

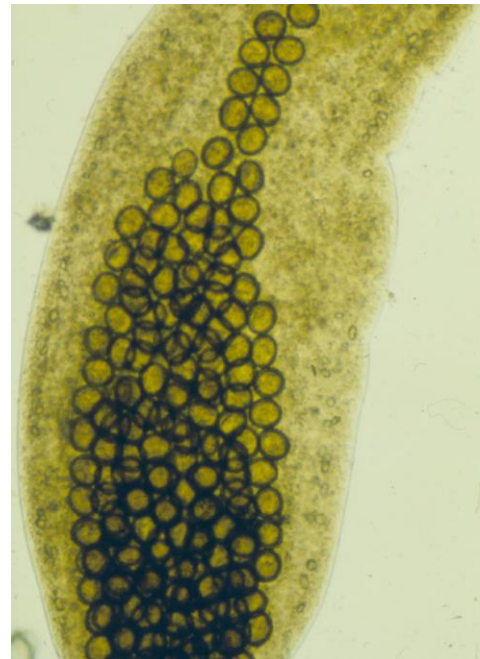
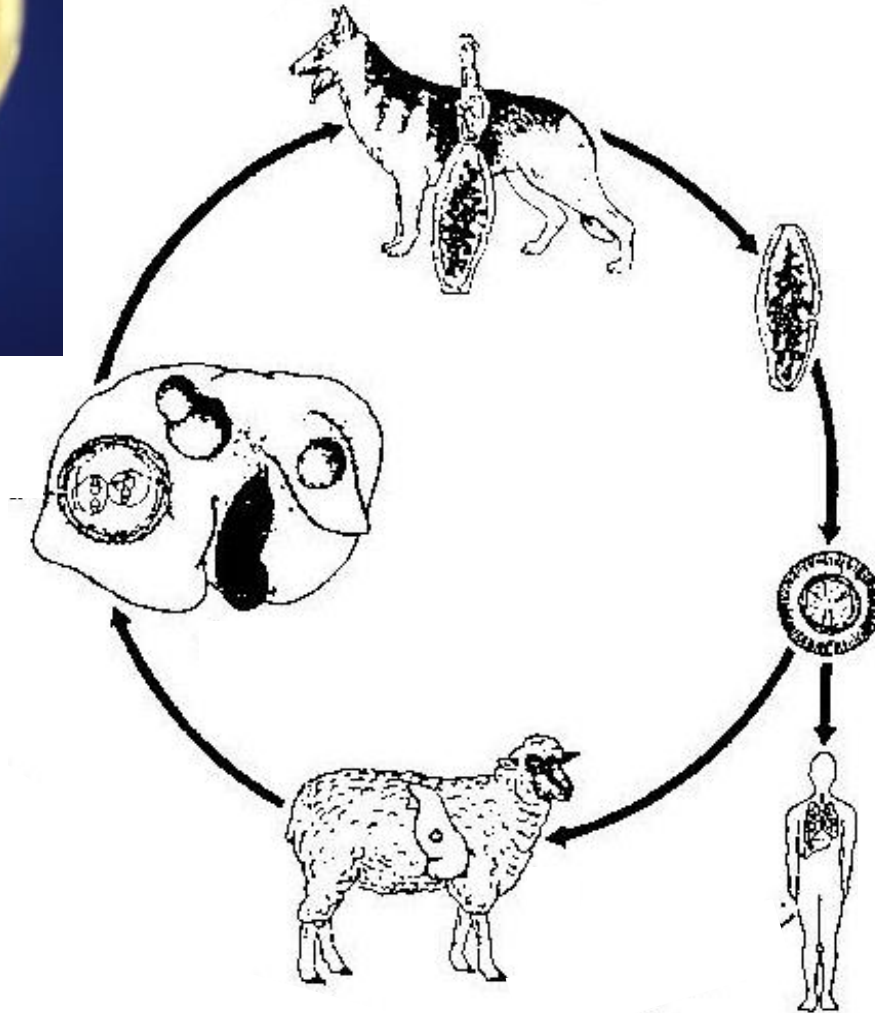


Global diversity of cystic echinococcosis

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Echinococcus: generalized lifecycle

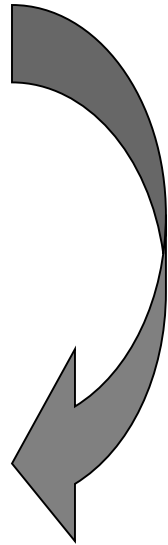
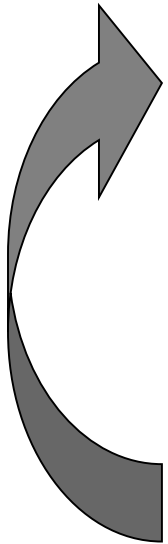




