UNIKASSEL VERSITÄT | ÖKOLOGISCHE AGRAR WISSENSCHAFTEN

Detection of multiple feeding behaviours in calves using noseband and accelerometer sensors

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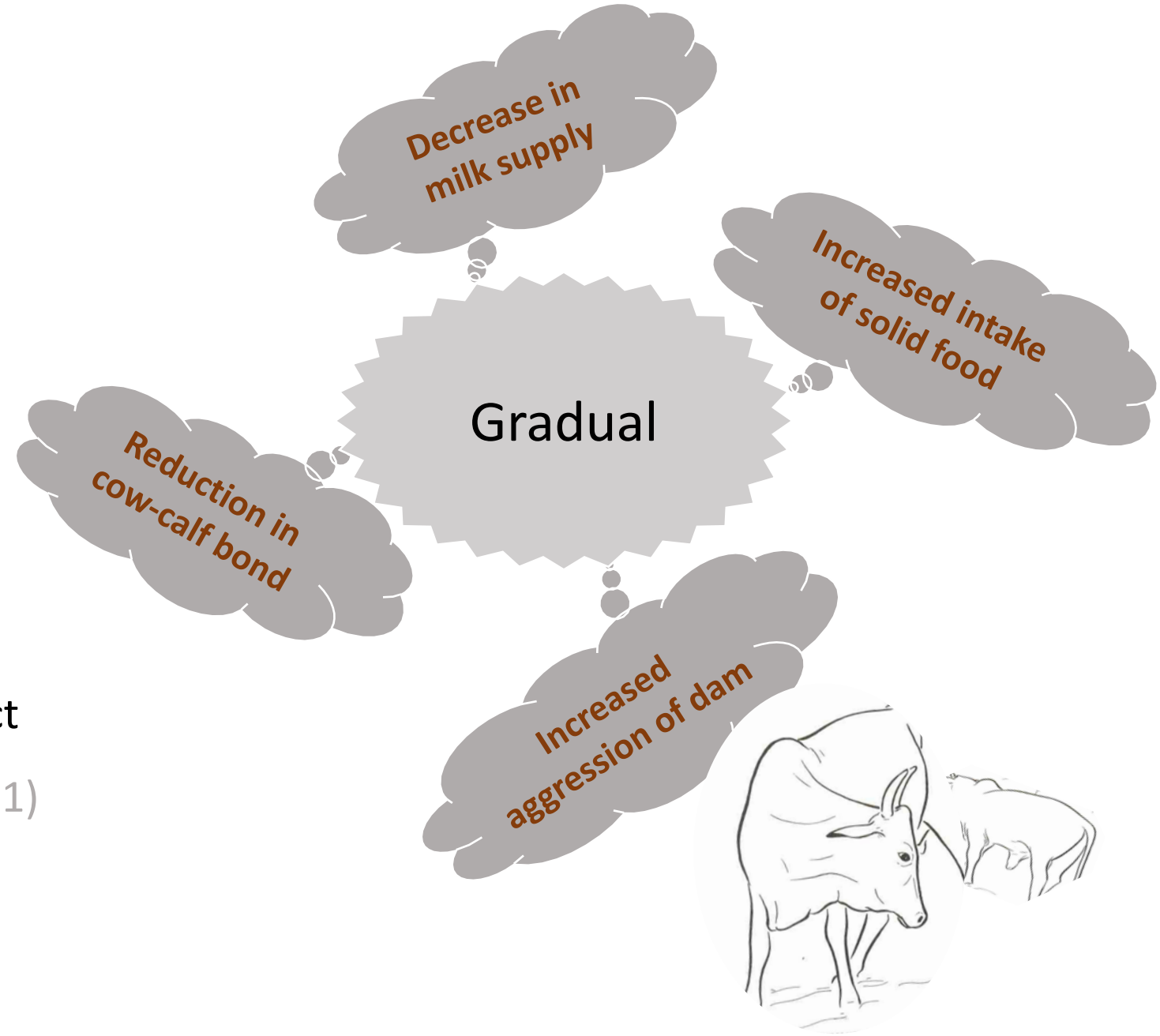
Background

Natural Weaning

- Gradual process (Reinhardt & Reinhardt, 1981)
- Between 7 and 14 months
- Exposure to physiological, social & environmental stressors that impact calves' welfare (Enríquez et al., 2011)



