Index

AVHRR, see Satellite data
Acarina, 31, 337
_Acheta domestica_, 290, see also Orthoptera
Acridoids, 8, 10, 33, 199–201, 209, 211, 214, 220, 336, 337–41, 347, 377–95, 399–411, 413–21, see also Grasshoppers, Locusts, Orthoptera
Acronyms in remote sensing and geographic information systems, 348
_Acyrthosiphon pisum_, 226, 247, 252, see also Aphids, Homoptera
Adipokinetic hormones, 293, 295 and phase in locusts, 293
Adventitious displacements, 437
Aerodynamics, 303–11
advance ratios, 308
biomechanical analysis, 303
intra- and inter-specific variation, 311
kinematic analysis, 303, 305, 306, 310
mechanical power requirements, 308, 310
and lipid loading, 312
morphological analysis, 303, 306, 310
profile drag coefficient, 306, 307, 308
profile power and forward airspeed, 309
quasi-steady aerodynamic theory, 305, 310
total power requirements, 306
wingbeat frequency, 306–9
East, 11, 13, 14, 142, 324–6, 330–2, 341–3
Horn of, 11, 14
North, 20, 254
northwest, 13, 339, 410
Sahel, 8, 10, 389, 390, 391
western, 343
southern, 14, 201, 256
southwestern, 15
sub-Saharan, 11, 256, 383
West, 8, 10, 377, 383–92
 Sahelian zone, 385, 386
 Sudan zone, 385, 386
African Armyworm, see _Spodoptera exempta_
African–European region, 3–29
climatic zones, 4
vegetation zones, 4, 5
weather, 4–7
African Horse Sickness virus, 14, 15
Agriculture, Forestry and Fisheries Research Council (Japan), 117
Agrochemical industry, 324, 399, 409
_Agroisps spp._, 143, see also Lepidoptera
_Agroisps infusa_, 142
return migration in autumn, 142
_Agroisps ipsilon_, 13, 14, 16, 20, 33, 38, 50, 51, 54, 57, 59, 196, 203, 207, 212, 213, 214, 215, 282, 284, 286, 287, 412
migration from temperate latitudes in autumn, 57
_Agroisps segetum_, 14
_Alabama argillacea_, 34, 38, 53, 57, 58, see also Lepidoptera
Alaska, 55
_Algeria_, 13, 14, 17, 410
Allatostatins, 289
response to environmental cues, 290
Alliance For Aerobiology Research (North America), 60
Along track scanning radiometer ATSR–2, 344
_América_, Central, 58, 310
North, 20, 31–66, 249, 253, 254, 281, 292, 412
climatic of, 32, 35–43
geographical features, 34–6
South, 310, 344

459
Index

Anacridium spp., 10, see also Orthoptera 460
Angola, 15
Anti-Locust Research Centre (UK), 407
Anticarsia gemmatalis, 34, 38, 48, 49, 57, see also Lepidoptera
Aphids, 21, 43, 46, 49, 195, 196, 220, 221, 251, 324, 332, 411, 412, 416, 448, see also Homoptera, Acyrthosiphon, Aphid, Diaphus, Macrosiphum, Megoura, Myzus, Pherodon, Rhoaphisphum, Schizaphis, Sitobion, T osoptra autumn migrants, 21 primary and secondary hosts, 21 range of migration, 21 virulence to crop varieties, 412 wing-morph determination, 226 Aphid fabrici, 216, 217, 218, 223, 226, 227, 330, see also Aphids, Homoptera
Aphis spp., 311, see also Lepidoptera
Aphis virens, 252, see also Coleoptera
Apoproteins, 293
Arabia, 12 southern, 13 southwestern, 341
Araneae, 31
Arctic, 35
Army Cutworm, see Euxoa auxiliary
ARTEMIS, see Remote sensing
Ascension Island, 15
Asia, 7, 265, 344, 412
climate of, 73 geographical features, 68
South, 249
southeast, 361
Assam, 410
Aster Leathopper, see Macroteles fascifrons
Aster Yellows, 47
Athetaus argentarius, 206, see also Coleoptera
Atlantic, 17 crossed by Schistocerca gregaria gregaria, 10
south, 15
Australia, 265
Australasia, 207, 208
Channel Country, 154, 340
climate of, 131, 132, 153, 173
rainfall and El Niño / Southern Oscillation, 131, 153
eastern, 131–50, 151–72, 187, 207, 208, 214, 283, 340–1, 416–17, 445
far inland, 153–69
landform and vegetation types, 154–6
western, 173–90, 213, 416
arid-zone rainfall, 183
arid-zone vegetation associations, 173–5
biodimic regions, 174
crops, 173–5
topography, 173
Australian Plague Locust, see Chortoicetes terminifera
Australian Plague Locust Commission, 416
Autographa gamma, 210, 219, 223, 229, 254, 255, 282, 286, 446, see also Lepidoptera
Azores, 290
Bahamas, 51
Bai-u summer rainy season, 67, 73–6, 80–3, 365–71
Balclutha sp., 15, see also Homoptera
Barley, 132
Bay of Bengal, 74
Beet Armyworm, see Spodoptera exigua
Beet Leathopper, see Circulifer tenellus
Bermuda High, 41, 45, 49, 55
Bet-hedging, 217, 246
Biotypes, 375
Black Catworm, see Agrotis ipsilon
Blackfly, see Simulium
Bluettongue virus, 15
Bogong Moth, see Agrotis infusa
Bohai Sea, 94, 98, 114, 215
Bombus terrestris, 306–8, see also Hymoptera
Botswana, 12, 14, 266
Britain, 17, 18, 21
Brown Planthopper, see Nilaparvata lugens
Bumblebees, 305, see also Bombus terrestris
Butterflies, 3, 15, 21, see also Lepidoptera, Aphrasia, Cynthis, Danaus, Historia, Marpesia, Parnara, Phoebis
migration, 316
effect of winds on direction of, 315
from temperate latitudes in autumn, 59
in the tropics, 316
in Venezuela, 316
physiological ecology of, 316
CIRAD-PRIFAS (France), 377, 388
Cabbage Looper, see Trichoplusia ni
Calling behaviour, 267, 284
and juvenile hormone, 282
and male quality, 288
time of occurrence, 286
Index

