

Contents

Preface — vii

Nannomecoptera and Neomecoptera – an overview — xiii

List of contributing authors — xv

1 Nannomecoptera, Nannochoristidae, Nannochorista — 1

Rolf G. Beutel, Phillip Sutter & Frank Friedrich

1.1 Taxonomy and distribution — 1

Phillip Suter & Rolf G. Beutel

1.2 Biology — 1

1.3 Morphology of adults — 5

Rolf G. Beutel & Frank Friedrich

1.3.1 Head — 5

1.3.1.1 Head capsule — 5

1.3.1.2 Tentorium — 6

1.3.1.3 Labrum — 7

1.3.1.4 Antenna — 7

1.3.1.5 Mandible — 8

1.3.1.6 Maxilla — 9

1.3.1.7 Labium — 10

1.3.1.8 Epipharynx — 13

1.3.1.9 Hypopharynx — 13

1.3.1.10 Pharynx and esophagus — 13

1.3.1.11 Salivarium — 16

1.3.1.12 Cerebrum, suboesophageal complex, and stomatogastric nervous system — 16

1.3.1.13 Glands — 18

1.3.1.14 Circulatory system — 18

1.3.1.15 Tracheal system — 18

1.3.1.16 Fat body — 18

Frank Friedrich & Rolf G. Beutel

1.3.2 Thorax — 19

1.3.2.1 General appearance — 19

1.3.2.2 Cervical region and prothorax — 19

1.3.2.3 Mesothorax — 22

1.3.2.4 Metathorax — 25

1.3.2.5 Legs — 29

1.3.2.6 Wings — 30

Rolf G. Beutel

1.3.3 Pregenital abdomen — 31

Frank Hünefeld & Rolf G. Beutel

1.3.4 Female postabdomen — 31

1.3.4.1 External morphology — 31

1.3.4.2 Internal parts of the genital system — 34

Gerhard Mickoleit & Rolf G. Beutel

1.3.5 Male postabdomen — 34

1.3.5.1 Segment VIII and genital capsule of segment IX — 34

1.3.5.2 Copulatory apparatus — 34

1.3.5.3 Function — 39

Bożena Simiczyjew & Rolf G. Beutel

1.3.6 Ovaries — 41

1.4 Morphology of larvae — 43

Rolf G. Beutel, Frank Friedrich, Hans Pohl &
Niels P. Kristensen

1.4.1 Head — 43

1.4.1.1 Head capsule, external features — 43

1.4.1.2 Internal skeletal structures — 45

1.4.1.3 Eyes — 48

1.4.1.4 Labrum — 49

1.4.1.5 Antenna — 50

1.4.1.6 Mandible — 50

1.4.1.7 Maxilla — 51

1.4.1.8 Labium — 53

1.4.1.9 Epipharynx — 54

1.4.1.10 Hypopharynx — 54

1.4.1.11 Cephalic digestive tract — 55

1.4.1.12 Labial glands and salivarium — 57

1.4.1.13 Nervous system — 58

1.4.1.14 Aorta and retrocerebral organs — 59

1.4.1.15 Fat body — 59

Rolf G. Beutel & Frank Friedrich

1.4.2 Thorax — 59

Maximilian Fraulob, Frank Hünefeld & Rolf G. Beutel

1.4.3 Abdomen — 61

1.4.3.1 Abdominal segments I–IX — 61

- 1.4.3.2 Abdominal segment X — **61**
- 1.4.3.3 Anal papillae — **65**
- 1.4.3.4 Digestive tract — **66**

