

ICAR 2019 – June 18 – Sheep, Goats and Camelids WG Meeting,

New developments in large camelids' pheno- and genotyping

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LARGE CAMELIDS

- On the origin of the species
- Domestication of Old World camels
- Old World camel genome research

PHENOTYPING

- Relevant phenotypes for production
- Results of the large camelids questionnaire
- Where to go from here...



resources

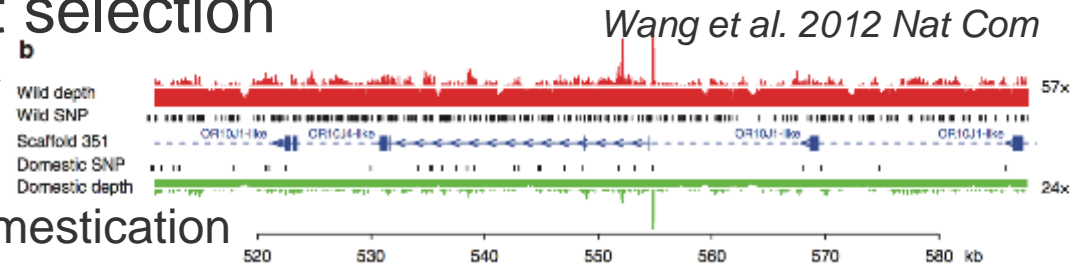
■ De novo assembly of a female dromedary genome

- 66-fold coverage, 2.06 GB
- annotation of 452 (98.7%) CEGs
- genome-wide heterozygosity 0.74×10^{-3}

Fitak et al. & Burger 2015 Mol Ecol Res
Elbers et al. & Burger 2019 Mol Ecol Res

■ Genome-wide divergent selection

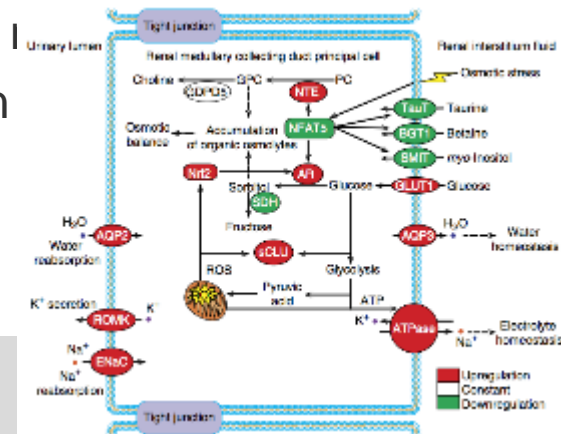
- overall lower heterozygosity in the domestic genome
- artificial selection during domestication



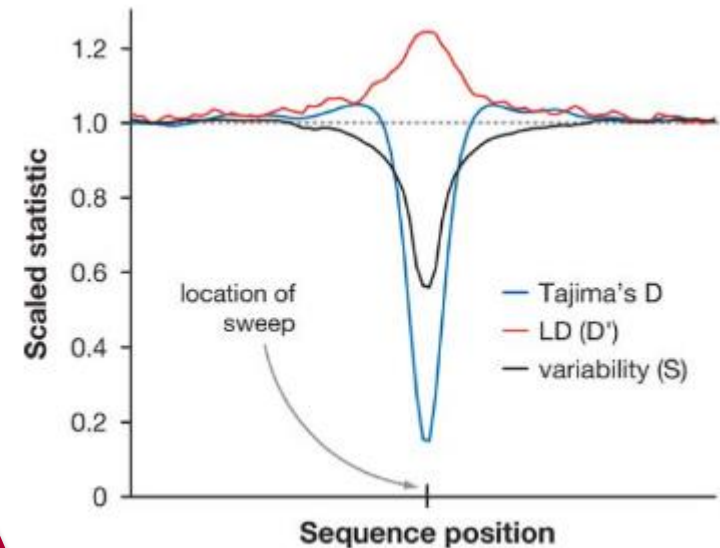
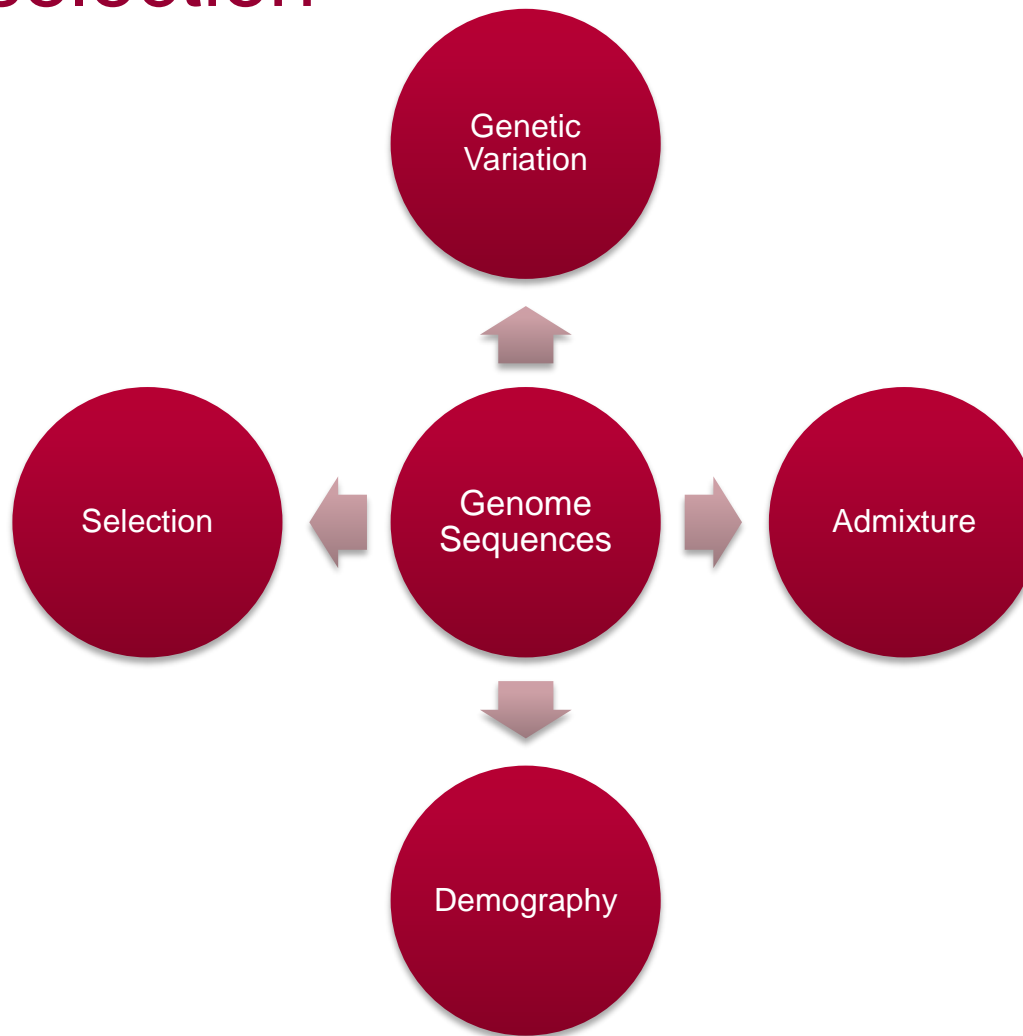
■ Adaptation to desert environment

- Lineage specific accelerated evolutionary
- GO categories enriched genes involved in
 - fat and energy metabolism
 - salt metabolism
 - osmoregulation and water reservation

Wu et al. 2014 Nat Com



Genome re-sequencing. searching for signals of selection



‘selective sweep’

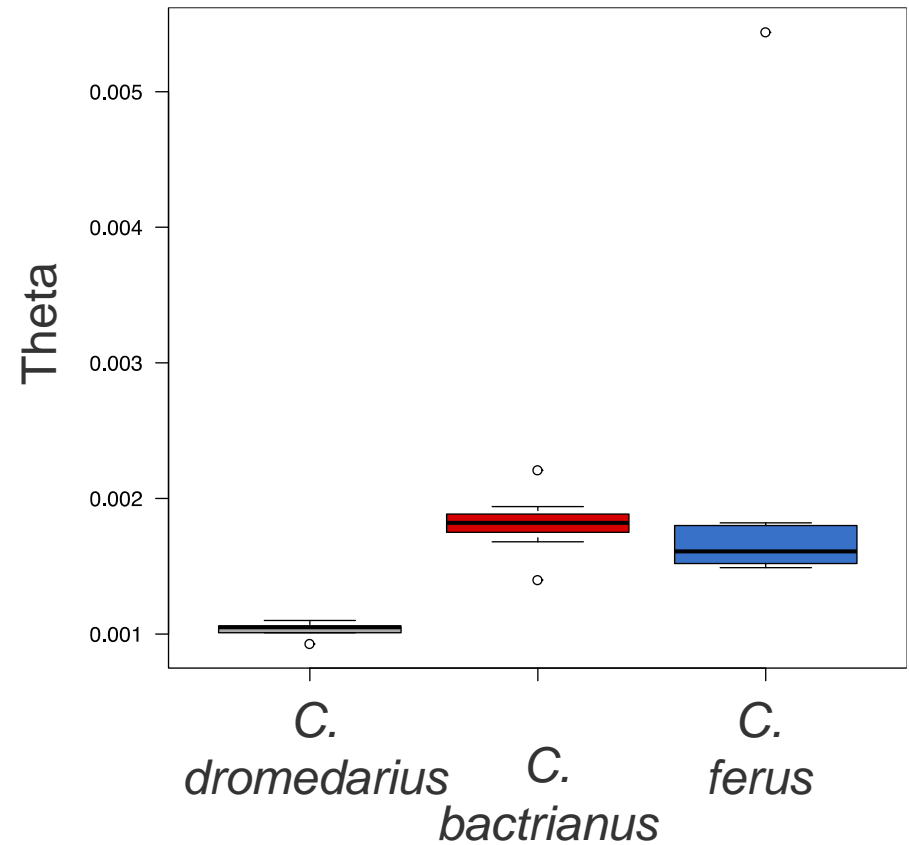
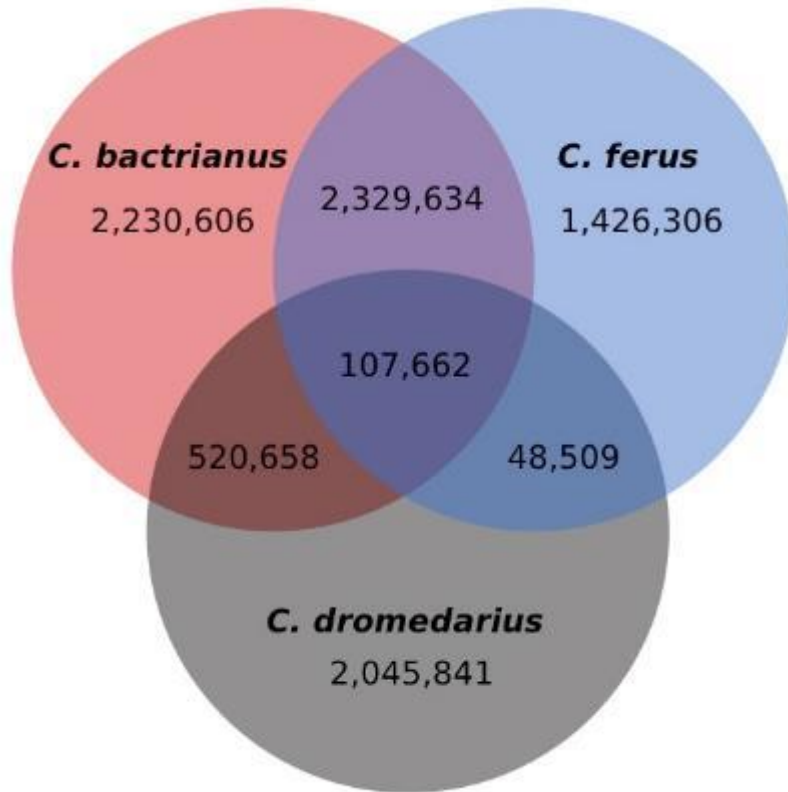
- reduced variability
- negative Tajima's D
- higher LD