Callosoobruchus maculatus, 252, see also Coleoptera
Canada, 35, 252, 286, 291
Caspian region, 17
Chad, 383, 389, 410
Chickpeas, 151
eastern, 113, 119, 120, 121, 353–64, 365, 366
northeastern, 93–104, 445
southern, 124, 371
Chorisiomeura luniitera, 202, 217, 287, 288, see also Lepidoptera
Chorizagrotis auxiliaris, 212, 215, 253, see also Lepidoptera
Chorizaces terminifera, 131, 175–80, 185–8, 196, 199, 217, 237, 340–1, 347, 416, 421, 445, see also Locusts, Orthoptera
breeding areas, 178, 340
development rates, 177
diapause, 179, 188
dormancy, 179, 188
habitat quality and rainfall, 175
host plants, 340
low-density populations, 175
migration
altitude of, 180
and delayed reproduction, 179
and lipid reserves, 175, 177, 179
and plague development, 177
and wind direction, 179
distance, 177
into inland Australia, 180, 188
into southwestern rangelands in Western Australia, 177
mortality during, 185
sources and destinations of, 177–80
migratory strategy, 185
outbreaks, 175
overwintering, 179
permanent populations in inland Australia, 187
pest status in Western Australia, 175, 177
plagues
1989–90 plague, 177–80
and rainfall, 175, 186
reproductive rate and development of, 177
populations monitored by field surveys, 175
redistribution by local and migratory flight, 186
reproductive rate and rainfall, 185
swarms, 180
diurnal flights of, 180
Cicadulina spp., 202, see also Homoptera
Cicadulina mibia, 211, 256
Cicatricifer tenellus, 33, 47, see also Homoptera
Climate
of African–European region, 4–7
of Australia, 131–2, 153, 173
of East Asia, 73–7
and availability of host plants, 85
of North America, 32, 35–43
and availability of host plants, 37
Climate change, 259, 453
Climatic zones, 4, 85, 432
Choral frequencies
geographic variation in, 251
Cnaphalocrocis medinalis, 195, 196, 203, 207, 412, see also Lepidoptera
Cochliomyia hominivorax, 311, see also Diptera
Cold-temperature (DCC), see Remote sensing, Satellite data
Coleoptera, 20, 33, 197, 316, see also Apion, Callosoobruchus, Diabrotica, Hippodamia, Hylotrupes, Lepinototarsa, Sitona
Colorado Beetle, see Lepinototarsa decemlineata
Common Armyworm, see Mythimna convecta
Convolvus updraughts, 43, 195
Corn Leaf Aphid, see Rhopalosiphum maidis
Corpora allata, 283, 285, 288
inhibition by adipokinetic hormone, 295
Corpora cardiaaca, 293
Cotton, 53, 151, 165
Cotton Bollworm, see Helicoverpa zea
Cotton Leafworm, see Alabama argillacea
Crete, 17
Crop losses, 353
assessing long-term impact of migrant pests, 401
compensation for, 329
Crop resistance to insect pests, 59
Caba, 49, 51
Calicoides spp., 14, 15
Cynthis cardui, 15, see also Lepidoptera
Cyprus, 14, 15
Danaus plexippus, 194, 196, 197, 203, 207, 209, 215, 218, 219, 266, 290, 294, 315, see also Lepidoptera
eastern population, 203, 219
western population, 203
Data management systems
for African Armyworm forecasting –
WormBase, 332, 416
for aphid forecasting – FLYPAST, 332, 416
for Brown Planthopper forecasting, 359, 416
for locust forecasting, 413–16
Dealation, 197, 216, 457
Denmark, 18
Desert Locust, see Schistocerca gregaria
gregaria
Desert Locust Control Organisation for
East Africa, 325
Diabolicactinos paspalii, 10, 197, 199, see also Grasshoppers, Orthoptera
Diabolothrips auricoma, 33, 38, see also Coleoptera
Diabolothrips virgifera virgifera, 33
Diacylglucer, 293
Diamondback Moth, see Plutella xylostella
Dispar, 35, 37, 51, 56, 136, 144, 151, 163, 168, 169, 179, 185, 188, 197, 209, 219, 220, 386, 388, 389, 390, 447
Diaphania nitidalis, 33, 38, see also Lepidoptera
Dictyoptera, see Diploptera, Periplaneta
Diploptera punctata, 289, see also Dictyoptera
Diptera, 8, 10, 14, 15, 19, 72, 316, 337, see also Mosquitoes, Culicoides, Coelioomyia, Glossina, Simulium
Dianthia noxia, 14, see also Aphids, Homoptera
Domance, 252, 440
Doratura stylar, 206, see also Homoptera
Dormancy, 169, 185, 188, 279, 436, 442, see also Diapause
Dysdercus spp, 209, see also Heteroptera
Dysdercus fasciatus, 255
Dysdercus voeltkii, 11
EARTS–1, 338, see also Satellites
East China Sea, 67, 73, 76, 81, 206, 358, 365, 366, 371
Egypt, 11, 13, 16, 410
Egyptian Cotton Leafworm, see Spodoptera littoralis
El Niño / Southern Oscillation and rainfall, 131, 153, 432
Emigration, 19, 71, 221
and habitat quality, 274, 282
and rainfall, 379
and reproductive status, 156, 198, 199, 213, 214, 281, 282
in males, 219
and weather, 83, 196, 199, 217, 220, 291, 417
and wind direction, 187, 292
and windspeed, 71
behaviour at, 265
loss of genes for macroptery by, 252
synchronous, 80
time of, 43
timing after fledging in locusts, 417
Emperor moth, see Homoptera
Eumacula fabae, 33, 38, 45–7, 54, 59, 292, 412
migration from temperate latitudes in autumn, 56
overwintering northern limits of, 56
England, 17, 19
English Grain Aphid, see Macrosiphum avenae
Environmental cues, 58, 144–5, 193, 221, 225–9, 246, 248–54, 258, 271–4, 279, 281–2, 286–8, 291–2, 348, 433, 438, 441, 442, 446, 448
and induction of altotaxistatins, 290
and juvenile hormone production, 282–5
crowding, 144, 225, 246, 252, 287
experienced at time of spring and autumn migrations, 286–7
food availability and quality, 144, 225, 246, 248, 271, 272, 282
level of sex pheromone, 287
of habitat deterioration, 248
photoperiod, 58, 144, 225, 246, 248, 253, 254, 261
response to changing photoperiod, 228
reliability of, 225, 226–9
temperature, 58, 144, 225, 246, 248, 253, 254, 271, 281
token, 225
variation in response to, 226–9, 451
water stress, 271
Epistasis, 440
Equatorward-transporting synoptic
weather system, 25–8
Estonia, 18
Ethiopia, 8, 11, 12, 410
highlands, 14
Europe, 3–7, 15–22
eastern, 17
northern, 18, 19, 21
southern, 20, 265
western, 17, 254
European Space Agency (ESA), 339
Exaex fraxini, 34, see also Lepidoptera
Index

Evolution of forivory in flying animals 312
power requirements and dietary mass, 312
Evolution of migration, 193–4, 243–6, 450
and habitat stability, 246, 271
influence of speed of flight, 315
phylogenetic constraints, 243
Expert systems, see Forecasting
FLYPAST, see Data management systems
Faba beans, 151
Fall Armyworm, see Spodoptera frugiperda
False-colour composites, see Remote sensing
Farmers, 324, 399, 409
monitoring for pests, 325
subsistence, 324
risk-averse, 324, 326, 330
Fecundity
and transfer of male resources at mating, 288
differential fecundity between wing morphs, 70, 252
effects of migration on, 218
Feeding
before, during and after migration, 218, 313
Field beans, 330, 416
Field peas, 151
Finland, 18, 19
Flight, see also Migratory flight
aerodynamic power, 306
airspeed, 3, 70, 303, 309, 310–11
measurement from a boat, 310–11
and degradation of juvenile hormone, 290
and reproductive development, 290
body temperature during, 289, 310, 315
duration, 70
and age, 198
and reproductive status, 211–12
and water stress, 70
effects of load, 312, 313
effects on reproduction, 216, 218
elastic energy storage, 305–8
energetic expenditure, 304, 311
maximum range speed, 304
effect of lipid depletion, 313
mechanical power requirements for, 304–9
and airspeed, 305–9
induced power, 305
inertial power, 305
parasitic power, 305
profile power, 305
metabolic power requirements for, 304
metabolic rates during, 307
measurement in free flight, 305
minimum power speed, 304
effect of lipid depletion, 313
performance
and lipid loading, 312
and reproductive development, 312
post-migratory, 216, 217, 429, 447
soaring and gliding, 314, 315
temperature thresholds for, 22, 45, 72
tethered, 70, 97, 119, 200, 211–12, 221,
223, 224, 244, 254, 256, 266,
267–70, 274, 295
diurnal distribution of, 195
duration and reproductive status, 97,
211–12, 215
speed of, 97
termination of, 73
wingbeat frequency, 303
Flight boundary layer, 3, 34, 194, 198,
303, 314–15, 428, 433
Flight capacity, 194, 220–4, 265, 437
and level of sex pheromone, 287
and male quality, 288
and reproductive status, 211–12, 267–70
and spatial heterogeneity of habitats, 287
effect of environmental cues on, 438
crowding, 223, 226
food availability and quality, 272
expression through pre-reproductive period, 224
genetic correlations, 441
genetic variation in, 221, 222, 256
polygenic inheritance of, 221, 258, 269,
440
variation within aphid clones, 223
Flight fuels, 437, see also Lipids
accumulation before migration, 292
and phase in locusts, 292
carbohydrates, 312
consumption during tethered flight, 70
mobilisation and utilisation, 292–5
Flight muscles, 244, 437
asynchronous, 307, 309
effect of octopamine on power output, 295
efficiency, 292, 304, 305, 307, 311
synchronous, 309
Flight period, 289, 290
Food and Agriculture Organisation (FAO), 339, 379, 406, 407, 413, 417, 419
Desert Locust Bulletin, 407
Remote Sensing Group, 416
Foraging behaviour, 197, 437
Forecasting, 59, 68, 83, 102, 106, 112, 117,
123–7, 164, 323–34, 337, 341–43,
464

