Principal characteristics of suitable broiler genotypes adapted to outdoor system

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

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ALIMENTARI E AMBIENTALI

INRAE

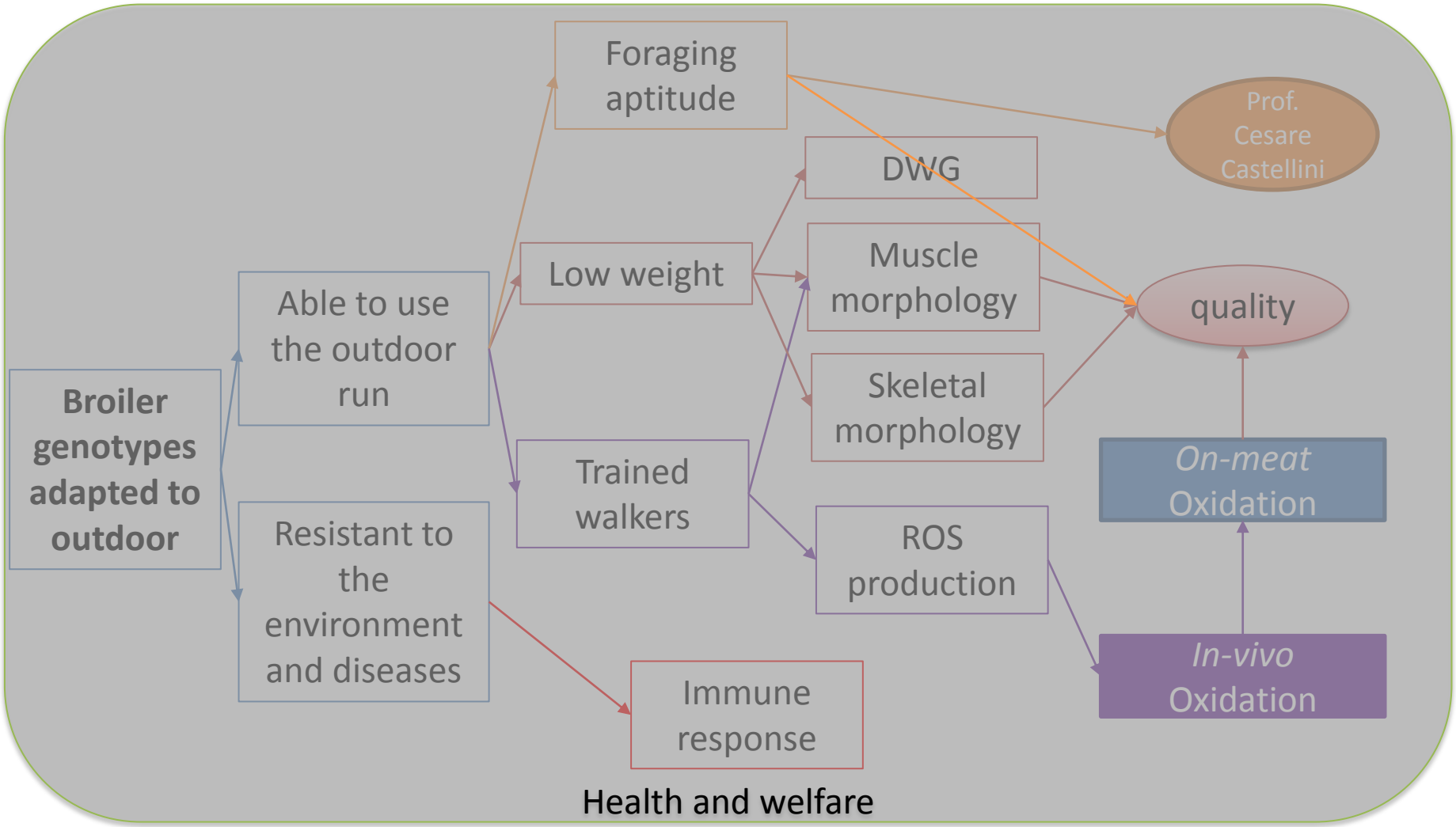
Day 2 - Session: Co-adapted systems, genotypes and animals

Principal characteristics of suitable broiler genotypes adapted to outdoor system

Simona Mattioli
Department of Agricultural, Food and Environmental Sciences (DSA3), University of Perugia
Italy

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

France


Foraging aptitude
Prof. Cesare Castellini
DWG
Low weight
Muscle morphology
quality
Able to use the outdoor run
Broiler genotypes adapted to outdoor
Skeletal morphology
On-meat Oxidation
Trained walkers
ROS production
Resistant to the environment and diseases
In-vivo Oxidation
Immune response
Health and welfare

Able to use the outdoor run

Outdoor system mandatory conditions

- the chickens need to **go out**

too much sun, rain, wind

Environmental enrichments

- presence of **pasture**

vs

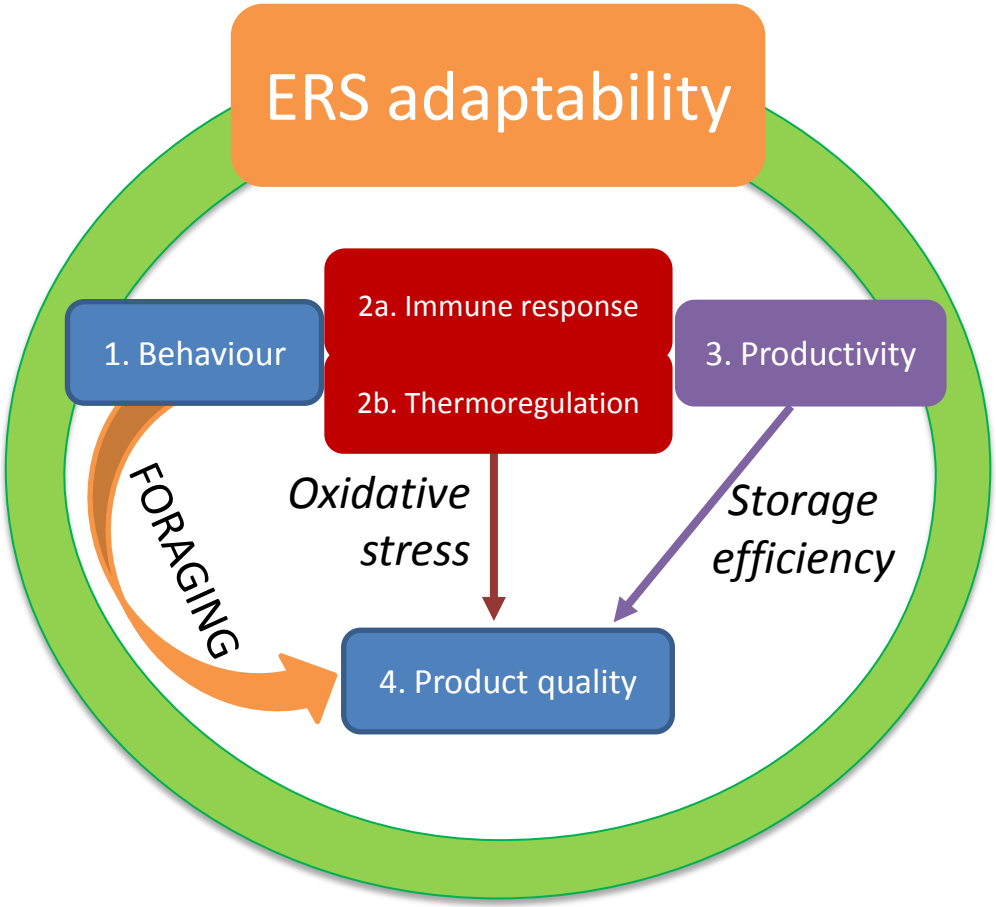
Broiler genotypes adapted to outdoor

Able to use the outdoor run

Resistant to the environment and diseases

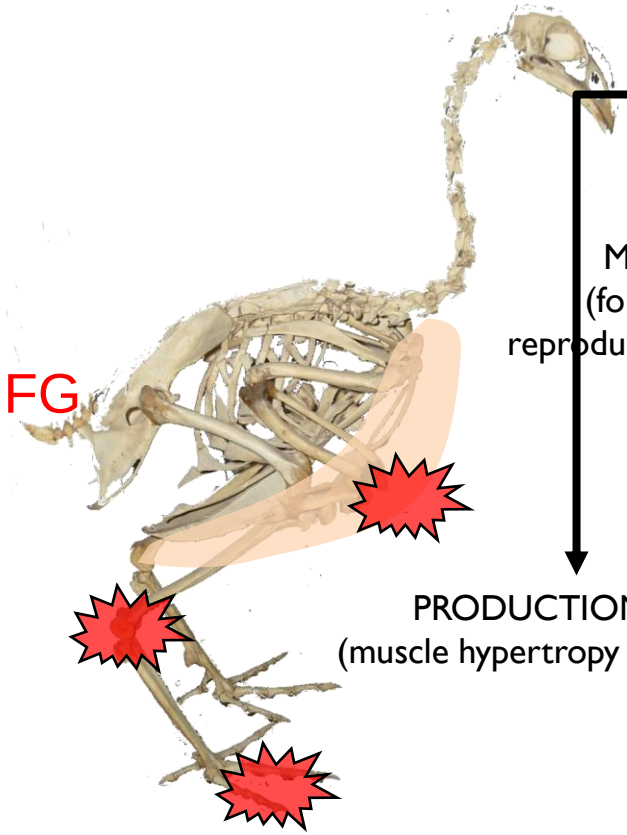
Outdoor adaptability criteria

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



FG

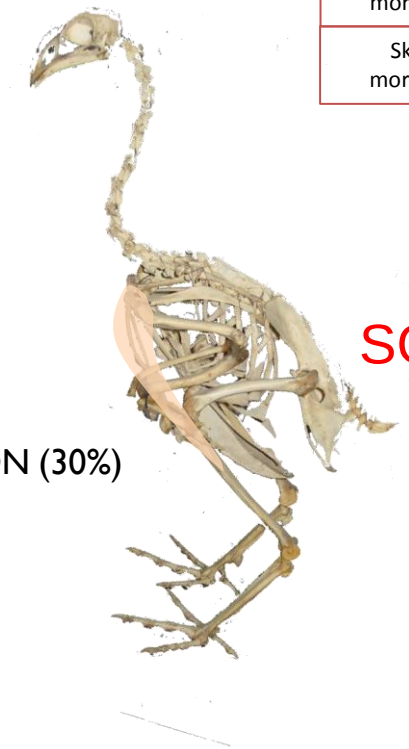
intake

MANTEINANCE
(foraging behaviour, reproduction, immune system)

MANTEINANCE
(70%)

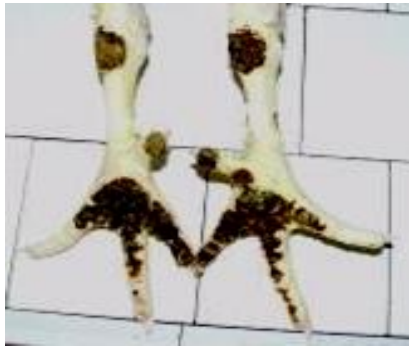
PRODUCTION (50%)
(muscle hypertropy & hyperlasia)

PRODUCTION (30%)



