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References

A

- Abdallah F.B., Chahine J.M.E.H., 1999. Transferrins, the mechanism of iron release by ovo-transferrin. *European Journal of Biochemistry* **263**: 912–920.
- Abdel-Hafez S.I.I., 1984. Survey of airborne fungus spores at Taif, Saudi Arabia. *Mycopathologia* **88**: 39–44.
- Abolins S.R., Pocock M.J.O., Hafalla J.C.R., Riley E.M., Viney M.E., 2011. Measures of immune function of wild mice, *Mus musculus*. *Molecular Ecology* **20**: 881–892.
- Adamo S.A., 2004. How should behavioural ecologists interpret measurements of immunity? *Animal Behaviour* **68**: 1443–1449.
- Adelman J.S., Bentley G.E., Wingfield J.C., Martin L.B., Hau M., 2010. Population differences in fever and sickness behaviors in a wild passerine: a role for cytokines. *Journal of Experimental Biology* **213**: 4099–4109.
- Aguilera O., Quiros L.M., Fierro J.F., 2003. Transferrins selectively cause ion efflux through bacterial and artificial membranes. *FEBS Letters* **548**: 5–10.
- Aisen P., 1998. Transferrins, the transferrin receptor, and the uptake of iron by cells. In: *Metal in Biological Systems* (Sigel A., Sigel H., eds). New York: Marcel Dekker; 585–665.
- Alcaide M., Lemus J.A., Blanco G., Tella J.L., Serrano D., Negro J.J., Rodríguez A., García-Montijano M., 2010. MHC diversity and differential exposure to pathogens in kestrels (*Aves: Falconidae*). *Molecular Ecology* **19**: 691–705.
- Al-Suwaine A.S., Bahkali A.H., Hasnain S.M., 1999. Seasonal incidence of airborne fungal allergens in Riyadh, Saudi Arabia. *Mycopathologia* **145**: 15–22.
- Al-Suwaine A.S., Hasnain S.M., Bahkali A.H., 1999. Viable airborne fungi in Riyadh, Saudi Arabia. *Aerobiologia* **15**: 121–130.
- Andersen A.A., 1958. New sampler for the collection, sizing, and enumeration of viable airborne particles. *Journal of Bacteriology* **76**: 471–484.
- Ardia D.R., 2005a. Tree swallows trade off immune function and reproductive effort differently across their range. *Ecology* **86**: 2040–2046.
- Ardia D.R., 2005b. Individual quality mediates trade-offs between reproductive effort and immune function in tree swallows. *Journal of Animal Ecology* **74**: 517–524.
- Ayres J.C., Taylor B., 1956. Effect of temperature on microbial proliferation in shell eggs. *Applied Microbiology* **4**: 355–359.

B

- Babu S., Blauvelt C.P., Kumaraswami V., Nutman T.B., 2006. Regulatory networks induced by live parasites impair both Th1 and Th2 pathways in patent lymphatic filariasis: implications for parasite persistence. *Journal of Immunology* **176**: 3248–3256.
- Bach J-F., 2002. The effect of infections on susceptibility to autoimmune and allergic diseases. *New England Journal of Medicine* **347**: 911–920.
- Bachar A., Al-Ashhab A., Soares M., Sklarz M., Angel R., Ungar E., Gillor O., 2010. Soil microbial abundance and diversity along a low precipitation gradient. *Microbial Ecology* **60**: 453–461.
- Bailly J., Fraissinet-Tachet L., Verner M-C., Debaud J-C., Lemaire M., Wesolowski-Louvel M., Marmeisse R., 2007. Soil eukaryotic functional diversity, a metatranscriptomic approach. *ISME Journal* **1**: 632–642.
- Becker W.A., 1984. *A Manual of Quantitative Genetics*, 4th ed. Pullman, Washington: Academic Enterprises.
- Behnke J.M., Eira C., Rogan M., Gilbert F.S., Torres J., Miquel J., Lewis J.W., 2009. Helminth species richness in wild wood mice, *Apodemus sylvaticus*, is enhanced by the presence of the intestinal nematode *Heligmosomoides polygyrus*. *Parasitology* **136**: 793–804.
- Beissinger S.R., Cook M.I., Arendt W.J., 2005. The shelf life of bird eggs: Testing egg viability using a tropical climate gradient. *Ecology* **86**: 2164–2175.
- Belovsky G.E., 1981. Food plant-selection by a generalist herbivore - the moose. *Ecology* **62**: 1020–1030.
- Berger S., Disko R., Gwinner H., 2003. Bacteria in starling nests. *Journal of Ornithology* **144**: 317–322.

- Bisson I.-A., Marra P., Burt E., Sikaroodi M., Gillevet P., 2007. A molecular comparison of plumage and soil bacteria across biogeographic, ecological and taxonomic scales. *Microbial Ecology* **54**: 65–81.
- Blaser M.J., Falkow S., 2009. What are the consequences of the disappearing human microbiota? *Nature Reviews Microbiology* **7**: 887–894.
- Blount J.D., Houston D.C., Møller A.P., Wright J., 2003. Do individual branches of immune defence correlate? A comparative case study of scavenging and non-scavenging birds. *Oikos* **102**: 340–350.
- Board R.G., Fuller R., 1974. Nonspecific antimicrobial defences of avian egg, embryo and neonate. *Biological Reviews of the Cambridge Philosophical Society* **49**: 15–49.
- Bonisoli-Alquati A., Rubolini D., Romano M., Cucco M., Fasola M., Caprioli M., Saino N., 2010. Egg antimicrobials, embryo sex and chick phenotype in the yellow-legged gull. *Behavioral Ecology and Sociobiology* **64**: 845–855.
- Bonneaud C., Mazuc J., Gonzalez G., Haussy C., Chastel O., Faivre B., Sorci G., 2003. Assessing the cost of mounting an immune response. *American Naturalist* **161**: 367–379.
- Boots M., Bowers R.G., 2004. The evolution of resistance through costly acquired immunity. *Proceedings of the Royal Society of London Series B: Biological Sciences* **271**: 715–723.
- Bordes F., Morand S., 2009. Coevolution between multiple helminth infestations and basal immune investment in mammals: cumulative effects of polyparasitism? *Parasitology Research* **106**: 33–37.
- Bordes F., Morand S., 2009. Parasite diversity: an overlooked metric of parasite pressures? *Oikos* **118**: 801–806.
- Boulinier T., Staszewski V., 2008. Maternal transfer of antibodies: raising immuno-ecology issues. *Trends in Ecology and Evolution* **23**: 282–288.
- Bradley J.E., Jackson J.A., 2008. Measuring immune system variation to help understand host-pathogen community dynamics. *Parasitology* **135**: 807–823.
- Brown C.R., Brown M.B., Rannala B., 1995. Ectoparasites reduce long-term survival of their avian host. *Proceedings of the Royal Society of London Series B: Biological Sciences* **262**: 313–319.
- Bruce J., Drysdale E.M., 1994. Trans-shell transmission. In: *The microbiology of the avian egg* (Board R.G., Fuller R., eds). London, UK: Chapman and Hall; 63–91.
- Buehler D.M., Encinas-Viso F., Petit M., Vézina F., Tieleman B.I., Piersma T., 2009. Limited access to food and physiological trade-offs in a long-distance migrant shorebird. II. Constitutive immune function and the acute-phase response. *Physiological and Biochemical Zoology* **82**: 561–571.
- Buehler D.M., Piersma T., Matson K., Tieleman B.I., 2008. Seasonal redistribution of immune function in a migrant shorebird: Annual-cycle effects override adjustments to thermal regime. *American Naturalist* **172**: 783–796.
- Buehler D.M., Piersma T., Tieleman B.I., 2008. Captive and free-living red knots *Calidris canutus* exhibit differences in non-induced immunity that suggest different immune strategies in different environments. *Journal of Avian Biology* **39**: 560–566.
- Buehler D.M., Tieleman B.I., Piersma T., 2009. Age and environment affect constitutive immune function in Red Knots (*Calidris canutus*). *Journal of Ornithology* **150**: 815–825.
- Buehler D.M., Tieleman B.I., Piersma T., 2010. How do migratory species stay healthy over the annual cycle? A conceptual model for immune function and for resistance to disease. *Integrative and Comparative Biology* **50**: 346–357.
- Burley R.W., Vadehra D.V., 1989. *The Avian Egg: Chemistry and Biology*. New York: John Wiley and Sons.
- Burrows S.M., Elbert W., Lawrence M.G., Poschl U., 2009. Bacteria in the global atmosphere - Part 1: Review and synthesis of literature data for different ecosystems. *Atmospheric Chemistry and Physics* **9**: 9263–9280.
- Burt E.H., Ichida J.M., 1999. Occurrence of feather-degrading bacilli in the plumage of birds. *Auk* **116**: 364–372.

