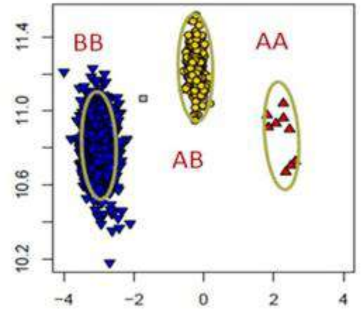
Duck Breeding:
From Genetics to Genomics



Dr. Anne Rae

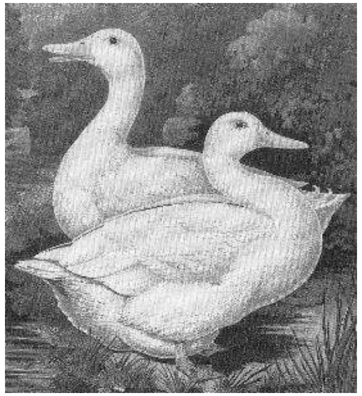
Cherry Valley Farms Ltd. Head of Genetics, Research and Development

History of Duck Domestication

- Archaeology of ancient Egypt suggests that duck has been an important food source for many centuries.
- The earliest reference to domestication of duck is found in the archaeology of the Western Zhou Dynasty 1046-771 BC.
- In China, force-feeding of ducks is documented from the tenth century, among several breeds they created was one named *shi-chin-ya-tze*, which roughly translates to "ten-pound duck"
- By the middle ages duck was consumed in increasing amounts in Europe, Asia and North Africa.
- Since the 1690s ducks were farmed in Aylesbury. In the 18th century selective breeding of white common ducks led to a white domestic duck. ‘Aylesbury ducks’ were reared in backyards in Buckinghamshire and walked the 40 miles to London to be sold as delicacies to the wealthy.
- The Pekin duck (a descendant of the mallard) was introduced from China to the USA in the 1870s leading to the establishment of the Long Island Breed by 1886.

Hieroglyphic duck

Wine vessel in the form of a duck, China



Prize winning Aylesbury duck, 1873

The Pekin Duck in the West

- In 1872, **fifteen** Pekin ducks were shipped to the USA; **nine** survived the voyage; five were eaten on arrival in the States, leaving just **four** as a founding population for breeding.
- By July 1873, the three hens had laid more than three hundred eggs
- At the same time, the Pekin duck was introduced into the UK. The Pekin was hardier and cheaper to raise than the local Aylesbury duck. Many breeders switched to the Pekin duck or to Aylesbury-Pekin crosses.
- The success of the US Long Island Pekin duck, meant that by the 1950s it had been imported to many parts of the world including Europe

Aylesbury

American Pekin

German Pekin

- The Aylesbury duck is reported to have an unusually large keel, and a horizontal stance with its body parallel to the ground
- The American Pekin is large and solidly built, with a rectangular as seen from the side and is held at about 40º to the horizontal
- German Pekin was bred to be more upright, and generally weigh less than American Pekin. German Pekins are show birds and lay far fewer eggs than the American Pekin

Types of Ducks

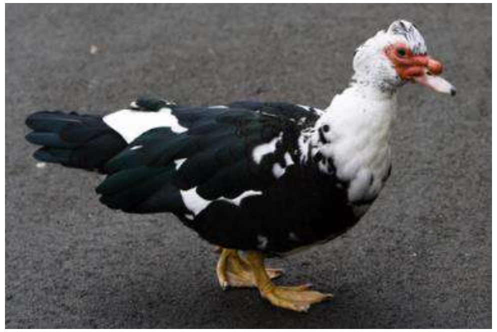
Meat Type

Anas platyrhynchos

Pekin

Mallard

Liver Production



Muscovy/Barbary
(*Cairina moschata*)

Moulard/Mule
(Muscovy x Pekin)

Aylesbury

Egg Type

Anas platyrhynchos

Indian Runner

Rouen

Karkhi cambell

S.E. Asia:

Alabio

Philippines: Balut production

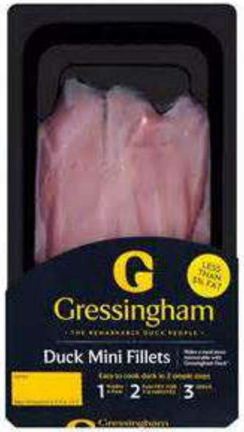
Products and Market Preference

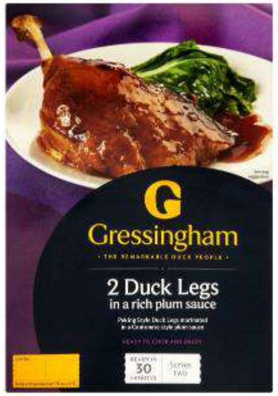
Whole Bird

Portions
- Breast
- Legs

Cooked products
- whole bird
- half bird
- portions
- ready meals

By-products
- feet
- tongues
- offal
- fat
- blood
- feather





The same Pekin duck strain may be killed at 28 days (2 kg) for China small bird market, or 56 - 65 days (4 kg) for improved meat texture in Japan/Indonesia.

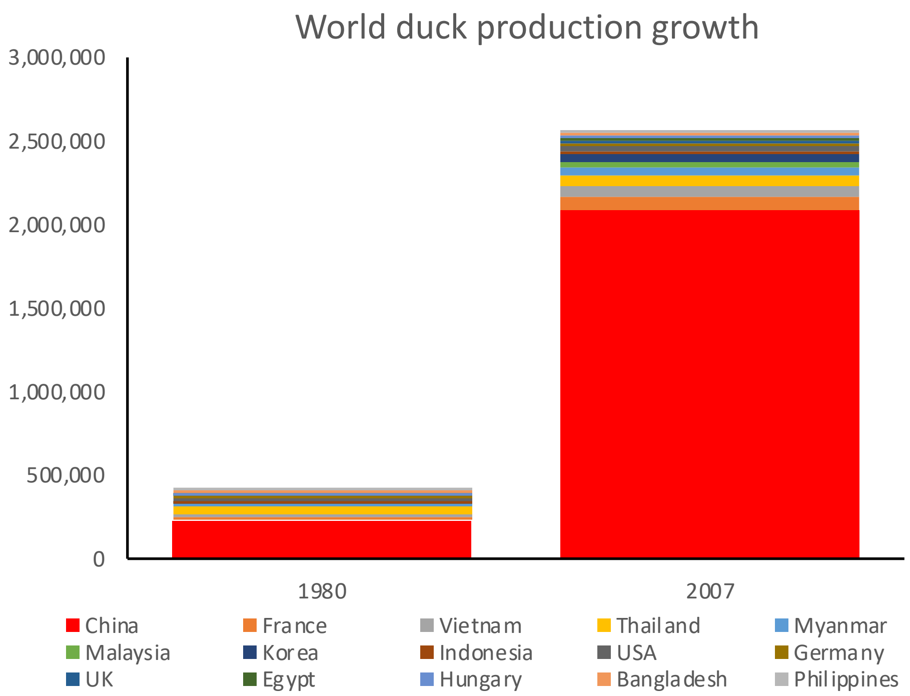
World Production and Consumption

Asia

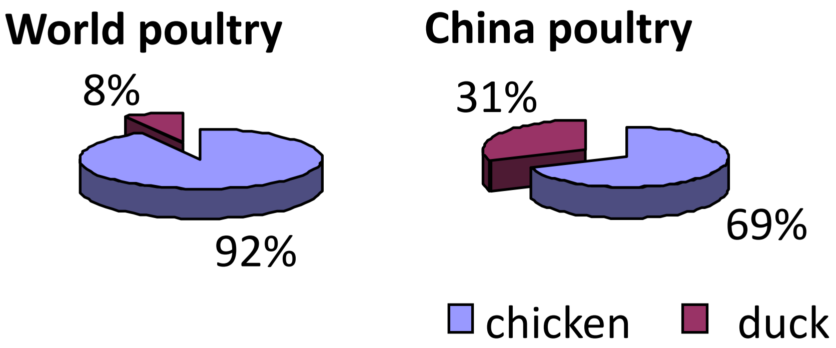
China – 3,300 M
South Korea – 50 M
Vietnam – 36 M
Thailand – 30 M
Malaysia – 15 M
Taiwan – Traditional
Indonesia – Developing industry
Japan – Import

Europe

- Germany – 50 M
- UK – 18 M
- Denmark – 5 M
- Holland – 5 M
- Portugal – 3 M
- Hungary – 15 M
- France < 3 M (Pekin)



- 80% of ducks are produced and eaten in China
- The duck industry grew 6 fold during the last 30 years (10 fold in China)

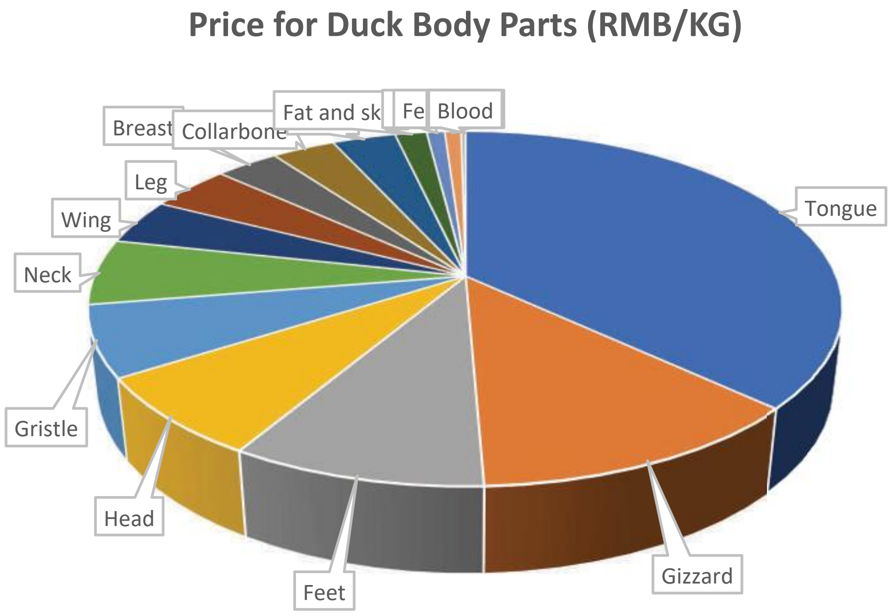


- Duck, broiler and traditional chicken breeds have almost equal market share of 1/3 each in China
- In the rest of the World, excluding China, duck makes up less than 3% of the total poultry consumption

China Duck Market

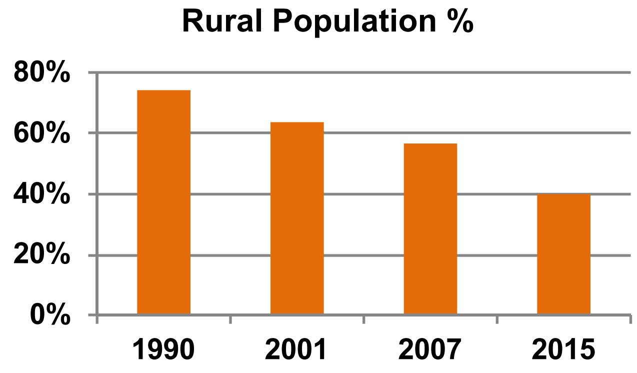
China poultry association:

Type	Number (Millions)	% of total ducks
Pekin	2880	73.1%
Muscovy and Mule	260	6.6%
"Ma" duck and egg layers	800	20.3%
Total	3940	100.0%



- Duck is the cheapest protein to produce/market in China
  - The China market has been expanding 5-10% per annum
  - Predicted continued growth due to urbanisation

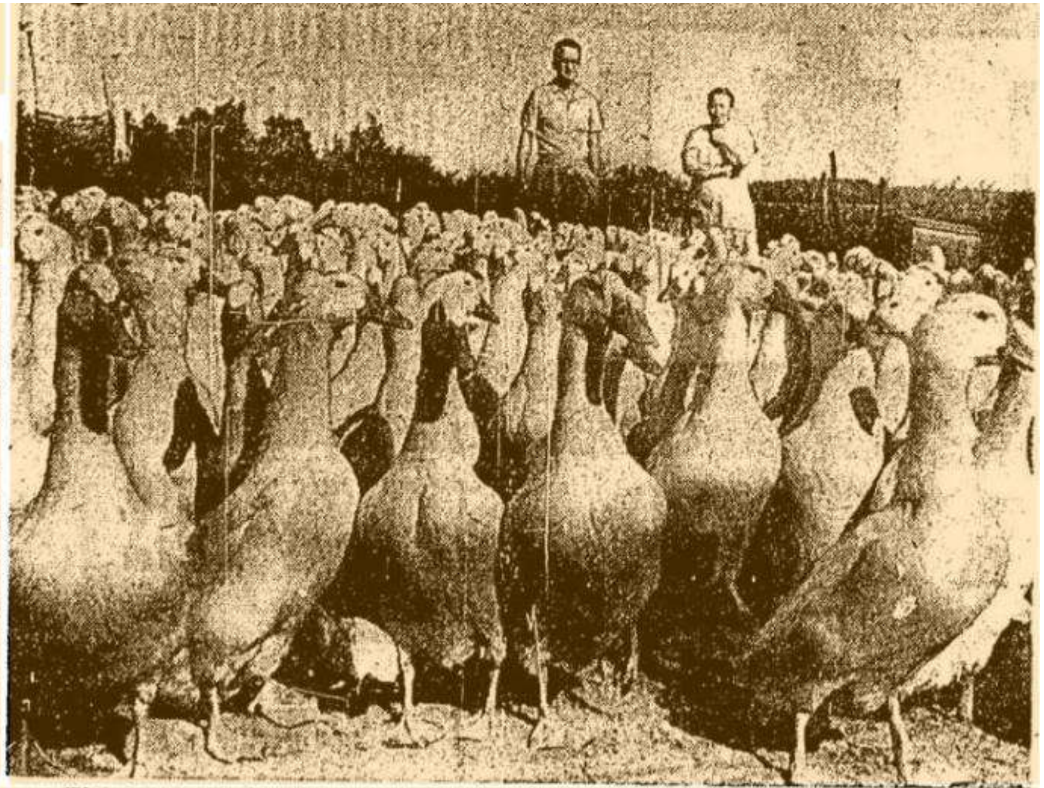
	Poultry Consumption (kg)
China Average	**12.08**
Urban Average	22.26
Rural Average	4.40



- Recent increase in demand for duck meat to replace Pork loss due to African Swine Fever

Pekin Duck Breeding in the USA

CHICAGO SUNDAY TRIBUNE: OCTOBER 16, 1960



Eight week old ducklings averaging 6½ pounds each on Maple Leaf Duck farm, Milford, Ind. In background (center) is Don Wentzel, owner of farm, and at right is Mrs. Roma Slabaugh, one of several farmers who raise duck for Wentzel on contract. Ronnie Gatesma, farm employe, is at left.

[TRIBUNE Photo]

Feed Requirements Cut

Ten years ago it required five pounds of feed to produce one pound of live duck. Today one pound of duck can be produced on 3½ pounds of feed—an example of what improved feeds and better breeding has done for the duck industry.

In 1950:
FCR of 5.0

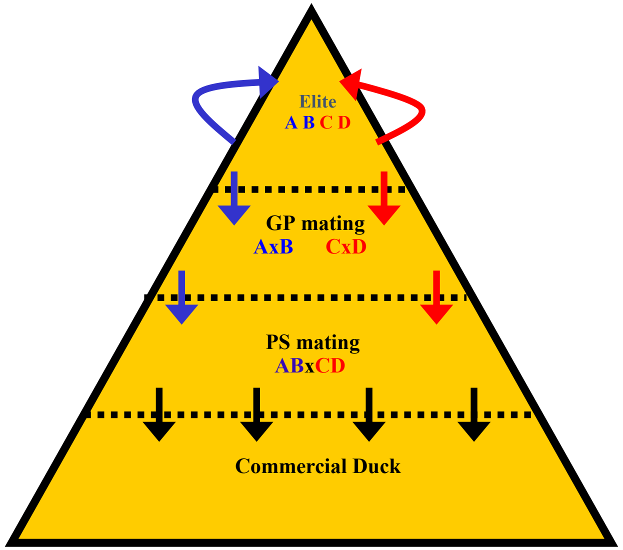
In 1960:
2.95 kg at 56 days
with an FCR of 3.5

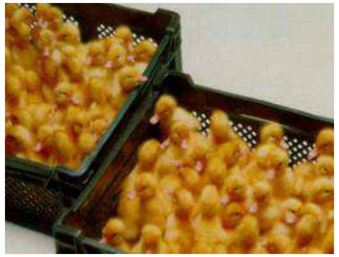
Genetic Improvement in the UK

- Cherry Valley Farms Ltd. was established in Lincolnshire by Sir Joseph Nickerson in 1959 and produced the first oven ready frozen duck in the UK.
- The need for good genetic stock led to the CVF breeding programme starting soon afterwards.
- In the 1970s CVF started supplying genetic breeding stock and technical support to duck producers globally.
- In 1971 Green Label Foods were founded and started breeding the Gressingham duck in the 1980s.