Cystic echinococcosis: geographical spread

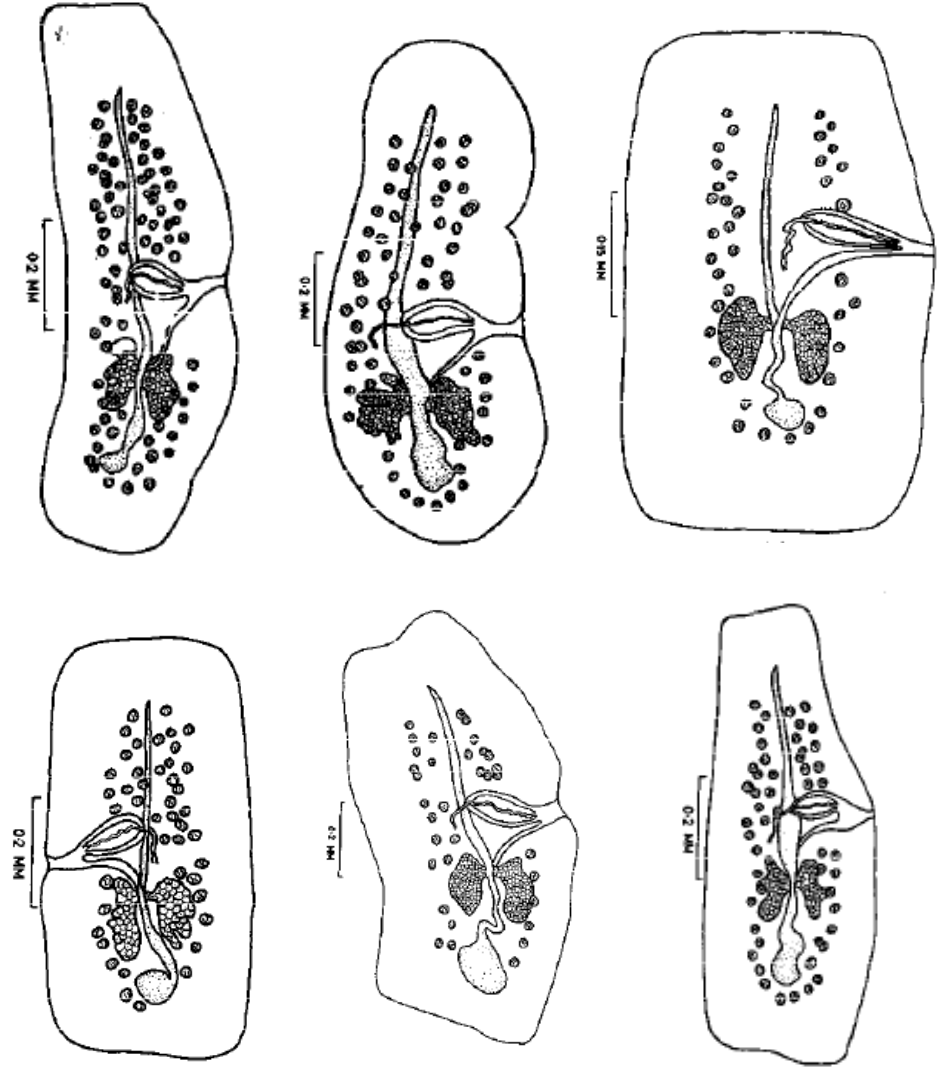
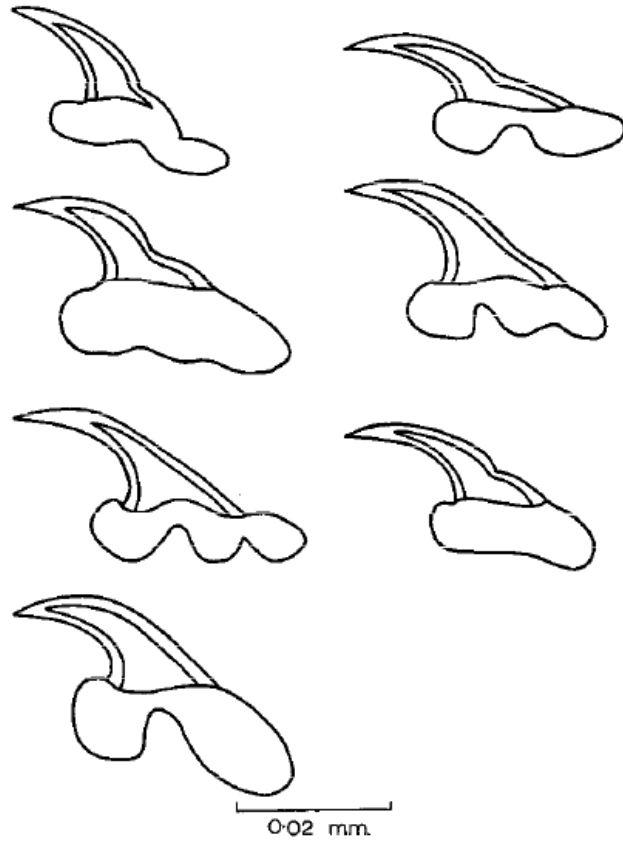
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Acephalocystis cystifera
Acephalocystis prolifera socialis
Astoma acephalocystis
Cysticercus pedunculatus
Discostoma acephalocystis
Echinococcus altricipariens
Echinococcus cysticus fertilis
Echinococcus echinococcus
Echinococcus femoris
Echinococcus hydatidosus exogenus
Echinococcus infusorium
Echinococcus retroperitonealis
Echinococcus simiaecynomolgi
Echinococcus subphrenicus
Echinococcus variabilis
Echinococcus veterinorum
Finna idatoides
Hydatis erratica
Splanchnococcus echinatus
Taenia echinococcus scolecipariens
Taenia hydatigena granulosa
Taenia serrata juvenalis rollii
Taenia visceralis granulosa