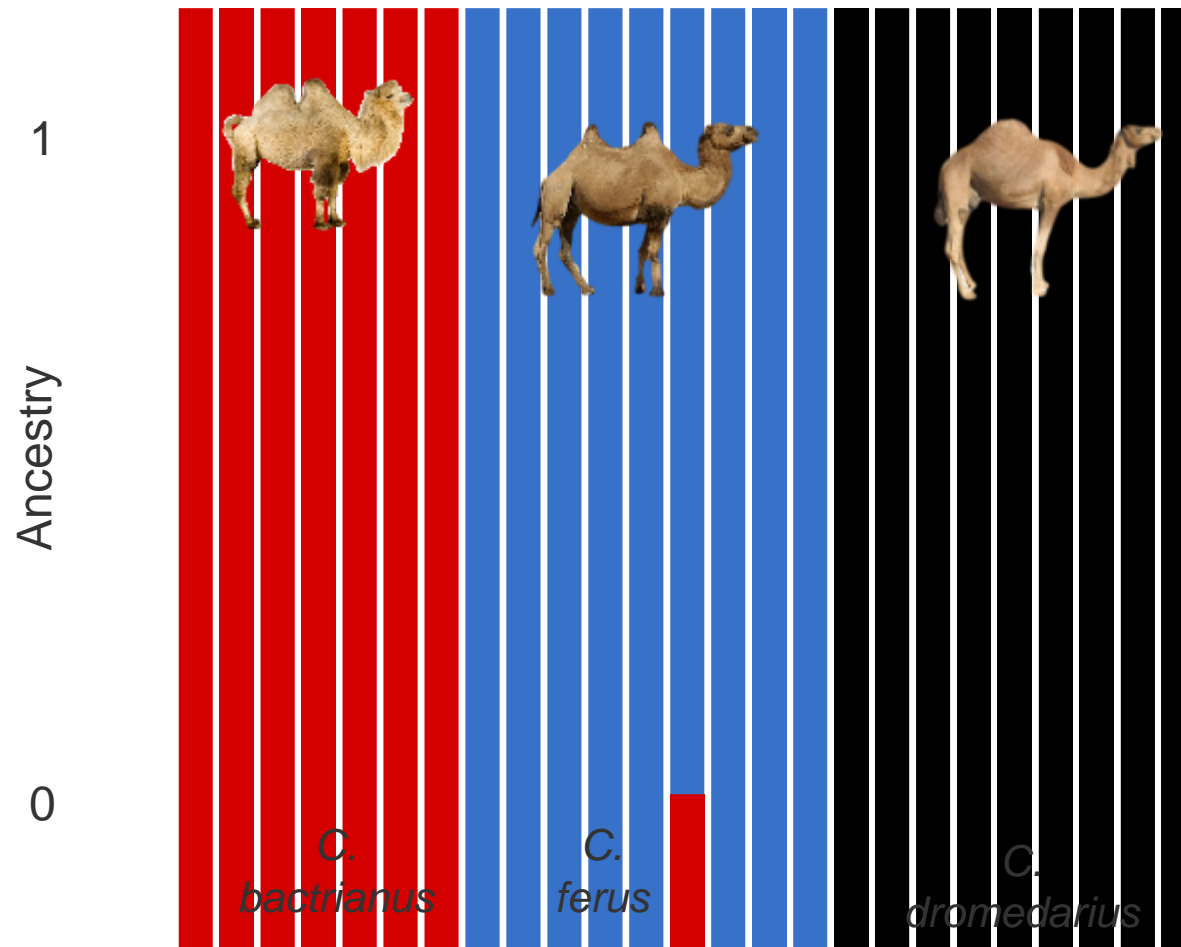
● *C. dromedarius* ○ 9
 ● *C. bactrianus* ○ 3
 ● *C. ferus* ○ 2
 ○ 1



