AVIATOR'S LOFT PRESENTS

SCIENTIFIC GUIDE
TO THE RACING PIGEON

Pathology · Pharmacology · Genomics 2024 · Physiology · Selection

8 Performance Genes · Updated Scientific Data 2024 · 83 pages

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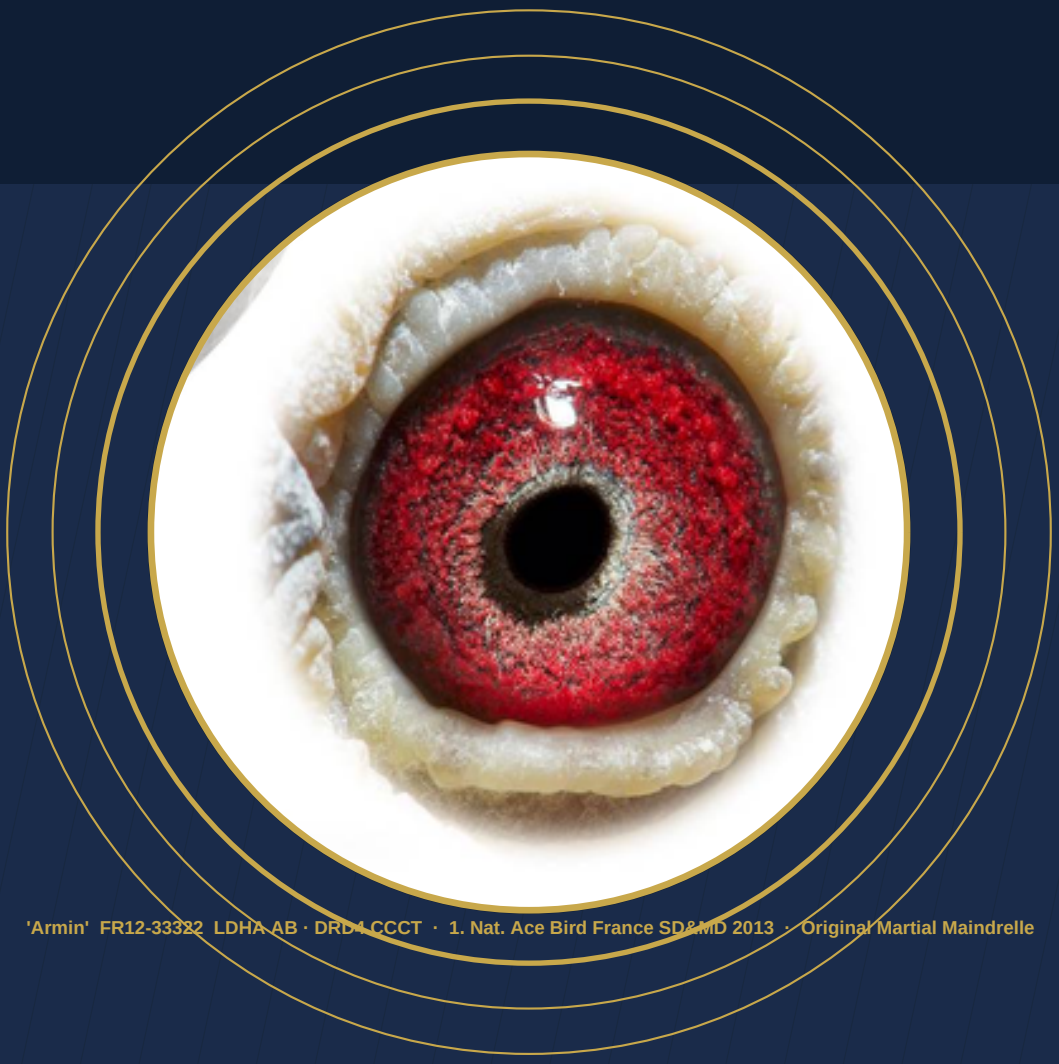

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Preface

This guide is the most complete scientific synthesis ever published on the pathology, genomics and management of the competition racing pigeon. It integrates the genomic discoveries of 2022–2024 (8 performance genes including the newly validated CRY1, LRP8, GSR and CASK), the 2024 veterinary protocols, and the expert veterinary data from Martial Maindrelle's Aviator's Loft blog.

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PART I

HEALTH & VETERINARY PATHOLOGY

Chapter 1

Virology of the Racing Pigeon — Major Viral Diseases

The virology of racing pigeons has advanced considerably thanks to high-throughput sequencing. The molecular characterisation of strains and the updating of vaccination protocols represent major breakthroughs of the 2014–2024 decade.

1.1 Paramyxovirosis — APMV-1

Paramyxovirosis is caused by **Avulavirus type 1 (APMV-1)**, a negative-sense single-stranded enveloped RNA virus belonging to the Paramyxoviridae family. It possesses two surface glycoproteins: haemagglutinin-neuraminidase (HN) and fusion protein (F). Pigeon strains belong to **genotypes VI.a and VI.b** (Aldous 2014), distinct from industrial strains (VII, XVII — classical Newcastle Disease). This genetic specificity justifies the use of vaccines specifically formulated for pigeon strains.

Epidemiology and transmission

Enzootic in all European racing pigeon populations since 1981–1984. Seroprevalence reaches 80–100 % in unvaccinated lofts. Transmission is both direct (contact, droppings, secretions — contagious from D-2 before clinical signs) and indirect (water, equipment, aerosols — survives 21 days in dry droppings at 4 °C). Reservoirs: wood pigeons, turtle doves, starlings and gulls.

Pathophysiology and clinical signs

After initial replication in the respiratory and digestive epithelium (D0–4), secondary viraemia leads to dissemination to target organs: central nervous system (torticollis, tremors, circling, convulsions — irreversible in 60–80 % of cases), kidneys (interstitial nephritis — polyuria, very watery greenish-yellow droppings — present in 80–100 % of cases), and digestive tract (anorexia, weight loss). Mortality 0–80 % depending on vaccination status. Incubation: 5–14 days.

Table 1.1 — Differential neurological diagnosis

Clinical sign	PMV-1	Paratyphosis	Lead poisoning
Torticollis	Frequent (60–80 %)	Rare (<5 %)	Frequent (if severe)
Polyuria / watery droppings	Major (80–100 %)	Variable	No
Arthritis / lameness	No	Very frequent (60 %)	No
Infertility	Possible	Yes (genital form)	No
Prognosis without vaccination	Poor (0–80 % mortality)	Good if treated	Variable

European regulation 2024

Regulation (EU) **2016/429** (Animal Health Law) — Category B disease (mandatory notification). Implementing Regulation **(EU) 2021/620** — mandatory vaccination of racing pigeons participating in competitions (Art. 12), annual veterinary certificate, restriction zones (10 km radius) if confirmed outbreak, mandatory RFID traceability. **France**: Order of 18 January 2023 — annual veterinary certificate, adjuvanted inactivated vaccine, two primary vaccinations.

PMV-1 VACCINATION PROTOCOL — 2024 Recommendations

Vaccine: Inactivated mineral oil (e.g. Colombovac PMV®, Layomune PMV®, Avac®)

Primary vaccination: 2 SC or IM injections, 4 weeks apart — from 4 weeks of age

Booster: Annual MANDATORY — ideal timing: January–February (before the season)

Immunity onset: 1 month post-vaccination → do not train before

Efficacy: >95 % when protocol is followed — Duration: ≥12 months

Warning: Immunosuppressed pigeon (PiCV) → reduced vaccine response → treat first

Scientific references

- Dortmans JM et al. (2011). PMV-1 outbreaks in chickens. Vet Microbiol 148:337-46.
- Aldous EW et al. (2014). Serological discrimination of pigeon PMV-1. Avian Pathol 43:20-6.
- Regulation (EU) 2016/429 | Implementing Regulation (EU) 2021/620.
- ANSES (2023). Epidemiological review of bird diseases 2023. Maison-Alfort.

1.2 Adenovirosis (PAdV-1) and Viral Co-infections

Adenovirosis is caused by Pigeon Adenovirus 1 (PAdV-1), a non-enveloped double-stranded DNA virus (Adenoviridae), highly resistant in the environment (survives for weeks at ambient temperature). It mainly affects young birds aged 3–8 weeks: repeated vomiting (crop regurgitation), watery green diarrhoea, rapid prostration. Post-mortem: multifocal necrotising hepatitis + haemorrhagic enteritis of the small intestine. Mortality 5–15 % in single infection.