C

- Callewaert L., Michiels C., 2010. Lysozymes in the animal kingdom. *Journal of Biosciences* **35**: 127–160.
- Carroll M.C., Prodeus A.P., 1998. Linkages of innate and adaptive immunity. *Current Opinion in Immunology* **10**: 36–40.
- Carrillo C.M., Valera F., Barbosa A., Moreno E., 2007. Thriving in an arid environment: High prevalence of avian lice in low humidity conditions. *Ecoscience* **14**: 241–249.
- Cerón J.J., Martínez-Subiela S., Ohno K., Caldin M., 2008. A seven-point plan for acute phase protein interpretation in companion animals. *The Veterinary Journal* **177**: 6–7.
- Chamanza R., Toussaint M.J.M., van Ederen A.M., van Veen L., Hulskamp-Koch C., Fabri T.H.F., 1999. Serum amyloid A and transferrin in chicken. A preliminary investigation of using acute-phase variables to assess diseases in chickens. *Veterinary Quarterly* **21**: 158–162.
- Cichoń M., Sendecka J., Gustafsson L., 2003. Age-related decline in humoral immune function in Collared Flycatchers. *Journal of Evolutionary Biology* **16**: 1205–1210.
- Cook M.I., Beissinger S.R., Toranzos G.A., Rodriguez R.A., Arendt W.J., 2003. Trans-shell infection by pathogenic micro-organisms reduces the shelf life of non-incubated bird's eggs: a constraint on the onset of incubation? *Proceedings of the Royal Society of London Series B: Biological Sciences* **270**: 2233–2240.
- Cook M.I., Beissinger S.R., Toranzos G.A., Arendt W.J., 2005a. Incubation reduces microbial growth on eggshells and the opportunity for trans-shell infection. *Ecology Letters* **8**: 532–537.
- Cook M.I., Beissinger S.R., Toranzos G.A., Rodriguez R.A., Arendt W.J., 2005b. Microbial infection affects egg viability and incubation behavior in a tropical passerine. *Behavioral Ecology* **16**: 30–36.
- Corby-Harris V., Pontaroli A.C., Shimkets L.J., Bennetzen J.L., Habel K.E., Promislow D.E.L., 2007. Geographical distribution and diversity of bacteria associated with natural populations of *Drosophila melanogaster*. *Applied Environmental Microbiology* **73**: 3470–3479.
- Cotgreave P., Clayton D.H., 1994. Comparative analysis of time spent grooming by birds in relation to parasite load. *Behaviour* **131**: 171–187.
- Cox-Foster D.L., Conlan S., Holmes E.C., Palacios G., Evans J.D., Moran N.A., Quan P-L., Briese T., Hornig M., Geiser D.M., Martinson V., vanEngelsdorp D., Kalkstein A.L., Drysdale A., Hui J., Zhai J., Cui L., Hutchison S.K., Simons J.F., Egholm M., Pettis J.S., Lipkin W.I., 2007. A metagenomic survey of microbes in honey bee colony collapse disorder. *Science* **318**: 283–287.
- Cramp S., ed, 1988. Tyrant Flycatchers to Thrushes. Oxford: Oxford University Press.
- Cray C., Zaias J., Altman N.H., 2009. Acute phase response in animals: A review. *Comparative Medicine* **59**: 517–526.
- Cucco M., Guasco B., Ottonelli R., Balbo V., Malacarne G., 2009. The influence of temperature on egg composition in the grey partridge *Perdix perdix*. *Ethology, Ecology and Evolution* **21**: 63–77.

D

- D'Alba L., Oborn A., Shawkey M., 2010. Experimental evidence that keeping eggs dry is a mechanism for the antimicrobial effects of avian incubation. *Naturwissenschaften* **97**: 1089–1095.
- D'Alba L., Shawkey M., Korsten P., Vedder O., Kingma S., Komdeur J., Beissinger S., 2010. Differential deposition of antimicrobial proteins in Blue Tit (*Cyanistes caeruleus*) clutches by laying order and male attractiveness. *Behavioral Ecology and Sociobiology* **64**: 1037–1045.
- Daszak P., Cunningham A.A., Hyatt A.D., 2000. Emerging infectious diseases of wildlife - threats to biodiversity and human health. *Science* **287**: 443–449.
- Deeming D.C., 2002. Embryonic development and utilisation of egg components. In: Avian Incubation: Behaviour, Environment, and Evolution (Deeming DC, ed). Oxford: Oxford University Press.

- Delers F, Strecker G., Engler R., 1988. Glycosylation of chicken haptoglobin - isolation and characterization of 3 molecular variants and studies of their distribution in hen plasma before and after turpentine-induced inflammation. *Biochemistry and Cell Biology* **66**: 208–217.
- del Hoyo J., Elliott A., Christie D.A., eds, 2004. Cotingas to Pipits and Wagtails. Barcelona: Lynx Edicions.
- de Martonne E., 1926. Une nouvelle fonction climatologique: *L'indice d'aridité*. *La Météorologie* **2**: 449–458.
- Dobryszczycka W., 1997. Biological functions of haptoglobin - New pieces to an old puzzle. *European Journal of Clinical Chemistry and Clinical Biochemistry* **35**: 647–654.

