AGF/CRO/11/007/REG	DATE: 13TH OCTOBER 2017

JAIF PROJECT PROGRESS REPORT

PROJECT TITLE:	**Taxonomic capacity building to support market access for agricultural trade in the ASEAN region**	
PROJECT PROGRESS REPORT:	☐ 1st ☐ 2nd ☐ 4th ☐ 5th XXXX	
PROJECT START AND END DATES	From: MAY 2015	To: JUNE 2018
PERIOD COVERED BY THIS REPORT:	From: 1 MAY 2017	To: 30 SEPTEMBER 2017
IMPLEMENTING AGENCY:	ASEAN Plant Health Cooperation Network (APHCN) - ASEANET	
CONTACT PERSONS:	Names: DR LUM KENG YEANG (Chairperson & Project Manager) & DR SOETIKNO S. SASTROUTOMO (Technical Secretary) Tel: +60-3-8943-2921 Fax: +60-3-8942-6490 E-mail: ky.lum@cabi.org AND s.soetikno@cabi.org	

OVERVIEW:

Briefly describe: (i) the objective of the project; (ii) progress in project implementation to date; (iii) any particular issues faced and/or results achieved during this reporting period.

(i) **Overall objective:**
The project will develop and strengthen capacities in taxonomic knowledge to identify and manage quarantine risks associated with agricultural commodities and to accurately diagnose pests and diseases among the ASEAN Member States (AMS).

Intermediate objective: To increase taxonomic capacity of scientists/officers from AMS in 3 groups of insect pests and diseases, i.e. in plant viruses, aphids and leaf miners of agricultural importance.

(ii) Progress till September 2017:

Only one activity wai carried out in the period from May to September 2017, i.e. on Activity 1.1. Training Workshop on Weevils of Quarantine Importance (I,ncluding Storage Pests) held at the Institute of Weed Science, Entomology and Plant Pathology, UPLB, Los Banos-Philippines from 10-22 July 2017. Thirty project briefs were distributed to the participants of this Training Workshop. In addition, the website for this project has been updated with the uploading of the 4th Progress Reports of the Project, training materials, and reference materials and reports of the attachment program.

One additional activity of the Component 1-1: Study Visit and Training Workshop on Identification of Fruitflies in Japan has been approved by ASEC and JAIF Management Team for implementation from the unspent Project Fund, and at the same time the Project has been approved for no-cost extension until 30th June 2018. This activity will be held in Japan from 18th November to 2nd December 2017 and the logistic preparation has been running very smoothly. Eight participants, one each from eight ASEAN member states have been nominated, accompanied by a coordinator from ASEANET-APHCN, to attend the training. All of their return air-tickets have been purchased and issued, and they are ready for travel to Tokyo in November 18.

(iii) **Results:**

The following outputs have been achieved:

1. Report of the Training Workshop on Weevils of Quarantine Importance in the Philippines
2. Training Manual on Weevils of Quarantine Importance.
3. Updated Project Website (http://aseanet.org/JAIF1.asp)
4. Proposal and tentative program for the Study Visit & Training Workshop on Identification of Fruitflies in Japan.

PART A: PROGRESS & RESULTS

A. PROGRESS & ACHIEVEMENTS:

Describe progress in implementation during this reporting period, including key outputs/outcomes, based on the approved project document.

1. Training Workshop on Diagnostics of Weevils of Quarantine Importance

The training workshop was organized in the Philippines with the collaboration of the Institute of Weed Science, Entomology and Plant Pathology (IWEP), UPLB, Los Banos-Philippines from 10-22 July 2017. The training workshop was coordinated by Dr. Sheryl A. Yap from IWEP-UPLB, assisted by Dr. Priscilla Barcial and graduate students. Several senior lecturers from UPLB, e.g. Dr. Pio Javier, Research Professor, Dr. Celia dR. Medina, Associate Professor, Dr. Barbara L. Caoili, Professor contributed. The only resource person from Japan was Dr. Hiraku Yoshitake from the Insitute of Agro-Environmental Sciences, NARO, Tsukuba. Nineteen participants from 10 ASEAN member states (2 each from Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam, and one from Singapore) attended the training workshop.

The 2-weeks Training Workshop comprised 12 sessions, i.e. Opening Program & Introduction, Habitat Identification of Weevils, Weevils in Agricultural Crops, Field Collection in Storage Facilities and Agricultural Areas, Weevils as Storage Pests and their Control, Collection and Preservation Techniques, DNA Sequencing, Quarantine Policies, Information Resources on Weevils from the Web, and Training Evaluation and Closing Program.

To fully assess the comprehension of each of the participants, a one-hour post evaluation test in the form of an exam was administered covering the lectures taught in the training course. An evaluation form was also distributed to trainees to assess the effectiveness of the training workshop in fulfilling the proposed objectives as well as the efficiency of the training team. Based on the result of the test, the top 5 participants are: (1) Mr. Kemas Usman (78.18%, Indonesia), (2) Mr. Ittipon Bannakan (74.55%, Thailand), (3) Ms. Norkhadijah Binti Haji Latip (70.91%, Brunei), (4) Mr. Joni Hidayat (67.27%, Indonesia), and (5) Mr. Peter Magdaraog (56.36%, Philippines). Based on their performances in the class and laboratory as well as the evaluation results, the 5 resource persons involved in the training selected 3 participants, one each from Indonesia, Thailand and Vietnam for the 2-months attachment program in Japan, pending approval from their superiors.

The full training workshop report prepared by Dr. Sheryl A. Yap is appended in this report as **Attachment 1** and the **Training Manual** as **Attachment 2**.

2. Study Visit & Training Workshop on Identification of Fruitflies in Japan

This activity was in the priority list of proposed activities (in total 10 activities) endorsed by the 18th Meeting of the ASEAN EWG-PS held in Vientiane, Lao PDR from 18-19 July 2016.

The Study Visit & Training Workshop will be organized by **Prof. Dr. Keiko NATSUAKI**, Dean, Graduate School of Agriculture, Tokyo University of Agriculture, Japan in collaboration with the Plant Quarantine Office, Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan from 18th November to 2nd December 2017. Nine participants from the ASEAN member states accompanied by a coordinator from ASEANET-APHCN, have been nominated by their respective member states to attend the training. All of their return airtickets have been purchased and issued, and they are ready for travel to Tokyo in November 18.

The proposal for the Study Visit & Training Workshop and its tentative program is given in **Attachment 3.**

3. Attachment Program on Diagnostics of Weevils of Quarantine Importance

We had originally planned to organize this attachment in October 2017, however, after consultation with the resource persons (International & Regional) during the training at UPLB, Philippines and also through intensive communication by e-mail, the attachment can only be organized in mid-January 2018, with one month each in the Philippines and Japan. This is largely due to the limited space and equipment at Dr. Hiraku Yoshitake's laboratory and also his other research commitments at his Institute.

B. TIMEFRAME AND BUDGETING

Explain whether the project is on-track with regard to: (i) the budget; and (ii) the original timeframe. If either the expenditures and/or timeframe are off-track, please explain and describe the corrective actions being taken.

Approval for Project Extension: Project implementation is behind schedule, as a result of the cancellation of one activity of the Component 1-1: Training Workshop and Attachment Program on Diagnostics of Aphids which would have started in September 2016. Therefore, request for project extension with no cost was submitted to JAIF Management Team through the ASEAN Secretariat in July 10th, 2017. The Project was approved in 19th July for extension until 30th June 2018 with the additional activity on "Study Visit & Training Workshop on Identification of Fruitflies in Japan".

End Project Meeting: This planned meeting would involve members of the Project Steering Committee and would only be implemented upon completion of the above two activities, i.e. on the Study Visit & Training Workshop on Identification of Fruitflies in Japan and Attachment Program on Weevils, and the draft Final Project Report is prepared for discussion at the meeting. It is proposed that the meeting be organized in late April or early May 2018.

Project Budget

Budget expenditure during this reporting period was only US$ 119,273.36 (**Attachment 4**).

C. OTHER IMPLEMENTATION ISSUES

Describe any significant changes to the project design, context or partners during the reporting period, or any other issues faced, and actions that are being taken in response, if appropriate.

One additional activity on *"Study visit to Japan national SPS/Plant Health laboratories cum Training workshop on the Identification of Fruit Flies"* has been approved by JAIF Management Team through the ASEAN Secretariat for implementation under the current project funding. This activity will be implemented from 18 November to 2 December 2017.

D. OTHER COMMENTS:

Please provide any other relevant information or observations on the project, e.g. on lessons learned, particular challenges or issues that may arise in the next reporting period, changes to the logframe, etc.

Proposal for JAIF Phase 2 Project

ASEC has given several comments on the proposal for Phase 2, after consultation with JAIF Management Team in December 2016 for further revision, improvement and re-submission. A clarification has been given for completion and answers by the Project Manager. ASEC has also suggested the APHCN-ASEANET conduct a survey in the AMS especially for ex-participants of the Phase 1 of the Project on the benefits of the project as well the status of their capabilities relating to their diagnostics expertise and facilities. The survey has been conducted using "survey questionnaire" given by ASEC from February to April 2017 and the summary results are given in the **Attachment 5**.

The proposal has been revised with a budget, as suggested by JAIF-MT, of less than US$ 500,000.- will only cover 2 (two) training workshops and 1 (one) attachment program in Japan, i.e. on:

a). Training workshop on Diagnostic of Plant Parasitic Nematodes to be held in Indonesia with a Japanese resource person, Dr. Prof. Dr. Hideaki Iwahori from Department of Bioresource Sciences, Faculty of Agriculture, Ryukoku University, Otsu, Shiga 520-2194, Japan.

b). Training workshop on Diagnostics of Begomovirus and the Use of LAMP-PCR to be held in the Philippines with a Japanese resource person, Prof. Dr. Masashi Ugaki from Laboratory of Bioresource Technology, Department of Integrated Biosciences, Graduate School of Frontier Science, The University of Tokyo, Kashiwa-shi, Chiba-ken 277-8561, Japan.

c). Attachment program on Diagnostics of Plant Parasitic Nematodes to be held at the Department of Bioresource Sciences, Faculty of Agriculture, Ryukoku University, Otsu, Shiga 520-2194, Japan under the supervision of Prof. H. Iwahori.

The revised proposal has been submitted to ASEC and JAIF-MT on 29th May 2017 for their funding consideration and approval. It was informed by JAIF-MT that the revised proposal would be considered by them only after the Phase 1 Project is near completion (before June 2018). Recently (18th September) ASEC has informed ASEANET-APHCN that the members of the ASEAN Expert Working Group on Phytosanitary Measures (EWGPS) in its meeting held in July in Malaysia has expressed support for the development of project proposal of ARDN Phase II. It was suggested by ASEC that the revised proposal should be migrated to the new format of ASEAN Project Proposal which was released in May 2017. Currently we are in the process of migrating the proposal before re-submission to ASEC and JAIF-MT at the appropriate time.

Provide a list of key documents (e.g. mission reports, training materials, workshop reports, etc.) produced during this reporting period. Copies of the final versions of these documents should be attached to this report.

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1. Report of the Training Workshop on Weevils of Quarantine Importance in the Philippines
2. Training Manual on Weevils of Quarantine Importance.
3. Proposal and tentative program for the Study Visit & Training Workshop on Identification of Fruitflies in Japan.
4. Financial Report from 1st May to 30 September 2017
5. Output Survey Report- JAIF Project on Taxonomic Capacity Building to support market access for agricultural trade in the ASEAN region

E: FINANCIAL OVERVIEW (SEE ATTACHMENT 5)

	JAIF*	**In kind / Other****	**Total**
a) Total project budget (US$)	892,354.10	-	892,354.10
b) Total amount received to date (US$)	847,736.40	-	847,736.40
c) Total expenditure during the reporting period*	119,273.36	-	119,273.36
d) Total expenditure to date (US$)	556,076.14	-	556,076.14
e) Unspent funds a) – d) (US$)	336,277.96	-	336,277.96

Attachment 1

Terminal Report on Training Workshop on Weevils of Quarantine Importance

at
The Institute of Weed Science, Entomology and Plant Pathology – UPLB, Los Banos, Philippines

10 - 22 July, 2017

Organized by:

Institute of Weed Science, Entomology and Plant Pathology, UPLB, Los Banos, Philippines

In Collaboration with:

ASEAN Network on Taxonomy

2017

TERMINAL REPORT

Training Workshop on Diagnostics of Weevils of Quarantine Importance

(PROJECT NO. AGF/CRO/11/007/REG)

IWEP, University of the Philippines Los Baños| 10-22 July 2017

Funded by:

Japan – ASEAN Integration Fund (JAIF)

Through

ASEAN Plant Health Cooperation Network of the ASEANET

(APHCN-ASEANET)

EXECUTIVE SUMMARY

The project entitled "Training Workshop on Diagnostics of Weevils of Quarantine Importance" was facilitated by the Institute of Weed Science, Entomology and Plant Pathology in partnership with ASEAN Plant Health Cooperation Network of ASEANET project on "Taxonomy capacity building to support market access for agricultural trade in the ASEAN region". The project was funded by Japan-ASEAN Integration Fund (JAIF) with intensive training period conducted from 10-22 of July 2017.

This two-week training program (10-22 July) was participated by 19 quarantine officers in which some of them were working as field quarantine officer or in quarantine laboratories. Participants were from Brunei Darussalam, Cambodia, Indonesia, Laos PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

The main objective of this workshop is to provide the participants basic knowledge, understanding, and practical skills on the importance of taxonomy, biology, and ecology of weevils in the context of pest management.

The training course covered the following topics: basic taxonomy, biology, ecology, identification and collection techniques, and basic DNA barcoding techniques of weevils with quarantine importance. Likewise, participants were taught of proper pest management strategies of these weevils.

To fully meet the goal of this training workshop, a combination of 15 interactive lectures including 2 field collections in storage facilities and agricultural farms and 8 laboratory works encompassing the classification, biology, ecology, preservation techniques as well as DNA sequencing of weevils were fully covered.

Post evaluation test were given at the end of the training workshop to fully assess the comprehension and performance of each participants, to determine the effectiveness of the training workshop in meeting the objectives proposed, for further improvement, and to evaluate the organizing team involved.

Session 1. Opening Program and Introduction

The training workshop was opened formally with welcome message led by Dr. Teresita U. Dalisay, IWEP Director. Shortly after, an introductory message was given by Dr. Soetikno S. Sastroutomo, secretary of ASEANET-APHCN team who provided an overview of the mandate of the training workshop and the expected outcomes in conjunction with the training's objectives. The 19 participants from ASEAN countries were introduced individually by Dr. Sheryl Yap as well as the resource speakers and members of the training team. After introducing the participants, a group picture were taken at the IWEP, UPLB commemorating the opening of the awaited workshop.

Lectures were also given by Dr. Hiraku Yoshitake a research scientist for Insect Systematics from the Institute for Agro-Enviromental Sciences, NARO Kannondai in which he tackled the classification, biology, ecology as well as economic importance of weevils.

After the lecture, individual presentation of country's reports were presented in which one representative per country briefly introduced the nature of their work, their organization as well as the current status of weevils infestation to their cash crops and what are the necessary precautions their organizations undertook to manage the pest infestation.

Before the day one of the training ends, a welcome dinner for the participants was held at Kamayan, Bay, Laguna to showcase diversity in Filipino cuisines showcasing the famous delicacies in the country like Buko pie (a traditional Filipino baked of young coconut with custard pie) and balut (a developing duck embryo that is boiled and eaten from the shell).

Figure 1. Group photo taken at the IWEP, University of the Philippines, Los Baños, Philippines on July 10, 2017.

Figure 2. Dr. Dalisay delivering the welcome and opening message to the participants.

Figure 3. Dr. Soetikno delivering the mandate of the training workshop to the participants.

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Figure 4. Dr. Yap formally introducing the19 participants, resource speakers and the training team.

Figure 5. Dr. Hiraku Yoshitake delivering his lectures on classification, biology and ecology of weevils.

Figure 6. Dr. Peter Magdaraog (Philippines) delivering country report of weevils infestation for the training workshop.

Figure 7. Welcome dinner reception for the training participants held at Kamayan, Bay, Laguna.

Figure 8. Dr. Yoshitake accepting the Balut eating challenge.

Session 2. Habitus Identification of Weevils using Keys

Morning and afternoon session covered the practical assessment regarding habitus identification of weevils using keys as taught by Dr. Yoshitake. Basically it is an application of the morphology and taxonomy of weevils covered in the previous lectures.

In this session, participants were given 40 specimens of unknown weevils to be identified using a dissecting microscope. Unknown specimens were identified starting from the taxonomic rank order to subfamily level.

Figure 9. Dr. Yoshitake interactively mentoring the participants on identification of unknown weevils using keys.

Figure 10. Dr. Hieu (Vietnam) doing the taxonomic work on the identification of unknown weevils.

Session 3. Weevils in Agricultural Crops

In the morning session, common weevils infesting economically important agricultural crops were discussed by Dr. Celia Medina. These includes common pests of weevils found in banana, sweet potato, coconut, and mango. Dr. Medina also discussed the destructive effect brought by these weevils and the different control measures usually undertaken to control these pest below damaging level. The latter resource speaker also shared her research experience aligned with the topic regarding the possible implications of being heat tolerant of Mango Pulp Weevil as an adaptive mechanism.

Dr. Medina also demonstrated some sample specimens with keys in identifying the sex of the insect either by looking at the genitalia or noting their distinct morphological character differences between males and females.

In the afternoon session, participants were tasked to perform identification of weevils in agricultural crops by using the sample specimen brought by Dr. Medina and her team. Each participants also performed dissection of genitalia.

Figure 11. Dr. Medina discussing the common weevils attacking economically important crops.

Figure 12. Sample specimens of weevils attacking economically important crops brought by Dr. Medina and her team.

Figure 13. Dr. Medina with her team answering queries regarding identification of the sample weevils presented.

Figure 14. Dr. Medina (middle) with her research assistant, Ms. Gena (left) and Mr. Peejay (Right).

Figure 15. Mr. Peejay Rejuso assisting Mr. Rasey (Cambodia) on the identification of weevils in agricultural crops.

Figure 16. Awarding of certificate to Dr. Medina for sharing her expertise on weevils.

Session 4: Field Collection in Storage Facilities

Field trips were basically conducted for the purpose that each participants will have an actual experience on how to collect weevils and for interactive identification of weevils outside laboratory setup.

The first field trip was conducted at the Institute of Plant Breeding (IPB), a forefront institution for plant breeding research and germplasm collection. The participants toured inside a corn storage facility of IPB and were able to have a thorough discussion with the research assistant assigned to the group regarding corn grits and the current infestation rate brought by some weevils on corn. Afterwards, participants were brought in a rearing facility for corn weevils such as *Sitophilus zeamais*. Rearing methods and control methods of the latter insect were discussed with the help of a research assistant assigned on the facility. Shortly after, participants were able to have a first-hand experience of collecting weevils in a corn storage facility.

After the IPB trip, participants visited the Pagkaing Alay sa Mag-Anak na Nagsisikap (PAMANA) which is an organic sensitive vegetable farm. This time, participants were able to have a first-hand contact with the collection of *Cylas formicarius*, a sweet potato infesting weevils using pheromone trapping. The collected sweet potato weevils were put inside of a killing jar or small vials.

After the collection, participants did ocular visit at the IRRI Riceworld Museum of which is a prime international agricultural research. Rice museum is dedicated in showcasing artifacts concerning rice by describing different ways how rice is grown all throughout the world, different rice products like rice cakes, traditional way of farming rice. Not only that, the museum also exhibits the important role of rice as cereal in feeding billions of people.

Figure 17. Thorough exchange of discussion regarding corn grits and some weevils infesting corn.

Figure 18. Ms. Ramos (Philippines) viewing the *Sitophilus zeamais* under dissecting microscope at the rearing facility.

Figure 19. Participant's visit at the corn storage facility in IPB, UPLB.

Figure 20. Weevils field collection at the corn storage of IPB.

Figure 21. Dr. Yoshitake (left) and Mr. Crispolon (Right) collecting samples of corn weevils.

Figure 22. Group photograph taken during the trip to Institute of Plant Breeding, UPLB.

Figure 23. Participants collecting some *Cyclas formicarius*, a sweet potato weevil using pheromone trapping at PAMANA, UPLB.

Figure 24. Group picture taken after the trip in PAMANA, UPLB.

Figure 25. Ocular visit done at the IRRI Riceworld Museum, IRRI, UPLB.

Figure 26. Mr. Rasey (Cambodia), Ms. Vanna (Cambodia), Ms. Thua (Vietnam), Ms. Ramos (Philippines), Ms. Sounaly (Laos) taking height measurement against deepwater rice plant at the IRRI Riceworld Museum.

Figure 27. Ms. Siti (Malaysia) and Ms. Helwa (Brunei) (from left to right) buying some souvenir at IRRI, UPLB.

Session 5. Field Collection in Agricultural Farms

Before the actual field trip, a quick detour was done at the Entomological museum of the university. Basically, the said museum holds the largest amount of collected arthropods in the country. This includes not only the 6-legged arthropods but as well as its relatives in the family of Acari.

The second field trip was held at APA Farms, Majayjay, Laguna. APA Farms is known for its “Lambanog” wine making, a Filipino alcoholic beverage made from coconut. Not only that, the farm showcases also other products like pure honeybee. The farm is approximately 40 hectares dominated by coconuts, banana and other fruit trees. The farm also have stingless bee farm and cock pen encompassing wide agricultural land.

During this field trip, participants were able to conduct a hands-on collection of weevils infesting important economically crops like those found in coconut, banana, cacao, sweet potato etc. Method of collection was done using sweeping net, vials, killing jar with ethyl acetate, beating sheet and handpicking.

After collection, a lunch was served at the luncheon hall of APA Farm displaying various cuisines and freshly caught fried tilapia which is one of the attractions of the farm. A videoke fun activity followed which is a usual hanging out session of Filipinos.

After lunch, a 30 minutes tour from APA Farm to a vegetable farm was visited. This time, a snap bean farm is being featured as the collection site which involves a 25 minutes of almost 1km walk in a rocky road detour before you can reach the said farm.

This type of farm showcases the traditional farming in the Philippines against the famous vertical farming practice. Participants were then able to conduct the second round of their insect collection.

A short trip to Liliw Laguna, the shoe capital in the province of Laguna were visited by the participants. Participants were then able to do some sightseeing and souvenir shopping with the enigmatic view of Mt. Banahaw and a century old Catholic church.

Figure 28. Mr. Jeremy Naredo (right), curator and expert of the Acari Family introducing the museum to the participants.

Figure 29. Participants during their visit at the entomological museum of IWEP, UPLB.

Figure 30. Trademark logo of APA Farms, Majayjay, Laguna.

Figure 31. Mr. Rasey (Cambodia) doing field work collection on weevils at APA Farms.

Figure 32. Mr. Touy (Laos), Mr. Si Hao (Singapore) and Ms. Sounnaly (Laos) (from left to right) collecting *Cylas formicarius*, a sweet potato weevil.

Figure 33. Dr. Yoshitake and Mrs. Barcial ransacking banana pseudostem for the collection of *Cosmopolites sordidus,* a banana weevil.

Figure 34. Picture taken during lunch at the Luncheon Hall of APA Farms.

Figure 35. Mr. Usman (Indonesia) singing during videoke session at the APA Farms.

Figure 36. Ms. Siti (left) and Ms. Helwa (right) transferring their collected insects on a vial during the collection trip at a vegetable farm in Majayjay, Laguna.

Figure 37. Picture taken during field collection in a vegetable farm at Majayjay, Laguna.

Figure 38. Group photo taken after collection trip at the APA Farms, Majayjay, Laguna.

Figure 39. Sightseeing at the Liliw, Laguna, a shoe capital in Laguna Province.

Figure 40. A century old Catholic church located at Liliw, Laguna.

Figure 41. Mr. Lang Khaw Htang (Myanmar) (left) and Dr. Ko (Myanmar) (right) buying some wallet souvenirs at Liliw, Laguna.

Sightseeing Visit at Tagaytay

For the first weekend experience of the participants in the country, a sightseeing tour in some breathtaking sceneries in Tagaytay were visited by the participants. These includes the cinematic view of Mt. Taal the world's smallest active volcano and People's Park. The participants were then able to visit shopping mall located at the urban sprawl of Manila.

Figure 42. Group photo taken during the sightseeing tour at Mt. Taal in Tagaytay.

Figure 43. Walking detour along the streets of Tagaytay.

Figure 44. Surreal view of Tagaytay taken above.

Figure 45. Tagaytay-Talisay road with some steep sections with serpentine twists and turns.

Session 6. Weevils as Storage Pest and their Control

Some weevils are also a notorious pest of stored grain which makes them a serious suspect for a quality decline of some stored grains. Identification of common storage pest as well its corresponding parasitoid were discussed in this session. Dr. Pio Javier, a research professor led the discussion in which he introduced some common storage pest infesting economically important crops in the country and their morphology and ecology. Not only that, he also discussed the parasitoid used as a biological control agent as one of the methods of control management strategies currently being practiced in the country.

Under this session, participants were expected to identify taxonomically the unknown specimens of some storage pests with the help of dissecting microscope.

Figure 46. Dr. Ko (Myanmar) carefully looking at the morphology of an unknown storage pest.

Figure 47. Mr. Nazri (Malaysia) collecting storage pest for taxonomic identification.

Figure 48. Picture taken during the laboratory work on the identification of storage pest.

Figure 49. Mr. Ittipon (Thailand) (left) and Mr. Magdaraog (Philippines) (right) collecting directly some storage pest.

Figure 50. Awarding of certificate to Dr. Pio Javier for sharing his expertise on storage pest held at IWEP, UPLB.

Session 7. Preservation techniques

Knowledge on proper preservation of an insect is an essential asset that an entomologist should be fully aware of. Proper preservation techniques should be fully employed especially in identifying unknown insects that can serves as your reference and record for future use.

During this session, lectures regarding preservation techniques of weevils were demonstrated by Dr. Sheryl Yap, an insect taxonomist from University of the Philippines. In this session, Dr. Yap explained the importance of preserving specimens properly. She demonstrated various technique starting from proper pinning, labelling of specimens (including collection information). Proper maceration using chemicals and genitalia dissection with the use of dead insect bodies. Essential tools used in preservation techniques were also introduced like pinning stage, insect pin, vials, killing jar etc.

Participants are expected to be able to do and master the tasks mentioned above since it is a basic entomological technique.

Figure 51. Sample experimentation setup on the maceration of insect dead bodies using chemicals like KOH.

Figure 52. Participants doing maceration techniques using chemicals like KOH.

Figure 53. Participants cutting some board to make an improvised pinning stage.

Figure 54. Mr. Danai (Thailand) doing proper labelling of an insect sample.

Figure 55. Sample finished output of proper insect labelling done by the participants.

Session 8-9. DNA Sequencing Techniques

Application of molecular approach in taxonomy was introduced by Dr. Barbara Caoili, an insect pathologist professor from University of the Philippines. The approach uses DNA barcodes, as the name implies it works like a barcode found in a Universal Product Code since DNA is uniquely inherent in each species making barcodes distinct.

In this session, lectures regarding proper application of DNA techniques such as extraction of DNA, detection of DNA and sequencing and identification of DNA was introduced. Under this session, 4 practical exercises were conducted that covers 2 day sessions. Protocol regarding DNA extraction were already prepared by the Insect Pathology Lab Team. Expected outcomes are that participants were be able to do proper sequencing up to identification of DNA using different species of weevils.

Figure 56. Dr. Barbara Caoili introducing the lecture outline for DNA techniques lectures.

Figure 57. Ms. Vanna (Cambodia) performing the first step in DNA extraction using pipettor.

Figure 58. Mr. Usman (Indonesia) performing centrifugation to remove protein precipitate.

Figure 59. Group 1 photo taken at the Insect Pathology Laboratory with Ms. Helwa (Brunei), Ms. Thua (Vietnam), Dr. Caoili, Ms. Vanna (Cambodia), Ms. Sounaly (Laos) and Mr. Joni (Indonesia) (from left to right).

Figure 60. Group 2 photo taken at the Insect Pathology Laboratory with Mr. Touy (Laos), Ms. Norkhadijah (Brunei), Mr. Ittipon (Thailand), Mr. Usman (Indonesia) and Mr. Aaron Ogot (Research Assistant).

Figure 61. Group 3 and 4 photo taken at the Insect Pathology Laboratory with Ms. Ramos (Philippines), Mr. Si Hao (Singapore), Mr. Danai (Thailand), Mr. Lang Khaw Htang (Myanmar), Mr. Hieu (Vietnam), Ms. Siti (Malaysia), Dr. Ko (Myanmar).

Figure 62. Awarding of certificate to Dr. Caoili for sharing her expertise on application of molecular approach in taxonomy held at IWEP, UPLB

Session 10. Quarantine Policies

As the coming ASEAN integration, many adjustments should be made. One is to have an effective quarantine policies to prevent unwanted entry of foreign insect pest brought by trading system. In this session, a representative from the Bureau of Plant Industry named Mr. Joselito Antioquia introduced the organization and its functions by showing organizational map structure. The latter speaker also discussed established quarantine laws in the country covering areas of plant quarantine, seed quality control, crop production and protection, and technology development.

Figure 63. Mr. Antioquia introduced the Bureau of Plant Industry to the participants.

Session 11. Resources of Weevils on the Web

If one want to check database of weevils at the ease of time, websites storing data regarding weevils are already accessible at the click of your finger. In this session, Dr. Hiraku led the discussion by giving lists of websites as a legitimate resources for weevils. This includes database on some private/public organization aligned to the study of weevils.

Figure 64. Dr. Hiraku Yoshitake discussing some website resources for the easy access of weevils information

Session 12. Evaluation and Closing Program

To fully assess the comprehension and learnings of each participants, a 1 hour post evaluation tests in a form of an exam were administered covering the lectures taught for two weeks. An evaluation form were also given to assess the effectiveness of the training workshop in fulfilling the proposed objectives as well as the efficiency of the training team.

After the post evaluation test, awarding of certificates to the 19 participants, resource person and training team was held at IWEP Auditorium, UPLB. After the awarding ceremony, social night was held also at the same place to celebrate the ending of training workshop and to build fellowship among the participants as well as the training team.

Figure 65. Dr. Lang Khaw Htang answering the post evaluation test as last required activity during the training workshop.

Figure 66. Awarding of certificates to the 19 participants held at IWEP Auditorium, UPLB.

Figure 67. Awarding of certificate to the resource persons held at the IWEP Auditorium, UPLB.

Figure 68. Videoke session during social night held at IWEP, Auditorium, UPLB.

TERMINAL REPORT

I. BASIC INFORMATION

A. Project Title: Training Workshop on Diagnostics of Weevils of Quarantine Importance

Project Coordination:

- Dr. Lum Keng Yeang, Chairperson, ASEANET-APHCN
- Dr. Soetikno S. Sastroutomo, ASEANET-APHCN
- Dr. Sheryl A. Yap, Regional Training Coordinator/Collaborator (IWEP-UPLB)
- Dr. Priscilla Barcial, Assistant Regional Training Coordinator (IWEP-UPLB)

Resource Persons:

- Dr. Yoshitake Hiraku, Research Scientist, NARO, Kannondai
- Dr. Pio Javier, Research Professor (IWEP, UPLB)
- Dr. Celia dR. Medina, Associate Professor (IWEP-UPLB)
- Dr. Barbara L. Caoili, Professor (IWEP-UPLB)
- Dr. Sheryl A. Yap, Assistant Professor (IWEP-UPLB)

Support Staffs:

- Mr. Aldrin Alvarez
- Mrs. Ira Joey L. Celis
- Ms. Nikka H. Hamor
- Mrs. Ruby Ana P. Laude

B. Proponent and Address

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños (UPLB)
College, Laguna 4031
Philippines

C. Implementing Agencies

Lead Agencies:

- ASEAN Plant Health Cooperation Network of ASEANET (APHCN-ASEANET)
  Building A-19 MARDI Complex, Serdang, Selangor, 43400 Malaysia

- Institute of Weed Science, Entomology and Plant Pathology
  College of Agriculture and Food Science
  University of the Philippines Los Baños (UPLB)

College, Laguna 4031
Philippines

- Bionet-Aseanet

Funding Agency:

- Japan-ASEAN Integration Fund

D. Project Duration: Two (2) Weeks

a. Date Project Started: 10 July 2017

b. Expected Date of Completion: 22 July 2017

E. Period Covered by this Report: 10-22 July 2017

II. Technical Description

A. Background

Weevils are an antagonist group of insects that continuously hamper crop yield translating to severe financial loss to farmers. Not only known of its notorious infestation to a vegetative stage of a crop but also to stored products displaying a wide array of its devastating effect.

As the progressive implementation of ASEAN Integration, threat of potential entry of an “invasive” insect pest is inevitable due to impending influx of imports/exports of economically important crops brought by free-trade system. Thus, preventive measure is an effective forefront management tactics to prevent unwanted entry of this pest.

To further address the issue, correct diagnostic approach of taxonomic classification of an insect and good quarantine policy is an effective measure. Therefore knowledge on taxonomy should be an asset of a good quarantine official since they have a pivotal role of ensuring the future of a country’s reputation being free from the unwanted entry of invasive insect pest.

B. Course Description

This workshop is coordinated by the Institute of Weed Science, Entomology and Plant Pathology, College of Agriculture, and Food Science, University of the Philippines Los Banos through the ASEAN Plant Health Cooperation Network (APHCN) of ASEANET project on "Taxonomy capacity building to support market access for agricultural trade in the ASEAN region." This project is funded by the Japan-ASEAN Integration Fund (JAIF) that will be implemented for 2017 covering several activities related to training and attachment programs.

This workshop aims to provide the participants basic knowledge, understanding, and practical skills on the importance of taxonomy, biology, and ecology of weevils in the context of pest management. The training course will cover the following topics: basic taxonomy, biology, ecology, identification and collection techniques, and basic DNA barcoding techniques of weevils with quarantine importance. Likewise, participants will also be taught of proper pest management strategies of these weevils.

C. Objectives

General Objectives

Lecture: At the end of the training, the participants should be able to analyze the importance of controlling or managing weevils, their biology, and ecology.

Laboratory: At the end of the training, the participants should be able to demonstrate basic skills in identifying the species, genera and families of weevils based on morphology and habits, DNA barcoding, collecting, and preservation and labelling of specimens.

Specific Objectives

Lecture:

1) To describe the taxonomy, biology, and ecology of weevils with quarantine importance.
2) To recognize the importance of weevils in quarantine.
3) To discuss that weevils can invade one region to another
4) To design appropriate pest management strategies in controlling weevils

Laboratory:

1) To describe signs of weevil infestation.
2) To identify weevil species based on morphology and DNA barcoding.
3) To demonstrate basic techniques in identification, collection in the field, preservation of specimens, and DNA sequencing.

D. Training Course Outline

SESSION 1. OPENING PROGRAM AND INTRODUCTION

- Registration
- Welcome Message
- Introduction and Overview of the Training Course
- Introduction of Participants, Resource Person and Training Team
- Group Photograh
- Lecture 1: Classification, Biology and Ecology of Weevils
- Lecture 2: Economic Importance of Weevils
- Lecture 3: Taxonomy of Weevils

SESSION 2. HABITUS IDENTIFICATION OF WEEVILS

- Lecture: Morphology and terminology
- Practice: Identification of specimens using keys

SESSION 3. WEEVILS IN AGRICULTURAL CROPS

- Lecture: Important weevils attacking economically important crops
- Lecture: Control strategies and management of weevils

SESSION 4 & 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS

- Practice: Field observation and sampling
- Practice: Preliminary identification of specimens

SESSION 6. WEEVILS AS STORAGE PESTS AND THEIR CONTROL

- Lecture: Common Storage pests
- Lecture: Control strategies and management of storage pests
- Practice: Identification of storage pests

SESSION 7. COLLECTION AND PRESERVATION TECHNIQUES

- Lecture: Collection and Preservation techniques
- Practice: Demonstration
- Practice: Hands-on work

SESSION 8 & 9. DNA SEQUENCING

- Lecture: Proper DNA techniques and application
- Lecture: Extraction of DNA
- Lecture: Detection of DNA
- Lecture: Sequencing and identification of DNA
- Practice: Demonstration of DNA Techniques
- Practice: Extraction of DNA
- Practice: Detection of DNA
- Practice: Sequencing and identification of DNA

SESSION 10. QUARANTINE POLICIES

- Lecture: Quarantine policies and protocols

SESSION 11. RESOURCES OF WEEVILS ON THE WEB

- Browsing of web sites concerning with weevils

SESSION 12. EVALUATION AND CLOSING PROGRAM

- Post-test evaluation
- Closing Program

E. Training Content and Schedule

Date/Time/Venue	Topic/Activity	Resource Person(s)/Facilitator
Sunday, 09 July 2017		
	Arrival of Participants	Dr. Sheryl A. Yap and Ms. Priscilla M. Barcial, IWEP
Week 1: Monday, 10 July 2017		
Venue: CPC Auditorium	SESSION 1. OPENING AND INTRODUCTION	
08:45 - 09:00	Registration	Ms. Priscilla M. Barcial
09:00 - 09:30	Welcome Address	Dr. Enrico P. Supangco, Dean, College of Agriculture and Food Science
	Opening Remarks	Dr. Teresita U. Dalisay, Director, IWEP
09:30 - 09:40	Workshop Context and Overview	Dr. Sheryl A. Yap
09:40 - 10:00	Introduction of Participants, trainers and training team	
10:00 - 10:15	Group photograph	Mr. JP Aquino, OPR
10:15 - 10:45	Tea/coffee break	
Venue: CPC Auditorium	SESSION 2. CLASSIFICATION, BIOLOGY AND ECOLOGY OF WEEVILS	
10:45 - 12: 00	Lecture: Classification, biology and ecology of weevils	Dr. Hiraku Yoshitake, Institute for Agro-Environmental Sciences, NARO
12:00 - 13:00	Lunch break	
13:00 - 14:30	Lecture: Classification, biology and ecology of weevils	
14:30 -15:00	Lecture: Economic importance of weevils	
15:00 - 15:15	Tea/coffee break	
15:15 - 17:00	Country reports	All participants
Venue: Kamayan sa Palaisdaan	DINNER RECEPTION	All participants Resource persons Training team
Week 1: Tuesday, 11 July 2017		
Venue: Lab room	SESSION 3. HABITUS IDENTIFICATION OF WEEVILS	
09:00 - 10:30	Lecture: Morphology and Taxonomy	Dr. Hiraku Yoshitake

10:30 -10:45	Tea/Coffee break	
10:45 - 12:00	Practice: Identification of specimens using keys	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
12:00 - 13:00	Lunch break	
13:00 - 14:45	Practice: Identification of specimens using keys	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
14: 45 - 15:00	Tea/coffee break	
15:00 - 17:00	Practice: Identification of specimens using keys	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
Week 1: Wednesday, 12 July 2017		
Venue: Lab room	SESSION 4. WEEVILS IN AGRICULTURAL CROPS	
09:00 - 10:30	Lecture: WEEVILS IN AGRICULTURAL CROPS	Dr. Celia dR. Medina, IWEP
10:30 -10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Control Strategies and Management of Storage pests	Dr. Celia dR. Medina, IWEP
12:00 - 13:00	Lunch break	
13:00 - 14:30	Identification of Weevils in agricultural crops	
14: 30 - 14:45	Tea/coffee break	
14:45 - 15:45	Identification of Weevils in Agricultural Crops	Dr. Celia dR. Medina, Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
15:45 - 17:00	Identification of Weevils in Agricultural Crops	Dr. Celia dR. Medina, Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
Week 1: Thursday, 13 July 2017		
Venue: Storage facilities (Industry: Raw materials)	SESSION 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS	
07:00 - 07:30	Preparation for field trip (Venue: Hotel)	Training team All participants All resource persons

07:30 - 09:30	Travel from hotel to storage facilities	
09:30 - 10:30	Arrival and briefing of the facility	
10:30 -11:30	Observation and sampling	
11:30 - 13:30	Lunch	
13:30 -15:00	Observation and sampling	
15:00	Return to Hotel	
17:00	Arrival at the hotel	

Week 1: Friday, 14 July 2017		
Venue: Storage facilities (Agricultural products)	SESSION 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS (continued)	
07:00 - 07:30	Preparation for field trip (Venue: Hotel)	Training team All participants All resource persons
07:30 - 09:30	Travel from hotel to storage facilities	
09:30 - 10:30	Arrival and briefing of the facility	
10:30 -11:30	Observation and sampling	
11:30 - 13:30	Lunch/Prayer for Moslems	
13:30AM -15:00	Observation and sampling	
15:00	Return to Hotel	
17:00	Arrival at the hotel	

Week 1: Saturday, 15 July 2017

Venue: Farm areas	SESSION 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS (continued)	
07:00 - 07:30	Preparation for field trip (Venue: Hotel)	Training team All participants All resource persons
07:30 - 09:30	Travel from hotel to the farm	
09:30 - 10:30	Arrival	
10:30 -11:30	Observation and sampling	
11:30 - 13:30	Lunch	
13:30AM -15:00	Observation and sampling	
15:00	Return to Hotel	
17:00	Arrival at the hotel	

Week 1: Sunday, 16 July 2017		
	REST DAY	

Week 2: Monday, 17 July 2017		
Venue: Lab room	SESSION 6. WEEVILS AS STORAGE PESTS AND THIER CONTROL	
09:00 - 10:30	Lecture: Common Storage pests	Dr. Pio A. Javier,
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Control strategies and management of storage pests	
12:00 - 13:00	Lunch break	
13:00 - 14:30	Identification of storage pests	Dr. Pio A. Javier, Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake
14:30 - 15:00	Tea/Coffee break	

15:00 - 17:00	Identification of storage pests	Dr. Pio A. Javier, Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake

Week 2: Tuesday, 18 July 2017		
Venue: Lab room	SESSION 7. PRESERVATION TECHNIQUES	
09:00 - 10:30	Lecture: Preservation Techniques	Dr. Sheryl A. Yap, IWEP
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Preservation Techniques	Dr. Sheryl A. Yap, IWEP
12:00 - 13:00	Lunch break	
13:00 - 14:30	Practice: Demonstration	Dr. Sheryl A. Yap, IWEP
14:30 - 15:00	Tea/Coffee break	
15:00 - 17:00	Practice: Hands-on work	Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake

Week 2: Wednesday, 19 July 2017		
	SESSION 8. DNA SEQUENCING	
9:00 - 10:30	Lecture: DNA techniques and their application	Dr. Barbara L. Caoili, IWEP
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Extraction of DNA	
12:00 - 13:00	Lunch break	
13:00 - 14:30	Lecture: Detection of DNA	Dr. Barbara L. Caoili
14:30 - 15:00	Tea/Coffee break	
15:00 - 17:00	Lecture: Sequencing and identification of DNA	Dr. Barbara L. Caoili

Week 2: Thursday, 20 July 2017		
	SESSION 9. DNA SEQUENCING (continued)	
09:00 - 10:30	Practice: Demonstration of DNA Techniques	Dr. Barbara L. Caoili/Insect Path lab team
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Practice: Extraction of DNA	Dr. Barbara L. Caoili/Insect Path lab team
12:00 - 13:00	Lunch break	
13:00 - 14:30	Practice: Detection of DNA	Dr. Barbara L. Caoili/Insect Path lab team
14:30 - 15:00	Tea/Coffee break	
15:00 - 17:00	Practice Sequencing and identification of DNA	Dr. Barbara L. Caoili/Insect Path lab team
Week 2: Friday, 21 July 2017		
	SESSION 10. QUARANTINE POLICIES	
9:00 - 10:30	Lecture: Quarantine policies and protocols	Quarantine officer
10:30 - 10:45	Tea/coffee break	
10:45 - 12:00	SESSION 11. RESOURCES OF WEEVILS ON THE WEB	
	Browsing of web sites concerning with weevils	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
12:00 - 13:00	Lunch break	
	SESSION 12. EVALUATION AND CLOSING PROGRAM	
13:00 - 16:00	Post-test evaluation	Dr. Sheryl A. Yap
14:00 - 14:30	Tea/coffee break	
14:30 - 16:30	Closing remarks	Dr. Hiraku Yoshitake

Information related to Attachment Program	ASEAN representative
Official closing	Dr. Teresita U. Dalisay
Presentation of certificates	Dr. Hiraku Yoshitake
	Dr. Sheryl A. Yap
	Dr. Teresita U. Dalisay
Response from participants	Participant
Week 2: Saturday, 22 July, 2017	
DEPARTURE	

E. Resource Persons

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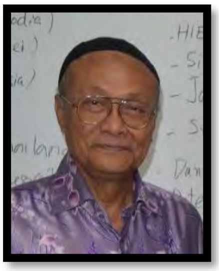
F. Training Team



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H. List of Participants

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K. Participant Groupings

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Ms. Hoang Kim Thoa
Ms. Roeun Vanna
Mr. Joni Hidayat

Group 2
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Mr. Mohd Nazri bin Mohd Joha
Mr. Kemas Usman
Mr. Ittipon Bannakan
Ms. Norkhadijah Binti Haji Latip

Group 3
Mr. Chua Si Hao
Mr. Ko Ko
Ms. Jacqueline Ramos
Ms. Siti Aisah Binti Jumaat
Mr. Bui Duc Hieu

Group 4
Mr. Peter Magdaraog
Mr. Chheng Rasey
Mr. Lang Khaw Htang
Mr. Danai Chaireunkaew

L. General Information

Accommodation

Participants were accommodated at BP-International Makiling (El Cielito Hotel).

Meals

Breakfast-complement of the hotel
Snacks and Lunch- served at the training venue
Dinner- at their pleasure and choice except during dinner reception, 21 July 2017

Local Transportation

The training coordinator as well as the support staffs arranged the transportation from Ninoy Aquino International Airport (NAIA) to UPLB as well as back to the NAIA.

UPLB Location/Address

College, Los Banos
4031, Laguna, Philippines

Contact Person

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09175959477

Helpful Contact Numbers

Mrs. Priscilla Barcial
Asst. Regional Training Coordinator
09553123863

University Police Force (for emergencies)

049-536-2243 or 049-536-2803

II. Methodology

The training was conducted at the Institute of Weed Science, Entomology and Plant Pathology, College of Agriculture, and Food Science, UPLB. Consisting of lectures on the proper identification of weevils of quarantine importance and how to manage them. There were also laboratory or hands-on exercises where participants are exposed to the actual specimens. Likewise, visit(s) to facilities such as warehouses or agricultural field experiment stations was conducted for the participants to have an experience on how to collect weevils.

Basically, the 2 weeks training utilized the interactive lectures, laboratory activities, short demonstration, field tour and collection visit to fully assess the potential of each participants. The entire training course was divided into 11 major sessions such as Session 1. Opening Program and Introduction, Session 2. Habitus Identification of weevils, Session 3. Weevils found in Agricultural Crops, Session 4. Field Collection on storage Facilities, Session 5. Field Collection on Agricultural Farms, Session 6. Weevils as Storage Pests and their Control, Session 7. Collection and Preservation Techniques, Session 8 & 9. DNA Sequencing, Session 10. Quarantine Policies, and Session 11. Resources of Weevils on the Web.

Each session consisted of 2 to 3-hour lectures done prior to 3-hours laboratory activities. Lectures were presented by Dr. Hiraku Yoshitake, Research Scientist for Insect Systematics from Institute for Agro-Environmental Sciences, NARO, Kannondai, Dr. Sheryl Yap from University of the Philippines Los Baños, Laguna, Philippines (IWEP-UPLB), Dr. Celia dR Medina from the University of the Philippines Los Baños, Laguna, Philippines (IWEP-UPLB), Dr. Barbara Caoili from the University of the Philippines Los Baños, Laguna, Philippines, Dr. Pio Javier from the University of the Philippines Los Baños, Laguna, Philippines.

Prior to the training proper, each participant was provided with a Training Workshop Manual (See attached Manual) which includes the training schedules and laboratory protocols. A country report was also initiated to assess the participants' professional background, nature of work and status of quarantine in their country. IPB Corn Storage facilities, IPB PAMANA, UPLB Entomological Museum, and IRRI Rice Museum were showcased.

Attachment 2

Training Manual on Diagnostic of Weevils of Quarantine Importance

Prepared by:

Institute of Weed Science, Entomology and Plant Pathology, UPLB, Los Banos, Philippines

In Collaboration with:

ASEAN Network on Taxonomy

2017

DIAGNOSTIC OF WEEVILS OF QUARANTINE IMPORTANCE

TRAINING MANUAL

Dr. Barbara L. Caoili
Dr. Pio A. Javier
Dr. Celia dR. Medina
Dr. Sheryl A. Yap
Dr. Hiraku Yoshitake

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

Funded by:
Japan – ASEAN Integration Fund
(JAIF)

Japan-ASEAN Cooperation

Through
ASEAN Plant Health Cooperation Network of the ASEANET
(APHCN-ASEANET)

Table of Contents

TRAINING WORKSHOP ON DIAGNOSTICS OF WEEVILS OF QUARANTINE IMPORTANCE

July 10 - 22, 2017

Institute of Weed Science, Entomology and Plant Pathology
Wing A, Biological Sciences Building
College of Agriculture and Food Science
University of the Philippines Los Banos

I. Project Title: Training Workshop on Diagnostics of Weevils of Quarantine Importance

II. Project Duration: Two weeks, from July 10-22, 2017

III. Training Outline

A. Background

Weevils are small to medium insects that belongs to the Order Coleoptera. They are usually dark-colored, brownish to black. Many are considered as pests of crops or stored products. Most of the small weevils can be present in imported agricultural and stored products. Weevils belonging to genus *Sitophilus, Callosobruchus, Anthonomus, Acanthoscelides, Merhynchites,* and *Cosmopolites* are the most serious pests of storage products. The damage that they cause is very destructive and expensive.

On the other hand, there are many other species of weevils that attack agricultural crops, for example, *Sternochetus frigidus,* these weevil is responsible in the down-fall of mango export industry in Palawan Island. Currently, there are observation of weevils feeding or attacking crops in some farm areas especially those areas that where converted from forest or shrubland into agricultural lands. These weevils are not previously seen or recorded feeding on agricultural crops. Hence, quick and accurate identification is vital in quarantine processes and converted farm areas. The proper identification could be able to limit or eliminate entry of these destructive pest to the importing countries as well as proper management or control strategies can be administered.

In this workshop, we aim to teach the participants how to identify weevils with economic importance, and the importance of taxonomy and ecology in managing or controlling pests such as weevils. Also, participants will be able to learn techniques in identification based on morphology and DNA sequences.

B. Course description

This workshop is coordinated by Crop Protection Cluster, College of Agriculture, University of the Philippines Los Banos through the ASEAN Plant Health Cooperation Network (APHCN) of ASEANET project on "Taxonomy capacity building to support market access for agricultural trade in the ASEAN region." This project is funded by the Japan-ASEAN Integration Fund (JAIF) that will be implemented for 2017 covering several activities related to training and attachment programs.

This workshop aims to provide the participants basic knowledge, understanding, and practical skills on the importance of taxonomy, biology, and ecology of weevils in the context of pest management. The training course will cover the following topics: basic taxonomy, biology, ecology, identification and collection techniques, and basic DNA barcoding techniques of weevils with quarantine importance. Likewise, participants will also be taught of proper pest management strategies of these weevils.

C. General Objectives

Lecture: At the end of the training, the participants should be able to analyze the importance of controlling or managing weevils, their biology, and ecology.

Laboratory: At the end of the training, the participants should be able to demonstrate basic skills in identifying the species, genera and families of weevils based on morphology and habits, DNA barcoding, collecting, and preservation and labelling of specimens.

D. Specific Objectives

Lecture:

1) To describe the taxonomy, biology, and ecology of weevils with quarantine importance.

2) To recognize the importance of weevils in quarantine.

3) To discuss that weevils can invade one region to another

4) To design appropriate pest management strategies in controlling weevils

Laboratory:

1) To describe signs of weevil infestation.

2) To identify weevil species based on morphology and DNA barcoding.

3) To demonstrate basic techniques in identification, collection in the field, preservation of specimens, and DNA sequencing.

E. Training Methodology

The training will be conducted at the Crop Protection Cluster, UPLB. This would consist of lectures on the proper identification of weevils of quarantine importance and how to manage them. There will also be laboratory or hands-on exercises where participants will be exposed to the actual specimens. Likewise, visit(s) to facilities such as warehouses or agricultural field experiment stations will be conducted so that participants will have an experience on how to collect weevils.

F. Training Contents

a. Course Outline

SESSION 1. OPENING AND INTRODUCTION
- Registration
- Welcome/Opening Program
- Introduction and overview of the training course
- Group photograph

SESSION 2. CLASSIFICATION, BIOLOGY AND ECOLOGY OF WEEVILS
- Lecture: Classification, biology and ecology of weevils
- Lecture: Economic importance of weevils
- Lecture: Taxonomy of Weevils

SESSION 3. HABITUS IDENTIFICATION OF WEEVILS
- Lecture: Morphology and terminology
- Practice: Identification of specimens using keys

SESSION 4. WEEVILS IN AGRICULTURAL CROPS
- Lecture: Important weevils attacking economically important crops
- Lecture: Control strategies and management of weevils

SESSION 5: FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS
- Practice: Field observation and sampling
- Practice: Preliminary identification of specimens

SESSION 6. WEEVILS AS STORAGE PESTS AND THIER CONTROL
- Lecture: Common Storage pests
- Lecture: Control strategies and management of storage pests
- Practice: Identification of storage pests

SESSION 7. DISSECTION OF GENITALIA
- Practice: Demonstration
- Practice: Hands-on work

SESSION 8. PRESERVATION TECHNIQUES
- Lecture: Preservation techniques
- Practice: Demonstration
- Practice: Hands-on work

SESSION 9. DNA SEQUENCING
- Lecture: Proper DNA techniques and application
- Lecture: Extraction of DNA
- Lecture: Detection of DNA
- Lecture: Sequencing and identification of DNA
- Practice: Demonstration of DNA Techniques
- Practice: Extraction of DNA
- Practice: Detection of DNA

- Practice: Sequencing and identification of DNA

SESSION 10. QUARANTINE POLICIES
- Lecture: Quarantine policies and protocols

SESSION 11. RESOURCES OF WEEVILS ON THE WEB
- Browsing of web sites concerning with weevils

SESSION 12. EVALUATION AND CLOSING PROGRAM
- Post-test evaluation
- Closing Program

G. PROGRAM OF THE TRAINING WORKSHOP

Date/Time/Venue	Topic/Activity	Resource Person(s)/Facilitator
Sunday, 09 July 2017		
	Arrival of Participants	Dr. Sheryl A. Yap and Ms. Priscilla M. Barcial, IWEP
Week 1: Monday, 10 July 2017		
Venue: CPC Auditorium	SESSION 1. OPENING AND INTRODUCTION	
08:45 - 09:00	Registration	Ms. Priscilla M. Barcial
09:00 - 09:30	Welcome Address	Dr. Enrico P. Supangco, Dean, College of Agriculture and Food Science
	Opening Remarks	Dr. Teresita U. Dalisay, Director, IWEP
09:30 - 09:40	Workshop Context and Overview	Dr. Sheryl A. Yap
09:40 - 10:00	Introduction of Participants, trainers and training team	
10:00 - 10:15	Group photograph	Ms. Nikka H. Hamor
10:15 - 10:45	Tea/coffee break	
Venue: CPC Auditorium	SESSION 2. CLASSIFICATION, BIOLOGY AND ECOLOGY OF WEEVILS	
10:45 - 12: 00	Lecture: Classification, biology and ecology of weevils	Dr. Hiraku Yoshitake, Institute for Agro-Environmental Sciences, NARO
12:00 - 13:00	Lunch break	
13:00 - 14:30	Lecture: Classification, biology and ecology of weevils	

14:30 -15:00	Lecture: Economic importance of weevils	
15:00 - 15:15	Tea/coffee break	All participants
15:15 - 17:00	Country reports	
Venue: Kamayan sa Palaisdaan	DINNER RECEPTION	All participants Resource persons Training team
Week 1: Tuesday, 11 July 2017		
Venue: Lab room	SESSION 3. HABITUS IDENTIFICATION OF WEEVILS	
09:00 - 10:30	Lecture: Morphology and Taxonomy	Dr. Hiraku Yoshitake
10:30 -10:45	Tea/Coffee break	
10:45 - 12:00	Practice: Identification of specimens using keys	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
12:00 - 13:00	Lunch break	
13:00 - 14:45	Practice: Identification of specimens using keys	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
14: 45 - 15:00	Tea/coffee break	
15:00 - 17:00	Practice: Identification of specimens using keys	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
Week 1: Wednesday, 12 July 2017		
Venue: Lab room	SESSION 4. WEEVILS IN AGRICULTURAL CROPS	
09:00 - 10:30	Lecture: Weevils in agricultural crops	Dr. Celia dR. Medina, IWEP
10:30 -10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Control strategies and management of storage pests	
12:00 - 13:00	Lunch break	
13:00 - 14:30	Identification of weevils in agricultural crops	Dr. Celia dR. Medina, Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake

14: 30 – 15:00	Tea/coffee break	
15:00 – 17:00	Identification of weevils in agricultural crops	Dr. Celia dR. Medina, Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake
15:45 - 17:00	Practice: Hands-on work	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
Week 1: Thursday, 13 July 2017		
Venue: Storage facilities (Industry: Raw materials)	SESSION 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS	
07:00 - 07:30	Preparation for field trip (Venue: Hotel)	Training team All participants All resource persons
07:30 - 09:30	Travel from hotel to storage facilities	
09:30 - 10:30	Arrival and briefing of the facility	
10:30 -11:30	Observation and sampling	
11:30 - 13:30	Lunch	
13:30 -15:00	Observation and sampling	
15:00	Return to Hotel	
17:00	Arrival at the hotel	
Week 1: Friday, 14 July 2017		
Venue: Storage facilities (Agricultural products)	SESSION 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS (continued)	
07:00 - 07:30	Preparation for field trip (Venue: Hotel)	Training team All participants All resource persons
07:30 - 09:30	Travel from hotel to storage facilities	
09:30 - 10:30	Arrival and briefing of the facility	

10:30 -11:30	Observation and sampling	
11:30 - 13:30	Lunch/Prayer for Moslems	
13:30AM -15:00	Observation and sampling	
15:00	Return to Hotel	
17:00	Arrival at the hotel	
Week 1: Saturday, 15 July 2017		
Venue: Farm areas	SESSION 5. FIELD COLLECTION IN STORAGE FACILITIES AND AGRICULTURAL AREAS (continued)	
07:00 - 07:30	Preparation for field trip (Venue: Hotel)	Training team All participants All resource persons
07:30 - 09:30	Travel from hotel to the farm	
09:30 - 10:30	Arrival	
10:30 -11:30	Observation and sampling	
11:30 - 13:30	Lunch	
13:30AM -15:00	Observation and sampling	
15:00	Return to Hotel	
17:00	Arrival at the hotel	

Week 1: Sunday, 16 July 2017		
	REST DAY	
Week 2: Monday, 17 July 2017		
Venue: Lab room	SESSION 6. WEEVILS AS STORAGE PESTS AND THIER CONTROL	
09:00 - 10:30	Lecture: Common Storage pests	Dr. Pio A. Javier
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Control strategies and management of storage pests	

12:00 - 13:00	Lunch break	
13:00 - 14:30	Identification of storage pests	Dr. Pio A. Javier, Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake
14:30 - 15:00	Tea/Coffee break	
15:00 - 17:00	Identification of storage pests	Dr. Pio A. Javier, Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake
Week 2: Tuesday, 18 July 2017		
Venue: Lab room	SESSION 7. DISSECTION OF GENITALIA	
09:00 - 10:30	Practice: Demonstration	Dr. Hiraku Yoshitake
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Practice: Hands-on work	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
12:00 - 13:00	Lunch break	
	SESSION 8: PRESERVATION TECHNIQUES	
13:00 - 14:30	Lecture: Preservation techniques	Dr. Sheryl A. Yap
14:30 - 15:00	Tea/Coffee break	
15:00 - 17:00	Practice: Demonstration and Hands on work	Dr. Sheryl A. Yap, Dr. Hiraku Yoshitake
Week 2: Wednesday, 19 July 2017		
	SESSION 9. DNA SEQUENCING	
9:00 - 10:30	Lecture: DNA techniques and their application	Dr. Barbara L. Caoili, IWEP
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Lecture: Extraction of DNA	
12:00 - 13:00	Lunch break	

13:00 - 14:30	Lecture: Detection of DNA	Dr. Barbara L. Caoili
14:30 - 15:00	Tea/Coffee break	
15:00 - 17:00	Lecture: Sequencing and identification of DNA	Dr. Barbara L. Caoili

Week 2: Thursday, 20 July 2017

	SESSION 9. DNA SEQUENCING (continued)	
09:00 - 10:30	Practice: Demonstration of DNA Techniques	Dr. Barbara L. Caoili/Insect Path lab team
10:30 - 10:45	Tea/Coffee break	
10:45 - 12:00	Practice: Extraction of DNA	Dr. Barbara L. Caoili/Insect Path lab team
12:00 - 13:00	Lunch break	
13:00 - 14:30	Practice: Detection of DNA	Dr. Barbara L. Caoili/Insect Path lab team
14:30 - 15:00	Tea/Coffee break	
16:00 - 17:00	Practice Sequencing and identification of DNA	Dr. Barbara L. Caoili/Insect Path lab team

Week 2: Friday, 21 July 2017

	SESSION 10. QUARANTINE POLICIES	
9:00 - 10:30	Lecture: Quarantine policies and protocols	Quarantine officer
10:30 - 10:45	Tea/coffee break	
10:45 - 12:00	SESSION 11. RESOURCES OF WEEVILS ON THE WEB	
	Browsing of web sites concerning with weevils	Dr. Hiraku Yoshitake, Dr. Sheryl A. Yap
12:00 - 13:00	Lunch break	
	SESSION 12. EVALUATION AND CLOSING PROGRAM	

13:00 - 16:00	Post-test evaluation	Dr. Sheryl A. Yap
14:00 - 14:30	Tea/coffee break	
14:30 - 16:30	Closing remarks	Dr. Hiraku Yoshitake
	Information related to Attachment Program	ASEAN representative
	Official closing	Dr. Teresita U. Dalisay
	Presentation of certificates	Dr. Hiraku Yoshitake
		Dr. Sheryl A. Yap
		Dr. Teresita U. Dalisay
	Response from participants	Participant
Week 2: Saturday, 22 July, 2017		
	DEPARTURE	

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ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

SESSION 2

CLASSIFICATION, BIOLOGY AND ECOLOGY OF WEEVILS

Lecture Notes by:

DR. HIRAKU YOSHITAKE
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CLASSIFICATION, BIOLOGY AND ECOLOGY OF WEEVILS

1. Classification of Weevils

Weevils mean beetles which belong to the superfamily Curculionoidea having a worldwide distribution.

Kingdom Animalia

Phylum Arthropoda

Subphylum Hexapoda

Class Insecta

Order Coleoptera

Suborder Polyphaga

Infraorder Cucujiformia

Superfamily Curculionoidea

- Weevils are most diverse in tropical and subtropical latitudes.
- Currently comprise 62,000 described species in ca 5,800 described genera (Oberprieler *et al.*, 2007).
- The total number of existing weevil species has been estimated at ca. 220,000 or higher (Oberprieler *et al.*, 2007), due to the presence of numerous unknown species.
- Virtually all taxa of seed plants in both terrestrial and freshwater habitats, and nearly all plant parts, are utilized as food by weevils (Oberprieler *et al.*, 2014).

The higher classification system of Curculionoidea has not been settled yet. A varying number of weevil families are recognized from 7 to over 20 in different systems.

In modern phylogenetic classifications, the superfamily Curculionoidea comprises 7 families (e.g., Oberprieler *et al.*, 2014):

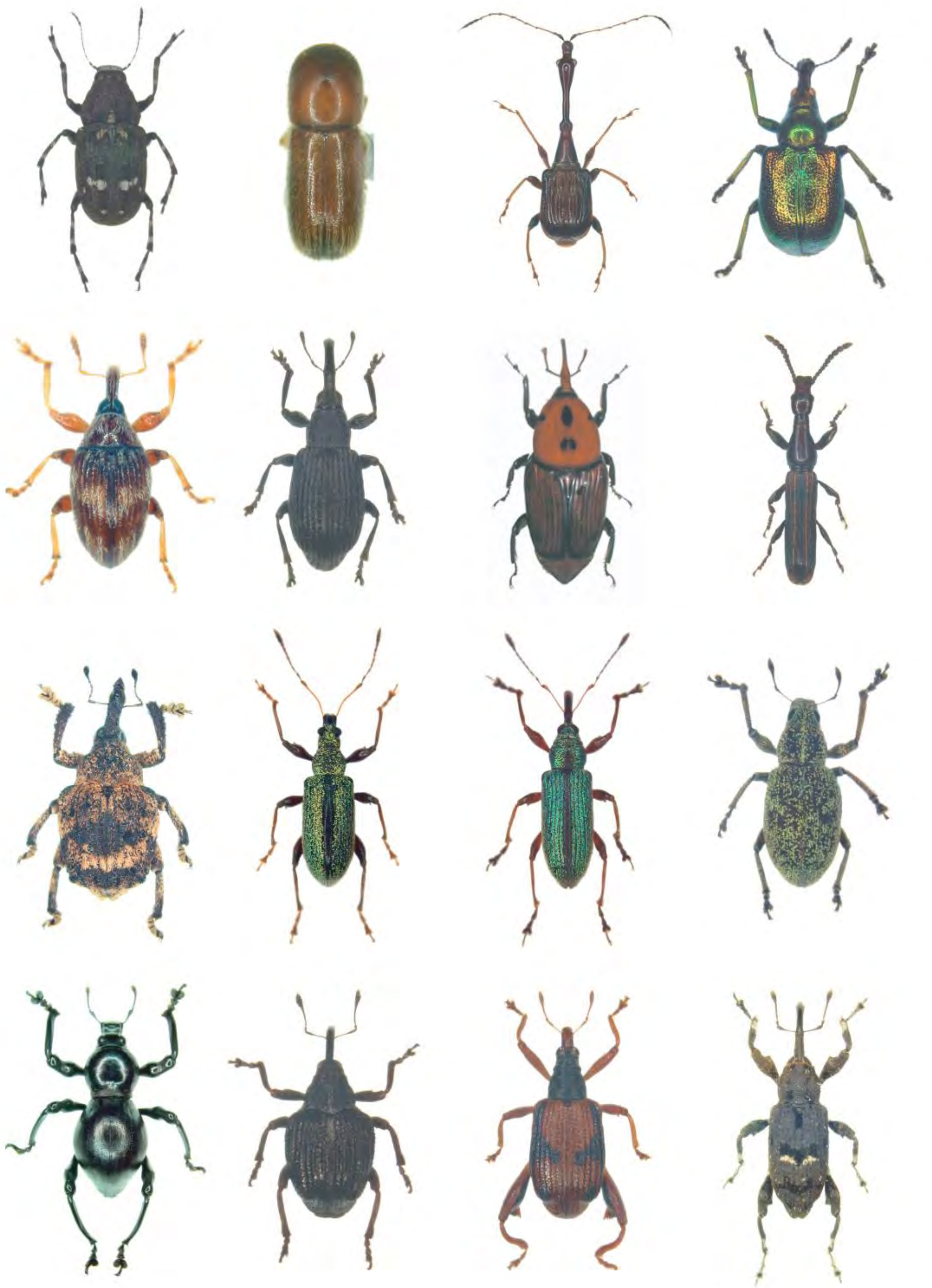
1) **Family Nemonychidae**
2) **Family Anthribidae**
3) **Family Belidae**
4) **Family Attelabidae** (incl. Rhynchitidae)
5) **Family Caridae**
6) **Family Brentidae** (incl. Apionidae, Nanophyidae)
7) **Family Curculionidae** (incl. Brachyceridae, Dryophthoridae, Platypodidae, Scolytidae)

However, this system is somewhat hard to use especially in morphological identification of major groups placed in Curculionidae, the largest family in Curculionoidea. In this lecture, therefore, we fundamentally follow this system, but recognize the following 11 families as major weevil groups from the ASEAN region for convenience in the subsequent lecture “HABITUS IDENTIFICATION OF WEEVILS”.

1) **Family Anthribidae**
2) **Family Attelabidae**
3) **Family Rhynchitidae**
4) **Family Brentidae**
5) **Family Apionidae**
6) **Family Nanophyidae**
7) **Family Curculionidae**
8) **Family Brachyceridae**
9) **Family Dryophthoridae**
10) **Family Platypodidae**
11) **Family Scolytidae**

Bibliography

1) Leschen R. A. B. & Beutel R. G. (eds), 2014. Handbook of Zoology, Arthropoda: Insecta; Coleoptera, Beetles, Volume 3: Morphology and Systematics (Phytophaga). Walter de Gruyter, Berlin/Boston.675 pp.
2) Morimoto, K., H. Kojima & S. Miyakawa, 2006. The Insects of Japan, Volume 3: Curculionoidea: General Introduction and Curculionidae: Entiminae (Part 1). Phytobiini, Polydrusini and Cyphicerini (Coleoptera). 406 pp. Touka Shobo, Fukuoka.
3) Oberprieler, R.G., A.E. Marvaldi & R.S. Anderson, 2007. Weevils, weevils, weevils everywhere. Zootaxa, 1668: 491-520.



Various weevils

2. Biology and Ecology of Weevils

Family Nemonychidae (based mainly on Anderson *et al.*, 2014)

This is a small weevil family comprising 78 described species in 26 genera.

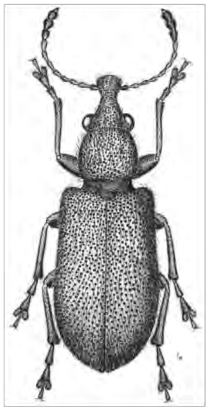


Fig. 3.1.1 *Cimberis compta* (LeConte), adult, dorsal habitus (© Agriculture Canada; illustration by C. Paquette).

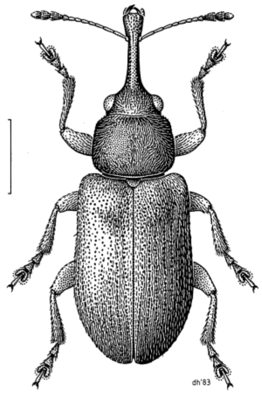


Fig. 3.1.2 *Atopomacer ites* Kuschel adult, dorsal habitus, scale line = 1 mm (© Landcare Research, New Zealand; illustration by D. W. Helmore).

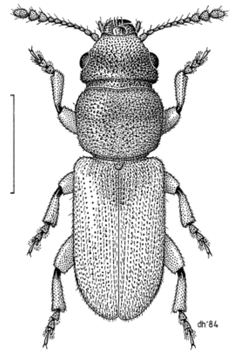


Fig. 3.1.3 *Brarus mystes* Kuschel, adult, dorsal habitus, scale line = 1 mm (© Landcare Research, New Zealand; illustration by D. W. Helmore).

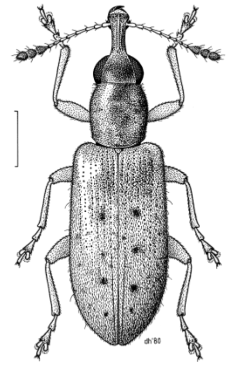


Fig. 3.1.5 *Notomacer araucariae* Kuschel, adult, dorsal habitus, scale line = 1 mm (© Landcare Research, New Zealand; illustration by D. W. Helmore).

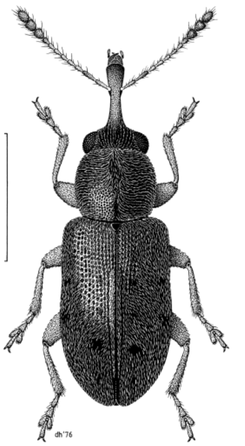


Fig. 3.1.6 *Rhinorhynchus rufulus* (Broun), adult, dorsal habitus, scale line = 1 mm (© Landcare Research, New Zealand; illustration by D. W. Helmore).

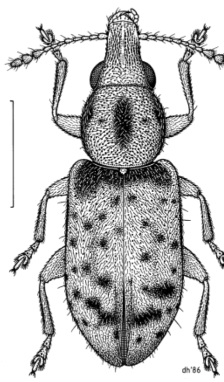


Fig. 3.1.4 *Bunyaeus monteithi* Kuschel, adult, dorsal habitus, scale line = 1 mm (© Landcare Research, New Zealand; illustration by D. W. Helmore).

Fig. 3.1.8 *Zimmiellus fronto* Kuschel, adult, lateral view (© Landcare Research, New Zealand; illustration by B. Rhode).

Nemonychidae species

Distribution:

- Nemonychidae are distributed in the Australian, Nearctic, Neotropical and Palaearctic regions.
- No species are known from the Afrotropical and Oriental regions.
- Nemonychids are most diverse in the southern-temperate Neotropical region (Chile, Argentina and Brazil) and the eastern Australian one (including New Guinea, New Caledonia and New Zealand).

Biology and Ecology:

- Nemonychidae are largely associated with conifers of the families Araucariaceae, Pinaceae and Podocarpaceae, only three genera living on angiosperms: two on Nothofagaceae in the southern-temperate Neotropical region and one on Ranunculaceae in the Palaearctic region.

- Adults of all Nemonychidae appear to feed primarily if not exclusively on pollen of their hostplants.
- The eggs of the conifer-associated nemonychids are placed against the pollen-sacs in male cones before shedding the pollen. Larvae feed mainly on pollen and tender sporophylls. The full-grown larvae drop to the ground and then pupate in the soil.
- The larvae of an angiosperm-associated nemonychid, *Nemonyx lepturoides*, are consistently found inside the follicles of *Consolida regalis* (Ranunculaceae). They feed on the large soft seeds and fall to the ground when the fruit capsule splits, and then pupate in a spherical cocoon.

Araucaria araucana pollen cones
http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:261681-1

General appearance:

- Adults: body approximately 1.5–6.0 mm in length, moderately elongate and slightly convex, setose with both decumbent and erect hairs but without any broad scales; cuticle shining or matte, rarely slightly metallic, not otherwise brightly colored.
- Larvae: body usually less than 10 mm long, cylindrical, soft, white; legs very small; vestiture consisting of scattered long and short setae.

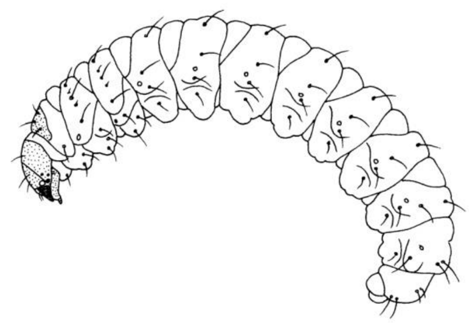


Fig. 3.1.9 *Rhinorhynchus rufulus* (Broun), larva, lateral view (© Landcare Research, New Zealand; illustration by B. M. May).

Family Anthribidae (based mainly on Mermudes & Leschen, 2014)

Currently including 3,861 species in 3 subfamilies: Anthribinae (28 tribes, 308 genera, 3148 species), Choraginae (5 tribes, 62 genera, 630 species), and Urodontinae (8 genera, 83 species).

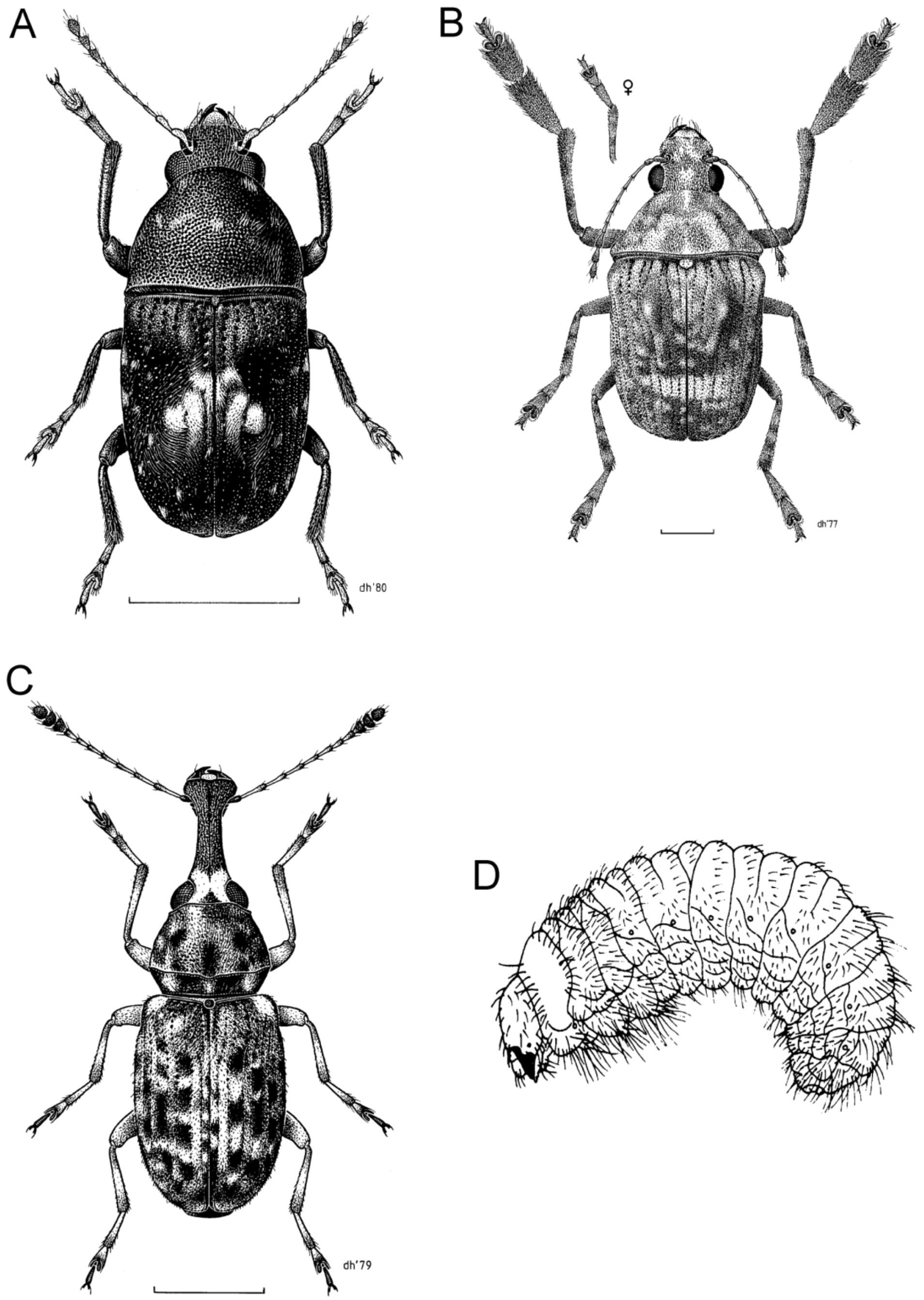


Fig. 3.2.1 Anthribidae. A, *Notochoragus crassus* (Sharp), adult; B, *Araecerus palmaris* (Pascoe) male with female leg (insert); C, *Helmoreus sharpi* Holloway, adult; D, *Arecopais spectabilis* (Broun), larva (© Landcare Research, New Zealand; illustration by D. W. Helmore), scale line = 1 mm.

Distribution:

- Anthribinae and Choraginae are distributed worldwide.
- Urodontinae occur in the Afrotropical and Palaearctic regions.