Background

Natural Weaning

- Little knowledge about cattle behaviour during natural weaning
- Behaviour changes during lasts at least 2 months (Johansen 2018)
- Only chance observations of suckling bouts until now
- Live observation and video technique can be challenging under natural conditions
- Sensor-based assessment of behaviour needed

Background

- Sensor-based systems now in use
  - ✓ CowManager, AfiAct Pedometer Plus...
  - ✓ Extensive use of triaxial accelerometer (Riaboff et al., 2022)
  - ✓ No clear recommendations
- Little research on techniques to assess suckling, feeding and rumination in **calves**
  - ✓ Kour et al., 2018
  - ✓ Carslake et al., 2020


Photo: Zipp

Aim

To predict suckling, feeding and ruminating behaviours of calves using a combination of noseband pressure and triaxial accelerometer sensor variables

- ✓ Compare 6 different epoch datasets
- ✓ Compare 3 different machine learning (ML) algorithms

Contribution to methods of assessing multiple behaviour of calves under near-natural condition


Photo: Zipp

Materials & Methods

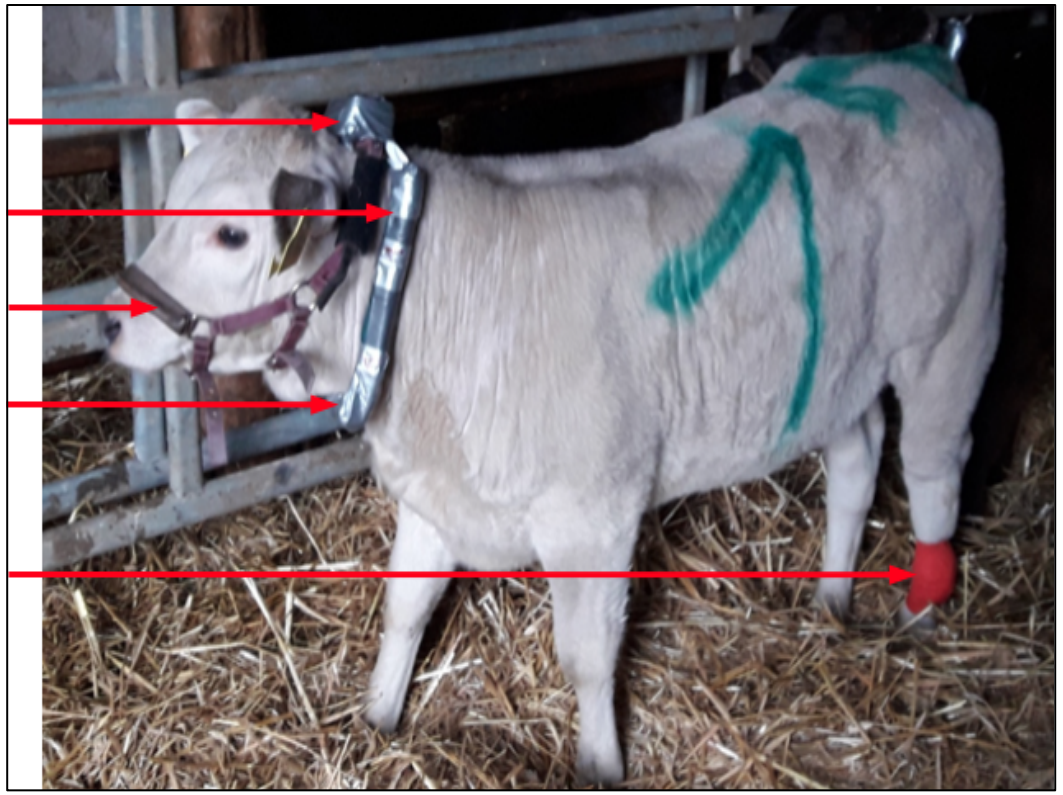
Animals

- 6 Males & 4 Females
- Charolais X Welsh Black
- 61 – 85 days of age
- Fed grass silage, hay and concentrate

Data recording

- MSR Electronics GmbH (145) logger
- 2- 3 days of familiarization
- Recording frequency of 20 Hz (mostly)