E

- Ellison R.T., Giehl T.J., 1991. Killing of gram-negative bacteria by lactoferrin and lysozyme. *Journal of Clinical Investigation* **88**: 1080–1091.
- Ezenwa V.O., Etienne R.S., Gordon L., Beja-Pereira A., Jolles A.E., 2010. Hidden consequences of living in a wormy world: Nematode-induced immune suppression facilitates Tuberculosis invasion in African buffalo. *American Naturalist* **176**: 613–624.

F

- Falconer D.S., Mackay T.F.C., 1996. Introduction to Quantitative Genetics, 4th ed. Essex, UK: Longman.
- Fallon P.G., Alcamí A., 2006. Pathogen-derived immunomodulatory molecules: future immunotherapeutics? *Trends in Immunology* **27**: 470–476.
- Field C.B., Behrenfeld M.J., Randerson J.T., Falkowski P., 1998. Primary production of the biosphere: Integrating terrestrial and oceanic components. *Science* **281**: 237–240.
- Figuerola J., 1999. Effects of salinity on rates of infestation of waterbirds by haematzoa. *Ecography* **22**: 681–685.
- Figuerola J., Green A.J., 2000. Haematzoan parasites and migratory behaviour in waterfowl. *Evolutionary Ecology* **14**: 143–153.
- Finlay B.B., Falkow S., 1997. Common themes in microbial pathogenicity revisited. *Microbiology and Molecular Biology Reviews* **61**: 136–169.
- Finlay B.B., McFadden G., 2006. Anti-immunology: evasion of the host immune system by bacterial and viral pathogens. *Cell* **124**: 767–782.
- Fitze P.S., Tschirren B., Richner H., 2004. Life history and fitness consequences of ectoparasites. *Journal of Animal Ecology* **73**: 216–226.
- Franklin D.C., Whelan P.I., 2009. Tropical mosquito assemblages demonstrate 'textbook' annual cycles. *PLoS ONE* **4**: e8296.
- Friedberg I., Avigad G., 1966. High lysozyme concentration and lysis of *Micrococcus lysodeikticus*. *Biochimica et Biophysica Acta (BBA) - General Subjects* **127**: 532–535.
- Froeschke G., Harf R., Sommer S., Matthee S., 2010. Effects of precipitation on parasite burden along a natural climatic gradient in southern Africa – implications for possible shifts in infestation patterns due to global changes. *Oikos* **119**: 1029–1039.

G

- Gage K.L., Burkot T.R., Eisen R.J., Hayes E.B., 2008. Climate and vectorborne diseases. *American Journal of Preventative Medicine* **35**: 436–450.
- Gambino R., Desvarieux E., Orth M., Matan H., Ackattupathil T., Lijoi E., Wimmer C., Bower J., Gunter E., 1997. The relation between chemically measured total iron-binding capacity concentrations and immunologically measured transferrin concentrations in human serum. *Clinical Chemistry* **43**: 2408–2412.
- Garcia K.O., Berchieri A., Santana A.M., Freitas-Neto O.C., Fagliari J.J., 2009. Experimental infection of commercial layers using a *Salmonella enterica* serovar Gallinarum strain: Leukogram and serum acute-phase protein concentrations. *Brazilian Journal of Poultry Science* **11**: 263–270.

- Gasparini J., McCoy K.D., Haussy C., Tveraa T., Boulinier T., 2001. Induced maternal response to the Lyme disease spirochaete *Borrelia burgdorferi* sensu lato in a colonial seabird, the kittiwake *Rissa tridactyla*. *Proceedings of the Royal Society of London Series B: Biological Sciences* **268**: 647–650.
- Gentry T., Wickham G., Schadt C., He Z., Zhou J., 2006. Microarray applications in microbial ecology research. *Microbial Ecology* **52**: 159–175.
- Georgieva T.M., Koinarski V.N., Urumova V.S., Marutsov P.D., Christov T.T., Nikolov J., Chaprazov T., Walshe K., Karov R.S., Georgiev I.P., Koinarski Z.V., 2010. Effects of *Escherichia coli* infection and *Eimeria tenella* invasion on blood concentrations of some positive acute phase proteins (haptoglobin (PIT 54), fibrinogen and ceruloplasmin) in chickens. *Revue de Médecine Vétérinaire* **161**: 84–89.
- Giansanti F., Giardi M.F., Massucci M.T., Botti D., Antonini G., 2007. Ovotransferrin expression and release by chicken cell lines infected with Marek's disease virus. *Biochemistry & Cell Biology* **85**: 150–155.
- Giansanti F., Rossi P., Massucci M.T., Botti D., Antonini G., Valenti P., Seganti L., 2002. Antiviral activity of ovotransferrin discloses an evolutionary strategy for the defensive activities of lactoferrin. *Biochemistry & Cell Biology* **80**: 125–130.
- Gilbride K.A., Lee D.Y., Beaudette L.A., 2006. Molecular techniques in wastewater: Understanding microbial communities, detecting pathogens, and real-time process control. *Journal of Microbial Methods* **66**: 1–20.
- Giraudeau M., Czirják G.Á., Duval C., Guiterrez C., Bretagnolle V., Heeb P., 2010. No detected effect of moult on feather bacterial loads in mallards *Anas platyrhynchos*. *Journal of Avian Biology* **41**: 678–680.
- Godard R.D., Wilson C.M., Frick J.W., Siegel P.B., Bowers B.B., 2007. The effects of exposure and microbes on hatchability of eggs in open-cup and cavity nests. *Journal of Avian Biology* **38**: 709–716.
- Goodenough A., Stallwood B., 2010. Intraspecific variation and interspecific differences in the bacterial and fungal assemblages of Blue Tit (*Cyanistes caeruleus*) and Great Tit (*Parus major*) nests. *Microbial Ecology* **59**: 221–232.
- Graham A.L., Shuker D.M., Pollitt L.C., Auld S.K.J.R., Wilson A.J., Little T.J., 2011. Fitness consequences of immune responses: strengthening the empirical framework for ecoimmunology. *Functional Ecology* **25**: 5–17.
- Grindstaff J.L., 2008. Maternal antibodies reduce costs of an immune response during development. *Journal of Experimental Biology* **211**: 654–660.
- Grindstaff J.L., Hasselquist D., Nilsson J.A., Sandell M., Smith H.G., Stjernman M., 2006. Transgenerational priming of immunity: maternal exposure to a bacterial antigen enhances offspring humoral immunity. *Proceedings of the Royal Society of London Series B: Biological Sciences* **273**: 2551–2557.
- Gruys E., Toussaint M.J.M., Niewold T.A., Koopmans S.J., 2005. Acute phase reaction and acute phase proteins. *Journal of Zhejiang University SCIENCE B* **6**: 1045–1056.
- Guernier V., Hochberg M.E., Guegan J.E.O., 2004. Ecology drives the worldwide distribution of human diseases. *PLoS Biology* **2**: e141.
- Guerra C.A., Howes R.E., Patil A.P., Gething P.W., Van Boeckel T.P., Temperley W.H., Kabaria C.W., Tatem A.J., Manh B.H., Elyazar I.R.F., Baird J.K., Snow R.W., Hay S.I., 2010. The international limits and population at risk of *Plasmodium vivax* transmission in 2009. *PLoS Neglected Tropical Diseases* **4**: e774.