Rolf G. Beutel & Margarita Yavorskaya

- 1.5 Morphology of pupae — 66**

- 1.6 References — 68**

2 Neomecoptera, Boreidae, Caurininae, Caurinus — 71

Loren K. Russell & Rolf G. Beutel

- 2.1 Taxonomy and distribution — 71**

Loren K. Russel

- 2.2 Biology — 71**
 - 2.2.1 Climatic factors — **71**
 - 2.2.2 Feeding — **72**
 - 2.2.2.1 Adult feeding behavior — **72**
 - 2.2.2.2 Larval feeding behavior — **72**
 - 2.2.3 Host relations and ecology — **73**
 - 2.2.4 Host phytochemicals — **73**
 - 2.2.5 Parasites and predation — **75**
 - 2.2.6 Locomotion — **75**

- 2.3 Morphology of adults — 75**

Frank Friedrich & Rolf G. Beutel

- 2.3.1 Head — **76**
 - 2.3.1.1 Head capsule — **76**
 - 2.3.1.2 Tentorium — **77**
 - 2.3.1.3 Labrum — **77**
 - 2.3.1.4 Antenna — **78**
 - 2.3.1.5 Mandible — **79**
 - 2.3.1.6 Maxillolabial complex — **79**
 - 2.3.1.7 Epipharynx — **81**
 - 2.3.1.8 Hypopharynx — **82**
 - 2.3.1.9 Pharynx and oesophagus — **84**
 - 2.3.1.10 Salivarium — **84**
 - 2.3.1.11 Cerebrum, suboesophageal complex, and stomatogastric nervous system — **84**
 - 2.3.1.12 Glands — **85**
 - 2.3.1.13 Circulatory system — **85**
 - 2.3.1.14 Tracheal system — **85**
 - 2.3.1.15 Fat body — **85**

Frank Friedrich, Loren K. Russell & Rolf G. Beutel

- 2.3.2 Thorax — **85**
 - 2.3.2.1 Cervical region and prothorax — **85**
 - 2.3.2.2 Pterothorax — **87**
 - 2.3.2.3 Legs — **89**
 - 2.3.2.4 Wings — **89**

Frank Hünefeld & Rolf G. Beutel

- 2.3.3 Pregenital abdomen — **90**

Frank Hünefeld & Rolf G. Beutel

- 2.3.4 Female postabdomen — **91**

Frank Hünefeld & Rolf G. Beutel

- 2.3.5 Male postabdomen — **92**

Bożena Simiczyjew & Rolf G. Beutel

- 2.3.6 Ovaries — **93**

Loren K. Russell & Rolf G. Beutel

- 2.3.7 Eggs — **95**

Romano Dallai, Loren K. Russell & Rolf G. Beutel

- 2.3.8 Spermatophore and spermatozoa — **97**

Loren K. Russell & Rolf G. Beutel

- 2.3.9 Organ systems — **99**
 - 2.3.9.1 The digestive system and associated organs — **99**
 - 2.3.9.2 The nervous system — **101**

Rolf G. Beutel, Benjamin Fabian, Hans Pohl & Frank Friedrich

- 2.4 Morphology of larvae — 101**

- 2.4.1 Head — **101**
 - 2.4.1.1 Head capsule — **101**
 - 2.4.1.2 Tentorium — **103**
 - 2.4.1.3 Eyes — **104**
 - 2.4.1.4 Labrum — **104**
 - 2.4.1.5 Antennae — **104**
 - 2.4.1.6 Mandibles — **104**
 - 2.4.1.7 Maxillolabial complex — **104**
 - 2.4.1.8 Preoral cavity and mouth opening — **106**
 - 2.4.1.9 Pharynx — **106**
 - 2.4.1.10 Salivary system — **107**
 - 2.4.1.11 Brain and suboesophageal ganglion — **109**

- 2.4.2 Thorax — 109
- 2.4.3 Abdomen — 109

2.5 References — 110

3 Neomecoptera, Boreidae, Boreinae, *Boreus*, and *Hesperoboreus* — 113

Rolf G. Beutel & Loren K. Russell

3.1 Taxonomy and distribution — 113

Loren K. Russell

3.2 Biology — 114

- 3.2.1 Habitats — 114
- 3.2.2 Life cycle — 114
- 3.2.3 Mating and oviposition — 115
- 3.2.4 Oviposition and fecundity — 116
- 3.2.5 Egg development and eclosion — 117
- 3.2.6 Larval biology — 117
- 3.2.7 Pupation — 118
- 3.2.8 Adult behavior — 118
 - 3.2.8.1 Activity — 118
 - 3.2.8.2 Adult feeding behavior — 119
 - 3.2.8.3 Predators and parasites — 119

