
Index

- accentors, female song 127
 African shrike, antiphonal singing 215
 alder flycatcher, song development 78
 alpine accentor, female song 127
 American redstart, repertoire organisation 211–212
 American sparrow, dawn chorus 130
 amplitude modulation, disadvantages in sound transmission 91–92
 amplitude of sound waves, and volume of sound 20
 anterior vocal pathway
 role in song learning 36, 39–40
 role in song production 39
 antiphonal singing 215, 216
 area X in the brain 32–33, 36, 39–40
 atmospheric turbulence, effects on sound transmission 91–92
 attenuation of sound 86–91
 auditory field L *see* field L
 auditory template model of song development 52–55
 auditory template model variations 55–72
 accuracy of learning 68–70
 female song learning 71–72
 individuals who young birds copy 67–68
 memorisation stage influences 61–64
 production stage influences 64–66
 social influences 61–66
 timing of memorisation 56–61
 Australian magpie, chorusing 219–220

 background noise *see* environmental noise responses
 banded wren, interactive playback experiments 149
 Barrington, Daines 2–3
 bay wren, song control centre development 42–43
 Beau Geste hypothesis 145–146
 behaviour, interplay of nature and nurture 49–50

 Bewick's wren, competition for acoustic space 136–137
 black-capped chickadee
 effects of habitat fragmentation 264
 female eavesdropping 177–178
 female mate choice and dawn chorus 134
 sound localisation 107
 black-headed grosbeak, female song 126
 black redstart, parent-offspring recognition 160
 blackbird *see* European blackbird
 blue-black grassquit, singing behaviour 93
 blue-throated hummingbird, Lombard effect 101–102
 blue tit
 extra-pair paternity and the dawn chorus 135
 female mate choice and dawn chorus 134
 interactive playback experiments 148–149
 song variability 263
 blue-winged warbler
 daily pattern of singing 70
 song variability 263
 bluethroat, singing behaviour 93
 bobolink, turnover of song types 265
 Bonelli's warbler, species recognition by song (Bremond) 152, 154
 brain
 areas involved in hearing in birds 29, 36
 evolution of the song system in birds 37
 IEG activity during singing 38–39
 neurogenesis in the adult 40–42
 sexual dimorphism in song control centres 42–44
 sexual selection on the song system 44–48
 similarities to the mammalian brain 37
 song control nuclei and pathways 29, 36
 song learning pathway 36–37, 39–40
 song production (motor) pathway 36–37, 37–39
 sound signal processing 32–33, 36
 breathing, coordination with sound production 22

 breeding cycle and singing 114–120
 'dual function' theory 114
 fertility announcement hypothesis 119–120
 influence of the seasons 114–116
 link with female fertile period 119–120
 song and sperm competition 118–120
 song before and after pairing 116–117
 song cycles in mockingbirds 117–118
 song production and egg-laying 114–116
 Bremond's experiments, species recognition by song 150–152, 154
 bright-rumped attila, unlearned vocalisations 271
 brown-headed cowbird
 dialect spread 262
 dialects in flight whistle 254, 261
 social influences on song production 64
 song features in noisy environments 103
 brown thrasher
 estimate of repertoire size 205, 207–208
 syrinx anatomy 21
 two-voice theory of song production 24–25
 budgerigar, vocal learning 79–80
 bullfinch, individuals who young birds copy 68

 cadence of singing behaviour 137–138
 call, definition 8
 canary
 breathing and sound production 22
 effects of singing on song nuclei 121
 female response to 'sexy syllables' in male song 47–48, 179–181
 female song system 47–48
 HVC neurogenesis 40–42
 IEG expression in females 47–48
 main motor pathway and song production 37
 playback induction of ZENK IEG 35
 repertoire of 'sexy syllables' 44
 repertoire size and size of song nuclei 44, 45
 sexual dimorphism in brain structure 42

INDEX

- 'sexy syllable' production and male quality
198
two-voice theory of song production 23
ZENK IEG expression in females 47–48
- capture-recapture method 206–207
- cardinal, female song learning 71
- Carolina wren
song features and habitat 98
sound localisation 105, 106
- catbird, song development 65
- chaffinch
accuracy of song learning 69, 70
dialects in calls 253–254
exhaustion theory 231
geographic variation in song 245–246, 249
male song analysis 9
male song repertoire 8–9
repertoire organisation 209–210
singing position 92
song development case study 50–52
song development studies 53–55
song features and habitat 98