Cruveilhier, 1829; *Acephalocystis sterilis* Cruveilhier, 1829; *Acephalocystis surculigera* Laennec, 1812; ? *Astoma acephalocystis* Goodsir, 1844; *Cysticercus echinococcus* (Zeder 1803); *Cysticercus pedunculatus* Wilson, 1845; *Discostoma acephalocystis* Küchenmeister, 1855; *Echinococcus altricipariens* Küchenmeister, 1855; *Echinococcus arietis* Blanchard, 1848; *Echinococcus cerebrales* Perroncito, 1882; *Echinococcus cerebrales* Spiering, 1862; *Echinococcus coenuroides* Küchenmeister, 1855; *Echinococcus cordis* Minich, 1899; *Echinococcus cysticercus* Daniels, 1910; *Echinococcus cysticercus* Huber, 1891; *Echinococcus cysticus fertilis* Braun, 1903; *Echinococcus cysticus sterilis* (Cruveilhier, 1829); *Echinococcus echinococcus* (Zeder, 1803); *Echinococcus endogena*, *Echinococcus exogena*; *Echinococcus femoris* Schulze, 1911; *Echinococcus giraffae* Gervais, 1847; *Echinococcus hepatis* Scholler, 1862; *Echinococcus hominis* (Zeder, 1803); *Echinococcus humanus* (Zeder, 1803); *Echinococcus hydatidosus* Leuckart, 1863; *Echinococcus hydatidosus endogenus* (Kuhn, 1830); *Echinococcus hydatidosus exogenus* (Kuhn, 1830); *Echinococcus hypophrenicus* Geelvink, 1893; *Echinococcus infusorium* Leuckart, 1827; *Echinococcus multiplex* Stiller, 1882; *Echinococcus peritonei* Rochell, 1863; *Echinococcus polymorphus* Diesing, 1850; *Echinococcus polymorphus unilocularis* (Huder, 1896); *Echinococcus pulmonum* Huppert, 1875; *Echinococcus racemosus* Leuckart, 1886; *Echinococcus retroperitonealis* Bitter, 1886; *Echinococcus scolecipariens* Küchenmeister, 1855; *Echinococcus simiae* Rudolphi, 1810; *Echinococcus simiaecynomolgi* Oken, 1815; *Echinococcus simplex* Leuckart, 1886; *Echinococcus sterilis* (Cruveilhier, 1829); *Echinococcus subphrenicus* Huber, 1896; *Echinococcus unilocularis* Huber, 1896; *Echinococcus unilocularis hepatis* Haffter, 1875; *Echinococcus unilocularis hydatidosus* (Leuckart, 1863); *Echinococcus variabilis* Siebold, 1837; *Echinococcus veterinorum* Rudolphi, 1810; *Finna idatoides* Brera, 1810; *Hydatigena granulosa* Batsch, 1786; *Hydatis acephalocystis* Dunglisson, 1893; *Hydatis echinococcus* Zeder, 1803; *Hydatis granulata* Bosc, 1802; *Hydatis erratica* Blumenbach, 1805; *Hydatis simplex* (Leuckart, 1886); *Splanchnococcus echinatus* Bremser, 1819; *Splanchnococcus laevis* Bremser, 1819; *Taenia cateniformis* Rudolphi, 1808; *Taenia echinococcus* Siebold, 1853; *Taenia echinococcus scolecipariens* Küchenmeister, 1855; *Taenia echinococcus veterinorum* Rudolphi, 1810; *Taenia granulosa* (Batsch, 1786); *Taenia hydatigena granulosa* Rudolphi, 1805; *Taenia nana* of Beneden, 1861; *Taenia serrata* of Roell, 1852; *Taenia serrata juvenalis rollii* Küchenmeister, 1855; *Taenia socialis granulosa* Goeze, 1782; *Taenia visceralis granulosa* Goeze, 1782.



(from Verster, 1965)



Strains and genotypes...

E. granulosus (Batsch, 1796)

sheep strain	G1
Tasmanian sheep strain	G2
buffalo strain	G3
horse strain	G4
cattle strain	G5
camel strain	G6
pig strain	G7
American cervid strain	G8
Fennoscandian cervid strain	G10
lion strain	

(e.g. Thompson & Lymbery, 1990; Thompson et al., 1995; Bowles et al., 1992; Bowles & McManus, 1993)



Strains and genotypes...

Differences in:

- Phylogenetic distance
- Biological characters (development, host affinities, pathogenicity...)
- Morphology

<i>E. granulosus</i>	G1-3 (sheep / buffalo strains)
<i>E. equinus</i>	G4 (horse strain)
<i>E. ortleppi</i>	G5 (cattle strain)
<i>E. canadensis</i>	G6/7 (camel-pig strain) G8 (,American ' cervid strain) G10 (,European ' cervid strain)
<i>E. felidis</i>	(lion strain)