Triple infection PiCV + PAdV-1 + HVP-1 (Raue 2005): Circovirus immunosuppresses the bursa of Fabricius → ineffective vaccination → massive invasion by adenovirus and herpesvirus. Mortality can exceed 30–50 %. Treatment is purely symptomatic: oral rehydration (Ringer lactate), multi-strain avian probiotics, B-complex and K vitamins, easily digestible diet for 10–14 days.

Table 1.2 — Viral co-infections and prognosis

Pathology	Agents	Mortality	Treatment	Prevention
Adenovirosis alone	PAdV-1	5–15 %	Symptomatic	Hygiene + quarantine
Adeno + Circovirus	PAdV-1 + PiCV	15–30 %	Symptomatic	Strict hygiene + biosecurity
Triple infection	PAdV + PiCV + HVP-1	30–50 %+	Emergency — intensive care	Mandatory quarantine
Circovirus alone	PiCV	<5 %	Stress prevention	PCR screening

Scientific references

- Schachner A et al. (2018). Pigeon adenovirus 1 — review. Avian Pathol 47:111-118.
- Raue R et al. (2005). Simultaneous infections in pigeon colony. J Vet Med B 52:253-259.

1.3 Pigeon Circovirus (PiCV) — The Underestimated Immunosuppressor

Circular single-stranded DNA (~2000 nt), Circoviridae family. Destroys B-lymphoid cells in the **bursa of Fabricius** → profound humoral immunosuppression (compromised antibody production). Prevalence 30–80 % in European lofts according to PCR studies. High genetic diversity of strains (Duchatel 2005). Faeco-oral and vertical (egg) transmission. No commercial vaccine available.

Diagnosis: qPCR (gold standard) on droppings or bursa of Fabricius. Histology: basophilic intranuclear inclusions in lymphoid cells (pathognomonic sign). Viral load >10■ copies/mg → severe immunosuppression.

■ ■ Practical consequences of PiCV

- Potentially ineffective vaccinations in infected pigeons
- Increased susceptibility to opportunistic infections (E. coli, Chlamydia, Aspergillus)
- Recurrent unexplained drops in form despite good management
- Strategy: annual PCR screening, strict quarantine, minimal stress
- Immune support: vitamins A, E, selenium, zinc — before vaccination

1.4 Pigeon Pox (Avipoxvirus)

Table 1.3 — Clinical forms of pigeon pox

Form	Location	Lesions	Frequency	Prognosis
Cutaneous	Unfeathered skin: eyes, beak, legs, cloaca	Epithelial nodules → brown crusts 3–15 mm	60–75 %	Favourable
Diphtheritic	Mucous membranes: mouth, larynx, trachea	Yellow-white pseudomembranes. Asphyxia if laryngeal	20–40 %	Guarded
Mixed	Cutaneous + diphtheritic	Combination of both forms	10–20 %	Guarded

Prevention: Live attenuated vaccine (wing-web scarification). Immunity from D+14, duration ≥2 years. Recommended before the vector season (April–June) and in endemic areas. **Symptomatic treatment:** local disinfection, doxycycline 50 mg/kg/day × 10 days (prevention of bacterial superinfections), gentle debridement of diphtheritic lesions.

1.5 Emerging Viruses — Rotavirus, Reovirus, Metagenomics

Viruses previously poorly documented in colombiculture are attracting growing interest. Rotaviruses cause acute gastroenteritis in young pigeons, often associated with adenovirosis. Avian reoviruses can cause tenosynovitis and enteritis. Metagenomic viral studies (next-generation NGS sequencing) carried out on European racing pigeon populations have identified several emerging viruses: astrovirus, bocaparvovirus, avian coronaviruses — whose precise pathogenic role remains to be defined. These discoveries remind us that the virome of the racing pigeon is still largely unknown, and that certain unexplained drops in form may have an as-yet uncharacterised viral origin.

Metagenomics — Benefits for colombiculture

Viral metagenomics (NGS) makes it possible to detect ALL viruses present in a sample, even unknown ones. Practical applications:

- Identify the causative agent of an unexplained disease in a batch
- Monitor the emergence of new pathogenic viruses
- Understand complex viral co-infections

Cost still high (€200–500 per sample) but falling rapidly.

1.6 Avian Influenza (HPAI) — Impact on Colombiculture 2020–2024

Table 1.4 — HPAI epizootics and impact on European colombiculture

Season	Strain	EU countries	Impact on colombiculture
2020–2021	H5N8 clade 2.3.4.4b	NL, BE, DE, FR, PL…	Regional lockdowns, partial cancellations
2021–2022	H5N1 clade 2.3.4.4b	39 EU countries (record)	Major restrictions, highly disrupted season
2022–2023	H5N1 clade 2.3.4.4b	France — record	Prolonged national lockdown → season cancelled
2023–2024	H5N1 multi-clades	Partial moderation	Progressive easing, almost normal season

Scientific references

- EFSA (2024). Avian influenza overview Dec.2023–Mar.2024. EFSA Journal 22:8754.
- DGAL (2023). Technical instruction on HPAI measures in France. DGAL/SDSPA service note.
- OIE WAHIS (2024). Avian Influenza situation reports. World Animal Health Information System.

Chapter 2

Bacteriology, Parasitology and Mycology

Bacterial and parasitic diseases constitute the majority of daily clinical conditions in racing pigeon management. The drug resistances documented since 2020 require a revision of therapeutic approaches.

2.1 Trichomoniasis (Trichomonas gallinae) — Pathology No. 1

Strict anaerobic flagellated protozoan, Parabasalia. Trophozoite 15–19 µm: 4 anterior flagella, recurrent flagellum (undulating membrane), rigid axostyle. **No cystic stage** → survival outside the host <1 hour. Transmission is exclusively direct (beak-to-beak, drinking water, crop milk). Prevalence 40–90 % in European lofts (PCR). High variability in pathogenicity according to genotypes (A > B > D — Foronda 2022).

Clinical forms: Pharyngeal form (70 %): yellowish caseous lesions in the throat/larynx ("yellow button"), risk of asphyxia in young birds — therapeutic emergency if laryngeal obstruction. Umbilical form (15 %): infection of the navel at hatching. Visceral form (10 %): liver, lungs, spleen — nodular necrotic lesions. Cutaneous form (5 %): lesions on the skull, rare but severe.

Resistance to treatments — Critical emerging problem 2020–2024

Emergence of resistance to 5-nitroimidazoles has been documented in the European veterinary literature since 2015. **Mechanisms:** reduction of anaerobic activation of the prodrug (PFOR — pyruvate-ferredoxin oxidoreductase), overexpression of efflux pumps. A preliminary Spanish study (biorxiv, January 2026) reports **81 % metronidazole resistance** across 42 isolates from 11 lofts (MICs from 5 to >100 µg/mL). Systematic preventive treatments are the main factor selecting resistant strains.

Table 2.1 — Resistance to 5-nitroimidazoles (Europe 2024)

Drug	Dose	Duration	EU Resistance	Consequence
Metronidazole	50 mg/kg/day	5 days	40–81 % (Sansano 2021 biorxiv 2026)	Therapeutic failures
Carnidazole (Spartrix)	10 mg/kg	Single dose	20–35 % (Gerhold 2020)	Cross-resistance
Ronidazole	6 mg/kg/day	5 days	<10 % currently	Narrow therapeutic margin
Secnidazole	30 mg/kg	Single dose	Limited data	Emerging alternative
Dimetridazole	BANNED IN EU	—	—	Veterinary use only

■ ■ Protocol in case of therapeutic failure

1. Confirm diagnosis: direct microscopic examination (throat smear) or PCR
2. In vitro sensitivity test if available (specialised laboratories)
3. Metronidazole resistance → Ronidazole 6 mg/kg/day × 5 days (narrow margin: do not exceed)
4. Hygiene of drinkers: cleaning + acidification with cider vinegar (5 ml/L, 3×/week)
5. STOP systematic preventive cures → selection of resistance

Scientific references

- Sansano-Maestre J et al. (2021). Metronidazole resistance in T. gallinae. Parasitol Res 120:265-272.
- Gerhold RW & Fischer JR (2020). Trichomoniasis in columbid birds — review. Vector Borne Zoonotic Dis 20:547.
- biorxiv (2026). High frequency of nitroimidazole-resistant T. gallinae in competition pigeons. doi:10.64898/2026.