March, 2020



Deep-bedded stable

Photo: Freytag

Materials & Methods

Continuous focal observation

- Time period: 06:30-18:30
- 10 h/animal and split into 30 min observation window
- Pocket Observer (Noldus Information Technology BV)
- Start and stop timestamp of each behavioural activity
- Activities other than *suckling, feeding* and *ruminating* denoted as "**other**"

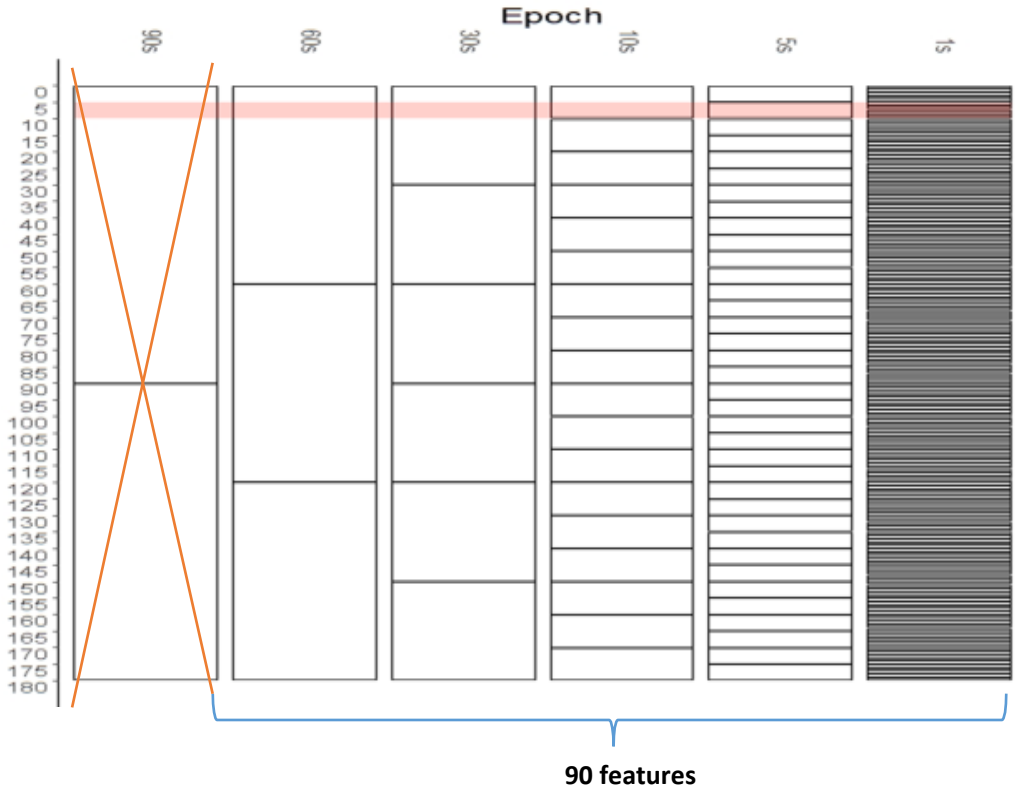
Photo: Freytag

Behaviour	
Suckling at the udder	Start/Stop
Feeding (eating)	Start/Stop
Ruminating	Start/Stop
Walking	Start/Stop
Lying	Start/Stop
Standing	Start/Stop

Materials & Methods

Data processing

- Data fusion by timestamp (R software)
- Feature extraction from raw data
  - ✓ Raw: pressure, acc_x, acc_y, acc_z
  - ✓ 18 features: adapted to Barwick et al., 2018; Benaissa et al., 2019
  - ✓ Summary over fixed time intervals (Epochs): 1s, 5s, 10s, 30s, and 60s
  - ✓ Generation of mixed epoch dataset by combining all 5 datasets according to timestamp (Chang et al. 2022)



Chang et al. 2022: Adapted

Example of a 1 s epoch dataset (18 X 34,247)

Timestamp	meanP	meanX	meanY	meanZ	minP	minX	minY	minZ	maxP	maxX	maxY	maxZ	sdP	sdX	sdY	sdZ	meanAll3	MI_acc	Activity
3/7/2020 9:34:01	1383.7	0.911	-0.1767	0.2799	1372.2	0.766	-0.25	0.219	1421	1.00	-0.109	0.313	15.987	0.06977	0.04176	0.0326	1.0142	0.970258	Rumination
3/7/2020 9:34:02	1391.0	0.923	-0.1845	0.2765	1370.8	0.797	-0.25	0.219	1423	1.02	-0.141	0.359	20.793	0.07008	0.03802	0.0471	1.0154	0.982714	Rumination

