Italy China, Japan, China China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan China, France, Italy China, Japan, Cuba, Egypt, France, Italy China, Japan, China Counta, Vietnam, Burma, India, Malaysia China, China, Japan, Chipa, Egypt, France, Italy China, Japan, Chipa, Malaysia China, Japan, Chipa, Malaysia China, Japan, Chipa, Malaysia China, Vietnam, Burma, India, Malaysia China, Japan, Chipa, Malaysia China, France, Italy China, Japan, Chipa, Malaysia Chipa, Vietnam, Burma, India, Malaysia Chipa, Japan, Chipa,	Bombyx mori	Temperate zone, Subtropical and tropi-
II. Saturniidae Antheraea pernyi A. paphia A. yamamai A. assamensis A. polyphemus Philosamia cynthia ricini Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V Pieridae China, Korea, India, Japan, Cuba, Egypt, France, Italy China, Japan, India, Korea, Indonesia Southeastern Asia Southeastern Asia Japan, China China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan California (U.S.A) Zaire, Togo and Neighbouring Countries Cameroon Zaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Southeastern Europe V. Pieridae		cal zone
Antheraea pernyi A. paphia A. yamamai A. yamamai A. assamensis A. polyphemus Philosamia cynthia ricini Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Pieridae A. sasam (India, Japan, Russia India Japan, China, Korea, Indonesia Southeastern Asia Southeastern Asia Southeastern Asia Southeastern Asia Ochina, Vietnam, Burma, India, Malaysia China, Japan China, Japan China, Japan China, Japan California (U.S.A) III. Notodontidae Anaphe venata A. infracta A. reticulata Uganda Epanaphe carteri E. moloneyi E. vuilleti Cameroon V. Lasiocampidae Botswana Mexico Southeastern Europe V. Pieridae		China, Japan, Korea
A. paphia	II. Saturniidae	
A. yamamai Japan, China, Korea A. assamensis Assam (India) A. polyphemus Massachusetts (U.S.A) Philosamia cynthia ricini India, China, Japan, Cuba, Egypt, France, Italy P. cynthia China, Japan, India, Korea, Indonesia Attacus atlas Southeastern Asia Actias seleme Southeastern Asia Dictyopoea japonica Eriogyna pyretorum China, Vietnam, Burma, India, Malaysia Saturnia boisduvali China, Eastern Siberia Rhodinia fugax China, Japan Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Zaire, Togo and Neighbouring Countries A. reticulata Uganda Epanaphe carteri Cameroon E. moloneyi Zaire, Togo and Neighbouring Countries Cameroon V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Mexico Pachypasa otus V Pieridae Japan, China, Japan, Cuba, Egypt, France, Italy China, Japan, China China, Vietnam, Burma, India, Malaysia China, Pastern Siberia China, Pastern Siberia China, Pastern Siberia China, Japan, China China, Vietnam, Burma, India, Malaysia China, Pastern Siberia Astern Siberia China, Pastern Siberia Astern Siberia China, Pastern Siberia China, Past	Antheraea pernyi	
A. assamensis A. polyphemus Philosamia cynthia ricini P. cynthia Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus A. infracta A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Pieridae Andyna Cuhina, China, Japan, India, Korea, Indonesia Southeastern Asia Southeastern Asia Japan, China China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan California (U.S.A) Saturnia boisduvali China, Eastern Siberia China, Japan California (U.S.A) Saturnia boisduvali China, China, Fusta Surma, India, Malaysia Capan, China Capan, China Capan, China Capan, Cuba, Egypt, France, Italy China, Japan, Cuba, Egypt, France, Italy China, Japan, Cuba, India, Korea, Indonesia Asialy Capan, China Capan, China Capan, China Capan, China Capan, Cuba, Egypt, France, Italy China, Japan, India, Korea, Indonesia Asian, Japan, Cuba, India, Korea, Indonesia Asian, Japan, China China, Vietnam, Burma, India, Malaysia Capan, China China, Vietnam, Burma, India, Malaysia Capan, China Capan, China China, Vietnam, Burma Burma, India, Korea, Indonesia Actiasy China, Japan, China China, Vietnam, Burma Burma, India, Korea, Indonesia		
A. polyphemus Philosamia cynthia ricini Philosamia cynthia ricini P. cynthia Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus Massachusetts (U.S.A) India, China, Japan, India, Korea, Indonesia Southeastern Asia Southeastern Asia China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan California (U.S.A) III. Notodontidae Anaphe venata Zaire, Togo and Neighbouring Countries Cameroon Zaire, Togo and Neighbouring Countries Cameroon V. Lasiocampidae Botswana Madagascar Africa Botswana Mexico Southeastern Europe V. Pieridae	A. yamamai	Japan, China, Korea
Philosamia cynthia ricini Philosamia cynthia ricini P. cynthia Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus China, Dapan China, Vietnam, Burma, India, Malaysia China, Eastern Siberia China, Japan China, Japan China, Japan China, Burma, India, Malaysia China, Eastern Siberia China, Japan China, Fastern Siberia Alaysia China, Fastern Siberia Alaysia China, Fastern Siberia C		
France, Italy China, Japan, India, Korea, Indonesia Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Epanaphe carteri Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus France, Italy China, Japan, India, Korea, Indonesia Southeastern Asia China, Flagari Malacysia China, Flagari Malacys		
P. cynthia Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus Southeastern Asia Southeastern Asia Japan, China China, Japan, China China, Japan, India, Korea, Indonesia Southeastern Asia Southeastern Asia Japan, China China, Vietnam, Burma, India, Korea, Indonesia Actias Southeastern Asia Southeastern Asia Japan, China China, Vietnam, Burma, India, Korea, Indonesia Actias Southeastern Asia Japan, China China, Japan California (U.S.A) III. Notodontidae Zaire, Togo and Neighbouring Countries Cameroon Vaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Mexico Southeastern Europe V. Pieridae	Philosamia cynthia ricir	