E. granulosus s.l.

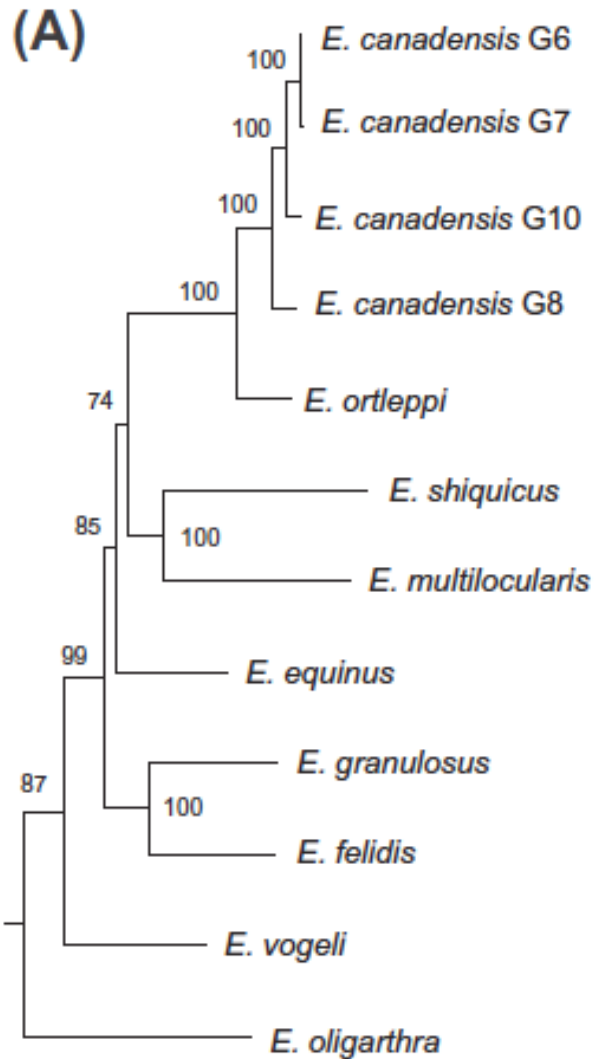
E. multilocularis

E. shiquicus

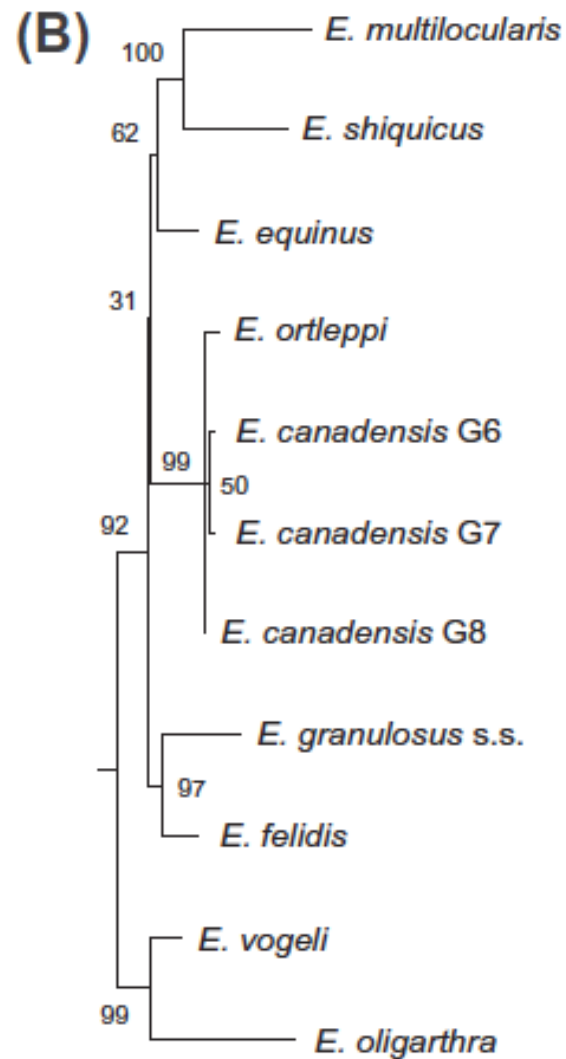
E. oligarthra

E. vogeli

mt genomes



nuclear protein-coding genes



Knapp et al.,
2011
Nakao et al.,
2013



2

3

4

4

5

4

1



Echinococcus granulosus s.s.

- worldwide distribution in livestock and wildlife
- frequent and highly fertile in sheep
- well adapted to pigs and other livestock species
- frequent, but often infertile in cattle
- most frequent agent of human CE

Of 1661 genotyped cyst isolates from humans worldwide (Alvarez Rojas et al., 2014):

