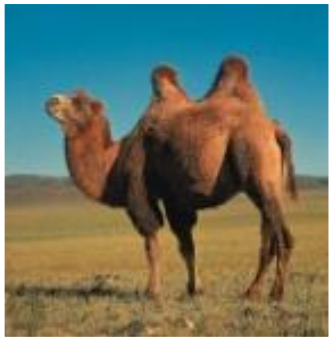



BIO 235
Plants &
People
Evolution &
Domestication




Lecture 9 – Cattle, pigs, goats & sheep – similarities and differences between crop and livestock domestication

- The dog – the earliest animal domesticate
- Centres of agricultural origins and livestock domestication
- Diversity of domestic livestock
- Domestication syndrome of livestock – herd-living herbivores
- Morphological markers of domestication
- Where, when, how many times and from what progenitors were domestic livestock domesticated?
- The Fertile Crescent
- Goats, pigs, cats, chickens & donkeys
- Complex origins of animal domesticates
- Hybrids & polyploids
- Diversification after domestication
- Conclusions

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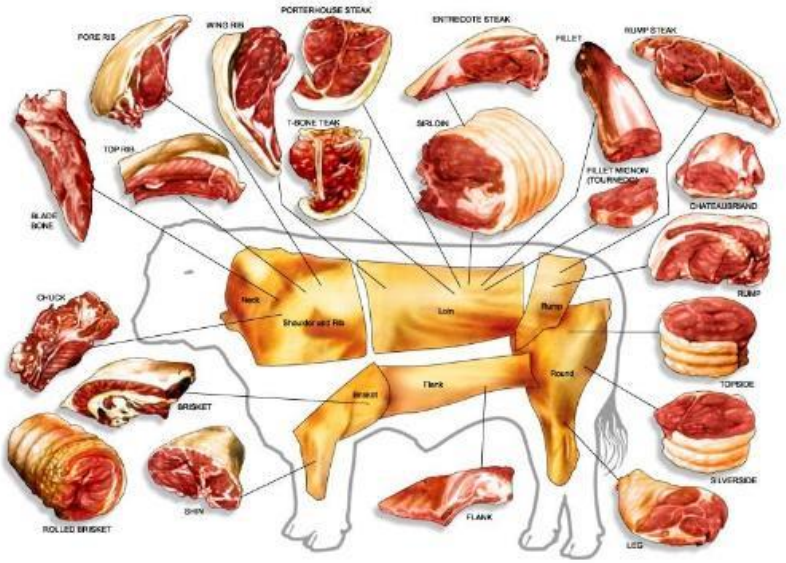
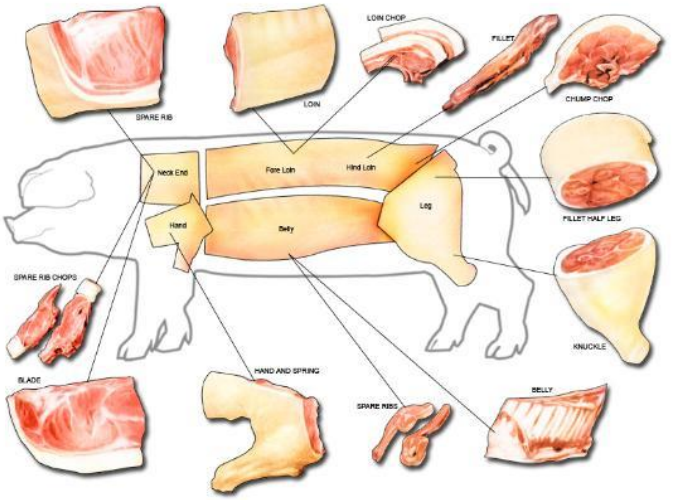
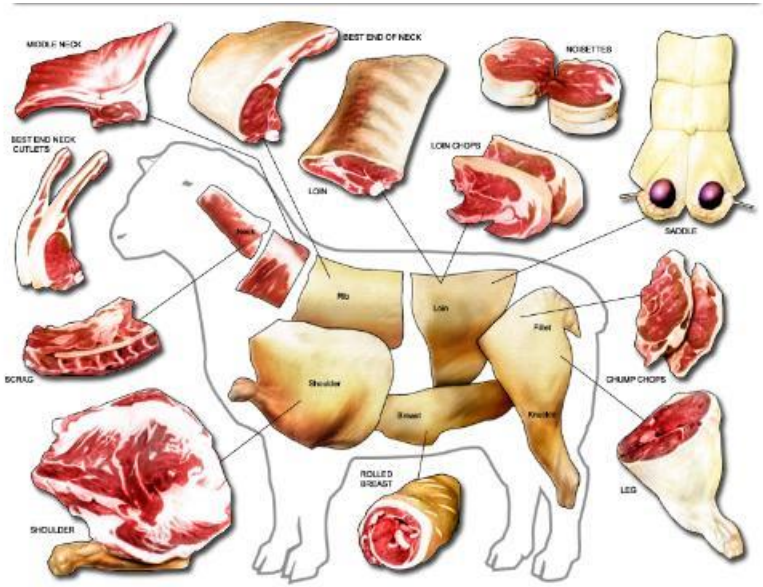
Question for this week

How many species of animals have been domesticated?

What do we eat today?







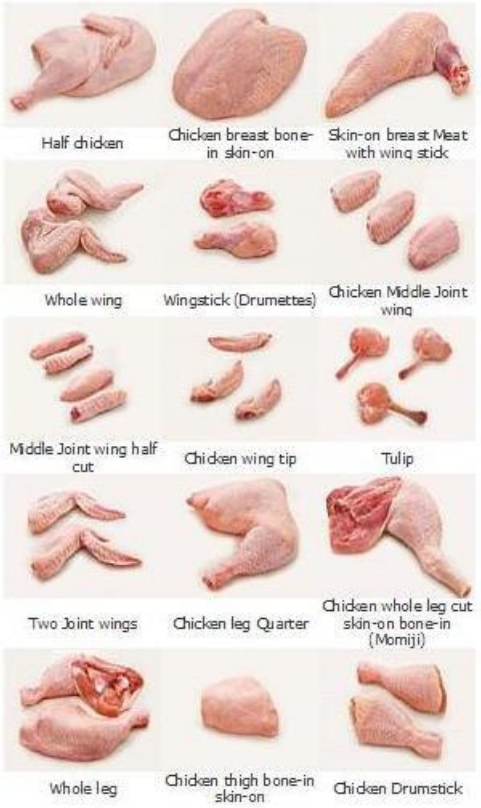
Diversity of Livestock

Beef
Lamb / mutton
Pork
Chicken

Duck, Goose, Turkey
Goat, Horse

3-4 species,
maybe maximum 8

Plus chamois, wild boar,
deer from hunting



Domestication of the Dog

The earliest domesticated animal. The dog is the only animal that accompanied humans to every continent in ancient times and therefore has a central place in human history. 'Man's best friend'. Analogous to the bottle gourd – both the earliest domesticates were non-food domesticates, the dog for hunting and sentry duties in hunter-gatherer communities.

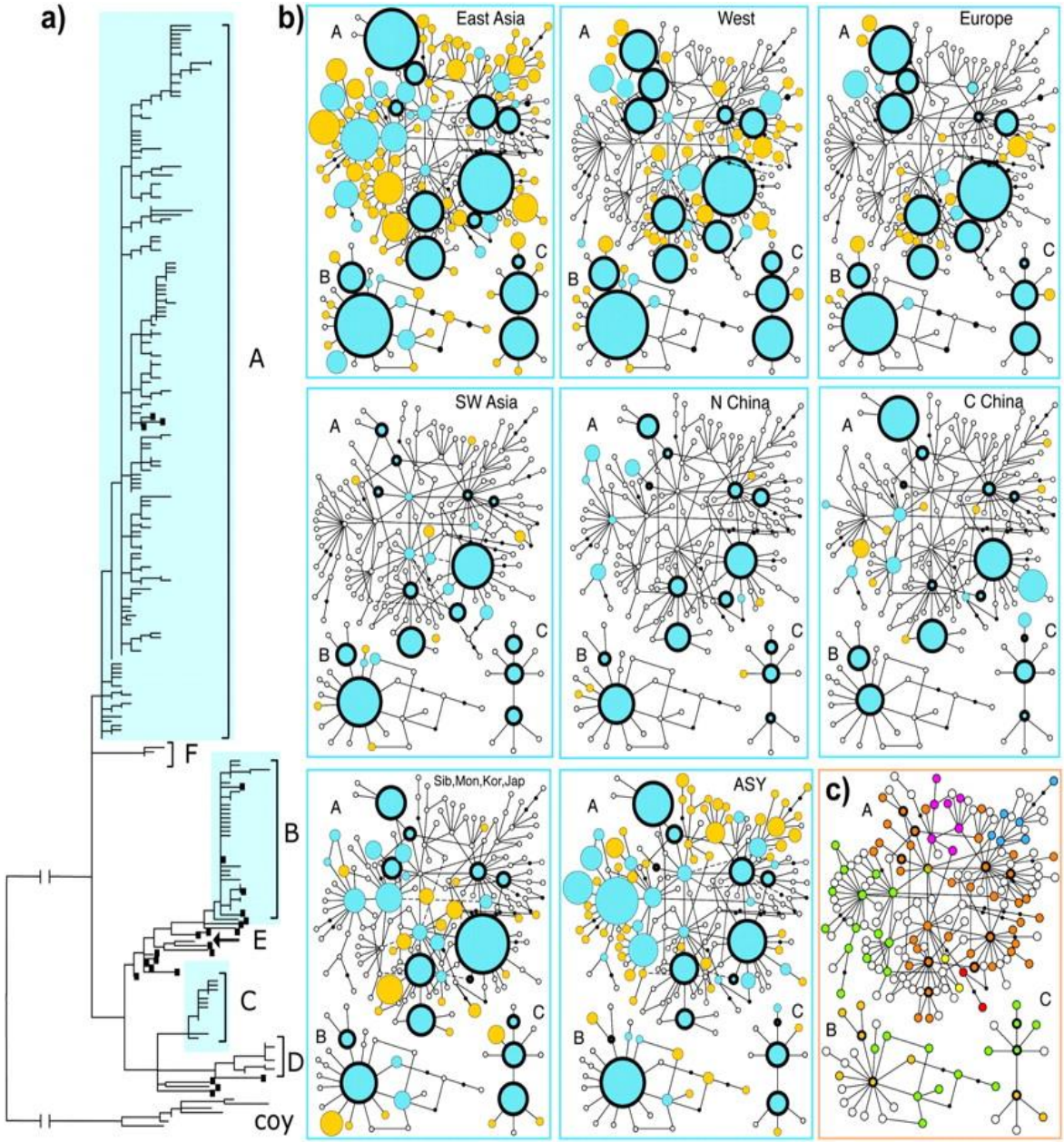
It is clear that dogs were domesticated from wolves, *Canis lupus*.

Earliest firm archaeological evidence for domesticated dogs comes from 12,000 BP from Israel, suggesting SW Asia as the area of origin, with subsequent evidence from 10,000 in Europe, 8,100 in N. America and 7,100 in China. However, also similarities Between dog and wolves from China.

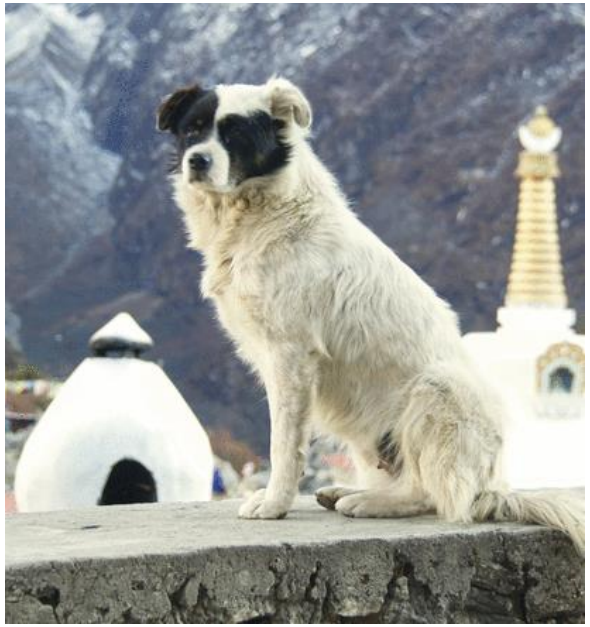
The wolf - *Canis lupus*

Domestication of the Dog

- Wolf sequences are interspersed with dog sequences across 6 clades, suggesting multiple independent origins in different parts of Eurasia, but there is very little mtDNA variation among wolves upon which to base firm conclusions.
- The sharing of haplotypes across the whole of Eurasia and across clades A, B and C suggests that a common origin.
- The full extent of diversity is found only within a region of East Asia S of the Yangtze River, suggesting a common origin from a single gene pool in East Asia, 15,000-16,000BP.
- American dogs originated from multiple Old World lineages of dogs that accompanied Pleistocene humans across the Bering Strait.



Savolainen et al (2002); Leonard et al (2002); Pang et al (2009)



PNAS

Genetic structure in village dogs reveals a Central Asian domestication origin

Laura M. Shannon[a], Ryan H. Boyko[b], Marta Castelhano[c], Elizabeth Corey[c], Jessica J. Hayward[a], Corin McLean[d], Michelle E. White[a], Mounir Abi Said[e], Baddley A. Anita[f], Nono Ikombe Bondjengo[g], Jorge Calero[h], Ana Galov[i], Marius Hedimbi[j], Bulu Imam[k], Rajashree Khalap[l], Douglas Lally[m], Andrew Masta[n], Kyle C. Oliveira[a], Lucía Pérez[o], Julia Randall[p], Nguyen Minh Tam[q], Francisco J. Trujillo-Cornejo[o], Carlos Valeriano[h], Nathan B. Sutter[r], Rory J. Todhunter[c], Carlos D. Bustamante[s], and Adam R. Boyko[a,1]

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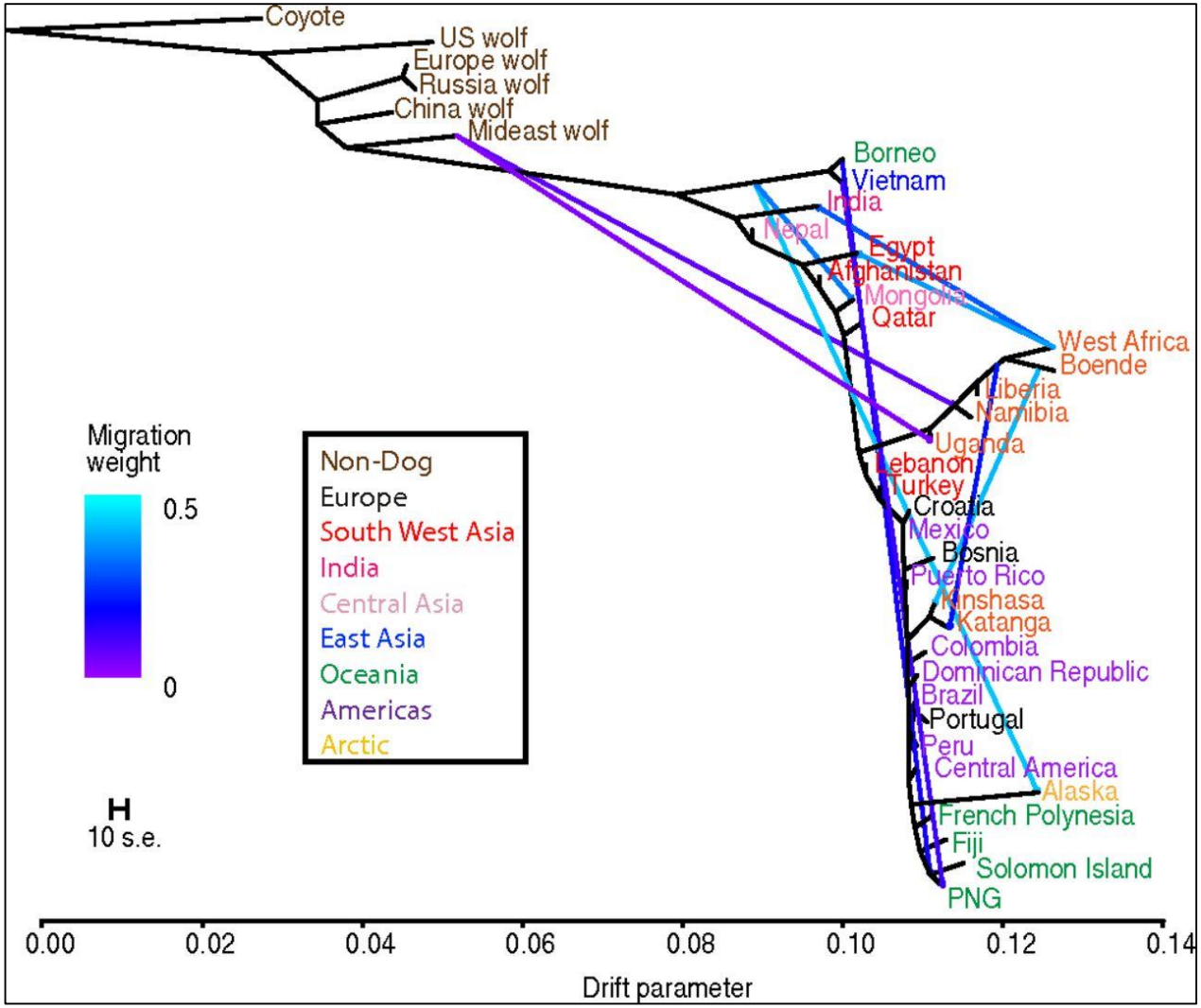


Shannon et al. (2015)

Dog Diversification after Domestication

Although domestication happened c 15,000 BP, the spectacular phenotypic diversity exhibited among breeds is thought to have originated much more recently, largely through artificial selection and strict breeding practices to perpetuate desired characteristics.