Attacus atlas Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Epanaphe carteri E. moloneyi E. vuilleti Cameroon IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus Southeastern Asia Southeastern Surma Actions, Malacysia China, Daise C		
Actias seleme Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Epanaphe carteri E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Pieridae Southeastern Asia Japan, China China, Vietnam, Burma, India, Malaysia China, Japan California (U.S.A) Saturnia boisduvali China, Japan California (U.S.A) U.S.A) U.S.A) California (U.S.A) III. Notodontidae Caire, Togo and Neighbouring Countries Cameroon Zaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Southeastern Europe V. Pieridae		
Dictyopoea japonica Eriogyna pyretorum Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria paponica Pachypasa otus V. Pieridae Japan, China China, Vietnam, Burma, India, Malaysia China, Papan, China China, Vietnam, Burma, India, Malaysia China, Pachypasa otus Alapan, China China, Vietnam, Burma, India, Malaysia China, Pachypasa otus China, Pietnam, Burma, India, Malaysia China, Pachypasa otus China, Vietnam, Burma, India, Malaysia China, Vietnam, Burma, India, Malaysia China, Vietnam, Burma, India, Malaysia China, Pachypasa otus Cairc, Togo and Neighbouring Countries Cairc, T		
Eriogyna pyretorum China, Vietnam, Burma, India, Malaysia Saturnia boisduvali Rhodinia fugax China, Eastern Siberia China, Eastern Siberi		
Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Epanaphe carteri E. moloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus Medina, Eastern Siberia China, Eastern Siberia China, Eastern Siberia (L.S.A) Zaire, Togo and Neighbouring Countries Cameroon Cameroon Valaecosoma descention Cameroon Madagascar Africa Botswana Mexico Mexico Southeastern Europe V. Pieridae		
Saturnia boisduvali Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus China, Eastern Siberia China, Japan California (U.S.A) III. Notodontidae Zaire, Togo and Neighbouring Countries Cameroon Zaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Mexico Southeastern Europe V. Pieridae	Eriogyna pyretorum	
Rhodinia fugax Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta Epanaphe carteri E. moloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus China, Japan California (U.S.A) Zaire, Togo and Neighbouring Countries Cameroon Zaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Mexico Southeastern Europe V. Pieridae	0-1	
Hyalophora euryalus III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria posidii Malacosoma incarvum azteam Pachypasa otus III. Notodontidae Zaire, Togo and Neighbouring Countries Cameroon Zaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Mexico Southeastern Europe V. Pieridae		
III. Notodontidae Anaphe venata A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti Cameroon IV Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria posidii Malacosoma incarvum azteam Pachypasa otus Zaire, Togo and Neighbouring Countries Cameroon IV Lasiocampidae Botowana Madagascar Africa Botswana Mexico Mexico Southeastern Europe V. Pieridae		,
Anaphe venata A. infracta A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus Zaire, Togo and Neighbouring Countries Cameroon V Auganda V A		California (U.S.A)
A. infracta A. reticulata Epanaphe carteri E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Zaire, Togo and Neighbouring Countries Cameroon V. Cameroon Madagascar Africa Botswana Mexico Mexico Mexico Southeastern Europe V. Pieridae		Zoiro Togo and Najahhauring Countries
A. reticulata Uganda Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V Qamero Cameroon V Aeighbouring Countries Cameroon Madagascar Africa Africa Botswana Mexico Mexico Mexico Southeastern Europe V. Pieridae		
Epanaphe carteri E. moloneyi E. vuilleti V Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus Cameroon V Cameroon V Aleighbouring Countries Cameroon Wadagascar Africa Africa Botswana Mexico Mexico Mexico Southeastern Europe V. Pieridae		
E. moloneyi E. vuilleti V. Lasiocampidae Borocera cajani Gonometa postica G. ruforunnea Gloreria psidii Malacosoma incarvum azteam Pachypasa otus V. Zaire, Togo and Neighbouring Countries Cameroon Madagascar Africa Botswana Mexico Mexico Mexico Southeastern Europe V. Pieridae		
E. vuilleti Cameroon IV Lasiocampidae Borocera cajani Madagascar Gonometa postica Africa G. ruforunnea Botswana Gloreria psidii Mexico Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		
IV Lasiocampidae Borocera cajani Madagascar Gonometa postica Africa G. ruforunnea Botswana Gloreria psidii Mexico Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		
Borocera cajani Madagascar Gonometa postica Africa G. ruforunnea Botswana Gloreria psidii Mexico Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		Carreroon
Gonometa postica Africa G. ruforunnea Botswana Gloreria psidii Mexico Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		Madagascar
G. ruforunnea Botswana Gloreria psidii Mexico Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		
Gloreria psidii Mexico Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		
Malacosoma incarvum azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		
azteam Mexico Pachypasa otus Southeastern Europe V. Pieridae		Mexico
Pachypasa otus Southeastern Europe V. Pieridae		Mexico
V. Pieridae		
Eucheira socialis Mexico		
	Eucheira socialis	Mexico