H

- Haas D., Unteregger M., Habib J., Galler H., Marth E., Reinthaler F., 2010. Exposure to bioaerosol from sewage systems. *Water, Air, and Soil Pollution* **207**: 49–56.
- Hackl E., Zechmeister-Boltenstern S., Bodrossy L., Sessitsch A., 2004. Comparison of diversities and compositions of bacterial populations inhabiting natural forest soils. *Applied and Environmental Microbiology* **70**: 5057–5065.

- Hallquist N.A., Klasing K.C., 1994. Serotransferrin, ovotransferrin and metallothionein levels during an immune response in chickens. *Comparative Biochemistry and Physiology Part B: Comparative Biochemistry* **108**: 375–384.
- Hörak P., Saks L., Ots I., Kollist H., 2002. Repeatability of condition indices in captive Greenfinches (*Carduelis chloris*). *Canadian Journal of Zoology* **80**: 636–643.
- Horrocks N.P.C., Matson K.D., Tieleman B.I., 2011. Pathogen pressure puts immune defense into perspective. *Integrative and Comparative Biology* **51**: 563–576.
- Horrocks N.P.C., Tieleman B.I., Matson K.D., 2011. A simple assay for measurement of ovotransferrin – a marker of inflammation and infection in birds. *Methods in Ecology and Evolution* **2**: 518–526.
- Hulme M., Marsh R., Jones P.D., 1992. Global changes in a humidity index between 1931–60 and 1961–1990. *Climate Research* **2**: 1–22.
- Hurnik G.I., Reinhart B.S., Hurnik J.E., 1978. Relationship between albumen quality and hatchability in fresh and stored hatching eggs. *Poultry Science* **57**: 854–857.
- Huttunen K., Kaarakainen P., Meklin T., Nevalainen A., Hirvonen M-R., 2010. Immunotoxicological properties of airborne particles at landfill, urban and rural sites and their relation to microbial concentrations. *Journal of Environmental Monitoring* **12**: 1368–1374.

I

- Ibrahim H.R., Iwamori E., Sugimoto Y., Aoki T., 1998. Identification of a distinct antibacterial domain within the N-lobe of ovotransferrin. *Biochimica et Biophysica Acta (BBA) - Molecular Cell Research* **1401**: 289–303.
- Ibrahim H.R., Sugimoto Y., Aoki T., 2000. Ovotransferrin antimicrobial peptide (OTAP-92) kills bacteria through a membrane damage mechanism. *Biochimica et Biophysica Acta (BBA)-General Subjects* **1523**: 196–205.
- Ilmonen P., Taarna T., Hasselquist D., 2000. Experimentally activated immune defence in female pied flycatchers results in reduced breeding success. *Proceedings of the Royal Society of London Series B: Biological Sciences* **267**: 665–670.

J

- Jackson J., Friberg I., Bolch L., Lowe A., Ralli C., Harris P., Behnke J., Bradley J., 2009. Immunomodulatory parasites and toll-like receptor-mediated tumour necrosis factor alpha responsiveness in wild mammals. *BMC Biology* **7**: 16.
- Jacquinet P.-M., Leger D., Wieruszkeski J.-M., Coddeville B., Montreuil J., Spik G., 1994. Change in glycosylation of chicken transferrin glycans biosynthesized during embryogenesis and primary culture of embryo hepatocytes. *Glycobiology* **4**: 617–624.
- Janeway C.A., Travers P., Walport M., Shlomchik M.J., 2004. Immunobiology: the immune system in health and disease, 6th ed. New York: Garland Publishing.
- Jex A.R., Schneider M.A., Rose H.A., Cribb T.H., 2007. Local climate aridity influences the distribution of the elasmotomatoid nematodes of the Australian giant burrowing cockroach. *Parasitology* **134**: 1401–1408.
- Jolles A.E., Ezenwa V.O., Etienne R.S., Turner W.C., Olf H., 2008. Interactions between macroparasites and microparasites drive infection patterns in free-ranging African buffalo. *Ecology* **89**: 2239–2250.
- Jones A.M., Harrison R.M., 2004. The effects of meteorological factors on atmospheric bioaerosol concentrations - a review. *Science of the Total Environment* **326**: 151–180.
- Jones K.E., Patel N.G., Levy M.A., Storeygard A., Balk D., Gittleman J.L., Daszak P., 2008. Global trends in emerging infectious diseases. *Nature* **451**: 990–993.

K

- Keesing F., Brunner J., Duerr S., Killilea M., LoGiudice K., Schmidt K., Vuong H., Ostfeld R.S., 2009. Hosts as ecological traps for the vector of Lyme disease. *Proceedings of the Royal Society of London Series B: Biological Sciences* **276**: 3911–3919.
- Klasing K.C., 2004. The costs of immunity. *Acta Zoologica Sinica* **50**: 961–969.

- Klasing K.C., Leshchinsky T.V., 1999. Functions, costs, and benefits of the immune system during development and growth. In: Proceedings of the 22nd International Ornithological Congress (Adams N.J., Slotow R.H., eds). Durban: BirdLife South Africa, Johannesburg; 2817–2832.
- Klomp J.E., Murphy M.T., Smith S.B., McKay J.E., Ferrera I., Reysenbach A.L., 2008. Cloacal microbial communities of female spotted towhees *Pipilo maculatus*: microgeographic variation and individual sources of variability. *Journal of Avian Biology* **39**: 530–538.
- Ko K.Y., Mendoncam A.F., Ismail H., Ahn D.U., 2009. Ethylenediaminetetraacetate and lysozyme improves antimicrobial activities of ovotransferrin against *Escherichia coli* O157: H7. *Poultry Science* **88**: 406–414.
- Korpela J.K., Kulomaa M.S., Elo H.A., Tuohimaa P.J., 1981. Biotin-binding proteins in eggs of oviparous vertebrates. *Experientia* **37**: 1065–1066.
- Kulkarni S., Heeb P., 2007. Social and sexual behaviours aid transmission of bacteria in birds. *Behavioural Processes* **74**: 88–92.

