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Principal characteristics of suitable broiler genotypes adapted to outdoor system

Claire Bonnefous, Simona Mattioli, Bertrand Méda, Théophile de Rauglaudre, Karine Germain, Laure Ravon, Julie Collet, Pascal Chartrin, Vanessa Guesdon, Vitor Hugo Bessa Ferreira, et al.

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Claire Bonnefous, Simona Mattioli, Bertrand Méda, Théophile de Rauglaudre, Karine Germain, et al.. Principal characteristics of suitable broiler genotypes adapted to outdoor system. PPILOW autumn school - How to improve welfare in poultry and pig low input outdoor and organic farms?, EAAP – European Federation of Animal Science, Oct 2023, Assisi, Italy. hal-04372822

HAL Id: hal-04372822

<https://hal.inrae.fr/hal-04372822v1>

Submitted on 4 Jan 2024

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Day 2 - Session: Co-adapted systems, genotypes and animals

Principal characteristics of suitable broiler genotypes adapted to outdoor system

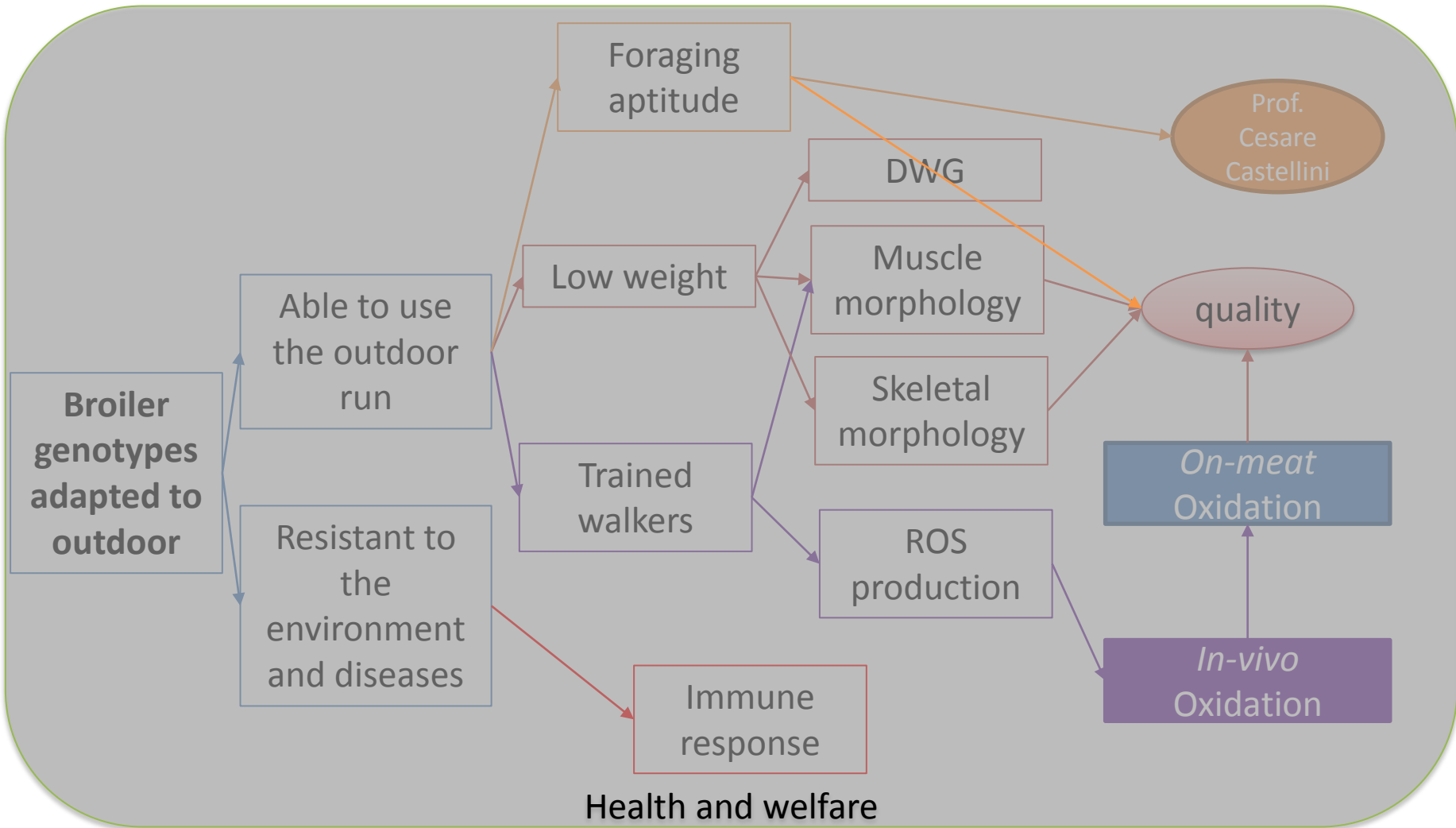
Simona Mattioli

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Perugia
Italy

Claire Bonnefous

French National Institute for Agriculture, Food,
and Environment (INRAE)

France



Outdoor system mandatory conditions

- the chickens need to go out

too much sun, rain, wind



Environmental enrichments

- presence of pasture

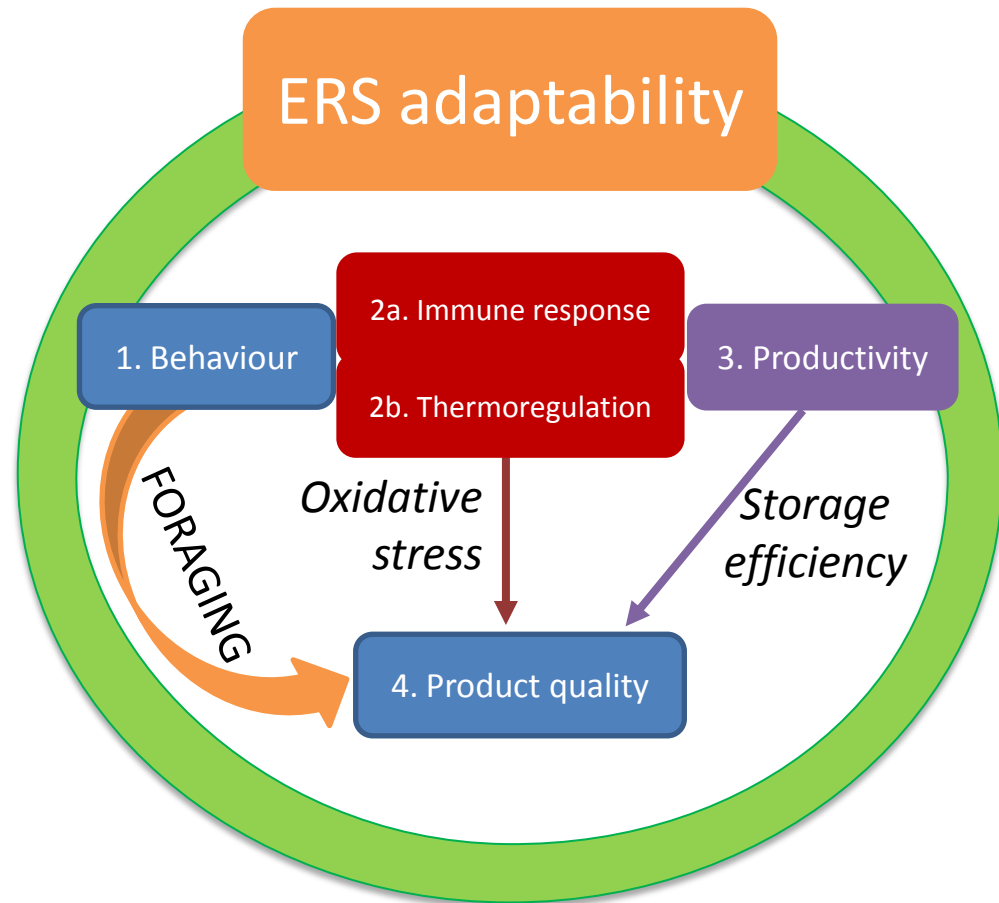


VS

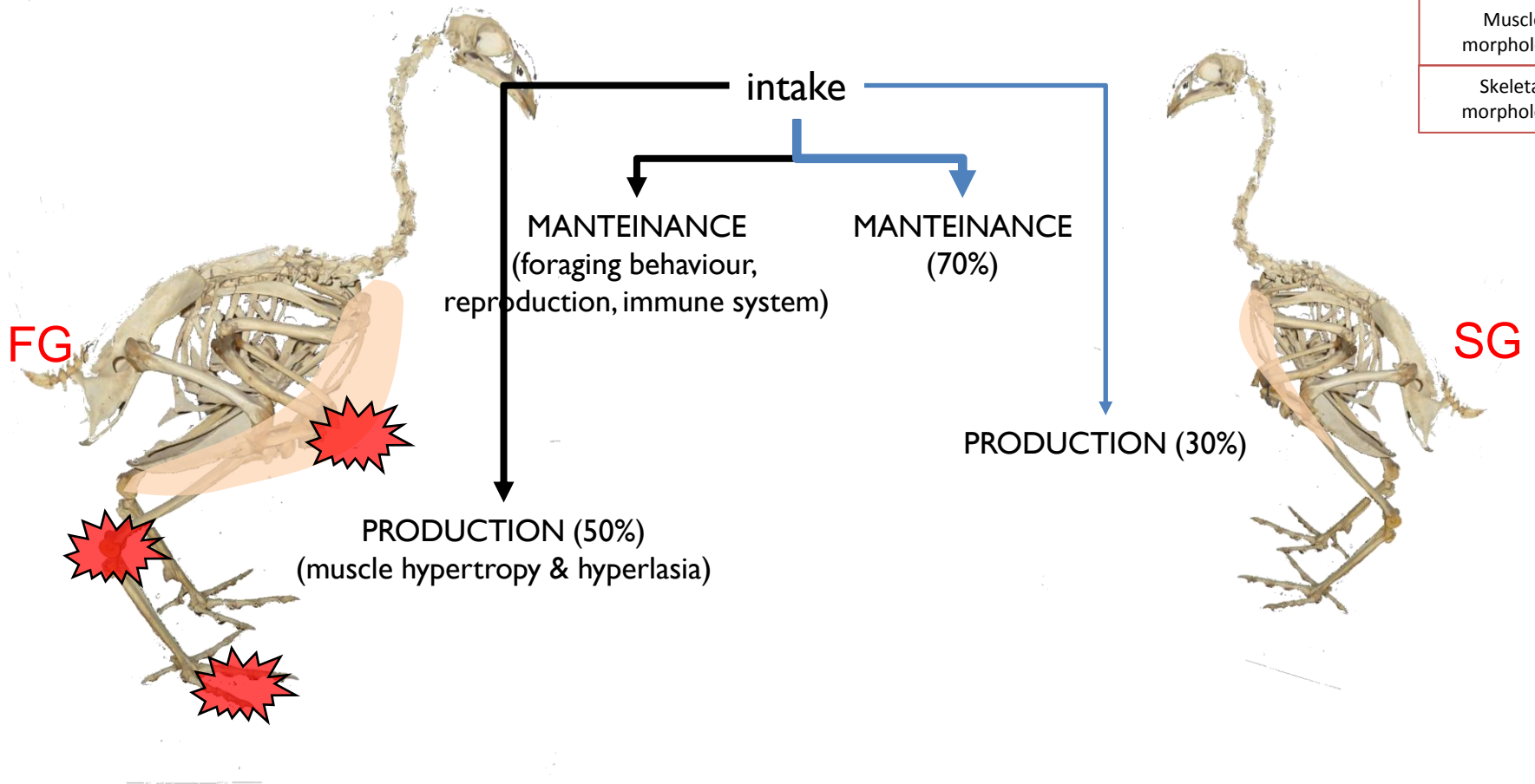


Outdoor adaptability criteria

Extensive Rearing System (ERS)
must **optimize a production
system that promotes
biodiversity, environmental
sustainability and food safety**
(National Organic Standards
Board, 1995)



