TECNIPLAST

DVC ANALYTICS
SCIENTIFIC PLATFORM

DVC®Analytics Instruction Manual ver. 4.1

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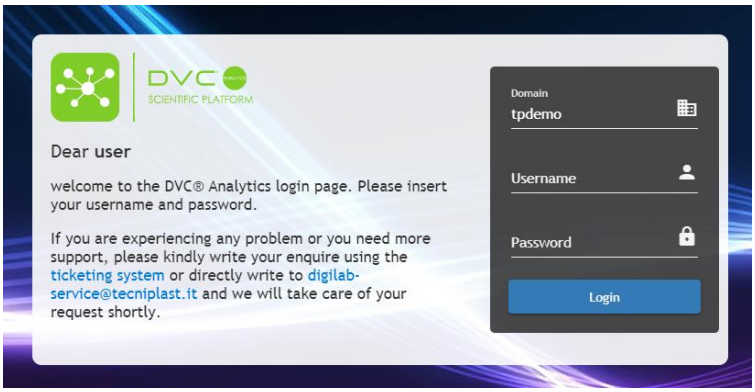
Revision History

Date	***Version***	***Author***	***Summary of Changes***
15/05/17	V1.0	Giorgio Rosati	First Draft
16/05/17	V1.1	Giorgio Rosati	Explanation of how to download raw data
27/07/2018	V2.0	Giorgio Rosati	DVC Analytics version 2
19/09/2019	V3.0	Giorgio Rosati	DVC Analytics version 3
01/01/2024	V4.0	Giorgio Rosati	DVC Analytics version 4
10/02/2025	V4.1	Giorgio Rosati	Refined cosmetics + extra features

1 Login page

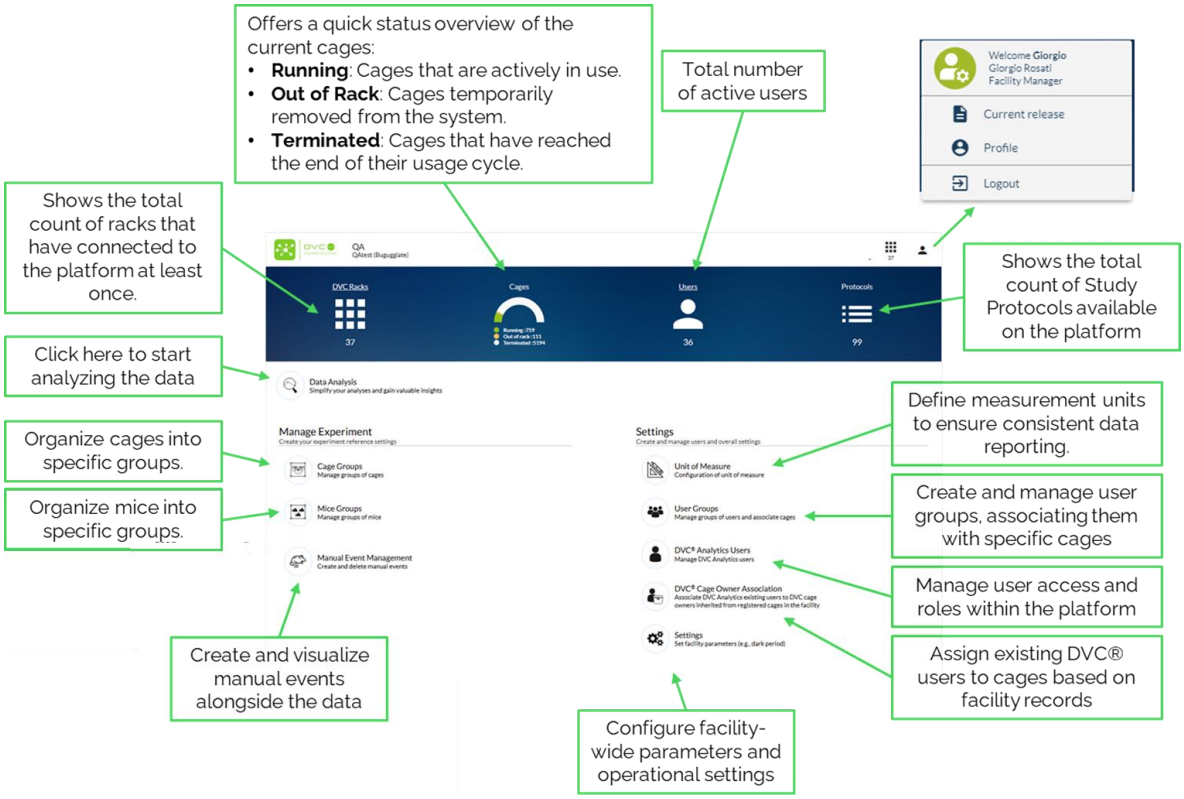
To login into the system, go to: https://analytics.dvc.tecniplast.it/login/XXX (XXX provided to you by Tecniplast or got during the registration) and enter your Username and Password that have been previously created.



2 Home Page Overview

In the DVC® Analytics there are two available profiles:

- **Facility Manager Profile**: Upon login, you gain full access to all platform functionalities.
- **Researcher Profile**: After logging in, you are automatically redirected to the Data Analysis section, where only the cages assigned to you are displayed. The upper section of the home page features a dark blue background and provides essential details about your facility, including the name of the facility.



2.1 Role-Specific Functionalities in DVC® Analytics:

Facility Manager:

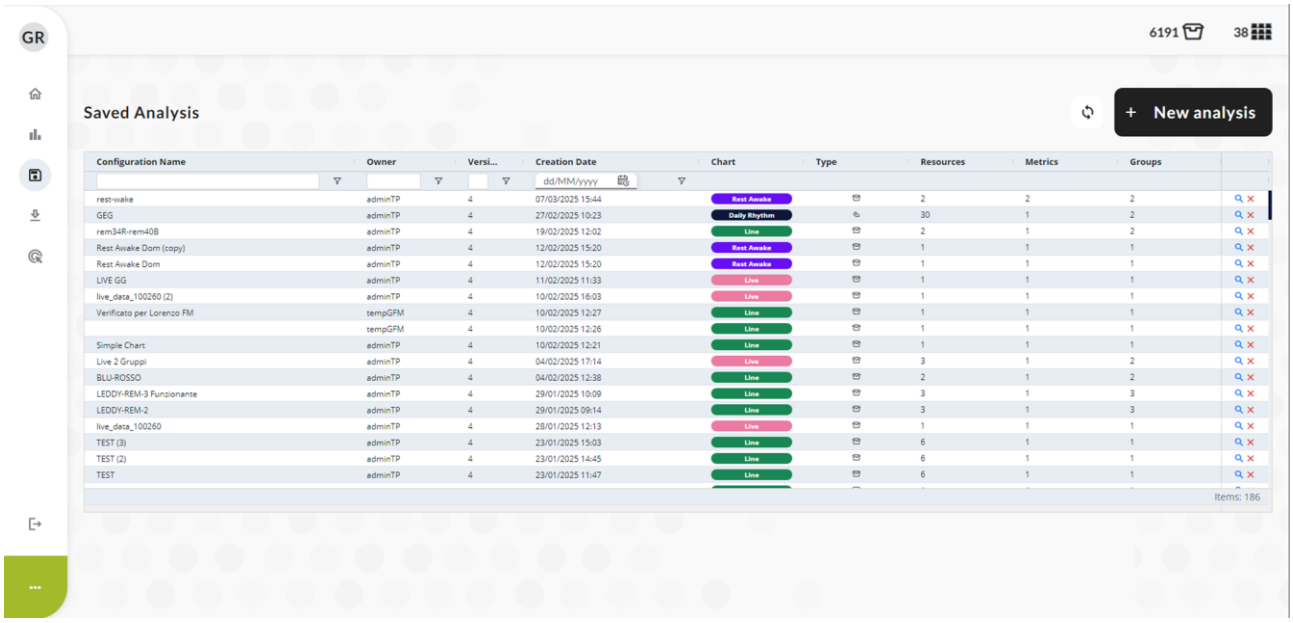
- **Access**: Full access to all features within the DVC® Analytics system.
- **Main capabilities**:
  - View all registered DVC® cages.
  - Register new users and associate them with DVC® cages.
  - Organize DVC® users into groups and link them to specific cages.
  - Modify facility settings, including designated dark hours.

Researcher:

- **Access**: Restricted to ensure privacy and prevent data overlap, allowing researchers to view only relevant data.
- **Main capabilities**:
  - View only the DVC® cages assigned to the researcher.
  - Create and manage cage and mouse groups using only the assigned cages.

3 Data Analysis section

Clicking on the "Data Analysis" button takes you to a menu where, if available, any saved configurations are displayed.



You can delete any pre-saved configuration by simply clicking the corresponding **X** icon. Conversely, to load a pre-saved configuration, click the appropriate icon 🔍 to restore all previously selected settings such as cages, groups, metrics, charts, and more.

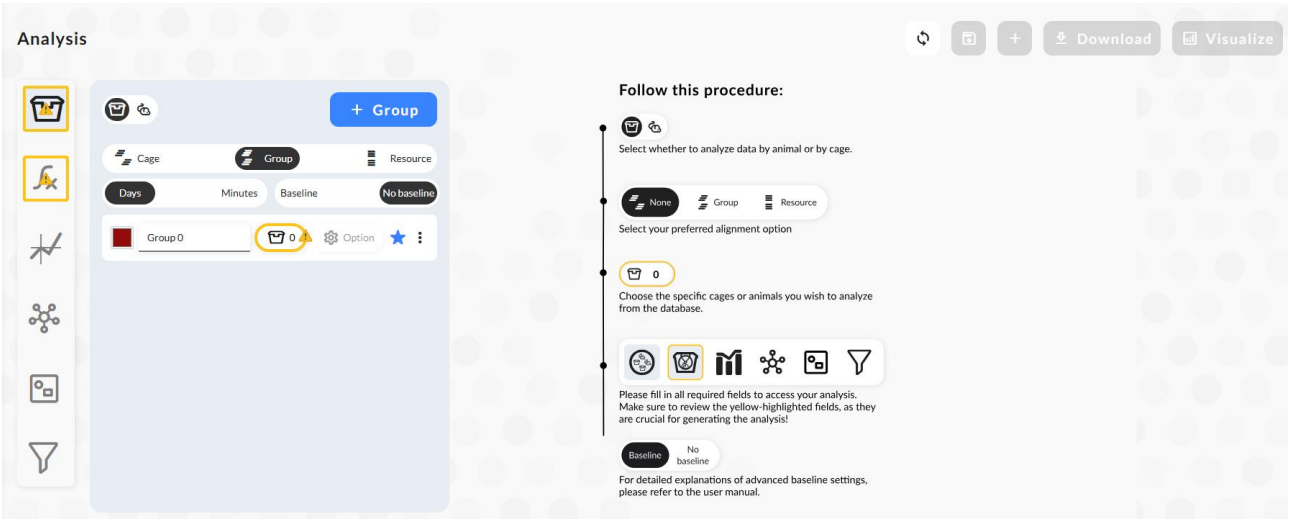
You can retrieve and update a previously saved configuration at any time. However, remember that the analysis duration was set when the configuration was initially saved. If you access it later, the duration will still reflect the original setting. If the cages are active or running, updating the duration is essential to ensure the analysis remains aligned with your desired timeframe in the system.

3.1 New Analysis

The "+ New Analysis" button is needed to start a new analysis where all the fields must be filled out step-by-step based on the experiment.

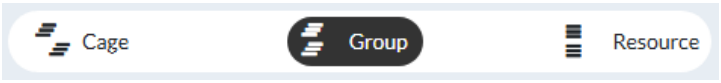
3.2 Data Analysis set up

In any section of the Analysis interface, please make sure to review the yellow-highlighted fields, as they are crucial for generating the analysis.