Thus, the canine genome, shaped by centuries of strong selection, likely contains many important lessons about the genetic architecture of phenotypic variation and the basis of short-term evolution.

Genome-wide scan for selection in 275 dogs from 10 diverse breeds identified 155 genomic regions that possess strong signatures of recent selection and contain candidate genes for size, coat colour and texture, behaviour, skeletal morphology & physiology.

A first-generation map of selection in the dog and a framework for understanding the mechanistic basis of how artificial selection promotes rapid and pronounced phenotypic evolution

Domestication
c.15,000 BP
East Asia

The wolf - *Canis lupus*

Akey et al (2010)

Studies of crop and animal domestication show some obvious similarities

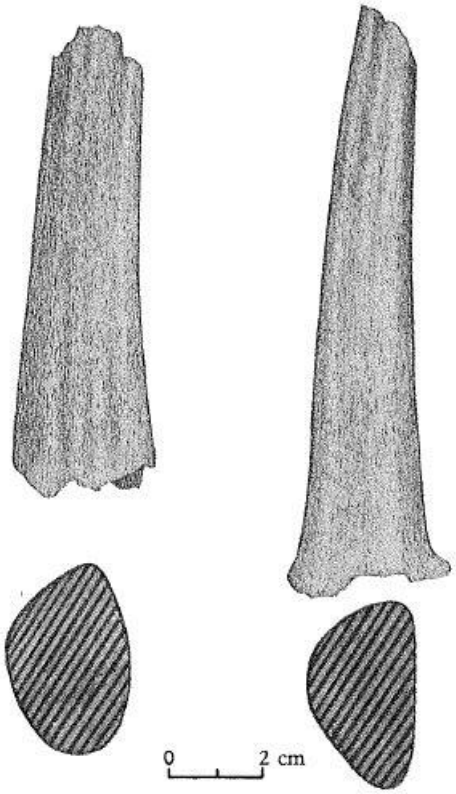
- Similar techniques and the same weighing up of complementary evidence from genetics and archaeology. Ancient DNA, AMS radiocarbon dating to answer the when, where and how many times questions.

- The earliest plant domesticate, the bottle gourd, like the dog was not used for food, but rather to support hunting and gathering activities – a container plant to carry water and a hunting companion / sentry were the first organisms to be domesticated by humans. Both were apparently domesticated in the Old World and moved very early on to the New World by humans.

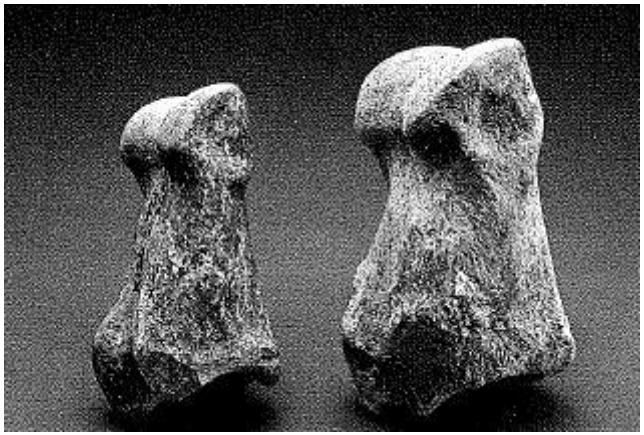
- Selection and massive diversification after domestication – divergent behaviours for different uses, divergent morphologies – all the different dog breeds that we are familiar with today from Great St. Bernard's to poodles, Great Danes to Chihuahuas.

- Genomic data are revealing the genetic architecture of phenotypic diversity and the genes associated with phenotypic change brought about by domestication.

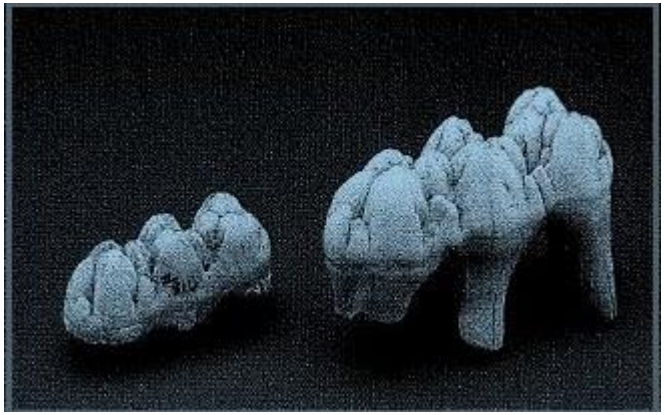
Morphological markers of domestication in animals



Horns of wild and domestic goats differ in cross-section and thickness



Bones are smaller in domesticated cattle, reflecting an overall reduction in size – left a 6,000 yr-old toe bone of a domesticated animal from NE Syria; right a 7,000 yr-old auroch bone from the same area



Domesticated pigs have shorter snouts and smaller teeth than wild pigs – left a 7,600 yr-old domesticated pig molar from NE Syria; right a larger wild pig molar from S Israel.

Patterns of change in large assemblages of bones, representing whole herds or flocks assessed through time to look for herd age profiles or sex ratios indicative of increasing captivity and human control of breeding. For example, infections caused by corralling alpacca at night lead to higher juvenile mortality.

Smith (1998)

Domestication syndrome of animals

Table 1 List of traits modified in the "domestication syndrome" in mammals*

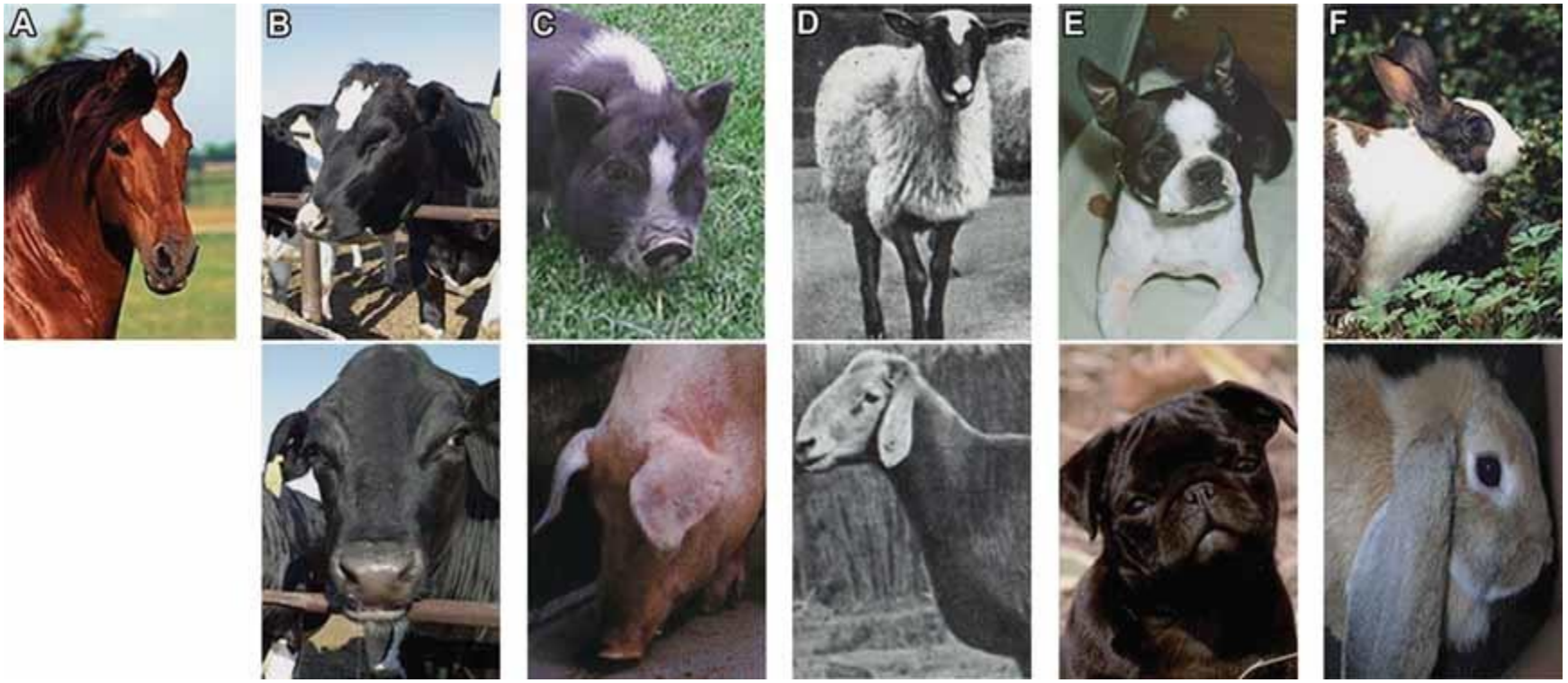
Trait	Animal species	Location/source	References
Depigmentation (especially white patches, brown regions)	Mouse, rat, guinea pig, rabbit, dog, cat, fox, mink, ferret, pig, reindeer, sheep, goat, cattle, horse, camel, alpaca, and guanaco	Cranial and trunk	[a]
Floppy ears	Rabbit, dog, fox, pig, sheep, goat, cattle, and donkey	Cranial	[b]
Reduced ears	Rat, dog, cat, ferret, camel, alpaca, and guanaco	Cranial	[c]
Shorter muzzles	Mouse, dog, cat, fox, pig, sheep, goat, and cattle	Cranial	[d]
Smaller teeth	Mouse, dog, and pig	Cranial	[e]
Docility	All domesticated species	Cranial	[f]
Smaller brain or cranial capacity	Rat, guinea pig, gerbil, rabbit, pig, sheep, goat, cattle, yak, llama, camel, horse, donkey, ferret, cat, dog, and mink	Cranial	[g]
Reproductive cycles (more frequent estrous cycles)	Mouse, rat, gerbil, dog, cat, fox, goat, and guanaco	Cranial and trunk (HPG axis)	[h]
Neotenous (juvenile) behavior	Mouse, dog, fox, and bonobo	Cranial	[i]
Curly tails	Dog, fox, and pig	Trunk	[j]

*Relative to those in the corresponding presumed wild ancestors.
[a] Darwin 1868; Belyaev and Trut 1989; Gariépy *et al.* 2001; Trut *et al.* 2009.
[b] Darwin 1868; Belyaev and Trut 1989.
[c] Hemmer 1990; Arbuckle 2005.
[d] Darwin 1868; Zeuner 1963; Clutton-Brock 1999.
[e] Darwin 1868; Clutton-Brock 1999.
[f] Darwin 1868; Belyaev 1969.
[g] Kruska 1988a; Hemmer 1990; Kruska 2005.
[h] Darwin 1868; Kruska 1988a; Arbuckle 2005; Kruska 2005; Trut *et al.* 2009.
[i] Price 1999; Trut 1999; Gariépy *et al.* 2001; Hare *et al.* 2012.
[j] Darwin 1868; Trut *et al.* 2009.

Wilkins et al (2014)

Domestication syndrome of animals

De-pigmentation
Floppy ears

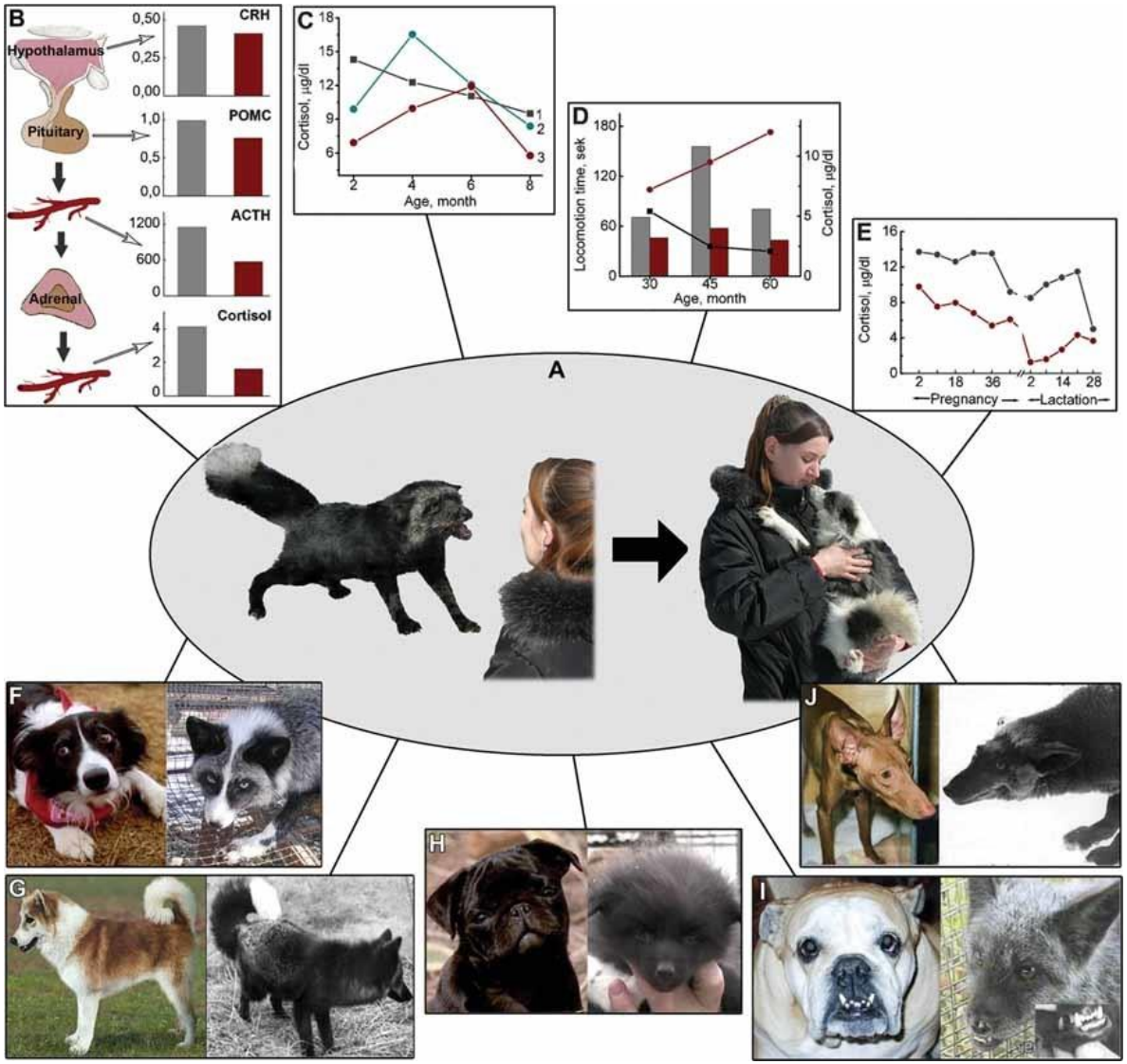


Trut et al. (2009)