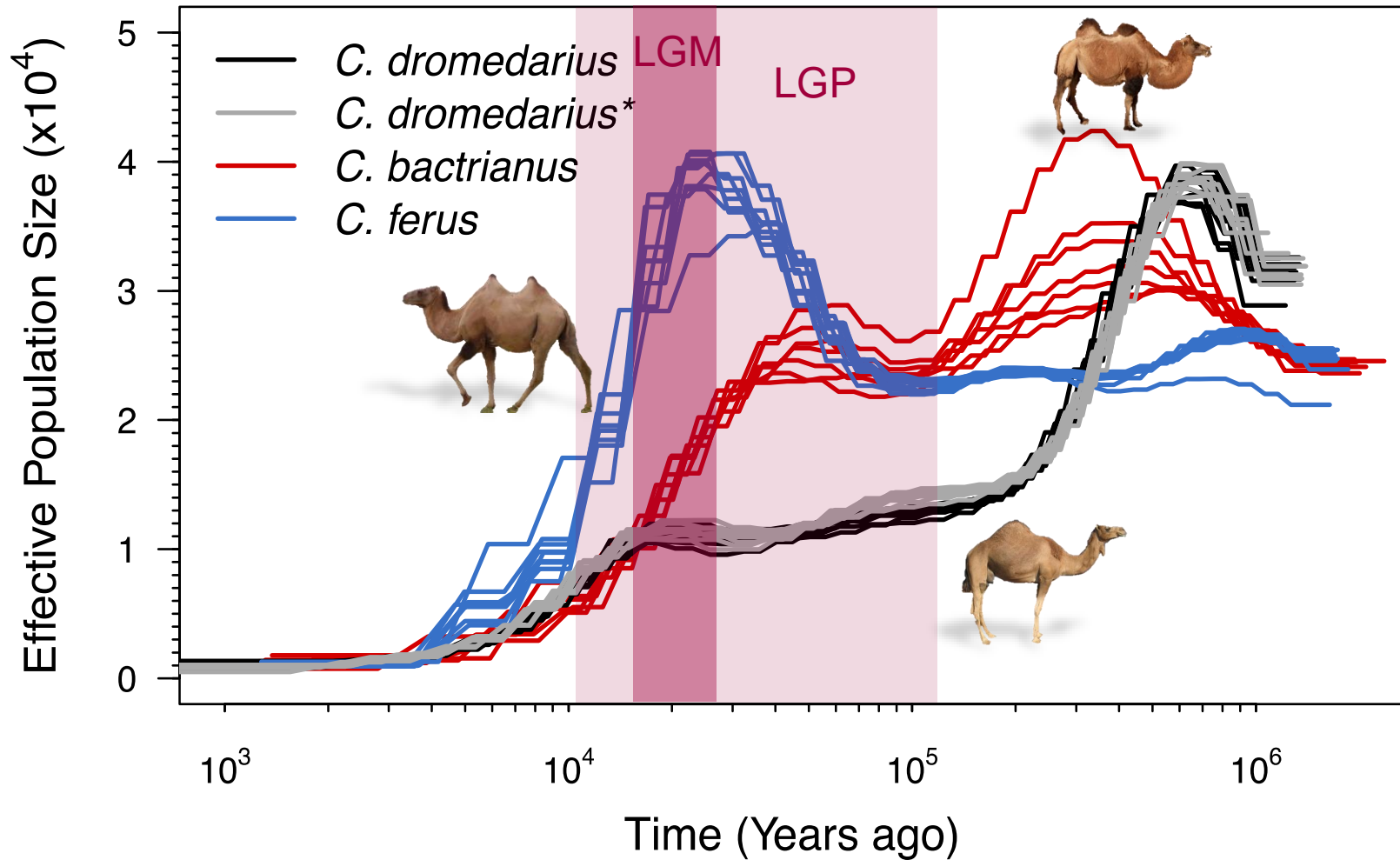
Genetic Variation



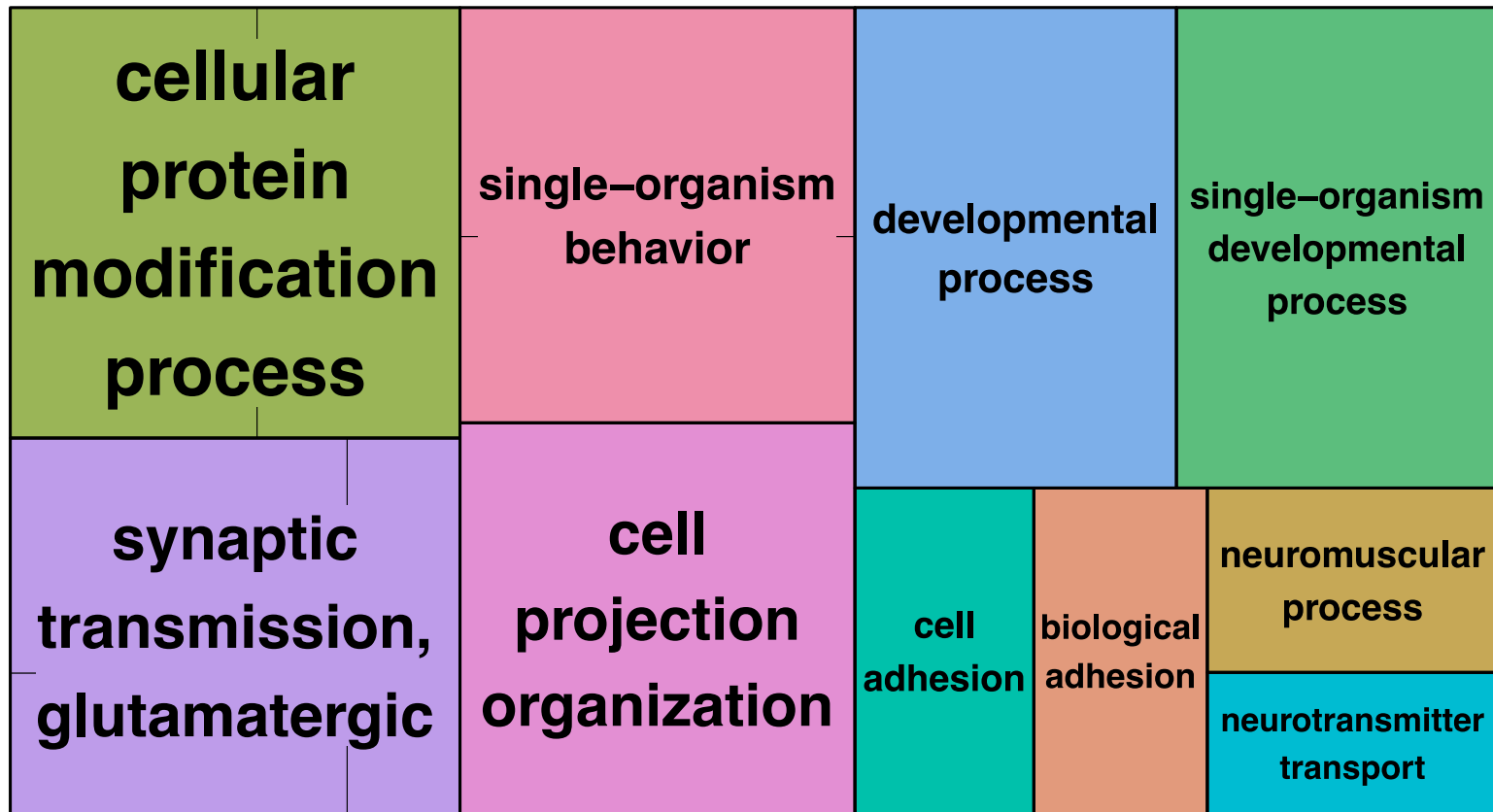
Admixture/ hybridization



Genome wide demographic history



■ Extreme H_E and S^2F_{ST} : *C. dromedarius*



Summary – genomic resources

- Introgression from domestic to wild camel threatens the genomic integrity of *Camelus ferus*
- Population expansion/ hybridisation of the wild camel during the last glacial maximum followed by a rapid decline
- Selection during domestication affects genes associated with neural-physiology
 - “domestication syndrome”





LARGE CAMELIDS

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PHENOTYPING

- Relevant phenotypes for production
- Results of the large camelids questionnaire
- Where to go from here...





Relevant phenotypes

- Milk yield and content
 - Growth, meat, carcass
 - Reproduction
 - Wool/ fiber
 - Health, immunity
 - Beauty
 - Racing
 - Animal welfare
- No standardized phenotype recording
 - No animal ID system in place





Large camelids questionnaire

- Identify people working with camels
- Information about
 - ☐ Animal ID system
 - ☐ Trait recording
 - ☐ Milk
 - ☐ Meat
 - ☐ Reproduction
 - ☐ Wool
 - ☐ Others





Content

1. GENERAL PERFORMANCE OF THE SURVEY
2. INFORMATION ON THE RESPONDENT
3. SPECIES INCLUDED
4. ANIMAL IDENTIFICATION
5. TRAIT RECORDING
6. SELECTION PROGRAMMS

- Special thanks to Cesare for implementation in 3 languages!