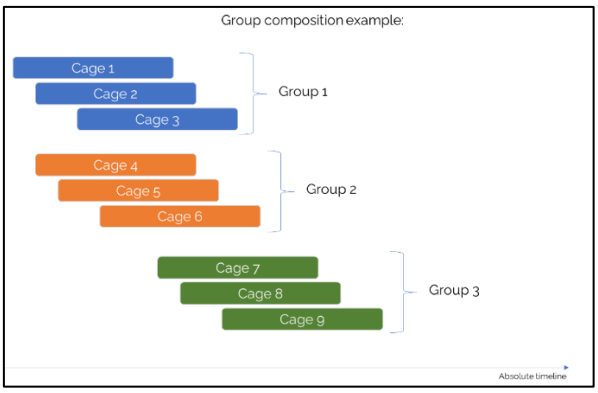


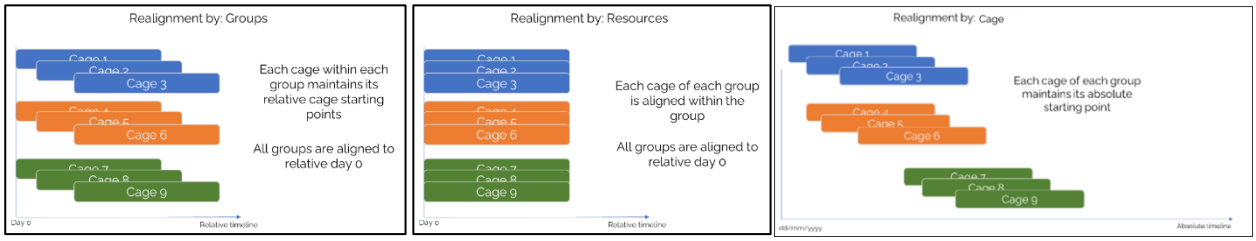
You begin by setting up the resources of your analysis (cage or animal). By default, the cage is selected as the primary resource. Alternatively, you can search for resources based on the animal's identifier. Keep in mind that DVC® data is always associated with cages. Selecting an animal as a resource allows you to locate cage data using the animal's ID.

Then, select your preferred alignment option choosing among the below ones:



Refer to the below example to understand the difference between these three options:





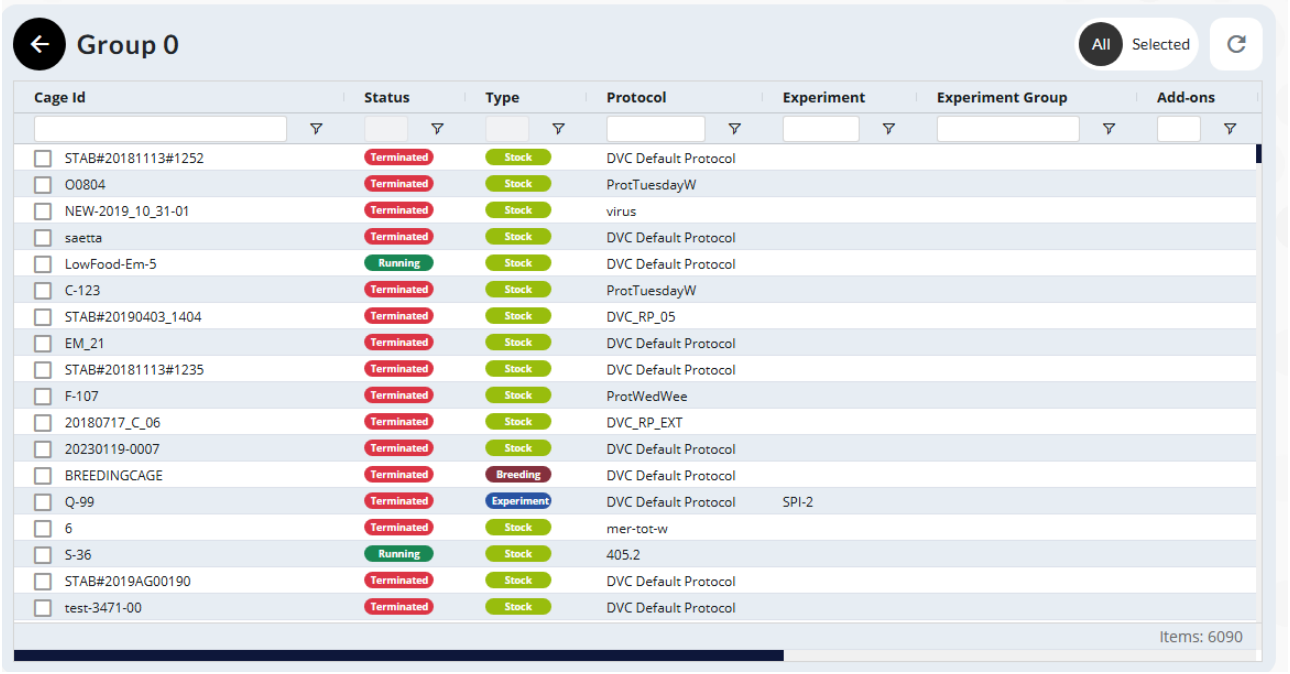
Then, decide the granularity of your temporal settings: by day (default) or by minute. 

Keep in mind that, when you select the day, the analysis starts from 00:00 (midnight).

Then, select whether to apply a Baseline to your original data. This feature is detailed later in this document.

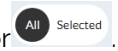
Now, it is time to select the resource(s) by clicking the corresponding icon 

. A lateral section opens where all the resources are listed by Cage ID in a big table with different columns:



Suppose you have registered the cages (or animals) with different information, such as the cage type (Stock, Experiment, Breeding), the Study Protocol, the experiment, or the Add-ons (Running Wheel, for instance). In that case, these are displayed in this table and help you immediately find the cages to analyze.

The status of the resources (Running, Terminated or Out of Rack) is directly triggered by the DVC® in the Animal Room.

For your first group of analysis, you can select one or multiple resources. You can retrieve the selected ones by clicking the specific selector 

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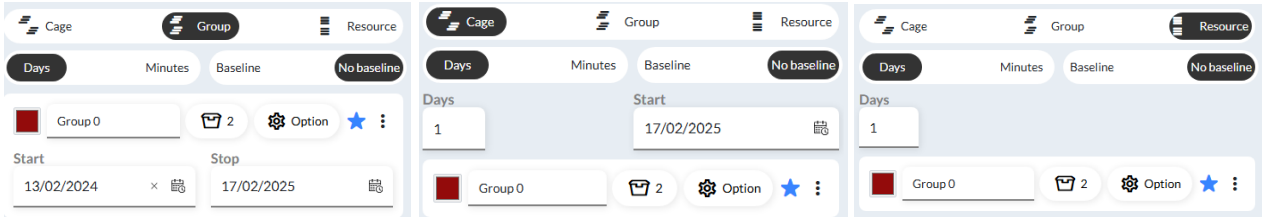
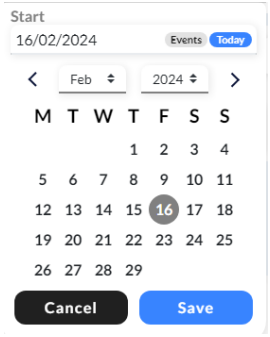
When a resource is selected, the first Group is created. “Group 0” name is assigned by default, you can rename it (and assign a different colour for the charts) 

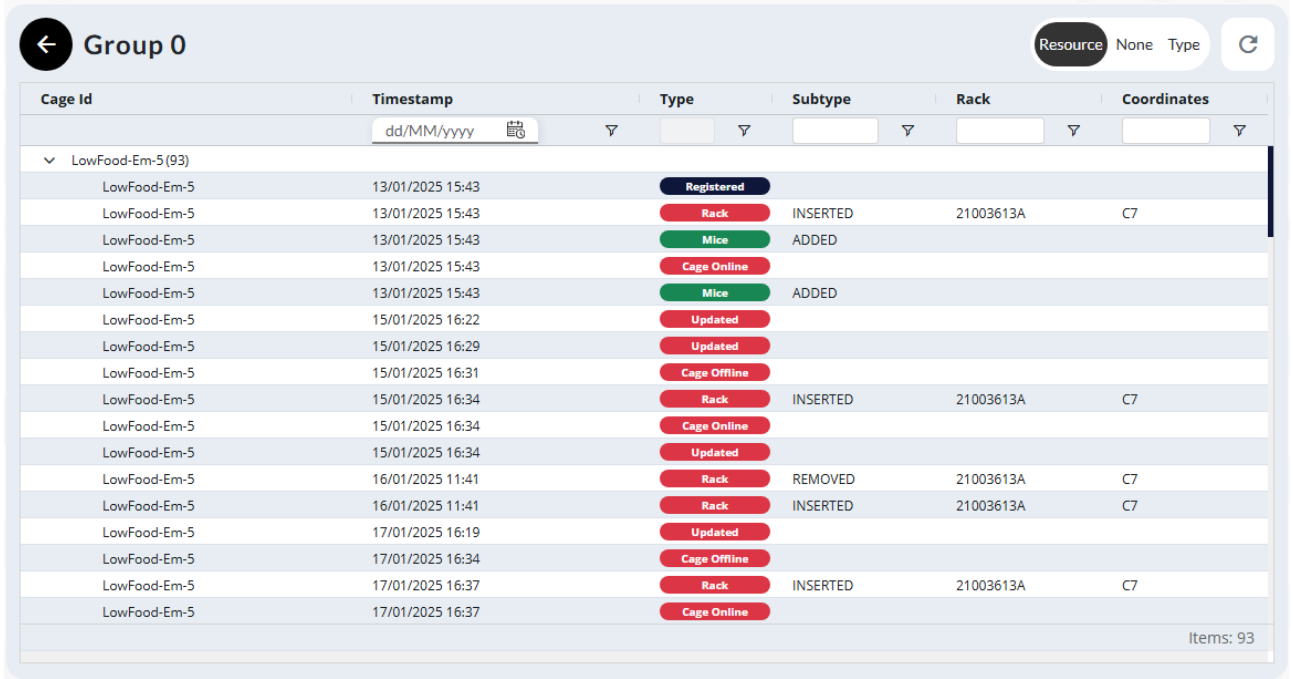
Then, depending on your previous selection of Realignment type, you are requested to define Start and Stop dates (in case of Realignment by Group), only the Start and duration (in case of Realignment by Cage), or even only the duration (in case of Realignment by Resources).



Whenever you select a date, you can either select it directly from the Calendar and then click the “Save” button:

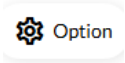


Or leverage the “Events” button to select the date from the list of (DVC) events generated by the cage:

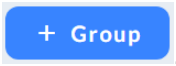


The DVC® system tracks a variety of events that occur within the facility, each categorised by type, subtype, and a brief description:

- **Registered**: This event marks when a cage is officially registered within the DVC® system.
- **Mice**:
  - ***Added***: Indicates a new mouse has been added to a specific cage.
  - ***Moved***: Reflects an already existing mouse being transferred from one cage to another.
  - ***Culled***: Records when a mouse has been culled from the cage.
- **Rack**:
  - ***Inserted***: Documents when a cage has been placed into the DVC® Rack.
  - ***Removed***: Notates when a cage has been removed from the DVC® Rack.
- **Update**: Occurs when any field of the cage's information (such as Owner, Protocol, etc.) is updated.
- **Bedding Change**: Tracks the event of a bedding change within a cage to maintain cleanliness and health standards.
  - ***Partial***: only the cage bottom is changed, the cage top is shared
  - ***Total***: integral cage change procedure
- **Cage Offline**: Logs any instances when a cage goes offline, which could be due to network issues.
- **Cage Online**: Captures the moment a cage returns online after a network restoration or similar events.
- **Cage Dismiss**: the event of termination for the cage

Once the group is created, the "Option" button 

becomes available. This feature is detailed later in this document.