L

- Lambert L.A., Perri H., Halbrooks P.J., Mason A.B., 2005. Evolution of the transferrin family: Conservation of residues associated with iron and anion binding. *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology* **142**: 129–141.
- Lee D.C., McKnight G.S., Palmer R.D., 1980. The chicken transferrin gene. Restriction endonuclease analysis of gene sequences in liver and oviduct DNA. *Journal of Biological Chemistry* **255**: 1442–1450.
- Lee K.A., 2006. Linking immune defenses and life history at the levels of the individual and the species. *Integrative and Comparative Biology* **46**: 1000–1015.
- Lee K.A., Wikelski M., Robinson W.D., Robinson T.R., Klasing K.C., 2008. Constitutive immune defences correlate with life-history variables in tropical birds. *Journal of Animal Ecology* **77**: 356–363.
- Lessells C.M., Boag P.T., 1987. Unrepeatable repeatabilities - a common mistake. *Auk* **104**: 116–121.
- Lindström K., Foufopoulos J., Pärn H., Wikelski M., 2004. Immunological investments reflect parasite abundance in island populations of Darwin's finches. *Proceedings of the Royal Society of London Series B: Biological Sciences* **271**: 1513–1519.
- Little R.M., Earlé R.A., 1995. Sandgrouse (Pterocleididae) and sociable weavers *Philetarius socius* lack avian haematozoa in semi-arid regions of South Africa. *Journal of Arid Environments* **30**: 367–370.
- Lochmiller R.L., Deerenberg C., 2000. Trade-offs in evolutionary immunology: just what is the cost of immunity? *Oikos* **88**: 87–98.
- Lozano G.A., Lank D.B., 2003. Seasonal trade-offs in cell-mediated immunosenescence in Ruffs (*Philomachus pugnax*). *Proceedings of the Royal Society of London Series B: Biological Sciences* **270**: 1203–1208.
- Lucas F.S., Moureau B., Jourdie V., Heeb P., 2005. Brood size modifications affect plumage bacterial assemblages of European starlings. *Molecular Ecology* **14**: 639–646.

M

- Mahdy H.M., El-Sehrawi M.H., 1997. Airborne bacteria in the atmosphere of El-Taif region, Saudi Arabia. *Water, Air, and Soil Pollution* **98**: 317–324.
- Maizels R.M., Yazdanbakhsh M., 2003. Immune regulation by helminth parasites: cellular and molecular mechanisms. *Nature Reviews Immunology* **3**: 733–744.
- Malik S., Beer M., Megharaj M., Naidu R., 2008. The use of molecular techniques to characterize the microbial communities in contaminated soil and water. *Environmental International* **34**: 265–276.
- Martin II L.B., Hasselquist D., Wikelski M., 2006. Investment in immune defense is linked to pace of life in house sparrows. *Oecologia* **147**: 565–575.
- Martin II L.B., Pless M., Svoboda J., Wikelski M., 2004. Immune activity in temperate and tropical house sparrows: a common-garden experiment. *Ecology* **85**: 2323–2331.

- Martin L.B., Weil Z.M., Nelson R.J., 2008. Seasonal changes in vertebrate immune activity: mediation by physiological trade-offs. *Philosophical Transactions of the Royal Society London Series B: Biological Sciences* **363**: 321–339.
- Matson K., Cohen A., Klasing K., Ricklefs R., Scheuerlein A., 2006. No simple answers for ecological immunology: relationships among immune indices at the individual level break down at the species level in waterfowl. *Proceedings of the Royal Society of London Series B: Biological Sciences* **273**: 815–822.
- Matson K.D., 2006. Are there differences in immune function between continental and insular birds? *Proceedings of the Royal Society of London Series B: Biological Sciences* **273**: 2267–2274.
- Matson K.D., Ricklefs R.E., Klasing K.C., 2005. A hemolysis-hemagglutination assay for characterizing constitutive innate humoral immunity in wild and domestic birds. *Developmental and Comparative Immunology* **29**: 275–286.
- Matson K.D., Tieleman B.I., Klasing K.C., 2006. Capture stress and the bactericidal competence of blood and plasma in five species of tropical birds. *Physiological and Biochemical Zoology* **79**: 556–564.
- Matsuura K., Tamura T., Kobayashi N., Yashiro T., Tatsumi S., 2007. The antibacterial protein lysozyme identified as the termite egg recognition pheromone. *PLoS ONE* **2**: e813.
- Mazmanian S.K., Liu C.H., Tzianabos A.O., Kasper D.L., 2005. An immunomodulatory molecule of symbiotic bacteria directs maturation of the host immune system. *Cell* **122**: 107–118.
- Mendes L., Piersma T., Hasselquist D., Matson K.D., Ricklefs R.E., 2006. Variation in the innate and acquired arms of the immune system among five shorebird species. *Journal of Experimental Biology* **209**: 284–291.
- Mendes L., Piersma T., Lecoq M., Spaans B.E., Ricklefs R., 2005. Disease-limited distributions? Contrasts in the prevalence of avian malaria in shorebird species using marine and freshwater habitats. *Oikos* **109**: 396–404.
- Messens W., Grijspeerd K., Herman L., 2005. Eggshell penetration by Salmonella: a review. *World's Poultry Science Journal* **61**: 71–86.
- Millet S., Bennett J., Lee K.A., Hau M., Klasing K.C., 2007. Quantifying and comparing constitutive immunity across avian species. *Developmental and Comparative Immunology* **31**: 188–201.
- Mitchell T.D., Jones P.D., 2005. An improved method of constructing a database of monthly climate observations and associated high-resolution grids. *International Journal of Climatology* **25**: 693–712.
- Møller A.P., 1998. Evidence of larger impact of parasites on hosts in the tropics: investment in immune function within and outside the tropics. *Oikos* **82**: 265–270.
- Møller A.P., Erritzoe J., 1998. Host immune defence and migration in birds. *Evolutionary Ecology* **12**: 945–953.
- Moyer B.R., Drown D.M., Clayton D.H., 2002. Low humidity reduces ectoparasite pressure: implications for host life history evolution. *Oikos* **97**: 223–228.
- Muscattello G., Gilkerson J.R., Browning G.F., 2009. Detection of virulent *Rhodococcus equi* in exhaled air samples from naturally infected foals. *Journal of Clinical Microbiology* **47**: 734–737.

N

- Nelson R.J., Demas G.E., 1996. Seasonal changes in immune function. *Quarterly Review of Biology* **71**: 511–548.
- Nelson R.J., Demas G.E., Klein S.L., Kriegsfeld L.J., 2002. Seasonal patterns of stress, immune function, and disease. Cambridge: Cambridge University Press.
- Norris K., Evans M.R., 2000. Ecological immunology: life history trade-offs and immune defense in birds. *Behavioral Ecology* **11**: 19–26.
- Nunn C.L., 2002. A comparative study of leukocyte counts and disease risk in primates. *Evolution* **56**: 177–190.

- Nunn C.L., Altizer S.M., Sechrest W., Cunningham A.A., 2005. Latitudinal gradients of parasite species richness in primates. *Diversity and Distributions* **11**: 249–256.
- Nunn C.L., Gittleman J.L., Antonovics J., 2003. A comparative study of white blood cell counts and disease risk in carnivores. *Proceedings of the Royal Society of London Series B: Biological Sciences* **270**: 347–356.

O

- Ochsenbein A.F., Zinkernagel R.M., 2000. Natural antibodies and complement link innate and acquired immunity. *Immunology Today* **21**: 624–630.
- Osserman E.F., Lawlor D.P., 1966. Serum and urinary lysozyme (muramidase) in monocytic and monomyelocytic leukemia. *Journal of Experimental Medicine* **124**: 921–952.