song features in noisy environments
102–103
song learning and information
transmission 81
song sharing 243–244, 245
song type changes over time 267–269, 267,
268
song variation from place to place 3, 52
two-voice theory of song production 23
- chestnut-sided warbler, songs with different
functions 233
- chiffchaff 3
- chipping sparrow, function of dawn chorus
133
- choruses 215, 219–221
- CMM area of the brain 29, 32, 36
- coal tit, performance drift theory 230–231
- collared flycatcher
female attraction to male song 174, 175
function of the dawn chorus 134–135
- common rosefinch, geographic variation in
song 246
- communication
benefits to senders and receivers 4–5
cooperation and conflict 4–5
definition 3–4
reasons for evolution 4–5
reliability and deception 5–6
song as form of 3–4
transmission of information 5–6
- communication channels
advantages of sound for birds 6–7
comparison of sensory channels 6–7
olfactory system in birds 6
visual signalling in birds 6, 7
- communication networks 166–169
- comparative studies 11
repertoire size and female choice
193–196
song complexity 239
- competition for acoustic space 135–138
avoidance of overlap of songs 138
cadence of singing behaviour 137–138
deliberate overlap of songs 138
from other species 136–137
from same species individuals 137–138
intersong intervals 137–138
temporal song asynchrony 136–137
- computer-based sound analysis 14–15
- context studies 10–11, 17–18
- corn bunting
accuracy of song learning 69
dialect boundaries 259
dialect spread 262
repertoire sharing 242, 243
sharp dialect boundaries 243, 252
singing position 92
- correlation studies 11
- cultural change over time 264–270
sampling some years apart 266–270
year to year changes 265–266
- Darwin, Charles ix
theory of sexual selection 172–174
- Darwin's finches
female song preferences 71–72
individuals who young birds copy 67–68
song sharing 243–244
song type changes over time 269, 270
- Darwin's medium ground finch, song type
changes over time 269, 270
- dawn chorus 128–135
earliest starters 129
extra-pair paternity 135
feeding conditions at dawn 130–132
female mate assessment 134–135
females and fertility at dawn 134–135
mate guarding 134
sound transmission at dawn 129–130
stochastic dynamic programming (SDP)
models 130–132
territory and vacancies at dawn 132–134
- deception in communication 5–6
- degradation (distortion) of sound 86, 91–92
- developmental stress, effects on song
complexity 199–201
- developmental stress hypothesis 199–201
- dialect areas 245
changes in dialect areas 262–263
creation of sharp dialect boundaries 262–263
isogloss maps of boundaries 252, 253
reasons for sharp boundaries 254
sharp boundaries 243, 249–254
white-crowned sparrow 250–252
- direct song-selective pathway 36, 39–40
- directional assessment, sound localisation
107–108
- directional transmission of sound 94–95
- distance assessment, sound localisation
104–107, 94
- DLM area of the brain 32–33
- dual function hypothesis 114, 239
- duets 215–219
antiphonal singing 215, 216
possible functions 216–219
- duncock
female song 127
mate recognition 163
- Dupont's larks, effects of habitat
fragmentation 264
- dusky antbird, sound localisation 106
- dusky warbler, song and breeding activity 119
- eastern marsh wren, repertoire size and size of
song nuclei 45–46
- eastern phoebe, song development 78–79
- eastern towhee, repertoire size and size of
song nuclei 45
- eastern whipbird
antiphonal singing 215, 248
regional variation in female song 246–247, 248
stereotypical male song 246–247, 248
- eastern wood peewee 3
- eavesdropping 166–169
by females 176–178
- element (note), definition 9
- environmental noise
addition of visual component 103
adjustment of song phrases 102
'cocktail party effect' 104
increase in signal to noise ratio 101–102
Lombard effect 101–102
noise made by other animals 101
raising amplitude of vocalisations 101–102
raising pitch of vocalisations 102–103
receiver strategies 103–104
redundancy in the signal 102–103
repetition of the message 102–103
singing more loudly 101–102
- environmental noise responses 101–104
- signaller strategies 101–103
- European blackbird
accuracy of song learning 68–69
competition for acoustic space 138
dawn chorus 130
directional transmission of sounds 94
female fertility and the dawn chorus 134
interactive playback experiments 147
mate guarding and the dawn chorus 134
receiving position 93–94
singing position 93–94
song sharing 243–244
- European cuckoo, host-specific chick begging
