

Applied Genetics and Genomics in other Species of Economic Interest

Organised by a Standing Committee: YES NO

Meeting information

Date: July 4, 2023
Time: 14:00
Number of participants: 50

Chair

Name: Amparo Martínez
Affiliation: University of Córdoba, Cordoba, Spain.
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Co-Chair (optional)

Name: Marcela Martinez
Affiliation: Sociedad Rural de Argentina, Argentina
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Agenda

2:00 PM	Welcoming remarks
2:10 PM	Pig CT Discussion – Amparo Martínez.
2:20 PM	Dromedary CT Discussion - Marcela Martinez.
2:30 PM	Alpaca/Llama CT Discussion – Angelika Mąsior.
2:40 PM	Pigeon CT Discussion - Angelika Mąsior.
2:50 PM	Sheep CT Discussion - Agata Piestrzynska-Kajtoch.
3:00 PM	Goat CT Discussion - Clementina Rodellar.
3:10 PM	A future buffalos CT proposal.
3:20 PM	Candidates of new Duty Labs for 2024-2025 Comparison tests. Election of the committee and any other business.
3:30 PM	Tea/coffee break.
4:00 PM	The development of a 61K Illumina? SNP chip for dromedaries under the frame of the 2019 Agricultural Greater Good (AGG) initiative. M. Di Civita. (89679).
4:15 PM	Selection of an Ovine SNP Parentage Panel for Consideration as the ISAG Comparison Test Panel. R Ferretti. (89810).



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4:30 PM	High-throughput detection of single nucleotide polymorphisms with flexible content panels. Not presented
4:45 PM	Genetic differentiation of <i>Camelus bactrianus</i> from Kazakhstan. Kairat Dossybayev. (89370).
5:00 PM	Genetic diversity and population structure among Central European native sheep breeds using microsatellite markers. Zuzana Sztankoova. (89526).
5:15 PM	Genome-wide association study between copy number variations and economically important traits in American mink. P Davoudi. (89600).

Summary of the meeting

1. Welcoming Remarks

One hundred thirty-six laboratories have participated in the CT organised by these Standing Committee (10 in alpaca/llama CT, 7 in dromedary CT, 36 in goat CT, 29 in pig CT, 13 in pigeon CT and 41 in sheep CT).

2. Pig CT Discussion

The University of Cordoba (Spain) was the Duty lab. Thirty-two labs requested samples. Twenty-nine labs reported results. Twenty-two samples (including two reference samples) were submitted to all participants. The relative overall marker concordance among labs was good, ranging from a minimum of 87.76% (S0386) to a maximum of 98.45% (S0227). Twenty-eight labs answered both parentage questions correctly, and one lab didn't answer the parentage correctly. Marker S0386 showed a discrepancy between labs regarding allele 177 in PCT4, PCT9, PCT10, PCT14 and PCT17 samples. This issue was discussed during the previous CTs of 2014, 2017, 2019 and 2021. The low concordance for these samples could be explained by using primers unable to amplify allele 177 or using an inappropriate temperature. It is recommended to remember again to use the correct primer sequences as proposed in DNA microsatellite analysis for parentage control in Austrian pigs. Nechtelberger D, Kaltwasser C, Stur I, Meyer JN, Brem G, Mueller M, Mueller S., *Anim Biotechnol.* 2001. Nov; 12(2):141-4. PMID: 11808629. The recommended primers are Fw: 5'-GAA CTC CTG GGT CTT ATT TTC TA, Rv: 5'-GTC AAA AAT CTT TTT ATC TCC AAC AGT AT. The recommended amplification temperature is **48 °C**. Many labs reported an incorrect denomination for one allele of the marker S0005 in samples PCT5, PCT6, PCT7 and PCT10. The correct genotypes of this marker are: PCT5, 245/281; PCT6, 241/275; PCT7, 231/275; PCT10, 251/275. Another recurrent error is the 135 of the marker SW951, and many labs did not report this allele or call it incorrectly. Since these situations have previously arisen, these mismatches were considered errors in the final ranking system.