Finally, you can add as many groups as you want by clicking the corresponding button 

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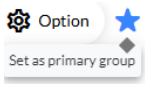
If you selected a Realignment by Group type, the primary group (by default, the first group to be created) sets the duration of the analysis, as the difference between the Stop and Start dates. All the other groups can only set the Start of the analysis because the primary group fixes the duration.

Any group can become the primary one by clicking the little star close to it 

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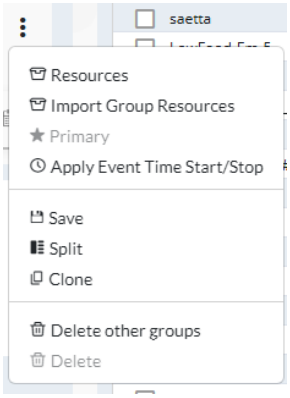
Finally, thanks to the little vertical dots at the end of the group section
, it is possible to have multiple group features:



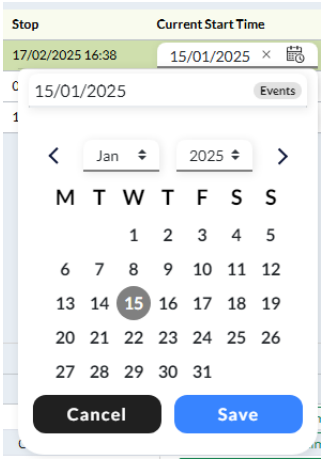
Where:

Item	Comment
Resources	Open the side menu to highlight the selected resources.
Import Group Resources	Open the side menu to select groups already created in the past.
Apply event Time Start/Stop	Automatically apply the first and last dates available in the system based on the first and last datapoints collected. By default, this is always applied. This feature helps to reset it from scratch in case it has been locally modified.
Primary	Set this group as the primary one (if not yet)
Save	Save this group for future retrieval.
Split	Split the group into individual correspondent resources.
Clone	Clone the group with the same resources
Delete other groups	Delete all the other groups (only if this is the primary group)
Delete	Delete itself (only if this is not the primary group)

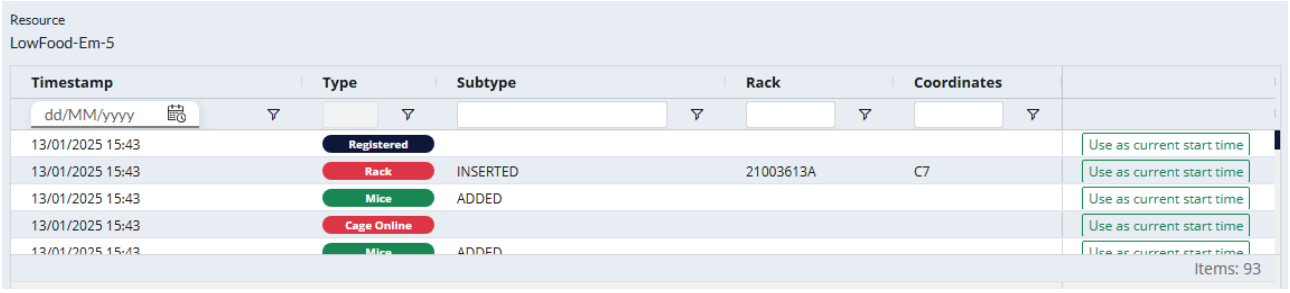
3.2.1 Option feature

This functionality is enabled when the Realignment type is set to 'Resources'. By default, the start date used to realign all resources is the first data point ('Start Date'). However, you can individually adjust the start date for a specific cage by modifying the corresponding 'Current Start Time' section.

This is possible either by directly clicking the calendar, choosing a specific date, and clicking "Save":



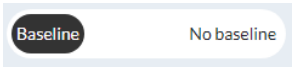
Or by clicking the "Events" button and then select the date ("Use as current start time") from the list of the below (DVC) events generated by this specific cage:



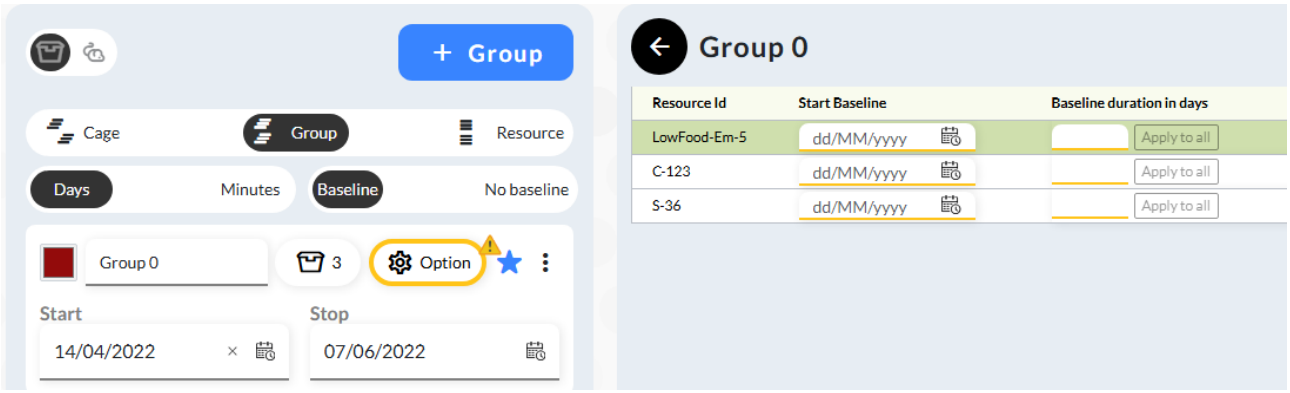
This Current Start Time then acts as day 0 for that specific cage, enabling a realignment feature that adjusts the timeline for each selected cage individually.

3.2.2 Baseline setting

You can click the corresponding button to create a baseline period for cages belonging to a specific group (it is disabled by default).



When enabled, it requires to fill the specific fields:



More specifically, for each cage, it is possible to assign a "Start Baseline" date and specify the duration of this baseline period in days. This baseline period is calculated based on additional settings, including data aggregation methods and selected filters. The calculated baseline is then used to normalise the data for the subsequent days of the analysis period, ensuring consistency and comparability across the dataset.

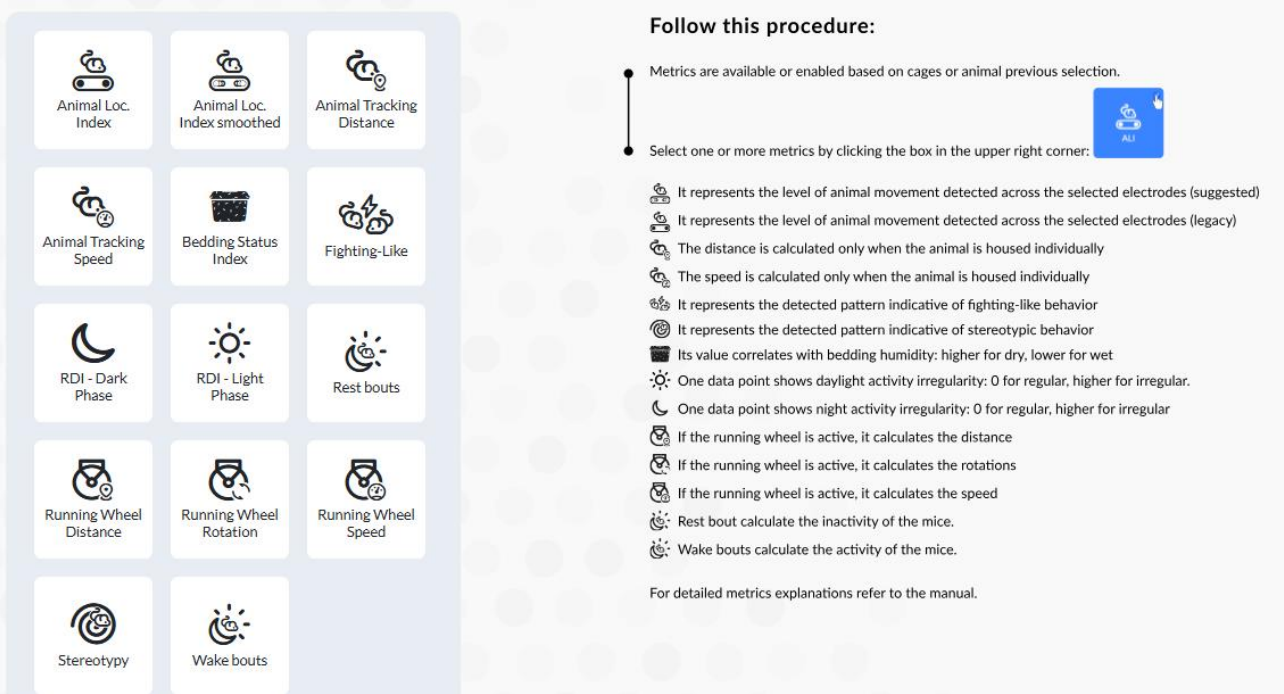
The formula we apply is the following:

$$Data_{bas} = \frac{data - baseline}{baseline} \%$$

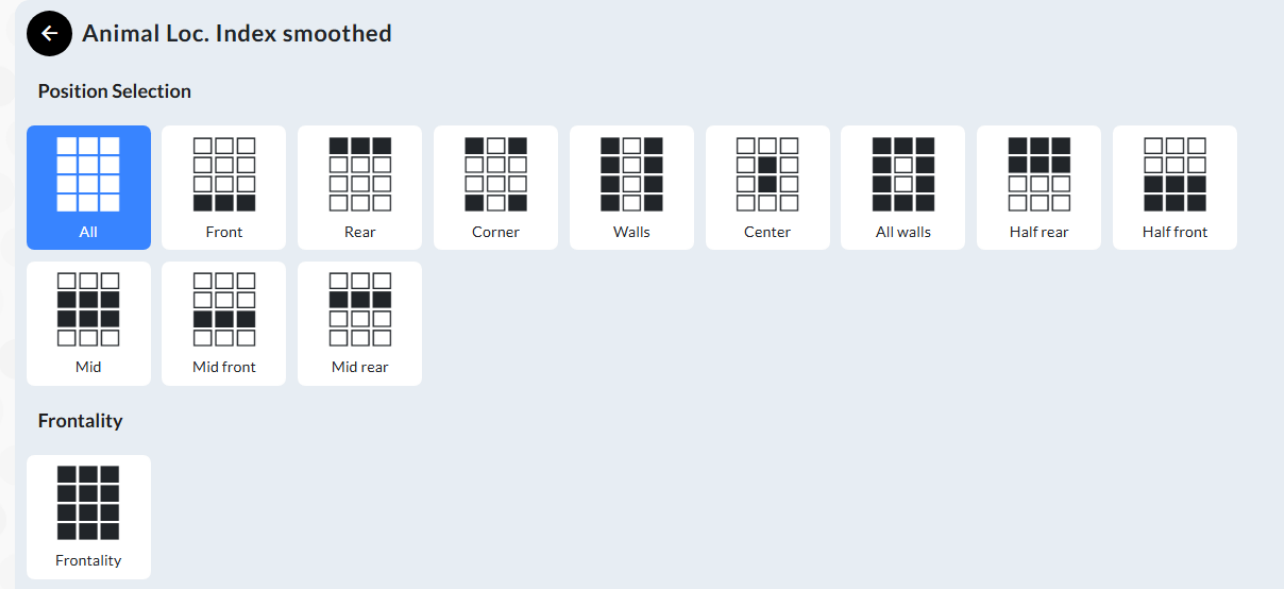
3.3 DVC® Metrics Selection

Once you have selected the resources to be analysed and their settings and realignments, you can select the DVC® metrics for the analysis. The availability of these metrics depends on the type of content specified during the cage registration in the DVC® system. For instance, metrics such as "Animal Tracking Distance" and "Animal Tracking Speed" are only accessible if the cage has been initially registered with a single animal. Additionally, "Running Wheel Distance/Rotation/Speed" metrics are available only if a Running Wheel is registered as an add-on to the cage.