Forecasting (cont.)
345, 353–64, 365–76, 377–95, 399–426, 453, see also Forecasts
African Armyworm, 324–26, 330–2, 341–3, 345
Brown Planthopper, 353–64, 365–76
centralised, 325, 332
v. regional and local, 406, 419, 421
communications, 332
constraints, 417
and trade-offs, 327
on data interpretation and modelling, 418
recipient constraints, 327
costs and benefits, 329
cost outcomes of response, 329, 330
data acquisition, 401–7, 408, 411
computer and satellite
communication, 406
fixed-site trap catches, 412
logistical problems, 406
data management and analysis, 331–3,
413–16
data management systems, 359
FLYPAST – Aphids, 332
WormBase – African Armyworm, 332
databases, 332, 359, 411, 413
of historical locust data, 415
decision makers, 323–6, 399, 407, 409,
411
objectives of, 331
decisions
analysis, 359
computers in decision-making, 359
frequency of, 324
spatial scale of, 324
supported by long-, medium- and
short-term forecasts, 409
term of, 324
evaluation, 328–31, 418–21
sources of difficulty, 420
expert systems, 332, 359, 416
field surveys
for acridoids, 382, 390, 391
for rice pests and diseases, 374
forecaster constraints, 325, 327, 399
reduction of, 332
Helicoverpa spp., 164
historical data, 332, 407, 412
international dimension, 127, 411
organisations, 324
locusts, 381–5, 400–11, 413–22
optimum rainfall concept for acridoids,
381–91
Oriental Armyworm, 102, 123
recipients, 323, 325, 399, 407, 411
constraints, 327
dialogue with forecasters, 419, 421

Index
payment by, 333
questionnaires, 400, 419
requirements, 333, 399, 419
resources, 333
training, 333
Regional African Armyworm
Forecasting Service, 325, 332
remote sensing, 328, 332, 337–43
Senegalese Grasshopper, 386–92
technical constraints, 327
weather data, 356, 374, 406
Forecasts, see also Forecasting.
accuracy, 327, 407, 421
trade-off with resolution and term,
327, 328
customised, 331
dissemination, 328, 356, 374
evaluation, 328–31, 333, 391, 418–21
feedback from recipients, 419
methodology, 420
objectives, 419
of impact on decision makers, 418
questionnaires, 419
frequency of, 326
improvement of, 411–18
preparation
office procedures and methods, 407
probabilistic, interpretation by
recipients, 420
recommending responses, 331, 356
resolution, spatial and temporal, 326
targeting, 331
term of, 326, 332, 407–11
and spatial resolution, 410
long-term, 326, 407–11
medium-term, 327, 407–11
short-term, 326
types of information used, 410
timing of, 325
types of, 325, 407–11
Forest Tent Caterpillar, see Malacosoma
distria
France, 16, 282, 284
GIS, see Geographic information systems
GOES, 341, see also Satellites
Gastrimargus africanaus, 199, see also
Orthoptera
Gastrimargus nigericus, 199
Genetically engineered organisms, 59
Genetics, 219, 221–3, 226, 228, 229, 244,
246, 249–59, 265, 299–31, 440,
447–8, 451, 452
generic clines of migratory potential,
146, 253–4
‘generic complex’ underlying the
‘migration syndrome’, 430, 440
generic correlations, 224, 440
Index

Habitat template, 221–2, 243, 246, 247, 251, 253, 257, 271
and contemporary natural selection, 257–9

Habitats
aggregated, 245, 247
discontinuous, 444
isolated, 247
island, 247
mountain top, 247
salt marsh, 249
spatial stability, 243, 252–7, 449
spatiotemporal distribution, 19–22, 194, 223, 229, 243, 245, 449, 450
and rainfall, 255, 256
spatial stability, 243, 245, 248–52

Helioverpa spp., 151–72, 204, 217, 271, see also Lepidoptera, H. armigera, H. punctigera, H. zeae
breeding areas in eastern Australia, 163 field surveys of, 156, 157, 158, 159, 161, 162, 165
in the south in summer, 167
proportions of H. punctigera and H. armigera in, 157, 162, 168
winter, 154, 157, 158
breeding areas in western Australia, 163 field surveys of, 180, 182
spring and summer, 183
winter, 181, 182
development rates
simulation modelling, 163, 164
diapause, 151, 163, 165, 168, 169, 185, 188
dormancy, 169, 185, 188
forecasting, 164
habitat quality
seasonal variation, 155, 161, 181
habitats
and rainfall, 154, 158, 159, 161, 175, 181, 183, 187
on floodplains, 154, 159
persistence in arid conditions, 155
remote sensing, 156, 158, 161, 165
seasonal distribution, 154, 180
host plants, 154, 155, 162, 167, 168, 176, 181
immigration
and rainfall in inland Australia, 183
evidence for, 163, 164
synchronic, 153, 157, 183
migration, 151
and dispersal, 181, 186
and wind direction, 158, 165, 181
distance, 151, 157, 168, 183, 186
evidence for, 151, 153, 168
catalytic, 153, 168
from inland Australia, 156, 165, 181
Helicoverpa spp., migration (cont.)
into inland Australia, 167, 183, 188
obligatory, 151
sources and destinations, 158, 164, 166
sources in arid regions, 153
sources indicated by moth-borne
pollen, 157, 164
successive flights, 157
migratory strategies, 168, 186
pest status, 151, 180
and winter breeding, 183
contribution of local emergence and
immigration, 165
summer populations in inland Australia,
168

Helicoverpa armigera, 14, 15, 17, 18, 20,
151–72, 207, 210, 212, 214, 215,
219, 223, 248, 255, 265–77, 282, see
also Helicoverpa spp.
migration
and gene flow, 153, 168
and insecticide resistance, 153

Helicoverpa punctigera, 131, 143, 151–72,
175, 180–8, 207, 213, 214, 266, see
also Helicoverpa spp.
permanent populations in inland
Australia, 167

Helicoverpa zeas, 34, 48, 49, 51, 56, 151,
208, 214, 215, 271, 285

Heliotris complex, 412, see also
Lepidoptera

Heliosia spp., 214, 217

Heliothis virescens, 34, 151, 169

Hemiptera, 8, 11, 67–91, 202, 206, 209,
211, 249, 353–64, 365–76, see also
Homoptera, Heteroptera

Heritability, 221, 255, 258, 448
of flight capacity, 255, 270
of pre-reproductive period, 255, 269
of wing length, 255

Heteroptera, see Dysdercus, Lygaeus,
Neocorystus, Nezara, Nysius,
Oncocephalus

Hibernacula, 215

Hippodamia convergens, 215, 216, see also
Coleoptera

Histerus acrodon, 311, see also
Lepidoptera

Homoecosoma electellum, 33, 52, 53, 282,
see also Lepidoptera

Homoptera, 15, 21, 33, 34, 45–9, 55,
67–91, 353–62, 365–76, see also
Aphids, Planthoppers, Aphysaoma,
Balclutha, Cicadulina, Circulifer,
Doratura, Emoeca, Laodelphax,
Macrolestes, Nilaparvata,
Prokelisia, Sogatella

Index

migration
from temperate latitudes in autumn,
55
into temperate latitudes in spring and
summer, 45–9

Hong Kong, 77

Hop Aphid, see Phorodon hamuli

Hops, 21

Horticultural crops, 151

Hylobius abietis, 20, see also Coleoptera

Hymenoptera, 197, 316, see also Bombus

IITC or ITZ, see Intertropical
Convergence Zone

Immigration
and reproductive status, 120, 213–17,
296
influence of topographical features, 73,
113, 360

India, 207, 269, 271, 337, 410

Indonesia, 70, 249, 361

Insect size
and airspeed, 314
and diurnal/nocturnal migration, 315
and migratory flight strategy, 314