Biology and Ecology:

- Anthribinae contain herbivores, fungivores, and carnivores.
  Herbivores: e.g., larvae of *Ptychoderes* species feed on living stems or recently fallen tree trunks.
  Fungivores: e.g., *Euparius* species feed on polypore fungi.
  Carnivores: e.g., larvae of *Anthribus* species are predators of Sternorrhyncha such as scale insects.
- The majority of Choraginae are fungivores as adults and larvae, developing in fungus-infected wood of mainly angiosperms.
- Urodontinae weevils are herbivores, and larvae of most species develop in seeds.

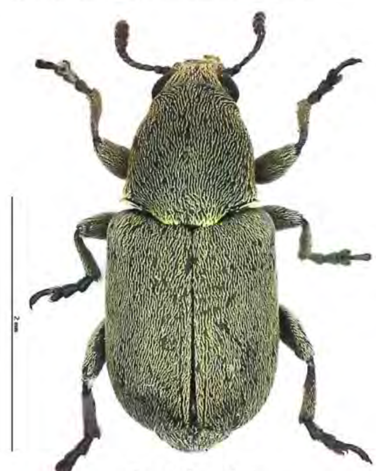
General appearance:

- Adults: body excluding rostrum 1.0–35.0 mm in length, compact, short to elongate, and convex or depressed; surfaces matte, subglabrous, or rarely glabrous; color black, brown, reddish-brown to gray, rarely green, and often with stripes or maculae.
- Larvae: body cylindrical, c-shaped, circular in cross-section (slightly flattened in), soft, white or pallid; legs usually present; vestiture consisting of scattered setae.

Anthribus nebulosus
http://www.colpolon.biol.uni.wroc.pl/brachytarsus%20nebulosus.htm

Family Belidae (based mainly on Marvaldi and Ferrer, 2014)

Containing 38 currently recognized genera and approximately 350 described species. The family is classified into 2 subfamilies, Belinae (ca. 145 species in 25 genera and 3 tribes) and Oxycoryninae (ca. 200 species in 13 genera and 3 tribes).



Bruchela rufipes
http://www.coleo-net.de/coleo/texte/bruchela.htm

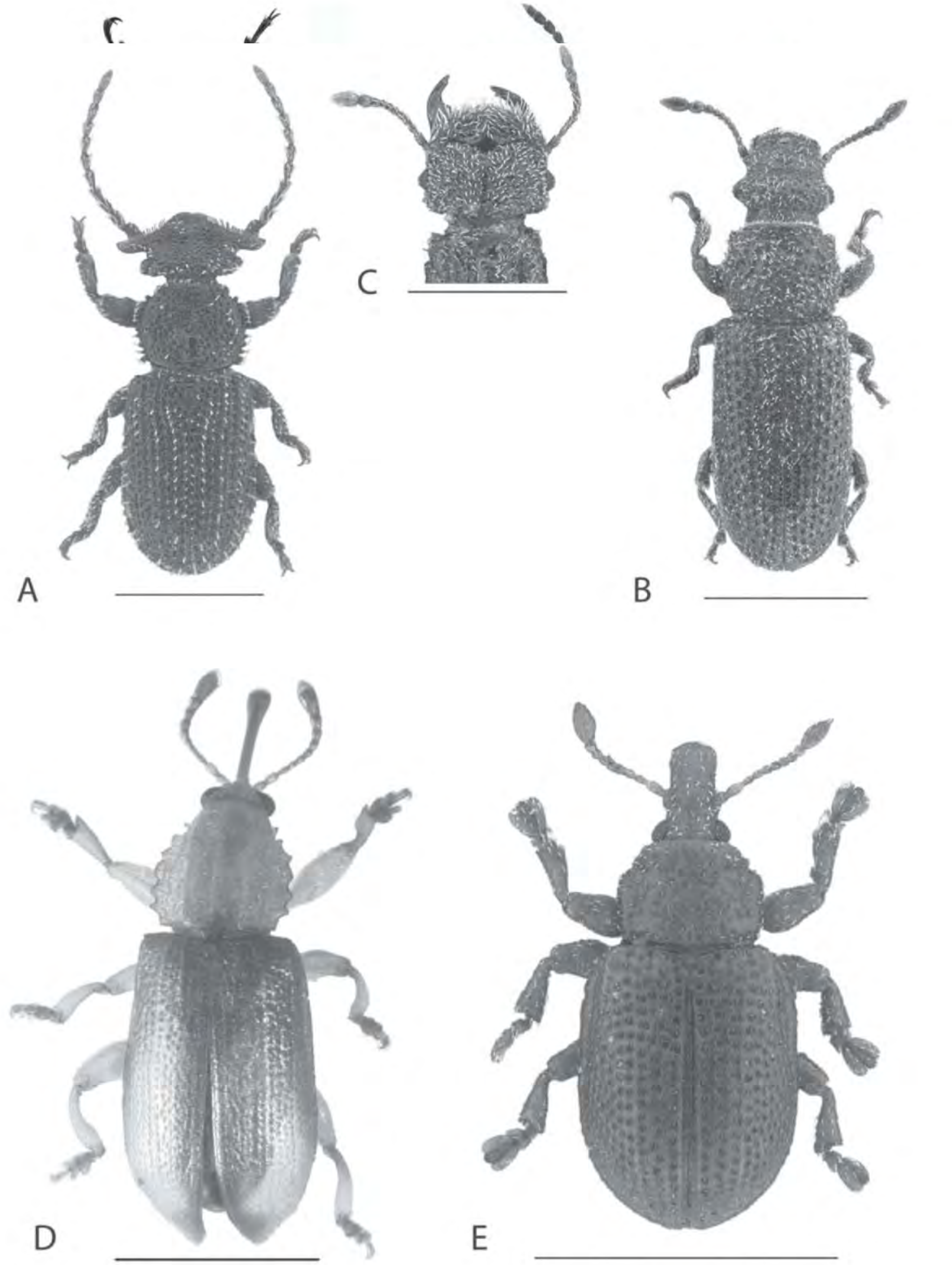


Fig. 3.3.4 A–D, Oxycoryninae, adults. A, *Aglycyderes setifer* Westwood (Aglycyderini). B, C, *Aralius wollastoni* (Sharp) (Aglycyderini). B, female habitus; C, male head and pronotal anterior margin. D, *Metrioxena* sp. (Metrioxenini: Metrioxenina). E, *Afrocorynus turbatus* Marshall (Metrioxenini: Afrocorynina). Scale lines = 1 mm (A–D, F, © CSIRO, Australia; E, © A. E. Marvaldi).

Distribution:

- Belidae are distributed worldwide, with the greatest diversity in the southern hemisphere.
- Belinae are restricted to the southern continents, with the highest diversity in the Australian region (128 species in 21 genera) and a few also in South America (17 species in four genera).
- Oxycoryninae have broader but fragmented ranges, with the three tribes showing an American, Asian-African, and Pacific-Atlantic island distribution, respectively.

Biology and Ecology:

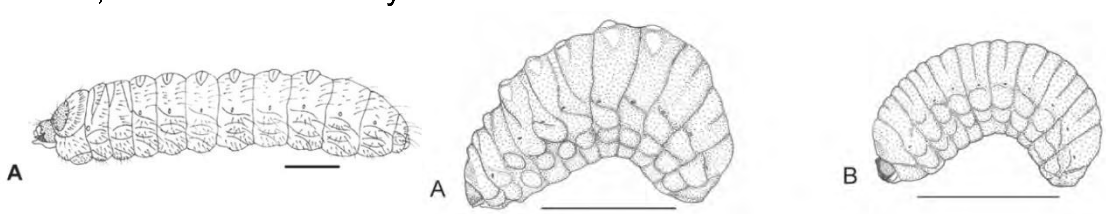
- The eggs are deposited inside plant tissues and the larvae develop endophytically.
- The larvae of Belinae are borers in stems and branches of shrubs and trees. Those of many Pachyurini and Agnesiotidini develop in gymnosperms (conifers of Araucariaceae, Podocarpaceae and Cupressaceae), and the Belini have mostly angiosperm hosts (especially acacias in Australia).
- Oxycoryninae develop mostly in reproductive plant organs, of gymnosperms (araucarias and cycads) as well as of angiosperms, but also in stems or under bark. The American species develop in reproductive organs, such as female cones of araucaria, male strobili of cycads, root-parasitic angiosperms, fleshy inflorescences of Balanophoraceae, and flowers and fruiting bodies of Hydnoraceae. Aglycyderini are associated with a wide variety of plants (mostly eudicotyledons), with the larvae growing in dead branches or twigs (usually under bark), mining leaves, or boring in freshly dead or dying branches.

General appearance:

- Adults: body 1.5–20 mm in length, flattened to moderately convex and elongate; cuticle dark to reddish-brown or brownish-yellow, with a metallic sheen in a few species; subglabrous or with vestiture, including hair-like setae ranging from sparse to dense.
- Larvae: body form variable, elongate, slightly flattened and parallel-sided to robust and strongly curved, of even width to widest at middle of abdomen.

Family Attelabidae (based mainly on Riedel, 2014)

Composed of ca. 2,500 described species in roughly 150 genera belonging to 2 subfamiles, Attelabinae and Rhynchitinae.



Larvae of Belidae weevils (Marvaldi & Ferrer, 2014)

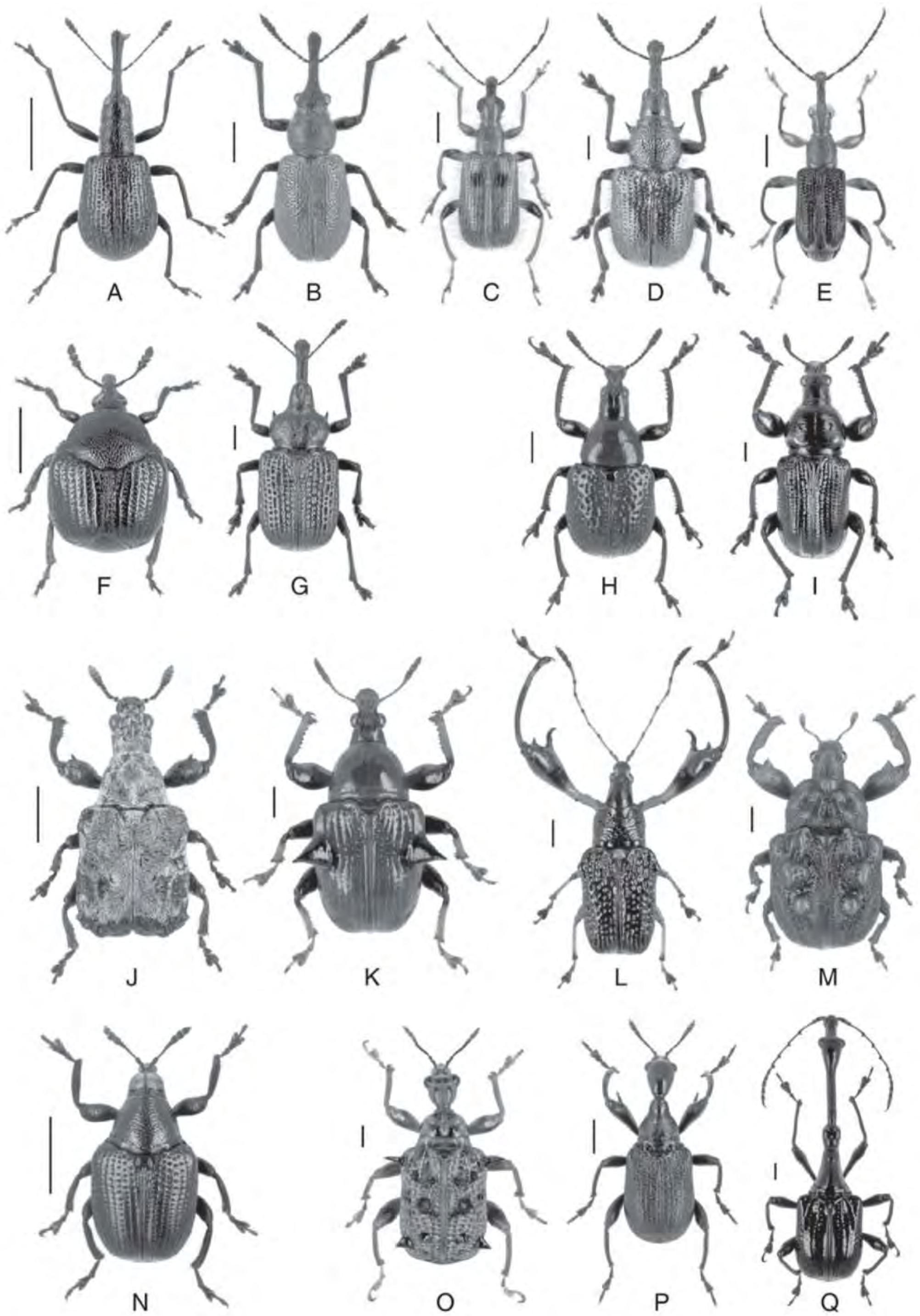


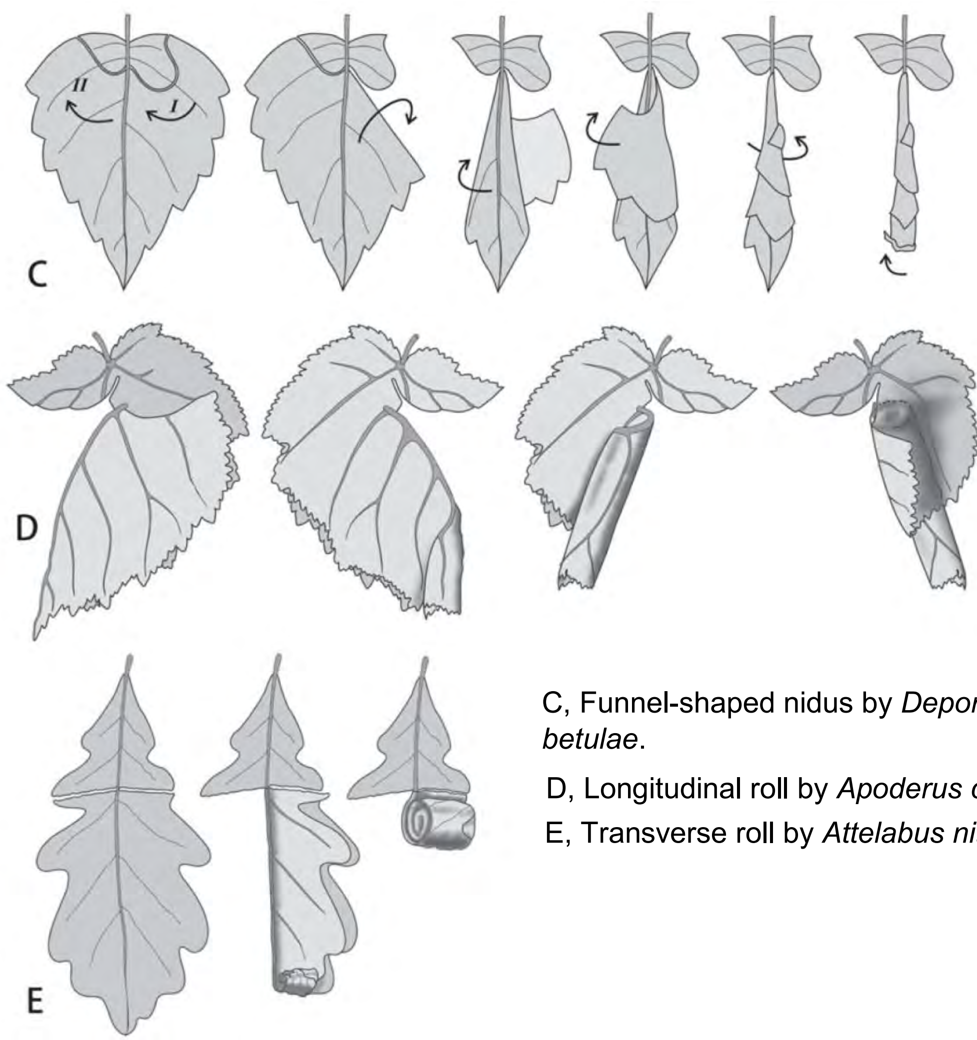
Fig. 3.4.1 Attelabidae, habitus of adults, scale bar = 1 mm. A, *Minurus seniculus* (Chile); B, *Auletobius consimilis* (North India); C, *Eugnamptus bimaculatus* (North India); D, *Rhynchites auratus* (Europe); E, *Scolocnemus wallacei* (Sumatra); F, *Pterocolus ovatus* (Florida); G, *Aspidobyctiscus pavei* (North India); H, *Attelabus variolosus* (Morocco); I, *Pilolabus viridans* (Mexico); J, *Euscelophilus* sp. (China: Kunming); K, *Lamprolabus bispinosus* (Sumatra); L, *Euscelus scutellatus* (Dominican Republic); M, *Phymatopsinus pustula* (Zimbabwe); N, *Euops indicus* (India); O, *Hoplapoderus hystrix* (South India); P, *Allapoderus manaliensis* (North India); Q, *Paratrachelophorus brachmanus* (Vietnam).

Distribution:

- Attelabidae are found in all major zoogeographic regions but are most diverse in the tropics and absent from New Zealand and Pacific islands. There is one species known from New Caledonia.

Biology and Ecology:

- Their host range at the family level is broad.
- Most attelabids are associated with dicotyledons, such as Rosaceae, Fagaceae, Betulaceae and Salicaceae in the Holarctic region, Myrtaceae in Australia, and Anacardiaceae in America.
- A few Rhynchitinae are associated with gymnosperms, such as Pinaceae and Cupressaceae.
- Oviposition behavior among Attelabidae is diverse, with many shoot-cutting, leaf-cutting, and leaf-rolling species. There are some fruits and seed eaters.



C, Funnel-shaped nidus by *Deporaus betulae*.

D, Longitudinal roll by *Apoderus coryli*.

E, Transverse roll by *Attelabus nitens*.

Nidus construction by the female from a leaf of a food plant (Riedel, 2014).

General appearance:

- Adults: body 2.0 mm to 25.0 mm in length, subglabrous, setose or pilose, but without any broad scales; sensory setae present on elytral sides of most Rhynchitinae, sparse or absent in Attelabinae and Bytiscini; cuticle often metallic or otherwise brightly colored.

- Larvae: body usually C-shaped and subcircular in cross-section, but orthosomatic and depressed in leaf-miners, with a sparse to moderately dense vestiture of setae and moderately densely arranged asperities, which are indistinct in Attelabinae, but distinct in Rhynchitinae.

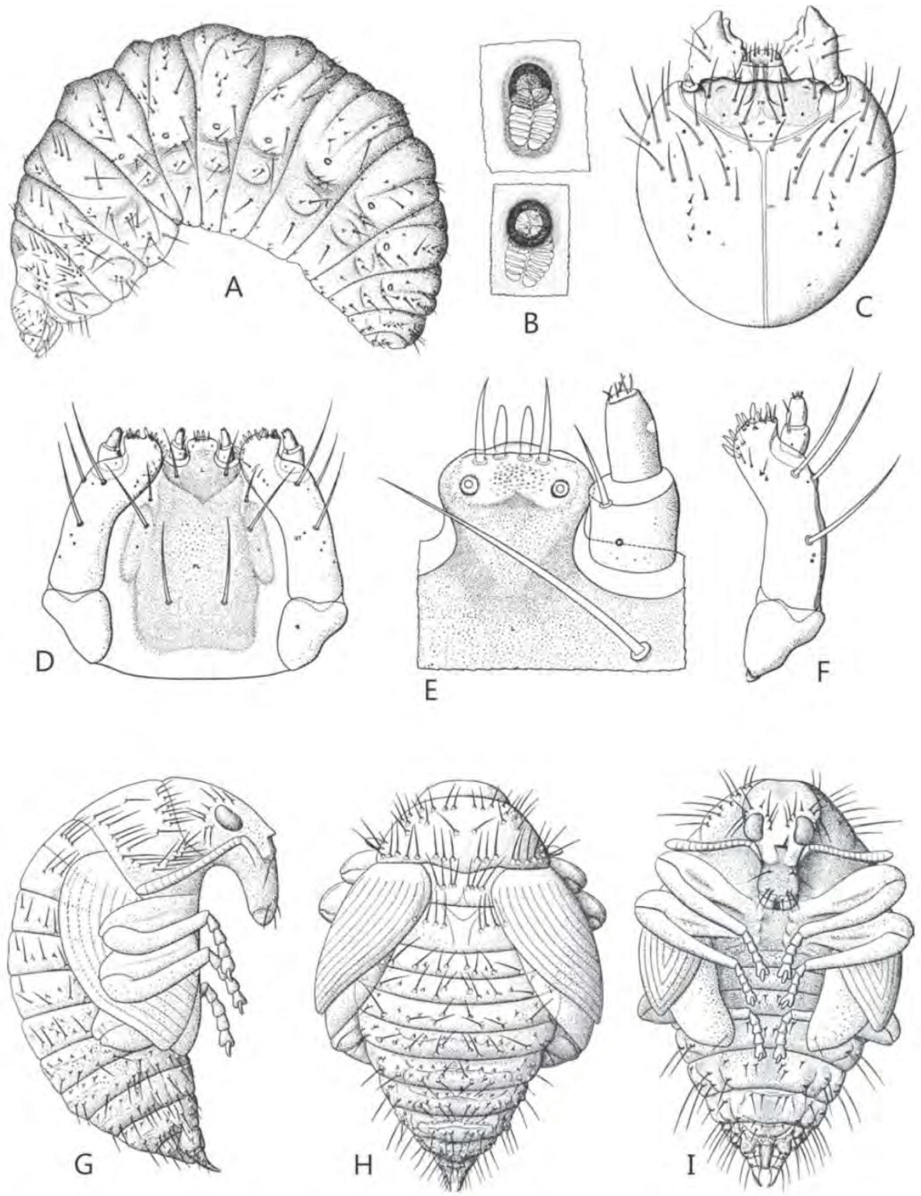


Fig. 3.4.7 Larva and pupa of *Attelabus nitens*; from Fenili (1952), with friendly permission from the publisher; A, fully grown larva, lateral view; B, abdominal spiracle, ventral (above) and dorsal view (below); C, head of larva, dorsal view; D, larval maxillae and labium, ventral view; E, details of labium; F, maxilla; G, pupa, lateral view; H, pupa, dorsal view; I, pupa, ventral view.

Family Caridae (based on Oberprieler, 2014)

The smallest weevil family containing only 4 described genera and 6 described species, but several further species occur in Australia.

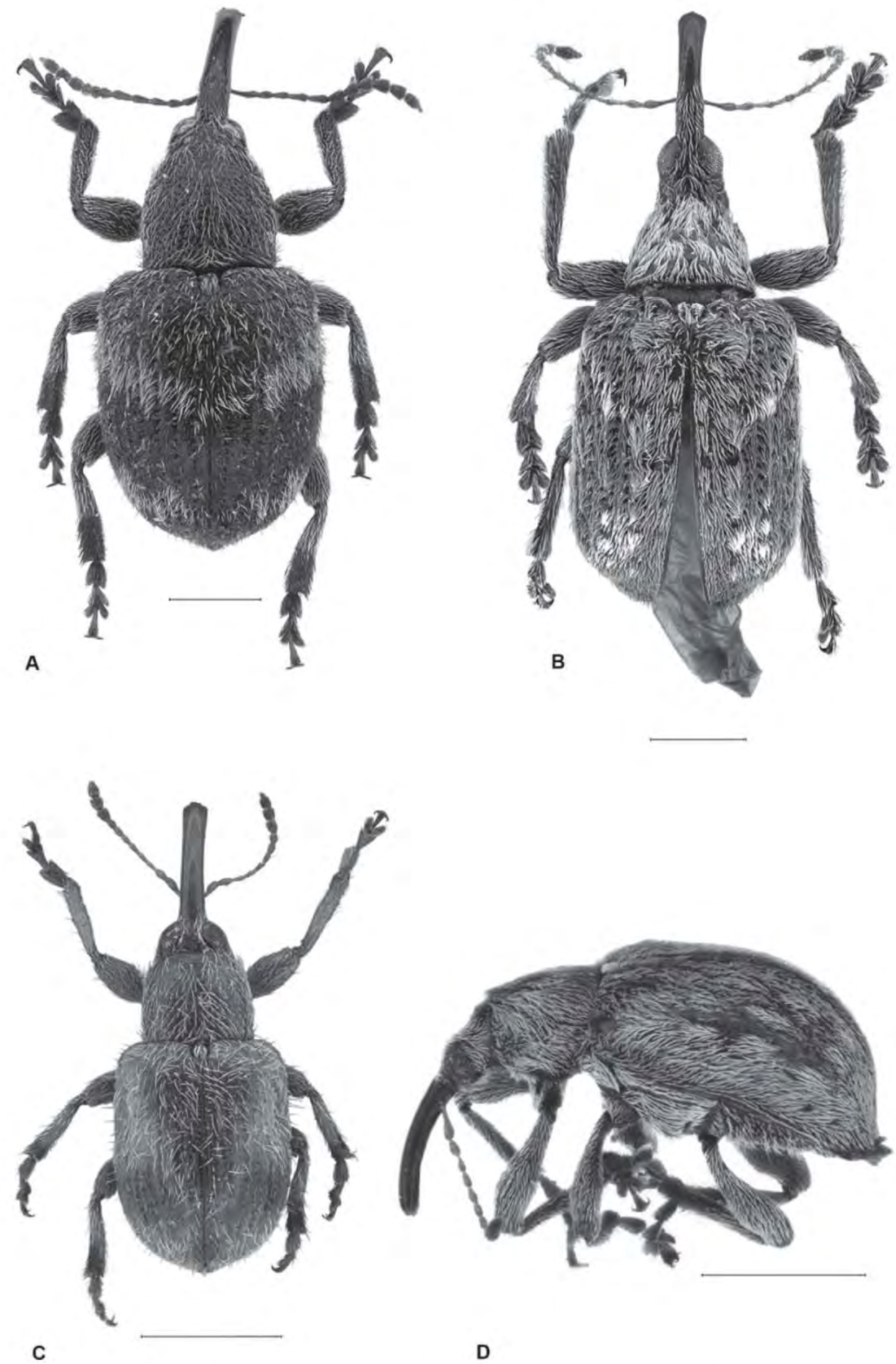


Fig. 3.5.1 Caridae, adults, dorsal habitus. A, *Car condensatus* Blackburn; B, *Carodes relevatus* Zimmerman; C, *Car pini* Lea; D, *Caenominurus topali* Voss (© Landcare Research, New Zealand; illustration by B. Rhode). Scale bars: 1 mm.

Distribution:

- This family is restricted to Australia, New Guinea, and South America.
- The genus *Car* occurs throughout Australia and another genus *Carodes* is known only from northern Queensland, Australia.
- An undescribed genus with several species is present in New Guinea
- The American genera *Caenominurus* and *Chilecar* are mostly known from southern Chile, South America.

Biology and Ecology:

- All Caridae are associated with conifers, in particular Cupressaceae.
- Much of the biology of the family remains to be discovered.
- In southeastern Australia, the females of a large *Car* species oviposit in young, closed female strobili (cones) of *Callitris endlicheri*.

Callitris endlicheri

http://chabg.gov.au/images/photo_cd/cupressaceae/

- The larva generally feeds in the thick basal parts of the sporophylls, around the woody stem of the strobilus.
- The full-grown larva bores out of the strobilus and drops to the ground, and then pupates in a small cell in the soil.

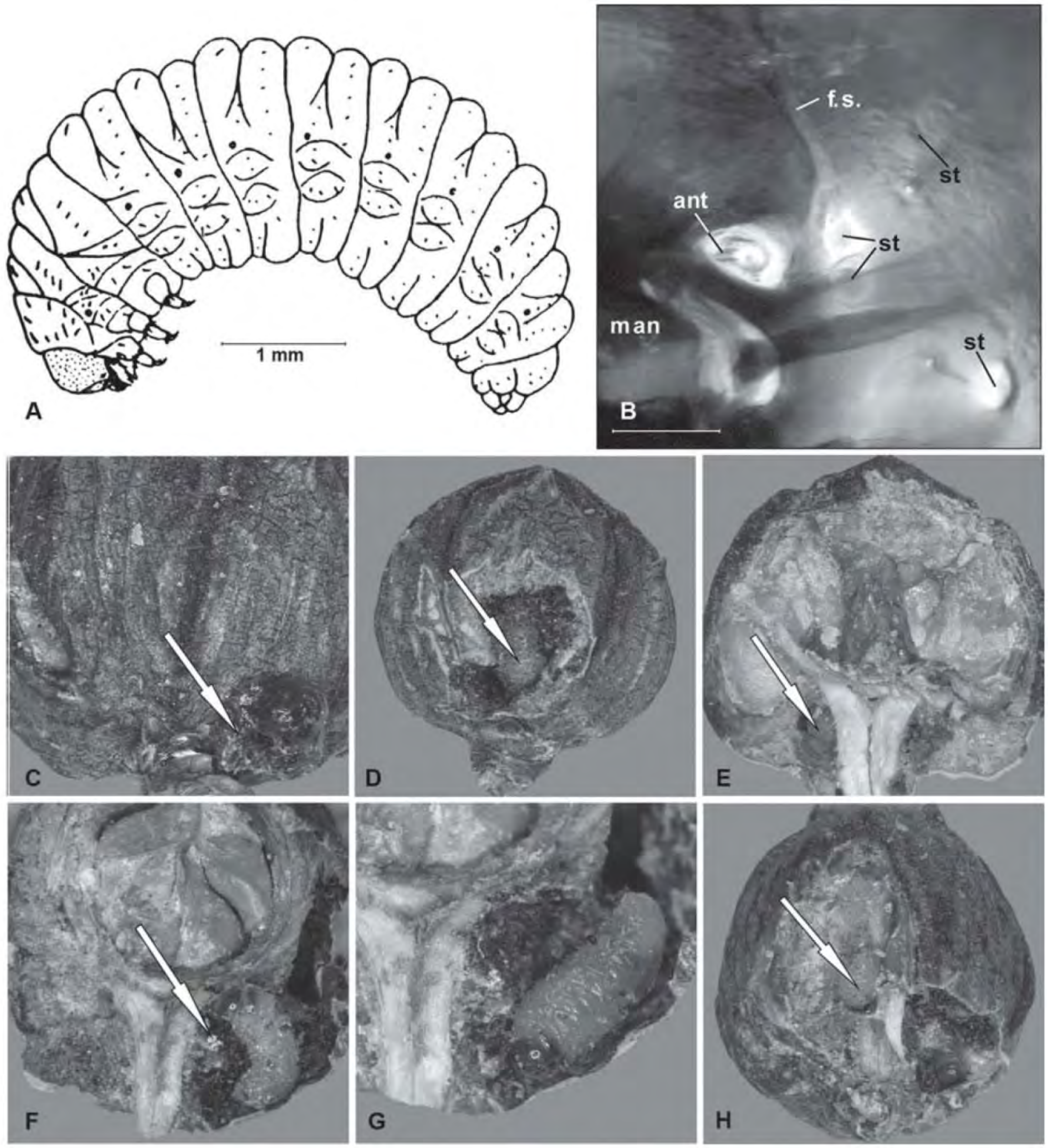


Fig. 3.5.3 Caridae, larva. A–B, *Car condensatus* Blackburn, C–H, *Car* sp. (*Car condensatus* group) tunneling in female strobilus of *Callitris endlicheri* (larva indicated by arrow). A, larval habitus, lateral view (from May 1994); B, antennal area of head capsule (from Oberprieler 2000) (ant, antenna; f.s., frontal suture; man, mandibular base; st, stemma); scale bar: 1 mm. C, Oviposition hole in strobilus with resin plug; D, larva in base of sporophyll; E, larva tunneling in bases of sporophylls around woody stem of strobilus; F–G, larva feeding in base of sporophyll near stem of strobilus; H, strobilus with two larvae, one in base of sporophylls, the other in seed chamber.

General appearance:

- Adults: body 2.0–5.0 mm in length, shortly elongate, often subparallel in dorsal view, moderately coarsely setose, without scales; cuticle pale testaceous to black.
- Larvae: Body <10.0 mm in length, robust and cylindrical, slightly curved; cuticle sparsely covered with short, fine setae.

Family Brentidae (based on Oberprieler, 2014 and other authors)

The family Brentidae in the wide sense includes the two large subfamilies Apioninae and Brentinae and 4 smaller groups, the Eurhynchinae, Ithycerinae, Microcerinae, and Nanophyinae. In this composition, the Brentidae comprise ca. 540 genera and 4,400 described species.

Distribution:

- The Brentidae are cosmopolitan in distribution, but the different lineages generally have more restricted ranges.
- Eurhynchinae (3 genera & 29 species) is endemic to Australia and New Guinea, the monotypic Ithycerinae to North America, and Microcerinae (3 genera & 67 species) to Africa.
- Apioninae (ca. 205 genera and subgenera & <2,200 species and subspecies), Brentinae (291 genera & ca. 1,760 species) and Nanophyinae (33 genera & ca. 310 species) are more widely distributed and most diverse in tropical regions.

Biology and Ecology:

- The larvae of Eurhynchinae, Ithycerinae and Microcerinae are stem- or root-borers.
- The larvae of Brentinae have adapted to tunneling in dead or dying wood (and also adopted more specialized lifestyles of mycetophagy, predation and myrmecophily).
- The larvae of Apioninae and Nanophyinae have adapted to developing in the softer, living tissues of stems, leaves, flowers, fruits and seeds (including the induction of galls).
- The hosts of Brentidae are predominantly dicotyledonous angiosperms.
- Only a few Apioninae develop on conifers or cycads.

General appearance:

See the figure plates in the following pages. The family Brentidae in the broad sense is too diverse to be grouped by appearance.

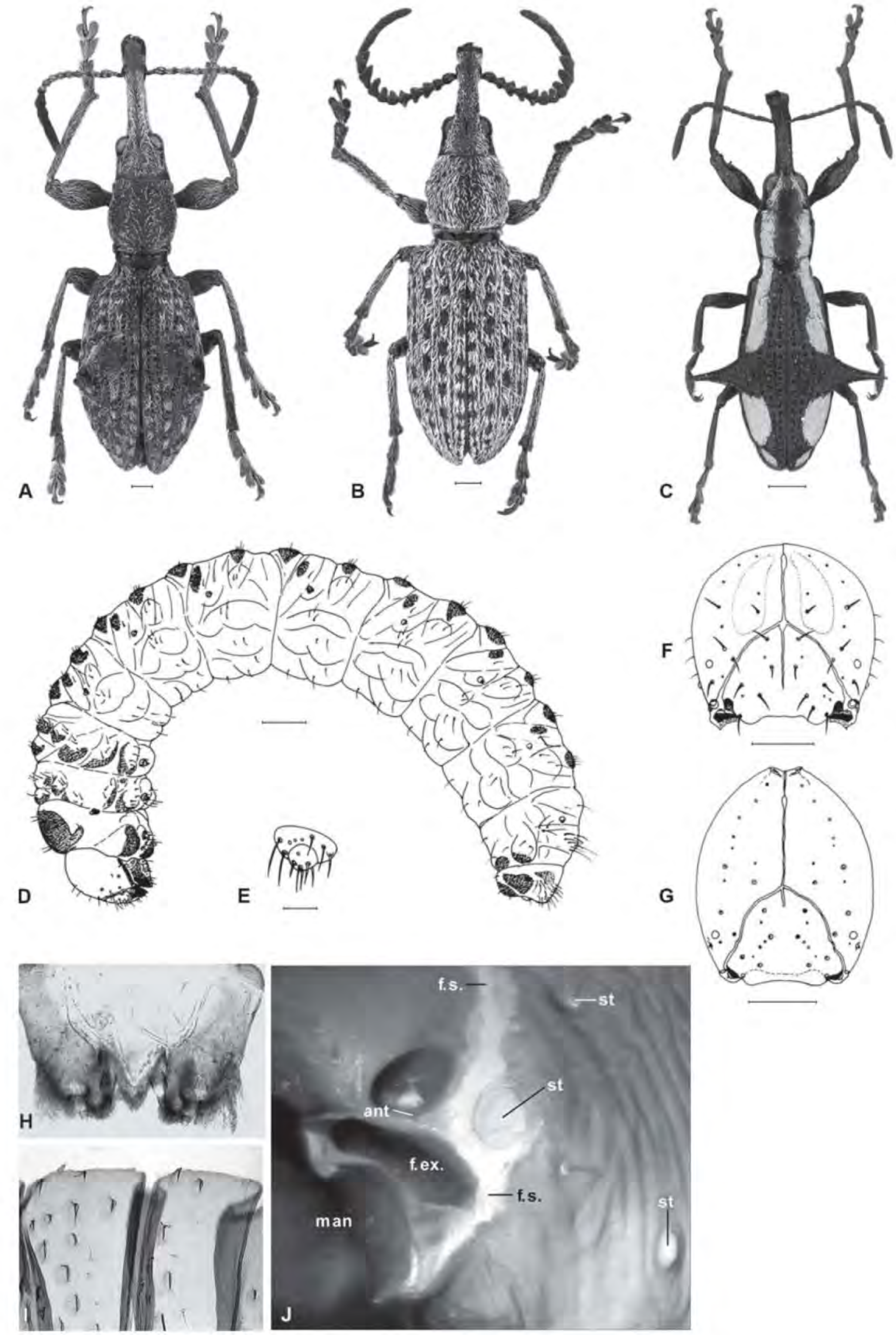


Fig. 3.6.1.1 Eurhynchinae. A, *Eurhynchus quadrituberculatus* (Boheman), ♂, dorsal habitus; B, *Ctenaphides maculatus* (Pascoe), ♂, dorsal habitus; C, *Aporhina pulchra* Oberprieler, ♂, dorsal habitus; D, *Eurhynchus laevior* (Kirby), larva, lateral view; E, *Eurhynchus laevior* (Kirby), larva, mesothoracic leg, lateroventral view; F, *Eurhynchus laevior* (Kirby), larva, head, frontal view; G, *Aporhina australis* (Heller), larva, head, frontal view; H, *Aporhina australis* (Heller), larva, maxillae and labium, ventral view; I, *Aporhina australis* (Heller), larva, abdominal segments I and II, showing dorsal carinulae, lateral view; J, *Eurhynchus laevior* (Kirby), larva, left antenna and mandibular attachment, frontal view. Scale bars: A–D, 1 mm; E, 0.1 mm; F, G, I, 0.5 mm. (D–G, I–J after Oberprieler 2000.)

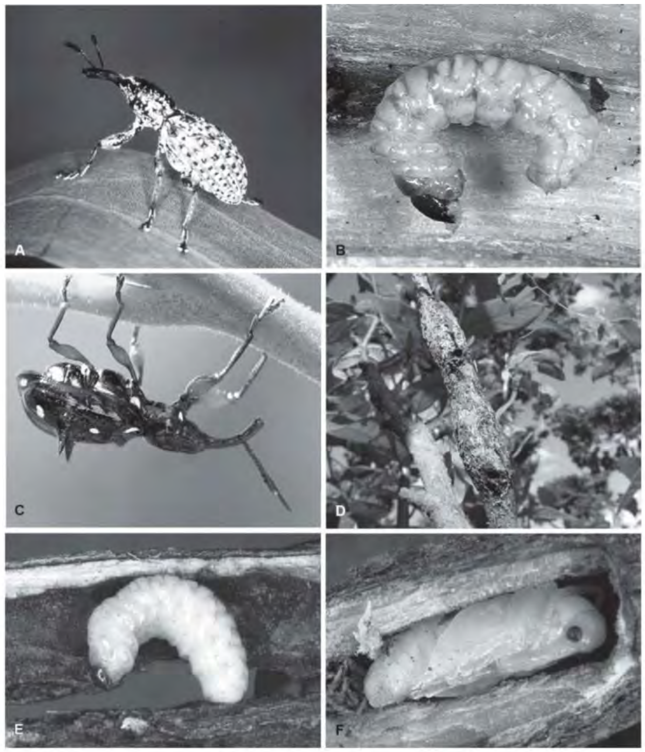


Fig. 3.6.1.2 Eurhynchinae, life history. A, *Eurhynchus laevior* (Kirby), ♀ on leaf of *Persoonia levis* (Proteaceae); B, *Eurhynchus laevior* (Kirby), larva on tunnel in stem of *Persoonia levis*; C, *Aporhina australis* (Heller), ♀ on stem of *Litsea leefiana* (Lauraceae); D, *Aporhina australis* (Heller), larval galls in stem of *Litsea leefiana*; E, *Aporhina australis* (Heller), larva in stem gall on *Litsea leefiana*; F, *Aporhina australis* (Heller), pupa in upper part of stem gall on *Litsea leefiana*. (C, D, F courtesy of Jack Hasenpusch, Innisfail.)

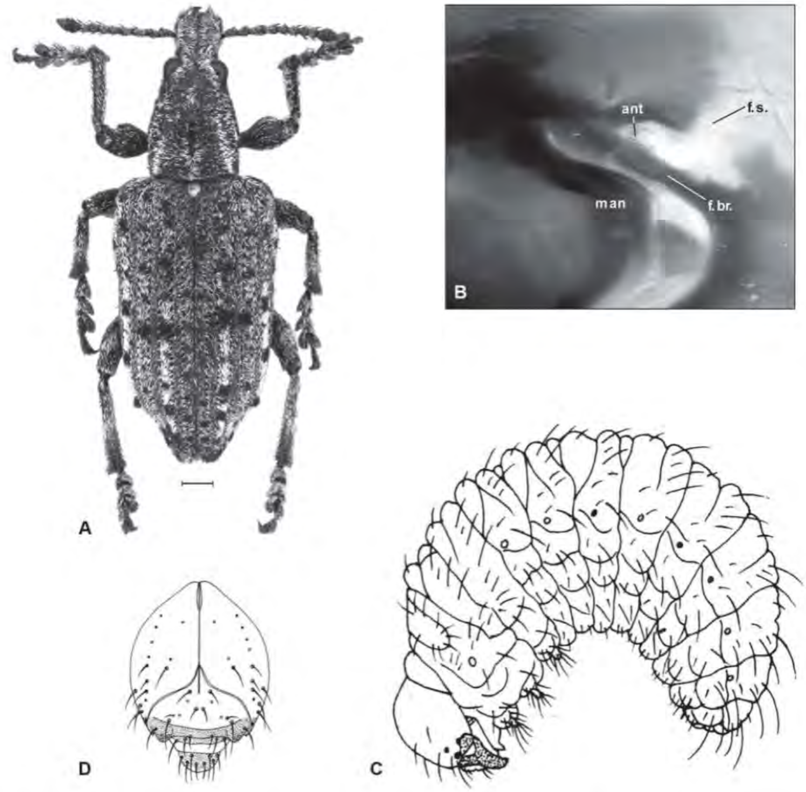


Fig. 3.6.1.3 Ithycerinae. A, *Ithycerus noveboracensis* (Forster), ♂, dorsal habitus; B, same, larva, left antenna and mandibular attachment, frontal view; C, same, larva, lateral view; D, same, head, frontal view. Scale bars: 1mm. (B after Oberprieler 2000; C–D after May 1993).

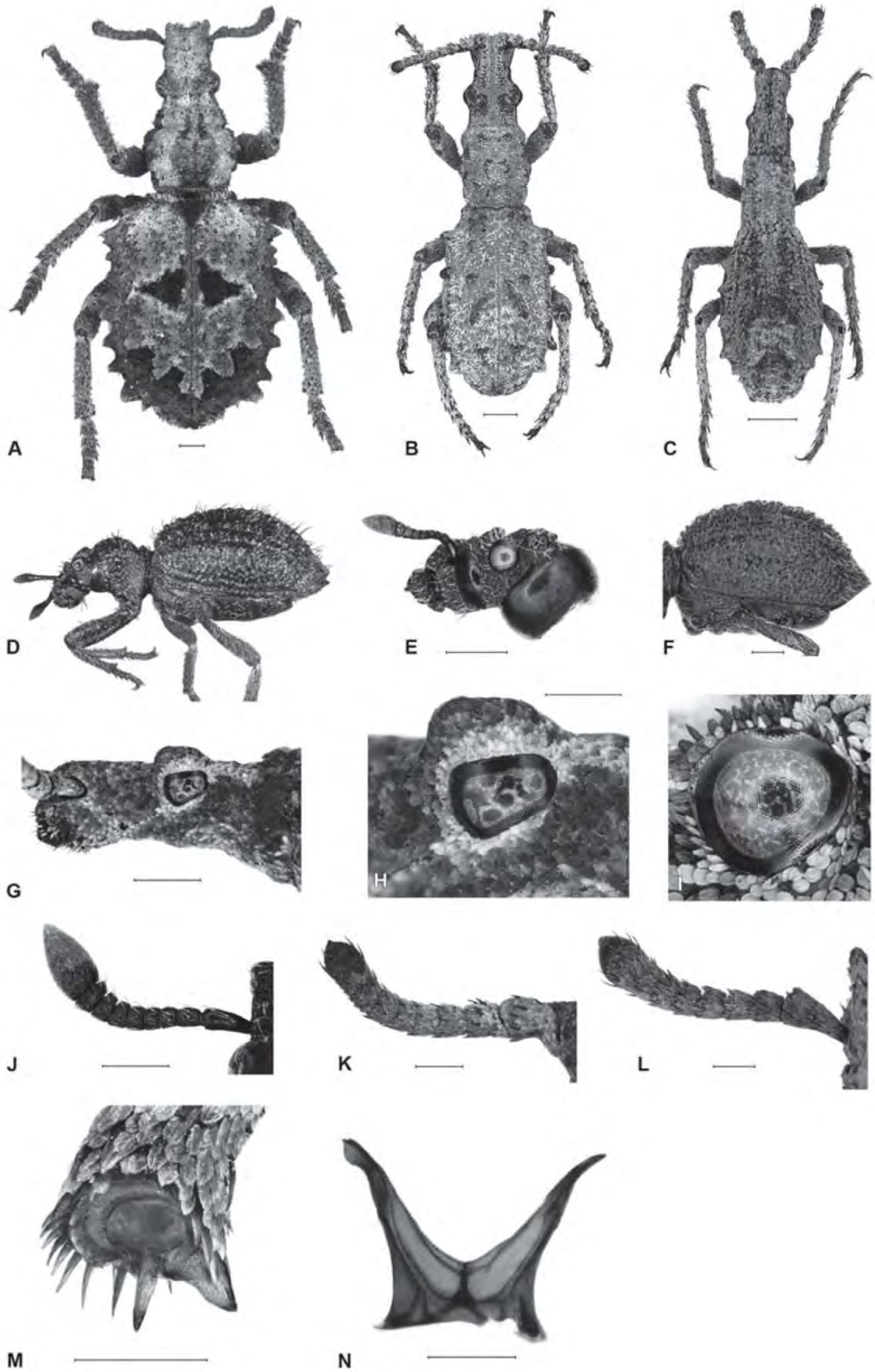


Fig. 3.6.1.4 Microcerinae. A, *Microcerus latipennis* Fåhraeus, ♀, dorsal habitus; B, *Episus gibbosus* Aurivillius, ♂, dorsal habitus; C, *Episus westermanni* Aurivillius, ♂, dorsal habitus; D–F, *Gyllenhalia crinita* Marshall, ♀, lateral habitus; G, *Episus fictus* Gyllenhal, ♂, head in lateral view; H, *Episus fictus* Gyllenhal, ♂, eye; I, *Microcerus latipennis* Fåhraeus, ♀, eye; J, *Gyllenhalia crinita* Marshall, ♀, left antenna, dorsal view; K, *Episus fictus* Gyllenhal, ♂, left antenna, dorsal view; L, *Microcerus latipennis* Fåhraeus, ♀, left antenna, dorsal view. M, *Microcerus latipennis* Fåhraeus, ♂, apex of left hind tibia showing mucro and single spur; N, *Microcerus costalis* Fåhraeus, metendosternite. Scale bars: A–I, 1mm; J–M, 0.5 mm.

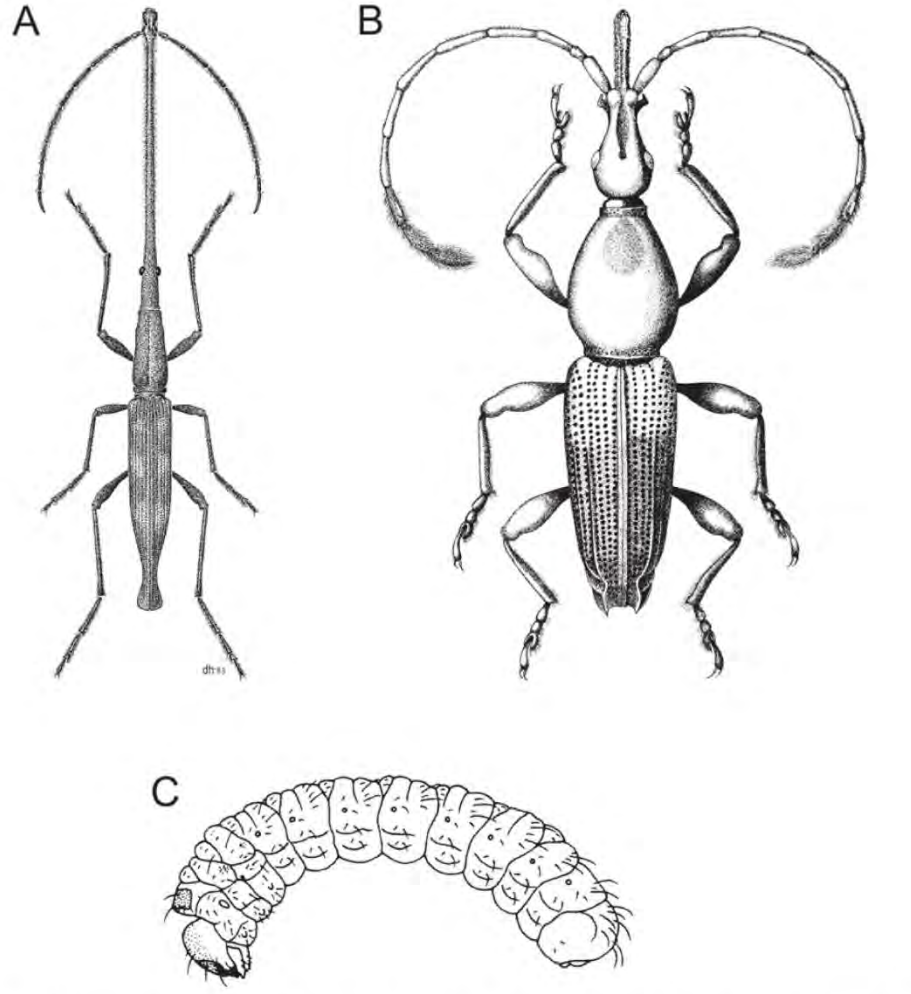


Fig. 3.6.2.1 Brentinae. A, *Lasiorhynchus barbicornis* (Fabricius), adult; B, *Anomobrentus kuscheli* Damoiseau, adult; C, *L. barbicornis*, larva (© Landcare Research, New Zealand).

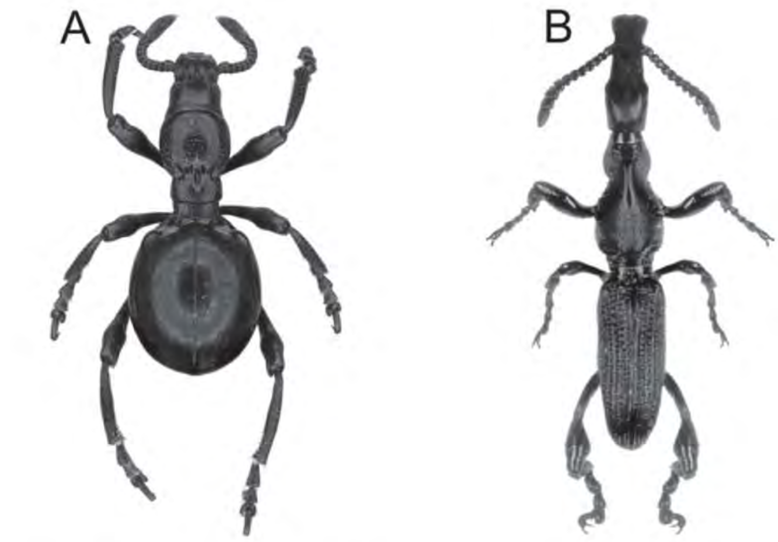


Fig. 3.6.2.2 Brentinae. A, *Cylas* sp. (South Africa) (© CSIRO, Canberra); B, *Cyphagogus* sp. (Malaysia) (© Landcare Research, New Zealand).

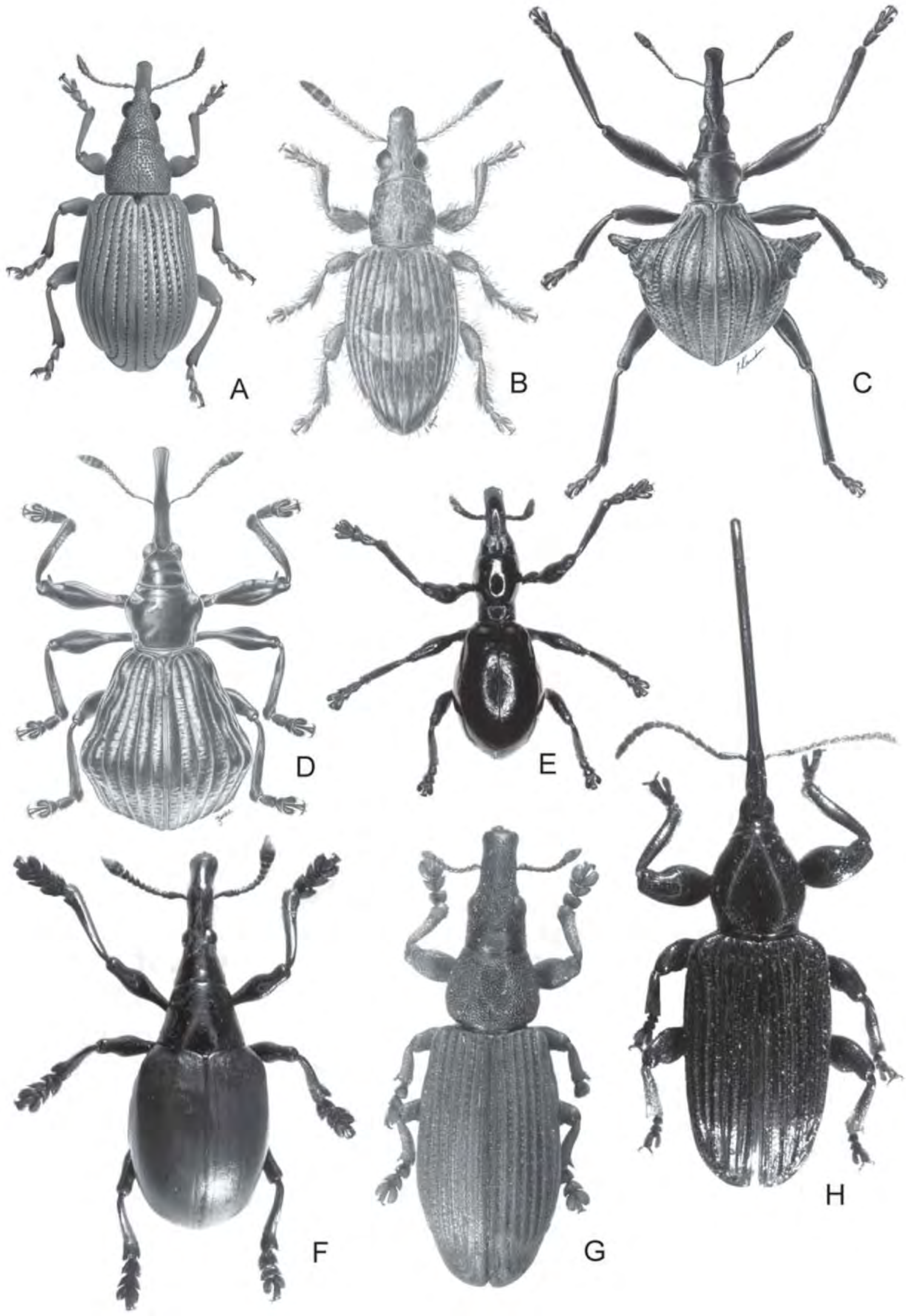


Fig. 3.6.3.1 Apioninae, adults. A, type species of *Apion, Apion frumentarium* (Linnaeus); B, *Lepanomus crinalis* Balfour-Browne (by A. Stojczew); C, *Pterapion wagneri* Heller (by J. Kania); D, *Megatracheloides chloris* (Faust) (by J. Świętojańska); E, *Myrmacicelus* sp.; F, *Cybebus dimidiatus* (Olivier); G, *Tanaos interstitialis* Fåhraeus; H, *Antliarhis peglerae* Péringuey. Not at the same scale (Fig. A, © M. Russell; Fig. B, C, © M. Wanat; Fig. D from Wanat 2001, © Mantis, Olsztyn and M. Wanat).

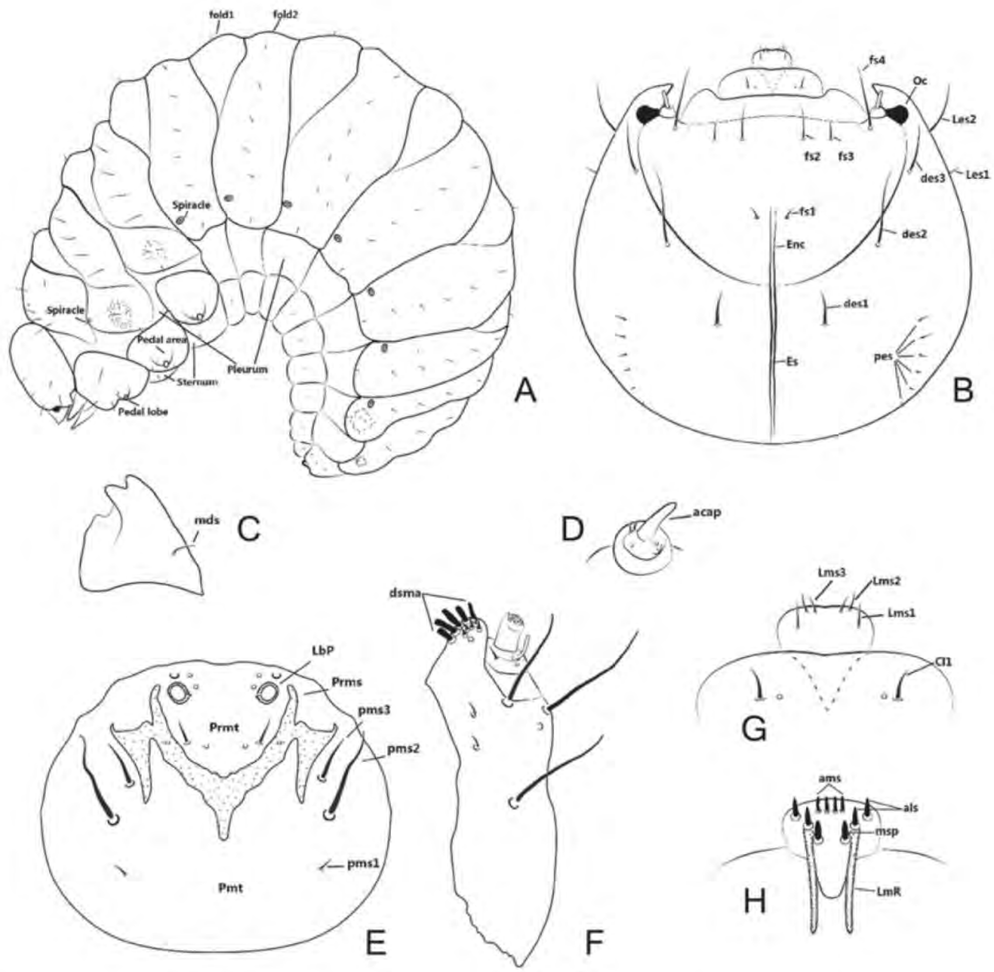


Fig. 3.6.3.6 *Pseudaspidapion botanicum* Alonso-Zarazaga & Wang, third instar larva. A, habitus, lateral; B, head, dorsal; C, mandible, dorsal; D, antenna, dorsal; E, labium, ventral; F, left maxilla, ventral; G, clypeus and labrum, dorsal; H, epipharyngeal lining, ventral. Not at the same scale (all © Wang Zh.-L.).

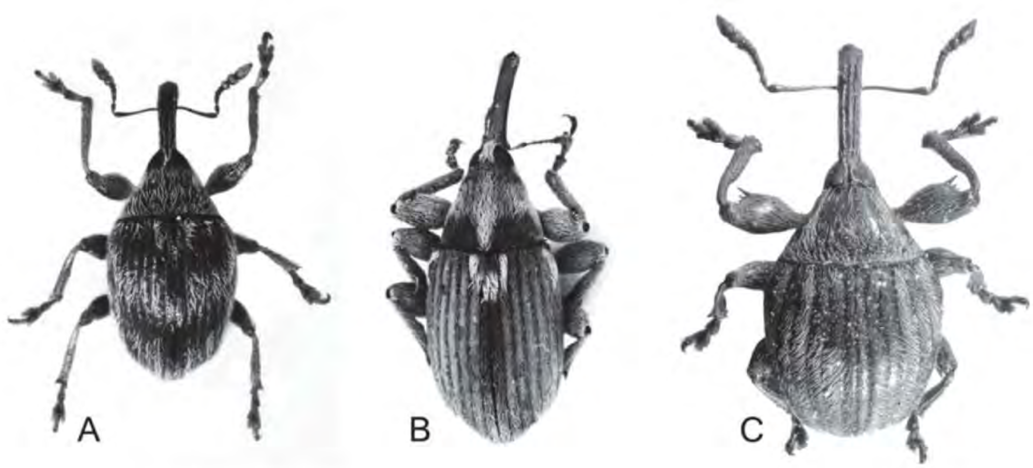


Fig. 3.6.4.1 Brentidae Nanophyinae, adults, dorsal. A, *Nanophyes brevis* Boheman (Nanophyini), length = 1.8 mm; B, *Corimalia* nr. *aliena* (Faust) (Corimaliini), length = 3.0 mm; C, *Lyalia curvata* Alonso-Zarazaga & Perrin (Nanophyini), length = 4.58 mm; all © M. A. Alonso-Zarazaga.

Curculionidae (based on Oberprieler, 2014 and other authors)

The family Curculionidae in the wide sense includes 10 major subfamilies: Brachycerinae (ca. 8 tribes, 95 genera & 1,350 species), Dryophthorinae (152 genera & 1,200 species), Platypodinae (<1,400 species in 34 genera), Cyclominae (ca. 8 tribes, 148 genera & 1,550 species), Entiminae (ca. 1,370 genera & <12,000 species), Curculioninae (ca. 350 genera & 4,500 species), Molytinae (ca. 989 genera & 8,700 species), Conoderinae (7,571 species in 940 genera), Cossoninae (ca. 1,700 species in 275 genera), and Scolytinae (ca. 250 genera & 6,000 species) (Oberprieler et al. 2007). In the wide sense, the family Curculionidae, which is the largest among Curculionoidea families, comprises ca. 4,600 genera & 51,000 species.

Distribution:

- The family Curculionidae in the wide sense is cosmopolitan in distribution, occurring in all kinds of habitats from seashores to high mountains and from deserts to rainforests to lakes and rivers.
- All the major subfamilies are also cosmopolitan, although Dryophthorinae and Platypodinae are largely limited to tropical regions.

Biology and Ecology:

- Curculionid larvae generally live endophytically in all parts of plants, from roots to trunks and stems to leaves, flowers, fruits and seeds.
- Many also feed ectophytically on roots in the soil or under water.
- Curculionidae are associated with all groups of plants, apparently ancestrally with angiosperms but secondarily with conifers and cycads, pteridophytes (ferns), bryophytes (mosses) and even algae.
- They have also formed extensive and specialized associations with monocotyledons (especially Brachycerinae and Dryophthorinae but also several groups of Curculioninae, Conoderinae and Molytinae).
-

General appearance:

See the figure plates in the following pages. The family Curculionidae in the broad sense is too diverse to be grouped by appearance.

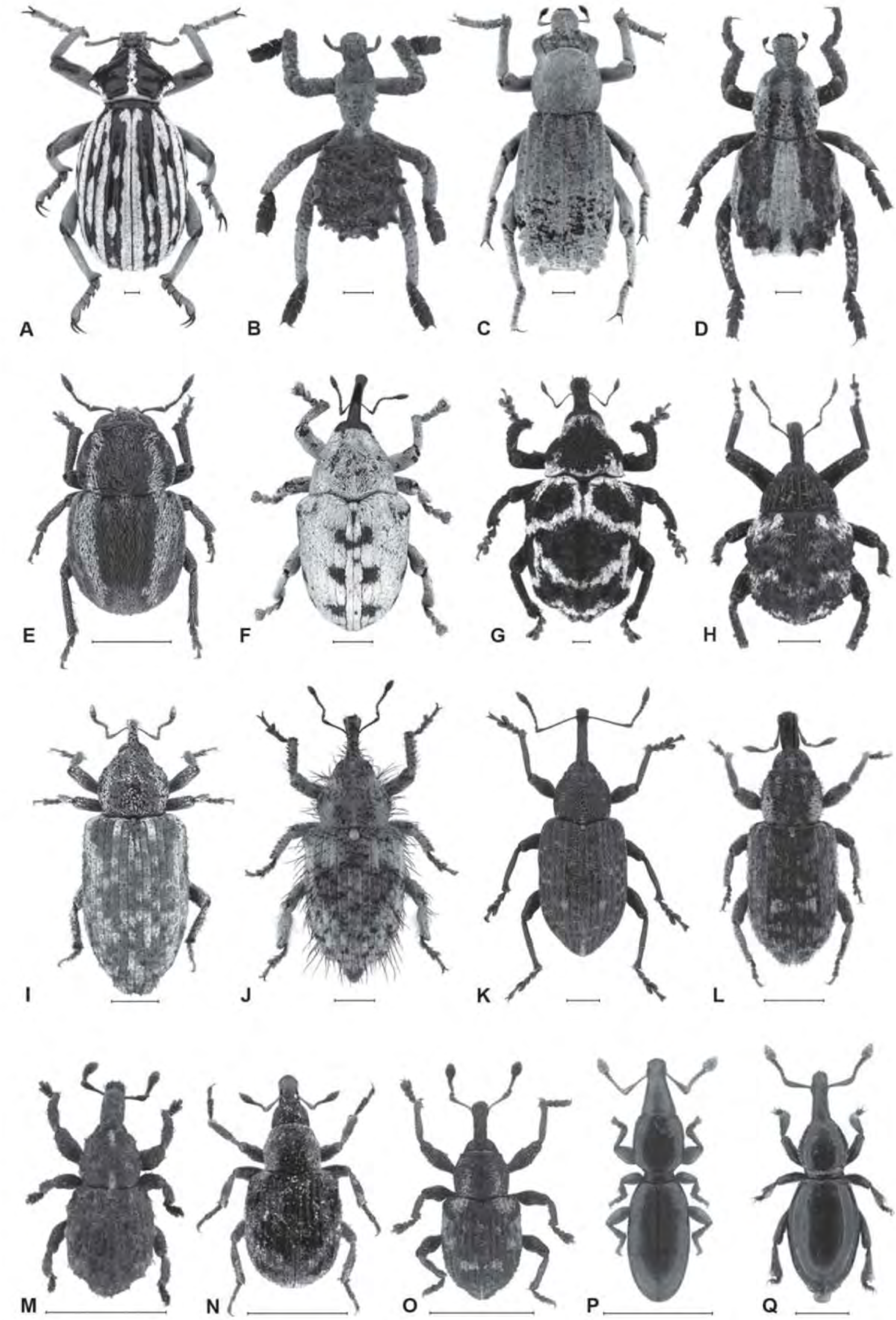


Fig. 3.7.1.1 Brachycerinae, dorsal habitus. A–D. Brachycerini: A, *Brachycerus albotectus* Péringuey; B, *Euretus aurivillii* Péringuey; C, *Byrsops deformis* (Boheman); D, *Synthocus nigropictus* Pascoe; E, Cryptolaryngini: *Cryptolarynx* sp.; F–L. Erirhinini: F, *Aonychus* sp.; G, *Desmidophorus cumingi* Boheman; H, *Ocladius* sp.; I, *Tadius erirhinoides* Pascoe; J, *Trichocaulus longipilis* Fairmaire; K, *Notaris scirpi* (Fabricius); L, *Echinocnemus* sp.; M–O. Tanysphyrini: M, *Baeosomus uvidus* (Oke); N, *Stenopelmus rufinasus* Gyllenhal; O, *Tanysphyrus lemnae* Paykull; P, Myrtonymini: *Myrtonymus* sp.; Q, Raymondionymini: *Ubychia leonhardi* Reitter. Scale bars : 1 mm except 0.5 mm for P and Q.

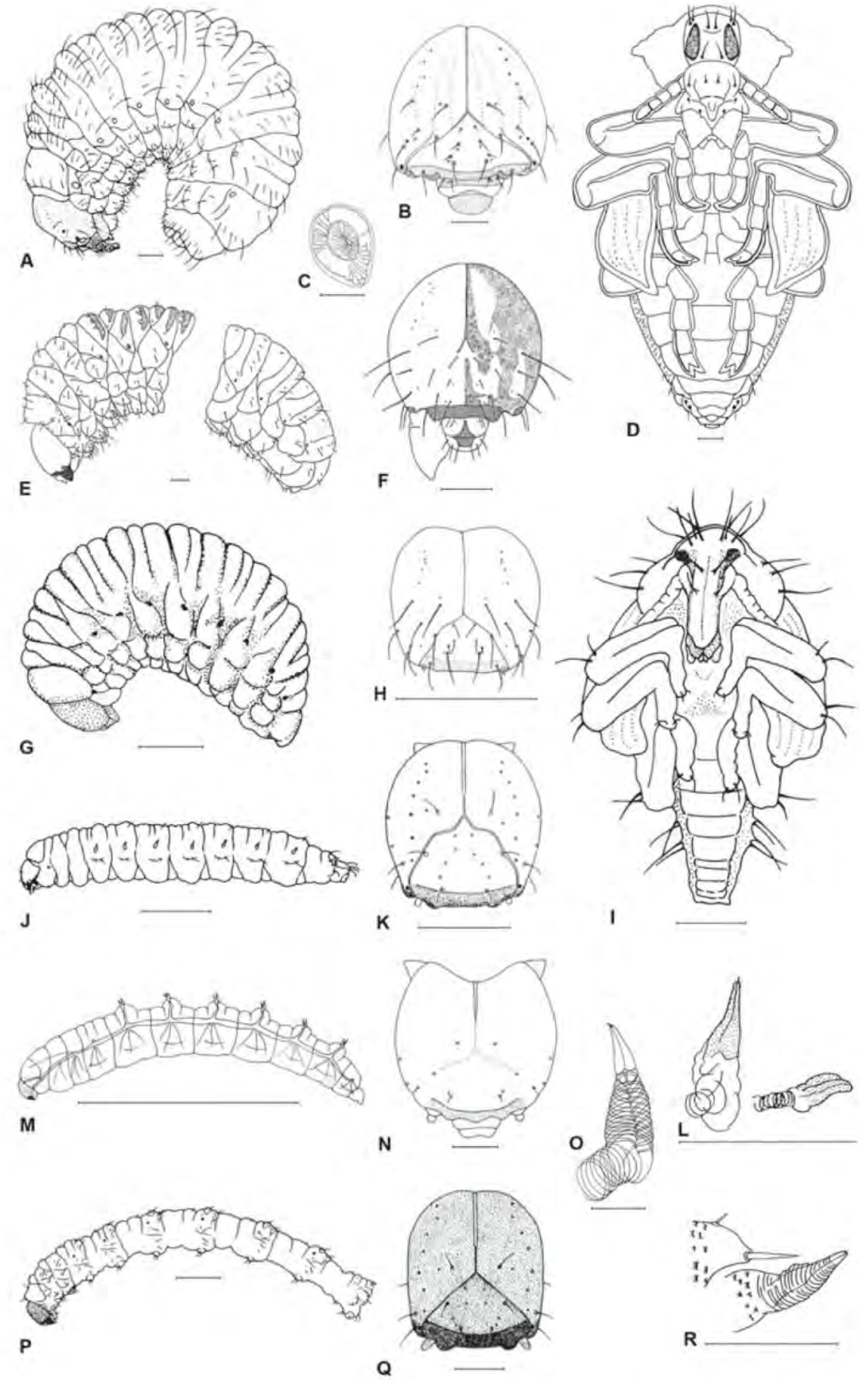


Fig. 3.7.1.4 Brachycerinae, immature stages. A, *Brachycerus monachus* Fåhraeus, larva, lateral view; B, *Brachycerus monachus* Fåhraeus, larva, head, anterior view; C, *Brachycerus monachus* Fåhraeus, larva, thoracic spiracle, lateral view; D, *Brachycerus ornatus* (Drury), pupa, ventral view; E, *Desmidophorus crassus* Hubenthal, larva, lateral view; F, *Desmidophorus crassus* Hubenthal, larva, head, anterior view; G, *Ocladius dianthi* Marshall, larva, lateral view; H, *Ocladius dianthi* Marshall, larva, head, anterior view; I, *Ocladius dianthi* Marshall, pupa, ventral view; J, *Echinocnemus* sp., larva, lateral view; K, *Echinocnemus* sp., larva, head, anterior view; L, *Echinocnemus* sp., larva, spiracles of abdominal segments VII and VIII; M, *Lissorhoptrus oryzophilus* Kuschel, larva, lateral view; N, *Lissorhoptrus oryzophilus* Kuschel, larva, head, anterior view; O, *Lissorhoptrus oryzophilus* Kuschel, larva, spiracle of abdominal segment VIII, lateral view; P, *Neochetina eichhorniae* Warner, larva, lateral view; Q, *Neochetina eichhorniae* Warner, larva, head, anterior view; R, *Neochetina eichhorniae* Warner, larva, spiracle of A8. Scale bars: A, B, D, P, 2 mm; E–J, M, 1 mm; C, K, L, N, Q 0.2 mm; O, R, 0.1 mm. (A–C, M–O after May 1994; D after Louw 1990; E–F after Morimoto & Kojima 2006; G–I after Marvaldi 2000; J–L, P–R after May 1994.)

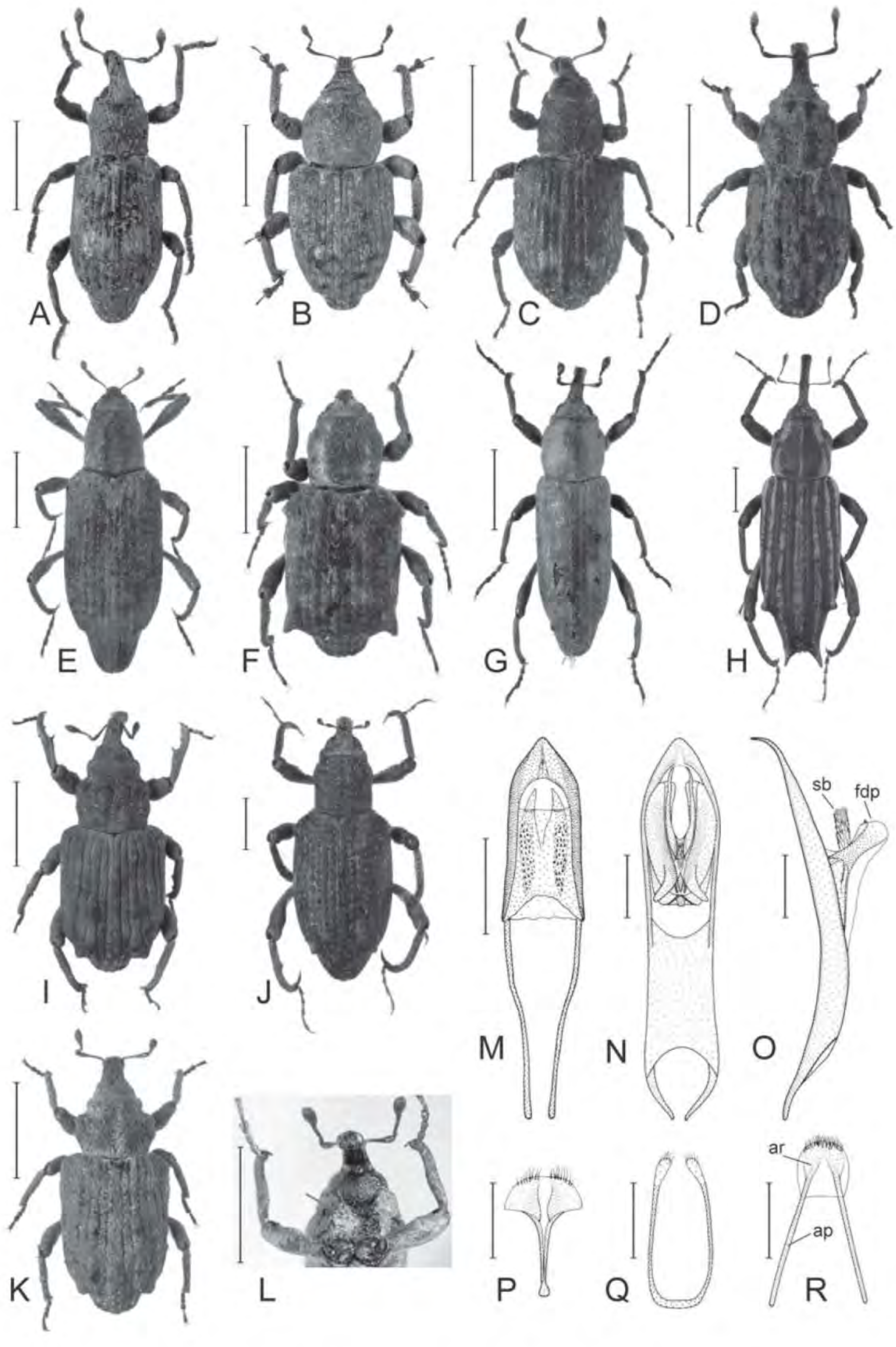


Fig. 3.7.2.1 Bagoini. A, *Bagous alismatis* (Marsham), dorsal habitus; B, *B. luteitarsis* Hustache, dorsal habitus; C, *B. contrarius* O'Brien, dorsal habitus; D, *B. longirostris* Vitale, dorsal habitus; E, *B. longulus* Gyllenhal, dorsal habitus; F, *B. utriculariae* O'Brien, dorsal habitus; G, *B. tubulus* Caldara & O'Brien, dorsal habitus; H, *B. elegans* (Fabricius), dorsal habitus; I, *Bagous* sp. near *interruptus* Faust, dorsal habitus; J, *B. trapae* Parshad, dorsal habitus; K, *B. setosus* LeConte, dorsal habitus; L, *B. tempestivus* (Herbst), prosternal canal (arrow), ventral view; M, *B. olcesei* Tournier, penis, dorsal view; N, *B. peregrinus* Gratschev, penis, dorsal view; O, *B. geniculatus* (Hochhuth), penis, lateral view, sb = setal brush, fdp = "false" dorsal process; P, *B. glabrirostris* (Herbst), spiculum ventrale; Q, *B. freti* Caldara & O'Brien, spiculum ventrale; R, *B. brevipennis* Kirsch, *spiculum ventrale*; ap = arm, ar = apodeme. Scale bars 1 mm except 0.25 mm for M–R.

