

# CONTENTS

Acknowledgements and image credits.....	8
Repository abbreviations.....	9
List of figures by order.....	10
List of figures by deposit.....	11
<b>Introduction</b> .....	12
<b>A note on the geological timescale and the dating of insect fossils</b> .....	15
<i>Summary of the Devonian Period</i> .....	16
<i>Summary of the Carboniferous Period</i> .....	18
<i>Summary of the Permian Period</i> .....	20
<i>Summary of the Triassic Period</i> .....	22
<i>Summary of the Jurassic Period</i> .....	24
<i>Summary of the Cretaceous Period</i> .....	26
<i>Summary of the 'Tertiary' Period</i> .....	28
<b>Insects and their fossilization</b> .....	30
<i>What are fossils and how are they preserved?</i> .....	30
<i>Amber</i> .....	31
<i>Rock</i> .....	35
<i>Why study fossil insects?</i> .....	36
<b>How to study fossil insects</b> .....	41
<i>Insects in amber</i> .....	41
<i>Insects in rock</i> .....	43
<i>The palaeospecies concept</i> .....	46
<i>Identification of fossil insect species</i> .....	46
<i>How to formally describe new fossil insects</i> .....	50
<b>Significant fossil insect localities</b> .....	51
<b><i>Europe</i></b> .....	51
Rhynie Chert, Scotland, UK.....	51
Commentary, France.....	51
Oboro, Czech Republic.....	51
Nierdermoschel, Germany.....	51
Lodève Basin, France.....	51
Vosges, France.....	52
Pałęgi clay-pit, Poland.....	54
Solnhofen, Germany.....	54
Lias of Europe.....	54
Lower Cretaceous of southern England, UK.....	55
Purbeck Limestone Group and Wealden Supergroup.....	55
El Montsec (and Las Hoyas), Spain.....	55
Mo Clay, Fur Formation, Denmark.....	55
Messel, Germany.....	57
Eckfelder Maar, Germany.....	57
Bembridge Marls (Insect Limestone Bed), England, UK.....	57
Enspel, Westerwald, Germany.....	61
Various Tertiary deposits, France.....	61
Various Tertiary deposits, Slovenia.....	61
Randeck Maar, Germany.....	63
Río Rubielos, Teruel, Spain.....	63

Hrútagil, Iceland.....	63
Willerhausen, Germany.....	63
Spanish amber.....	63
Charentese amber.....	64
Oise amber.....	64
Baltic amber.....	64
Rovno amber.....	64
Bitterfeld amber.....	64
<b>(Eur)Asia</b> .....	66
Tshekarda, Urals.....	66
Karatau, Kazakhstan.....	66
Daohugou, China.....	66
Zaza Formation, Baissa, Siberia.....	66
Yixian Formation, China.....	67
Shanwang, China.....	67
Lebanese and Jordanian ambers.....	67
Burmese (Myanmar) amber.....	67
Russian amber.....	67
Indian amber.....	73
Chinese amber.....	73
<b>Australia</b> .....	73
Newcastle Coal Measures, Belmont, NSW.....	73
Ipswich Coal Measures, Mount Crosby, Queensland.....	73
Perth Basin, Western Australia.....	73
Talbragar Fish Beds, NSW.....	76
Koonwarra, Victoria.....	76
Redbank Plains Series and Dinmore, Queensland.....	76
Cape York amber.....	76
<b>New Zealand</b> .....	76
Foulden Maar, Otago.....	76
South Island amber.....	77
<b>Africa</b> .....	77
Estcourt Formation, Karoo Basin, South Africa.....	78
Molteno Formation, Karoo Basin, South Africa.....	78
Orapa, Botswana.....	78
Mfwanganu and Ruzinga Islands, Lake Victoria, Kenya.....	78
Ethiopian amber.....	78
<b>The Americas</b> .....	78
Mazon Creek, Illinois, USA.....	78
Elmo, Kansas, USA.....	79
Cascade, Virginia, USA.....	79
Mendoza and Los Rastros Provinces, South America.....	79
Crato Formation, Brazil.....	79
Okanagan Highlands, British Columbia, Canada (and Washington State, USA).....	79
Green River Formation, USA.....	80
Florissant Formation, USA.....	83
Barstow Formation, USA.....	83
Rancho La Brea, USA.....	83