RESOURCE ALLOCATION



Low weight

DWG

Muscle morphology

Skeletal morphology



sternal lesions

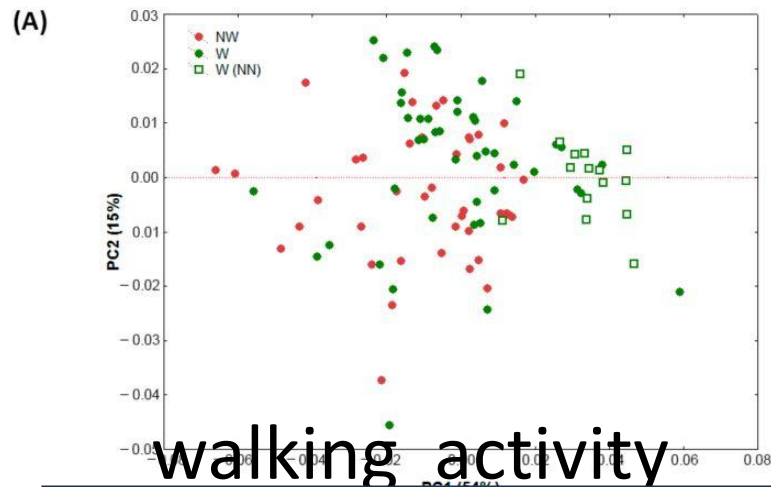


plantar lesions

VSG <30g/d SG 30-45 g/d FG >45 g/d

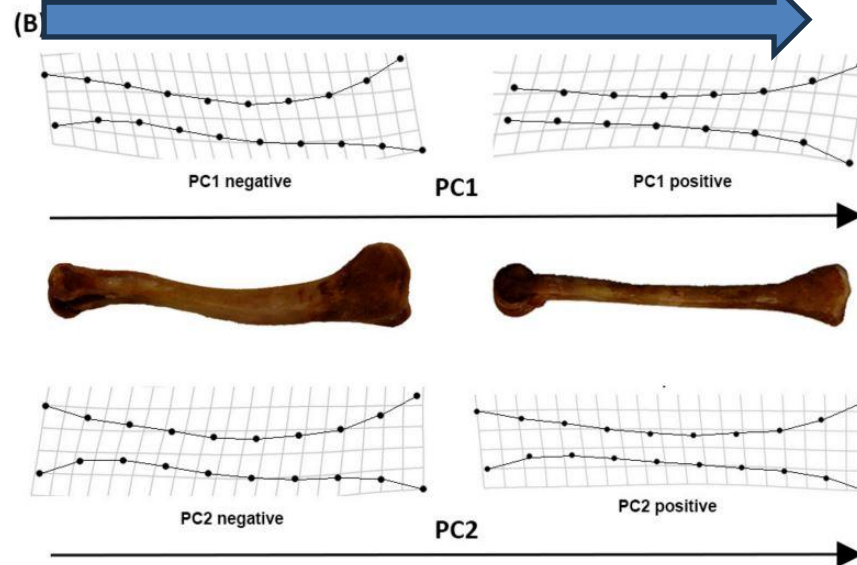


Tibia length and shape

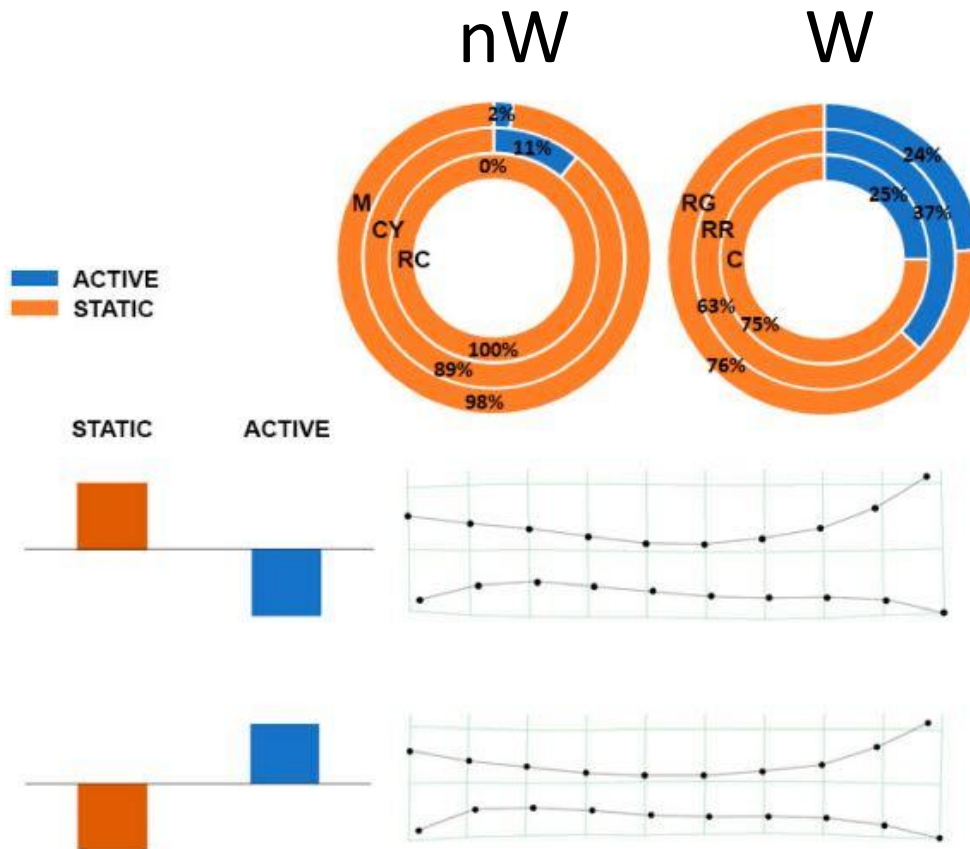


(A) Principal component analysis plot of chicken classified on the basis of walking activity.

- walking (W)
- not-walking (NW)
- walking naked neck (W-NN)



(B) Shape variation along PC1 and PC2 was represented by splines relative to positive and negative extremes of the axes. For shape variation along PC1, tibiae of two extreme individuals were reported.



Partial least squares (PLS) showing the **morphological relationship between the tibia and the walking/resting behavior** described as a percentage of time spent in two main activities (Walking W and Not Walking—NW).

Percentages for each genotype are represented in pie charts. The splines depict tibia shape configuration corresponding to opposite patterns of behavior.



DWG
(g/d/bird)

32.11

32.50

34.91

41.90

42.36

44.83

48.87

Walking (W) chickens

Not-Walking (NW) chickens

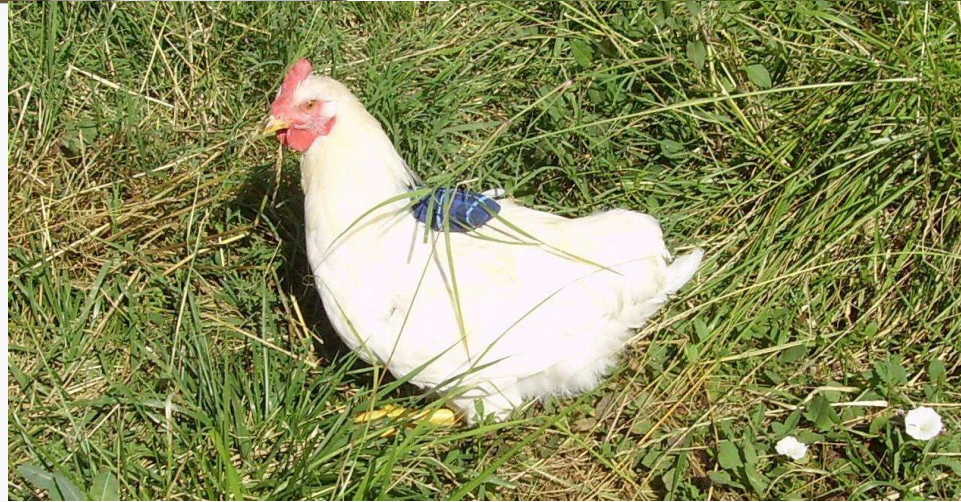
Cartoni Mancinelli et al. (2021)
Pulcini et al. (2021)

Use of outdoor run*



* Schematic representation of the exploitation of the outdoor run by the different genotypes on the basis of behavioral observations or GPS movement detection in different experimentations

Behavior of different strains



(link:www.trackstick.lu/htm)

Device Name: Trackstick
Device Type: Super Trackstick (v 4.05)
Created By: Trackstick Manager 3.0.0

Covered distance (mt)

Slow growing Organic-plus

Records: 2361 - 2481
Dates: 06/27/2008 08:00 AM - 06/27/2008 20:00 AM
Duration: 12 hr 00 min
Distance: 1.13 kilometers
Latitude: 43 00 0972N Longitude: 12 17 5125E
Course: S Altitude: 238.1 m
GPS Fix: Y Signal: 3
Av. Temp: 27.1°C
Map Link: <http://maps.google.com/maps?q=43.000972+12.175125&h=en&t=h>



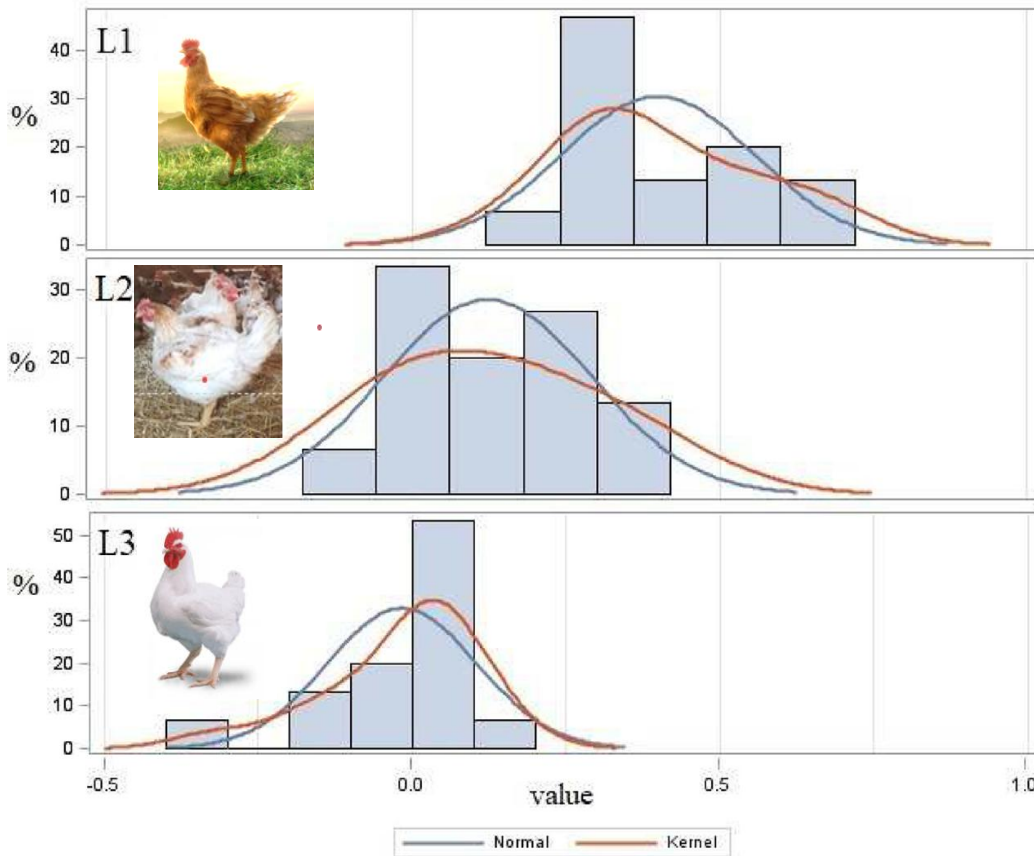
Fast growing organic

Records: 4145 - 4265
Dates: 06/28/2008 08:00 AM - 06/28/2008 20:00 AM
Duration: 12 hr 00 min
Distance: 0.22 kilometers
Latitude: 43 00 0837N Longitude: 12 17 4834E
Course: S Altitude: 229.9 m
GPS Fix: Y Signal: 3
Av. Temp: 26.9 °C
Map Link: <http://maps.google.com/maps?q=43.000837+12.174834&h=en&t=h>



KINETIC ACTIVITY

Activity index



Probability distribution expressed as percentage, normal and density curves of Activity index in three commercial lines.

Commercial lines:

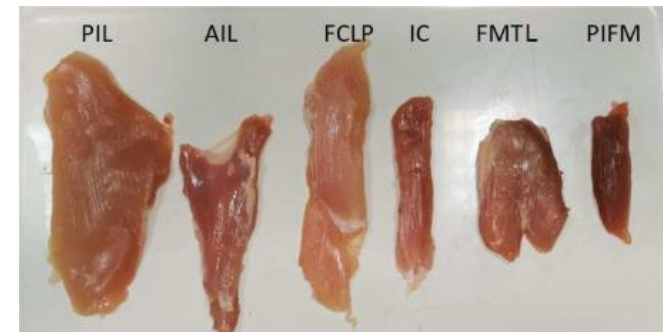
L1 = active commercial line;

L2 = sedentary commercial line;

L3 = Fast Growing Ross 308.