calls 161–162
- European redwing
dialect areas 252–253
dialect boundaries 259
microgeographic variation in song 245
two types of song 233
- European robin
application of SDP model 131–132
female song 126
foraging success and song output 131–132
hormone levels and song 122–123

- species recognition by song (Bremond) 150–152
- European starling
- dialects in whistles 252
 - mimicry 73, 74, 75
 - repertoire organisation 206, 213
 - repertoire size and female choice 192–193
 - repertoire size and size of song nuclei 45
 - song and breeding activity 119
 - song features in noisy environments 103
 - song learning 59
 - song discrimination 32, 36
 - types of song 234
- eventual variety, repertoire organisation 207, 209–210
- evolution of song complexity 237–239
- evolutionary change 270–273
- phylogenetic trends in song 272–273
 - song learning and speciation 274
 - unlearned vocalisations 270–272
- excess attenuation, sound transmission 87–91
- exhaustion avoidance theory 229–232
- female attraction to male song 174–176
- active choice by females 176, 177
- female choice
- and sexual selection 44–48
 - and song quality 27–28
 - influence of song output 181–185
 - metabolic costs of high song output 197–198
 - reliability and honesty of signalling 196–201
 - sexual selection in song structure 172–174
- song performance and male quality 198
- female choice and repertoire size 185–196
- comparative approach 193–196
 - European starling 192–193
 - great reed warbler 190–191
 - great tit 187
 - red-winged blackbird 191–192
 - sedge warbler 187–190
 - song sparrow 185–186, 187
- female eavesdropping on male-male interactions 176–178
- female mate assessment, dawn chorus 134–135
- female song 123–128
- red-winged blackbird 124–126
- female song discrimination 47–48
- female song learning 71–72
- female song preferences, influence of learning 71–72
- female song system 46–48
- female stimulation by male song 178–181
- females, species recognition by song 158
- fertility announcement hypothesis 119–120
- field L (auditory field L) 29, 32, 36, 37
- five-striped sparrow, two types of song 233
- forebrain song system, evolution 40
- frequency of sound waves
- and pitch of sound 20
 - effects on sound transmission 87–90, 91–92
- gene expression in the brain 34–36
- genetic adaptation, geographical variation process 258–260
- geographical variation in song 245–249
- detection by birds 249
- geographical variation processes 254–264
- changes in dialect areas 262–263
 - creation of sharp dialect boundaries 262–263
 - genetic adaptation 258–260
 - geographical barriers 262
 - habitat matching 255–258
 - historical processes 262–263
 - mistakes in song copying 261–263
 - social adaptation 260–261
 - songs on isolated islands 263–264
- golden-winged warbler, song variability 263
- great reed warbler
- female choice and male song complexity 176, 177
 - repertoire size and female choice 190–191
 - singing position 92–93
 - two types of song 233, 234
- great tit
- accuracy of song learning 69
 - dawn chorus 129, 130, 131
 - eavesdropping experiments 168, 169
 - feeding conditions and dawn chorus 130, 131
 - female eavesdropping 176–177
 - female fertility and the dawn chorus 134
 - functions of dawn chorus 132, 133–134
 - geographic variation in song 246
 - habitat and song variation 257
 - hearing threshold compared to hawk 108–109, 110
 - individuals who young birds copy 67
 - mate guarding and the dawn chorus 134
 - mate recognition 163
 - neighbour-stranger recognition 165–166
 - performance drift theory 229–230
 - repertoire size and female choice 187
 - repertoire size and territorial defence 145
 - seasonal testosterone levels 121
 - song before and after pairing 116–117
 - song features and habitat 98, 99
 - song features in noisy environments 102
 - sound localisation 106
 - speaker replacement experiments 143–144
 - territorial behaviour 132
- greater racket-tailed drongo, mimicry 73
- greenish warbler, role of song in speciation 273, 274
- grey catbird, two-voice theory of song production 21, 24–25
- ground effects in sound transmission 88, 89–90
- guillemot, parent-offspring recognition 159–160
- habitat and song features
- comparisons between species 95–97
 - comparisons within species 97–101
- habitat isolation, and song variation 263–264
- habitation avoidance theory 226–229
- hearing in birds 28–36
- ability to localize sound 31
 - auditory pathway 29, 36
 - basilar membrane 29
 - brain areas involved 29, 36