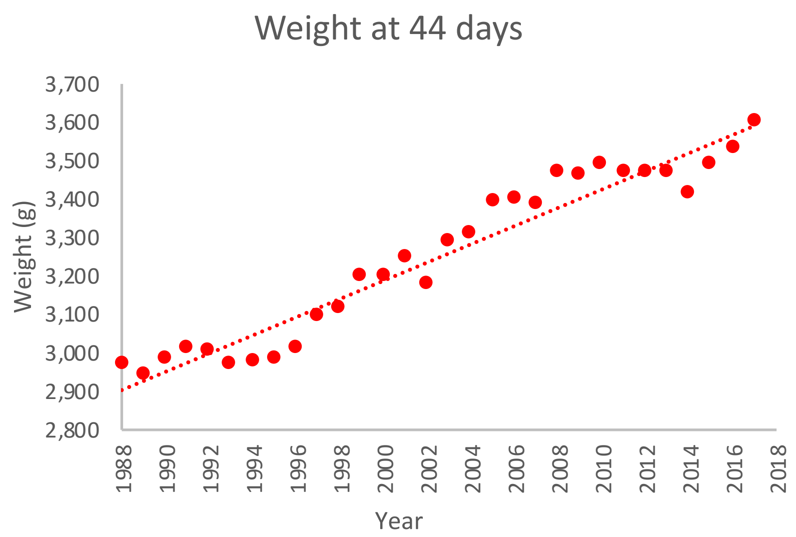
	1966	1967	1968
49 day males	3274	3457	3578
Change		+183	+121

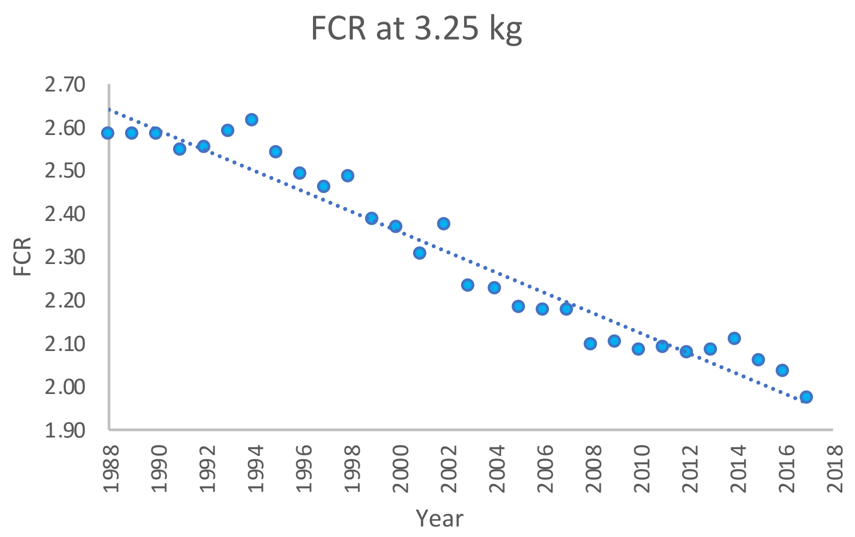
	50 Years ago	Now
Growth	3.0 kg at 56 days	>3.5 kg at 42 days
FCR	3.5 at 3.0 kg	< 2.0 at 3.25 kg
Egg production	60-70 %	> 85%

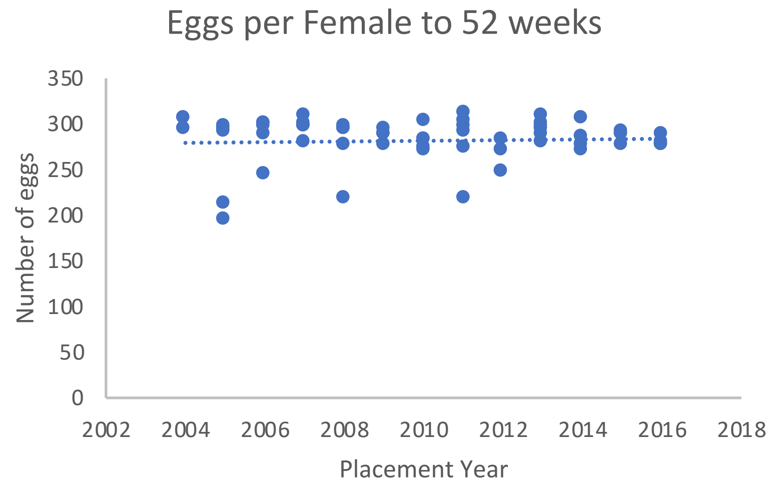


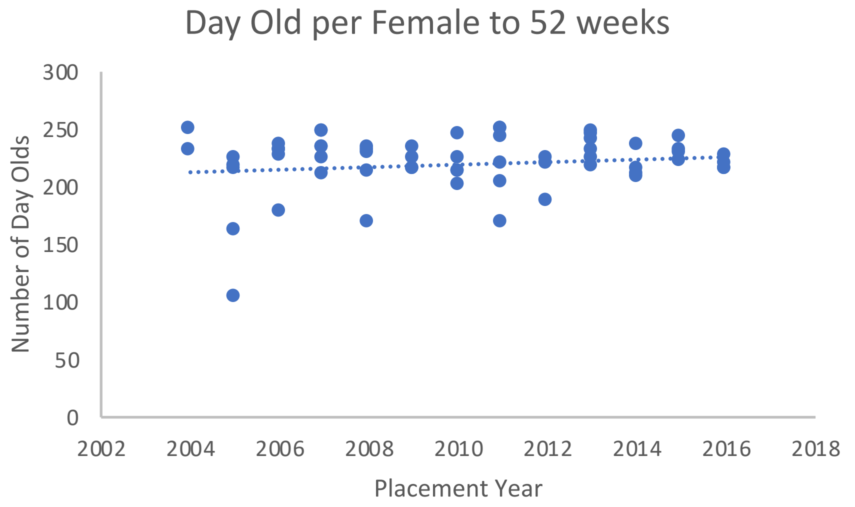


Pekin Duck Commercial Improvement









Data from commercial grower ducks

Current Pekin Genetic Products

UK
Cherry Valley
Gressingham

France
Orvia
GRIMAUD FARMS

USA
Maple Leaf Farms

China
Beijing University of Agriculture

Parents

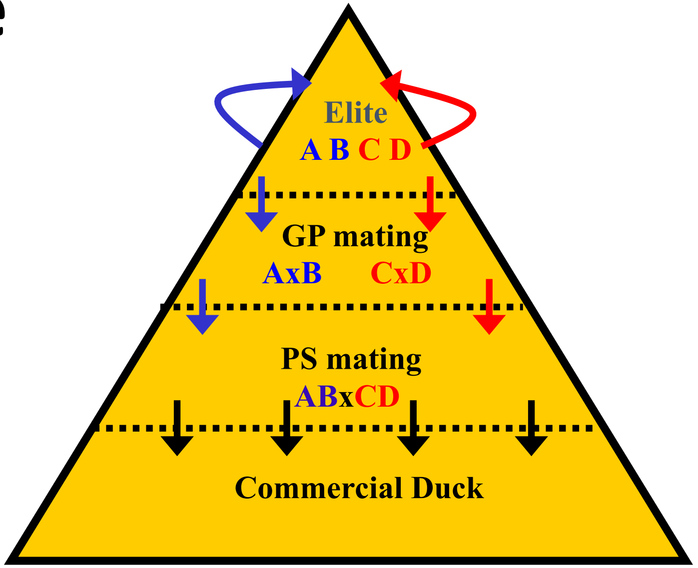
- Age at POL - 24 wks
- Lay length - 50 wks
- Eggs per female - 280 - 295
- Average hatchability - 84%
- Dayolds per female - 240

Commercial

- Production age - 36 to 49 days
- Process Weight - 3.0 to 3.9 kg
- Feed efficiency - 1.75 to 2.29
- Farm losses - 3%
- Processing Rejects - 2%

A Typical Poultry Breeding Programme

High Selection Intensity: 1-10% selected
Calculate genetic potential (EBVs) for multiple selection traits

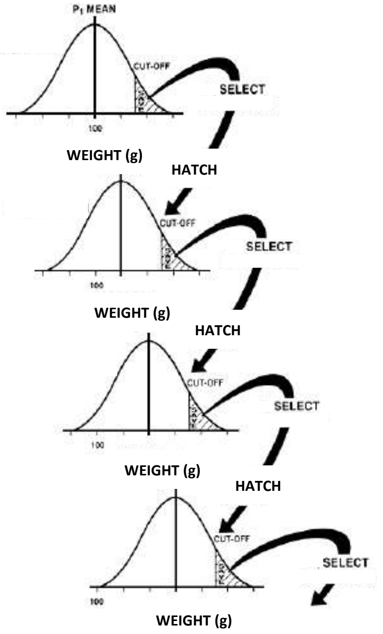


Growth
- Weight
- Average Daily Gain
- Feed Conversion Rate
- Meat yield

Health & Robustness
- Mobility
- Pododermatitis
- Liveability
- Fitness
- Carcass quality

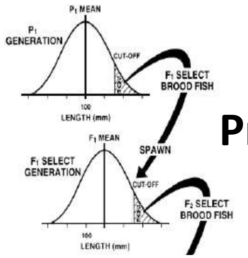
Reproduction
- Egg number
- Fertility
- Hatchability

Pedigree
- Parent/relative records



- Balance performance, reproduction & health characteristics
- Balance selection intensity against inbreeding

A Rough History of Animal Breeding



Practice

Herdbooks recorded

1800 1850 1900 1950 2000 2020

1700s: Breed the best with the best

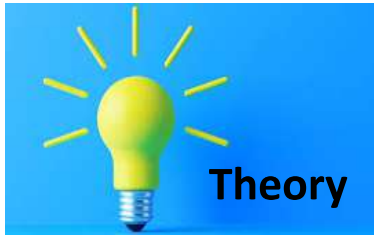
1859: Darwin Origin of Species

1865: Mendelian Genetics

1953: Crick & Watson

1977: DNA sequence

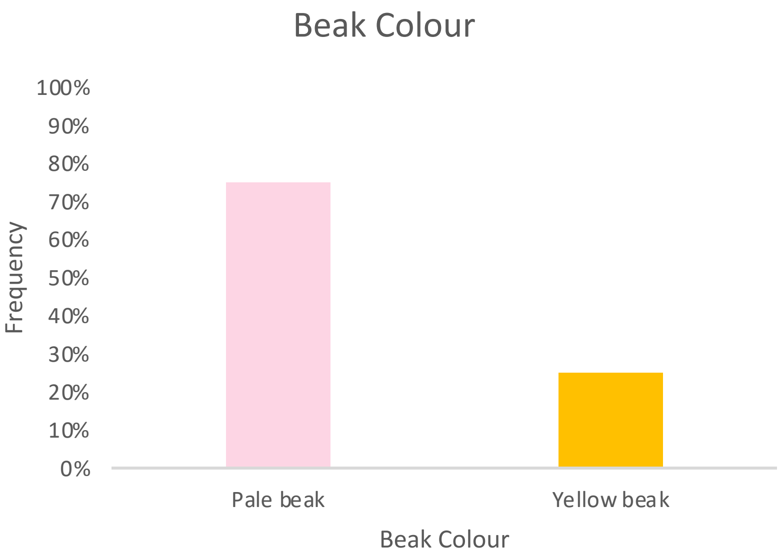
2004: Chicken sequence



Mendelian versus Quantitative Genetics

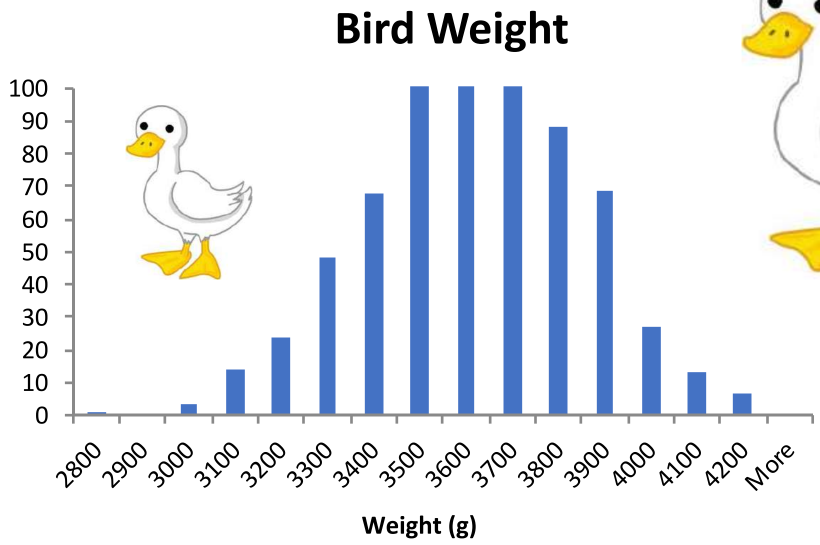
Mendelian genetics:
Single Gene e.g. Beak colour

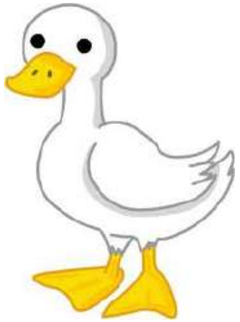
Controlled by a single gene with two or more forms e.g. beak colour
Pale beak is dominant over yellow beak.



Quantitative genetics:
Normal/continuous distribution, e.g. Weight

Controlled by many genes with small effect, and affected by the environment. Traits of importance to breeders are often quantitative.

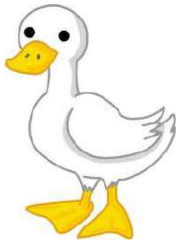




Quantitative Traits: Duck weight

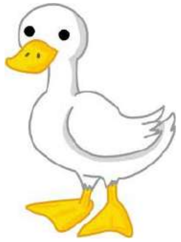
Individual genes affecting a trait cannot be easily identified.

Many genes controlling a single trait (e.g. weight) means that the same sized duck could be produced by many gene combinations.



+4	+4
-1	-2
-2	-1

=2



-2	-2
-1	+5
+5	-3

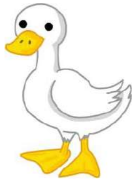
= 2

-2	+2
+2	-1
+3	-2

= 2

The same genes can be affected by the environment can give rise to different sized ducks.

Genetic Potential	Good Env	Poor Env
+5/+5	+4/+4	+2/+2
+4/+4	+3/+3	0/0
+3/+3	+2/+2	-1/-1



Genetics = 24
Trait =18
Good environment

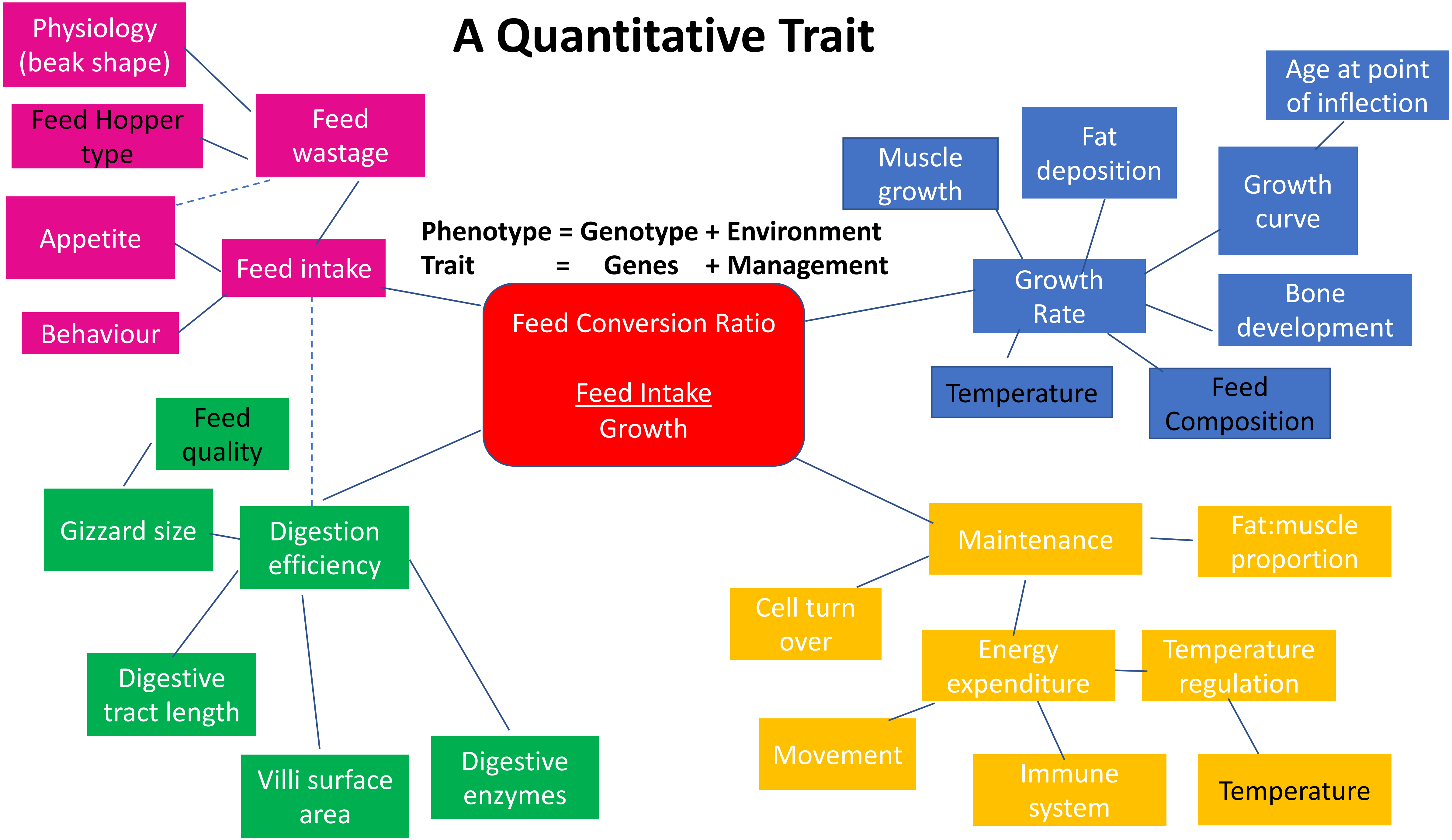
Genetic =24
Trait = 2
Poor environment

Environment = Climate, Management, Feed quality, etc.