The blue lines indicate normal distribution;

The red lines indicate kernel density estimation.



Failla et al., 2021 – Poultry Science

$$\text{Activity index} = \frac{\text{White m (n - 3 HUFA)} / \text{ALA} - \text{Red m (n - 3 HUFA)} / \text{ALA}}$$

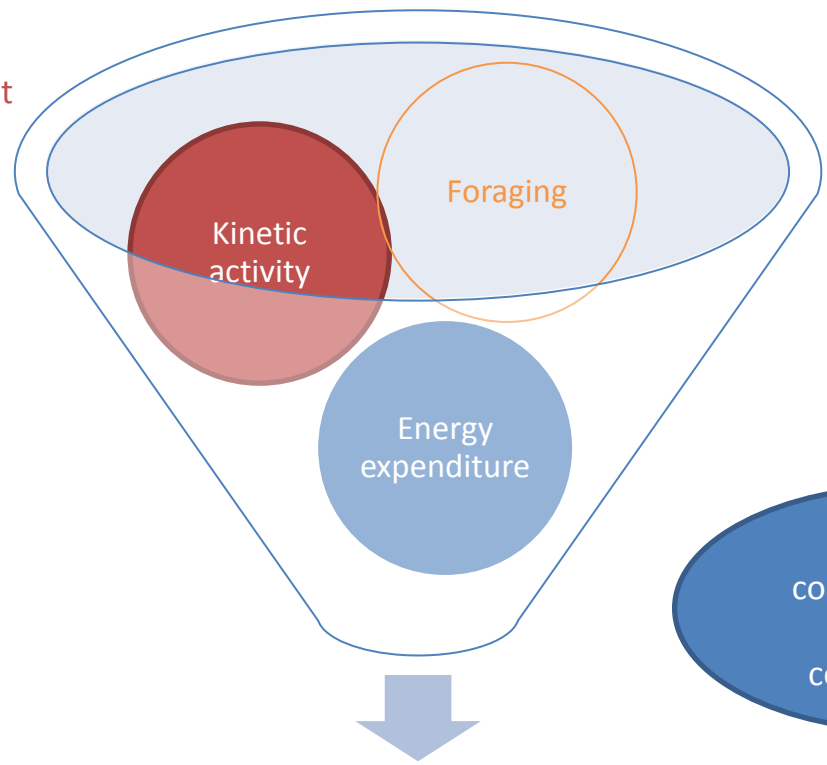


In vivo
Oxidation

Antioxidants
PUFA n-3

↑lipid/protein oxidation of meat
↓ Shelf-life of meat
↓ technological quality

↑ animal welfare (disease)
↑ meat antioxidants
↓ meat oxidation
↓ technological quality



Activity index

LC-PUFA
consumption for
energy
compensation

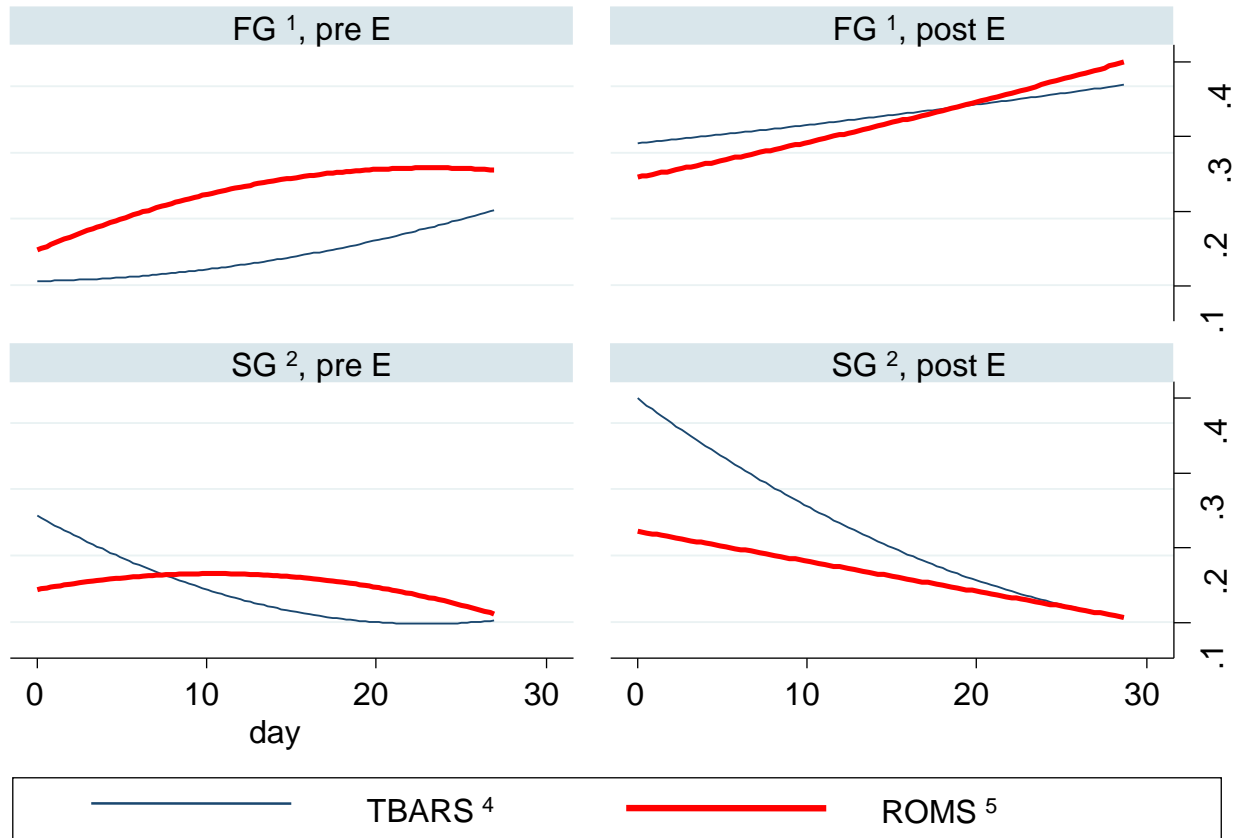
↓ fat deposit
↓ lipid % in meat
↓ healthy PUFA

Failla et al., 2021 – Poultry Science



TREINED Walking: EXERCISE IN FAST vs SLOW-GROWING

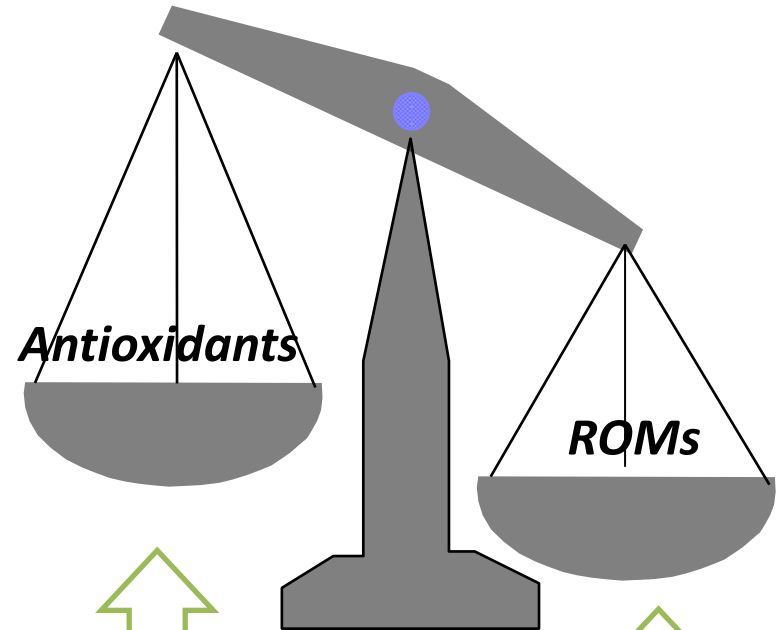
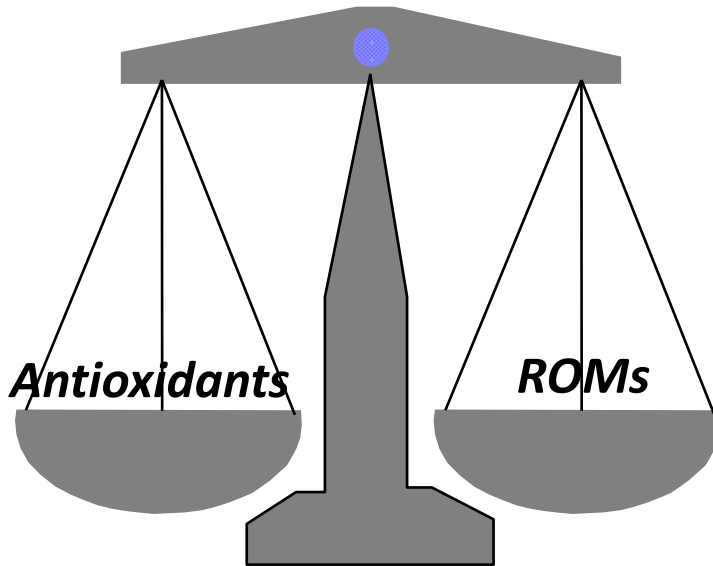
Kinetic activity



Mattioli et al., 2014 –Poultry Science

IN VIVO

What means
*Trained and not
trained animals?*

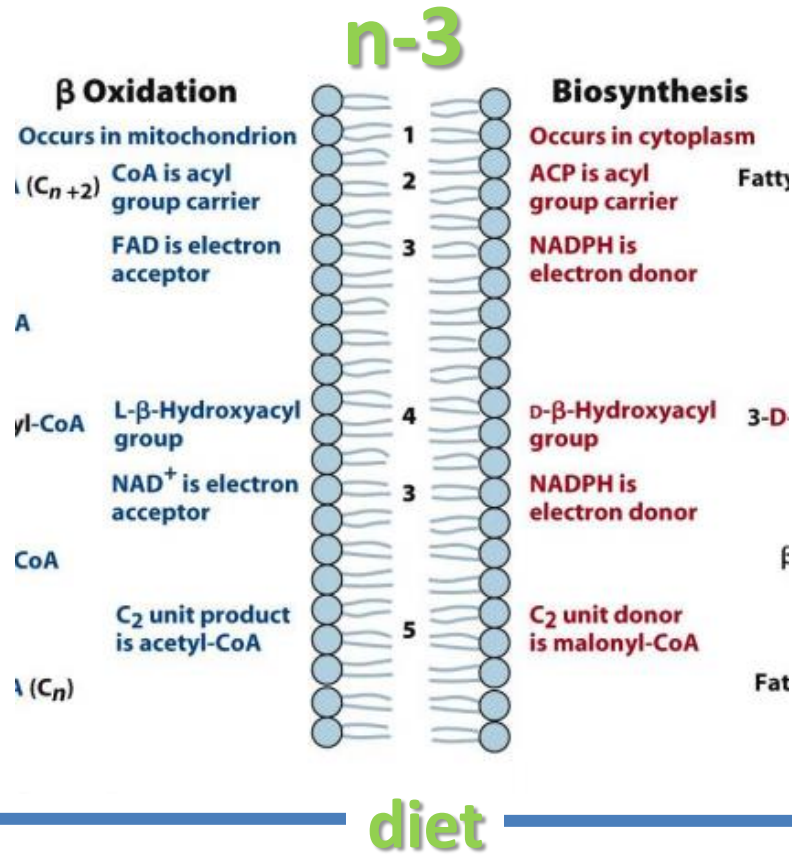
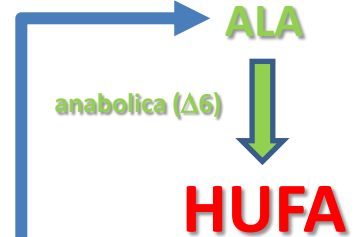
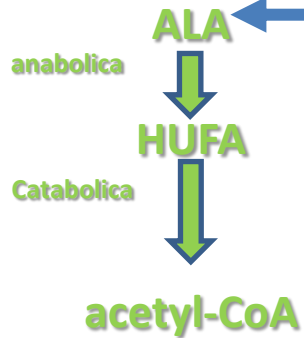