All other metrics can be applied regardless of the cage content. The final section of this manual provides detailed information on how each metric is calculated.



Specific metrics utilise the DVC® board electrodes as individual data points, allowing for a more detailed analysis. For these metrics, you have the option to refine your analysis further by selecting specific electrodes to include in the calculations:



By default, all the electrodes are always selected. Moreover, the advanced option called "Frontality" applies the following calculation:

$$\frac{avg(front)}{[avg(front) + avg(rear)]}$$

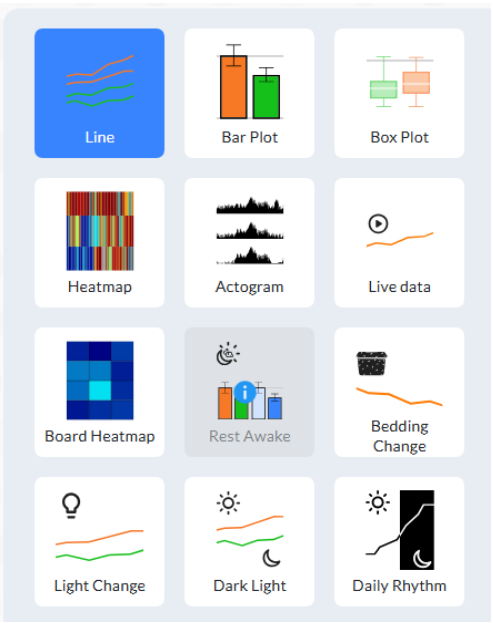
Where the:

- Frontal electrodes are  (electrodes # 7-8-9-10-11-12)
- Rear electrodes are  (electrodes # 1-2-3-4-5-6)

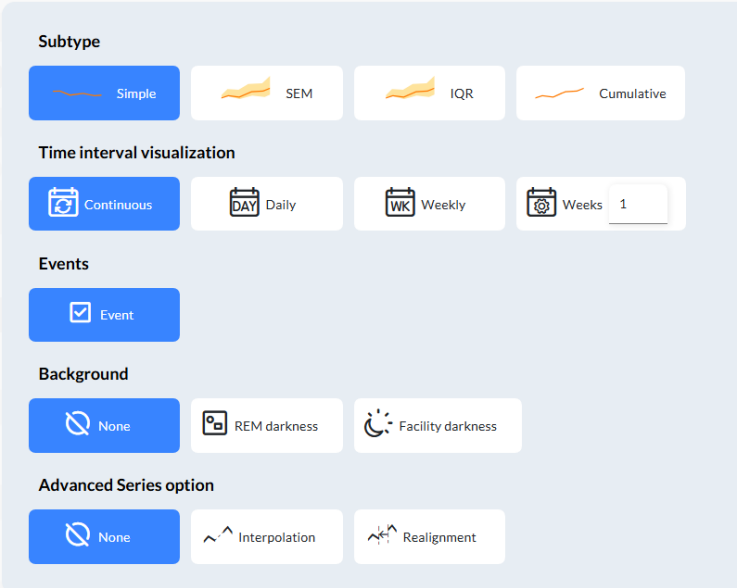
Please pay attention to the fact that, to properly select any metric, you have to click the corresponding box:

3.4 Charts Selection

Once you have selected the desired metric(s), the next step is to choose how to visualize the corresponding data. There are several visualization options available to help you interpret and present the data effectively:



The Line plot is a straightforward visualisation option with various subtypes and other options to enhance data interpretation:



Subtypes:

- **Simple:** Displays a continuous line representing data points collected by the DVC® system throughout the selected interval.
- **SEM (Standard Error of the Mean):** Features a continuous line with an overlay of the SEM, available only for groups with multiple cages.
- **IQR (Interquartile Range):** Shows a continuous line with overlays of the 2nd and 3rd quartile limits, also available only for groups with multiple cages.
- **Cumulative:** Summarizes all data to show a cumulative progression over time within the specified interval

Time Interval of Visualization:

- **Continuous:** Displays data continuously across the chosen time interval.
- **Daily:** Generates seven distinct graphs, one for each day of the week. For intervals exceeding one week, multiple lines represent each weekday repeatedly.
- **Weekly:** Produces a single graph with multiple lines, each representing a week within the selected period.
- **Weeks:** Allows for the creation of weekly graphs tailored to the number of weeks chosen.

Events:

- **(DVC® and manual) Events:** Can be included to show occurrences within the timeline.

Background:

- **None:** Applies no background lighting effects.
- **REM Darkness:** Uses actual light conditions if the REM system is installed, reflecting actual light/dark cycles.
- **Facility Darkness:** The background reflects the dark/light settings of the facility.

Advanced Series and Options:

- **None:** Standard visualisation without additional modifications.
- **Interpolation:** Connect the data points for a clearer trend line.
- **Realignment:** Move the data points to recreate a continuous line.

Moreover, there are multiple other charts:

Bar Plot: This plot uses rectangular bars to represent data, with the height of each bar corresponding to the value of the data in the selected interval.

Box Plot: Displays the standard five-number summary (minimum, first quartile, median, third quartile, and maximum) of a dataset for a selected aggregated interval.

Heatmap: This chart aggregates data daily, with each line representing 24-hour data. Each data point corresponds to the selected "Data Time Aggregation" (hour, minute, custom), and the data are colour-coded from blue (low values) to red (high values).

Actogram: Data are aggregated daily, with each line representing 24-hour data and each point corresponding to minute aggregation. The height of each line is proportional to the data value collected.

Live Data: A simple line plot that displays the last 15, 30 or 60 minutes and is updated every minute. This is applicable only if the selected cage is active in the DVC® system.

Board Heatmap: Visualizes the magnitude of a metric colour-coded for each corresponding electrode on the DVC® board, with each board reflecting a different time interval (week, day, or custom).

Rest-wake Charts: Shows 2 different histograms with the wake and rest bout distribution across system-defined duration intervals. Rest

Bedding Change Response: A line chart that spans a user-defined minute period following a bedding change event. If the analysis period includes multiple bedding change events, the chart displays the average of the events.

Light Change Response: This consists of two line charts spanning a user-defined minute period following the lights on and lights off events, per Facility Settings. If the analysis period includes multiple lights on/off events, the chart displays the average of these events.

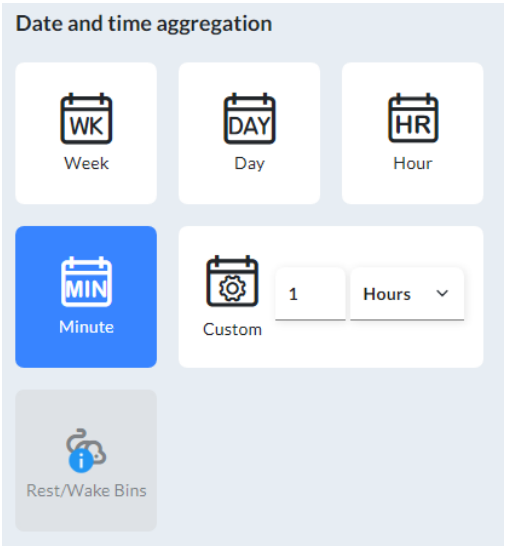
Light/Dark: Shows two continuous lines, one for the light phase and one for the dark phase of the selected period, each point representing the metric value in the aggregated time interval.

Daily Rhythm: Displays a single 24-hour cycle, minute by minute, of the selected metric across the overall selected analysis period. Each data point is the smoothed average of all identical time-of-day data points from all included days, illustrating an animal's circadian pattern. This is available only with the activity metric selected.

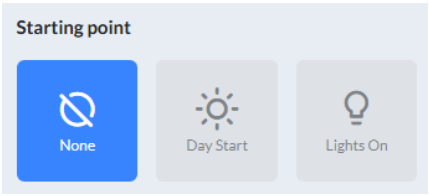
These different visualisations are designed to offer comprehensive insights into the data collected, allowing for precise analysis and interpretation of various metrics and events.

3.5 Data aggregation selection

Based on prior selections, data can be aggregated in several ways, including by minute, hour, day, week, or using custom intervals or variables (such as Rest-Wake histogram bins). The available selections depend on the previous metrics and charts that have been selected.

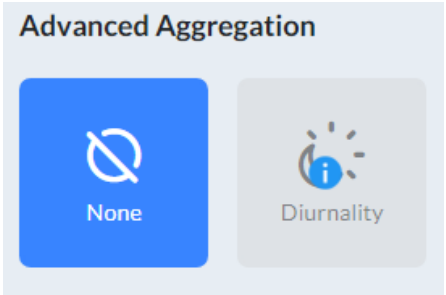


Additionally, for specific charts, it's necessary to specify the starting point for the data time aggregation. By default, no starting point time is applied.



The starting point varies depending on the chart selected. For instance, if the Heatmap visualisation is selected, you have the option to start the aggregation from "Day Start" (i.e., midnight) or from "Lights On" (as set in the Facility settings). However, no specific starting point is required if a Simple Line chart is selected. This flexibility allows for tailored visualisation and analysis, enhancing the interpretation of the aggregated data based on the research needs.

Finally, more detailed aggregation options include a new feature called diurnality, which is available only when "Day" or "Week" aggregation is chosen.



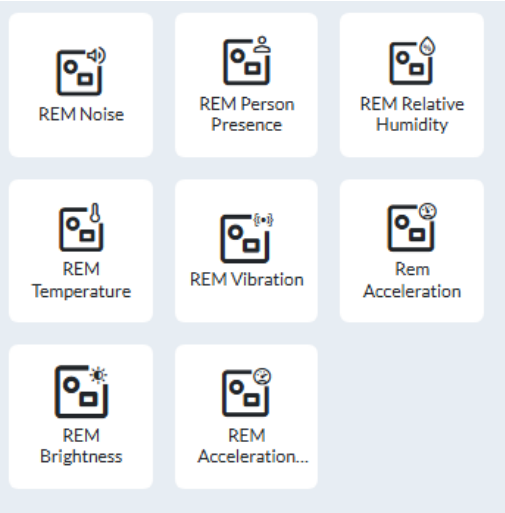
This function calculates the average activity during light and dark periods using the formula:

$$avg(light) * \frac{nsamples(light)}{[avg(light) * nsamples(light) + avg(dark) * nsamples(dark)]}$$

This specific advanced aggregation would be significant for exploring potential deviating patterns occurring during the daylight phase.

3.6 REM Selection

This is an optional section. Depending on your previously performed metrics, charts, and data aggregation selections, you can enable the REM data to be displayed.



A detailed explanation of the various thresholds and metrics used in the REM are the following:

Noise: Measures noise levels within a range of 35 to 112 dB with an accuracy of ± 5 dB. It calculates the maximum noise peak over a 60-second interval.

Temperature: Monitors temperature within a range of -10°C (14°F) to 85°C (185°F) with an accuracy of ±0.4°C (±0.7°F), calculating the maximum temperature value in a 60-second period.

Brightness: Gauges brightness levels from 0 to 120k lux with an uncertainty of ±10 lux, computing the average value over a 60-second span.

Person Presence: Represents the count of detected events, one every sec, normalized over a 60-second interval, likely indicating human activity or movement within the environment.