Experimental domestication of the silver fox

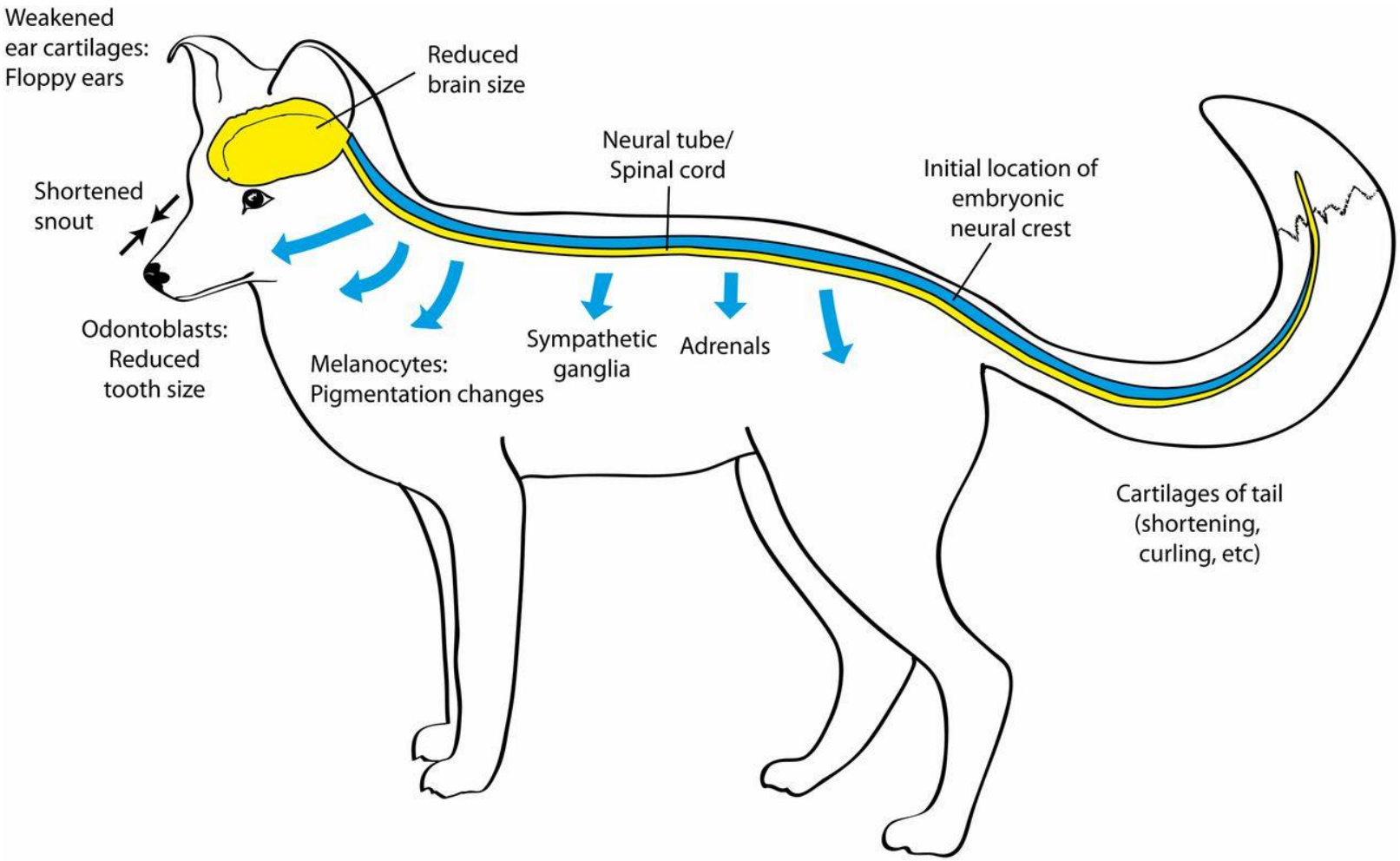
Trut et al. (2009)

Experimental domestication of the silver fox



Trut et al. (2009)

The domestication syndrome in mammals: a unified explanation based on neural crest cell behaviour and genetics



Wilkins et al (2014)

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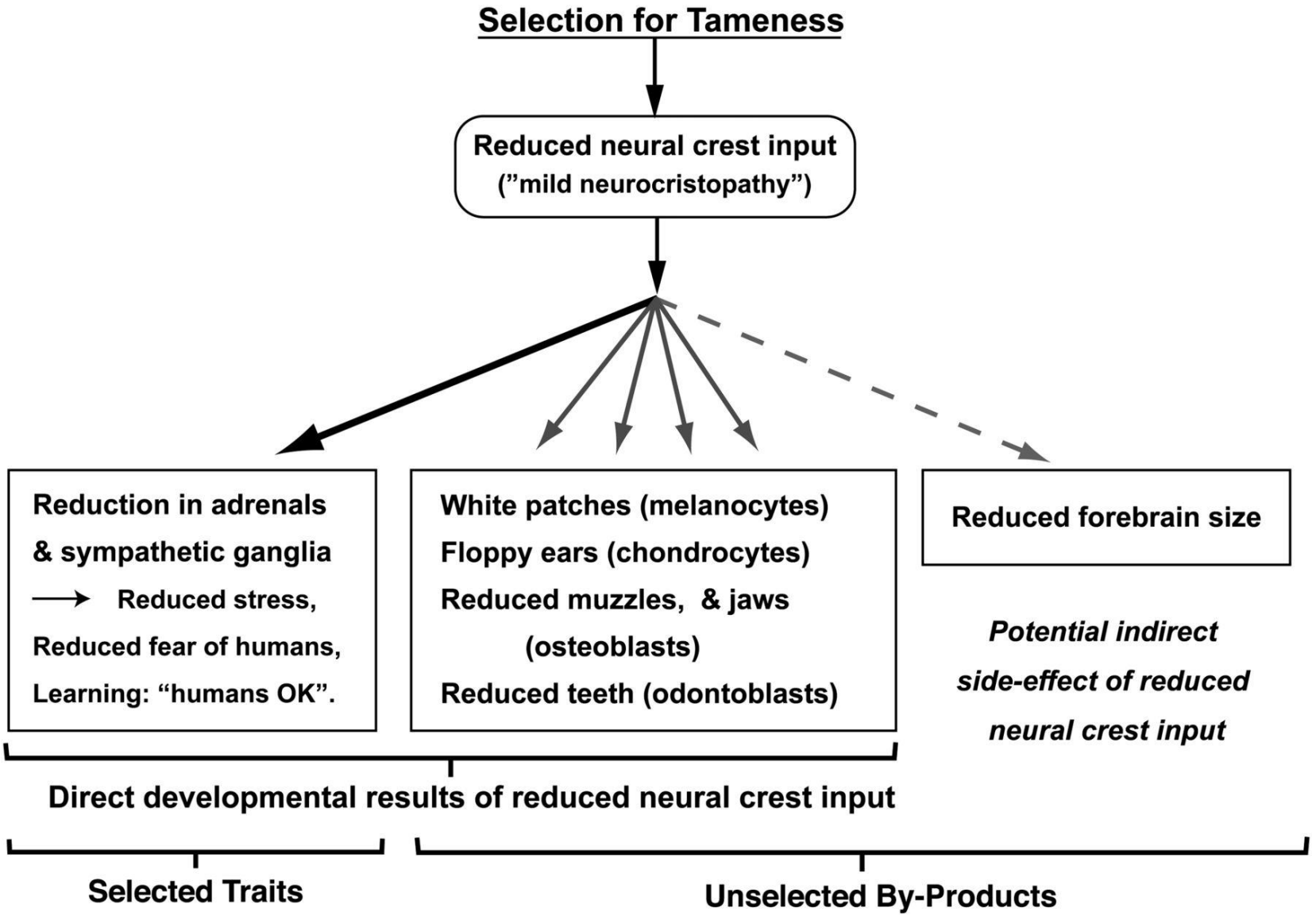


Wilkins et al (2014)

Animal domestication pathways

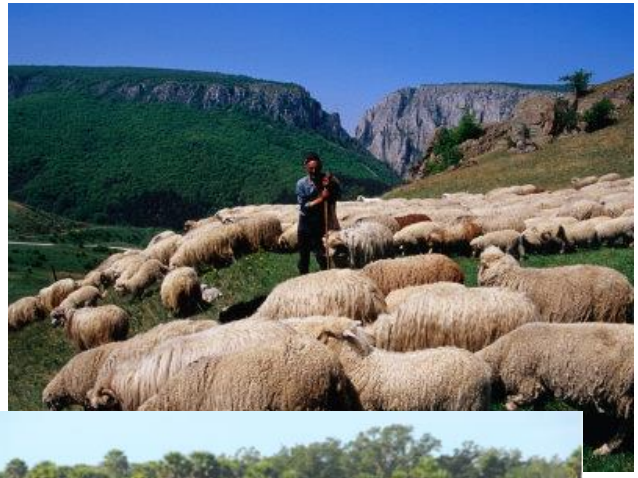
1. Commensal – no intentional action by humans; wild animals attracted to elements of the human niche (food waste, smaller prey animals); habituation leading to adaptations and divergence of tamer, less aggressive individuals and populations / ecotypes; eventually captivity, human-controlled breeding; later deliberate human selection. Dog, cat, pigeon, guinea pig, possibly pigs & chickens

2. Prey – altered hunting strategies to increase the efficiency of hunting large herbivores targetted as prey (killing young males and allowing females to produce > offspring); herd management (perhaps driven by over-hunting); divergence of more docile herded populations; eventually domestication and direct breeding. Sheep, goat, cow, reindeer, llama, alpacca & turkey

1. Directed – deliberate objective to domesticate; only after humans were already reliant on domestic plants and animals; often in regions outside those where early animanl domestication started. Donkey, horse, Eurasian camels, honey bee, silk worm, rabbit, geese

Zeder (2012) Larson & Fuller (2014)

Herd-living herbivores & the prey pathway to domestication



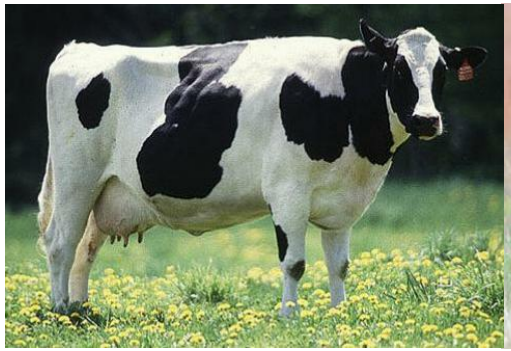
- Most domestic livestock are animals that were already hunted for food before domestication.
- The successful domesticates were those most behaviourally pre-adapted to domestication – generally herd-living herbivores whose ancestors followed a dominant individual. Neolithic peoples exploited this dominance hierarchy by, in effect, supplanting the alpha individual and gaining control of the herd.
- Usually these behavioural changes lead to a significant dependence on humans for food and shelter.
- Domestication should not be confused with taming. Taming is conditioned behavioural modification of an individual; domestication is a permanent genetic modification of a bred lineage that leads to a heritable predisposition toward human association.
- A domestic animal is one whose mate choice is influenced by humans and whose tameness and tolerance of humans is genetically determined. Controlled breeding amounts to pre-zygotic selection, a critical element in domestication because captive breeding allows for the strongest and most direct artificial selection.

Why were so few wild species domesticated? 14 out of 148

Comparisons of domesticated species (left) and their never-domesticated close relatives


Reindeer Elk


Horse Zebra




Cow American buffalo


Sheep North American Bighorn Sheep


Goat Rocky Mountain goat

Unconscious Selection

The first cohort of animal domesticates were all either commesnals or prey domesticates, neither driven by the intention to domesticate – early animal domestication unintentional & a long, protracted co-evolutionary process. Only later was directed selection involved to add > species & secondary products such as fibres, milk, egg-laying and traction.

Artificial Selection

Weak: selection pressure applied post-zygotically – e.g. selective culling of deer – and natural selection proceeds from this modified genetic baseline

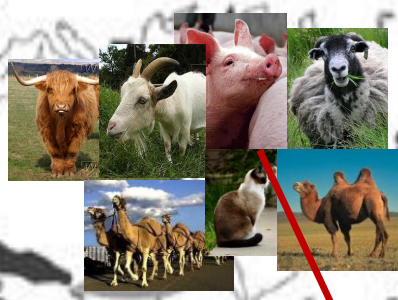
Strong: selection is pre-zygotic as well as post-zygotic, i.e. captive breeding – e.g. mating male offspring of high yielding dairy cows to other high yielding cows – leading to a dramatic acceleration of evolutionary processes and a much greater level of control over the selected organism

Independent Centres of Agriculture & Livestock Domestication

Lapland
- Reindeer

Eastern N America
-NONE!

Himalaya
•Yak



China
•Dog
•Chicken

Mesoamerica
- Turkey

ONLY ONE!

Andes
- Llama
- Alpacca
- Guinea pig

NE Africa
- Donkey

Fertile Crescent
/ Near East
- Cattle
- Sheep
- Pig
- Goat
- Horse
- Dromedary camel
- Bactrian camel
- Cat

New Guinea
-NONE!

Draught animal power & the origins of agriculture

Livestock domestication & evolution and the spread of human diseases

- measles and tb from cattle,
- influenza from pigs and chickens

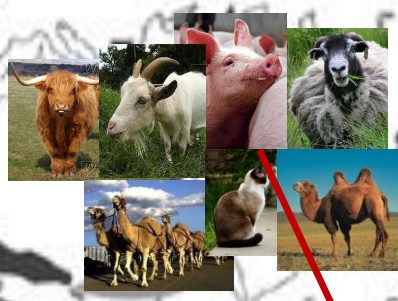
- Agents of conquest originating in the Old World

Independent Centres of Agriculture & Livestock Domestication

Lapland
- Reindeer

Eastern N America
-NONE!