3. Dromedary CT Discussion

Qatar Genetic Lab (Qatar) was the Duty lab. Eight labs requested samples, and seven labs reported results. Twenty-five samples (including two reference samples) were submitted to all participants. The relative overall marker concordance among labs was good, ranging from a minimum of 97.45% (LCA56) to a maximum of 100.0% (LCA65, LCA66, LCA8 and YWLL29). Marker LCA19 of the core panel was mono-allelic. In the backup panel, markers (LCA24, LCA77, YWLL36 and VOLP59) were also mono-allelic. This was also the case in several previous CT. All seven labs answered the first parentage question correctly, and the second one answered correctly by six out of seven labs.

Because of low PE, changes in the current core and backup ISAG panels were suggested, and including more polymorphic markers such as (LGU49, VOLP3, CVRL01 and CVRL05) were also proposed. UC Davis in

VGL commented that the panel was useful for their work and requested to be the duty lab for the next ISAG session to provide another set of samples and check whether the panels must be changed.

4. Alpaca/Llama CT Discussion

The Duty lab was the National Research Institute of Animal Production (Poland). Twelve labs requested samples. Ten labs reported results. Twenty-two samples (5 llama samples and 17 alpaca samples, including two alpaca reference samples) were submitted to all participants. The relative overall marker concordance among labs was very good, ranging from a minimum of 96.5% (LCA37) to a maximum of 100.0% (LCA5, LCA99, YWLL29 and YWLL40). Two loci were problematic for some participants. In the ACT20 sample, an extreme allele 186 was observed at the LCA37 locus and was omitted from some participants' reports. A similar situation occurred in the ACT12 sample at the LCA19 locus, where the extreme allele 136 was found. Both alleles overlap with areas of other markers, making them easy to miss.

All participants answered both parentage questions correctly.

5. Goat CT Discussion

The Duty lab was the University of Zaragoza, LAGENBIO Lab (Spain). Thirty-seven labs requested samples. Thirty-six labs reported results. Twenty samples (including one reference sample_GCT01) were submitted to all participants. There were a few minor problems with some samples: specifically, we had to send five new samples because there was too little DNA or the tubes were empty (1 to France and 4 to Brazil).

All labs' absolute and relative genotyping ranged between 100% and 85% in both cases, except for one lab whose accuracy was 48.5%. Looking at the ranks, concerning absolute accuracy, 69.4% of the labs are in Rank 1, and 72% are in Rank 1. Regarding relative accuracy, 97.2% of the labs answered correctly to the parentage question, and only one lab failed. Accuracy relative to overall marker concordance among labs was good and similar to the last comparison test, ranging from a minimum of 94.88% (SRCRSP05) to a maximum of 98.98% (INRA005).

Some discrepancies have been observed in 2 markers, particularly in one sample in each. For sample GCT20 at marker **SRCRSP05**, 20 labs reported a heterozygous genotype (171/173), 15 reported a homozygous genotype 173/, and 1 identified the sample as 175/177.

The second marker in which differences between labs were observed was **MAF065** in sample 14. Although genotype homozygous 151/ is the majority (18 labs), the rest of the laboratories (18 labs) assigned 10 different genotypes for this sample. The possibility of accepting the different genotypes proposed by the laboratories for these two markers is proposed but not accepted.

To determine the correct genotype of sample GCT20 for marker SRCRSP05 and sample GCT14 for marker MAF65, it is proposed to sequence both samples and Agata Piestrzynska-Kajtoch, from Poland, sequenced these samples. According to the results, this allele 171 of SRCRSP05 seems different from other analysed homozygous alleles - it has more AT repeats. While alleles 169, 173 and 175 differ in the number of AC repeats (19, 21, 22, respectively) and have the same number of AT repeats (4), allele 171 seems to have 15 AC repeats and 9 AT repeats. This allele 171 has not previously been reported in any CT, so we propose that, although the correct genotype is heterozygous, not consider the genotype 173 homozygous as an error for sample GCT20 in this round.

The sequencing analysis results of the GCT14 sample support that the correct genotype of the MAF065 is 151 homozygous.