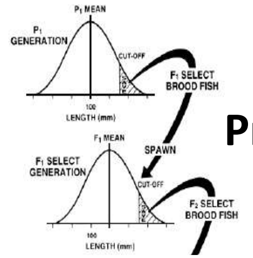
A Quantitative Trait

Phenotype = Genotype + Environment

Trait = Genes + Management



A Rough History of Animal Breeding



Practice

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1865: Mendelian Genetics

1859: Darwin Origin of Species

Estimated Breeding Values

1950: BLUP proposed for estimated breeding values

1953: Crick & Watson

1977: DNA sequence

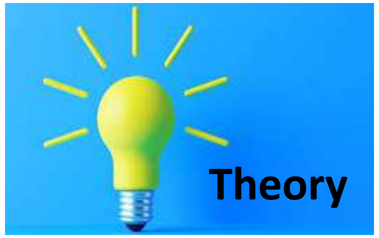
1980: BLUP used for selective breeding

1980s: QTL mapping

2001: Genomic Selection proposed

2004: Chicken sequence

2012: Genomic Selection in Chicken



BLUP: Best Linear Unbiassed prediction - a technique for estimating genetic merits

QTL: Quantitative Trait Loci - a section on DNA that correlates with variation in a quantitative trait

EBV Genetic Breeding Programme

Phenotype = Genotype + Environment

Combine effect of all influential genes (G1 + G2 + G3 + ….)

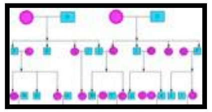
Effect of environment and management

$$\textbf{Heritability} = \frac{\textbf{Genetic Variation}}{\textbf{Phenotypic Variation}}$$

Growth, Feed Efficiency, Meat Yield & Welfare Traits

Environment:
Hatch
Farm
Pen

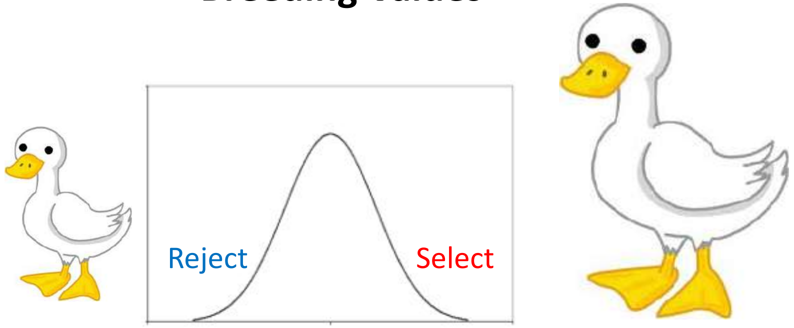
Reproduction
Egg, fertility, Hatchability



Relatives
Sex
Dam effect

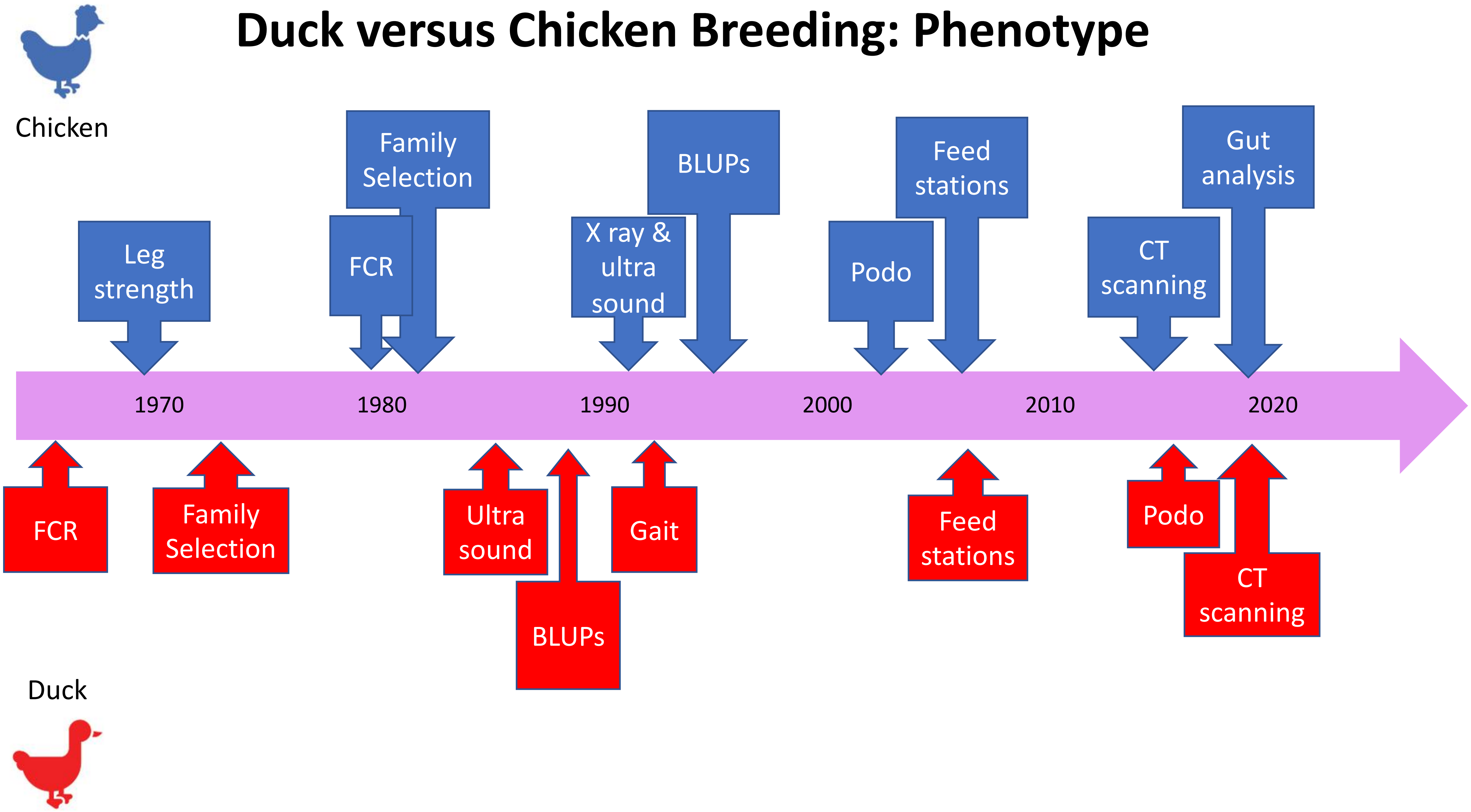
Genetic parameters: Heritability, Genetic correlations

Breeding Values

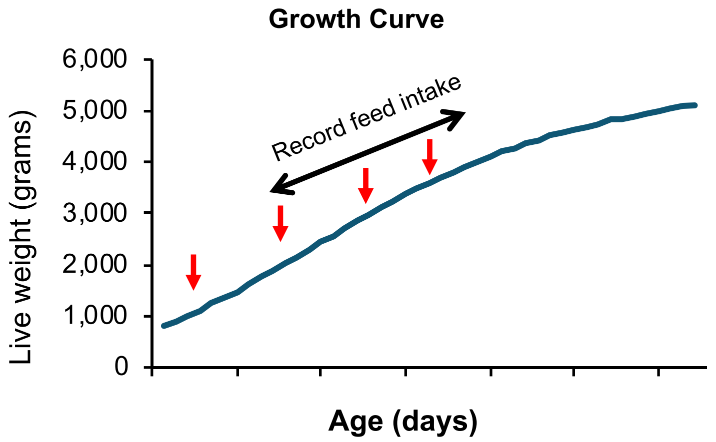


- Select top percent

Duck versus Chicken Breeding: Phenotype



Selection for improved feed efficiency

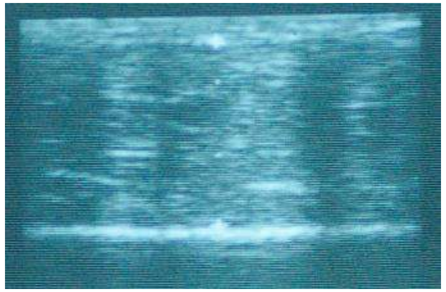


Feed station Auto Recording System:
Automatic recording for individual duck feed intake and feed conversion rate.
Feed stations introduced to the UK breeding programme in 2009, and China in 2013.

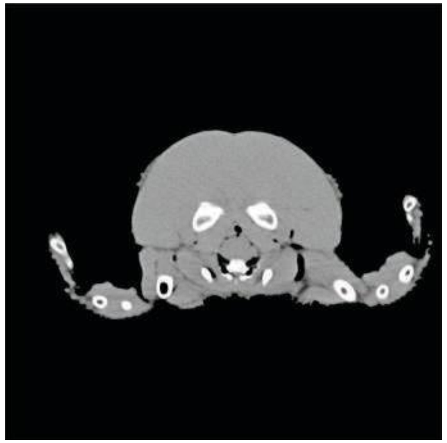
15% – 20 % rate increase in genetic improvement.

- higher correlation between feed station and commercial house feed intakes (social feeding)
- increased selection intensity
  - Increased number of birds tested
  - fewer rejected due to poor gait
  - longer test period
- additional information about behavioural and temporal pattern of feed intake
- mobility & welfare

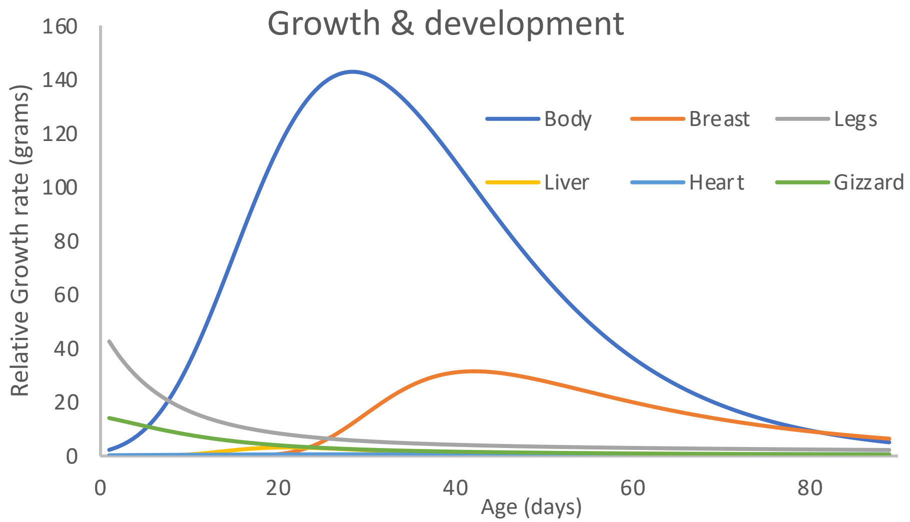
Carcass quality



Ultra sound for breast fillet

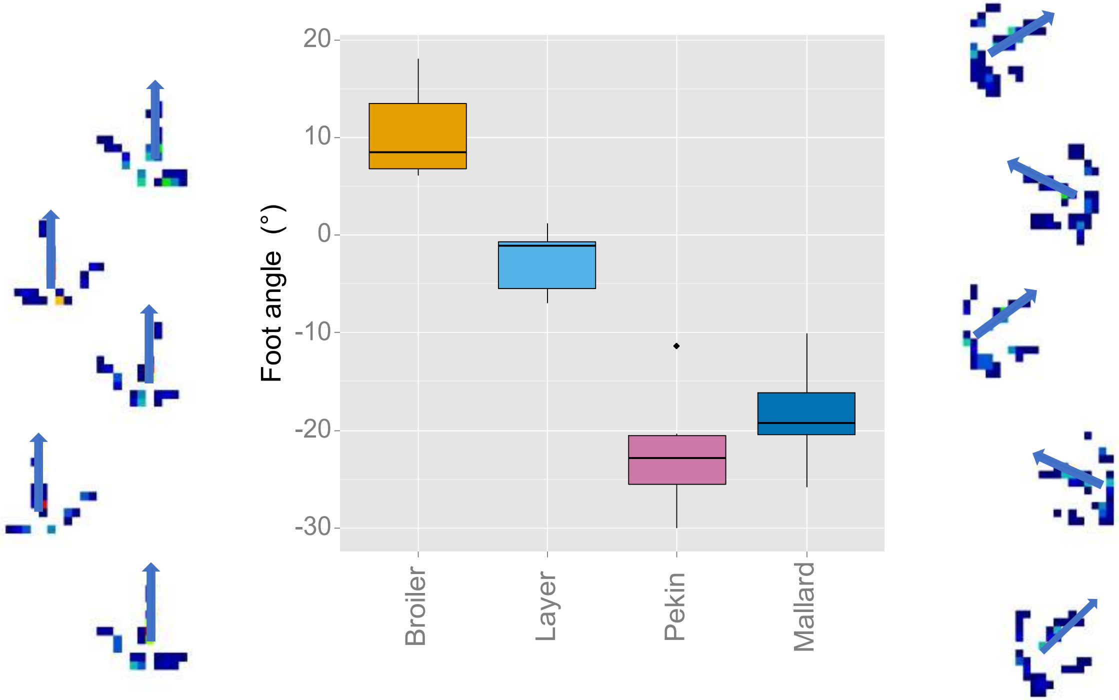


CT scan for meat yield



Learning From Broilers

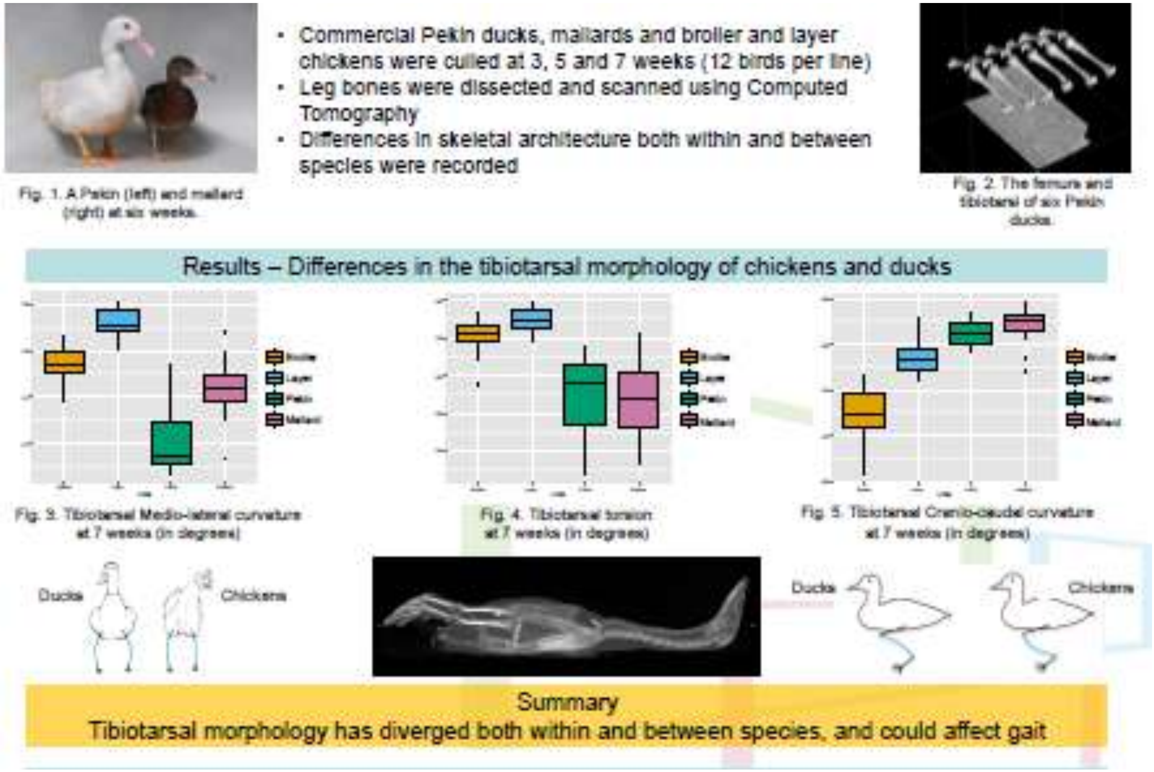
Subjective Gait scoring



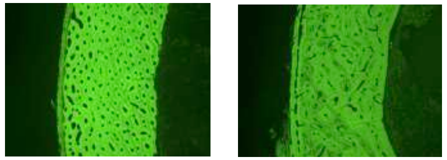
Understanding Duck Gait

Differences between Ducks and Broilers

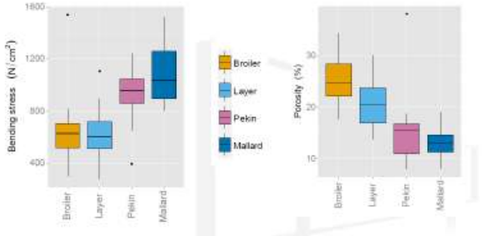
- Duck lines developed adult sized legs at an earlier stage than chickens
- Duck tibiotarsi were relatively stronger than those of chickens
- The curvature of the duck tibiotarsi may be an adaptation to swimming
- Heavy lines have adapted their gait to deal with increased loads