Vibration: Reports the highest peak of vibration measured in PGA (Peak Gravity Acceleration) within a 60-second window.

Acceleration (max): Captures the maximum acceleration event detected in a 60-second timeframe, expressed in mm/sec^2.

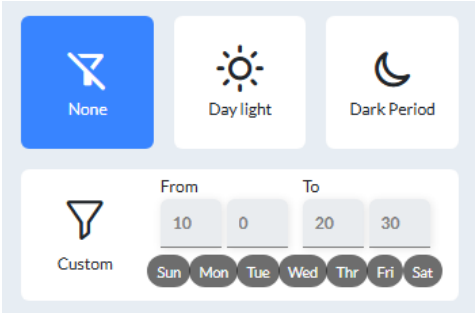
Relative Humidity: Tracks humidity within a range of 0 to 80% RH with a 3% margin of error, calculating the average value every 60 seconds.

Acceleration: Reports the average acceleration event detected over a 60-second interval, also expressed in mm/sec^2.

Please pay attention to the fact that Vibration refers to a metric provided by an older than year 2020 REM device and Acceleration(s) are provided by newer REMs.

3.7 Day Filtration

This is an optional section. Depending on your previously performed metrics, charts, and data aggregation selections, you can enable the DAY FILTRATION data to be displayed.

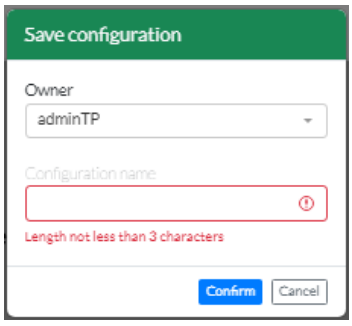


More specifically, you can select to apply a temporal filtration to the data and display only “Day Light” or “Dark Period” data, or even more customised, a specific period of hours and days.

3.8 Save configuration

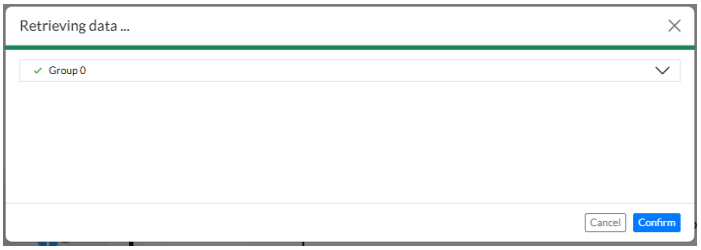
Once you are happy with your selections, you can easily save your specific settings for future use by clicking the "Save" button.

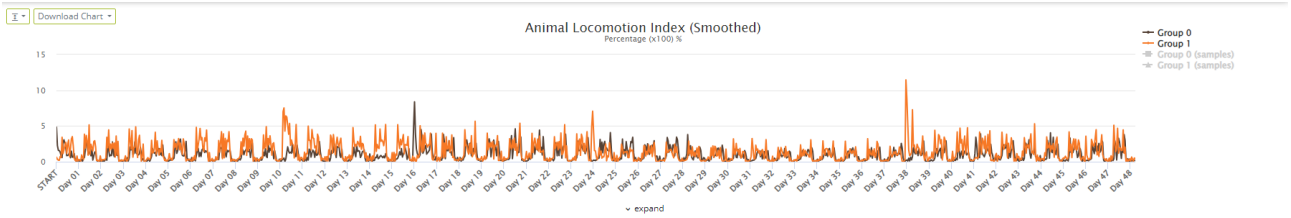
You must name and assign it to a specific Owner who can only use it (or delete it).



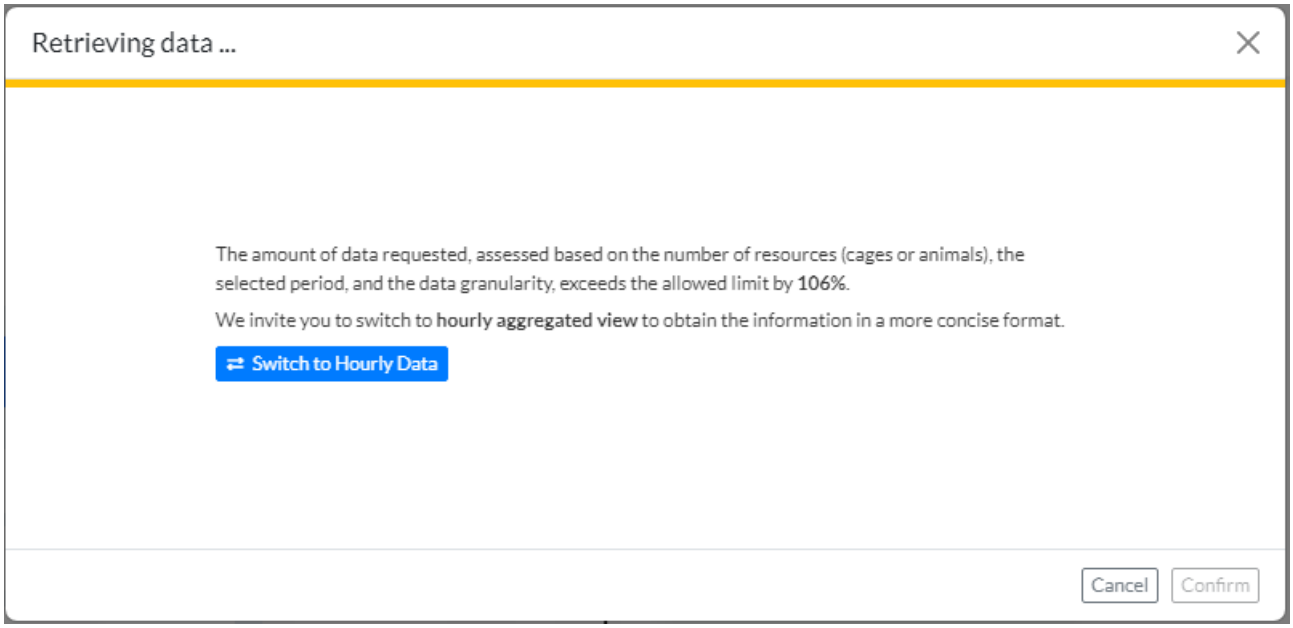
3.9 Visualize the analysis.

To run the analysis based on your specific multiple settings, click the icon Visualize and the corresponding data and charts are displayed:





Suppose the request is too big to be displayed (for instance, aggregation by minute of several months). In that case, the system proposes to switch to a more considerable aggregation period (for example, by hour) or directly download the data:



The current limit of data to be retrieved for visualization in the system is based on the following limits:

The calculation is performed for each group using the following formula:

$$w = \text{number of resources} \times \text{requested duration (in minutes)}$$

There are two thresholds:

- **When aggregation is set to minute-level: LIMIT1 = 450 days/resources.** For instance, 30 days × 15 resources.
- **When aggregation is set to hour-level: LIMIT2 = 1.350 days/resources.** For instance, 90 days × 15 resources.

Minute-Level Aggregation:

- If w > LIMIT2, download the data instead.
- If LIMIT2 > w > LIMIT1, switch to hourly aggregation instead.

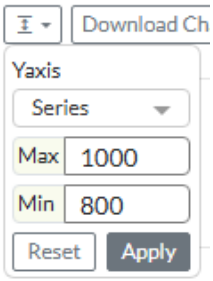
Otherwise, the request is valid.

Hour-Level Aggregation:

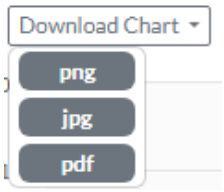
- If w > LIMIT2, download the data instead.
- Otherwise, the request is valid.

3.10 Extra functionalities of the chart

In some cases, for some charts, it is possible to resize the Y-axis, by selecting the "Series," clicking the corresponding button , then inserting the value and clicking "Apply":



For any displayed chart, it is possible to download it in high resolution by clicking and selecting the proper format:

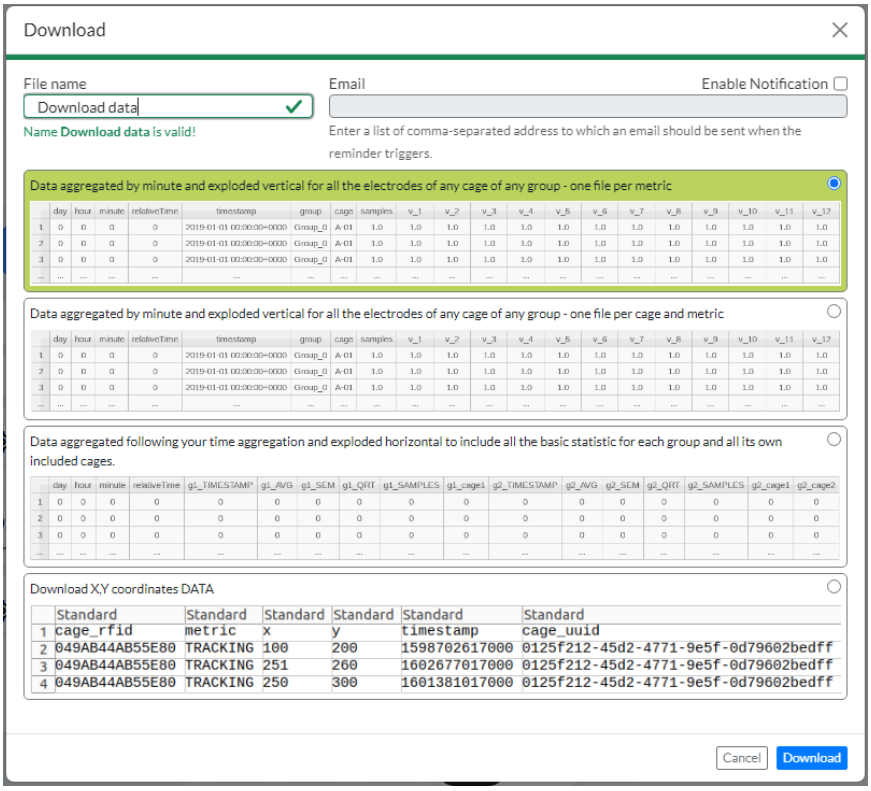


For specific charts, you can zoom in by clicking on the desired position within the chart and holding down the left mouse button, dragging it across the area you wish to enlarge. To reset the zoom level back to the original view, click the reset icon Reset zoom associated with the zoomed graph. Additionally, if you need a closer look at any part of the graph for more detailed analysis, you can enlarge the entire chart by clicking the icon located below the chart .

3.11 Prepare Download

When all the selections have been performed, it is also possible to prepare the download of the corresponding selected data.

Clicking on the icon Download it is then possible to choose between three different options:



Type 1 (Upper Choice): Data is aggregated and presented in vertical sequential order by minutes or hours across all group cage electrodes. One file is generated for each metric, incorporating all cages in the global selection. The file includes columns for:

- **Day:** The day since the start date of observation.
- **Hour:** The hour of the day (1-24).
- **Minute:** The minutes of that hour (1-60).
- **Relative Time:** The absolute time in seconds from the previous midnight of the starting date.
- **Timestamp:** The absolute timestamp in Coordinated Universal Time (UTC).
- **Group:** The name of the group.
- **Cage:** The name of the cage within the selected group.
- **Samples:** The number of samples collected within the specified timeframe, indicating potential data loss due to cage removal.
- **V_1/2/3/.../12:** Values of the selected metrics for each electrode on the DVC® board (if available by the metric).