Materials & Methods

Modelling

- Application of 3 ML algorithms to each of the 6 dataset
  - ✓ Classification and regression tree (**CART**) – rpart (Therneau et al., 2022)
  - ✓ Conditional inference tree (**ctree**) – party (Hothorn et al., 2022)
  - ✓ Random forest (**RF**) – Scikit-learn (Pedregosa et al., 2011)
- Individual prediction model
  - ✓ Training & validation sets – 70%:30%
- Generic model
  - ✓ Leave-one-out CV (Mixed epoch, RF)
- Balancing of training dataset (SMOTETomek)
  - ✓ Combination of over- and under-sampling methods

Validation

$$\text{accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{sensitivity} = \frac{TP}{TP + FN}$$

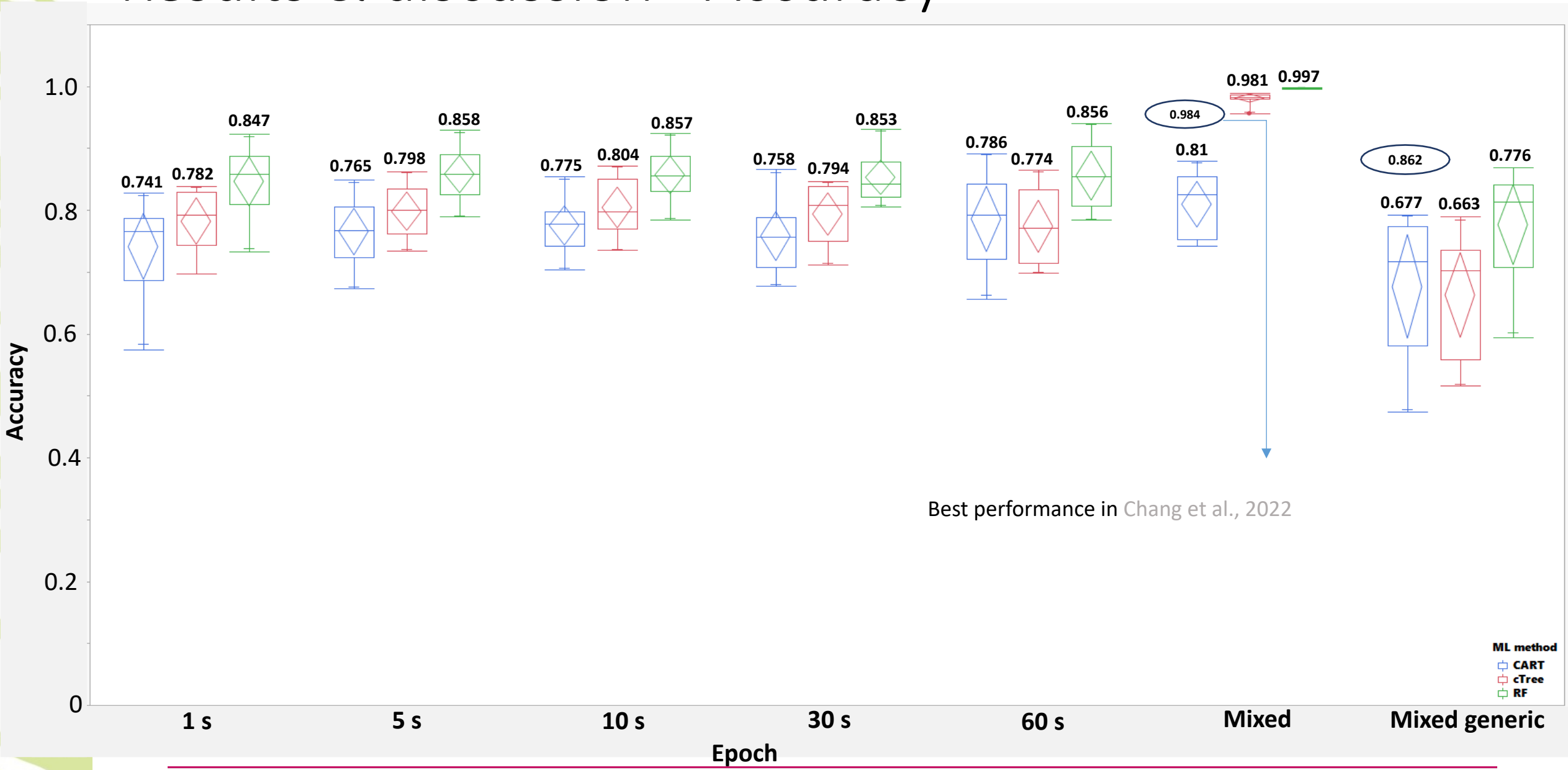
$$\text{specificity} = \frac{TN}{TN + FP}$$