SG

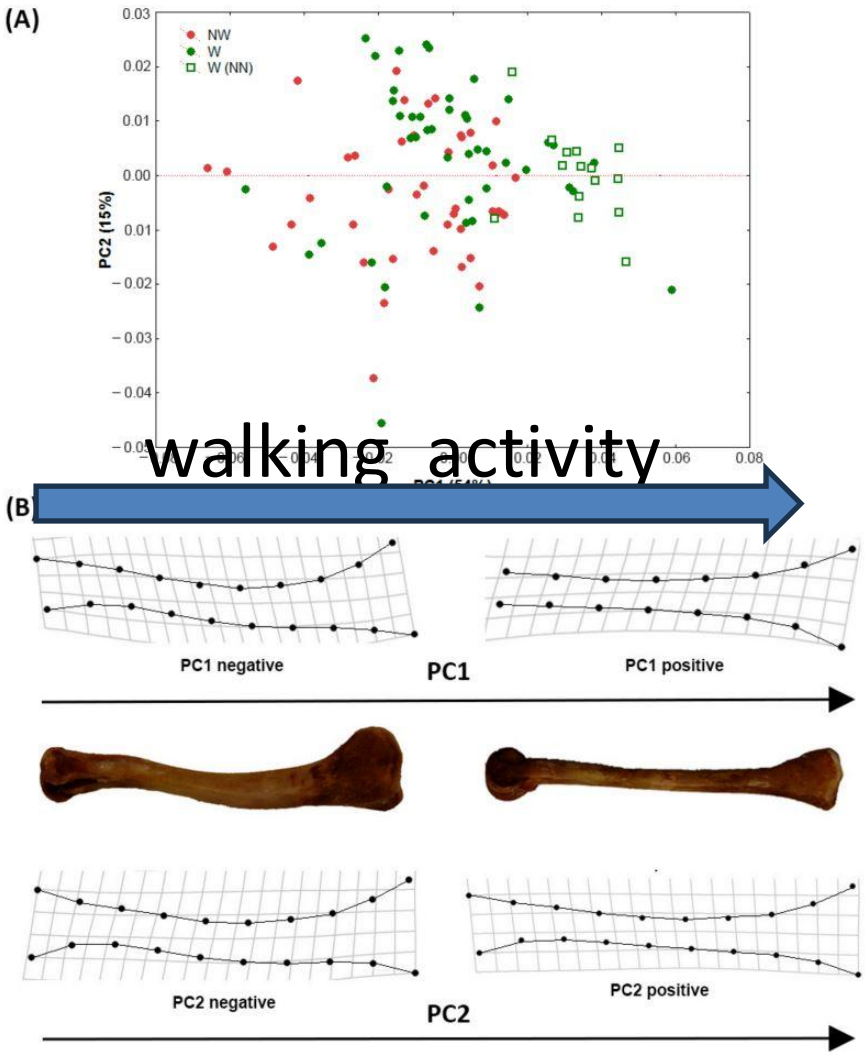
sternal lesions



plantar lesions

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

Tibia length and shape

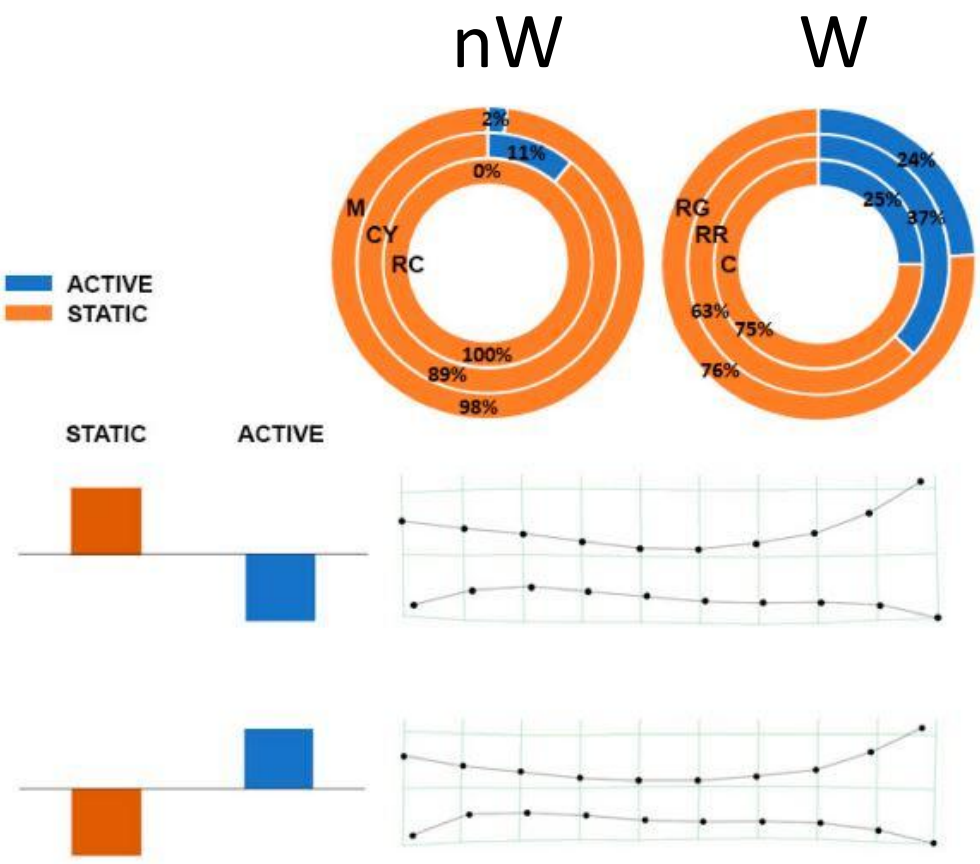


(A) Principal component analysis plot of chicken classified on the basis of walking activity.

- 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.

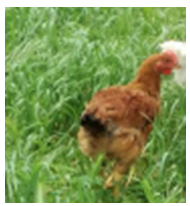
Pulcini et al., 2022 - *Animals*

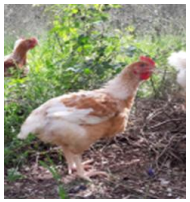


Partial least squares (PLS) showing the **morphological relationship between the tibia and the walking/resting behavior** described as a percentage of time spent in two main activities (Walking W and Not Walking—NW).

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

Pulcini et al., 2022 - *Animals*



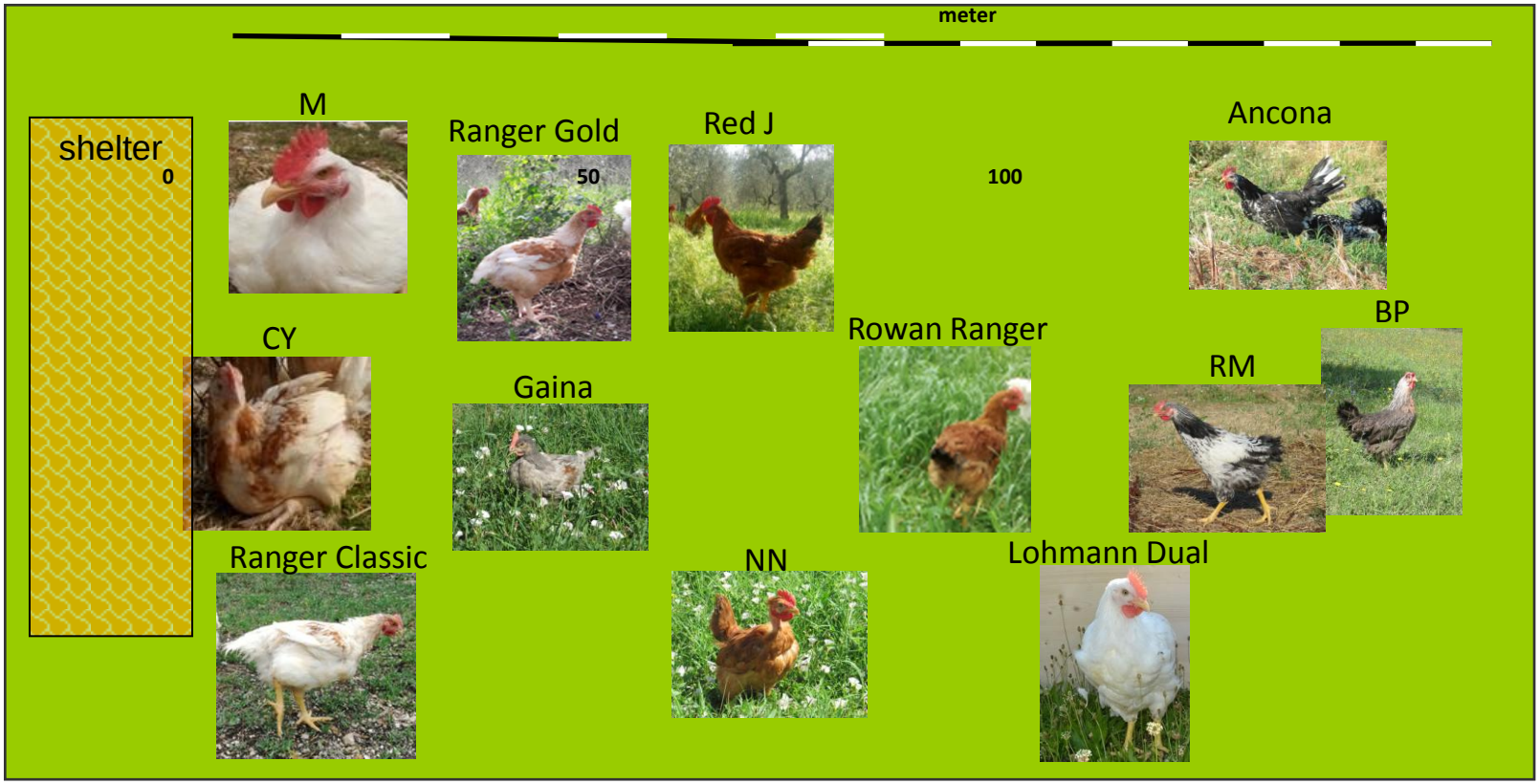

DWG (g/d/bird)	32.11	32.50	34.91	41.90	42.36	44.83	48.87

Walking (W) chickens

Not-Walking (NW) chickens

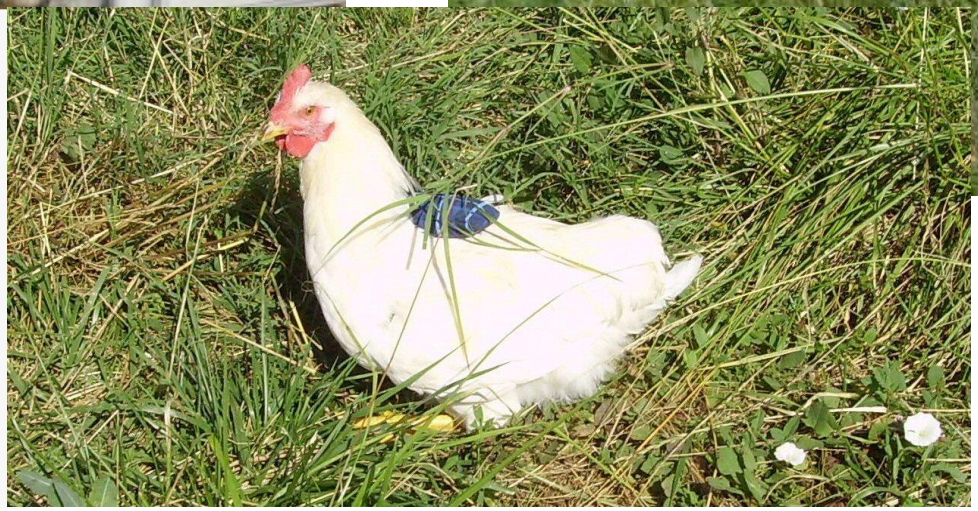
Cartoni Mancinelli et al. (2021)
Pulcini et al. (2021)