88.44% *E. granulosus s.s.*

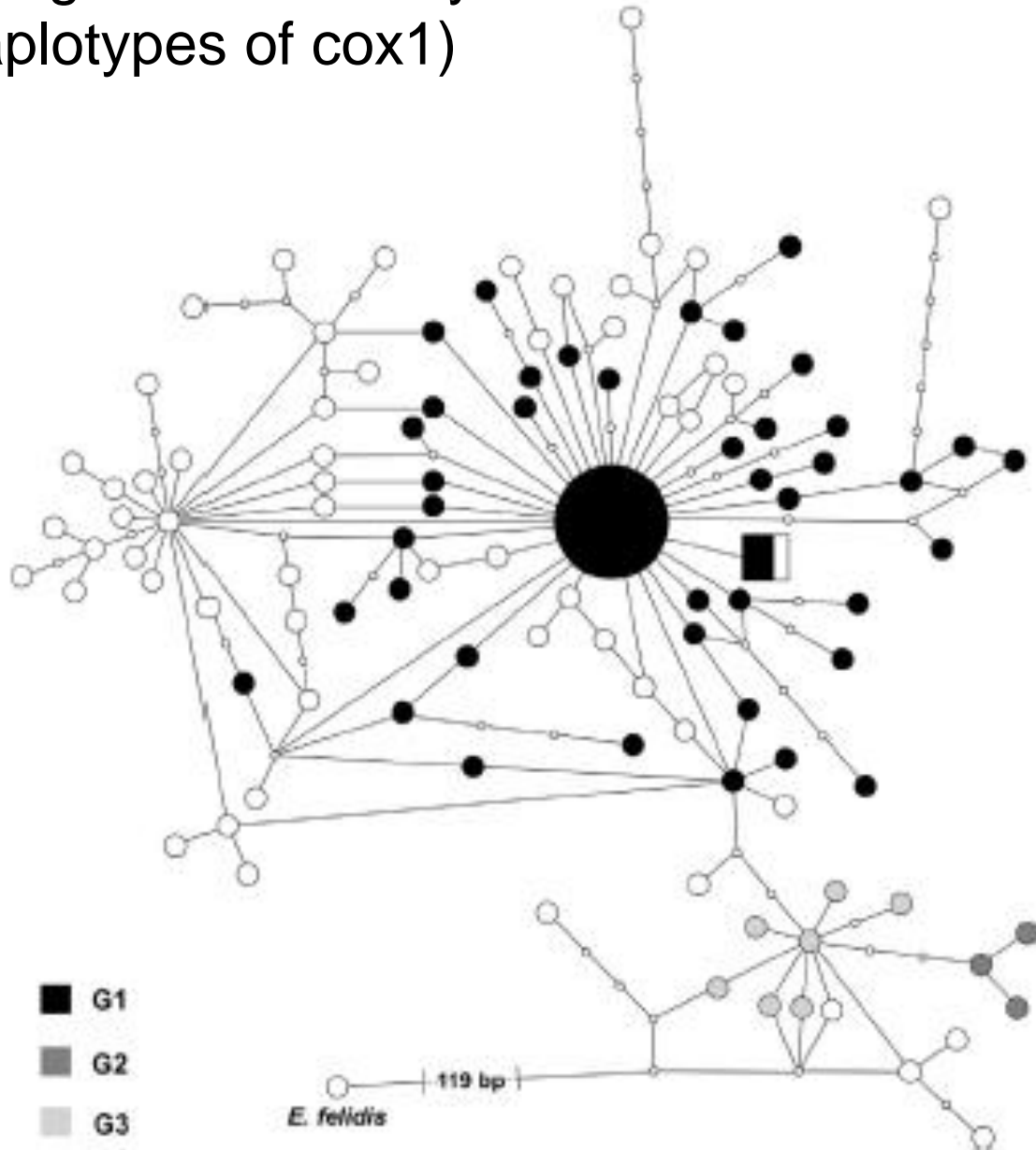
11.07% *E. canadensis* G6/7

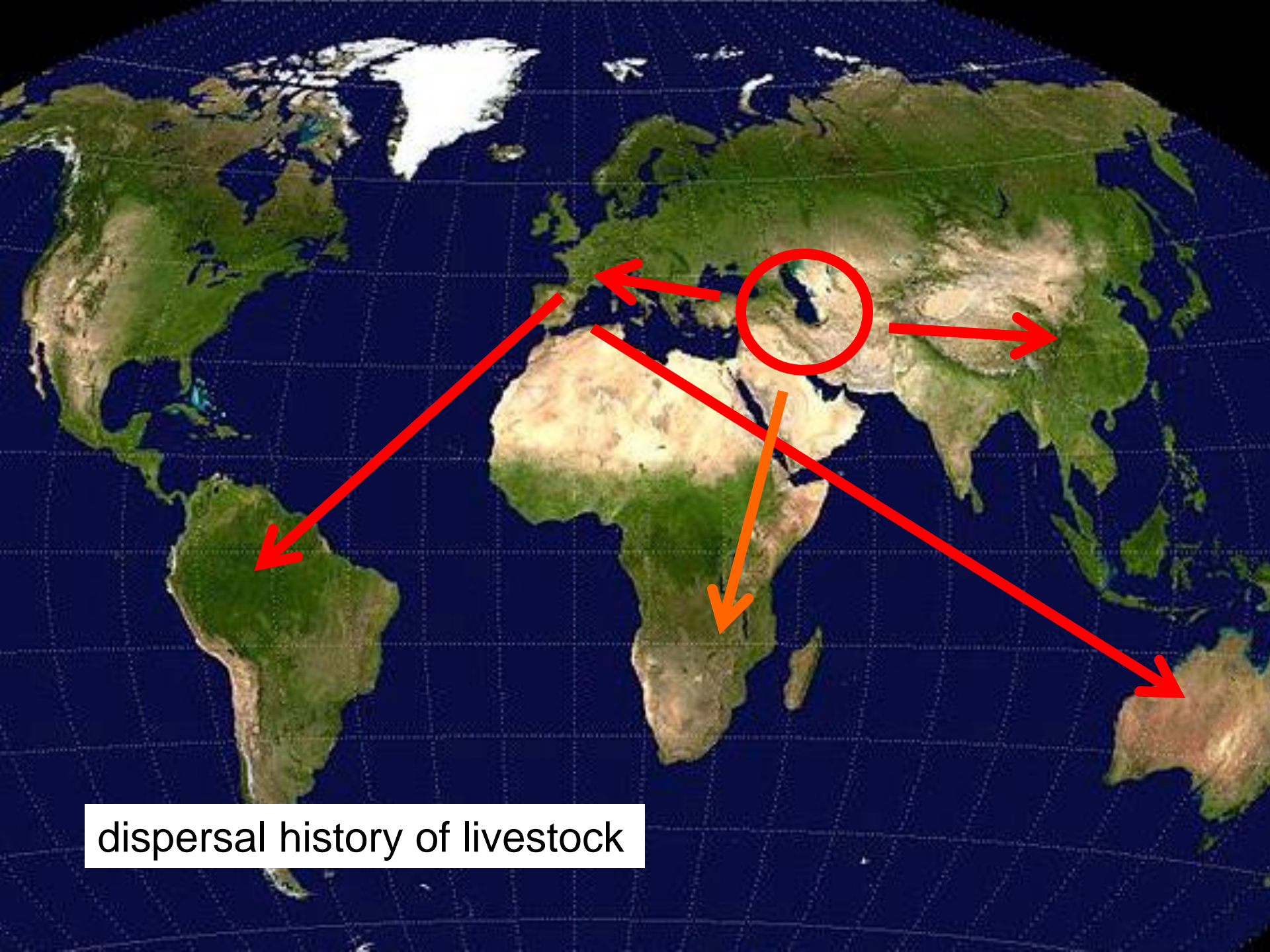
0.36% *E. ortleppi*

0.12% *E. canadensis* G8 and G10

- infraspecific variants with different host affinities?