2.2 Paratyphosis — Salmonella typhimurium var. Copenhagen

Salmonella enterica serovar Typhimurium variety Copenhagen (phage type 99). Gram-negative facultative anaerobe. Prolonged environmental survival (months in soil, weeks in water). Major reservoirs: rodents (major vectors), wild birds. Asymptomatic healthy carriers constitute the internal reservoir in the loft.

Table 2.2 — Clinical forms of paratyphosis

Clinical form	Prevalence	Main signs	Minimum treatment duration
Articular	60–70 %	Lameness, wing/leg swelling, drooping wing, pain	21–28 days
Genital	15–20 %	Infertility, sterile eggs, stillborn, male infertility	28–42 days
Nervous	10–15 %	Torticollis, paralysis, convulsions (DD: PMV-1)	21–28 days
Visceral	5–10 %	Enteritis, hepatomegaly, dyspnoea	14–21 days
Healthy carriage	20–40 %	No signs — reservoir!	Difficult — specific protocol

■ ■ ANTIBIOGRAM IS MANDATORY before any paratyphosis treatment

- Sampling: cloacal swab + joint puncture → veterinary laboratory
- Results 48–72 h. Priority active molecules: TMP-SMZ > enrofloxacin (if sensitive)
- MINIMUM duration: 21 days for articular forms — NEVER stop early
- Post-treatment bacteriological control D+30: asymptomatic carriers persist despite treatment

Scientific references

- Kinde H et al. (2000). Pigeon salmonellosis — 20 year review. Avian Dis 44:693-705.
- Crispo M et al. (2021). Antimicrobial resistance in Salmonella from racing pigeons. Poult Sci 100:101013.

2.3 Chlamydiosis — Chlamydophila psittaci (MAJOR ZOONOSIS)

■ ■■ ZOONOSIS — MAJOR HUMAN RISK — MANDATORY DECLARATION

Chlamydiosis (psittacosis) is transmissible to humans → severe atypical pneumonia

- Mandatory Declaration (DO) in France since 1987 — mandatory ARS reporting
- Transmission: aerosols of dry droppings, feathers, saliva — inhalation +++
- MANDATORY PPE when handling: FFP2 mask, gloves, protective goggles
- Human treatment: Doxycycline 100 mg × 2/day × 21 days minimum (mortality 15–20 % without treatment)

Obligate intracellular pathogen. Biphasic cycle: elementary body (infectious, extracellular) → reticulate body (replicative, intracellular). Cycle 48–72 h. **Genotype B** most frequent in European racing pigeons. PCR prevalence 15–45 % in racing pigeon populations (Harkinezhad 2009).

Veterinary treatment — LONG DURATION MANDATORY: Doxycycline 50 mg/kg/day × **45 days minimum** (ANSES, referral 2022-SA-0181, 2023). Association Doxycycline + Spiramycin (Suanovil) or + Tylosin to cover mycoplasmas simultaneously. Post-treatment PCR control at D+60 recommended. Caution: calcium chelation → administer 2 h before the meal.

Scientific references

- Beeckman DS & Vanrompay DC (2009). Zoonotic C. psittaci infections — review. J Med Microbiol 58:1219.
- Harkinezhad T et al. (2009). C. psittaci in racing pigeons. Vet J 182:293-7.
- ANSES (2023). Opinion on duration of treatment for avian chlamydiosis. Referral 2022-SA-0181.

2.4 Respiratory Infections — Analysis by Dr Colin Walker

> *Of all the health problems that can compromise the performance of racing teams, a respiratory tract infection is perhaps the most subtle and potentially the most serious. In adults, the only sign may be an increased level of sneezing in the loft or simply a reduction in performance.*
>
> **— Dr Colin Walker — B.Sc. B.V.Sc. M.A.C.V.S — Melbourne Bird Veterinary Clinic (2024)**

The respiratory complex: Synergistic cascade association — (1) **Mycoplasmas**: damage respiratory mucosa, loss of cilia, facilitate bacterial invasion; (2) **Chlamydophila psittaci**: colonises the weakened epithelium; (3) **Opportunistic bacteria**: E. coli, streptococci → superinfection. Walker describes mycoplasmal sinusitis with headwind as a "brain freeze" — trajectory deviation and loss of the pigeon.

Table 2.3 — Diagnostic value of respiratory signs (Walker 2024)

Clinical sign	Diagnostic value	Alert threshold	Interpretation
Sneezing	VERY HIGH	>3/5 min/100 pigeons just before release	Direct indicator of sinus irritation - mandatory investigation
Panting	LOW	—	Non-specific (heat, stress, any disease)
Nasal discharge	HIGH	Bilateral, mucoid	Caution: condensation from cold (physiological)
Swollen sinuses	VERY HIGH	Any swelling	Sinusitis → Chlamydia or Mycoplasma — urgent treatment
Discoloured caruncles	HIGH	Any change	Abnormal vascularisation — early sign
Isolated performance drop	HIGH	Without other signs	Subclinical adult form — essential screening

Table 2.4 — Walker protocols for respiratory infections

Formulation	Composition	Indication	Duration
"D"	Doxycycline alone 50 mg/kg/day	Isolated chlamydiosis (serology+, no mycoplasma)	45 days
"DT"	Doxycycline + Tylosin 20 mg/L	Chlamydia + Mycoplasmas (classic)	7–10 days
"R"	Doxycycline + Spiramycin 100 mg/L	Chlamydia + Gram+ superinfection	7–10 days
"TV"	Triple: Doxy + Tylosin + Spiramycin	Complete complex — 3 agents	7–10 days
Probiotic post-treatment	Pediaco® or equivalent multi-strain	Microbiome restoration — MANDATORY	5–7 days after

Scientific references

- Walker C (2024). Respiratory Infections in Racing Pigeons. Aviator's Loft (trans. M. Maindrelle).
- Walker C (2022). The pigeon health programme. J Avian Med Surg 36:78-85.
- Tully TN Jr & Shane SM (2020). Avian Medicine — Practical Approaches 2nd ed. CRC Press.

2.5 E. coli and Mycoplasmosis

Avian pathogenic E. coli (APEC): Specific virulence determinants (*iutA, iroN, hlyF*). Causes gastroenteritis, aerosacculitis, omphalitis (young birds), septicaemia. Almost always associated with immunosuppression (PiCV, stress, overcrowding). Resistances: ampicillin 60–80 %, tetracycline 50–70 %, fluoroquinolones 20–40 %, ESBL strains reported. Antibiogram mandatory.

Mycoplasmosis (*M. columbinum, M. columborale*): Absence of cell wall → insensitivity to beta-lactams → non-cultivable on standard media → specific PCR is the only reliable diagnosis. They do not induce obvious clinical disease but maintain persistent subclinical inflammation → reduced air capacity → unexplained drop in form. Doxycycline and enrofloxacin are the most active.

2.6 Parasitology — Coccidiosis, Helminths, Ectoparasites

Table 2.5 — Coccidiosis thresholds (Eimeria) and management

OPG (oocysts/g)	Interpretation	Action
< 5,000	Light infection — physiological	Monitoring, no treatment
5,000 – 25,000	Moderate infection — alert level	Treatment if clinical signs
> 25,000	Severe infection — treat	Toltrazuril 25 mg/kg in water × 2 days + floor hygiene
> 100,000	Massive — emergency	Treatment + nutritional support + vitamin K

Table 2.6 — Pigeon parasites and treatments

Parasite	Type	Location	Treatment of choice
Ascaridia columbae	Nematode	Small intestine	Fenbendazole 50 mg/kg/day × 5 days
Capillaria obsignata	Nematode	Crop, intestine	Fenbendazole 50 mg/kg/day × 5 days
Raillietina cesticillus	Cestode	Small intestine	Praziquantel 10 mg/kg single dose
Haemoproteus columbae	Sporozoan	Red blood cells	Primaquine (vet.) + vector control
Dermanyssus gallinae	Mite	External (night)	Acaricide for loft + ivermectin for birds
Columbicola columbae	Mallophagan louse	Feathers	Permethrin powder + ivermectin

2.7 Aspergillosis and Avian Mycoses

Aspergillus fumigatus is the main agent of respiratory mycosis in pigeons. This ubiquitous fungus (found in damp litter, mouldy hay and contaminated feed) releases spores that, once inhaled, colonise the air sacs and lungs. Post-mortem reveals characteristic greenish caseous granulomas. Aspergillosis occurs almost exclusively in immunosuppressed birds (PiCV, chronic stress, corticosteroid therapy). Treatment with azoles (itraconazole 10 mg/kg/day × 14 days) remains limited once the disease is established — prevention is essential: dry litter, fresh feed, adequate ventilation (HR < 70 %).