↑
*Health status
Antioxidants intake*

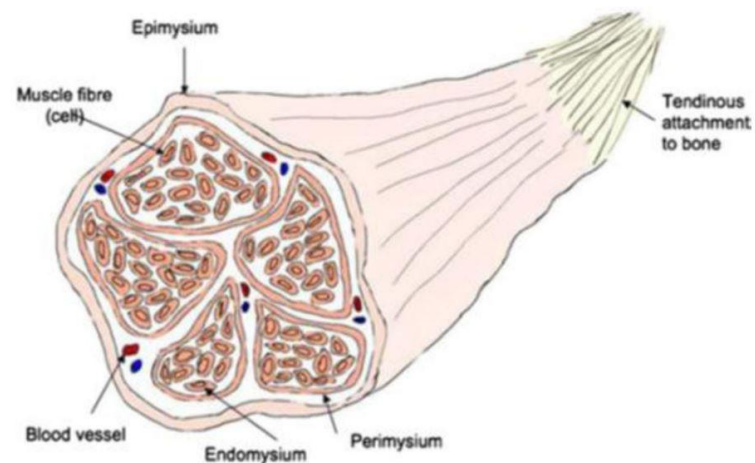




Energy expenditure



Muscle chickens' changes in the last 70 years



Chang et al., 2016 – *Animal Production Science*
Smith et al., 2010 – *Meat science*

Meat Cuts morphology



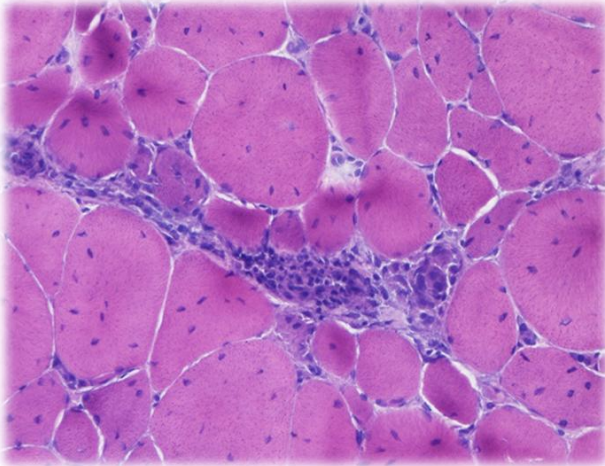
Muscle fiber and genetic strain

	Fiber	Slow-growing	Fast-growing
<i>Pectoralis major</i>	α R (1)	4	0
	α W (2)	96	100
<i>Biceps femoris</i>	α R	56	37
	α W	44	63

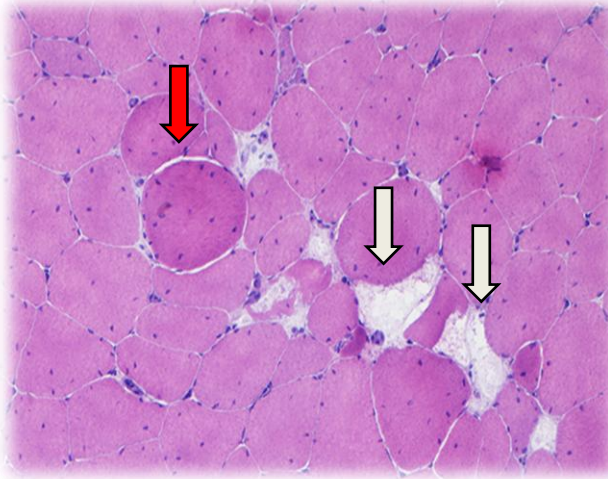


Branciari et al., 2009 – *Journal of Animal Science*

Muscle anomalies in broilers



Ross; *PM*. Inflammatory infiltrates composed mainly by lymphocytes, plasma cells and macrophages.

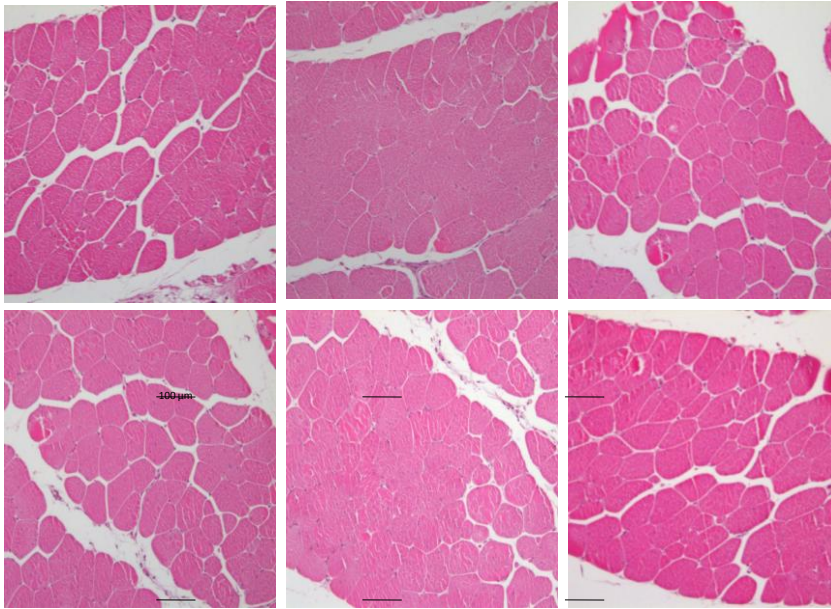


Ross; *PM*. with muscle fibers necrosis (black arrows) and giant fiber (red arrow)

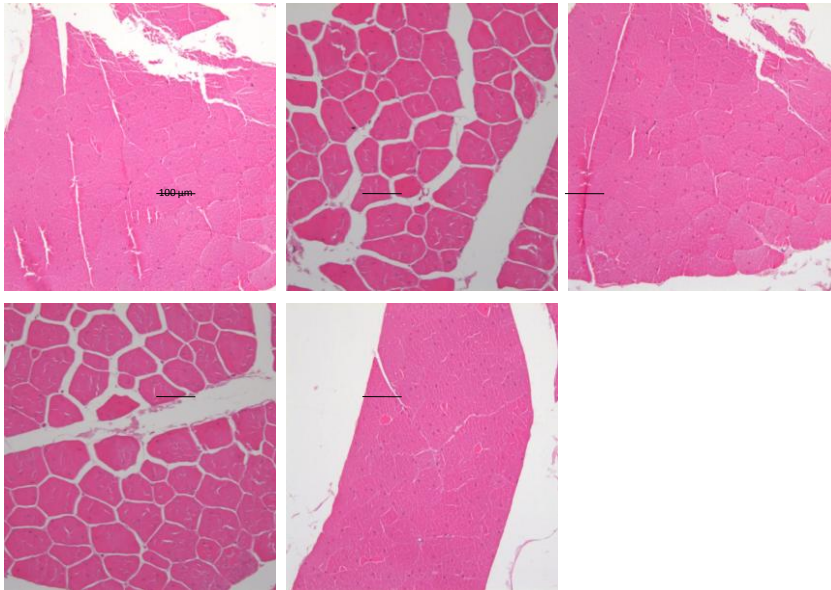
	Broiler	Leghorn
Fibers (n/microscopic field)	49.99 _a	140.15 _b
Capillaries (n/microscopic field)	24.56 _b	22.35 _a

Sforna et al., 2017 – *Italian Journal of Animal Science*

FG



SG



Many more nuclei
within the myofibers in
SG than FG

Number
of fibers

direction

Research In progress

METABOLIC ASPECT: STORAGE CAPABILITY of LIPID



Very Slow growing

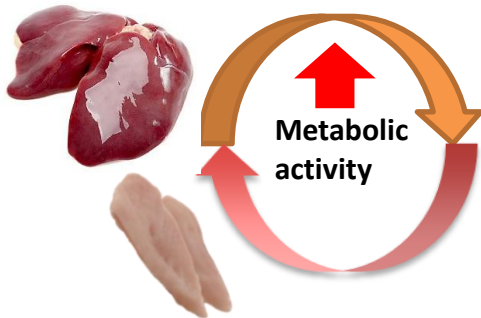


medium growing

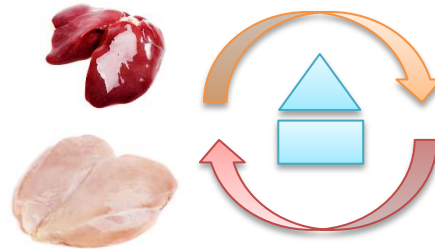


Fast growing

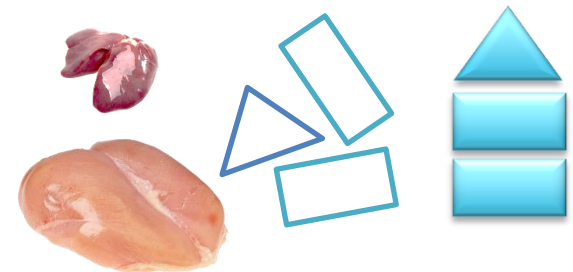
RECYCLE and TURNOVER



INTERMEDIATE trend

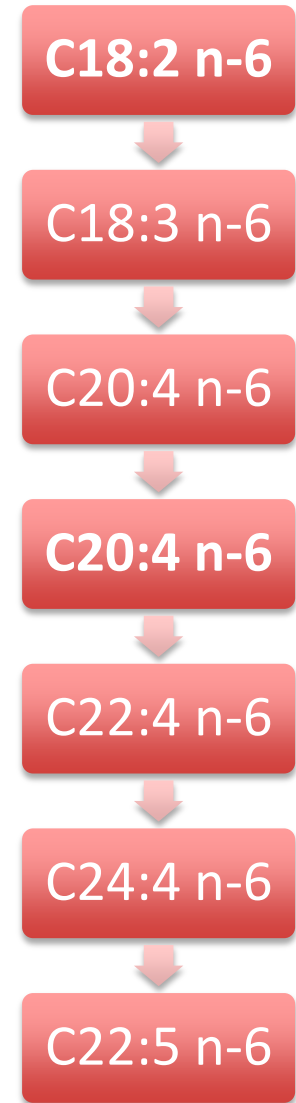
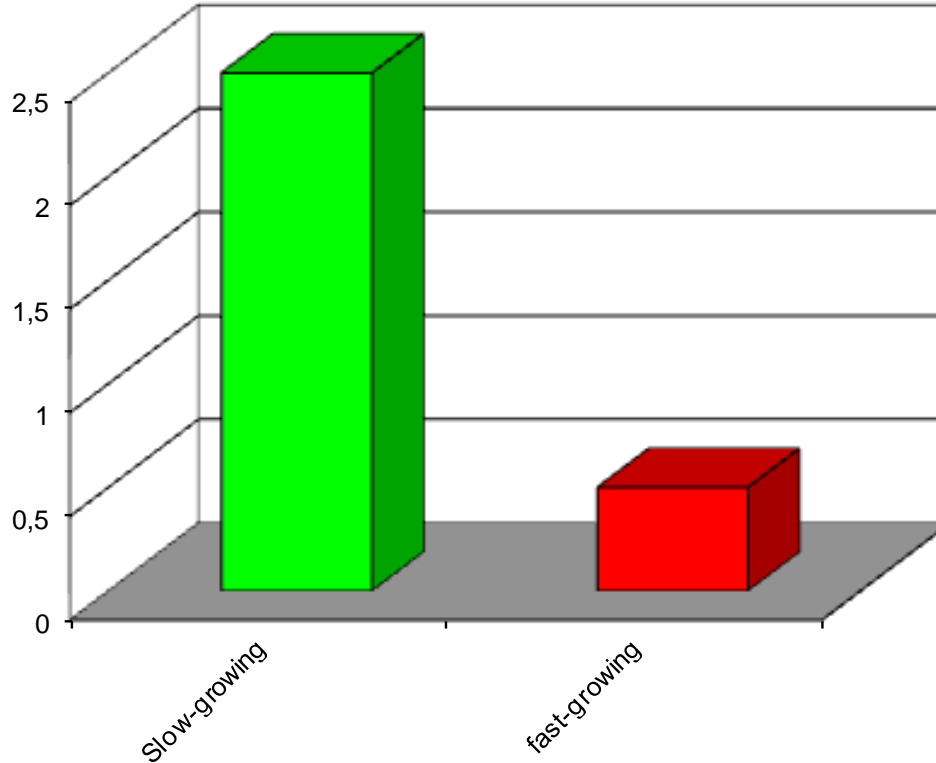
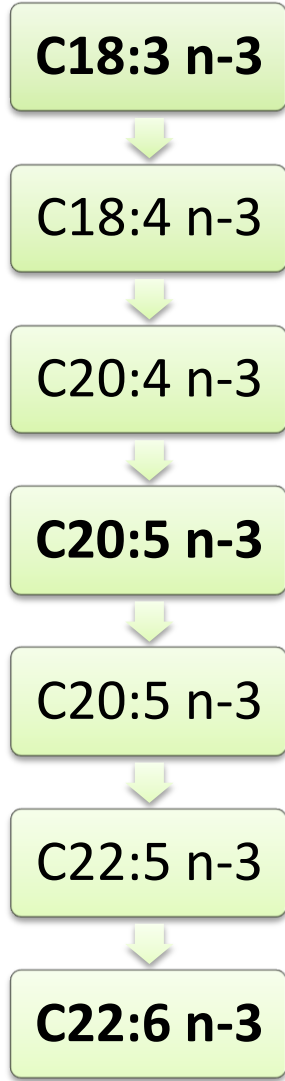