$$\text{precision} = \frac{TP}{TP + FP}$$

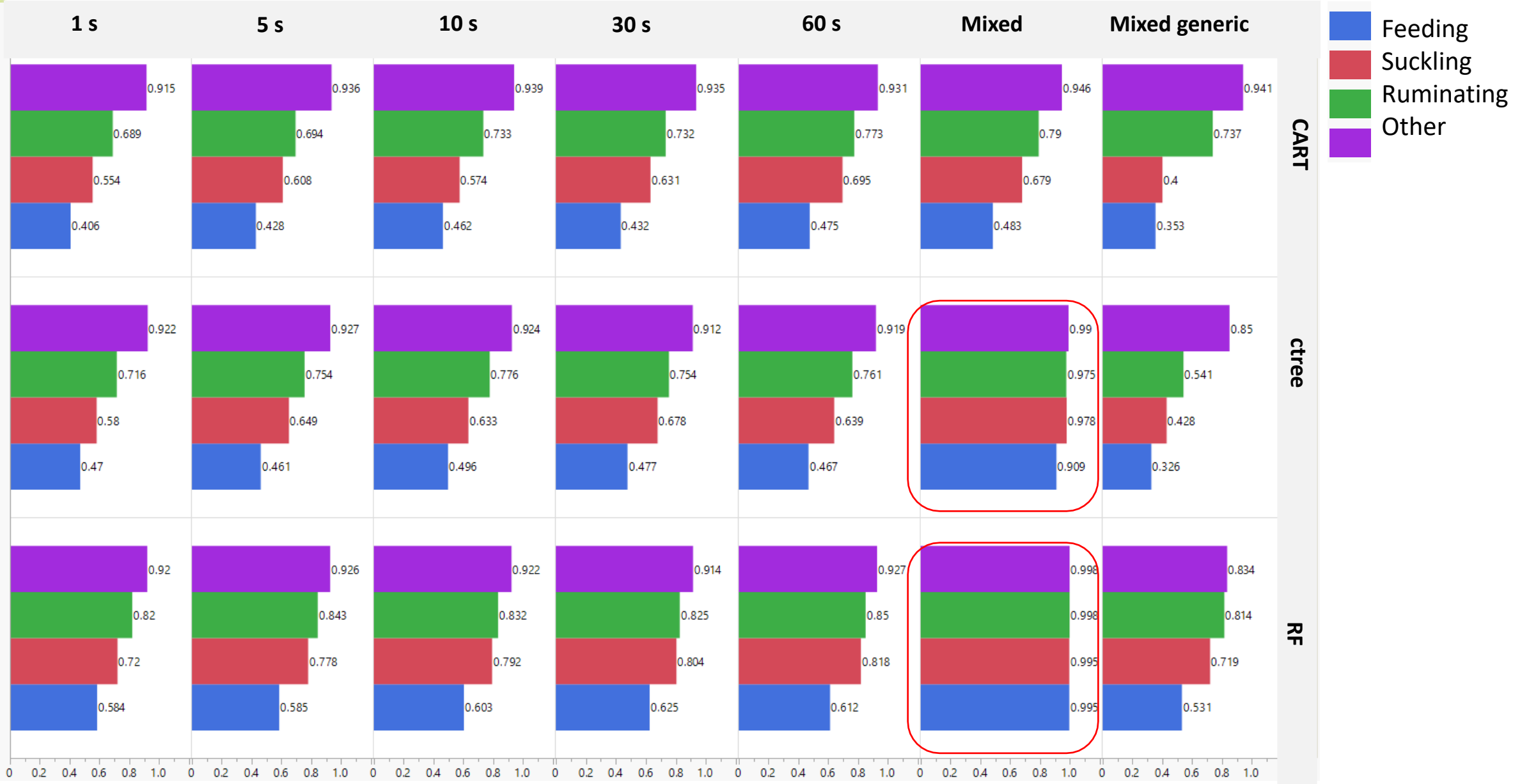
Contribution of variables

The permutation importance of variables was calculated to rank predictors

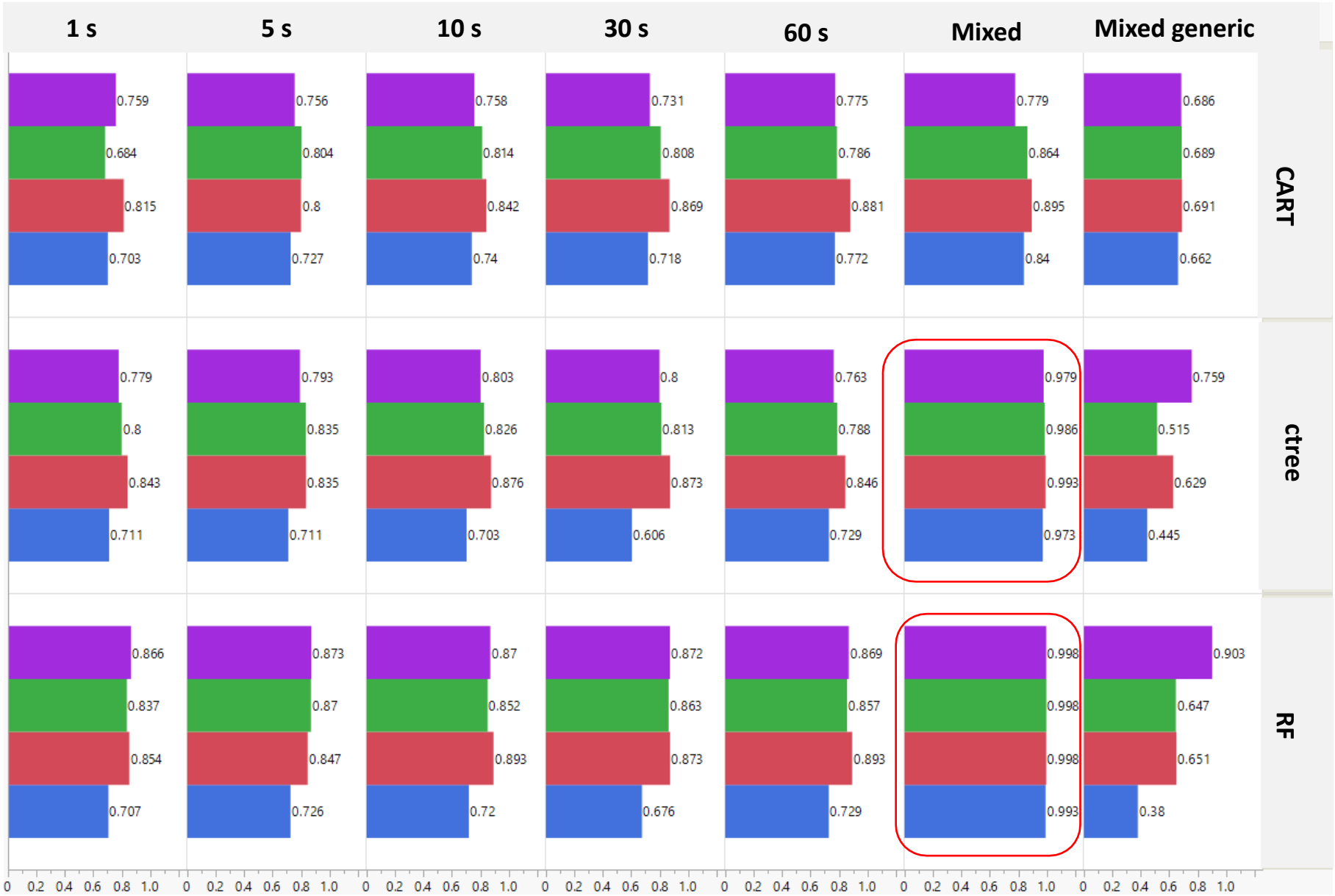
Results & discussion - Accuracy



Results & discussion - Precision

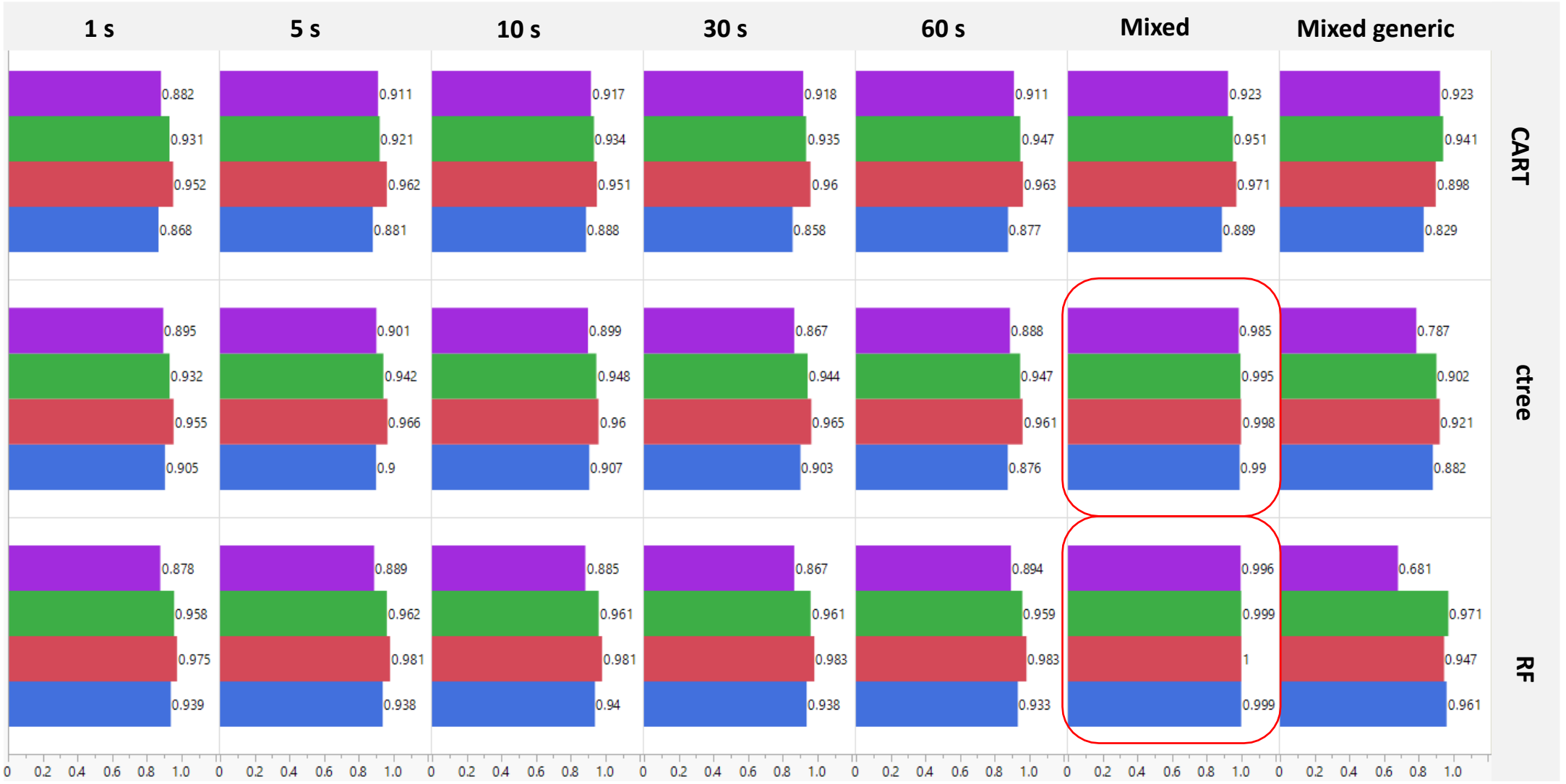


Results & discussion - Sensitivity



Feeding
Suckling
Ruminating
Other

Results & discussion - Specificity