^{*}Zhejiang Agricultural University, Hangzhou 310029, China Received on 28.12.94 and accepted for publication on 14.11.95.

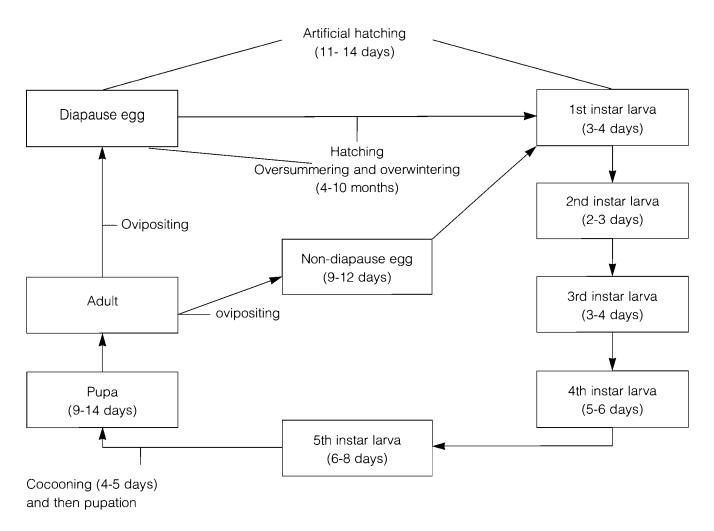


Fig. 1. Life cycle of Bombyx mori (7)