STORAGE and STRUCTURE

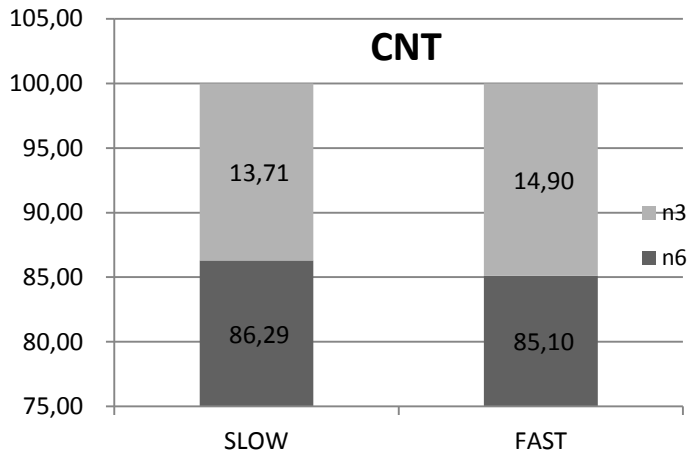


Cartoni Mancinelli et al., 2022 – *Scientific report*

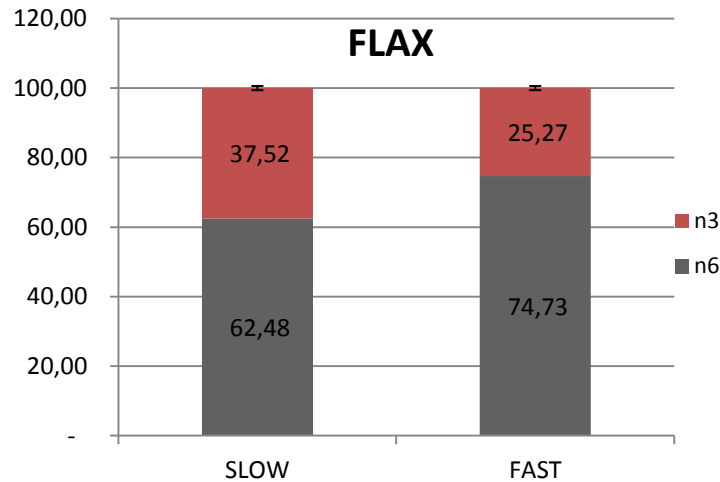
LCP n-3 in poultry strains



Diet and Genotype



Δ6-desaturase activity (da 18:3 ω3): CONTROL				
	num	liver	pmoli/mgprot/30min	Media
SLOW	10	C1	76,88	85,11±11,6
	13	C5	93,33	
FAST	12	C1	84,76	99,34±20,6
	15	C2	113,91	

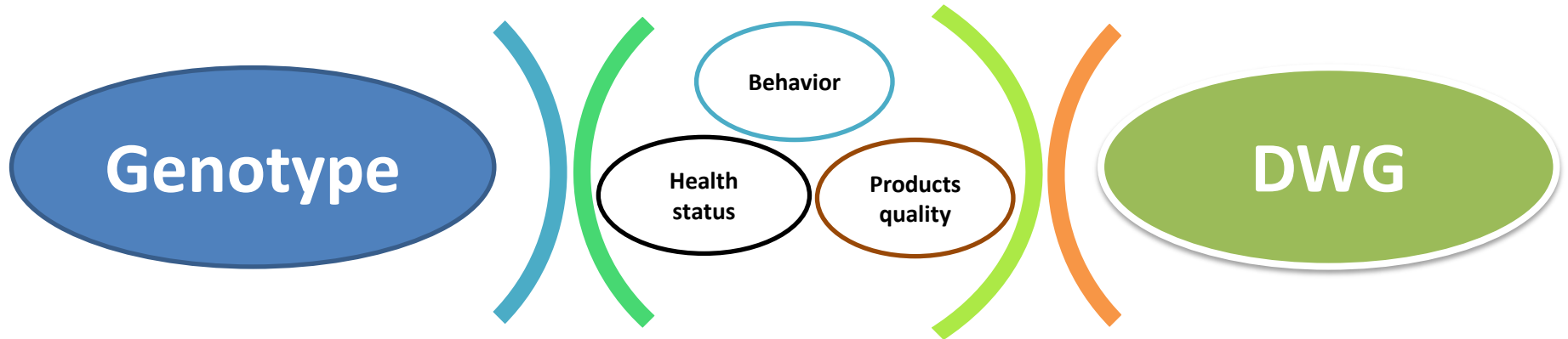


Δ6-desaturase activity (da 18:3 ω3): FLAX				
	num	liver	pmoli/mgprot/30min	Media
SLOW	24	L5	288,79	285,77±4,8
	25	L2	282,74	
FAST	27	L1	135,51	207,91±65,5
	28	L2	262,98	
	29	L5	225,24	

Mattioli et al., 2014 – PhD dissertation

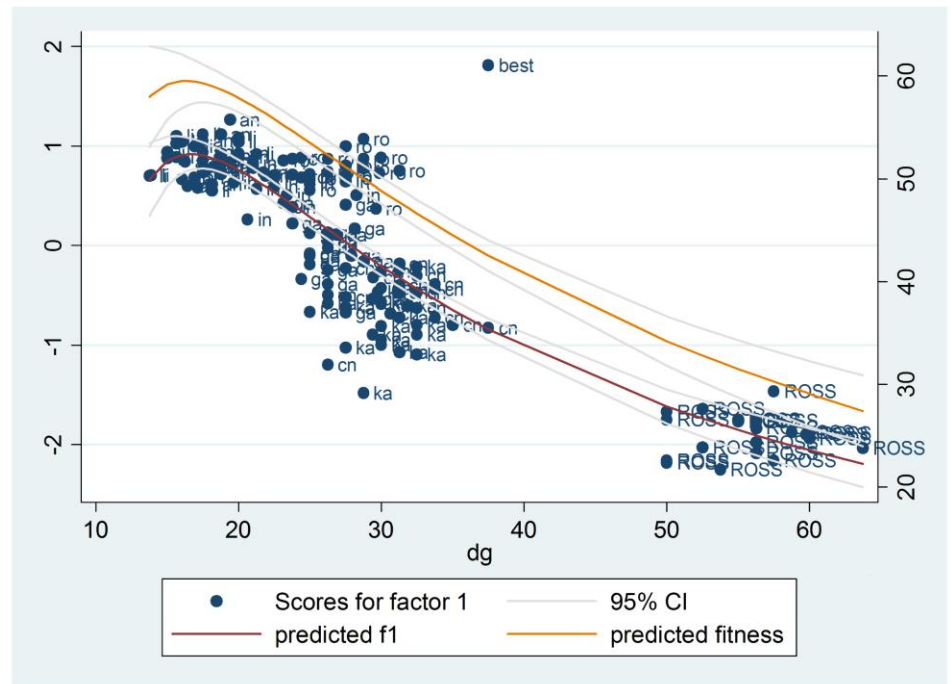
What means “suitable broiler genotypes adapted to outdoor system»?

ADAPTABILITY



	Leghorn	Ancona	Crossbreed	Gaina	Robusta Maculata	Kabir	Naked Neck	Ross 308	Pooled SE
Adaptability index	0.49	0.50	0.58	0.41	0.94	0.56	0.18	-1.77	0.50
	VSG			SG				FG	
Mean±SD	0.53±0.41			0.52±0.90				-1,77±0.48	

Behavior
Welfare
(lesions, feather condition, TI)
Health status
(physiological parameters)



Castellini et al., 2016 – Italian Journal of animal science



Ranger Classic (R1)



Ranger Gold (R2)



Rowan Ranger (R3)



Campese (A)

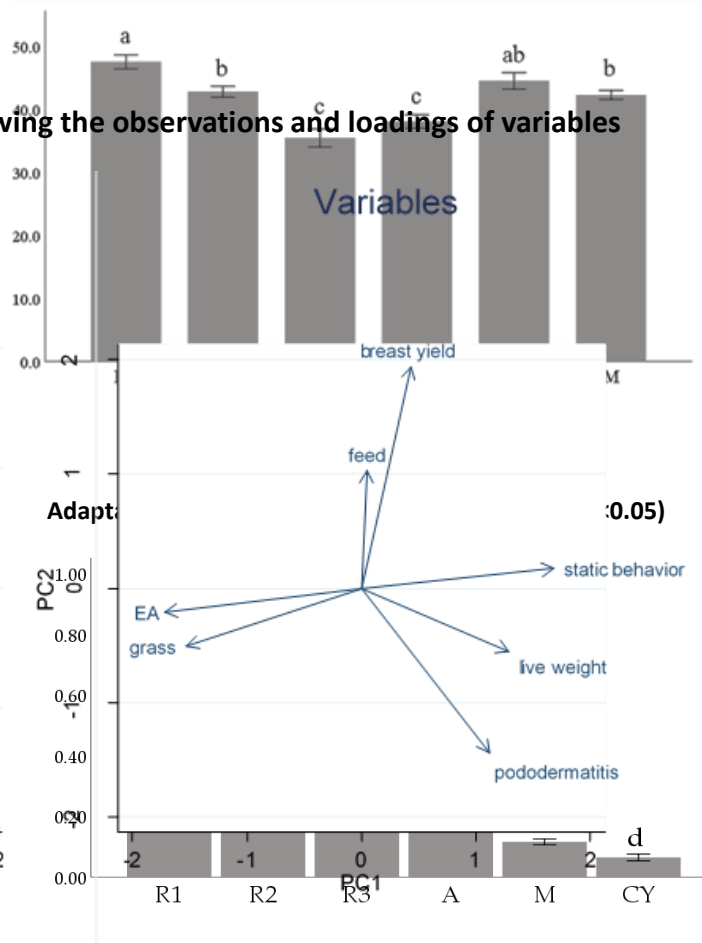


CY Gen 5 x JA87 (CY)

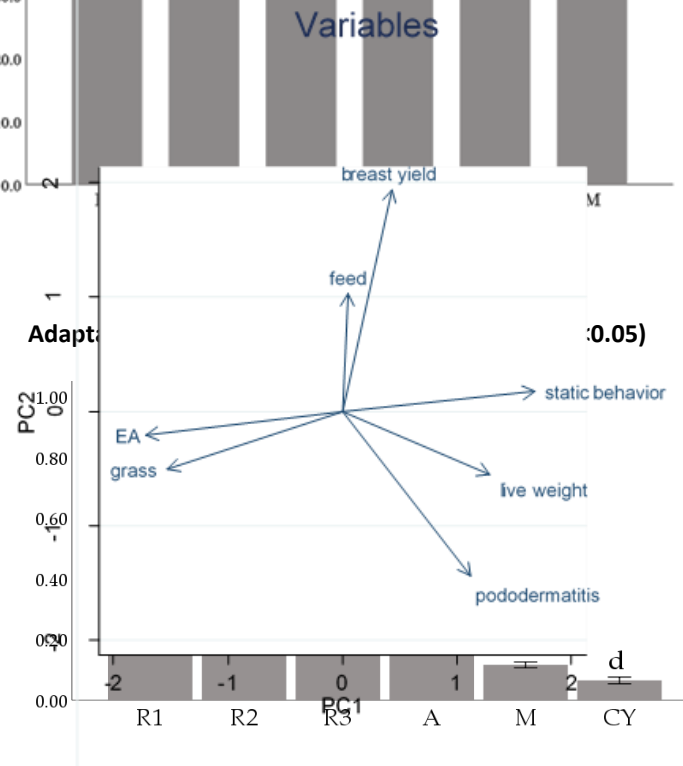


M22 x JA87 (M)

Daily weight gain (g/d) of six poultry genotypes on the entire rearing cycle (p<0.05)



Principal Component Analysis plot showing the observations and loadings of variables



Behaviour
Welfare
(lesions, feather condition, TI)
Performances

Cartoni Mancinelli et al., 2020 – *Animals*





Ranger Classic (R1)



Ranger Gold (R2)



Rowan Ranger (R3)



Campese (A)

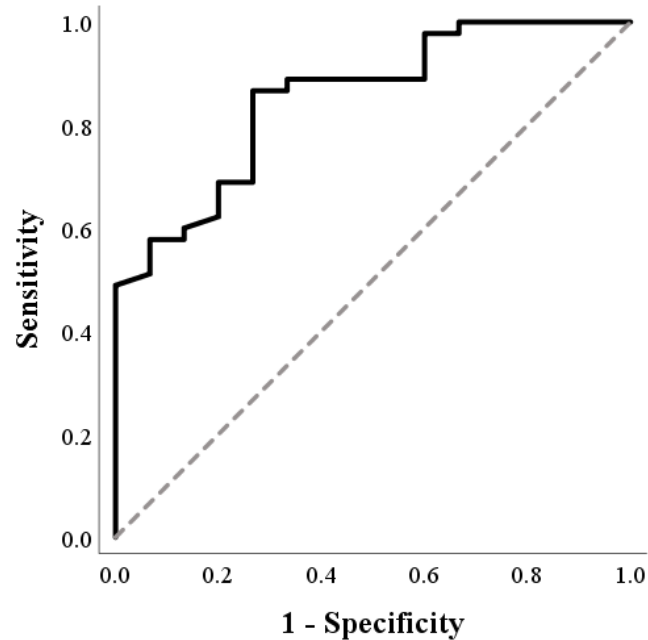


CY Gen 5 x JA87 (CY)



M22 x JA87 (M)

ROC curve, indicated that the DWG was a moderately accurate predictor of adaptability and that, when DWG was ≥ 38.6 g/d, it predicted a low adaptability with a sensitivity of 87% and a specificity of 73%. Moreover, for each 1 g/d increase in DWG, the odds of having a low adaptability increased by 42%.