Results & discussion - Precision

Variable importance

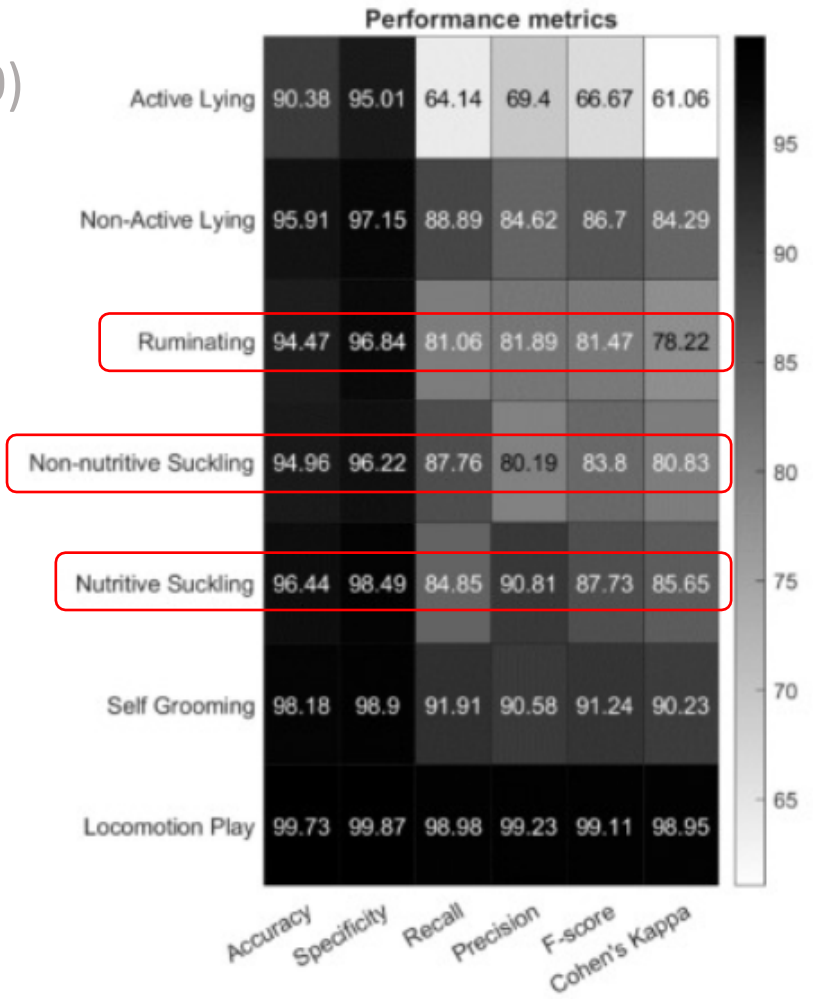
- Highest ranking variables from pressure (100%)
- Variance in pressure at 30 s & 60 s epoch equally important
- 60 s consistent with Chang et al. 2022

Best ranking variables – 3 out of 90

Animal	1st	2nd	3rd
1	sd(P)_30s	sd(P)_60s	min(Y)_60s
2	max(P)_60s	mean(Z)_60s	min(X)_60s
3	mean(P)_60s	max(P)_30s	sd(P)_60s
4	sd(P)_60s	max(Z)_30s	max(Y)_60s
5	sd(P)_60s	sd(X)_60s	max(Z)_30s
6	min(P)_30s	meanAll_30s	sd(P)_30s
7	sd(P)_30s	max(P)_60s	mean(P)_60s
8	sd(P)_30s	sd(Z)_30s	sd(P)_60s
9	sd(P)_30s	sd(Z)_30s	sd(X)_60s
10	max(P)_60s	sd(P)_60s	mean(P)_60s

Results & discussion - General

- Previous comprehensive study in calves (Carslake et al., 2020)
  - ✓ 4 h of data & 44 variables from accelerometer readings
  - ✓ Windows sizes of 1 s – 10 s with a 50% overlap (**3 s optimal**)
  - ✓ Overall accuracy of 95.72% < 99% (mixed; RF or ctree)
- Sensor positioning may not be ideal for practical implementation
- Benefit/cost of using multiple sensors



Conclusion

- A combination of pressure and acceleration variables offers a huge potential to simultaneously predict different feeding behaviours in calves
- The implementation of a mixed epoch dataset with RF and ctree seems promising for higher prediction performance

Thank you for your attention

References

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