Insect vectors, 11, 16

Insecticide resistance, 153, 361, 412
management of, 59

Insecticides, 325, 326

prophylactic treatment, 330

Inter-tropical convergence zone, 4–12,
384–6, 388

concentration of insects by, 7

movement of, 4

International Rice Research Institute
(Philippines), 69

Iran, 14

Iraq, 14

Isotherms
January
in East Asia, 68, 74, 118
in North America, 35, 38

July
in East Asia, 68
in North America, 35, 38

Israel, 15, 16

Japan, 67–91, 105, 113, 114, 117–29, 206,
207, 213, 249, 355–76, 445

Japan Meteorological Agency, 366

Japan Meteorological Association, 366

Juvenile hormone, 197, 215
allotostatins and biosynthesis, 289
and flight, 279
and oogenesis, 279
differential degradation of homologues,
290
esterases, 290
Index

Leucania pallens, 120
Leucania striata, 120
Leucoma saliceti, 219, see also Lepidoptera
Levant, 16
Lexis diagrams, 381
Libya, 16
Life-History strategy, 20, 58
Lifetime tracks, 436
Linkage disequilibrium, 440
Lipids, see also Flight fuels
accumulation before migration, 312, 437
competition between flight metabolism and oogenesis, 312
effect of depletion on power requirements for flight, 313
haemolymp levels during flight, 292, 294
lipid loading
and parasite and total power requirements for flight, 312
release from fat body by adipokinetic hormone and octopamine, 293
reserves during flight, 310, 311
transport to flight muscles, 293
Lipophorins, see Lipoproteins
Lipoproteins
high- and low-density transport
lipophorins, 293
Locusta migratoria capito, 377, see also
Locusts, Orthoptera
Locusta migratoria migratorioidea, 10,
196, 199, 200, 219, 377
Locusts, 10, 12, 13–15, 20 173–80,
199–201, 217, 336, 337–41, 347,
377–95, 399–426, see also
Orthoptera, Anacridium, Choristocercus, Locusta, Orihnhacris,
Patanga, Schistocerca,
adoptive significance of downwind
placement, 13, 400
breeding
and vegetation, 417
monsoon, 11, 13
net reproductive rate, 381
opposition and rainfall, 379, 382, 417
breeding areas, 12, 341, 410
spatial and temporal links, 400
control
cost-benefit analysis, 401
preventive control of solitary populations, 379, 400, 401
strategies, 418
targets, 417
g orientation and weather, 379, 417
timing after fledging, 417
forecasting, 381–5, 400–11, 413–22
gregarisation, 337, 377–85, 415
density thresholds for, 381

JH I, JH II, JH III, 283
levels and age, 283
development migration, 286
levels in females and male quality, 288
octopamine and biosynthesis, 290
production and environmental cues, 282–5
temperature and biosynthesis, 289
temperature and levels, 289–91
transfer in the spermatophore, 288
Juvenile hormone acid
JHA I, JHA II, JHA III, 283
Kagoshima Prefectural Agricultural
Experiment Station (Japan), 374
Kenya, 11, 12
Korea, 74, 101, 105–16, 121
Kyushu National Agricultural Experiment
Station (Japan), 367
LLJs, see Low-level jets
Landsat, 336, 339, 340, 341
Loa loa, 67, 206, see also
Humoptera, Rice plant hoppers
migration, 67
Large Pine Weevil, see Hyllobius abietis
Larval development
effect of photoperiod and temperature
during, 286
Lebanon, 15
Lepidoptera, 8, 11, 13–21, 33, 34, 49–53,
56–9, 72, 93–104, 105–16, 117–29,
131–50, 151–72, 180–8, 203–5,
207–10, 212, 265–77, 279–302, see also
Butterflies, Agrois, Alabama,
Anticarsia, Aphrissia, Autographa,
Choristoneura, Chorizagrotis,
Cephalocricus, Cynthis, Danaus,
Diaphania, Euxoa, Helicoverpa,
Heliothis, Historis, Homoecosa,
Leucania, Leucoma, Malacosoma,
Manduca, Marpesia, Margarita,
Mythimna, Nomophila, Ostrinia,
Palaip, Parnara, Peptomhora,
Peridroma, Persectania,
Philogophora, Phoebs, Plathyptera,
Plutella, Pontia, Pseudoplasia,
Spodoptera, Trichoplusia, Urania,
Uetheisa
migration
from temperate latitudes in autumn,
56–8
into temperate latitudes in spring and
summer, 49–53
Lepidoptera decemlineata, 19, see also
Coleoptera
Leslie population matrix, 359
Leucania loewyi, 120, see also Lepidoptera
Index

Locusts, gregarisation (cont.)
- spatial scale and outbreaks, 381
  habitats
  and rainfall, 12, 379, 400
  on floodplains, 10, 384
  immigration
  and wind convergence, 380
  and wind direction, 379
  invasion areas, 379, 400, 405
  life tables, 381
  migration, 12, 410
  and gregarisation, 381, 383
  and rainfall, 417
  and vegetation, 417
  between complementary breeding areas, 384
  direction, 380, 381
  distance, 379
  diurnal, 199–201
  effects of weather, 13, 400
  of gregarious populations, 377
  of solitarious populations, 377, 380, 406
  nocturnal, 199–201, 379, 406, 413
  ‘southern circuit’, 10
  outbreak areas, 383
  outbreaks
  and rainfall, 379
  and spatial scale of gregarisation, 381
  phase
  and lipid release, 293
  and lipid storage, 292
  transformation, 400, see also Locusts, gregarisation
  phase gregaria, 10, 197, 199, 200, 201
  night flights by, 199, 200, 201
  phase solitaria, 10, 199, 200, 201
  phase transiens, 200, 201
  plagues, 337
  development of, 379, 417, 418
  frequency of, 401
  populations
  distribution and rainfall, 380
  dynamics of solitarious populations, 379
  low-density, 337
  recession, 415
  tiered sampling of, 406
  recession areas, 337, 339, 405
  surveillance, 383
  swarms, 10, 11, 12, 14, 18, 377, 381, 382, 385, 389, 401, 405, 415
  movements of, 13, 400, 401, 410, 417, 419, 421
  Longevity
  and transfer of male resources at mating, 288

Low-level jets, 44, 45, 47, 51, 57, 58, 106, 108, 157, 195, 365–75
and planthopper forecasting, 365–74
Bai-u L.Ls, 74, 81, 366
northward shift through Bai-u season, 371
identification by computer program, 106, 366, 374
windspeed in, 44, 366
Lepidoptera, see Margarita
Lupins, 180, 183
Lygaeus kalnii, 255, see also Heteroptera
Macroisphum avenae, 33, 46, 47, see also Aphids, Homoptera
Macrostyris fuscifrons, 33, 38, 47, 412, see also Homoptera
Madagascar, 377
Maize, 51, 95, 105, 121, 122, 151
Malacosoma disstria, 33, see also Lepidoptera
Malagasy Anti-acridian Service (Madagascar), 379, 382
Malawi, 267, 268, 271
Malaysia, 249
Mali, 10, 383, 410
Manduca sexta, 285, 294, 295, 307, see also Lepidoptera
Mapping
locust data, 400
projections, 345
Hacker–Altolf, 346
Metacosis, 346
Maps
digitisation of, 335
distribution
of grasshopper oviposition, 390
of habitat suitability, 346
of locust habitat, 408
of locusts, 383, 406, 408
of grasshopper transpiration, 340
frequency of incidence, 415
GIS maps for locust forecasting, 415
land classification, 340
output of data management systems, 415
probability of infestation
of grasshoppers, 389
locusts, 407
soil moisture, 343
weather, 19, 40, 42, 46, 48, 50, 52, 54, 75, 79, 82, 101, 124, 125, 166, 179, 184, 400
rainfall, 339, 340, 383
wind profiles, 368, 370, 372
Margarita sticticalis, 19, see also Lepidoptera
Index