Bone density

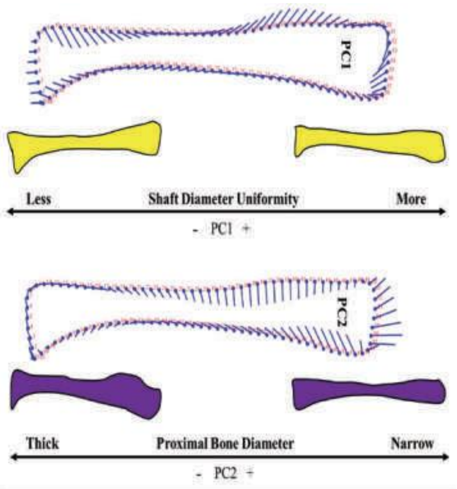


Broiler chicken | Pekin duck



Ducks have better bone quality than chickens

Leg Bone Development

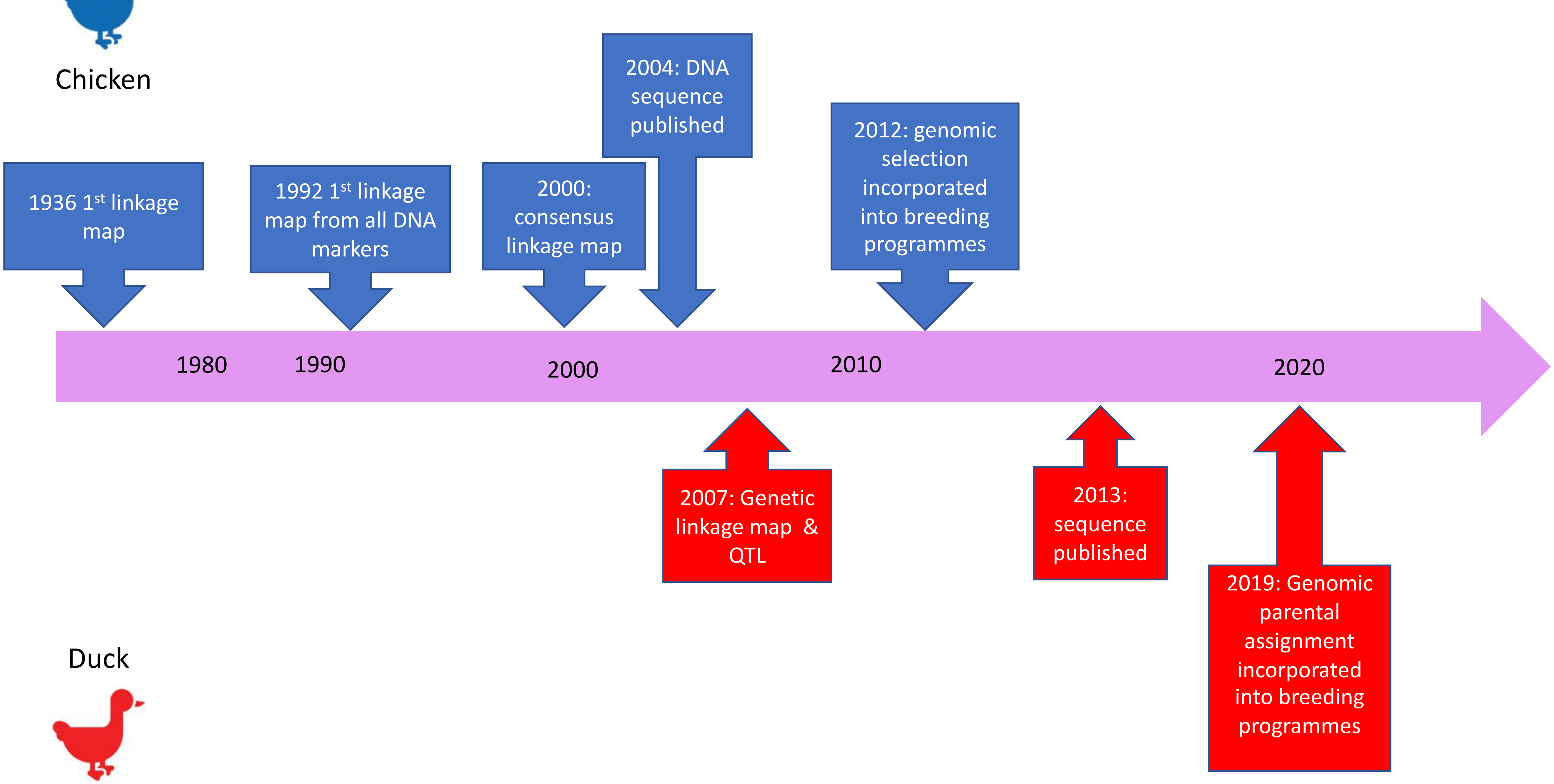


Variation in bone shape is primarily based around changes to the outline of the uniformity of the shaft and in the thickness of the proximal tibiotarsus (on right)

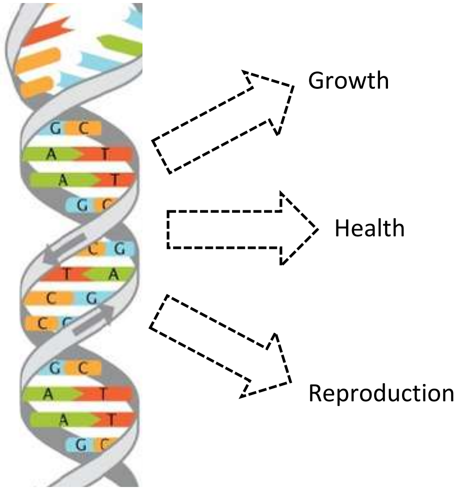
Publications:

- Differences in hindlimb morphology of ducks and chickens: effects of domestication and selection. Genetic Selection Evolution: 2015 Nov 17;47:88.
- Gait in ducks (*Anas platyrhynchos*) and chickens (*Gallus gallus*) – similarities in adaptation to high growth rate. Biology Open 2016
- Differences in leg morphology in avian species from different adaptive environments. In Preparation

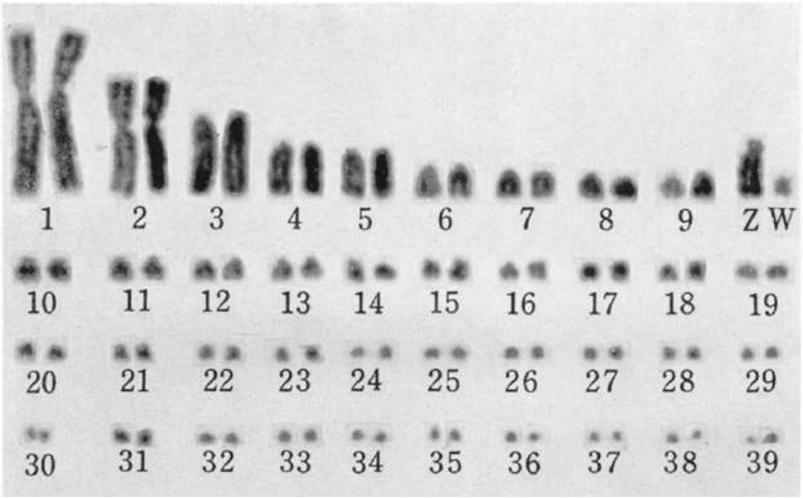
Duck versus Chicken Breeding: Genotype

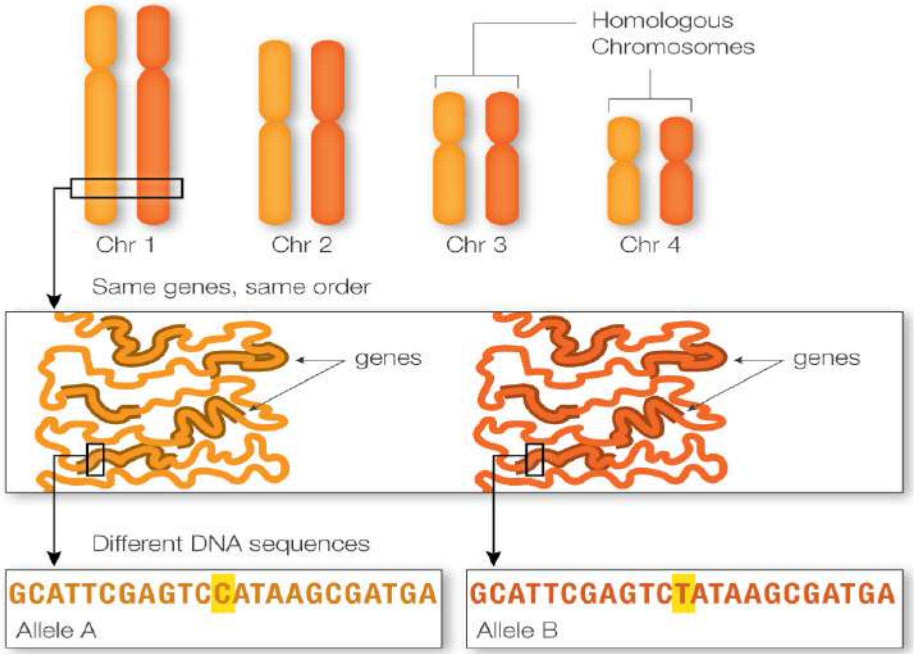


Duck DNA organised into 40 pairs Chromosomes

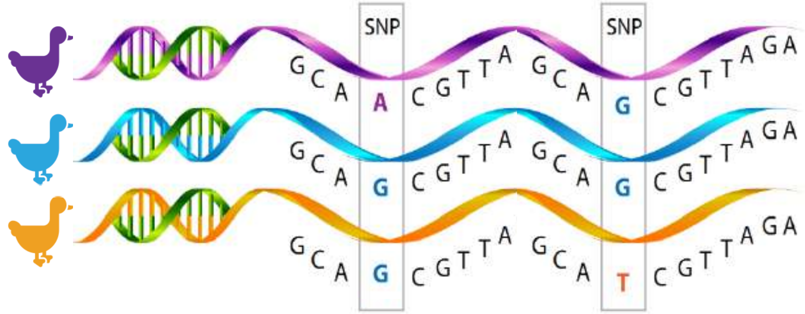


Duck Chromosomes:
40 pairs of chromosome
- 8 Macro-chromosomes
- 31 Micro-chromosomes
- 1 sex chromosome:
  male ZZ; female ZW





Molecular Markers:
- Microsatellites (Simple Sequence Repeats: SSR)
- AFLPs
- SNPs

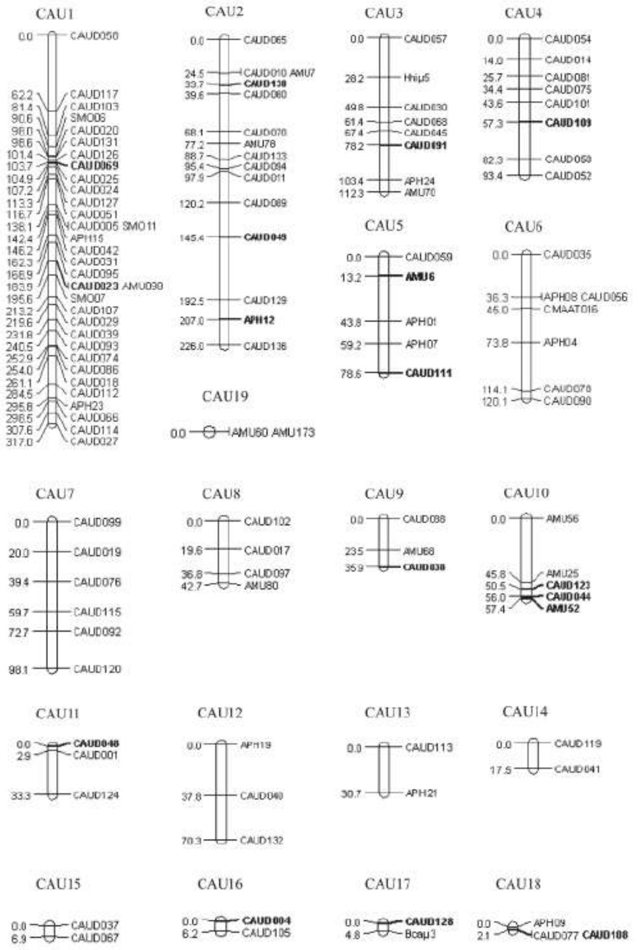


Linkage maps in Ducks

DOI: 10.1534/genetics.105.053256

A Genetic and Cytogenetic Map for the Duck (*Anas platyrhynchos*)

Yinhua Huang,* Yonghui Zhao,* Chris S. Haley,† Shengqiang Hu,‡ Jinping Hao,‡ Changxin Wu§ and Ning Li*,1



Genetics Selection Evolution BioMed Central

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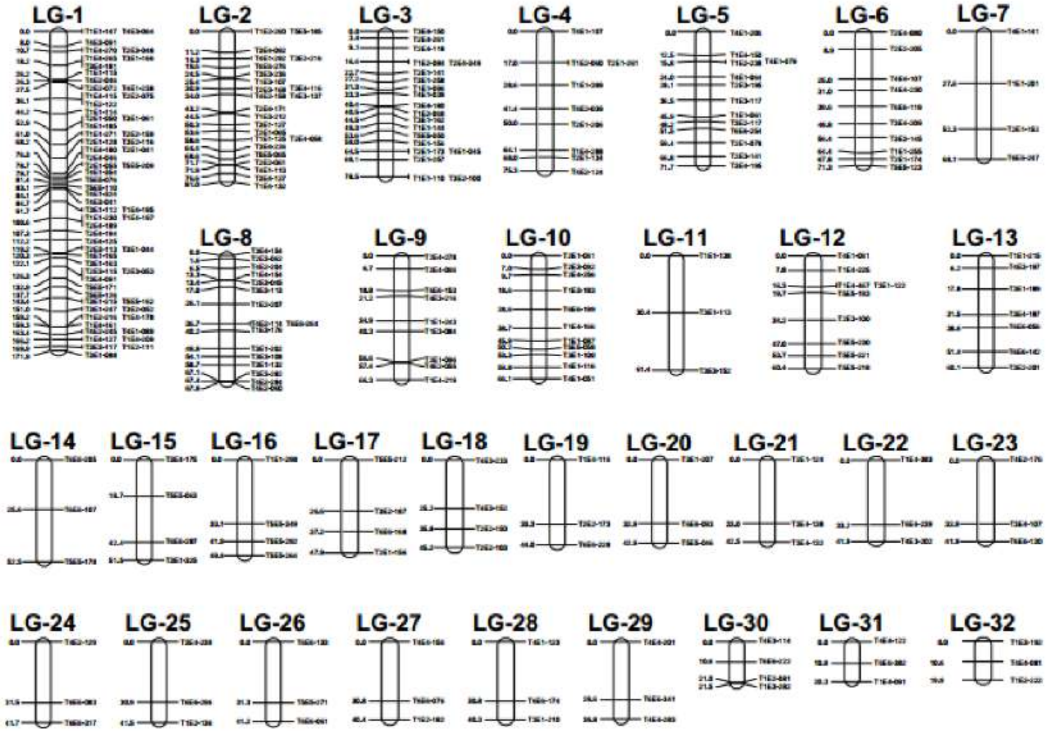
Duck (*Anas platyrhynchos*) linkage mapping by AFLP fingerprinting

Chang-Wen Huang[1,2], Yu-Shin Cheng[3], Roger Rouvier[4], Kuo-Tai Yang[1,5], Chean-Ping Wu[1,6], Hsiu-Lin Huang[1] and Mu-Chiou Huang*[1]



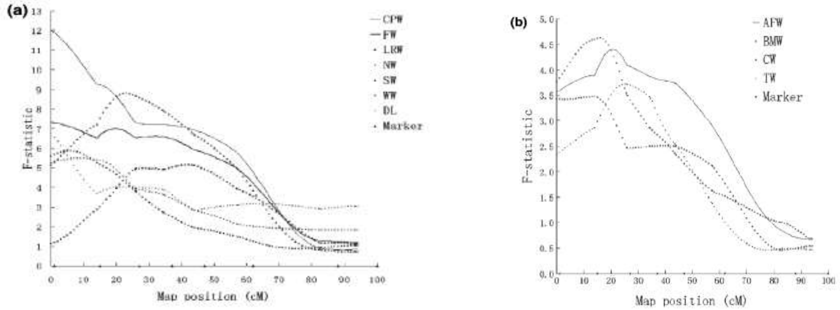
QTL in Ducks

doi:10.1111/j.1365-2052.2007.01571.x

Genetic mapping of quantitative trait loci affecting carcass and meat quality traits in Beijing ducks (*Anas platyrhynchos*)

Y. Huang*, C. S. Haley[†], F. Wu*, S. Hu[‡], J. Hao[‡], C. Wu[§] and N. Li*

*State Key Laboratory for Agrobiotechnology, China Agricultural University, Beijing 100094, China. [†]Roslin Institute, Roslin, Midlotthian EH25 9PS, UK. [‡]Gold Star Duck Production, Beijing 100076, China. [§]College of Animal Science and Technology, China Agricultural University, Beijing 100094, China



Cluster of QTL on CAU2 & CAU4

- 10 QTL for six carcass and two meat traits
- Explain 3.3 – 17.7 % variation
- QTL confidence intervals 23cM to 204cM

SHORT COMMUNICATION

doi:10.1111/j.1365-2052.2007.01637.x

Detection of quantitative trait loci for body weights and conformation traits in Beijing ducks

Y. Huang*,[†], C. S. Haley[†], S. Hu[‡], J. Hao[‡], C. Wu[§] and N. Li*

*State Key Laboratory for Agrobiotechnology, China Agricultural University, Beijing 100094, China. [†]Roslin Institute, Roslin, Midlothian EH25 9PS, UK. [‡]Gold Star Duck Production, Beijing 100076, China. [§]College of Animal Science and Technology, China Agricultural University, Beijing 100094, China

- 20 QTL for eight body weight and six conformation traits
- Explain 5.9 – 7.9 % variation
- QTL confidence intervals 70cM – 257cM

- Cross between high body weight and high egg number

Marker Assisted Selection (MAS)

- Selection of chromosome region using markers linked to selection traits
- Markers are not the cause, but are linked to the phenotype
- Recombination over generations breaks down the link between the markers and traits
- Relationship between marker and trait tend to be population specific: i.e. may only hold in one pure line
- Negative correlations with other traits