1. GENERAL PERFORMANCE OF THE SURVEY

Total responses

■ Total responses: 264

■ Complete: 163

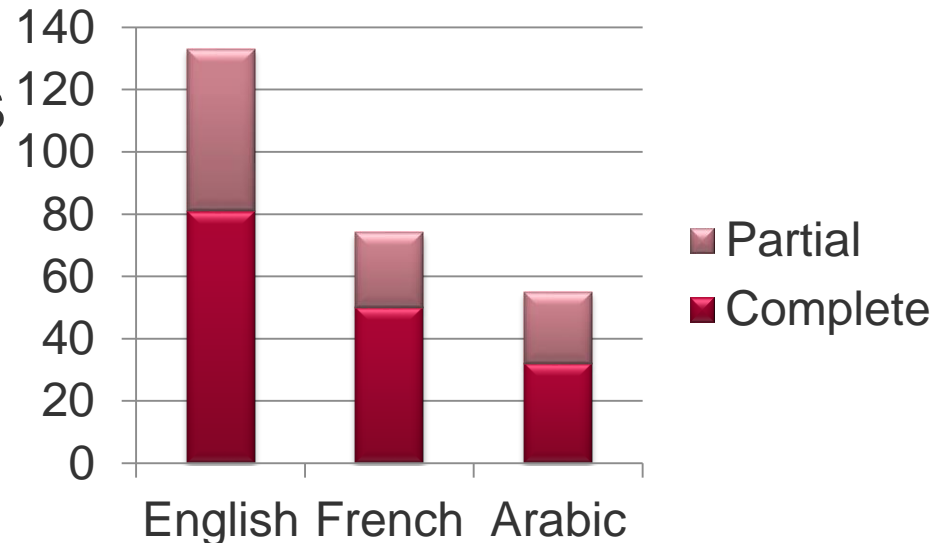
■ Partial: 101

In 3 different languages

■ English: 133/ 81/ 52

■ French: 74/ 50/ 24

■ Arabic: 57/ 32/ 25

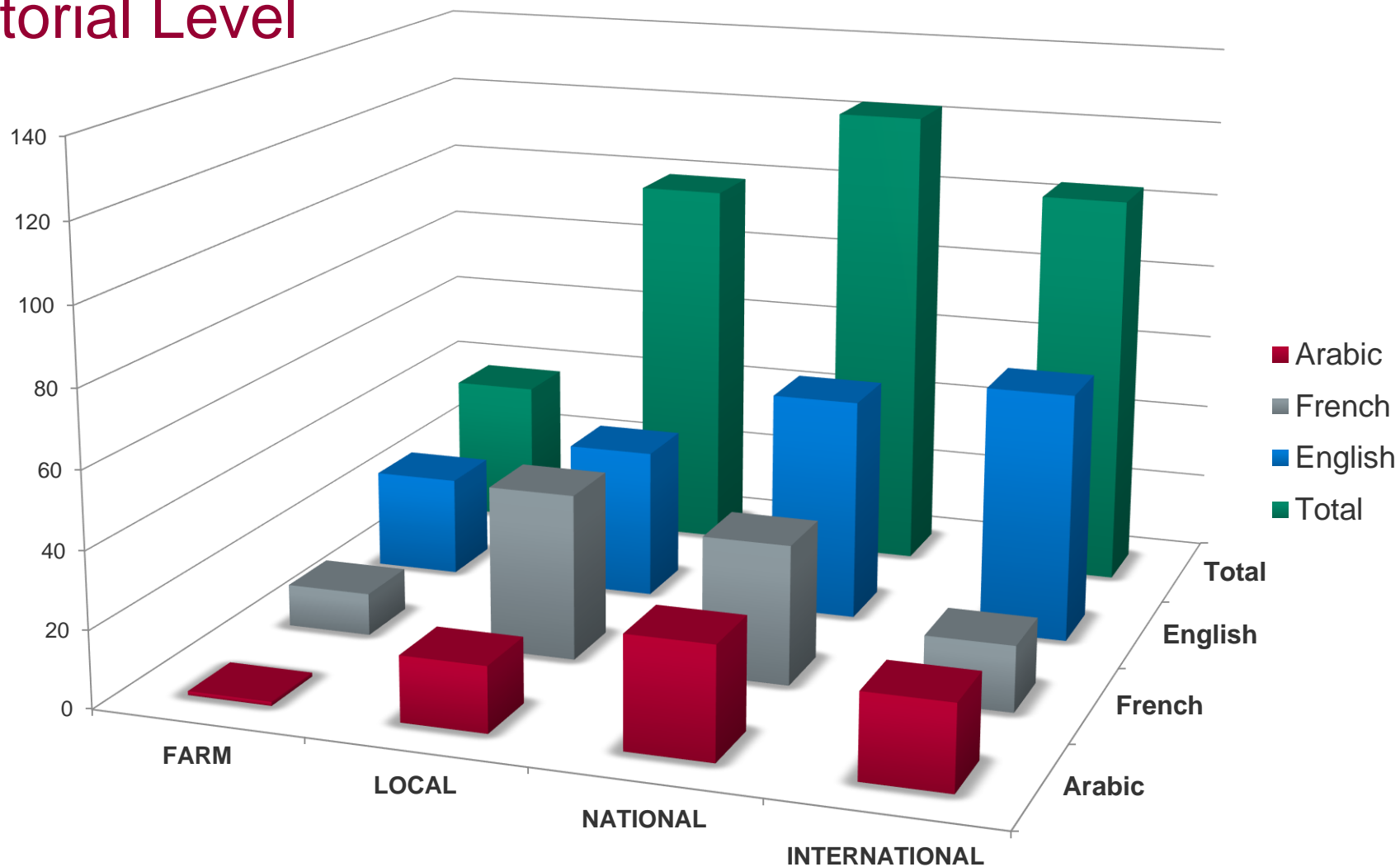


1. GENERAL PERFORMANCE OF THE SURVEY



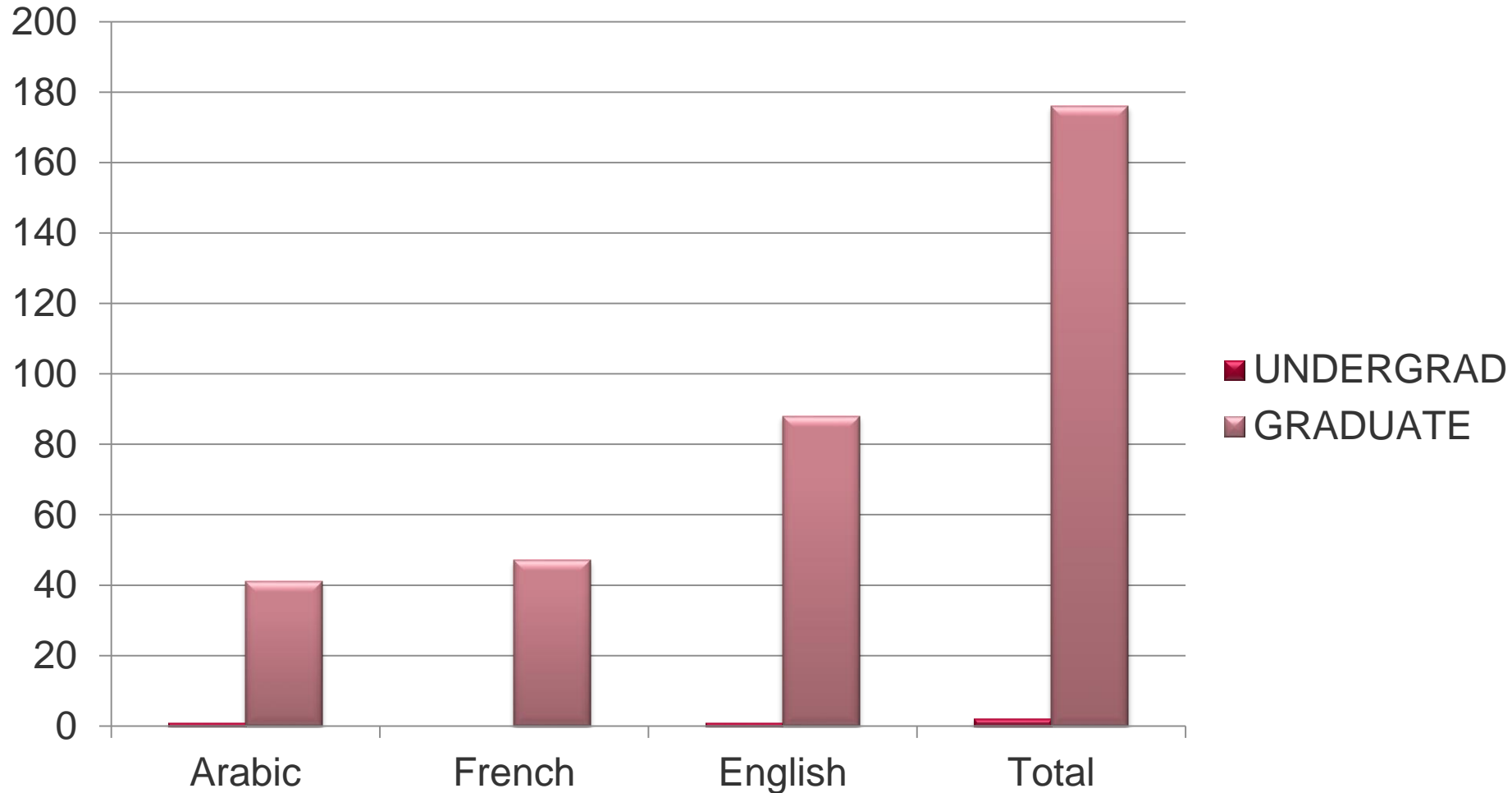
2. THE RESPONDENT

Territorial Level



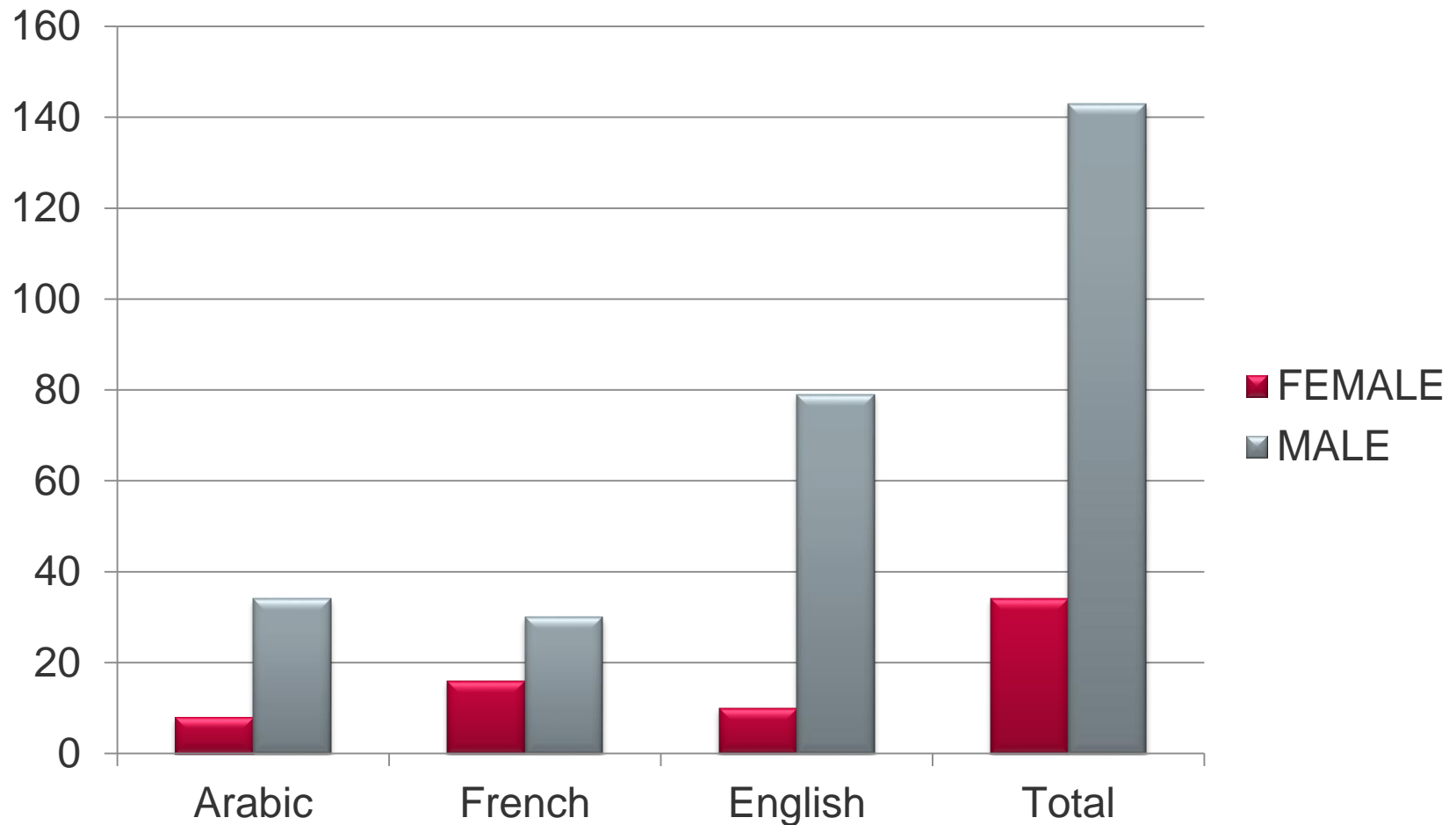
2. THE RESPONDENT

Education Level (67.5% responded)



2. THE RESPONDENT

Sex (67% responded)



3. SPECIES INCLUDED

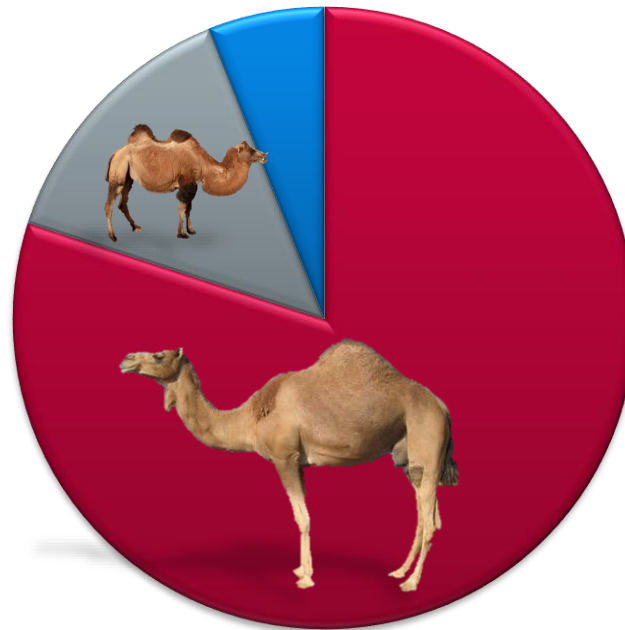
Dromedary 80%



Bactrian camel 14%



Hybrid 6%



■ Dromedary

■ Bactrian camel

■ Hybrid



3. SPECIES:



Main breeding reasons

18.

