# Forensic Entomology

## An Introduction

**Dorothy E. Gennard**
*University of Lincoln, UK*

# Forensic Entomology

# Forensic Entomology

## An Introduction

**Dorothy E. Gennard**
*University of Lincoln, UK*

Telephone (+44) 1243 779777

Email (for orders and customer service enquiries): cs-books@wiley.co.uk
Visit our Home Page on www.wiley.com



***Other Wiley Editorial Offices***

John Wiley & Sons Inc., 111 River Street, Hoboken, NJ 07030, USA

Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741, USA

Wiley-VCH Verlag GmbH, Boschstr. 12, D-69469 Weinheim, Germany

John Wiley & Sons Australia Ltd, 33 Park Road, Milton, Queensland 4064, Australia

John Wiley & Sons (Asia) Pte Ltd, 2 Clementi Loop #02-01, Jin Xing Distripark, Singapore 129809

John Wiley & Sons Canada Ltd, 22 Worcester Road, Etobicoke, Ontario, Canada M9W 1L1

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Anniversary Logo Design: Richard J. Pacifico

***Library of Congress Cataloging in Publication Data***

Gennard, Dorothy E.
Forensic entomology : an introduction / Dorothy E. Gennard.
p. cm.
Includes bibliographical references.
ISBN: 978-0-470-01478-3 (cloth : alk. paper)
ISBN: 978-0-470-01479-0 (pbk. : alk. paper)
1. Forensic entomology. I. Title.
RA1063.45.G46 2006
614′.1—dc22 2006032094

***British Library Cataloguing in Publication Data***

A catalogue record for this book is available from the British Library

ISBN 978-0-470-01478-3 (HB) 978-0-470-01479-0 (PR)

Typeset in 10.5/12.5pt Times by Integra Software Services Pvt. Ltd, Pondicherry, India
Printed and bound in Great Britain by Antony Rowe Ltd, Chippenham, Wiltshire
This book is printed on acid-free paper responsibly manufactured from sustainable forestry in which at least two trees are planted for each one used for paper production.

# Contents

# List of figures

# List of tables

# Preface

This book is an introduction to forensic entomology for undergraduates, particularly those studying for a degree in forensic science. Responding to comments over the past 6 years from students studying forensic entomology, this book provides a basic entomological background, with descriptions of practical techniques and the legal aspects of using insects to estimate the time since death and help solve crime. I have included sections on the ecological implications of the presence of some of the more frequent insect visitors to a corpse (human and non-human). I have also included information from a range of countries to broaden the application of the textbook, as students travel widely and may go on to find employment across the world.

I hope that, by using *Forensic Entomology: An Introduction*, students will find studying entomology interesting and its role and application as a forensic tool to solve crime scenarios a fascination, irrespective of any fears about the smell!

*Dorothy Gennard*

# Acknowledgements

I am grateful to the following for permission to reproduce illustrations, or quote from publications:

The Amateur Entomologists' Society, for permission to quote from Dear J. P. *Carrion* (1978). In Stubbs A. and Chandler P. *A Dipterist's Handbook*. The Amateur Entomologist 15. The Amateur Entomologists' Society: London (1978).

Dr Mark Benecke, for providing a copy of his RAPD profile of *Oiceophoma thoracicum* L. and *Calliphora vicina* (Robineau-Desvoidy).

Professor Michael Claridge, the Royal Entomological Society of London and Dr B. R. Laurence, for permission to reproduce his photograph of the tequila bottle from *Antenna* **6**(3) (1982).

Dr Jonathan Cooter, Hereford Museum, for permission to quote his comments about the distribution of *Necrobia ruficollis* in the UK.

The Etnografisch Museum of Antwerp, for providing a CD of photographs of the paintings by Morishige (1673–1680) entitled 'The nine contemplations of the impurity of the human body' (Figures 1.1–1.7) and for permission to reproduce them.

Dr Sharon Erzinçlioğlu, for permission to quote the case of Mike Evans and Zoë, from Erzinçlioğlu Y. Z. *Maggots, Murder and Men.* Harley Books: Colchester (2000).

Elsevier, for permission to quote details of lower temperature limits, published in Marchenko M. L. Medico-legal relevance of cadaver entomofauna for the determination of the time of death. *Forensic Science International* **120**(1–2): 89–109 (2001) and a section of Forensic Science International 98.

Benecke M., Random amplified polymorphic DNA (RAPD) typing of necrophageosis insects (Diptera: Coleoptera) in criminal forensic science: validation and use in practice (Figure 4) p. 164 © (1998) with permission from Elsevier (presented in this book as Figure 3.17).

Dr Susan Giles, Curator, Bristol Museums, Galleries and Archives, Bristol City Council, for the opportunity to photograph the Bristol Mummy.

Dr Martin Hall, British Museum, Natural History, for permission to quote his comments on the species of fly recovered from the bodies of two children murdered in Soham, Cambridgeshire.