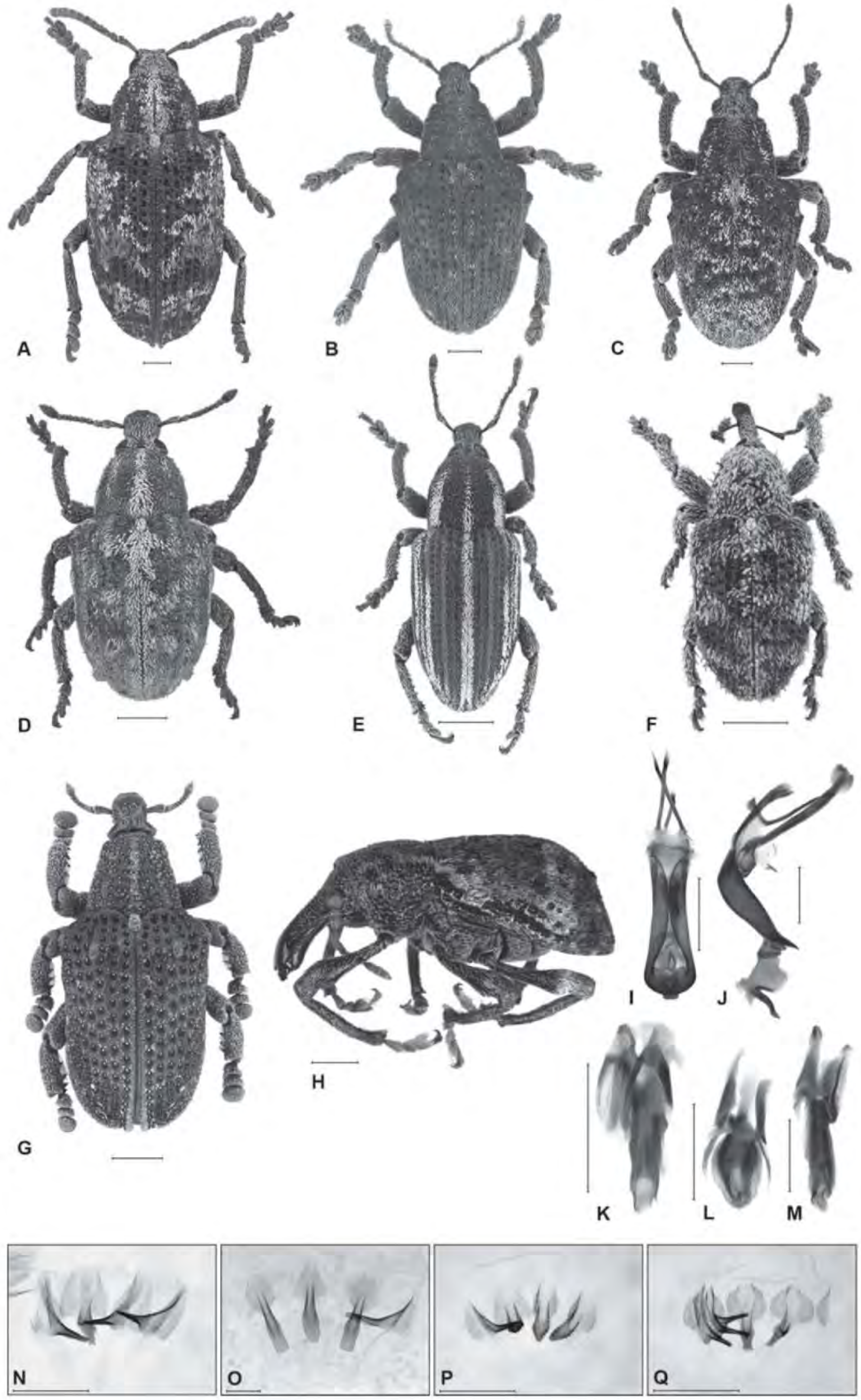


Fig. 3.7.2.2 Gonipterini. A, *Bryachus squamicollis* Pascoe, dorsal habitus; B, *Gonipterus platensis* (Marelli), dorsal habitus; C, *Oxyops* sp., dorsal habitus; D, *Iptergonus aberrans* (Lea), dorsal habitus; E, *Pantoreites vittatus* Pascoe, dorsal habitus; F, *Prophaesia cretata* Pascoe, dorsal habitus; G, *Syarbis* sp., dorsal habitus; H, genus from New Caledonia, lateral habitus; I, *Gonipterus* sp., penis in dorsal view; J, *Gonipterus* sp., penis with endophallic sclerite evaginated, lateral view; K, *Gonipterus* sp., endophallic sclerite; L, *Gonipterus platensis* (Marelli), endophallic sclerite; M, *Gonipterus pulverulentus* Lea, endophallic sclerite; N, *Gonipterus lepidotus* Gyllenhal, proventricular armature; O, *Oxyops excavatus* Boisduval, proventricular armature; P, *Iptergonus aberrans* (Lea), proventricular armature; Q, *Syarbis* sp., proventricular armature. Scale bars 1 mm, except K–M, 0.5 mm.

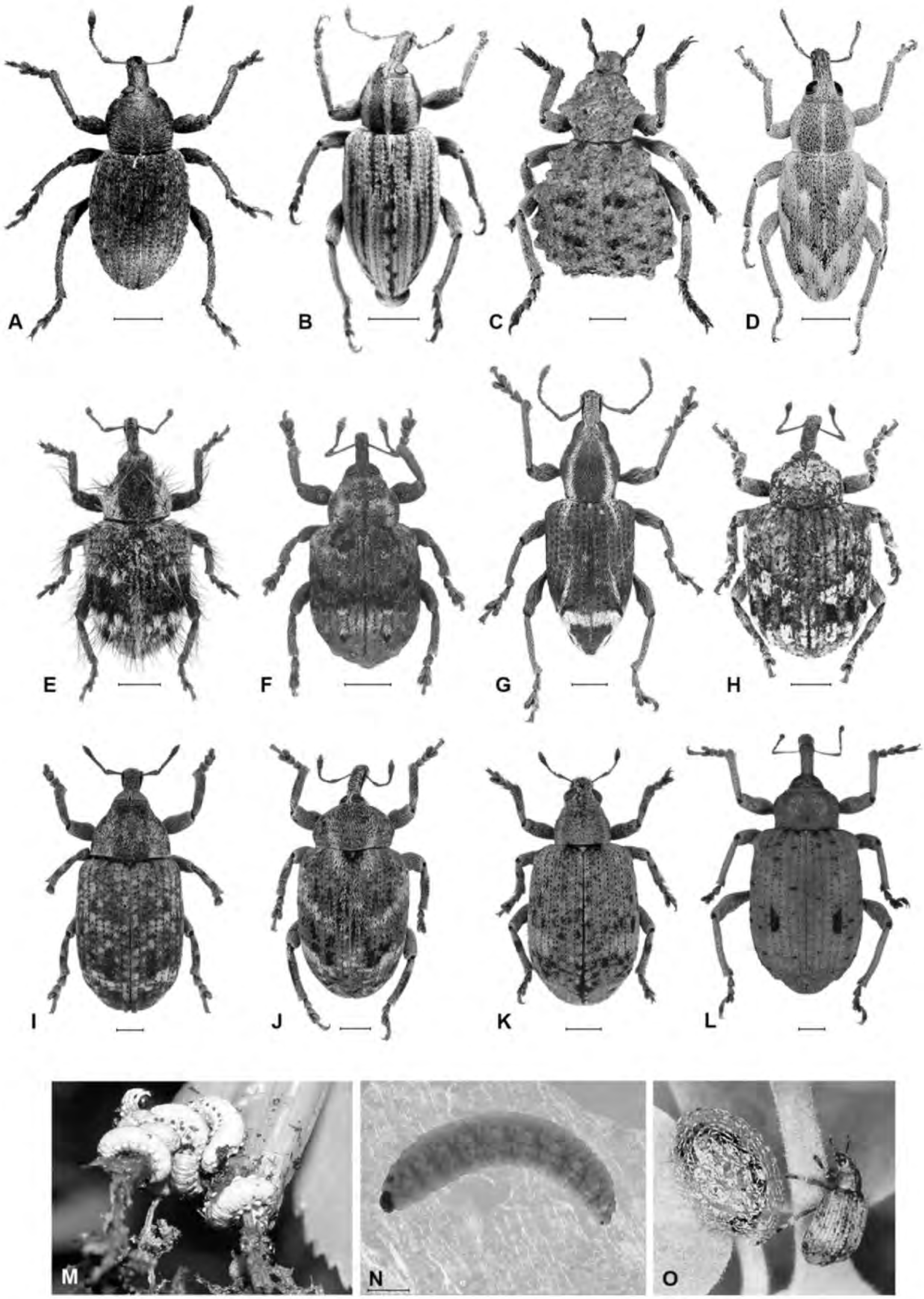


Fig. 3.7.2.3 Hyperini. A, *Donus nidensis* Mazur & Petryszak, dorsal habitus; B, *Hypera arator* (Linnaeus), dorsal habitus; C, *Herpes porcellus* (Lacordaire), dorsal habitus; D, *Coniatus tamarisci* (Fabricius), dorsal habitus; E, *Agriochaeta crinita* Pascoe, dorsal habitus; F, *Gerynassa nodulosa* Pascoe, dorsal habitus; G, *Lycosura bispinosa* Pascoe, dorsal habitus; H, *Nothyperus cionodes* Marshall, dorsal habitus; I, *Cepurus torridus* Olivier, dorsal habitus; J, *Choropholus africanus* Marshall, dorsal habitus; K, *Frontodes brevicornis* Marshall, dorsal habitus; L, *Phelypera distigma* (Boheman), dorsal habitus; M, *Hypera arundinis* (Paykull) larvae feeding on stem of *Sium latifolium* (Apiaceae); N, *Gerynassa* sp., larva, lateral view; O, *Frontodes brevicornis* Marshall with cocoon. Scale bars 1 mm.

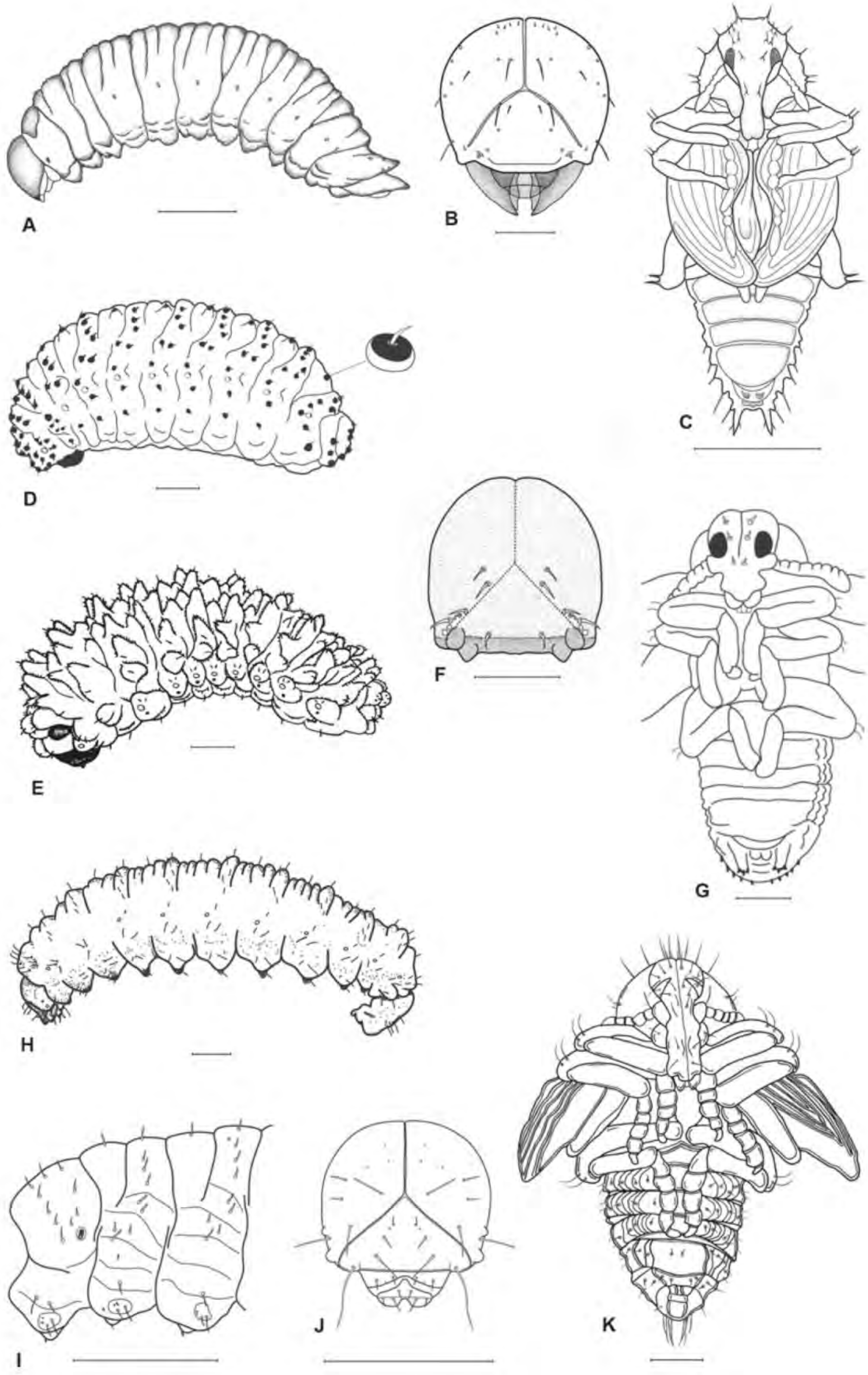


Fig. 3.7.2.4 Immature stages. A, *Bagous lutulentus* (Gyllenhal), larva, lateral view; B, *Bagous lutulentus* (Gyllenhal), head capsule, anterior view; C, *Bagous lutulentus* (Gyllenhal), pupa, ventral view; D, *Gonipterus platensis* (Marelli), larva, lateral view; E, *Oxyops concretus* Pascoe, larva, lateral view; F, *Bryachus squamicollis* Pascoe, head capsule, anterior view; G, *Bryachus squamicollis* Pascoe, pupa, ventral view; H, *Hypera postica* (Gyllenhal), larva, lateral view; I, *Hypera postica* (Gyllenhal), larva, thoracic segments, lateral view; J, *Hypera rumicis* (Gyllenhal), head capsule, anterior view; K, *Hypera arundinis* (Paykull), pupa, ventral view (A–C, after Gosik 2009; D–G, after May 1994; H, after Skuhrovec 2006 a; I, after Skuhrovec 2005 a; J, after Skuhrovec 2006 b; K, after Gosik 2008 b).

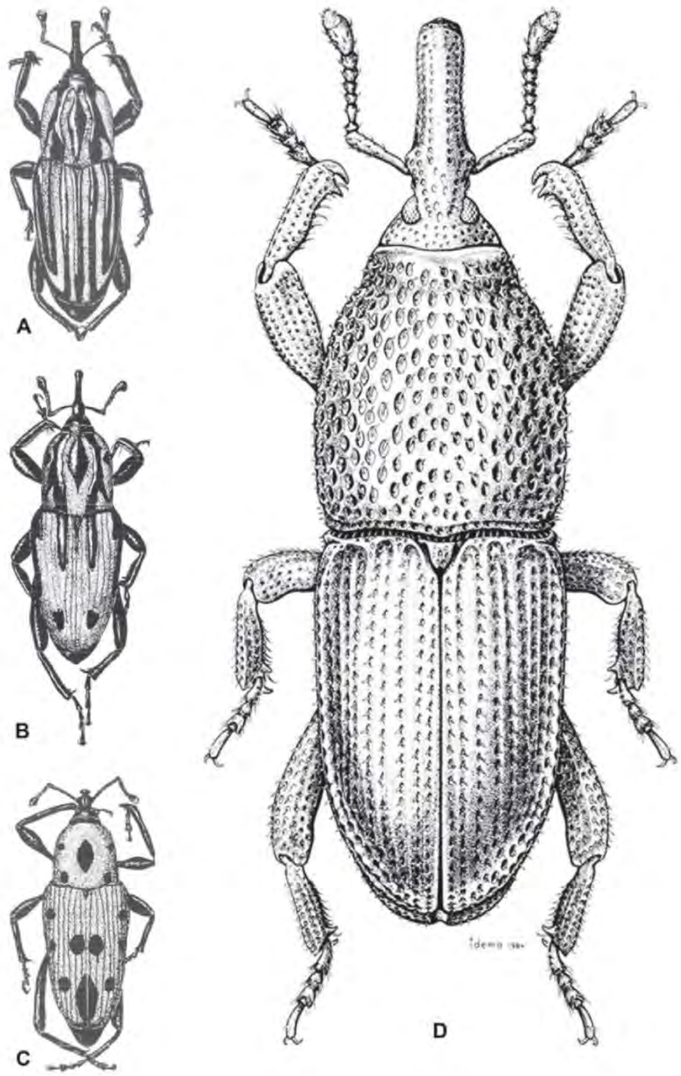


Fig. 3.7.3.1 Dryophthorinae, adults. A, *Sphenophorus australis* Chittenden (Rhynchophorini), habitus, dorsal, length = 12.0 mm. B, *Sphenophorus cariosus* (Olivier) (Rhynchophorini), habitus, dorsal, length = 10.0 mm. C, *Rhodobaenus tredecimpunctatus* (Illiger) (Rhynchophorini), habitus, dorsal, length = 10.0 mm. D, *Sitophilus granarius* (Linnaeus) (Rhynchophorini), habitus, dorsal, length = 4.0 mm. (From Dillon & Dillon 1972 © Dover Publications; from Bousquet 1990 © Agriculture and Agri-Food Canada.)

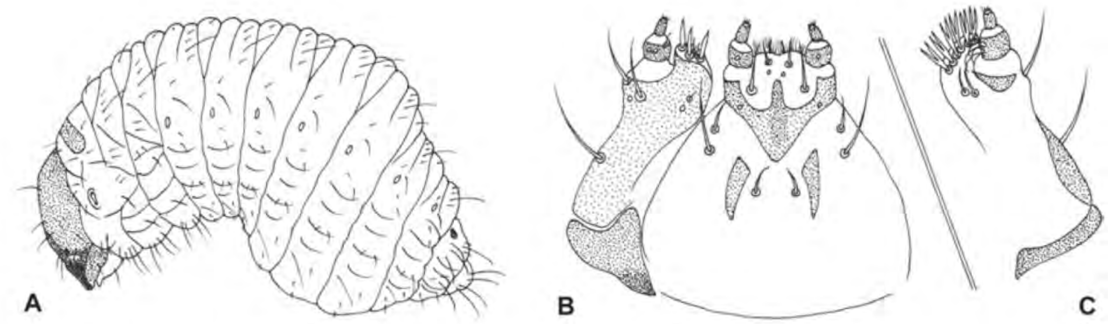


Fig. 3.7.3.3 Dryophthorinae, *Sphenophorus brunnipennis* (Germar), (Rhynchophorini), larva. A, habitus, lateral, length = 9.0 mm. B, Maxilla and labium, ventral. C, Maxilla, dorsal (note branched setae). (From May 1993: FNZ, Figs. 1062, 1068a, 1068b, © Landcare Research, New Zealand.)

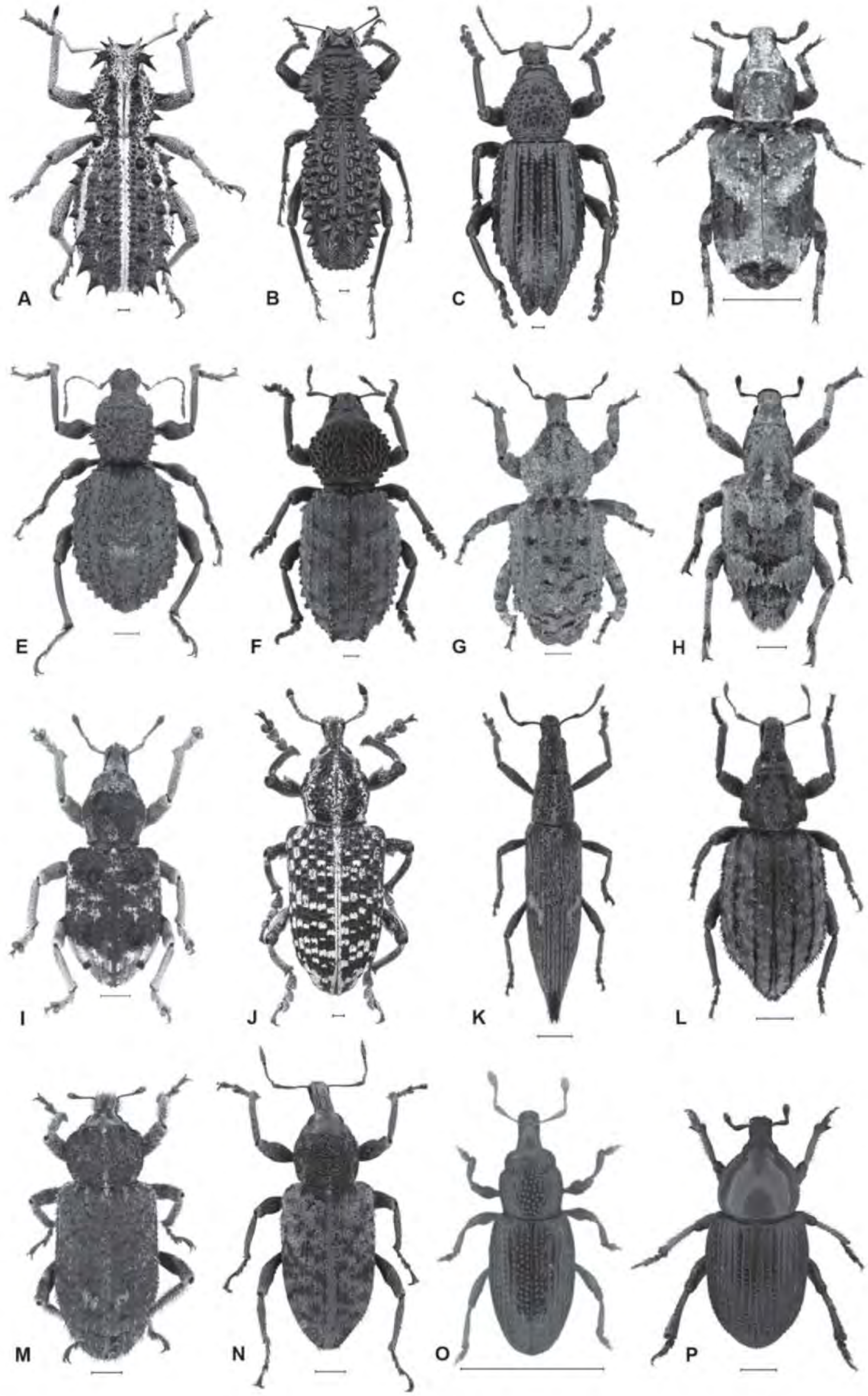


Fig. 3.7.4.1 Cyclominae, dorsal habitus. A, *Acantholophus niveovittatus* Blackburn (Amycterini); B, *Gagatophorus draco* (Macleay) (Amycterini); C, *Bronchus verrucosus* (Linnaeus) (Hipporhinini); D, *Gronops lunatus* (Fabricius) (Hipporhinini); E, *Epicthonius coronatus* (Boheman) (Cyclomini); F, *Somatodes misumenus* Gyllenhal (Cyclomini); G, *Rhythirrinus inaequalis* (Fabricius) (Rhythirrinini); H, *Aparete palpebrosa* Pascoe (Rhythirrinini); I, *Aades cultratus* (Fabricius) (Aterpini); J, *Chrysolopus spectabilis* (Fabricius) (Aterpini); K, *Euthyphasis acuta* Pascoe (Aterpini); L, *Dichotrachelus sulcipennis* Stierlin (Dichotrachelini); M, *Listroderes difficilis* Germain (Listroderini); N, *Steriphus major* (Blackburn) (Listroderini); O, *Notiomimetes pascoei* Wollaston (Notiomimetini); P, *Aphela helopoides* Pascoe (Notiomimetini). Scale bars 1 mm.

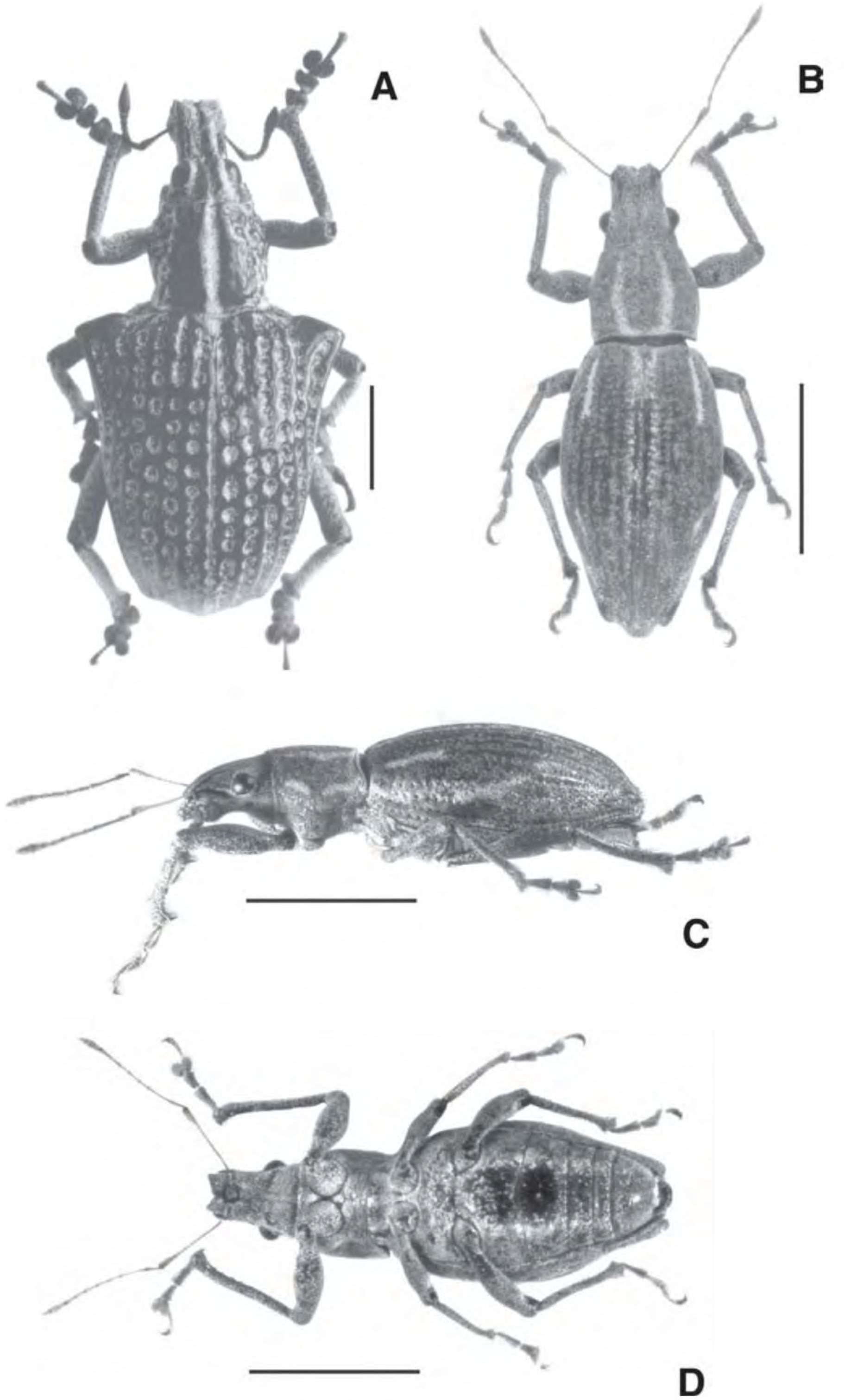


Fig. 3.7.5.2 A, B, Adults, general habitus. A, *Entimus sastrei* Viana; B–D, *Naupactus xanthographus* (Germar). B, Dorsal; C, lateral; D, ventral. Scale bar 5 mm.

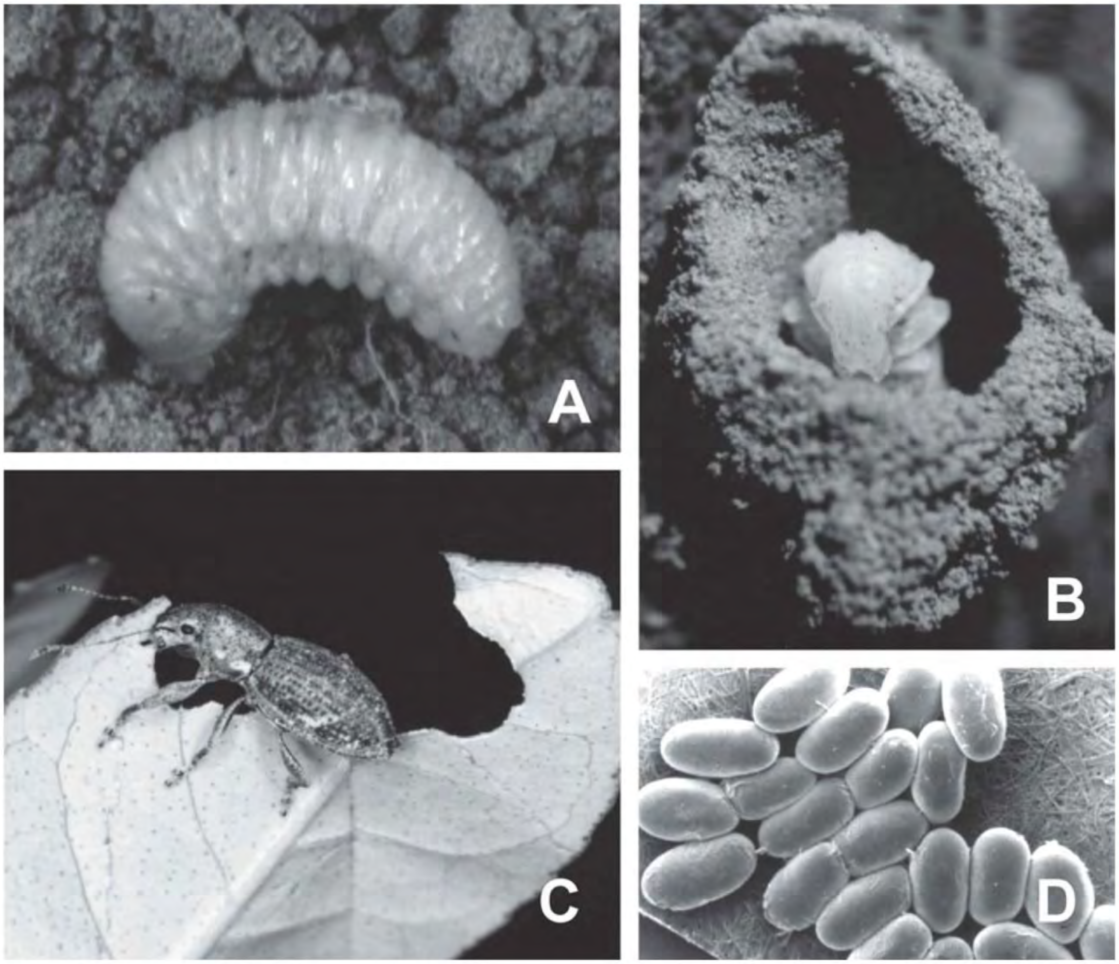


Fig. 3.7.5.1 Life cycle of Entiminae. A, *Naupactus leucoloma* Boheman, mature larva in soil; B, *N. leucoloma*, pupa in earth cell; C, *N. cervinus* Boheman, adult feeding; D, *Atrichonotus taeniatulus* Berg, posture.

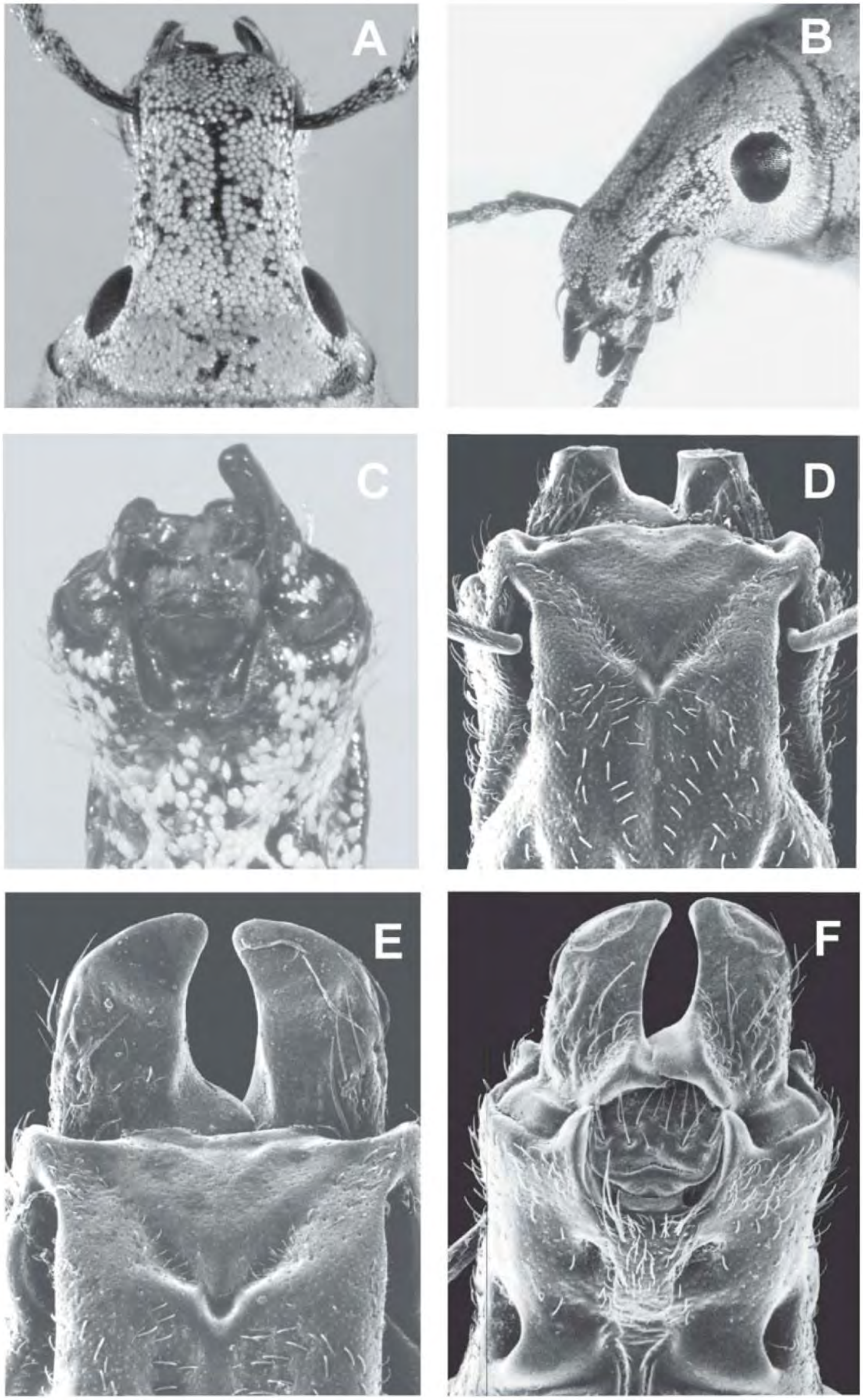


Fig. 3.7.5.3 A–F, Adult morphology, head and mouthparts. A–C, *Platyaspistes argentinensis* Kuschel. A, head, dorsal; B, head and antenna, lateral; C, rostrum and mouthparts, ventral, with scar and process; D–F, *Prostomus scutellaris* Schoenherr, mandibles. D, female, dorsal; E, male, dorsal; F, male, ventral.

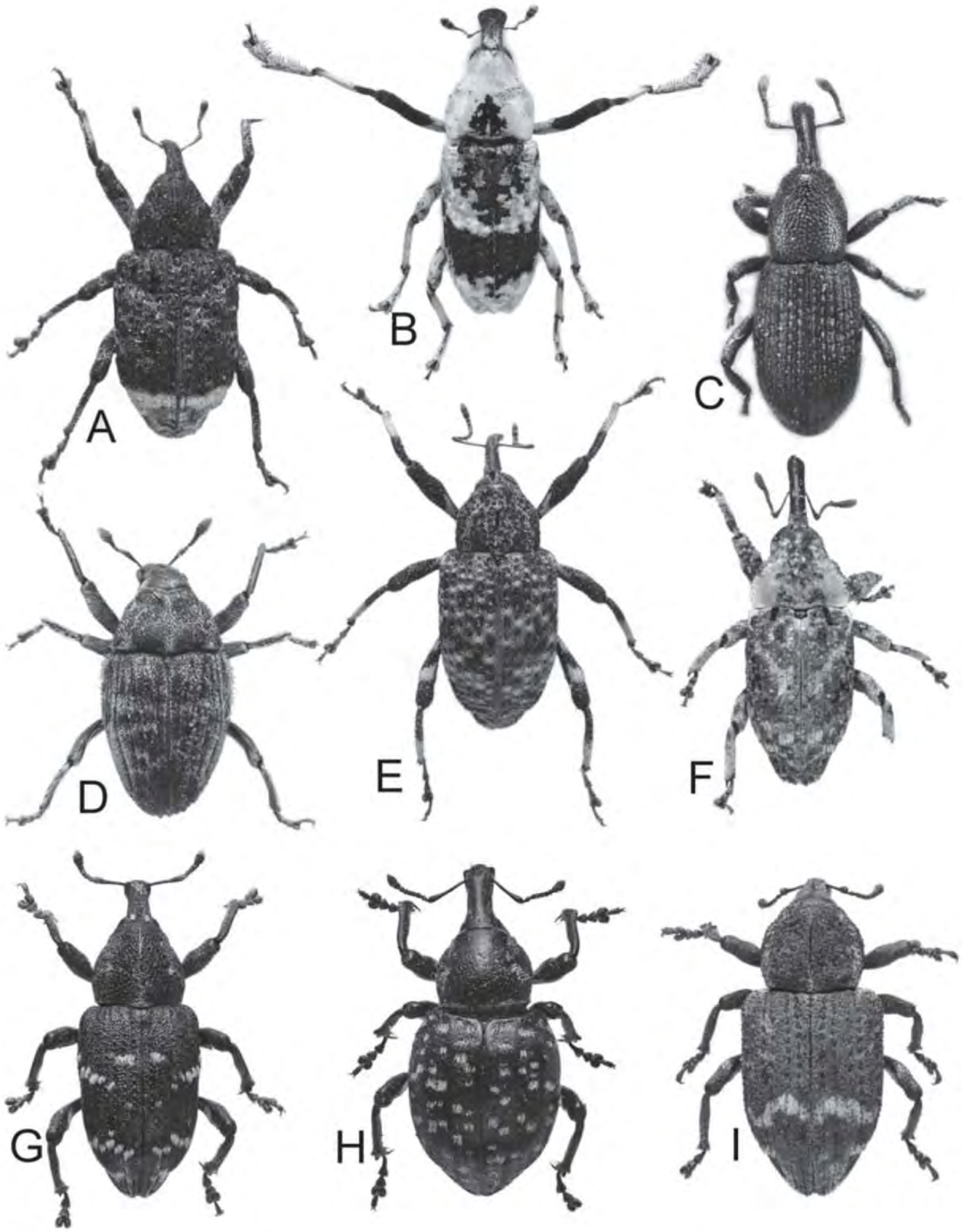


Fig. 3.7.7.1 Molytinae adults, dorsal: A, *Cryptorhynchus lapathi* Dejean (Cryptorhynchini), length = 8.2 mm; B, *Gasterocercus longipes* Kôno (Gasterocercini), length = 11.2 mm; C, *Torneuma sardoum* Desbrochers (Torneumatiini), length = 2.8 mm; D, *Psepholax sulcatus* White (Psepholacini), length = 7.8 mm; E, *Mechistocerus nipponicus* Kôno (Aedemonini), length = 9.6 mm; F, *Sophrorhinus inseperata* Faust (Sophrorhinini), length = 5.9 mm; G, *Hylobius abietis* (Linnaeus) (Molytini: Hylobiina), length = 12.7 mm; H, *Liparus germanus* (Linnaeus) (Molytini: Molytina), length = 15.3 mm; I, *Plinthus megerlei* (Panzer) (Molytini: Plinthina), length = 11.3 mm; (lengths given from base of rostrum to posterior of abdomen) © Natural History Museum, UK.

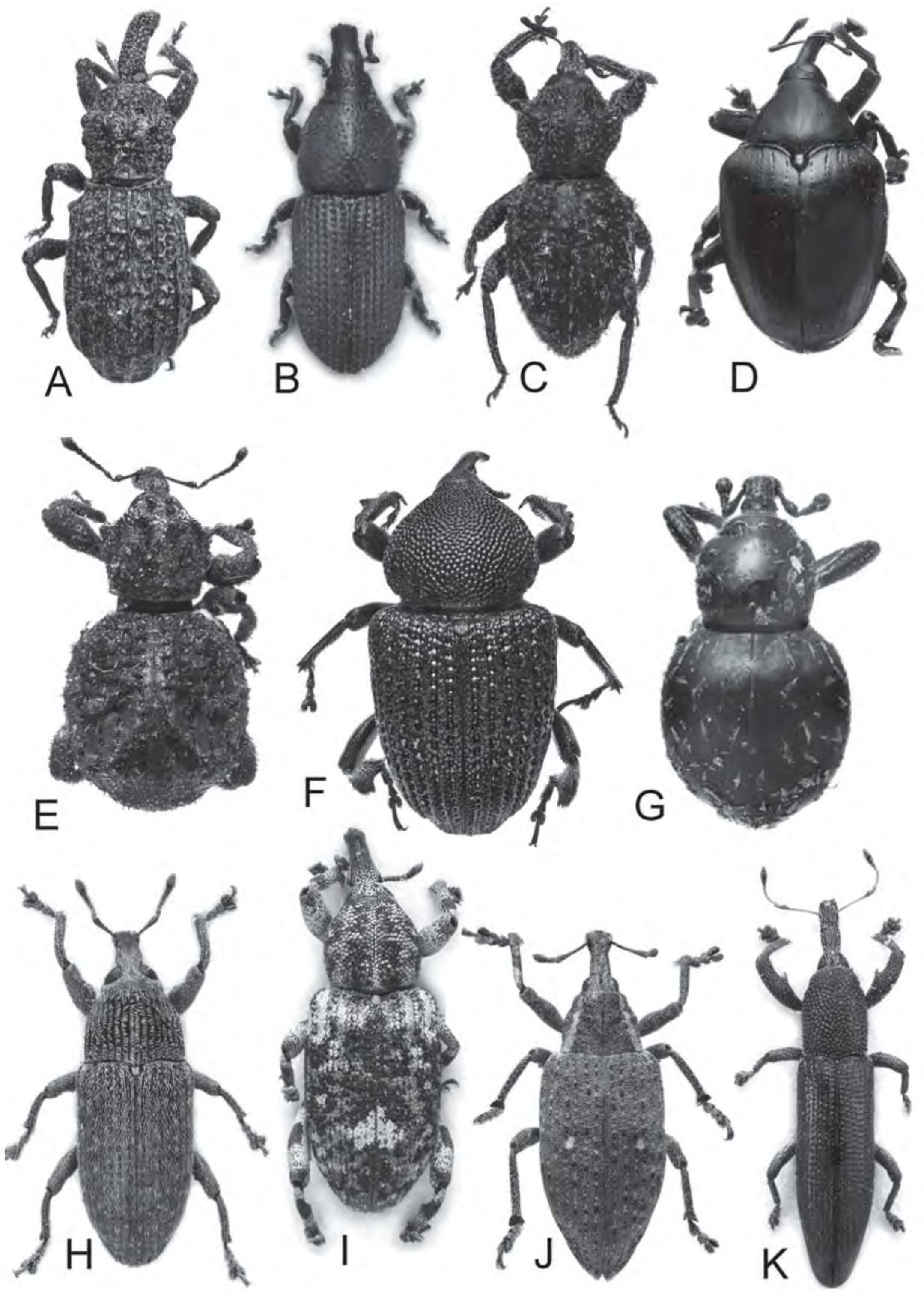


Fig. 3.7.7.2 Molytinae adults, dorsal: A, *Typoderus machadoi* Marshall (Typoderini), length = 4 mm; B, *Amorphocerus talpa* Schoenherr (Amorphocerini), length = 5.7 mm; C, *Dreuxetes carinirostris* (Champion) (Anchonini), length = 6 mm; D, *Cleogonus rubetra* (Fabricius) (Cleogonini), length = 9.9 mm; E, *Cycloteres audouini* Boheman (Cycloterini), length = 11.7 mm; F, *Sclerocardius africanus* Boheman (Sclerocardiina), length = 15.2 mm; G, *Theogenete campbelli* Anderson (Lymantini), length = 2.4 mm; H, *Euderes lineicollis* (Wiedemann) (Euderini), length = 8.8 mm; I, *Ithyporus setulosus* Hustache (Ithyporini), length = 8.8 mm; J, *Lepyrus pinguis* Casey (Lepyrini), length = 13.2 mm; K, *Phoenicobates vittatus* Champion (Phoenicobatini), length = 4.3 mm; (lengths given from base of rostrum to posterior of abdomen) © Natural History Museum, UK.

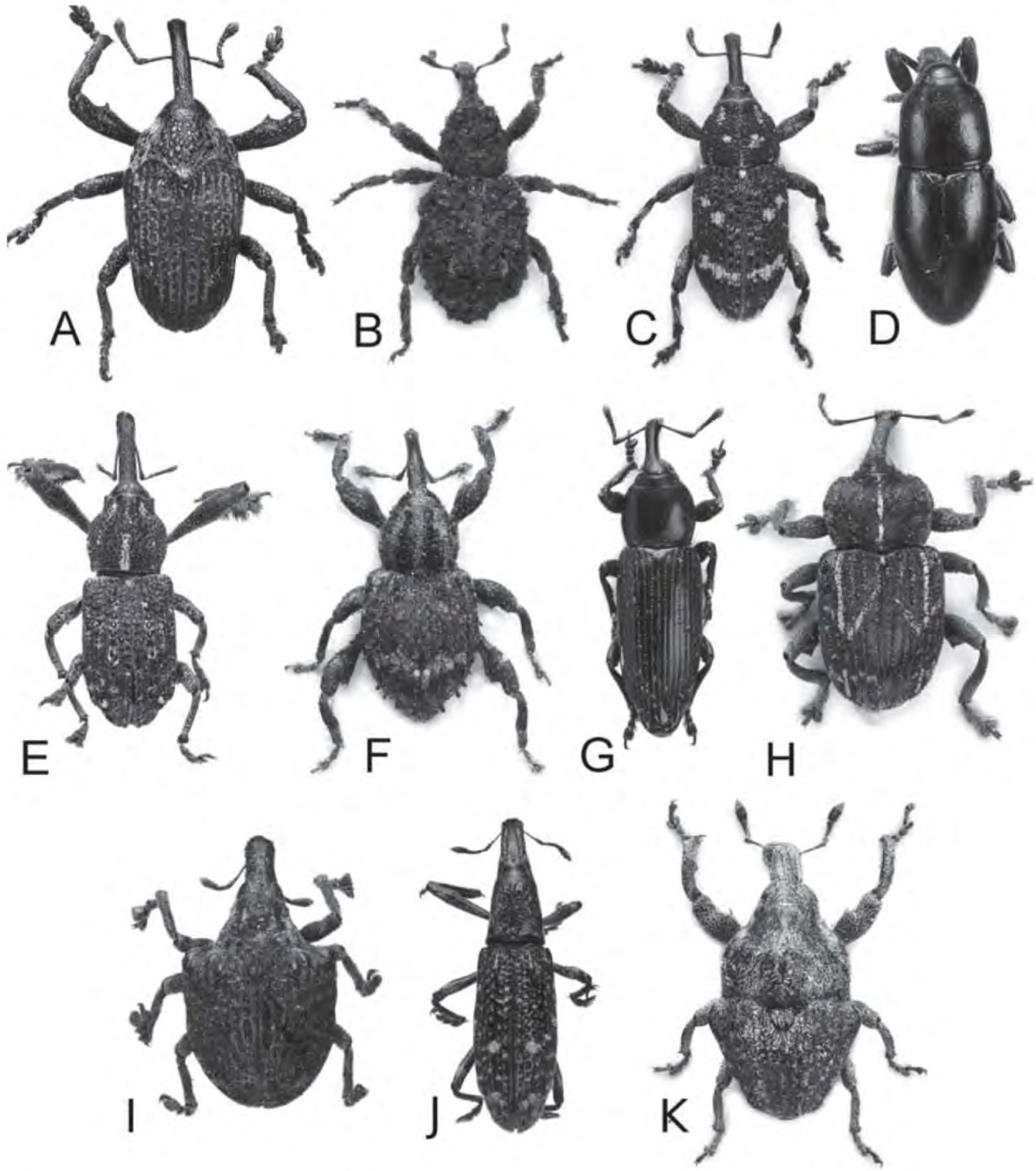


Fig. 3.7.7.3 Molytinae adults, dorsal: A, *Alcidodes senex* Sahlberg (Mecysolobini), length = 4.3 mm; B, *Phrynixus intricatus* Broun (Phrynixini), length = 4.6 mm; C, *Pissodes pini* (Linnaeus) (Pissodini), length = 7.9 mm; D, *Juanorhinus ruficeps* (Aurivillius) (Juanorhinini), length = 3.3 mm; E, *Orthorhinus cylindrirostris* (Fabricius) (Orthorhinini), length = 18.6 mm; F, *Trachodes hispidus* (Linnaeus) (Trachodini), length = 3.7 mm; G, *Aorus anthracinus* Brancsik (Amalactini), length = 9.2 mm; H, *Petalochilus gemellus* (Gyllenhal) (Petalochilini), length = 10.3 mm; I, *Omophorus stomachosus* Boheman (Metatygini), length = 10.2 mm; J, *Peribleptus scalptus* Boheman (Paipalesomini), length = 14.1 mm; K, *Trigonocolus vitticollis* Marshall (Trigonocolini), length = 4.0 mm; (lengths given from base of rostrum to posterior of abdomen) © Natural History Museum, UK.

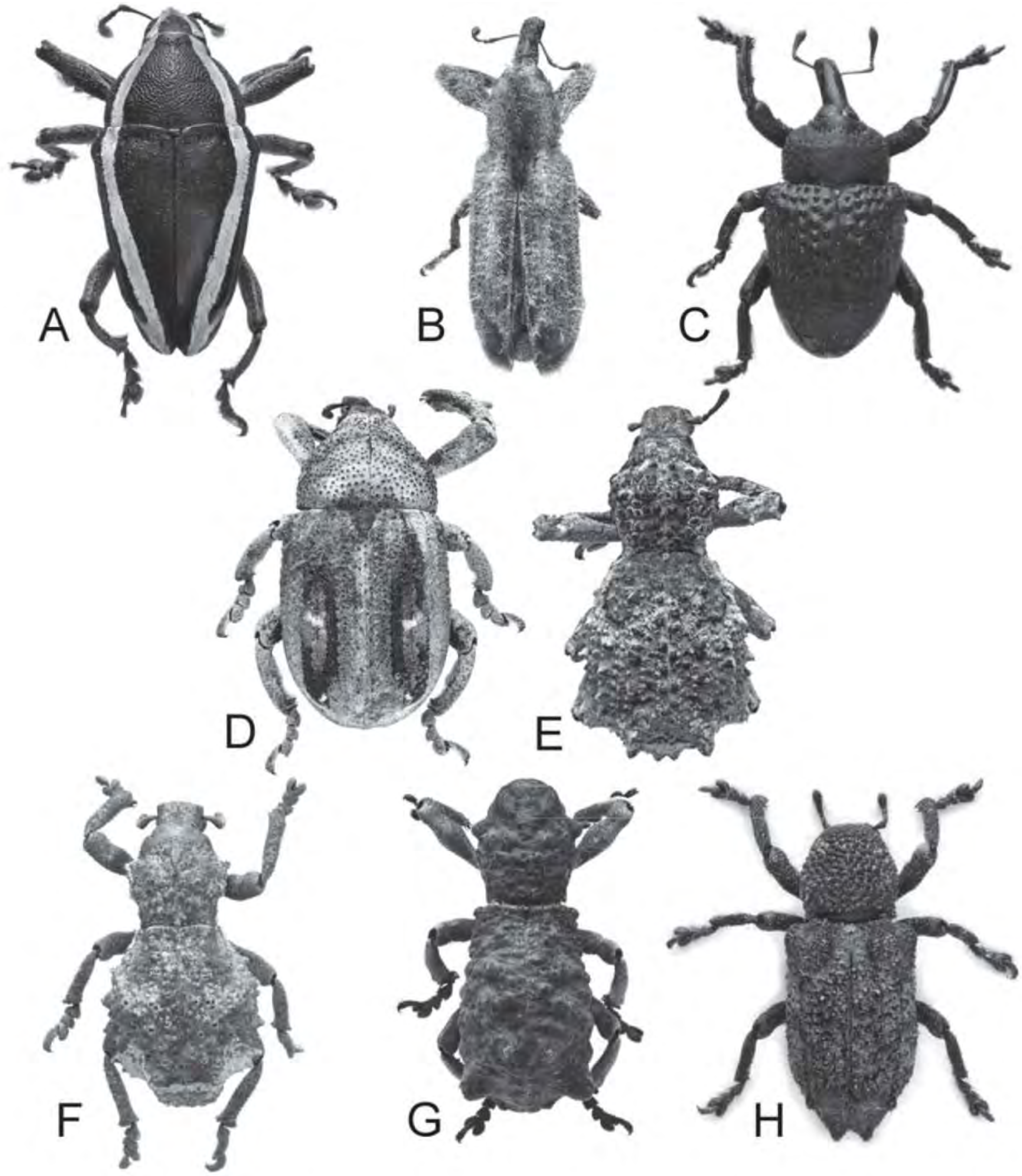


Fig. 3.7.7.4 Molytinae adults, dorsal: A, *Cholus albicinctus* Germar (Cholini), length = 14.4 mm; B, *Pacholenus canescens* Vanin & Reichardt (Pacholenini), length = 9.6 mm; C, *Sternechus cicatricosus* Fiedler (Sternechini), length = 8.2 mm; D, *Guioperus griseus* Perty (Guioperini), length = 14.3 mm; E, *Dinomorphus pimeloides* Perty (Dinomorphini), length = 22 mm; F, *Brachyceropsis tuberculosus* (Gyllenhal) (Brachyceropseini), length = 17.4 mm; G, *Lithinus superciliosus* Klug (Lithinini), length = 22.4 mm; H, *Styanax scrobiculatus* Roelofs (Styanacini), length = 8.3 mm; (lengths given from base of rostrum to posterior of abdomen) © Natural History Museum, UK.

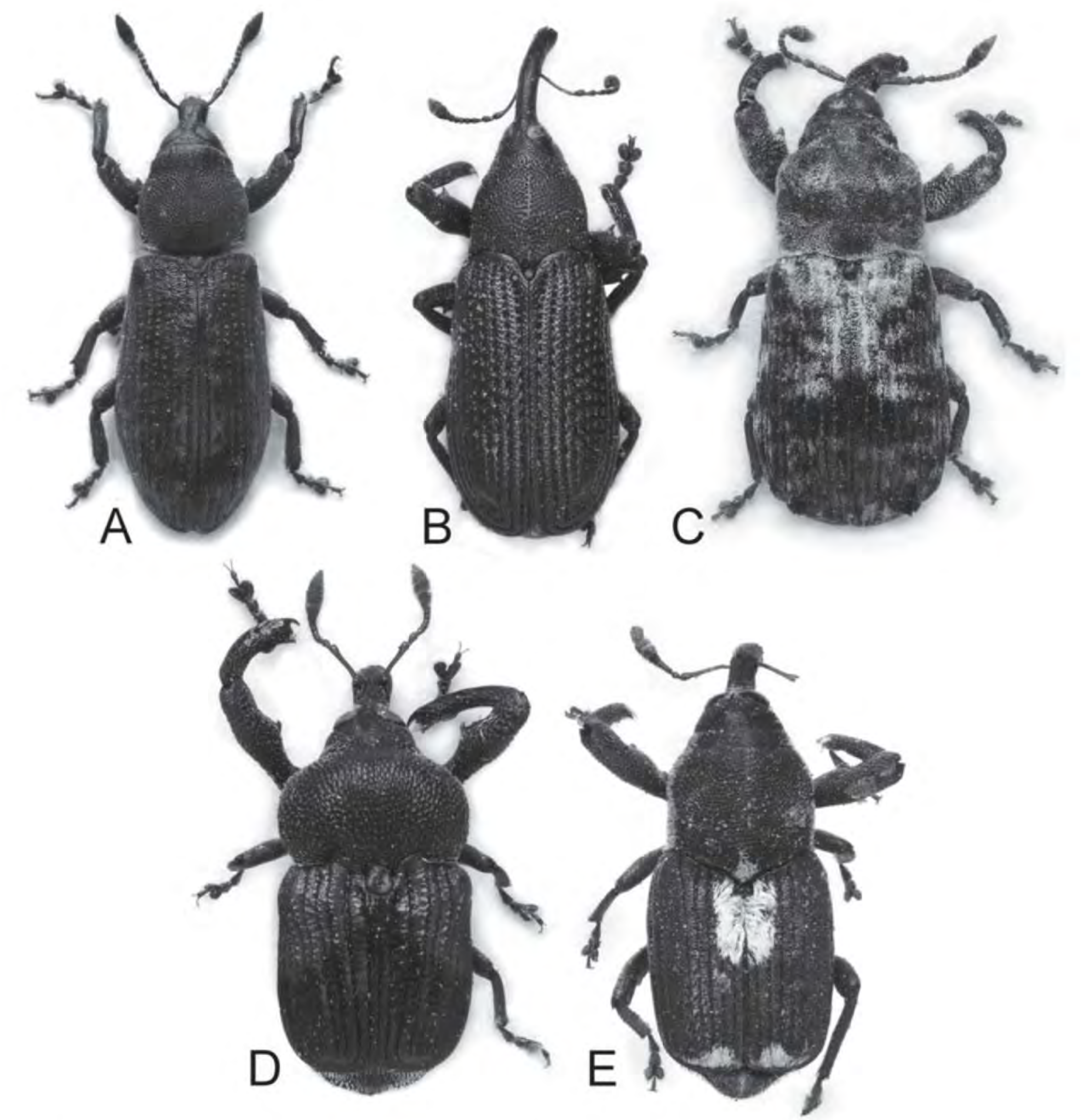


Fig. 3.7.8.1 Mesoptiliinae adults, dorsal. A, *Carcilia strigicollis* Roelofs (Carciliini), length = 10 mm; B, *Magdalis memnonia* Gyllenhal (Magdalidini), length = 6.5 mm; C, *Apocnemidophorus blandus* Hustache (Mesoptiliini), length = 5.5 mm; D, *Laemosaccus ruficornis* Champion (Laemosaccini (North America), length = 4.5 mm; E, *Neolaemosaccus notatus* (Pascoe) (Laemosaccini, Australia), length = 5.6 mm (lengths given from base of rostrum to posterior of abdomen).

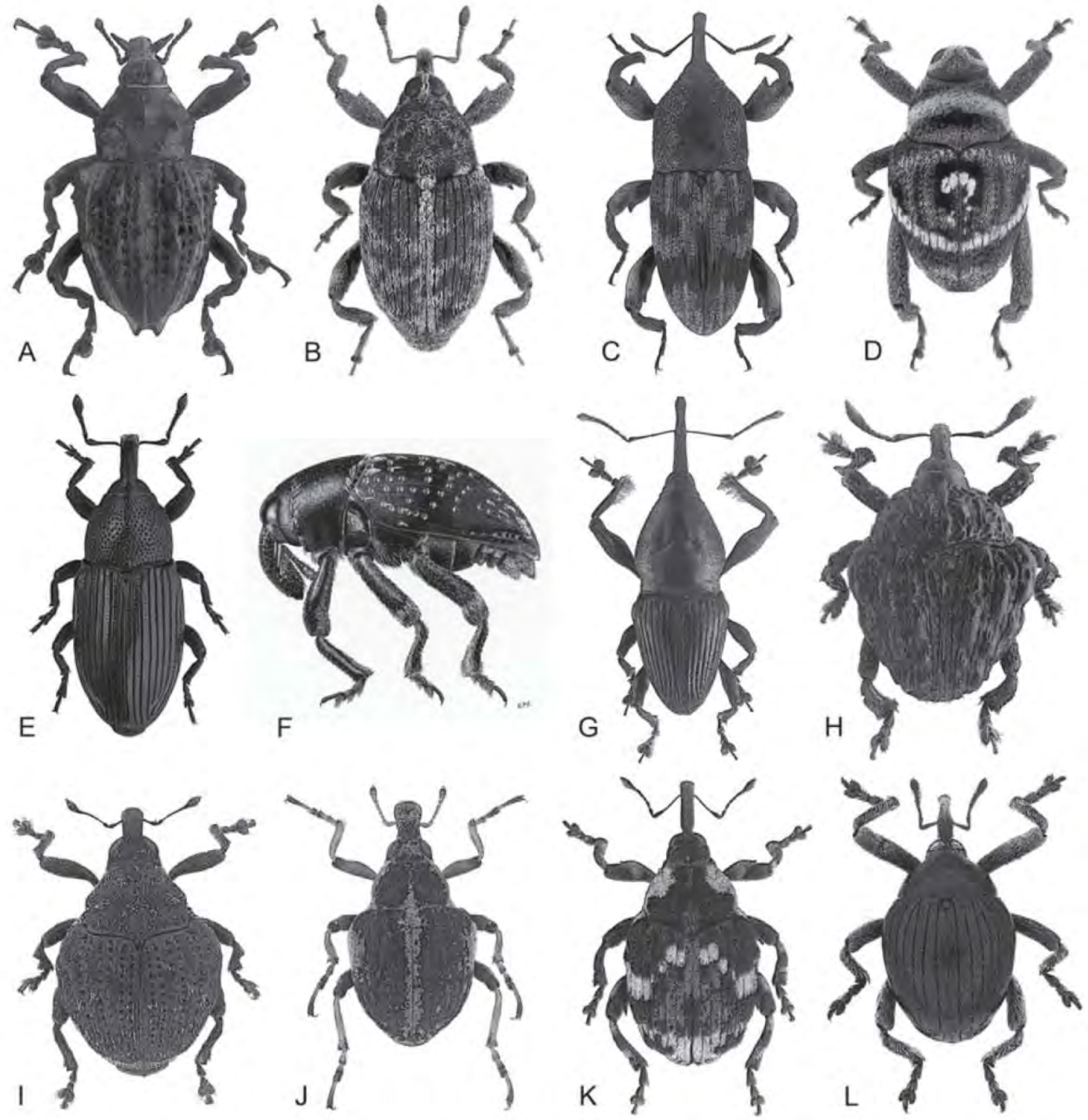


Fig. 3.7.9.1 Curculionidae, Conoderinae: dorsal habitus of Conoderitae (A–D), Bariditae (E–H), Ceutorhynchitae (I–K), and Orobitiditae (L); length without rostrum. A, *Cratosomus vaginalis* (Linnaeus), length = 25 mm; B, *Coryssomerus capucinus* (Beck), length = 2.9 mm; C, *Campyloscelus westermanni* Boheman, length = 10.8 mm; D, *Copturus curvaturatus* (Heller), length = 7.0 mm; E, *Baris artemisiae* (Panzer), length = 4.2 mm; F, *Eisonyx crassipes* LeConte, length = 4.9 mm (from Pakaluk & Carlow 1994, © E. P. Roberts); G, *Apostasimerus serrirostris* Boheman, length = 6.5 mm; H, *Diorycentrinus tuberculatus* Hustache, length = 4.6 mm; I, *Craponius inaequalis* (Say), length = 3.3 mm; J, *Eubrychius velutus* (Beck), length = 2.0 mm; K, *Hadroplontus trimaculatus* (Fabricius), length = 3.9 mm; L, *Orobitis cyanea* (Linnaeus), length = 2.4 mm.

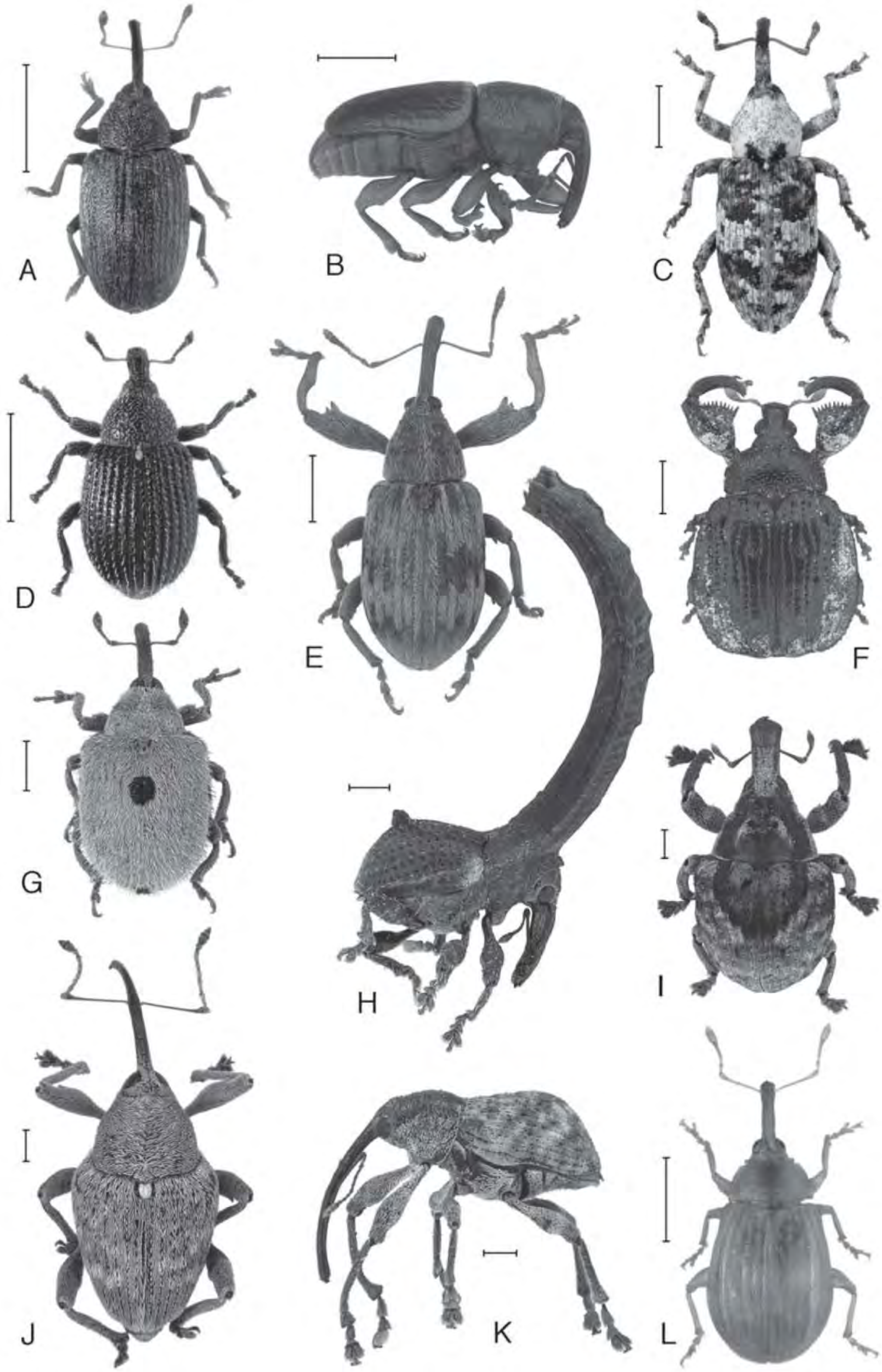


Fig. 3.7.10.6 Habitus, adults. A, *Acalyptus carpini* (Schoenherr) (Acalyptini); B, *Eudelodes bicolor* (Faust) (Acalyptini); C, *Acentrus histrio* (Schoenherr) (Acentrusini); D, *Anoplus roboris* Suffrian (Anoplini); E, *Anthonomus rectirostris* (Linnaeus) (Anthonomini); F, *Camarotus* sp. (Camarotini); G, *Cionus olivieri* Rosenschöld (Cionini); H, *Cerocranus extremus* Kuschel (Cranopoeini); I, *Sigastus fuscodorsalis* (Heller) (Cryptoplini); J, *Curculio glandium* Marsham (Curculionini); K, undescribed genus from Australia with horizontal mandibles, seven-segmented funicles, divaricate claws and trochanteral setae (Curculionini); L, *Derelomus piriformis* (Hoffmann) (Derelomini). Scale bars 1 mm.

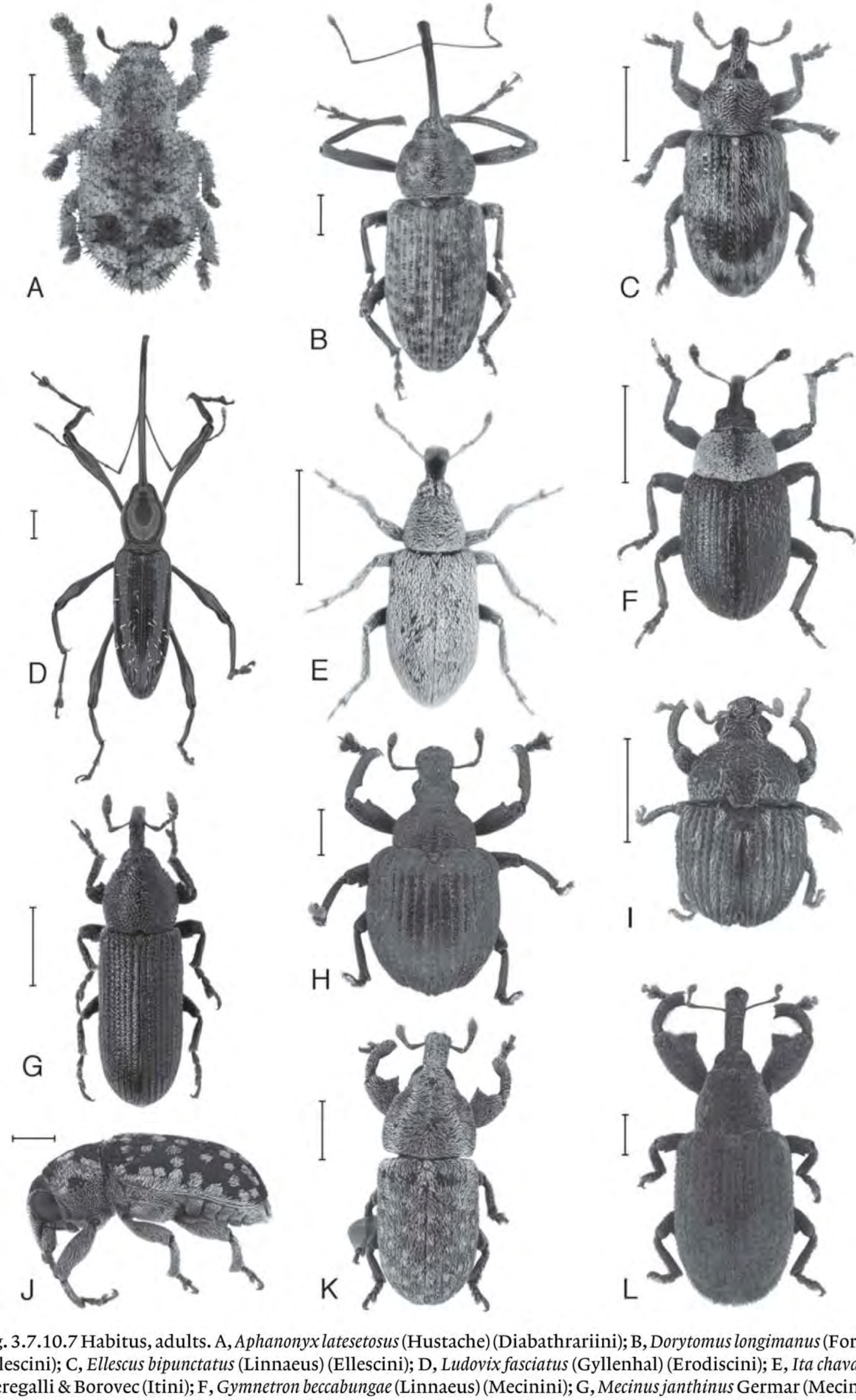


Fig. 3.7.10.7 Habitus, adults. A, *Aphanonyx latesetosus* (Hustache) (Diabathrariini); B, *Dorytomus longimanus* (Forster) (Ellescini); C, *Ellescus bipunctatus* (Linnaeus) (Ellescini); D, *Ludovix fasciatus* (Gyllenhal) (Erodiscini); E, *Ita chavanoni* Meregalli & Borovec (Itini); F, *Gymnetron beccabungae* (Linnaeus) (Mecinini); G, *Mecinus janthinus* Germar (Mecinini); H, *Galloisia inflata* Hustache (Microstylini); I, *Microstylus rufus* Schoenherr (Microstylini); J, *Nerthops guttatus* Schoenherr (Nerthopini); K, *Acallopistus* sp. (Nerthopini); L, *Teinomphasus robustus* Oberprieler (Ochyromerini). Scale bars 1 mm.

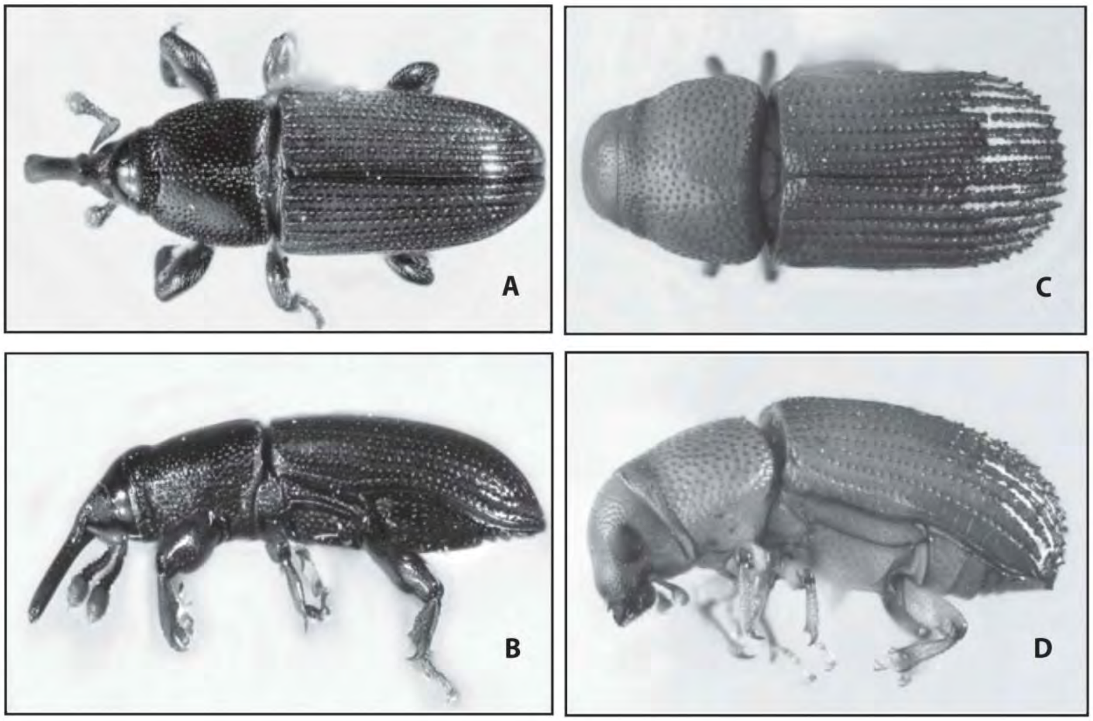


Fig. 3.7.11.1 A, B, *Mesites fusiformis* Wollaston, tribus Cossonini (length 4.0 mm); C, D, genus near *Stenoscelodes*, tribus Onycholipini (length 4.0 mm).

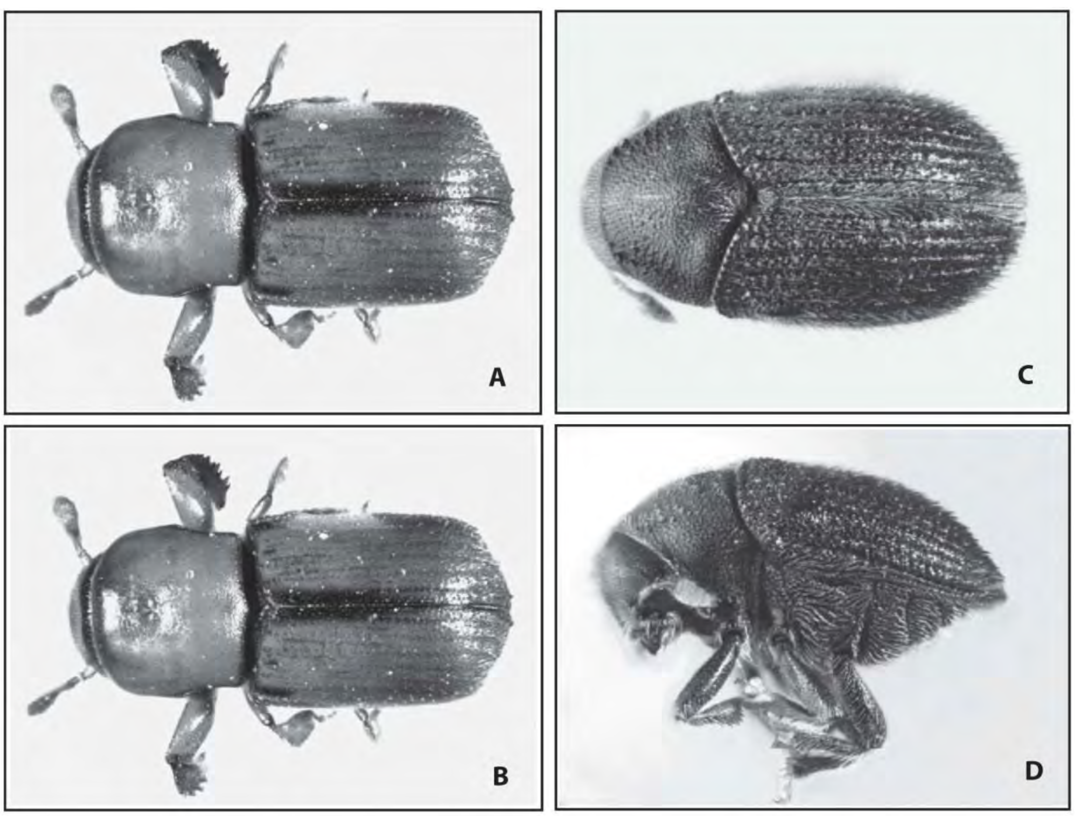


Fig. 3.7.12.1 A, B, Scolytinae – *Scolytoplatypus tycon* Blandford (female), tribe Scolytoplatypodini (length 4.2 mm); C, D, *Hylesinus crenatus* (F.), tribe Hylesinini (length 4.5 mm).