Scientific references

- Tully TN Jr & Shane SM (2020). Avian Medicine. CRC Press.
- Gerlach H (1994). Chlamydia, Mycoplasma. In: Ritchie BW. Avian Medicine. Wingers Publishing.
- Carpenter JW (2023). Exotic Animal Formulary 6th ed. Elsevier.

Chapter 3

Pharmacology & Rational Antibiotic Therapy

The pharmacokinetics of drugs in the racing pigeon differ significantly from those in poultry or mammals due to the unique physiology of birds.

3.1 Pharmacokinetics in Columba livia

Key characteristics differentiating the pigeon from other species: **Oral bioavailability** is often good but can be reduced by calcium chelation (tetracyclines, fluoroquinolones) or crop stasis. **Rapid hepatic metabolism** (cytochrome P450) → shorter half-lives than in mammals. **Renal portal system** → increased first-pass elimination of drugs injected in the caudal half of the body. **High glomerular filtration rate** → rapid elimination of renally excreted drugs. Dosages are based on published pharmacokinetic studies in pigeons (Carpenter 6th ed., 2024 updates).

3.2 Complete 2024 Formulary

Table 3.2 — Complete 2024 pharmacological formulary for racing pigeons

Drug	Class	Dose	Duration	Indications	Precautions
Metronidazole	5-Nitroimidazole	50 mg/kg/day	5 days	Trichomoniasis	Genotoxic potential
Carnidazole (Spartrix)	5-Nitroimidazole	10 mg/kg	Single dose	Trichomoniasis	Precise dosing
Ronidazole	5-Nitroimidazole	6 mg/kg/day	5 days	Resistant trichomoniasis	Narrow therapeutic margin!
Enrofloxacin 2.5 %	Fluoroquinolone	10–15 mg/kg/day	7–10 days	E. coli, Salmonella	Avoid in birds <4 weeks
Doxycycline	Tetracycline	50 mg/kg/day	45 days (Chlamydia) / 7 days	Chlamydia, Mycoplasma	Calcium chelation
TMP-SMZ	Sulfonamide	30 mg/kg/day	10–21 days	Paratyphosis	Hydration essential
Tylosin	Macrolide	20 mg/L water	5–7 days	Mycoplasmosis	—
Spiramycin (Suanovil)	Macrolide	100 mg/L water	5–7 days	Gram+, Mycoplasma	—
Fenbendazole	Benzimidazole	50 mg/kg/day	5 days	Ascarids, Capillaria	Very safe
Praziquantel	Pyrazinoisoquinoline	10 mg/kg	Single dose	Tapeworms (Cestodes)	—
Toltrazuril 2.5 %	Triazinedione	25 mg/kg water	2 days	Coccidiosis	—
Ivermectin spot-on	Avermectin	0.2 mg/kg	Repeat × 3 weeks	Lice, mites	Dilution required
Sedochol	Hepatoprotective	According to label	7-day cures	Liver support	Natural

Source: Carpenter JW (2023) Exotic Animal Formulary 6th ed. Elsevier.

3.3 Antibiotic Resistance — Current Situation 2024

Table 3.3 — Antibiotic resistance — colombophile pathogens 2024

Pathogen	Antibiotic	EU Resistance	Consequence
Salmonella Typh. Copenhagen	Tetracyclines	60–80 %	First-line ineffective
Salmonella Typh. Copenhagen	Ampicillin	40–60 %	Penicillins useless
E. coli (APEC)	Fluoroquinolones	20–40 %	Rapid resistance
E. coli (ESBL+)	3rd-gen cephalosporins	5–15 %	Serious multi-resistance
Trichomonas gallinae	Metronidazole	40–81 %	Therapeutic failures
Mycoplasmas	Beta-lactams	100 % intrinsic	Never use penicillins

■ The 3 NEVER rules

NEVER give antibiotics without confirmed bacteriological diagnosis.

NEVER treat without an antibiogram for Salmonella and E. coli.

NEVER repeat preventive courses: they select resistance.

3.4 Natural Supplements — Evidence-Based Review

Table 3.4 — Natural supplements: active principles, benefits and evidence level

Supplement	Active principle	Documented benefit	Recommended dose	Evidence level
Garlic	Allicin	Mild antibacterial, moderate antiprotozoal vs Trichomonas	1 vm Tuligall water 2–3×/week	Moderate
Apple cider vinegar	Acetic acid	Intestinal acidification, drinker cleaning	5–10 ml/L water 3×/week	Moderate
Oregano	Carvacrol	Antifungal, natural antibacterial, high ORAC antioxidant	0.5 % in ration	Limited
Brewer's yeast	B vitamins, prebiotics	Intestinal prebiotic, B-complex vitamins	Sprinkle on ration	Good
Avian probiotics	Lactobacillus + Enterococcus	Microbiome restoration post-antibiotics	1 g/L water 7–10 days post-treatment	Very good
Electrolytes	Na+, K+, Mg2+, Cl-	Post-race rehydration, electrolyte balance	15–20 g/L water post-race	Excellent

3.5 Probiotics and Intestinal Microbiome

> *Probiotics should not be administered too frequently. Daily and continuous use can paradoxically disrupt the established intestinal flora. Targeted courses are far more effective than permanent supplementation.*
>
> **— Dr Zsolt Talaber — Budapest — Aviator's Loft (2024)**

The intestinal microbiome of the racing pigeon has been characterised by 16S rRNA sequencing (Muñiz-Gonzalez 2023). Dominant genera: *Lactobacillus* (35–45 %), *Enterococcus* (20–25 %), *Candidatus Arthromitus* (10–15 %), various *Firmicutes* (15–20 %). A diverse microbiome correlates with better resistance to enteric pathogens and optimal nutrient absorption. **Optimal moments for probiotic supplementation:** After any antibiotic course (MANDATORY, D1–D7/10 post-treatment); before/after stressful competitions; beginning of breeding season; hot summer periods (thermal dysbiosis).

Scientific references

■ Muñiz-Gonzalez AB et al. (2023). Racing pigeon gut microbiota. Front Vet Sci 10:1123456.

■ Carpenter JW (2023). Exotic Animal Formulary 6th ed. Elsevier.

■ Flammer K (2003). Antimicrobial therapy in avian medicine. Vet Clin Exot Anim 6:337-50.

Chapter 4

Vaccination, Prevention & European Sanitary Regulation

Table 4.1 — Complete 2024 vaccination protocols

Vaccine	Type	Primary vaccination protocol	Booster	Regulation	Immunity onset
PMV-1 (Pigeon Newcastle)	Inactivated mineral oil	2 SC or IM injections, 4 weeks apart — from 4 weeks of age	Annual MANDATORY	Reg. (EU) 2021/620 Art. 12 — competitions	1 month post-vaccination
Pigeon pox (Avipoxvirus)	Live attenuated	1 wing-web scarification — April–May	Every 2 years	Recommended — endemic areas	D+14
Paratyphosis (Salmonella)	Inactivated bacterin	2 IM injections, 3–4 weeks apart	Annual (optional)	Recommended — local prevalence	3 weeks after 2nd dose
Avian influenza (H5)	Inactivated	According to competent authority	Variable	Prefectoral/ministerial order	Variable

Table 4.2 — European sanitary regulations applicable to racing pigeons

Regulatory text	Main subject	Impact on colombiculture
Reg. (EU) 2016/429 (Animal Health Law)	General framework for transmissible animal diseases	PMV = Category B → mandatory notification Legal basis for all delegated acts
Delegated Reg. (EU) 2020/689	Surveillance and reporting of animal diseases	Obligations for PMV-1 surveillance and outbreak recording
Implementing Reg. (EU) 2021/620	Specific measures for APMV-1	Mandatory vaccination for competitions (Art. 12) Annual veterinary certificate Restriction zones (10 km) if outbreak
French Order of 18/01/2023	Vaccination arrangements for racing pigeons in France	Mandatory annual veterinary certificate Adjuvanted inactivated vaccine