Frances Harcourt-Brown, for permission to reproduce her photograph (Figure 1.11) of a rabbit exhibiting myiasis.

Dr Kate Horne, Secretary of the Council for the Registration of Forensic Practitioners, for permission to reproduce the tenets of the Council for the Forensic Practitioner.

The Regents of the University of California, for permission to reproduce a modification of Figure 4A from Wilson L. T. and Barnett W. W. Degree-days: an aid in crop and pest management. *California Agriculture* (**January–February**): 4–7 (1983). ™©1983 Regents, University of California (presented in this book as Figure 7.3).

John Newton and Rentokil Initial plc, for permission to reproduce diagrams of antennae, insect larvae and pupae (Figures 2.3, 3.4 and 3.5), from Munro J. W. *Pests of Stored Products*. The Rentokil Library. Benham and Co: Colchester (1965).

Tecknica Ltd, for providing the 2006 MapMate data and for permission to reproduce the Checklist of UK Recorded Calliphoridae, 2006, and also selected families of the Checklist of UK Coleoptera.

Dr Chris Pamplin, Editor, UK Register of Expert Witnesses, for permission to reproduce a section of *Taking Experts out of Court*, citing evidence for the Daubert test of evidence.

Warrant Officer Thierry Pasquerault Colonel J. Hebfard, of the Criminal Research Institute of the French and National Gendarmerie, for permission to use his photograph of packaging of entomological specimens recovered from a crime scene.

I would like to thank the following people for their comments, discussion and advice:

Mr Bill Barnett; Dr Trevor Crosby, Curator NZ Arthropod Collection, Landcare Research, University of Auckland; Keith Butterfield, University of Lincoln; Mr Lindsay Cutts; Dr John Esser; Susan Giles, Curator, Bristol Museums, Galleries and Archives, Bristol City Council; Katrina Hanley; Lorna Hanley; Karen Inckle; Mr Simon Jelf, Bond Solon Training Ltd; Helen Joiner; Mark Lawton; Helen Lonsdale; Dr Robert Nash, Ulster Museum; Professor Brian McGaw, University of Lincoln; Dr Brett Ratcliffe, Curator and Professor, Systematics Research Collections, University of Nebraska, Lincoln, NE, USA; Sean Riches, CAB Product Manager, Novartis Ltd, Paula Saward, formerly of Centrex; Kate Stafford; Dr J. Van Alphen, Etnografisch Museum of Antwerp, Belgium; Arpad Vass, Oakridge National Laboratory, TN, USA; Janet L. White,

Executive Editor, *California Agriculture*; Dr Lloyd T. Wilson, Texas A&M University; Laura Woodcock and Dr Frank Zalom, University of California.

I am most grateful to Rachael Ballard and Elizabeth Kingston, of John Wiley & Sons Ltd, for their help, encouragement and support; especially to Elizabeth Kingston and Lesley Winchester (Freelance Editor) for their editing assistance in the production of this manuscript.

I am grateful to Dr Darren Mann and Mr James Hogan of the Hope Entomological Collections, Oxford University Museum of Natural History, for providing, on extended loan, dipteran specimens for photography.

I am especially grateful to Mr David Padley, formerly police photographer with the Lincolnshire Police, for his excellent photography of the entomological specimens.

# 1

# The breadth of forensic entomology

Forensic entomology is the branch of forensic science in which information about insects is used to draw conclusions when investigating legal cases relating to both humans and wildlife, although on occasion the term may be expanded to include other arthropods. Insects can be used in the investigation of a crime scene both on land and in water (Anderson, 1995; Erzinçlioğlu, 2000; Keiper and Casamatta, 2001; Hobischak and Anderson, 2002; Oliveira-Costa and de Mello-Patiu, 2004). The majority of cases where entomological evidence has been used are concerned with illegal activities which take place on land and are discovered within a short time of being committed. Gaudry *et al.* (2004) commented that in France 70 % of cadavers were found outdoors and of these 60 % were less than 1 month old.

The insects that can assist in forensic entomological investigations include blowflies, flesh flies, cheese skippers, hide and skin beetles, rove beetles and clown beetles. In some of these families only the juvenile stages are carrion feeders and consume a dead body. In others both the juvenile stages and the adults will eat the body (are necrophages). Yet other families of insects are attracted to the body solely because they feed on the necrophagous insects that are present.

## 1.1 History of forensic entomology

Insects are known to have been used in the detection of crimes for a long time and a number of researchers have written about the history of forensic entomology (Benecke, 2001; Greenberg and Kunich, 2002). The Chinese used the presence of flies and other insects as part of their investigative armoury for crime scene investigation and instances of their use are recorded as early as the mid-tenth century (Cheng, 1890; cited in Greenberg and Kunich, 2002). Indeed, such was the importance of insects in crime scene investigation that in 1235, a training manual on investigating death, *Washing Away of Wrongs*, was written by Sung Tz'u. In this medico-legal book it is recorded that the landing of a number of blowflies on a particular sickle caused a murderer to confess to murdering a fellow Chinese farm worker with that sickle.