 - cochlea 29
 - discrimination between sounds 31–34, 36
 - gene expression in the brain 34–36
 - hearing ranges 29–31
 - IEG expression 34–36
 - match with sound production 30–31
 - peripheral auditory system 29
 - song control nuclei and pathways in the brain 29, 36
 - sound signal processing in the brain 32–33, 36
 - ZENK immediate early gene induction 34–36
- high frequency, sound transmission problems 87–88
- hill mynah, mimicry 73
- history of study of bird song 2–3
- honesty of signalling *see* reliability and honesty of signalling
- honeysucker, mimicry 73
- hooded warbler, neighbour-stranger recognition 166, 167
- hormones *see* seasonal song and hormones
- house finch, song sharing 243–244
- hummingbirds (Trochiliformes)
- evolution of the song system 37
 - forebrain song system 40
 - Lombard effect 101–102
 - song learning 80
- HVC (high vocal centre) 32–33
- neurogenesis in the adult 40–42
 - role in female song discrimination 47–48
 - role in song production 37–39
 - seasonal changes 120–121
- HVC shelf 29
- hypoglossal nucleus, role in song production 37
- hypothesis formulation 10–11
- hypothesis testing 11
- IEG (immediate early gene) expression
- during singing 38–39
 - in female canaries 47–48
 - induction by playback 34–36
- immediate variety, repertoire organisation 207, 211
- indigo bunting
- dialect formation 260–261
 - element types 246
 - individuals who young birds copy 67
 - song learning 59
 - song type changes over time 266–267
 - species-specific song structures 65
- individual recognition by song 158–169
- communication networks 166–169

INDEX

- eavesdropping 166–169
 mate recognition 162–163
 neighbour-stranger recognition 163–166, 167
 parent-offspring recognition 159–162
- information
 definition 5
 reliability and deception 5–6
 transmission between birds 5
- innate behaviour, interplay with learned
 behaviour 49–50
- interactive playback experiments 147–149
- intersong intervals 137–138
- interspecific territorialism 154–156
- invariant features hypothesis (species
 recognition by song) 153–154
- Japanese quail, Lombard effect 101–102
- Kentucky warbler
 song sharing 243
 sound localisation 106
- kin recognition 156–157
- lazuli bunting, species-specific song structures
 65
- learned behaviour, interplay with innate
 behaviour 49–50
- learning *see* song learning *see* vocal learning
- least flycatcher, competition for acoustic space
 137
- little greenbul, song features and habitat 100
- LMAN area in the brain 32–33
 role in female song discrimination 47–48
 role in song learning 36, 39–40
- Lombard effect 101–102
- low frequency, sound transmission problems
 89–90
- lyrebird, mimicry 74, 75
- macrogeographic variation 245
- male quality
 and song output 184–185
 and song performance 198
- males, song matching 221–226
- manx shearwater, mate recognition 162
- marsh warbler
 mimicry 74, 75
 song before and after pairing 117
 song development compared to sedge
 warbler 76–77
- marsh wren
 repertoire size and size of song nuclei 45–46
 sensitive phase for song learning 56–57
 song development 77
- matched countersinging 221–226
- mate recognition by song 162–163
- medial tympaniform membranes (MTM)
 21–22
- microgeographic variation 245, 245
- microphone arrays to locate birds 17–18
- microphone systems for recording birds
 12–13
- migration, influence on song development
 76–77
- mimicry 72–76
- mini-breath hypothesis of sound production
 22
- mockingbirds, song and breeding cycles
 117–118
- muting experiments 141–143
- nature and nurture, interplay in animal
 behaviour 49–50
- NCM area of the brain 29, 32, 36
- neighbour-stranger recognition by song
 163–166, 167
- neurogenesis in the adult brain 40–42
- New World sparrows, syllable bandwidth and
 repetition rate 27–28
- nightingale (common)
 accuracy of song learning 68–69, 69–70
 competition for acoustic space 138
 directional transmission of sounds 95
 eavesdropping experiments 168–169
 interactive playback experiments 147–148
 Lombard effect 101–102
 ‘mixed singing’ between species 75–76
 repertoire organisation 212–213
 song learning 57–58, 60–61
 temporal arrangement of songs 69–70
 temporal song asynchrony 137
 territorial behaviour and dawn chorus 132,
 133
- non-oscine passerines
 lack of forebrain song system 40
 lack of song learning 40
- non-passerines, vocal learning 79–81
- northern cardinal, song features and habitat
 100
- northern gannet, mate recognition 162
- northern mockingbird