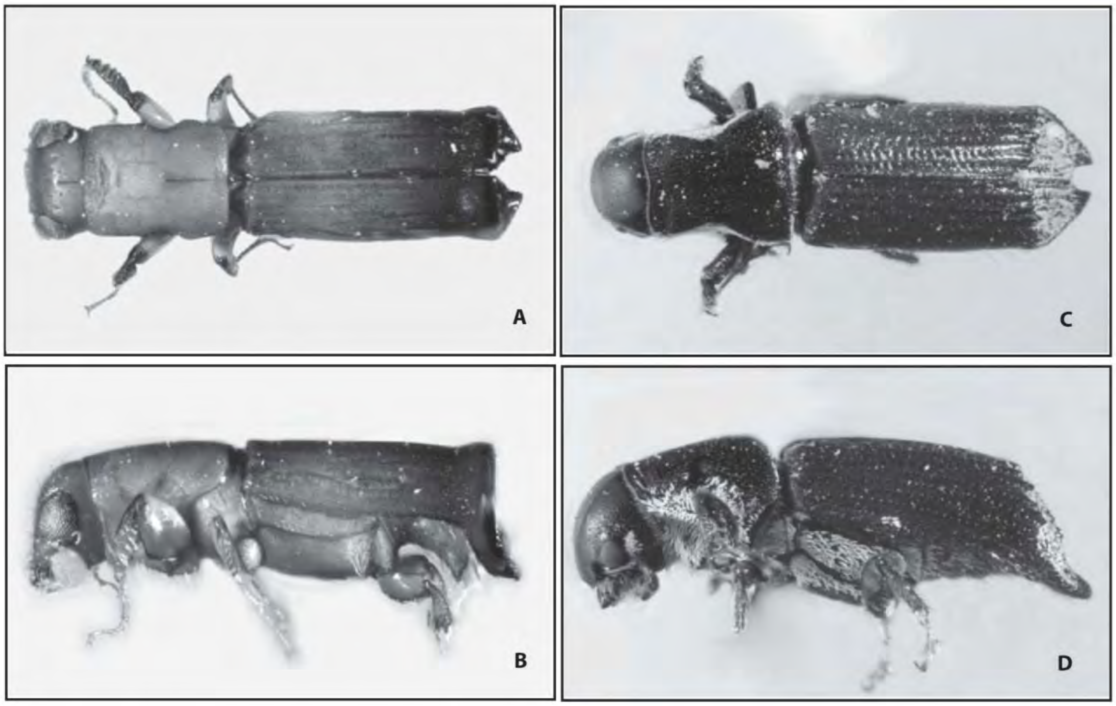


Fig. 3.7.13.1 A, B, *Dinoplatypus pseudocupulatus* Schedl (male, length 3.5 mm); C, D, *Schedlarius mexicanus* (Chapuis) (length 5.6 mm).

3. Economic Importance of Weevils

Due to their broad host range at the superfamily level, Curculionoidea contains a large number of agricultural, forestry, and storage pests.

Agricultural pests:

- Rice water weevil, *Lissorhoptrus oryzophilus* (Curculionidae)
  Serious pest in rice production. Native to N America. Spread to other regions including Asia.
- Sweet potato weevil, *Cylas formicarius* (Brentidae)
  Most serious pest of sweet potato. Widely distributed in tropical regions.
- Red palm weevil, *Rhynchophorus ferrugineus* (Dryophthridae)
  The most damaging pest of palms. Native to SE Asia but introduced to many other regions.
- Mango palp weevil, *Sternochetus frigidus* (Curculionidae)
  Serious pest of the flesh of mango. Probably originated from Malaysia.

… and many other examples

Forestry pests:

- Bark beetles (Scolytidae spp.)
  Containing many injurious pests in wood production.
- Oak ambrosia beetle, *Platypus quecivorus* (Platypodidae)
  Injurious pest of oaks and chinquapin trees. Widely distributed in Asia, including temperate, subtropical and tropical zones.

… and many other examples

Storage pests:

- Rice Weevil, *Sitophilos oryzae* (Dryophthoridae)
  Is distributed worldwide.

- Maize weevil, *Sitophilus zeamais* (Dryophthoridae)
  Is distributed worldwide, but less common in temperate zones.

Invasion risks of pest weevils:

- An invasive species tends to cause serious damages in “new ground”.
- Invasion risks of pest species are increasing due to the accelerated international trades by globalization.
- Importance of plant quarantine is greatly increasing.
- Quick and accurate species identification is important for monitoring invasive species and taking prompt measures against them.
- Generally, species identification of weevils is very difficult due to the delay in weevil taxonomy. A new pest weevil can be an undescribed species, which is new to science.

Bibliography

1) Genka, M. & H. Yoshitake, 2014. Chronological change of taxonomic composition of exotic weevils (Coleoptera, Curculionoidea) intercepted by Japanese plant quarantine. Research bulletin of the Plant Protection Service Japan, (50): 17–46. (In Japanese, with English summary.)
2) Yoshitake, H., S. Miyahara, M. Nishino & K. Suzuki, 2012. *Metapocyrtus* (*Trachycyrtus*) *hederaephilus* sp. nov. (Coleoptera, Curculionidae, Entiminae), a pest of the English ivy cultivated in Mie Prefecture, Honshu, Japan. Japanese Journal of Systematic Entomology, 18: 261-267.
3) Yoshitake, H., T. Fujisawa & J. Goto, 2011. A new *Ceutorhynchus* species (Coleoptera, Curculionidae) attacking field-cultivated wasabi (Brassicaceae) in Northern Japan. Japanese Journal of Systematic Entomology, 17: 293-299.

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

SESSION 3 & 4

HABITUS IDENTIFICATION OF WEEVILS

Lecture Notes by:

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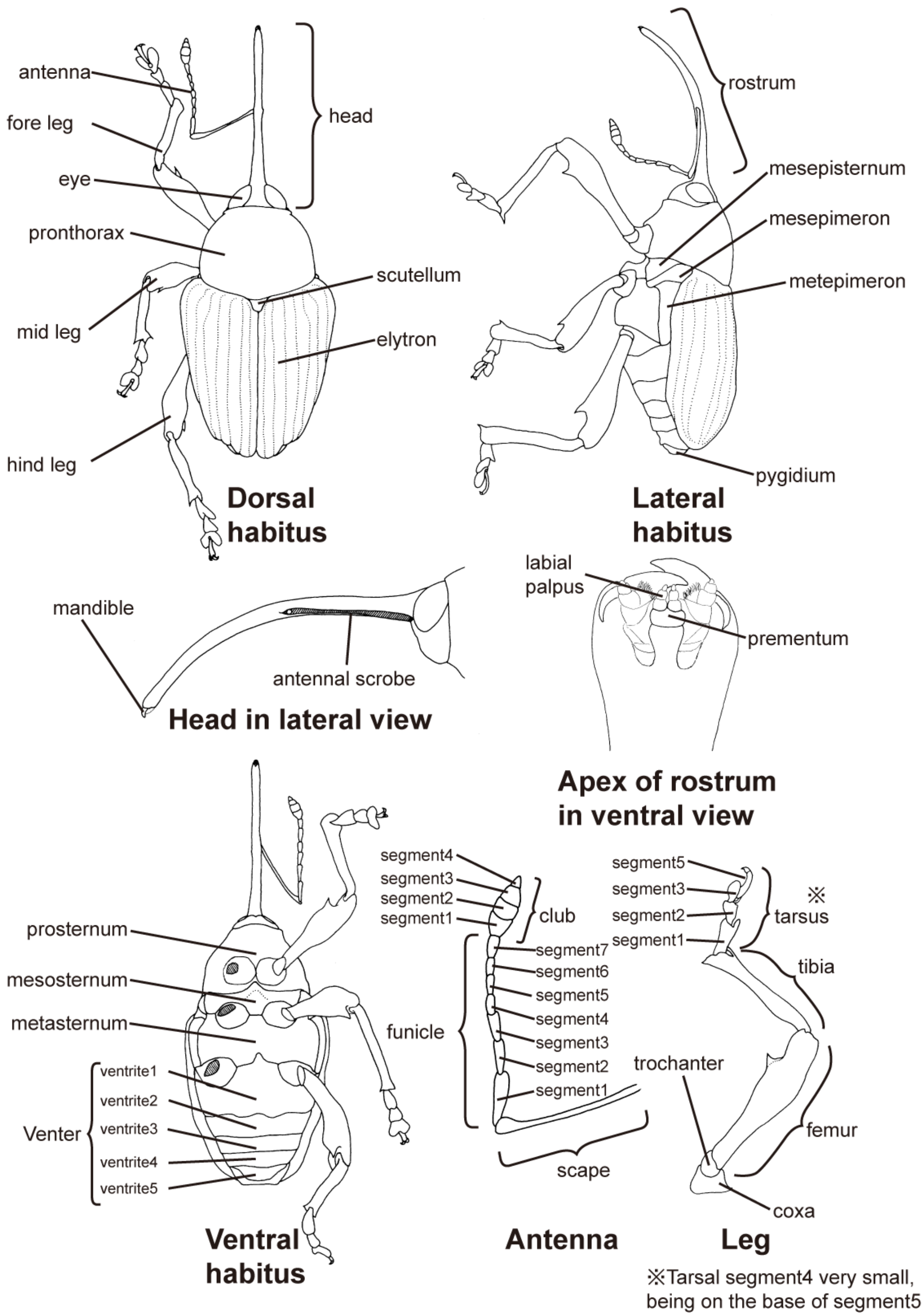
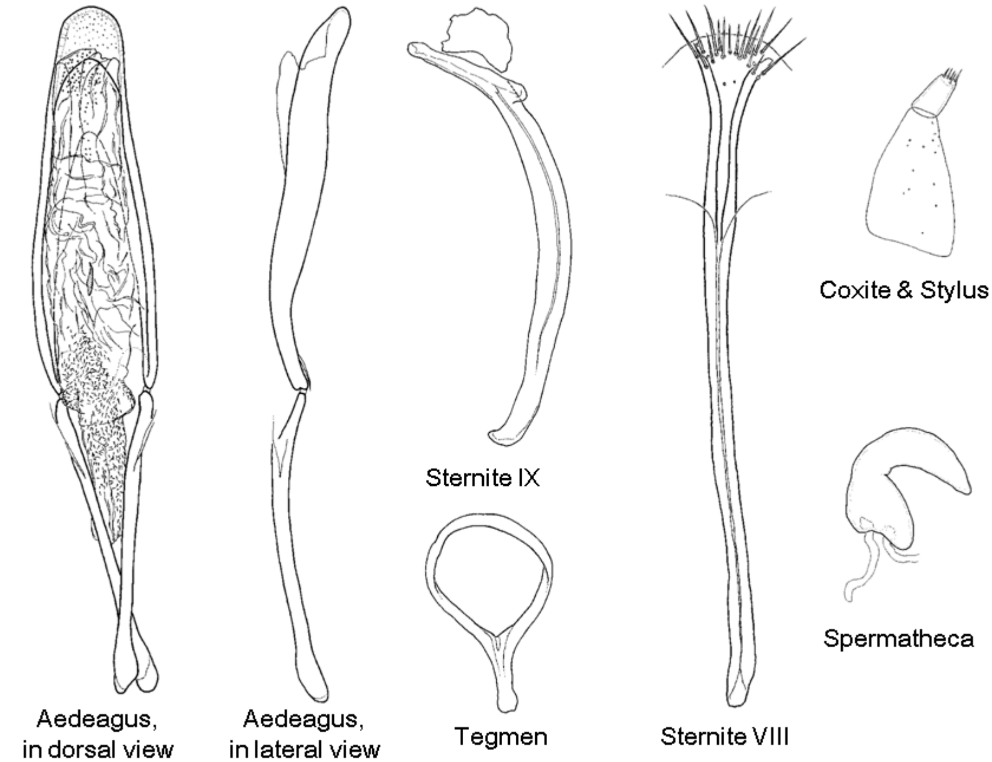
Institute for Agro-Environmental Sciences
NARO, Tsukuba, Japan

HABITUS IDENTIFICATION OF WEEVILS

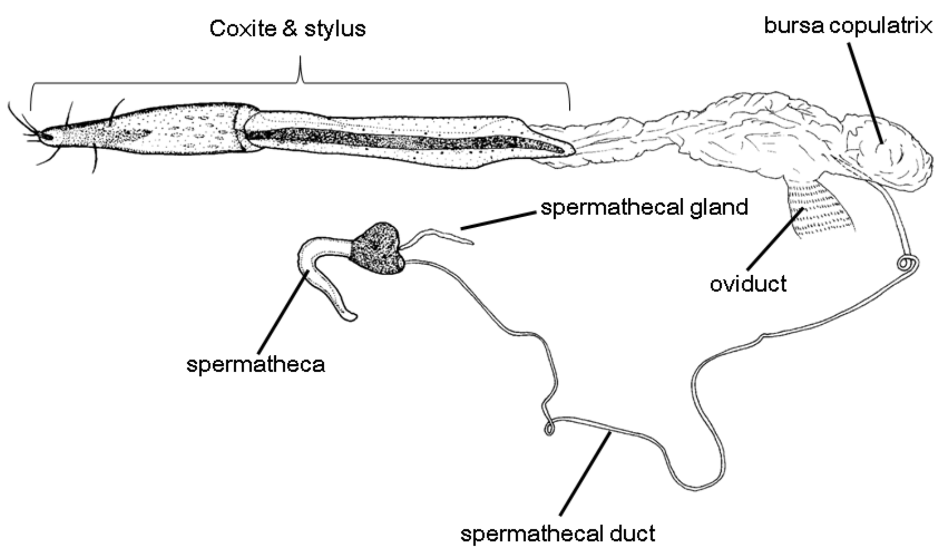
1. Morphology and Terminology – Adults: General



1. Morphology and Terminology – Adults: Genitalia



Male genitalia **Female genitalia**



Female genitalia, in lateral view

2. Morphology and Terminology – Larvae (Oberprieler et al. 2014)

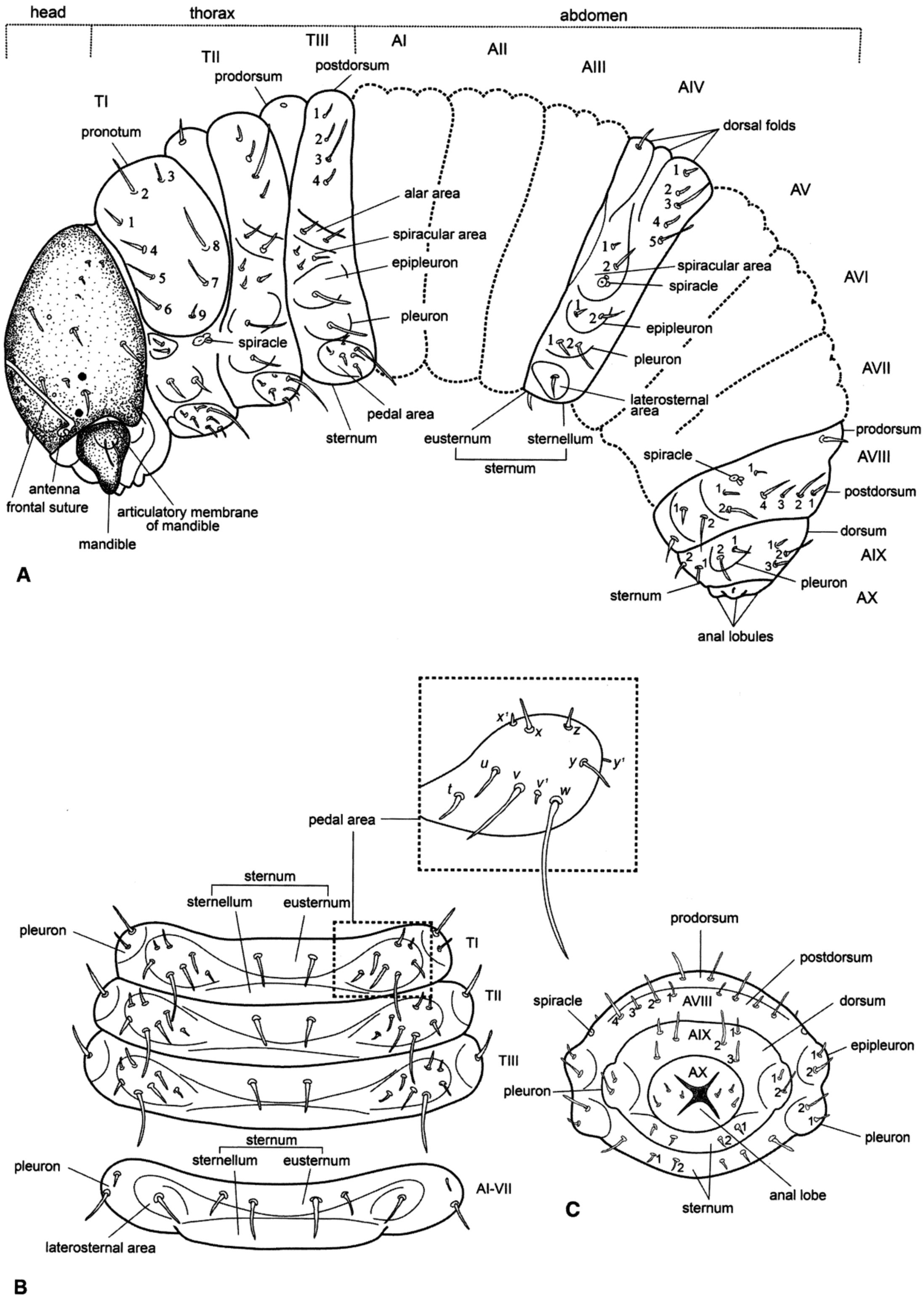


Fig. 3.5 Structure and chaetotaxy of generalized weevil larva (modified after Marvaldi 1999). A, lateral view; B, ventral view; C, caudal view.

3. **Morphology and Terminology – Pupae** (Oberprieler et al. 2014)

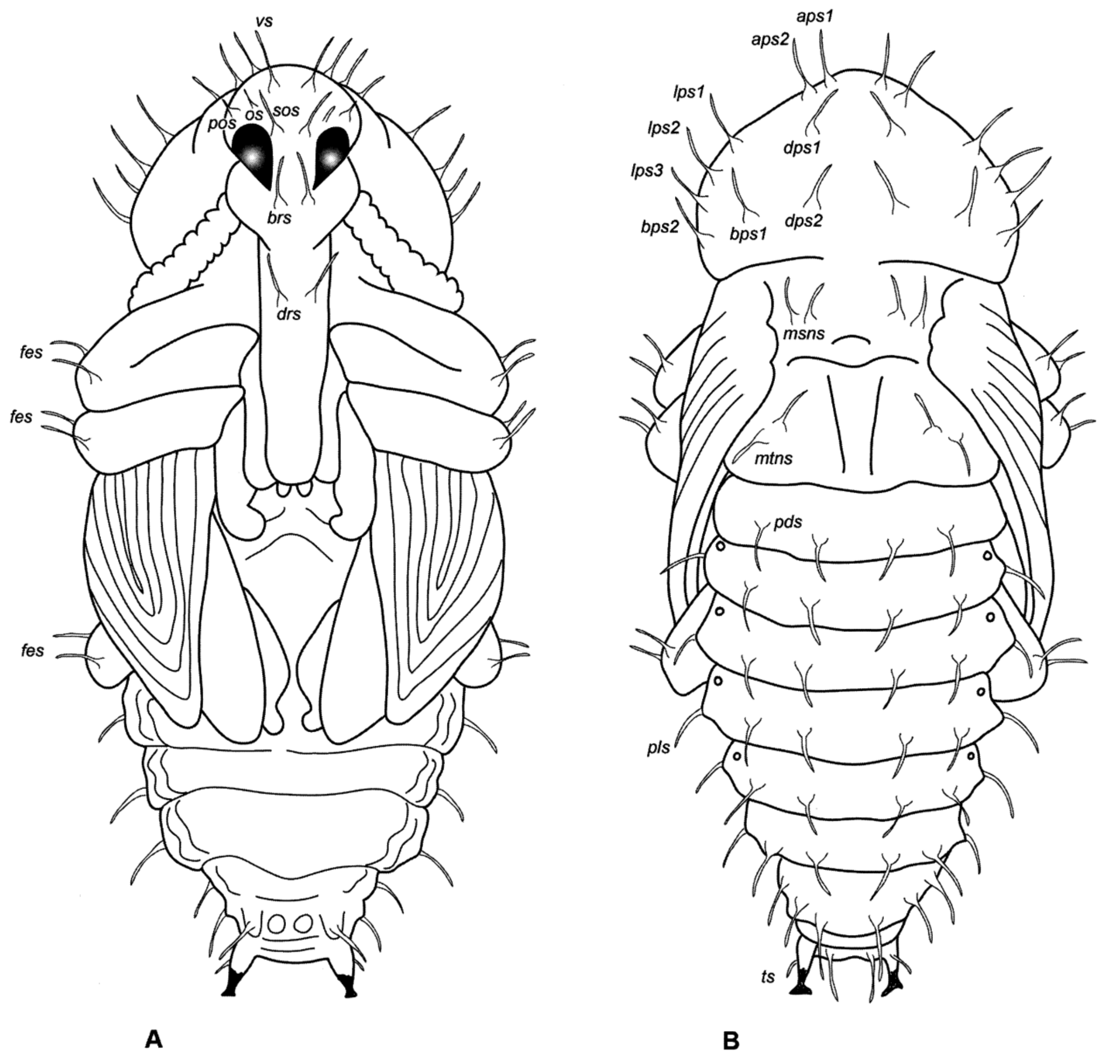


Fig. 3.6 Structure and chaetotaxy of weevil pupa (*Tranes* Schoenherr, Curculionidae) (modified after May 1994). A, ventral view; B, dorsal view (*aps*, apical pronotal seta; *bps*, basal pronotal seta; *brs*; basirostral seta; *dps*, discal pronotal seta; *drs*, distirostral seta; *fes*, femoral seta; *lps*, lateral pronotal seta; *msns*, mesonotal seta; *mtns*, metanotal seta; *os*, orbital seta; *pds*, postdorsal seta; *pos*, postorbital seta; *sos*, supraorbital seta, *pls*, pleural seta; *ts*, tergal seta; *vs*, vertical seta).

Weevil pupae are exarate, with free appendices and distinct body regions (head, thorax, abdomen). The integument is usually creamy white. Setae vary in shape, number and disposition in different taxa. The head is deflexed beneath the prothorax and the rostrum onto the legs.

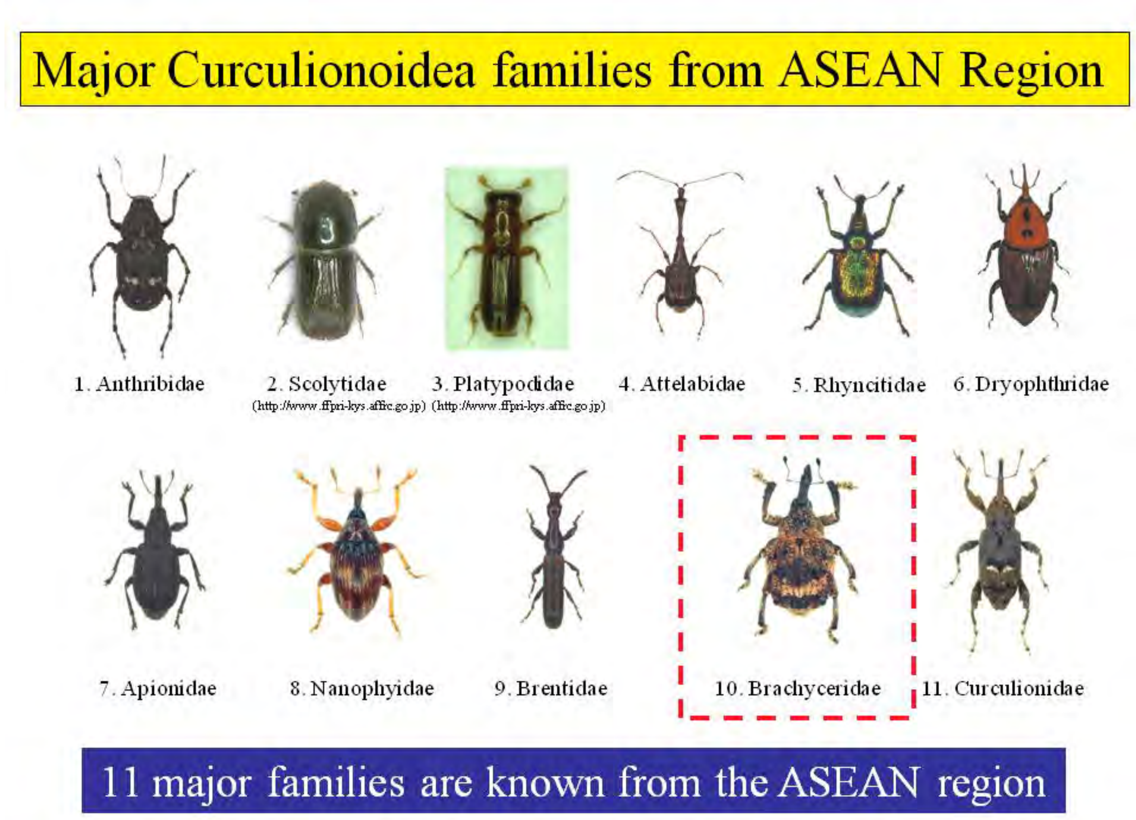
HABITUS IDENTIFICATION OF WEEVILS

2. Identification of specimens using keys

In this training workshop, a key to major families of the superfamily Curculionoidea and a key to major subfamilies of the family Curculionidae mainly from the ASEAN region are provided in order to learn how to sort weevil specimens based on morphological traits.

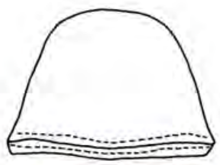
In addition, an illustrated key to *Caulophilus oryzae* (Curculionidae) and *Sitophilus* species (Dryophthridae), all of which are important storage pests, is given in order to learn species identification of weevils practically based on morphological traits.

See **Appendix: Glossary of Weevil Characters** when necessary.



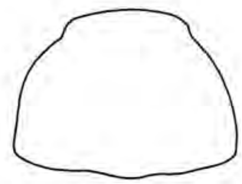
An Illustrated Key to Major Curculionidea Families from the ASEAN Region

Pronotum with a transvers carina basally.



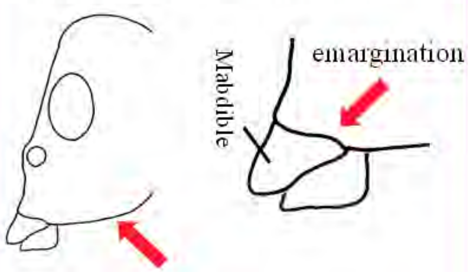
Anthribidae

Pronotum simple basally.



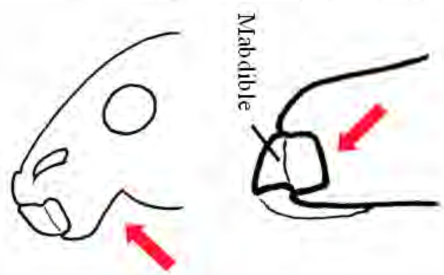
Next

Head without rostrum, shallowlly emarginate on each side at apex.



Next (I)

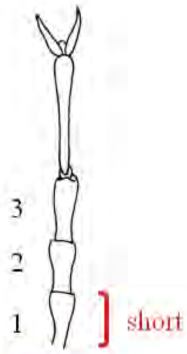
Head with rostrum, deeply emarginate on each side at apex.



Next (II)

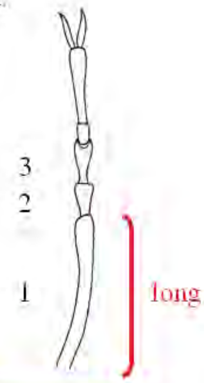
(I)

The first segment of each tarsus shorter than the second and third combined.



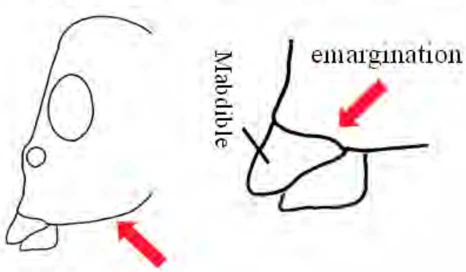
Scolytidae

The first segment of each tarsus longer than the second and third combined.

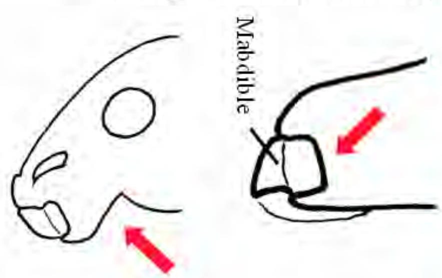


Platypodidae

Head without rostrum, shallowlly emarginate on each side at apex.



Head with rostrum, deeply emarginate on each side at apex.

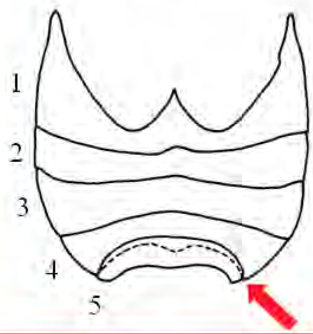


Next (I)

Next (II)

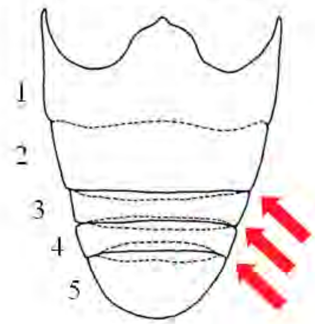
(II)

Ventrite similarly articulate from 1st to 4th.5th ventrite deeply articulate with 4th basally.



Next (III)

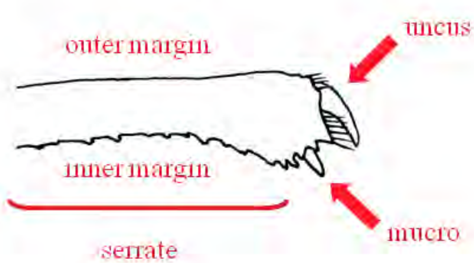
1st and 2nd ventrites fused together. 3rd to 5th deeply and similarly articulate to each other basally.



Next (IV)

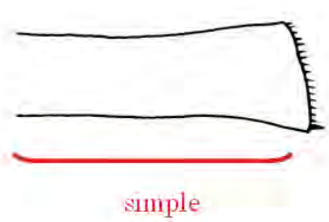
(III)

Tibiae mucronate in both sexes, uncinate in males. Inner margins of fore tibiae serrate.



Attelabidae

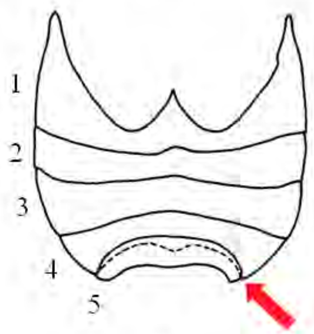
Tibiae simple apically. Inner margins of fore tibiae simple.



Rhynchitidae

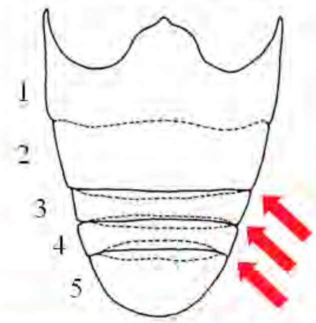
(II)

Ventrite similarly articulate from 1st to 4th.5th ventrite deeply articulate with 4th basally.



Next (III)

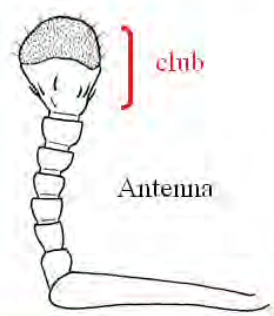
1st and 2nd ventrites fused together 3rd to 5th deeply and similarly articulate to each other basally.



Next (IV)

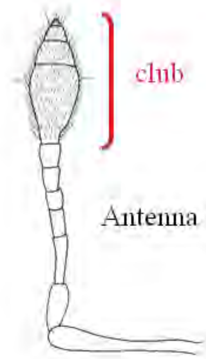
(IV)

The first segment of antennal club smooth, sparsely setiferous.



Dryophthoridae

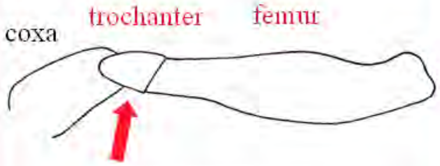
Antennal club entirely pubescent.



Next (V)

(V)

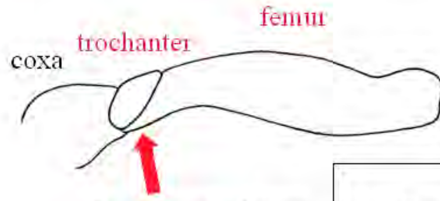
Legs with trochanters elongate, separating femora from coxae distantly.



Leg in ventral view

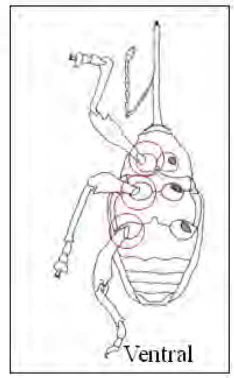
Next (VI)

Legs with trochanters small, allowing femora to approach coxae closely.



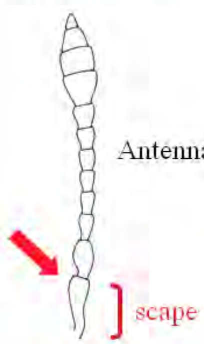
Leg in ventral view

Next (VII)



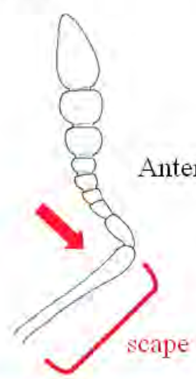
(VI)

Antennae with scape short, orthocerous.



Apionidae

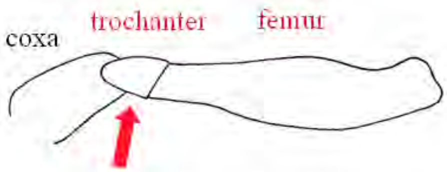
Antennae with scape long, geniculate.



Nanophyidae

(V)

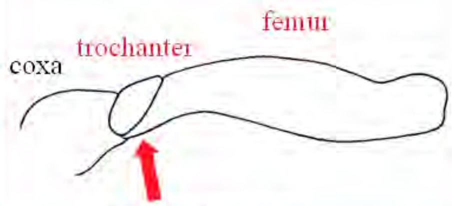
Legs with trochanters elongate, separating femora from coxae distantly.



Leg in ventral view

Next (VI)

Legs with trochanters small, allowing femora to approach coxae closely.

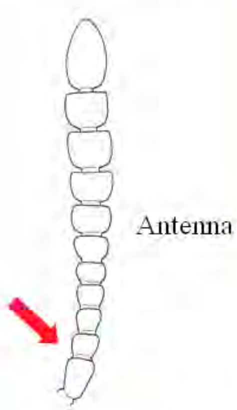


Leg in ventral view

Next (VII)

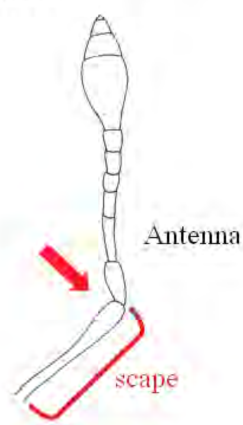
(VII)

Antennae orthocerous.



Brentidae

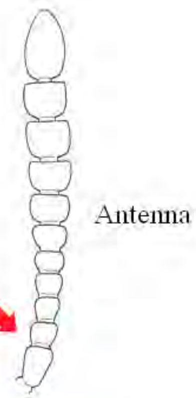
Antennae with scape long, geniculate.



Curculionidae

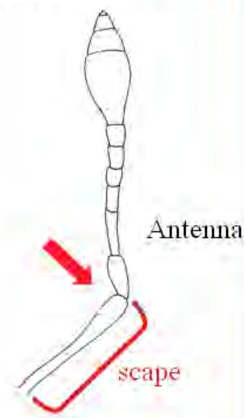
(VII)

Antennae orthocerous.



Brentidae

Antennae with scape long, geniculate.



Curculionidae

Brachyceridae

Desmidophorus crassus

- Distributed mainly in Africa
- Several species from the ASEAN region
- Containing some pests of *Hybiscus*

An Illustrated Key to Major Subfamilies of the Family Curculionidae from the ASEAN region

Hind tibiae mucronate or simple apically, not uncinate

Next

Tibiae uncinate apically on all legs.

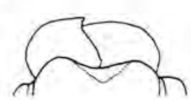
②

Each mandible with a deciduous cusp or its scar on external surface (with a few exceptions)

Rostrum short, flat on dorsum (with a few exceptions)

Entiminae

Mandibles neither with cusp nor its scar.



Rostrum longer, cylindrical in most taxa.

①

Entiminae

Exceptional taxa

Pachyrhynchini
- Mandibles neither with cusp nor its scar.
- Many species from the Philippines

Sitonini
- Mandibles neither with cusp nor its scar.
- Several species from the Philippines

Euphyllobiomorphus
- Rostrum slender, cylindrical
- Known only from the Ryukyus, Japan
- Just great if you find it in the Philippines (possibly in high mountains)

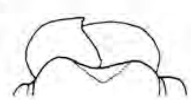
Each mandible with a deciduous cusp or its scar on external surface (with a few exceptions)

scar of deciduous cusp

Rostrum short, flat on dorsum (with a few exceptions)

Entiminae

Mandibles neither with cusp nor its scar.

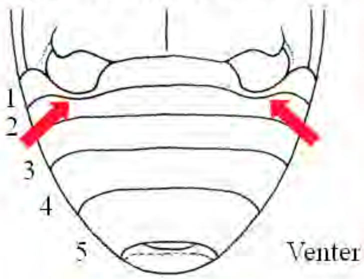


Rostrum longer, cylindrical in most taxa.

①

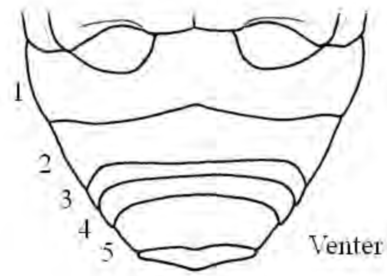
①

1st ventrite strongly narrowed behind hind coxae and nearly subdivided into three parts by coxal cavities



Orobitidinae

1st ventrite normal, not subdivided by coxal cavities



Next

Orobitidinae

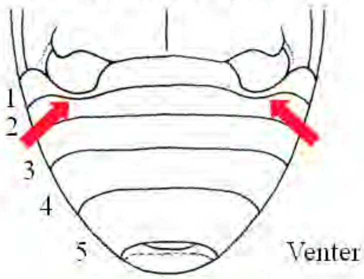
- Only 1 sp. of *Orobitis* is known from East Asia
- Feeding on Violaceae plants
- Just great if you find it in the ASEAN region (possibly in high mountains)

Orobitis species

A larva of *Orobitis* species in a seed capsule of *Viola* sp.

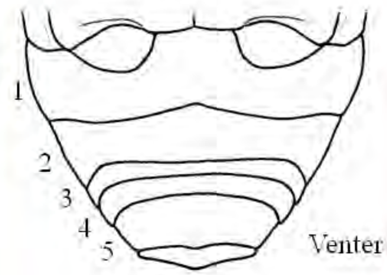
①

1st ventrite strongly narrowed behind hind coxae and nearly subdivided into three parts by coxal cavities



Orobitidinae

1st ventrite normal, not subdivided by coxal cavities



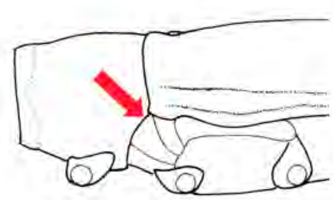
Next

Mesepimera almost as large as mesepisterna, strongly ascended and visible dorsally between bases of pronotum and elytra

Ceutorhynchinae

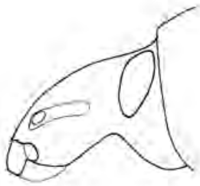
Only a few species have been known from the Philippines, but there are many undescribed species

Mesepimera not ascended, invisible dorsally



Next

Rostrum stout



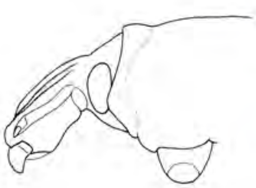
Next

Rostrum more or less slender, cylindrical

Curculioninae

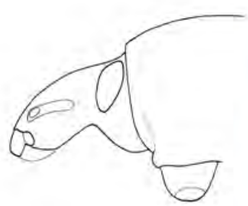
Many species have been known from the Philippines, but there are still many undescribed species

Prothorax with postocular lobes or prosternum deeply concave on anterior margin.



Cyclominae

Prothorax without postocular lobes.



Hyperinae

An Illustrated Key to Major Subfamilies of the Family Curculionidae from the ASEAN region

Hind tibiae mucronate or simple apically, not uncinate

Next

Tibiae uncinate apically on all legs.

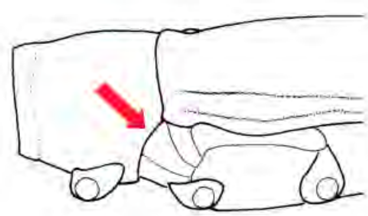
②

②

Mesepimera strongly ascended and visible dorsally between bases of pronotum and elytra

Next

Mesepimera not ascended, invisible dorsally



Next

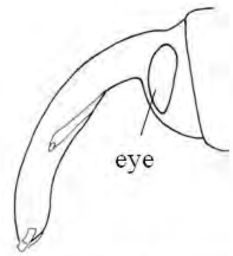
Eyes large, dorsal to dorso-lateral, occupying the major part of forehead

Head in lateral view

Conoderinae

Tibiae uncinate from dorsal corners of apex

Eyes of normal size, lateral or latero-ventral



Head in lateral view

Baridinae

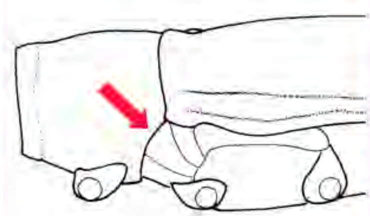
Tibiae uncinate from ventral corners of keeled flange

②

Mesepimera strongly ascended and visible dorsally between bases of pronotum and elytra

Next

Mesepimera not ascended, invisible dorsally

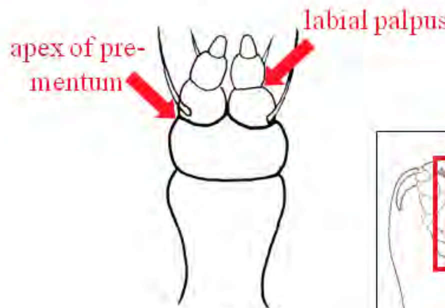


Next

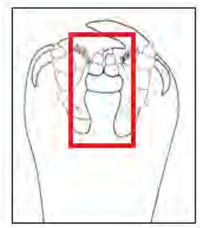
Labial palpi 1- or 2-segmented, rigid, inserted in a holeat latero-ventral corners of prementum behind apex, or often obliterate. Prementum truncte, vertical and thick at apex.

Lixinae

Labial palpi 3-segmented, inserted on Apical margin of prementum, whichi is more or less rounded and not forming a vertical flat surface at apex.



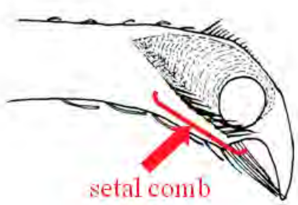
③



Apex of rostrum in ventral view

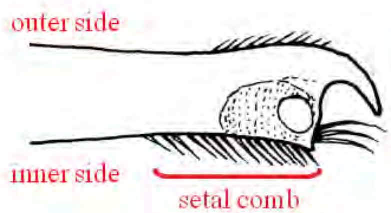
③

Tarsal grooves of fore legs oblique to tibial axis, trouth-like for receiving tarsi when contacted and bordered laterally by setal comb oblique to axis of tibia.



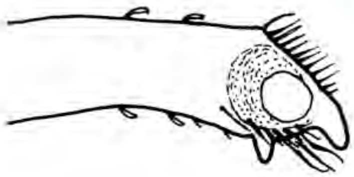
Next

Tarsal grooves of fore legs broadly flattened and bare behind tarsal sockets occupying major exterior surface behind apex. Inner setal comb translocated to ventral margin.



Cossoninae

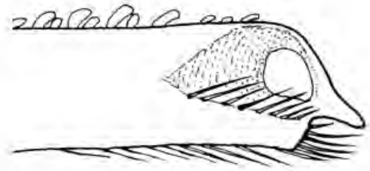
Uncus large, nearly as wide at base as tibia, continuously prolonged from tibial apex. body covered with smooth varnish-like coating over scales.



Bagoinae

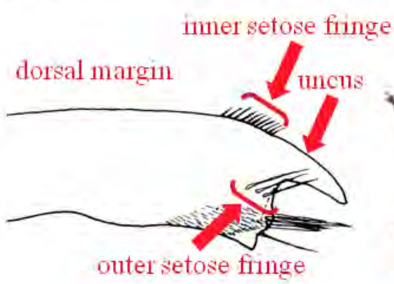
Semi-aquatic weevils

Uncus much narrower at base than tibia.



Next

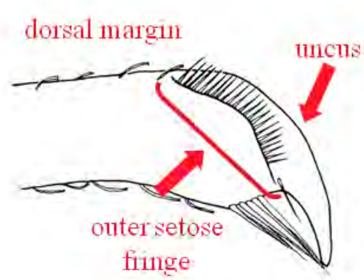
Uncus formed of direct prolongation of acute dorsal edge of tibiae, outer and inner setose fringes short. Body mostly cylindrical.



Mesoptiliinae

On dead or weekend trees, often attracted by light

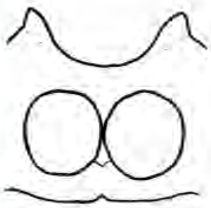
Uncus arising from inner flange of tibial apex.



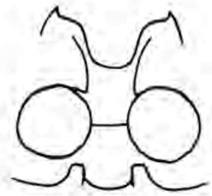
④

④

Fore coxae contiguous



Fore coxae separated by prosternal process



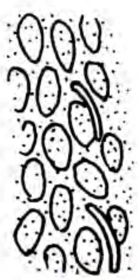
(If contiguous, prosternum canaliculated and slender rostrum with postmedian antennal insertions)

Next (A)

Next (B)

(A)

Body covered mostly with round scales and usually with a varnish-like coating over scales.



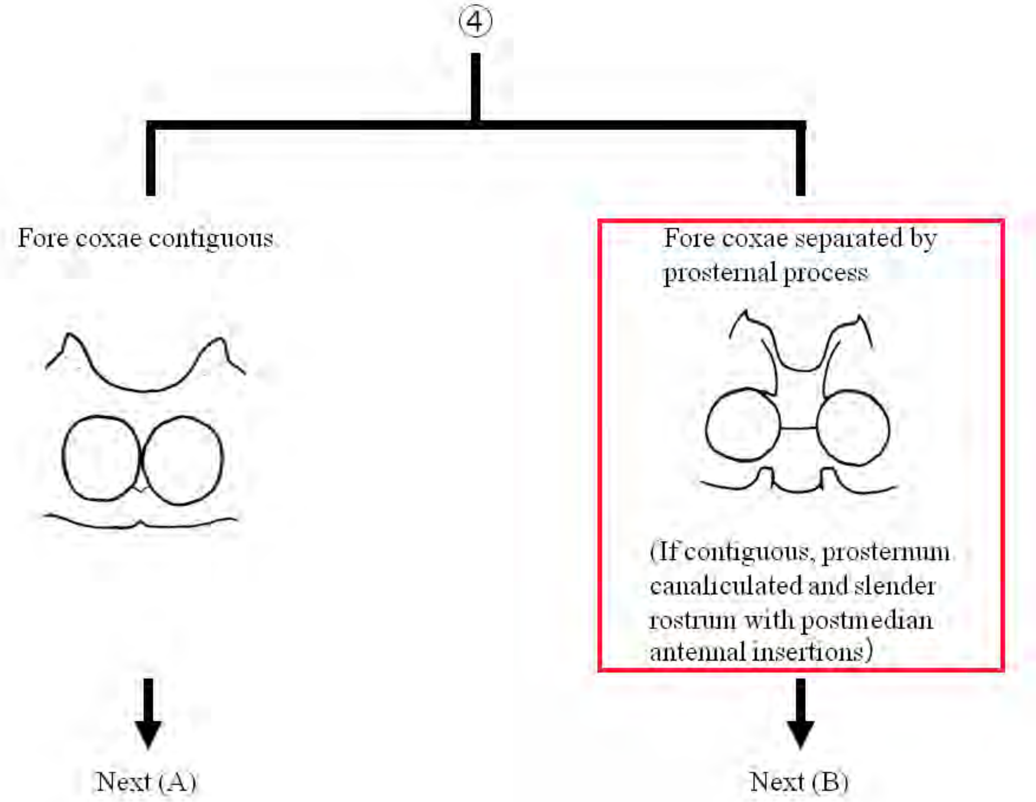
Erirhininae

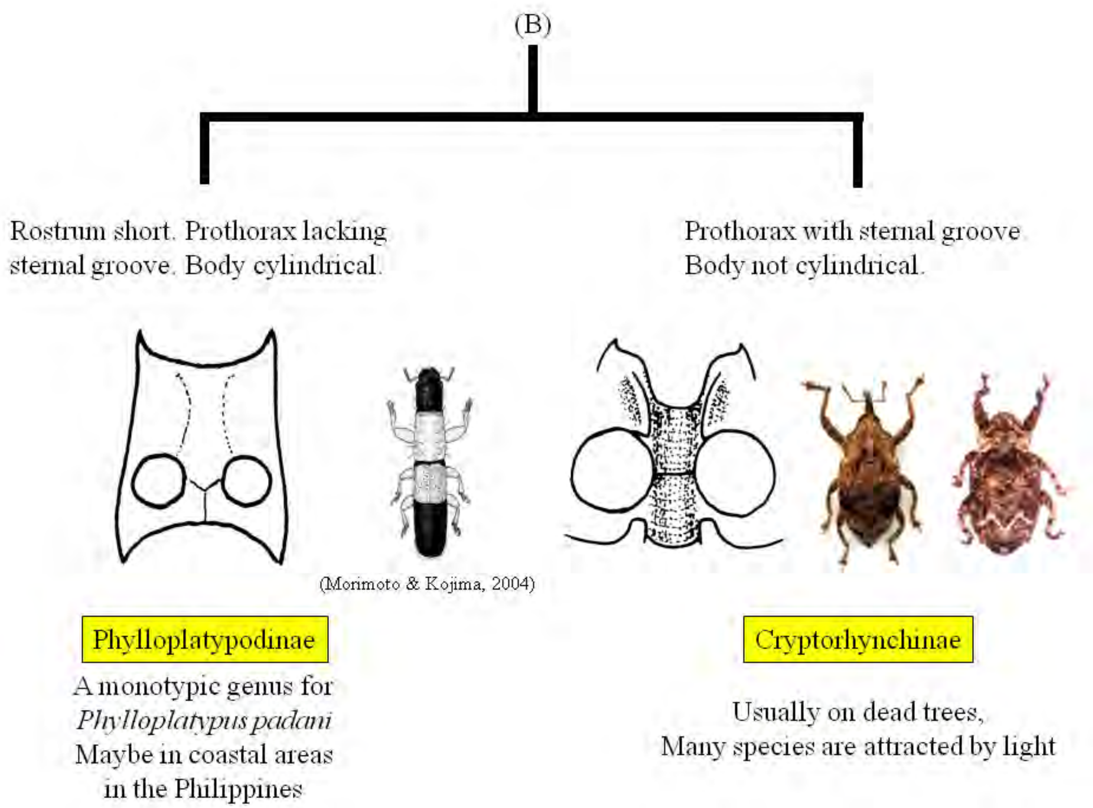
Semi-auatic weevils

Body with or without narrower scales or setae, no coating.

Molytinae

Usually on dead trees,
Many species are attracted by light





An Illustrated Key to Species feeding on Storage seeds
(modified from Yoshida, Watanabe & Sonoda, 1989)

1A Antennal club pubescent at apex (Fig. 1A-a). Antennal funicle six-segmented (Fig. 1A-b). Pygidium exposed. -- 2

1B Antennal club entirely pubescent (Fig. 1B-a). Antennal funicle seven-segmented (Fig. 1B-b). Pygidium not exposed. Body dark to blackish brown, about 3.0 mm in length.-------------------------- ***Caulophilus oryzae*** **(F14-1)**

Central American species which extends to the West Indies and the far south of the USA. Known as the broad-nosed grain weevil, an important pest of storage seeds.

2A Rostrum (Fig. 2A-a) more than twice as long as head, with antennal scrobes which do not touch eyes posteriorly (Fig. 2A-b). ---------------------------- 3

2B Rostrum (Fig. 2B-b) nearly twice as long as head; upper margins of antennal scrobes touching eyes posteriorly. Body dark to blackish brown, 3.0–5.0 mm in length. -------------------------------------- ***Sitophilus linearis*** **(F15-1)**

Pan-tropical. Known as the tamarind weevil, an important pest of tamarind and other Caesalpinioideae.

3A Pronotum with elliptical punctures (Fig. 3A). Elytral striae deep but weakly punctured; each interval nearly as wide as stria. Body entirely dark brown, shiny, 2.5–4.0 mm in length. ------------------------------------ ***Sitophilus granarius*** **(F15-2)**

Subcosmopolitan. Known as the wheat weevil, grain weevil or granary weevil, a serious pest of stored cereal grains.

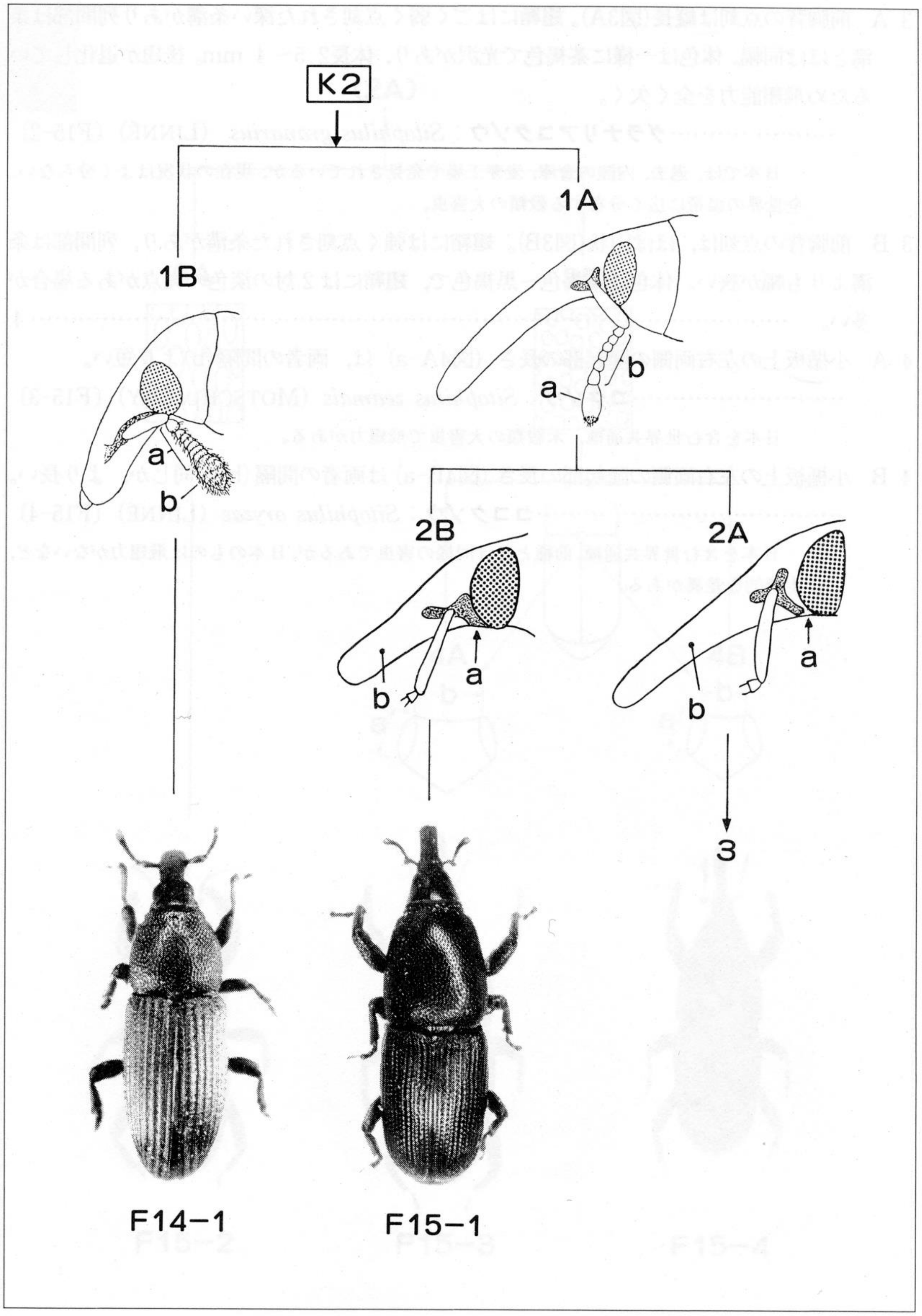
3B Pronotum with subovate punctures (Fig. 3B). Elytra strongly striate-punctured; each interval narrower than stria. Body dark to blackish brown; elytra usually with two pairs of light-colored patches. --------------------------------- 4

4A Scutellum with lateral margin (Fig. A-a) shorter than basal margin (Fig. A-b). -- ***Sitophilus zeamais*** **(F15-3)**

Cosmopolitan. Known as the maize weevil or as the greater rice weevil, an injurious pest of cereal crops.

4 B Scutellum with lateral margin (Fig. B-a) as long as basal margin (Fig. B-b). ----- ***Sitophilus oryzae*** **(F15-4)**

Cosmopolitan. Known as the rice weevil, an injurious stored product pest attacking cereal crops, including wheat, rice, and maize.


K2
1B
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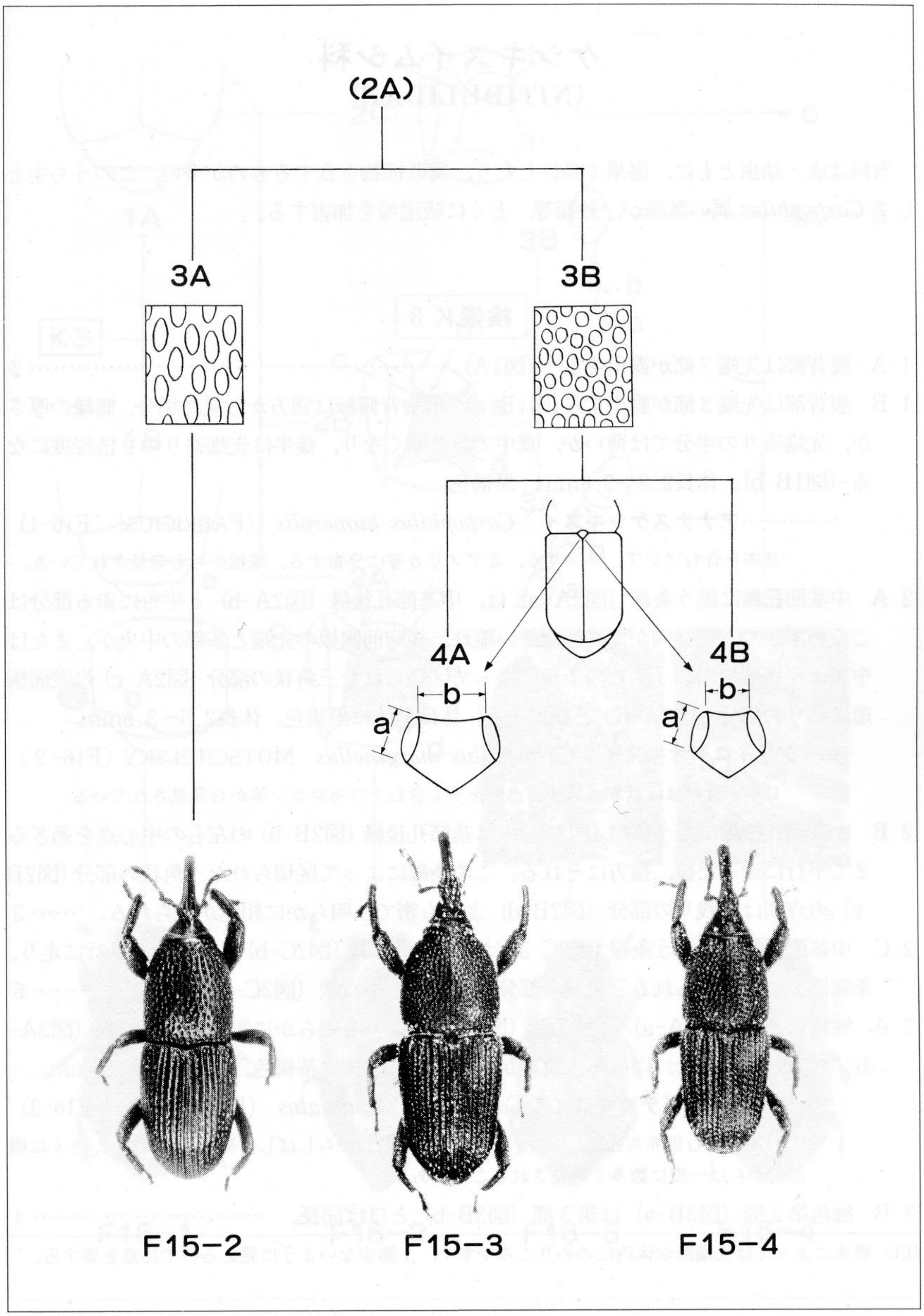
F15−1



HABITUS IDENTIFICATION OF WEEVILS

Appendix: Glossary of Weevil Characters
(http://weevil.info/glossary-weevil-characters)

Accessory glands (female genitalia) – glands associated with the female genitalia, which in at least some cases contain symbiotic organisms. Probably not homologous throughout Curculionoidea, and appear in different forms and attached to different parts of the genitalia. See Kuschel (1987).

Adelognatha (informal group of weevils) - a group of Curculionidae characterised by the adelognathous character state (q.v.), broadly equivalent to the Entiminae sensu Thompson (1992). They are thus also characterised by a short, broad rostrum, the deciduous mandibular process present, larval antennae lacking a projecting apical part; larvae living free in soil. Some Entiminae have phanerognathous mouthparts, however (q.v.). The group has no formal status. See also ‘Phanerognatha’.

Adelognathous (head, mouthparts) – refers to the maxillae being concealed by the prementum. Thompson (1992) notes that in some cases the stipites are visible at the posterior angles of the prementum, and that in fact the degree to which the maxillae are concealed by the prementum is very variable. The contrasting term is ‘Phanerognathous’ (q.v.)

Adelphic – female mating with more than one male – not limited to weevils.

Aedeagal apodemes (male genitalia) – see Penis apodemes

Aedeagus (male genitalia) – Combined structure comprising the tegmen and penis. See also 'pedal' and 'pedotectal' as types of aedeagus.

Aggonoporium (male genitalia) – Term coined by Arzanov (2003) for sclerite or complex of sclerites in the endophallus around the junction with the ductus ejaculatorius. The sclerites may participate in attaching the endophallus to the bursa copulatrix during copulation. See Transfer apparatus.

Airtube (larva) – respiratory appendage (May, 1994)

Annulated – segmented; in rings – sometimes used of antennal club.

Anapleural suture (metathorax) – see metanepisternal suture (preferred term).

Anepisternum (thorax) - anterior sclerite of the peluron, discernable on the mesothorax and metathorax in weevils (mesanepisternum, metanepisternum). Synonym: episternum. (definition changed May 2012)

Anophthalmic (head) – lacking eyes.

Antenna (head) - sensory appendage on either side of the rostrum, comprising 11 articles: scape, 7-segmented funicle and 3-segmented club) (see under ‘Antennal segment’ for discussion of terminology of the antennal ‘segments’). Although sometimes referred to as 12-segmented, this depends on the interpretation of the club components (q.v.) and is apparently a misapprehension. (see states: geniculate antenna, subgeniculate antenna) See also Antennal segment, desmomere, antennomere. (definition changed 1/06/2012)

Antennal article (head) – see Antennal segment (preferred term). (definition changed 23/11/2011)

Antennal club (head) - see under Club.

Antennal insertion (head) – point of attachment of the antenna. Antennal insertions are considered to be exposed when at least some portion of each antennal socket is visible from above the long axis of the rostrum. (After Lawrence, Beutel, Leschen & Slipinski, 2010).

Antennal segment (head, antenna) – individual elements of the antenna. The terms used suffer from a difference in meaning between morphological correctness and in practice. Morphologically the antenna, like other insect antennae, comprises three true 'segments': a scape, pedicel and flagellum. The flagellum may be secondarily subdivided into a number of antennomeres, which are not true segments (in terms of holding muscle insertions). However, the traditional division in weevils is into scape, funicle and club, the funicle comprising the pedicel and up to 6 antennomeres of the flagellum (rarely seven if an antennomere more usually part of the club is separate), and the club a further three flagellum antennomeres. The pedicel is sometimes referred to as the first antennomere or first segment of the funicle. The terms pedicel and flagellum are not used in weevil taxonomy. This provides confusion over terminology, with the different articles being termed segments, antennomeres, desmomeres, joints etc. The elements of the club are rarely termed antennomeres but the term 'clubomere' has been used (not recommended here). The term 'segment' is adopted here for all articles, recognizing the morphological inappropriateness of this. Synonyms: antennal article, antennomere, desmomere (in part), clubomere (in part), joint. (definition changed 1/06/2012).

Antennomere (head, antenna) – see Antennal segment (preferred term).The issues surrounding the use of this and other terms for the structure are discussed under 'Antennal segment' above. (definition changed 01/06/2012).

Anterior tentorial pit (head) – the invagination of the head capsule corresponding to the position of the anterior arms of the tentorium inside the head. The Anterior Tentorial Pits lie at the anterior end of the subgenal sulcus in weevils, near the mandibular articulation (Lyal, 1995).

Apical membranous lobe (male genitalia) – unsclerotised posteriorly-directed extensions of parameroid lobes on tegmen (Wanat, 2007).

Apical setal comb (leg, tibia) – row of strong setae around the apex of the tibia and projecting distad. There is often a gap dorsally between the comb on the posterior and anterior faces, to allow the tarsus to be reflexed. The anterior comb may extend along the dorsal face of the tibia (e.g. some Molytinae), in which case it is termed 'ascending'. (Thompson, 1992). See also 'secondary comb', 'corbel'. Synonyms: distal comb, tibial comb, setose fringe, fringing setae.

Apodeme - chitinous ingrown of the exoskeleton to which muscles are attached; rod-like projection from any of several structures (e.g. penis, tegmen).

Apodemes of penis (male genitalia) – see Penis apodemes.

Apodeme of tegmen (male genitalia) – See Tegminal apodeme

Appendiculate claw (leg, tarsus) - See Tarsal Claw.

Apterous – lacking wings

Baculum (pl – baculi) (female genitalia) – Sclerotised bars or struts which serve to support a membranous ovipositor.

Basal arms (of spiculum gastrale) (male genitalia) – the posterior fork of the spiculum gastrale, on which various muscles attach. Synonym; furcal arms.

Basal piece (male genitalia) – see Tegminal ring (sometimes also tegminal apodeme).

Basal pocket (elytra, submarginal fold) - the region of the sublarginal fold that diverges away from the outer wall of the elytra to form a more or less deep pocket to accommodate the pleurite of the basal ventrites and the metathoracic lateral sclerites. See also 'Submarginal fold'.

Basal sclerites (male genitalia) – paired (usually) sclerites lying near the junction of the endophallus with the ductus ejaculatorius. Of variable form. See Transfer apparatus.

Basisternum (thorax) - the anterior part of each sternum, meeting the sternellum posteriorly. Sometimes used incorrectly for the sternellum (q.v.) on the prothorax, but can be distinguished from this because the sternellum lies between and behind the coxae, whilst the basisternum is before the fore coxae.

Beak see rostrum (preferred term).

Bevel (leg, tibia) – see discussion under Corbel

Bifid claw (leg, tarsus) see "Tarsal Claw"

Buccal cavity (head, mouthparts) – mouth cavity

Bursa (female genitalia) – large closed membranous lobe of female genitalia branching from vagina generally at same point as common oviduct and spermathecal duct. Synonyms: bursa copulatrix; copulatory pouch; vaginal bursa. [emended June 2012]

Bursa copulatrix (female genitalia) – see Bursa

Bursal sclerite (female genitalia) – sclerite lying in the vaginal and bursal floor around the junction with the common oviduct and spermathecal duct.

Cap-piece (male genitalia) – see Parameroid plate.

Cardo (head, mouthparts) – basal piece of the maxilla

Cervical sclerites (head) - small trapezoidal triangular sclerite or pair of sclerites at the posterior end of the gular suture(s) (Lyal, 1995). Synonym: postgula.

Claw (leg, tarsus) - see 'Tarsal claw" (preferred term).

Club (head, antenna) - the apical antennal segments. The club generally has three segments (see under ‘Antennal segment’ for discussion of terminology of the antennal ‘segments’), either separate as in some basal groups or combined as in most Curculionoidea. In many weevils there appear to be 4 club segments, each delimited by a suture and each bearing a ring of elongate setae. However, the form of the groove between the apical 'segment' and the others differs from that between the true antennomeres (Wanat, 2001). The apparent 4-segmented club has been termed 'pseudotetramerous' by Wanat, 2001. The elements may be termed ‘club segments’, ‘club antennomeres’ or ‘antennomeres of the club’, the first of these being least clumsy (although inaccurate); the term ‘clubomere’ has also been used but is linguistically dubious. Key character states: loose: articulation between segments and segment 'neck' visible; compact: articulation and basal constrictions not seen, but borders between segments clearly visible; connate: borders or sutures between segments partly or completely lost. (Wanat, 2001) Synonym: Antennal club. (definition changed 1/06/2012)

Clubomeres (head, antennal club) – the antennomeres that make up the club of the antenna. – see Antennal segment (preferred term). (definition changed 23/11/2011)

Collar (prothorax) – anterior of prothorax when delimited, at least laterally, by a groove or simply an angle, from the rest of the prothorax to enclose the base of the head capsule; often developed into postocular lobes.

Collum (female genitalia, spermatheca) – the part of the spermatheca to which the spermathecal duct is connected (see duct lobe). [Emended June 2015].

Common oviduct (female genitalia) – see median oviduct.

Complex apparatus (male genitalia, endophallus) – see transfer apparatus.

Connate - of two segments or other articulating parts of the body. Not freely moving against one another. There may or may not be a line between them marking the original suture. (emended June 2012)

Copulatory pouch (female genitalia) – see Bursa.

Corbel (leg, tibial apex) – area at apex of tibia defined by setal combs and tibial ridges. The terminology has been and continues to be confused, and relevant terms are summarised here to facilitate understanding. Thompson (1992) recommends the term ‘corbel’ be abandoned in favour of ‘outer bevel’ (q.v.) and ‘inner flange’ (q.v.), an argument based partially on an argument on Latin derivation of the term, since challenged by Oberprieler (in press). Synonyms: Körbichen, corbulae,

Apical setal comb - ring of stout setae around the tibial apex directed distad (q.v.). Anterior and posterior sides of the ring may not be joined, and ring may be incomplete.

Bevel – a slanted area between the tibial apex and the anterior face of the tibia. An ambiguous term.

Inner flange – anterior / distal margin of the tibial socket when raised into a carina or ridge. It may be raised only near the tibial insertion or extend from dorsal to ventral margins of the tibia; it lacks setae. Often it is associated with the uncus, which may have the flange as its base. It can occur on all three tibiae (Thompson, 1992)

Open corbel - apex of tibia with apical setal comb (anterior and posterior) but no secondary comb and no inner flange. The space delimited by the inner flange and the anterior aical setal comb lacks setae or scales. Synonym: simple [tibial apex]; [tibial apex] without corbel.

Enclosed corbel: see True corbel

False Corbel - tibial apex with inner flange raised distal to setal comb (Thompson, 1992). Synonym: Semi-enclosed corbel.

True corbel – more or less flat or concave area at an angle between the tibial apex and the anterior face of the (particularly hind) tibia, demarcated distally by the anterior apical setal comb and proximally by a secondary setal comb (closed or enclosed corbel) or lacking a proximal setal row. The surface may be lacking scales or with scales. Synonym: outer bevel.

Cornu (female genitalia, spermatheca) – the apical, generally curved, more or less acuminate part of the spermatheca.

Coxite (female genitalia) - see Gonocoxite (preferred term)

Coxite-stylus (female genitalia) - term applied to the structure where the stylus and gonocoxite are believed to have fused. Coined by Howden (1992) in discussion of eyeless weevils in the Nearctic and Neotropics. Synonym: vaginal palp.

Deciduous mandibular process (head, mandible) – horn- or blade-like processes on the mandibles of Entiminae some Brachycerinae that almost always fall off in early adult life, leaving a distinct scar. The deciduous process may sit on a pedicel, which is present after the process has fallen off. See extended discussion in Thompson, 1992. Synonyms: pupal mandibles, mandibular appendages, mandibular cusp, deciduous pieces, false mandibles, provisional mandibles, Supplementzähne.

Declivity (elytra) – the posterior part of the elytra that slopes ventrad.Synonym: elytral declivity.

Desmomere (antenna, funicle) – the pedicel and antennomeres that make up the funicle of the antenna (Alonso-Zarazaga, 1989) – see discussion under Antennal segment (preferred term). Synonyms: antennomere, funicle segments, antennal segment. (definition changed 1/06/2012)

Disc (thorax, pronotum) – dorsal portion of the pronotum.

Discrimen (thorax, metathorax) - Median longitudinal depressed line sometimes present on the metaventrite, corresponding with a median ridge internally representing the invagination of the true metasternum. The ridge is usually connected with the metendosternite. May also be visible on the mesoventrite.

Dorsal Adventitious Tooth (leg, tibia) - tooth on apex of tibia dorsally in addition to uncus.

Dorsal Apical Projection (leg, tibia) - dorsal projection on hind tibia lying at the basal end of the apical setal comb when this is ascending.

Dorsal plate (male genitalia) – see Parameroid plate.

Duct-lobe (female genitalia, spermatheca) – the part of the spermatheca from which the spermathecal duct arises. Sometimes extended into a lobe or a tube. Synonym: collum.

Ductus ejaculatorius (male genitalia) – duct between the testes and endophallus. Synonym: ejaculatory duct.

Ejaculatory duct (male genitalia) – see Ductus ejaculatorius.

Elbowed antenna – see geniculate antenna

Elytral declivity see declivity.

Elytral file – see file.

Elytral strigil – see file.

Elytral stria (pl - Elytral striae) (elytra) – longitudinal groove or row of punctures along elytra. There are usually 10, with striae III and VIII often joining posteriorly. The first stria is the one closest to the sutural margin of the elytron. Synonyms: stria.

Elytral submarginal fold (Elytra) – the projecting longitudinal ridge on the ventral surface of the elytra near the costal margin. In the basal third it may be more or less strongly curved away from the elytron inner surface, this character having been used for the Baridiidae of Zherikhin & Egorov (1990). The fold is likely to function in locking the elytron to the abdomen and metathorax, the fold width and depth basally being related to the size of the metepisternite. Discussed by Davis (2009). Synonyms: epipleural fold, inferolateral flange.

Elytral sutural flange (elytra) - flange on the sutural margin of each elytron ventral to the margin itself. The flange on the right hand elytron fits in the groove between the dorsal surface of the left hand elytron and the flange below it. The margin of the left-hand elytron is wider than that of the right-hand elytron in 'higher' weevils, but about the same in 'lower' weevils. In higher weevils the extension of the flange allows for elytral locking when closed. In cases where the elytra are 'fused' the 'fusion' may be due to the flanges being curled around each other and thus immovable.

Elytro-tergal stridulation system (elytra and abdomen) – the organ responsible for sound production in many higher weevils. It comprises a file – a closely-set patch of parallel ridges on the inner surface of the elytra near the apex or along the sutural margin, and a plectrum – usually a patch or row of tubercles or a single tubercle each side of the mid-line on abdominal tergite 7. The plectrum may be a ridge or pair of ridges in some taxa. In Ithyporina and some Cryptorhynchina the female has the file on tergite 7, derived from the wing-binding patch. The organization of the tubercles and the shape and position of the file can provide useful characters. (Lyal & King, 1996).

Emarginate – notched at the margin. May be used to indicate a concave (in plan) part of a margin.

Enclosed corbel (leg, tibia) – see discussion under corbel.

Endophallus (male genitalia) – membranous sac lying within penis contiguous with ductus ejaculatorius and penis. Sometimes armed with a variety of sclerites (see Transfer apparatus). Everts during copulation. Arzanov (2003) recognized and named a number of lobes of the endophallus. Synonym: internal sac.

Epimeron (thorax) – posterior sclerite of the pleuron discernable on the mesothorax and metathorax in weevils (mesepimeron, metepimeron)

Epipleural bridge (prothorax) – see Hypomeral lobe (preferred term)

Epipleural fold - see elytral submarginal fold (preferred term)

Epipleuron (thorax, elytra) – the inflexed portion of the elytron laterally when the elytra are closed (Torre-Bueno, 1989).

Episternum (thorax) – see Anepisternum (preferred term)

Epistome (head, mouth) – sclerite immediately posterior to the labrum; since the labrum is lost / fused to the clypeus in most adult weevils other than Nemonychidae and Anthribidae the epistome is often used to discuss the sclerite immediately above the buccal cavity without having to decide if it is clypeus or clypeus + labrum fused. It may be fairly clearly demarcated from the dorsal part of the rostrum lying posterior to it (part of the frons) by colour and a ridge or depression (epistomal ridge and epistomal suture respectively) or a transverse row of setae. Laterally there may be a depression (termed the paraclypeal depression by Morimoto & Kojima, 2003), which often has a small tuft of setae (termed the paraclypeal setae by Morimoto & Kojima, 2003). Synonyms: epistoma, clypeus.

Eye-flaps see postocular lobes (preferred term).

False spiculum (male genitalia) – see Spiculum relictum (preferred term)

False strut (male genitalia) – see Spiculum relictum (preferred term)

Fenestrae (male genitalia) – unsclerotised area of the parameroid plate (q.v.) bounded by sclerites (see suprafenestral sclerite and subfenestral sclerite). Homology across Curculionoidea is unlikely. (see Wanat, 2007).

Fifth tarsomere (leg, tarsus) - the distal tarsomere, bearing the tarsal claws. Synonyms: unguitractor, onychium.

File (elytra – elytro-tergal stridulation system) – patch of fine, parallel ridges on the internal surface of the elytra, generally near the apex, which form part of the elytro-tergal stridulation system. Synonyms: elytral file, elytral strigil, pars stridens, stridulatory rasp, stridulatory file.

First connecting membrane (male genitalia) - see Post-tegminal membrane. The First connecting membrane of Clark (1977) is the Pre-tegminal membrane.

Flagellum (male genitalia) – long tubular sclerite sometimes present within the endophallus with the gonopore at its apex. In some cases (more rarely) the flagellum is one or a pair of rods within the ejaculatory duct but outside the endophallus. The two structures are not homologous. See also 'Transfer apparatus'. See Wanat, 2007.