6. Sheep CT Discussion

The Duty lab was the National Research Institute of Animal Production (Poland). Forty-three labs requested samples. Forty-one labs reported results. Twenty-one samples (including 1 reference sample) were submitted to all participants. The relative overall marker concordance among labs was good, ranging from 93,5% (MCM527) to AMEL (99,47%). Parentage questions were answered correctly by forty and 39 labs, respectively. The genotypes of the samples OCT08 and OCT10 in marker OARFCB20 were discussed. Nine and eight labs reported these samples as 91/ homozygotes instead of 89/91 heterozygotes. The duty lab sequenced both samples and proved that **the correct genotype for both samples is 89/91**. This issue was also discussed during the previous ISAG CT 2020-2021, and the mistakes will be counted as errors in the ranking. For sample OCT15 in marker INRA172 five different genotypes were reported (126/140 – 18 Lab; 126/138 – 16 labs; 126/ - 3 labs, 126/139 – 1 Lab, 133/144 – 1 lab). The duty lab sequenced this sample and proved that **the correct genotype of this sample is 126/140**. Because 138 or 140 allele case was discussed in previous CTs, for this year's CT, an incorrectly reported 138 allele will be counted as an error for the ranking. It was suggested to use the samples OCT08 or OCT10, and OCT15 (if possible – or samples with the same or similar alleles in OARFCB20 and INRA172) as reference samples in the next CT round.

7. Pigeon CT Discussion

The Duty lab was the National Research Institute of Animal Production (Poland). Thirteen labs requested samples. All labs reported results. Twenty-one samples (including one reference sample) were submitted to all participants. The relative overall marker concordance among labs was good, ranging from 91.15% (ClpD16) to a maximum of 100% (ClpD11). There were no disputed loci in the core panel in this PCT round. Only minor errors occurred in individual laboratories. The first parentage question was answered correctly by all labs. The second parentage question was answered correctly by four out of thirteen labs. The reason for a high percentage of incorrect answers was the fact that some labs considered only a core panel. Therefore, it is suggested that the core panel is insufficient for parentage testing when only one parent is considered. The Beijing Microread Genetics laboratory sequenced the PIGN 12 marker (backup panel) and proposed a new nomenclature of alleles occurring in this locus. It was proposed that an e-mail would be sent to PCT participants and, on this basis, a decision on a possible change of the nomenclature would be made.

8. Pig, Goat, and Sheep SNP panels for parentage verification

In the last CT (2020-21), participants expressed interest in SNP panels for Pig, Goat and Sheep. The committee investigated the options to set up SNPs panels for Pigs, Goats and Sheep. However, only NEOGEN presented a proposal for a panel for sheep based on the presentation "Selection of an Ovine SNP Parentage Panel for Consideration as the ISAG Comparison Test Panel" in 2024-2025. This lab volunteers to generate reference calls. Labs with allele frequency data that can be shared need to get in touch with the committee chair.

9. Enclosing disease markers in next CTs

All duty labs are encouraged to include a disease marker in the next CT. This is not required and is only possible if the duty lab can access samples with heterozygous and/or homozygous mutant genotypes for a disease marker.

COMPARISON TEST (2021-2023) YES NO

Duty laboratory Pig

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Duty laboratory Dromedary

Contact person: Marwa Chourabi

Affiliation: Qatar genetic lab, Qatar

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Duty laboratory Alpaca/Llama

Contact person: Angelika Mąsior

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Duty laboratory Pigeon

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Duty laboratory Sheep

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Duty laboratory Goat

Contact person: Clementine Rodellar

Affiliation: Laboratorio de Genética Bioquímica (LAGENBIO). University of Zaragoza, Spain

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Election of the committee and any other business.

New Committee chair

Chair: Amparo Martinez

Term of service: first term of service 2017-2021, second term of service 2021-2025

Affiliation: University of Cordoba, Spain

E-mail address: ib2mamaa@uco.es

New Committee co-chair

Co-Chair: Emiliano Lasagna
Term of service: first term of service 2019-2023, second term of service 2023-2025
Affiliation: Università degli Studi di Perugia, Italy
E-mail address: emiliano.lasagna@unipg.it

New Committee members

Other committee members	First term of service	Second term of service	Email address
Ntanganedzeni Mapholi	2017-2021	2021-2025	maphon@unisa.ac.za
Younes Miar	2017-2021	2021-2025	miar@dal.ca
Foluke Eunice Sola-Oja	2019-2023	2023-2027	solaojo.fe@unilorin.edu.ng
Angelika Mąsior	2021-2025	2025-2029	angelika.masior@iz.edu.pl
Rosina Fossati	2023-2027		fossati@genexa.com.uy
Jianseng Qiu	2023-2027		JQiu@neogen.com