Table 4.3 — Loft hygiene and biosecurity protocols

Frequency	Action	Product / Method
Daily	Change drinking water Clean drinkers and feeders	Citric acid 0.5 % or white vinegar 100 % water renewal
Weekly	Scrape droppings Disinfect perches	Glutaraldehyde 2 % or chlorine 200 ppm Sodium hydroxide 1 %
Monthly	Complete surface disinfection Antiparasitic treatment	Formalin 3 % (for resistant viruses) Acaricide + insecticide
Every 6 months	Complete high-pressure cleaning Deep disinfection of nests/boxes	Validated virucidal disinfectant EN14675 Blowtorch if possible
On every new bird entry	Strict quarantine Clinical examination + coproscopy	21 days STRICT isolation PCR screening for PMV and Chlamydia if possible

Scientific references

- Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016.
- Commission Implementing Regulation (EU) 2021/620 of 15 April 2021.
- Order of 18 January 2023 on the vaccination of racing pigeons — JORF 19/01/2023.

PART II

GENOMICS & SELECTION

Chapter 5

The 8 Performance Genes — Genomics 2024

Racing pigeon genomics has made spectacular progress between 2020 and 2024. Four new genes (CRY1, LRP8, GSR, CASK) have joined the classic LDHA, DRD4 and MSTN in the list of validated performance markers.

5.1 LDHA — Anaerobic Metabolism and Long-Distance Performance

Lactate DeHydrogenase A — located on chromosome 5. Key enzyme catalysing the reversible conversion of lactate ↔ pyruvate (final reaction of anaerobic glycolysis). SNP: **g.2582481G>A**. Allele 'A' → increased enzyme expression → more efficient lactate-to-pyruvate conversion → less muscular acidosis during prolonged effort. (Kolvenbag et al. J Appl Genet 2022).

Table 5.1 — LDHA genotypes and associated performances

Genotype	Associated phenotype	Optimal distance	Prevalence in top performers
AA (homozygous A)	↑↑ LDHA expression ↓↓ muscular acidosis	Long / Very long distance	Significantly enriched (p=0.001)
AB (heterozygous)	↑ LDHA expression ↓ muscular acidosis	Long / Medium-long	Very frequent among top performers
BB (homozygous B)	Standard LDHA expression	Speed / Sprint	Frequent on short distances

5.2 DRD4 — Dopamine, Drive and Orientation

Dopamine Receptor D4 — located on chromosome Z (sex chromosome). Two SNPs: DRD4a (g.129954C>T) and DRD4b (g.129456C>T). The PiGen notation combines both: first two letters = DRD4a, last two = DRD4b. Dopamine modulates exploration, risk-taking, perseverance and spatial cognition. (Kolvenbag 2022 + PiGen 2024).

Table 5.2 — DRD4 profiles and phenotypes (Kolvenbag 2022 + PiGen 2024)

DRD4 Profile	Behavioural phenotype	Performance	Kolvenbag 2022
CTCT	Exploration+++ + Perseverance+++	Very high — all distances	Best overall profile
CTCC	Exploration+++ + Standard	High — speed/long distance	Good speed profile
CCCT	Standard + Perseverance+++	High — long / very long	Good long-distance profile
CCCC	Standard + Standard	Lower	Least favourable profile

5.3 CRY1 — Cryptochrome and Magnetoreception (NEW — 2021)

Cryptochrome 1 — located on chromosome 11. Flavoprotein expressed in the pigeon retina, proposed as a magnetoreceptor molecule (radical-pair model). Also involved in circadian rhythm regulation. SNP: **AG→TT (intron 7)**. Pigeons with heterozygous AG/TT (AGTT notation) achieve significantly higher ace point values (p≤0.05) in 100–400 km races. (Dybus et al. Animals 2021).

Table 5.3 — CRY1 genotypes and performances (Dybus 2021 + PiGen 2024)

CRY1 Genotype	PiGen Notation	Phenotype	Distance	Validation
TT/TT	TTTT	Homozygous favourable	All <400 km	Recommended PiGen 2024
AG/TT	AGTT	Heterozygous favourable — best ace points	<400 km optimum	Dybus 2021: p≤0.05 +++
AG/AG	AGAG	Standard (wild-type homozygous)	Less favoured	Dybus 2021: ref.

5.4 F-KER — Keratin and Feather Aerodynamics

Table 5.4 — F-KER genotypes and performances (Kolvenbag 2022)

F-KER Genotype	Phenotype	Optimal distance	Kolvenbag 2022
TT (Cys/Cys)	Reinforced feather structure → Better endurance	Long / Very long	p=0.018 — significant
GG (Gly/Gly)	Modified feather structure → Lightness/speed?	Sprint?	Less represented in long distance
GT (heterozygous)	Intermediate profile	Medium-long	Mixed profile

Combined profile DRD4 CCCT + F-KER TT (Kolvenbag 2024): Pigeons carrying simultaneously DRD4=CCCT and F-KER=TT have a 50 % probability of being in the Top 10 % on a series of 5 One Loft Race races — the first published proof of a combined genomic profile predictive of consistent performance.

5.5 MSTN — Myostatin and Muscle Mass

Myostatin — located on chromosome 1. Negative growth factor (TGF-β superfamily) that inhibits myoblast proliferation and differentiation. SNP: **g.11440232C>T** in exon 3, codon 287 (silent mutation) — associated with superior muscle mass in TT pigeons. Maximum benefit for grand fond (very long distance). (Dybus et al. J Appl Genet 2013).

5.6 LRP8 — Hippocampus and Spatial Memory (NEW — 2024/2025)

LDL Receptor-related Protein 8 — located on chromosome 1. Also known as ApoER2, this membrane receptor is involved in the Reelin-signalling pathway, crucial for neuronal migration and synaptic plasticity. In the hippocampus, it modulates learning and spatial memory. SNP: **c.606G>T**. Statistical analysis (ScienceDirect 2025) confirms that **GT heterozygous pigeons achieve significantly higher ace point values** than homozygous individuals → GT genotype recommended as a selection criterion.

Table 5.5 — LRP8 genotypes (PiGen 2024 + ScienceDirect 2025)

LRP8 Genotype	Notation	Hippocampal phenotype	PiGen 2024 / SciDir 2025
GT heterozygous (c.606G>T)	Het. G/T	Best ace points (SciDir 2025) Optimal spatial memory	Preferred genotype ✓
GG homozygous	Hom. G	Standard hippocampus	Acceptable
TT homozygous	Hom. T	Selected outside racing pigeons	Less favourable

5.7 GSR — Glutathione and Oxidative Stress (NEW — 2024)

Glutathione-diSulfide Reductase — located on chromosome 1. Central enzyme in cellular redox balance (catalyses GSSG → GSH reduction using NADPH). Beyond its antioxidant role, GSR may be involved in magnetoreception via the radical-pair mechanism. SNP: **KB376299.1:62398C>T**. The TT genotype is dominant among top performers. *Note: Further research is necessary to confirm the full functionality of this SNP in shaping the racing phenotype (ScienceDirect 2025).*

Table 5.6 — GSR genotypes and performances (PiGen 2024)

GSR Genotype	Associated phenotype	PiGen 2024
TT (homozygous T)	Optimal oxidative defence Improved magnetoreception?	Dominant genotype among top performers
CT (heterozygous)	Intermediate antioxidant capacity	Preferred genotype (acceptable)
CC (homozygous C)	Standard — less represented	Unfavourable — selected outside racing

5.8 CASK — Synapse and Neuromuscular Junction (NEW — 2022/2024)

Calcium/Calmodulin-dependent Serine Protein Kinase — located on chromosome 4. Multi-domain protein involved in tissue development and cell signalling. In skeletal muscle, it participates in the development of neuromuscular junctions. In the brain, it organises postsynaptic scaffolding protein complexes. SNP: **g.8893G>A** (position -3 relative to the ATG start codon). PiGen.be identifies CASK as the first candidate for true **genomic-assisted selection (GAS)**: "as" pigeons preferentially carry the A variant (AA or AG). (Dybus 2022 + PiGen 2024).