Forceps (male terminalia) – externally-visible processes from 8th sternite in the amycterine Phalidura (Thompson, 1992).

Frena (male genitalia, endophallus) – paired sclerites in endophallus, situated sub-basally when endophallus everted, comma-shaped or hook-shaped. Kuschel (1995) suggested their presence is a plesiomorphic character state in Curculionoidea. (Wanat, 2001, 2007).

Frons (head, head capsule) – The area dorsally on the head anterior to the antennal insertions and posterior to the epistoma, where visible. The term is sometimes used for the area between the eyes, which might better be termed 'forehead'. (Davis 2011) suggested in Sitophilus that it extends ventrally and surrounds the scrobe. See discussion under head. [Emended June 2015]

Funicle (head, antenna) - the middle part of the antenna, lying between the scape and the club, comprising the pedicel and up to 6 'desmomeres' (antennomeres) ('pedicel' and 'flagellum' are terms rarely if ever used in weevil taxonomy).

Furcal arms (male genitalia) – see basal arms (of spiculum gastrale).

Furcasternum - see Sternellum (preferred term).

Gena (head) – the part of the head capsule on each side below the eye, bordered dorsally by the frontal suture, posteriorly by the occipital suture, ventrally by the subgenal suture. See also Head.

Geniculate antenna (head, antenna) - the state in higher weevils where the pedicel (basal segment of the funicle) inserts subapically on the scape, causing the funicle to be held at an angle to the scape. cf. subgeniculate antenna. Synonym: elbowed antenna.

Genital chamber (male genitalia) – see Genital pocket

Genital pocket (male genitalia) – membranous invagination between tergum VIII and sternum VIII and to which the spiculum gastrale is attached. It includes both genital opening and rectum. Wanat (2007) considers the pocket to extend from SVII, since SVIII is withdrawn dorsal to SVII at rest. Wanat also places the anterior end of the genital pocket at the base of the apodemes of the penis. Synonyms: genital chamber, genital sheath of Wanat 2007. [Emended June 2015]

Genital sheath (male genitalia) – see Genital pocket

Genital spiculum (female genitalia) - see Spiculum ventrale

Genital tract (female genitalia) – the vagina and bursa.

Gland-lobe (female genitalia, spermatheca) - see discussion under Spermatheca (ramus)

Gonatoceri (informal group term) – name applied to a grade of Curculionoidea with a geniculate antenna and male genitalia lacking a separate tectum (q.v.), broadly equivalent to the Curculionidae of Thompson (1992) which are characterised by this state. See also Gonatocerous, Orthocerous, Orthoceri, Heteroceri.

Gonatocerous (antenna) – see geniculate (preferred term). Term now also used to describe a group of weevils (see below) and as a ‘shorthand’ to describe typical character states (e.g. ‘gonatocerous genitalia’).

Gonatocerous (male genitalia) – see pedal genitalia (preferred term).

Gonocoxite (female genitalia) – one of a pair of conical sclerites apically on ovipositor, associated with segment IX and between which the female vulva opens. See also 'coxite-stylus'. Synonyms: hemisternite, coxite. May be proximal and distal elements – see Lanteri & del Rio, 2008

Gonopore (female genitalia) – the opening of the common oviduct into the vagina.

Gonopore (male genitalia) – the opening through which the sperm are transferred to the female genitalia on eversion of the endophallus. This may simply be the junction of the ductus ejaculatorius with the endophallus, at the tip of the flagellum, where present. Synonym: phallotreme.

Gula (head, head capsule) - the sclerite lying between the gular sutures, where these are separate (Lyal, 1995)

Gular cavity (head) – see mouth cavity.

Gular suture (head, head capsule – rostrum) - suture or pair of sutures extending from the posterior margin of the head capsule to the posterior tentorial pit(s). The sutures are often fused to a single suture in weevils. (Lyal, 1995)

Head (adult) – The head of the adult weevil has a more or less bulbous head capsule (q.v.) which accommodates the muscles of the mouthparts, and a variably elongate rostrum (q.v.) bearing the antennae and mouthparts and through which the tendons of the mandibles and maxillae pass. The various sclerites of the head are fused together and, particularly dorsally, sutures obscured; there are few reliable landmarks. Dorsal structures: The Vertex is the posterior part of the head, extending from the occiput to the level of the antennal insertions. Behind the eyes this may be called the Temple, between the eyes the Forehead, and between the anterior margins of the eyes and the level of the antennal insertions it may be called the Epifrons. Anterior to the epifrons the Frons may be separated by a groove, or the junction between the two simply be marked by some longer setae, at least laterally; the frons itself may lack setae or scales. Anterior to the frons the Epistome may be slightly lower or at a different angle to the frons, and may be fringed by a sparse row of setae posteriorly. The epistome and frons may be united as a distinct Nasal plate (=nasal plaque, plaga).

Lateral and Ventral structures: The ventral structures were discussed extensively by (Lyal 1995). See also Gena, Gula, Gular suture, Cervical sclerites, Hypostoma, Interocular pit, Submentum, Venter

Head capsule (head, adult) – the head apart from the rostrum. See more detailed discussion under Head.

Hemisternites (female genitalia) – see Gonocoxite (preferred term).

Hemisternite (male terminalia) – one of a pair of sclerites on sternum VIII

Heteroceri (informal group term) – name applied to a grade of Curculionoidea characterised by possession of geniculate antennae (q.v.) and orthocerous genitalia (q.v.). Comprises Dryophthoridae, Erirhinidae, Nanophyidae, Brachyceridae. See also Gonatoceri, Orthoceri.

Horn sheath (prothorax) – simple or bifurcate tube-like invagination between prothroacic horns of some Baridinae and Conderinae. (Davis, 2009). Synonym: sheath.

Humeral angle – see humerus

Humeral callus (mesothorax, elytra) – projection on humerus; may be used as simply another term for humerus.

Humerus (mesothorax, elytra) – anterolateral angle of elytron, sometimes produced. Tends to be rounded in apterous species. If there is a projection some authors term this a 'humeral callus' or a 'humeral umbone' (for a knob-like projection). Synonyms: humeral angle, humeral callus.

Hypomeral lobe (prothorax) - the sclerotised area behind the procoxae formed from pleural (hypomeral) projections, meeting in the midline and abutting anteriorly medially on the sternellum. Synonyms: pleural process; post-coxal bridge; post-coxal process; epipleural bridge; hypomeron.

Hypomeron - see Hypomeral lobe (preferred term).

Hypostoma (head) – ventral part of the head bearing the posterior articulation of the mandible (postcoila). In most weevils (not Scolytinae, Platypodinae) the hypostoma projects anteriad as a hypostomal process (q.v.)

Hypostomal process (head) – Anteriad process of the hypostoma bearing the lower (posterior) mandible articulation and thus projecting below the mandible and partially enclosing the pleurostomal sinus (q.v.). Synonyms: hypostomal tooth, postgenal arm

Hypostomal sinus (head) – The notch between the hypostoma (q.v.) and the labium, in which the maxillae can be seen. (Morimoto & Kojima, 2003). [Emended June 2015]

Hypostomal sulcus (head, rostrum) – part of subgenal sulcus posterior to the posterior mandibular articulation.

Hypostomal tooth – see hypostomal process.

Inferolateral flange (elytra) - see elytral submarginal fold (preferred term)

Inner flange (leg, tibia) – anterior / distal margin of the tibial socket when raised into a carina or ridge. It may be raised only near the tibial insertion or extend from dorsal to ventral margins of the tibia; it lacks setae. Often it is associated with the uncus, which may have the flange as its base. It can occur on all three tibiae (Thompson, 1992). See discussion on the Corbel. [emended June 2015]

Integument - exoskeleton, particularly outer covering of entire insect.

Intercoxal process (abdomen) – portion of ventrite 1 extending anteriad between hind coxae.

Intercoxal process (prothorax) – posterior extension of prothoracic sternum (basisternum) between fore coxae, meeting the sternellum if coxae sufficiently separated.

Interocular pit (head) – abrupt depression on dorsum of head, generally between eyes but sometimes more distally placed on the rostrum. This marks the junction of the dorsal tentorial arms with the head capsule (Davis 2011).

Internal sac (male genitalia) – see endophallus (preferred term).

Interstice see Interstria (preferred term).

Interstria (elytra) – raised longitudinal strip on elytra between striae. The interstria nearest the sutural margin is interstria I (Lawrence & Britton, 1991). Some authors (e.g. Vanin & Reichardt, 1976) numbered the interstriae in a different way, for example the first being called the sutural interval, the second as interstice I, the third as interstice II, and so on (Vanin, 2008). Synonyms: interval, interstice.

Interval see Interstria (preferred term)

Introse - with teeth on the apical margin of the mandible and the mandibles not opening beyond the lateral margins of the rostrum.

Joints of funicle see antennal segment.

Labium (head, mouthparts) – plesiomorphically in Coeloptera the labium comprises a tripartite prementum (bearing the labial palps), mentum and submentum. Curculionoidea have a prementum but the mentum and submentum are not visible as separate sclerites. The single sclerite may be known as the Postmentum (e.g. (Morimoto and Kojima 2003) or the submentum (e.g. Lyal, 1955). Davis (2011) refers to the projecting portion of this sclerite supporting the prementum as the postmentum and the region between this and the posterior tentorial pits as the submentum; earlier authors termed this projecting part the peduncle.

Labral rods (larva, mouthparts) see tormae (preferred term)

Lateral lobes (male genitalia) – see parameroid lobes.

Latero-ventral sulci (head, rostrum) - (Wanat, 2001)

Lenticular – lens-shaped

Ligula (head, mouthparts) –lobe of the labium, projecting anteriad of the mentum. Plesiomorphically this comprises the glossae and paraglossae, although as Crowson (1981) states these are absent in beetles the homology of the structure is unknown. [Emended June 2015]

Ligula (male genitalia) – see Ostiolar sclerite.

Mandibles (head, mouthparts) - In various forms across the suborder. Terms used may include: Extrose - with teeth on the external face, the mandibles rotating away from the midline and opening away from the midline of the rostrum and not meeting apically. Introse: Teeth on the anterior/interior face, meeting when mandibles closed (the more common situation). Plurisetose: numerous setae, often of similar length on the outside face of the mandible. Paucisetose: only a few setae present on the mandible. [emended June 2015]

Mandibular cusp (head, mouthparts) – see Deciduous mandibular process

Mandibular scar (head, mouthparts) – circular or oval scar left on mandible after loss of the deciduous mandibular process (q.v.).

Manubrium (male genitalia) – See Tegminal apodeme.

Median lobe – see Penis (peferred term)

Median Lobe Apodemes (male genitalia) – see Penis Apodemes (preferred term).

Median notch (male genitalia) – term applied to gap between parameroid lobes (Wanat, 2007)

Median oviduct (female genitalia) – the ectodermal oviduct opening into the bursa-vagina complex, often near the spermathecal duct. Sinonym: common oviduct.

Median struts (male genitalia) - see Penis Apodemes (preferred term).

Mentum (head) – middle plate of the labium, not visible as a separate plate in adult Curculionoidea.

Mesanepisternum (thorax, mesothorax) – anterior pleural sclerite of the mesothorax. Synonym: Mesepisternum. (definition changed June 2012).

Mesendosternite (thorax) - A pair of internal apodemes formed by invaginations within the mesocoxal cavities, probably homologous with the furca.

Mesepimeron (thorax, mesothorax) - Posterior pleural sclerite of the mesothorax.

Mesepisternum (thorax, mesothorax) – see Mesanepisternum (preferred term)

Mesonotum (thorax, mesothorax) – the dorsal sclerite of the mesothorax.

Mesorostrum (head, rostrum) - the section of the rostrum widened above the antennal insertion. If the broadening is absent, the term refers to the level of the antennal insertion. (Wanat, 2001). Purely a descriptive term lacking any mophological significance.

Mesosternal canal see Mesoventral canal.

Mesoventral canal (mesothorax) – channel on the mesosternum to receive the rostrum when the head is rotated down and the rostrum lies along the ventral surface of the thorax. Found in some groups currently within the Cryptorhynchinae and Molytinae. (cf mesoventral receptacle). Synonyms: mesosternal channel; mesosternal canal. [Emended June 2015]

Mesosternal channel see Mesoventral canal.

Mesosternal cup see Mesoventral receptacle.

Mesosternum see mesoventrite.

Mesothoracic receptacle see Mesoventral receptacle.

Mesoventral receptacle (thorax, Mesoventrite) – cup-shaped depression of the mesothorax that accepts the tip of the rostrum if this is bent between the front legs. It may be in the form of a full cup with lateral walls and a posterior wall, or with lateral walls only. Not homologous across Curculionoidea, although often used as an apomorphy for

Cryptorhynchinae. Synonyms: mesosternal cup; mesothoracic cup; mesothoracic receptacle; pectoral receptacle. [Emended June 2015]

Mesoventrite (thorax, mesothorax) - ventral sclerite lying in front of and between mesocoxal cavities, comprised of the fused preepisternum and basisternum (according to Wanat, 2001) or preepisterna and katepisterna (according to Lawrence et al, 2010). Generally referred to as the mesosternum in weevil taxonomic literature but the true mesosternum is invaginated. Synonym: Mesosternum.

Metanepisternal suture (metathorax) - suture between metaventrite and metepisternum. In cross-section metaventral part of suture is cup-shaped, holding the metepisternum and allowing it to flex during flight. In some higher weevils sclerolepidia are present along the suture, arising from the metaventrite. The suture may be lost in flightless weevils. (Lyal et al., 2006). Synonyms: anapleural suture, metepisternal suture, metathoracic pleurosternal suture.(term changed March 2012).

Metanepisternum (metathorax) – anterior pleural sclerite of the metathorax, lying laterad to the metaventrite and mesoventrad to the metepimeron. Often partially and sometimes completely hidden by elytra. Synonym: metepisternum. [Emended June 2015].

Metanotum (thorax, metathorax) – the dorsal sclerite of the metathorax.

Metarostrum (head, rostrum) - basal part of rostrum, from base to widening above antennal insertion (Wanat, 2001). Purely a descriptive term lacking any mophological significance.

Metasternal canal (metathorax) - see Metaventral canal

Metasternum see metaventrite.

Metathoracic pleurosternal suture see metanepisternal suture.

Metaventral canal (metathorax) - channel on the metasternum to receive the rostrum when the head is rotated down and the rostrum lies along the ventral surface of the thorax. Found in Aedemonini and Sophrorhinini. Synonym: metasternal canal. [Emended June 2015]

Metaventrite (thorax) - ventral sclerite lying behind and between mesocoxal cavities, comprised of the fused preepisterna and katepisterna (Lawrence et al, 2010). Generally referred to as the mesosternum in weevil literature but the true mesosternum is invaginated along the midline (see Discrimen). Synonym: metasternum.

Metendosternite (metathorax) – internal sclerite of the metathorax. It usually consists of a median stalk, two short to long lateral ‘furcal arms’ and a ‘longitudinal flange’ anterior to and between the arms from which a pair of tendons arise. There are often phylogenetically-important characters associated with this.

Metepimeron (thorax) – Posterior pleural sclerite of the metathorax, positioned laterad of and above the metanepisternum and mostly or completely concealed by the elytra. It may be fused to the metanpisternum.

Metepisternal suture see Metanepisternal suture (preferred term).

Metepisternum see Metanepisternum (preferred term)

Mouth cavity (head) – opening at the front of the head accommodating the mandibles, maxilla and labium. Synonyms; Buccal cavity, gular cavity.

Mucro (pl - mucrones) (leg, tibia) – tooth-like process on the inner (ventral) apical angle of the tibia, but not linked to the inner flange (q.v.). Proposed by Thompson (1992) to be homologous with the uncus (q.v.) following fusion with the inner flange. See also 'pre-mucro'. In many Apionidae and Nanophyidae it is present in males but not females. (Emended December 2012)

Mycangium (pl - mycangia) – structures on the body used for the transport of symbiotic fungi. Found in a number of weevils, particularly Scolytinae, and have clearly evolved more than once.

Nasal plaque – see Nasal plate.

Nasal plate (head) – plate formed from the fused frons and epistome, where demarcated. See discussion under head. Synonyms: nasal plaque, plaga.

Nodulus (female genitalia, spermatheca) – the basal part of the spermatheca, between the cornu, ramus and collum. [Emended June 2015]

Noto-sternal suture (prothorax) – suture, often obscured, between the notal and sternal components of the prothorax, extending anteriorly from the fore coxae externally. Synonym: pleuro-sternal suture.

Ocular lobe (prothorax) – see postocular lobe (preferred term).

Onychium – see fifth tarsomere

Open corbel (leg, tibia) – see discussion under Corbel

Orthoceri (informal group term) – name applied to a grade of Curculionoidea with Orthocerous antennae (q.v.) and male genitalia of the plesiomorphic 'orthocerous' type (q.v.). These are the basal weevils on the generally-accepted cladograms. See also Heteroceri, Gonatoceri.

Orthocerous (antenna) – straight, lacking an 'elbow' between the scape and funicle. cf 'geniculate antenna'.

Orthocerous genitalia (male genitalia) – see pedotectal genitalia (preferred term)

Ostiolar sclerites (male genitalia) – pair of sclerites on dorsal wall of penis adjacent to ostium. Synonym: ligula.

Ostium (male genitalia) – opening of penis through which the endophallus everts.

Outer bevel (leg, tibia) – The slope on the anterior face of the tibia between the anterior apical margin (as defined by the anterior apical setal comb) and the unmodified anterior face, delimited by a transverse swelling or ridge just basal to the tibial apex bearing with a secondary setal comb. Almost always on the hind tibia only (Entiminae, Brachycerinae). See discussion on the Corbel.

Ovipositor (female genitalia) – the organ by which the eggs are laid, including gonocoxites, styli and vulva. (changed June 2012).

Pappolepida (scales) – scales which divide multiple times at apex to give them a velvety or feathery appearance (Brown, 2015 (PhD); George et al, 2015)

Paracoila (head, mouthparts) – pouch for receiving the cardo of the maxilla near the base of the hypostomal sinus (Morimoto & Kojima, 2003).

Parameres see parameroid lobes (preferred term).

Parameral lobes (male genitalia) – see parameroid lobes.

Parameroid lobes (male genitalia) - lobes attached to the posterodorsal part of the tegminal ring. May have posteriad unsclerotised extensions termed 'apical membranous lobes'. The parameroid lobes are not unequivocally homologous with the parameres of other Coleoptera, hence the difference in terminology. See also parameroid plate. Synonyms: parameres, parameral lobes.

Parameroid plate (male genitalia) - dorsal section of tegmen extending posteriorly. Generally comprising the parameroid lobes or a single lobe, sometimes with additional sclerites or showing membranous areas surrounded by sclerite. It is a two-layered structure, and sometimes has different sclerites on the dorsal and ventral layers. The parameroid lobes are not unequivocally homologous with the parameres of other Coleoptera, hence the difference in terminology. See parameroid lobes, fenestrae, suprafenestral sclerites, subfenestral sclerites, prostegium. Synonyms: dorsal plate, tegminal plate, cap-piece.

Pars stridens see File.

Pectoral canal see Rostral canal

Pectoral receptacle - see Mesothoracic receptacle

Pedal genitalia (male genitalia) - the state found in majority of 'Gonatoceri', where the tectum (q.v.) is not visible, the penis body and its apodemes describe two separate curves when viewed laterally and are articulated with each other, the tegmen has two more or less distinct parameroid lobes. Compare with 'pedotectal genitalia' (q.v.). Synonym: gonatocerous genitalia.

Pedicel (head, antenna) - second of the three segments of the basic insect antenna (the other two being the scape and flagellum). 'Pedicel' and 'flagellum' are terms rarely if ever used in weevil taxonomy.

Pedon (male genitalia) – ventral plate of penis. See also pedotectal genitalia and tectum.

Pedotectal genitalia (male genitalia) – term describing the type of penis found in basal 'orthocerous' weevils. The dorsal and ventral plates of the penis body ('tectum' and 'pedon' respectively are separate for most of their length, united by a membrane, and fused at the base (c.f. tectum not visible), the apodemes and the penis body describe a smooth curve in profile (cf a double curve). The parameroid lobes are more or less fused together (cf separate). Synonym: orthocerous genitalia.

Peduncle (head) – the part of the submentum (q.v.) projecting between the maxillae and bearing the prementum (q.v.). See discussion under labium.

Penis (male genitalia) – the part of the male genitalia comprising the unpaired intromittent organ with its apodemes, and containing the eversable endophallus and the opening of the ductus ejaculatorius (gonopore). It is enclosed by the tegmen. The 'body' and apodemes (= temones, aedeagal apodemes) are sometimes compared in length as a taxonomic character. Synonyms: median lobe; 'aedeagus' of some authors, including Wanat 2007.

Penis apodemes (male genitalia) – a pair of apodemes extending anteriorly from the base of the penis. In more detail: invaginations of the post-tegminal membrane (first connecting membrane) lying anterior to the penis body, and generally connected to it by sclerotization. The apices of the apodemes support a pair of longitudinal muscles arising dorsolaterally on the tegminal ring and a pair arising on the apex of the tegminal apodeme; these serve as protractors of the penis (Burke, 1959, Cerezke, 1964), and possibly also retractors (Cerezke, 1964). Synonyms: aedeagal apodemes, median lobe apodemes, median struts, temones (in some cases the term 'temones' is applied to tegminal apodemes). [emended September 2015]

Penis body (male genitalia) – the part of the penis not including the apodemes.

Pennon (male genitalia) – fine filamentous sclerotized process within the genital pocket, fringing semi-permanent folds (visible when stained with chlorazol black). (Wanat, 2001, 2007).

Phallobase (male genitalia) – Anterior or basal part of the aedeagus from which the parameroid lobes or parameroid plate arise. See Tegmen.

Phallotreme (male genitalia) – see Gonopore. Sometimes applied to ostium, incorrectly.

Phanerognatha (informal group of weevils) – Curculionidae characterised by the phanerognathous (qv) character state, often also known as 'long-nosed' weevils, and also characterised broadly by a long slender rostrum; the mandibles lack a deciduous process, the larval antenna has a more or less conical and projecting apex, and the larvae are concealed within plants. The group is not monophyletic, and has no formal status. See also 'Adelognatha'.

Phanerognathous (head, mouthparts) – maxillae not covered by the prementum. (cf 'adelognathous mouthparts'. Characteristic of the 'Phanerognatha' (qv).

Plaga – see Nasal plate.

Plectral tubercles (abdomen, tergite VII) – two or more raised tubercles on tergite VII, each with a small seta posteriorly, that act against the stridulatory file in the elytro-tergal stridulatory system (q.v.) (Lyal & King, 1996)

Pleural process - see Hypomeral lobe (preferred term).

Pleuro-sternal suture (prothorax) – see Noto-sternal suture

Pleurostomal sinus (head) – emargination of buccal cavity margin between precoila and postcoila to accommodate the base of the mandible and allow it to rotate outside the margins of the rostrum. Shallow in Attelabidae, Scolytinae and Platypodinae, deeper in other weevils (Morimoto & Kojima, 2003).

Pleurostomal sulcus (head, rostrum) – part of subgenal sulcus dorsal to the mandible.

Postcolia (head) – the socket for the ventral (posterior) articulation of the mandibles (postartis), born on the hypostoma (q.v.). (Morimoto & Kojima, 2003) [Emended June 2015]

Post-coxal bridge - see Hypomeral lobe (preferred term).

Post-coxal lamellae (prothorax) – blade-like projections behind for-coxae, extending between coxa and posterior margin of prothorax, as a part of the sternal canal for the rostrum. Apomorphic for Curculionidae: Cryptorhynchinae: Aedemonini, and also for Aonychus (Erirhinini). Similar structures, anteriorly abutting the coxa and posteriorly meeting medially are found in the Camptorhinini (currently in the Cryptorhynchinae but being transferred to the Molytinae, and itself polyphyletic). Synonyms: post-coxal flanges, post-coxal walls of the pectoral canal.

Post-coxal process (prothorax) – see Hypomeral lobe (preferred term).

Posterior declivity (elytra) – distal part of elytra where, at rest, sutural margin curves ventrad towards lateral margin.

Posterior tentorial pit (head) – invaginations of the cuticle on the ventral surface of the head corresponding to the positions of the posterior tentorial arms internally. The pits mark the junction of the gular suture and the subgenal suture. They may be very difficult to see in weevils, and may be fused to a single pit or extend effectively along a single gular suture. See Lyal (1995) for a discussion.

Postgenal arm (head) – see hypostomal process.

Postgula (head) – see cervical sclerites (preferred term).

Postmentum (head) – see submentum (preferred term). Davis (2011) limits the postmentum to the projecting part of the labium supporting the prementum (peduncle, q.v.), terming the posterior part the submentum. See discussion under labium q.v. [Emended June 2015]

Postocular lobe (prothorax) – lobulate projection on the anterior margin of the pronotum, lying just behind the eye and covering it when the head is rotated ventrad. Often fringed with setae, probably having as an eye-cleaning function. Synonyms: ocular lobe; eye-flap. [Emended June 2015]

Post-tegminal membrane (male genitalia) – membrane between tegmen and base of penis (Wanat, 2007). Synonym: first connecting membrane.

Praemucro (leg) - see Premucro (preferred term)

Precoila (head, mouthparts) – the socket for the dorsal (anterior) articulation of the mandibles (preartis), born on the clypeus. The clypeus in weevils is not separated from the frons by a suture, so cannot be distinguished.

Pregula (head) – see Submentum

Prementum (head, mouthparts) – the anterior plate of the mentum, bearing the palpi. See discussion under Labium.

Premucro / pre-mucro (leg, tibia) – small preapical tooth arising ventrally (occasionally distally) at apex of tibia (Kuschel, 1951, Thompson, 1992), basal to mucro/uncus. It can co-exist with a mucro or uncus (i.e. is homologous with neither). It is marked by a paired tuft of long curved setae arising either side of its base and curving more or less over it. In some groups (e.g. many Lixinae, some Molytinae) it is more strongly-developed in females than males, and may be absent or very small in the latter. Synonyms: praemucro, pre-mucro, secondary mucro. (Emended December 2012)

Pretarsus (leg) – terminal segment of the leg, consisting of paired or, more rarely, single claws. See Tarsal Claw. (definition changed June 2012).

Pre-tegminal membrane (male genitalia) – membrane between 9th segment and the tegmen in males (Wanat, 2001, 2007) Synonym: second connecting membrane.

Pronotum (thorax, prothorax) – the dorsal sclerite of the prothorax.

Prorostrum (head, rostrum) - the part of the rostrum from the anterior end of the mesosrostrum (broadening above the antennal insertion) to the apex of the rostrum (Wanat, 2001). Purely a descriptive term lacking any mophological significance.

Prostegium (male genitalia) – sclerite in ventral layer of parameroid plate to which the arms between the tegminal apodeme and the parameroid lobes attach. Present on ‘orthocerous’ weevils and forming part of tegminal ring in more derived groups. (Wanat, 2007; Kuschel, 1989). Synonym: supra-annular sclerite.

Prosternal canal (prothorax) – channel on the prosternum (basisternum and sternellum) to receive the rostrum when the head is rotated down and the rostrum lies along the ventral surface of the thorax. It may extend between the separated coxae onto the sternellum or stop at the fore coxae, thus lying along the basisternum only. See also Rostral canal.

Prosternal process (prothorax) – the part of the prosternum lying between the fore coxae (if these are separated) and extending to the hind margin of the prosternum unless interrupted by the hypomeral lobes. Comprising an anterior basisternum and a posterior sternellum which, if they meet, are separated by the sternacostal suture.

Prosternum (prothorax) – the sternal element of the prothorax, comprising an anterior basisternum and a posterior sternellum which are either separated by contiguous procixae or, if they meet, are separated by the sternacostal suture.

Prothoracic horns (prothorax) – pair of short or long projections generally arising just anterior to fore coxae in some Baridinae and Conoderinae, used by males in fighting.

Proventriculus (alimentary canal) – posterior part of the foregut comprising eight longitudinal folds, variously sclerotised in some groups. See Kissinger, 1963 and Calder, 1989

Proximal comb (leg, tibia) – see secondary comb.

Pterygium (head, rostrum) - One of the two lateral expansions on the rostrum lying above and partly concealing the scrobes in which the antennae are concealed.

Pygidium (abdomen) – One or more of the apical abdominal tergites which are exposed by the elytra at rest and are more highly sclerotised and strengthened than the other tergites. Thompson (1992) uses a 'tergal formula' (TF) in which tergites concealed by the elytra are given in normal type '1-6', those forming the pygidium in bold type '**7**' and those concealed in the genital chamber in parentheses '(8)'.

Ramus (female genitalia, spermatheca) – the part of the spermatheca to which the spermathecal gland is attached. See Gland-lobe. [Emended June 2015]

Rectal loop – oblique sclerotized band surrounding the rectum, functioning as part of the cryptonephridial system (Lyal & Favreau, 2015)

Rectal ring – transverse sclerotized ring surrounding the rectum, functioning as part of the cryptonephridial system (Lyal & Favreau, 2015)

Rectal valve – sclerotized ring or loop surrounding the rectum, functioning as part of the cryptonephridial system (Lyal & Favreau, 2015)

Rostral canal (thorax) - channel on the thoracic sterna and ventrites to receive the rostrum when the head is rotated down and the rostrum lies along the ventral surface of the thorax. On the prothorax it is generally delimited by longitudinal carinae, probably marking the pleuro-sternal suture. Synonym: pectoral canal, rostral furrow, prosternal canal. [Emended July 2015]

Rostral furrow see Rostral canal (preferred term).

Rostrum (head) – the anterior part of the head, bearing the mouthparts, extended into a tube in most weevils, but may be short or absent (e.g. Scolytinae). See more detailed discussion under Head. Wanat (2001) considers the rostrum as comprising a 'Metarostrum' (q.v.), 'Mesorostrum' (q.v.) and 'Prorostrum' (q.v.) (base, middle and distal) but these terms are purely descriptive and do not relate strictly to morphological homologies. Synonyms: beak, snout. [Emended June 2015]

Scape (head, antenna) – the basal segment of the antenna.

Sclerolepidia (metathorax) – specialized scales arising from metaventrite along the metanepisternal suture (Lyal & King, 1996) (Emended June 2015)

Scrobe (head, rostrum) - The linear depression extending generally from the antennal insertion towards the head capsule (although sometimes deflected ventrad and occasionally with an anteriad element) into which the antennal scape fits when withdrawn against the rostrum. If shallow they are sometimes termed 'open'. [Emended June 2015]

Scutellar shield (mesothorax) – the part of the mesoscutellum which is exposed between the bases of the elytra. In most weevil literature this is just referred to as 'scutellum' (q.v.). Synonym: scutellum (in part).

Scutellum (mesothorax) – Posterior part of mesotergum. The term is often used to refer only to the portion of the scutellum that is visible between the bases of the elytra (see 'Scutellar shield'). Appropriate terminology is 'visible' vs 'concealed', not 'present' vs 'absent'.

Second connecting membrane (male genitalia) – see Pretegminal membrane.

Secondary mucro – see premucro.

Secondary (tibial) comb (leg, tibia) – row of stout setae subapically on dorsal surface of the tibia just basal to the apical comb. It may join the apical comb to produce the 'corbel' (q.v.)

Sheath – see Horn Sheath.

Spermatheca (female genitalia) – Sac-like structure, usually sclerotised in weevils, attached by the Spermathecal Duct to the genital tract and with a Spermathecal Gland. The spermatheca may be considered as having several different areas: Gland-lobe (= ramus) from which the Spermathecal Gland arises; Duct-lobe (= collum), where the Spermathecal Duct attaches, nodulus (basal part of the spermatheca on which the gland-lobe and duct-lobe arise, cornu, the apical often curved and acuminate part. A spermathecal compressor muscle may extend between the cornu and nodulus.[Emended January 2016]

Spermathecal duct (female genitalia) - duct between the Spermatheca and the Genital Tract, usually meeting it at the junction between the Common Oviduct and the Bursa. Variation in the position of this attachment can be useful systematically.

Spermathecal Gland (female genitalia) – gland attached to the spermatheca. After maceration the gland is largely lost, but the sac-like lumen of the gland remains, and is usually termed the 'spermathecal gland' in taxonomic descriptions.

Spicule plates (male genitalia) – sclerites in the second connecting membrane of the genital pocket adjacent to the base of the spiculum gastrale. In at least some cases likely to be homologous to the basal plate of the spiculum gastrale, although do not always have muscle attachments (see (Clark 1977))

Spiculum gastrale (male genitalia) – Internal apodeme of male sternite IX. Comprises a long apodeme (or manubrium) and a posterior sclerotized plate or pair of arms (basal arms). Very variable through Curculionoidea. The basal arms are fused to the genital pocket. Although derived from Sternite IX, it may not be wholly homologous with that sternite. Synonyms: urosternite, sternite IX. (edited 25/11/2011).

Spiculum relictum (male terminalia) - small pouch or apodeme sometimes invaginated between hemisternites on male sternum VIII (Thompson, 1992). Possibly serially homologous with the apodeme of sternum IX. Synonyms: false strut, false spiculum.

Spiculum ventrale (female terminalia) – internal apodeme of sternum VIII. Comprises a pair of basal arms, sometimes united to form a basal plate, and an apodeme, sometimes subsumed by the basal arms to give a V-shaped or U-shaped structure. Erbey et al (2010) termed the apodeme the 'genital spiculum'. Synonym: genital spiculum. (modified June 2012)

Spinasternum (prosternum) see Sternellum.

Sternacostal suture (thorax) – suture between basisternum and sternellum. (Davis, 2009)

Sternellum (thorax) - the second sclerite of the ventral part of each thoracic segment. In weevils it is generally distinct on the prothorax, forming for example the posterior part of the canal in Cryptorhynchinae and a small clear sclerite just behind and between the fore coxae in most others. On the mesothorax it is rarely if ever distinct, but would lie between the mid coxae. On the metathorax it is small and lies between the hind coxae, if discernible. Wood (2007-14), after Hopkins, 1909) figures the sternellum for each thoracic segment. The sclerite on the prothorax has also been called the 'furcasternum' and 'spinasternum'; homologising sclerites in this complex area is difficult. See the discussion on Characters and character-states: "Sternellum or Prosternal process" for further information and a terminological issue. Synonyms: 'furcasternum', 'spinasternum'.

Sternite IX (male genitalia) – see spiculum gastrale

Sternite VIII (female genitalia) – see spiculum ventrale

Striae – see elytral striae.

Stridulatory File – see file.

Stridulatory rasp – see file

Stylus (female genitalia) - a distal segment borne by the Gonocoxite (q.v.) in most species. Generally bears setae, and rarely 'lost' or fused to the Gonocoxite (see 'coxite-stylus').

Subfenestral sclerites (male genitalia) – sclerotised transverse sclerite adjacent to parameriod lobe anterior to an unsclerotsed area (fenestrae (q.v.) of the parameroid plate (q.v.). Homology across Curculionoidea is unlikely. (see Wanat, 2007).

Subgenal sulcus (head, rostrum) – sulcus on the ventral surface of the adult weevil head running between the anterior tentorial pits to the posterior tentorial pits. Synonyms: subgenal suture; pleurostomal sulcus + hypostomal sulcus.

Subgenal suture (head, rostrum) – see Subgenal sulcus (preferred term).

Subgeniculate antenna – state in some Apionidae where the apical part of the scape is sharply curved, causing the funicle to lie at an angle to the long axis of the scape, giving the impression of the geniculate state (q.v.) (Wanat, 2001)

Submarginal fold (elytra) – longitudinal furrow and carina internally on elytron close to costal margin, widening basally. The deeper wider "Basal pocket" of the fold fits over the raised sides of ventrite 1 + 2, and the metepisternite, the posterior part locks over the other abdominal ventrites. The particularly broad basal part has been used as a character of the Baridinae + Conoderinae + Ceutorhychinae.

Submentum (head, rostrum) – the posterior plate of the labium, posteriorly meeting the gula at the level of the posterior tentorial pits (q.v.) and anteriorly meeting the prementum. Within the Curculionoidea there is no separate mentum (median plate of the labium) but the submentum cannot be unequivocally synonymised with the submentum of other Coleoptera (where the mentum is present) or the more plesiomorphic postmentum of other insects. Davis (2011) distinguishes a postmentum (the anteriorly projecting part of the fused mentum + submentum) and the submentum, which lies between that and the posterior tentorial pits. Discussed by Lyal (1995), Morimoto & Kojima (2003) and Davis (2011). See discussion under Labium. Synonyms: postmentum; pregula.

Supra-annular sclerite (male genitalia) – see Prostegium.

Suprafenestral sclerites (male genitalia) – sclerotised transverse sclerite adjacent to parameriod lobe posterior to an unsclerotsed area (fenestrae (q.v.) of the parameroid plate (q.v.). Homology across Curculionoidea is unlikely. (see Wanat, 2007).

Tarsal groove (leg, tibia) – furrow on the apico-ventral surface to receive the tarsus if folded back along the leg.

Tarsal Claw (leg, tarsus) - paired claws at the apex of the tarsus. They may be simple (more or less gradually tapering from base to apex and lacking teeth or other projections), appendiculate (with a ventral tooth or other projection arising in the basal third, often arising from a process apparently splitting off from the claw, and sometimes directed between the claws), toothed or bifid (with the apex 'doubled' - split from the middle of the claw or nearer the apex to provide two teeth for each claw, one generally shorter than the other). Synonym: pretarsus.

Tarsomere (leg, tarsus) - the individual portion of a tarsus. There are five tarsomeres in the weevil tarsus, although the fourth is very small and often hidden between the lobes of the third, hence the description 'pseudotetramerous'. The only exception is the Raymondionymidae, where there are four tarsomeres only. See also fifth tarsomere; the fifth tarsomere is sometimes termed the onychium, although as this term is sometimes also used for the claws themselves, it is best avoided. Synonym: tarsal segment. [Emended June 2015]

Tectum (male genitalia) – dorsal plate of penis, when present. See also pedon and pedotectal genitalia.

Tegmen (male genitalia) - Anterior or basal part of the aedeagus, comprising a more or less complex ring or sheath surrounding the aedeagus (q.v.), a ventral apodeme directed anteriad (see 'apodeme of tegmen') and dorsal parameroid lobes (q.v.) or parameroid plate (q.v.). The shape of the tegmen, and particularly of the parameroid lobes / plate differs between the pedal and pedotectal type of aedeagus. Synonym: phallobase (in part). (emended June 2012)

Tegmenal (in conjunction with ring, apodeme etc) - see Tegminal.

Tegminal apodeme (male genitalia) - apodeme extending anteriad from base of tegmen ventrally. Wanat (2007) refers to the ‘basal piece’ as comprising the apodeme and arms curving round the side of the aedeagus and meeting a dorsal plate (tegminal plate), and an equivalent concept is used by Lawrence et al (2010). Synonyms: Apodeme of tegmen, manubrium, tegminal strut, basal piece (in some cases). [Emended September 2015]

Tegminal plate (male genitalia) – see Parameroid plate.

Tegminal ring (male genitalia) – the part of the tegmen that forms a more or less complete ring around the penis, from which arise the parameroid lobes or plate and the tegminal apodeme. Synonym: basal piece (in some cases).

Tegminal strut (male genitalia) – see Tegminal apodeme, Manubrium.

Temones (male genitalia) – see penis apodemes. Term used by Alonso-Zarazaga, 1989, 1990).

Temple (head, head capsule) - lateral part of the head between the posterior margin of the eye and the margin of the pronotum (Wanat, 2001). See discussion under Head.

Tentorium (head) – internal skeleton of the head, comprising plesiomorphically a pair of anterior arms joined to a pair of posterior arms, these united by a tentorial bridge. The anterior and posterior arms are apodemal invaginations arising at the anterior tentorial pits and posterior tentorial pits respectively. Discussed by Lyal (1995).

Tergal formula (abdomen) – see under Pygidium.

Thoracic horns (prothorax) - anteriorly-directed horns arising from the prothorax ventrally, just anterior to the coxal cavity. Often with a median more or less forked sheath between them. Image below is of a thorax viewed from the ventro-posterior aspect, with the sheath pointing towards the viewer and the horns pointing away.

Tormae (larva, mouthparts) - sclerotized rods in the labrum. Their shape can provide taxonomically-useful characters. Synonym: labral rods.

Transfer apparatus (male genitalia, endophallus) – more or less complex sclerotised elements in endophallus around the gonopore. Velázquez de Castro et al. (2007) distinguished three different sclerites in Sitonini: pinna, cucullus, and hamulus. cf flagellum. Synonyms: aggonoporium; basal sclerite; complex apparatus; armature sclerites; anterior endophallic sclerite; sclerotized structure of internal sac.

True corbel – see discussion under corbel

Uncus (leg, tibia) - Apical tooth of the tibia associated with the Inner Flange (q.v.). The traditional distinction between the uncus and the mucro (q.v.) is that the mucro arises from the ventral (inner) apical angle and is not continuous with the dorsal (outer) margin), while the uncus arises from, or is continuous with, the dorsal margin (Marvaldi & Lanteri, 2005). Thompson (1992) notes that the uncus is always associated with the inner flange, so that a mucro, once associated with the inner flange, is termed an uncus. There are cases where the flange and the mucro do not smoothly connect, even where both are present.

Unguitractor - see Fifth tarsomere (preferred term)

Urosternite - see spiculum gastrale (preferred term)

Vagina (female genitalia) – tubular part of the ovipositor between the junction with the common oviduct and the gonocoxites, where it opens through the vulva.

Vaginal palp see 'coxite-stylus'

Venter (abdomen) – the visible ventral surface of the abdomen.

Venter (head, head capsule) - area between the eyes ventrally, limited anteriorly by the base of the rostrum (level of the anterior margin of the eyes) and posteriorly by the posterior tentorial pit. Includes part of the submentum sensu Lyal, 1995 and part of the postgena. (Wanat, 2001). There is potential to confuse this use of the term with the more common use as applied to the ventral surface of the abdomen, and it is not in general use.

Ventral sulci (head, rostrum) - (Wanat, 2001)

Ventrite (abdomen) – visible (exposed) abdominal sternites. The first two sternites are concealed, forming part of the coxal cavity, so that the first ventrite is the third sternite. There are five ventrites visible in weevils. The nature of the sutures between the ventrites is discussed by Thompson (1992).

Vertex (head, head capsule) - posterior part of the head, extending from the occiput to the level of the antennal insertions. It, and its subdivisions, are discussed under the entry on Head. Some authors limit the term to the area behind the eyes dorsally, not including the part of the head capsule normally covered by the pronotum (i.e. lacking the sculpture and setation of the more normally exposed part of the head) [Emended June 2015]

Vulva (female genitalia) – opening of vagina between gonocoxites.

Wing-binding patch (abdomen) – patch of very fine spines generally found paired on abdominal sterna, used by the weevil in folding the wings under the elytra.

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

SESSION 4

WEEVILS IN AGRICULTURAL CROPS

Lecture Notes by:

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Weevils Attacking Economically Important Crops

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Weevils Attacking Mango

(Sternochetus frigidus, S. mangiferae, & S. olivieri)

Sternochetus mangiferae (Fabricius, 1775)

Other Scientific Names

Acryptorhynchus mangiferae (Fabricius)
Cryptorhynchus mangiferae (Fabricius)
Curculio mangiferae
Sternochetus ineffectus (Walker)

International Common Names

English: mango seed weevil, mango stone weevil; mango weevil; Spanish: gorgojo de la semilla del mango; picudo de la semilla del mango, French: charançon de la graine du manguier; charançon de la mangue

EPPO code

CRYPMA (*Sternochetus mangiferae*)

Distribution

Asia - Bangladesh, British Indian Ocean Territory, India, Indonesia, Myanmar, Nepal, Oman, Sri Lanka, Yemen (CABI as of August 2016)

(Invalid previous record: Bhutan, China, Hongkong, Malaysia, Pakistan, Philippines, Thailand, UAE, Vietnam)

Africa -Central African Republic, Gabon, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Seychelles, Tanzania, Zambia (Invalid previous record: Nigeria)

Not America - Hawaii

Central America & Caribbean - Barbados, British Virgin Islands, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, St. Lucia, St Vincent & Grenadines, Trinidad & Tobago, United States Virgin Islands **South America** - Brazil, Chile, French Guiana

Oceania - Australia (Northern Territory, NSW, Queensland), French Polynesia, Guam, New Caledonia, Northern Mariana Islands, Tonga, Wallis and Futuna Islands

Host Range

Complete development is only achieved on mangoes. Oviposition was obtained in the laboratory on potatoes, peaches, *Litchi chinensis*, plums, *Phaseolus vulgaris* and several cultivars of apples, but none of the resulting larvae reached maturity.

Biology & Ecology:

Adult habits and behavior

- feed on the leaves and tender shoots of mangoes during March and April in India
- nocturnal, fly readily and usually feed, mate and oviposit at dusk
- enter a diapause after emergence, which varies in duration with the geographic range (ie. southern India, all adults emerging during June enter a diapause from July until late February of the following year)
- onset and termination of diapause appear to be associated with photoperiod
- diapause under loose bark on mango tree trunks and in branch terminals, or in crevices near mango trees
- few adults live through two seasons with a diapause period in between
- females began oviposition 3-4 days after mating, when the fruit was about marble-size
- oviposition period varies from 3 - 5 weeks
- lay eggs mostly on the sinus of the fruit or sometimes on the stems
- female makes a boat-shaped cavity in the skin (epicarp) into which an egg is deposited
- One female may lay 15 eggs per day, with a maximum of almost 300 over a 3-month period in the laboratory (Balock and Kozuma, 1964)
- usually remain in the vicinity of the parent tree until the following fruiting season

Life cycle:

- egg incubation requires 5-7 days
- newly emerged larva burrows through the flesh of the fruit and into the seed
- tunnel and seed entry are completely obliterated as fruit develops, so that in time it is impossible to distinguish infested from non-infested seeds, unless they are cut open
- larval development usually occurs within the maturing seed, but also very occasionally within the flesh
- larval development takes about a month in S India, 22 days to 10 weeks in Hawaii
- five or seven larval instars
- pupates within the seed and rarely in the flesh
- pupal period lasts about a week
- one to six adults may develop per seed
- adults cut their way out of the naked seed, usually via a small circular hole made in the concave edge of the endocarp, generally 4-8 weeks after the fruit falls and decays
- move out of the seeds and seek hiding places by crawling, rather than flying.
- estimated time required for development from egg to adult is 35-54 days

Natural Enemy:

> “There is no published information about the parasites and predators of *S. mangiferae*. The only published record of any pathogen is a baculovirus affecting the larvae of *S. mangiferae* (Shukla et al., 1984).”

Sternochetus frigidus (Fabricius, 1787)

Other Scientific Names

Acryptorhynchus frigidus
Sternochetus gravis (Fabricius)
Cryptorrhynchus gravis Fabricius
Curculio frigidus Fabricius
Cryptorhynchus frigidus (Fabricius)
Acryptorrhynchus frigidus (Fabricius)

International Common Names

English: mango fruit weevil, mango weevil, mango pulp weevil, mango flesh weevil, northern mango weevil
Spanish: picudo del mango
French: charanÁon du manguier

EPPO code

CRYPGR (*Sternochetus frigidus*)

Distribution

Asia - Bangladesh, Brunei Darussalam, India, Indonesia, Malaysia, Philippines, Thailand, Myanmar (CABI as of August 2016) **Oceania** - Papua New Guinea

Host Range

Cultivated and wild *Mangifera* spp. (*Mangifera foetida* (bachang), *Mangifera odorata* (kurwini mango), *Mangifera sylvatica),* including all varieties of *M. indica* as well as *M. foetida*. However, oviposition on *M. foetida* is rare.

Biology & Ecology

Adult habits and behavior:

- In Tripura, India, reproductively immature adult S. frigidus overwinter inside seeds or other protective places from May until February. Mating occurs 10-15 days after termination of hibernation. Oviposition occurs from March to May on immature mango fruits.
- requires 6 weeks to be fully matured and able to mate
- hide during the day, for example in bark crevices or under epiphytic plants
- feed at night on the gum that exudes from puncture wounds on young fruits
- strong fliers but do not move far from their emergence sites
- mate repeatedly
- A female will often lay her total daily quota of eggs in one fruit.

- If suitable fruits are available, females lay about eight eggs daily, producing a total of 75 (maximum 180 eggs) in 3 weeks.
- If deprived of suitable fruits for 5 months, the egg production drops to three eggs per day; additional delays lead to further reduction in oviposition.
- Female dies soon after oviposition
- Large populations of *S. frigidus* are generally only found in sites with high humidity, containing large stands of mangga (M. indica), kekembem and kweni (M. foetida) trees which flower more than once a year.
- The weevils have only one generation during the fruit season Weevils that survive from the preceding year infest fruit formed after the earliest flowering.
- If early flowering does not occur, they attack the fruits formed after the main flowering period. An extended flowering period leads to the production of large numbers of weevils. In a dry year, or if only one flowering period occurs, the weevil population remains low (on average four eggs per fruit).

Life cycle:

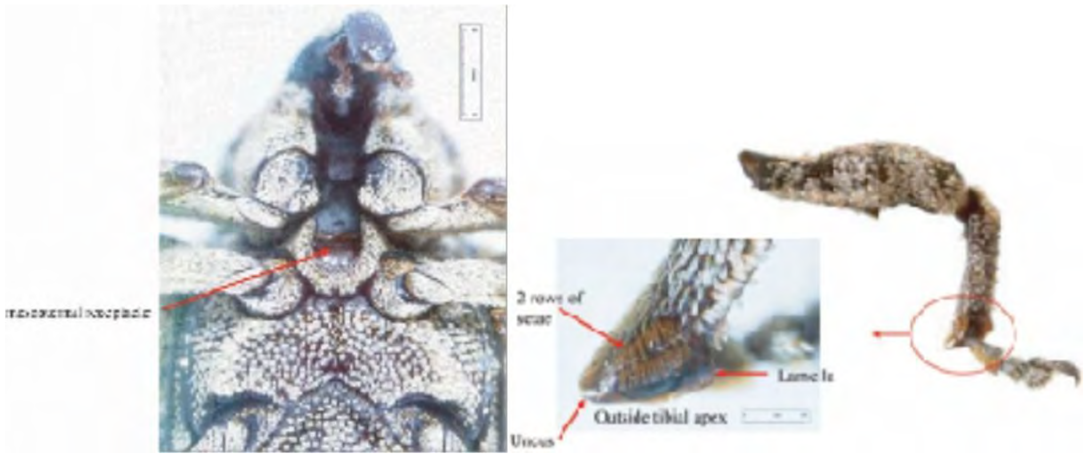
- The eggs are laid on fruits that has a minimum diameter of 6 cm.
- Similar to *S. mangiferae,* the females remove a piece of peel, oviposit, and cover the eggs with a brown layer of gum and faeces creating a crescent-shaped incision around the oviposition site.
- Eggs hatch after 4-65 days depending on the temperature (De and Pande, 1988).
- Newly hatched larva tunnels directly through the fruit pulp to the kernel. The shell of the kernel is not attacked but while boring through the pulp, the larvae imbibe the exuding sap, so that the tunnel remains relatively dry. The granular faeces accumulate in the hole formed by feeding.
- Larva undergoes 5 larval stadium over approximately 20 days
- Pupation takes place in a brown cocoon, constructed of frass, within these chambers.
- In the Philippines, total development from egg to adult is 32 days but the adult remains inside the fruit for another 37 days. In Bogor, Indonesia, it is observed to cover 5-7 weeks.
- Survival of newly hatched larvae reveal that exuding gum is responsible for 30-50% mortality. Dry conditions are thought to affect young adults adversely.

Natural enemy:

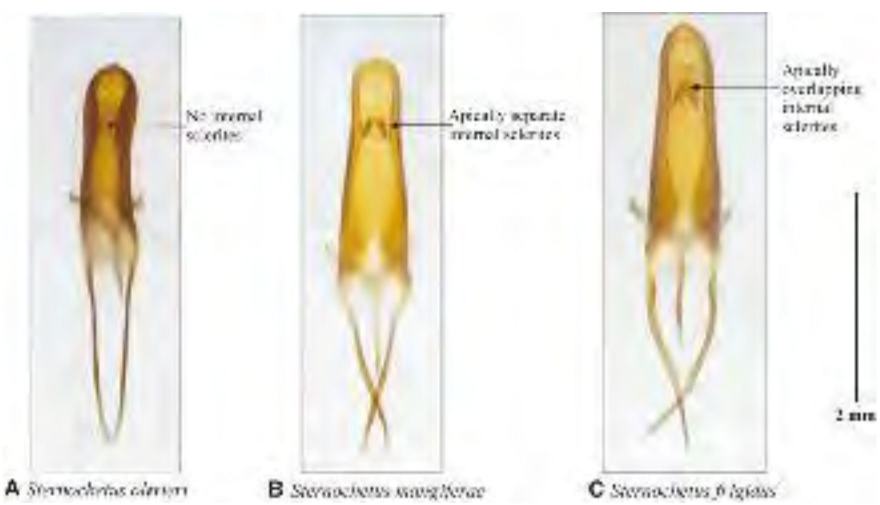
- *Flavopimpla mangae* - ichneumonid parasitic wasp
- Formicidae (*Oecophylla smaragdina, Camponotus* sp. and *Monomorium* sp.)
- Aspergillus sp. - entomogenous fungus
- *Rhizoglyphus* sp. - ectoparasitic mite (of hibernating adult

Diagnostic Protocol of Mango Weevils

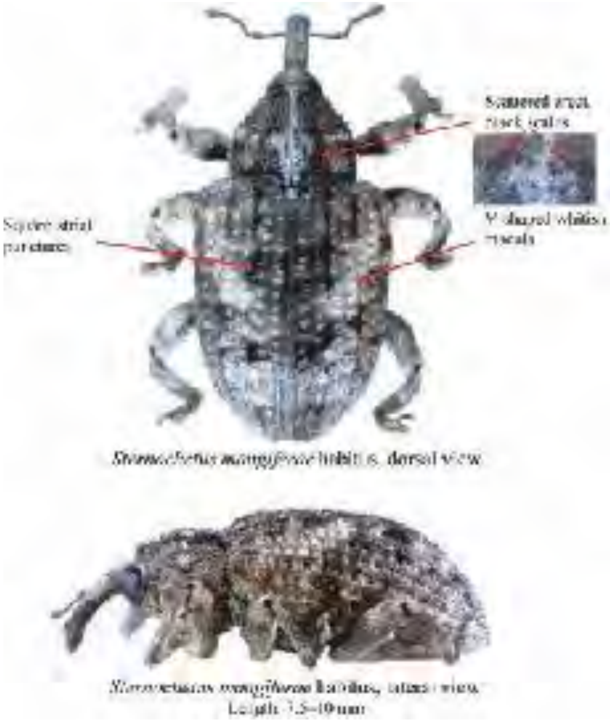
based Key to the species of mango weevils (Oberprieler & Banks, 2008 unpublished)
Source: European and Mediterranean Plant Protection Organization PM 7/106 (1)



Sternochetus mangiferae, mesosternum & mesothoracic leg (Photo courtesy of LSV)



Aedeagus, dorsal view. (A) *S. olivieri* (B) *S. mangiferae* (C) *S. frigidus* (Photos of CSIRO)



Sternochetus spp. habitus (i) dorsal view; (ii) lateral view (Photo courtesy of LSV)

Sternochetus mangiferae:

- Body length: 7.5-10mm
- Elytra with sides nearly parallel from base to beyond middle
- Interstriae flat to faintly but evenly costate (ridged)
- strial punctures rectangular to square
- whitish macula forming a more or less distinct V and transverse posterior band
- pronotum with erect black scales scattered over basal part of pronotal disk -aedeagus with pair of internal sclerites separate, not touching apically.

Sternochetus frigidus:

- Body length: 3.8-5.9mm
- Elytra narrowing from base to apex
- Odd interstriae except sutural one distinctly costate-tuberculate
- Strial punctures round
- Whitish macula fragmented but usually
  - forming a vague anterior inverted triangle inscribing a similar, smaller black median triangle and a broken posterior band on declivity
- Pronotum with erect black scales arranged in medial pair of loose clusters
- Aedeagus with pair of internal sclerites overlapping apically.

Sternochetus olivieri:

- Body length: length 6–8 mm.
- Elytra with a large, whitish macula (patch) stretching from just behind humeri (shoulders) to top of declivity, inscribing a black, inverted medial triangle before
- middle length and sometimes posteriorly interrupted by a fainter, dark, transverse band above declivity;
- Pronotum medially with a conspicuous carina (keel) in basal 2 / 3 of length, which is flanked on either side by a line of white scale and at its anterior end (in middle pronotum) by a tuft of dense, erect black scales;
- Aedeagus with sides nearly parallel, apically broadly rounded and no internal sclerites.

Control of Mango Weevils

Cultural control

Good orchard sanitation involving the destruction of all the fallen fruit, stones and fruits with seed weevil damage during and immediately after mango harvest.

In nursery, the seed may be shelled and only sound kernels planted.

Open center- canopy pruning makes the micro climate unfavourable to *S. frigidus.*

Fruits of the size of a chicken egg can be bagged individually using durable paper bags to reduce damage of *S. frigidus.*.

Biological control

The ant *Oecophylla smaragdina* is an effective biocontrol agent of *S. mangiferae* adults (Peng and Christian, 2004, 2007).

The only published record regarding pathogens is of a baculovirus affecting the larvae of *S. mangiferae* (Shukla et al., 1984).

Host plant resistance

In India, ten cultivars (out of 92 studied) were found to be free from *S. mangiferae* infestation, and these cultivars are Sindhu, Bombay Green, Firangi Ludua, Pulihora, Jahangir, Sabja, Salgadino, Hatizool, Dodamio and Fazri (Godse and Bhole, 2003). Larval penetration of the seed of the variety Itamaraca is reported to be impossible (Balock and Kozuma, 1964).

Chemical control

Chemical control has been used with some success and a wide range of insecticides have been recommended (see, for example, Shukla and Tandon, 1985; Villiers, 1987). The main strategy is to attack diapausing adults by trunk applications or to use foliar sprays at the time of oviposition.

Means of Movement & Dispersal

Longer-range dispersal occurs largely through transport of fruit and seeds containing the larvae, pupae or adults. The pest has been intercepted in mango fruits and seeds in international trade.

Phytosanitary Measures

Methyl bromide fumigation at the rate of 36 gm3 for 8 h at 21°C killed all stages but injured the fruit (Balock & Kozuma, 1964).

Balock & Kozuma (1964) found gamma radiation to be the most effective method for killing or sterilizing weevils within fruit.

In the Philippines, Obra et al (2014) At 150 Gy (measured doses 96.7–164.1 Gy) caused complete sterility of *S. frigidus*.

In Hawaii, Seo et al. (1974) treated packaged mangoes with cobalt-60 gamma irradiation. Minimum doses of 20.6 and 32.9 krad killed insects of all stages within the fruits; the few surviving adults were sterile and short-lived.

In South Africa, irradiation of ripe, marketable fruit protected it from damage and prevented adult emergence. The most effective dosages ranged from 0.5 to 0.85 kGy; higher rates tended to be phytotoxic (Kok, 1979).

Hot and cold treatment of fruit has also been tried but gave unreliable results and proved phytotoxic (Balock & Kozuma, 1964; Seo et al., 1970; Shukla & Tandon, 1985).

References:

CABI. (2007). Crop Protection Compendium, 2005 Edition. (c) CAB International Publishing. Wallingford, UK. www.cabi.org

Alam MZ, 1962. A list of insects and mites of East Pakistan. Dhaka, Bangladesh: Department of Agriculture.

Bagle BG, Prasad VG, 1985. Studies on varietal incidence and control of stone weevil, Sternochetus (=Cryptorrhynchus) mangiferae Fabricius (Coleoptera: Curculionidae). Indian Journal of Entomology, 47(3):362-364.

Balock JW, Kozuma TT, 1964. Notes on the biology and economic importance of the mango weevil, Sternochetus mangiferae (Fabricius), in Hawaii (Coleoptera: Curculionidae). Proceedings of the Hawaiian Entomological Society, 18:353-364.

Basio RG, Johnson PJ, Pua DR, Bergonia HT, Diloy CC, Villegas EL, 1994. Mango pulp weevil (Sternochetus frigidus (Fabr.)) (Curculionidae, Coleoptera) found in Palawan. Philippine Entomologist, 9(3):350-351.

De Jesus, L.R.A., and F. Cortez. 1998. Field infestation and chemical control of the mango pulp weevil, Sternochetus frigidus (Fabr.) in Palawan. Philipp. Agric. 81: 131–140.

De Jesus, L.R.A., and R. R. Gabo. 2000. Life history and host range of the mango pulp weevil, Sternochetus frigidus (Fabr.) in Palawan, Philippines. Philipp. Agric. Sci. 83: 145–150.

De Jesus, L.R.A., S.M.F. Calumpang, J. R. Medina, and K. Ohsawa. 2003. Feeding and reproductive behavior of the mango pulp weevil, Sternochetus frigidus (Fabr.), at different phenological stages of mango, Mangifera indica L. Philipp. Agric. Sci. 86: 282–289.

Dey K, Pande YD, 1987. Evaluation of certain non-insecticidal methods of reducing infestation of the mango nut weevil, Sternochetus gravis (F.) in India. Tropical Pest Management, 33(1):

27-28, 101, 105.

Dey K, Pande YD, 1987. Efficacy of insecticides in controlling Sternochetus gravis (Fabricius).

Indian Journal of Agricultural Sciences, 57(9):678-680.

Dey K, Pande YD, 1988. Bionomics and some behavioural aspects of the mango stone weevil, Sternochetus gravis (Fabricius) (Coleoptera: Curculionidae). Entomon, 13(1):17-24.

Devi MB, Prasad B, 1992. A note on the hibernation of mango fruit weevils (Curculionidae: Coleoptera). Bioved, 3(2):235-236.

EPPO, 2006. PQR database (version 4.5). Paris, France: European and Mediterranean Plant Protection Organization. www.eppo.org.Firman ID, 1982. Plant protection news. Information Circular, South Pacific Commission, No. 90:8 pp.; [7 fig.].

Follett PA, Gabbard Z, 2000. Effect of mango weevil (Coleoptera: Curculionidae) damage on mango seed viability in Hawaii. Journal of Economic Entomology, 93(4):1237-1240.

Kalshoven LGE, 1951. The Pests of Cultivated Plants in Indonesia. Part II. The Hague, Netherlands: Van Hoeve.Kalshoven LGE, Laan PAvan der (Reviser and translator), 1981. Pests of crops in Indonesia. Jakarta, Indonesia: Ichtiar Baru.

Kok IB, 1979. Control of the mango seed weevil by trapping and irradiation. Citrus and Subtropical Fruit Journal, No. 552:14-16; [1 fig.].

Medina CDR, Velasco LRI. 2001. Diagnostic characters to identify the sexes of the adult mango pulp weevil (Sternochetus frigidus (Fabr.) (Coleoptera: Curculionidae). Philipp. Ent. 15(2): 191-195.

Medina, J. R., O. S. Opina, L.R.A. De Jesus, and S.M.F. Calumpang. 2005. Development of an integrated pest management program for mango in Palawan, Philippines. Philipp. Agric. Sci. 88: 453–461.

Obra, G. B., S. S. Resilva, and L.R.A. Lorenzana. 2013. Irradiation as a potential phytosanitary treatment for the mango pulp weevil Sternochetus frigidus (Fabr.) (Coleoptera: Curculionidae) in Philippine super mango. Philipp. Agric. Sci. 96: 172–178.

Obra, GB, Resilva SS, Follett, PA, Lorenzana, LRJ. 2014. Large-Scale Confirmatory Tests of a Phytosanitary Irradiation Treatment Against *Sternochetus frigidus* (Coleoptera: Curculionidae) in Philippine Mango. J. Econ. Entomol 107(1)161-165.

Pande YD, Dey K, 1986. Outbreaks and new records. India. Sternochetus gravis (Col.: Curculionidae) causing serious damage to mangoes in northeast India. FAO Plant Protection Bulletin, 34(2):109.

Pinese, B., and Holmes, R. (2005). Managing mango seed weevil. Horticulture and Forestry Science Department of Primary Industries and Fisheries, The State of Queensland.

Rahman ML, Ahmad M, 1972. The immature stages of the mango fruit weevil, Sternochetus frigidus Fabricius (Coleoptera: Curculionidae). Pakistan Journal of Scientific and Industrial Research, 15:188-190.

Rahman MF, Khan S, 1989. Anatomy and histology of the alimentary canal of the adult mango weevil, Sternochetus frigidus (Fabricius) (Coleoptera: Curculionidae). Bangladesh Journal of Zoology, 17(2):189-195.

Seo, S. T., R. M. Kobayashi, D. L. Chambers, L. F. Steiner, C.Y.L. Lee, and M. Komura. 1974. Mango seed weevil: Cobalt-60 gamma irradiation of packaged mangoes. J. Econ. Entomol. 67: 504–505

Shukla RP, Tandon PL, Singh SJ, 1984. Baculovirus-a new pathogen of mango nut weevil, Sternochetus mangiferae (Fabricius) (Coleoptera: Curculionidae). Entomon, 10:215-218

Shukla RP, Tandon PL, 1985. Bio-ecology and management of the mango weevil, Sternochetus mangiferae (Fabricius) (Coleoptera: Curculionidae). Current Science, 53:593-594.SPC, 1989.

Shukla R.P. and Tandon P.L. (1985). Bio-ecology and control of the mango weevil Sternochetus mangiferae (Fabricius) (Coleoptera: Curculionidae) International J. Trop. Agri. Vol 3 No 4 pp 293 -303.

Silva, AC and Ricalde, MP. 2017. First occurrence of Sternochetus mangiferae (Fabricius) (Coleoptera: Curculionidae) in Brazil. Neotrop. Entomol May 24, 2017 doi: 10.1007/ s13744-017-0523-1. [Epub ahead of print]

Van Dine DL, 1907. Notes on Cryptorhynchus mangiferae (Coleoptera). Proceedings of the Hawaiian Entomological Society, 1:79-82.

Villiers EA de, 1987. Mango weevil must be controlled. Information Bulletin, Citrus and Subtropical Fruit Research Institute, South Africa, 176:12-13.

Voute AD, 1935. Cryptorhynchus gravis F. and the causes of its multiplication in Java. Archives NÈerlandaises de Zoologie, 2:112-142.

Waterhouse DF, 1993. The major arthropod pests and weeds of agriculture in Southeast Asia. Canberra, Australia: ACIAR.

Wheatley PE, 1961. Insect pests in the Coast Province of Kenya. 1-Mango. East African Agriculture For. Journal, 26:129-131.

Woodruff RE, 1970. The mango seed weevil, Sternochetus mangiferae (Fab.) (Coleoptera: Curculionidae). Entomology Circular, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, 93:1-2.

Wongsiri S, 1983. Insect pests of agricultural crops in Thailand. Bangkok, Thailand: Odeon Store Publishing.

Weevils Attacking Banana

Cosmopolites sordidus (Germar), Philicoptus iliganus (Heller)

Cosmopolites sordidus (Germar, 1824)

Other Scientific Names

Sphenophorus sordidus Germar
Calandra sordida Germar
Sphenophorus striatus Fabricius
Sphenophorus musaecola
Sphenophorus cribricollis Walker
Sphenophorus pygidialis Chevrolat
Sphenophorus liratus
Metamasius sordidus (Germar)
Cosmopolites striatus (Fabricius)
Metamasius striatus (Fabricius)

International Common Names

English: banana weevil, banana weevil borer, banana root weevil, banana root borer, banana rhizome weevil, banana borer, plaintain weevil, corm weevil, banana beetle, cosmopolitan root borer, plantain root borer

Spanish: picudo negro, picudo negro del banano, gorgojo del tallo del banano, gorgojo negro del platano, gorgojo del pl·tano, barrenillo del banano

French: charanÁon du bananier, charanÁon noir des bananiers, broca da bananeira, moleque da bananeira

EPPO code

COSMSO (*Cosmopolites sordidus*)

Distribution

Asia - Bangladesh, Brunei Darussalam, Cambodia, China, Hongkong, Taiwan, Christmas Is, Inida, Indonesia, Israel, Japan, S. Korea, Malaysia, Peninsular Malaysia, Maldives, Myanmar, Mepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam

Africa - Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Comoros, Congo, Gabon, Ghana, Guinea, Kenya, Madagascar, Malawi, Mauritania, Mauritius, Niger, Rwanda, Reunion, St Helena, Senegal, Sao Tome & Principe, Seychelles, Sierre Leone, Somalia, S. Africa, Tanzania, Togo, Uganda

North America - Florida (eradicated), Hawaii, Mexico

Central America & Caribbean - Bermuda, Costa Rica, Cuba, Dominica, El Salvador, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Nicaragua, Panama, Puerto Rico , Saint Lucia , Saint Vincent and the Grenadines ,Trinidad &Tobago

Europe - Madeira, Canary Island

South America - Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Easter Is, French Guiana, Guyana, Peru, Suriname, Venezuela

Oceania - American Samoa, Australia (NSW, Queensland, Western Australia), Belau, Cook Is, Fiji, French Polynesia, Guam, New Caledonia, Niue, Paps a New Guinea, Samoa, Solomon Is, Tonga, Vanatu, Wallis & Futuna Islands

Biology & Ecology

Life cycle:

- Wide variability in stage duration: 4-36 days for eggs, 12-165 days for larvae, 1-4 days for prepupae, 4-30 days for pupae and 24-220 days from egg to adult
- Under tropical conditions, the egg stage is normally 6-8 days, while the larval period is 20-25 days.
- After hatching the larvae tunnel into the host-plant tissues
- Larvae are variously reported have 5-8 instars
- Pupation is usually near the surface of the corm, inside an oval chamber
- Adults emerge from pupa in 5-8 days
- Adults are fully hardened in 5-7 days

Reproduction:

- Pre reproductive period is 5-20 days for females and for males at 18-31 days.
- Age at first oviposition is 27-41 days
- Egg production was influenced by temperature, but not rainfall or humidity.
- Eggs are laid throughout the year at a rate varying with temperature and up to 100/ female/year
- Under field conditions, egg density is greatest on flowering plants

- Eggs are placed singly in small cavities, chewed out by the female, with over 90% occurring in the base of the pseudostem, with the remaining eggs found in the corm and roots near the soil surface.
- In stands displaying high mat (a condition in which part of the corm appears above the soil surface), more eggs are found on the corm than on the pseudostem. The majority of eggs are normally placed below the soil surface.
- Crop residues also receive high levels of oviposition with as many as 200 eggs recorded from a single stump.

Adult survivorship:

- can survive extended periods without food
- sensitive to dessication and will die within 48 hours if kept in a dry substrate
- Preference for moist environments continues to breed throughout the year, provided that food supply is plentiful
- live 1 year or less but some adults may live as long as 2 years

Adult habits:

- gregarious and are found in clusters in cavities and depressions in the outer sheaths of the banana close to the ground surface and also below the surface
- found either in the base of leaf sheaths or in the soil around the mat
- some adults are found associated with cut crop residues
- sedentary for extended periods of time
- nocturnal active between 18:00 and 06:00 with greatest activity from 21:00-04:00
- rarely fly, but commonly walk over the soil surface and vegetation

Adult trivial movement:

- not strong flyers and only cover short distances
- unusually sedentary: of 400 marked weevils released at one point in a Ugandan plantation, 35% were recovered over an 8-month period within a radius of 10 yards of the original release point

Population build up

- In a field trial, weevils were released 11 months after planting. Four months later, weevil numbers remained stable in mulched plots, while declining by 38-53% in controls and intercrops
- Overall, the field population of weevils remained below release levels until 39 months after planting and peaked at 47 months at 40% higher than release levels.

Natural Enemies

- Beetle predators of egg and larva.: *Plaesius javanus* , *P. laevigatus; Hololepta quadridentata, Belonuchus ferrugatus, Priochirus unicolor, Thyreocephalus interocularis, Dactylosternum hydrophiloides, D. abdominale* and *Cathartus* sp.
- In Cuba, the ant *Tetramorium bicarinatum* is reported to keep *C. sordidus* but not *T. guineense* .
- No hymenopterous or dipterous parasitoids.
- Strains of *Beauveria bassiana* in laboratory tests.

Control of Banana Corm Weevil

Simon (1994) produced a bibliographical synthesis reviewing integrated control of *C. sordidus.*

Cultural Control

- Use clean planting materials in the planting of new stands
- 'Paring and Sterilization' - peel the rhizomes free of lesions and immerse in hot water at 54∞C for 10 minutes
- Dig out and remove old corms, trash and other materials in which weevils may breed
- Desucker and remove water suckers regularly and keep the plantation free of weeds at all times.
- 'Count, Cut and Dry' - Cut down the spent pseudostem close to the ground as soon as bunch is harvested. Cut it into lengths of up to 60 cm and split each along its length.
- Good husbandry practices, such as clean weeding, manuring and mulching produce vigorous banana plants which have improved weevil tolerance

Biological Control

Approaches include the use of endemics, exotics (classical biological control), secondary host association and microbial control.

- Fiji - *Plaesius javanus* and *P. laevigatus* in 1918
- Queensland - *P. javanus* from 1921 to 1928; *Dactylosternum hydrophiloides* in 1939
- Cook Island - P*. javanus* and *P. laevigatus* from 1937 to 1940
- Chiapas, Mexico - *P. javanus* in 1933
- Jamaica - *Dactylosternum hydrophiloides* and *D. abdominale* in1942
- St. Vincent - *Hololepta quadridentata* in 1976
- New Soth Wales - Nematodes *Steinernema carpocapsae, S. glaseri* and *S. bibionis* in 1991
- Cuba - the fungus *Beauveria bassiana* & ants *Tetramorium guineense* and *Pheidole megacephala*

Host-Plant Resistance

Early researches showed potential for development of resistant varieties. The most important resistance mechanism appears to be antibiosis.

Chemical Control

- Apply insecticides to the bases of the plants, including the suckers, and the surrounding soil surface for a distance of 30 cm around the plants, using knapsack sprayers, high volume spraying units or by sprinkling as dusts
- In Tonga, planting material is dipped in suitable insecticides or granules 2-3 times a year
- In Puerto Rico two nematicides controlled the borer in plantains

Trapping and Pheromonal Control

- Disk-on-stump traps- corm slices or leaves placed on top of harvested plants cut at the rhizome
- Pheromone traps “sordidin”; 4 traps/ha, changed and moved every month

References

Batra HN, 1952. Occurrence of three banana pests at Delhi. Indian Journal of Entomology, 14:60.

Beauhaire J, Ducrot PH, Malosse C, Rochat D, Ndiege IO, Otieno DO, 1995. Identification and synthesis of sordidin, a male pheromone emitted by Cosmopolites sordidus. Tetrahedron Letters, 36(7):1043-1046.

Bennett FD, Rosen D, Cochereau P, Wood BJ, 1976. Biological control of pests of tropical fruits and nuts. In: Huffaker CB, Messenger PS, eds, Theory and Practice of Biological Control. New York, USA: Academic Press, 359-395.

Braithwaite BM, 1958. Ground spray treatments for control of banana beetle borer (Cosmopolites sordidus Germ.). Journal of the Australian Institute of Agricultural Science, 24:27-34.

Budenberg WJ, Ndiege IO, Karago FW, 1993. Evidence for volatile male-produced pheromone in banana weevil Cosmopolites sordidus. Journal of Chemical Ecology, 19(9):1905-1916.

Cheng KH, 1957. Banana corm weevil and its control experiments. Agric. Res., 7:45-54.

Clausen CP, 1978. Introduced parasites and predators of arthropod pests and weeds: a world review. Agriculture Handbook, United States Department of Agricultre.

Collin PJ, Treverrow NL, Lambkin TM, 1991. Organophosphorus insecticide resistance and its management in the banana weevil borer, Cosmopolites sordidus (Germar) (Coleoptera:Curculionidae) in Australia. Crop Protection, 10(3):215-221.

Deang RT, Caburubias RB, Quero EM, 1969. Insecticide test for the control of abaca corm weevil. Philippine Journal of Plant Industry, 34(1/2):79-87.

Delattre P, 1980. Investigations into a method for estimating populations of the banana weevil, Cosmopolites sordidus Germar (Col., Curculionidae). Acta Oecologica, Oecologia Applicata, 1(1):83-92; [6 fig.].

Fogain R, Price NS, 1994. Varietal screening of some Musa cultivars for susceptibility to the banana borer weevil. Fruits (Paris), 49(4):247-251.

Franzmann BA, 1972. Banana weevil borer in north Queensland. Queensland Agricultural Journal, 98:319-321.

Gettman AD, Mitchell WC, Li P, Mau RFL, 1992. A hot water treatment for control of the banana root borer, Cosmopolites sordidus (Germar) (Coleoptera:Curculionidae) in banana planting stock. Proceedings of the Hawaiian Entomological Society, 31:59-63.

Gold CS, Speijer PR, Karamura EB, Tushemereirwe WK, Kashaija IN, 1994. Survey methodologies for pest and disease assessment in Uganda. African Crop Science Journal.

Gold CS, Night G, Abera A, Speijer PR, 1998. Hot-water treatment for the control of the banana weevil, Cosmopolites sordidus Germar (Coleoptera: Curculionidae), in Uganda. African Entomology, 6(2):215-221.

Gold CS, Night G, Speijer PR, Abera AMK, Rukazambuga NDTM, 1998. Infestation levels of banana weevil, Cosmopolites sordidus Germar (Coleoptera: Curculionidae), in banana plants established from treated propagules in Uganda. African Entomology, 6(2):253-263.

Greathead DJ, 1986. Opportunities for biological control of insect pests in tropical Africa. Revue de Zoologie Africaine, 100(1):85-96.

Greathead DJ, 1993. Report on miscellaneous observations made during a visit to Cuba for FAO to assist in setting up a programme for biological control of water hyacinth. 20 May - 4 July 1993. (Unpublished IIBC report) Wallingford, UK: CAB International.

Kalshoven LGE, 1951. The Pests of Cultivated Plants in Indonesia. Part II. The Hague, Netherlands: Van Hoeve.Kalshoven LGE, Laan PAvan der (Reviser and translator), 1981. Pests of crops in Indonesia. Jakarta, Indonesia: Ichtiar Baru.

Koppenhˆfer AM, 1993. Observations on egg-laying behaviour of the banana weevil, Cosmopolites sordidus (Germar). Entomologia Experimentalis et Applicata, 68(2):187-192.

Koppenhˆfer AM, 1993. Egg predators of the banana weevil, Cosmopolites sordidus (Germar) (Col., Curculionidae) in western Kenya. Journal of Applied Entomology, 116(4):352-357.

Koppenhˆfer AM, Reddy KVS, Madel G, Lubega MC, 1992. Predators of the banana weevil, Cosmopolites sordidus (Germar) (Col., Curculionidae) in western Kenya. Journal of Applied Entomology, 114(5):530-533.

Koppenhofer AM, Seshu Reddy KV, 1994. A comparison of rearing methods for the banana weevil, Cosmopolites sordidus (Germar) (Coleoptera:Curculionidae) on its natural host. Insect Sci. Appl., 15:191-195.

Mesquita ALM, Caldas RC, 1986. Effect of the age and of the cultivar of banana on the biology and preference of Cosmopolites sordidus (Germar, 1824) (Coleoptera, Curculionidae). Fruits, 41(4):245-249.