 directional transmission of sounds 94
 mimicry 74
 role of the song nuclei 37–38
- note element
- nutritional stress hypothesis 199
- observing sounds 10–11
- ochre-bellied flycatcher, muting experiments
 143
- olfactory system in birds 6
- orange-tufted sunbird, dialects 254
- oscine passerines (‘true’ songbirds) 7–8
 repertoire size and HVC volume 46
- ovenbird
 avoidance of song overlap 138
 competition for acoustic space 137
- parent-offspring recognition 159–162
- parrots (Psittaciformes)
 evolution of the song system 37
 forebrain song system 40
 mimicry 73
 vocal learning 79–80
- Passeriformes, oscine group (‘true’ songbirds)
 7–8
- penguin species
 chicks’ ability to discriminate parent’s call 104
 mate recognition 162–163
 parent-offspring recognition 160
- performance drift theory 229–230, 230–231
- phrase, definition 9
- pie'd flycatcher
 female attraction to male song 174, 175
 female choice of mate 176
 song output and reproductive success 183
 two types of song 233
- pitch of sound, and frequency of sound waves
 20
- plain-tailed wren, chorusing 220–221
- playback experiments 15–18
 induction of IEG expression 34–36
- population variations in song 242–245
- posterior vocal pathway 37–39
- pressure-gradient system for sound
 localisation 110
- pseudoreplication problems in research
 studies 16–17
- pure whistles (pure tones) 91
- RA (robust nucleus of the arcopallium), role
 in song production 37–39
- RA cup 29
- radio tracking 17–18
- ranging hypothesis, sound localisation
 105–106, 107
- recording of songs
 analysis 13–15
 equipment 12–13
 invention of the sound spectrograph 3
 reasons for 12
 sonagram interpretation 13–15
- recursive song-selective pathway 36, 39–40
- red-eyed vireo, competition for acoustic space
 137
- red-winged blackbird
 avoidance of song overlap 138
 directional transmission of sounds 94
 female song 124–126
 muting experiments 141–142
 repertoire size and female choice 191–192
 repertoire size and size of song nuclei 45
 selectivity of female response to song 179, 180
- redwing *see* European redwing
- reed warbler
 diurnal rhythms of song 128–129
 singing position 92–93
 song production and egg-laying 115
 reliability and honesty of signalling 5–6,
 196–201
 developmental stress hypothesis 199–201
 nutritional stress hypothesis 199
 song complexity and developmental stress
 199–201
 song performance and male quality 198
 song production costs 197–198

- repertoire, definition 8–9
 repertoire complexity, songs with different functions 232–235
 repertoire organisation 208–215
 American redstart 211–212
 chaffinch 209–210
 competitive models 208–209
 European starling 206, 213
 eventual variety 207, 209–210
 immediate variety 207, 211
 models 208–209
 nightingale 212–213
 sedge warbler 213–215
 sequential models 209
 repertoire size and female choice 185–196
 comparative approach 193–196
 European starling 192–193
 great reed warbler 190–191
 great tit 187
 red-winged blackbird 191–192
 sedge warbler 187–190
 song sparrow 185–186, 187
 repertoire size and territorial defence 145–146
 repertoire size and volume of song nuclei 44–48
 repertoire size estimation 204–208
 capture-recapture method 206–207
 cumulative plot method 205–206
 repertoire use
 choruses 215, 219–221
 duets 215–219
 repertoire versatility 226
 exhaustion avoidance theory 229–232
 habituation avoidance theory 226–229
 performance drift theory 229–230, 230–231
 repetition rate and syllable bandwidth 27–28
 reproductive success, and song output 181–185
 research techniques
 analysing recordings 13–15
 benefits of an integrated approach 17–18
 comparative studies 11
 computer-based sound analysis 14–15
 context studies 10–11, 17–18
 correlation studies 11
 experimenting 15–18
 field study 10–11
 hypothesis formulation 10–11
 hypothesis testing 11
 microphone arrays 17–18
 observing sounds 10–11
 playback experiments 15–18
 potentially confounding variables 17, 18
 pseudoreplication problems 16–17
 radio tracking 17–18
 recording of songs 12
 sonagram interpretation 13–15
 reverberation, effects on sound transmission 91–92
 robin *see* European robin
 rufous-and-white wren, sexual dimorphism in song control centres 42–43
 rufous bristlebird, effects of habitat fragmentation 264
 rufous-collared sparrow
 dialect variation 260
 habitat and local dialects 255–257
 song features and habitat 98–99
 song type changes over time 269–270
 saddleback
 cultural changes in songs 265–266
 dialect spread 262