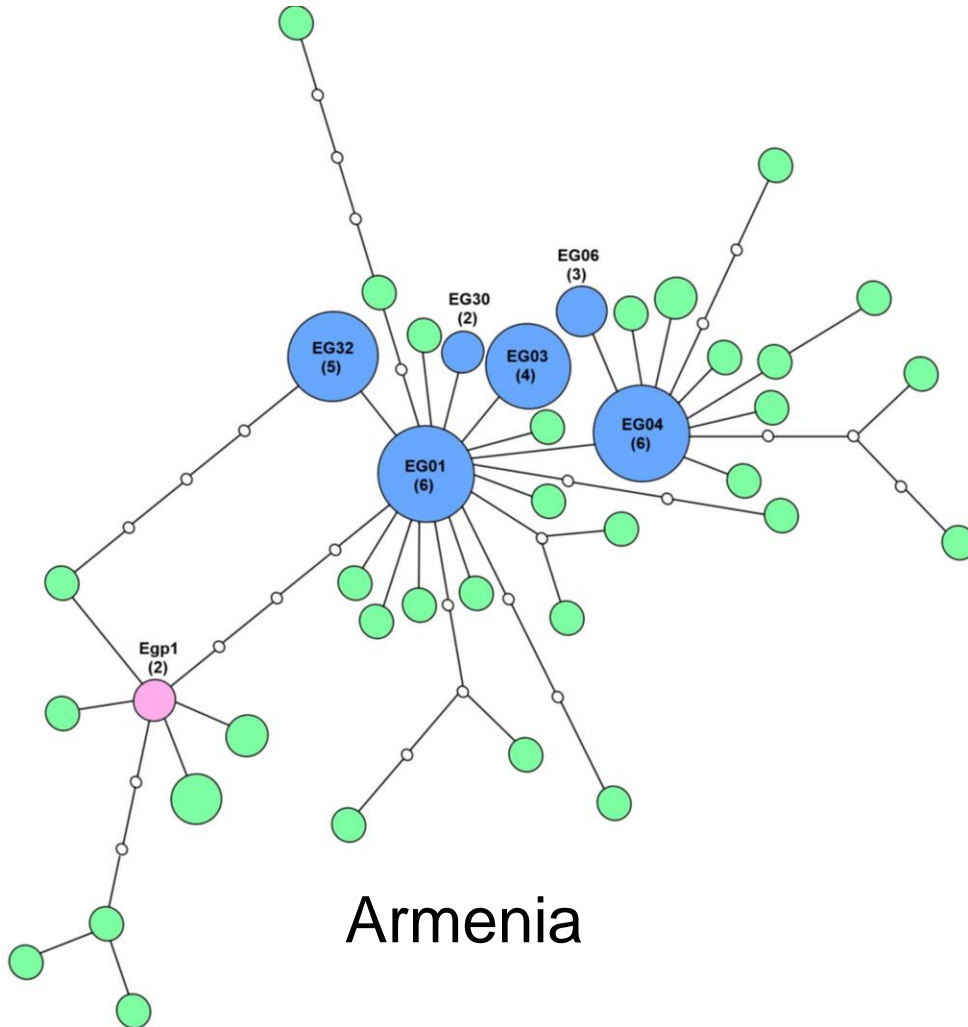
E. granulosus s.s.:
high genetic diversity
(haplotypes of cox1)