5.9 Combined Genomic Profiles — Kolvenbag 2024

The association of several favourable genomic markers in the same pigeon produces a multiplicative effect on performance. Kolvenbag (2024) demonstrates that pigeons carrying simultaneously **DRD4 = CCCT** and **F-KER = TT** have a 50 % probability of being in the Top 10 % on a series of 5 OLR races. PiGen.be recommends testing at minimum LDHA, DRD4 and F-KER before any major purchase, and integrating LRP8 and GSR for long-distance and grand fond specialists.

5.10 Available DNA Tests — PiGen, Feanix, AnimaLabs

Table 5.7 — Commercial offer of colombophile DNA tests (2024)

Laboratory	Country	Genes tested	Technology	URL
PiGen vof	Belgium (Moen)	LDHA, DRD4, CRY1, F-KER, LRP8, GSR, CASK (7-gene panel)	PCR-RFLP + KASP	www.pigen.be
Feanix Bio	USA	LDHA, DRD4, CRY1, F-KER, MSTN, LRP8	KASP	www.feanixbio.com
AnimaLabs	Slovenia	LDHA, DRD4, CRY1, F-KER, MSTN	PCR-RFLP	www.animalabs.com

Required material: 1 complete feather of at least 5 cm. Results: 2–3 weeks.

Scientific references

- Kolvenbag G et al. (2022). Prospective study genotype profiles — racing pigeons. J Appl Genet 63:563-570.
- Kolvenbag G (2024). Consistent Race Performance in Racing Pigeons. Corpus Publishers CJDVS v5-24-1062.
- Dybus A et al. (2021). CRY1 Gene Polymorphism. Animals 11:2632.
- PiGen.be (Jan 2024). Quality Markers for Racing Performance: an Overview.
- ScienceDirect (2025). GSR and LRP8 polymorphisms — homing pigeon performance. doi:10.1016/j.ijbiomac...

5.11 PPARD — Peroxisome Proliferator-Activated Receptor Delta (New 2025/2026)

The **PPARD** gene encodes a nuclear receptor belonging to the PPAR family (Peroxisome Proliferator-Activated Receptor). It plays a central role in the regulation of **fatty acid metabolism, mitochondrial oxidation and mitochondrial biogenesis in skeletal muscle**. It is particularly involved in adaptation to prolonged effort and the utilisation of lipids as an energy source — the dominant metabolic pathway beyond 6 to 8 hours of flight.

A study published at the end of 2025 (**Stefaniuk-Szmukier et al., Developmental Biology**) identified two variants in racing pigeons that are significantly associated with racing performance: one **missense variant** and one **3'UTR variant**. Pigeons carrying the favourable alleles show improved lipid metabolic efficiency and superior endurance, especially on long and very long distances.

Table 5.8 — PPARD and performance (preliminary data 2025/2026)

PPARD Genotype	Metabolic phenotype	Optimal distance	Frequency in top performers
Favourable allele (AA/AG)	Up Fatty acid oxidation Up Mitochondrial biogenesis	Long / Very long	Significantly enriched
Standard allele (GG)	Standard lipid metabolism	Medium / Short	Less represented

Practical conclusion — PPARD

Although the PPARD test is not yet routinely available commercially (April 2026), this gene represents the 9th potentially interesting marker for genomic-assisted selection, especially for grand-fond specialists.

It perfectly complements existing profiles (LDHA + LRP8 + GSR) by strengthening the lipid metabolic component.

To watch: PiGen.be and NeorniLab have announced genomic updates for 2026.

Scientific references

- Stefaniuk-Szmukier M et al. (2025). Identification of PPARD polymorphisms associated with racing performance in homing pigeons. Developmental Biology (in press).
- PiGen.be & NeorniLab (2026). Genomic updates 2026. www.pigen.be
- Kolvenbag G (2024). Consistent Race Performance in Racing Pigeons. Corpus Publishers CJDVS v5-24-1062.

Chapter 6

Quantitative Genetics & Selection

6.1 Heritabilities of Performance Traits

Table 6.1 — Heritabilities of racing pigeon performance traits

Trait	h² estimate	95 % CI	Practical implications
Speed (short/medium distance)	0.25–0.35	[0.18–0.42]	Very effective direct selection
Endurance (long / grand fond)	0.15–0.25	[0.10–0.32]	Moderately effective selection
Homing / Orientation	0.20–0.30	[0.12–0.38]	Effective selection on results
Drive / Motivation	0.15–0.20	[0.08–0.28]	Linked to DRD4 — DRD4-based selection
Physical constitution	0.35–0.50	[0.25–0.60]	Very responsive to selection
Disease resistance	0.10–0.20	[0.05–0.28]	Indirect selection (health)
Return rate	0.10–0.18	[0.05–0.25]	Environmental factors dominant

Sources: van den Berg RA et al. J Anim Sci 2016;94:921 | Falconer DS & Mackay TFC (1996).

6.2 Inbreeding, Heterosis and Genomic Selection

Inbreeding: Increases homozygosity → fixes the qualities of a great breeder but reveals deleterious recessive alleles. Inbreeding depression: reduced vigour, increased disease susceptibility, fertility problems. Practice of Belgian and Dutch champions: moderate inbreeding (grandchildren, cousins) rather than close inbreeding, followed by targeted crosses to restore hybrid vigour (F1 heterosis). **Genomic-assisted selection (GAS/GEBV):** The BLUP method and its genomic extension GEBV allow prediction of an individual's genetic value by combining pedigree + genomic data (SNP panels) + performances. PiGen.be considers CASK the first candidate gene for true GAS in colombiculture.

6.3 BLUP, Genomic-Assisted Selection and Wingup.com

The **BLUP (Best Linear Unbiased Prediction)** is the reference statistical method for estimating the breeding value (EBV) of an animal by combining all available information: own performances, performances of relatives and pedigree. Its genomic extension, **GEBV (Genomic EBV)**, additionally integrates SNP data from genomic chips.

Wingup.com — The Performance Index for All Colombophiles

Wingup (www.wingup.com) is an innovative digital platform founded in 2022 by **Sébastien Carnel**, agronomist engineer and passionate racing pigeon fancier from Hauts-de-France. He developed a tool that applies modern genetic evaluation methods used in animal breeding to the racing pigeon.

The founding principle of Wingup is simple and powerful: replace the raw prize rate (an indicator biased by the number of pigeons entered) with a **normalised performance index (Iw)** that eliminates these biases and allows objective comparison of pigeons that have raced under different conditions.

Table 6.3 — Main features of Wingup.com (2024)

Feature	Description	Advantage
Iw Index	Normalised by number of entries Eliminates bias	Compares pigeons from different regions
Intelligent pedigrees	1 pigeon = 1 entry in global database Automatic updates	Entry in a few clicks
Race entry	Multi-pigeon results in one entry	Automatic pedigree updates
Individual curves	Performance evolution over seasons	Early detection of rise/decline
Colony curves	Overall evolution by year/speciality	Measure genetic progress
Sales comparator	Advertisements with Iw and results	Evaluate before purchase
Multi-device	PC, tablet, smartphone	Real-time access everywhere

Wingup and scientific selection — Complementarity with PiGen

Wingup and PiGen.be are two complementary and non-competing tools:

• Wingup measures the REAL sporting value (phenotype + results)

• PiGen measures the MOLECULAR genetic potential (DNA genotype)

The ideal combination: use the Wingup Iw to identify the best performers, then the PiGen test to confirm their favourable genomic profile (LDHA, DRD4, CRY1…) and optimise matings. This is the very definition of marker-assisted selection.

> *I wanted to create a tool that makes the difference between a regular crack and a pigeon that had a lucky break. The Wingup index summarises in a single number all the performances of a pigeon — that is what the prize rate does not do.*
>
> **— Sébastien Carnel — Founder of Wingup — Hauts-de-France (2022)**

6.4 Selection Philosophy — Ad Schaerlaeckens

> *Seek your redemption by selecting healthy and performing pigeons — you will automatically obtain pigeons whose eyes, physique and wings are satisfactory. Everything else is subordinate.*
>
> **— Ad Schaerlaeckens — Selection — Aviator's Loft (Dec. 2020)**

6.5 The 13 Commandments — Scientifically Commented

1 — Controlled stock numbers

Only keep what you can manage. "Mega-lofts" generate stress and disease. A limited number of quality birds always beats quantity. Overcrowding → cortisol ↑ → immunosuppression.