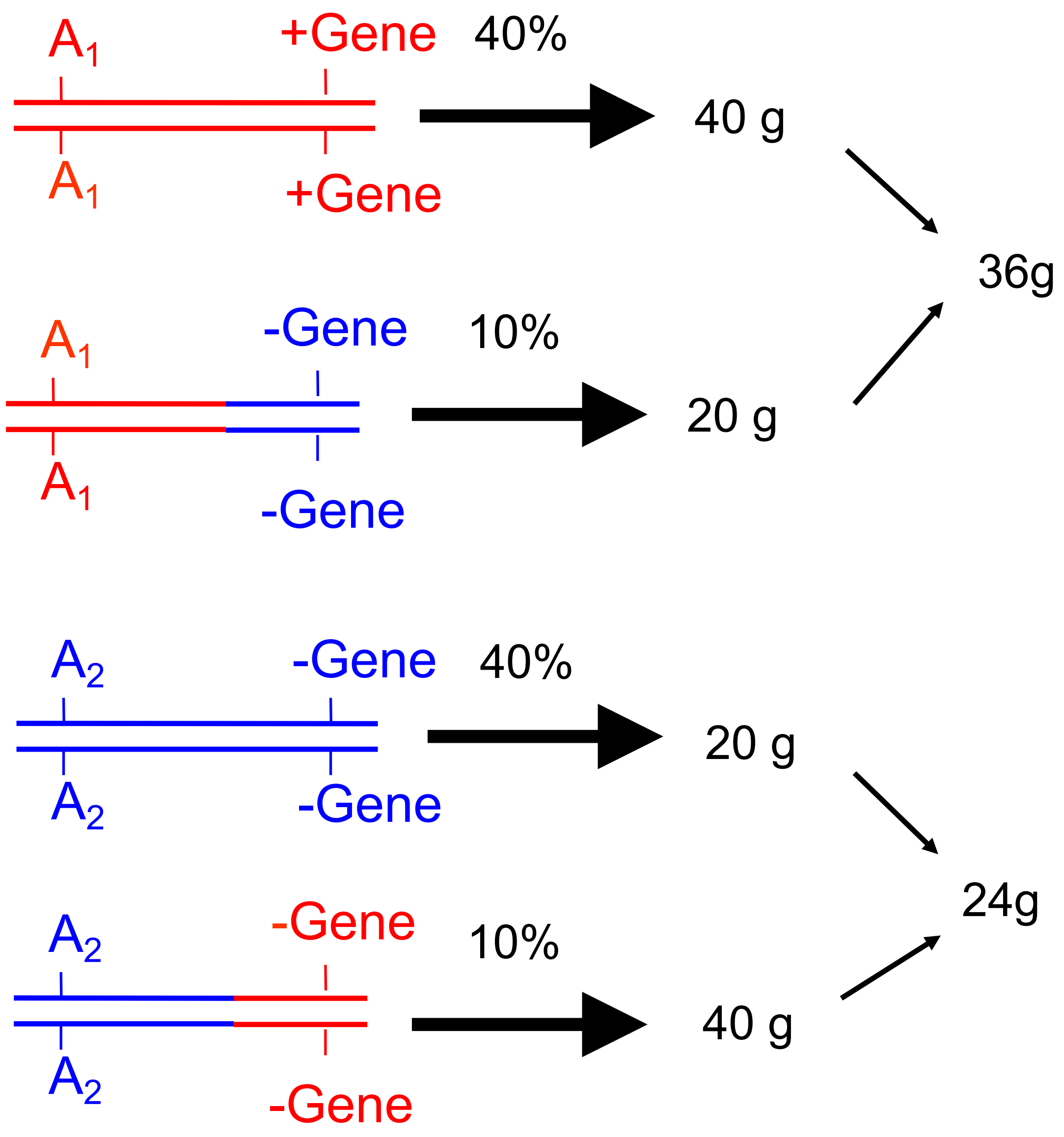
QTL mapping and breeding programmes

- Linkage maps & QTL mapping experiments usually involve diverse crosses (meat x egg)
  - QTL unlikely to be segregating in pure or commercial lines
- Limitation in fully informative markers
  - AFLPs present/absent, rarer SSRs are codominant
- Poor distribution of markers
  - Large, uneven gaps in linkage maps
- Large confidence intervals mean recombination over generations break down the linkage between the trait and the markers

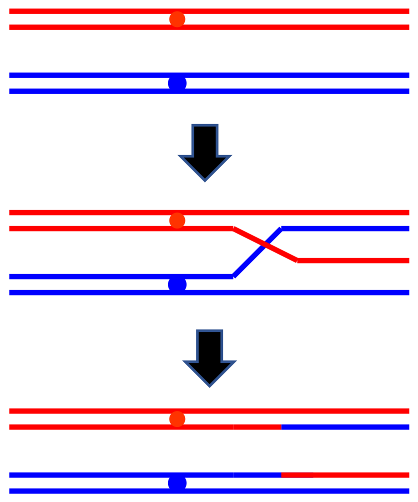
Candidate gene selection

- Remove unwanted genotypes e.g. feather pigmentation

MAS: link between Marker and Trait



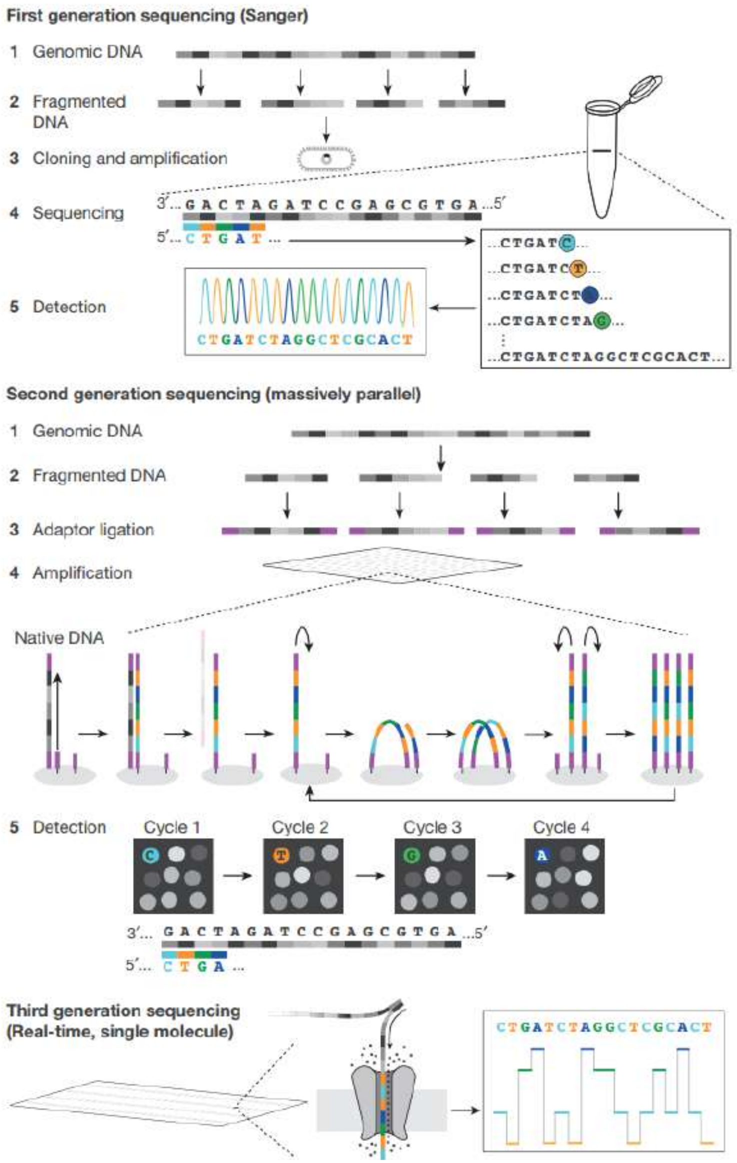
Recombination



The greater the distance between the marker and the gene the more the effect of the gene is underestimated.

More Markers Required

Sequencing



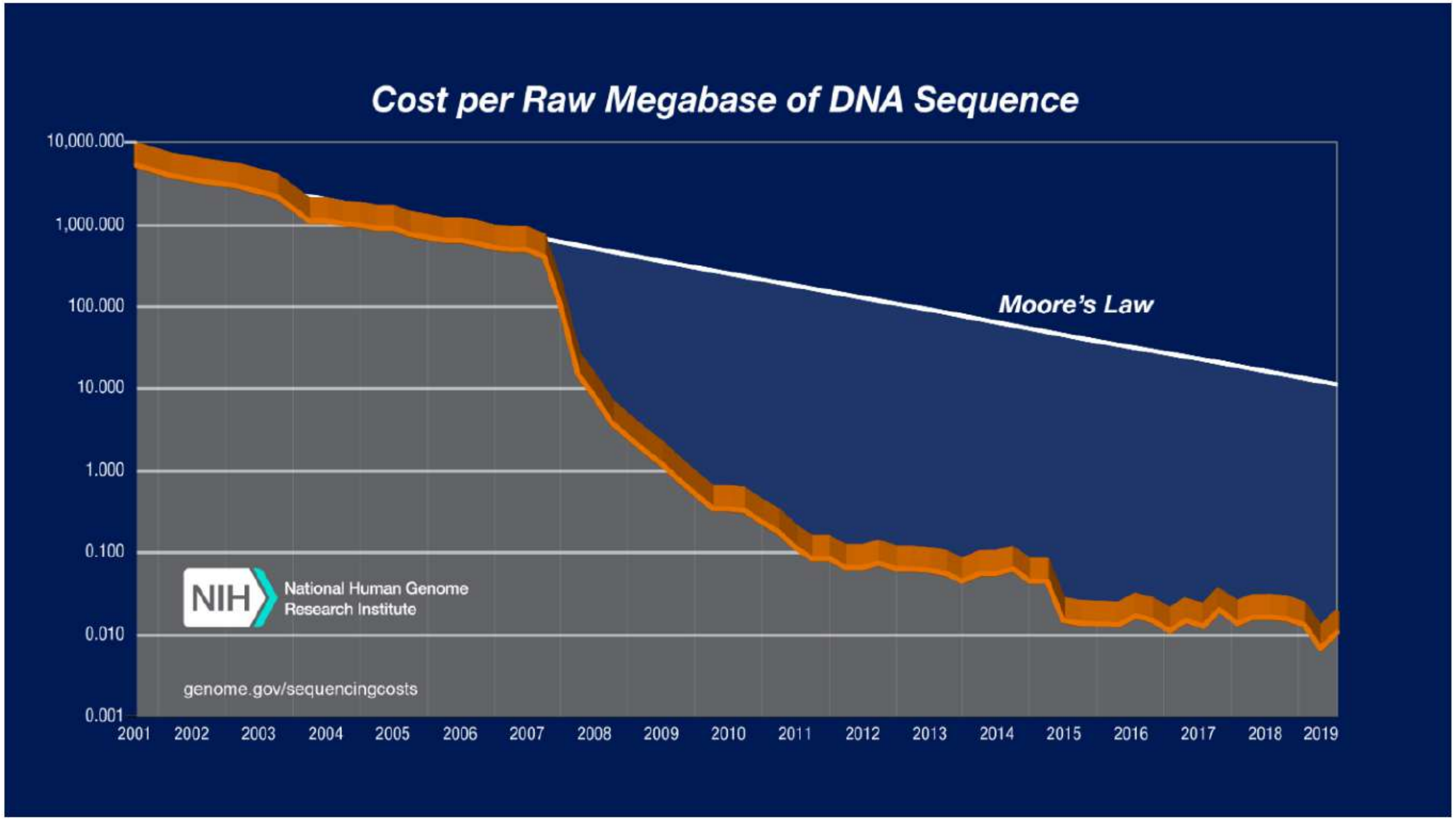
First generation of sequencing technology is based on the chain termination method developed by Sanger and Coulson in 1975 or the chemical method (chain degradation) invented by Maxam and Gulbert during 1976 and 1977.

Second generation of sequencing technology was born symbolized by Roche's 454 technology, Illumina's Solexa, Hiseq technology, and ABI's Solid technology.

The turn-around time of the second generation sequencing technology to complete a human genome project can just be one week, while that using the first generation sequencing technology to achieve the same goal is three years

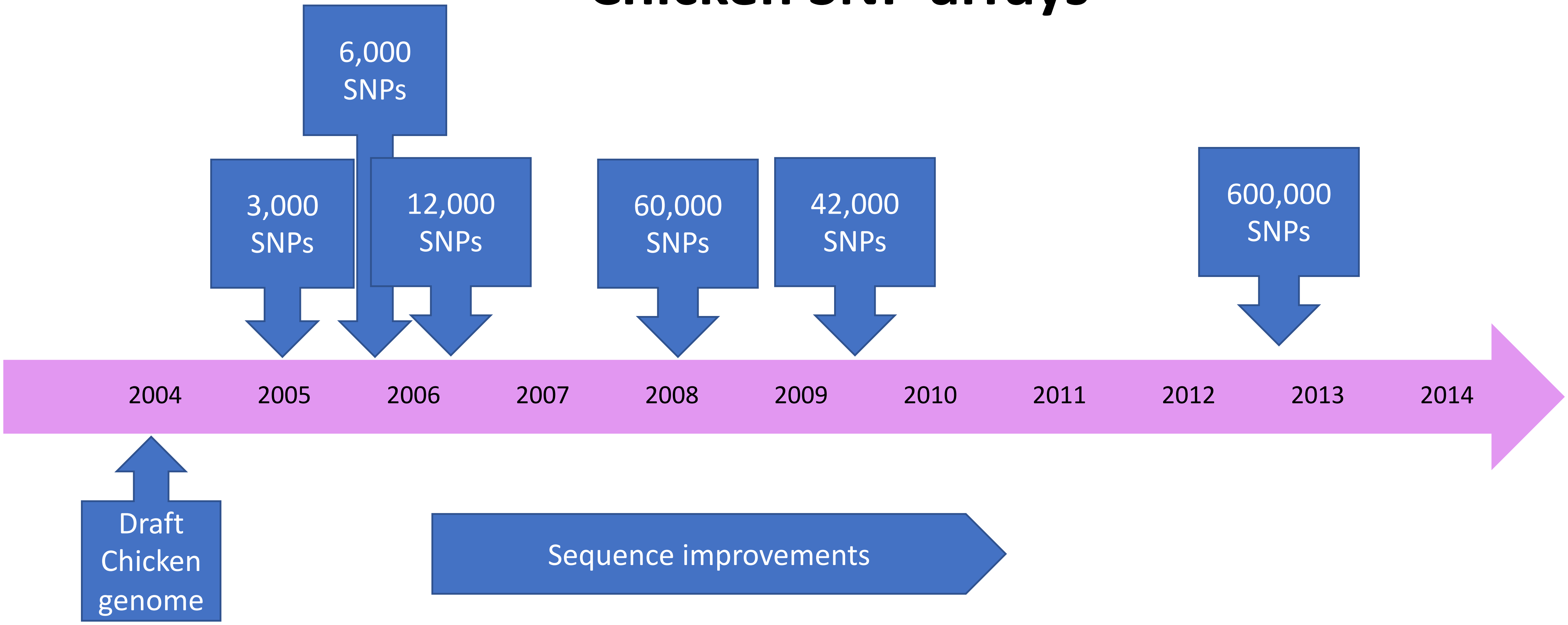
The most widely used **third generation technology** is probably the single molecule real time (SMRT) platform from Pacific Biosciences. During SMRT runs DNA polymerisation occurs in arrays of microfabricated nanostructures called zero-mode waveguides (ZMWs), which are essentially tiny holes in a metallic film covering a chip.

Cost of Sequencing



Sequencing cost per megabase - 2019

Chicken SNP arrays



2.8 M SNPs
(commercial
broilers & layers)

Public and privately (Industry) owned
SNP arrays for broilers and layers.

Duck Sequence

nature genetics OPEN

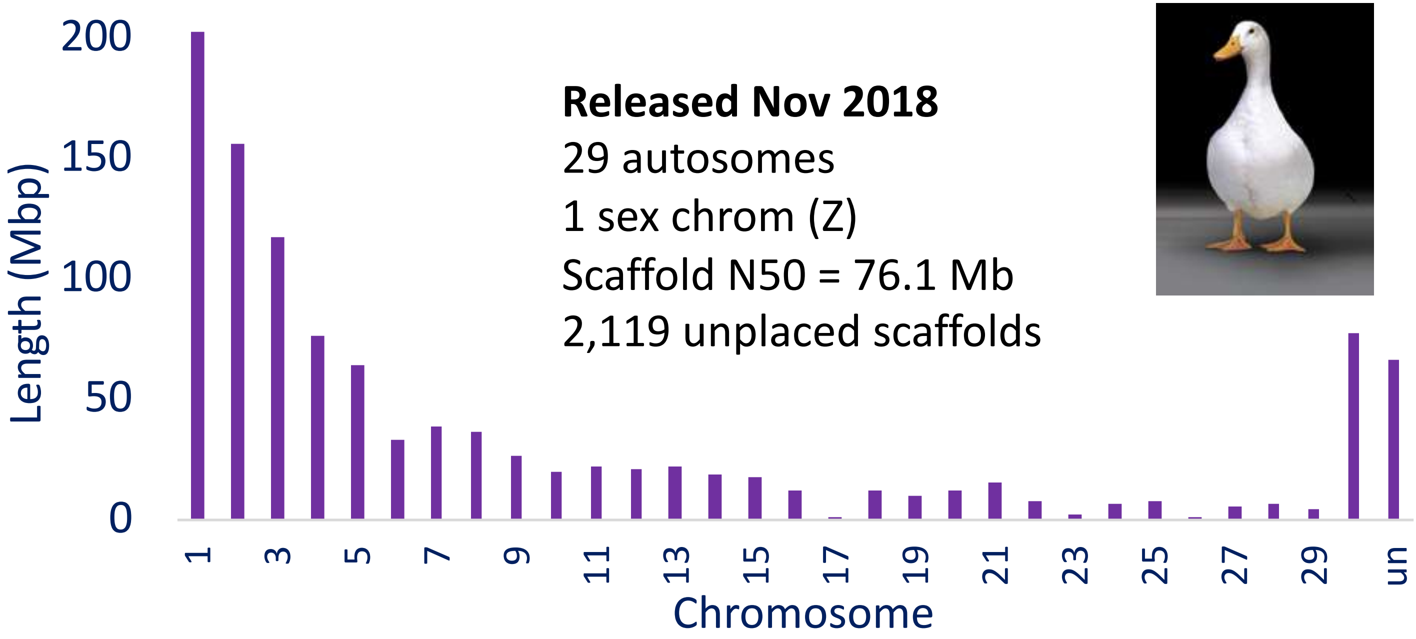
2013

The duck genome and transcriptome provide insight into an avian influenza virus reservoir species