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)

trackstick

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

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

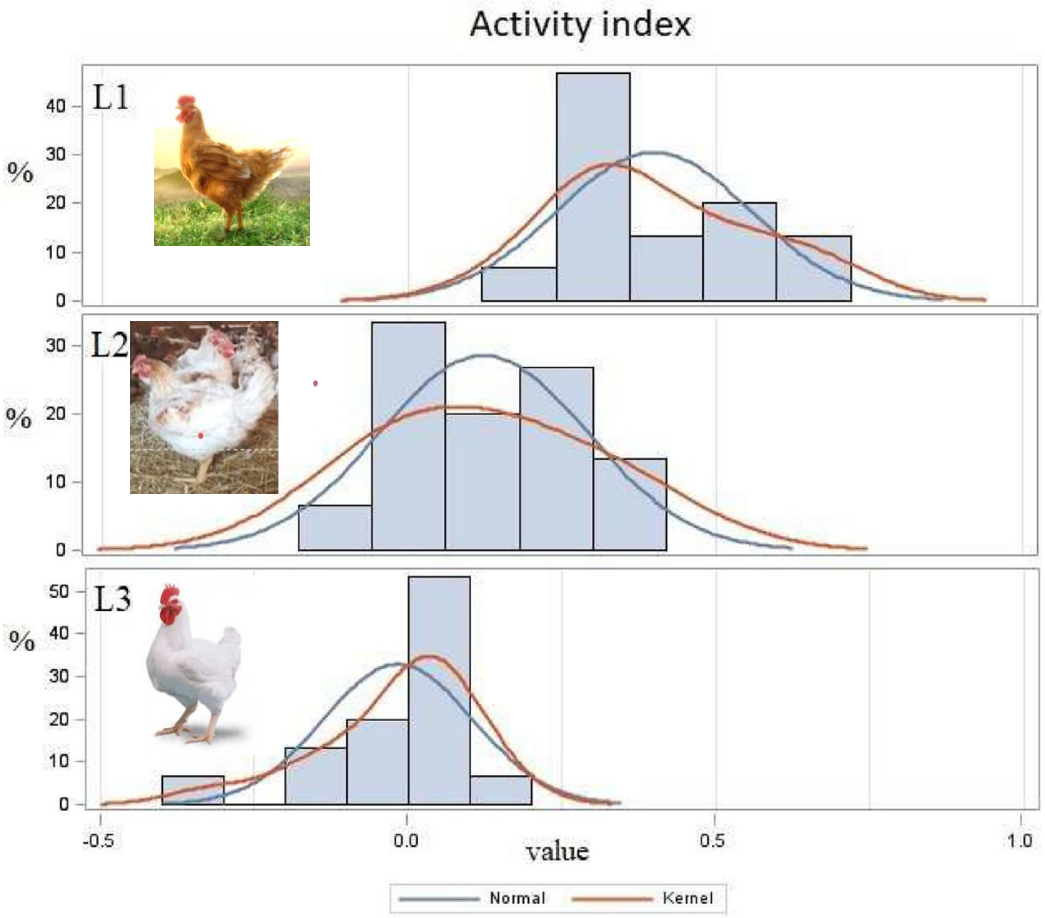
Fast growing organic

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

Covered distance (mt)

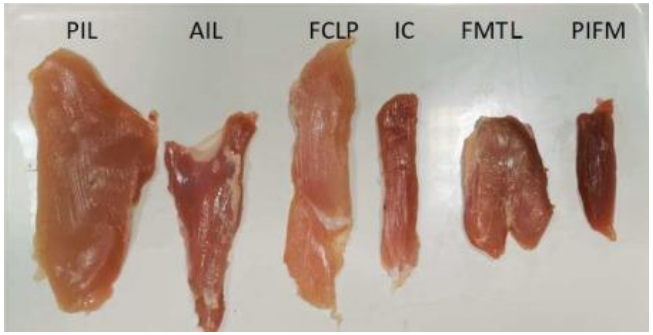
Google

KINETIC ACTIVITY



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 blu lines indicate normal distribution;
The red lines indicate kernel density estimation.



Failla et al., 2021 – *Poultry Science*

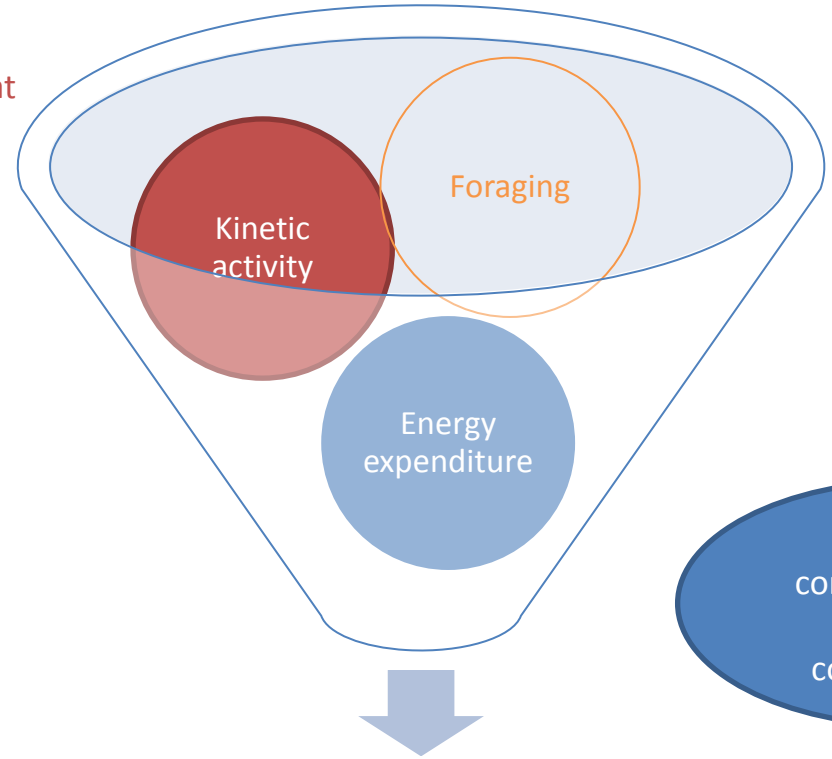
$$\text{Activity index} = \text{White m (n} - 3\,\text{HUFA)/ALA} - \text{Red m (n} - 3\,\text{HUFA)/ALA}$$

In vivo
Oxidation

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

Antioxidants
PUFA n-3

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



LC-PUFA consumption for energy compensation

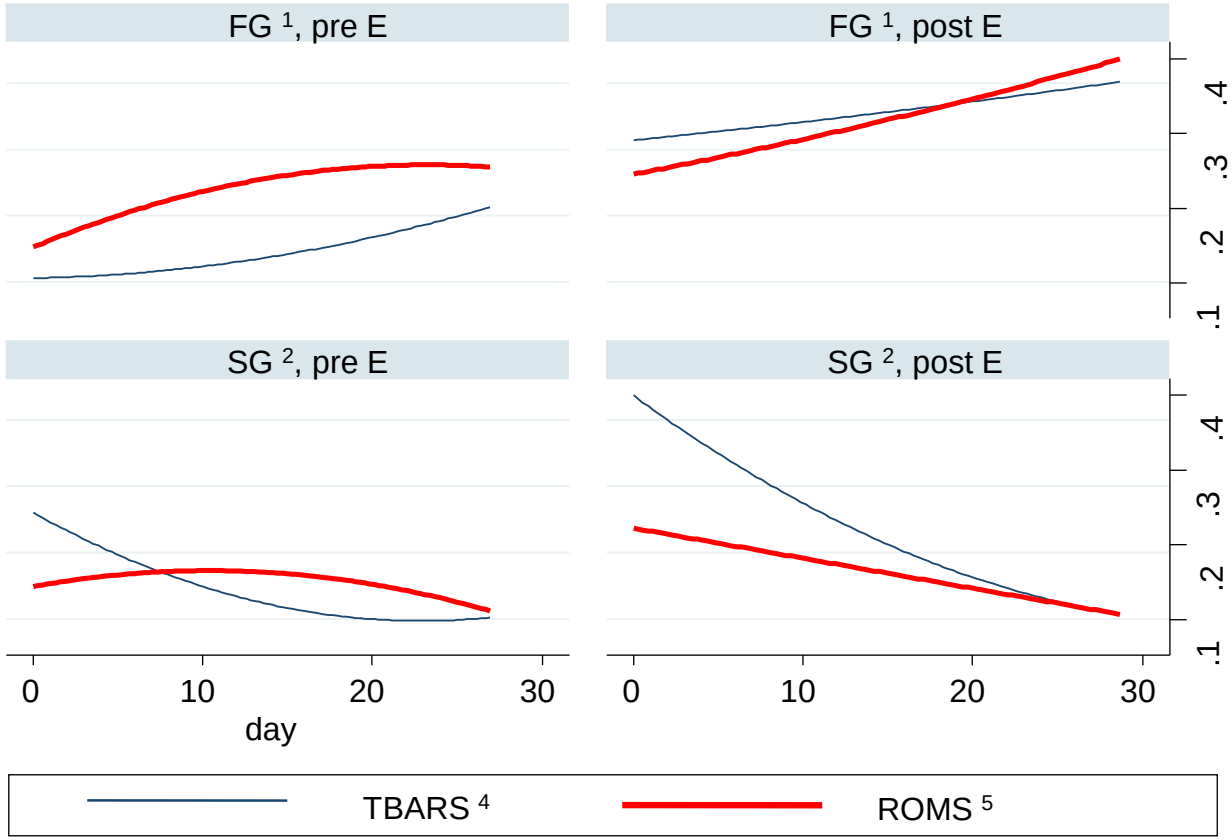
↓ fat deposit
↓ lipid % in meat
↓ healthy PUFA

Activity index

Failla et al., 2021 – *Poultry Science*

TREINED Walking: EXERCISE IN FAST vs SLOW-GROWING

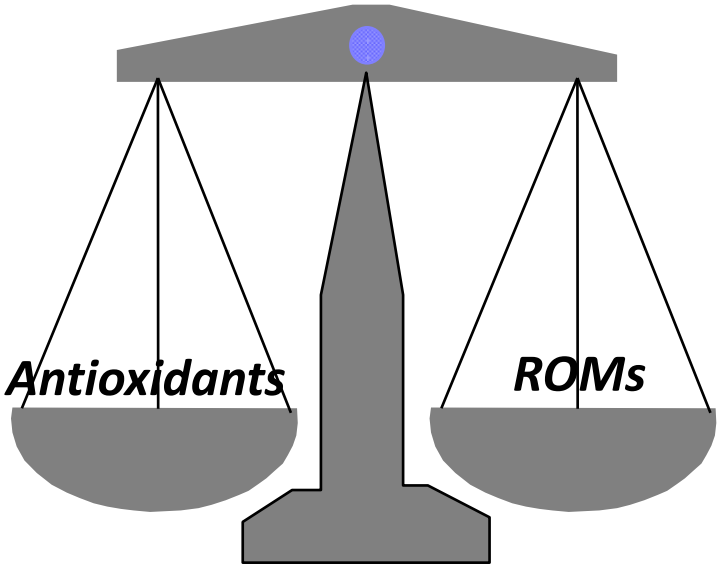
Kinetic activity

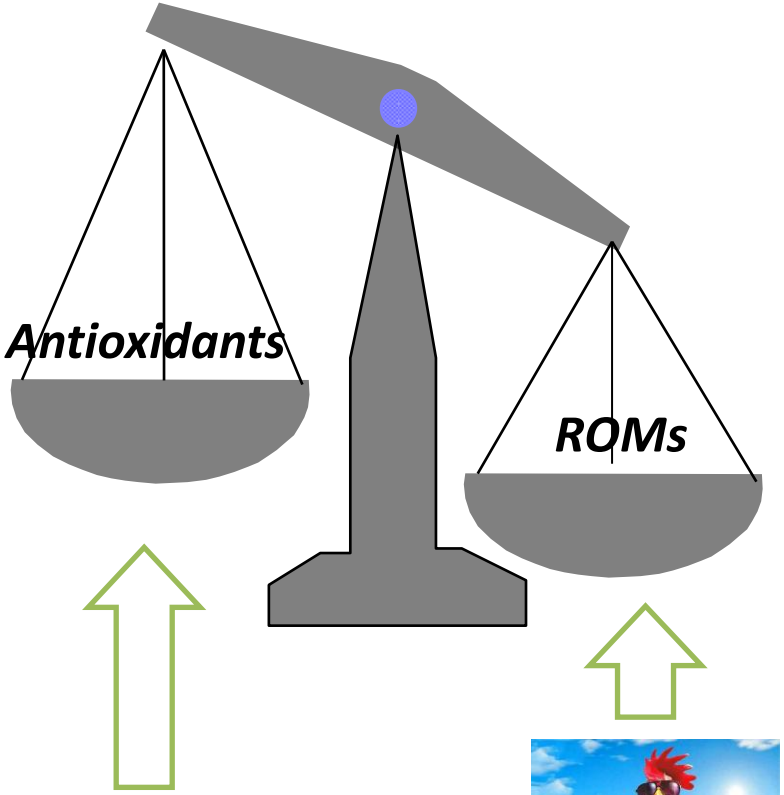


Mattioli et al., 2014 –Poultry Science

IN VIVO

What means *Trained and not trained animals?*





Health status
Antioxidants intake

PPILOW

Energy expenditure

ALA

anabolica

HUFA

Catabolica

acetyl-CoA

n-3

β Oxidation

Occurs in mitochondrion

(C_{n+2}) CoA is acyl group carrier

FAD is electron acceptor

A

yl-CoA L-β-Hydroxyacyl group

NAD^+ is electron acceptor

CoA

C_2 unit product is acetyl-CoA

(C_n)