Mark–recapture, 32, 53, 54, 57, 60, 71, 73, 95, 97, 146, 354, 358, 379
Marpesia spp., 311, see also Lepidoptera
Maternal effects, 225, 226, 246, 248, 250–1, 254, 440, 441, 448, 450
genetic variation in, 251
geographical variation in, 251
Mating strategies, 218
Mauritania, 10, 13, 337, 389
Maximum likelihood classification, 341
Mediterranean basin, 14, 15, 18, 21
northward migrations from, 16
southward migrations into, 17
Mediterranean Sea, 20
Megoura vicinae, 251, see also Aphids, Homoptera
Melanoplus sanguinipes, 33, 195, 200, 209, 211, 215, 216, 218, 223, 226, 256,
see also Grasshoppers, Orthoptera
Metapopulations, 451
Metacost, 336, 339, 340, 342, 346, 390
Mexico, 51, 53, 254
Middle East, 12, 13, 14, 265
Migrant pests
dependence on crops, 411
of North America, 33
outbreak areas of, 411
population monitoring, 336, 390, 399, 401
strategic control of, 339, 342, 379, 400, 401, 412, 418, 421
Migrants
aerial densities of, 72, 99, 357
appearance at oases, 13
captured on oil rigs, 56, 208, 215
captured on ships, 15, 65, 67, 84, 94, 97, 119, 195, 198, 206, 207
clonal, 440, 448
conservation of, 453
layer concentrations of, 43, 72, 99, 357
orientation within layers, 99
losses, 165
at sea, 73, 165, 180, 183, 186
during migration, 445
genetic implications of, 32, 58, 146, 167, 450, 452
in deserts, 16, 187
in unsuitable habitats, 21, 73, 165, 186, 445
overwintering
northern limits of, 35, 38, 49, 56, 74, 105, 354
reproductive rates of, 188
Migration
above the flight boundary layer, 3, 34, 151, 194, 196, 220, 221, 286, 303, 314, 428, 450
and insect size, 314
and minimum power speed, 304
common orientation, 21
evidence for selection of appropriate winds, 22, 59
adaptive significance of downwind displacement, 13, 19, 400
and fitness, 193, 216, 222, 428, 430, 432, 439, 442
in males, 219
and insecticide resistance, 362
and reproductive status, 56, 138, 139, 197–219, 205–9, 279, 286–8, 428, 437
causal interactions, 198, 215
differences between sexes, 198
in males, 218
by larval stages, 428
change in speed and direction with altitude, 43, 102
circuits, 20, 444, 451
costs of, 188, 217–18, 244, 247
definition of, see Preface
distance, 3, 10, 51, 57, 84, 97, 102, 143, 157, 181
facultative, 144, 193, 225, 229, 246, 266, 271, 281, 428, 436, 457, 458, 451
flux, 89
from temperate latitudes in autumn, 32, 37, 53–8, 77, 79, 83, 85, 103, 145, 146, 285, 448
from temperate latitudes in spring and summer, 187
inter-reproductive, 198, 199, 200, 201, 202, 203, 217, 220
evidence for, 199–203
into temperate latitudes in spring and summer, 32, 37, 44–53, 58, 77–80, 98, 186, 449
general implications of, 146, 253
into temperate latitudes in summer, 20, 228, 253, 270, 281, 285, 412
non-adaptive northwards migrations in autumn, 58
obligatory, 428, 437
physiological aspects, 279–302
physiological ecology of, 303
‘Pied Piper’ migrations, 21, 32, 58, 85, 146, 165, 186, 188, 445
pre-migratory condition, 56, 57, 59
pre-reproductive, 3, 56, 57, 59, 144, 197, 216, 266, 290, 311
evidence for, 120, 139, 199–212, 290
reproductive constraints, 311
seasonal reversal of windborne migration, 8, 86
single flight, 70, 196, 220
speed of displacement, 51, 122, 195
spring northward, 286
Migration (cont.)

successive flights, 98, 102, 157, 196, 220
termination of, 213, 215, 220, 229, 434,
438, 446, see also Immigration
to diapause sites, 19, 197, 203, 213,
216, 219, 220, 253, 286, 438, 444

trans-Saharan, 14
while gravid, 202, 213, 217, 287
within the flight boundary layer, 3, 21,
59, 194, 303, 314, 428, 450
and control over direction, 314
and insect size, 314
and maximum range speed, 304

Migration arena, 245, 251, 430, 431–3, 450
components, 432–3
core and periphery, 445
processes involving the migration arena,
441–3
properties of, 452

Migration syndrome, 218, 224, 429, 430,
437–40, 451
adaptation to the arena, 452
‘genetic complex’ underlying the migration
syndrome, 430, 440
analysis of, 453
and maintenance of variation in
syndrome traits, 451
processes involving the genetic
complex, 447
processes involving contemporary
natural selection, 449
and adaptation to the migration
arena, 452
processes involving the migration
syndrome, 446
quantitative representation, 453

Migration systems, 429–50
components, 430
quantitative representation, 452

Migratory behaviour, 220, 229, 266, 437
definition of, 220, 427, see also Preface

Migratory flight
airspeed during, 311, 314
altitude of, 31, 51, 71, 97, 99, 139, 428
and atmospheric conditions, 70
ascent during, 139, 181
on convective updrafts, 43, 49, 195, 315
rate of, 265
range of, on stored lipid reserves, 310
termination of, 73, 223, 438
and weather conditions, 73, 85, 113

Migratory Grasshopper, see Melanoplus
sanguinipes

Migratory Locust, see Locusta migratoria

Migratory period, 144, 194, 220–4, 254,
266, 281, 437

Migratory potential, 194, 220–5, 243–60,
265, 446
and habitat heterogeneity, 244–60
and reproductive status, 197–219,
265–9, 279, 286–8, 428, 437
components of, 220–4
environmental regulation, 221, 225–9,
248–51, 271–4, 428, 438, 440, 441,
446–8, 451

‘genetic partitioning’ by migration, 146,
254, 447, 448
genetic regulation, 145, 221, 223, 251,
255, 257–9, 269–71, 274, 440, 447–8

genetic variation, 144, 223, 246, 251,
253–9, 269, 446, 448, 449, 451
and multiple mating, 448
grographic variation, 85, 249–51, 253,
254, 258
isolated habitats, 247
maternal effects, 225, 226, 246, 248,
250–2, 254, 440, 441, 448, 450
polygenic inheritance, 221, 254, 255,
258, 269–70, 429, 440, 447

polymorphisms, 194, 220, 251

Migratory strategy, 144, 175, 185–8, 429

Millet, 93
Mississippi River Drainage Basin, 35, 37,
41, 43, 44, 45, 46, 49, 51, 53, 55,
56, 57

Mites, 31

Models
boxcar-train, 360
conceptual model of insect migration,
430–53
digital elevation model (DEM), 342
ecological, 8, 386, 388
forecasting
conceptual and mathematical, 411,
417
economic threshold, 359
expert systems, see Forecasting
simulation models, 359
habitat suitability, 337, 342
insect development, 407, 417
HEAPS, 163, 164
insect movement, 32, 337, 417
metapopulation, 451
migration systems, 452
pest distribution, 347
pest management, 359
population dynamics, 346, 413
grasshopper, 388
locust, 177
simulation, 341, 359
trajecory analysis, 357, 407, 412, 418
pollution, 358
Index