Yinhua Huang[1,2,20], Yingrui Li[3,20], David W Burt[2,20], Hualan Chen[4], Yong Zhang[3], Wubin Qian[3], Heebal Kim[5], Shangquan Gan[1], Yiqiang Zhao[1], Jianwen Li[3], Kang Yi[3], Huapeng Feng[4], Pengyang Zhu[4], Bo Li[3], Qiuyue Liu[1], Suan Fairley[6], Katharine E Magor[7], Zhenlin Du[1], Xiaoxiang Hu[1], Laurie Goodman[3], Hakim Tafer[8,9], Alain Vignal[10], Taeheon Lee[5], Kyu-Won Kim[11], Zheya Sheng[1], Yang An[1], Steve Searle[6], Javier Herrero[12], Martien A M Groenen[13], Richard P M A Crooijmans[13], Thomas Faraut[10], Qingle Cai[3], Robert G Webster[14], Jerry R Aldridge[14], Wesley C Warren[15], Sebastian Bartschat[8], Stephanie Kehr[8], Manja Marz[8], Peter F Stadler[8,9], Jacqueline Smith[2], Robert H S Kraus[16,17], Yaofeng Zhao[1], Liming Ren[1], Jing Fei[1], Mireille Morisson[10], Pete Kaiser[2], Darren K Griffin[18], Man Rao[1], Frederique Pitel[10], Jun Wang[3,19] & Ning Li[1]

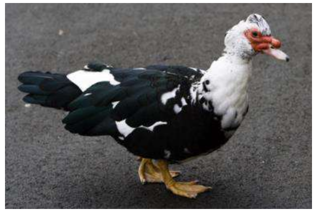
Single Female Pekin Duck Sequenced

Most Recent Sequence is 50 fold improvement (Pekin, layer & wild duck)



Released Nov 2018
29 autosomes
1 sex chrom (Z)
Scaffold N50 = 76.1 Mb
2,119 unplaced scaffolds

Moscovy Sequence of similar quality as the Pekin sequence
Cairina moschata genome from Thébault *et al.* 2019
28 autosomes
1 sex chrom (Z)
1,922 scaffolds not aligned to reference genome



SNP identification in Duck

UK Pekin Lines

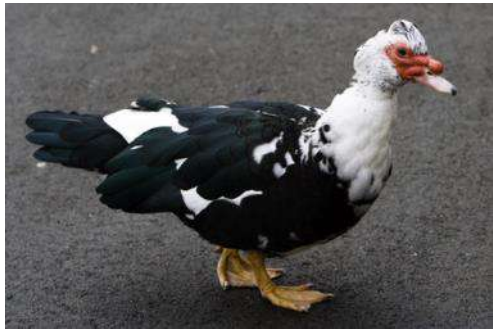
Polymorphic Loci	18.7 M
Quality filters (Phred score)	14.7 M
Biallelic	7.8 M
Minor Allele Frequency >0.25	2.5 M
Suitable for genotyping platform (no SNPs +/- 70 bp)	1.8 M

French: Common & Muscovy

* Grimaud Frères Sélection, Orvia Gourmaud Sélection, Experimental lines from INRA, Mallard breed used as game bird, Rouen duck

	*Common Duck	Muscovy Duck
Polymorphic Loci	23.6 M	9.2 M
Suitable for genotyping platform (no indels +/- 50 bp)	12.6 M	6.2 M
Suitable for genotyping platform (no SNPs +/- 35 bp)	8.1 M	4.5 M
Quality Filter (unique alignment to reference genome)	2.2 M	2.0 M
Minor Allele Frequency >0.05	2.2 M	1.9 M

Duck SNP arrays

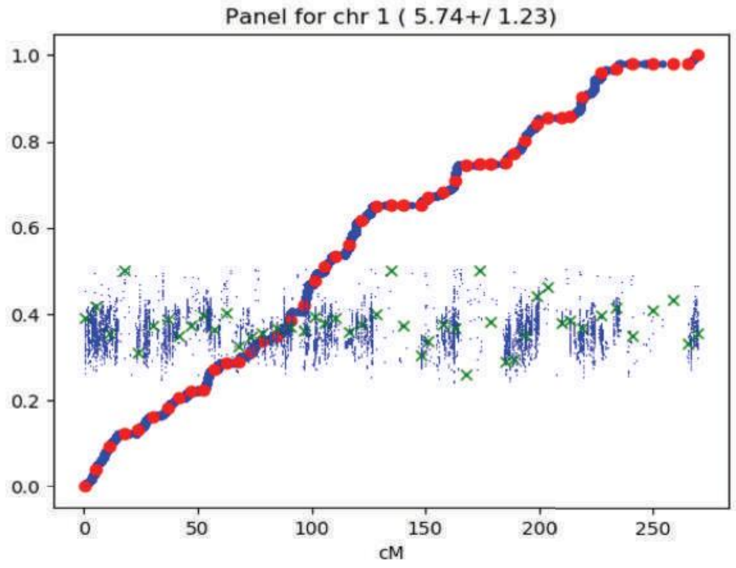


Common duck library
343,950 SNPs

Muscovy duck library
331,241 SNPs

Both libraries
673,886 SNPs

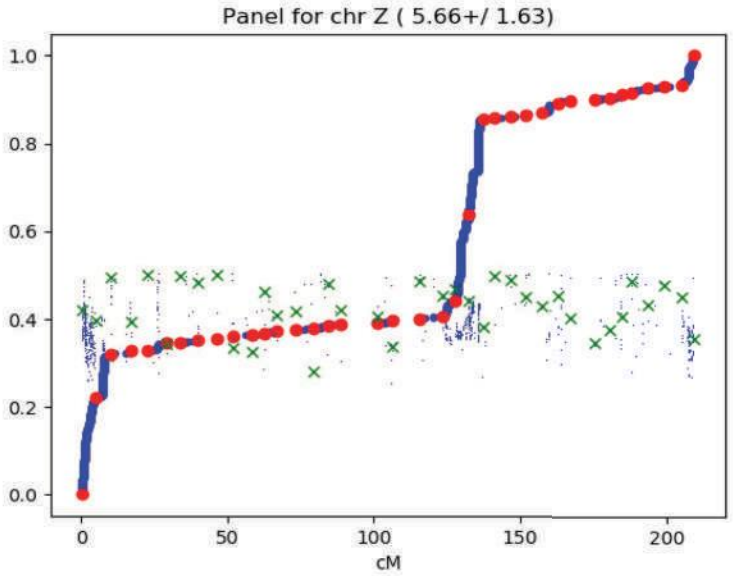
SNP Genome coverage

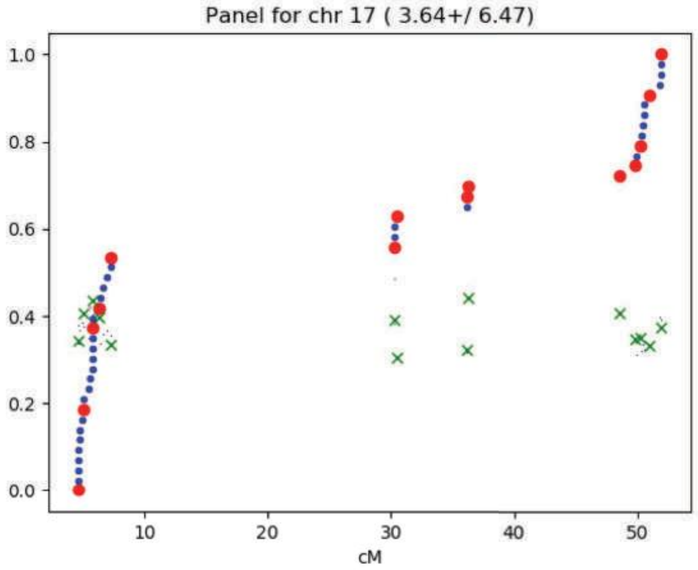


Reduced variation or sequencing issues leave gaps in SNPs availability on some chromosomes.

Z: sex chromosome

17: Major Histocompatibility Complex

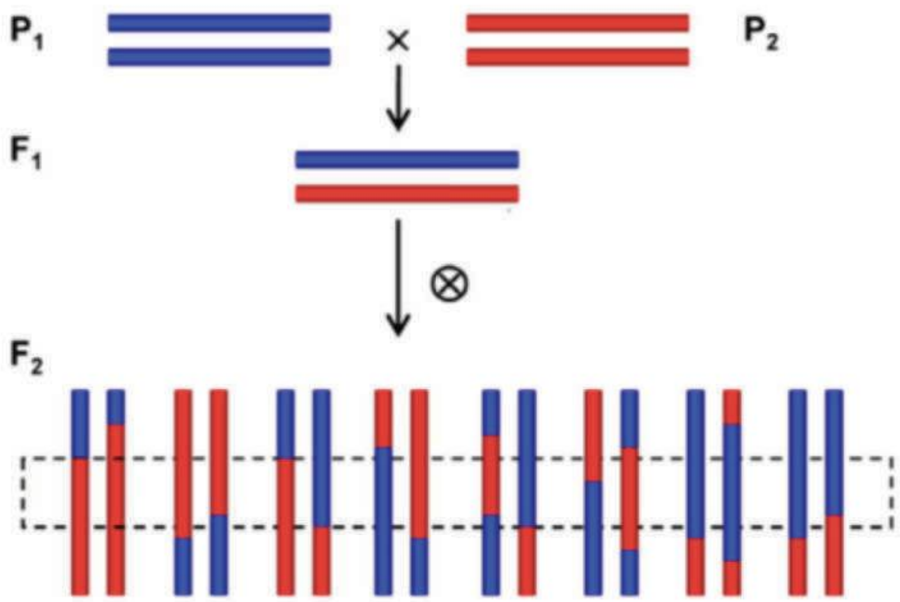




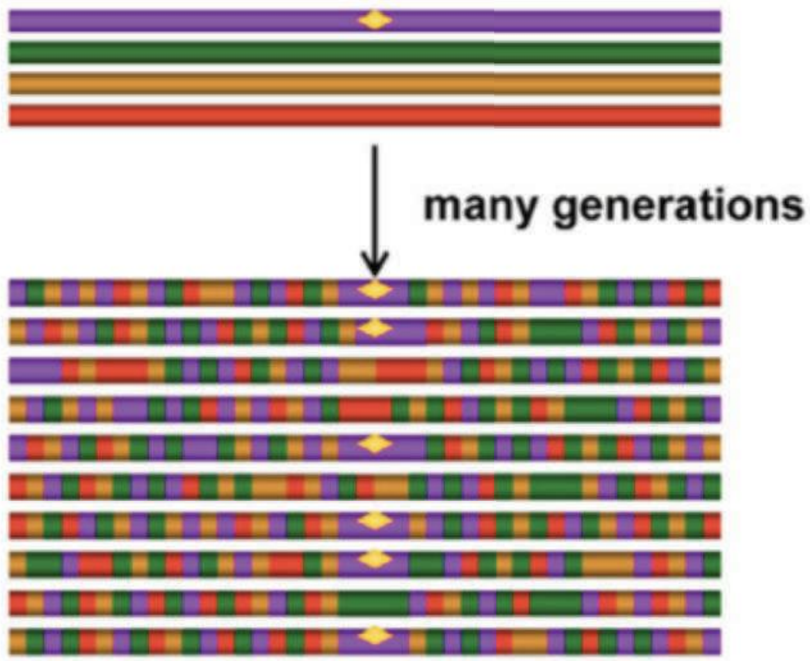
Genomic Selection

- The identification of a link or correlation between DNA molecular markers and a selection trait in a population.
- Select for DNA markers that correspond to the desired improvement in subsequent generations and populations.
- Molecular markers can be selected early in the animal’s life instead of waiting for the trait to be observed and measured.
- The marker is at the DNA level, it is known that it will be inherited in the next generation, but it is essential that the link between the trait and the marker is true.
- Genomic selection is particularly advantageous for ‘difficult to measure’ traits (e.g. behaviour such as sexual aggression), traits that may not be displayed in all individuals (e.g. sex specific traits, such as egg production in males) or traits that would prevent an individual reproducing or being used as breeding stock for the next generation i.e. traits that are destructive such as carcass quality, disease tolerance, etc.

Genome Wide Association Studies (GWAS)



Linkage analysis: few opportunities for recombination to occur within families, resulting in relatively low mapping resolution



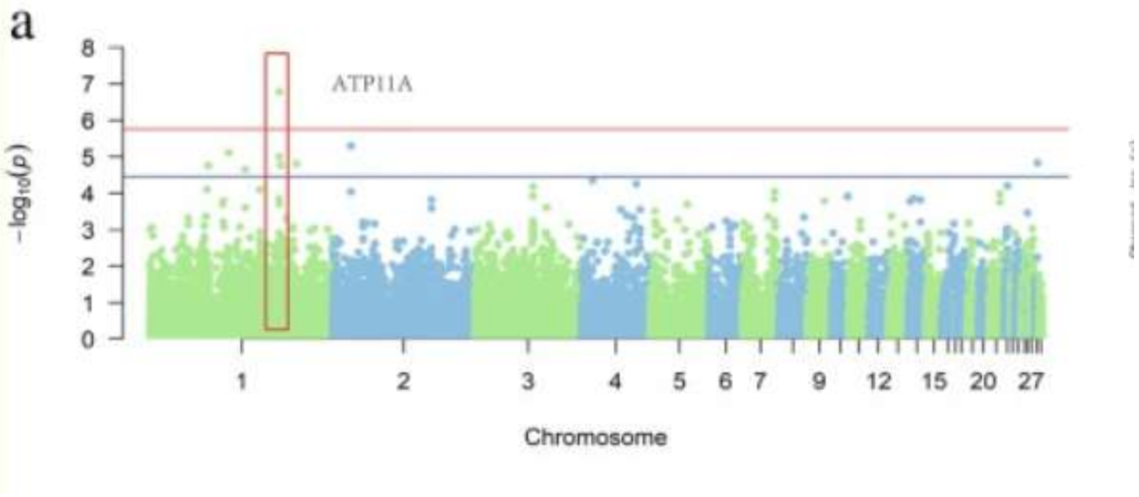
Association mapping relies on historical mapping and natural genetic diversity for high resolution mapping

Genome Wide Association Studies in Ducks

Deng et al. BMC Genomics (2019) 20:1
https://doi.org/10.1186/s12864-018-5379-1
BMC Genomics
RESEARCH ARTICLE Open Access

Genome-wide association study reveals novel loci associated with body size and carcass yields in Pekin ducks

Meng-Ting Deng[1†], Feng Zhu[1†], Yu-Ze Yang[2], Fang-Xi Yang[3], Jin-ping Hao[3], Si-Rui Chen[1] and Zhuo-Cheng Hou[1*]

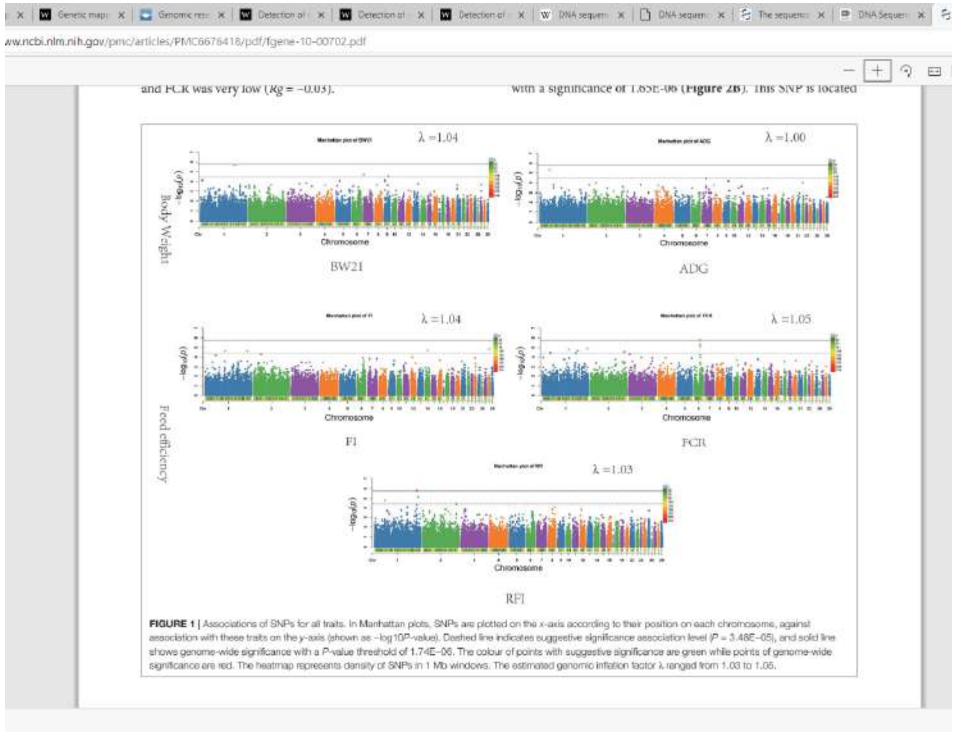


- 37 associations for 17 carcass traits
- *ATP11A* also associated with body weight and internal organ weight in chickens.
- This gene may be involved in basic growth and development processes,

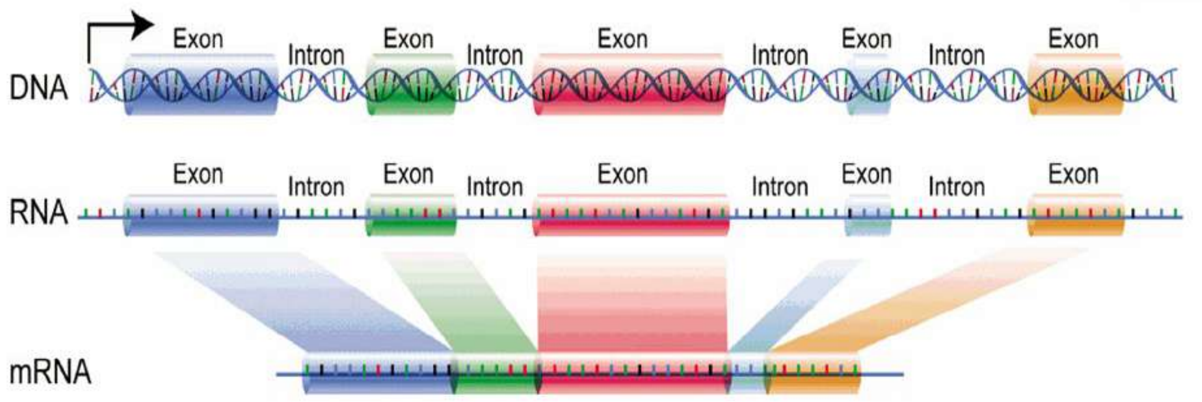
Genome-Wide Association Study of Growth and Feeding Traits in Pekin Ducks