Mesoamerica
- Turkey



Himalaya
- Yak

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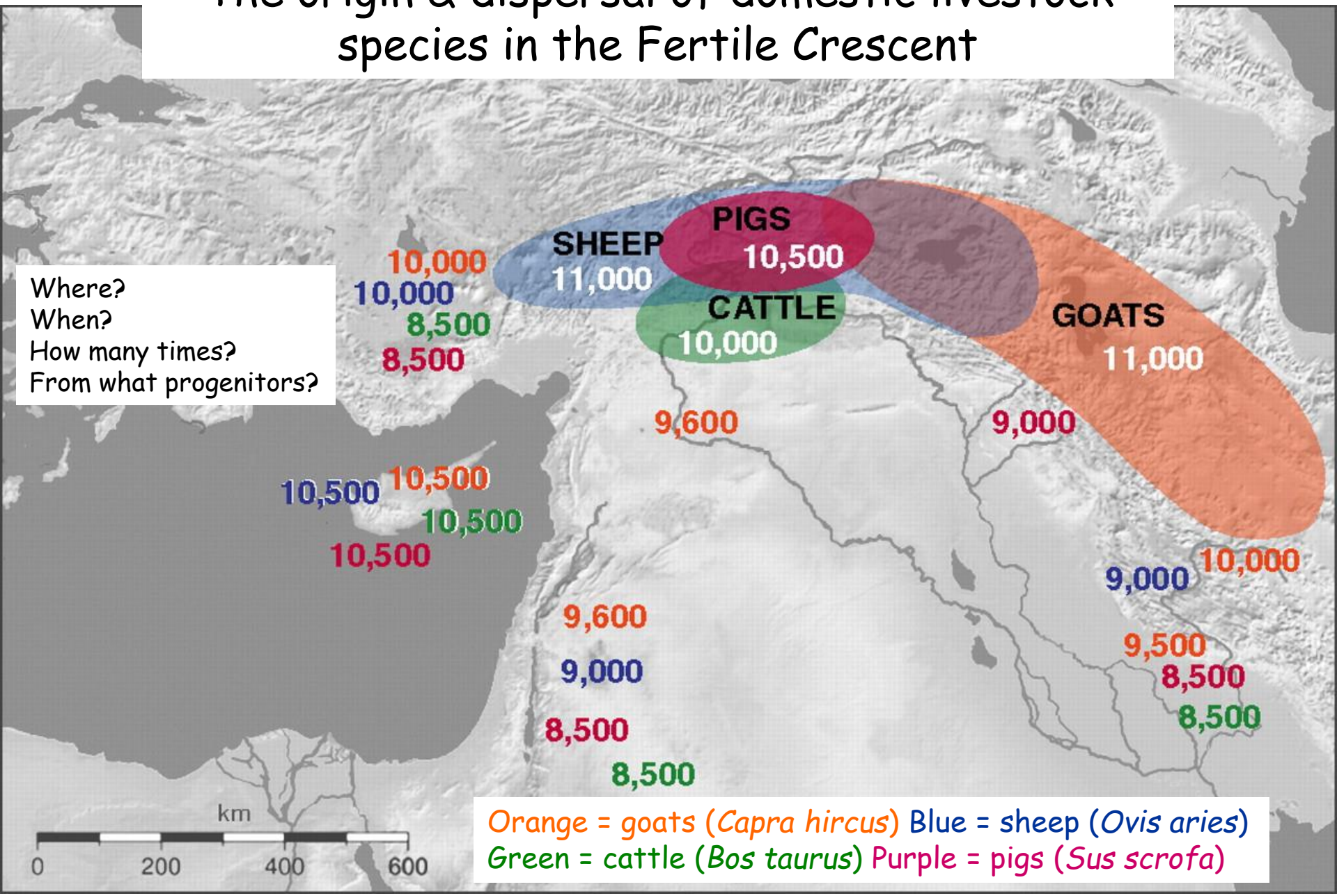
Fertile Crescent
/ Near East
- Cattle
- Sheep
- Pig
- Goat
- Horse
- Dromedary camel
- Bactrian camel
- Cat

New Guinea
-NONE!

The origin & dispersal of domestic livestock species in the Fertile Crescent



Zeder (2008)

Domestication of the Goat

Some archaeological sites from which claims for evidence of livestock domestication have been made

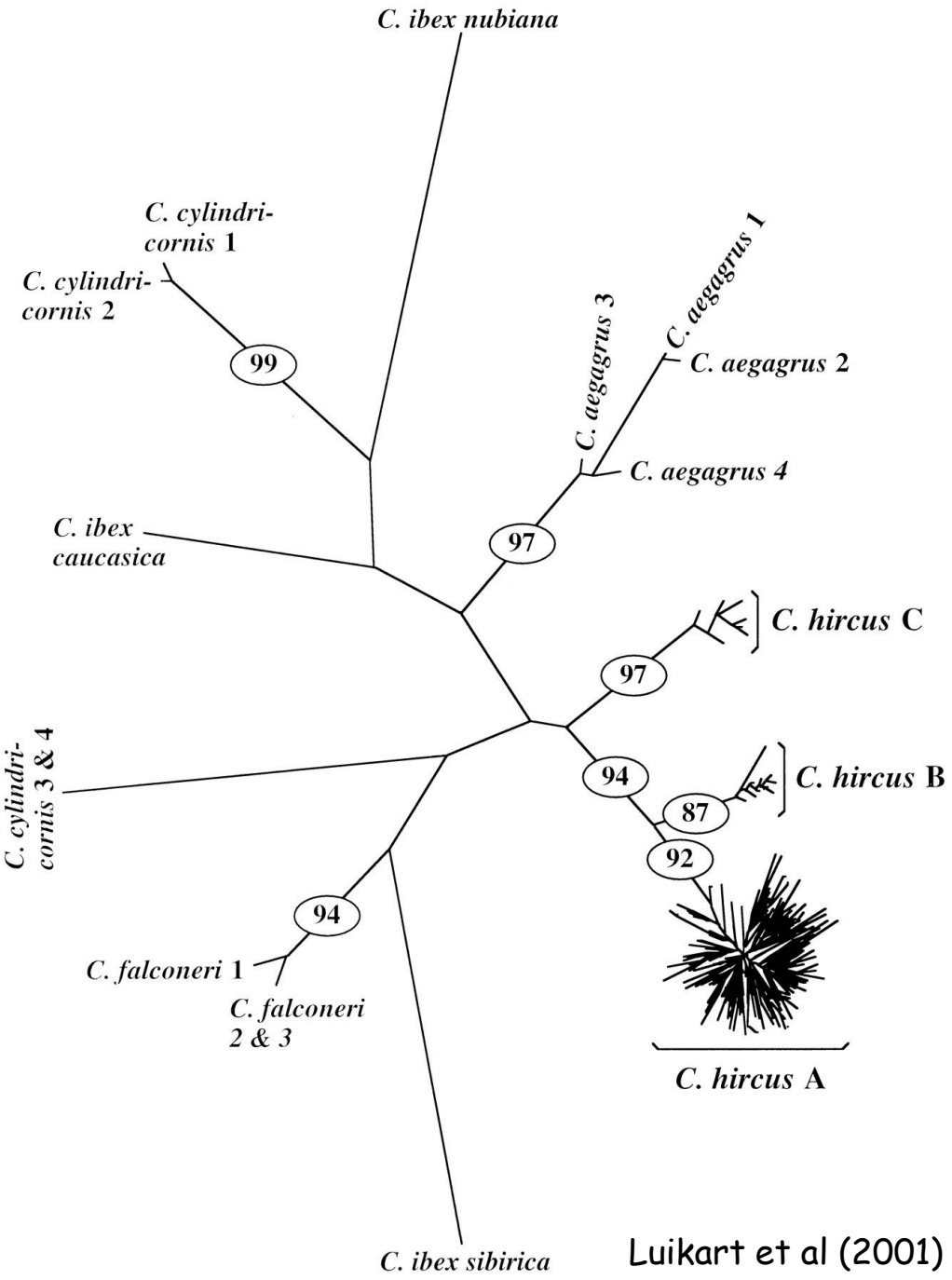
Area and country	Site	Predomestic/domestic species	Date calibrated
Taurus, Southeastern Turkey*	Nevali Çori	Goat, sheep, pig	8,500–8,000 B.C.
	Cayönü	Pig, goat?, sheep?	8,500–8,000 B.C.
Euphrates valley (N. Syria)	Tell Halula	Goat, cattle?	8,000–7,800 B.C.
	Tell Abu Hureyra	Goat, sheep	8,000–7,800 B.C.
Central Anatolia, Turkey†	Asikli Höyük	Goat, sheep	8,000–7,800 B.C.
Cyprus	Shillourokambos	Goat, sheep, pig, cattle	8,500–8,000 B.C.
Damas basin, Syria†	Choraifé	Goat?, sheep	7,600–7,500 B.C.
	Aswad	Goat?, sheep	7,600–7,500 B.C.
South Levant, Israel	Jericho	Goat, sheep	7,500 B.C.
South Levant, West Jordan	Ain Ghazal	Goat, cattle?	7,600–7,500 B.C.
	Basta	Goat, sheep, cattle	7,500–7,000 B.C.
West Zagros, Iran*	Ganj Dareh	Goat	8,000–7,800 B.C.
	Tepe Guran	Goat, sheep	7,500–7,000 B.C.
Baluchistan, Pakistan*	Mehrgarh	Goat, sheep, cattle	7,000 B.C.

- The domestic goat, *Capra hircus*, the poor man's cow - the most adaptable and geographically widespread livestock species - Siberia across the mountains of central Asia to the deserts of Africa.
- Goats a critically important resource

- 700 million goats worldwide providing meat, milk and skins
- Extensive early archaeological remains across the Near East from 8,000 to 10,000BC as well as further east in Pakistan.
- The origins of the goat have remained very uncertain and controversial. Little doubt that the goat was domesticated in the Fertile Crescent, but possibly also independently in Pakistan
- Independent domestications of the goat from different wild species of *Capra?*

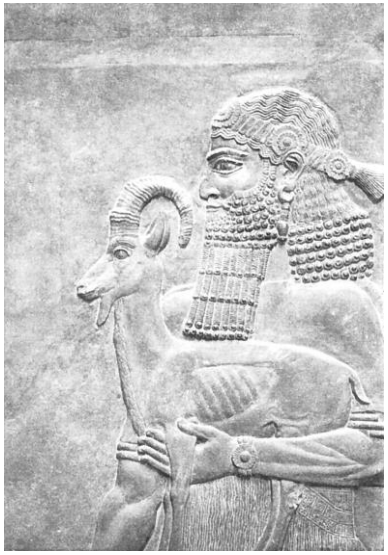
Domestication of the Goat

- mtDNA sequences of 406 goats suggest three divergent lineages of goats, providing possible evidence of three independent origins from different lineages, with the most closely related wild species the bezoar, *Caprus aegagrus*.
- However, given that these three lineages from a monophyletic group, with no intermingling of different wild goat exemplars, the alternative explanation of a single origin from one very large and diverse population remains a possibility.
- This is further complicated by the fact that several wild goat lineages are extinct.
- The domestic goat Clade C is present only in E and S Asia (Pakistan and further east), supporting the idea of at least two independent origins, one in the Fertile Crescent and one further east.

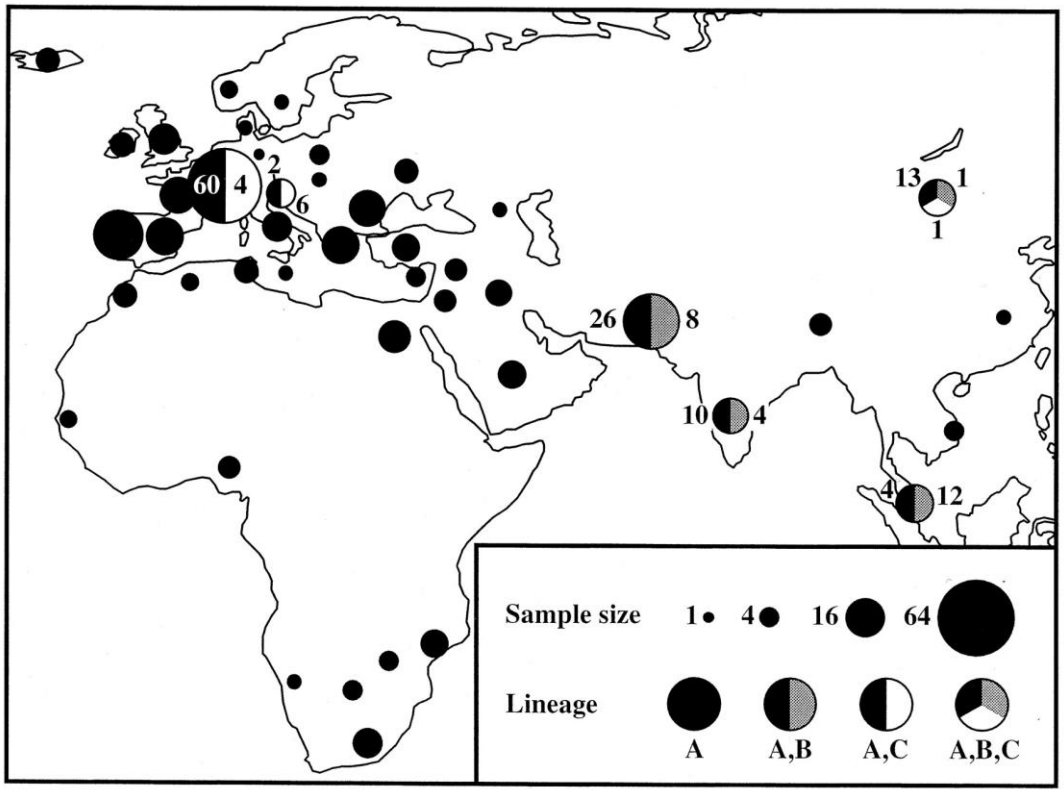


Luikart et al (2001)

Domestication of the Goat



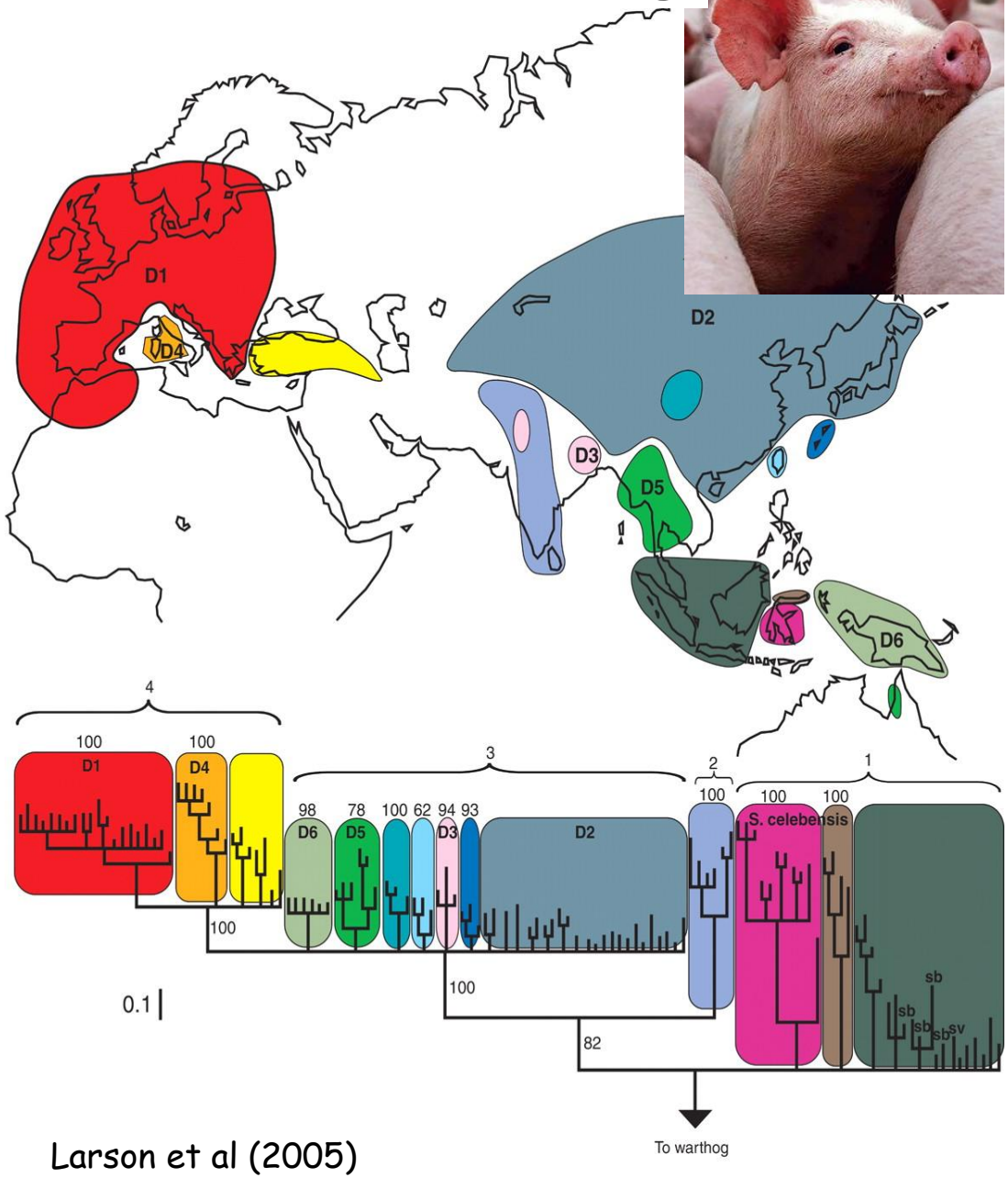
2300 – 2400 BP Mesopotamian stone carving of a man carrying either a wild or domesticated goat



- Very limited geographic structure amongst goat populations, indicative of extensive human mediated transport of goats. Goats appear to have been especially mobile perhaps due to their versatility and hardiness.
- Movement and likely geneflow complicate inferences about the origins of domestication
- Clearly domesticated in and moved extensively around Eurasia.