Ogenga-Latigo MW, Bakyalire R, 1993. Use of pseudostem traps and coefficient of infestation (PCI) for assessing banana infestation and damage by Cosmopolites sordidus Germar. African Crop Science Journal, 1(1):31-37.

Ortiz R, Vuylsteke D, Dumpe B, Ferris RSB, 1995. Banana weevil resistance and corm hardness in Musa germplasm. Euphytica, 86(2):95-102.

Ostmark HE, 1974. Economic insect pests of bananas. Annual review of entomology. Volume 19., 161-176. View Abstract

Peasley D, Treverrow N, 1984. Count, cut, dry. A new approach to banana weevil borer control in bananas. The Banana Bulletin, 12:13.

Roth L, Willis E, 1963. The humidity behavior of Cosmopolites sordidus Germar (Coleoptera:Curculionidae). Annals of the Entomological Society of America, 56:41-42.

Sein F Jr, 1934. Paring and heat sterilization of the corms to eliminate the banana root weevil Cosmopolites sordidus Germar. Journal of Agriculture. University of Puerto Rico, 18:411-416.

Simon S, 1994. Integrated control of the black banana weevil Cosmopolites sordidus. Fruits (Paris), 49(2):151-162.

Speijer PR, Budenberg WJ, Sikora RA, 1993. Relationships between nematodes, weevils, banana plantain cultivars and damage. Annals of Applied Biology, 123(3):517-525. View Abstract

Traore L, Gold CS, Pilon JG, Boivin G, 1993. Effects of temperature on embryonic development of banana weevil, Cosmopolites sordidus Germar. African Crop Science Journal, 1:111-116.

Treverrow N, Bedding RA, Dettmann EB, Maddox C, 1991. Evaluation of entomopathogenic nematodes for control of Cosmopolites sordidus Germar (Coleoptera: Curcilionidae), a pest of bananas in Australia. Annals of Applied Biology, 119(1):139-145.

Treverrow N, 1983. Banana weevil borer. Agfacts, No. H6.AE. 1:2 pp.; [3 fig.].

Viswanath B, 1978. Studies on the biology, varietal response and control of banana rhizome weevil, Cosmopolites sordidus (Germar) (Coleoptera:Curculionidae). Mysore Journal of Agricultural Sciences, 11:597-598.

Waterhouse DF, 1993. The major arthropod pests and weeds of agriculture in Southeast Asia.

Canberra, Australia: ACIAR.

Waterhouse DF, Norris KR, 1987. Biological control: Pacific prospects., viii + 454pp.; [many fig., 26x18 cm].

Woodruff RE, 1969. The banana root borer (Cosmopolites sordidus Germar) in Florida (Coleoptera: Curculionidae). Florida Department of Agriculture, Entomology Circular No. 88, 1-2.

Zimmerman EC, 1968a. Rhynchophorinae of southeastern Polynesia (Coleoptera:

Curculionidae). Pacific Insects, 10:47-77.

Zimmerman EC, 1968b. The Cosmopolites banana weevils (Coleoptera: Curculionidae:

Rhynchophorinae). Pacific Insects, 10:295-299.

Philicoptus iliganus (Heller, 1912)

Other Scientific Names

Coptorrynchus iliganus (Heller)
Philicoptus waltoni Boheman

International Common Names

English: Philippine banana peel scarring weevil

EPPO code

not listed

Distribution

ASIA - Philippines (Davao, General Santos and South Cotabato)

Host Plants

Main host plant: banana (*Musa* spp)

Other minor host plants: *Artocarpus integrifola* (jackfruit); *Citrus* sp.; *Coffea* spp. (coffee); *Dureo zibethinus* (durian); *Garcinia mangostana* (mangosteen); *Gliricidia sepium* (madre de cacao); *Lansium domesticum* (lansones); *Nephelium lappaceus* (rambutan); *Persea americana* (avocado); *Phaseolus aureus* (mungbeans); and *Theobroma cacao* (cacao) *Crassocephalum crepidioides* (Benth)

Biology & Ecology

Life cycle

- egg to adult development ranges from 111-176 days
- eggs singly or in a mass in the soil
- hatch in 10 days
- larva feeds on the corm
- total larval period from 102–174 days on banana suckers
- pupate in a chamber in the soil and this pupal period lasts 10–23 days

Adult behaviour & habits

- relatively immobile, unable to move long distances and cannot fly no hind wings and the elytra (first pair of wings) are firmly united at the suture
- hides in leaf axils, between touching leaves and concealed among fruit
- has periods of inactivity interspersed with periods of active crawling
- feeds on the surface of young fingers, youngest leaf of banana plants which have not yet fruited, lower bracts before young banana fingers are exposed
- tend to to remain within the same area for several years without spreading

References:

Dawi, NM. 1982. Biology, Ecology and Control of Banana Scarring Weevil, Philicoptus iliganus (Heller) (Coleoptera: Curculionidae). Unpublished PhD Thesis. Department of Entomology, UP Los Banos. 123pp.

Heller, KM. 1912. Philippine Russelkafer. Phil. J. Sci 7(5):295-415.

Ostmark, HE. 1974. Economic insects of banana. Ann. Rev. Entomol. 19:161-176.

Schultze, W. 1923. Eleventh contribution to Coleoptera fauna of the Philippines. Philipp. J. Sci 23(6): 595-607.

Schultze, W. 1924. A monograph of the pachyrrynchid group of Brachyderinae, Curculionidae: Part I. Philipp. J. Sci 24(3): 309-360.

Stephen, CS. 1976. Philippine banana peel scarring weevils in Mindanao farms, Part II.

Unpublished report. Mindanao Fruits Co., Tagum, Davao. p.2.

Weevils Attacking Coconut

Rynchophorus ferrugineus, R. palmarum & R. vulneratus

***Rynchophorus ferrugineus* (Olivier, 1790)**

Other Scientific Names

Calandra ferruginea Fabricius, 1801
Curculio ferrugineus Olivier, 1790
Rhynchophorus signaticollis Chevrolat, 1882

International Common Names

English: Asiatic palm weevil; coconut weevil; red stripe weevil, red palm weevil
Spanish: picudo asiático de la palma
French: charançon asiatique du palmier

EPPO code

RHYCFE (Rhynchophorus ferrugineus)

Distribution

Asia - Bahrain, Bangladesh, China, Georgia, India, Indonesia, Iran, Israel, Japan, Jordan, Kuwait, Laos, Lebanon, Malaysia,Myanmar, Oman, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Taiwan, Thailand, Turkey, United Arab Emirates, Yemen
Africa - Egypt, Libya, Morocco, Spain, Tunisia
North America - California (eradicated)
Central America & Caribbean - Aruba, Curacao, Netherlands Antilles
Europe - Albania, Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia, Spain
Oceania - Australia, Papua New Guinea, Samoa, Solomon Is, Vanatu

Host Plants

Main host plant: palms (Arecaceae) - *Areca catechu* (betelnut palm), *Arenga pinnata* (sugar palm), *Borassus flabellifer* (toddy palm), *Cocos nucifera* (coconut), *Elaeis guineensis* (African oil palm), *Metroxylon sagu* (sago palm), *Phoenix canariensis* (Canary Island date palm), *Phoenix dactylifera* (date-palm), *Washingtonia* (wshington-palm)

& non-palm: *Calamus merillii* (rattan) Philippines (Braza, 1988)

Rynchophorus palmarum **(Linnaeus, 1758)**

Other Scientific Names

Calandra palmarum (Linnaeus) 1801
Cordyle barbirostris Thunberg, 1797
Cordyle palmarum (Linnaeus) 1797
Curculio palmarum Linnaeus, 1758
Rhynchophorus barbirostris (Thunberg)
Rhynchophorus cycadis Erichson, 1847
Rhynchophorus depressus Chevrolet, 1880
Rhynchophorus languinosus Chevrolet, 1880

International Common Names

English: South American palm weevil, palm weevil; palm-marrow weevil
Spanish: casanga; gorgojo cigarrón; gorgojo cigarrón del cocotero; gorgojo prieto de la palma; gualpa; mayate prieto del cocotero; picudo de la palma de coco; picudo del cocotero; picudo negro de la palma
French: charançon du palmier

EPPO code

RHYCPA (Rhynchophorus palmarum)

Distribution

North America - Mexico, USA - Arizona, California, Texas
Central America & Caribbean - Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Honduras, Martinique, Nicaragua, Panama, Puerto Rico, St. Lucia, St Vincent and the Grenadines, Trinidad and Tobago
South America - Argentina, Bolivia, Brazil, Columbia, Ecuador, French Guiana, Guyana Paraguay, Peru, Surname, Uruguay, Venezuela

Host Plants

Main host plant: *Cocos nucifera* (coconut), *Elaeis guineensis* (African oil palm), *Euterpe edulis*, *Metroxylon sagu* (sago palm), *Phoenix canariensis* (Canary Island date palm), *Phoenix dactylifera* (date-palm), *Saccharum officinarum* (sugarcane)

Non-significant hosts (adult feeding only) are *Ananas comosus (*pineapple*), Annona reticulata* (atis)*, Artocarpus altilis* (breadfruit)*, Carica papaya* (papaya)*, Citrus spp., Mangifera indica* (mango)*, Musa spp., Persea americana* (avocado)*, Psidium guajava* (guava)*, Theobroma cacao* (cacao).

Biology & Ecology

Life cycle

- Eggs hatch after 3.2 ± 0.93 days.
- Larvae have between six and 10 instars over a period of 52.0 ± 10.0 days.
- Prepupal stage lasts 4–17 days, during which the larvae make a cocoon using vegetative fibres.
- Pupal metamorphosis period lasts for 8 –23 days.
- Newly enclosed adults remain in the cocoon for 7.8 ± 3.4 days

Adult habits & behaviour

- Fecundity average 245 ± 155 eggs during a period of 30.7 ± 14.3 days; max- 697-718 eggs
- post-oviposition period of 10 days before the weevil dies.
- longevity : male 44.7 ± 17.2 days and females 40.7 ± 15.5 days
- In Egypt, has three generations per year, the shortest generation (first) of 100.5 days and the longest (third) of 127.8 days

Natural enemy

- Nematode parasite of larvae - *Billaea brasiliensis, Paratheresia menezesi, Paratheresia rhynch*

Rynchophorus vulneratus **(Panzer, 1798)**

Other Scientific Names

*Curculio vulneratu*s Panzer, 1798
Calandra schach Fabricius, 1801
Rhynchophorus pascha Boheman in Schönherr, 1845
Rhynchophorus ferrugineus v. tenuirostris Chevrolat, 1882
Rhynchophorus glabrirostris Schaufuss, 1885

Hallett et al (2004) - synonym of *R. ferrugineus*
Rugman et al (2013) - *R. vulneratus* is valid species

International Common Names

English: Asiatic palm weevil; coconut weevil; red stripe weevil, red palm weevil
Spanish: picudo asiático de la palma
French: charançon asiatique du palmier

EPPO code

Distribution

Asia - Indonesia, Malaysia, Singapore, Thailand, Philippines (unconfirmed)
North America - California (eradicated)

Host Plants

Main host plant: palms (Arecaceae) -*Cocos nucifera* (coconut), *Elaeis guineensis* (African oil palm), *Metroxylon sagu* (sago palm)

Control of Palm Weevils

"Integrated pest management for R. ferrugineus has been developed and tested in coconut palms in India (Kurian et al., 1976; Sathiamma et al., 1982, Abraham et al., 1999). Included in the IPM programme were cultural measures such as plant and field sanitation; physical methods by preventing entry of weevils through cut ends of petioles and wounds; and use of attractants and other chemicals (including filling of leaf axils with gamma BHC and sand as a preventive measure). Abraham et al. (1989) found the IPM approach very effective in reducing the number of infested palms in Kerala, India. Abraham et al. (1998) suggested that the major components of the IPM strategy for R. ferrugineus are surveillance, trapping the weevil using pheromones lures, detecting infestation by examination of palms, eliminating hidden breeding sites, clearing abandoned gardens, maintaining crop and field sanitation, using preventive chemical treatments, curative chemical control, implementing quarantine measures, training and education. In the Al Qatif region of Saudi Arabia, Vidyasagar et al. (2000a) successfully developed an IPM programme which, in addition to mass pheromone trapping, included a survey of all the cultivated gardens, systematic checking of all palms for infestation, periodic soaking of palms, and mass removal of neglected farms. A review of control strategies and IPM for the weevil were also presented by various other authors (Ramachandran, 1998; Nair et al., 1998; Murphy and Brisco, 1999). Faleiro (2006) has reviewed the issues and management of R. ferrugineus in coconut and date palm over the past 100 years." (CABI, 2010)

Sterile Backcrosses /Sterile Insect Technique /Chemosterilization

"Ramachandran (1991) reported the effects of gamma radiation on R. ferrugineus whereby production of viable eggs decreased with increasing radiation dose, although there was no apparent effect on the F2 generation. Rahalker et al. (1973) reported that treatment of 1-2-day-old males of the weevil at a dose of 1.5 krad (15 Gy) resulted in 90% sterility with no adverse effect on survival. Treatment of higher doses increased sterility but reduced survival. A ratio of ten treated males to one normal one was needed for appreciable suppression of progeny production. Using chemosterilants Rahalkar et al. (1975) reported that treatment of male weevils with metepa or hempa did not result in a satisfactory level of sterility without adversely affecting their survival. However, metepa was more toxic than hempa." (CABI, 2010)

References

Abe F, Hata K, Sone K, 2009. Life history of the red palm weevil, Rhynchophorus ferrugineus (Coleoptera: Dryophtoridae), in southern Japan. Florida Entomologist, 92(3):421-425.

Abraham VA, 1971. Note on an effective method of preventing entry by red-weevil, Rhynchophorus ferrugineus Fabricius (Curculionidae: Coleoptera), into the stem of coconut palm through cut petioles. Indian Journal of Agricultural Sciences, 41(12):1130-1131

Abraham VA, Koya KMA, Kurian C, 1989. Integrated management of red palm weevil (Rhynchophorus ferrugineus F.) in coconut gardens. Journal of Plantation Crops, 16(Supplement):159-162

Abraham VA, Nair SS, Nair CPR, 1999. A comparative study on the efficacy of pheromone lures in trapping red palm weevil, Rhynchophorus ferrugineus Oliv. (Coleoptera : Curculionidae) in coconut gardens. Indian Coconut Journal (Cochin), 30(7):1-2; 6 ref.

Braza RD, 1988. Asiatic palm weevil destroys rattan too. Canopy International. 13(6):6.

CABI/EPPO, 2010. Rhynchophorus ferrugineus. [Distribution map]. Distribution Maps of Plant Pests, No.June. Wallingford, UK: CABI, Map 258 (3rd revision).

Copeland EB, 1931. The coconut. London, UK: Macmillan and Co., Ltd.

Dangar TK, 1997. Infection of red palm weevil, Rhynchophorus ferrugineus, by a yeast. Journal of Plantation Crops, 25(2):193-196

Dhileepan K, 1991. Insects associated with oil palm in India. FAO Plant Protection Bulletin, 39(2-3):94-99.

El-Ezaby FA, 1997. Injection as a method to control the Red Indian date palm weevil Rhynchophorus ferrugineus. Arab Journal of Plant Protection, 15(1):31-38.

El-Garhy ME, 1996. Field evaluation of the aggregation pheromone of the red palm weevil, Rhynchophorus ferrugineus, in Egypt. Brighton Crop Protection Conference: Pests & Diseases -1996: Volume 3: Proceedings of an International Conference, Brighton, UK, 18-21 November 1996., 1059-1064

EPPO, 2007. Rhynchophorus ferrugineus and Rhynchophorus palmarum. Bulletin OEPP/

Faghih AA, 1996. The biology of red palm weevil, Rhynchophorus ferrugineus Oliv. (Coleoptera, Curculionidae) in Saravan region (Sistan & Balouchistan province, Iran). Applied Entomology and Phytopathology, 63(1/2):16-18

Faleiro JR, 2006. A review of the issues and management of the red palm weevil Rhynchophorus ferrugineus (Coleoptera: Rhynchophoridae) in coconut and date palm during the last one hundred years. International Journal of Tropical Insect Science, 26(3):135-154.

Faleiro JR, Abraham VA, Nabil Noudi, Al Shuaibi MA, Kumar TP, 2000. Field evaluation of red palm weevil, Rhynchophorus ferruginous Oliv. pheromone (Ferrugineol) lures. Indian Journal of Entomology, 62(4):427-433.

Hagley E (1965) On the life history and habits of Rhynchophorus palmarum.

Annals of the Entomological Society of America 58, 22–28.

Hallett, R.H., Crespi, B.J., Borden, J.H. 2004. Synonymy of Rhynchophorus ferrugineus (Olivier), 1790 and R. vulneratus (Panzer), 1798 (Coleoptera, Curculionidae, Rhynchophorinae). J. Nat. Hist. 38:2863-2882

Hallett RH, Oehlschlager AC, Borden JH, 1999. Pheromone trapping protocols for the Asian palm weevil, Rhynchophorus ferrugineus (Coleoptera: Curculionidae). International Journal of Pest Management, 45(3):231-237

IPPC, 2007. Red Palm Weevil. IPPC Official Pest Report, No. TR-3/1. Rome, Italy: FAO. https://www.ippc.int/IPP/En/default.jsp

Jaffé K, Sánchez P, Cerda H, Hernández JV, Jaffé R, Urdaneta N, Guerra G, Martínez R & Miras B (1993) Chemical ecology of Rhynchophorus palmarum: attraction to host plants and to a male-produced aggregation pheromone. Journal of Chemical Ecology 19, 1703 –1720.

Jaya S, Suresh T, Sobhitha-Rani RS, Sreekumar S, 2000. Evidence of seven larval instars in the red palm weevil, Rhynchophorus ferrugineus Oliv. reared on sugarcane. Journal of Entomological Research, 24(1):27-31.

Justin CGL, Leelamathi M, Thangaselvabai T, Johnson SBN, 2008. Bioecology and management of the red palm weevil, Rhynchophorus ferrugineus Oliv. (Coleoptera: Curculionidae) on coconut - a review. Agricultural Reviews, 29(2):117-124.

Kurian C, Antony J, Abraham VA, Natarajan P, 1976. Pest management in coconut gardens. An integrated approach. Indian Farming, 7(9):31-35.

Kurian C, Mathen K, 1971. Red palm weevil - hidden enemy of coconut palm. Indian Farming, 21(1):29-31

Li YueZhong, Zhu ZengRong, Ju RuiTing, Wang LianSheng, 2009. The red palm weevil, Rhynchophorus ferrugineus (Coleoptera: Curculionidae), newly reported from Zhejiang, China and update of geographical distribution. Florida Entomologist, 92(2):386-387.

Menon KPV, Pandalai KM, 1960. Pests. In: The Coconut palm. A Monograph. Inrankulam,

South India: Indian Central Committee, 261-265.

Misra RM, 1998. Insect pests of oil palm (Elaeis guineensis L.) from India and their management. Indian Journal of Forestry, 21(3):259-263.

Muralidharan CM, Vaghasia UR, Sodagar NN, 1999. Population, food preference and trapping using aggregation pheromone (ferrugineol) on red palm weevil (Rhynchophorus ferrugineus). Indian Journal of Agricultural Sciences, 69(8):602-604.

Murphy ST, Briscoe BR, 1999. The red palm weevil as an alien invasive: biology and the prospects for biological control as a component of IPM. Biocontrol News and Information, 20(1): 35-46

Nair CPR, Sathiamma B, Chandrika Mohan, Murali Gopal, 1998. Newer approaches in the integrated pest management in coconut. Indian Coconut Journal (Cochin), 29(4):99-103.

Prabhu ST, Patil RS, 2009. Studies on the biological aspects of red palm weevil, Rhynchophorus ferrugineus (Oliv.). Karnataka Journal of Agricultural Sciences, 22(3):732-733.

Rahalkar GW, Harwalkar MR, Rananavare HD, Shantaram K, Ayengar ARG, 1973. Laboratory studies on radiation sterilization of the red palm weevil (Rhynchophorus ferrugineus Oliv.) males. In: Nayar NM, ed. Journal of Plantation Crops, 1:141-145

Rahalkar GW, Harwalkar MR, Rananavare HO, 1975. Laboratory studies on sterilization of the male red palm weevil, Rhynchophorus ferrugineus Oliv. International Atomic Energy Agency; Food and Agriculture Organization: Sterility principle for insect control 1974. Proceedings of the symposium on the sterility principle for insect control jointly organized by the IAEA and the FAO of the United Nations and held in Innsbruck, 22-26 July 1974. International Atomic Energy Agency. Vienna Austria, 261-267

Ramachandran CP, 1991. Effects of gamma radiation on various stages of red palm weevil, Rhynchophorus ferrugineus F. Journal of Nuclear Agriculture and Biology, 20(3):218-221

Ramachandran CP, 1998. The red palm weevil Rhynchophorus ferrugineus F.: a review and future strategies. Indian Coconut Journal (Cochin), 29(4):104-106; 25 ref.

Reginald C, 1973. Principal Insect Pests. In: Coconuts. Tropical Agriculture Series, London, UK:Longmans.

Rugman-Jones PF, Hoddle CD, Hoddle MS, Stouthamer R, 2013. The lesser of two weevils: molecular-genetics of pest palm weevil populations confirm Rhynchophorus vulneratus (Panzer 1798) as a valid species distinct from R. ferrugineus (Olivier 1790), and reveal the global extent of both. PLoS ONE, 8(10):e78379. http://www.plosone.org/article/ info%3Adoi%2F10.1371%2Fjournal.pone.0078379

Sacchetti P, Camèra A, Granchietti A, Rosi MC, Marzialetti P, 2006. Identification, biology and spread of the Red Palm Weevil Rhynchophorus ferrugineus (Olivier) in Italy. (Identificazione, biologia e diffusione del curculionide delle palme, Rhynchophorus ferrugineus (Olivier).) Informatore Fitopatologico, 56(6):35-40.

Salama HS, Zaki FN, Abdel-Razek AS, 2009. Ecological and biological studies on the red palm weevil Rhynchophorus ferrugineus (Olivier). Archives of Phytopathology and Plant Protection, 42(4):392-399.

Sathiamma B, Abraham VA, Kurian C, 1982. Integrated pest management of the major pests of coconut. Indian Coconut Journal, 12(6/9):27-29

Vidyasagar PSPV, Al-Saihati AA, Al-Mohanna OE, Subbei AI, Abdul Mohsin AM, 2000. Management of red palm weevil Rhynchophorus ferrugineus Oliv., a serious pest of date palm in Al Qatif, Kingdom of Saudi Arabia. Journal of Plantation Crops, 28(1):35-43.

Vidyasagar PSPV, Mohammed Hagi, Abozuhairah RA, Al-Mohanna OE, Al-Saihati AA, 2000. Impact of mass pheromone trapping on red palm weevil: adult population and infestation level in date palm gardens of Saudi Arabia. Planter, 76(891):347-355.

Wang Feng, Ju RuiTing, Li YueZhong, Xu Ying, Du YuZhou, Zhou JianMing, 2009. Lab observation for biological characteristics and morphology of Rhynchophorus ferrugineus. Chinese Bulletin of Entomology, 46(4):556-560.

Wattanapongsiri A, 1966. A revision of the Genera Rhynchophorus and Dynamis. Department of Agricultural Science Bulletin. Bangkok, Thailand.

Wilson M (1963) Investigations into the development of the palm weevil, Rhynchophorus palmarum. Tropical Agriculture Trinidad 40, 185–196.

Weevils Attacking Sweet Potato

Cylas formicarius **(Fabricius, 1798)**

Other Scientific Names

Brentus formicarius Fabricius, 1798
Cylas elegantulus (Summers, 1875)
Cylas formicarius elegantulus Summers
Cylas formicarius formicarius
Cylas turcipennis Boheman
Otidocephalus elegantulus Summers, 1895

International Common Names

English: sweet potato borer, sweet potato weevil
Spanish: gorgojo del camote; piogán de la batata (Dominican Republic); tetuán del boniato (Cuba)
French: charançon de la patate douce; charançon faux-fourmi

EPPO code

CYLAFO (Cylas formicarius)

Distribution

Asia - Bangladesh, British Indian Ocean, Brunei Darussalam, Cambodia, China, Christmas Is, Cocos Is, India, Indonesia, Japan, Laos, Malaysia,Maldives, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam
Africa - Cameroon, Chad, Congo, Ethiopia, Ghana, Kenya, Livberia, Libya, Madagascar, Mauritius, Mozambique, Reunion, Senegal, Seycheles, Somalia, S Africa, Sudan, Swaziland, Tanzania, Uganda, Zimbabwe
North America - Mexico, USA - Alabama, Arakansas, Florida, Georgia, Hawaii, Louisiana, Mississippi, New Mexico, N Carolina, S. Carolina, Texas
Central America & Caribbean - Anguilla, Antigua & Barbuda, Bahamas, Belize, Cayman Is, Cuba, Dominican Republic, Guadelope,, Guatemala, Haiti, Jamaica, Netherlands Antilles, Puerto Rico, St Lucia, Trinidad and Tobago, US Virgin Islands **South America** - Guyana & Venezuela
Oceania - American Samoa, Australia, Cook Is, Fiji, French Polunesia, Guam, Kiribati, Marshall Is, Micronesia, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Is, Tonga, Tuvalu, Vanuatu, Wallis & Futuna Is

Host Plants

Main host plant: *Calystegia sepium* (great bindweed)*, Colocasia esculenta (*taro*), Cuscuta (*dodder*), Ipomoea (*morning glory*), Ipomoea aquatica* (swamp morning-glory)*, Ipomoea batatas* (sweet potato*), Ipomoea cairica* (five-fingered morningglory)*, Ipomoea pes-caprae* (beach morning glory*), Ipomoea purpurea (*tall morning glory*), Ipomoea quamoclit (*Cupid's-flower*), Jacquemontia tamnifolia (*Smallflower morningglory*), Pharbitis nil* (Japanese morning glory*)*

Biology and Ecology

Life cycle

- Eggs are laid singly in cavities in the root or stems.
- Egg incubation period ranges from 4 days at 30°C to 7.9 days at 20°C or 4 to 56 days at mean temperatures of 20 and 10.5°C, respectively.
- Larvae feed inside roots or stems for 25-35 days during which they complete three larval instars. In USA, larval development in the field ranges 12-154 days.
- Pupation takes place within the sweet potato roots or stems where larvae feed.
- Pupal period lasts 4-8 days or 5 to 10.7 days at 25 and 20°C, respectively.
- Soon after emergence from the pupa, the adult stays in the pupal chamber and then cuts its way through the plant tissue.
- Adults mate soon after emergence but pre - oviposition period has a minimum of 4.5 days at 30°C or 7.7 days at 20°C.
- Egg to egg development time - 84.7, 33, and 33.7 days at 20, 27 and 30°C, respectively.
- Life cycle duration of 36-43 days under undefined conditions.

Adult behaviour & habits

- Longevity - maximum of 113 days (Indonesia), males 63-120 days and females 81-107 days (Philippines), males 94 days and 1females 09 days (India)
- Fecundity - 90-340 eggs per female, (Philippines), 185 eggs (Indonesia), 1-319 eggs (USA) with an average of 119 and 97-216 eggs (India).

Natural Enemy

- Fungal pathogen of adults - *Beauveria, Metarrhizium*
- Wasp parasitoid of larvae - *Bracon mellitor, B. cylasovoros, B. punctatus, Drapetis exilis, Euderus purpureas*
- Nematode parasite of larvae - *Heterorhabditis bacteriophora, Heterorhabditis heliothidis,Metapelma spectabile, Rhaconotus menippus*
- Ant Predator of adult - *Pheidole megacephala*

Prevention and control

Cultural Control - crop rotation, intercropping, mulching, sanitation, destruction of crop residues, flooding of infested fields, use clean cuttings as planting materials and removal of alternative hosts. Planting cuttings deep in the soil, use of deep-rooted cultivars, and harvesting the crop as soon as it has developed roots of acceptable size (Edwards, 1930; Holdaway, 1941; Sherman and Tamashiro, 1954; Sutherland, 1986a).

Host-Plant Resistance - no resistant variety

Chemical Control - pre-plant application to dip vines for planting; post-plant application is difficult with conventional spraying, dusting, fumigation or side-dressing of insecticide granules with presently available insecticides, once weevils are present within the crown or the tuberous root. Control achieved by post-plant applications appears to be due to mortality of weevil adults searching for feeding or oviposition sites.

Sex pheromone - female sex pheromone isolated, identified and synthesized the chemical (Z)-3-dodecen-1-ol(E)-2-butenoate. This chemical has great potential for attracting male sweet potato weevils (Proshold et al., 1986; Jansson et al., 1992) and reducing the weevil populations in the field (Talekar and Lee, 1989).

Biological Control - *Beauveria bassiana* is produced in large quantities and used intensively for the control of the sweet potato weevil in Cuba. Sprays of the fungus have largely replaced the use of insecticides (Castellón et al., 1992).

References

Ahmad M, Hossain MB, 1979. Notes on weevils (Curculionidae: Coleoptera) of the Bangladesh Agricultural University area, Mymensingh. Bangladesh Journal of Zoology, 7(1):61-66

Alcazar J, Cisneros F, Morales A, 1997. Large-scale Implementation of the IPM for Sweetpotato Weevil in Cuba: A collaborative effort. Lima, Peru: International Potato Center, 185-190.

APPPC, 1987. Insect pests of economic significance affecting major crops of the countries in Asia and the Pacific region. Technical Document No. 135. Bangkok, Thailand: Regional Office for Asia and the Pacific region (RAPA).

Braun AR, Fliert Evan de, 1999. Evaluation of the impact of sweetpotato weevil (Cylas formicarius) and of the effectiveness of Cylas sex pheromone traps at the farm level in Indonesia. International Journal of Pest Management, 45(2):101-110; 26 ref.

CABI/EPPO, 2004. Cylas formicarius. Distribution Maps of Plant Pests, No. 278. Wallingford, UK: CAB International

Cockerham KL, 1943. The host preference of the sweetpotato weevil. Journal of Economic Entomology, 36:471-472.

Cockerham KL, Deen OT, Christian MB, Newsom LT, 1954. The biology of the sweet potato weevil. Technical Bulletin Louisiana Agricultural Experiment Station No. 483.

Coffelt JA, Vick KW, Sower LL, McClellan WTM, 1978. Sex pheromone of the sweetpotato weevil, Cylas formicarius elegantulus laboratory bioassay and evidence for a multiple component system. Environmental Entomology, 7(5):756-758

Gonzales SS, 1925. The sweet potato weevil (Cylas formicarius, Fabr). Philippine Agriculturist, 14:257-281.

Heath RR, Coffelt JA, Sonnet PE, Proshold FI, Dueben B, Tumlinson JH, 1986. Identification of sex pheromone produced by female sweetpotato weevil, Cylas formicarius elegantulus (Summers). Journal of Chemical Ecology, 12(6):1489-1503

Jansson RK, 1996. Infectivity and reproduction of three heterorhabditid nematodes (Rhabditida:

Heterorhabditidae) in two insect hosts. Florida Entomologist, 79(3):363-373; 18 ref.

Jansson RK, Bryan HH, Sorensen KA, 1987. Within-vine distribution and damage of sweetpotato weevil, Cylas formicarius elegantulus (Coleoptera: Curculionidae), on four cultivars of sweet potato in southern Florida. Florida Entomologist, 70(4):523-526

Jayaramaiah M, 1975. Bionomics of sweet potato weevil Cylas formicarius (Fabricius) (Coleoptera: Curculionidae). Mysore Journal of Agricultural Sciences, 9(1):99-109

Jayaramaiah M, 1975. Reaction of sweet potato varieties to the damage of the weevil, Cylas formicarius (Fab.) (Coleoptera: Curculionidae) and on the possibility of picking up of infestation by weevil. Mysore Journal of Agricultural Sciences, 9(3):418-421

Li ZZ, 1998. Control of Cylas formicarius Fabricius with pheromone. Plant Protection, 24(5): 28-30.

Miyatake T, Moriya S, Kohama T, Shimoji Y, 1997. Dispersal potential of male Cylas formicarius (Coleoptera: Brentidae) over land and water. Environmental Entomology, 26(2): 272-276; 23 ref.

Morales A, 1988. El cultivo del boniato (Ipomoea batatas (L.) Lam.) y su principal enemigo al Cylas formicarius var. elegantulus. In: Proccedings of a Sweet Potato Workshop, International Potato Center (CIP), Santo Domingo, Dominican Republic. Dominican Republic: CIP.

Moriya S, Hiroyoshi S, 1998. Flight and locomotion activity of the sweetpotato weevil (Coleoptera: Brentidae) in relation to adult age, mating status, and starvation. Journal of Economic Entomology, 91(2):439-443; 24 ref.

Mullen MA, 1981. Sweetpotato weevil, Cylas formicarius elegantulus (Summers): development, fecundity, and longevity. Annals of the Entomological Society of America, 74(5):478-481.

Nottingham SF, Son KC, Severson RF, Arrendale RF, Kays SJ, 1989. Attraction of adult sweet potato weevils, Cylas formicarius elegantulus (Summers), (Coleoptera: Curculionidae), to sweet potato leaf and root volatiles. Journal of Chemical Ecology, 15(3):1095-1106

Palaniswami MS, Mohandas N, Saraswathy P, 1991. On farm survey on the incidence, extent and intensity of Cylas formicarius F. damage on sweet potato in Kerala. Journal of Root Crops, 17(Special issue):180-196; 8 ref.

Proshold FI, Gonzalez JL, Asencio C, Heath RR, 1986. A trap for monitoring the sweetpotato weevil (Coleoptera: Curculionidae) using pheromone or live females as bait. Journal of Economic Entomology, 79(3):641-647

Sato K, Uritani I, Saito T, 1982. Properties of terpene-inducing factor extracted from adults of the sweet potato weevil, Cylas formicarius Fabricius (Coleoptera: Brenthidae). Applied Entomology and Zoology, 17(3):368-374

Sherman M, Tamashiro M, 1954. The sweetpotato weevils in Hawaii, their biology and control. Hawaii Agricultural Experiment Station Technical Bulletin No. 23

Shimizu T, Moriya S, 1996. Daily locomotor activity in the Indian sweet potato weevil, Euscepes postfasciatus (Fairmaire) (Coleoptera: Curculionidae) and sweet potato weevil, Cylas formicarius (Fabricius) (Coleoptera: Brentidae) monitored by an actograph system. Applied Entomology and Zoology, 31(4):626-628; 3 ref.

Shimizu T, Moriya S, 1996. Flight time and flight age in the sweet potato weevil, Cylas formicarius (Fabricius) (Coleoptera: Brentidae). Applied Entomology and Zoology, 31(4):575-580; 13 ref.

Singh B, Yazdani SS, Singh R, Hameed SF, 1984. Effect of intercropping on the incidence of sweet potato weevil, Cylas formicarius Fabr., in sweet potato (Ipomoea batatas Lam.). Journal of Entomological Research, 8(2):193-195

Smit NEJM, 1997. The effect of the indigenous cultural practices of in-ground storage and piecemeal harvesting of sweetpotato on yield and quality losses caused by sweetpotato weevil in Uganda. Agriculture, Ecosystems & Environment, 64(3):191-200; 23 ref.

Sorensen KA, 1987. Cultural, regulational and educational programmes on the sweetpotato weevil in the United States. Insect Science and its Application, 8(4-6):825-830

Soumik Mondal, Tarafdar J, Sen H, 2006. Use of sex pheromone trap for monitoring and management of sweet potato weevil (Cylas formicarius, Fabricius). Environment and Ecology, 24S(Special 3):525-528.

Suenaga T, Setokuchi O, Sakp K, 1987. Distribution of the sweet potato weevil Cylas formicarius Fabricius and the small sweet potato weevil, Euscepes postfasciatus Fairmaire in the Amami Islands. Proceedings of the Association for Plant Protection of Kyushu, No. 33:116-118

Sugimoto T, Sakuratani Y, Fukui H, Kiritani K, Okada T, 1996. Estimating the reproductive properties of the sweet potato weevil, Cylas formicarius (Fabricius) (Coleoptera, Brentidae). Applied Entomology and Zoology, 31(3):357-367; 30 ref.

Sutherland JA, 1985. The chemical control of Cylas formicarius (Fab.) using insecticides at low volume rates, with some considerations on the economics of control. Journal of Plant Protection in the Tropics, 2(2):97-103

Sutherland JA, 1986a. A review of the biology and control of the sweet potato weevil, Cylas formicarius (Fab.). Tropical Pest Management, 32:304-315.

Swindale A, 1992. Measurement of the economic importance of sweetpotato weevil.

Unpublished discussion paper 13. Lima, Peru: International Potato Center.

Talekar NS, 1983. Infestation of a sweetpotato weevil (Coleoptera: Curculionidae) as influenced by pest management techniques. Journal of Economic Entomology, 76(2):342-344
Talekar NS, 1987. Feasibility of the use of resistant cultivar in sweetpotato weevil control. Insect Science and its Application, 8(4-6):815-817

Talekar NS, Lai RM, Cheng KW, 1989. Integrated control of sweetpotato weevil at Penghu Island Plant Protection Bulletin, Taiwan, 31(2):185-191.

Talekar NS, Lee ST, 1989. Studies on the utilization of a female sex pheromone for the management of sweetpotato weevil, Cylas formicarius (F.) (Coleoptera: Curculionidae). Bulletin of the Institute of Zoology, Academia Sinica, 28(4):281-288

Trehan KN, Bagal SR, 1958. Life-history, bionomics, and control of sweet potato weevil (Cylas formicarius) with short notes on some other pests of sweet potato in Bombay State. Indian Journal of Entomology, 19:245-252.

Waterhouse DF, 1993. The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia. ACIAR Monograph No. 21. Canberra, Australia: Australian Centre for International Agricultural Research, 141 pp.

Waterhouse DF, Norris KR, 1987. Biological control: Pacific prospects. viii + 454pp
Wilson DD, Son KC, Nottingham SF, Severson RF, Kays SJ, 1989. Characterization of an oviposition stimulant from the surface of sweet potato Ipomoea batatas storage roots for the sweet potato weevil, Cylas formicarius elegantulus. Entomologia Experimentalis et Applicata, 51(1):71-75

Wilson DD, Son KC, Severson RF, Kays SJ, 1990. Effect of a pentacyclic triterpene from sweet potato storage roots on oviposition by the sweetpotato weevil (Coleoptera: Curculionidae). Environmental Entomology, 19(6):1663-1665

Wolfe GW, 1991. The origin and dispersal of the pest species of Cylas with key to the pest species groups of the world. In: Jansson RK, Raman, KV, eds. Sweet Potato Pest Management: A Global Perspective. Boulder, USA: Westview Press.

Yasuda K, 1989. Infestation of the sweetpotato weevils (Euscepes postfasciatus Fairmaire and Cylas formicarius Fabricius) in sweet potato fields. I. Invasion with cutting. Proceedings of the Association for Plant Protection of Kyushu, 35:120-122

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

SESSION 6

WEEVILS AS STORAGE PESTS AND THEIR CONTROL

Lecture Notes by:

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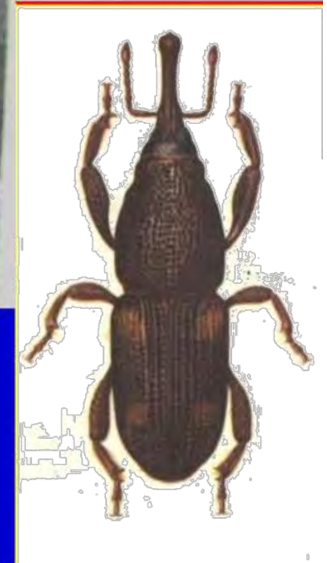
COMMON STORAGE STORAGE PESTS



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Economic Importance of SPPs

- Among the pests that degrade and destroy food crops, insects are the most important during storage.
- Stored commodities that are free from insect infestation & damage is of utmost importance. In grains alone, millions of dollars could be lost due to insect damage.
- Damage estimates caused storage pests ranged from 5-10% weight loss of all foodstuffs
- Losses due to storage pests in corn in the Philippines:
- 17% weight loss for 6 months storage
- 43% weight loss for 12 months storage
    - due to mixed pop of corn weevil & red flour beetle
- 42% weight loss in 13 NFA warehouses

Economic Importance

- Corn weevil consume about 10 – 20 mg food
- Extremely rapid population increase = 100X in each generation of 1 month
- Reduces seed viability and quality
- Contamination of grains (dead insects & body parts) caused spoilage & loss of cash value

INTRODUCTION

- **Stored commodities that are free from insect infestation & damage is of utmost importance. In grains alone, millions of dollars could be lost due to insect damage in storage**

- **In the Philippines, storage losses in rice & corn amount to 15% & 12%, respectively. The country imports 5-10% of its total grain reqmts. Prevention of storage losses could be a better strategy (proactive) to attain food security to complement increased food production in the farm.**

PREDOMINANT STORAGE INSECT PESTS

40 coleopteran families are reported attacking stored products worldwide

23 are of importance in the tropics

14 are involved in the major & minor storage pests in Southeast Asia

Anobiidae	Cleridae	Dermestidae	Nitidulidae
Anthribidae	Cucujidae	Lophacateridae	Silvanidae
Bruchidae	Scolytidae	Trogositidae	Tenebrionidae
Bostrichidae	Curculionidae		

Major Stored Product Coleopteran Families

1. Anobiidae

- Adults are small, subcylindrical (wood- boring, oval or nearly globular (general feeders) w/ prothorax more or less covering the deflexed head.
- With 11-segmented antennae w/ a loose 3-segmented serrate club.
- Elytra completely cover the abdomen
- With 5 visible abdominal sternites
- All tarsi are 5-segmented w/ segments 1-4 decreasing in length.
- Two species are important in storage:

  * *Lasioderma serricorne* * *Stegobium paniceum*

Cigarette Beetle, *Lasioderma serricorne* (F.)

- **Beetle is 2-4 mm long, oval, reddish to dark brown, covered w/ fine hairs.**
- **Antennae about half as long as the body and have 11 segments**
- **Elytra smooth with very short hairs but w/o striae.**
- **Common pest of tobacco & tobacco products; also common in many spices & animal feed concentrates.**
- **Adult lives for 2-6 weeks producing about 100 eggs.**
- **Found in temperate, sub-tropical & tropical regions**
- **When disturbed, adult conceals its head under the large pronotum**

Cigarette Beetle, *Lasioderma serricorne*

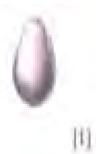
- **Eggs are laid in crevices or folds in the substrate.**
- **Hatch in 5-6 days at 35°C.**

- **Newly hatched larvae are very active & often move around & bore into packaged goods.**
- **Fleshy larvae are distinctly hairy, pass through 4-6 instars.**
- **Larval period at 32.5°C ~ 16 day**

- **Larva pupates within a cell among the substrate or within the grain.**
- **Pupal devt. lasts for 4 d at 30–37.5°C.**

Drugstore Beetle, *Stegobium paniceum* (L.)

Egg



Larva

Pupa

Adult

- Light brown beetle, 2-2.5 mm long & slightly hairy elytra with longitudinal ridges
- Last 3 antennal segments form a large loosely segmented club
- At 20-25°C & 6-80% RH, female lays ~ 75 eggs w/ life span of ~40-90 d.
- W/ 4-6 larval instars. Full grown larva constructs a cocoon where it pupates.
- Adult cannot fly & dispersal depends on passive distribution during movement of goods.
- Cold-hardy & can survive winter conditions in temperate regions.
- Cosmopolitan pest but is more temperate than tropical.
- Common pest of stored products, most serious on processed foods, spices and drugs.
- An occasional pest of stored grains.

2. Anthribidae

- Antennae are 11-segmented, thread-like or filiform with a loose 3-segmented club.
- All tarsi are 5-segmented.
- Mostly of tropical distribution, associated with old wood, dead branches & fungi.
- Only one species, *Araecerus fasciculatus,* is of economic importance on stored products

Coffee Bean Beetle

Araecerus fasciculatus

- Most impt. insect pest of stored coffee; attacks coffee beans
- Larvae bore into the beans & once damaged the bean may then be damaged by secondary insect pests
- Also attacks cocoa beans, cassava chips & occasionally corn
- Adult measures 3-5 mm long
- Prothorax & elytra bear many patches of light colored setae giving a mottled appearance
- The 3 terminal segments of antennae are longer than the other segments forming a loose club
- Life cycle ~ 46-66 days;female lays~50 eggs; adults live for ~ 17 weeks

3. Bostrichidae

- **Body is cylindrical and prothorax coarsely tuberculate concealing the deflexed head.**
- **Antennae are straight & terminate in a loose**
- **3- or 4-segmented club**
- **Apically, the elytra are somewhat flattened & sloped ventrally or less steeply. This sloping region is referred to as declivity. This is marked with carinae, tubercles or hooks which are useful recognition features**
- **Tarsi are all 5-segmented**
- **Cosmopolitan, mainly wood-boring beetles; attack timber of dry wood and occasionally, unhealthy trees.**
- **Three species frequently infest stored grains:**

* *Rhizopertha dominida*

* *Dinoderus minutus*

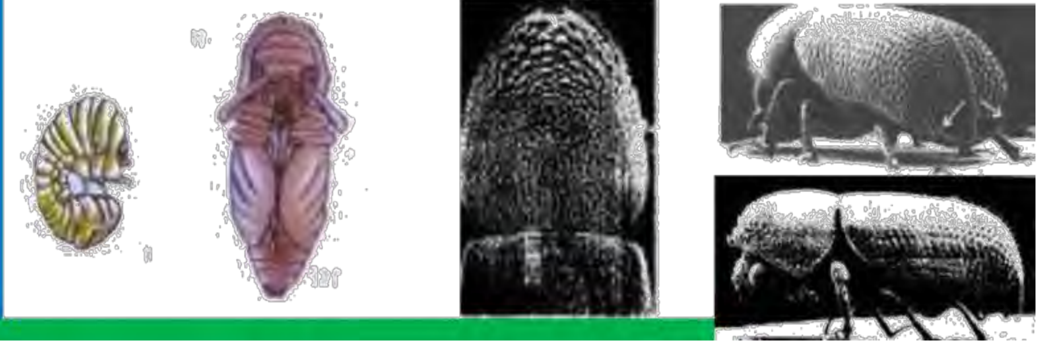
* *Prostephanus truncatus*

Lesser Grain Borer

Rhizopertha dominica

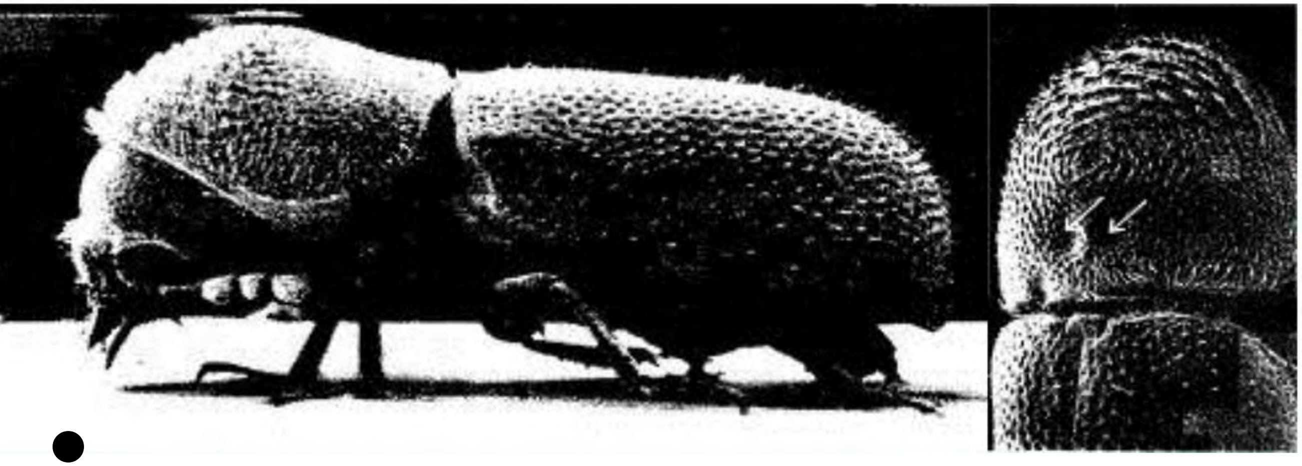
- 2.5-3 mm long, dark brown, body is cylindrical & head is concealed ventrally by the prothorax, which is dotted with many small tubercles
- Pronotum is rounded & there is transverse rows of teeth
- Elytra w/ regular rows of punctures & short setae that curve posteriorly
- Cosmopolitan but of particular importance in tropical & subtropical regions
- Bores & feeds on a wide variety of foods, chiefly cereals, including grains of al l kinds, dried cassava, flour, macaroni, beans, dried potato and many other materials. Adults are surface feeders while larvae are primarily internal feeders
- Attacks rough rice which is resistant to attack of most storage pests
- Female lays 200-600 eggs, which hatches in 7-8 days
- Larval development on whole meal at 28°C and 70% RH is 27-31 days.

Larger Grain Beetle
Prostephanus truncatus



- Serious pest of stored corn and dried cassava roots, & appears to attack corn in the field just before harvest. Adults bore into a wide range of foodstuffs & some other materials, e.g. wood
- Development from egg to adult in corn at 27°C & 70% RH is 32.5 days
- Introduced to Tanzania in late 1970 & has since spread into corn & cassava growing areas of tropical Africa
- Known to occur in South America, Mexico, Central America and the extreme south of USA
- Absent in Southeast Asia; important as a quarantine pest
- The declivity of elytra is flattened & steep & with many tubercles over its surface
- The limits of declivity, apically and laterally are marked by a carina
- Antennae are 10-segmened & have a loose 3-segmented club
- Body is 3-4.5 mm long

Powder Post Beetle, *Dinoderus minutus* (F.)



- Closely resembles *Rhizopertha* and *Prostephanus* except for the following:

  - there is a pair of shallow depressions at the base of the pronotum

  - scutellum is transverse, its width about twice its length. Elytral hairs are short & erect.

- Infests dried cassava, bamboo & wood. Can also attack cocoa beans, starch, sago and corn.

4. Bruchidae

- Clothed with hairs, w/c are usually colored forming distinct patterns
- Elytra do not cover the last abdominal segment
- Adults are small, strongly convex beetles.
- Antennae are relatively long; eyes are large (except genus *Caryedon*)
- Antennae are 11-segmented without a club, usually filiform w/ some segment which are compressed in the males of some *Callosobruchus*
- Tarsi are distinctly 4-segmented w/ the 3rd segment broadly dilated and deeply emarginate
- Hind femur are somewhat thickened or strongly enlarged and each bear one or more teeth
- Upon hatching, bruchid grubs have 3 thoracic legs but after the first molt they become apodous.
- Bean beetles do not possess the elongate rostrum of true weevils. All species that are impt as pest of stored products are legume feeders.
- Common species: *Acanthoscelides obtectus, Callosobruchus chinensis* and *C. maculatus*

Cowpea Bean Beetle

Callosobruchus chinensis

- Adult are 2.5-3.5 mm in length with typical white markings on the scutellum.
- Has a pair of distinct ridges (inner & outer) on the ventral side of each hind femur. Each ridge has a tooth near the apical end. Inner tooth is slender, rather parallel-sided, & equal to the outer tooth.
- Antennae are pectinate in male & serrated in female.
- Elytra are pale brown w/ small median dark marks and larger posterior dark patches, w/c may merge to make the entire posterior part of the elytra dark
- Primary pest of legumes in tropical & subtropical climates, particularly chickpeas, Adzuki beans & cowpeas

Southern Cowpea Bean Beetle

Callosobruchus maculatus

- Females have two large lateral dark patches midway along the elytra and smaller patches at the anterior and posterior ends, leaving a paler brown cross-shaped area covering the rest.

- Males are brown all over with small blackish markings.

Bean Beetle

- *Acanthoscelides obtectus*

Hind

femur

- Cosmopolitan species that is a serious primary pest of common bean & lima beans. Also attacks other legumes.
- Beetle 3-4.5 mm long; elytra variegated w/ yellowish & dark brown patches of hairs; elytra do not completely cover the abdomen.
- Body colors are grey, brown or reddish brown w/o any distinctive pattern.
- Each hind femur has an inner ventral ridge near the apex, a large tooth followed by 2 or 3 smaller, sharp teeth
- Serrated antennae are dark grey except for segments 1-5 & 11, w/c are reddish.
- Legs are reddish except for the ventral half of hind & middle femur which is black.

Bean Beetle

Acanthoscelides obtectus

- Eggs are laid on ripening pods while in the field.
- Eggs are laid loosely w/in pod cavity or among stored seeds
- Newly hatched larva develops entirely w/in a single seed eventually forming a pupation chamber under the seed coat
- Adult that emerges from the chamber is short-lived and does not feed.

5. Cleridae

- Cleridae or "chequered beetles" are brightly colored pubescent insects of moderate size.
- Antennae is 11-segmented with the apical segment enlarged to form a distinct club.
- Elytra generally completely cover the abdomen
- There are 5 or 6 visible abdominal sternites.
- Tarsi are all 5-segmented w/ the 1st & 4th often small and indistinct
- Mostly predaceous feeding on wood borers

Red-legged Ham Beetle

(Copra Beetle)

Necrobia rufipes

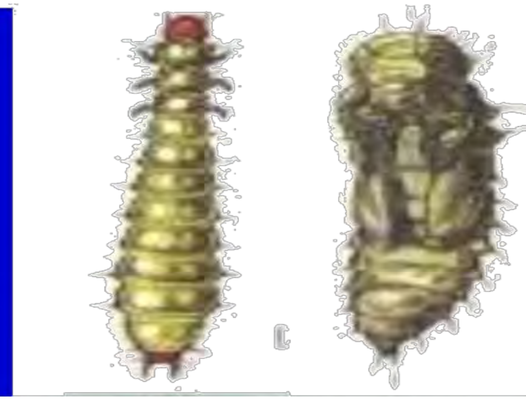
- **Beetle 4-5 mm long, metallic blue or bluish-green, red basal segment of antennae & legs**
- **Common insect pest of dried copra, dried fish & fish meal. Also attacks animal products such as ham & bacon, oil seeds & spices**
- **Larvae & adults are attracted to the steric & palmitic acid of rotting moldy copra**
- **Eggs are laid in batches of up to 30 in cracks & crevices**
- **With 3-4 larval instars, which are completed in ~17 days. Larvae are cannibalistic & predatory, attacking the eggs and larvae**
- **Female lives for up to 6 months & may produce as many 3000 eggs. Adults are active fliers**
- **Life cycle is completed in 42 days at 30°C and 65-70%RH.**

6. Cucujidae

- **Small beetles (1.5 to 2.5), flattened & reddish-brown**
- **Filiform antennae are usually long, up to half the body length to nearly as long as the body**
- **Prothorax possesses an entire, sub-lateral ridge (carina) on both sides w/c are more or less parallel**
- **In females, tarsi are 5-segmented while in males the front & mid-tarsi are 4-segmented**
- **Most species have been found under bark of trees, in damaged seed or in tunnels made by other beetles**
- **Some species are often predatory but *Cryptolestes* is of importance in stored products. It is both a predator and grain feeder**
- **The male and female closely resemble each other in appearance**
- **Determination of species is based on characteristics of the genitalia & antennae and the ratio of body length of male to that of female.**

Rust Grain Beetle

Cryptolestes ferrugineus



- Smallest pest of stored grain, about 1/16 inch long
- Reddish-brown beetle with flattenned body chractererized by the presence of a very long antenna.
- Head & prothorax are very conspicuous & account for half of body length
- Cosmopolitan & is one of the most common insect pest of stored grains
- Adults are unable to survive in sound and uninjured grains.
- Follow-up the attack of the more vigorous grain insect pests

Flat Grain Beetle

Cryptolestes pusillus (Schoner)

Cosmopolitan; attack same range of commodities infested by *C. ferrugineus*

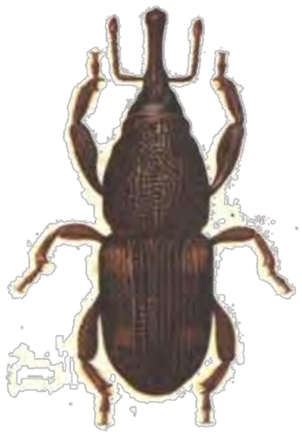
Unable to survive in sound, uninjured grains; also a scavenger, larva feeds on the remains of dead insects; often associated with grain & meat in poor conditions.

External appearance, life cycle & behavior is very similar to *C. ferrugineus* but not tolerant to low temperature and below 60% RH.

7. Curculionidae

- **The species under this family is known as true weevils or snout beetles.**
- **Form the largest single family in Order Coleoptera that attack many growing crops of many kinds throughout the world.**
- **Approximately 30 species have been recorded in stored food products.**
- **Includes Genus *Sitophilus*, which contains 3 of the world's most destructive pests of stored grain.**
- **Adults may be distinguished from other stored product species by having the head protruded in front of the eyes to form a well defined snout (rostrum), antennae are elbowed and one-clubbed.**
- **All tarsi are 4-segmented.**
- **Larvae are legless in all species, stout, and slightly curved and are creamy white with a pale brown or yellowish head.**

Sitophilus spp.- Rice weevil complex (*Sitophilus zeamais* & *S. oryzae*)



Sitophilus granarius

- Primary pest of all cereal grains but mainly found in corn, wheat, rice & sorghum
- Body color reddish-brown to black; elbow-like antennae

Pits on pronotum	Round	Oblong
Elytra	w/ 4 yellow spots	w/o yellow spots
Flight	Good flyer	Rarely fly
Distribution	Tropical	Temperate

Sitophilus spp.

Sitophilus granarius

- Primary pest of all cereal grains but mainly found in corn, wheat, rice & sorghum
- Head is prolonged into a snout; two light spots on each front wings
- Body color reddish-brown to black
- Small, round, closely compacted pits on pronotum
- Hind wings function as flight wings; infest corn in the field
- Larvae are white, wrinkled & legless; require 4 molts and growth period before transforming to adults
- Lives on an average of 4-5 months & each female lay 300 – 400 eggs
- Common in semi-tropical countries
- Can be identified by their genitalia

8. Dermestidae

- Adults are small to moderately large beetles (1.5 to 12 mm long), densely covered w/ hairs or colored scales
- Head is small & somewhat deflexed.
- Antennae are 5 to 11-segmented, w/ a fairly distinct 3-segmented club.
- Elytra completely cover the abdomen.
- All tarsi are 5-segmented.
- Larvae are characteristically very hairy. Their setae, which are often of taxonomic importance, may be detached from the shed larval skin.
- Live larvae can cause contamination or pose a health hazard when inhaled
- About 55 species have been reported as injurious to stored products.
- The most impt species belong to the *Trogoderma* and *Dermestes*

Khapra Beetle

Trogoderma granarium

- Occurs in hot and dry conditions; in areas w/ a mean T^{o} >$20^{o}C$ & <50% RH; larva is highly resistant to starvation & may live for months or even years without food.
- One of the most damaging pests of stored products of agricultural origin throughout the world; most important quarantine pest.
- Wheat, barley, rice & spices seem to be the most attractive commodities but also feeds on almonds, walnuts, spaghetti & egg noodles, tapioca, dried beans, powdered skim milk, oilseed cake, corn meal, fishmeal, coconut and to a lesser extent, dried fruits.

Khapra Beetle

Trogoderma granarium

- Originated in India & had established in some Asian, Middle-East & African countries, being distributed mainly by shipping & international trade through the agency of man.
- Adults are dark brown mottled with black; body clothed with fine yellowish hairs; oblong oval approx. 1.75 – 3.5 mm long.
- Antennal segment is usually 11 but there can be as few as 9; antennal club consists at most of 4-5 segments for males, at least 3 segments for females.
- Life cycle varies from 4-6 months to several years depending upon the temperature and food supply

Hide Beetle, *Dermester maculatus*

- The only beetle with enzymes necessary for, ***Dermestes maculatus*** breaking down keratin
- 5.5-10 mm long; head, pronotum and elytra dark gray to black
- Pronotum & elytra w/ uniformly-colored whitish or pale yellowish hairs
- Scutellum yellowish-brown to reddish-brown
- Antennae clubbed, basal segments reddish-orange, last 3 segments forming club
- Abdomen w/ dense covering of grayish-white hairs except for black spot in anterior-lateral corner of each abdominal segment, and an irregular-margined black band at base of abdomen
- Adults feed on dried or drying fish & lay up to 800 eggs. Rate of egg-laying is greatly increased if water is available for the female to drink.

9. LOPHOCATERIDAE

- Formerly under the Family Trogosidae.
- Only one species, *Lophocateres pusillus*, is known to occur in stored products.
- *Lophocateres pusillus* occurs widely in tropical & subtropical regions & has been recorded on many stored products such as cereals (particularly rice), pulses, cassava and groundnuts.
- Usually only a minor pest & is often found in association w/ the major primary pests.
- Common in South and Southeast Asia & its pest status may be higher in this situation.

Siamese Grain Beetle

Lophacateres pusillus King

- Occurs widely in tropical and subtropical regions.
- Found on many stored products such as cereals, legumes, cassava, & groundnuts; a minor pest occurring in large number on both paddy & milled rice in association with *S. oryzae* and *R. dominica* in South & Southeast Asia.
- Eggs are deposited in crevices; as many as 3-14 eggs may be laid per batch; at 30^{o}C & 75%RH, egg hatches in about 7 days.
- Larval and pupal development are completed within 42 days.
- Found to develop adequately on a diet of frass from *S. oryzae*, but development was better on a medium of whole-wheat flour plus yeast.

10. Nitidulidae

- **Large family of more than 2,000 species; extremely variable inform, structure & habits. Many inhibit flowers.**
- **Others are found in decaying animal & vegetable remains, in fungi, & in exuded sap.**
- **Some larvae are predatory**
- **Those important to stored products are attracted to moldy grains, cured meats, & dried or decaying fruits.**
- **Beetles are oblong with 11-segmented antennae terminating apically in a distinct 3-segmented club.**
- **Elytra are short: 2 or 3 abdominal sternites are always visible.**
- **All tarsi are 5-segmented, w/ the 4th segment shorter than the rest, while the 1st 3 segments are dilated & hairy beneath.**

Corn Sap Beetle

Carpophilus dimidiatus

- Widespread in the tropical, subtropical & warm areas.
- Found in cereals and cereal products, peanuts copra, cotton seed & maize in cobs both in the field & storage; often inhabits rice mills breeding in accumulations of broken rice.
- Not attracted to clean, dry grains in good condition; presence of the insect is an indication of inadequate drying or of damp, even moldy conditions in storage

Corn Sap Beetle, *Carpophilus dimidiatus*

- 2-4 mm long, oblong, shining beetle w/ dark red to nearly black body.
- Elytra truncate, each usually bearing a large central dull orange-yellow spot with indefinite margins.
- Body cuticle is dull & moderately clothed w/ conspicuous pale yellow hairs.
- 11-segmented antennae w/ a compact 3-segmented oval or round club
- In most species, the elytra do not cover the apical two or three segments of the abdomen.
- Eggs are laid on or in decaying plant materials like moldy grain.
- Larva passes through 4 instars in the soft & moldy parts of a fruit
- Pupa is generally spent in the soil
- Female lays about 1,000 eggs over 3-4 months; adults fly readily, congregating at suitable breeding and oviposition sites.

11. Scolytidae

- **Beetles of this family are mainly wood & bark borers. Only a few species are associated w/ stored products.**

- **Closely related to Fam. Curculionidae, & some taxonomist classify them as a subfamily of the latter.**

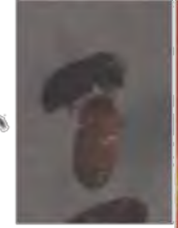
- **Many species are superficially similar to Bostrichidae but they are readily distinguished by anntenal features: in Scolytidae, the first abdominal segment is about a third of the length of the antennae, w/c has a compact 3-segmented club; while in Curculionidae, antennae are elbowed & one-segmented club.**

- ***Hypothenemus hampei* is a serious pest of coffee berries and beans**

Coffee Berry Borer (CBB)

Hypothenemus hampei (Ferr.)




- **Endemic in Central Africa; introduced in the 1920s in Malaysia, Ceylon, India, & in the Phil (1960).**
- **CBB attacks coffee berries in the field; cause severe damage to beans if not treated before storage.**
- **An initial infestation of 20% of newly harvested berries could increase to 100% after 6 weeks of storage.**
- **Larva & adult CBB directly damage coffee by feeding on the tissues of the beans.**
- **Black beetle, subcylindrical and about 1.3 - 1.5 mm long.**
- **Mean life cycle of female is 86.5 d & longevity is 41.60 d while mean life cycle for male is 66.2 d and longevity is 25.83 d.**
- **Average longest female longevity is 156 d.**

12. Silvanidae

- **Small family closely related to the Cucujidae**
- **Beetles are generally parallel-sided, distinctly flattened, & rather short (2-4 mm).**
- **Most species have projections on the prothorax in the form of swellings or teeth in the anterior angle or several teeth along the lateral margin as in *Oryzaephilus.***
- ***Tarsi are all 5-segmented.***
- **Most species are probably predaceous, but two species of *Oryzaephilus* are of great importance as secondary pest attacking broken or milled cereals and oilseeds.**
- **Other species such as *Ahasverus advena & Cathartus quadricollis are found in moldy foods (cocoa, grains* and many others). is a serious pest of coffee berries and beans**

SAW-TOOTHED BEETLE

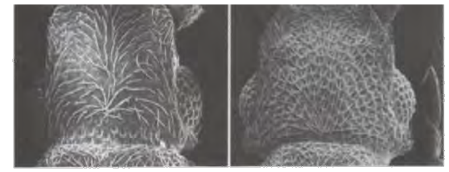
Oryzaephilus surinamensis (L.)

- Slender, dark-brown beetle, about 0.5-3 mm long.
- Cosmopolitan secondary pest of cereals, mainly milled products like flour, breakfast foods, stock & poultry feeds, copra, desicated coconut confectionary, and dried fruits.
- Larva enters damaged & broken kernel to feed especially on the germ.
- Adults & larvae are able to enter small cracks, so they can often attack packaged or nuts in shell.

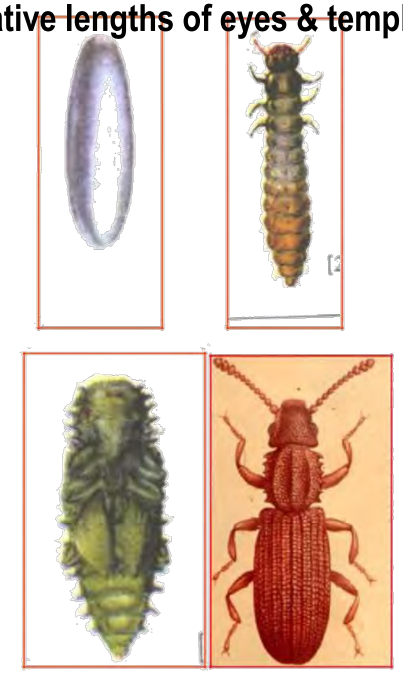
SAW-TOOTHED BEETLE, *Oryzaephilus surinamensis*

- Prothorax has 6 distinctive tooth-like projections along each side
- Antennae are relatively short
- Length of temple (side of head behind the eye) is much shorter in *O. mercator* than in *O. surinamensis*
- Female lays some 375 eggs (at 30^{O}C over a life span of 6-8 months; eggs are laid loosely among the substrate or tucked into crevices in the grain at the rate of 6-10 per day
- The pale yellow, elongate, somewhat flattened larva passes through two to four instars depending on feeding condition & freedom of movement.; full grown larva is about 4-5 mm longFull grown larva pupates within a cocoon-like structure of small grains or food particles
- Development is completed in 22 days at 30 ^{O}C & 68 days at 20 ^{O}C (70% RH).

O. mercator *O. surinamensis*



Relative lengths of eyes & temple



13. Tenebionidae

- **Large family (>10,000) & ~100 species are associated w/ stored products.**

- **Several species are recognized as secondary pests.**

- **Adults vary in size from 3-10 mm long & more or less parallel-sided & nearly always uniformly black or brown**

- **Antennae of most Tenebrionids have 11 segments, of moderate length, generally thickened or clubbed towards the apeces**
- **In most species, each compound eye is partly divided horizontally by a backward projection of the side of the head.**
- **Tarsi of hind leg are 4-segmented; front & middle legs = 5-segmented.**

- **Larvae are cylindrical, yellow to brown, generally well sclerotized, often w/ a distinctly banded appearance & w/ one or two pointed projections (urogomphi) at the end of the body.**
- **Many species =carnivorous, cannibalism is common, some are predators.**

- **Most important genera are *Tribolium, & Latheticus*; less impt: *Alphitobius, Gnatocerus* and *Palorus.***

Red Four Beetle, *Tribolium castaneum*

- Cosmopolitan but is more of a pest in tropical & warm temperate regions.

- Major pest of cereals, cereal products, legumes, oilseeds, nuts, spices & animal products.

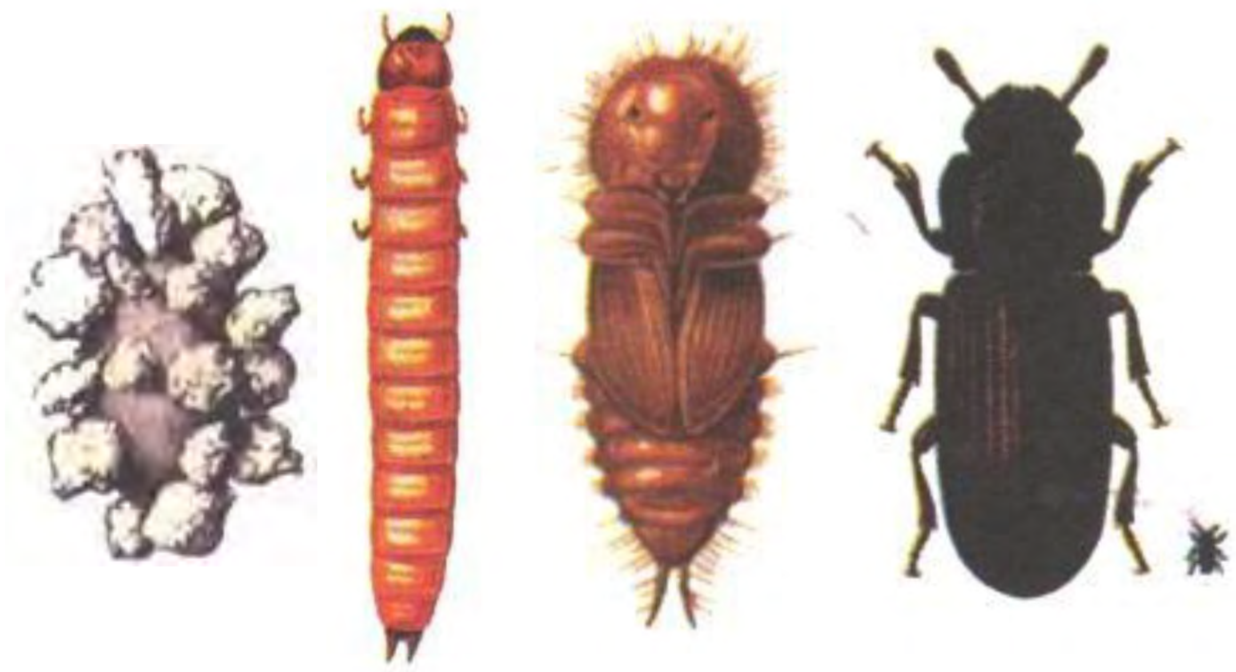
- Benzoquinones secreted by the adults produce an unpleasant odor under high population.

- Reddish-brown beetle; 2.3-4.4 mm long.

- Appearance is similar to *T. confusum*, but antennae has distinct 3-segmented club.

Confused Flour Beetle

Tribolium confusum



T. confusum

T. castaneum

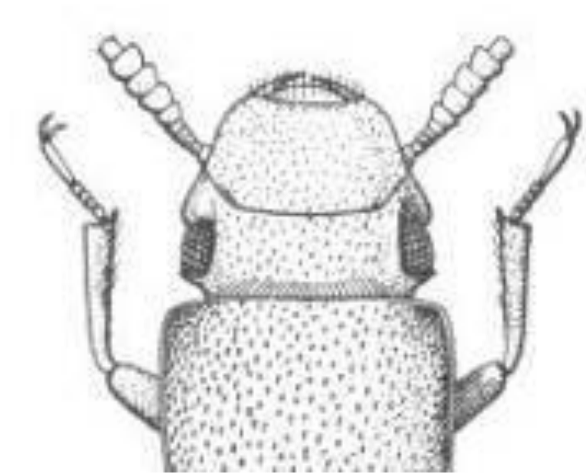
- **Abundant in temperate regions & is less frequently found in the tropics**
- **Antennae have no distinct club, that expands gradually**

Long-headed Flour Beetle

Latheticus oryzae

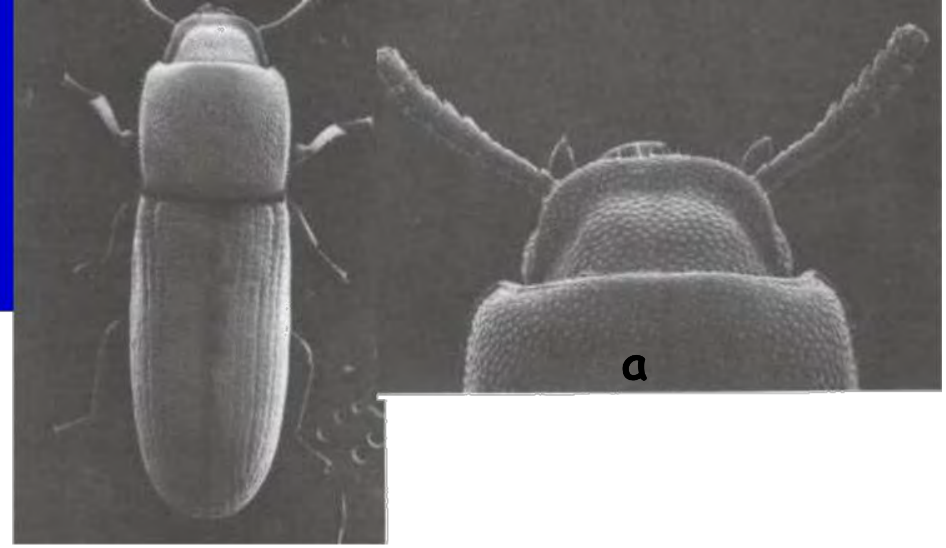
- Cosmopolitan secondary pest of some importance in the tropics & subtropics and especially common in South & Southeast Asia.

- Antennal club has 5 segments w/ terminal segment distinctly smaller than the others.



- Causes damage on whole grains & cereal products & causes same type of damage as that of *Tribolium* spp.

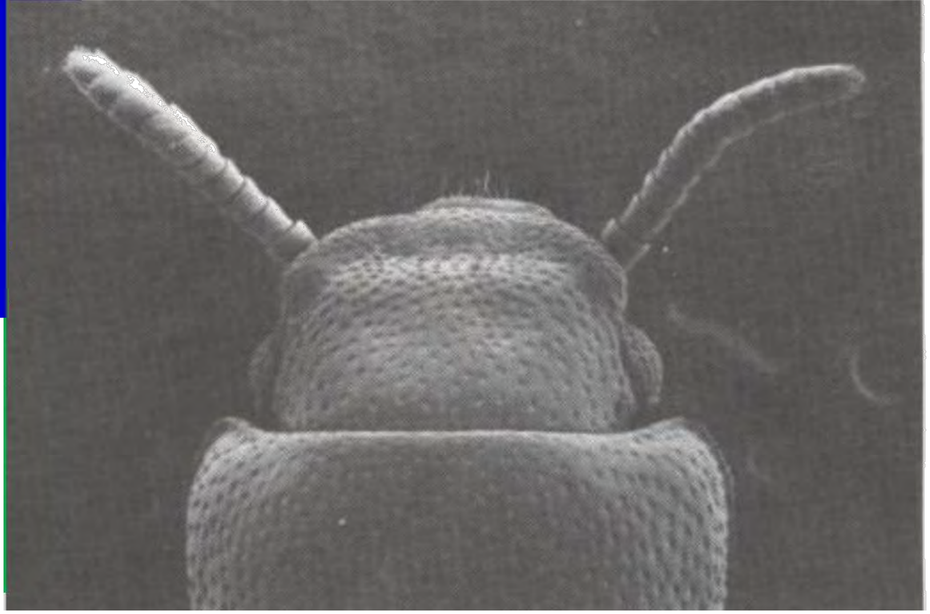
Depressed Flour Beetle
Palorus subdepressus



- **Adult beetle is reddish-brown; 2.7 – 3 mm long.**
- **Head with sides flexed upwards & a distinct ridge above the eye covering the anterior portion (a).**
- **Eyes are large with vertical diameter exceeding the horizontal diameter and completely undivided**
- **Often found in most tropical and subtropical regions.**
- **Minor secondary pest of cereal & cereal products especially the residues of damp & moldy grain; often found in association w/ *Sitophilus* spp.**

Small-eyed Flour Beetle

Palorus ratzeburgii



- Beetle is reddish-brown, flattened and somewhat oblong; 2- 3 mm long.
- Head with sides not strongly flexed upwards while the ridge above the eye is feeble and indistinct.
- Eyes are small and round
- Cosmopolitan but generally most common and more widely distributed than *P. subdepressus*.
- Appears to be of relatively minor economic importance.

14. Trogositidae

- Members vary considerably in size, form and habits
- Adults are obovate (egg-shaped) to parallel without hairs or scales or at most with a very short, microscopic hairs
- Antennae are 11-segmented that terminate in a 3-segmented club
- Elytra completely cover the abdomen
- Tarsi are 5-segmented but the basal segment is sometimes so small that they appear 4-segmented
- Most tropical spp. are often associated w/ decaying wood preying on larvae of other insect pests. Some spp. are mycophagous (fungivorous).

Cadelle Beetle

Tenebroides mauritanicus

- Cosmopolitan; infests various commodities especially cereals & cereal products
- Excessive feeding by adults & larval feeding lowers germination
- Large (7-11 mm long), shining dark brown-black & dorsoventrally flattened
- Prothorax w/ base distinctly separated from abdomen by a narrow neck & w/ distinctive forwardly projecting front angles; elytra possess longitudinal ridges
- White eggs are laid in clusters in food material; hatch from 7-10 d
- Larva completes its growth from 2-14 mos then pupates in secluded place
- Female lays about 1,000 eggs under favorable conditions
- Both larvae & adults can live for considerable period w/o food

Stored Product Lepidoptera

Moths, skippers and butterflies; few species of moths are known as storage pests.

Families Gelechiidae & Pyralidae: most important

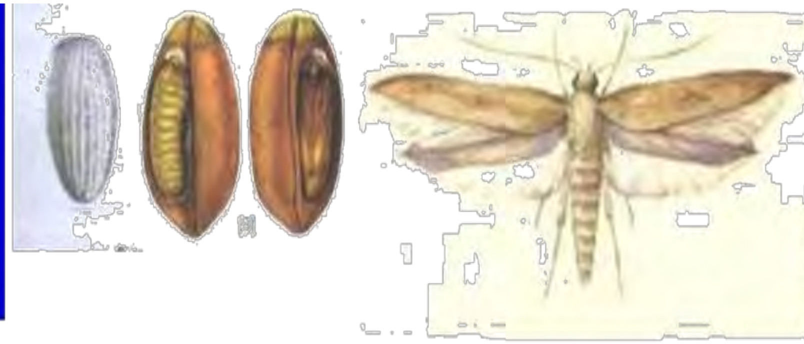
Family Gelechiidae

Have long recurved labial pulps, a proboscis that is densely covered with scales and pointed wing tips.