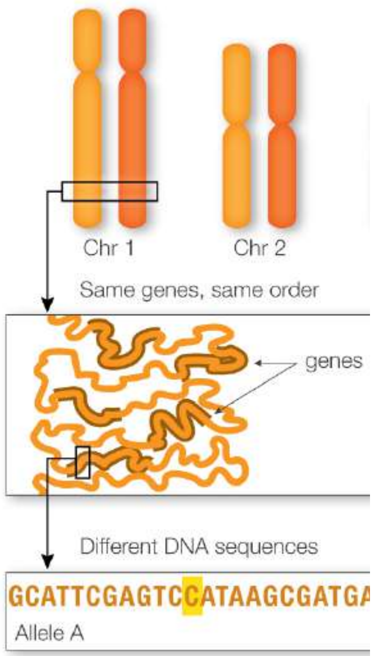
Feng Zhu[1], Si-Rui Cheng[1], Yu-ze Yang[2], Jin-Ping Hao[3], Fang-Xi Yang[3] and Zhuo-Cheng Hou[1*]

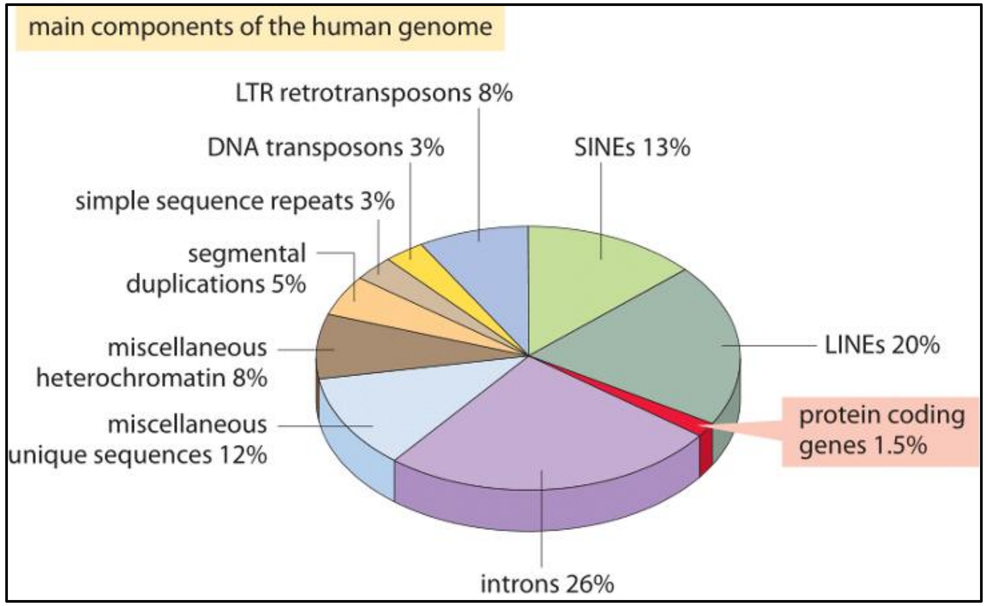
[1] National Engineering Laboratory for Animal Breeding and Key Laboratory of Animal Genetics, Breeding and Reproduction, MARA, Department of Animal Genetics and Breeding, China Agricultural University, Beijing, China, [2] Beijing Municipal General Station of Animal Science, Beijing, China, [3] Duck Industry Center, Beijing Golden Star Duck Inc., Beijing, China



Coding and Non coding DNA







In Humans 1.5% of the genome consists of the ≈20,000 protein-coding sequences.

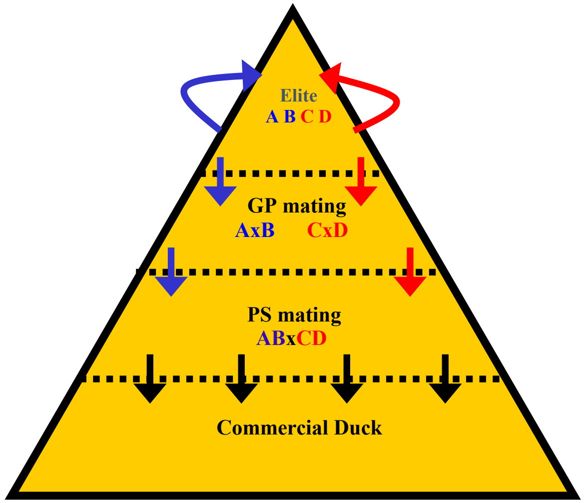
26% Introns (non coding regions within a gene sequence)

40-50% Transposable elements (Long interspersed nuclear elements, Short Interspersed Nuclear elements, defunct genomic remnants)

8%Heterochromatin – tightly packed DNA which may affect the transcription of genes near by.

Genomic Selection: Dairy versus Poultry

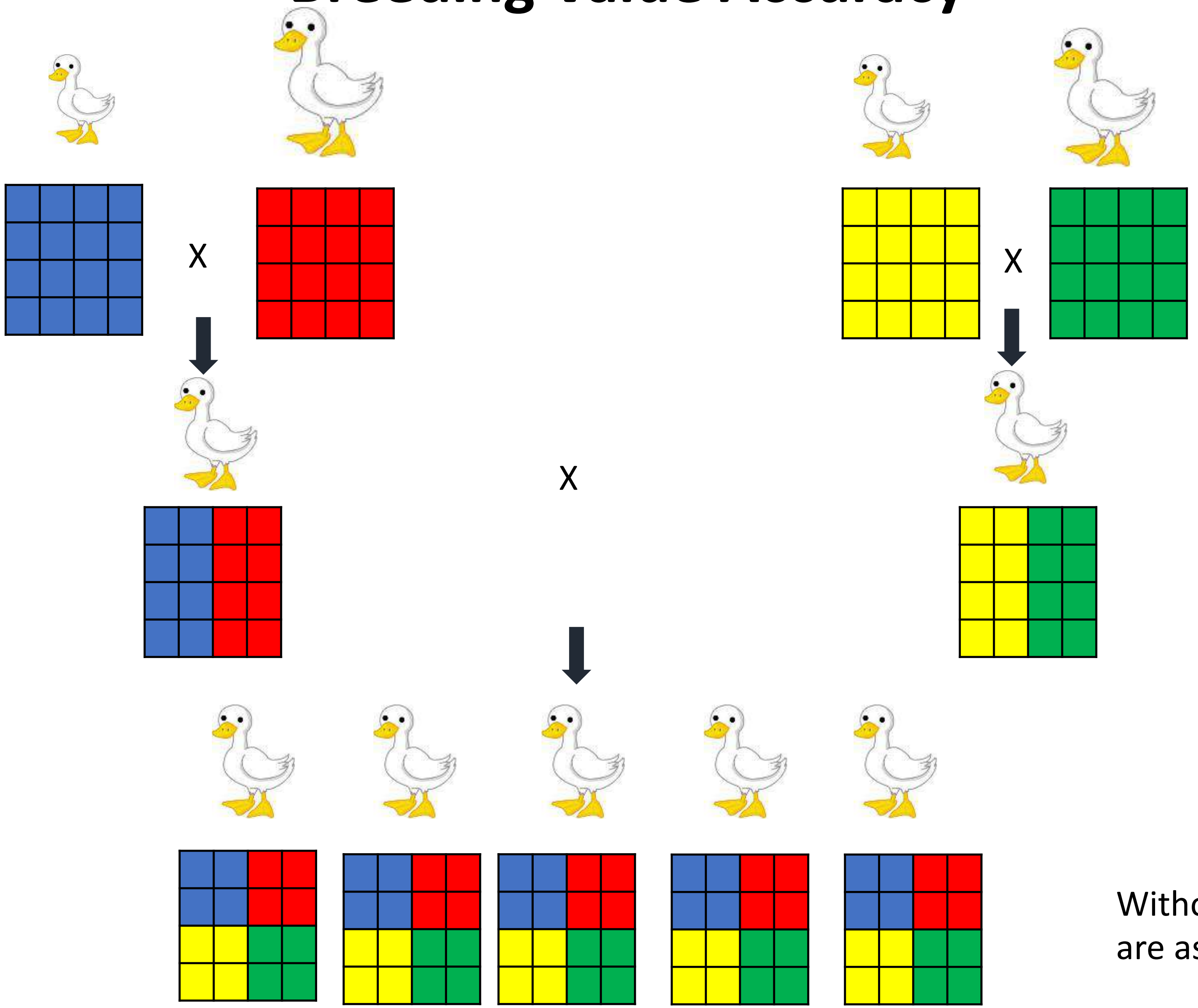
- Poultry already have short generation times
- Very large numbers of selection candidates and high selection intensities
- Selection carried out on pure lines that each feed down to make up 25% of the commercial birds
- In diary, semen is collected in large volumes and can be frozen and stored
- Poultry has no pedigree information on commercial descendants of the pure lines



Costs of genotyping:
42k SNP chip and 60k SNP chip cost US$200 per sample
600k SNP chip costs US$250 per sample
(Wolc et al. 2016)

The cost of genotyping per SNP is reducing, but the cost per sample is not.

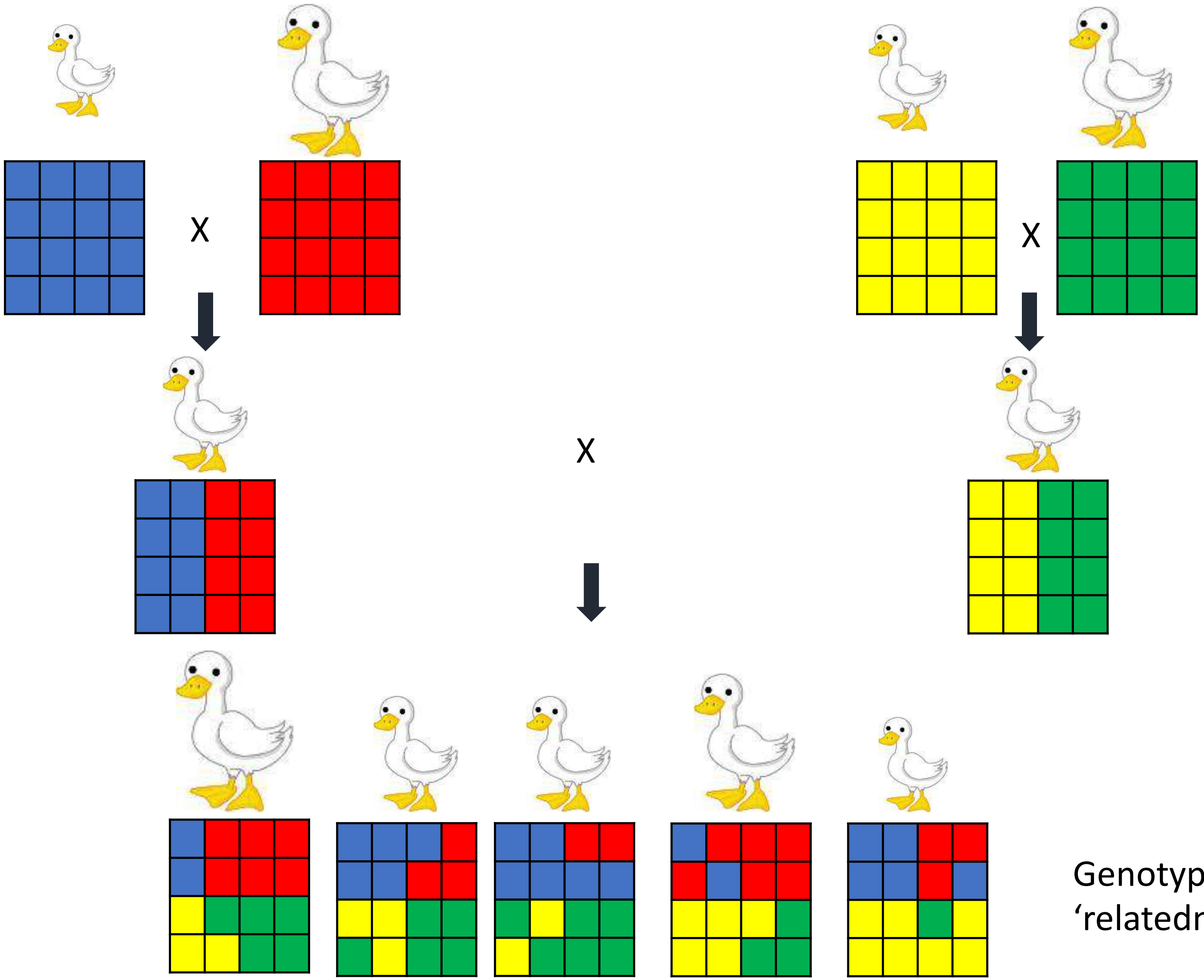
Breeding Value Accuracy



Assume all progeny are 25% similar to each grandparent

Without phenotype data, all siblings are assumed to be the same.

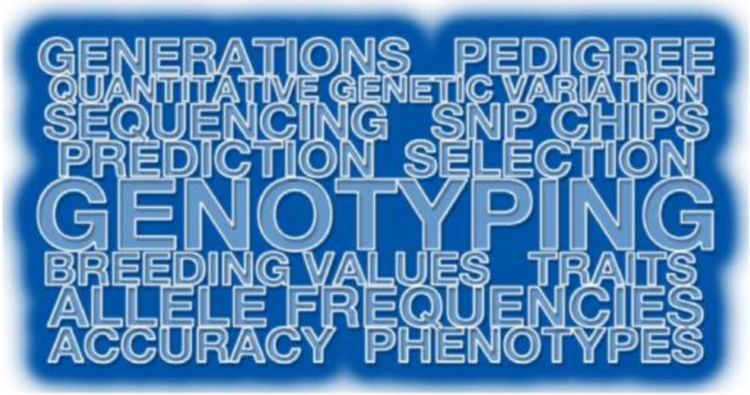
Breeding Value Accuracy



Genotype data shows different ‘relatedness’ between siblings

Increased Accuracy in Poultry Breeding Values

Trait	Improvement in Breeding Value Accuracy
Fertility	20%
Egg Production	45%
Feed intake	50%
Body Weight	50%



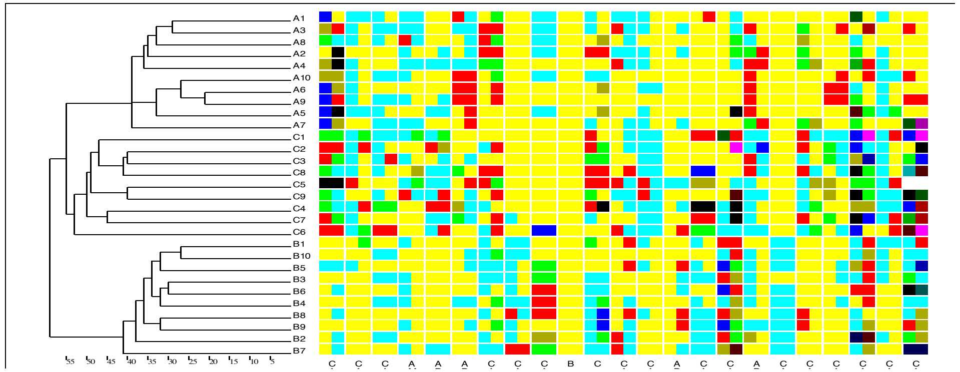
Genomics in duck breeding

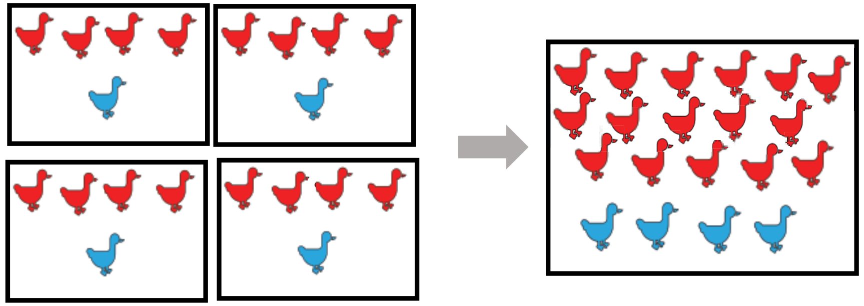
DNA 'Finger printing'
- Strain or bird identification
- Assessing genetic diversity and inbreeding
- Pedigree tracking
- Requires 10-500 DNA markers

Assess genetic diversity:
- Predict genetic/selection potential
- Assess hybrid vigour potential
- Inform decisions about developmental strains
- Monitor inbreeding during selection
- Guard against reproductive issues and inbreeding depression
- Assess external genetic resources

Quality Control
- Identify birds
- Identify lines

Identify Pedigree ducks:
- Increased fertility/hatchability
- Increased genetic diversity -> selection potential
- Improved perceived welfare
- Improved space usage
- Extended reproductive data
- Reduction in errors
- Better relationship data for new strains
- A form of pedigree security





1 male x 4 females x 4 pens
= 16 combinations

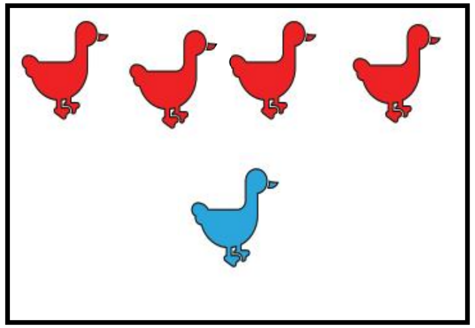
4 male x 16 females x 1 pens
= 64 combinations

Pedigree Tracking and Recording

- Sires and dams are “married up” in pedigree nests based on their genetic potential and relationship
- Eggs are labelled and tracked through the hatchery
- Each chick is sexed and given a unique ID that relates to its parentage