1 2 3 4 3 5

Biosynthesis

Occurs in cytoplasm

ACP is acyl group carrier

NADPH is electron donor

D-β-Hydroxyacyl group

NADPH is electron donor

C_2 unit donor is malonyl-CoA

Fatty

3-D

β

Fat

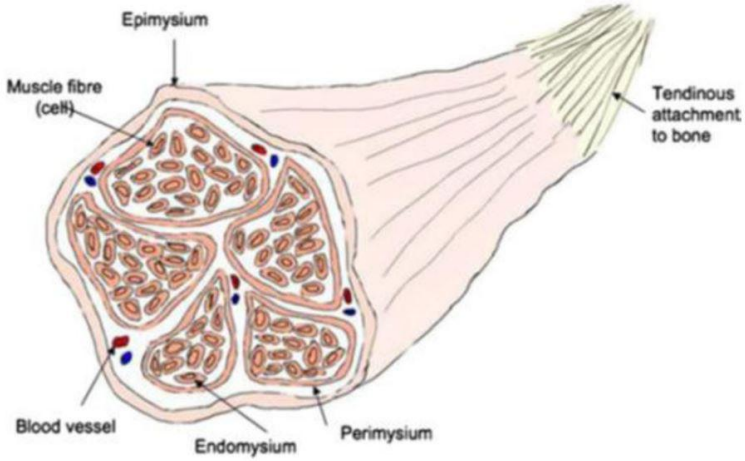
diet

ALA

anabolica (Δ6)

HUFA

Muscle chickens' changes in the last 70 years

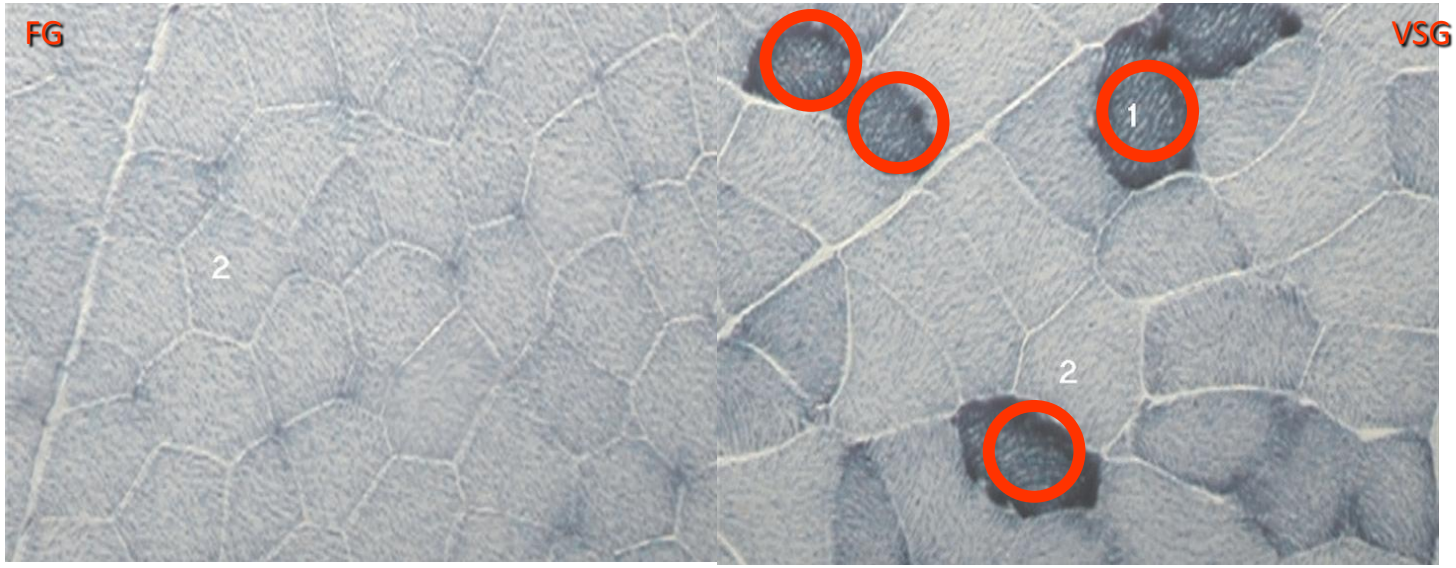


Chang et al., 2016 – *Animal Production Science*
Smith et al., 2010 – *Meat science*

Meat Cuts morphology

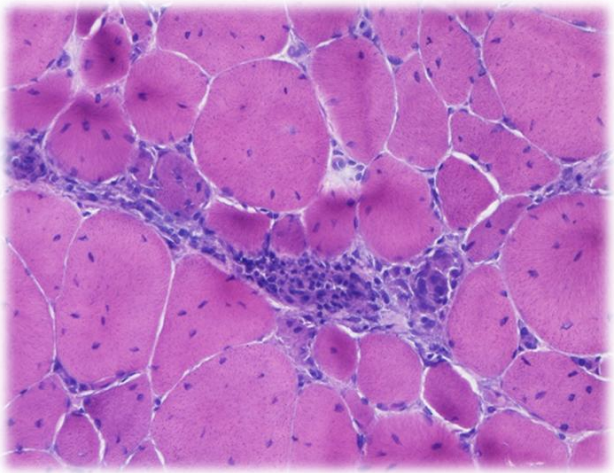
Muscle fiber and genetic strain

	Fiber	Slow-growing	Fast-growing
Pectoralis major	αR (1)	**4**	**0**
	αw (2)	96	100
Biceps femoris	αR	56	37
	αw	44	63

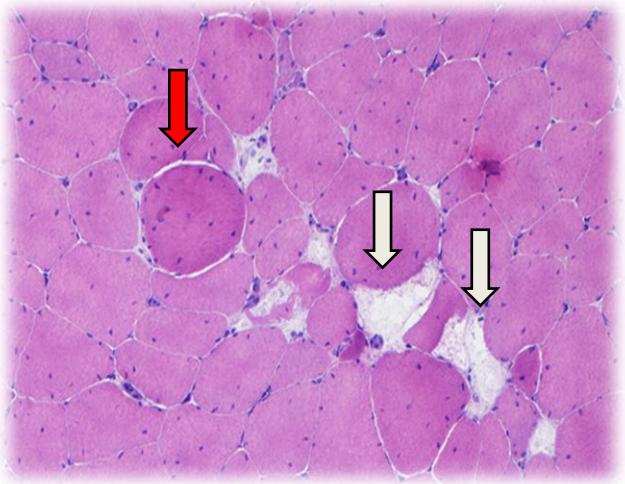


Branciari et al., 2009 – *Journal of Animal Science*

Muscle anomalies in broilers



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

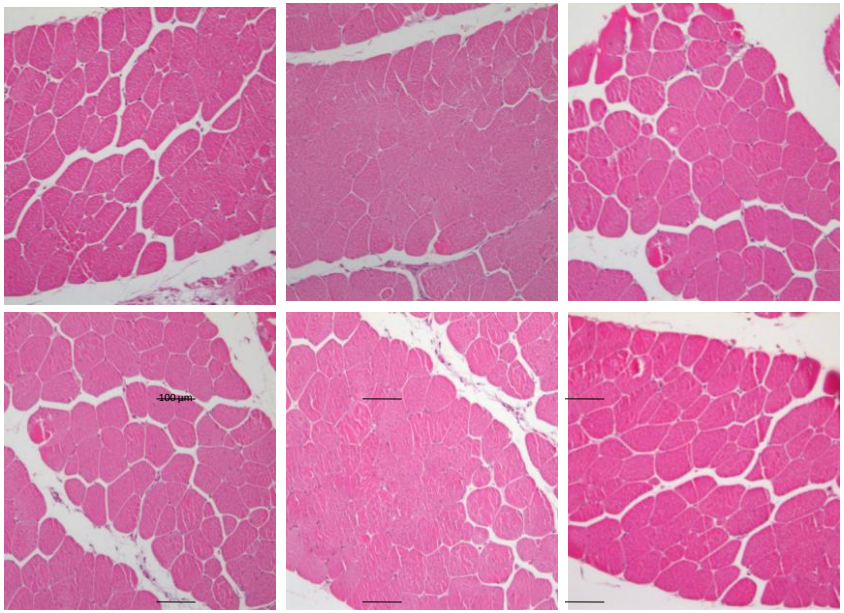


Ross; *PM.* with muscle fibers necrosis (black arrows) and giant fiber (red arrow)

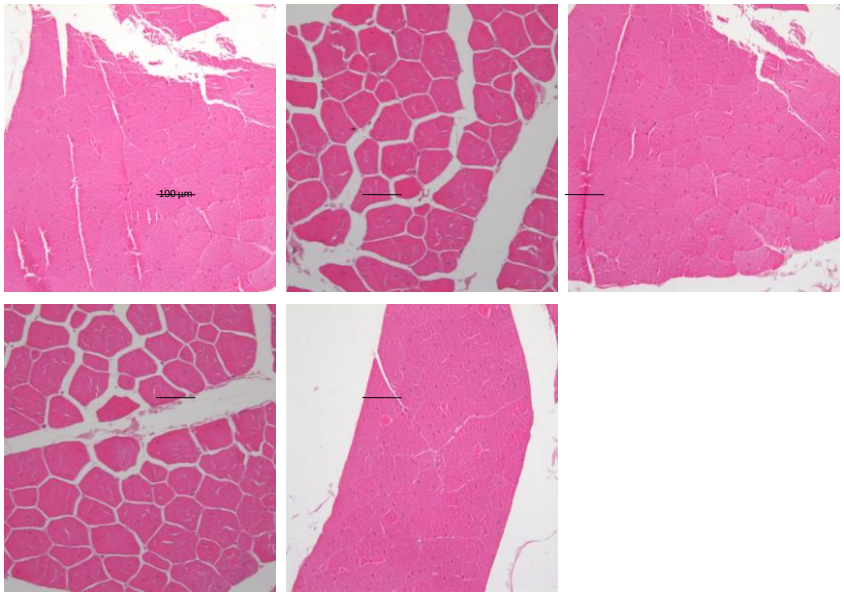
	Broiler	Leghorn
Fibers (n/microscopic field)	49.99 $_{a}$	140.15 $_{b}$
Capillaries (n/microscopic field)	24.56 $_{b}$	22.35$_{a}$

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

FG



SG



Many more nuclei within the myofibers in SG than FG

Number of fibers

dir ion

Research In progress

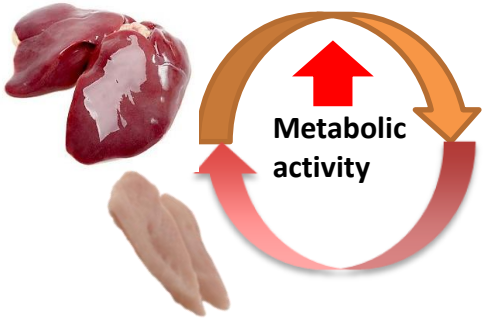
METABOLIC ASPECT: STORAGE CAPABILITY of LIPID