Luikart et al (2001); MacHugh & Bradley (2001)

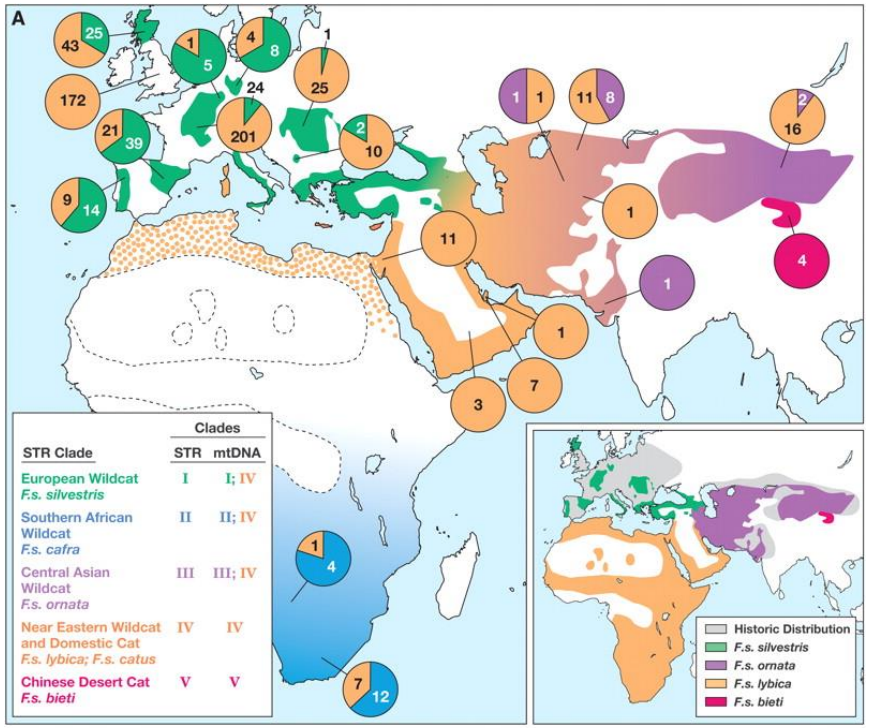
Domestication of the Pig

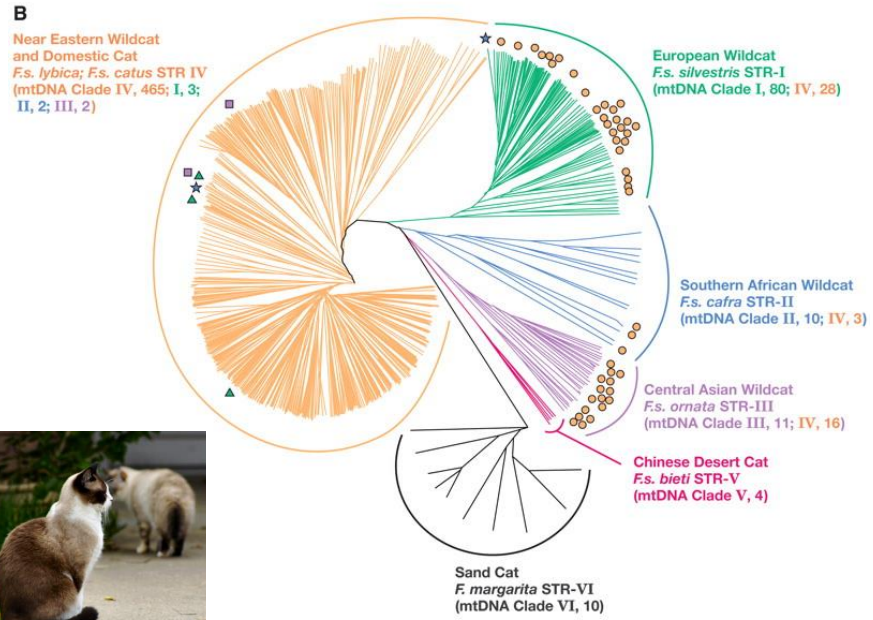


Larson et al (2005)

- Wild boar important prey animals for hunter-gatherers across Eurasia.
- Archaeological evidence of domestic pigs from 9,000 BP in the Near East, suggesting original domestication in the Fertile Crescent
- Much debate about whether one or multiple domestications.
- The phylogeny of wild and domestic pigs shows strong geographic structure; first branching lineages in SE Asia and European boar in a more recently derived clade.
- Domestic pigs are found in 6 different lineages (clades D1-D6), suggesting multiple centres of domestication across Eurasia.
- European domestic pigs are within the European cluster and lack any affinity with wild boar lineages from the Near East, suggesting independent domestication, probably at least twice within Europe.

Domestication of the Cat

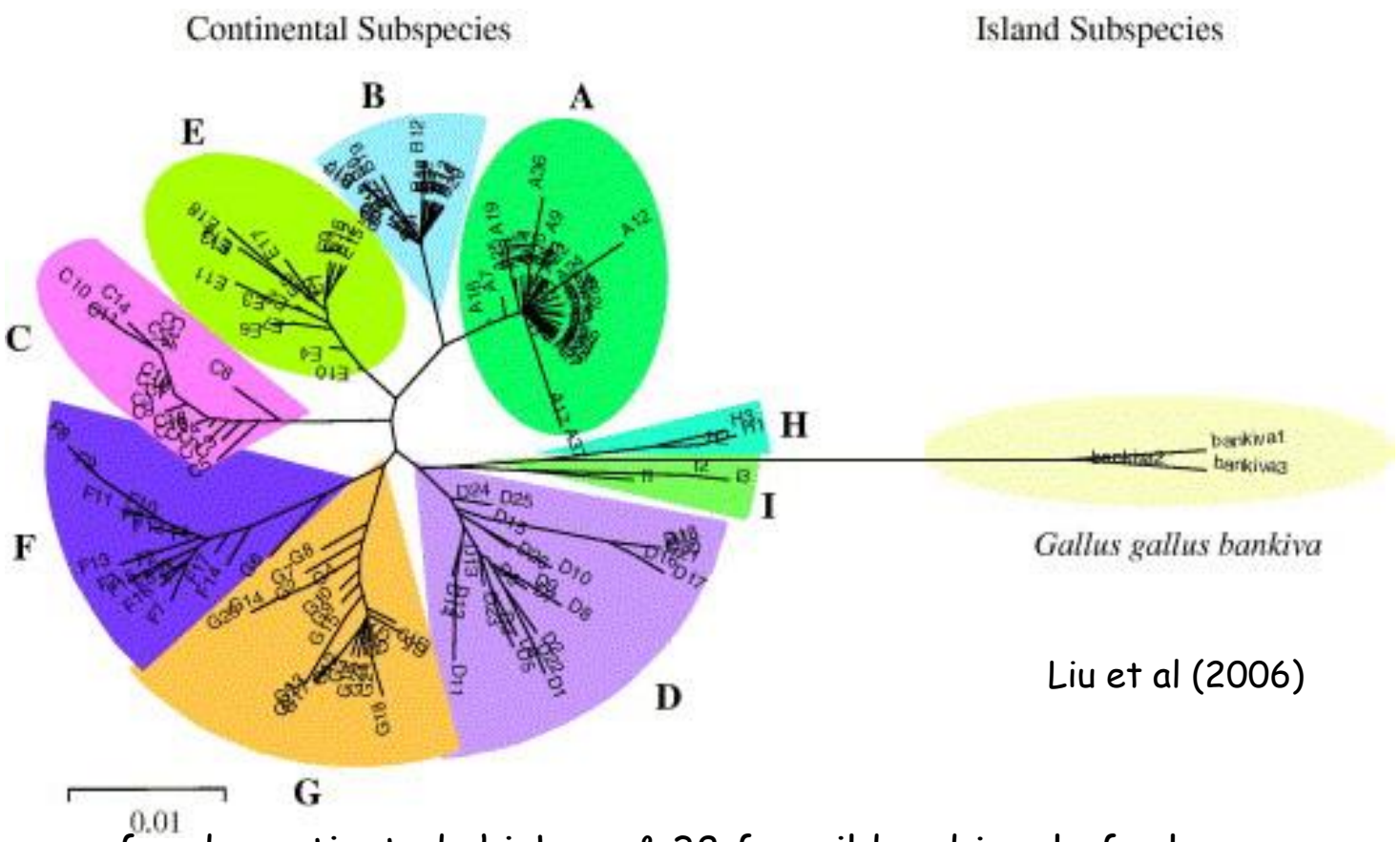




Driscoll et al (2007)

- Each wildcat group represents a genetically & geographically distinct subspecies.
- Wildcats - obligate carnivores, solitary, defend exclusive territories, utility is debatable. Nevertheless the domestic cat is overwhelmingly tolerant of people.
- Cats domesticated in the Near East, probably as commensal feeders on rodent pests in grain stores of the first farmers coincident with agricultural village development in the Fertile Crescent c 3,600BP.
- Likely that tolerated and over time and space gradually diverged from their wild ancestors.
- Domestic cats derive from a single protracted domestication episode involving at least five probably sympatric founders from across this region and differ in behaviour, tameness and coat colours.
- Descendants of these first domestic cats were transported across the world by humans in some areas interbreeding with wild cats and blurring the boundaries between subspecies in some areas.
- Now c 1 billion domestic / feral cats on the planet – the world's most numerous pet.

Domestication of the Chicken – *Gallus gallus* subsp. *domesticus*



Liu et al (2006)

- 542 mtDNA sequences for domesticated chickens & 38 for wild red jungle fowl
- Clade H – only wild red jungle fowls
- Clade C – only domesticated chickens
- The other 7 clades include samples of both domesticated chickens and red jungle fowl
- All 7 clades include samples from Yunnan Province, China
- Domestication of chickens replicated in several places from several lineages of red jungle fowl across different areas of S & SE Asia
- Patterns potentially complicated by gene flow due to human movement and hybridization

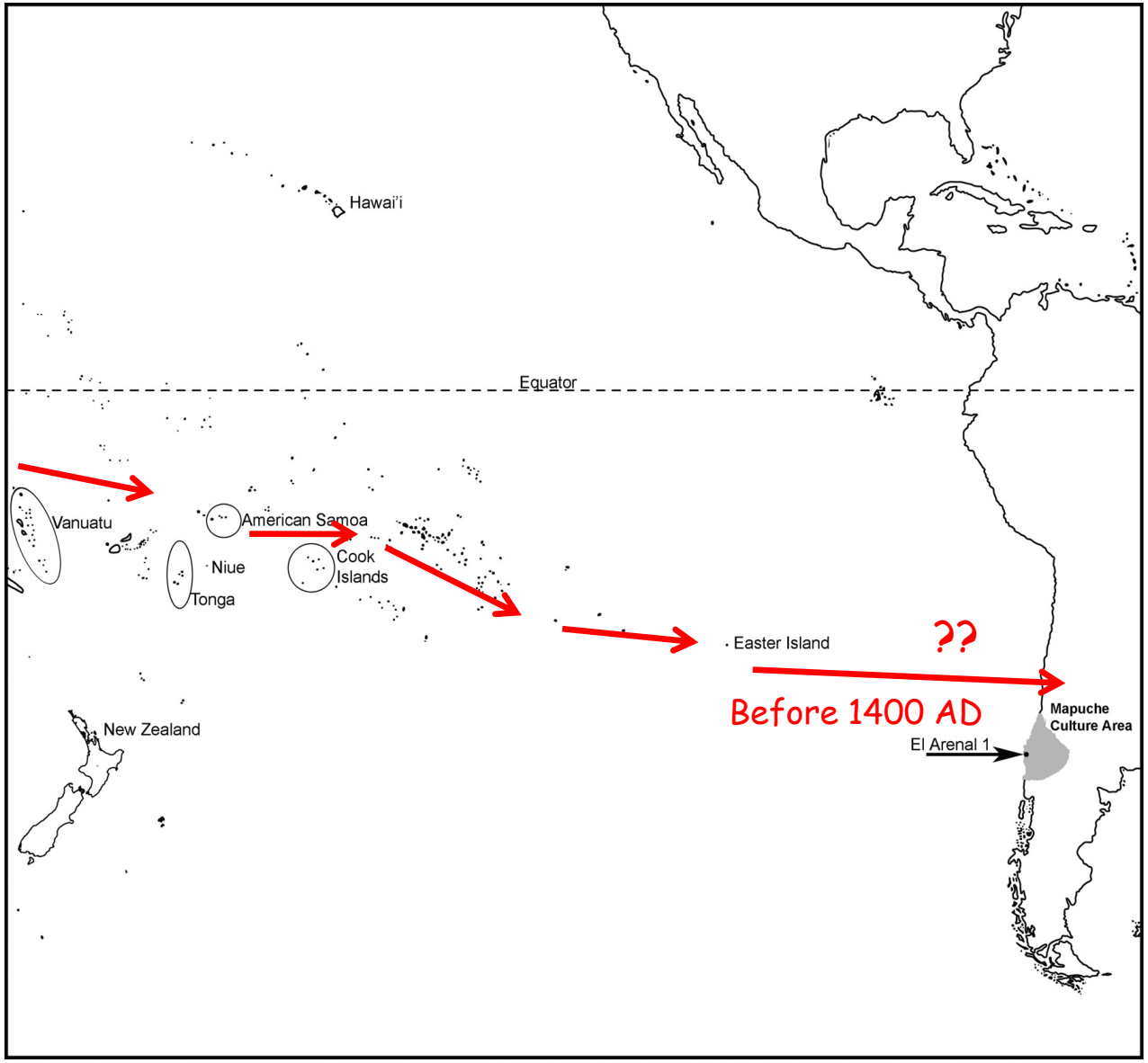
Arrival of the chicken in the New World

Chickens are the only widespread domestic livestock that apparently didn't have its origins in the Near or Middle East

Chickens well integrated into Incan culture when Pizzaro arrived in 1532

Ancient DNA from 650 year-old Chilean chicken bones most similar to Polynesian chicken DNA

Old World chickens, along with dogs apparently reached the New World prior to the arrival of the Europeans