Please indicate the reasons for rearing animals referring exclusively to the TERRITORIAL LEVEL you selected by ticking all that apply

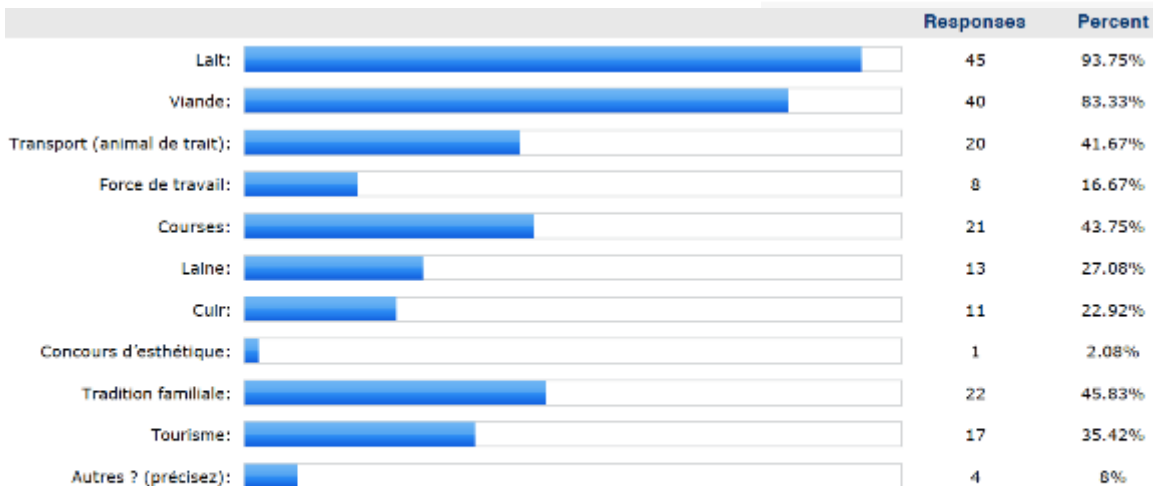
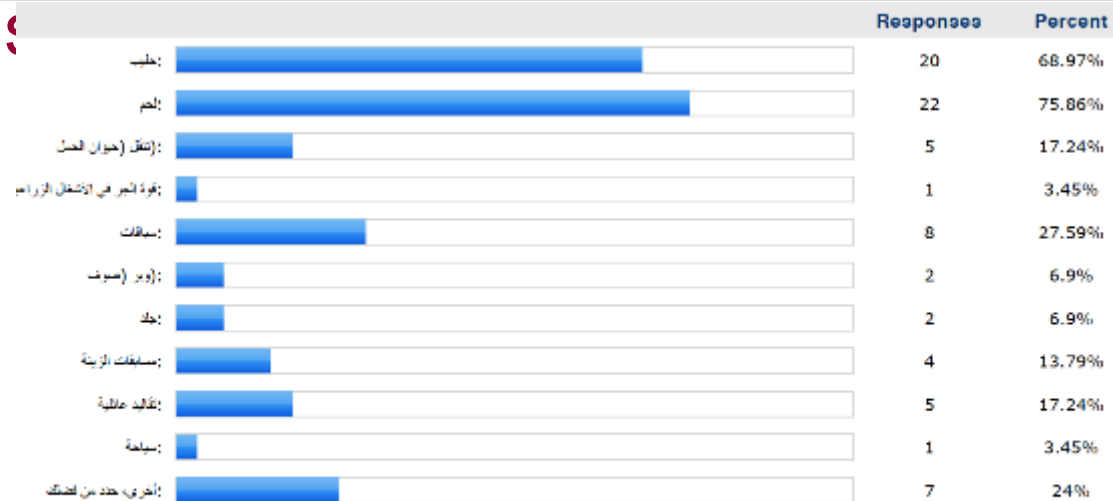
	Responses	Percent
Milk:	43	72.88%
Meat:	37	62.71%
Transport (pack animal):	21	35.59%
Tractive force for land work:	12	20.34%
Racing:	19	32.2%
Wool:	2	3.39%
Leather:	4	6.78%
Beauty contests:	10	16.95%
Family tradition:	19	32.2%
Tourism:	16	27.12%
If other, please specify:	14	23%
Total Responded to this question:		59 44.36%
Total who skipped this question:		74 55.64%
Total:		133 100%



3. SPECIES:

DROMEDARY

Main breeding reasons



Total Responded to this question:	29	50.88%
Total who skipped this question:	28	49.12%
Total:	57	100%

Total Responded to this question:	48	64.86%
Total who skipped this question:	26	35.14%
Total:	74	100%



3. SPECIES: BACTRIAN



CAMEL Main breeding reasons

Please indicate the reasons for rearing animals referring exclusively to the TERRITORIAL LEVEL you selected by ticking all that apply

		Responses	Percent
Milk:	<div><div></div></div>	6	75%
Meat:	<div><div></div></div>	6	75%
Transport (pack animal):	<div><div></div></div>	4	50%
Tractive force for land work:	<div><div></div></div>	1	12.5%
Racing:	<div><div></div></div>	2	25%
Wool:	<div><div></div></div>	4	50%
Leather:	<div><div></div></div>	1	12.5%
Beauty contests:	<div><div></div></div>	0	0%
Family tradition:	<div><div></div></div>	5	62.5%
Tourism:	<div><div></div></div>	5	62.5%
If other, please specify:	<div><div></div></div>	1	12%
Total Responded to this question:		8	6.02%
Total who skipped this question:		125	93.98%
Total:		133	100%



3. SPECIES: Hybrids



24.

Please indicate the reasons for rearing animals referring exclusively to the TERRITORIAL LEVEL you selected by ticking all that apply

	Responses	Percent
Milk:	3	100%
Meat:	2	66.67%
Transport (pack animal):	1	33.33%
Tractive force for land work:	0	0%
Racing:	0	0%
Wool:	0	0%
Leather:	1	33.33%
Beauty contests:	0	0%
Family tradition:	1	33.33%
Tourism:	1	33.33%
If other, please specify:	2	66%
Total Responded to this question:		3
Total who skipped this question:		130
Total:		133

2.26%

97.74%

100%

24.

Please indicate the reasons for rearing animals referring exclusively to the TERRITORIAL LEVEL you selected by ticking all that apply

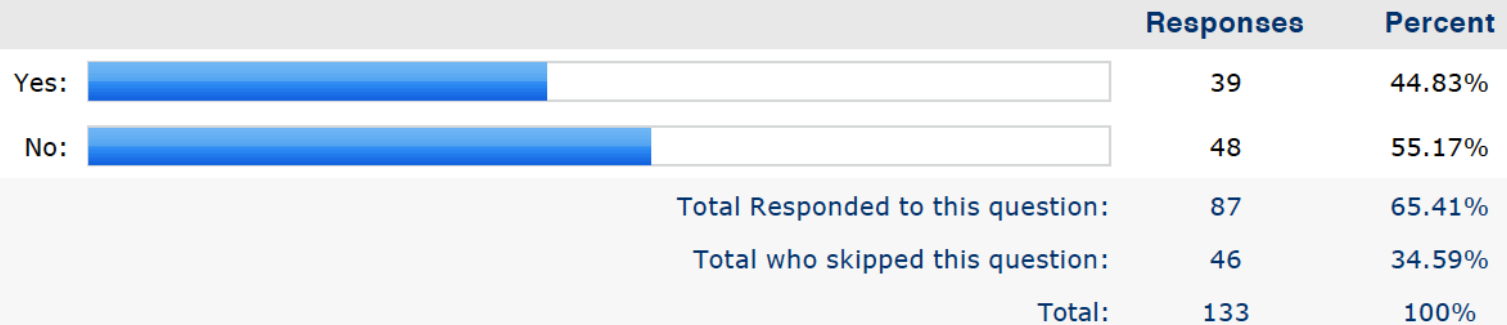
Response	Comments
1	wrestling
2	Male F1 hybrid for camel wrestling

4. ANIMAL IDENTIFICATION



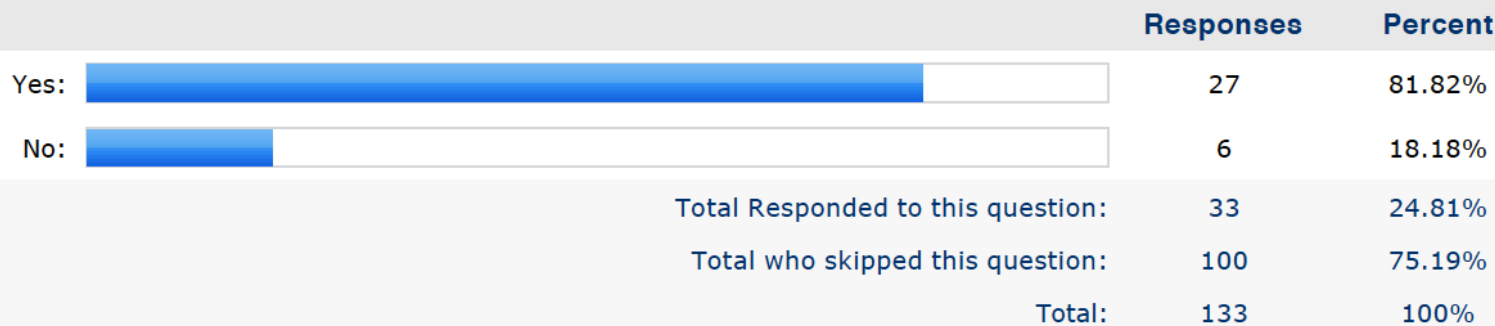
ID system available?