List of recommended markers with primer information

Dromedary:			
ISAG STR Core Panel - Dromedary			
Locus	Forward	Reverse	
LCA8	GCTGAACCACAATGCAAAGA	AATGCAGATGTGCCTCAGTT	
LCA37	AAACCTAATTACCTCCCCCA	CCATGTAGTTGCAGGACACG	
LCA56	ATGGTGTTCACAGGGCGTTG	GCATTACTGAAAAGCCCAGG	
LCA65	TTTTTCCCCTGTGGTTGAAT	AACTCAGCTGTTGTCAGGGG	
LCA66	GTGCAGCGTCCAAATAGTCA	CCAGCATCGTCCAGTATTCA	
YWLL29	GAAGGCAGGAGAAAAGGTAG	CAGAGGCTTAATAACTTGCAG	
YWLL44	CTCAACAATGCTAGACCTTG	GAGAACACAGGCTGGTGAATA	
ISAG Additional Markers - Dromedary			
Locus	Forward	Reverse	
CVLR01	GAAGAGGTTGGGGCACTAC	CAGGCAGATATCCATTGAA	
CVLR04	CCCTACCTCTGGACTTTG	CCTTTTTGGGTATTTTCAG	
CVLR05	CCTTGGACCTCCTTGCTCTG	GCCACTGGTCCCTGTCATT	
LCA99	CAGGTATCAGGAGACGGGCT	AGCATTATCAAGGAACACCAGC	
LGU49	TCTAGGTCCATCCCTGTTGC	GTGCTGGAATAGTGCCAGT	
VOLP3	AGACGGTTGGGAAGGTGGTA	CGACAGCAAGGCACAGGA	
VOLP32	GTGATCGGAATGGCTTGAAG	CAGCGAGCACCTGAAAGAA	
VOLP59	CCTCCTCAGAATCCGCCACC	CCCGCGACCAAGCAG	



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YWLL08	ATCAAGTTTGAGGTGCTTTCC	CCATGGCATTGTGTTGAAGAC
YWLL36	AGTCTTGGTGTGGTGGTAGAA	TGCCAGGATACTGACAGTGAT

Alpaca/Llama:

ISAG STR Core Panel - Llamas and Alpacas

Locus	Forward	Reverse
LCA5	GTGGTTTTTGCCCAAGCTC	ACCTCCAGTCTGGGGATTTC
LCA8	GCTGAACCACAATGCAAAGA	AATGCAGATGTGCCTCAGTT
LCA19	TAAGTCCAGCCCCACACTCA	GGTGAAGGGGCTTGATCTTC
LCA37	AAACCTAATTACCTCCCCCA	CCATGTAGTTGCAGGACACG
LCA56	ATGGTGTTTACAGGGCGTTG	GCATTACTGAAAAGCCAGG
LCA65	TTTTTCCCCTGTGGTTGAAT	AACTCAGCTGTTGTCAGGGG
LCA66	GTGCAGCGTCCAAATAGTCA	CCAGCATCGTCCAGTATTCA
LCA94	GTCCATTCATCCAGCACAGG	ACATTTGGCAATCTCTGGAGAA
LCA99	CAGGTATCAGGAGACGGGCT	AGCATTTATCAAGGAACACCAGC
YWLL29	GAAGGCAGGAGAAAAGGTAG	CAGAGGCTTAATAACTTGCAG
YWLL40	CACATGACCATGTCCCCTTAT	CCAGTGACAGTGTGACTAAGA
YWLL44	CTCAACAATGCTAGACCTTGG	GAGAACACAGGCTGGTGAATA
LGU49	TCTAGGTCCATCCCTGTTGC	GTGCTGGAATAGTGCCCACT
LGU50	CTGCTGTGCTTGTACCCTA	AGCACCATGCCTCTAAGT

ISAG Additional Markers - Llamas and Alpacas

Locus	Forward	Reverse
LCA24	ACTCACGGGTGACATACAGTG	GAGCAGTGTTTGGTTTGCATT
YWLL08	ATCAAGTTTGAGGTGCTTTCC	CCATGGCATTGTGTTGAAGAC
YWLL36	AGTCTTGGTGTGGTGGTAGAA	TGCCAGGATACTGACAGTGAT
YWLL43 (X-linked)	ATACCTCTCTTGTCTCTCTC	CCTCTACAACCATGTTAGCCA
YWLL46	AAGCAGAGTGATTTAACCGTG	GGATGACTAAGACTGCTCTGA