Monarch butterfly, see *Danaus plexippus* 471
Monitoring, see Migrant pests 471
Monsoon rains, 10, 11, 13 471
winds, 4, 7, 10, 11, 19, 365, 384, 387 471
Morocco, 16, 17, 18 471
Mosquitoes, 337 471
Multiple mating, 448 471
*Nymphula convexitia*, 131–50, 204, 208, 210, see also Lepidoptera 471
concentration of flying moths, 140 471
development rates optimum temperature, 138 471
emigration ascent, 139 471
habitat quality and frosts, 136 471
and rainfall, 142 471
seasonal variation in, 137, 139–45 471
habitats permanent, 141, 142 471
persistence of, 144 471
predictability of, 147 471
temporary, 145 471
immigration and rainfall, 142 471
migration and agriculture, 145 471
and reproductive status, 135, 138, 139 471
and wind direction, 145, 144, 146 471
direction, 140, 141 471
distance, 143, 146 471
evidence for, 138 471
facultative, 144 471
from temperate latitudes in summer and early autumn, 146 471
into inland Australia, 140–3, 187 471
into temperate latitudes, 145 471
out of inland Australia, 143 471
seasonal occurrence, 140 471
short-range, 143 471
sources and destinations, 134, 140 471
migratory strategy, 144 471
outbreaks and rainfall, 142 471
seasonal occurrence of, 137, 142 471
synchronous, 140 471
overwintering, 136 471
mortality during, 136 471
oviposition sites, 143 471
pest status, 132, 137 471
seasonal distribution, 133–44 471
summer breeding, 137, 140 471
and rainfall, 138 471
survival of temperature extremes, 139 471
trap catches seasonal variation, 135 471
winter breeding, 136 471
Mythimna loreyi, 14 471
daytime flight over water, 119 471
development periods, 112 471
emigration, 119 471
forecasting, 102, 112, 117, 123–7 471
immigration and rainfall, 113 471
correlation with southwesterly airflows, 97, 108, 113, 120, 122, 124, 125 471
into northwest China, 102 471
seasonal incidence, 108, 109 471
spatial distribution, 108, 110 471
larval densities in winter, 119, 122 471
low-density populations, 112 471
migration, 93, 105 471
and agriculture, 145 471
and wind direction, 99 471
distance, 102, 105 471
evidence from field surveys, 93 471
flux, 99 471
from temperate latitudes in autumn, 95, 103, 145 471
influence of topographical features, 113, 123 471
into temperate latitudes in spring and summer, 95, 98, 145 471
nocturnal, 98, 119 471
overflights, 99 471
pre-reproductive, 120 471
sources and destinations, 102, 105, 113, 120, 121, 124 471
southward in autumn in Japan, 123 471
successive flights, 98, 102 471
nocturnal behaviour in the field, 97 471
outbreaks, 105, 106, 117 471
and weather, 122 471
correlation with temperature and rainfall, 125 471
distribution in Japan, 121, 122 471
larval densities, 123 471
seasonal occurrence, 122 471
simultaneous in Japan and Korea, 121 471
overwintering, 94 471
in Japan, 118, 121, 122 471
northern limits of, 105 471
success and forecasting, 124 471
oviposition sites, 119 471
pest status, 93, 112, 120, 123 471
in Korea, 105 471
seasonal incidence of damage, 120 471
pupation sites, 120 471
seasonal distribution in eastern China, 95, 96 471
Index

flight duration, 357, 358
sources and destinations, 357, 357, 358, 365
outbreaks, 69
distribution, 354
extent, 353
frequency, 353
overwintering
northern limits of, 354
pest status, 68–9, 353
population dynamics, 354
resistance to insectscidals, 361
Nile Delta, 16
Nomadacris, see Patanga
Nomaphila noctuella, 17, see also Lepidoptera
Normalised Difference Vegetation Index (NDVI), see Vegetation indices
Norms of reaction, 249
Northern temperate zone, 17, 21
Norway, 18
Nysius vinitor, 202, 207, 211, 219, see also Heteroptera
Oat Bird-cherry Aphid, see Rhopalosiphum padi
Octopamine
and lipid release from fat body, 293
effect on flight-muscle power output, 295
effect on juvenile hormone biosynthesis, 290
phase in locusts and lipid release, 293
Oedaleus spp., 14, see also Grasshoppers, Orthoptera
Oedaleus senegalensis, 8, 10, 19, 200, 377, 386–91
Okinawa, 74
Old-World Cotton Bollworm, see Helicoverpa armigera
Onoecclus fasciatus, 195, 196, 209, 211, 215, 216, 218, 219, 223, 224, 225, 228, 229, 254, 255, 279, 280, see also Heteroptera
Ooctye development, 213, 215
and juvenile hormone, 282
and power requirements for flight, 312
Oogoneitis-flight syndrome, 197, 266, 269, 279, 280, 282, 283, 286, 311, 437
Oriental Armyworm, see Mythimna separata
Oriinphaci spp. 10, see also Locusts, Orthoptera
Orthoptera, 8, 10, 12, 13–15, 19, 20, 33, 173–180, 199–201, 214, 217, 220, 336–41, 377–95, 339–426, see also Grasshoppers, Locusts, Acheta, Anacridium, Diabolocautetes,
Index

Gastriamargus, Gryllus, Melanoplus, Oedaleus, Orniithacris, Raptrota
Ostrinia nubilalis, 18, see also Lepidoptera
Overseas Development Administration (UK), 357

Pacific Ocean, 35, 131
Pakistan, 410, 411
Palpita unimacula, 18, see also Lepidoptera
Panama, 310, 311
Parnara gutata, 203, 207, see also Lepidoptera
Pasture, 105, 120, 122, 138
Patanga gutulosa, 196, 197, 200, see also Locusts, Orthoptera
Patanga septemfasciata, 201
Peckiphora gossypiella, 33, 412, see also Lepidoptera
Pepides, effects on flight-muscle contractions, 295
Peridroma saucia, 34, 284, see also Lepidoptera
Periplaneta americana, 293, see also Dictyoptera
Persectania ewingii, 133, 143, see also Lepidoptera
Pest management, 59, 323, 359
Pesticides, 409, 412, 413
Phace polyphemus, in locusts, 337, 377–85, 400, 415
in Spodoptera exempta, 341
Phenome synthesis and juvenile hormone, 282
Philippines, 70, 249, 361
Phlogophora meticulosa, 284, see also Lepidoptera
Phorbas spp., 311, see also Lepidoptera
Phorodon humili, 21, see also Aphids, Homoptera
autumn migration, 21

Pickleworm, see Diaphania nitidalis
Pink Bollworm, see Pectinophora gossypiella
Planetary boundary layer, 43, 195
atmospheric pressure, 43
geostrophic winds, 43
stability at night, 43, 315
wind speeds, 43
Plant Protection Division, Ministry of Agriculture, Fisheries and Forestry (Japan), 123, 371
Plants seen, Homoptera, Rice planthoppers
Platypleura scabra, 34, 38, 52, 53, see also Lepidoptera
Plutella xylostella, 13, 18, 33, see also Lepidoptera
Poleward-transporting synoptic weather system, 44–53, 58
duration of, 45
Pollution
trajectory analysis models, 358
Polygryma, see Migratory potential, Wing polymorphism
Pontia daplidice, 219, see also Lepidoptera
Population pathway, 434, 436, 444, 445, 451
Population trajectory, 430, 433–7, 438–9, 443–53
and winds, 445
branching and convergence of strands, 436, 438, 443, 445, 446, 448, 451
spatial cycling and loops, 444, 451
topology, 444
reliculate, 437, 451
Portugal, 16
Potato Leafhopper, see Empoasca fabae
Potato virus Y, 416
Potential breeding activity factor (PBAF), see Remote sensing, of locust habitats
Power curves for flight, 304–9
J-shaped, 305
U-shaped, 304
Pre-calling period, 267, 269, 272–4, 281, 282, 286, 287, 289–91, see also Pre-reproductive period
Pre-oviposition period, 267
Pre-reproductive period, 144, 145, 198
209–10, 219, 220–5, 228, 229, 244, 254–7, 265, 267, 457, 441, see also Reproductive development and preparation for migration, 291
and spatial heterogeneity of habitats, 252–4, 256, 260
effect of environmental cues, 291, 438
crowding, 144, 209
food availability and quality, 144, 209, 210, 272–4, 282
photoperiod, 144, 145, 209, 225, 228, 281
temperature, 209, 225, 271, 281
water stress, 271
genetic variation in, 145, 219, 221, 222, 223, 253, 257, 291
in males, 267, 281
independent inheritance, 224, 441
phenotypic plasticity in response to photoperiod, 229
polygenic inheritance, 221, 255, 258, 269, 440
X-linked, 269, 270

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by Y. A. Drake and A. G. Gatehouse