25. Is an animal identification system available?



ID system mandatory?

26. Is the identification system mandatory?



4. ANIMAL IDENTIFICATION



ID system available?

25. هل هناك نظام ترقيم الإبل؟



ID system mandatory?

26. هل نظام الترقيم اختياري؟



4. ANIMAL IDENTIFICATION



ID system organization

29.

Which Organization is in charge of animal identification?

	Responses	Percent
National:	19	61.29%
Local:	8	25.81%
None:	3	9.68%
If other, please specify:	1	3.23%
Please provide the name of the Organisation:	17	54.84%
Total Responded to this question:	31	23.31%
Total who skipped this question:	102	76.69%
Total:	133	100%

	Responses	Percent
وطنية:	12	70.59%
محلية:	3	17.65%
لا أحد:	2	11.76%
أخرى، حدد من فضلك:	0	0%
أعط من فضلك اسم المؤسسة:	12	70.59%
Total Responded to this question:	17	29.82%
Total who skipped this question:	40	70.18%
Total:	57	100%

4. ANIMAL IDENTIFICATION



The identification system is achieved by the use of (tick all that apply):

ID systems

		Responses	Percent
Ear Tag:	<div><div></div></div>	18	52.94%
Tattoo:	<div><div></div></div>	6	17.65%
Fire brand:	<div><div></div></div>	13	38.24%
Rumen Electronic Device:	<div><div></div></div>	1	2.94%
Hypodermic Electronic Device:	<div><div></div></div>	11	32.35%
If other, please specify:	<div><div></div></div>	10	29%
Total Responded to this question:		34	25.56%
Total who skipped this question:		99	74.44%
Total:		133	100%

		Responses	Percent
حلقة الأذن:	<div><div></div></div>	13	76.47%
وشم:	<div><div></div></div>	2	11.76%
علامة بالنار:	<div><div></div></div>	7	41.18%
جهاز إلكتروني في البطن:	<div><div></div></div>	5	29.41%
جهاز إلكتروني تحت الجلد:	<div><div></div></div>	3	17.65%
طريقة أخرى، حدد من فضلك:	<div><div></div></div>	2	11%

Total Responded to this question:		17	29.82%
Total who skipped this question:		40	72.8%
Total:		57	100%

4. ANIMAL IDENTIFICATION



Meta-data recording

30.

What data is recorded at the farm level (tick all that apply)?

		Responses	Percent
Animal birth date:		23	74.19%
Animal father:		19	61.29%
Animal mother:		17	54.84%
Animal sex:		24	77.42%
Birth type (single, twins):		15	48.39%
Date of animal movements in/out the herd:		14	45.16%
Culling date and reason:		16	51.61%
Date of death:		18	58.06%
Breed:		19	61.29%
Individual health problems:		20	64.52%
Individual health treatments and drugs:		18	58.06%
Total Responded to this question:		31	23.31%
Total who skipped this question:		102	76.69%
Total:		133	100%





4. ANIMAL IDENTIFICATION



31.

Is a molecular parentage verification system available (Please refer exclusively to the selected TERRITORIAL LEVEL you indicated)




	Responses	Percent
Yes: 	8	25.81%
No: 	23	74.19%

Total Responded to this question:	31	23.31%
Total who skipped this question:	102	76.69%

Molecular parentage testing

32.

Which molecular parentage verification system has been implemented (tick all that apply)

	Responses	Percent
STR (Short Tandem Repeats or Microsatellites): 	6	60%
SNP (Single Nucleotide Polymorphisms): 	2	20%
If other, please specify: 	3	30%

Total Responded to this question:	10	7.52%
Total who skipped this question:	123	92.48%
Total:	133	100%

32.



Which molecular parentage verification system has been implemented (tick all that apply)

Response	Comments
1	Not applicable
2	we are going to do GBS parentage test in future.
3	Not used yet, still planning



5. TRAIT RECORDING



35. Is a trait recording system available (Please refer exclusively to the TERRITORIAL LEVEL you indicated)

	Responses	Percent
Yes: 	18	22.22%
No: 	63	77.78%
Total Responded to this question:	81	60.9%
Total who skipped this question:	52	39.1%
Total:	133	100%

36. Is the milk yield trait recorded? **Milk recording**



	Responses	Percent
Yes: 	12	63.16%
No: 	7	36.84%
Total Responded to this question:	19	14.29%
Total who skipped this question:	114	85.71%
Total:	133	100%



5. TRAIT RECORDING





35. Is a trait recording system available (Please refer exclusively to the TERRITORIAL LEVEL you indicated)

	Responses	Percent
Yes: 	18	22.22%
No: 	63	77.78%
Total Responded to this question:	81	60.9%
Total who skipped this question:	52	39.1%



Milk recording

36. Is the milk yield trait recorded?

	Responses	Percent
Yes: 	12	63.16%
No: 	7	36.84%
Total Responded to this question:	19	14.29%
Total who skipped this question:	114	85.71%
Total:	133	100%

Milking type recording

37. Milking type

	Responses	Percent
Manual: 	5	45.45%
Machine: 	6	54.55%
Total Responded to this question:	11	8.27%
Total who skipped this question:	122	91.73%
Total:	133	100%



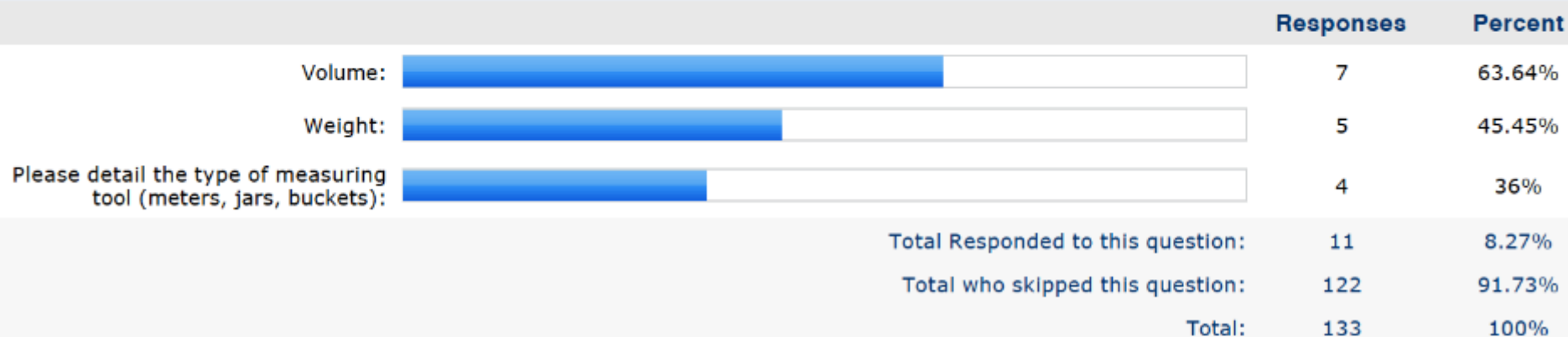
5. TRAIT RECORDING





Milk quantity recording

39. Milking quantity recording method



39. Milking quantity recording method

Response	Comments
1	buckets
2	electronic balance
3	Via milking machine computer
4	Bucket



5. TRAIT RECORDING



42.
Average lactation length (days)

Average lactation length

Responses:



Responses

10

Percent

100%

Total Responded to this question:

10

7.52%

Total who skipped this question:

123

92.48%

Total:

133

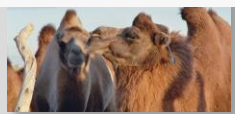
100%

42.
Average lactation length (days)

Response

Response Text



- | | |
|----|---|
| 1 | 15-16 month |
| 2 | 280 |
| 3 | 400 |
| 4 | 330 |
| 5 | 200 |
| 6 | Not sure ... my department is reproductive technology ...ET and cloning |
| 7 | 270-300 |
| 8 | 12-16 months |
| 9 | 3day |
| 10 | 60 days depending on the season and the vegetation cover |






5. TRAIT RECORDING



44. Milking system **Milking and suckling**

	Responses	Percent
Milking from calving: 	7	70%
Milking after a suckling period: 	3	30%
Total Responded to this question:	10	7.52%
Total who skipped this question:	123	92.48%
Total:	133	100%

45. Presence of calf during milking

	Responses	Percent
Present and suckling: 	7	70%
Present and not suckling: 	2	20%
Absent: 	1	10%
Total Responded to this question:	10	7.52%
Total who skipped this question:	123	92.48%
Total:	133	100%



5. TRAIT RECORDING



Milking and suckling



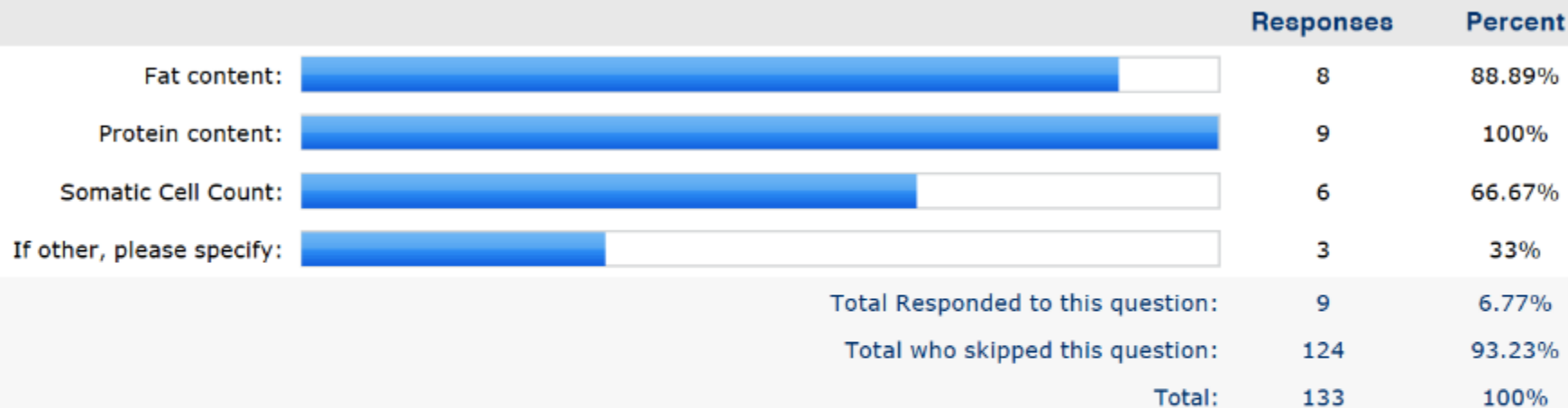
5. TRAIT RECORDING



Milk composition

47.