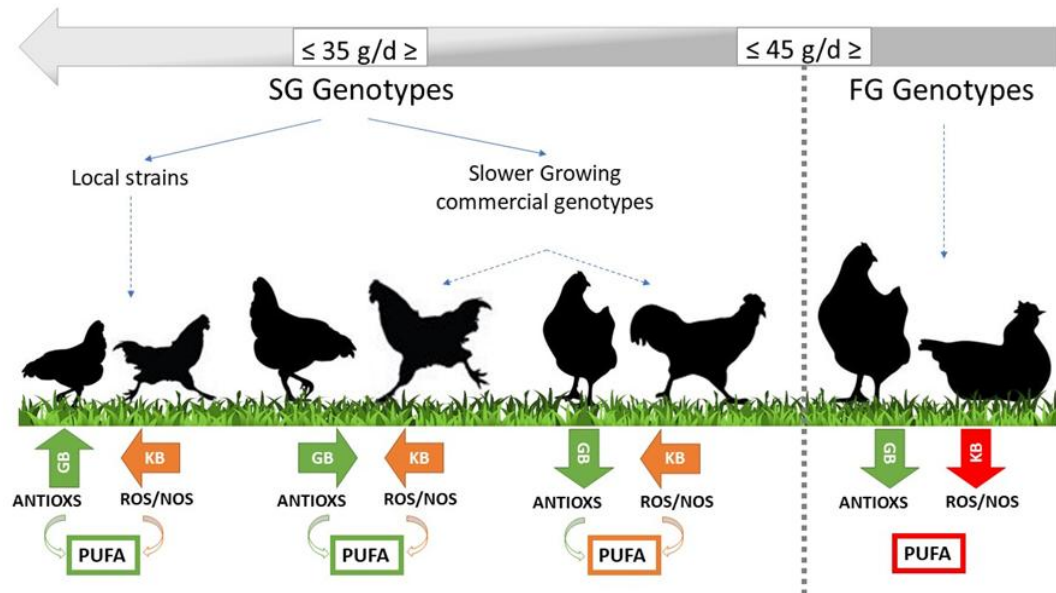


Behavior
Welfare
(lesions, feather condition, TI)
Performances

Cartoni Mancinelli et al., 2020 – *Animals*

How to choose the best genotype to use in ERS?

- ❖ DWG~35 g/d and < 45 g/d
- ❖ Use a multicriteria approach which take into account many aspects (behaviors, welfare, physiology, health status, performance, quality)



Dal Bosco et al., 2021 – *Animals*

PPILOW results are coming, see you after break

Experiment conducted in spring 2021 to better understand range use

Dual-purpose
16g/d
Reared for 14
weeks

JA757
36g/d
Reared for 10
weeks

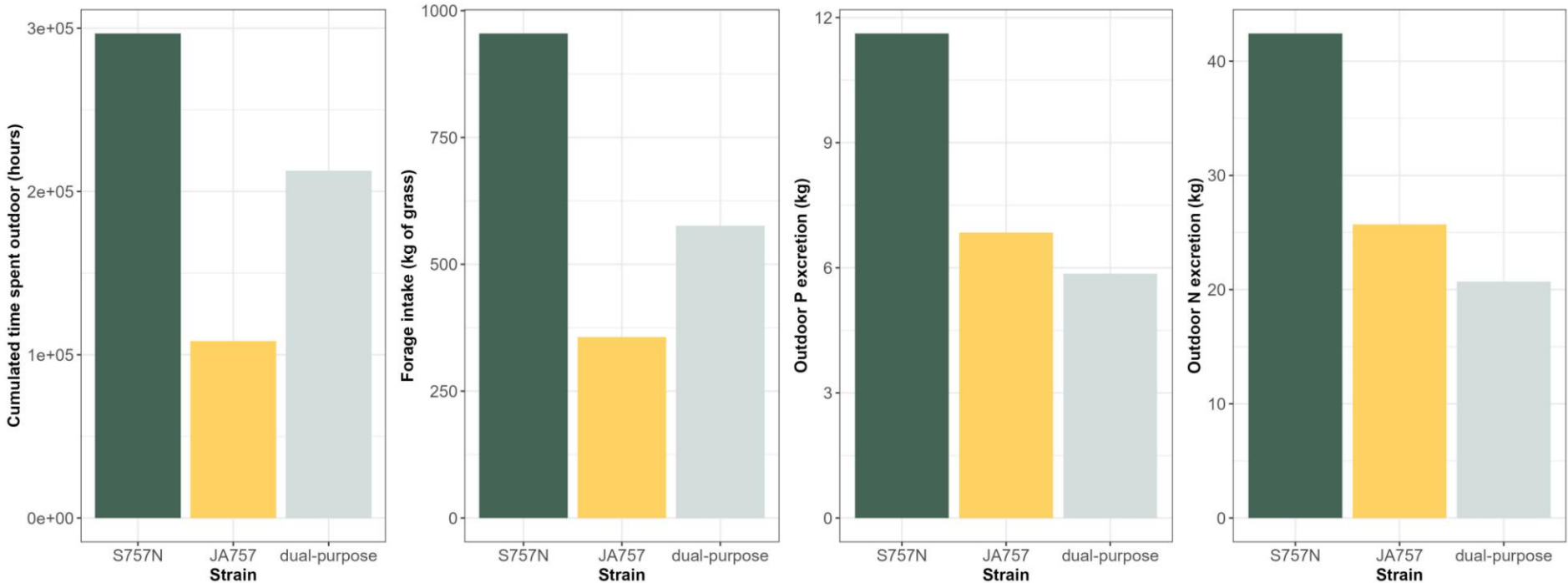
S757N
26g/d
Reared for 12
weeks

White Bresse
23g/d
Reared for 15
weeks



750 mixed sex chickens

Environment and range use ?



The S757N strain spent twice more time outdoors than the two other strains

The S757N strain consumed about twice as much grass per day as the two other strains

The S757N chicken outdoor excretions of N and P per day of outdoor access were about 200% and 30% greater than those of dual-purpose and JA757 chickens, respectively

At the level of the individual ?

Is range use a personality trait ?

- Time-consistent?
- Consistent across season?

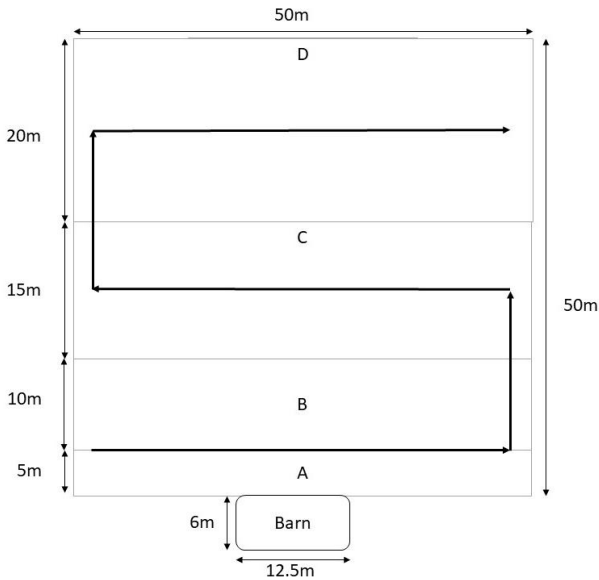
Ferreira et al
S757N strain
Meadow
Behavioural observations

Bonnefous et al
JA757, S757N,
White Bresse and
a dual purpose
strain
Tree covered
grassy outdoor
Behavioural
observations

Collet et al
JA757, S757N,
and a dual
purpose strain
Tree covered
grassy outdoor
Radio Frequency
Identification

Behaviour: methods

Behavioural observations

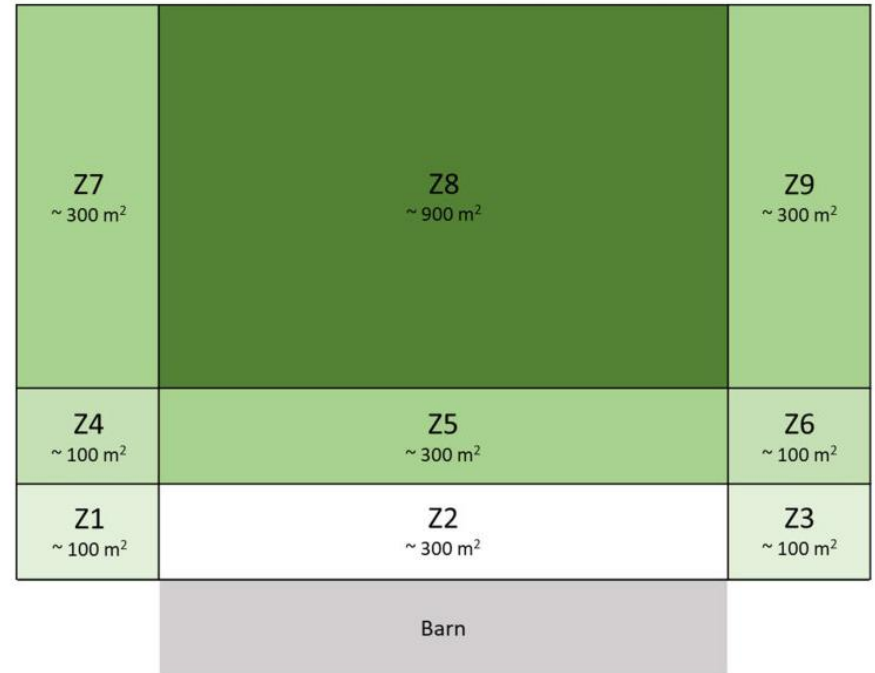


7 scans per
day of
observations
11 to 15
days of
observation

Distance index
 $= NTa \times 2.5 + NTb \times 10 + NTc \times 22.5 + NTd \times 40$

Discontinuous
Accurate indicator of range use
4 strains

Radio Frequency Identification



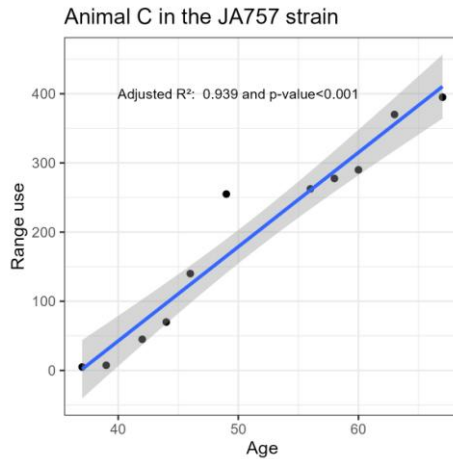
Continuous
Error rate of 15% for JA757 and
only around 2 % for dual-purpose
and S757N
3 strains