year. Diapause eggs could hatch after treatment with brine acid with specific gravity of 1.075 for 4.5-5.5 minutes under 46°C. The larvae mainly feed mulberry leaves. Each larva ingests about 20-25g fresh leaves during the whole larval period, and 85-88% of that quantity during the 5th instar or last instar. Its life cycle is summarized in Fig. 1

2.2 Antheraea pernyi

The Chinese oak silkworm or Chinese tussah silkworm, Antheraea pernyi produces two generations a year in the region north of 35° N and one generation to the south of this region. It overwinters as diapause pupa. The adults of monovoltine silkworm emerge, oviposit from March to April. Eggs hatch from early to mid April and larvae cocoon and pupate from mid to late May. Pupae then diapause until eclosion appears in late March and early April of the next year. As for bivoltine silkworm, in the overwintering generation the adults emerge and oviposit in early April. Eggs hatch from April to May and larvae cocoon and pupate from mid to late June. Adults emerge and oviposit from early to mid July. The second generation eggs hatch from July to August and larvae cocoon and pupate from mid to late September(4).

Larvae feed on more than 30 plant species of 11 families. They mainly favour Quercus plants such as Q. acutissima, Q. liaotungensis, Q. mongolica, Q. varialilis and Q. dentata. The younger larvae favour tender leaves but the older ones mature leaves. The total amount ingested by the larva is 30-35g fresh leaves in spring and 50-55g in autumn. In China the stadia of 1st, 2nd, 3th, 4th and 5th instar larva of the first generation are 7, 10, 9, 11 and 15 days, respectively, and those of the second generation are 6, 5.5, 5, 8.5 and 18 days. The suitable temperature and relative humidity (R.H.) are 17-25 °C and 85-90%, respectively. The male and female moths can mate as from the first day after emergence. Each female moth oviposits about 200-300 eggs in the whole adult period. Generally egg period lasts about 10 days. The proper temperature and relative humidity (R.H.) for egg hatching are 22-26 °C and 75-85%.

2.3 Antheraea yamamai

The Japanese oak silkworm, *Antheraea yamamai* produces one generation a year and overwinters as pharate first-instar larva in the egg shell. In Northeast China the hatching larvae appear in early and mid May. Larvae cocoon and pupate from late June to

early July. Moths emerge and lay eggs in early August. The fertilized eggs complete their embryonic development for about 10 days after oviposition. Pharate first-instar larvae do not hatch at once but diapause. In Japan, the silkworm also has one generation a year and overwinters as pharate first-instar larva, eggs hatch from late April to early May. Larvae cocoon and pupate in early July, then some moths emerge and oviposit in late July. Others however exhibit summer dormancy and lay eggs in late September (1). Diapause of pharate first-instar larva could be broken down after treatment with midazole, I-binzyle-5-[(e)-2,6-dimethy-1,5-heptadienyl]-imidazole (KK-42) and its analogs (6).

The fodder plants of the silkworm are chiefly *Quercus* plants e.g. *Q. fabri, Q. acutissima, Q. mongolica, Q. dentata.* Among them *Q. fabri* is regarded as the best one (3,8). Total ingested leaves amount to 30-40g fresh leaves. Under 20 °C and R.H.of 70 %, the stadia of 1st, 2nd, 3rd, 4th, 5th, instar larvae are 7, 7, 11, 12 and 17 days, respectively. The optimal temperature and relative humidity (R.H.) for 1st-2nd, 3rd, 4th-5th instar larvae are 29 °C, 27 °C, 25 °C and 75-80%, 70%, 60-65%, respectively. The moths mainly emerge during 19:00-21:00 hours and 5:00-6:00 hours of the next day. The optimal temperature for mating is about 12-19 °C. Over 20° C mating percentage is very low. Each moth lays 120-190 eggs during the whole adult period (2).