***Sitotroga cereallela* and *Pthorimaea opercullela* are important in Southeast Asia.**

Angoumois Grain Moth

Sitotroga cerealella (O.)



- Important primary pest of cereal grains in the tropics & in warm temperate regions

- Moth is a good flier attacking standing crop in the field & infestation is carried over to storage

- Moth is yellow-brown w/ a wing span of 10-18 mm

- Forewings have a small black spot in the distal half; hind wings have long fringe of hairs, longer than half of the wings & are sharply pointed at the tip

- When moth is at rest, wings are folded in sloping manner over the abdomen, antennae point backward & are slightly raised above the wings, while the long, slender & pointed labial palpi are raised upwards like two horns.

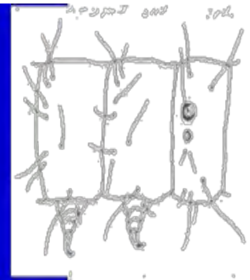
Stored Product Lepidoptera……… continuation

Family Pyralidae

- **All have straight or recurved labial palps & rounded wing *tips***
- **Include *Corcyra cephalonica, Doloesa viridis, Plodia interpunctella, Ephestia cautella* and *E. elutella***

Rice Moth

Corcyra cephalonica






- **Found throughout the humid especially in South & SE Asia; widespread & common in Africa.**
- **Common pest of rice, corn, sorghum, millet & other cereals; other commodities such as cocoa, copra, legumes, dried fruits, nuts & spices are known to support infestation.**
- **Adult moth is nocturnal and short-lived.**
- **Webbings formed by larvae are tough &closely woven, later tightly matted together w/ the food particles, frass & cast skins; this white aggregation characterizes the infestation of this moth & most distinctive when attach to bag surfaces; the last instar larva pupates w/in this aggregation.**

Rice Moth

Corcyra cephalonica (Stain.)

- Medium-sized w/ a wing span of 15-20 mm.
- Forewings are uniformly greyish-brown w/ thin vague lines of darker brown along the veins while the hind wings are pale buff; fringes along the wing margins are relatively short.
- Female labial palps long & pointed while short, blunt & inconspicuous in male.
- Larvae are generally creamish-white except the head capsule & prothoracic tergite w/c is brown;
- There are well-developed prolegs on abdominal segments 3-6 and 10.
- With a conspicuous seta above each spiracle; on the 8th abdo.segment, this seta arises from a clear patch of cuticle surrounded by a ring.
- Female lays an avg. of 154 eggs w/ a max. of 268 eggs; hatch in 3-9 d.
- w/ 7-8 larval instars; larval period is 29-50 d in female & 28-46 d in male.
- Pupal period is 6-11 days for both sexes.

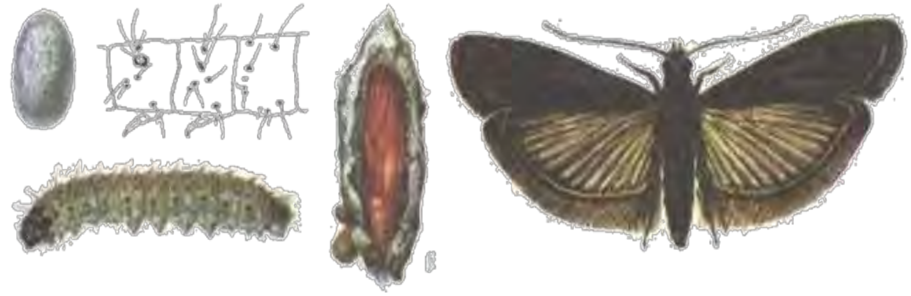
Cacao Moth

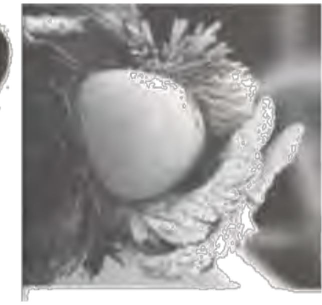
Ephestia cautella

- Found throughout the tropics & subtropics but is rather less common in arid areas.
- Serious pest of wide range of commodities especially cereal flours & cereal products, nuts, cocoa, dried fruit, spices, etc; in the Phil, it is a common pest of cocoa beans, frequently found in milled rice and corn.
- Adult forewings are greyish-brown w/ indistinct pattern; wing span is 11-20 mm & both fore & hind wings have broadly rounded tips & only short fringes of hairs.
- Labial palps curve upward in front of the head, rather blunt at the tip

Cacao Moth

Ephestia cautella





- Female lays up to 300 eggs on stored commodity for the first 3-4 days & few in the remaining 4-5 days of life; hatch in ~3 d at $30^{o}C$.

- Normally undergoes 5 larval instars in about 22 days under optimum conditions of $32.5^{o}C$ & 79% RH on the embryo of softer seeds.

- Larva spins silken threads while eating w/c pull the other grains and frass together (webbing) the characteristic infestation of storage moth.

- Before pupation, last instar larva spins a cocoon w/c is both thinner & looser than *C. cephalonica;* pupal period ~7-11 d.

- Under optimum conditions, devt from egg to adult ~29-31 d.

Indian Meal Moth

Plodia interpunctella (Hubner)





- **Cosmopolitan in warm climates but can survive in heated buildings in cool temperate countries.**
- **Although recorded in the Phil. In 1950s, the pest was rarely observed since the late 1970s.**
- **Serious pest of stored grains, legumes, oil & vegetable seeds and of processed and milled products, nuts, dried fruits and chocolates.**

Indian Meal Moth
Plodia interpunctella (Hubner)

- Moth wing span of 20 mm; forewing is cream colored in the basal 2/5; while the rest is red-brown w/ some grey markings.
- The slightly separated labial palps point directly forward like an open beak.
- Larva may be distinguished by the absence of dark spots at the bases of the setae together w/ the evenly thickened and poorly sclerotized rims in the spiracles.
- Female lays up to 400 eggs (average = 212 days).
- At 30oC a & 70% RH, larva undergoes 4-7 molts in ~16 d.
- Pupal period is about 7 d.
- Total development is about 27 d.

Potato Tuber Moth, *Pthorimaea opercullela*(Zeller)

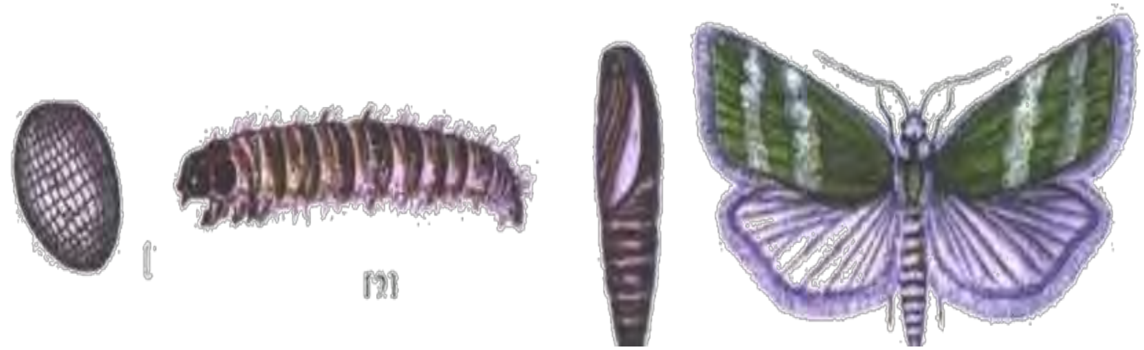
- Cosmopolitan but apparently absent in West Africa; found in Africa, Asia, Australia, Central America & West Indies.
- First recorded in the Philippines in 1966 but could have existed earlier; could have been introduced thru importation of seed tubers prior to World War II from China, Germany, Japan & United States.
- Both a field & storage pest of potato; although it infests growing crops of many species of the family Solanaceae, but it is only a storage problem in potato tubers.
- The 7-9 mm long moth is generally grayish brown but mottled with dark brown.

Potato Tuber Moth, *Pthorimaea opercullela* (Zeller)

- **Hind wings are fringed w/ long hairs & wing span is about 12 mm long; w/ black dots on the forewings.**
- **Female lays ~100-300 eggs w/c hatch in 5-9 days at 20-25^{o}C.**
- **Newly hatched larva is creamy & becomes brownish or yellow pale pink after feeding; undergoes 4 instars in 11-30 days in potato tubers.**
- **Under field conditions, pupal period is 5-12 d; on the growing plant larva passes the pupal stage in curl or rolled leaves.**
- **Life cycle is from 20-65 days in the laboratory**
- **Female life cycle ~41-68 days & the male from 37-53 days**

Green Moth

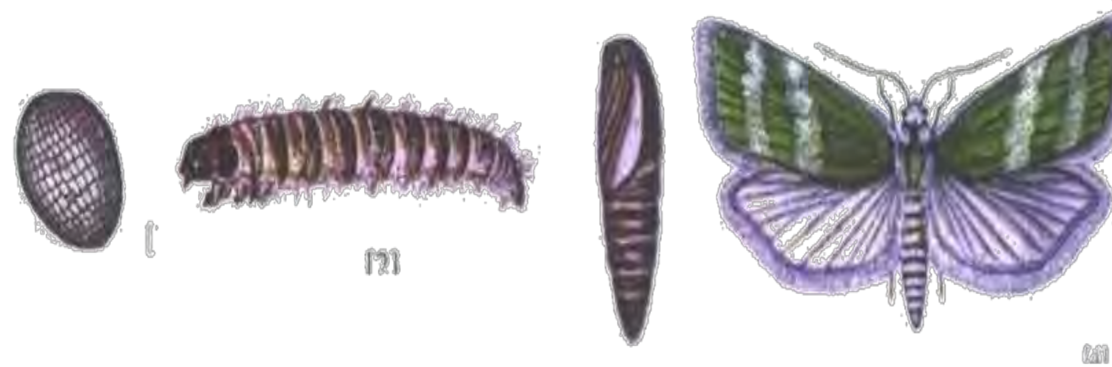
Doloessa viridis (Zell.)



- Found in rice, maize, peanut & copra; reported as a potential pest of stored grains, shelled peanuts & dried fruits in Indonesia; & in copra in Malaysia & rice & corn in the Phil.
- In early 1960s, this pest was used for rearing of *Trichogramma* parasitoids in the Philippines;
- became scarce in 1970 & was replaced by *C. cephalonica*.
- Moth wing span of 13-25 mm; easily recognized by its emerald green forewings w/ 4 irregular black patches forming a discontinuous oblique bands across the middle to posterior part of wings; another set of 5 smaller irregular patches form an oblique band across the posterior area of the wings; & 10 irregular black spots form a discontinuous narrow band in the wings.

Green Moth

Doloessa viridis (Zell.)



- Female laid an avg. of 87 eggs w/c hatch in 6-7 days.
- Passed through six larval instars within 26 to 36 days; feeds on the embryo or softer parts of the seed until it matures, & silk thread spin (webbings).
- Infestation is characterized by the presence of clumps formed by the webbings to w/c the grains & frass adhere, that may ultimately contain the cocoon.
- Larva forms a pupation cell by spreading a mat of web to cover the whole body length; pupal period varies from 7-11 d.
- Adult longevity w/o food is 7 days; total life cycle in rice ranges from 43-54 d (avg = 47 d)

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

SESSION 7

DISSECTION OF GENITALIA

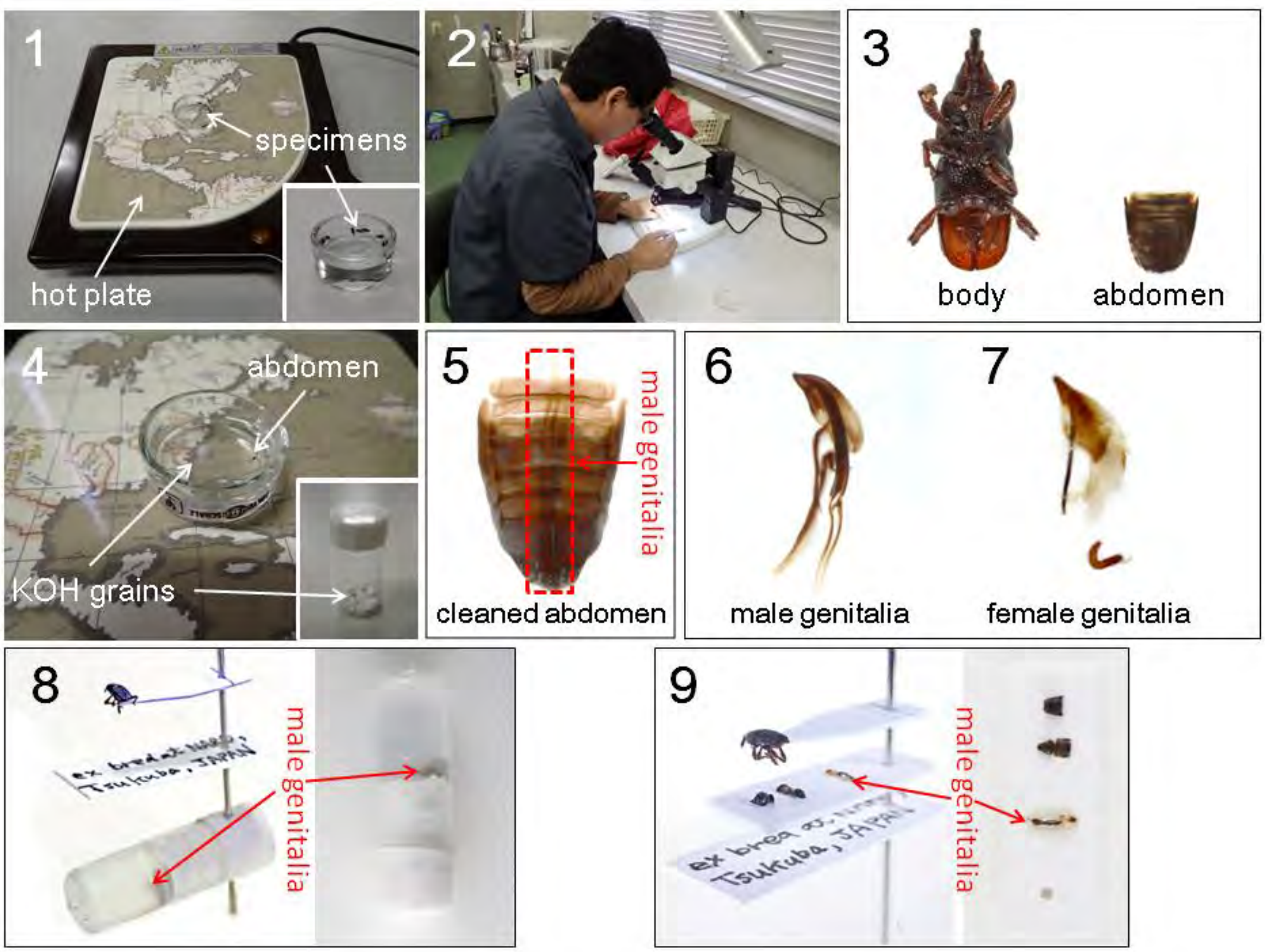
Lecture Notes by:

DR. HIRAKU YOSHITAKE
Institute for Agro-Environmental Sciences
NARO, Tsukuba, Japan

DISSECTION OF GENITALIA

Procedure

1) To examine male and female genitalia, specimens are macerated in hot water (Fig. 1) for 10 minutes to 24 hours, depending on the condition of each specimen.
2) Each specimen is dissected under the stereoscopic microscope, using a pin and tweezers (Fig. 2).
3) The abdomen (or a part of abdomen) is removed from the body (Fig. 3).
4) The abdomen is cleaned in hot 10% KOH solution (Figs. 4, 5) for 2 to 15 minutes, depending on the condition of each specimen.
5) The male and female genitalia extracted from the abdominal segments are mounted on hole slides with glycerol (male; Fig. 6) or water (female; Fig. 7), and examined with stereoscopic or optical microscope, depending on the size of each specimen.
6) After examination, the male and female genitalia (as well as abdomen) are preserved in microtubes with glycerol (Fig. 8) or glued to cards (Fig. 9) and pinned with the body of each specimen (Figs. 8, 9).



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SESSION 8

PRESERVATION TECHNIQUES

Lecture Notes by:

DR. SHERYL A. YAP

Institute of Weed Science, Entomology and Plant Pathology College of Agriculture and Food Science
University of the Philippines Los Baños

COLLECTION AND PRESERVATION METHOD

SHERYL A. YAP ***Ph.D.***

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science, UP Los Baños Los Baños, Laguna, Philippines sayap3@up.edu.ph

TRAINING WORKSHOP ON DIAGNOSTICS OF WEEVILS OF QUARANTINE IMPORTANCE (Proj. No. AGF/CRO/11/007/REG)

10-22 July 2017, IWEP, CAFS, UPLB, PHILIPPINES

Funded by: Japan – ASEAN Integration Fund (JAIF)

Through: ASEAN Plant Health Cooperation Network of the ASEANET (APHCN-ASEANET)

Where Weevils can be found?

Locating insects:

Weevils can be found almost anywhere in the world.

Weevils are commonly found in:

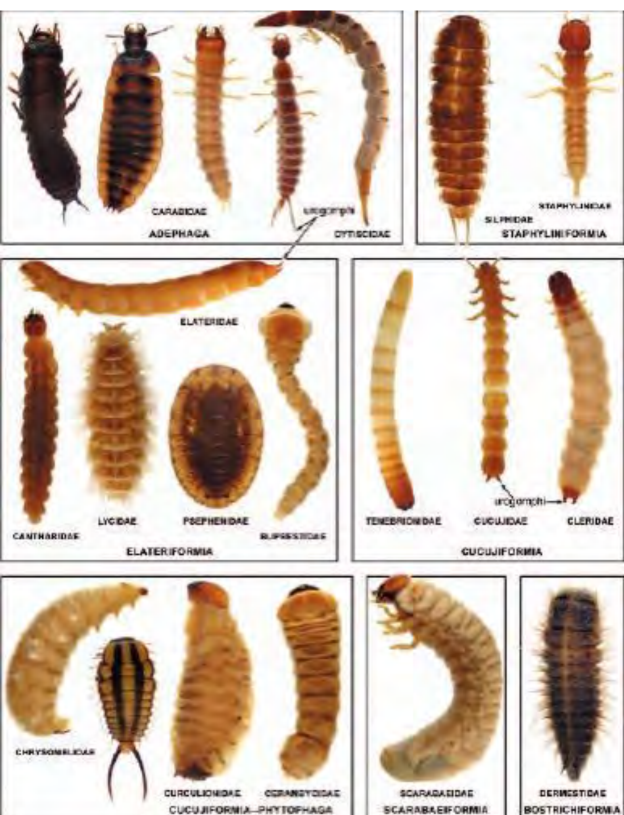
- ***flower and vegetable garden***
- ***grasses in lawns and fields weeds***
- ***bushes***
- ***fruit and shade trees***
- ***storage facilities***
- ***homes***

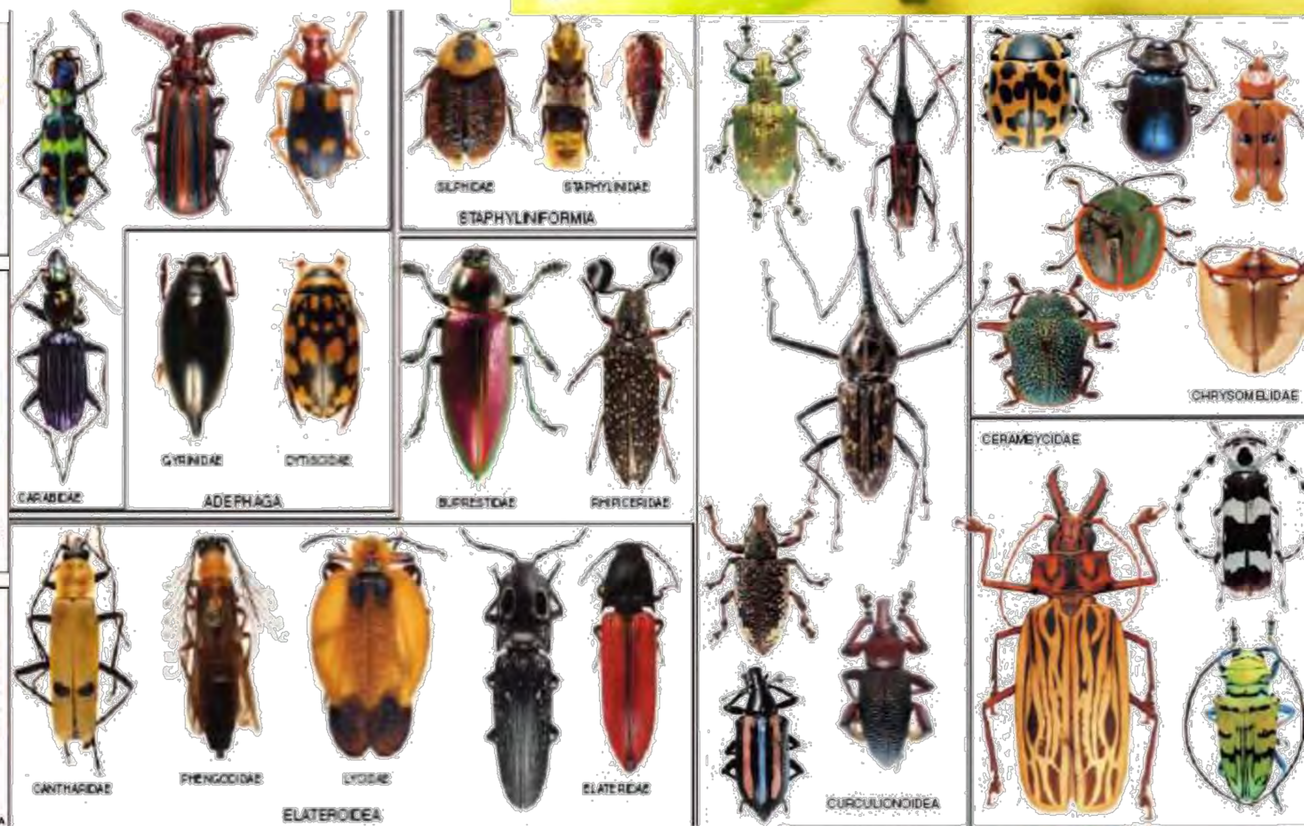
COLEOPTERA

beetles

weevils

Pinterest





COLEOPTERA

- **forewings: modified into hard plate-like coverings**
- **hindwings: membranous**
- **chewing mouthparts**

Habitat: **All habitats**

Equipment to use: **Sweep nets, light, traps**

Collection method: **Beating, sweep vegetation, examine trap samples, hand pick**

Preparation: **Pin adults, larvae 80-85% EtOH**

COLLECTION OF SPECIMENS

Beating

Sweeping

Traps

Sex pheromone trap

Pecan weevil trap

PRESERVATION AND STORAGE OF SPECIMENS

PRESERVATION OF SPECIMENS

TEMPORARY STORAGE

- Refrigeration

  a. medium-sized to large specimens may be left in tightly closed bottles for several days in a refrigerator and still remain in good condition for pinning

  b. After refrigeration, moisture must be removed by drying or by placing an absorbent paper

TEMPORARY STORAGE

- Dry preservation

  a. Place in small boxes, paper tubes, triangles, or envelopes for an indefinite period

  b. To allow specimens to become dry

  c. Under the sun or oven

STORAGE OF SPECIMENS

TEMPORARY STORAGE

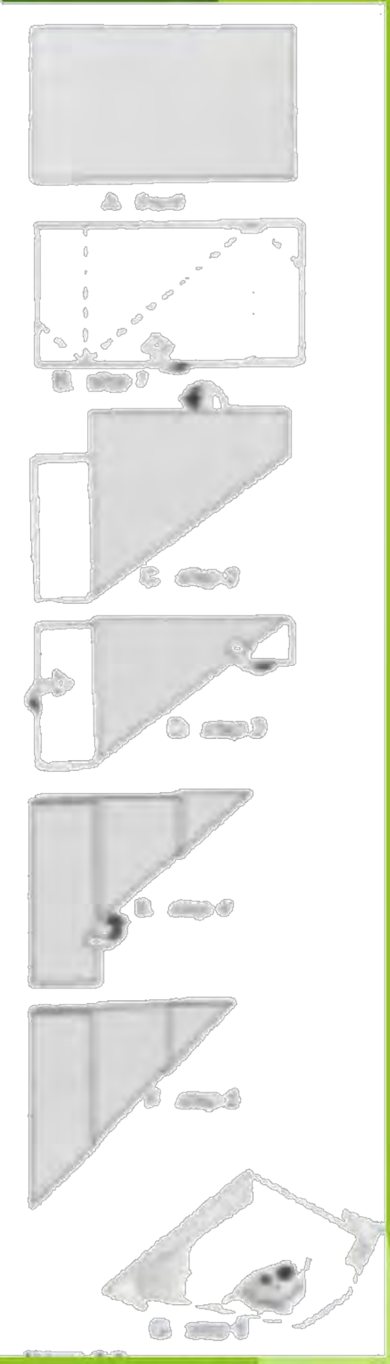
- **Dry preservation**

- Small boxes, paper tubes or triangles, or envelopes
  - **NO** - Soft-bodied insects
  - **NO** - Tightly closed, impervious containers of metal, glass or plastic
  - **NO** – specimen collected at different times or places in the same container
  - **Can be layered in the same container** – each layer with data

TEMPORARY STORAGE

Papering

- Do not pack specimens together
- No – airtight containers or envelopes



MOUNTING/PERMANENT PRESERVATION

a. so that they may be handled and examined with the greatest convenience

b. with the least possible damage

" The value of specimens may depend on how well they are preserved."

MOUNTING/PERMANENT PRESERVATION

- Dry specimens
  - must first be relaxed so that body and appendages will not break
  - it can also be rearranged and repositioned

MOUNTING/PERMANENT PRESERVATION

- **Liquid-preserved specimens**

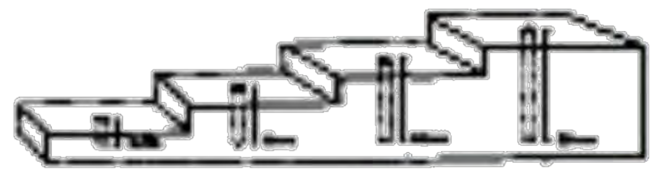
  a. for soft-bodied specimens

  b. it can also be rearranged and repositioned

  c. stored in small containers or vials with ethyl alcohol or other preservatives

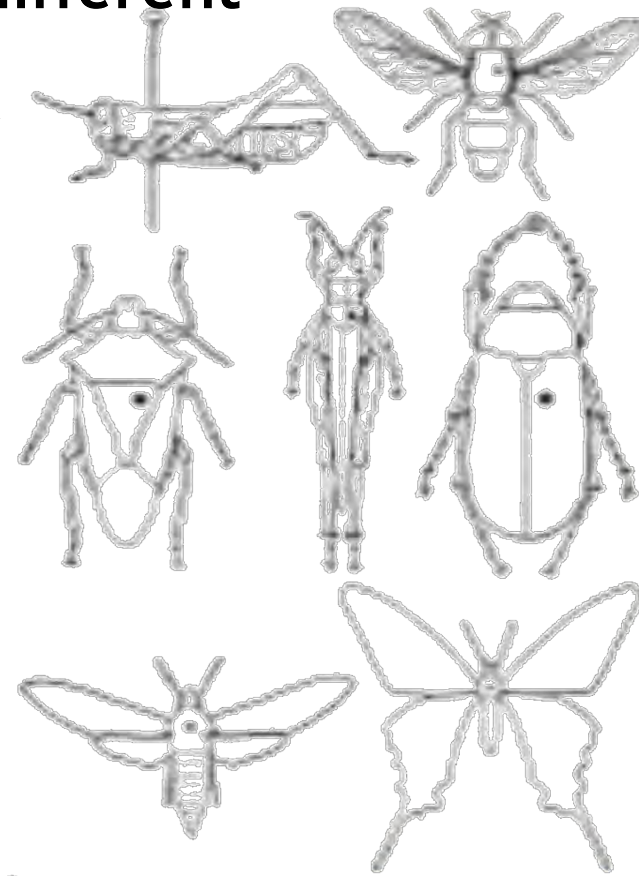
- **Slide mounting**

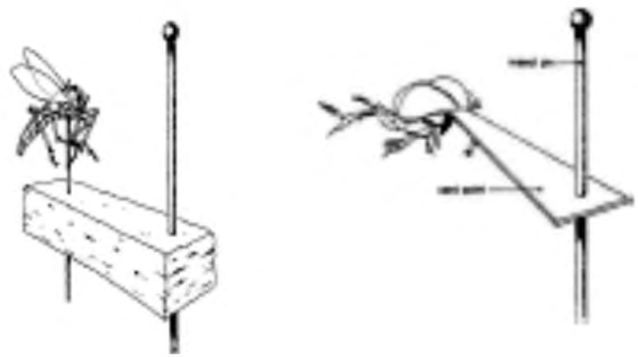
  a. for small and minute specimens such as mites



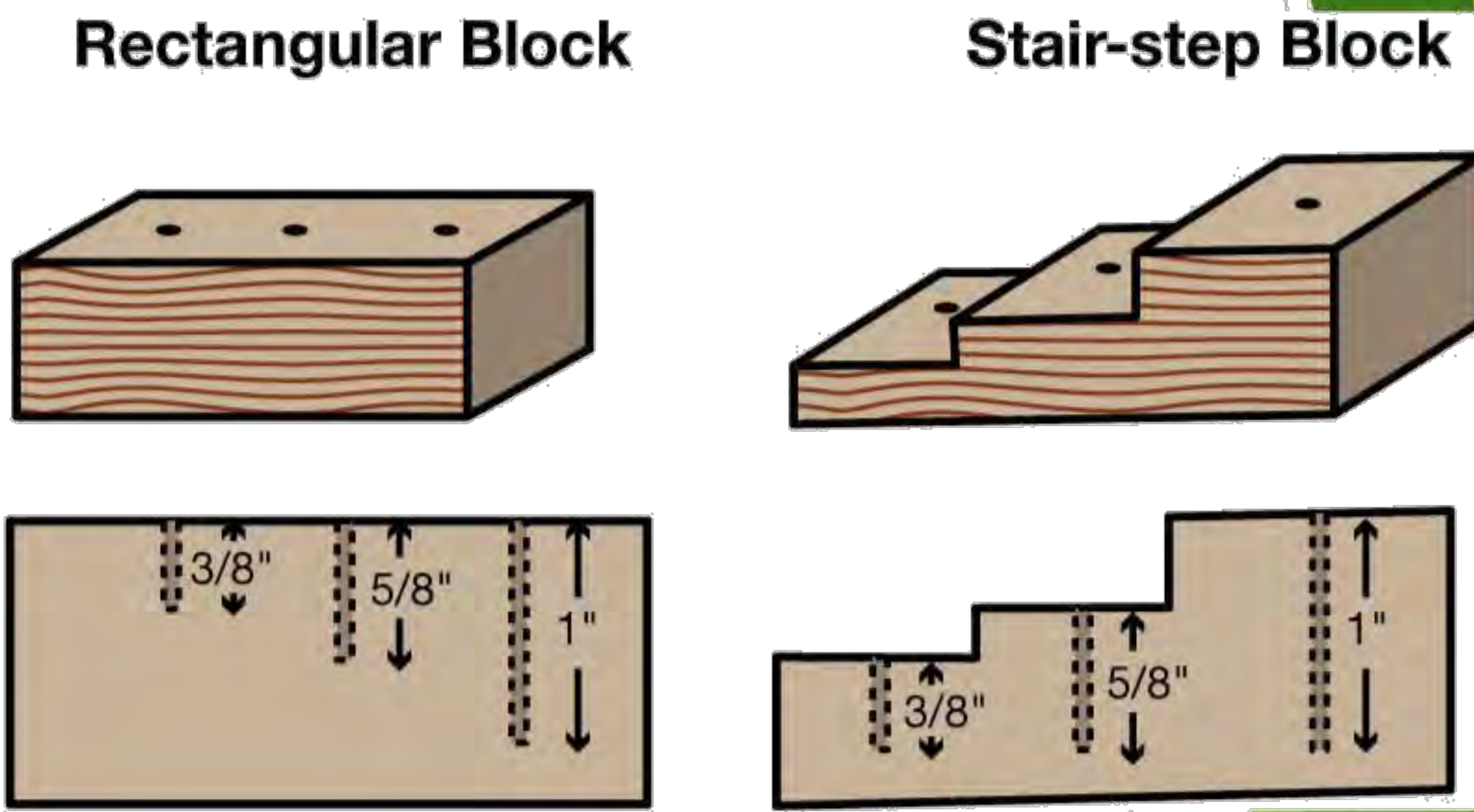
PINNING (INSECTS)

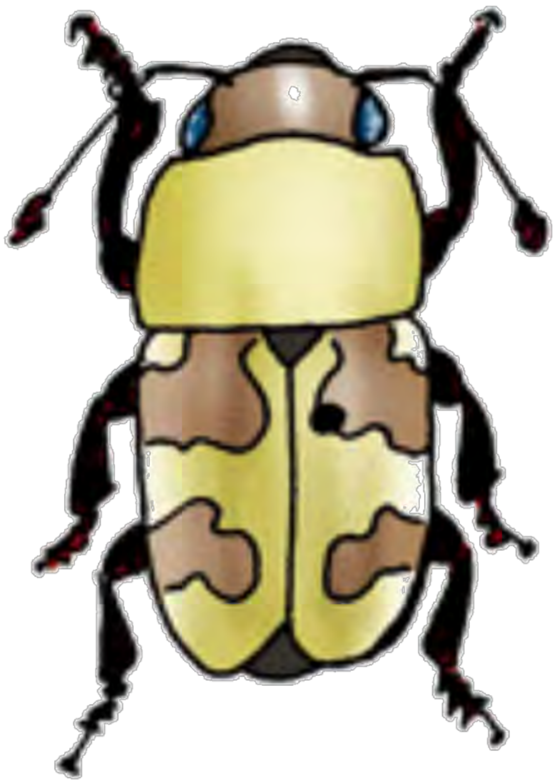
a. insect pins are available in different sizes b. made of stainless steel





Pinning Blocks



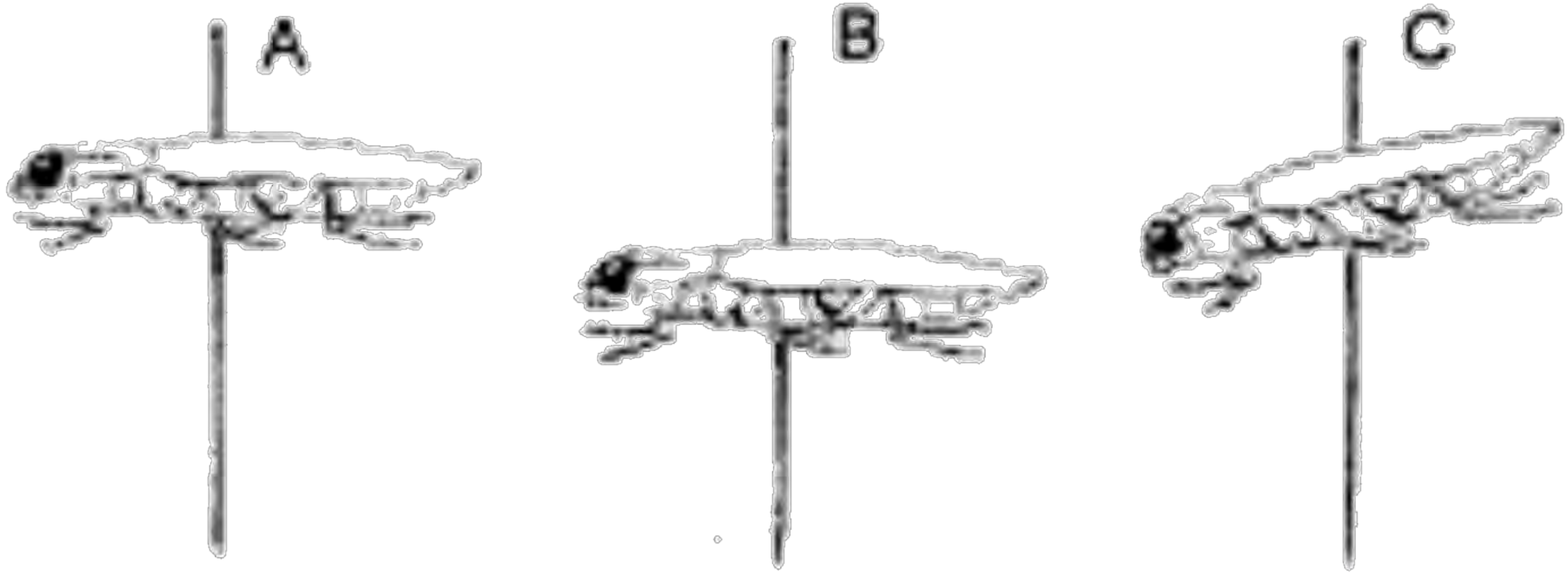


Large Coleoptera

Right forewing (wing cover or elytron) near the base.

Do not spread the wings of beetles.

Which is correctly pinned?

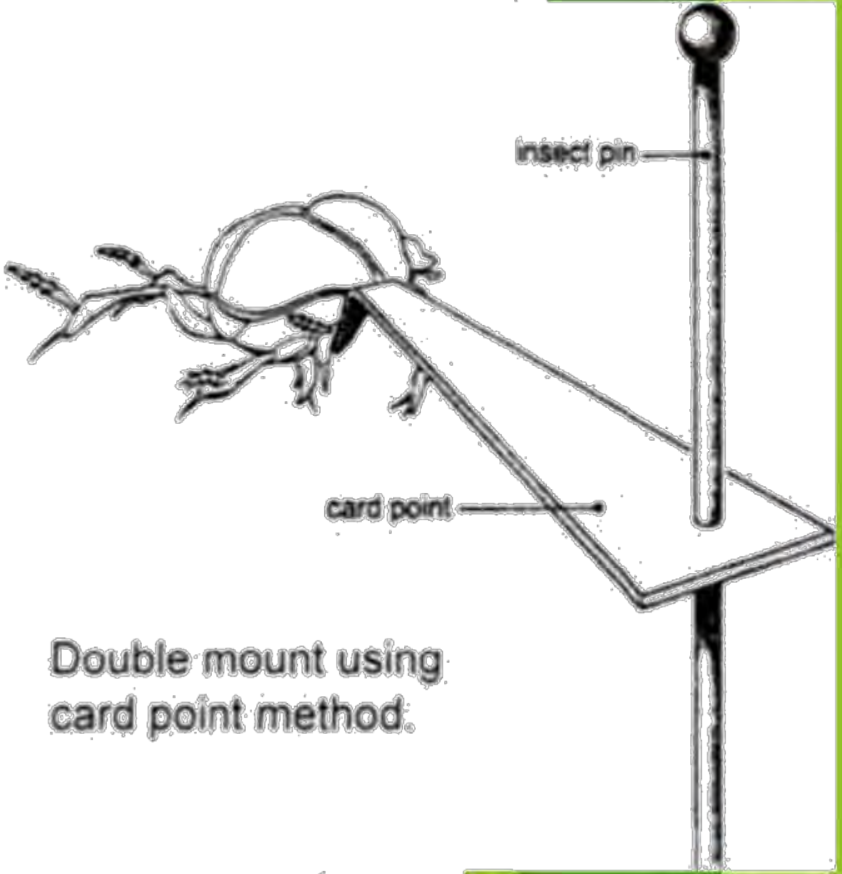


A. correctly pinned specimen
B. specimen mounted too low
C. specimen not level

STORAGE OF SPECIMENS

Double mounts

- for insects that are too small to be pinned directly on standard pins – minuten pin or card points (acid-free)
- Adhesive - white glue or carpenter's glue – soluble in a solvent
- Right side of the specimen, with the left side and midventral area clear
- Card point - side of the thorax not on the wings



Double mount using card point method.

LABELING

- it is important so that specimens will have a scientific value

a. paper must be 100% rag content – not acidic

b. pens must have a permanent ink and will not “run” or blot

c. labels must be lettered carefully – readable

d. size must be relative to the specimens – not too small, not too large

Label data includes:
- Locality
- Date of collection
- Name of collector
- Other useful data such as host plants, etc

Philippines: Luzon Is. Brgy.
Pinaglubayan, Polillo, Quezon
March 12, 2001
SA Yap

LABELING

- Collection data should accompany specimens at all times during preparation
- The label or the information is as important as the specimen

No label, no SCIENTIFIC VALUE

Paper

- An appropriate is important
  - Acid free
  - Made of cotton fibers
  - 100% rag content
  - Should be heavy
  - Surface of the paper should be smooth

Lined ledger paper =100% rag & 36 -pound weight

2-ply Bristol board

Herbarium sheets

Pens

- "rapidograph" or technical drawing pens
- 0.25 mm (no. 000) to 0.30 mm (no.00)

Ink

- India ink
- Permanent
- Will not “run” – placed in jars or vials with liquid preservatives
- Soft lead pencil

Lettered and Printed Labels

- Labels may be lettered carefully by

  - **hand with a fine-pointed pen**

  - **printers - Arial, size 4 to 6**

Size of Labels

- The maximum size of a label should be about **7 x 18 mm**
- **5 lines** or about **13 capital letters**

- Use multiple labels - to accommodate all of the information that must be presented

Label Data

- accurate, concise and unambiguous

Locality

- it can be found in any good map
- Coordinates of latitude and longitude may be given
- Countries: capital letters
- U.S.: capital letters = States

e.g. PHILIPPINES: Laguna, Los Baños,
64km, 14.1667°N, 121.2167°E

Label Data

Date

- Avoid ambiguity
- Cite the day, month and year
- Day and year = Arabic numerals
- Month = Roman numerals
- Hyphens or periods can be place in between

e.g. 01–XII–2012

01.XII.2012

Label Data

Collector

- Very useful
- Last name = spelled out
- Given and middle name/s = initials
- Many collectors = Leader’s name followed by et al.

e.g. S.A. Yap

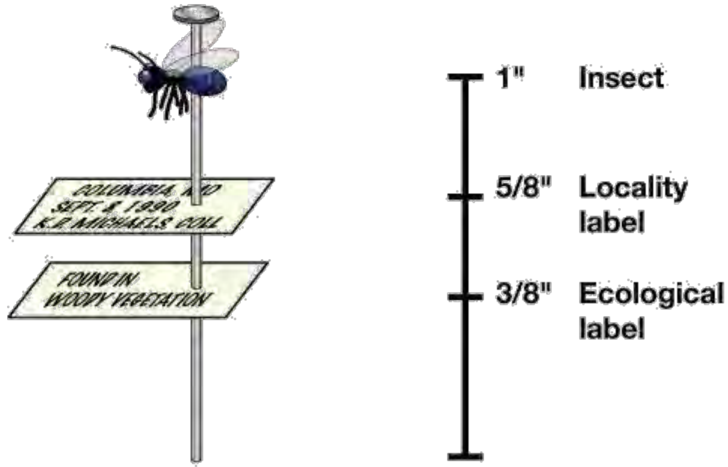
S.A. Yap et al.

Label Data

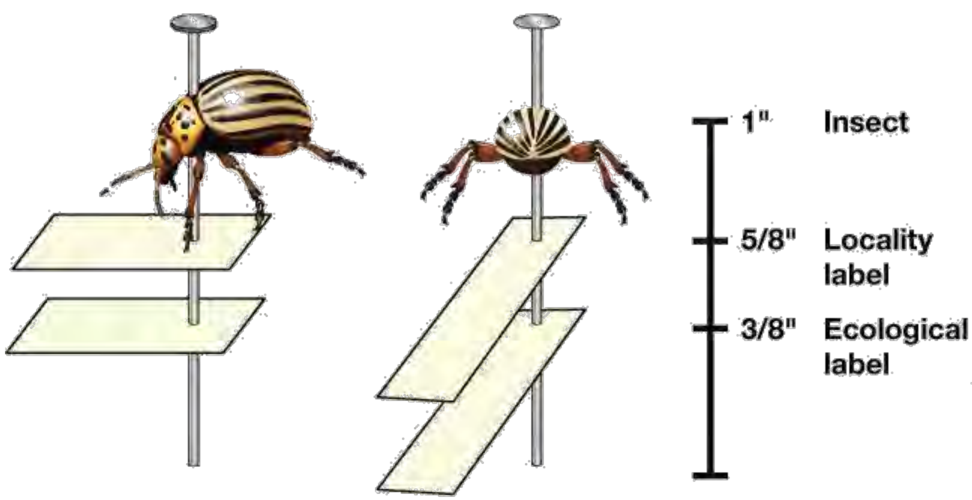
- **Other data**
  - Very useful or relevant to the specimens or collector
  - E.g.: hosts of parasites or host plants = as much as possible do not give vernacular or common names, at least give the genus or family name (Host: *Homo sapiens sapiens)*
  - E.g.: details of the habitat (elevation, ecological types and conditions of collection)

    (1500masl, collected by Malaise trap)

Mounted Insect and Label Placement



A small insect mounted on a point



A properly mounted beetle

Placing the Labels

- use pinning block – desired height

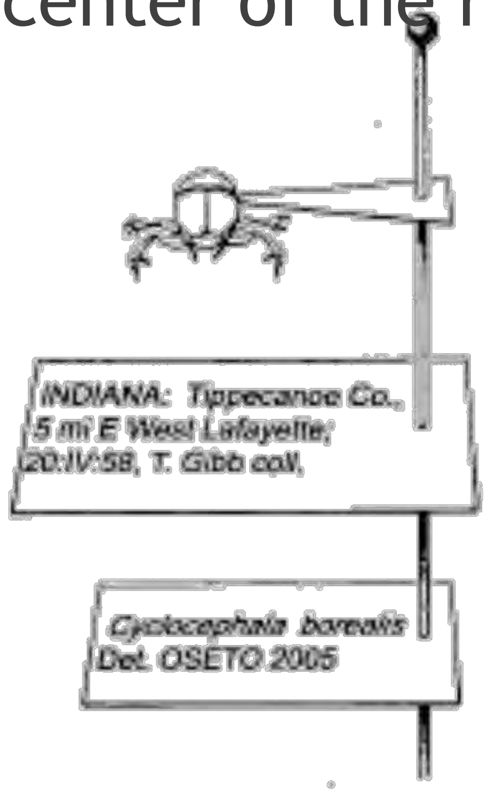
- Direct pinning:
  - Centered under the specimen
  - Long axis (length) = long axis of the specimen
  - Should be aligned transversely at right angles to the axis of the body with the upper margin toward the head

Placing the Labels

- **use pinning block - desired height**

Double-mounted insects:

pin = center of the right side of the label

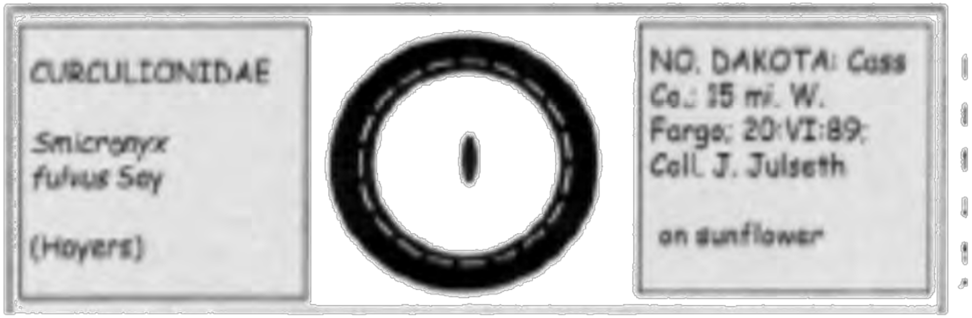


Placing the Labels

- Vials or jars:
  - Large labels that includes all collection data
  - Do not fold the label – minimize damage and loss of small specimens
  - Place labels inside the vials or jars
  - Pencil or ink can be use

Placing the Labels

- Microscope slides:
  - With pressure-sensitive adhesive
  - Left side = taxonomic information
  - Right side = collection information
  - Mounting medium must be included



Placing the Labels

- Identification labels:

  Used when specimens are sent to an expert for identification:

  - All collection data or information must accompany the specimens including field notes if available

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

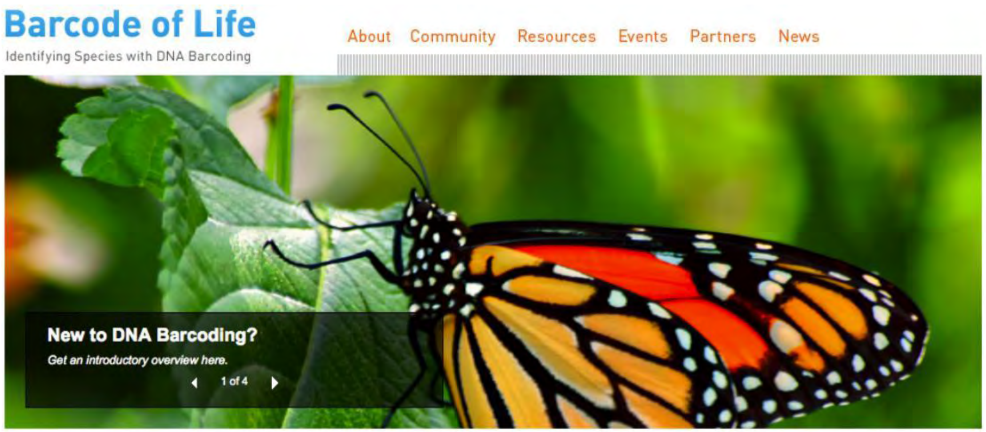
SESSION 9

DNA SEQUENCING

Lecture Notes by:

DR. BARBARA L. CAOILI
Institute of Weed Science, Entomology and Plant Pathology College of Agriculture and Food Science
University of the Philippines Los Baños

DNA Barcodes for Insect Identification



Barbara L. Caoili, Ph.D.

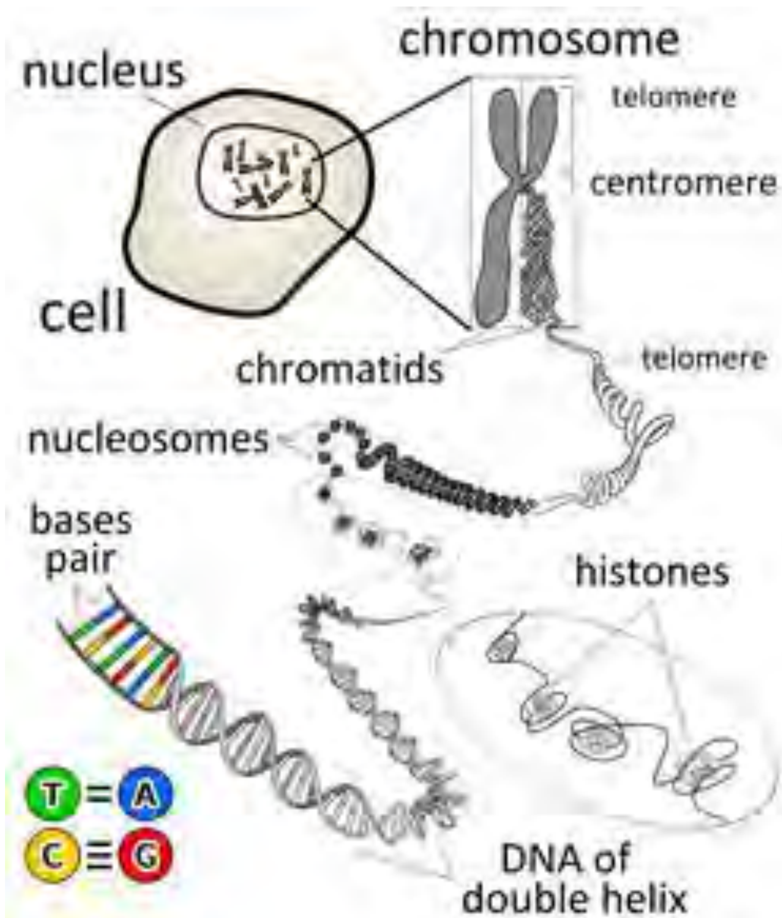
Institute of Weed Science, Entomology and Plant Pathology College of Agriculture and Food Science
University of the Philippines Los Baños

ASEAN Regional Training Workshop on Diagnostics of Weevil of Quarantine Importance
July 10 to 22, 2017
IWEP, CAFS, UPLB

Lecture Outline

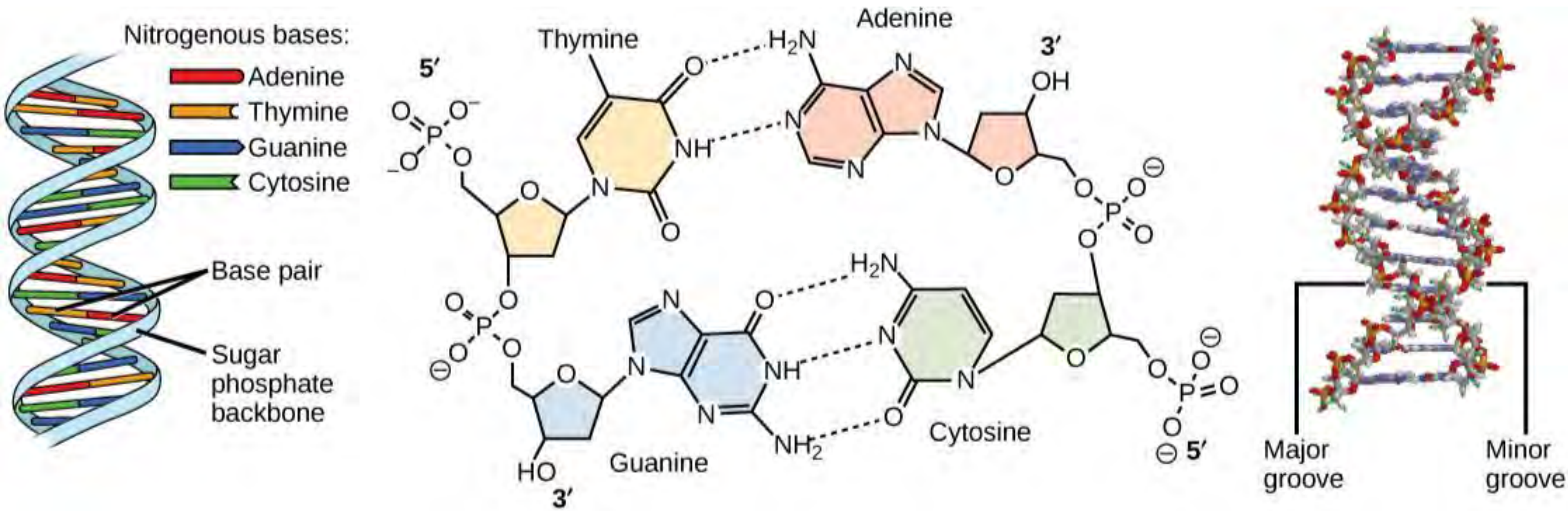
What is DNA?

- deoxyribonucleic acid
- genetic material



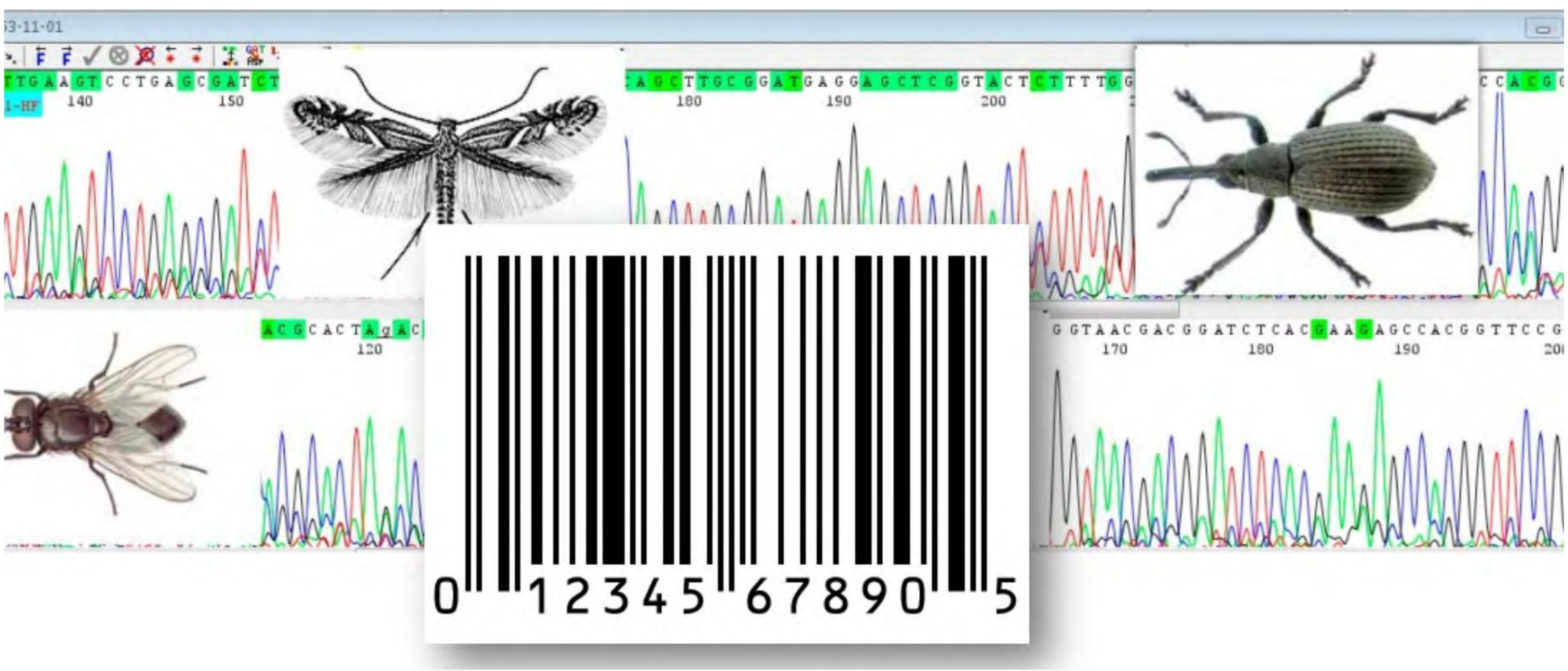
What is DNA?

DNA Structure



What is a DNA Barcode?

A unique pattern of DNA sequence that can identify a species like how the unique patterns in universal product codes identify products



What is DNA Barcode?

- Standardized short sequence of DNA between 400 to 800 bp long
- Can be easily isolated and characterized for all species on the planet
- Used to identify species through reference to DNA sequence libraries or databases

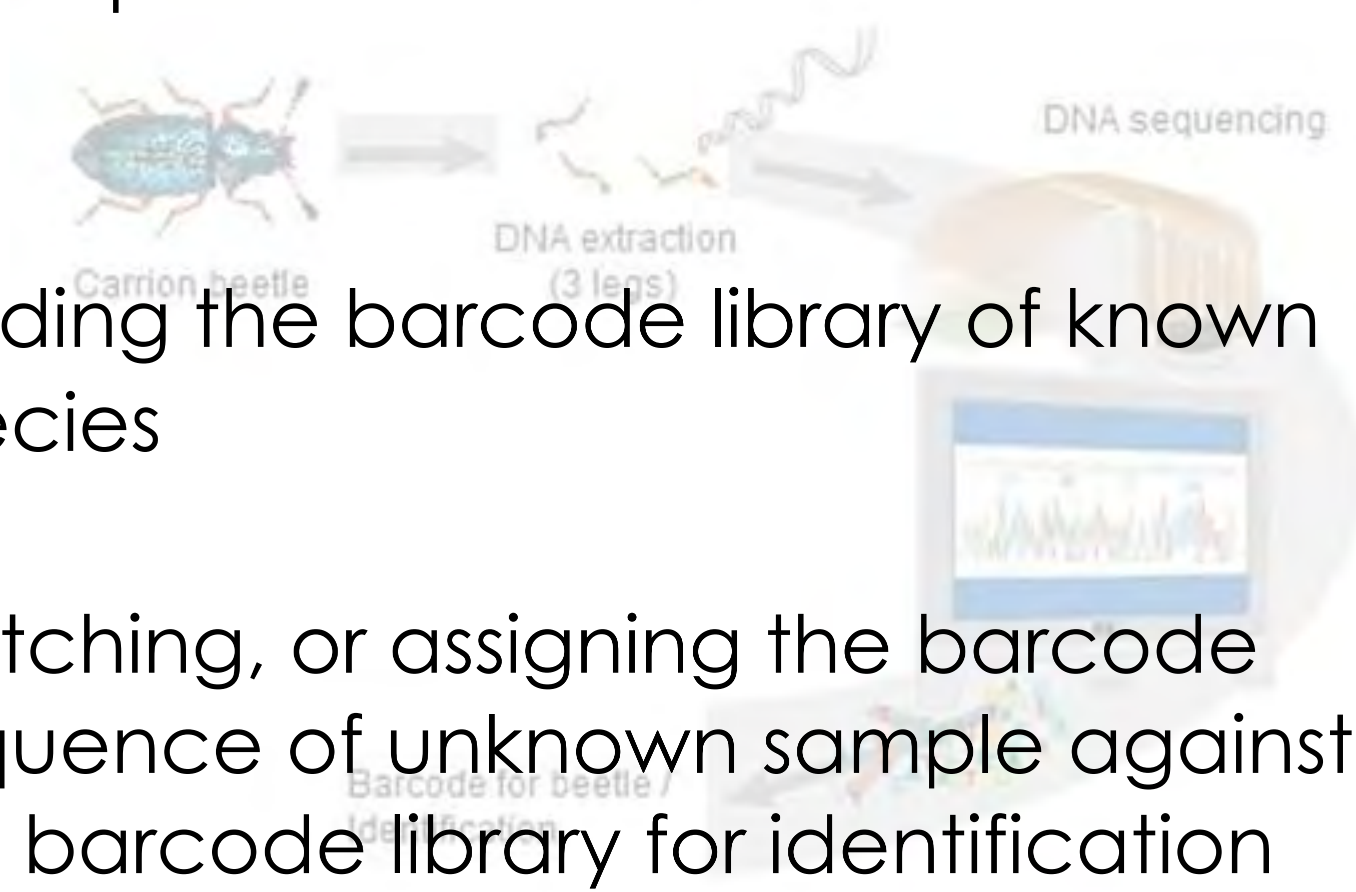
The Uses of DNA Barcodes

As a research tool to:

1. assist taxonomist in species identification
2. identify regulated species (invasive and endangered)
3. survey of arthropods for microbial pathogens
4. test the identity and purity of biological products
5. new and cryptic species discovery
6. address fundamental ecological and evolutionary questions

DNA Barcoding Methods in Brief

Basic Steps:



1. Building the barcode library of known species

2. Matching, or assigning the barcode sequence of unknown sample against the barcode library for identification

What it takes to be a DNA Barcode

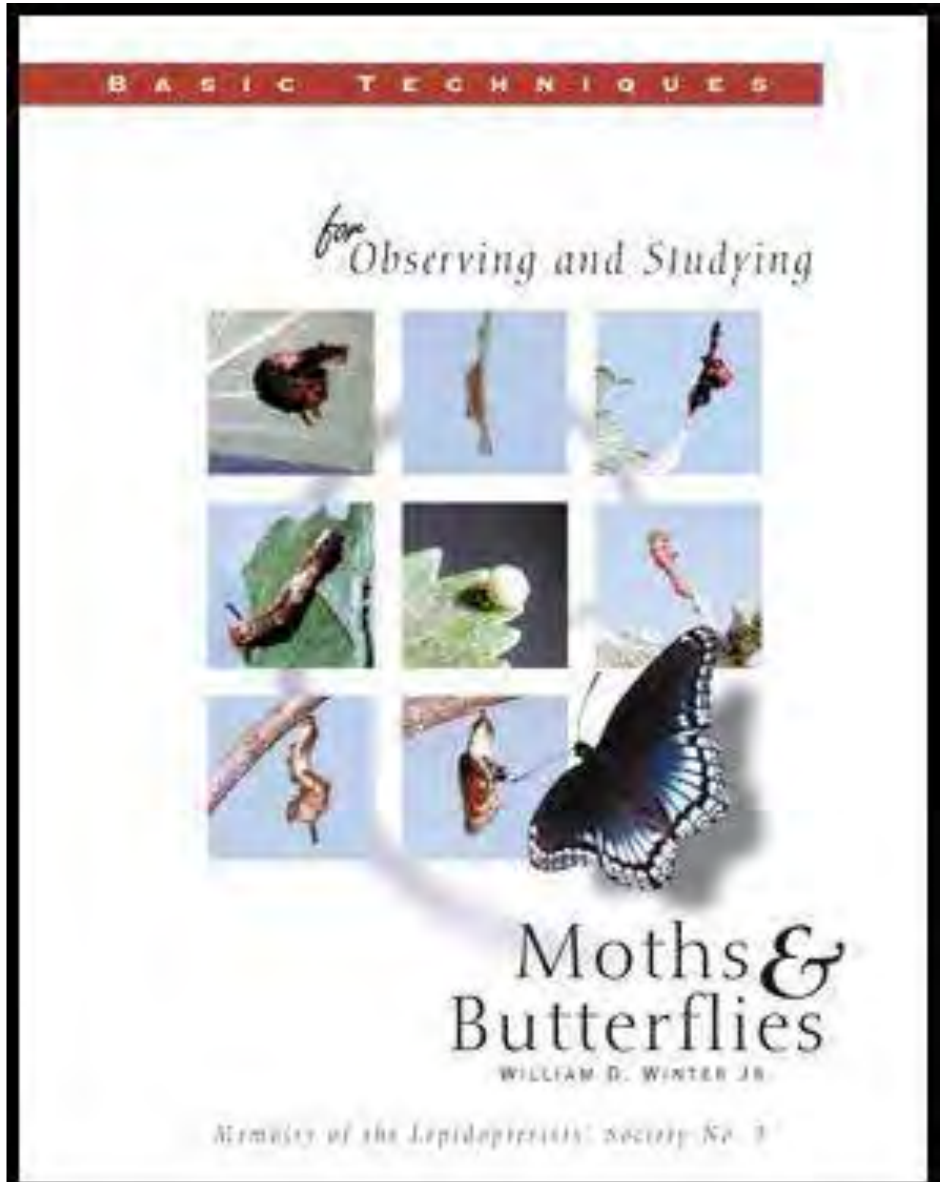
A DNA barcode should:

1. contain significant species-level genetic variability and divergence
2. process conserved flanking sited for developing universal PCR primers for the widest taxonomic application
3. be of appropriate sequence length so as to facilitate current capabilities of

   DNA extraction and sequencing

Specimen Collection

For beginners:



Specimen Collection

Specimen collection information

Specimen/ Field ID	Collectors	Collection Date	Location (GPS)	Notes	Storage Condition
IPL-01	Gelyn D. Sapin	July 17, 2017	47.9053, -124.6261	Light trap	Collected into an individual tube of 99.9% EtOH which was transferred to the -20C freezer on return to lab

DNA Extraction Methods

Basic Steps:

1. Cell lysis
2. Lipid removal
3. Protein removal
4. DNA precipitation

DNA Extraction Methods

Museum Sample: Modified QIAGEN Animal Tissues Spin Column Protocol (Sutrisno, 2012 modified from DNeasy Blood and Tissue Handbook)

Remove abdomen from the specimen

↓

Transfer into sterile microcentrifuge tube

↓

Add 1% PK Buffer (20 ul of Proteinase K (20 mg/ml) in 180 ul ATL Buffer

↓ Incubate at 55°C for 2 to 4 hours

Add 0.1 ml 1% PK Buffer

↓ Incubate overnight at 55°C

Remove abdomen and process following the manufacturer's protocol

DNA Extraction Methods

Fresh or Pickled Sample: Modified CTAB Method (Latina et al., 2017 modified from Clark et al., 2001)

Grind beetles in 500 ul CTAB buffer + 5 ul Proteinase K (20 mg/ml)

↓ vortex, 1 minute

Incubate samples at 65°C for 1 h. vortex every 20 mins

↓ cool down sample at room temperature

Add 10 ul RNAse A (8 mg/ml); Incubate at 37°C for 2 h; vortex every 30 mins

10,000 x g, 10 mins, room temperature

Transfer supernatant into a new microcentrifuge tube with 500 ul chloroform: isoamyl alcohol (24: 1), vortex

10,000 x g, 15 mins, room temperature

Transfer supernatant into a new microcentrifuge tube with 500 ul 100% isopropanol; mix by gentle inversion (30 x)

DNA Extraction Methods

Fresh or Pickled Sample: Modified CTAB Method (Latina et al., 2017 modified from Clark et al., 2001)

Continuation ...