P

- Parmentier H.K., Lammers A., Hoekman J.J., Reilingh G.D.V., Zaanen I.T.A., Savelkoul H.F.J., 2004. Different levels of natural antibodies in chickens divergently selected for specific antibody responses. *Developmental and Comparative Immunology* **28**: 39–49.
- Pedersen A.B., Babayan S.A., 2011. Wild immunology. *Molecular Ecology* **20**: 872–880.
- Piersma T., 1997. Do global patterns of habitat use and migration strategies co-evolve with relative investments in immunocompetence due to spatial variation in parasite pressure? *Oikos* **80**: 623–631.
- Poiani A., 1992. Ectoparasitism as a possible cost of social life: a comparative analysis using Australian passerines (Passeriformes). *Oecologia* **92**: 429–441.
- Promislow D.E.L., Harvey P.H., 1990. Living fast and dying young: A comparative analysis of life-history variation among mammals. *Journal of Zoology* **220**: 417–437.

Q

- Quaye I.K., 2008. Haptoglobin, inflammation and disease. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **102**: 735–742.

R

- R Development Core Team, 2009. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.
- Råberg L., Graham A.L., Read A.F., 2009. Decomposing health: tolerance and resistance to parasites in animals. *Philosophical Transactions of the Royal Society London Series B: Biological Sciences* **364**: 37–49.
- Råberg L., Grahn M., Hasselquist D., Svensson E., 1998. On the adaptive significance of stress-induced immunosuppression. *Proceedings of the Royal Society of London Series B: Biological Sciences* **265**: 1637–1641.
- Rakoff-Nahoum S., Paglino J., Eslami-Varzaneh F., Edberg S., Medzhitov R., 2004. Recognition of commensal microflora by Toll-like receptors is required for intestinal homeostasis. *Cell* **118**: 229–241.
- Rappé M.S., Giovannoni S.J., 2003. The uncultured microbial majority. *Annual Review of Microbiology* **57**: 369–394.
- Rath N.C., Anthony N.B., Kannan L., Huff W.E., Huff G.R., Chapman H.D., Erf G.F., Wakenell P., 2009. Serum ovotransferrin as a biomarker of inflammatory diseases in chickens. *Poultry Science* **88**: 2069–2074.
- Reijrink I.A.M., Meijerhof R., Kemp B., Van Den Brand H., 2008. The chicken embryo and its micro environment during egg storage and early incubation. *World's Poultry Science Journal* **64**: 581–598.
- Reneerkens J., Versteegh M.A., Schneider A.M., Piersma T., Burt E.H., 2008. Seasonally changing preen-wax composition: Red knots' (*Calidris Canutus*) flexible defense against feather-degrading bacteria. *Auk* **125**: 285–290.
- Ricklefs R.E., 1990. Seabird life histories and the marine-environment: some speculations. *Colonial Waterbirds* **13**: 1–6.

- Ricklefs R.E., 2000. Density dependence, evolutionary optimization, and the diversification of avian life histories. *The Condor* **102**: 9–22.
- Ricklefs R.E., Wikelski M., 2002. The physiology/life-history nexus. *Trends in Ecology and Evolution* **17**: 462–468.
- Ritchie R.F., Palomaki G.E., Neveux L.M., Navolotskaia O., Ledue T.B., Craig W.Y., 1999. Reference distributions for the negative acute-phase serum proteins, albumin, transferrin and transthyretin: A practical, simple and clinically relevant approach in a large cohort. *Journal of Clinical Laboratory Analysis* **13**: 273–279.
- Roff D.A., 1992. The evolution of life histories: theory and analysis. New York: Chapman & Hall.
- Rohde K., Heap M., 1998. Latitudinal differences in species and community richness and in community structure of metazoan endo- and ectoparasites of marine teleost fish. *International Journal for Parasitology* **28**: 461–474.
- Romanoff A.L., 1944. Hydrogen-ion concentration of albumen and yolk of the developing avian egg. *Biological Bulletin* **87**: 223–226.
- Rook G.A.W., 2009. Review series on helminths, immune modulation and the hygiene hypothesis: The broader implications of the hygiene hypothesis. *Immunology* **126**: 3–11.
- Rosebury T., 1962. Microorganisms Indigenous to Man. New York: McGraw-Hill.
- Rosenberg E., Ben-Haim Y., 2002. Microbial diseases of corals and global warming. *Environmental Microbiology* **4**: 318–326.
- Round J.L., Mazmanian S.K., 2009. The gut microbiota shapes intestinal immune responses during health and disease. *Nature Reviews Immunology* **9**: 313–323.
- Ruiz-de-Castañeda R., Vela A.I., Lobato E., Briones V., Moreno J., 2011a. Bacterial loads on eggshells of the Pied Flycatcher: Environmental and maternal factors. *The Condor* **113**: 200–208.
- Ruiz-de-Castañeda R., Vela A.I., Lobato E., Briones V., Moreno J., 2011b. Prevalence of potentially pathogenic culturable bacteria on eggshells and in cloacae of female Pied Flycatchers in a temperate habitat in central Spain. *Journal of Field Ornithology* **82**: 215–224.
- Ruiz-Rodríguez M., Soler J.J., Lucas F.S., Heeb P., Palacios M.J., Martín-Gálvez D., de Neve L., Pérez-Contreras T., Martínez J.G., Soler M., 2009. Bacterial diversity at the cloaca relates to an immune response in magpie *Pica pica* and to body condition of great spotted cuckoo *Clamator glandarius* nestlings. *Journal of Avian Biology* **40**: 42–48.

S

- Sadd B.M., Schmid-Hempel P., 2009. Principles of ecological immunology. *Evolutionary Applications* **2**: 113–121.
- Saether B-E., 1988. Pattern of covariation between life-history traits of European birds. *Nature* **331**: 616–617.
- Saino N., Dall'ara P., Martinelli R., Møller A.P., 2002. Early maternal effects and antibacterial immune factors in the eggs, nestlings and adults of the barn swallow. *Journal of Evolutionary Biology* **15**: 735–743.
- Saino N., Romano M., Ambrosini R., Ferrari R.P., Møller A.P., 2004. Timing of reproduction and egg quality covary with temperature in the insectivorous Barn Swallow, *Hirundo rustica*. *Functional Ecology* **18**: 50–57.
- Salkeld D.J., Trivedi M., Schwarzkopf L., 2008. Parasite loads are higher in the tropics: temperate to tropical variation in a single host-parasite system. *Ecography* **31**: 538–544.
- Salton M.R.J., 1957. The properties of lysozyme and its action on microorganisms. *Bacteriological Reviews* **21**: 82–100.
- Schmid-Hempel P., 2003. Variation in immune defence as a question of evolutionary ecology. *Proceedings of the Royal Society of London Series B: Biological Sciences* **270**: 357–366.
- Schmid-Hempel P., Ebert D., 2003. On the evolutionary ecology of specific immune defence. *Trends in Ecology and Evolution* **18**: 27–32.
- Schulenburg H., Kurtz J., Moret Y., Siva-Jothy M.T., 2009. Introduction. Ecological immunology. *Philosophical Transactions of the Royal Society London Series B: Biological Sciences* **364**: 3–14.