2.4 Philosamia cynthia ricini

The number of generation per year for *Philosamia* cynthia ricini varies with the region. Seven to eight generations per year are recorded in Southern China, four to six generations in Eastern China, three generations in Northern China and two to three generations in Northeast China (4).

The larvae feed on leaves of *Ricinus communis*, *Manihot utilissima*, *Hetropana fragrans*, *Carica papaya*, *Evodia fraxinifolia*, *Ailanthus excelsa* or *Coriaria sinica*. *R. communis* is widely cultivated in China. Each larva consumes about 30-35g *R. communis* fresh leaves. The total larval stadium is 23-30 days under 15-20 °C,18-23 days under 20-25 °C and 14-18 days under 25-30 °C. A female lays about 500 eggs during the whole adult period.

3. Cocoon and silk

3.1 Bombyx mori

The cocoon of mulberry silkworm, *B. mori* consists of four parts i.e. cocoon floss, cocoon shell, pupal body and cast skin, of which the cocoon shell is for reeling. Depending on the shape, cocoons are classified as elliptic, peanut-shaped, spindle-shaped and globe-shaped. The prevailing colour is white, but yellow, red or green also exists. Properties of cocoon and silk are summarized in Table 2.

Table 2. Cocoon and silk properties of B. mori

Properties	Spring	Summer	
		and Autumn	
Cocoon weight (g)	2.0-2.5	1.5-1.8	
Cocoon shell weight (g)	0.45-0.55	0.23-0.30	
Silk weight (g)	0.35-0.45	0.22-0.27	
Cocoon filament length (m)	1000-1400	700-1000	
Cocoon filament size (denier)	2.5-3.0	2.0-2.7	

B. mori silk is widely used for producing various silk fabrics such as dresses, kimonos, quiltcovers and ties. By-products of cocoons such as inferior cocoon, unreelable cocoon, pupal shirt, cocoon floss and waste filaments are utilized as raw materials in cosmetics, foodstuffs and in the electric industry.

3.2 Antheraea pernyi

In *A. pernyi* the shape of cocoon is long-elliptic. For bivoltine silkworm, length and width of spring cocoon are 4.2-4.8 cm and 2.1-2.5 cm, respectively, those of autumn cocoon are individually 5.1-5.5 cm and 2.4-2.5 cm. For monovoltine silkworm, those are 4.0-4.2 cm and 2.0-2.1 cm, respectively. The whole cocoon weights of monovoltine and bivoltine silkworm are 8-9 g and 9-10 g. Their cocoon shell and cocoon filament weights are 0.7-1.0 g and 0.60-0.80 g, respectively. Its filament is thicker, more resistant to acid and alkali than that of mulberry silkworm.

The long filaments are used for weaving silk fabric as cloths and ornaments. It can also be mixed with cotton, flax or sheep wool for making various cloths. It is also used in the electric industry.

3.3 Antheraea yamamai

In *A. yamamai* the cocoon is long-elliptic. Its colour is mainly green but light green or golden yellow also exists. The length and width of the cocoon are 4.5-5.3 cm and 2.3-2.7 cm. The whole cocoon weight, cocoon shell weight are 2.4-3.6 g and 0.19-0.35 g, and they vary with the season, fodder plants and temperatures.

This silk has great cultural and ritualistic significance. It is utilized for producing small tablecloths, neckties, obis (belts) and cloths for Buddhist altars. Many of these fabrics are very costly.

Differences of cocoon and silk characteristics between *B. mori*, *A. pernyi* and *A. yamamai* are summarized in Table 3.