Which components are recorded (please tick all that apply)?



47.

Which components are recorded (please tick all that apply)?



Response	Comments
1	Lactise Content
2	lactose,ash,freez point
3	SNF and lactose





Udder morphology

48. Is optimal udder morphology (teat position and size, udder depth and attachment) recorded?

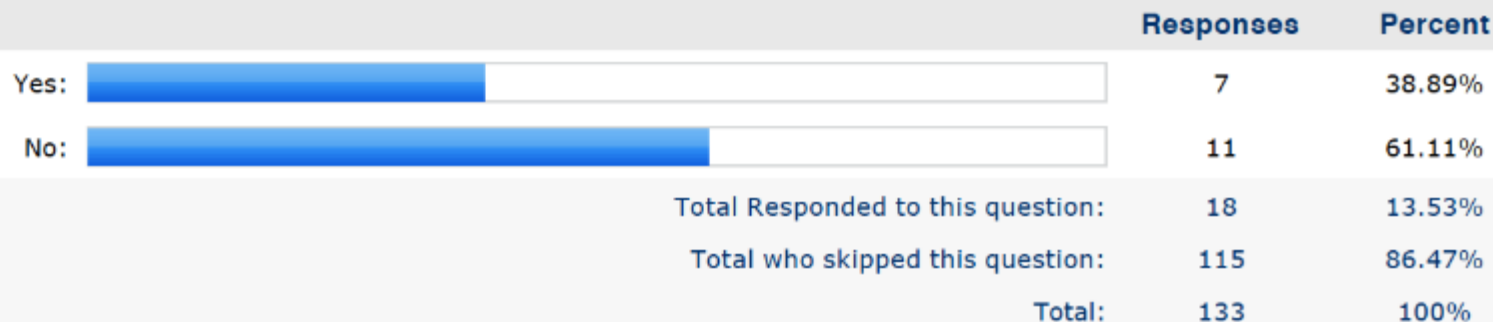
	Responses	Percent
Yes: 	5	27.78%
No: 	13	72.22%
Total Responded to this question:	18	13.53%
Total who skipped this question:	115	86.47%
Total:	133	100%





Growth traits

50. Are growth traits recorded?



50. هل تتم مراقبة صفات النمو؟





Growth traits

51.
Which growth traits are recorded (please tick all that apply)?

		Responses	Percent
Birth weight:	<input checked="" type="checkbox"/>	7	100%
Weaning weight:	<input checked="" type="checkbox"/>	4	57.14%
Weaning age:	<input checked="" type="checkbox"/>	4	57.14%
Post weaning weight:	<input checked="" type="checkbox"/>	5	71.43%
Live weight gain:	<input checked="" type="checkbox"/>	4	57.14%
If other, please specify:	<input type="text"/>	0	0%
Total Responded to this question:		7	5.26%
Total who skipped this question:		126	94.74%
Total:		133	100%



5. TRAIT RECORDING



Which traits for the adult size are recorded (please tick all that apply)?

		Responses	Percent
Chest girth:	<input checked="" type="checkbox"/>	5	55.56%
Hump girth:	<input checked="" type="checkbox"/>	3	33.33%
Height at withers:	<input checked="" type="checkbox"/>	6	66.67%
Body length:	<input checked="" type="checkbox"/>	8	88.89%
Fore limb length:	<input checked="" type="checkbox"/>	4	44.44%
Chest width:	<input checked="" type="checkbox"/>	3	33.33%
Chest depth:	<input checked="" type="checkbox"/>	3	33.33%
Fore hoof circumference:	<input checked="" type="checkbox"/>	4	44.44%
Head length:	<input checked="" type="checkbox"/>	5	55.56%
Distance between eyes:	<input checked="" type="checkbox"/>	2	22.22%
Ear length:	<input checked="" type="checkbox"/>	2	22.22%
Neck length:	<input checked="" type="checkbox"/>	4	44.44%
Neck circumference:	<input checked="" type="checkbox"/>	2	22.22%
Tail length:	<input checked="" type="checkbox"/>	3	33.33%
Thigh circumference:	<input checked="" type="checkbox"/>	1	11.11%
If other, please specify:	<input checked="" type="checkbox"/>	1	11%
Total Responded to this question:		9	6.77%
Total who skipped this question:		124	93.23%
Total:		133	100%



Carcass traits

55. Which carcass traits are recorded?

		Responses	Percent
Pre-slaughter - live weight:	<div><div></div></div>	3	75%
Pre-slaughter - Other live carcass assessment*:	<div><div></div></div>	1	25%
Post-slaughter - Carcass weight:	<div><div></div></div>	2	50%
Post-slaughter - Carcass quality (e.g. evaluation grids or schemes)*:	<div><div></div></div>	1	25%
Post-slaughter - Saleable meat yield/cuts:	<div><div></div></div>	2	50%
Post-slaughter - Meat quality (e.g. sensory):	<div><div></div></div>	2	50%
Post-slaughter - Other trait*:	<div><div></div></div>	0	0%
*Please specify the "Other traits" recorded contained in the list:	<div><div></div></div>	0	0%
Total Responded to this question:		4	3.01%
Total who skipped this question:		129	96.99%
Total:		133	100%





Wool traits

57. Which traits for the wool quality are recorded?

		Responses	Percent
Fibre diameter:	<div><div></div></div>	3	60%
Colour:	<div><div></div></div>	3	60%
Staple length:	<div><div></div></div>	3	60%
Staple strength:	<div><div></div></div>	2	40%
If other, please specify:	<div><div></div></div>	0	0%
Total Responded to this question:		5	3.76%
Total who skipped this question:		128	96.24%
Total:		133	100%



5. TRAIT RECORDING



Racing traits

59. Which racing traits are recorded?

		Responses	Percent
Placing:	<div><div></div></div>	3	50%
Best racing time:	<div><div></div></div>	4	66.67%
Average racing time:	<div><div></div></div>	4	66.67%
Total earnings:	<div><div></div></div>	1	16.67%
If other, please specify:	<div></div>	0	0%
Total Responded to this question:		6	4.51%
Total who skipped this question:		127	95.49%
Total:		133	100%

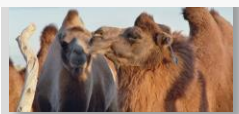
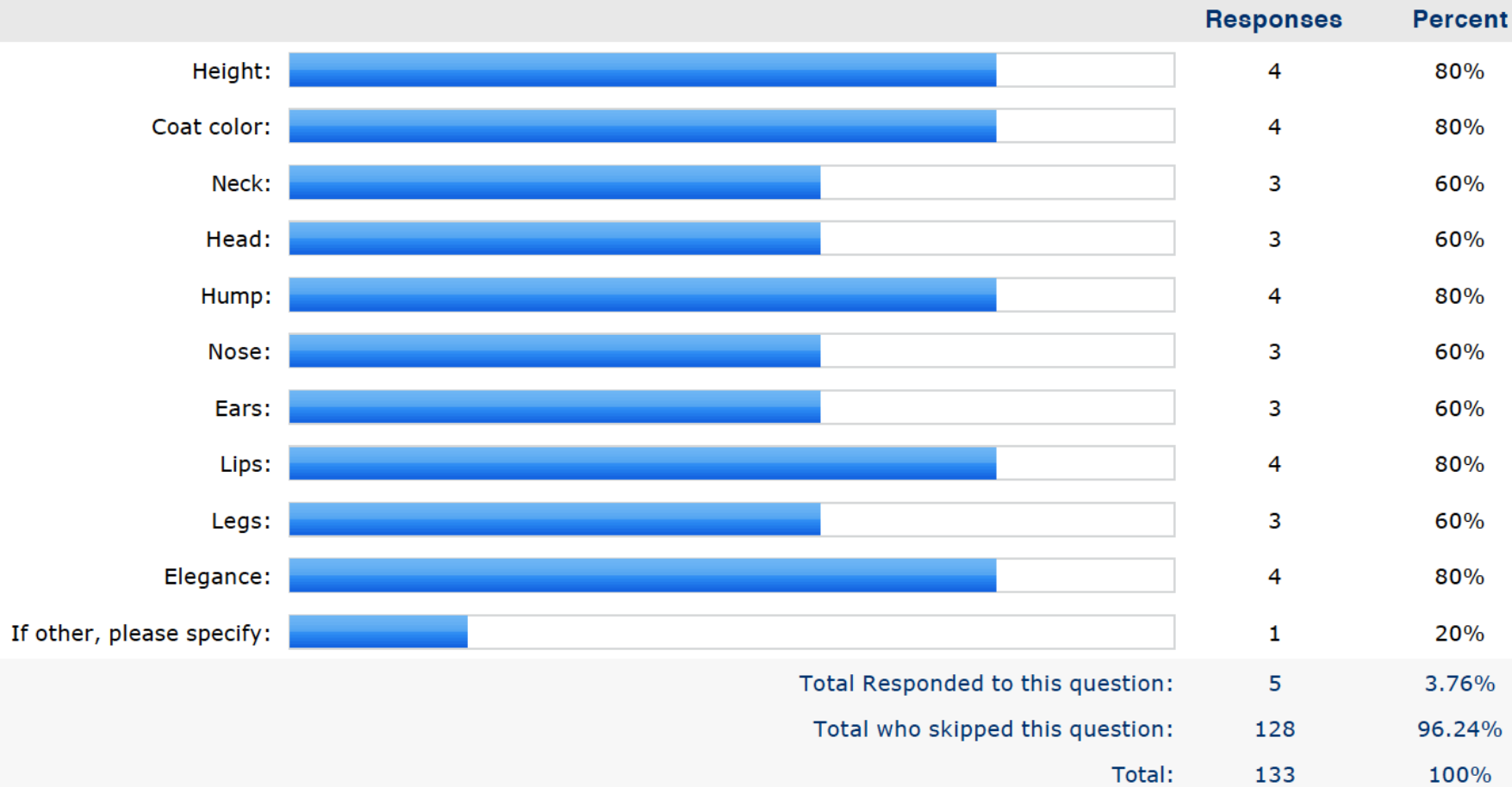