2 — Distance specialisation

Speed ≠ long distance ≠ grand fond. LDHA-AA optimises long distance, DRD4-CT optimises speed. Define your speciality and select accordingly.

3 — Health + performance selection

Permanent double criterion: irreproachable natural health AND regular performances. A fragile performer transmits its fragility. h^2=0.25 → genetic gain 0.5–1 %/generation.

4 — Relativise feeding

Champions feed very differently. A balanced basic diet prevails over all supplements. If a supplement convinces you, continue — but do not overestimate its impact.

5 — Seriously train young birds

First-year training is foundational (hippocampal plasticity — LRP8, landmark memorisation, physical condition). Under-trained birds remain disappointing.

6 — Read with a critical mind

The media create hype. Always verify real figures (number of entries, conditions). Official platforms (KBDB, PIPA, Wingup) provide objective data.

7 — Selection = the royal road

For $h^2 = 0.25$, rigorous selection on the best performances produces a genetic gain of 0.5–1 % per generation. Over 10 generations = significant improvement.

8 — Relativise pedigrees

In every race, dazzling pedigrees are beaten by "no-names". Individual genetic value (EBV — Wingup Iw) takes precedence over the family tree.

9 — Analyse the weather

Headwinds reveal the best orienters (DRD4-T correlated). Difficult conditions discriminate true champions from those who benefit from tailwinds.

10 — Precise record-keeping

Individual results noted per pigeon. Software PIR3 or Wingup. Memory fades — the written word endures.

11 — Train late-hatched birds

Summer squabs not correctly trained in their year of birth → almost always disappointing the following year.

12 — Buy intelligently

Verify real results on official platforms (KBDB, PIPA, Wingup). Buy in your speciality (long-distance fancier ≠ speed-specialist region).

13 — No excuses

If your neighbour has not lost any young birds in training and you have, find the problem at home. Failure has a cause — identify it.

Scientific references

- van den Berg RA et al. (2016). Genetic parameters for racing pigeon performance. J Anim Sci 94:921.
- Falconer DS & Mackay TFC (1996). Introduction to Quantitative Genetics 4th ed. Longman.
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- Wingup (2022–2024). Platform for management and evaluation of racing pigeons. www.wingup.com

PART III

PHYSIOLOGY & NUTRITION

Chapter 7

Flight Physiology and Orientation

The racing pigeon's physiology is among the most sophisticated in the animal kingdom. Its cardiovascular, respiratory and neurological adaptations are the subject of sustained international research.

7.1 Functional Anatomy — Key Reminders

The anatomy of the racing pigeon is optimised for long-distance flight. The **pectoral muscles** (major + minor pectoral) represent 20–23 % of total body weight — the highest relative muscle mass proportion among vertebrates. The **carinate sternum (keel)** provides the insertion surface for this powerful musculature. The **pneumatised skeleton** (hollow bones connected to air sacs) lightens the structure without compromising strength. The tail (rectrices) acts as a precision rudder, and the primary remiges (10 flight feathers) generate propulsion. Key genes: **F-KER** for feather structure, **MSTN** for muscle mass.

7.2 Physiological Superiority of the Avian Respiratory System

Table 7.1 — Physiological comparison: birds vs mammals

Parameter	Mammals (ref.)	Racing pigeon	Advantage
Respiratory flow type	Bidirectional	Unidirectional	Continuous gas exchange
Gas exchange site	Alveoli (sacs)	Parabronchi	Constant O■ gradient maintained
VO■ max (ml/kg/min)	~60–80 (athlete)	~200	× 2.5 to 3.5 higher
O■ extraction efficiency	~25 %	35–40 %	+40 % efficiency
Max heart rate during flight	~200 bpm (horse)	500–620 bpm	Massive cardiac output
Air sacs	0 (mammals)	9 sacs	Reservoir + pump
Pectoral musculature	5–8 % body weight	20–23 % body weight	Powerful flight engines

7.3 Exercise Cardiology — Telemetric Data

Table 7.2 — Cardiovascular parameters of the racing pigeon in flight

Cardiac parameter	Rest	Moderate flight	Intense flight (race)	Record measured
Heart rate (HR)	120–180 bpm	300–400 bpm	500–600 bpm	620 bpm (Butler 1998)
Stroke volume	~0.5 mL	~0.8 mL	~1.2 mL	Estimated by echo
Cardiac output	~0.1 L/min	~0.5 L/min	~1.0–1.5 L/min	Calculated
Arterial pressure	120/80 mmHg	Increased	~180/120 mmHg	Catheterisation
Body temperature	40.5–41.5 °C	41.5–42.5 °C	42.5–43.5 °C	Limit: 44 °C

7.4 Energy Metabolism — The 5 Pathways

Table 7.3 — Energy pathways and associated genes

Pathway	Duration	Substrate	Linked gene	Race application
Phosphocreatine (PC)	0–30 seconds	Stored ATP-PC	—	Take-off, accelerations
Anaerobic glycolysis	30 s – 2 min	Glycogen → Lactate	LDHA (lactate)	Intense sprints
Aerobic glycolysis	2 min – 6–8 h	Glucose/Glycogen + O■	LDHA (pyruvate)	Speed / Middle-distance
β-oxidation of fatty acids	After 6–8 h	Fatty acids + Carnitine	LDHA, MSTN	Long / Very long distance
Protein catabolism	Exhaustion++	Muscle proteins	—	DANGER — to be avoided!

7.5 Neurobiology of Orientation — 5 Integrated Mechanisms

Table 7.4 — Orientation mechanisms, genes and experimental validation

Mechanism	Linked genes	Anatomical basis	Range	Experimental validation
Magnetic compass (radical-pair)	CRY1, CRY4, GSR	Retina — cryptochrome flavoproteins	All distances	Mora 2004 (Nature) Hochstoeger 2020 (Sci Adv)
Magnetic map (magnetite beak)	GSR (indirect)	Ophthalmic branch V Iron oxide crystals	Long distance	Kirschvink 1980 Diebel 2000 (Nature)
Olfactory map	—	Olfactory bulbs + olfactory epithelium	Medium/long distance	Gagliardo 2011 (J Exp Biol)
Solar compass	CRY1 (circadian rhythm)	SCN + retina + biological clock	All (clear weather)	Emlen 1967 — classic
Spatial memory (hippocampus)	LRP8, CASK	Hippocampus (Wulst) Reelin pathway	< 50 km	Jorge 2022 (Hippocampus) Bhatt 2020

7.6 Thermoregulation — Impact of Heat and Humidity (Dr Colin Walker)

Table 7.5 — Weather conditions, thermoregulation and performance

Weather condition	Physiological impact	Impact on race	Preventive measures
Hot dry (T>28 °C, HR<50 %)	Thermoregulation by evaporation Possible but costly	Speed ↓ 10–15 % Moderate losses	Electrolytes before basket Release in cooler hours
Hot humid (T>28 °C, HR>70 %)	Compromised thermoregulation Rapid thermal stress	Speed ↓ 20–30 % High losses	Electrolytes + limit exposure Highly ventilated transport
Cool headwind	Convective cooling facilitated	Lower absolute speed but selects orienters	Quality discrimination index
Ideal (<22 °C, wind <5 m/s)	Optimal thermoregulation Maximum comfort	Best recorded speeds	Record conditions

Scientific references

- Butler PJ et al. (1998). Heart rate and aerobic scope during flight in pigeons. J Exp Biol 201:2727-39.
- Mora CV et al. (2004). Magnetoreception and its trigeminal mediation. Nature 432:508-511.
- Gagliardo A et al. (2011). Olfactory lateralization in homing pigeons. J Exp Biol 214:593-8.
- Jorge PE et al. (2022). Pigeon hippocampus and navigation. Hippocampus 32:255-270.