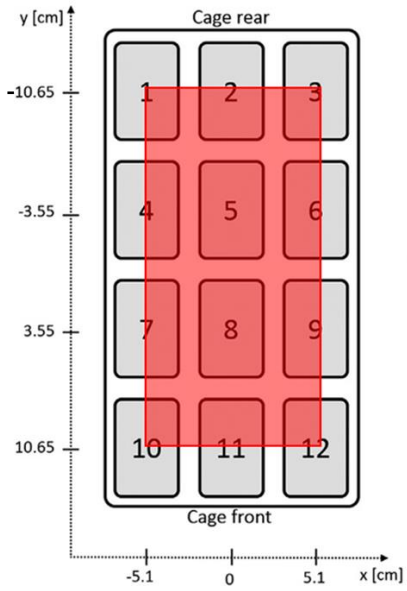
Type 1-bis (Middle - Upper Choice): This format mirrors Type 1 but splits the data into multiple files—one for each cage and metric. This format is beneficial for lengthy observation periods spanning several months or years.

Type 2 (Middle - Lower Choice): Data is horizontally aggregated according to your chosen time aggregation and includes essential statistics for each group and its cages. The file structure features columns for:

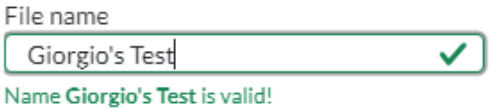
- **Day, Hour, Minute, Relative Time:** Similar to Type 1.
- **g1_TIMESTAMP, g2_TIMESTAMP:** Absolute UTC timestamps for groups 1 and 2.

- **g1_AVG, g2_AVG:** Metric averages for groups 1 and 2.
- **g1_SEM, g2_SEM:** Standard errors for groups 1 and 2.
- **g1_QRT, g2_QRT:** Quartiles for groups 1 and 2 [Minimum, Lower Quartile, Median, Upper Quartile, Maximum].
- **g1_SAMPLES, g2_SAMPLES:** The total samples collected, providing insights into potential data disruptions from cage removal.
- **g1_cage1, g2_cage1, g2_cage2:** Metric averages for the first and second cages in groups 1 and 2, respectively.

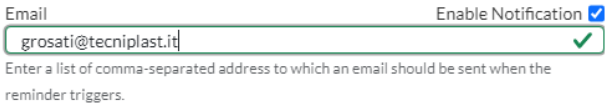
Type 3 (Lower Choice): This format is available only when selecting one or more resources that support individual tracking features (i.e., one animal per cage). The downloaded data consists of raw x-y coordinates of the trajectory, as calculated by the DVC board for the chosen resource within the selected timeframe. These coordinates correspond to the spatial representation of the DVC board shown below.:

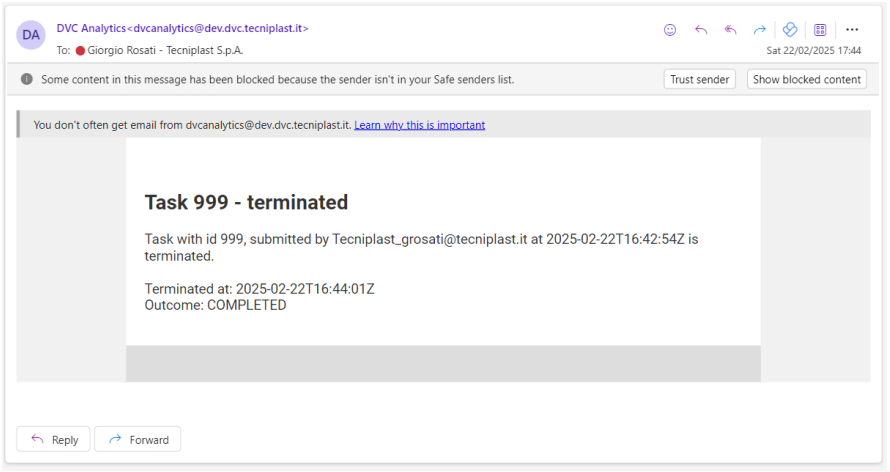


Then, to start preparing the download, you must fill in the File name section to activate the Download button.

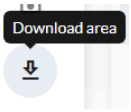


Additionally, you can enable notifications to complete download tasks. Click on the corresponding icon and enter your email address in the provided field to receive alerts when the download is complete.

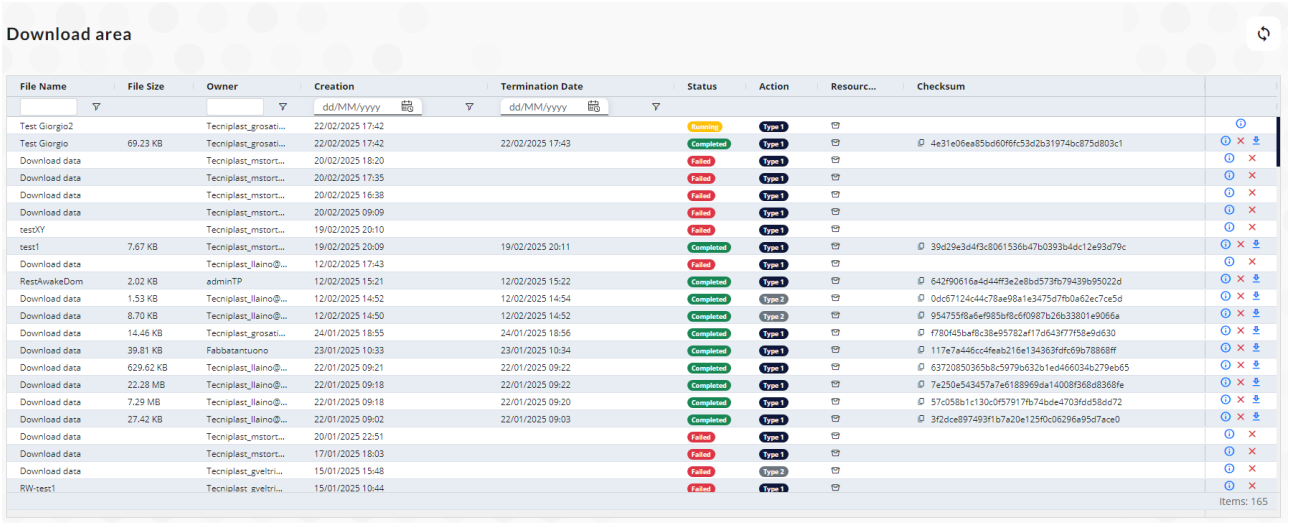




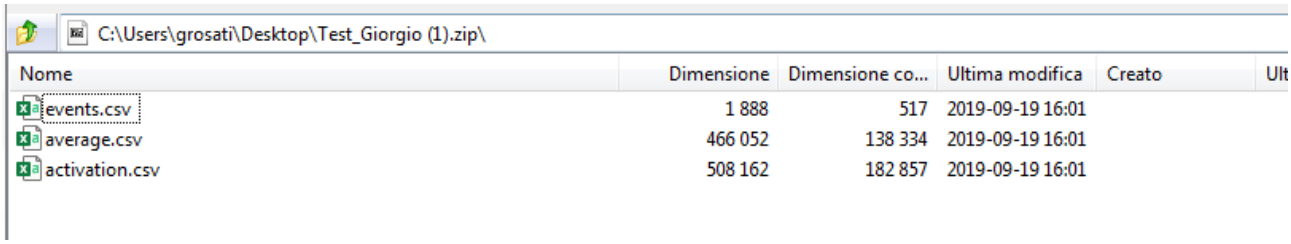
PLEASE NOTE: you will find the "Downloaded data" in the dedicated section called Download Area

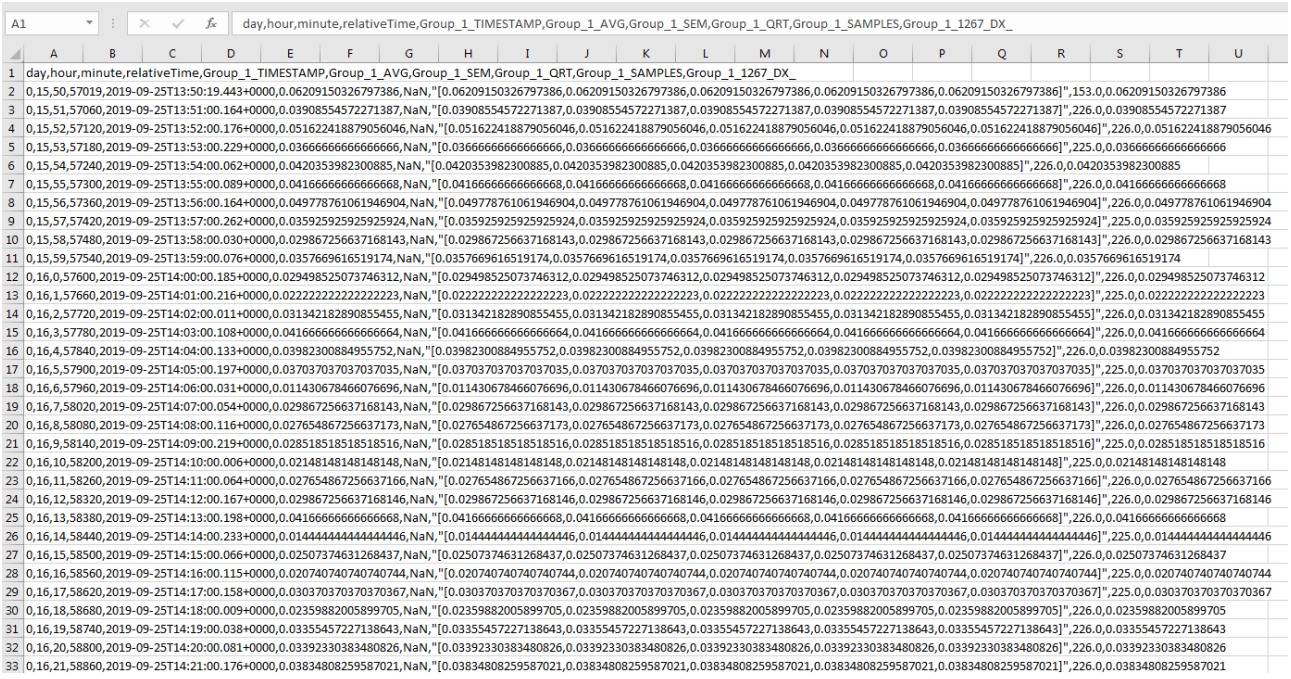


You can finally download the data on your PC by clicking the icon or delete it.



The file you download is a .zip archive that contains multiple .csv files, each representing a different metric you selected earlier. For example, suppose you chose the Bedding Status Index, Animal Locomotion Index, and DVC events. In that case, there will be a separate .csv file for each of these metrics: one for average values, one for activation levels, and one for event data, respectively. Each file is formatted as a comma-separated value (CSV) document, making it easy to import and analyse in various data processing applications.