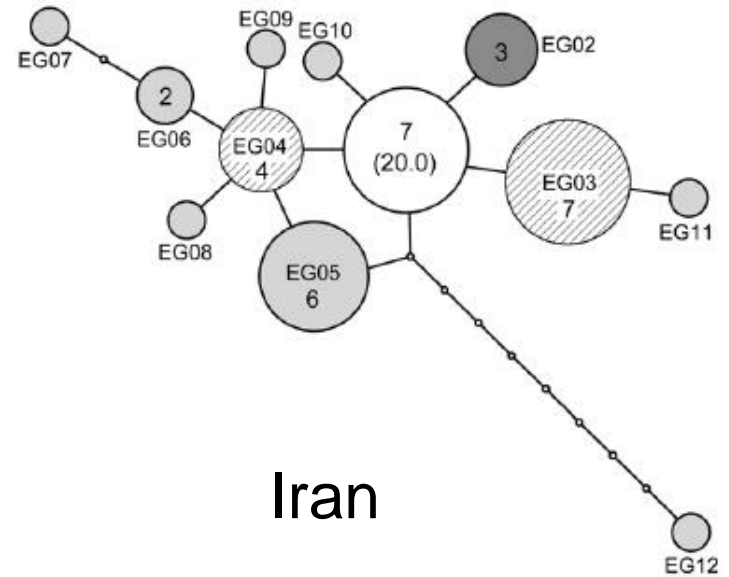


dispersal history of livestock

E. granulosus s.s. in western Asia: high complexity (complete cox 1)

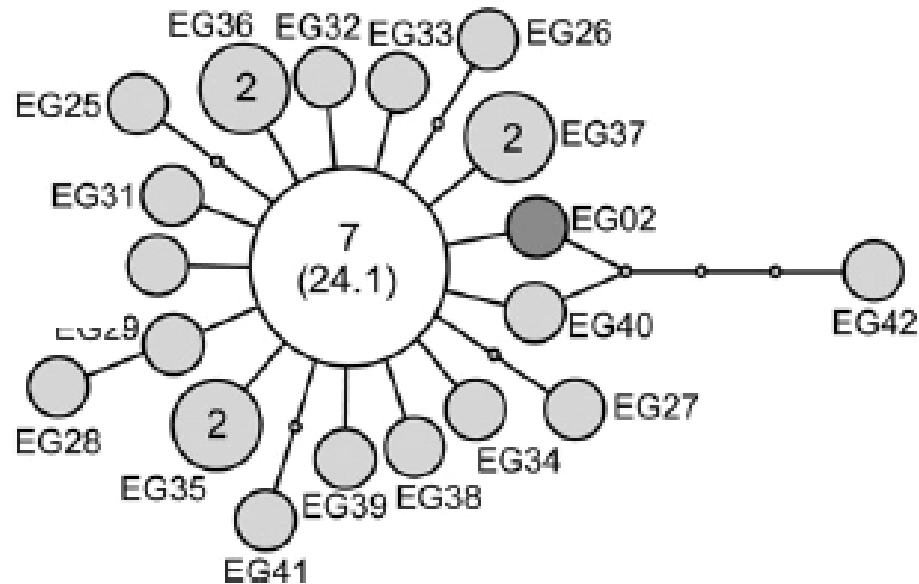


Ebi & Gevorgyan, unpubl.

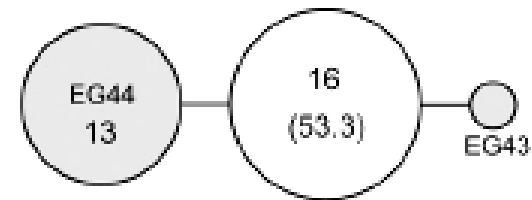


Yanadiga et al., 2012

E. granulosus s.s. elsewhere:
Reduced complexity
(complete cox 1)

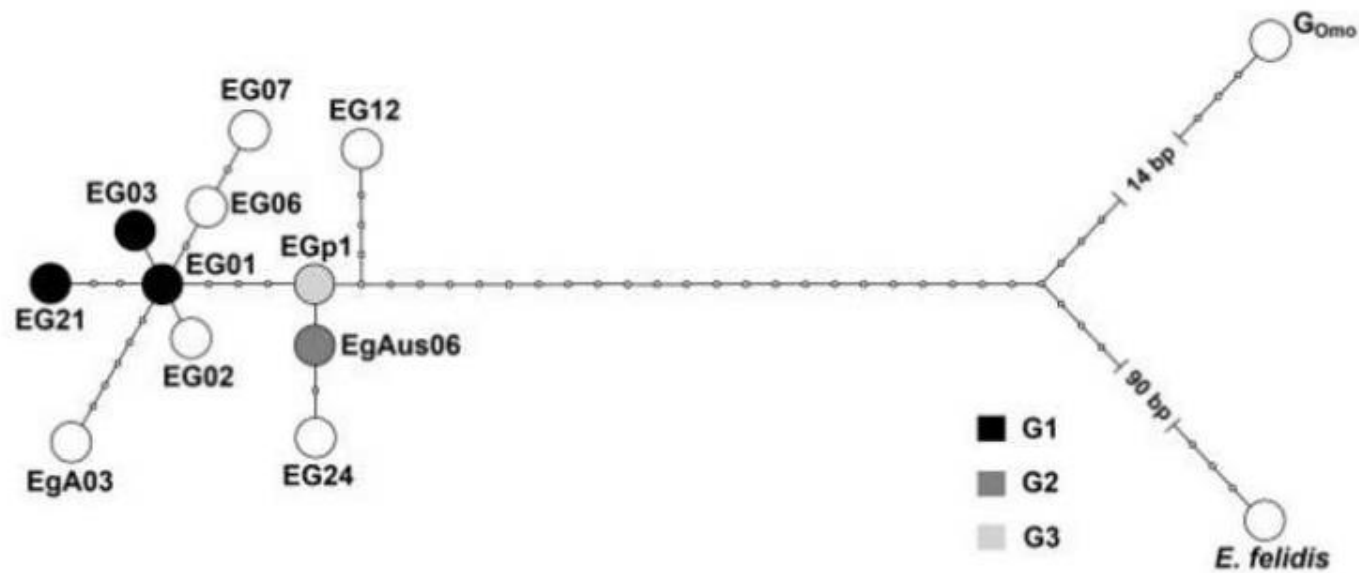


China



Peru

E. granulosus s.s.:
Distinct genotype in eastern
Africa (complete cox 1)





Echinococcus felidis

(,lion strain ‘)

- described from lions in South Africa
- molecular identification from South African and Ugandan material
- Sister taxon to *E. granulosus*

Hüttner et al., 2008

Hüttner et al., 2009

Kagendo et al., 2014



Confirmed presence of *E. felidis*



Echinococcus felidis

(,lion strain ‘)

- epidemiology unclear (host range, geography, human infectivity, involvement of livestock)
- possibly specific to the pig family as intermediate hosts
- possibly not zoonotic



Echinococcus equinus

Intermediate host spectrum limited to Equidae?

Worldwide dog – horse/donkey cycles

No human cases known

Wildlife cycle in southern Africa







Echinococcus ortleppi

Typical cycle: dog – cattle

Worldwide, usually rare (no home slaughter of cattle?)