Pigeon:

ISAG STR Core Panel - Pigeons

Locus	Forward	Reverse
ClipD11	CCAATCCCAAAGAGGATTAT	ACTGTCCTATGGCTGAAGTG
ClipT43	GGGAAAGGAAATTTGACACTG	ACTGTGCATGCCATTAAGAC
ClipD01	GATTTCTCAAGCTGTAGGACT	GTTTGATTTGGTTGGGCCATC
PIGN57	CTCTGTATGTCCATCTGAAC	ACCCATTTACCACTCTCTAA
ClipT13	CTGTGAGCAGTAACAGTCC	GTTTGCAAGCCCTGGTTATCTCA
ClipD16	GCAGTGATAAAGTTCTGGAACA	GTTTGCCTCACCGTGACATCA
ClipD19	CTGCCCGTTTCTTCTAATGCAC	GTTTGGATTTCTGGGAGTGTATG
ClipT02	AGTTTTAATGAAGGCACCTCT	TGTAGCATGTCAGAAATTGG
ClipD17	TCTTACACACTCTCGACAAG	GTTTCCACCCAAATGAGCAAG
ClipD35	GGGAGCTTAAGGGATTATTG	ATTCCTTGCATGCCTACTTA
ClipT17	ATGGGTTTGGAGATGTTTTG	GTTTGATGGAGTTGCTATTTTGCT
PIGN04	GGTTTTTCTGTTTCCTCACG	GGGATTCTGGGATTATTTTTTC

ISAG Additional Markers - Pigeons

Locus	Forward	Reverse
PIGN15	TTTCCTTTTCATTTGCTGTGG	AACCAGGCATTGGAGTCTTT
PIGN10	TTCCACTGAATGGGTCTCAG	CTGCCAGAAGGTAAATGACAC
PIGN26	TCACTGTATTCACCAAAGTCTG	CAATGTGGGGGCGTCTATG
PIGN12	CAGATCCAGCAGTCTTGAAG	CCCATCTAATGCGATAAATCC

Pig:

ISAG STR Core Panel - Pig

Locus	Forward	Reverse
S0005	TCCTTCCCTCCTGGTAACTA	GCACTTCCTGATTCTGGGTA
S0090	CCAAGACTGCCTTGTAGGTGAATA	GCTATCAAGTATTGTACCATTAGG
S0101	GAATGCAAAGAGTTCAGTGTAGG	GTCTCCCTCACACTTACCGCAG
S0155	TGTTCTCTGTTTCTCCTCTGTTTG	AAAGTGAAAAGAGTCAATGGCTAT
S0227	GATCCATTTATAATTTTAGCACAAAAGT	GCATGGTGTGATGCTATGTCAAGC
S0228	GGCATAGGCTGGCAGCAACA	AGCCACCTCATCTTATCTACACT
S0355	TCTGGCTCCTACACTCCTTCTTGATG	TTGGGTGGGTGCTGAAAAATAGGA
S0386*	GAACTCCTGGGTCTTATTTTCTA	GTCAAAAATCTTTTTATCTCCAACAGTAT
SW24	CTTTGGGTGGAGTGTGTGC	ATCCAAATGCTGCAAGCG
SW240	AGAAATTAGTGCCTCAAATTGG	AAACCATTAAGTCCCTAGCAAA
SW72	ATCAGAACAGTGCGCCGT	TTTGAAAATGGGGTGTITTC
SW857	TGAGAGGTCAGTTACAGAAGACC	GATCCTCCTCAAATCCCAT
SW911	CTCAGTTCTTTGGGACTGAACC	CATCTGTGGAAAAAAAAAGCC
SW936	TCTGGAGCTAGCATAAGTGCC	GTGCAAGTACACATGCAGGG
SW951	TTTCACAACTCTGGCACCAG	GATCGTGCCCAAATGGAC