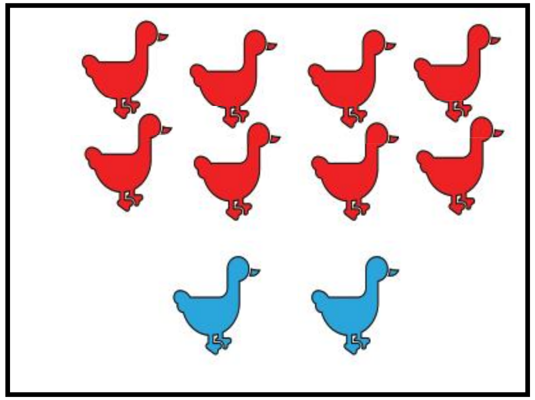
Larger pens gives more mating combinations

1 male x 4 females
= 4 combinations



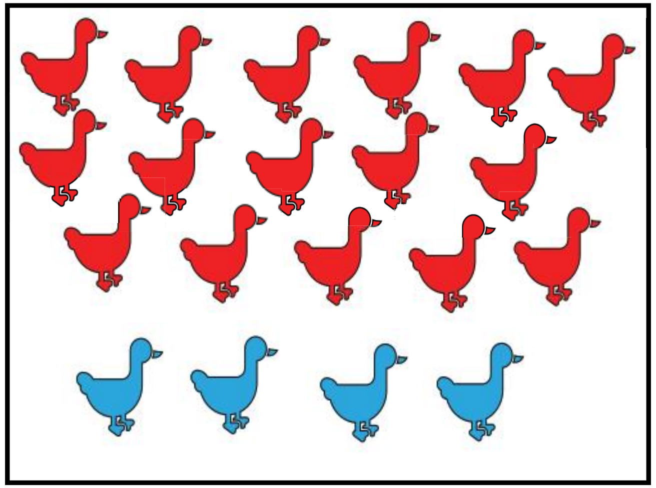
4 combinations x 64 pens
= 256 combinations

2 male x 8 females
= 16 combinations



16 combinations x 32 pens
= 512 combinations

4 male x 16 females
= 64 combinations

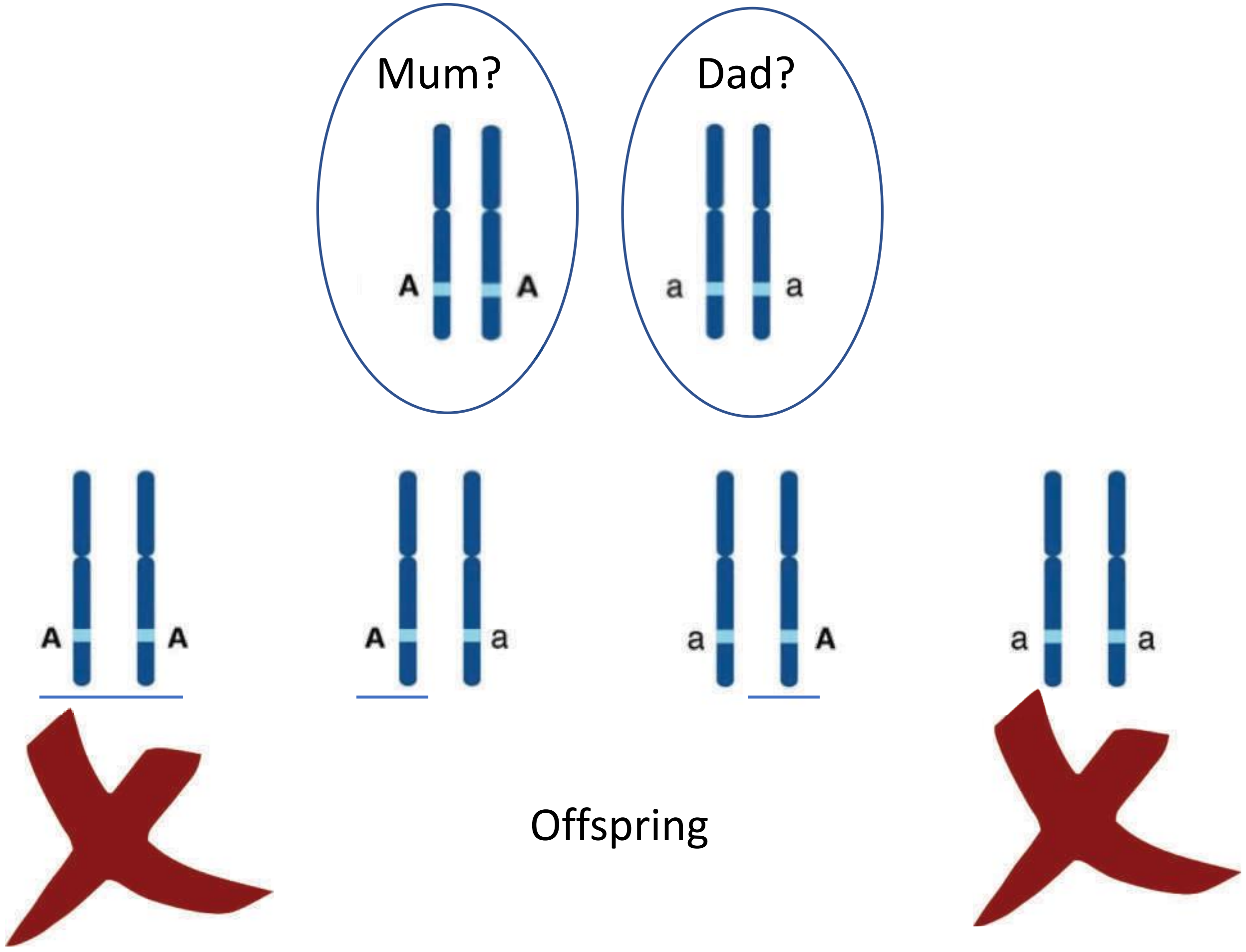


64 combinations x 16 pens
= 1024 combinations

	Pedigree pens	Small pens	Medium pens	Large pens
Males per pen	1	4	32	64
Females per pen	4	16	128	256
Number of pens	64	16	2	1
Potential Combinations	256	1,024	8,192	16,384

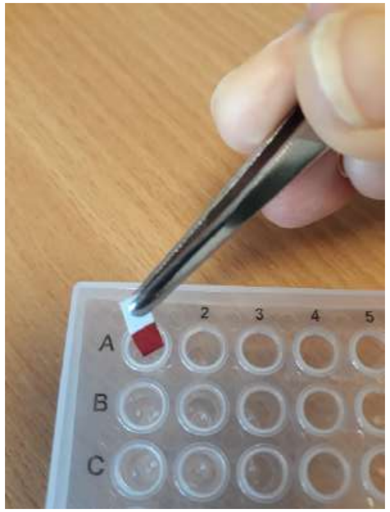
The actual number of pairings will be less than the potential number and will be dependant on mating behaviour.

Parental Assignment



1) Exclusion
2) Maximum Likelihood

X 100 - 500 SNPs



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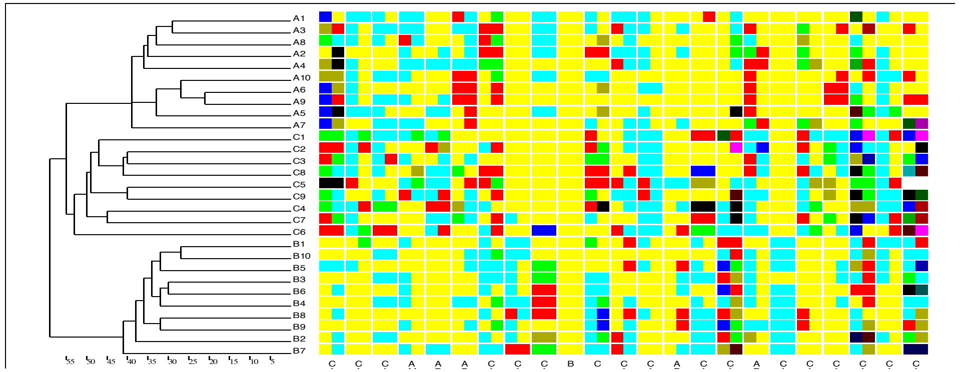
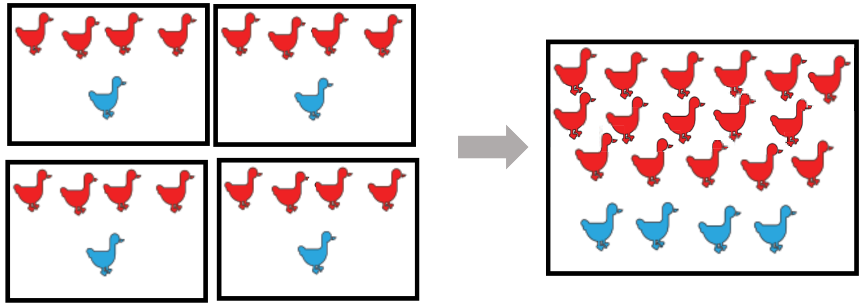
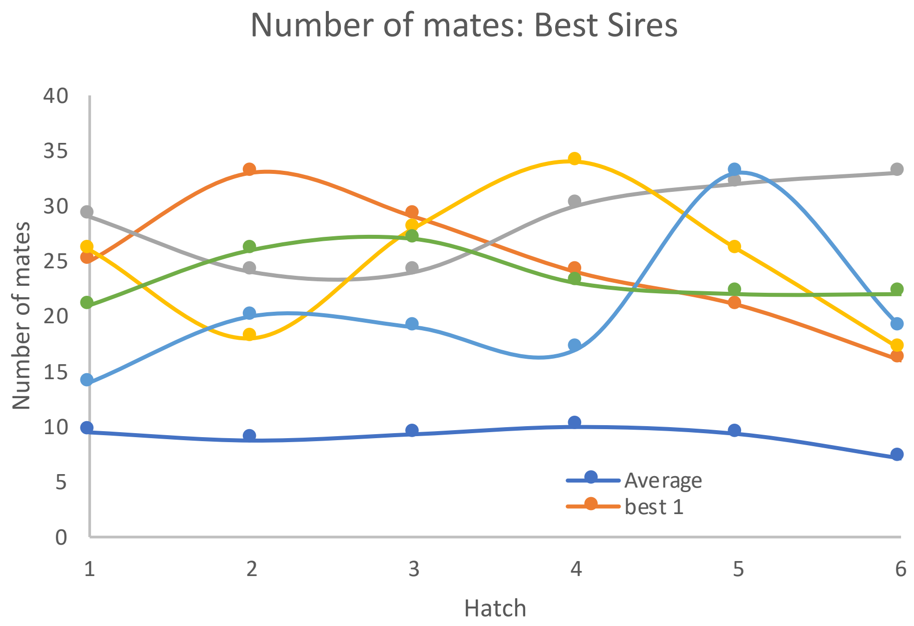




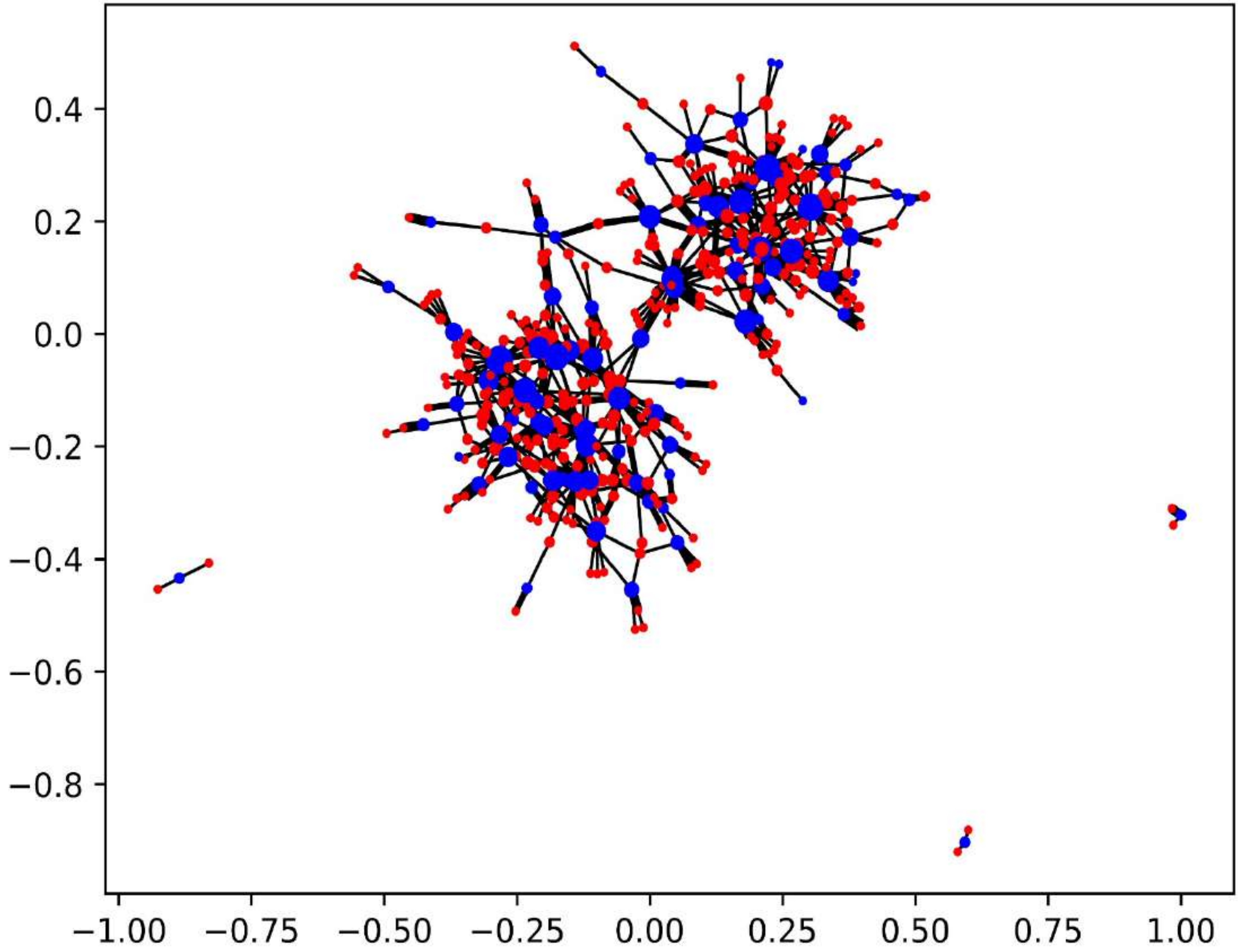
1 male x 4 females x 4 pens
= 16 combinations

4 male x 16 females x 1 pens
= 64 combinations

Mating Behaviour



Mating dominance Networks



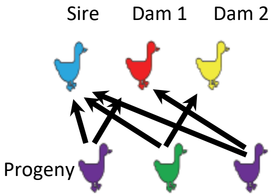
Future: Genomic Selection - Imputation

G0 : Parents

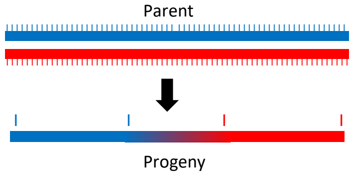
High Density genotyping:
100s bird: 10,000s SNPs

G1 : Progeny

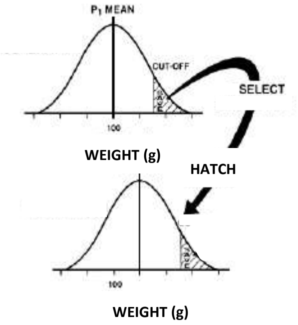
Low Density genotyping:
1000s bird: 100s SNPs



- Parentage assignment
- Imputation of High Density genotype
- Genomic selection



High Density imputation
1000s bird: 10,000s SNPs



G1 : Selected for next generation

High Density genotyping:
100s bird: 10,000s SNPs

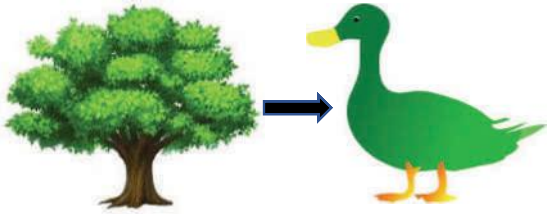
G2 : Progeny

Low Density genotyping:
1000s bird: 100s SNPs

The Future Duck

- Keep improving Growth and Feed Efficiency?

28 days incubation : 28 days rearing
Bigger chicks or shorten incubation?

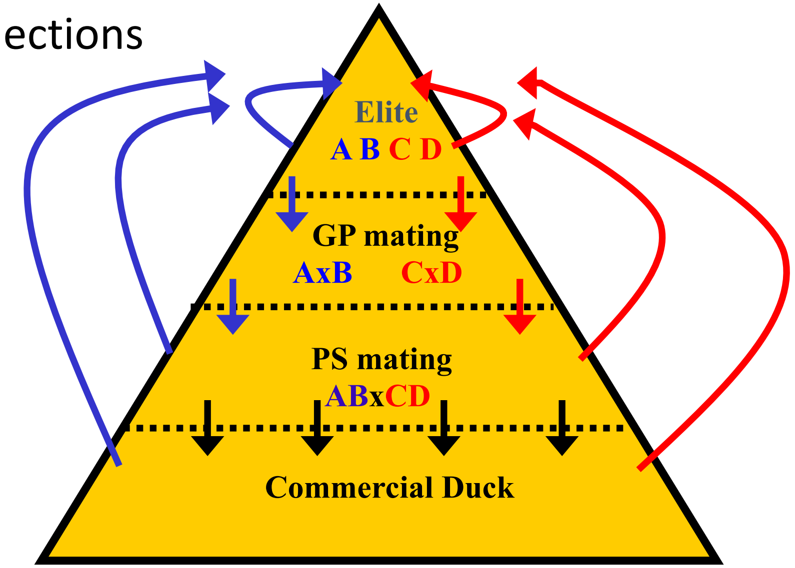


FCR < 1
Duck produces energy by photosynthesis!

- Diversify to niche markets
  - Meat texture and taste -> Slow growing
  - Portions -> carcass conformation
  - Egg layers, Duo purpose

- Health and Welfare
  - Mobility
  - Disease resistance
  - Water use

- Use genomic data to feed back into pure line selections



- International Bird movement:
  - Avian Influenza
  - Brexit

Ducks are not just waterproof chickens

Thank you for your attention.