	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	day,hour,minute,relativeTime,Group_1_TIMESTAMP,Group_1_AVG,Group_1_SEM,Group_1_QRT,Group_1_SAMPLES,Group_1_1267_DX_																				
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4	0,15,52,57120,2019-09-25T13:52:00.176+0000,0.051622418879056046,NaN,"[0.051622418879056046,0.051622418879056046,0.051622418879056046,0.051622418879056046]",226.0,0.051622418879056046																				
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6	0,15,54,57240,2019-09-25T13:54:00.062+0000,0.0420353982300885,NaN,"[0.0420353982300885,0.0420353982300885,0.0420353982300885,0.0420353982300885]",226.0,0.0420353982300885																				
7	0,15,55,57300,2019-09-25T13:55:00.089+0000,0.04166666666666668,NaN,"[0.04166666666666668,0.04166666666666668,0.04166666666666668,0.04166666666666668]",226.0,0.04166666666666668																				
8	0,15,56,57360,2019-09-25T13:56:00.164+0000,0.049778761061946904,NaN,"[0.049778761061946904,0.049778761061946904,0.049778761061946904,0.049778761061946904]",226.0,0.049778761061946904																				
9	0,15,57,57420,2019-09-25T13:57:00.262+0000,0.035925925925925924,NaN,"[0.035925925925925924,0.035925925925925924,0.035925925925925924,0.035925925925925924]",225.0,0.035925925925925924																				
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11	0,15,59,57540,2019-09-25T13:59:00.076+0000,0.0357669616519174,NaN,"[0.0357669616519174,0.0357669616519174,0.0357669616519174,0.0357669616519174]",226.0,0.0357669616519174																				
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13	0,16,1,57660,2019-09-25T14:01:00.216+0000,0.022222222222222223,NaN,"[0.022222222222222223,0.022222222222222223,0.022222222222222223,0.022222222222222223]",225.0,0.022222222222222223																				
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18	0,16,6,57960,2019-09-25T14:06:00.031+0000,0.011430678466076696,NaN,"[0.011430678466076696,0.011430678466076696,0.011430678466076696,0.011430678466076696]",226.0,0.011430678466076696																				
19	0,16,7,58020,2019-09-25T14:07:00.054+0000,0.029867256637168143,NaN,"[0.029867256637168143,0.029867256637168143,0.029867256637168143,0.029867256637168143]",226.0,0.029867256637168143																				
20	0,16,8,58080,2019-09-25T14:08:00.116+0000,0.027654867256637173,NaN,"[0.027654867256637173,0.027654867256637173,0.027654867256637173,0.027654867256637173]",226.0,0.027654867256637173																				
21	0,16,9,58140,2019-09-25T14:09:00.219+0000,0.028518518518518516,NaN,"[0.028518518518518516,0.028518518518518516,0.028518518518518516,0.028518518518518516]",225.0,0.028518518518518516																				
22	0,16,10,58200,2019-09-25T14:10:00.006+0000,0.021481481481481481,NaN,"[0.021481481481481481,0.021481481481481481,0.021481481481481481,0.021481481481481481]",225.0,0.021481481481481481																				
23	0,16,11,58260,2019-09-25T14:11:00.064+0000,0.027654867256637166,NaN,"[0.027654867256637166,0.027654867256637166,0.027654867256637166,0.027654867256637166]",226.0,0.027654867256637166																				
24	0,16,12,58320,2019-09-25T14:12:00.167+0000,0.029867256637168146,NaN,"[0.029867256637168146,0.029867256637168146,0.029867256637168146,0.029867256637168146]",226.0,0.029867256637168146																				
25	0,16,13,58380,2019-09-25T14:13:00.198+0000,0.04166666666666668,NaN,"[0.04166666666666668,0.04166666666666668,0.04166666666666668,0.04166666666666668]",226.0,0.04166666666666668																				
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27	0,16,15,58500,2019-09-25T14:15:00.066+0000,0.02507374631268437,NaN,"[0.02507374631268437,0.02507374631268437,0.02507374631268437,0.02507374631268437]",226.0,0.02507374631268437																				
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29	0,16,17,58620,2019-09-25T14:17:00.158+0000,0.030370370370370367,NaN,"[0.030370370370370367,0.030370370370370367,0.030370370370370367,0.030370370370370367]",225.0,0.030370370370370367																				
30	0,16,18,58680,2019-09-25T14:18:00.009+0000,0.02359882005899705,NaN,"[0.02359882005899705,0.02359882005899705,0.02359882005899705,0.02359882005899705]",226.0,0.02359882005899705																				
31	0,16,19,58740,2019-09-25T14:19:00.038+0000,0.03355457227138643,NaN,"[0.03355457227138643,0.03355457227138643,0.03355457227138643,0.03355457227138643]",226.0,0.03355457227138643																				
32	0,16,20,58800,2019-09-25T14:20:00.081+0000,0.03392330383480826,NaN,"[0.03392330383480826,0.03392330383480826,0.03392330383480826,0.03392330383480826]",226.0,0.03392330383480826																				
33	0,16,21,58860,2019-09-25T14:21:00.176+0000,0.03834808259587021,NaN,"[0.03834808259587021,0.03834808259587021,0.03834808259587021,0.03834808259587021]",226.0,0.03834808259587021																				

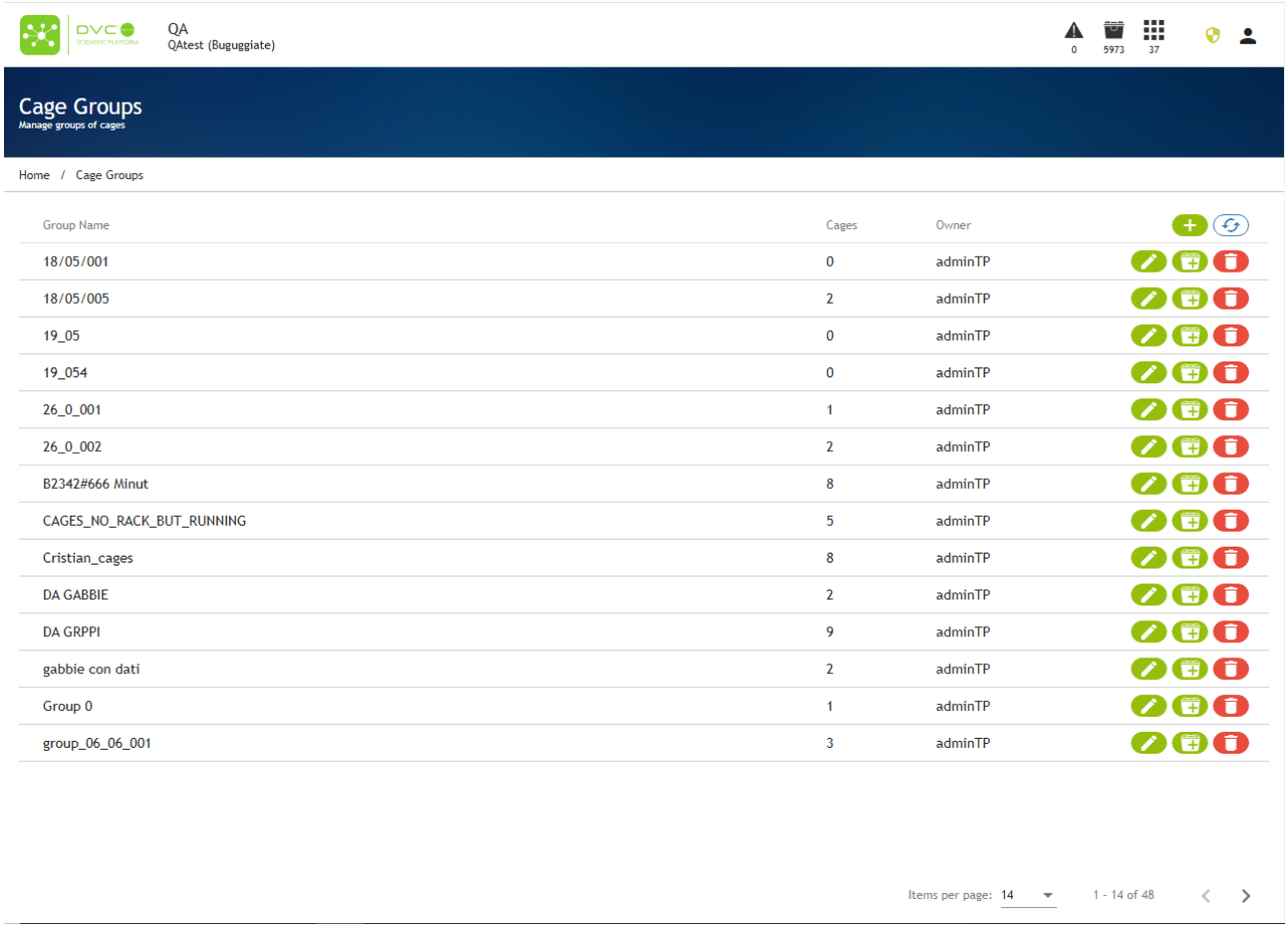
PLEASE NOTE: TIMESTAMP are produced in UTC (https://en.wikipedia.org/wiki/Coordinated_Universal_Time). If you use MS Excel to open these files, remember to set the "." as the decimal separator.

4 Manage Experiment

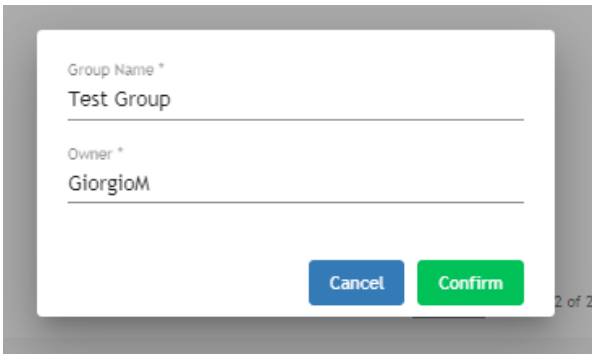
The section "Manage Experiment" contains several options:

4.1 Cage Groups

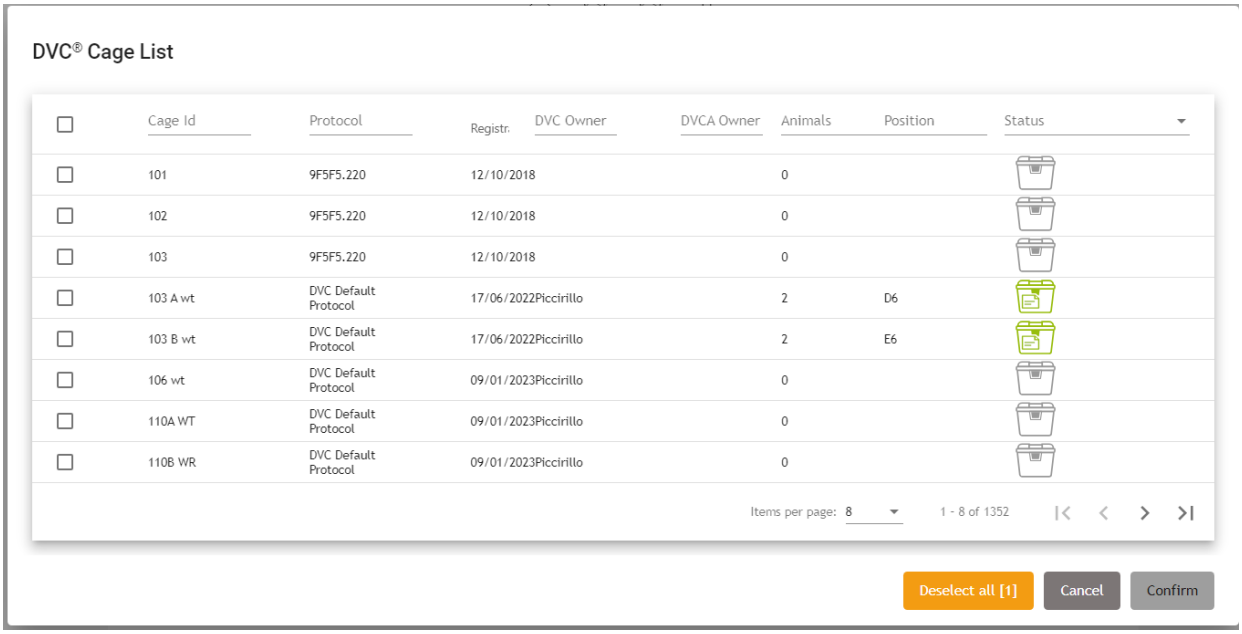
In this section, it is possible to create specific groups of cages and assign them to (already) existing DVC® Analytics users.



The first step is to create the group by clicking the corresponding icon +. A pop-up area appears, and you are requested to insert the group's name and owner.