© Cambridge University Press
www.cambridge.org
Pre-reproductive period (cont.)
variation in, 198, 209, 210
in males, 219
Prokelisia marginata, 249, 250, see also Homoptera
host plants, 250
Pseudactia unipuncta, see Mythimna unipuncta
Pseudopluta includens, 34, 57, see also Lepidoptera
Pyrenees, 282, 284
Radar, 71, 265, 336, 356, 427, 453
airborne, 31, 51, 60
ground-based, 8, 22, 31, 43, 44, 60, 72,
84, 93, 95, 98, 138, 151, 159, 199,
200, 357, 385
aerial densities of migrants, 56, 98
scanning pencil-beam, 98
Rainfall
and El Niño / Southern Oscillation, 131
and topography
orographic lifting, 131
in East Africa
‘long rains’, 11, 12
‘short rains’, 11
rainstorms, 222
spring rains in Japan, 74
Rainforest
equatorial, 7
Recombination, 447
Red Sea, 13, 14, 338
Remote sensing, 260, 328, 332, 335–52,
406, see also Satellite data
ARTEMIS system, 339, 342
acoustic sounding, 336
calibration of products, 344, 406
definition of, 336
false-colour composites, 338, 340
in pest management, 347
forecasting, 337–43
strategic control of locusts, 339
low-light optical methods, 336
microwave sensing, 336
multispectral scanning, 336
of crops, 336
of habitats, 336, 418
African Armymworm, 342
Helicoverpa, 156, 158, 161, 165
locust, 338–41, 385, 401, 415, 417
non-migratory species, 337
of insect damage, 336
of insects, 336
of migration arenas, 453
of populations
African Armyworm, 342
locust, 338
of rainfall, 339, 341, 390, 401, 416, 418
Index
cold-cloud duration (CCD), 339, 342
with Meteorat thermal-infrared data, 339
of soil moisture, 340, 390
of soil type, 341
of vegetation, 156, 158, 161, 338, 344,
408, 416, 418
NIR/R index, 340
Normalised difference vegetation
index (NDVI), 338–45
photography
aerial, 336
ground, 336
satellite, 336
resolution of, 336, 338, 345, 346
thermal imaging, 336
videography, 336
Reproductive development, 437
and juvenile hormone, 282
biomechanical and physiological
constraints, 312
delayed, 144, 198, 209, 213, 216, 272,
281, 287, 451
and early fecundity of immigrants, 451
in response to crowding, 144, 209, 210
in response to food availability and
quality, 144, 209, 210
in response to photoperiod, 144, 145,
209, 210, 219, 287
in response to temperature, 209, 210,
219
costs of, 218, 451
effect of ambient and body
temperature, 289–91
inhibition by adiopokinetic hormone, 295
rate of, 267
Reproductive maturation, see
Reproductive development
Rhopalophilum multid, 33, 58, 47, 49, see
also Aphids, Homoptera
Rhopalophilum padi, 33, 47, 223
Rice, 67, 93, 105, 117, 122, 249, 353, 365
cropping practices in East Asia, 69
high-yielding varieties and planthopper
damage, 69
losses to insect pests in China, 353
planthopper-resistant varieties, 361
vulnerability to planthopper invasion,
69
Rice Grassh-Stunt virus, 69
Rice leafhoppers, 117, see also
Homoptera
Rice planthoppers, 117, see also
Homoptera, Nilaparvata lugens,
Laodelphax striatellus, Sogatella
fuscifera
aerial densities, 72
biotypes, 375
breeding areas
permanent, 74
emigration, 71
from source areas, 374
flight duration, 70
forecasting, 68, 83, 353–64, 365–76, 421
immigration
and frontal depressions, 365
and LLLs, 366–74
and temperature, 73
and wind direction, 67, 84
annual fluctuations in scale of, 374
distribution of, 372
synchronised, 83
timing of, in East Asia, 81
migration
evidence from field surveys, 84
from temperate latitudes in autumn, 77, 79, 83, 85
in subtropical/temperate zones in the Bai-u season, 80–3
into temperate latitudes in spring and summer, 77–80
non-adaptive migrations in East Asia, 86
on Bai-u LLLs, 75
on monsoon winds, 365
post-Bai-u season, 83
range, 72, 73, 84, 87
sources and destinations of migrants, 72, 76
within permanent breeding areas, 84
migratory potential in the tropics, 87
overwintering
northern limits of, 74
pest status, 68, 81, 83
growth stage of rice, 69
hopperburn, 68
rice-cropping practices, 69
seasonal distribution in East Asia, 85
wing dimorphism, 69, 87
density, 249, 375
Rice Ragged-Stunt virus, 69
Rift Valley Fever virus, 11
Kruspia differens, 10, 15, see also Orthoptera
Russia, 18
Russian Wheat Aphid, see Diuraphis noxia
SPOT, 336, see also Satellites
Sahara, 12, 14, 20
Sahel, 8, 10, 389, 390, 391
western, 343
Satellite data, 335
ARTEMIS, 345

AVHRR global-area-coverage (GAC), 338–40, 345, 346
AVHRR local-area-coverage (LAC), 338–40, 345
acquisition and processing, 346
appropriate scale, 345
atmospheric influences, 344
calibration, 343, 406
cold-cloud duration (CCD), 339, 342
optimum temperature thresholds, 339
reliability for estimating rainfall, 343
degradation, 345
resolution, 338, 339
spatial and temporal integrity, 343
Satellite receivers, 346
Satellites
carth observation, see Landsat, SPOT, ERTS–1
meteorological, see GOES, Mетеосат, NOAA
Saudi Arabia, 338, 410
Savana, 8
Scandinavia, 18
Scanning electron microscopy of moth-borne pollen, 157, 164
Schistocerca gregaria flaviceps, 12, 14, see also Locusts, Orthoptera
Schistocerca gregaria gregaria, 10, 11, 12, 18, 20, 201, 337–40, 347, 377, 399–411, see also Locusts, Orthoptera
crossing the Atlantic, 10
forecasting, 400–11
invasion, recession and breeding areas, 400
Schizaphis graminum, 33, 38, 46, 47, see also Aphids, Homoptera
Screw-worm Fly, see Cochliomyia hominivorax
Sea of Japan, 77
Senegal, 10
Senegalese Grasshopper, see Oedaleus senegalensis
Sex linkage
and rate of fixation, 270, 440
of migration-syndrome traits, 440
of pre-reproductive period, 269
Sex pheromone, 281, see also Traps
detection by cophpecific females, 287
Shu-rin autumn rainy season, 77
Simulium spp., see also Diptera
savanah species, 19
Simulium damnosum complex, 8, 10
Simulium sirbanum, 8, 10
Simulium yahense, 8
Sitobion avenae, 391, see also Aphids, Homoptera
Sitona hispidula, 243, 252, see also Coleoptera
Index

476

Small Brown Plant hopper, see Laodelphax striatella
Sogatella furcifera, 67, 202, 206, 209, 365–76, 412, see also Homoptera, Rice plant hoppers forecasting, 365–76
migration, 67, 365
range, 83
Sogatella vittata, 72, see also Homoptera, Rice plant hoppers
Somalia, 14, 410
Sorghum, 151, 165
South Africa, 12, 14
South China Sea, 367
Southern Armyworm, see Persectania wangi
Soybean Looper, see Pseudoplusia includens
Soybeans, 151
Spain, 16, 17
Spatial data, 335
raster format, 335
vector format, 335
Spermatophores, 213, 266, 288
Spiders, 31
Spitzenberg, 18
Spodoptera exempta, 11, 142, 144, 147, 205, 210, 212, 213, 215, 218, 219, 222, 223, 224, 226, 255, 256, 324, 325, 326, 330, 332, 336, 337, 341–3, 345, 347, 411, 413, 416, 420, 421, see also Lepidoptera
concentration of flying moths, 12, 342
forecasting, 324, 325, 330, 331, 332, 341–3, 345, 416, 419
habitats
dry season, 142
durational stability, 342
remote sensing, 342
spatial distribution and migratory potential, 256
low-density populations, 11, 341, 343
migration, 12
into southern Africa, 12
outbreaks, 12, 341, 343
critical, 342
primary, 342
secondary, 342
Regional African Armyworm
Forecasting Service, 342
strategic control, 342
Spodoptera exigua, 17, 18, 20, 34
Spodoptera frugiperda, 34, 38, 50, 51, 57, 58, 146, 147, 412
outbreaks, 51
Spodoptera littoralis, 16
Spotted Cucumber Beetle, see Diabrotica undecimpunctata howardi