 individuals who young birds copy 67
 Sardinian warbler, estimate of repertoire size 207, 208
 satin bowerbird
 habitat and song variation 257
 song features and habitat 100
 savannah sparrow, geographic variation in song 246
 scarlet tanager, song features and habitat 100
 seabirds
 mate recognition 162–163
 parent-offspring recognition 159–160
 seaside sparrow, muting experiments 142
 seasonal song and hormones 120–123
 changes in song nuclei 120–121
 female song 123–128
 hormone levels in European robins 122–123
 hormone levels in wild birds 121–122
 red-winged blackbird 124–126
 testosterone 120–121
 sedge warbler
 diurnal rhythms of song 128–129
 repertoire organisation 213–215
 repertoire size and female choice 187–190
 repertoire size and size of song nuclei 44
 singing position 92–93
 sonagram interpretation 13–15
 song before and after pairing 116, 128
 song development 65
 song development compared to marsh warbler 76–77
 song production and egg-laying 115
 sedge wren, song development strategies 77
 'seep' alarm call, avoidance of localisation 108–109, 110
 sexual dimorphism in brain song control centres 42–44
 sexual selection
 evolution of the song system 44–48
 female choice 44–48
 reliability and honesty of signalling 196–201
 song complexity 237–239
 song structure 172–174
 'sexy syllables' in male canary song and female choice 44
 and male quality 198
 attractiveness to females 179–181
 female canary response 47–48
 Seychelles warbler
 singing position 92–93
 song production and egg-laying 115–116
 sharp dialect boundaries 243, 249–254
 creation 262–263
 signal, song as form of 3–4
 singing position, and sound transmission 92–95
 skylark, singing in the presence of predators 93
 snow bunting, song sharing 243
 social adaptation, and geographical variation in song 260–261
 social influences on song development 61–66
 social modelling theory of song development 66
 sonagram interpretation 13–15
 sonagram (sound spectrograph) 13–15
 song
 as communication 3–4
 communication advantages 6–7
 definition 8, 9
 distinction from call 7–8
 elements (notes) 9
 phrases 9
 repertoire 8–9
 strophe 10
 syllables 9
 time intervals between 9
 units of analysis 8–10
 versions (song types) 8–9
 song complexity 205, 235–239
 comparative studies 239
 dual function hypothesis 239
 effects of developmental stress 199–201
 evolution of 237–239
 functions of song 235–237
 sexual selection pressures 237–239
 song control centres, sexual dimorphism in the brain 42–44
 song control nuclei and pathways in the brain 29, 36
 song control system, influence of sexual selection 44–48
 song copying mistakes and geographical variation 261–262, 262–263
 song development
 accuracy of learning 68–70
 action-based learning 64
 auditory template model 52–55
 auditory template model variations 55–72
 chaffinch case study 50–52
 distribution of song learning 77–81
 female song learning 71–72
 individuals who young birds copy 67–68
 influence of migration 76–77
 memorisation stage influences 61–64
 memory-based learning 64
 production stage influences 64–66
 reasons for variety of strategies 76–77
 social influences 61–66
 social modelling theory 66
 sub-oscine passerines 77–79

INDEX

- timing of memorisation 56–61
 song discrimination in females 47–48
 song features and habitat
 comparisons between species 95–97
 comparisons within species 97–101
 song functions, and complexity 235–237
 song learning 2–3
 and speciation 272–273, 274
 direct song-selective pathway 36, 39–40
 distribution of 77–81
 evolution in birds 80–81
 functional significance 81–84
 hummingbirds 80
 neural pathway 36–37, 39–40
 reasons for 81–84
 reasons for variety of strategies 76–77
 recursive song-selective pathway 36, 39–40
 role of the anterior vocal pathway 36, 39–40
 see also vocal learning
 song learning explanations 81–84
 adaptation to habitat 82
 avoidance of aggression 84
 ‘cultural trap’ theory 83, 84
 feature of early evolution of the oscines 84
 genetic adaptation 82
 indicator of male quality 83–84
 social adaptation 82
 transmission of complex information 81
 vocal flexibility for loud singing 84
 song matching 221–226
 song nuclei, seasonal changes 120–121
 song output
 and male quality 184–185
 and reproductive success 181–185
 and territory quality 182–183
 influence on female choice 181–185
 song performance and male quality 198
 song production
 activity of IEGs 38–39
 metabolic costs 197–198
 neural pathway 36–37, 37–39
 posterior vocal pathway 37–39