Behaviour: time-consistency of range use

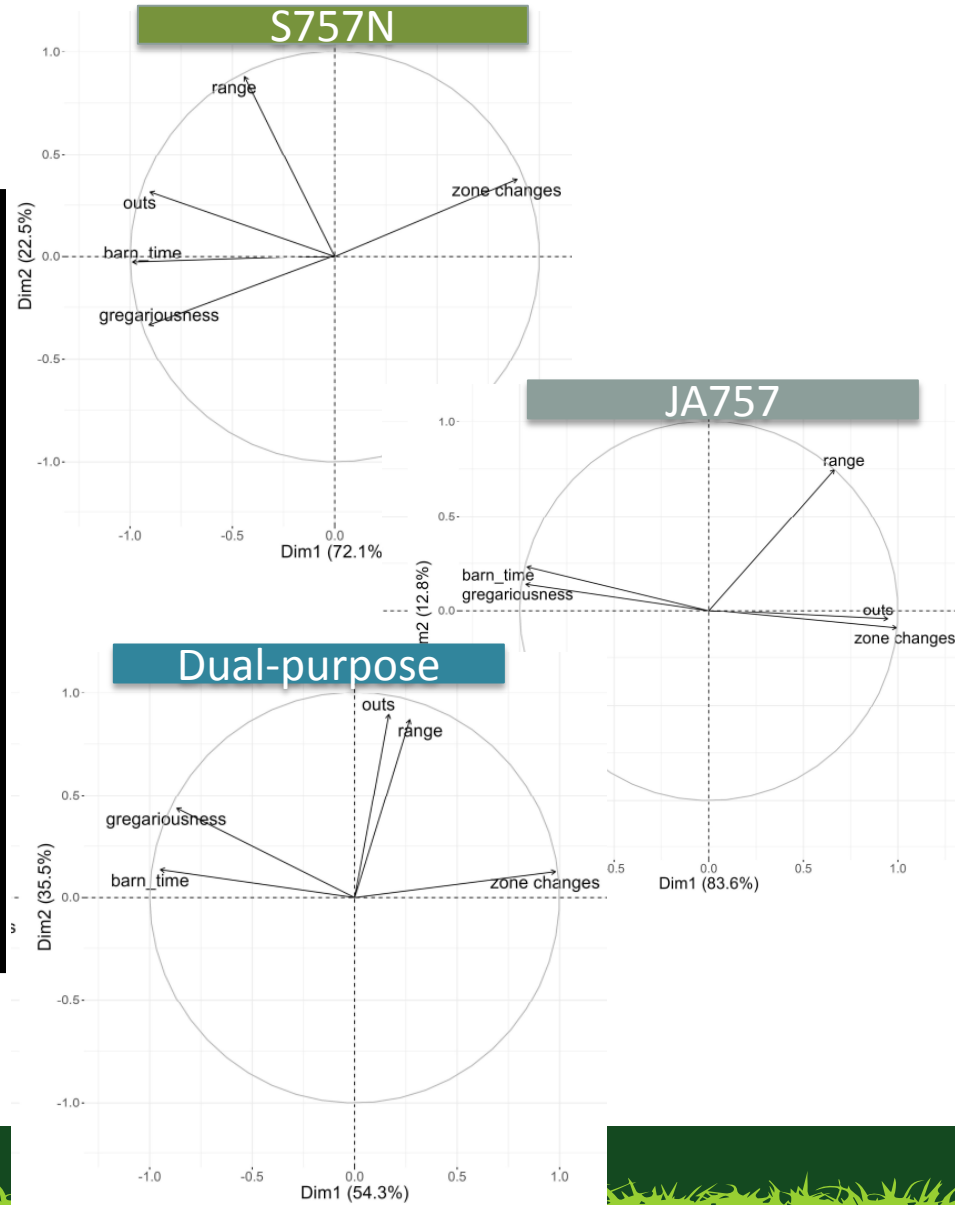
Behavioural observations

S757N: sum of the five first days of scans and the five last days of scans

	0.8	0.5	0.3	0.1	$x <$
	$< x$	$< x <$	$< x <$	$< x <$	0.1
	0.8	0.5	0.3		
JA757	86	8	3	1	0
S757N	89	10	1	0	0
White Bresse	99	1	0	0	0
Dual-purpose	82	12	3	0	1



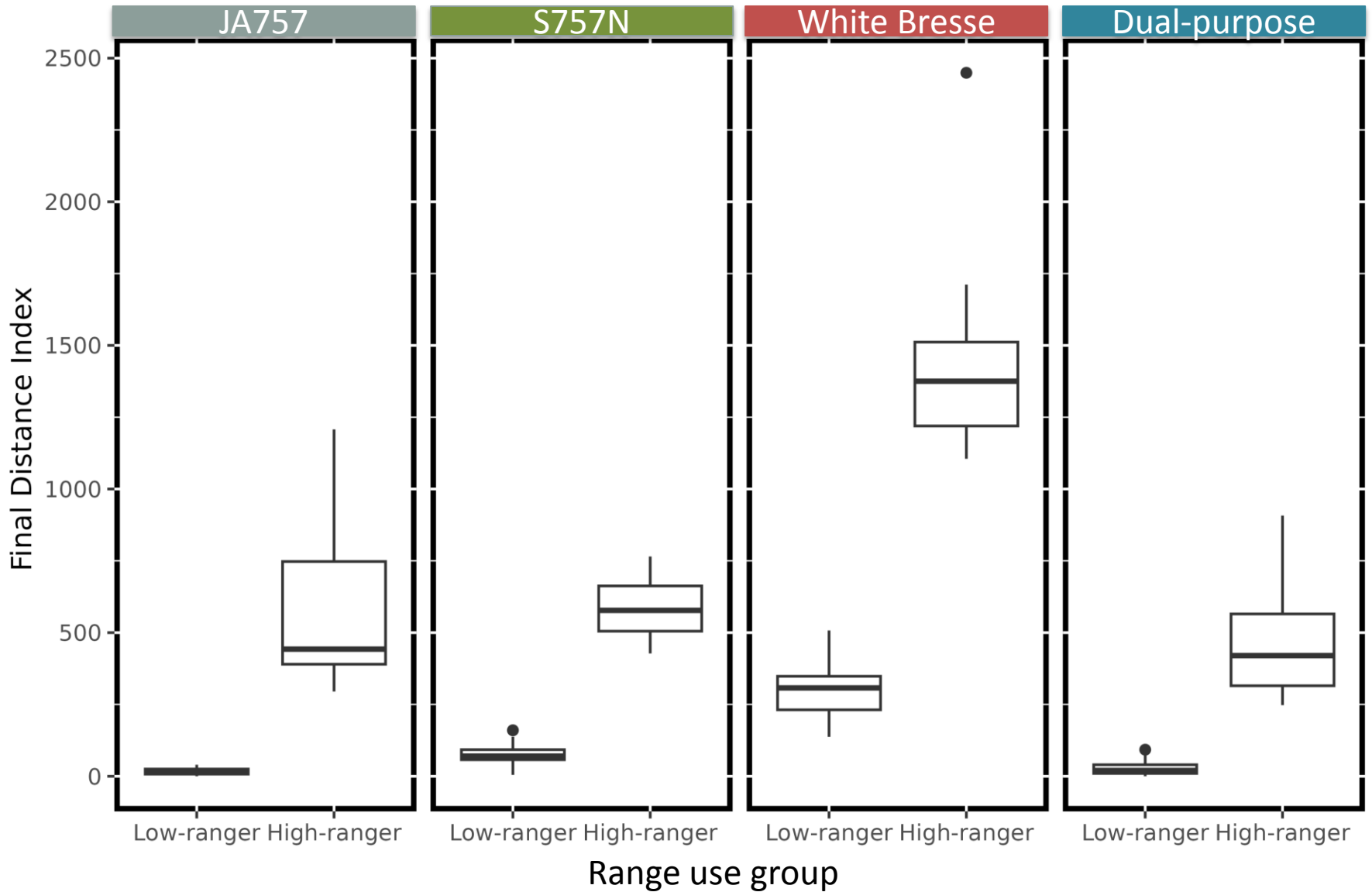
Radio Frequency Identification



Consistency between strains and in time



Behaviour: selecting chickens on their range use



Behaviour: variables related to range use

Ferreira et al., first work : cognition, foraging and motivation to work for food

Simple cognitive capacities:

- Preference test
- Color guidance

No difference between high and low-rangers

Complex cognitive capacities:

- Spatial memory
- Flexibility

Low-rangers showed higher performances than high-rangers

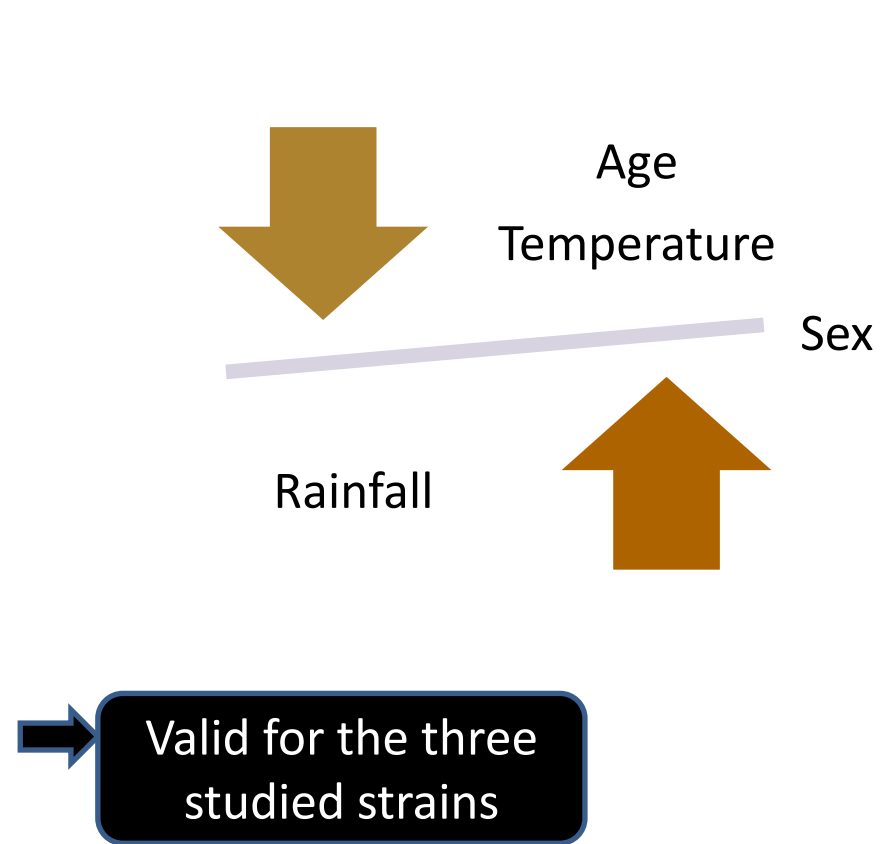
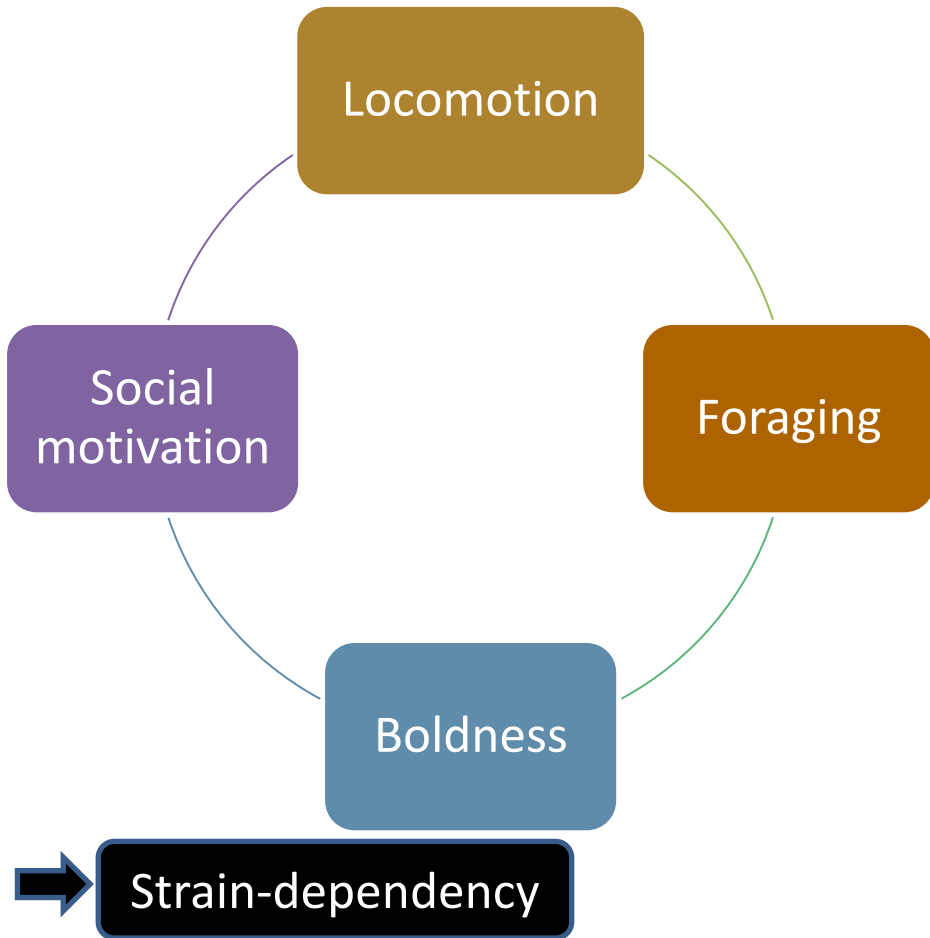
Foraging
Contrafreeloading