Incubate at 4°C, 2 h

10,000 x g, 15 mins, 4°C

Remove the supernatant & wash DNA pellet with 700 ul 70% ethanol

10,000 x g, 15 mins, 4°C

Remove the supernatant & wash DNA pellet with 700 ul 100% ethanol

10,000 x g, 15 mins, 4°C

Remove ethanol and air-dry, 10 mins

Resuspend DNA pellet in 30 ul TE Buffer

Polymerase Chain Reaction

- *In vitro* technique for amplification of a specific DNA sequence
- Based on the ability of DNA polymerase to synthesize a new strand of DNA complementary to the template strand
- Target DNA sequence can be amplified a billion fold in several hours
- Requires a DNA template and the free 3'-

OH

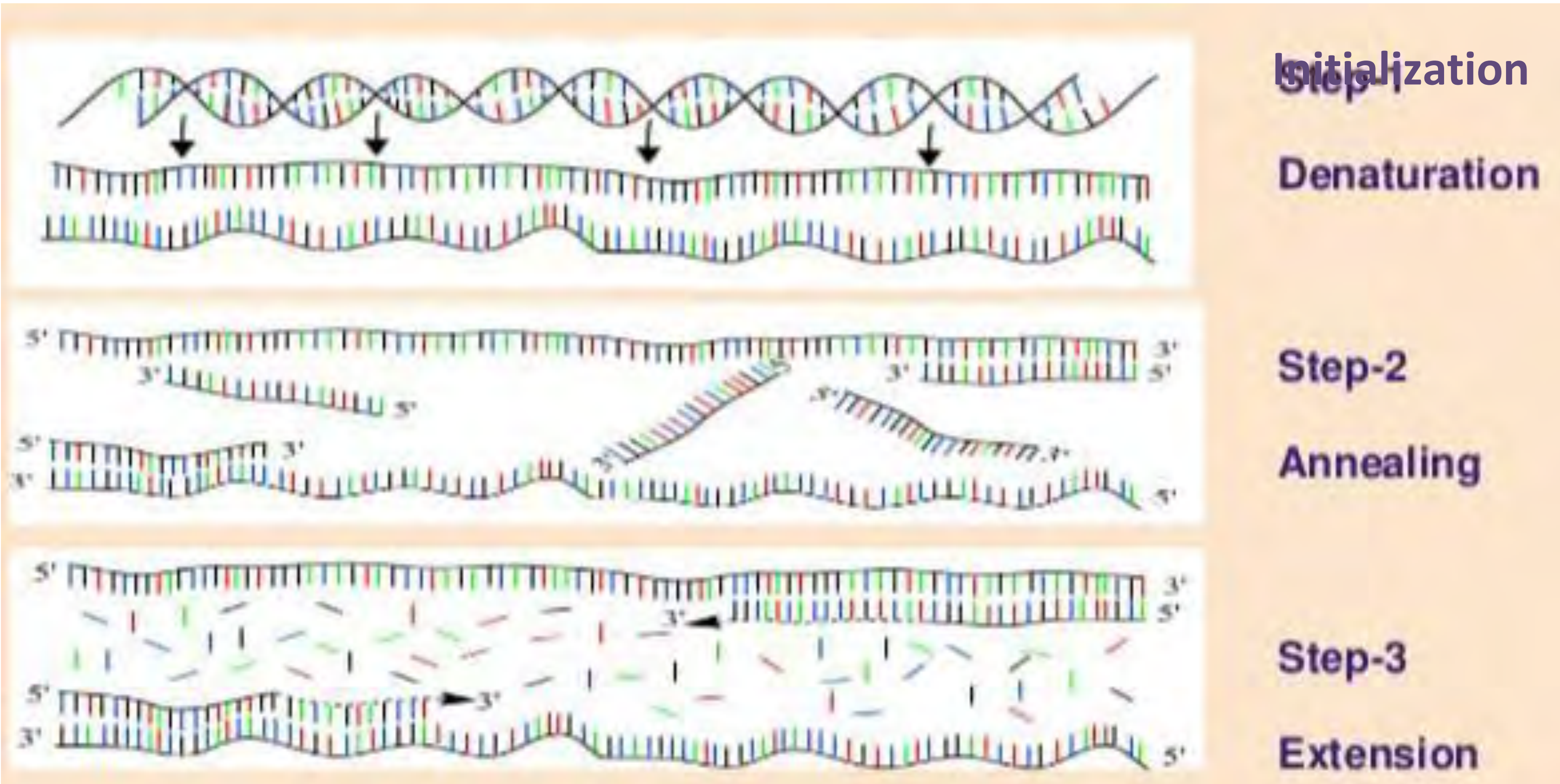
Polymerase Chain Reaction

Components:

1. DNA template
2. Oligonucleotide primers (forward and reverse)
3. Deoxynucleotide triphosphates (dNTPs)
4. Buffer
5. Divalent cations (Mg^{2+} or Mn^{2+})
6. DNA polymerase: *Taq* polymerase
7. Sterile deionized water

Polymerase Chain Reaction

The three-step reaction



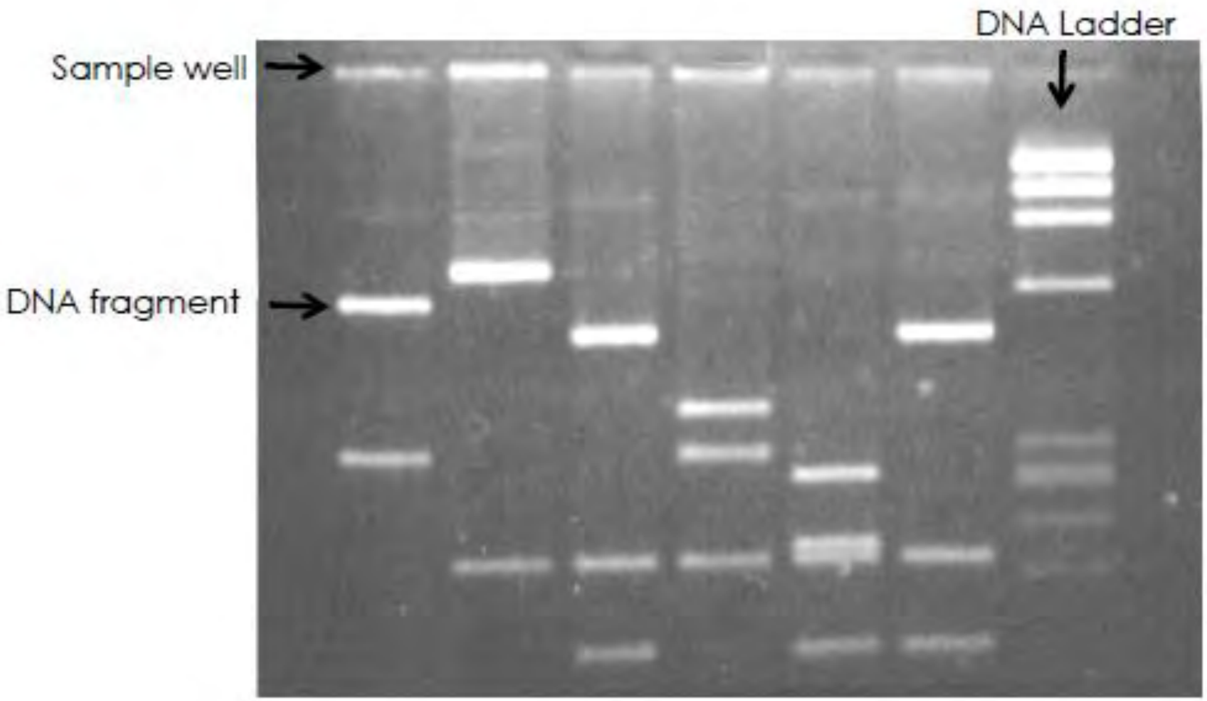
Initialization

Final Elongation

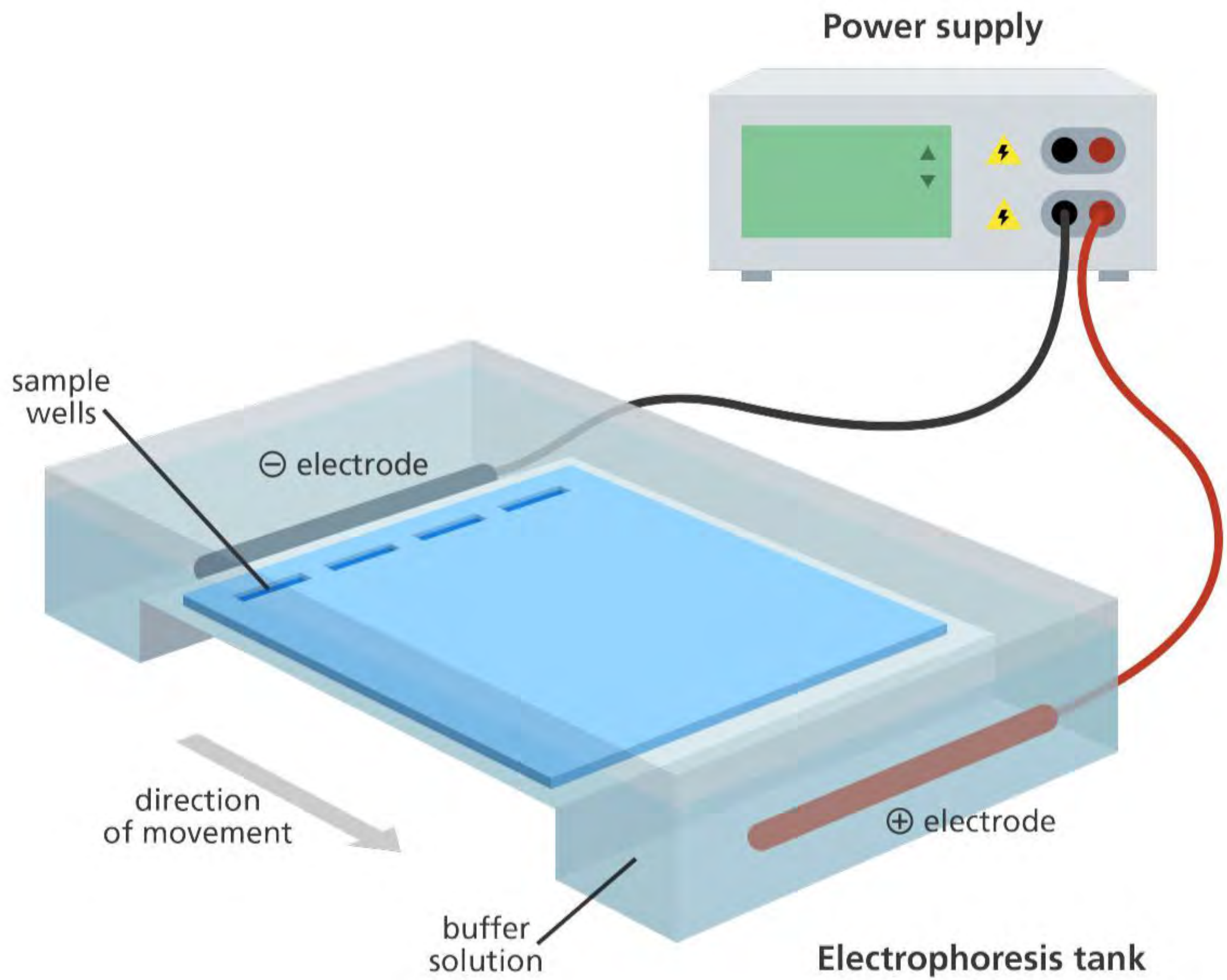
Final Hold

Agarose Gel Electrophoresis

A separation technique based on the mobility of ions in electric field

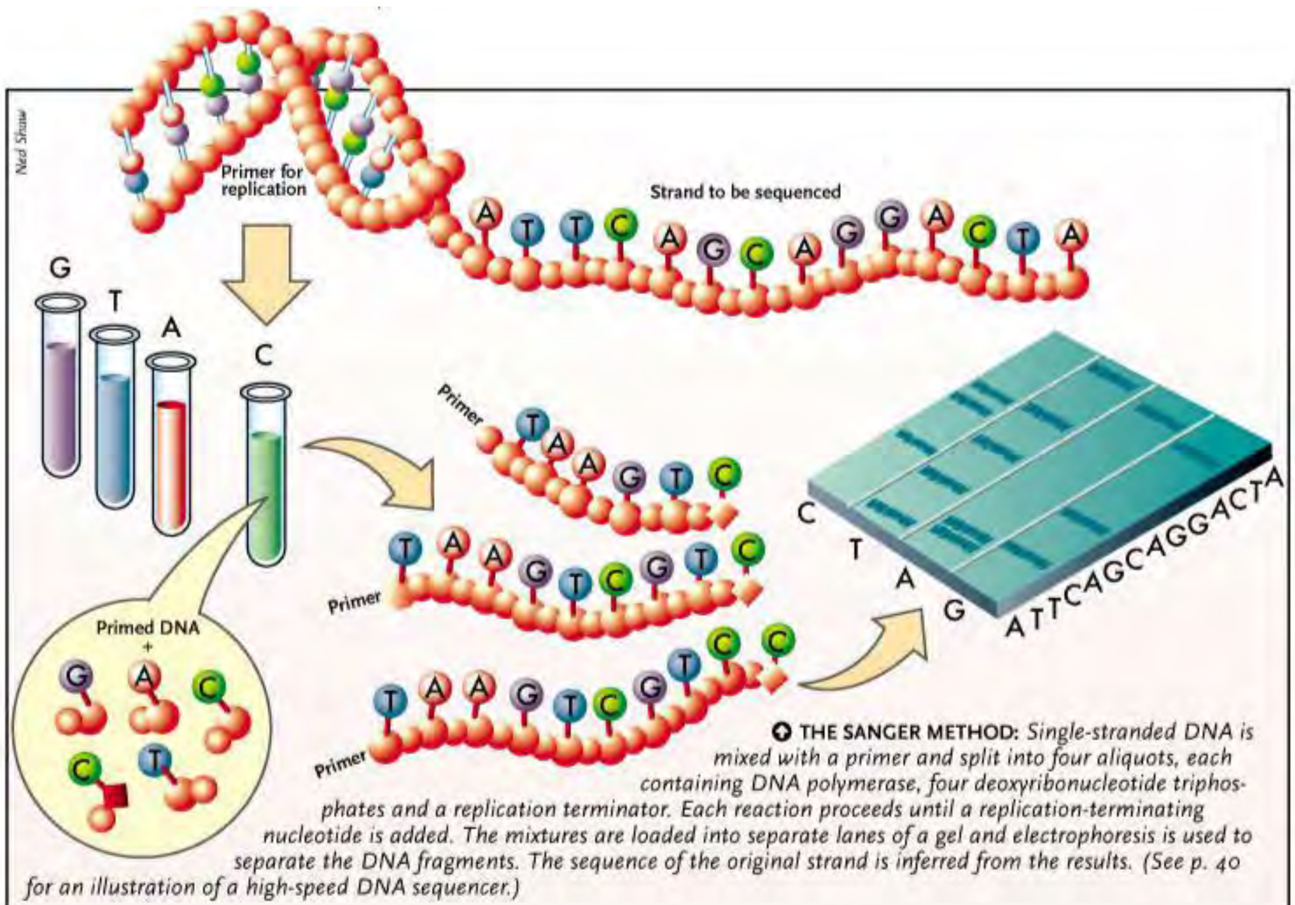


Agarose Gel Electrophoresis



DNA Sequencing

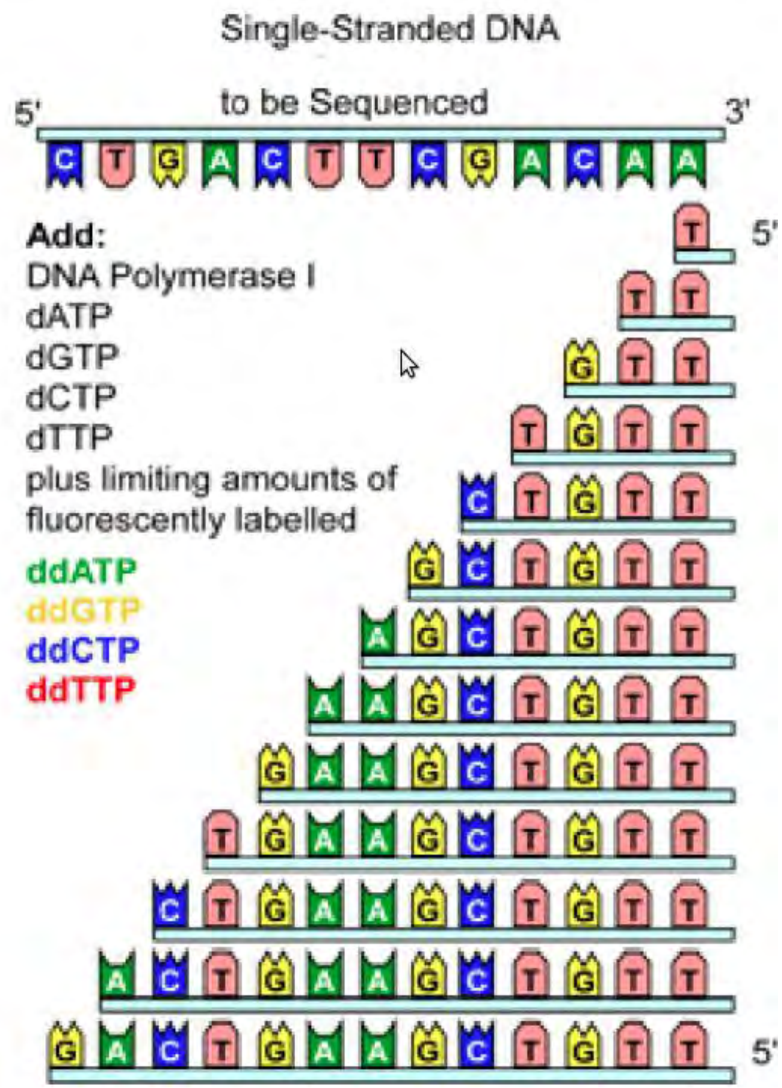
Process of determining the precise sequence of nucleotides in a DNA fragment



THE SANGER METHOD: *Single-stranded DNA is mixed with a primer and split into four aliquots, each containing DNA polymerase, four deoxyribonucleotide triphosphates and a replication terminator. Each reaction proceeds until a replication-terminating nucleotide is added. The mixtures are loaded into separate lanes of a gel and electrophoresis is used to separate the DNA fragments. The sequence of the original strand is inferred from the results. (See p. 40 for an illustration of a high-speed DNA sequencer.)*

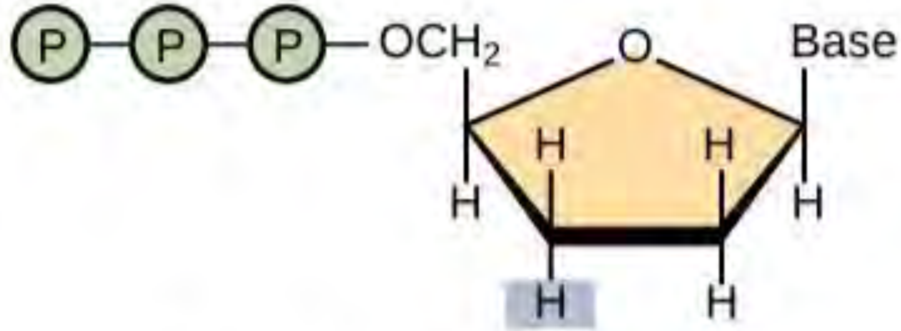
DNA Sequencing

Components

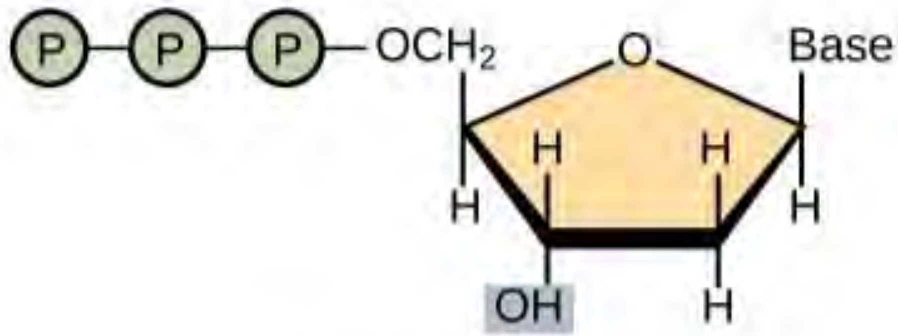


DNA Sequencing

Difference between ddNTP and dNTP

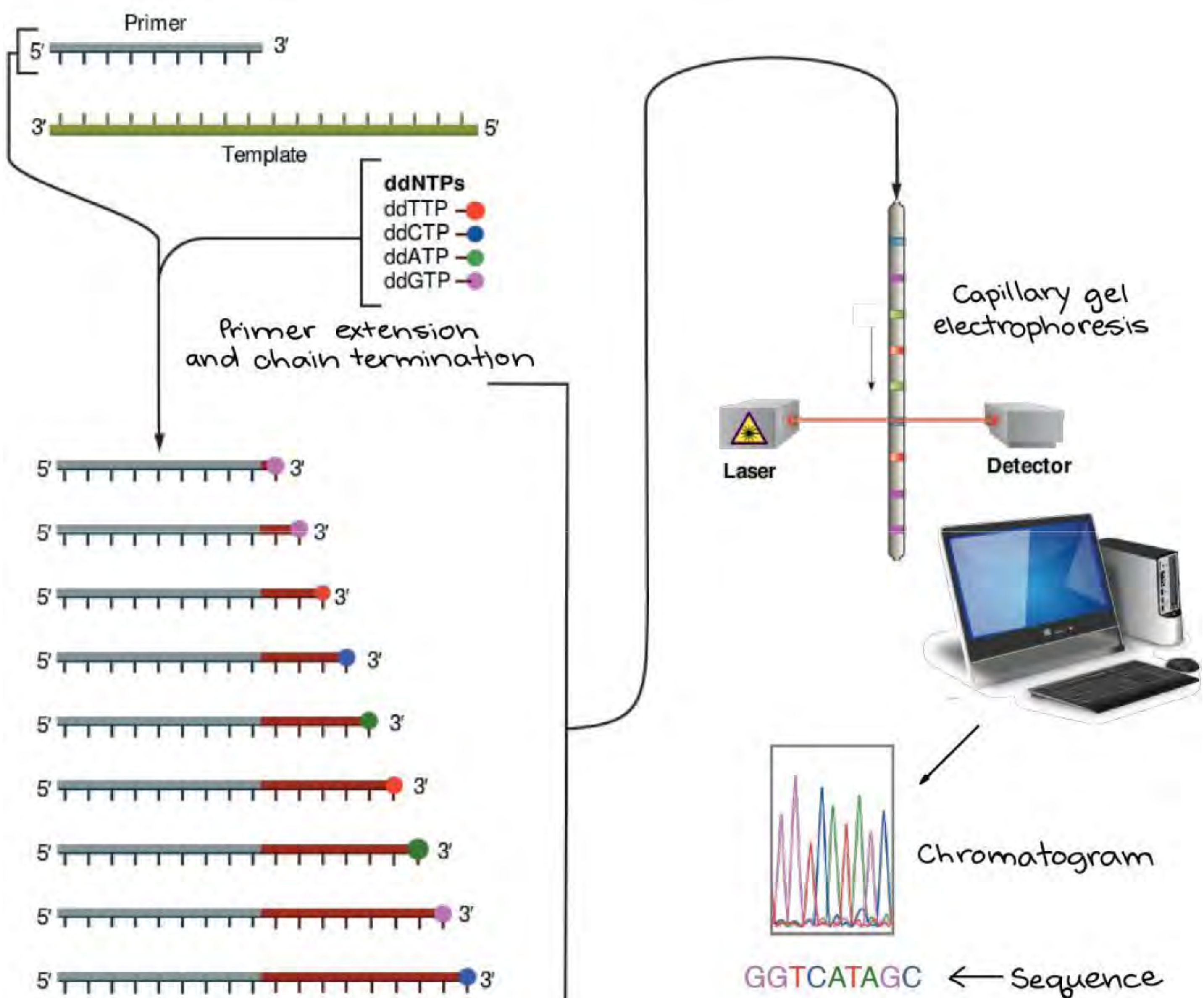


Dideoxynucleotide (ddNTP)



Deoxynucleotide (dNTP)

DNA Sequencing



Data Analysis

Bioinformatics Softwares

- computer programs used to process data
  - BioEdit
  - BLAST
  - Clustal X
  - Sequin

References

Clark, T.L., Meinke, L.J. and Foster, J.E. (2001. Molecular phylogeny of *Diabrotica* beetles (Coleoptera: Chrysomelidae) inferred from analysis of combined mitochondrial and nuclear DNA sequences. *Insect Molecular Biology*, 10, 303–314.

Hebert PDN, Cywinska A, Ball SL, deWaard JR (2003) Biological identifications through DNA barcodes. Proc R Soc B 270:313–321.doi: 10.1098/rspb.2002.2218

Savolainen V, Cowan RS, Vogler AP et al (2005) Towards writing the encyclopedia of life: an introduction to DNA barcoding. Philos Trans Ser B 360:1850–1811. doi: 10.1098/ rstb.2005.1730

Winter WD Jr (2000) Basic techniques for observing and studying moths & butterflies (Memoir No 5). The Lepidopterist's Society, Cambridge

MODIFIED CTAB DNA EXTRACTION PROTOCOL FOR RICE and SWEET POTATO WEEVIL

1. Grind fresh live beetles (or 95% Ethanol-preserved or frozen (-80)) in 500 ul CTAB buffer (100 mM Tris-HCl, 1.4 M NaCl, 0.02 M EDTA (pH 8.0), 2.0% CTAB, and 0.2% □mercaptoethanol). Add 5 ul of 20 mg/ml of proteinase K to each sample and vortex for 1 minute.

2. Hold the samples at 65 °C for 1 h with vortexing at 20 min intervals.

3. Cool the samples to room temperature then add 10ul of 8mg/ul RNase A. Vortex and incubate at 37 °C for 2 h. (Vortex the samples at 30 min intervals).

4. Subject the samples to centrifugation at 10 000 x g for 10 min at room temperature. Transfer the supernatant to a fresh tube, with 500 ul of a chloroform: isoamyl alcohol (24: 1). Vortex the mixture and centrifuge for 15 min at 10 000 x g.

5. Transfer the upper aqueous layer to a fresh tube with 500 ul of 100% isopropanol (–20 °C). Mix the tubes through gentle inversion for 30 times then place them at 4 °C for at least 2 h followed by centrifugation at 10 000 x g at 4 °C for 15 min.

6. Remove the supernatant and wash the DNA pellet with 700 ul of 70% and 100% ethanol (–20 °C), respectively. Centrifuge the samples at 10 000 x g at 4 °C for 15 min for every wash.

7. After the final wash and ethanol removal, air-dry the DNA pellet for 10 minutes and re-suspend it in 30ul of TE buffer (10 mM Tris-HCl, 1 mM EDTA (pH 7.6)) or nuclease-free water.

Reference:

Clark, T.L., Meinke, L.J. and Foster, J.E. (2001) Molecular phylogeny of *Diabrotica* beetles (Coleoptera: Chrysomelidae) inferred from analysis of combined mitochondrial and nuclear DNA sequences. *Insect Molecular Biology*, 10, 303–314.

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SESSION 10

QUARANTINE POLICIES

(The Philippine Plant Quarantine System)

Lecture Notes by:

Mr. Joselito Antioquia

Bureau of Plant Industry
National Plant Quarantine Service Division
Department of Agriculture

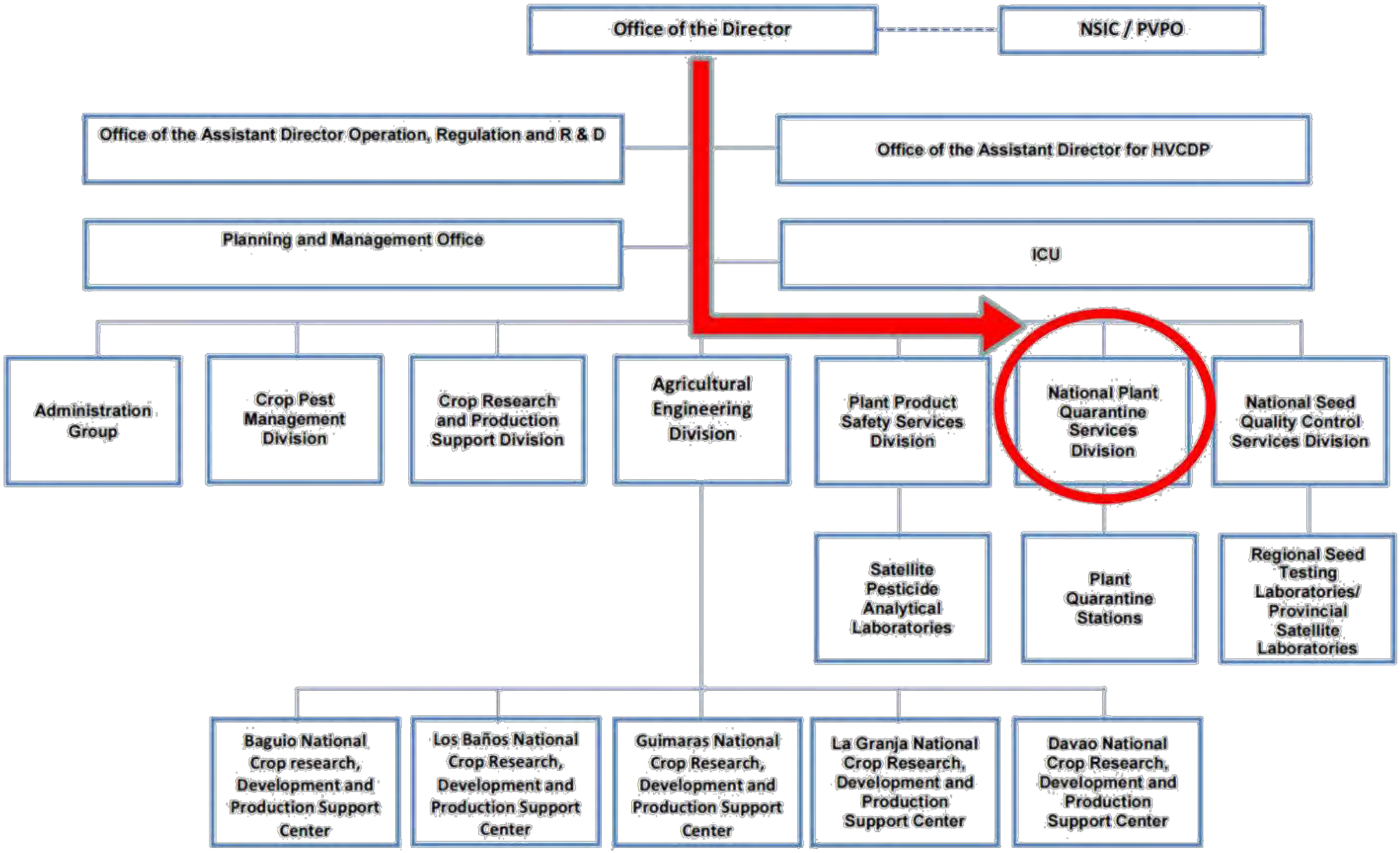
PHILIPPINE PLANT QUARANTINE SYSTEM

Bureau of Plant Industry

N National Plant Quarantine Services Division

BUREAU OF PLANT INDUSTRY (BPI)

Organizational Structure



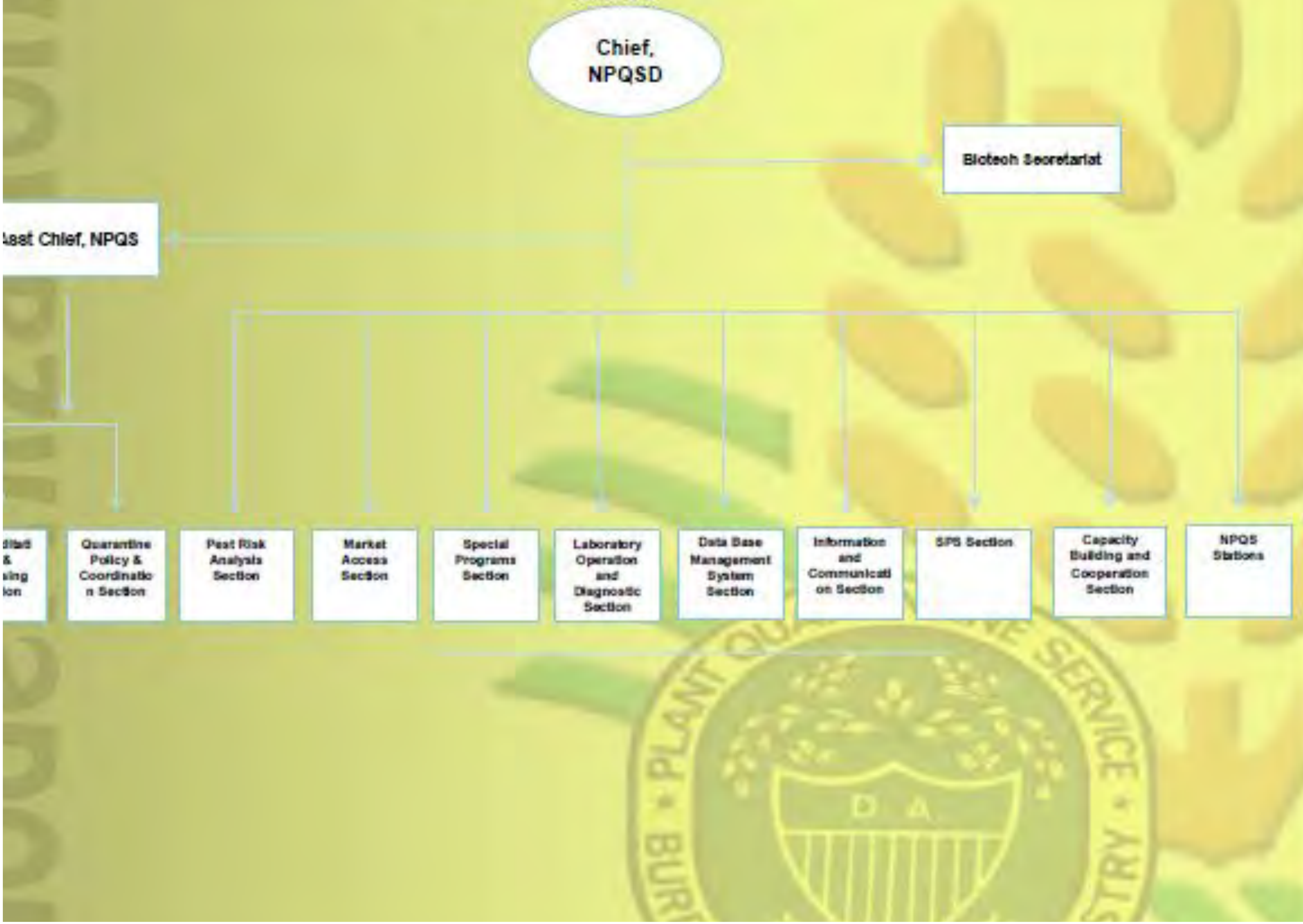
GOVERNING LAW

Philippine Plant Quarantine is being enforced by the Bureau of Plant Industry- National Plant Quarantine Services Division by virtue of **PRESIDENTIAL DECREE 1433,** as amended otherwise known as the **Plant Quarantine Law of 1978.**

Mandate

- prevent the entry (and establishment) of foreign pests into the country
- prevent spread of pests already existing in the country and;
- comply with international standards

NATIONAL PLANT QUARANTINE SERVICES DIVISION



NATIONAL PLANT QUARANTINE SERVICES DIVISION

Chief, NPQSD SG-24

Biotech Secretariat

Asst Chief, NPQS SG-22

Accreditation & Licensing Section

- Import
-Export
- (Exporter/ Facility Operator/ Farmer)
-Treatment Providers (Vapor Heat Treatment/ Extended Hot Water Treatment /Fumigators, Heat Treatment)
- Clearances

Quarantine Policy & Coordination Section

-Supports activities of the PQ Board
-Drafts Memo/ AO & National Guidelines in compliance with approved international standards
-Coordinates with other regulatory agencies of DA which has overlapping functions w/ the NPQS
-Identifies/ formulates/ reviews quarantine policies & issuances
-Coordinates w/ the PRA group on the formulation of AOs, agreements,

Pest Risk Analysis Section

PRA conducts Risk Analysis for Imported products (pest categorization, risk assessment and risk management)
-Conducts PRA in situations where there is pest outbreak in the country of import or in the Philippines
-Revisit the existing PRA's where there is high pest detection, changed in policies/regulations and new pest information in the country of import
-Establishment/ updating pest data base
-Review of PQ import conditions
-Communicates with stakeholders & trading partners on the result of the PRA
-Visit exporting country to determine the phytosanitary measures to be implements

Market Access Section

-Develop a work programme for the market access proposals
-Gather information & compile dossier
-Prepare market access submissions
-Consider results of risk analysis by importing country
-Recommend policy & operation of regulatory requirements
-Identifies/ request/maintain market for agriculrtural products
-Drafts Multi-lateral and Bilateral Agreements/ workplan based on results of PRA
-Engages in actual negotiations with other countries
-Consultation with stakeholders

Special Programs Section

-Low Monitoring Survey
-Mango Program
-Okra Program

Laboratory Operation and Diagnostic Section

- Oversee the implementation of all laboratories of the NPQS
- Function as a center for pests identification and standardization of diagnostic procedures
-Develop new procedures for diagnosis & control of pests
- Provide accurate & timely identification of pest to be used as basis for any quarantine actions or decisions
-Collaborate w/ experts/scientist in proving technical assistance on matters related to different plant pest groups
--Evaluate the needs & prepare action plan for development/ improvemnet of each of the

Data Base Management System Section

- Collects, organize, stores, modifies, updates, extract and provides information on Plant Quarantine
- Consolidation of monthly regional report & annual reports
- Establish /maintain/update/manage export & import data for agricultural plants & plant products

Information and Communication Section

-IEC
-Press Release
-Maintenance/ updating of the PQS website

SPS Section

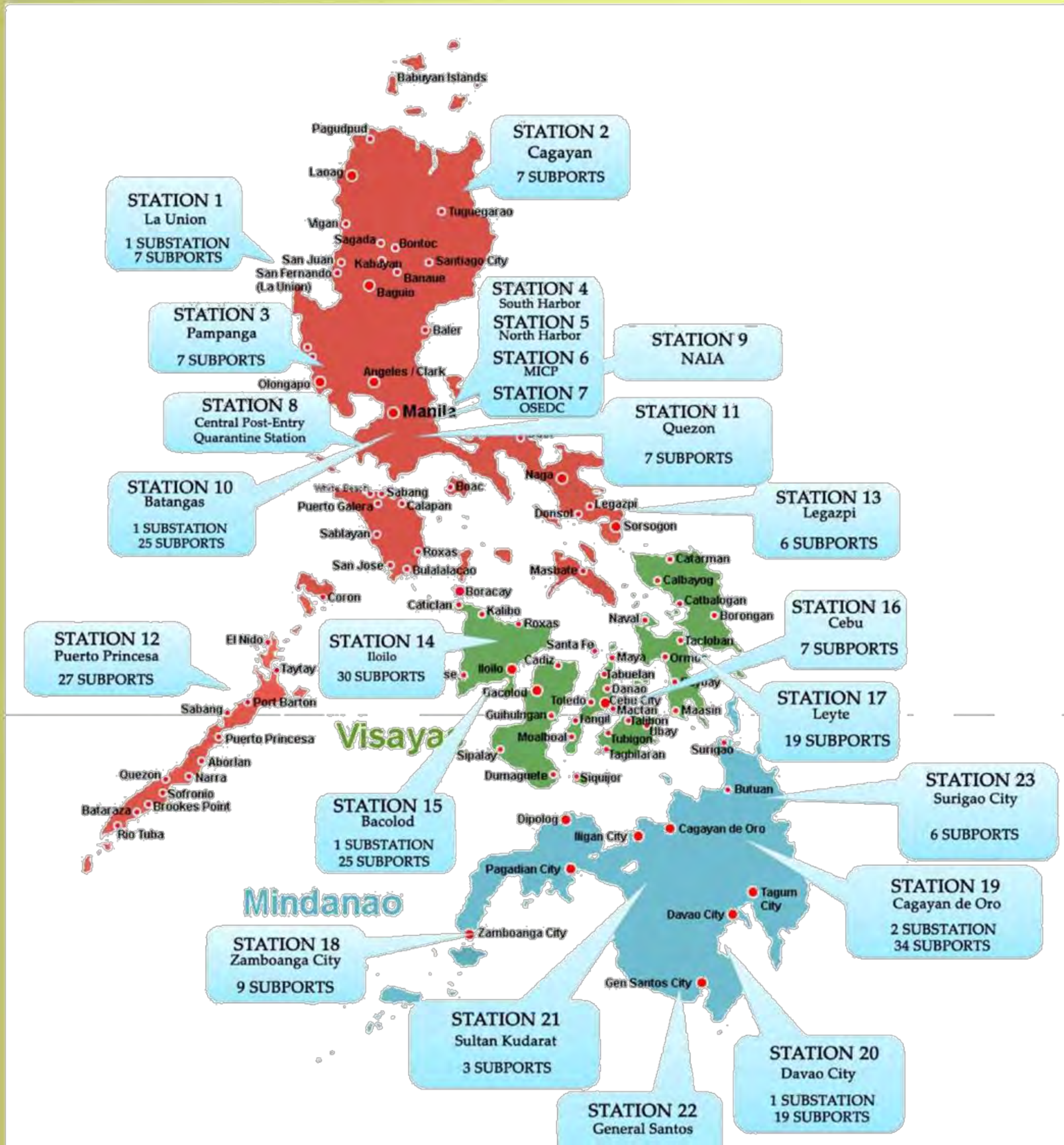
-Gather/ update/submit/ upload required info in compliance w/ the Phil. National reporting obligations to the IPPC, APPPC
-review comment, act on notification related to trade
-Review/ evaluate/ comment on the draft ISPM
-Address issues/concerns on the implementation /enforcement of the food safety act
-Negotiate dispute on any matter that may arise under the SPS Agreement
-Prepares position papers/briefer for delegations ,attending international forums such as SOM-AMAF,CPM, WTO, BIMP,etc.

Capacity Building and Cooperation Section

-Identify possible source of fund for capacity/capability building for all aspects of quarantine
-Coordinates w/ funding agencies which will support the capability enhancement programs
-formulate proposals to be submitted to possible funding agencies
-determine capacity/cap. Enhancement needs of the NPSQD
-Manage the financial & administrative aspect of quarantine

NPQS Stations

-Inspects targeted cargo for pests and diseases
-Direct the treatment, reshipment, re-exportation, or destruction of consignment when harboring pests, pathogens are found
-Encode relevant data to the DA Trade System
-Organize and conduct diagnostic tests as required



Babuyan Islands
Pagudpud
Laoag
STATION 2
Cagayan
7 SUBPORTS
STATION 1
La Union
1 SUBSTATION
7 SUBPORTS
Tuguegarao
Vigan
Sagada
Bontoc
San Juan
Kabayan
Santiago City
San Fernando (La Union)
Banaue
Baguio
STATION 3
Pampanga
7 SUBPORTS
STATION 4
South Harbor
STATION 5
North Harbor
STATION 6
MICP
STATION 7
OSEDC
STATION 9
NAIA
Baler
Angeles / Clark
Olongapo
STATION 8
Central Post-Entry Quarantine Station
Manila
STATION 11
Quezon
7 SUBPORTS
STATION 10
Batangas
1 SUBSTATION
25 SUBPORTS
Naga
Sabang
Boac
Puerto Galera
Calapan
Legazpi
Donsol
Sorsogon
STATION 13
Legazpi
6 SUBPORTS
Sablayan
Roxas
San Jose
Bulalacao
Masbate
Catarman
Calbayog
Boracay
Coron
Caticlan
Catbalogan
Kalibo
Borongan
Roxas
Naval
STATION 16
Cebu
7 SUBPORTS
STATION 12
Puerto Princesa
27 SUBPORTS
El Nido
STATION 14
Iloilo
30 SUBPORTS
Santa Fe
Tacloban
Cadiz
Maya
Taytay
Iloilo
Tabuelan
Bacolod
Danao
Toledo
Cebu City
Sabang
Port Barton
Mactan
Maasin
Guihulngan
Tangil
Talibon
STATION 17
Leyte
19 SUBPORTS
Visayas
Puerto Princesa
Moalboal
Ubay
Tubigon
Surigao
Sipalay
Tagbilaran
Aborlan
Quezon
Narra
Dumaguete
Siquijor
Butuan
STATION 23
Surigao City
6 SUBPORTS
Sofronio
Bataraza
Brookes Point
STATION 15
Bacolod
1 SUBSTATION
25 SUBPORTS
Dipolog
Rio Tuba
Iligan City
Cagayan de Oro
Pagadian City
STATION 19
Cagayan de Oro
2 SUBSTATION
34 SUBPORTS
Tagum City
Mindanao
Davao City
Zamboanga City
STATION 18
Zamboanga City
9 SUBPORTS
Gen Santos City
STATION 21
Sultan Kudarat
3 SUBPORTS
STATION 20
Davao City
1 SUBSTATION
19 SUBPORTS
STATION 22
General Santos



Where We Work

3. **23** Plant Quarantine stations
4. **5** Sub-stations
5. **143** Sub-ports
6. **38** major seaports
7. **50** sub-seaports
8. **56** airports/ sub-airports

main office is located at Bureau of Plant Industry, 692 San Andres St. Malate Manila.

Manpower Complemen

PERMANENT

304 incumbents

51 vacant positions (for filling up)

JOB ORDER

171 incumbents

What We do

- Promulgation and Enforcement of Plant Quarantine Rules and Regulations
- Bilateral discussions / negotiations (Market Access)
- Conduct Plant Pest Risk Analysis (PRA)
- Conduct Laboratory Analysis
- Commodity Inspection and treatment
- Post Entry Quarantine

What We do…

- Registration/Accreditation of Importers, Exporters, Farmers/Growers, Treatment Facilities and Treatment Providers
- Pest Survey
- Establishment of Pest Free Area (PFA)
- Other relevant functions to achieve its mandate (e.g. formulate rules, guidelines, orders, etc)

Commodity Inspection

Forms and Requirements SPS Import Clearance

Republic of the Philippines
Department of Agriculture
BUREAU OF PLANT INDUSTRY

SPS Import Clearance

This SPS Import Clearance is good for a single shipment only

1. SPS Import Clearance No.	2. Place Issued	3. Date Issued	4. Must Ship Out by Date

5. Name of Importer
6. Business Address of Importer / Handler / Company
7. TIN
8. Contact No.
9. Name of Manufacturer / Producer / Plant
10. Business Address of Manufacturer / Producer/ Plant
11. Establishment No. of Manufacturer/ Producer / Plant
12. Name of Exporter / Supplier
13. Address of Exporter / Supplier
14. Country of Source
15. Country of Origin via
16. Place of Origin
17 Purpose of Importation

18. Tariff code 19. Product / Commodity Name 20. Brand Name 21. Generic Common Name 22. Scientific / Chemical Name	23. Description / Specification / Classification	24. Quantity & Unit of Measure	25 Allowable Tolerance (% of qty)	26. Total Value (FOB US$)

28. Quarantine Site for live plants / animals / fish
29. Final Destination / Warehouse / Cold Storage / Plant
30. Recommending Approval
31. Approval
32. Authentication

Republic of the Philippines
Department of Agriculture
BUREAU OF PLANT INDUSTRY

SPS Import Clearance

33. Import Conditions

1.This shipment shall be accompanied by a Phytosanitary Certificate issued by a duly authorized Plant Quarantine Officer of the country of origin and must be absolutely free from soil.

2.Immediately upon arrival of said plant materials at the port of entry they are to be turned over to the Plant Quarantine Service for inspection.

3.None of the above -described plant materials may be released at the port of entry unless cleared by the Plant Quarantine Officer thereat.

4.If the plant materials are found upon inspection to be infested with pests or infected with any plant disease so that they can no be phytosantized by any treatment available, they may be destroyed, and such destruction can not be made the basis of a claim for damages against the Bureau of Plant Industry.

5.Corresponding fees for inspection, treatment, etc., shall be paid by the importer prior to release of said plant materials.

34. Other Conditions / Requirements

35. Import Clearance Fee
36. OR No.
37. Inspection fees (indicative : actual depending on actual volume imported and inspection
38. Conforme / Acceptance (Signature over Printed Name of Importer)
39. Date Signed

To be Accomplished by the DA Border Inspector at the Port of Entry

40. Signature over Printed Name of Inspecting Officer
41. Date Inspected
42. Da Border Inspector's Report No.
43. Inspector's Stamp
44. Fees Collected
45. OR No.

Forms and Requirements

Phytosanitary Certificate from the country of origin

ORIGINAL

Name and Address of exporter:

M-SQUARE TRADING PTY LTD
3 HAWKESWORTH PLACE
CHERRYBROOK NSW 2126
AUSTRALIA

No. 7107580

Australian Government

Department of Agriculture, Fisheries and Forestry

PHYTOSANITARY CERTIFICATE

Plant Protection Organisation of the Australian Government

Declared name and address of consignee:

M-SQUARE MERCHANDIZING GROUP INC.
50 G DE JESUS ST
BAGONG BARRIO, BARANGAY 139,
CALOOCAN CITY
PHILIPPINES

Place of Origin: NEW SOUTH WALES — Code: 2000

Country of Final Destination: PHILIPPINES — Code: PH

TO: Plant Protection Organisation of: PHILIPPINES

Declared means of conveyance: AIR FREIGHT/PR212

Declared point of entry: MANILA

Import Permit Number: ICDABPI1414034171 9-OCT-2014

Distinguishing marks and container numbers	Number and Description of packages		Name of produce/quantity declared	Total net contents KGM	Botanical Name of plants	Commodity Code
	5	CARTONS	LEEKS	50.000	*Allium ampeloprasum porrum*	07039000
	20	CARTONS	BROCCOLI	160.000	*Brassica oleracea var. italica*	07041000
	48	CARTONS	LETTUCES	576.000	*Lactuca sativa*	07051900
	6	CARTONS	CAULIFLOWERS	120.000	*Brassica oleracea var botrytis*	07041000
	5	CARTONS	CARROTS	100.000	*Daucus carota*	07061000
	30	CARTONS	MUSHROOMS	120.000	*Psalliota campestris*	07095115

ADDITIONAL DECLARATIONS
No Additional Declaration

Number of Packages (Total): 114 — Mass (Total): 1126.000 KGM

DATE — DISINFESTATION AND/OR DISINFECTION TREATMENT

NO TREATMENTS

This is to certify that the plants, plant products or other regulated articles described herein have been inspected and/or tested according to appropriate official procedures and are considered to be free from the quarantine pests specified by the importing contracting party and to conform with the current phytosanitary requirements of the importing contracting party, including those for regulated non-quarantine pests.

Place of issue: NSW — Code: 2129

Name of Inspector: MARK WILSON — Inspection Date: 3RD DECEMBER 2014 — Code: 2129

Seal: DEPARTMENT OF AGRICULTURE, FISHERIES & FORESTRY — AUSTRALIA — 3660

Name of Authorised Officer: Bev Beacham

Signature of Authorised Officer an Officer of the Dept

ORIGINAL

Form P.Q. 7-1

Department of Agriculture

Ministry of Agriculture and Cooperatives, Bangkok, Thailand

Phytosanitary Certificate

Plant Protection Organization of Thailand

TO : Plant Protection Organization (s) of PHILIPPINES

No. 4763305

1. Name and address of exporter : LEE ORCHIDS CO., LTD. 34/19 MOO 1 PETCHKASEM RD., BANGPAI BANGKAE BANGKOK 10160 THAILAND

2. Declared name and address of consignee : EXIMARK TRADING INC SUITE 416 BPI CONNDOMINIUM PLAZA BINONDO, MANILA PHILIPPINES

3. Number and description of packages : 9 CARTONS

4. Distinguishing marks :

5. Place of origin : THAILAND

6. Declared means of conveyance : AIR

7. Declared point of entry : MANILA , PHILIPPINES

8. Name of produce and quantity declared :
DENDROBIUM HYBRIDS 300,000 STEM(S)
MOKARA HYBRIDS 1,206,000 STEM(S)
ARANTHERA HYBRIDS 400,000 STEM(S)
(9 CARTONS OF FRESH ORCHID CUT FLOWERS)

9. Botanical name of plants : DENDROBIUM HYBRID,MOKARA HYBRID,ARANTHERA HYBRID

This is to certify that the plants , plant products or other regulated articles described herein have been inspected and/or tested according to appropriate official procedures and are considered to be free from the quarantine pests specified by the importing contracting party and to conform with the current phytosanitary requirements of the importing contracting party , including those for regulated non – quarantine pests.

Additional Declaration

NOTHING TO DECLARE

Disinfestation and/or Disinfection Treatment

10. Date :	11. Treatment :	12. Chemical (active ingredient) :
MARCH 11, 2015	FUMIGATION	METHYL BROMIDE (CH_3Br)
13. Duration and temperature :	**14. Concentration :**	**15. Additional information :**
1.5 HRS/21 DEGREES CELSIUS OR ABOVE	20.00 GMS./CU.M.	TREATED BY EXPORTER

16. Stamp of organization : DEPARTMENT OF AGRICULTURE

17. Place of issue : SUVARNABHUMI AIRPORT,SAMUTPRAKAN THAILAND

18. Date : MARCH 11, 2015

19. Name and signature of authorized officer : MS. PROM CHAROENSRI FOR CHIEF, SUVARNABHUMI AIRPORT PLANT QUARANTINE STATION

NOTE : No financial liability with respect to this certificate shall attach to the Ministry of Agriculture and Cooperatives, Thailand or to any of its officers or representatives of that Ministry.

982809

Inspection of Passengers Luggage at the Arrival Area

Inspection of Passengers luggage at the arrival area

Some of the confiscated commodities brought in by passengers

Interception at the Cargo Area


Omaha Persimmons
NORDIC

PQ INSPECTORS CHECK CONTAINER NUMBER AGAINST THE IMPORT DOCUMENTS


ZIM
Jolly

Confiscation Procedures

❖

INSPECTION AND SEIZED COMMODITIES

CONFISCATED COMMODITIES

MISDECLARATION OF GOODS

DISPOSAL OF SEIZED COMMODITIES

Presentation of the 67 boxes fresh ginger

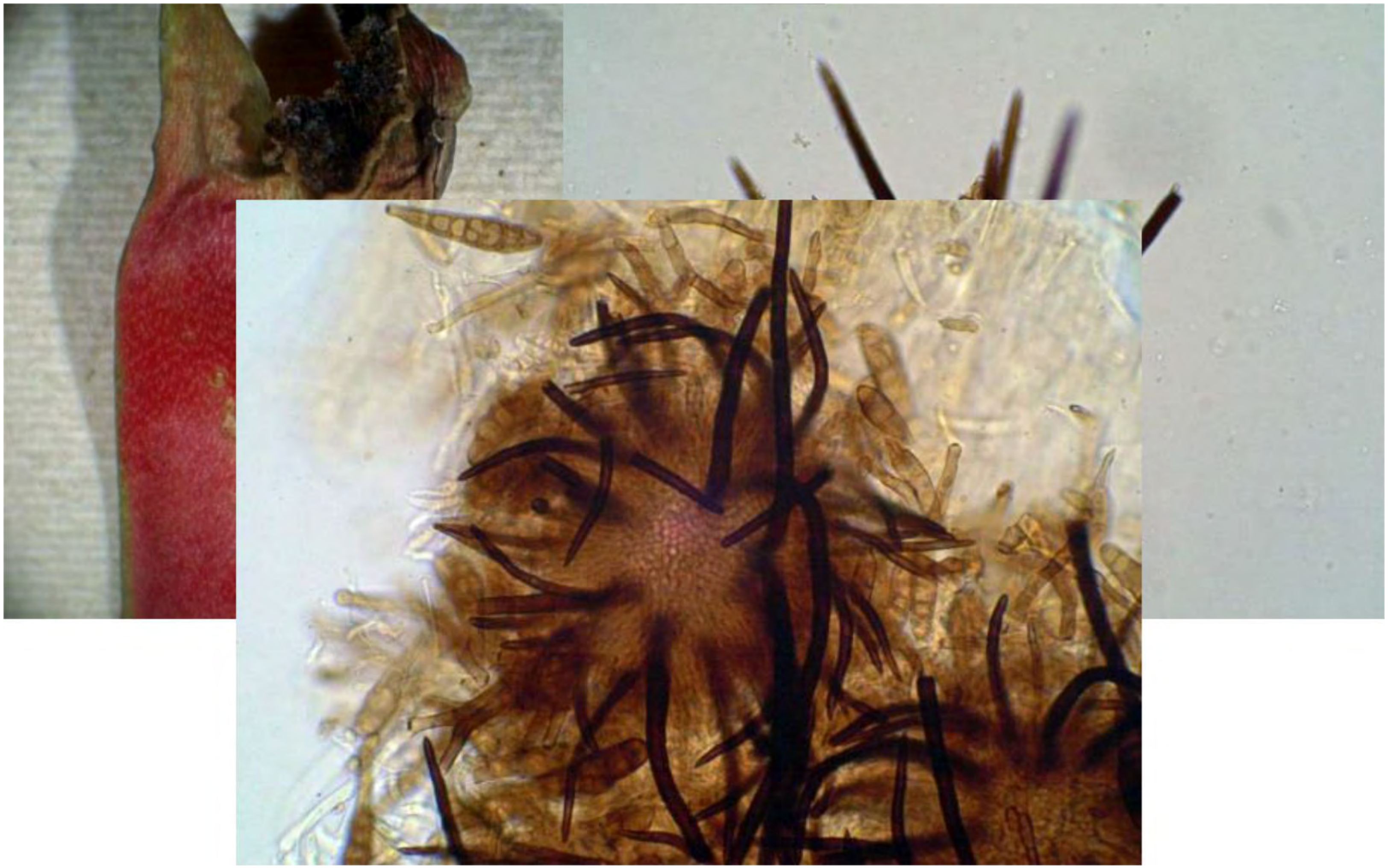
Pouring of diesel fuel by PQ Inspector

Initiating the burning of the ginger

Boxes of fresh ginger on fire

Laboratory Procedures

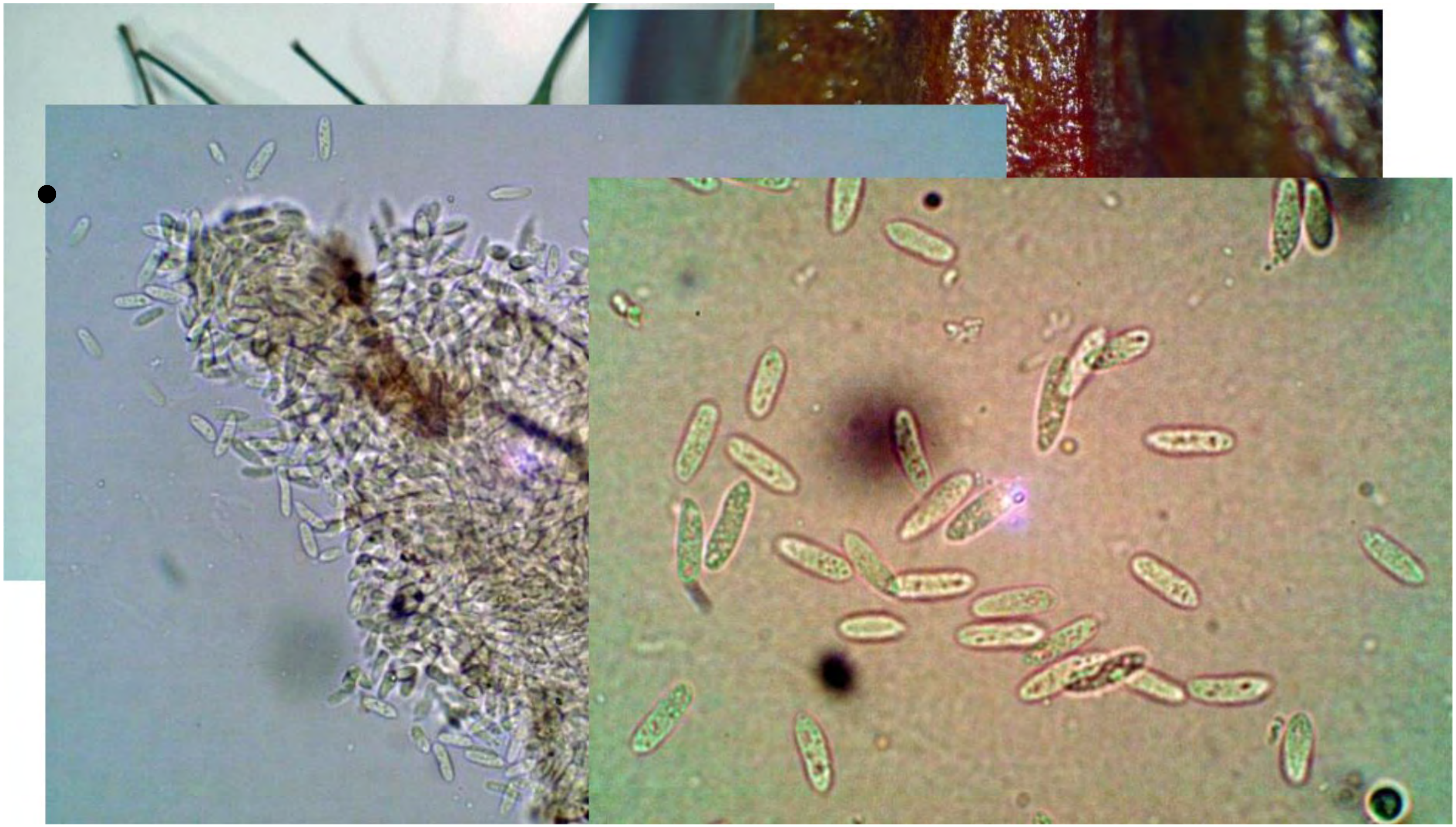
Laboratory Analysis of Intercepted ommodities



Detection of *Colletotrichum trichellum* on dragon fruit

Laboratory Analysis of Intercepted Commodities

•



Detection of *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. on capsicum at NAIA

Laboratory Analysis of Intercepted Commodities

Baermann funnel method done for confiscated olive plant

Penicillium italicum
(Blue mould) of citrus)

Penicillium expansum
(Blue mould /soft rot)

Brown rot – lychee with
Fusarium growth)

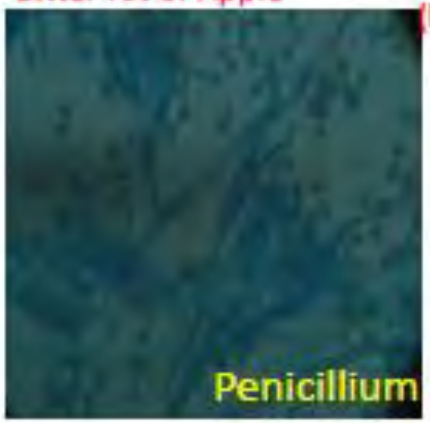
Brown rot

Bitter rot of Apple

Apple mealybug
(Planoccocus acaris)

Dead larva on apple
(unidentified)

Black powdery mould



Penicillium sp.

Aspergillus sp.

Alternaria sp.

Fusarium sp.

Laboratory Examination

Mango varieties susceptible to seed weevil

Laboratory Analysis of Intercepted Commodities

Mango seed weevil was detected from intercepted mango from Thailand on 22 April 2014

Laboratory Examination



Domestic Quarantine

BPI Special Quarantine Administrative Order No. 20, series of 1987

Declaring Mango Pulp Weevil *Sternochetu* *frigidus* (Fabr.) a Dangerous Pest and injurious to Mangoes and Placing the Palawan Island Group Under Quarantine to Prevent the Spread of Said Pest

inset
KALAYAAN
GROUP OF
ISLANDS
BUSUANGA
CORON
CULION
LINAPACAN
EL NIDO
AGUTAYA
LIMINANGCONG
TAYTAY
CUYO
SAN VICENTE
ARACELI
DUMARAN
ROXAS
PUERTO PRINCESA
MANGO PULP WEEVIL
FREE AREA
ABORLAN
NARRA
ESPAÑOLA
BATARAZA
BALABAC
Southern Palawan infested of Mango
Pulp Weevil

Movement, transfer or carrying of mango trees, fruits, or parts thereof capable of harboring mango pulp weevil from Palawan Group of Island is prohibited.

It may be allowed in limited quantity and for experimental purpose only subject to the conditions that a permit for such purpose is first secured from the Director of BPI.

- Mangoes determined to be detected with the presence of the MPW will automatically be confiscated and disposed accordingly to prevent the spread of MPW within the City.
- Proper disposal shall include soaking with insecticides and burning of mango fruits.
- All mangoes in Non-Commercial quantity, wherein each mango only weigh less than 125 grams, but has to be transported and brought to and within the City shall undergo internal examination.
- Only mangoes weighing 125 grams and above shall be tested for MPW by passing through the City MPW Detection machine
- Checkpoints manned by the City PNP and personnel of BPI shall be established in the Northern and Southern part of Puerto Princesa

Establishment of Pest Free Areas

DA Administrative Circular No. 06, series of 2014

- Declaring the Whole Philippines as Area Free from Mango Seed Weevil (MSW) *Sternochetus mangiferae* Fabr. And Except for Palawan, Area Free From Mango Pulp Weevil (MPW) *Sternochetus frigidus* (Fabr.) and Prohibiting Importation From Countries Where the Pests Exist.

DA Administrative Circular No. 06, series of 2014

Movement, transfer or carrying of mango trees, fruits, or parts thereof capable of harboring mango pulp weevil from Palawan Group of Island is prohibited.

Importation / entry of mango fruits/mango plants and parts thereof / planting material from areas, places or countries where MPW and MSW exist is likewise prohibited.

Recognition as a Pest Free Area

October 1, 2014 – USDA issued the Final Rule Declaring the Philippines as Area free from MPW (except Palawan) and MSW

USDA
APHIS

Australian Government
Department of Agriculture, Fisheries and Forestry

December 18, 2015 - DAFF recognition of the whole Philippines, except Palawan, as MPW and the whole Philippines as MSW free area.

NATIONWIDE LOW MONITORING OF MANGO PULP AND SEED WEEVIL ON

MANGO PRODUCTION REGIONS/ PROVINCES OF THE PHILIPPINES

FRUIT COLLECTION

FRUIT DISSECTION

ASEAN Regional Training Workshop on Diagnostics of Weevils of Quarantine Importance

July 10-22, 2017

Institute of Weed Science, Entomology and Plant Pathology
College of Agriculture and Food Science
University of the Philippines Los Baños

SESSION 11

RESOURCES OF WEEVILS ON THE WEB

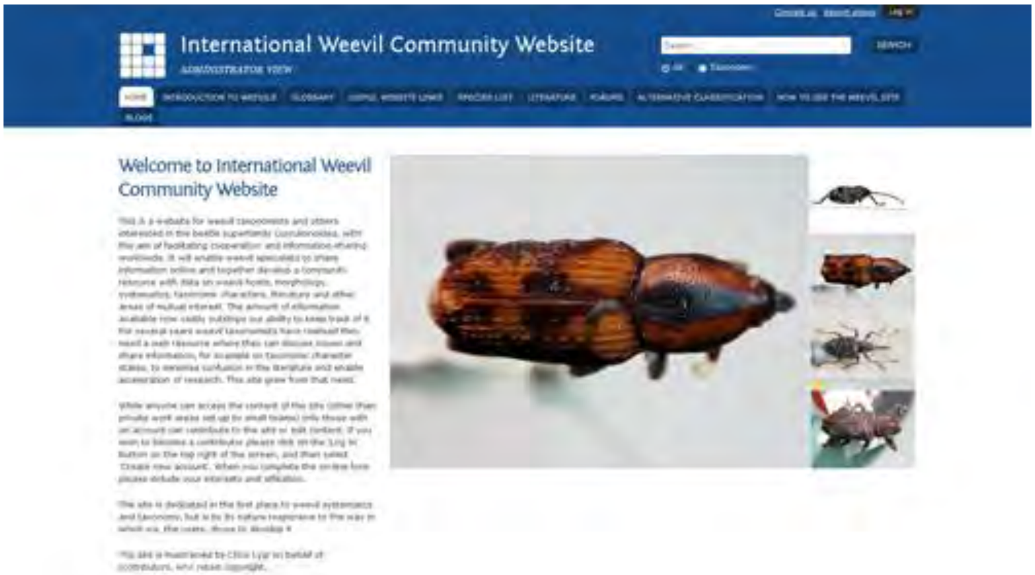
Lecture Notes by:

DR. HIRAKU YOSHITAKE
Institute for Agro-Environmental Sciences
NARO, Tsukuba, Japan

RESOURCES OF WEEVILS ON THE WEB

Browsing of web sites concerning with weevils

International Weevil Community Website



http://weevil.info/

A website of International Weevil Community containing many fundamental data of weevils.

Electronic Catalogue of Weevil names (Curculionoidea)

http://wtaxa.csic.es/

A database of scientific names of weevils, but is still under development.

Japanese Weevil Database

http://de05.digitalasia.chubu.ac.jp/

A database of Japanese weevils, containing images of many species in common to / related to those from the ASEAN region. All the navigation is in Japanese, but it is very easy to find your way around.

Integrated insect types database of Taiwanese species

http://twinsecttype.nmns.edu.tw/

A database of the type specimens preserved in various institutions throughout world, containing data of Taiwanese weevils, most of which are in common to / related to those from the ASEAN region.

New Zealand Weevil Images

http://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/systematics/weevils

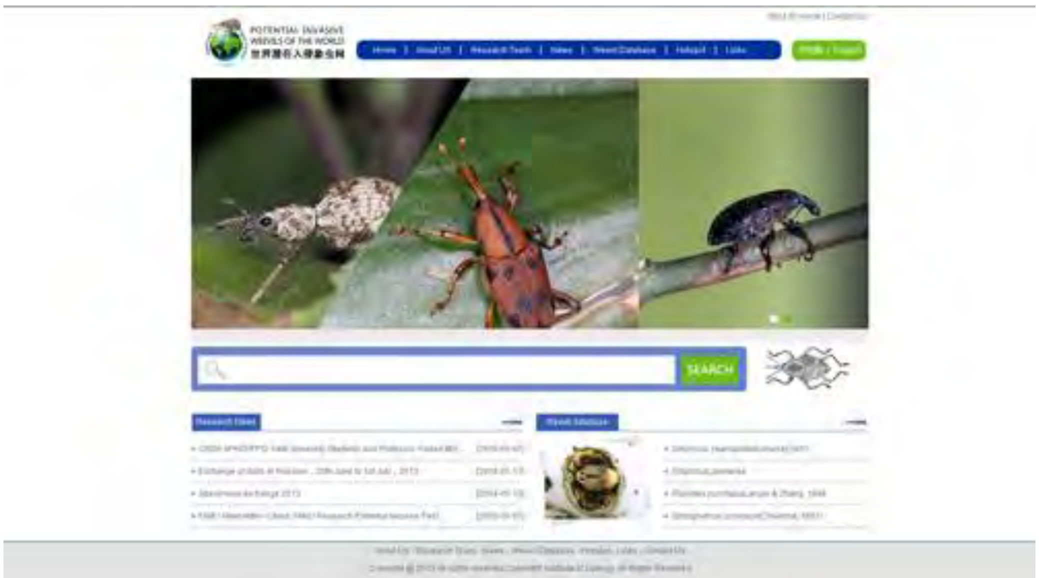
A database of New Zealand weevils, some of which are in common to / related to those from the ASEAN region, containing many habitus images.

Curculio Institute - Center for western Palearctic Curculionoidea

http://www.curci.de/institute3/index.php

The website of the Curculio Institute containing a series of "Digital-Weevil-Determination" for Curculionoidea of West Palaearctic on "SNUDEBILLERonline". The annual membership fee of EUR 50,00 to log in SNUDEBILLERonline and view all current articles.

Potential Invasive Weevils of the World



http://www.piweevils.com/?app.html

A database of important weevils for plant quarantine due to the high invasion risk.

Attachment 3

Study Visit to Japan National SPS/Plant Health Laboratories *cum* Training Workshop on the Identification of Fruit Flies

at
Laboratory of Tropical Plant Protection
Tokyo University of Agriculture (Tokyo NODAI), Japan

November 18 – December 2, 2017

Organized by:

Tokyo University of Agriculture
(Tokyo NODAI), Japan

In Collaboration with:

ASEAN Network on Taxonomy

2017

"Study visit to Japan national SPS/Plant Health laboratories cum Training workshop on the Identification of Fruit Flies"

as a part of the JAIF project phase 1 of "Taxonomic capacity building to support market access for agricultural trade in the ASEAN region"

BACKGROUND INFORMATION & JUSTIFICATION

The ASEAN Plant Health Cooperation Network (APHCN) – ASEANET Project **"Taxonomic capacity building to support market access for agricultural trade in the ASEAN region",** funded by the Japan ASEAN Integration Fund (JAIF) has successfully implemented several activities related to capacity building activities for the ASEAN Plant Quarantine & Plant Protection officers and this project is due to be concluded in April 2017. We are considering proposing a 2nd Phase, based on the recommendations from the 10 ASEAN member countries, to organize more capacity building (mostly Training Workshop on Diagnostics of major pests and diseases for 2 weeks).

One key activity identified as the highest priority to be proposed is a "study visit" to Plant Quarantine & Plant Protection System in Japan to allow ASEAN plant health and quarantine personnel to better understand and appreciate the role played by an efficient plant quarantine system in preventing pest incursions. The National Plant Protection Office of Japan has demonstrated a very efficient plant quarantine and plant protection system in the Asia-Pacific and as a trading partner of ASEAN it is timely that this study visit *cum* training workshop should be organized under the project.

The activity has been planned to offer a hands-on opportunity for senior plant protection and quarantine officials to gain practical knowledge on the efficient operation of a national system in the developed world. This opportunity is not possible through something like to training workshop. Additionally, face-to-face interaction with Japanese personnel will help build relationships that will help in trade-related activities between Japan and ASEAN.

OBJECTIVES:

1. To have an overview on the plant quarantine and plant protection system in Japan
2. To understand the functions and operations of each division under the plant quarantine system of Japan (domestic and international quarantine, export and import divisions, Pest Risk Analysis, etc.)
3. To visit the Research Center, Yokohama & Nara Plant Protection Station
4. To discuss, learn and share field experiences in plant quarantine (inspection, interception, and identification of exotic pests, e.g. fruit flies) from Japanese plant quarantine officers

PARTICIPANTS:

A maximum of twelve senior officers from ASEAN NPPOs and ASEANET (as coordinators) will participate in the study visit. The senior plant quarantine and plant protection officers from the 10 ASEAN countries will be selected by their NPPO/Project Focal Points (one per country). All travel arrangements to Japan would be done by ASEANET and their costs in Japan (food & accommodation, etc.) would be paid by JAIF project, after their approval, through ASEANET.

The candidates who meet one or more of the following criteria would be proposed for consideration:

- Has been in the position of Division/Section/Department Head and or as policy makers
- Minimum with BS degree in biology, agriculture or related field

- Has been working as researcher in entomology or closely related fields for more than 10 years.
- Plant health or quarantine officer involved in insect pest diagnosis and preferably in fruit flies with 10 or more years of experience.
- The successful candidate will have a strong commitment to education and research, excellent communication skills, and the desire and ability to work cooperatively in their own country or in the regional-multi country projects.
- Willing to act as resource person in capacity building for other officers from the ASEAN member states following training.

SPECIFIC OBJECTIVES AND ARRANGEMENTS

1) ***Purpose***: the participants to the training visits will obtain the general idea of how Japan operates its plant protection by visiting several facilities and will be familiarized with fruit flies issues, such as pest risk analysis, ecological research, inspection, diagnostics using molecular technology and other regulatory perspectives.
2) ***Date and duration***: Two weeks from November 18 to December 2, 2017.
3) ***Financial issues***: Tokyo University of Agriculture (TUA) will do the necessities of financial issues based on the draft budget from the organizations including PPSs
4) ***Language to be used in the training***: English or Japanese (an interpreter to be hired)
5) ***Guide***: somebody may have to be hired to take the trainee group to various places (e.g. by train and/or micro-bus). The interpreter and the guide could be the same person.
6) Contact persons in Japan:
    - **Ms. Hiroko MATSUO**, Deputy Director, Plant Quarantine Office, Ministry of Agriculture, Forestry and Fisheries (MAFF), Phone: +81-3-3502-5978 E-mail: hiroko_matsuo290@maff.go.jp
    - **Prof. Dr. Keiko NATSUAKI**, Dean, Graduate School of Agriculture, Tokyo University of Agriculture, Sakuragaoka, Setagaya-ku, Tokyo 156-8502, JAPAN, E-mail: keiko@nodai.ac.jp
7) ***First draft of the training visit schedule*** is as below:

Study visit and training workshop in Japan
As a part of the JAIF Project phase 1 of "Taxonomic Capacity Building to Support Market Access for Agricultural Trade in the ASEAN Region"

Study visit and training workshop in Japan consists of the following contents.

*Highlighted by gray are holidays in Japan.

Date	Day	AM	PM	City to stay
Nov. 18 Sat.	1		=== > Arrival (Haneda or Narita)	Tokyo
Nov. 19 Sun	2	free		Tokyo
Nov. 20 Mon	3	Orientation (TUA, Setagaya, Tokyo)	Orientation (continued) Presentation on overview of plant protection in Japan [Reception]	Tokyo
Nov. 21 Tue	4	Lectures at TUA (Atsugi, Tokyo)		Tokyo
Nov. 22 Wed	5	Visit to Haneda airport	Haneda to Tsukuba (Post-entry quarantine station) Visit to post-entry quarantine facilities Tsukuba to Tokyo	Tokyo
Nov. 23 Thu	6	Tokyo --- > Haneda === > Naha		Naha
Nov. 24 Fri	7	Visit to the facilities operated by the Okinawa prefectural government on fruit flies	Overview of plant protection in Naha (eradication history and others)	Naha
Nov. 25 Sat	8	Naha === > Haneda --- > Tokyo --- > Yokohama	free	Yokohama
Nov. 26 Sun	9	Visit to the National Museum of Emerging Science and Innovation	free	Yokohama
Nov. 27 Mon	10	Lectures and discussions at Yokohama Plant Protection Station: ecology, control measures and treatments		Yokohama
Nov. 28 Tue	11	Lectures and practical exercises at Yokohama Plant Protection Station: classification and identification		Yokohama
Nov. 29 Wed	12	Lectures and practical exercises at Yokohama Plant Protection Station: diagnosis with molecular technology		Tokyo
Nov. 30 Thu	13	Lectures at TUA (Setagaya, Tokyo)		Tokyo
Dec. 1 Fri.	14	Presentation by the trainee (individually or in groups) at TUA	Presentation by the trainee, for comments from the reviewers followed by general discussions Certificates of training completion [Farewell cocktail]	Tokyo
Dec 2 Sat.	15	Departure (from Haneda or Narita)=== >		

Hotels

City to stay	Arr. Date	Dep. Date	Recommendation1	Recommendation2
Tokyo	18th Nov	23rd Nov.	the b tokyo sangenjaya	
Naha	23rd Nov.	25th Nov.	Toyoko Inn Okinawa Naha Asahibashi Ekimae	Toyoko Inn Okinawa Naha Shin-toshin Omoromachi
Yokohama	25th Nov.	29th Nov.	Toyoko Inn Yokohama Sakuragicho	Toyoko Inn Yokohama Kannai
Tokyo	29th Nov.	2nd Dec.	the b tokyo sangenjaya	

ATTACHMENT 5

Output Survey Report
Japan ASEAN Integration Fund (JAIF)-supported Taxonomic capacity building to support market access for agricultural trade in the ASEAN region

In compliance with donor requirements for monitoring and evaluation to gauge the success of the above Project, and upon guidance from the ASEAN Secretariat, an output survey was carried out targeting personnel from ASEAN Member States (AMS) who participated in the training events organized under the Project. Where appropriate, Project counterparts have also been contacted for inputs based on the questionnaire prepared (please see Guidance Notes and Output Survey Questionnaire attached).

The Survey

Three main training activities have been successfully organized under Project funding with the objective of building taxonomic capacity of AMS personnel. Topics for these training events were chosen based on the consensus of the Project Steering Committee; the training events typically consisted of hands-on training in the form of a two-week workshop with participants drawn from AMS. The main objective of this activity is to achieve diagnostic capacity at least at generalist level for the pest taxonomic group targeted. From this training event, three participants who have demonstrated promise at the workshop were selected for a two-month attachment at the laboratories of the designated resource persons/experts for advanced/specialist training.
The three training topics organised were:

1. Diagnostics of Plant Viruses
2. Identification of leafminers of agricultural importance, and
3. Identification of weevils of quarantine importance.

The Response

At the close of the survey period, responses were received from practically all AMS, including ex-workshop participants as well as Project counterparts. The largest number of responses came from ex-participants of the weevils and leafminer training courses. In the case of leafminers, this perhaps reflects in some way, the popularity of the topic or the gravity of the pest problem among AMS. Not unexpected was the fact that the weevils course being the most recently completed, generated good response perhaps because the activity remained fresh in participants' minds. For a similar reason, less response was received for the training course on plants viruses, it being the earliest activity held.

The Feedback

A. Number of trained personnel before the Project, following the training event and after
Respondents appropriately confirmed the increase in personnel able to conduct diagnosis of the target pests and disease (at least at generalist level) following the taxonomic capacity building workshop. Where a country participant was chosen for the more advanced attachment program, this accordingly meant an increase in the number of competent diagnostician. In practically all cases, respondents expressed confidence that there will be in-country training following the Project which is expected to result in a 'cascading' effect of increasing overall taxonomic capacity to address the much-needed support for market access.

B. Number of pest specimens correctly identified
C. Number of specimens deposited in diagnostic laboratories
Respondents reported a significant increase in their ability to identify pest specimens in the target taxonomic group for which they received training. This is followed by a corresponding

increase in the number of specimens for these pest groups in their diagnostic collections, thus improving their value as reference resources. Although plant virus diagnosis typically requires more technical resources to facilitate diagnosis, respondents still were able to improve their diagnostic capacity as a result of the training.

A significant observation from the survey were comments that participants improved their ability to identify a larger range of species which have quarantine status in their respective countries. This has been made possible as a result of the training workshop environment, where participants are able to share information and specimens with each other and the wider knowledge of the resource person(s).

Some participants already reported that a number of publications have been produced with the benefit of the training received, leading to dissemination of new information.

D. Database/directory of experts

Participants reported an increase in their directory of personnel capable of diagnosis in the target pest groups for which training have been delivered. This, together with the various planned in-country training, would lead to a significant population of diagnosticians worthy of an updated ASEAN database.

E. ARDN website

While the ARDN website is already up, we expect that, as AMS deliver on their planned follow-on activities following the various JAIF training activities as well as in-country training and publications, much more related information (including an updated database of diagnosticians) will be uploaded to the ARDN website.

F. Number of policy recommendations

As the Project has only entered its second year of implementation, the relatively short time frame has yet to yield any policy recommendations based on new taxonomic knowledge and information. It is expected that new surveys and information gathered following this added competency will support any necessary changes/recommendations regarding policy.

G. Number of training course modules/ training manuals developed

Most AMS have indicated that they have made use of the training manuals provided at the workshops and other guides and handouts as the basis for national protocols in the diagnosis of the target pests. In some cases, as in the case for leafminers, the training has enabled national survey plans and factsheets. This is direct evidence of the longer-term impact of the Project and its sustainability.

A few MAS have indicated in-country training course are being planned to extend the newly-acquired skills to other plant protection and quarantine officers in the near future.

H. Information feedback from clients/stakeholders

I. Number of crops exported, volume and value

The two questions did not elicit any responses as they perhaps constitute not so useful indicator in view of short time frame of project. Market access applications take time and are influenced by factors beyond diagnostic capacity.

Output Survey Questionnaire
Japan ASEAN Integration Fund (JAIF)-supported Taxonomic capacity building to support market access for agricultural trade in the ASEAN region

---

Dear All,
The survey questionnaire below is an integral monitoring and evaluation process required by the ASEAN Secretariat in compliance with the requirements of the Japan ASEAN Integration Fund (JAIF) which has funded the above project in the past two years.
ASEAN Member States (AMS) which participated in this project are requested to complete the form below to help support our request to JAIF to continue support for taxonomic capacity building for AMS for another phase. We look forward to your prompt response to this request and hope to receive your comments as soon as possible.

Below are some notes to help guide you in responding to the questions. If you still have questions, please do not hesitate to contact us at ………………………………………….

Thank you for your continued support of ASEANET and the ASEAN Regional Diagnostic Network (ARDN) in its efforts to build diagnostic capacity in ASEAN.

Guidance Notes

In Phase 1 of the JAIF Project, a Training Workshop followed by an attachment program for selected participants have been organized for each of three topics: a) Diagnostics of Plant Viruses, b) Identification of Leafminers of Agricultural Importance, and c) Identification of Weevils of Quarantine Importance.

Question A. In this question we would like to know how many general diagnosticians and how many specialist diagnosticians you have i) before the start of the JAIF Project, ii) at the end of Phase 1 of JAIF Project and iii) the expected number of general and specialist diagnosticians by the end of Phase 2 (year 2018), particularly if you are planning to have your own in-country training activities.
Please provide figures separately for identification of a) Plant Viruses, b) Leafminers and c) Weevils

Question B. We would like to know if the JAIF Project has resulted in any increase in the number of specimens correctly identified for each of a) Plant Viruses, b) Leafminers, and c) Weevils.
Please give numbers separately for each of these three areas, before and after training.

Question C. Following on from the question above, please let us know if, as a result of officers trained by the JAIF Project, correctly identified specimens have been added to your specimen collection. These can be previously unidentified specimens or newly collected specimens.

Question D. If you have a list of trained personnel or experts, or a database, have you added the names of the newly-trained officers in a)plant viruses, b) leafminers and c) weevils to the list/database.

Question E & F. If you have additional comments, please add, thank you

Question G. In this question, we would like to know if you have organized (or are planning to organize your own in-country training in the diagnostics of a) plant viruses, b) leafminers, or c) weevils. Also, whether you have developed your own training manuals or identification guides in your own language, after the training from the JAIF Project.

Question H & I. Please let us have your comments on the JAIF Project so far. For example, how has it helped national diagnostic capacity? Or has it facilitated in securing or maintaining market access for your export crops?

Output Outline PP on Taxonomic capacity building to support market access for agricultural trade in the ASEAN region (Phase I and Phase II)				
	Baseline (condition before commencement of ARDN)	Achieved Level after Phase I (2015-2017)	Expected Condition after Phase II (2017-2018)	References data/hyperlink
A. No. of trained personnel/experts/ interns				
1. Training on diagnostics of plant viruses	*Number of generalists/specialists before project*	*Number of generalists/specialists following completion of training program*	*Additional number of staff to be trained in-country?*	ASEANET report based on email survey participating country/participant survey following training events
Generalist level (training workshop)				
Specialist level (attachment program)				
2. Training on identification of leafminers of agric. importance	*Number of generalists/specialists before project*	*Number of generalists/specialists following completion of training program*	*Additional number of staff to be trained in-country?*	ASEANET report based on email survey participating country/participant survey following training events
Generalist level (workshop)				
Specialist level (attachment program)				
3. Training on identification of weevils of quarantine importance	*Number of generalists/specialists before project*	*Number of generalists/specialists following completion of training program*	*Additional number of staff to be trained in-country?*	ASEANET report based on email survey participating country/participant survey following training events
Generalist level (workshop)				
Specialist level (attachment program)				
B. No. of insect/disease specimens correctly identified	*Number of identified specimens before project*	*Number of identified specimens after completion of training program*	-	
1. Plant viruses				ASEANET report based on email survey
2. Leafminers of agric. importance				

3. Weevils of quarantine importance				participating country/participant survey following training events
C. No. of specimens deposited in diagnostic laboratories	*Number of identified specimens in collection before project*	*Number of identified specimens in collection after project training*	-	
1. Plant viruses				ASEANET report based on email survey participating country/participant survey following training events
2. Leafminers of agric. importance				
3. Weevils of quarantine importance				
Number of publications /information materials disseminated	*Number of publications or Information materials available*	*Number of publications or Information materials after training*	-	
1. Plant viruses				
2. Leafminers of agric. importance				
3. Weevils of quarantine importance				
D. Database/directory of experts or trained diagnosticians developed for:	*Number of trained diagnosticians before project*	*Number of trained diagnosticians before project*	*Expected number of trained diagnosticians after further in-country training*	
1. Plant viruses				
2. Leafminers of agric. importance				
3. Weevils of quarantine importance				
E. Website on ARDN launched	No	Established but yet to be widely promoted	Widely promoted	
F. Number of policy recommendations (long-term measure	1. Support for project by AMS 2. Endorsement of ARDN concept by ASWGC and SOM AMAF	Establishment of national diagnostic network in Vietnam and Cambodia	More AMS establish functional national diagnostic networks	

beyond project duration)	3. Funding support from JAIF			
G. No. of training course modules developed; training manuals produced or training events conducted locally				
1. Plant viruses	-	Training manual and guides		
2. Leafminers of agric. importance	LUCID Guide	Training manual and guides		
3. Weevils of quarantine importance	ASEAN PLANTI guide	-		
H. No. of information feedbacks from clients/stakeholders (long-term measure beyond project duration)	-	*Has JAIF project had a positive impact on national diagnostic capacity?*	-	
I. No. of crops exported and its volume and value increased[a] (Has the project assisted in the market access for any of your export crops?)				

[a] Not a useful indicator in view of short time frame of project. Market access applications take time and are influenced by factors beyond diagnostic capacity