Very Slow growing

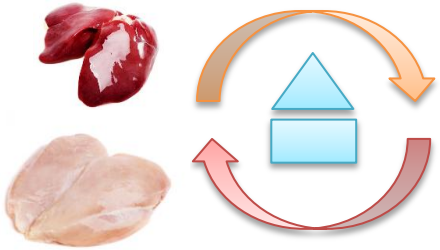
medium growing

Fast growing

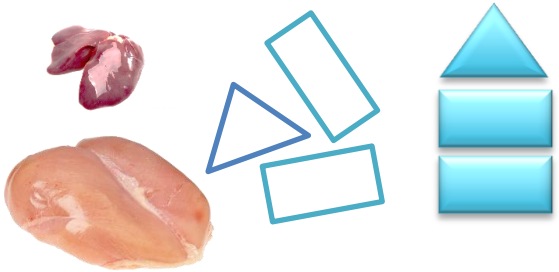
RECYCLE and TURNOVER



INTERMEDIATE trend



STORAGE and STRUCTURE



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

LCP n-3 in poultry strains

C18:3 n-3

C18:4 n-3

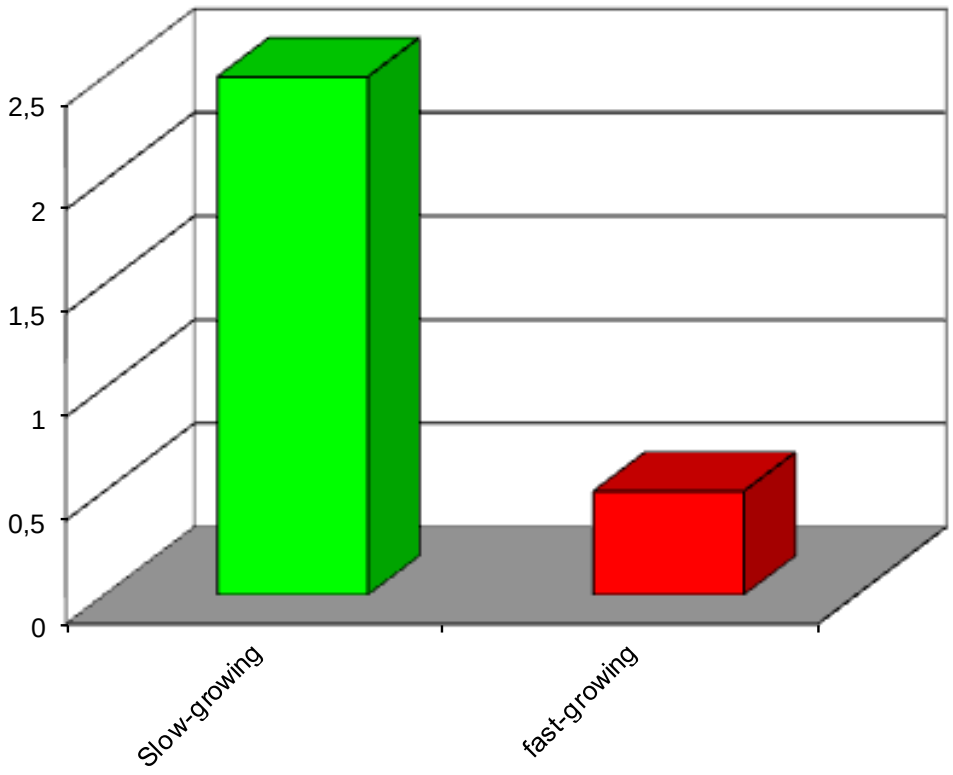
C20:4 n-3

C20:5 n-3

C20:5 n-3

C22:5 n-3

C22:6 n-3



C18:2 n-6

C18:3 n-6

C20:4 n-6

C20:4 n-6

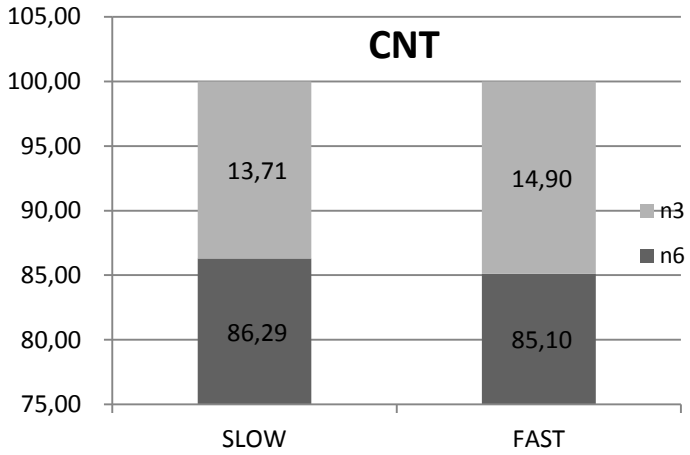
C22:4 n-6

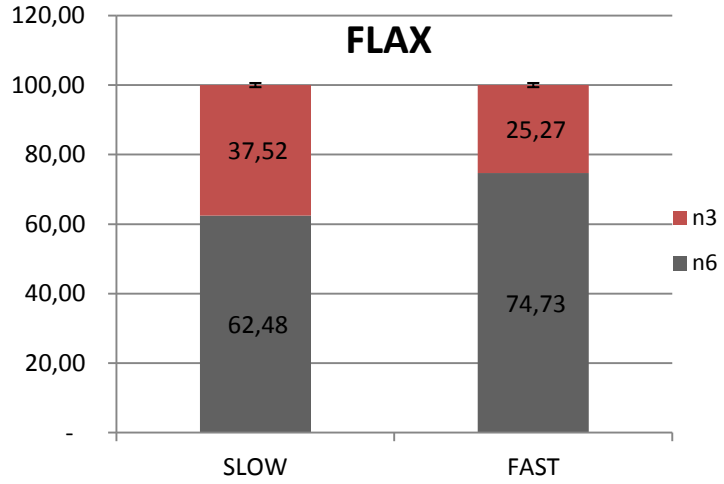
C24:4 n-6

C22:5 n-6

Mattioli et al., 2014 – *phD dissertation*

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	

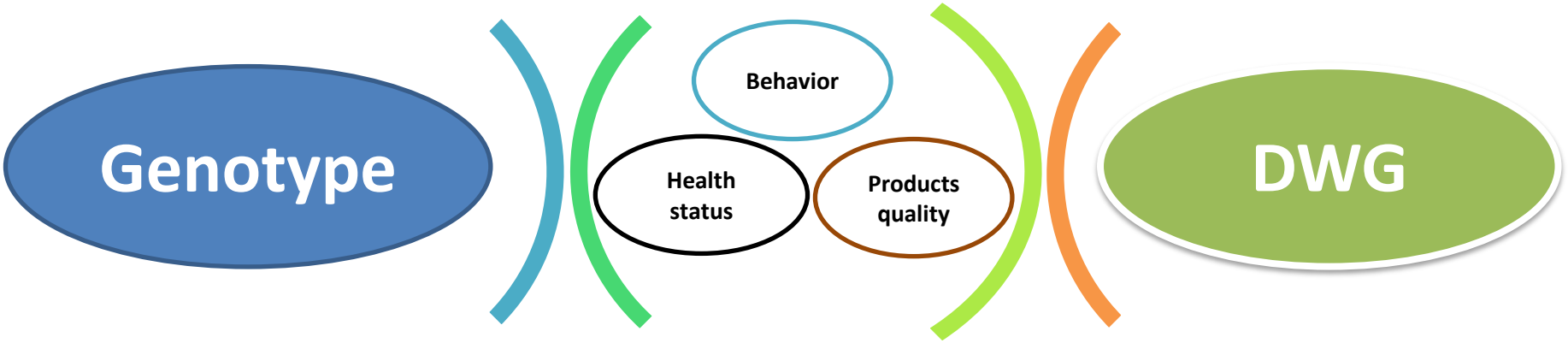
Δ6-desaturase activity (da 18:3 ω3): FLAX

	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*

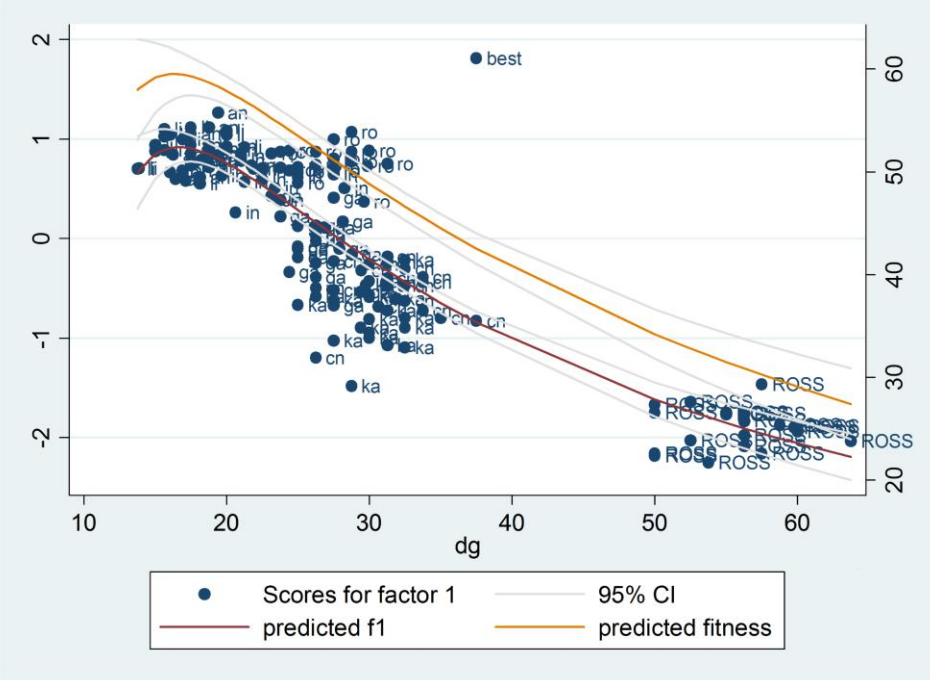
What means “suitable broiler genotypes adapted to outdoor system»?

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)

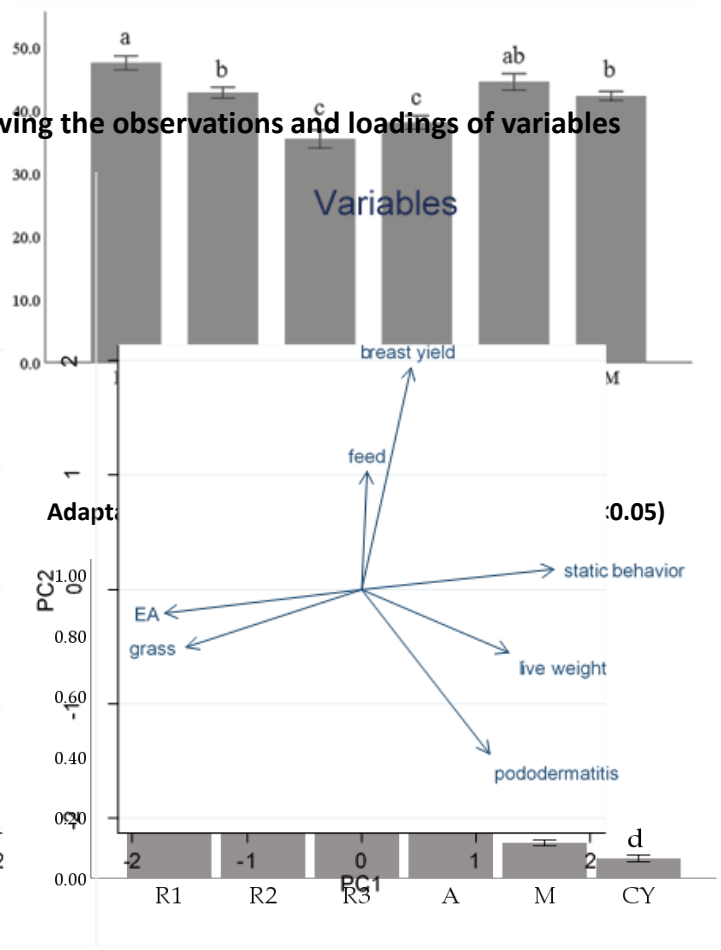
Rowan Ranger (R3)

Campese (A)

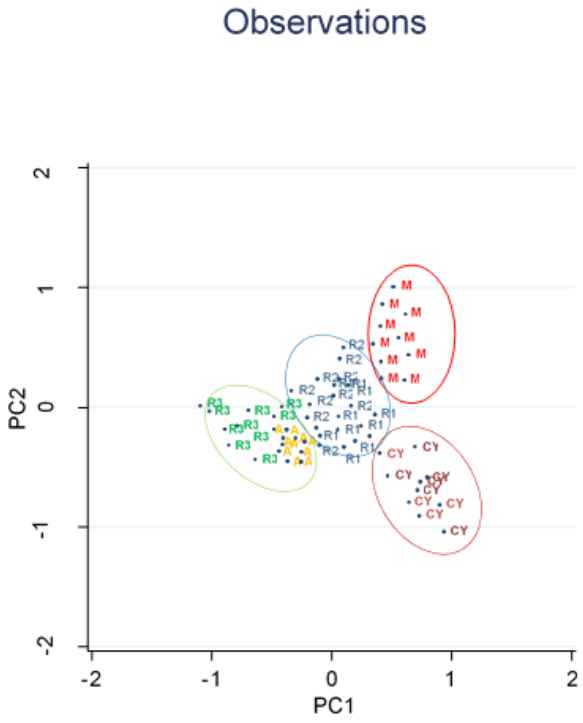
CY Gen 5 x JA87 (CY)

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)

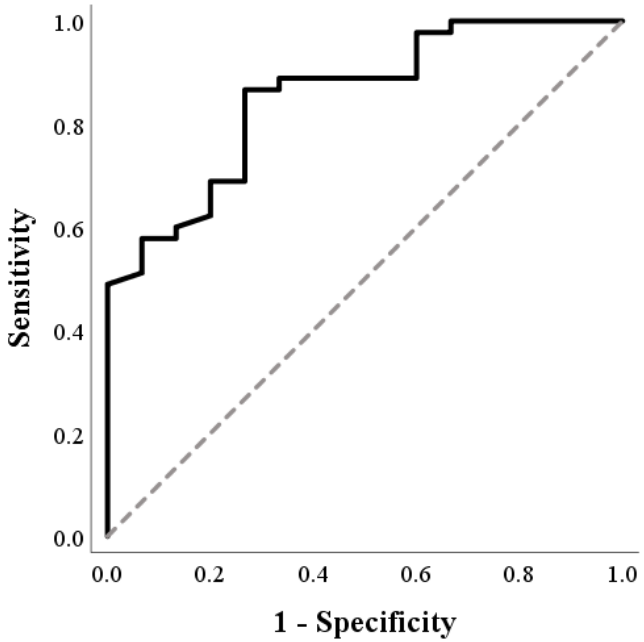
Rowan Ranger (R3)

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%.