- Semple S., Cowlshaw G., Bennett P.M., 2002. Immune system evolution among anthropoid primates: parasites, injuries and predators. *Proceedings of the Royal Society of London Series B: Biological Sciences* **269**: 1031–1037.
- Sharp P.F., Powell C.K., 1931. Increase in the pH of the white and yolk of hens' eggs. *Industrial and Engineering Chemistry* **23**: 196–199.
- Shawkey M.D., Firestone M.K., Brodie E.L., Beissinger S.R., 2009. Avian incubation inhibits growth and diversification of bacterial assemblages on eggs. *PLoS ONE* **4**: e4522.
- Shawkey M.D., Kosciuch K.L., Liu M., Rohwer F.C., Loos E.R., Wang J.M., Beissinger S.R., 2008. Do birds differentially distribute antimicrobial proteins within clutches of eggs? *Behavioral Ecology* **19**: 920–927.
- Shawkey M.D., Mills K.L., Dale C., Hill G.E., 2005. Microbial diversity of wild bird feathers revealed through culture-based and culture-independent techniques. *Microbial Ecology* **50**: 40–47.
- Shawkey M.D., Pillai S.R., Hill G.E., 2003. Chemical warfare? Effects of uropygial oil on feather-degrading bacteria. *Journal of Avian Biology* **34**: 345–349.
- Sheldon B.C., 1993. Sexually transmitted disease in birds: Occurrence and evolutionary significance. *Philosophical Transactions of the Royal Society London Series B: Biological Sciences* **339**: 491–497.
- Sheldon B.C., Verhulst S., 1996. Ecological immunology: costly parasite defences and trade-offs in evolutionary ecology. *Trends in Ecology and Evolution* **11**: 317–321.
- Singleton D.R., Harper R.G., 1998. Bacteria in old House Wren nests. *Journal of Field Ornithology* **69**: 71–74.
- Skaar E.P., 2010. The battle for iron between bacterial pathogens and their vertebrate hosts. *PLoS Pathogens* **6**: e1000949.
- Snaith T.V., Chapman C.A., Rothman J.M., Wasserman M.D., 2008. Bigger groups have fewer parasites and similar cortisol levels: a multi-group analysis in red colobus monkeys. *American Journal of Primatology* **70**: 1072–1080.
- Sokal R.R., Rohlf F.J., 1995. *Biometry: The principles and practice of statistics in biological research*, 3rd ed. New York: W.H. Freeman and Co.
- Soler J.J., de Neve L., Pérez-Contreras T., Soler M., Sorci G., 2003. Trade-off between immunocompetence and growth in magpies: an experimental study. *Proceedings of the Royal Society of London Series B: Biological Sciences* **270**: 241–248.
- Sparkman A.M., Palacios M.G., 2009. A test of life-history theories of immune defence in two ecotypes of the garter snake, *Thamnophis elegans*. *Journal of Animal Ecology* **78**: 1242–1248.
- Spottiswoode C., 2008. Cooperative breeding and immunity: a comparative study of PHA response in African birds. *Behavioral Ecology and Sociobiology* **62**: 963–974.
- Stearns S.C., 1992. *The evolution of life histories*. Oxford: Oxford University Press.
- Stecher B., Chaffron S., Käppli R., Hapfelmeier S., Friedrich S., Weber T.C., Kirundi J., Suar M., McCoy K.D., von Mering C., Macpherson A.J., Hardt W-D., 2010. Like will to like: Abundances of closely related species can predict susceptibility to intestinal colonization by pathogenic and commensal bacteria. *PLoS Pathogens* **6**: e1000711.
- Stecher B., Hardt W-D., 2008. The role of microbiota in infectious disease. *Trends in Microbiology* **16**: 107–114.
- Stow A., Briscoe D., Gillings M., Holley M., Smith S., Leys R., Silberbauer T., Turnbull C., Beattie A., 2007. Antimicrobial defences increase with sociality in bees. *Biology Letters* **3**: 422–424.
- Superti F., Ammendolia M.G., Berlutti E., Valenti P., 2007. Ovotransferrin. In: *Bioactive Egg Compounds* (Huopalahti R., López-Fandiño R., Anton M., Schade R., eds). Berlin & Heidelberg: Springer-Verlag 43–50.

T

- Talley S., Coley P., Kursar T., 2002. The effects of weather on fungal abundance and richness among 25 communities in the Intermountain West. *BMC Ecology* **2**: 7.

- Tang J.W., 2009. The effect of environmental parameters on the survival of airborne infectious agents. *Journal of The Royal Society Interface* **6**: S737–S746.
- Tella J.L., Scheuerlein A., Ricklefs R.E., 2002. Is cell-mediated immunity related to the evolution of life-history strategies in birds? *Proceedings of the Royal Society of London Series B: Biological Sciences* **269**: 1059–1066.
- Thibodeau S.N., Lee D.C., Palmiter R.D., 1978. Identical precursors for serum transferrin and egg white conalbumin. *Journal of Biological Chemistry* **253**: 3771–3774.
- Tieleman B.I., 2005. Physiological, behavioral and life history adaptations of larks along an aridity gradient: a review. In: *Ecology and Conservation of Steppe-Land Birds* (Bota G., Camprodon J., Manosa S., Morales M., eds). Barcelona: Lynx Edicions; 49–67.
- Tieleman B.I., van Noordwijk H.J., Williams J.B., 2008. Nest site selection in a hot desert: Trade-off between microclimate and predation risk? *Condor* **110**: 116–124.
- Tieleman B.I., Williams J.B., 2002. Effects of food supplementation on behavioural decisions of hoopoe-larks in the Arabian Desert: balancing water, energy and thermoregulation. *Animal Behaviour* **63**: 519–529.
- Tieleman B.I., Williams J.B., Bloomer P., 2003. Adaptation of metabolism and evaporative water loss along an aridity gradient. *Proceedings of the Royal Society of London Series B: Biological Sciences* **270**: 207–214.
- Tieleman B.I., Williams J.B., Buschur M.E., Brown C.R., 2003. Phenotypic variation of larks along an aridity gradient: Are desert birds more flexible? *Ecology* **84**: 1800–1815.
- Tieleman B.I., Williams J.B., Ricklefs R.E., Klasing K.C., 2005. Constitutive innate immunity is a component of the pace-of-life syndrome in tropical birds. *Proceedings of the Royal Society of London Series B: Biological Sciences* **272**: 1715–1720.
- Tieleman B.I., Williams J.B., Visser G.H., 2003. Variation in allocation of time, water and energy in Hoopoe Larks from the Arabian Desert. *Functional Ecology* **17**: 869–876.
- Tieleman B.I., Williams J.B., Visser G.H., 2004. Energy and water budgets of larks in a life history perspective: parental effort varies with aridity. *Ecology* **85**: 1399–1410.
- Tohjo H., Miyoshi F., Uchida E., Niiyama M., Syuto B., Moritsu Y., Ichikawa S., Takeuchi M., 1995. Polyacrylamide-gel electrophoretic patterns of chicken serum in acute-inflammation induced by intramuscular injection of turpentine. *Poultry Science* **74**: 648–655.
- Tong Y., Lighthart B., 1997. Solar radiation has a lethal effect on natural populations of culturable outdoor atmospheric bacteria. *Atmospheric Environment* **31**: 897–900.
- Tong Y., Lighthart B., 1999. Diurnal distribution of total and culturable atmospheric bacteria at a rural site. *Aerosol Science and Technology* **30**: 246–254.
- Torchin M.E., Lafferty K.D., Dobson A.P., McKenzie V.J., Kuris A.M., 2003. Introduced species and their missing parasites. *Nature* **421**: 628–630.
- Tortorella D., Gewurz B.E., Furman M.H., Schust D.J., Ploegh H.L., 2000. Viral subversion of the immune system. *Annual Review of Immunology* **18**: 861–926.
- Tranter H.S., Board R.G., 1984. The influence of incubation temperature and pH on the antimicrobial properties of hen egg albumen. *Journal of Applied Microbiology* **56**: 53–61.
- Traversa D., Otranto D., 2009. Biotechnological advances in the diagnosis of little-known parasitoses of pets. *Parasitology Research* **104**: 209–216.
- Treusch A.H., Kletzin A., Raddatz G., Ochsenreiter T., Quaiser A., Meurer G., Schuster S.C., Schleper C., 2004. Characterization of large-insert DNA libraries from soil for environmental genomic studies of Archaea. *Environmental Microbiology* **6**: 970–980.
- Trziska T., Clostermann G., 1993. Measuring the lysozyme-activity as method for estimating the egg quality. *Archiv Fur Geflügelkunde* **57**: 22–26.
- Tschirren B., Richner H., 2006. Parasites shape the optimal investment in immunity. *Proceedings of the Royal Society of London Series B: Biological Sciences* **273**: 1773–1777.