High-rangers express more foraging, more motivation to work for food than low-rangers

Behaviour: variables related to range use

Behavioural observations

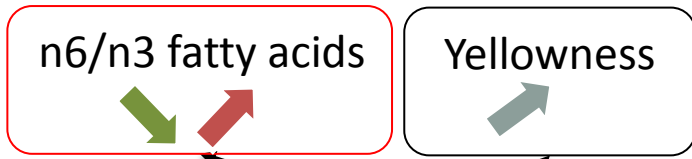
Radio Frequency Identification



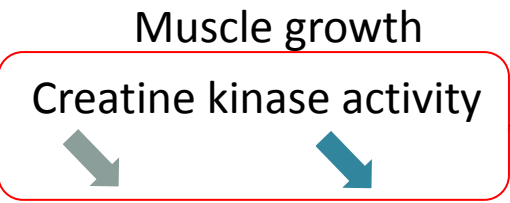
Variables related to range use at slaughter

Welfare indicators at slaughter

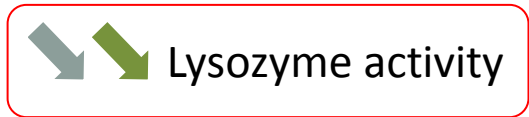
- ★ JA757
 - ★ S757N
 - ★ White Bresse
 - ★ Dual-purpose
- In the blood



No difference by range group :
 Pododermatitis
 Hock burns
 Duration of wing flapping
 Struggling on the slaughter line



Immunity / Anti-inflammatory systems



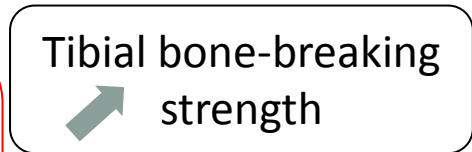
Performances

Redox status

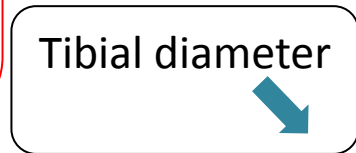
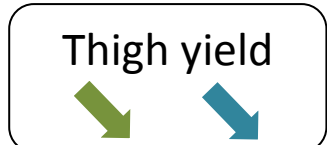
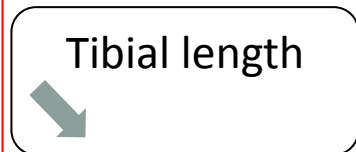
Bone Health



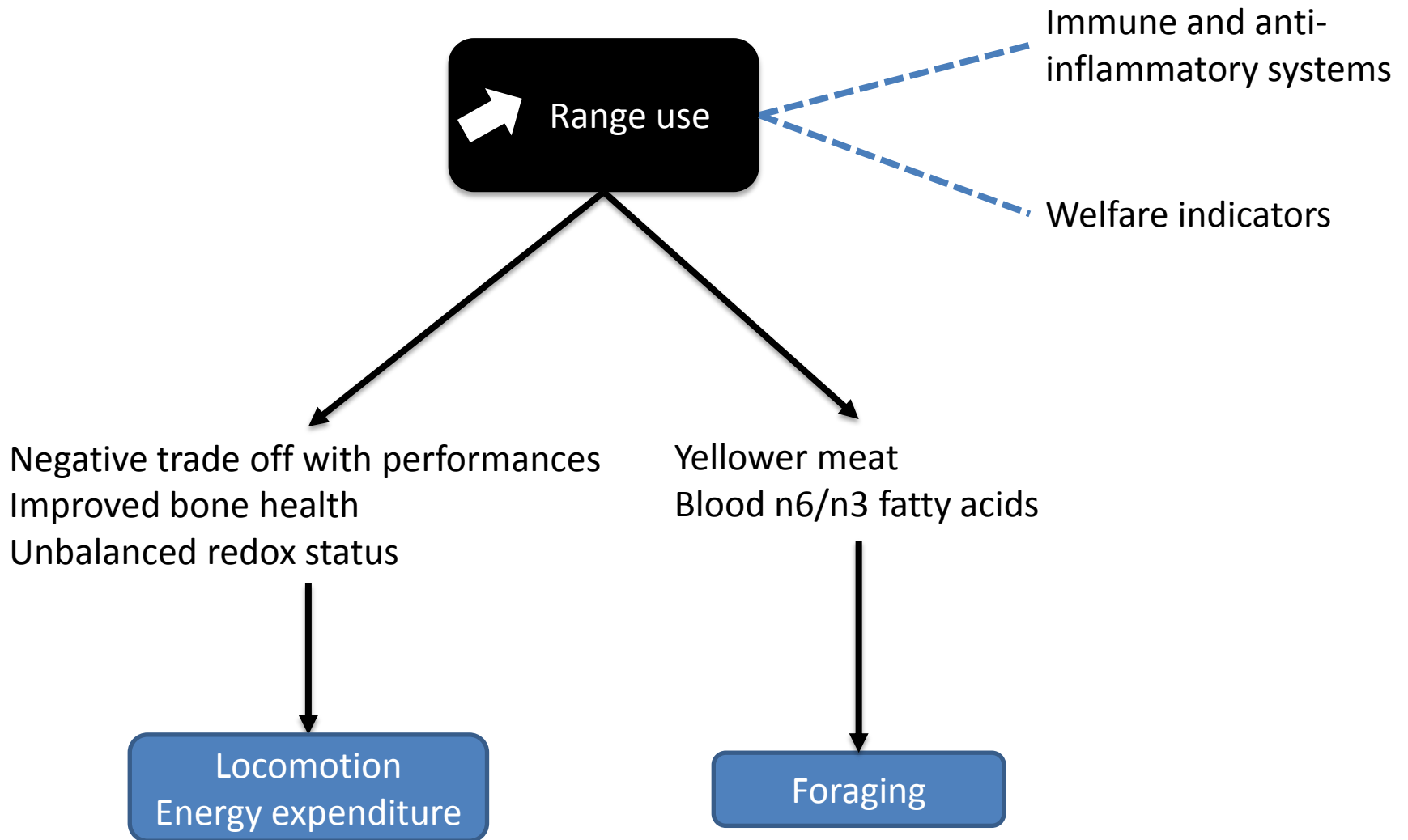
Oxidants : [H₂O₂]



Antioxidants :
 Σ [Tocols] (grey arrow pointing down)
 [Uric acid] (green arrow pointing down)
 Total Antioxidant Status (grey arrow pointing down, red arrow pointing up)



Range use relationship with indicators at slaughter



Only foraging was significantly correlated to range visits in all periods, even before range access!!

Period		Period 2 + Period 3
		Range visits
Period 1	Standing	-0.01
	Resting	-0.12
	Locomotion	-0.07
	Foraging	0.31
	Feeding/drinking	-0.14
	Comfort behaviors	-0.16
	Environment pecking	0.01
	Positive social pecking	-0.02
	Time spent near conspecifics (SM)	0.23
	Number of zones crossed (ET)	-0.01
	Foraging (ET)	-0.03

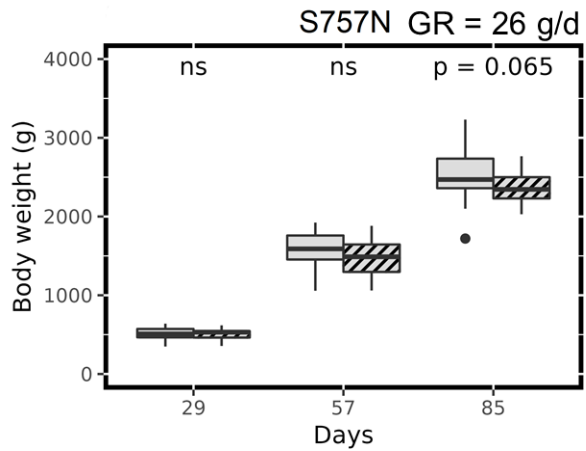
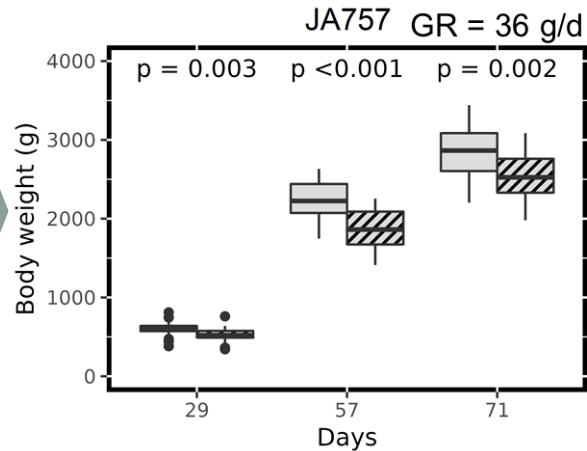
Indicators of later range use : behavioural indicators

	JA757	S757N	White Bresse	Dual-purpose
State behaviour recorded during focal sampling				
Standing	0.01	-0.01	-0.02	-0.15
Resting	-0.17	0.06	-0.08	0.00
Sleeping	-0.24	0.06	0.02	0.11
Locomotion	0.26	0.09	-0.01	0.06
Foraging	0.29	-0.02	0.17	0.04
Drinking & Eating	-0.17	-0.12	-0.02	0.06
Variables of the social motivation test				
Latency to exit	-0.09	-0.04	-0.08	-0.02
Latency to arrive to the zone close to conspecifics	-0.13	0.05	-0.10	0.09
Number of pecks	0.03	-0.14	-0.06	-0.09
Variables of the multivariate test				
Latency to make a first step	-0.09	0.05	0.07	0.00
Foraging	0.17	0.04	0.00	0.22
Number of times the chicken walked behind a wooden panel	0.05	-0.03	-0.04	-0.05
Time in the outer circle	0.02	0.20	0.00	-0.01

Indicators of later range use : body weight

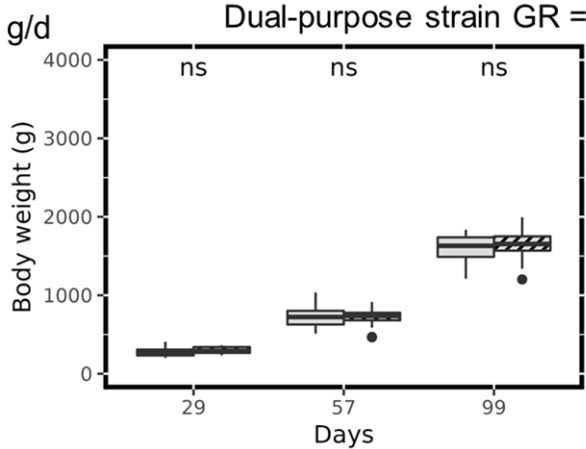
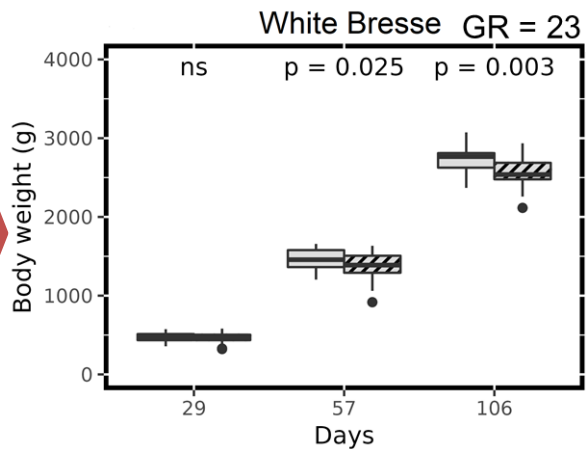
Low-rangers
 High-rangers

Differential body weight may be partly a cause of differential range use?



Differential body weight may be a consequence of differential range use?

Differential body weight may be a consequence of differential range use



No relationship between range use and body weight

Thank you for your attention