5. TRAIT RECORDING



Beauty traits

61. Which beauty traits are recorded?





Behavioural traits

65. Which behavioral traits are recorded?

		Responses	Percent
Reactivity (novelty and fearfulness tests):	<div><div></div></div>	5	62.5%
Activity (curiosity tests):	<div><div></div></div>	4	50%
Time to calm down:	<div><div></div></div>	5	62.5%
If other, please specify:	<div><div></div></div>	3	37%
Total Responded to this question:		8	6.02%
Total who skipped this question:		125	93.98%
Total:		133	100%

65. Which behavioral traits are recorded?

Response	Comments
1	calf acceptance, adaptability in the milking parlor and easy milk let down in the parlor
2	Male and female sexual behaviors are recorded only
3	COGNITIVE TRAITS



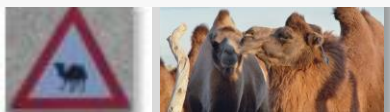
5. TRAIT RECORDING



Female reproduction traits

68. Please provide details about the female reproduction traits that are recorded

		Responses	Percent
Age at puberty:	<div><div></div></div>	9	75%
Pregnancy diagnosis via rectal palpation:	<div><div></div></div>	6	50%
Pregnancy diagnosis via laboratory methods:	<div><div></div></div>	5	41.67%
Pregnancy ultrasound scanning:	<div><div></div></div>	5	41.67%
Gestation length:	<div><div></div></div>	10	83.33%
Prenatal losses:	<div><div></div></div>	6	50%
Twinning:	<div><div></div></div>	3	25%
Birth ease:	<div><div></div></div>	5	41.67%
Weight at birth:	<div><div></div></div>	6	50%
Congenital defects at birth:	<div><div></div></div>	4	33.33%
If other, please specify:	<div><div></div></div>	0	0%
Total Responded to this question:		12	9.02%
Total who skipped this question:		121	90.98%
Total:		133	100%





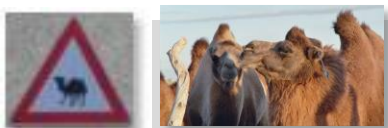
Male reproduction traits

67. Please provide details about the male reproduction traits that are recorded

	Responses	Percent
Scrotum and testis traits:	4	30.77%
Age at puberty:	10	76.92%
Sexual behavior:	11	84.62%
Semen traits (in case of Artificial Insemination):	6	46.15%
If other, please specify:	1	7%
Total Responded to this question:		13
Total who skipped this question:		120
Total:		133

67. Please provide details about the male reproduction traits that are recorded

Response	Comments
1	the maternal record, especially milk production potential of the parents





Survival and longevity traits

70. Which survival and longevity traits are recorded?

	Responses	Percent
Camelid survival at birth:	6	100%
Camelid survival at weaning:	4	66.67%
Camelid survival post weaning:	2	33.33%
If other, please specify:	0	0%
Total Responded to this question:		6
Total who skipped this question:		127
Total:		133
		4.51%
		95.49%
		100%



6. SELECTION



71. Are there any official selection programmes?

Yes:



14

17.5%

No:



66

82.5%

Responses

Percent

72. Who runs the selection program?

Responses:



12

100%

Responses

Percent

Total Responded to this question:

12

9.02%

Total who skipped this question:

121

90.98%

Total:

133

100%

Selection programmes

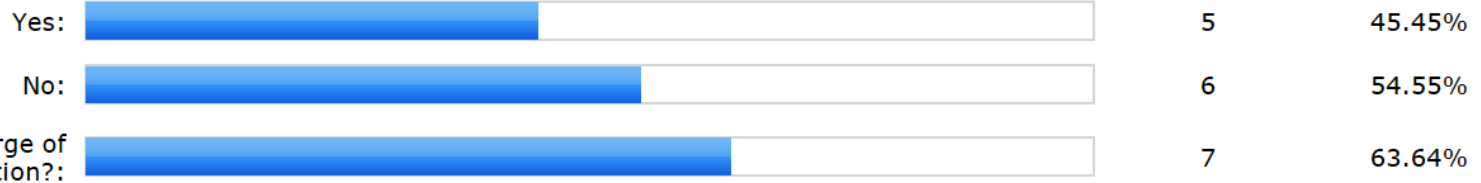
72. Who runs the selection program?

Response	Response Text
1	CBRS
2	Livestock and Veterinary Departments
3	Directorate General of Royal Camel Corps.
4	Other Deaprtments
5	Technical Manager
6	Sheikh and bedu trainer committee
7	African country (e.g. Somalia)
8	Specialists/ vets
9	Local Management
10	scientist from animal breeding discipline
11	Programa de selección por tipos de llamas.
12	The owner with the help extension experts



Genomic evaluation?

76. Is there a genetic evaluation of the selected traits?



Total Responded to this question:	11	8.27%
Total who skipped this question:	122	91.73%
Total:	133	100%

76. Is there a genetic evaluation of the selected traits?

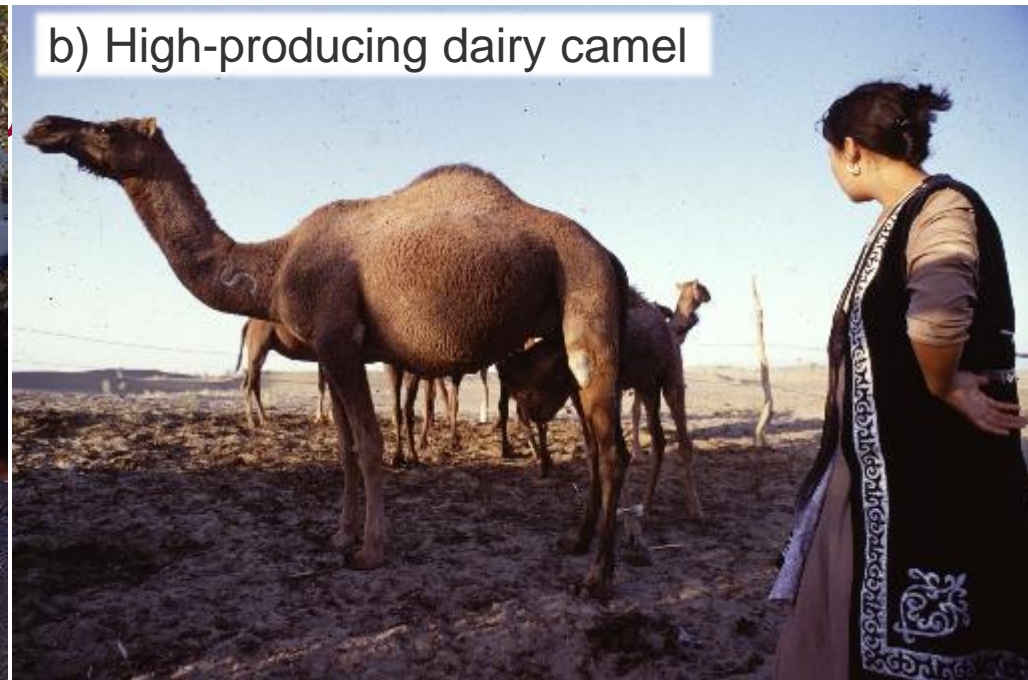
Response	Comments
1	Biotechnology Laboratory
2	NRC
3	Our in house Molecular Biology and DNA lab
4	Not yet
5	Not yet, but now we are working on genetic characterization research
6	National Research Centre on Camel
7	Fao



SUMMARY: camels ARE MULTI-PURPOSE



a) Hybrid camel



b) High-producing dairy camel



c) Dual-purpose camel



d) Racing camel



e) Bactrian camel



LARGE CAMELIDS

- On the origin of the species
- Domestication of Old World camels
- Old World camel genome research

PHENOTYPING

- Relevant phenotypes for production
- Results of the large camelids questionnaire
- **Where to go from here...**



Where to go from here



- Identify breeders for developing recording guidelines
- Animal Identification
- Collaboration with FAO
- Evaluate newly measured phenoty
- Initiate first GWAS study(ies)
- Develop genomic tools



ICC-GIC

International Camel Consortium for genetic improvement and conservation

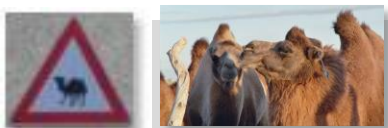
www.ICC-GIC.weebly.com



Mission:

support at various levels the network of involved scientists and professionals to boost, harmonize, coordinate and share activities on camel genetic conservation, management, animal phenotypic recording and genetic improvement.

Riyadh, Workshop April 2015



Illumina Announces Eleventh Agricultural Greater Good Initiative Grant Winner

Recipient Focused on Genetics Research of Camels



400 camel
whole
genomes
sequences

- Improvement of livestock is always an improvement for people
- Camels are the most promising livestock species for sustainable utilization
- Conservation of the last wild camels and of locally adapted diversity