U

- UNEP, 1992. World Atlas of Desertification. London: Edward Arnold.

V

- Valenti P, Antonini G., von Hunolstein C., Visca P, Orsi N., Antonini E., 1983. Studies on the anti-microbial activity of ovotransferrin. *International Journal of Tissue Reactions-Experimental and Clinical Aspects* **5**: 97–105.
- Valenti P, Visca P, Antonini G., Orsi N., 1985. Antifungal activity of ovotransferrin towards genus *Candida*. *Mycopathologia* **89**: 169–175.
- Valera F, Carrillo C.M., Barbosa A., Moreno E., 2003. Low prevalence of haematzoa in Trumpeter finches *Bucanetes githagineus* from south-eastern Spain: additional support for a restricted distribution of blood parasites in arid lands. *Journal of Arid Environments* **55**: 209–213.
- van de Crommenacker J, Horrocks N.P.C., Versteegh M.A., Komdeur J., Tieleman B.I., Matson K.D., 2010. Effects of immune supplementation and immune challenge on oxidative status and physiology in a model bird: implications for ecologists. *Journal of Experimental Biology* **213**: 3527–3535.
- van de Pol M., Wright J., 2009. A simple method for distinguishing within- versus between-subject effects using mixed models. *Animal Behaviour* **77**: 753–758.
- Van Riper III C., Van Riper S.G., Goff M.L., Laird M., 1986. The epizootiology and ecological significance of malaria in Hawaiian land birds. *Ecological Monographs* **56**: 327–344.
- Versteegh M.A., Helm B., Dingemans N.J., Tieleman B.I., 2008. Repeatability and individual correlates of basal metabolic rate and total evaporative water loss in birds: A case study in European stonechats. *Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology* **150**: 452–457.
- Viney M.E., Riley E.M., Buchanan K.L., 2005. Optimal immune responses: immunocompetence revisited. *Trends in Ecology and Evolution* **20**: 665–669.

W

- Walsberg G.E., King J.R., 1978. The relationship of the external surface area of birds to skin surface area and body mass. *Journal of Experimental Biology* **76**: 185–189.
- Walther B.A., Cotgreave P, Price R.D., Gregory R.D., Clayton D.H., 1995. Sampling effort and parasite species richness. *Parasitology Today* **11**: 306–310.
- Wang J.M., Firestone M.K., Beissinger S.R., 2011. Microbial and environmental effects on avian egg viability: Do tropical mechanisms act in a temperate environment? *Ecology* **92**: 1137–1145.
- Webb D.R., 1987. Thermal tolerance of avian embryos - a review. *The Condor* **89**: 874–898.
- Wellman-Labadie O., Picman J., Hincke M.T., 2007. Avian antimicrobial proteins: structure, distribution and activity. *World's Poultry Science Journal* **63**: 421–438.
- Wellman-Labadie O., Picman J., Hincke M.T., 2008. Enhanced C-type lysozyme content of Wood Duck (*Aix sponsa*) egg white: An adaptation to cavity nesting? *Physiological and Biochemical Zoology* **81**: 235–245.
- West J.S., Atkins S.D., Emberlin J., Fitt B.D.L., 2008. PCR to predict risk of airborne disease. *Trends in Microbiology* **16**: 380–387.
- Whyte P, Mc Gill K., Collins J.D., Gormley E., 2002. The prevalence and PCR detection of *Salmonella* contamination in raw poultry. *Veterinary Microbiology* **89**: 53–60.
- Wiersma P, Muñoz-García A., Walker A., Williams J.B., 2007. Tropical birds have a slow pace of life. *Proceedings of the National Academy of Sciences, USA* **104**: 9340–9345.
- Wilcox F.H., Daniel L.J., 1954. Reduced lysis at high concentrations of lysozyme. *Archives of Biochemistry and Biophysics* **52**: 305–312.
- Williams J.B., Tieleman B.I., Shobrak M., 1999. Lizard burrows provide thermal refugia for larks in the Arabian Desert. *The Condor* **101**: 714–717.
- Wilson K., Knell R., Boots M., Koch-Osborne J., 2003. Group living and investment in immune defence: an interspecific analysis. *Journal of Animal Ecology* **72**: 133–143.

X

- Xie H., Huff G.R., Huff W.E., Balog J.M., Holt P., Rath N.C., 2002a. Identification of ovotransferrin as an acute phase protein in chickens. *Poultry Science* **81**: 112–120.
- Xie H., Huff G.R., Huff W.E., Balog J.M., Rath N.C., 2002b. Effects of ovotransferrin on chicken macrophages and heterophil-granulocytes. *Developmental and Comparative Immunology* **26**: 805–815.
- Xie H., Newberry L., Clark F.D., Huff W.E., Huff G.R., Balog J.M., Rath N.C., 2009. Changes in serum ovotransferrin levels in chickens with experimentally induced inflammation and diseases. *Avian Diseases* **46**: 122–131.

Y

- Yamanishi H., Iyama S., Yamaguchi Y., Kanakura Y., Iwatani Y., 2002. Modification of fully automated total iron-binding capacity (TIBC) assay in serum and comparison with dimension TIBC method. *Clinical Chemistry* **48**: 1565–1570.
- Yousif A.N., Albright L.J., Evelyn T.P.T., 1994. In-vitro evidence for the antibacterial role of lysozyme in salmonid eggs. *Diseases of Aquatic Organisms* **19**: 15–19.

Z

- Zuk M., Johnsen T.S., 1998. Seasonal changes in the relationship between ornamentation and immune response in red jungle fowl. *Proceedings of the Royal Society of London Series B: Biological Sciences* **265**: 1631–1635.