Between the thirteenth and the nineteenth century, a number of developments in biology laid the foundation for forensic entomology to become a branch of scientific study. The two most notable were, perhaps, experiments in Italy by Redi (1668) using the flesh of a number of different animal species, in which he demonstrated that larvae developed from eggs laid by flies, and the work by Linnaeus (1775) in developing a system of classification. In so doing, Linnaeus provided a means of insect identification, including identifying such forensically important flies as *Calliphora vomitoria* (Linnaeus). These developments formed foundations from which determination of the length of the stages in the insect's life cycle could be worked out and indicators of time since death could be developed.

A particularly significant legal case, which helped establish forensic entomology as a recognized tool for investigating crime scenes, was that of a murdered newborn baby. The baby's mummified body, encased in a chimney, was revealed behind a mantelpiece in a boarding house when renovation work was being undertaken in 1850. Dr Marcel Bergeret carried out an autopsy on the body and discovered larvae of a fleshfly, *Sarcophaga carnaria* (Linnaeus), and some moths. He concluded that the baby's body had been sealed up in 1848 and that the moths had gained access in 1849. As a result of this estimation of post mortem interval, occupiers of the house previous to 1848 were accused and the current occupiers exonerated (Bergeret, 1855).

The next significant point in the history of forensic entomology resulted from observations and conclusions made by Mégnin (1894). He related eight stages of human decomposition to the succession of insects colonizing the body after death. He published his findings in *La Faune des Cadavres: Application de l'Entomologie à la Médicine Légale*. These stages of decomposition were subsequently shown to vary in speed and to be dependent upon environmental conditions, including temperature and, for example, whether or not the corpse was clothed. However, the similarity in overall decomposition sequence and the value of the association of insects has been demonstrated for decomposition of the bodies of a number of animal species. This knowledge about insect succession on a corpse became the basis for forensic entomologists' estimations of the time since death of the corpse.

In the twentieth century insects were shown to be of value in court cases involving insect colonization of body parts recovered from water and not just whole corpses found on land. On 29 September 1935, several body parts, later identified as originating from two females, were recovered from a Scottish river near Edinburgh. The identities of the deceased were determined and the women were named as Mrs Ruxton and Mary Rogerson, 'nanny' for the family. The presence of larvae of the blowfly *Calliphora vicina* Robineau-Desvoidy, in their third larval instar, indicated that the eggs had been laid prior to the bodies being dumped in the river. This information, combined with other evidence, resulted in the husband, Dr Ruxton, being convicted of the murder of his wife and Mary Rogerson.

The acceptance of forensic entomology has depended upon both academics and practitioners working alongside the police and legal authorities, to refine and develop forensic entomology as a scientific study in the late twentieth and early twenty-first centuries. A list of forensic entomologists, who are members of the American Board of Forensic Entomology, the European Association for Forensic Entomology and other professional entomological and medical organizations, can be found on the website: http://folk.uio.no/mostarke/forensic_entomologists.html

## 1.2 Indicators of time of death

In the first 72 hours after death, the pathologist is usually considered to be able to provide a reasonably accurate determination of the time of death. Historically, this has been based upon the condition of the body itself and such features as the fall in body temperature. Beyond this time, there is less medical information with which to correlate post mortem interval (PMI). So another area of expertise is required to clarify time of death. The forensic entomologist can provide a measure of the possible post mortem interval, based upon the life cycle stages of particular fly species recovered from the corpse, or from the succession of insects present on the body. This estimate can be given over a period of hours, weeks or years. The start of the post mortem interval is considered to coincide with the point when the fly first laid its eggs on the body, and its end to be the discovery of the body and the recognition of life stage of the oldest colonizing species infesting it. The duration of this stage, in relation to the particular stage of decay, gives an accurate measure of the probable length of time the person has been dead and may be the best estimate that is available.

## 1.3 Stages of decomposition of a body

The stages of decomposition of a body have been a topic of interest for both artists and scientists over a long period of time (Figures 1.1–1.8). There are three recognizable processes in corpse decomposition. These are autolysis, putrefaction and skeletal bone decomposition (diagenesis). In autolysis, a process of natural breakdown, the cells of the body are digested by enzymes, including lipases, proteases and carbohydrases. This process can be most rapid in organs such as the brain and liver (Vass, 2001). A ‘soup’ of nutrients is released which forms a food source for bacteria. Putrefaction is the breakdown of tissues by bacteria. As a result, gases such as hydrogen sulphide, sulphur dioxide, carbon dioxide, methane, ammonia, hydrogen and carbon dioxide are released. Alongside this, anaerobic fermentation takes place when the volatiles propionic and butyric acid are formed. The body undergoes active decay, in which protein sources are broken