(exceptions South and East Africa, southern Brazil, formerly central Europe)

Rarely in other animals: zebra (Namibia), pig (Kenya), captive deer (UK), captive monkeys (Vietnam)

Only six human cases known (globally distributed)





Echinococcus canadensis

Highest intra(?)specific complexity of all *Echinococcus* spp.

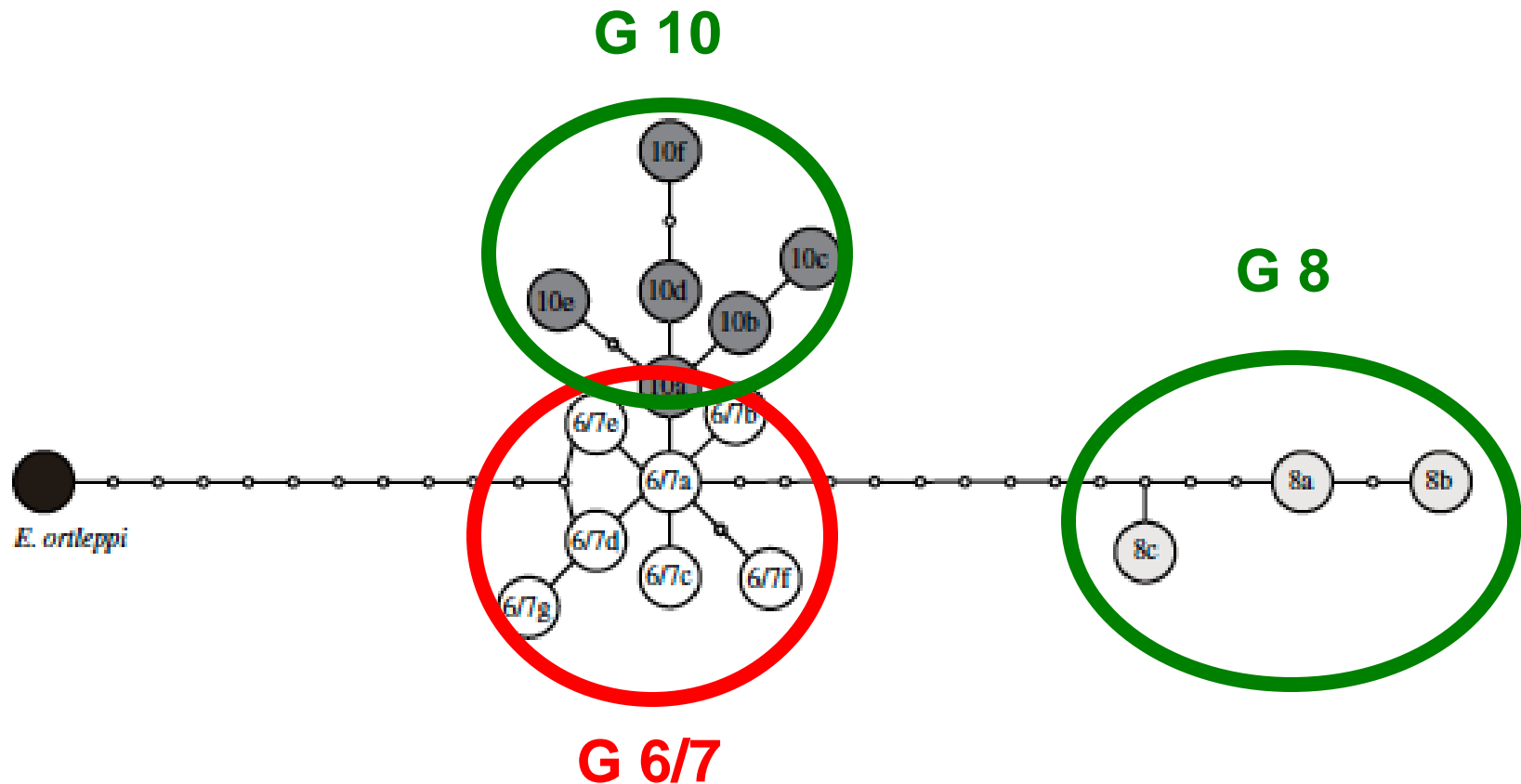
G6/7: Worldwide domestic cycles dog – pigs/camels/goats

G8 and G10: northern wildlife and semi-domestic cycles

Echinococcus canadensis

Taxonomic complexity (partial cox1):

(Nakao et al., 2013)





Echinococcus canadensis

G6/7

Dog – pig cycles worldwide, particularly in eastern Europe, central and South America

Dog – camel cycle in northern Africa, Middle East and central Asia





Echinococcus canadensis

G8:

wolf – moose / wapiti cycles in North America and Eurasia.

G10:

wolf – moose / wapiti / reindeer cycles in North America and Eurasia

(Lavikainen et al., 2006; Thompson et al., 2006, Moks et al., 2008; Schurer et al., 2013)

Introduction with domesticated reindeer into North America?

Differences in human pathogenicity?



„Gaps of knowledge“:

Large parts of epidemiological and clinical data on CE have to be re-evaluated

Intraspecific variability insufficiently known (genetic, biological.....)

More data needed on the nuclear genomes

Correlation of morphological characters and sequence data?

A wide-angle photograph of a savanna landscape. In the center-left, a large, mature acacia tree with a thick trunk and a wide, flat canopy stands prominently. To its left, a person wearing a green and red garment is walking. The foreground and middle ground are filled with a herd of cattle of various colors (black, brown, white) grazing on dry, yellowish grass. The background shows a flat horizon with scattered trees and a blue sky filled with large, white, fluffy clouds. The overall scene is peaceful and rural.

Thank you!