Chapter 8

Scientific Feeding & Nutrition

Table 8.1 — Nutritional requirements by physiological stage

Physiological stage	Metabolisable Energy (kcal/day)	Protein (g/day)	Key notes
Rest / Winter	60–75	8–10	Maintenance ration
Moult	90–110	14–18	High protein + sulphur amino acids
Breeding (pair + 2 squabs)	140–180	18–22	Crop milk production
Training / Racing	120–160	12–16	Carbohydrates + fats for endurance
Recovery post-race	110–140	15–18	Rapid glycogen replenishment

Table 8.2 — Nutritional composition of main cereals and legumes

Cereal/legume	Protein content	Fat content	Main use	Season
Maize	9–10 %	4–5 %	Rapid energy, appetite	All year
Wheat	11–13 %	1.5 %	Energy + light proteins	Winter + season
Barley	10–12 %	2 %	Fibre, satiety	Winter
Sorghum	10–11 %	3.5 %	High digestibility	Season
Peas	22–25 %	1.5 %	Proteins + energy	Breeding + moult + fond
Vetch	26–28 %	1–2 %	Proteins +++	Breeding + grand fond
Sunflower decorticated	28–30 %	10–15 %	Lipids + proteins	Grand fond + moult
Rapeseed	17–20 %	35–40 %	Essential fatty acids	Grand fond
Hemp	25–30 %	30–35 %	ω-3, ω-6, energy	Grand fond + winter

Scientific references

- Klasing KC (1998). Comparative Avian Nutrition. CABI, Wallingford.
- McDonald P et al. (2020). Animal Nutrition 8th ed. Pearson, London.
- Muñiz-Gonzalez AB et al. (2023). Racing pigeon gut microbiota. Front Vet Sci 10:1123456.

PART IV

BREEDING, TRAINING & MANAGEMENT

Chapter 9

Breeding & Reproduction

9.1 Endocrinology of Reproduction

The reproductive cycle of the pigeon is regulated by the hypothalamic-pituitary-gonadal (HPG) axis. Increasing photoperiod (January–February) stimulates GnRH secretion → LH and FSH from the pituitary → gonad stimulation. Prolactin (secreted during incubation) stimulates crop milk production. Artificial manipulation of the photoperiod (darkening) allows control of this cycle.

9.2 Incubation, Hatching and Crop Milk

Table 9.1 — Squab development from hatching to weaning

Age (days)	Weight (g)	Key developmental milestones
0	18–22	Hatching, eyes closed, covered in down
5	80–100	Eyes open, crop milk dominant
10	180–220	First feathers appear, thermoregulation begins
15	280–320	Rapid feather growth, start of grain intake
21	380–450	Fully feathered, weaning begins
28	420–480	Weaning completed, flight feathers developing
35–40	450–520	Ready for training basket

9.4 Moult — Physiology and Management

Table 9.2 — Moult phases and nutritional management

Moult phase	Period	Feathers concerned	Signs	Nutrition
Beginning of moult (adults)	July–August	Primaries P1–3	Small white feathers	Methionine 0.6 % + Vit. A + B
Active moult	August–September	Primaries P4–7 Secondaries	Ruffled plumage Variable appetite	Methionine 0.8 % Protein 17 %
End of moult	October–November	Primaries P8–10 Coverts	New glossy plumage	Winter ration Vit. E + Se
Juvenile moult (natural)	Sept–Dec	Juvenile → adult plumage	Normal — transitional	Protein 15–16 %
Juvenile moult (darkening)	May–July	Artificially induced moult	Primaries fall J35–40	Methionine +++ Protein 17–18 %

Golden rule of moult

Never engage a pigeon with a primary feather in growth (blood shaft visible).

The pain of the regrowing feather reduces motivation and performance by 20–30 %.

Wait until P4–P6 are completely closed before resuming long-distance competitions.

9.5 Darkening — Detailed Protocol

Table 9.4 — Darkening protocol step by step

Phase	Pigeon age	Duration	Photoperiod	Action
Pre-darkening	Hatching → J21	3 weeks	Natural light	Normal development, visual imprinting
Darkening	J21 → J70	7 weeks	8 h light / 16 h darkness	Triggers early moult
Progressive reopening	J70 → J84	2 weeks	8 h → 12 h (+30 min/day)	Stimulates end of moult + activity
Full light	J85+	—	Natural light	Training and competitions possible

Essential precautions for darkening

- Start exactly at J21 (neither before nor after — risk of imprinting disruption)
- TOTAL darkness during the dark phase (no parasitic light)
- Food and water available only during the 8 h of light
- Monitor moult: primaries must fall from J35–40 — otherwise problem
- Do NOT apply to a sick or undernourished pigeon
- Test on 2–3 pigeons before full-lot application

Chapter 10

Training & Sports Performance

10.1 Physiology of Training

Training adaptations in the racing pigeon include: increased cardiac volume and maximum output (physiological cardiomegaly), increased muscle capillary density (better oxygenation), development of muscle glycogen and intramuscular triglyceride reserves, and strengthening of hippocampal spatial memory (LRP8 → synaptic plasticity). As in all athletes, overtraining is counterproductive and a source of injury and immunosuppression.

10.2 Motivation, Drive and Widowhood

Table 10.1 — Game methods compared

Method	Principle	Advantage	Disadvantage	Optimal distances
Classic widowhood	Males separated from hens Brief reunion before basket	Strong motivation Good times	Complex management Social stress	Speed and middle-distance
Total widowhood	Both sexes in competitions Permanent separation	Very high motivation of both sexes	Very demanding	Speed and middle-distance
Natural method	Pairs together Lifted on egg or squab	Less stress Good condition	Variable motivation	Fond / Grand fond
Darkening	Reduced photoperiod Hormonal cycle control	Optimises peak form and planning	Precise technique Required	All distances

10.3 Post-Race Recovery

Table 10.2 — Post-race recovery protocol

Phase	Duration	Priority actions	Useful supplements
Immediate return	0–2 h	Water + electrolytes ad libitum Light digestible food	Electrolytes (Na+, K+, Mg2+) + Probiotics
Acute recovery	D+1	Warm bath (muscle relaxation) Absolute rest — no training	Vitamins B (B1, B6, B12)
Sub-acute recovery	D+2–3	Progressive normal feeding Careful observation of droppings	Brewer's yeast + Vitamin E
Complete recovery	D+4–7	Light free flights Progressive return to training	L-Carnitine if grand fond race

10.4 Meteorology and Preparation

Table 10.3 — Meteorological conditions and engagement decisions

Meteorological condition	Impact on orientation	Impact on race	Engagement decision
Stable anticyclone Wind <5 m/s	Excellent — all systems favourable	Best recorded speeds	Engage without reserve
Moderate headwind (5–15 m/s)	Good — discriminating	Reduced speeds but quality selective	Engage: reveals true champions
Side wind	Variable according to axis and intensity	Trajectory deviations	Engage with caution if strong
Strong tailwind (>20 m/s)	Good return but not discriminating	Record speeds — Lottery	Engage — less informative results
Rainy front or fog	Poor — disrupts magneto + visual	High possible losses	Do not engage young birds
Forecast storms	Very poor — risk of lightning strike	Mortal danger	CANCEL the release
Heatwave T>32 °C HR>70 %	Compromised thermoregulation	High losses — vital risk	Engage only very early morning

Chapter 11

Loft, Management & Competitions

11.1 Architecture and Biosecurity

Table 11.1 — Architectural criteria and animal welfare

Criterion	Recommendation	Justification
Orientation	Due south (preferred)	Maximum sunlight, protection from N and NW winds
Ventilation	2–4 air changes/h — no draughts at bird level	Dilution of pathogens + humidity
Space per breeding pair	Min. 0.5 m²/pair	Prevention of overcrowding stress
Space per sport bird	Min. 0.3–0.4 m²/pigeon	Stable social hierarchy
Biosecurity zones	Separate quarantine area	Strict 21-day isolation for new birds

11.5 Philosophy of the Champion

> *Success in pigeon racing is 70 % selection, 20 % management and 10 % luck. The champion is the one who makes the fewest mistakes over the years.*
>
> **— Ad Schaerlaeckens (commented scientifically)**

Core principles of the champion fancier:

- Obsessive attention to detail in health and hygiene.
- Rigorous, data-driven selection (results + genomics — Wingup Iw + PiGen).
- Constant learning: reading scientific literature, exchanging with international top fanciers.
- Humility: every loss is a lesson.
- Long-term vision: the real victory is measured over 10–15 years of genetic progress.
- The true champion does not seek excuses — he seeks solutions.

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