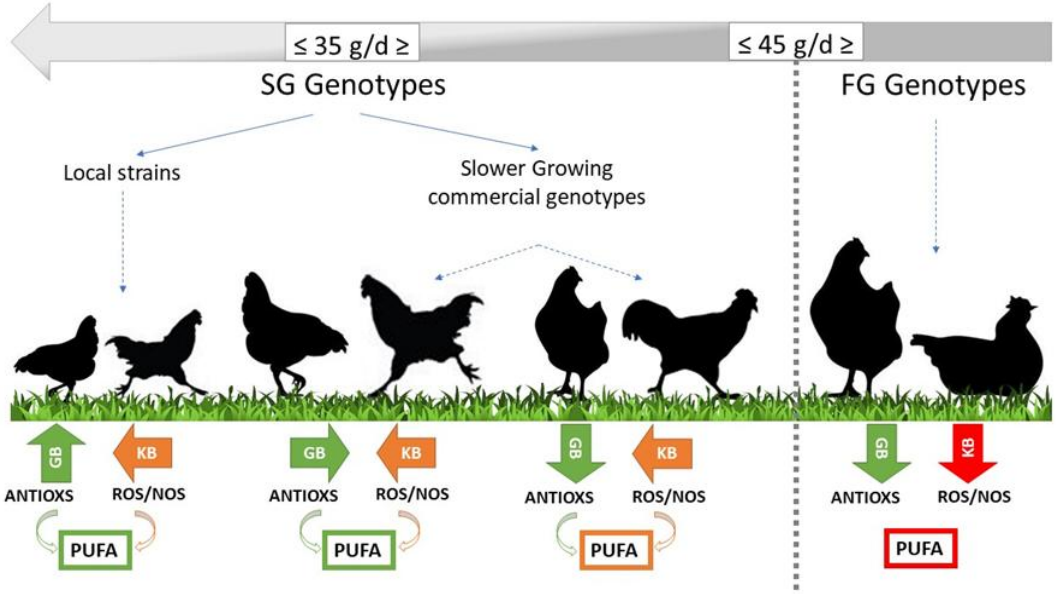


Behavior
Welfare
(lesions, feather condition, TI)
Performances

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*

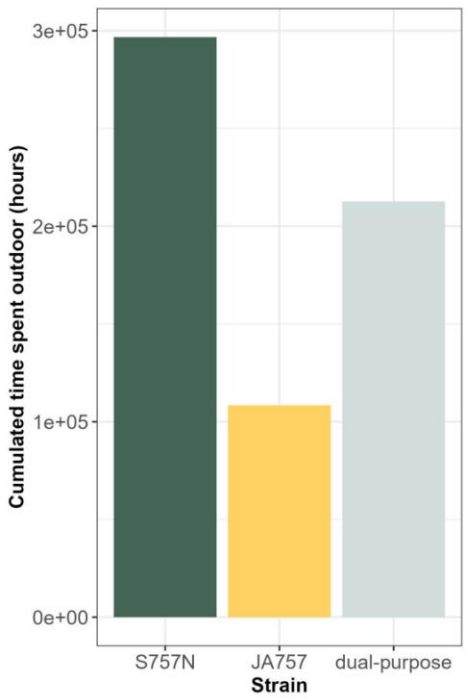
PPILOW results are coming, see you after break

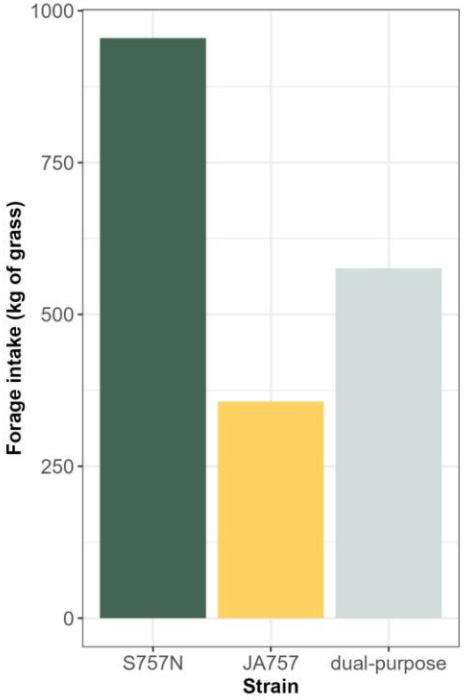
Experiment conducted in spring 2021 to better understand range use

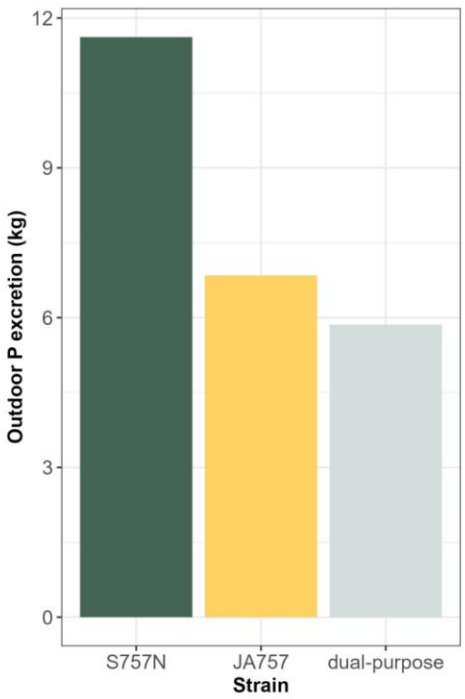
Dual-purpose	JA757	S757N	White Bresse
16g/d	**36g/d**	**26g/d**	**23g/d**
Reared for 14 weeks	Reared for 10 weeks	Reared for 12 weeks	Reared for 15 weeks

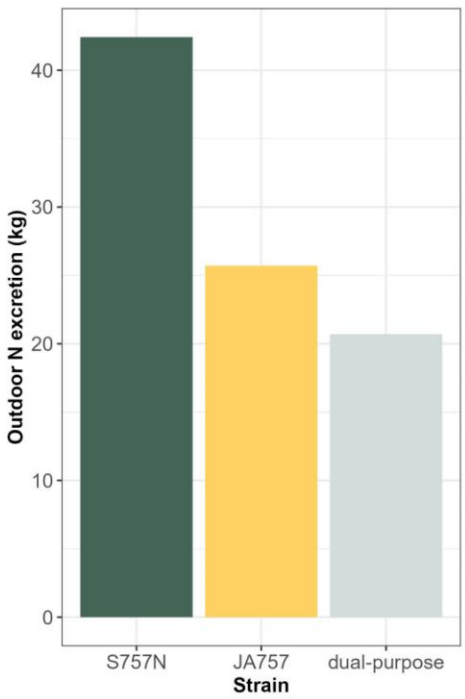
750 mixed sex chickens

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 ?

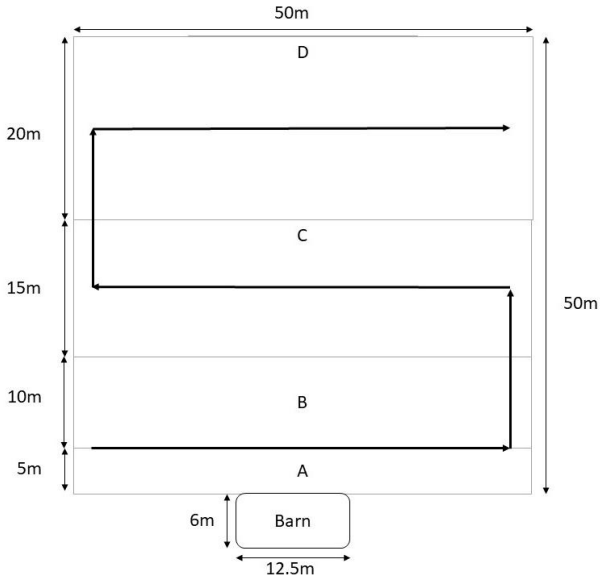
Is range use a personality trait ?

- Time-consistent?
- Consistent across season?

Ferreira et al	Bonnefous et al	Collet et al
S757N strain	JA757, S757N, White Bresse and a dual purpose strain	JA757, S757N, and a dual purpose strain
Meadow	Tree covered grassy outdoor	Tree covered grassy outdoor
Behavioural observations	Behavioural observations	Radio Frequency Identification

Behaviour: methods

Behavioural observations

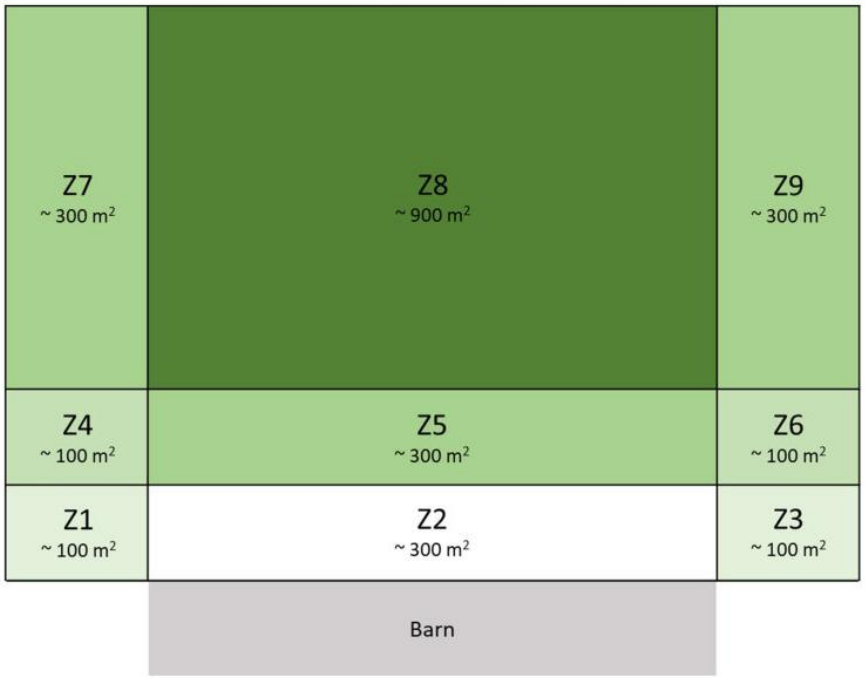


7 scans per day of observations 11 to 15 days of observation

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

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

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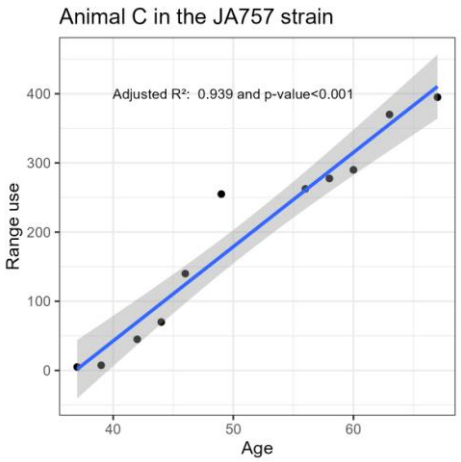
Behaviour: time-consistency of range use