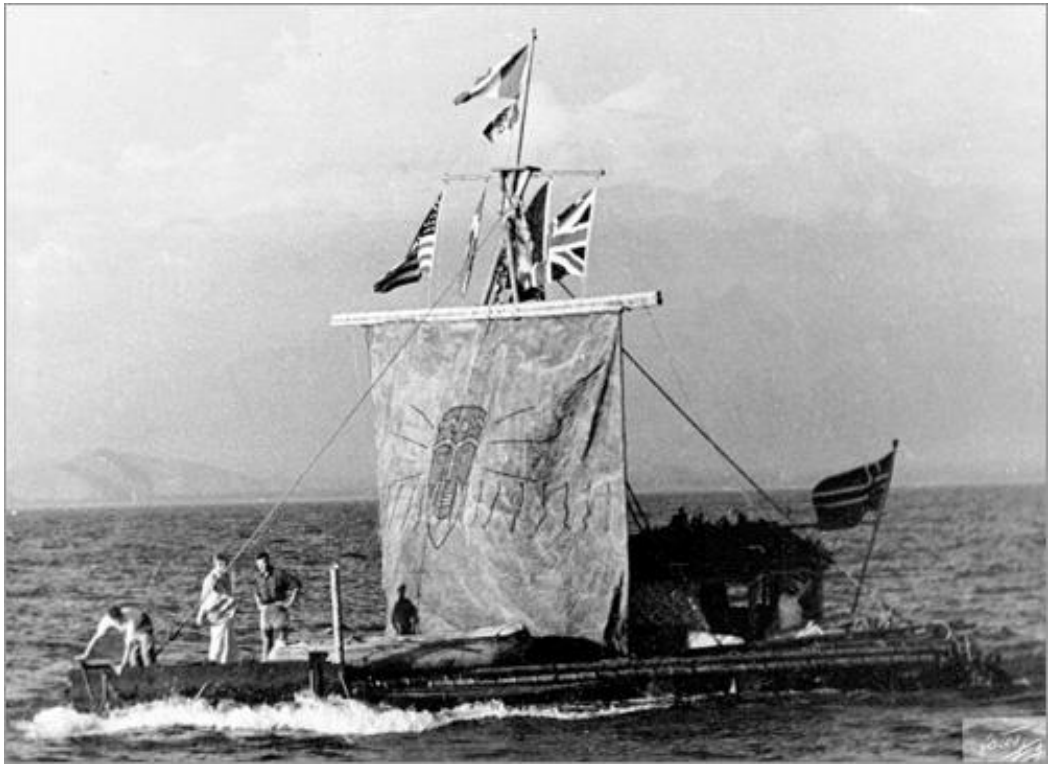


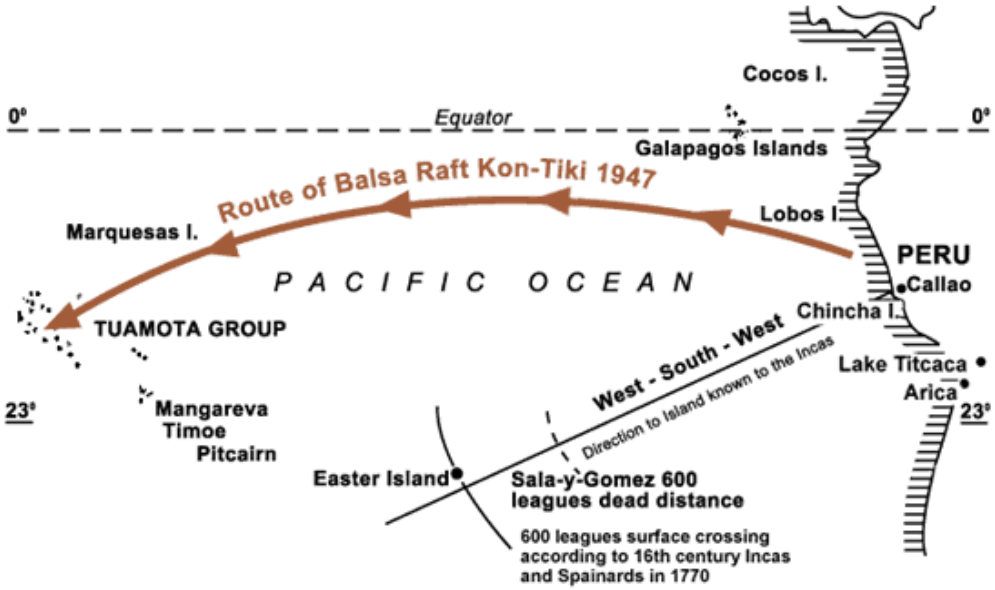
Storey et al (2007)

Kon-Tiki and Thor Heyerdahl

Aim to test the idea that there could have been Pre-Colombian South America – Polynesia connections

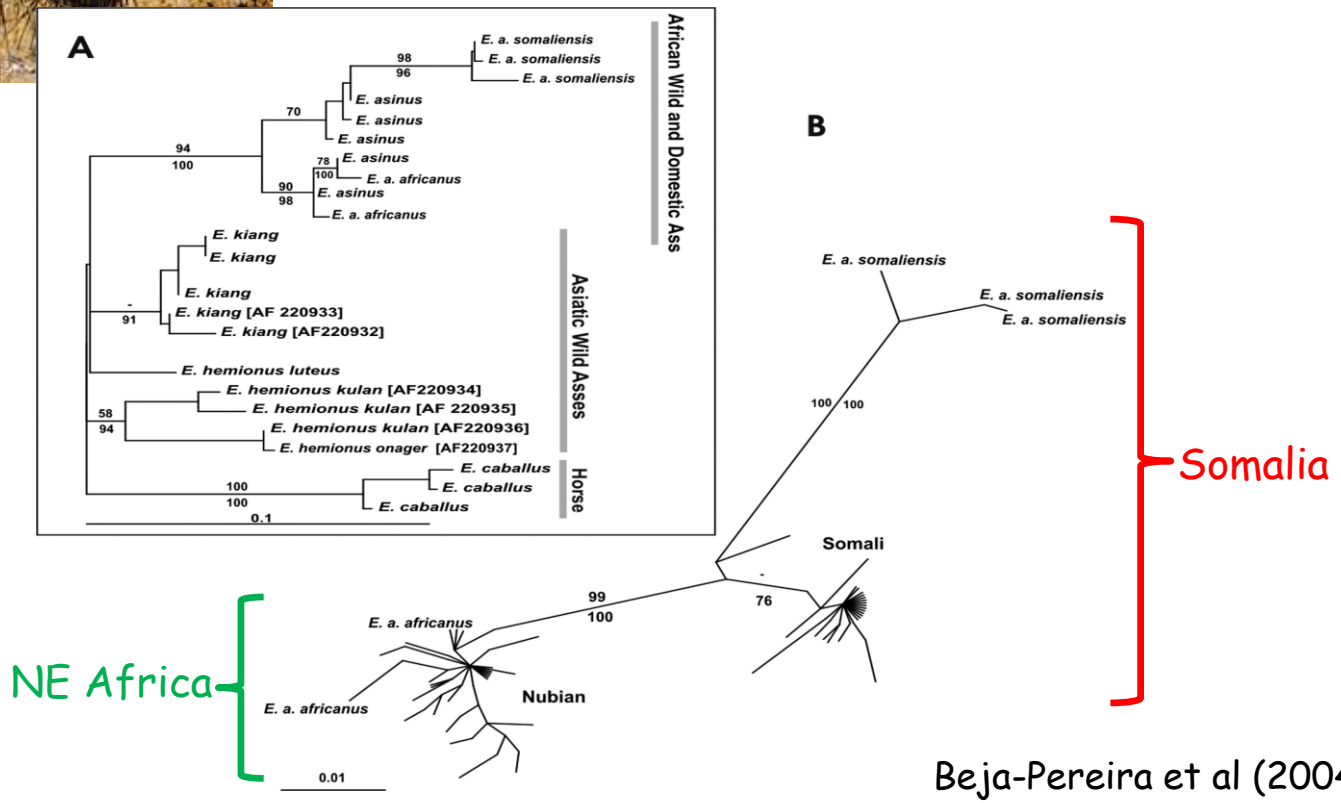
Kon Tiki sailed 6,800 km from Peru to Polynesia in 101 days





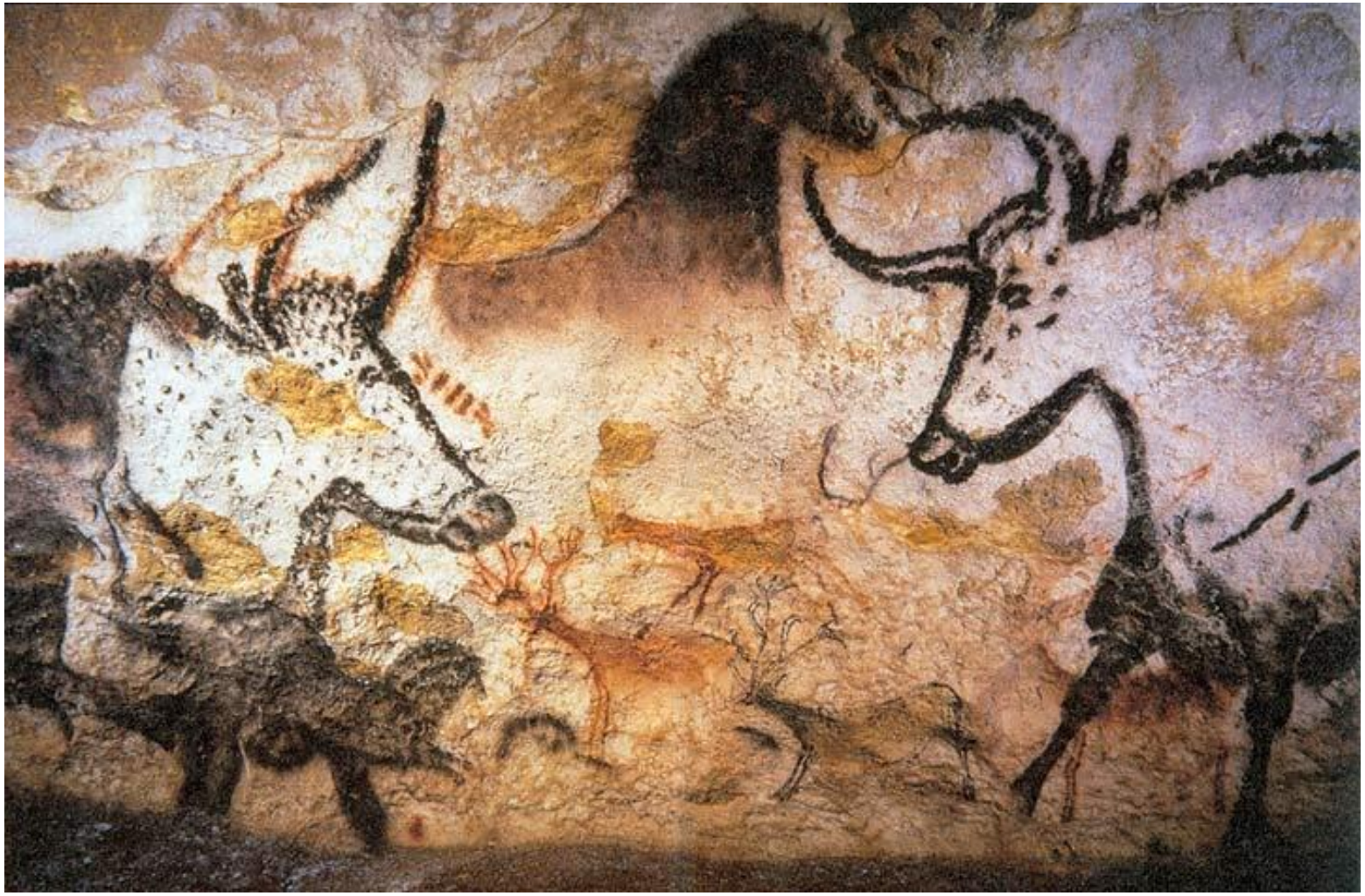
Donkey – Equus asinus

- Transportation
- African wild asses are likely progenitors. The only ungulate domesticated in Africa.
- Data suggest two independent maternal origins of the domestic donkey from two distinct wild populations, one from E. asinus africanus and one from E. asinus somaliensis, both in NE Africa



Beja-Pereira et al (2004)

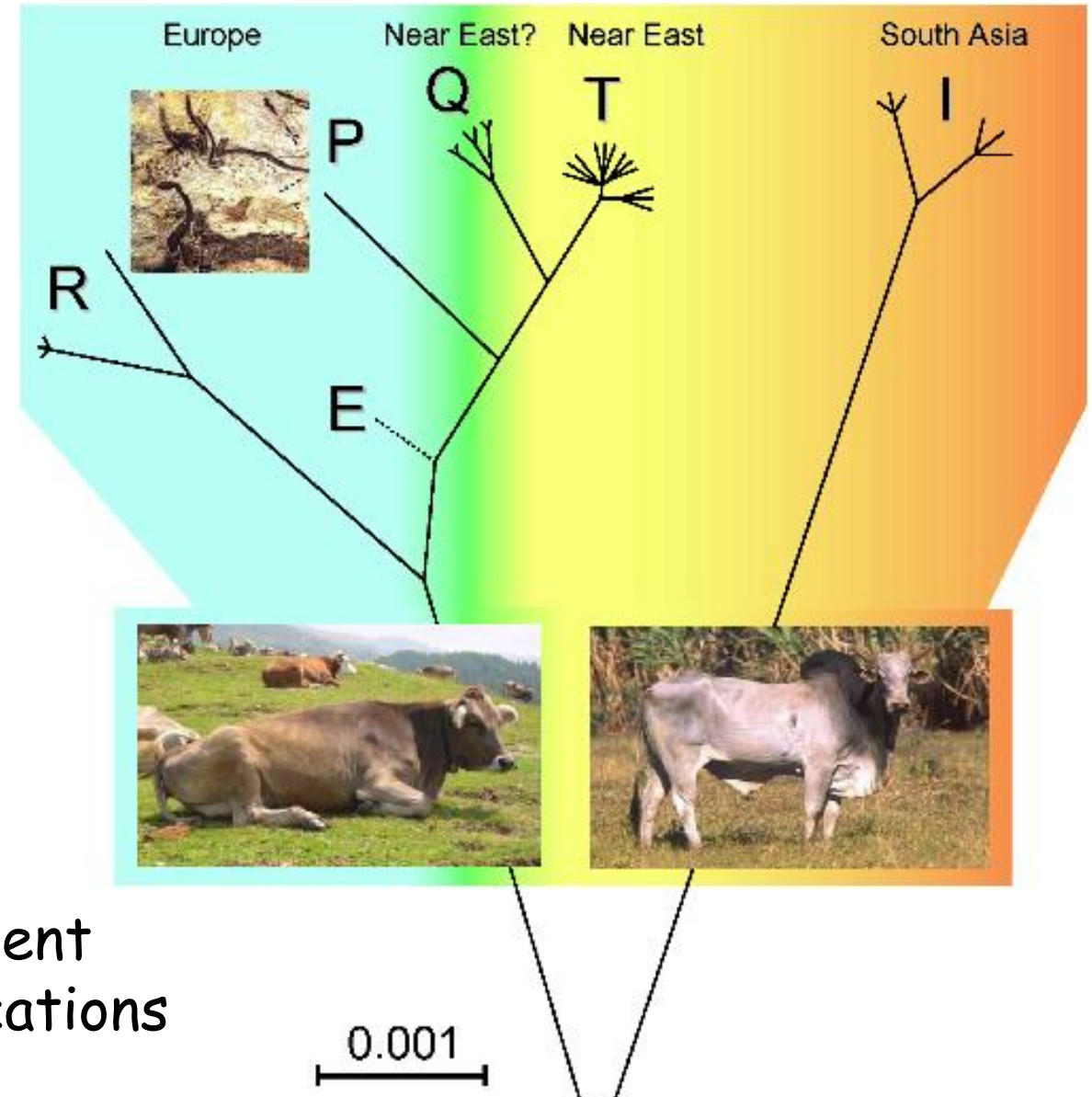
The Auroch – an extinct type of wild cattle and thought to be the ancestor of domestic cattle