New Jersey (Raritan) amber.....	88
Canadian amber.....	88
Dominican amber.....	88
Mexican amber.....	90
<b>Diversity of fossil insects.....</b>	<b>91</b>
Springtails (Collembola).....	91
Coneheads (Protura).....	91
Two-pronged bristletails (Diplura).....	92
Bristletails (Archaeognatha).....	92
Silverfish (Zygentoma).....	94
Chimera wings (†Coxopteroptera).....	94
Syntonopterids (†Syntonopterida).....	94
Mayflies (Ephemeroptera).....	95
Geropterans (†Geroptera).....	97
†Griffinflies (Protodonata).....	97
Damselflies and dragonflies (Odonata).....	97
6-wings (†Palaeodictyoptera).....	101
Diclipterans (†Dicliptera).....	102
Megasecopterans (†Megasecoptera).....	102
Diaphanopterans (†Diaphanopteroidea).....	102
Hypoperlids (†Hypoperlida).....	103
Stoneflies (Plecoptera).....	103
Webspinners (Embiodea).....	105
Angel insects (Zoraptera).....	106
Earwigs (Dermaptera).....	106
Rock and ice crawlers (Notoptera).....	107
Caloneurodeans (†Caloneurodeia).....	109
Titanopterans (†Titanoptera).....	110
Protorthopterans (†Protorthoptera).....	110
Grasshoppers and crickets (Orthoptera).....	112
Fossil water striders (†Chresmododea).....	112
Stick insects (Phasmatodea).....	113
Paoliids (†Paoliida).....	115
Cockroaches and termites (Blattodea).....	116
Praying mantises (Mantodea).....	117
Miomopterans (†Miomoptera).....	119
Bark, book and parasitic lice (Psocodea).....	121
Thrips (Thysanoptera).....	122
True bugs (Hemiptera).....	122
Beetles (Coleoptera).....	125
Glosselytrodeans (†Glosselytrodeia).....	127
Snakeflies (Raphidioptera).....	127
Fishflies, alderflies and dobsonflies (Megaloptera).....	129
Lacewings (Neuroptera).....	130
Rafaelids (†Schwickertoptera).....	134
Ants, bees, wasps and sawflies (Hymenoptera).....	134
Scorpionflies and hangingflies (Mecoptera).....	139
Fleas (Siphonaptera).....	141
Flies (Diptera).....	142

Skleropterans (†Skleroptera).....	144
Stylopids (Strepsiptera).....	145
Caddisflies (Trichoptera).....	145
Butterflies and moths (Lepidoptera).....	146
<b>Insect behaviour and ecology in the fossil record</b> .....	149
<i>Fossil insect assemblages: palaeobiocoenosis or taphocoenosis?</i> .....	149
<i>Intrapopulation interactions</i> .....	151
<i>Intraspecific interactions: mating</i> .....	157
<i>Intraspecific interactions: trophallaxis</i> .....	159
<i>Interspecific interactions: parasitism</i> .....	159
<i>Interspecific interactions: symbiosis</i> .....	164
<i>Interspecific interactions: phoresy</i> .....	166
<i>Interspecific interactions: predators and prey</i> .....	168
<i>Individual behaviours: general</i> .....	171
<i>Individual behaviours: communication (including crypsis)</i> .....	175
<b>Sub-fossil insects</b> .....	183
<i>Copal</i> .....	183
<i>Non-copal and archaeo-paleoentomology</i> .....	187
<i>As components of animal coprolites</i> .....	188
<b>Insect trace fossils</b> .....	190
<i>What are trace fossils?</i> .....	190
<i>Classification</i> .....	190
<i>Insect trace fossils</i> .....	191
Locomotion.....	191
Resting.....	191
Burrows.....	191
Fossil insect nests.....	192
Pupation chambers.....	192
Transportable cases.....	193
Oviposition traces.....	193
Feeding.....	193
<i>Feeding traces in wood</i> .....	194
<i>Fruit and seed damage</i> .....	194
<i>Feeding traces on leaves and stems</i> .....	194
<i>Leaf feeding</i> .....	194
<i>Leaf mines</i> .....	195
<i>Leaf galls</i> .....	195
<i>Plant sucking</i> .....	195
<i>Animal remains</i> .....	196
<i>Dung feeding</i> .....	196
<i>Feeding and exploitation of animal remains</i> .....	196
Coprolites.....	196
<b>How long does an insect species exist?</b> .....	198
<b>How to become a palaeoentomologist</b> .....	200
<b>Literature cited in the text</b> .....	202
<b>Internet resources</b> .....	222
<b>Index to genera cited in the text</b> .....	223