* Recommended amplification temperature: 48 °C

ISAG Additional Markers - Pig

Locus	Forward	Reverse
IGF1	GCTTGGATGGACCATGTTG	CATATTTTTCTGCATAACTTGAACCT
S0002	GAAGCCCAAAGAGACAACCTGC	GTTCTTTACCCACTGAGCCA
S0026	AACCTTCCCTTCCCAATCAC	CACAGACTGCTTTTTACTCC
S0215	TAGGCTCAGACCCTGCTGCAT	TGGGAGGCTGAAGGATTGGGT
S0225	GCTAATGCCAGAGAAATGCAGA	CAGGTGGAAAGAATGGAATGAA
S0226	GCACTTTTAACTTTTCATGATACTCC	GGTTAAACTTTTNCCTCAATACA
SW632	TGGGTTGAAAGATTTCCCAA	GGAGTCAGTACTTTGGCTTGA

Sheep:

ISAG STR Core Panel - Sheep

Locus	Forward	Reverse
AMEL	CAGCCAAACCTCCCTCTGC	CCCGCTTGGTCTTGTCTGTTGC
CSRD247	GGACTTGCCAGAACTCTGCAAT	CACTGTGGTTTGTATTAGTCAGG
ETH152	TACTCGTAGGGCAGGCTGCCTG	GAGACCTCAGGGTTGGTGATCAG
INRA005	TTCAGGCATACCCTACACCACATG	AAATATTAGCCAACTGAAAATGGG
INRA006	AGGAATATCTGTATCAACCGCAGTC	CTGAGCTGGGGTGGGAGCTATAAATA



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INRA023	GAGTAGAGCTACAAGATAAACTTC	TAACTACAGGGTGTAGATGAACTC
INRA063	GACCACAAAGGGATTTGCACAAGC	AAACCACAGAAATGCTTGGAAG
INRA172	CCAGGGCAGTAAAATGCATAACTG	GGCCTTGCTAGCCTCTGCAAAC
MAF065	AAAGGCCAGAGTATGCAATTAGGAG	CCACTCCTCCTGAGAATATAACATG
MAF214	AATGCAGGAGATCTGAGGCAGGGACG	GGGTGATCTTAGGGAGGTTTTGGAGG
McM042	CATCTTTCAAAGAAGTCCGAAAGTG	CTTGGAATCCTTCCTAACTTTTCGG
McM527	GTCCATTGCCTCAAATCAATTC	AAACCACTTGACTACTCCCCAA
OarFCB20	GGAAAACCCCATATATACCTATAC	AAATGTGTTTAAGATTCCATACATGTG

Goat:

ISAG STR Core Panel - Goat

Locus	Forward	Reverse
CSRD247	GGACTTGCCAGAACTCTGCAAT	CACTGTGGTTTGTATTAGTCAGG
ILSTS008	GAATCATGGATTTTCTGGGG	TAGCAGTGAGTGAGGTTGGC
ILSTS19	AGGGACCTCATGTAGAAGC	ACTTTTGGACCCTGTAGTGC
ILSTS87	AGCAGACATGATGACTCAGC	CTGCCTCTTTTCTTGAGAGC
INRA005	TTCAGGCATACCCTACACCACATG	AAATATTAGCCAAGTAAAAGTGGG
INRA006	AGGAATATCTGTATCAACCGCAGTC	CTGAGCTGGGGTGGGAGCTATAAATA
INRA023	GAGTAGAGCTACAAGATAAACTTC	TAACTACAGGGTGTAGATGAACTC
INRA063	GACCACAAAGGGATTTGCACAAGC	AAACCACAGAAATGCTTGGAAG
MAF65	AAAGGCCAGAGTATGCAATTAGGAG	CCACTCCTCCTGAGAATATAACATG
McM527	GTCCATTGCCTCAAATCAATTC	AAACCACTTGACTACTCCCCAA
OarFCB20	GGAAAACCCCATATATACCTATAC	AAATGTGTTTAAGATTCCATACATGTG
SRCRSP23	TGAACGGGTAAAGATGTG	TGTTTTTAATGGCTGAGTAG
SRCRSP5	GGACTCTACCAACTGAGCTACAAG	TGAAATGAAGCTAAAGCAATGC
SRCRSP8	TGCGGTCTGGTTCTGATTTAC	CCTGCATGAGAAAGTCGATGCTTAG

Duty laboratory for the next comparison test (2024 – 2025)

Duty laboratory Pig

Contact person:
Affiliation:
E-mail address:

Duty laboratory Dromedary

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Duty laboratory Alpaca/Llama

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Duty laboratory Pigeon

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Duty laboratory Goat

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SIGNATURES

Chair

Duty laboratory