 role of the anterior vocal pathway 39
 sound modulation in the vocal tract 25–28
 two-voice theory 21, 23–25
 song quality and female choice 27–28
 song rate, influence on female choice 181–185
 song-selective neurons 36, 39–40
 song-selective pathways, direct and recursive 36, 39–40
 song sharing within a population 242–245
 song sparrow
 accuracy of song learning 70
 female song 124
 neighbour-stranger recognition 166
 repertoire size and female choice 185–186, 187
 sensitive phase for song learning 57–58
 social influences on song memorisation 63
 song and breeding activity 119
 song matching 222, 223–224
 song production match with hearing range 30–31
 song sharing 244–245
 sound modulation in the vocal tract 26–27
 speaker replacement experiments 144–145
 species song discrimination 72
 song structure, intra- and intersexual selection 172–174
 song system
 evolution in different groups of birds 37
 in females 46–48
 sexual selection and evolution 44–48
 song type (version), definition 8–9
 song types with different functions 232–235
 song variation
 geographical 245–249
 within a population 242–245
 songbirds
 evolution of the song system 37
 oscine passerines 7–8
 sound, advantages as communication channel 6–7
 sound discrimination 31–34, 36
 sound environment hypothesis (species recognition by song) 154
 sound localisation 31, 104–110
 amplitude attenuation over distance 94, 104–105
 avoidance of localisation 108–109, 110
 directional assessment 107–108
 distance assessment 94, 104–107
 improving localisation 109–110
 intensity differences 108
 phase differences 108
 pressure-gradient system in birds 110
 ranging hypothesis 105–106, 107
 ‘seep’ alarm call 108–109, 110
 signal degradation analysis 105, 105
 time of arrival differences 107
 sound production
 avoidance of localisation 108–109, 110
 coordination with breathing 22
 improving localisation 109–110
 match with hearing in birds 30–31
 medial tympaniform membranes (MTM) 21–22
 mini-breath hypothesis 22
 modulation in the vocal tract 25–28
 properties of sound waves 20
 song quality and female choice 27–28
 syllable bandwidth and repetition rate 27–28
 syringeal muscles 22
 syrinx anatomy and function 21–22
 syrinx location 21, 23–25
 two-voice theory of song production 21, 23–25
 sound reception, positioning by birds 93–94
 sound shadow effect 88
 sound signal processing in the brain 32–33, 36
 sound spectrograph, invention 3
 sound transmission by birds
 at dawn 129–130
 directional transmission 94–95
 facing uphill in Himalayan species 95
 singing in flight 93
 singing position 92–95
 sound transmission problems 86–92
 atmospheric turbulence effects 91–92
 attenuation 86–91
 costs of singing loudly 90–91
 degradation (distortion) 86, 91–92
 disadvantages of amplitude modulation 91–92
 excess attenuation 87–91
 frequency effects 87–90, 91–92
 ground effects 88, 89–90
 high frequency problems 87–88
 low frequency problems 89–90
 physical limitations on sound production 90–91
 pure whistles (pure tones) 91
 reverberation 91–92
 sound shadow effect 88
 ‘sound window’ for different habitats 89–90
 spherical spreading 86, 87
 temperature and humidity effects 88
 vegetation effects 88
 sound waves
 amplitude and volume 20
 frequency and pitch 20
 properties 20
 ‘sound window’ for different habitats 89–90
 speaker replacement experiments 143–146
 species recognition by song 149–158
 Bremond’s experiments 150–152, 154
 important features 153–154
 interspecific territorialism 154–156
 invariant features hypothesis 153–154
 kin recognition 156–157
 recognising other species 154–156
 recognition by females 158
 sound environment hypothesis 154
 spherical spreading, sound transmission 86, 87
 starling *see* European starling
 stochastic dynamic programming (SDP)
 models 130–132
 stonechat
 song and breeding activity 119
 song output and male quality 184–185
 strophe, definition 9
 sub-oscine passerines, song development 77–79
 summer tanager, song features and habitat 100
 superb fairy-wren, female song 127
 swallow
 female fertility and the dawn chorus 134
 mate guarding and the dawn chorus 134
 parent-offspring recognition 160, 161
 swamp sparrow
 dialects and genetic adaptation 260
 element types 246, 247
 female choice and song performance 198
 sensitive phase for song learning 57–58

- social influences on song memorisation 63
 song development 60
 song production match with hearing range 30–31
 song quality and female choice 27–28