Paleolithic painting of Aurochsen from Lascaux cave, southern France

Taurine cattle – *Bos tauris*

Zebuine cattle – *Bos indicus*

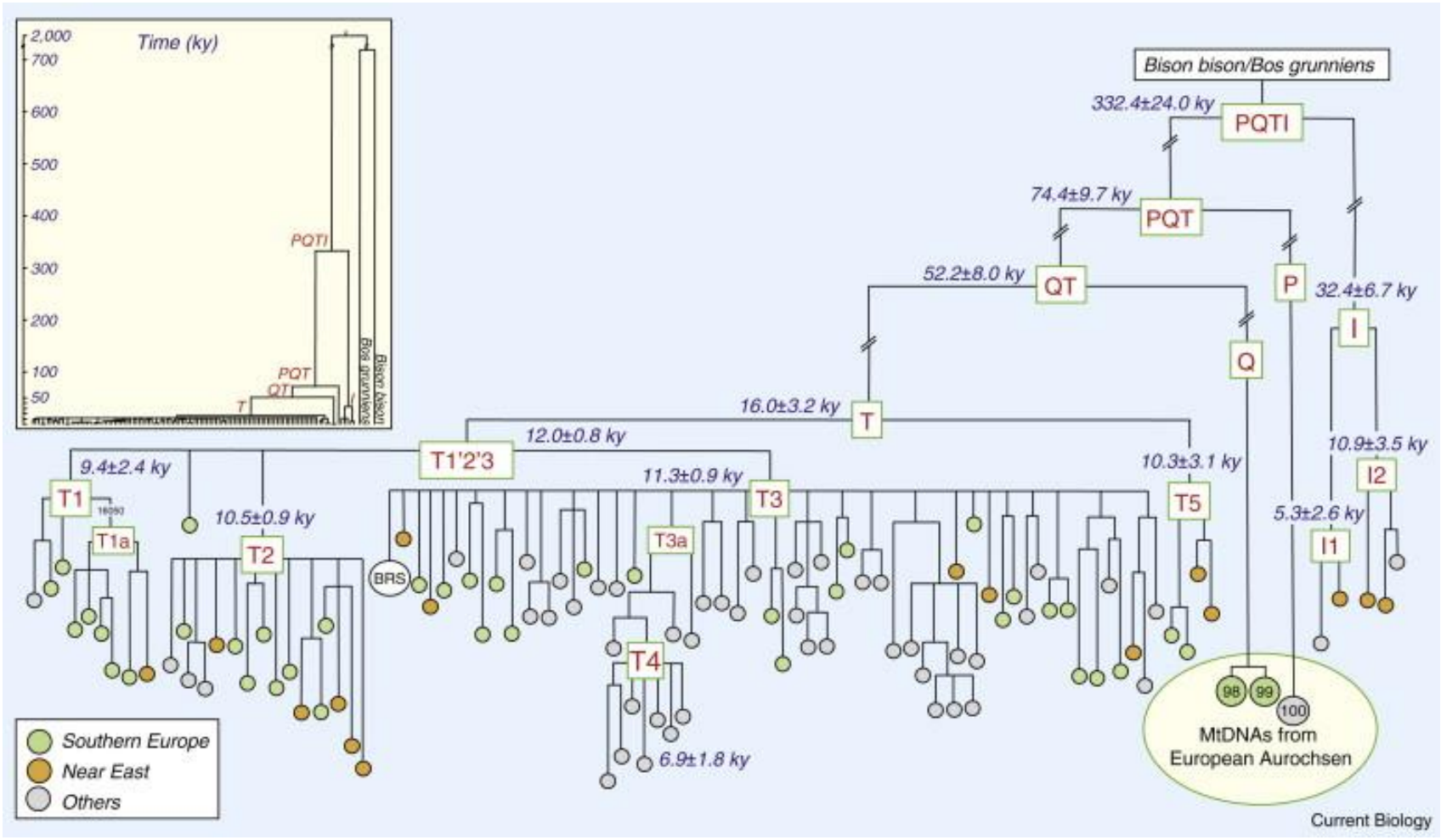


Two independent domestications of cattle

Auroch – *Bos primigenius*

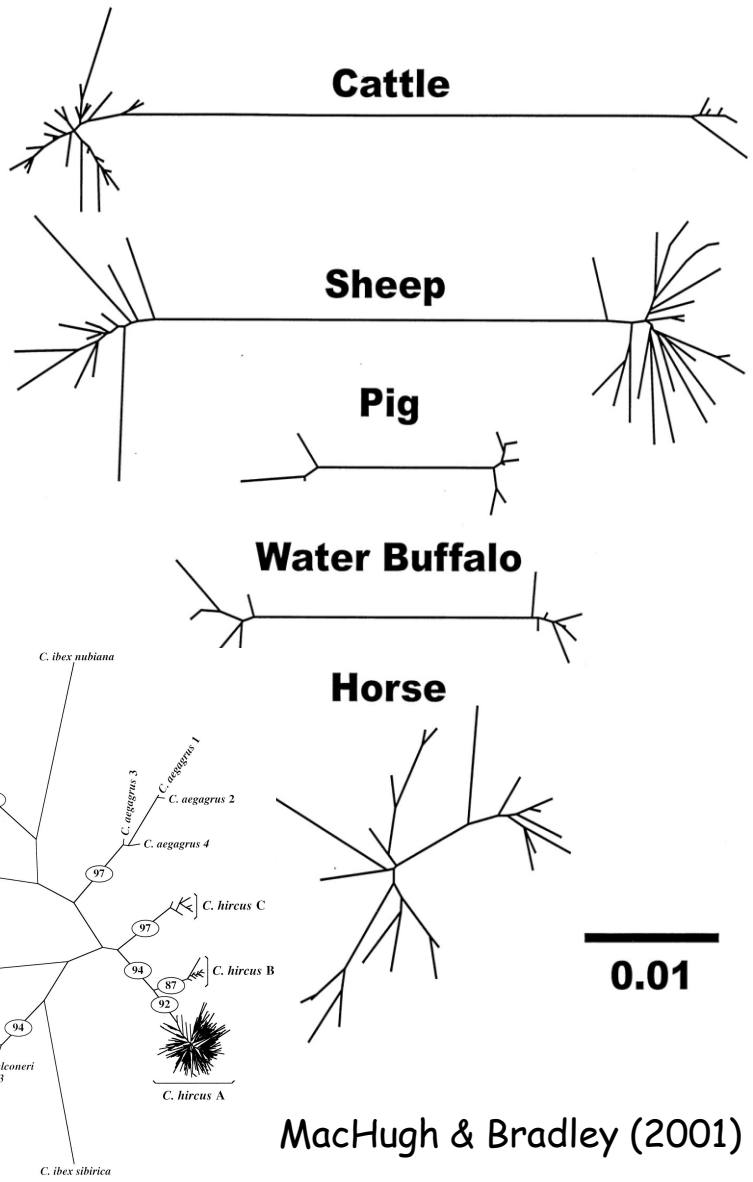
Achilli et al. (2009)

Two independent domestications of cattle



Achilli et al. (2014)

Complex Origins of Domestication of Livestock



MacHugh & Bradley (2001)

- Prevalence of multiple independent origins of domesticated livestock in Fertile Crescent and elsewhere in Eurasia, based on bicentric clade patterns for cattle, sheep, & water buffalo.
- Pig, goat & horse have even more complex patterns suggestive that Eurasian domestication was not so constrained in time and space.
- Phylogenies based on maternally-inherited non-recombining mitochondrial DNA
- Patterns complicated by extensive human-assisted transport.
- Possibility remains that apparently genetically independent domestication events are not necessarily culturally, or even biologically independent, but are rather the result of movement of a few domestic animals into an area, with the genetic signature of the founders subsequently submerged in recruitment of local wild animals – introgressive capture.

Hybrids & Livestock Domestication

The Mule

- Artificial F1 hybrids between ♂ donkey and ♀ horse
- Parents are distinct species with different chromosome numbers
- Infertile
- > patient, sure-footed, hardy & long-lived than horses
- < stubborn, faster and > intelligent than donkeys

Hybrids & Livestock Domestication

Yak bovid hybrids

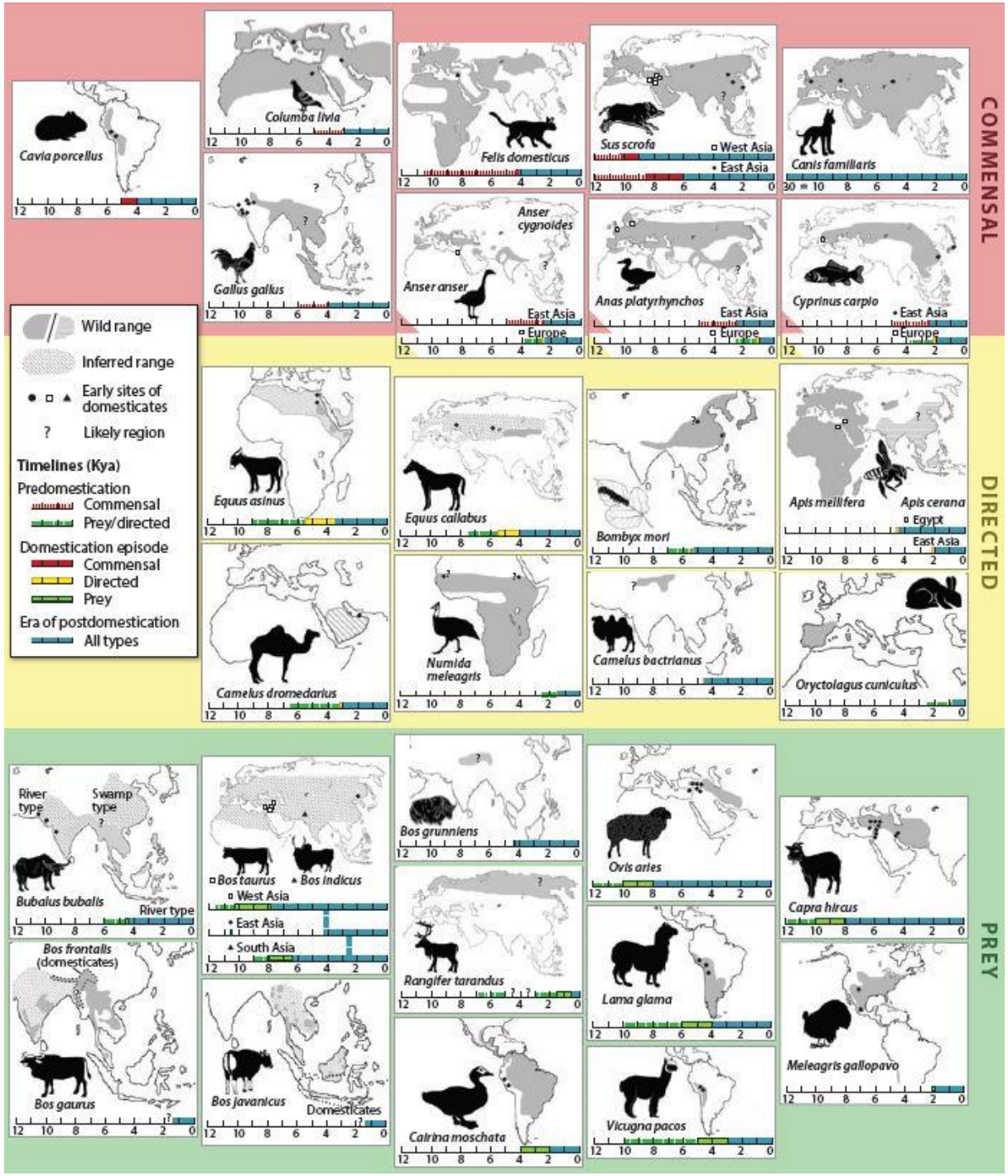
The **yak**, ***Bos grunniens***, a long-haired Himalayan domesticated bovine.

In the Nepal, Tibet & Mongolia domestic cattle crossed with yaks to produce the infertile male ***dzo*** as well as fertile females known as ***dzomo***, which may be crossed again with cattle.

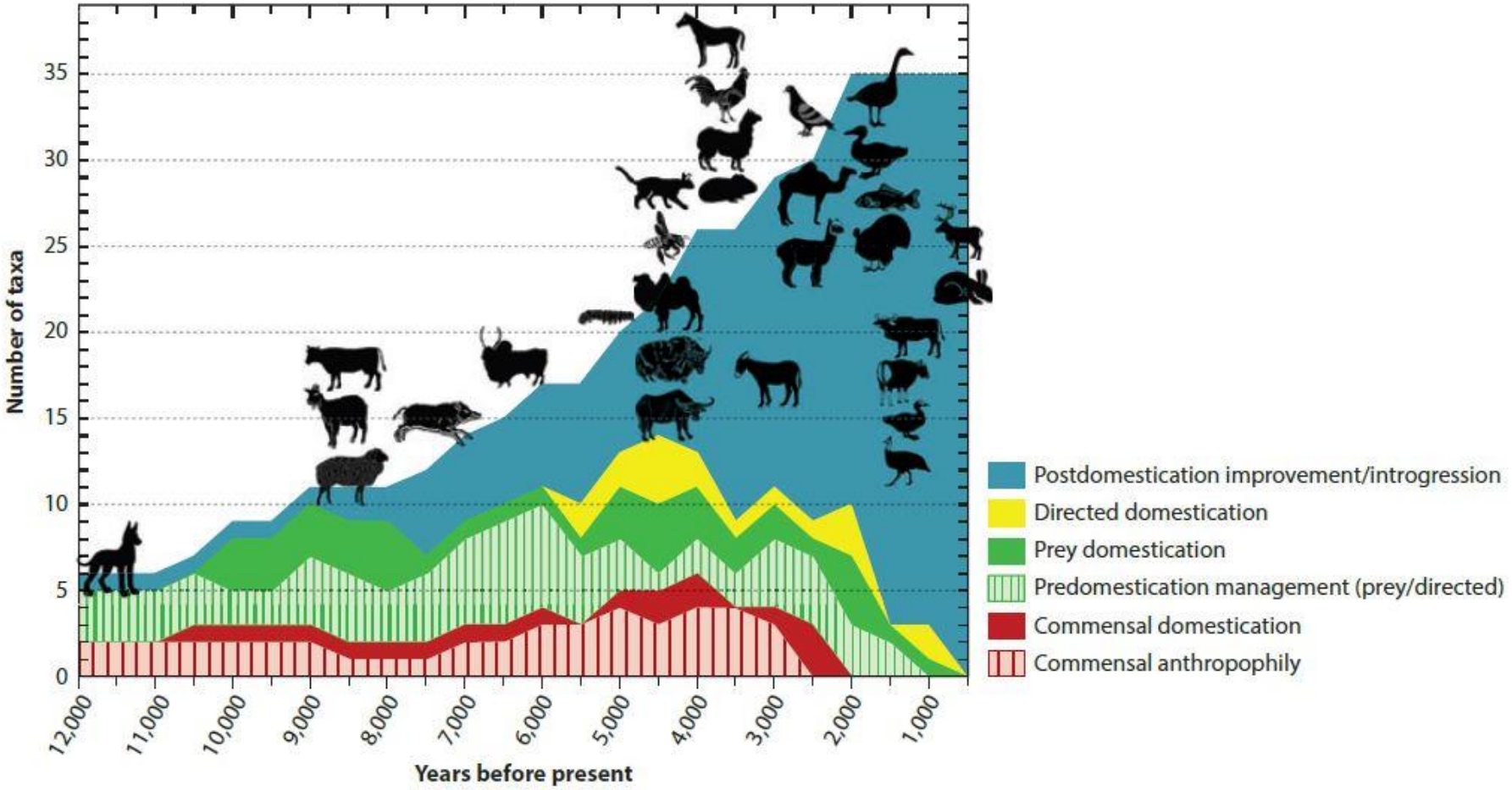
Crosses between yaks and domestic cattle have been recorded for at least 3,000 years. Crossbred females are an important source of milk and dairy products. Males used as draught animals or slaughtered for meat. These hybrids are very suitable for work as they are easily tamed and have better heat tolerance than pure yak.