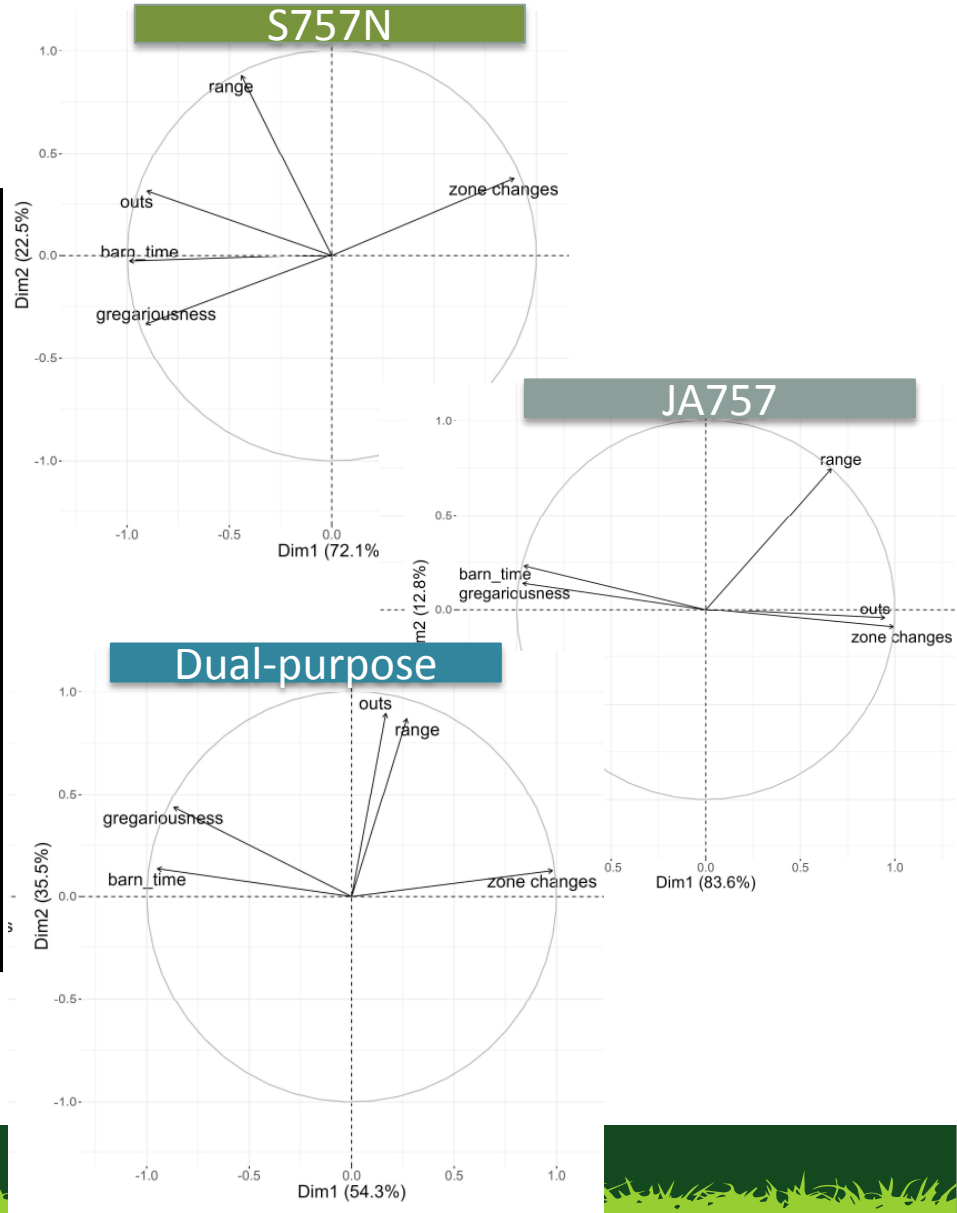
Behavioural observations

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

	0.8 < x	0.5 <x< 0.8	0.3 <x< 0,5	0.1 <x< 0.3	x < 0.1
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

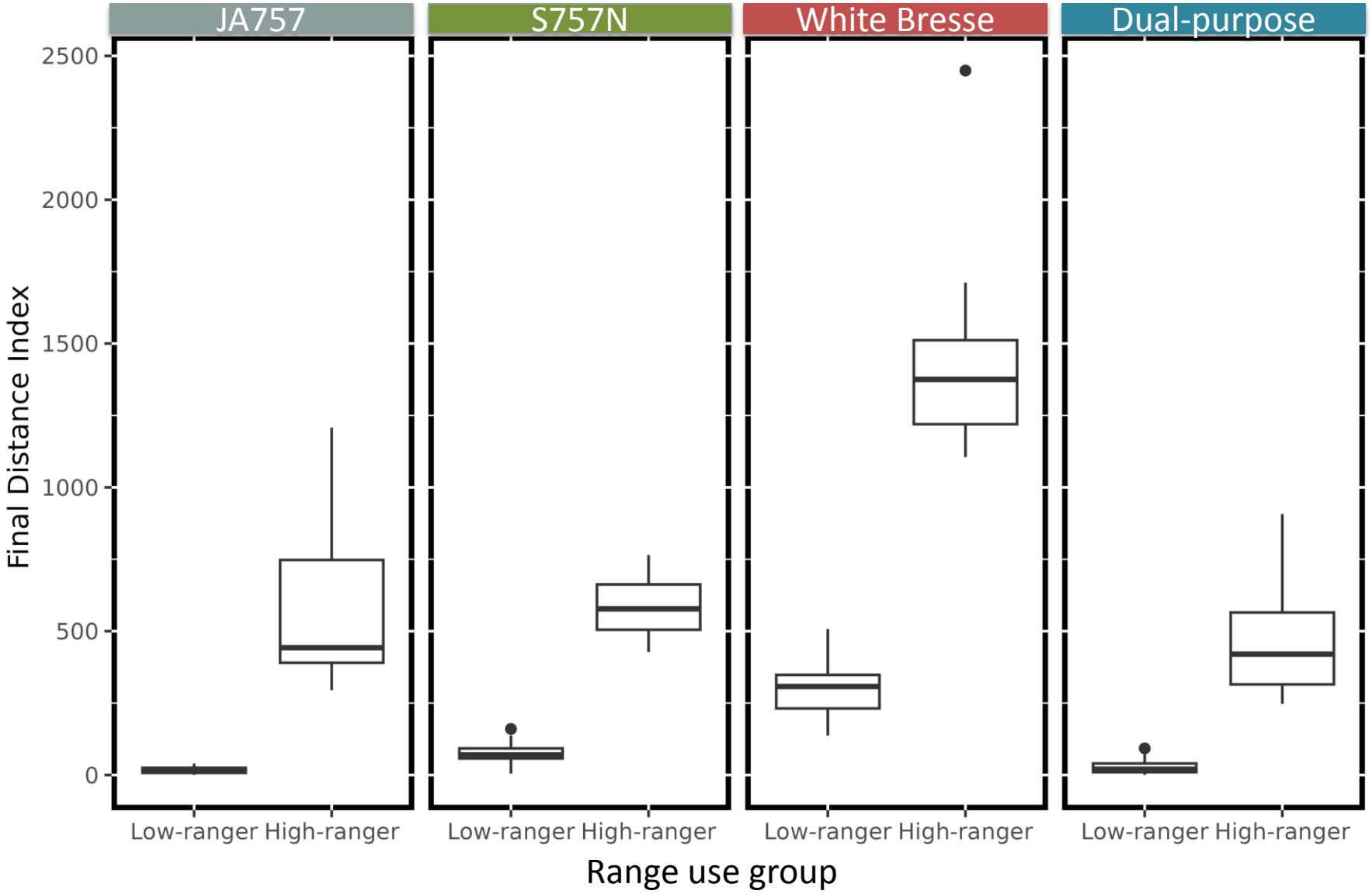


Radio Frequency Identification



Consistency between strains and in time

Behaviour: selecting chickens on their range use



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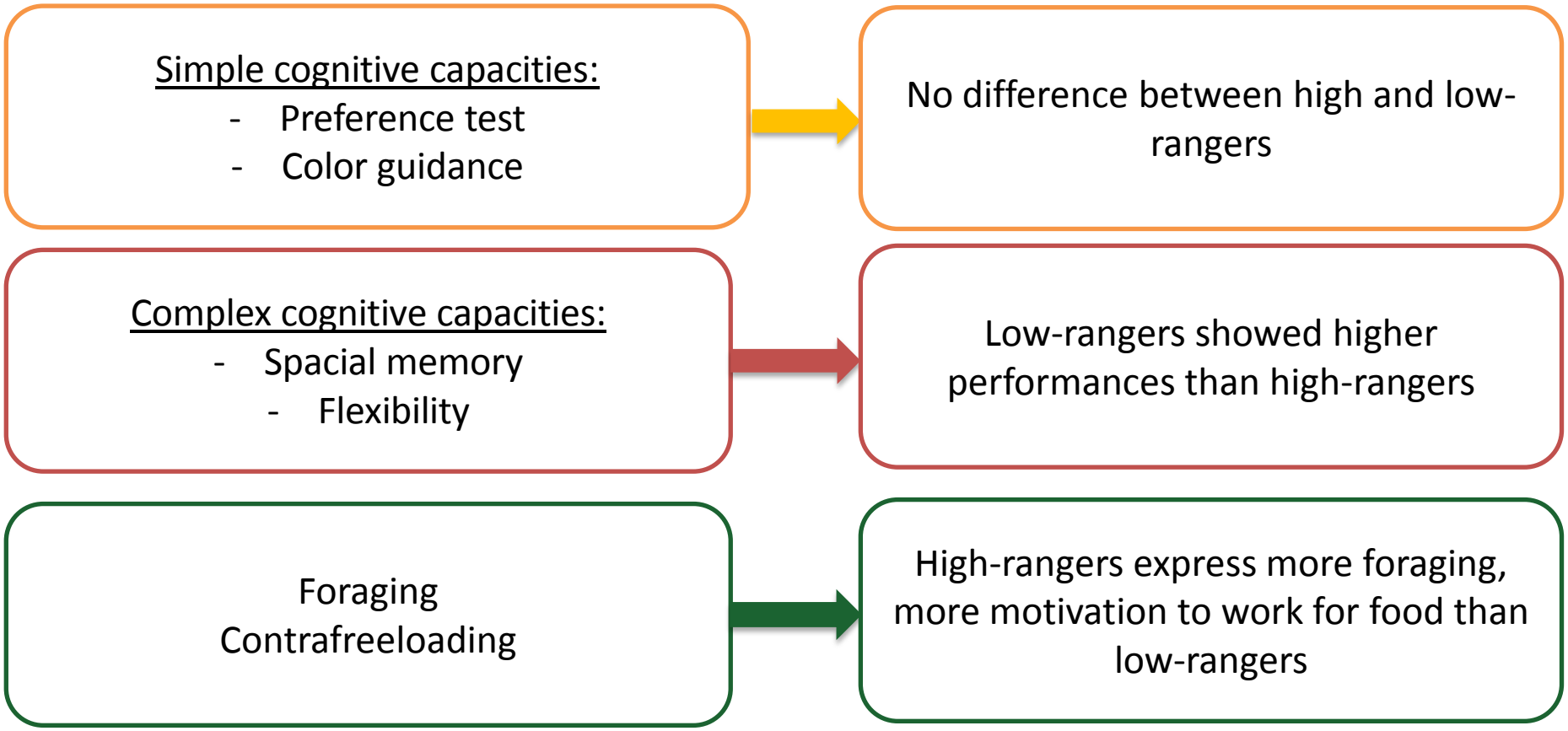
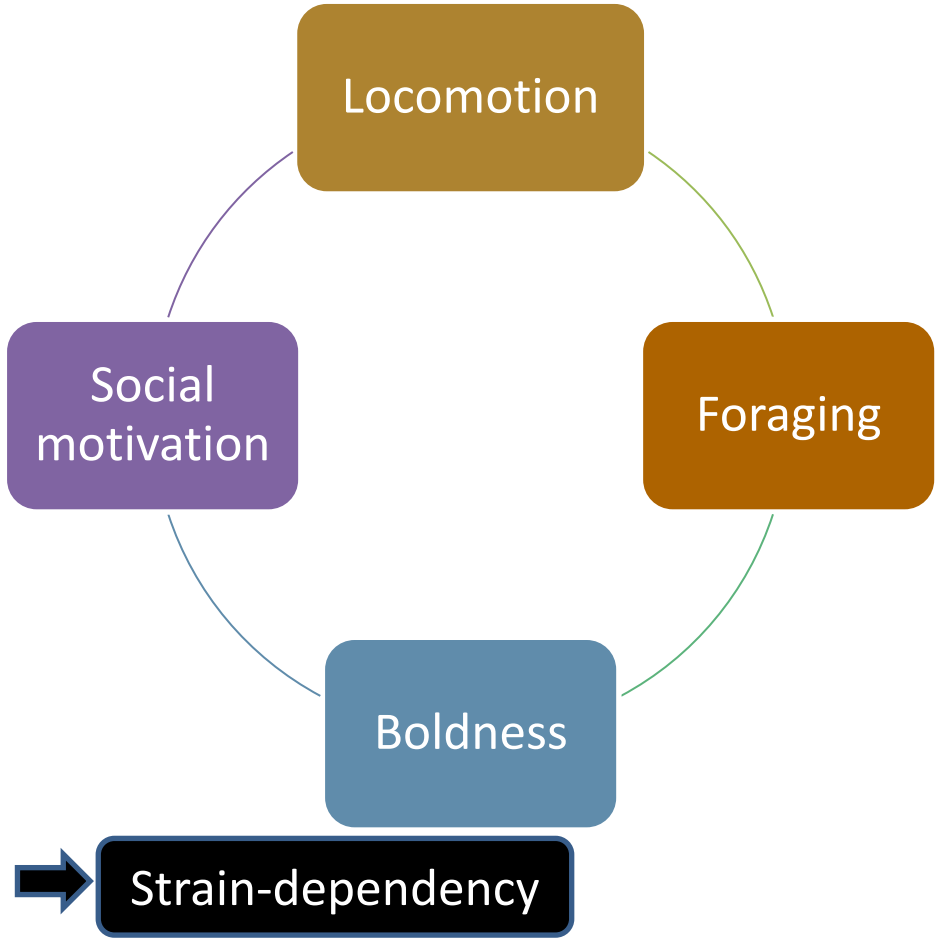
Behaviour: variables related to range use
Ferreira et al., first work : cognition, foraging and motivation to work for food