 species song discrimination 72
 species-specific song structures 65
 syllable bandwidth and repetition rate 27–28
- syllable, definition 9
see also 'sexy syllables' in male canary song
- syringeal muscles 22
- syrinx
 anatomy and function 21–22
 location 21, 23–25
 two-voice theory of song production 21, 23–25
- temperature and humidity, effects on sound transmission 88
- temporal changes in song *see* cultural change over time
- territorial defence by song 140–149
 Beau Geste hypothesis 145–146
 interactive playback experiments 147–149
 muting experiments 141–143
 origin of the concept 141
 repertoire size effects 145–146
 speaker replacement experiments 143–146
- territorialism, interspecific 154–156
- territory quality, and song output 182–183
- testosterone and seasonal song 120–121
- three-wattled bellbird, song development 79
- thrush nightingale
 song sharing 243–244
 speaker replacement experiments 143
 year to year changes in song 265
- time interval, definition of songs and parts of songs 9
- treecreeper, 'mixed singing' between species 75–76
- tufted titmouse, song sharing 243–244
- variation within a population 242–245
- vegetation, effects on sound transmission 88
- version (song type), definition 8–9
- viduine finches, song learning 72–73
- village indigobird
 accuracy of song learning 69
 repertoire sharing 242–243
 song learning 59
 year to year changes in song 265
- visual signalling in birds 6, 7
- vocal learning
 evolution in birds 80–81
 non-passerines 79–81
 parrots 79–80
see also song learning
- vocal tract, sound modulation 25–28
- volume of sound, and amplitude of sound waves 20
- warblers (*Acrocephalus* spp.)
 comparison of singing positions 92–93
 diurnal rhythms of song 128–129
 repertoire size and HVC volume 46
 song before and after pairing 116, 117, 128
 song features and habitat 96–97
 song production and egg-laying 115–116
 specific types of warbler
- western marsh wren, repertoire size and size of song nuclei 45–46
- western meadowlark
 song matching 221–223
 song sharing 243–244
- White, Gilbert 3, 141, 149
- white-browed robin-chat, antiphonal singing 215
- white-browed sparrow weaver, chorusing 220
- white-crowned sparrow
 dialect spread 262
 dialects and genetic adaptation 258–259, 259–260
 female song 123, 126, 127
 female song learning 71
 microgeographic variation in song 245
 sharp dialect boundaries 250–252
 social influences on song memorisation 61–63
 song changes over time 270
 song development 66
 song learning 57
 song learning strategies 77
 song sharing 244
 sound discrimination 32
 species song discrimination 72
- white-eyed vireo, song sharing 243–244
- white-throated sparrow
 avoidance of song overlap 138
 neighbour-stranger recognition 163–165
 song features and habitat 99–100
 speaker replacement experiments 144–145
- willow flycatcher, song development 78
- willow tit, seasonal testosterone levels 122
- willow warbler 3
 song and breeding activity 119–120
 song output and territory quality 182–183
- willow wren (now chiffchaff, willow warbler, wood warbler) 3
- winter wren
 'cocktail party effect' 104
 function of dawn chorus 132
 geographical barriers and variation 262
 singing and receiving positions 94
 territorial behaviour 132
- wood warbler 3
 two types of song 233
- wren, competition for acoustic space 136–137
- yellow-headed blackbird, song features and habitat 100
- yellow-naped amazon parrot, dialects in contact call 260
- yellow-rumped cacique, turnover of song types 265
- yellow warbler, daily pattern of singing 70
- yellowhammer
 persistence of song elements 270
 song and breeding competition 118–119
- zebra finch
 accuracy of song learning 68–69
 breathing and sound production 22
 female song preferences 71
 gynandromorphic form 43–44
 heritability of song nuclei 45
 individuals who young birds copy 68
 Lombard effect 101–102
 mate recognition 163
 neurogenesis in the adult brain 41, 42
 playback induction 35
 repertoire size and size of song nuclei 45
 role of HVC and RA in song production 38
 sensitive period for song learning 58
 sexual dimorphism in brain structure 42, 43–44
 social influences on song memorisation 63–64
 social influences on song production 64
 song development studies 54, 55
 song features in noisy environments 103
 song-selective neural pathways 40
 sound signal discrimination 32–33
 two-voice theory of song production 23
- ZENK IEG
 activity during singing 38–39
 expression in female canaries 47–48
 induction by playback 34–36