St Helena, 15
Steppe, 8
Stochastic polyphenism, 223, 440
Sudan, 11, 13, 14, 410
Sugar Beet Yellowing virus, 19
Sunflower Moth, see Homoeosoma euncellatum
Sunflowers, 151, 165
Sweden, 18
Switzerland, 16
Syria, 14, 15
Taiwan, 70
Take-off, see Emigration
Tanzania, 11, 12
Temperature inversion, 43, 44, 72, 195, 265, 315, 357
Teral period, 220
Thailand, 70
Tibetan Plateau, 74
Ticks, 337
Tobacco Budworm, see Heliothis virescens
Toxoptera graminum, 412, see also Aphids, Homoptera
Trajectory analysis, 31, 365, 407, 412, 417, 418
backtracking, 12, 18, 45, 46, 47, 48, 49, 50, 51, 52, 54, 138, 142, 156, 163, 166, 177, 195, 337, 357
computer simulation, 357
forwardtracking, 181, 183, 337, 357
Trap catches, see Traps
Traps, 97, 374
aerial, 32
balloon-borne, 198
kite-borne, 72, 98, 151, 198, 207, 208, 215, 219, 357
light, 16, 73, 83, 84, 117, 151, 152, 163, 168, 175, 177, 180, 182, 185, 199, 200, 202, 203, 204, 213, 266, 281, 283, 284, 286, 354, 355, 360, 371, 385, 412
black-light, 106, 127
efficiency for Oriental Armyworm, 108, 117
incandescent, 106
on towers, 138, 198, 207, 208, 214, 266, 283
variation in catches with moonlight and windspeed, 413
wind direction and catches, 185
lure, 17, 120, 123, 124, 125, 133, 137, 138, 204
mountain-top, 195, 198, 206, 207, 354
net, 67, 72, 83, 202, 366, 369, 412
networks for monitoring migrant pests, 71, 105, 107, 117, 125, 132, 133, 152, 156, 165, 174, 175, 180, 412
Index

on aircraft, 31, 71, 198, 206, 354
on oil rigs, 56, 208, 215
onboard ship, 67, 73, 76, 84, 195, 198, 206, 207, 354, 358
pheromone, 51, 56, 57, 123, 152, 163, 164, 169, 203, 204, 205, 219, 281, 286, 413
efficiency for Oriental Armyworm, 127
windspeed and catches, 413
physiological condition of catches, 180, 199–208
Rothamsted suction-trap network, 18, 412
suction, 202, 206, 412
Tricaprylglycerol, 292
conversion to diacylglycerol, 293
Trichoplusia ni, 14, 34, see also Lepidoptera
Trivial movements, 245
Tropic of Cancer, 74, 84
Tropical Development and Research Institute (UK), 358
Troposphere, 37, 43
True Armyworm, see Mythimna unipuncta
Tsetse flies, see Glossina spp.
Turkey, 14, 15

USA, 31, 203, 206, 207, 208, 214, 228, 249, 256, 412
Gulf States, 412
mid-western, 412
northern, 254
southern, 254, 281
USSR (former), 18, 19
United Kingdom, 324, 330
United Nations Development Program, 379
Urania fulgens, 308–11, see also Lepidoptera
Utetheisa pulchella, 17, see also Lepidoptera

Variegated Cutworm, see Peridroma saucia
Vegetables, 151
Vegetation indices, 345
NIR/R ratio, 340
Normalised difference vegetation index (NDVI), 156, 158, 161, 338–45
calibration of, 344
Vegetation types
in inland Australia, 154
Vegetation zones
African–European region, 4

Velvetbean Caterpillar, see Anticarsia gemmatalis
Venezuela, 316

Vietnam, 70, 361
Vitellogenesis, 199
inhibition by adipokinetic hormone, 295
Water vapour pressure deficit, 272
Weather
air masses, 37, 54
classification of, 37
definition of, 37
types in North America, 37, 39, 55
anticyclones, 7, 13, 17, 44, 74, 185
Bermuda High, 41, 45, 49, 55
definition of, 41
North Pacific subtropical anticyclone, 77, 81, 99
Siberian continental anticyclone, 73, 77, 79, 84, 85
stationary, 142
atmospheric circulation processes, 37
charts – 850-hPa, 106, 122, 366, 368, 374
cyclones, 7, 13, 15, 16, 17, 41
seasonal shifts in North America, 41, 42, 45
tropical, 157, 159, 161
typhoons, 77, 79, 83
definition of, 41
frequency of, 55
mid-latitude, 131
speed of movement, 41
temperate, 79, 119, 120
tracks, 49, 55
tropical, 77, 153, 177, 179
effects of geographical features on, 34
forecasts, 327, 333, 356, 410, 411
frontal orientation, 49
frontal wave, 41
fronts, 37, 51, 81
Bai-u, 74, 76, 80, 81, 85, 366
cold, 13, 14, 16, 17, 18, 41, 45, 54, 55, 56, 57, 72, 73, 131, 156, 157, 165, 167, 181, 187
definition of, 41
frequency of, 55
polar, 41, 55
Shu-ru, 84
warm, 41, 74
high-pressure cells, 142, 177, 181, 187
high-pressure ridges, 55
low-pressure cells, 180, 185, 187
low-pressure troughs, 177, 185
systems
frontal Gulf return, 44, 45
Poleward-transporting synoptic weather system, 44–53, 58
Index

478

Weather, systems (cont.)
  synoptic scale, 31
transient, 7
West Indies, 10
Western Corn Rootworm, see Diabrotica
  virgifera virgifera
Western Sahara, 10
Wheat, 49, 93, 120, 122
winter, 95
White-backed Planthopper, see Sogatella
  furcifera

Wind
  convergence, 7, 380
  concentration of flying insects, 12,
    140, 341
  fields, 20, 82, 111, 366, 410
  run, 341
  systems, 37
Winds
  change in speed and direction with
    altitude, 43, 102
  direction and emigration, 292
  Ekman spiral, 43
  equatorial westerly, 4
  equatorward in autumn, 53
  geostrophic, 43, 181
  Harmattan, 8, 11
  in the subtropics, 7
  in the temperate zone, 7
  in the tropics, 4
  influence of topography on, 7, 11, 14
  low-level jets, 44, 45, 47, 51, 57, 58,
    74, 81, 106, 157, 365, 366, 371, 374
  monitoring with pilot balloons, 98
  monsoon, 4, 7, 10, 11, 19, 384, 387
  consistency of direction, 19
  northern hemisphere, 4
  poleward, 18, 21
  postfrontal, 158
  prefrontal, 15, 57, 158, 163, 166
  prevailing surface winds in the
    African–European region, 6
  prodiplas, 370, 372
sea breezes, 142
seasonal, 4
  reversal of dominant winds, 19, 86
  southern hemisphere, 4
  speed, 265
  stochastic effect on displacements, 196,
    221, 228, 229, 428, 448
  suitability for sustained flight, 85
  supergeostrophic, 44
  trade, 4, 7, 11
  consistency of direction, 19
  variability
    in direction, 7, 16, 17, 450
    in speed, 450
  in the temperate zone, 20
Wing loading, 311, 312
Wing muscles, 293
histolysis, 197, 209, 213, 216, 437
Wing polymorphism, 69, 220, 226, 243,
  245, 248, 260, 375, 428
and habitat stability, 249–52
and nympha! density, 249
differences in juvenile hormone
  esterases between morphs, 290
  differential fecundity between morphs,
    70, 252
  flight capacity of macropters, 244, 260
  geographic variation in proportions of
    morphs, 70
  induction of macroptery, 437
  polygenic inheritance, 249, 258, 440
  seasonal variation in proportions of
    morphs, 70
  single-locus inheritance, 244, 252, 257,
    440
Winglength, 244
Wings, 437
WormBase, see Data management
  systems
Yellow Sea, 105, 108, 113, 114
Yemen, 11, 12, 410
Zimbabwe, 266