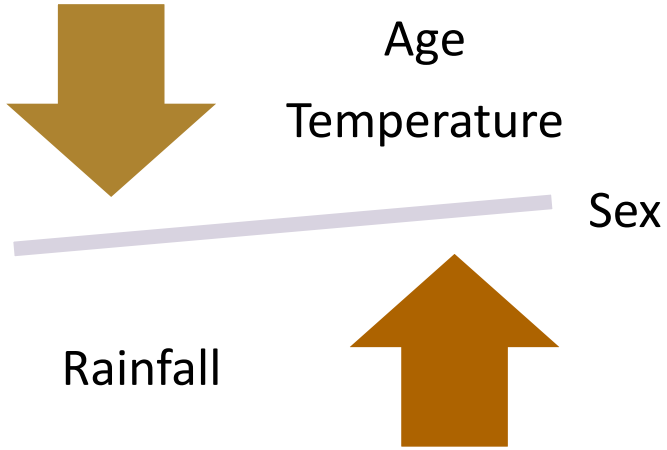
Behaviour: variables related to range use

Behavioural observations



Strain-dependency

Radio Frequency Identification



Valid for the three studied strains

Variables related to range use at slaughter

JA757
S757N
White Bresse
Dual-purpose

In the blood

n6/n3 fatty acids

Yellowness

Welfare indicators at slaughter

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

Muscle growth

Creatine kinase activity

Range use

Immunity / Anti-inflammatory systems

Lysozyme activity

Haptoglobin-like activity

Performances

Redox status

Bone Health

Carcass weight

Carcass yield

Breast weight

Thigh weight

Thigh yield

Oxidants : $[H_2O_2]$

Antioxidants :

∑ [Tocols]

[Uric acid]

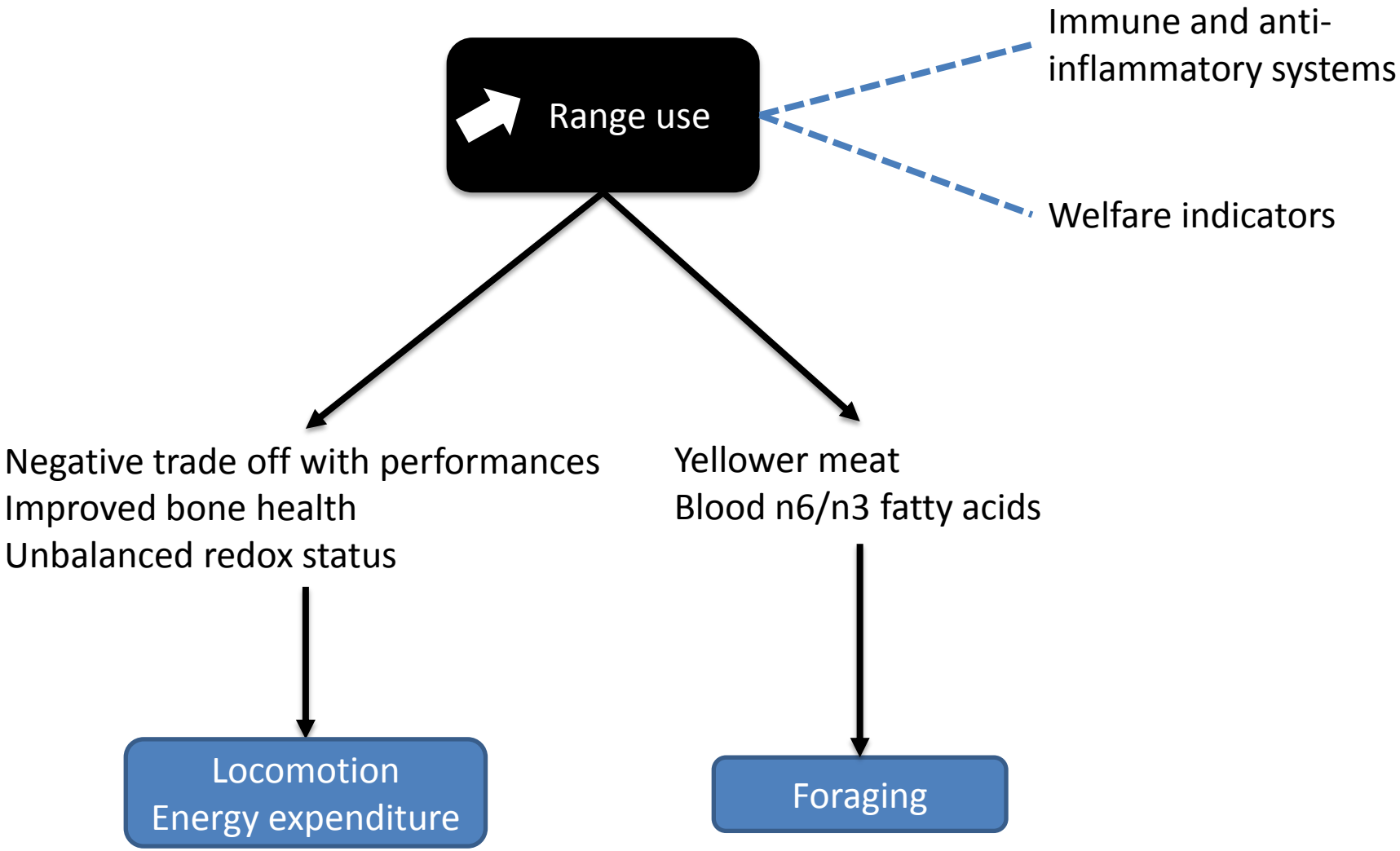
Total Antioxidant Status

Tibial bone-breaking strength

Tibial length

Tibial diameter

Range use relationship with indicators at slaughter



Indicators of later range use : behavioural indicators. Ferreira et al, 2021

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

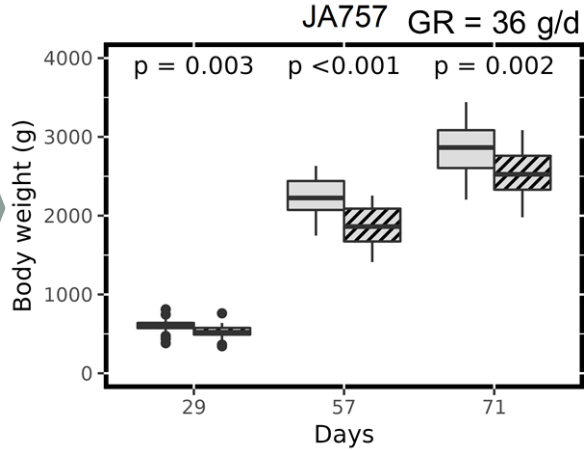
Indicators of later range use : behavioural indicators

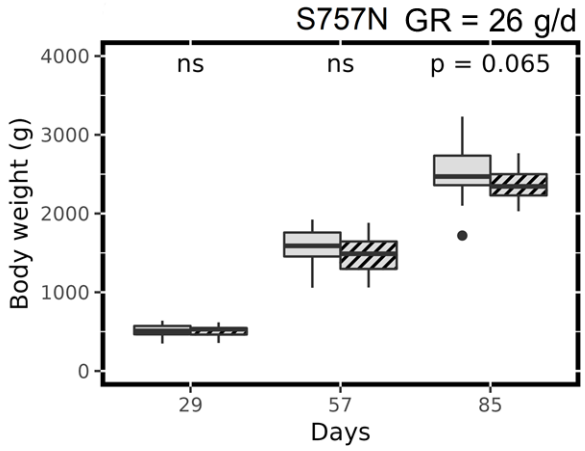
	JA757	S757N	White Bresse	Dual-purpose
State behaviour recorded during focal sampling				
Standing	0.01	-0.01	-0.02	-0.15
Resting	-0.17	0.06	-0.08	0.00
Sleeping	-0.24	0.06	0.02	0.11
Locomotion	0.26	0.09	-0.01	0.06
Foraging	0.29	-0.02	0.17	0.04
Drinking & Eating	-0.17	-0.12	-0.02	0.06
Variables of the 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

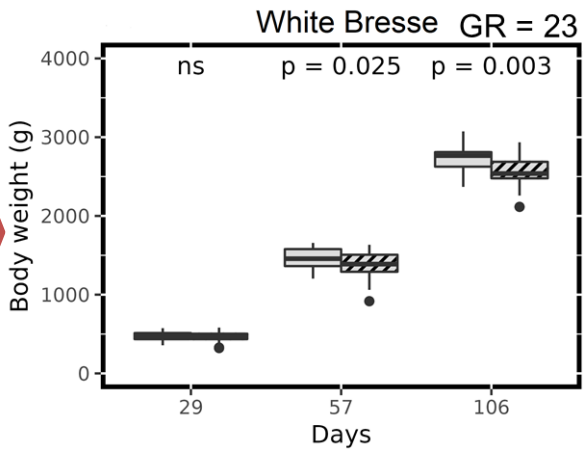
Differential body weight may be partly a cause of differential range use?

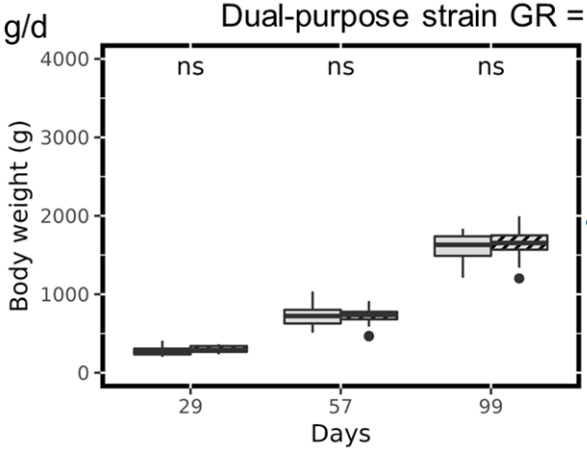




Differential body weight may be a consequence of differential range use?

Differential body weight may be a consequence of differential range use





No relationship between range use and body weight

Thank you for your attention

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