Table 3. Cocoon and silk characteristics of the three important silk-producing moths

tant one producing mone						
Characteristics	B. mori	A. pernyi	A. yamamai			
Cocoon colour	White	Brown	Green			
Whole cocoon weight (g)	2.0	8.0	3.5			
Cocoon shell percentage(%)	24.0	10.0	9.0			
Cocoon filament length (m)	1300-1500	600-700	500-600			
Cocoon filament weight (g)	0.38	0.26-0.30	0.30-0.35			
Cross shape of filament	Round	Depressed	Depressed			
	triangle	triangle	triangle			
Tenacity of silk (g)	10	20	25			
Elongation of silk (%)	22	32	53			
Size of silk (denier)	2.8-3.0	5.0	5.0-6.0			

3.4 Philosamia cynthia ricini

The cocoon of *P. cynthia* ricini is spindle-shaped. Its colour is white, grey yellow, cream-coloured or red brown. Its length and width of cocoon are 3.5-4.5 cm and 1.5-1.8 cm. The whole cocoon weight, cocoon shell weight, filament length and filament size are 2.3-

3.2 g, 0.35-0.49 g, 300-567 m and 2.35-2.36 denier, respectively (4).

The silk is only used for producing spun-silk fabrics. It can be mixed with the silk of *B. mori* or *A. pernyi* and plant fibres.

Literature

- Akai, H. & Kurabaysi, S., (ed.)., 1990 Tensan-science and technology, Science House.
- Hu Cui, (ed.)., 1991 A collection of research papers on the Japanese oak silkworm, Antheraea yamamai Guerin-Meneville, pp. 41-190, Shanghai Scientific and Technical Publisher.
- Hu Cui, Ye Gongyin., 1994 The effect of two fodder plants on the performance of the Japanese oak silkworm, Antheraea yamamai. Entomologia Sinica 1(3):251-258
- Lu Hongsheng., (ed.)., 1990 Sericulture in China, pp. 847-901, Shanghai Scientific and Technical Publishers.
- 5. Peigler, R.S., 1993 Wild silks of the world. Entomol. Soc. Am. 39(3) 151-161
- Suzuki, K., Fujisawa, T. & Kurihara, M., 1989 Artificial hatching in the silkworm, *Antheraea yamamai*: application of KK-42 and its analogs. Wild Silkmoths '88, pp.79-84.
- Zhang Qiuangxi & Xu Wenhua., 1990 Insects as Resource, pp. 31-68, Shanghai Scientific and Technical Publisher.
- Ye Gongyin, Hu Cui. Ye Zhiyi & Zhou Ailian., 1991 Preliminary comparison of *Quercus fabri* and *Quercus acutissima* as fodder of *Antheraea yamamai*, in A collection of research papers on the Japanese oak silkworm, *Antheraea yamamai* Guerin-Meneville, pp. 117-120, Shanghai Scientific and Technical Publisher.

Ye Gongyin, Chinese, Ph.D. of Entomology and major Insects as Resources. Hu Cui, Chinese, Professor.

INIVIT

Instituto de Investigaciones en Viandas Tropicales

(Institute for Research on Tropical Food) Ministry of Agriculture, Cuba

WHAT ARE THE MAIN WORKING CROPS?

We are working mainly with the following crops:
Cassava (Manihot esculenta Crantz), sweet potato (Ipomoea batatas Lam.),
plantain (AAB and ABB groups), banana (AAA group),
cocoyam (Colocasia esculenta Shot and Xanthosoma spp.), Yam (Dioscorea spp.),
papaya (Carica papaya), tomato (Lycopersicon esculentum) and potato (Solanum tuberosum).

Requests for further information may be adressed to: Dr. Sergio Rodriguez Morales, Director Lic. Nilo Maza Estrada, Head of Training

Address: INIVIT

Apartado # 6

Santo Domingo, Villa Clara, Cuba Tel. 4-2103 & 4-2344 - Telex 041-423 - Fax 335086