An experimental cross between yak and American bison is called a yakalo.

Limits to Hybridization: Poor reproductive performance in yak hybrids severely limits opportunties for crossbreeding.



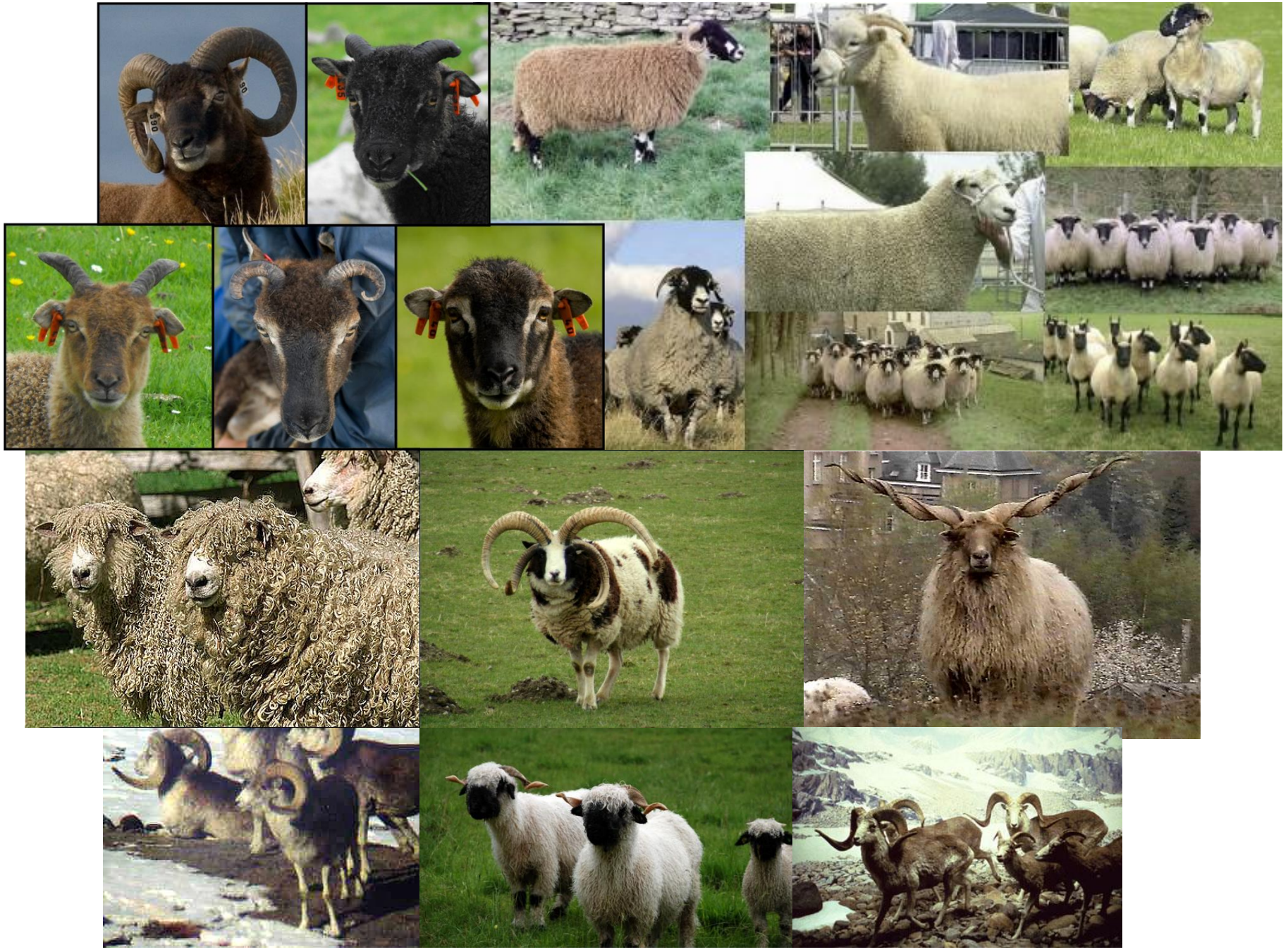
Larson & Fuller (2014)



Larson & Fuller (2014)

Diversification after Domestication

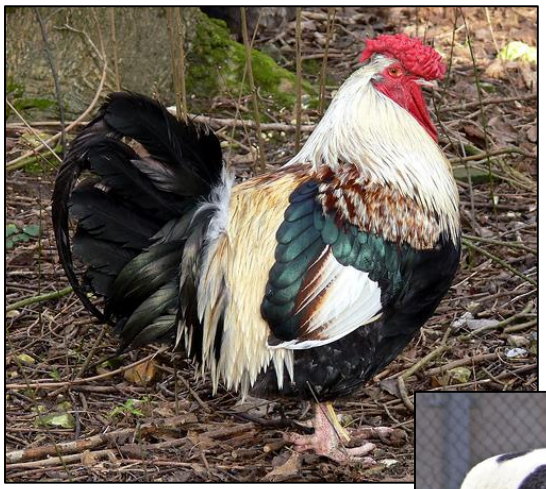
Diversification after Domestication



RBST
Rare Breeds Survival Trust

Throughout the world one breed of farm animal becomes extinct every month.

Between 1900 and 1973, 26 native breeds of livestock were lost in the UK, in addition to many varieties of poultry. Breeds with evocative names such as the Goonhilly ponies, Somerset Sheeted cattle, Lincolnshire Curly Coated pigs, and Limestone sheep, have all gone. Others are now rare.



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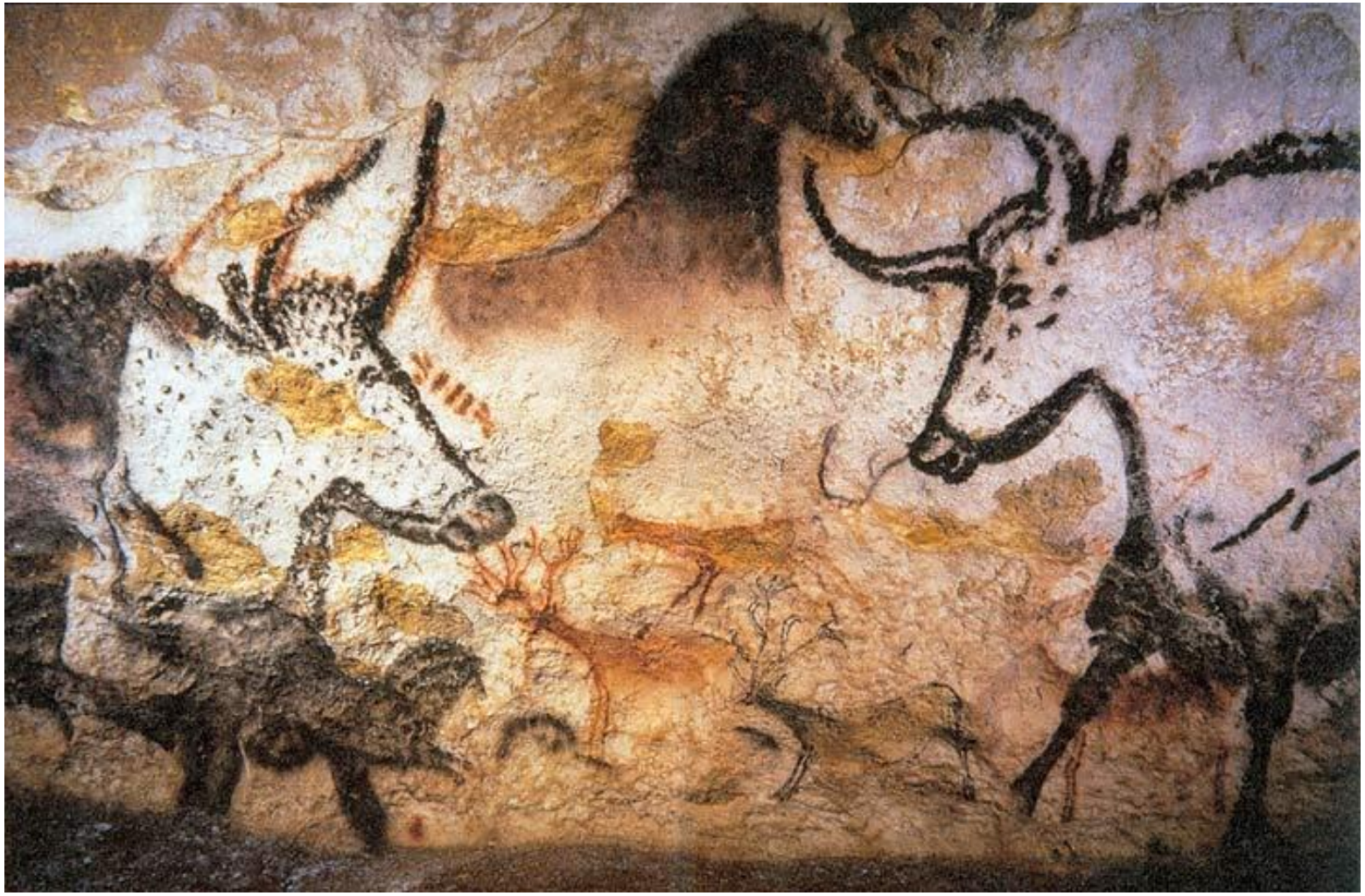


Willkommen bei ProSpecieRara

ProSpecieRara...

- Rettet und behütet die Vielfalt der Kulturpflanzen und Nutztiere
- Erhält und vermittelt das Wissen und die kulturellen Werte der traditionellen Sorten und Rassen
- Vermittelt den Zugang zu Saatgut und Zuchttieren für jedermann
- Stärkt die gefährdeten Sorten und Rassen über die Förderung der Vermarktung von Spezialitäten
- Leistet mit der Erhaltung der Kulturpflanzen- und Nutztiervielfalt einen wichtigen Beitrag an die Sicherheit unserer Nahrungsmittelversorgung

Mehr über die Ziele von ProSpecieRara.

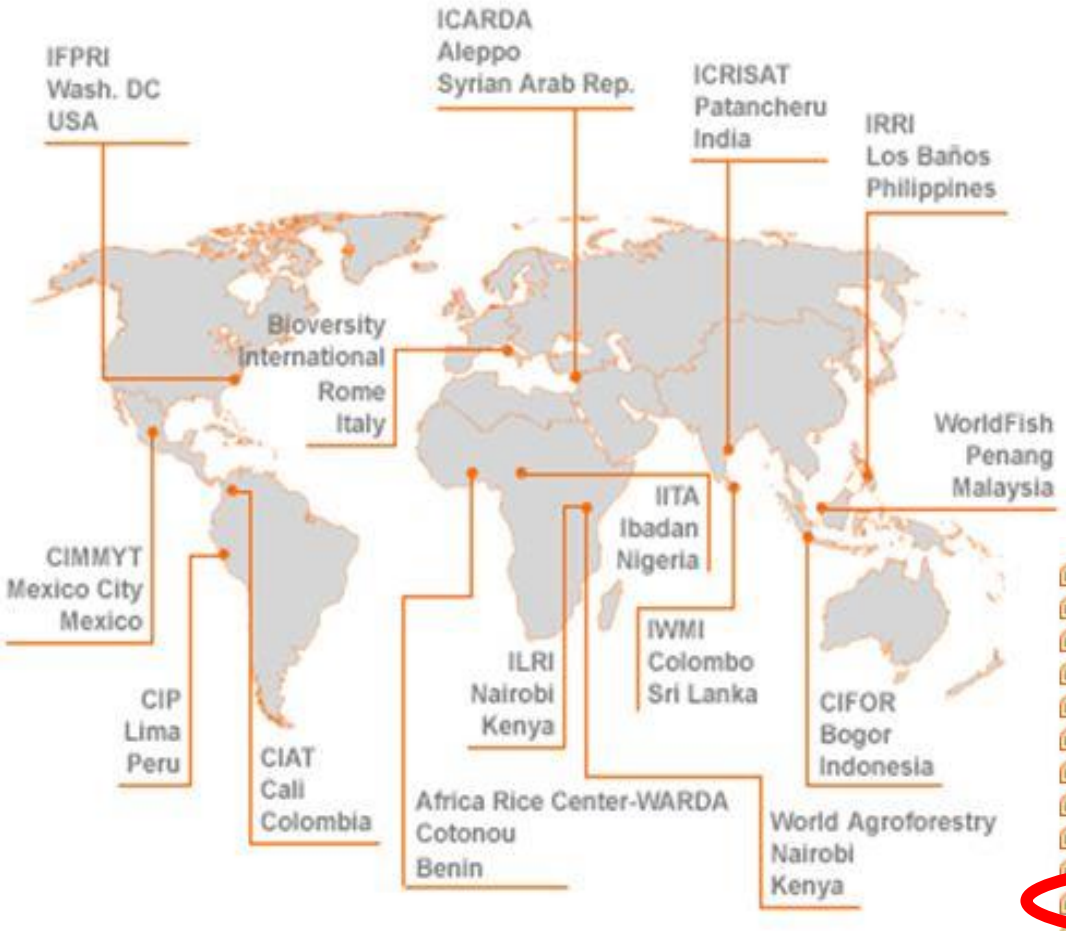
Newsletter abonnieren

Wenn rare Rohstoffe mit altem Seifenhandwerk veredelt werden...
...entstehen wertvolle Duschseifen. Diese sind aus der Zusammenarbeit von ProSpecieRara mit der Freiämter Seifenmanufakt...
mehr

Buchtipps
Die ProSpecieRara-Experten empfehlen ihre Buchfavoriten zu verschiedenen Themen....
mehr

Rückblick auf den Reutenmarkt
Bratwürste vom Engadinerschaf, Most frisch ab Press und über 40 Birnensorten zum Degustieren - dies die Kurzzusammenfass...
mehr

Gelungene zweite Auflage der Tier-Expo in Brunegg
Am 1. und 2. Oktober 2011 war die Vianco-Arena für einmal mehr das Mekka der Freunde rarer Nutztiere. Mit der Tier-Expo ...
mehr



International Livestock Research Institute, ILRI, Nairobi, Kenya

- Africa Rice Center
- Bioversity International
- CIAT - Centro Internacional de Agricultura Tropical
- CIFOR - Center for International Forestry Research
- CIMMYT - Centro Internacional de Mejoramiento de Maiz y Trigo
- CIP - Centro Internacional de la Papa
- ICARDA - International Center for Agricultural Research in the Dry Areas
- ICRISAT - International Crops Research Institute for the Semi-Arid Tropics
- IFPRI - International Food Policy Research Institute
- IITA - International Institute of Tropical Agriculture
- ILRI - International Livestock Research Institute
- IRRI - International Rice Research Institute
- IWMI - International Water Management Institute
- World Agroforestry Centre (ICRAF)
- WorldFish Center

Conclusions Crops & Livestock Domestication

- Similar approaches using archaeological and genetic evidence.

- But, morphological markers of domestication much more elusive for livestock animals than crop plants.

- Origins of domesticated livestock are much more controversial in terms of when, where and how many times, but evidence of multiple independent domestications complicated by evidence of extensive movement of livestock.

- Diversity of domesticated animal species is much lower than domesticated crops – just 5 mainstream livestock species used as food plus a few minor ones, a total of around 35 species.

- Hybrids and polyploidy of very limited importance in livestock compared to their central and pivotal importance in crops.

- Diversification after domestication has been equally important for livestock and crops, and there are similar concerns about erosion of rare livestock breeds as for traditional crop varieties – several wild progenitors are known to already be extinct…..

Question for next week

Why does crop diversity matter?