3.3 Adult morphology — 120

Frank Friedrich & Rolf G. Beutel

- 3.3.1 Head — 120
 - 3.3.1.1 Head capsule — 120
 - 3.3.1.2 Tentorium — 122
 - 3.3.1.3 Labrum — 122
 - 3.3.1.4 Antenna — 122
 - 3.3.1.5 Mandible — 122
 - 3.3.1.6 Maxillolabial complex — 124
 - 3.3.1.7 Epipharynx — 126
 - 3.3.1.8 Hypopharynx — 126
 - 3.3.1.9 Pharynx and oesophagus — 126
 - 3.3.1.10 Salivarium — 129
 - 3.3.1.11 Cerebrum, suboesophageal complex, and stomatogastric nervous system — 129
 - 3.3.1.12 Glands and neurosecretory organs — 129
 - 3.3.1.13 Circulatory system — 130
 - 3.3.1.14 Tracheal system — 130
 - 3.3.1.15 Fat body — 130

Frank Friedrich & Rolf G. Beutel

- 3.3.2 Thorax — 130
 - 3.3.2.1 General appearance — 130
 - 3.3.2.2 Prothorax and cervical region — 130
 - 3.3.2.3 Mesothorax — 132
 - 3.3.2.4 Metathorax — 135
 - 3.3.2.5 Legs — 137
 - 3.3.2.6 Wings — 138

Rolf G. Beutel

3.3.3 Pregenital segments I–VII — 139

Frank Hünefeld & Rolf G. Beutel

3.3.4 Female postabdomen — 139

Rolf G. Beutel

3.3.5 Male genital segments — 142

Bożena Simiczjew & Rolf G. Beutel

3.3.6 Ovaries — 143

Nobuo Suzuki, Loren K. Russell & Rolf G. Beutel

3.3.7 Eggs — 146

Romano Dallai & Rolf G. Beutel

3.3.8 Spermatophores and Spermatozoa — 146

Rolf G. Beutel & Kenny Jandausch

3.3.9 Digestive system — 148

Rolf G. Beutel, Hans Pohl & Frank Friedrich

3.4 Morphology of larvae — 149

- 3.4.1 Head — 150
 - 3.4.1.1 Head capsule — 150
 - 3.4.1.2 Tentorium — 151
 - 3.4.1.3 Light sense organs — 151
 - 3.4.1.4 Chaetotaxy — 151
 - 3.4.1.5 Labrum — 151
 - 3.4.1.6 Antennae — 151
 - 3.4.1.7 Mandibles — 151
 - 3.4.1.8 Maxillolabial complex — 152
 - 3.4.1.9 Preoral cavity and pharynx — 152
 - 3.4.1.10 Salivary ducts and glands — 152
 - 3.4.1.11 Brain, suboesophageal ganglion, and stomatogastric nervous system — 152
- 3.4.2 Thorax — 153

3.4.3	Abdomen — 153	Nobuo Suzuki & Rolf G. Beutel
3.4.4	Postcephalic internal organs — 153	3.6 Development — 155
3.4.4.1	Fat body — 153	
3.4.4.2	Postcephalic digestive tract and Malpighian tubules — 153	3.7 References — 156
3.4.4.3	Postcephalic nervous system — 153	
3.4.4.4	Tracheal system — 154	Rolf G. Beutel & Frank Friedrich
3.4.4.5	Circulatory system — 154	4 Phylogeny — 159
	Rolf G. Beutel & Frank Friedrich	4.1 References — 160
3.5	Morphology of pupae — 154	Index — 163