Then, you can add cages to this group by clicking on the icon / and selecting the cages to be included.

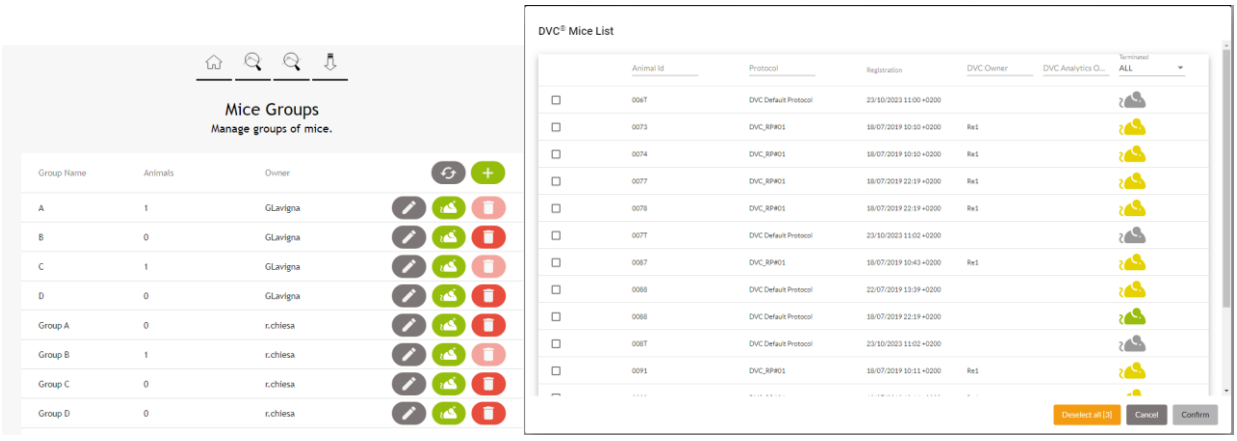


PLEASE NOTE: The same cage(s) can be assigned to different groups.

PLEASE NOTE: to delete a group, you must deselect all the cages before being able to delete the Cage Group with the corresponding icon .

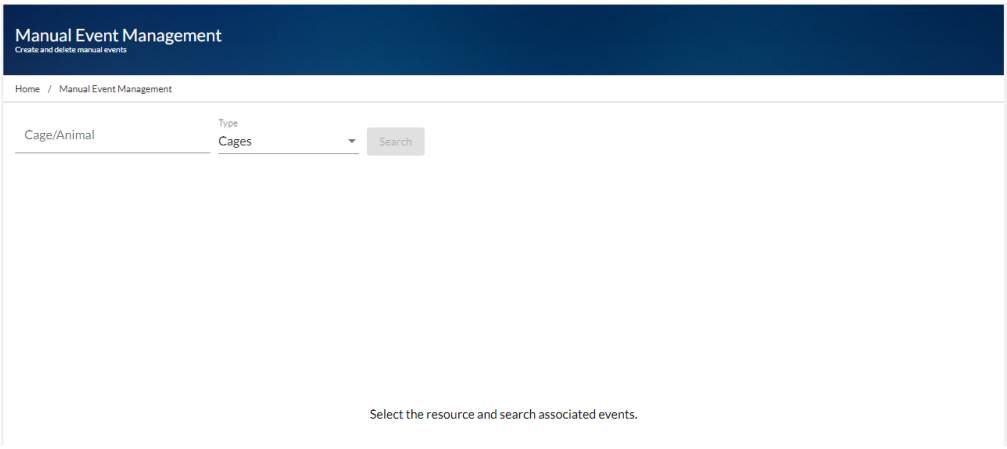
4.2 Mice groups

To create a Mouse group, please follow the previous workflow, with the only difference being that you must choose between available mouse IDs (instead of cage IDs).

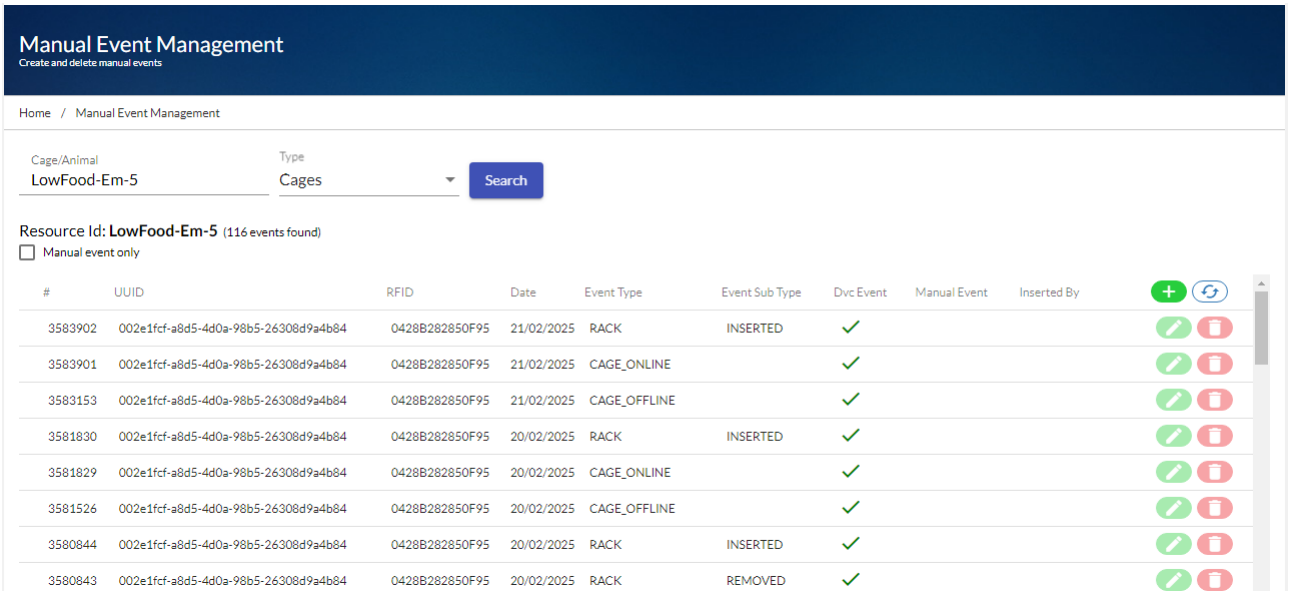


4.3 Manual Event Management

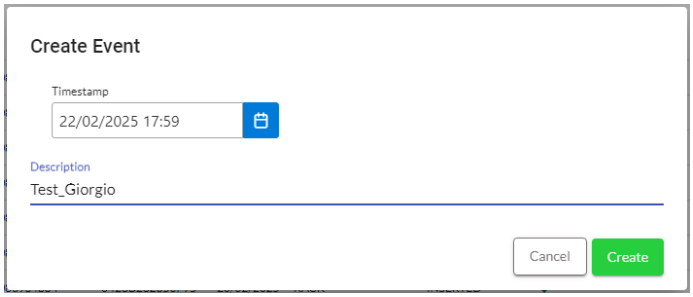
The DVC® events are generated automatically by using the DVC® system in the animal room. But now, generating "custom" events by entering them into this section is also possible.



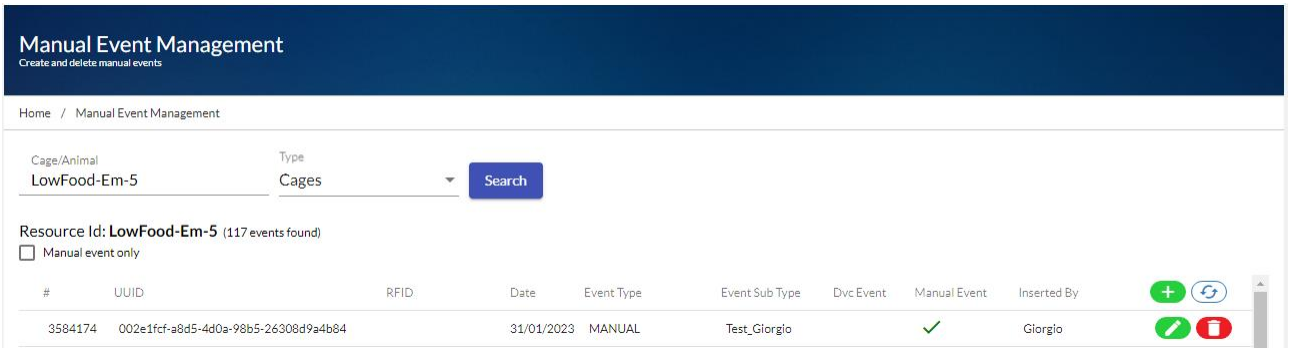
Step 1 is to Search for the specific resource to apply the manual event; it is possible to create it manually (and look for all the ones generated by the DVC®). It is also possible to generate an event to be added to the entire Resource Group:



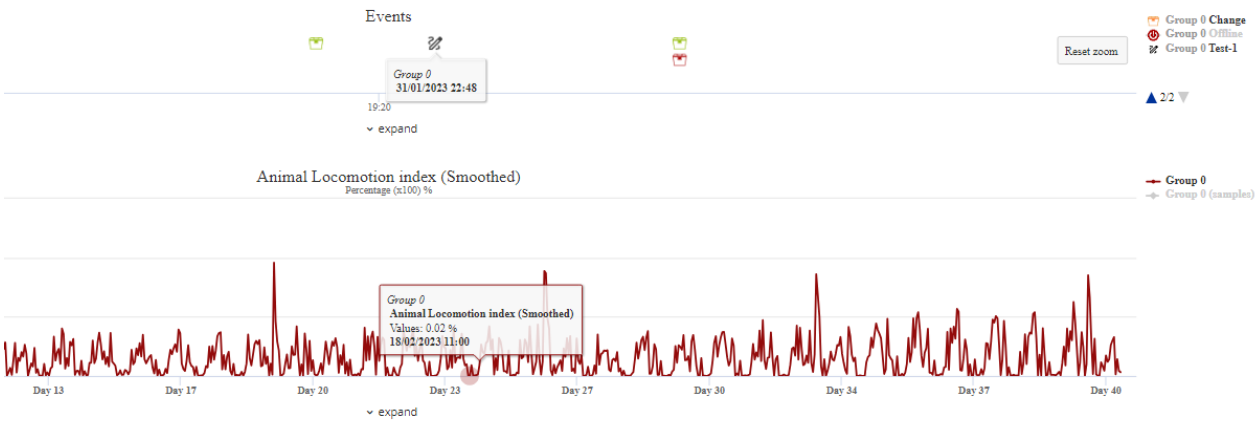
By clicking the + button, a specific pop-up appears where you can provide the name of the manual event and its timestamp.



PLEASE NOTE: you can only edit or delete Manual events (not the DVC®'s ones):

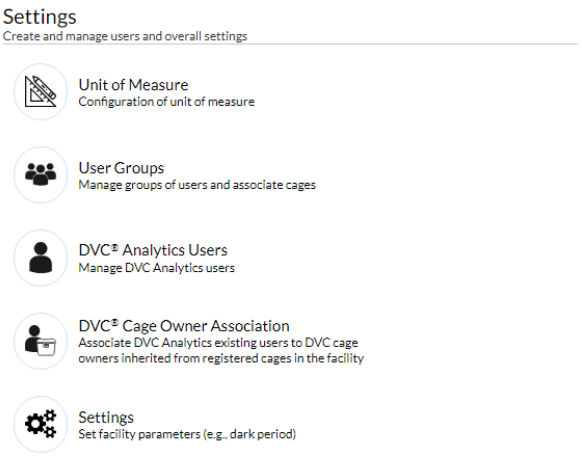


This generates the corresponding icon on the timeline of the events in the chart of the data



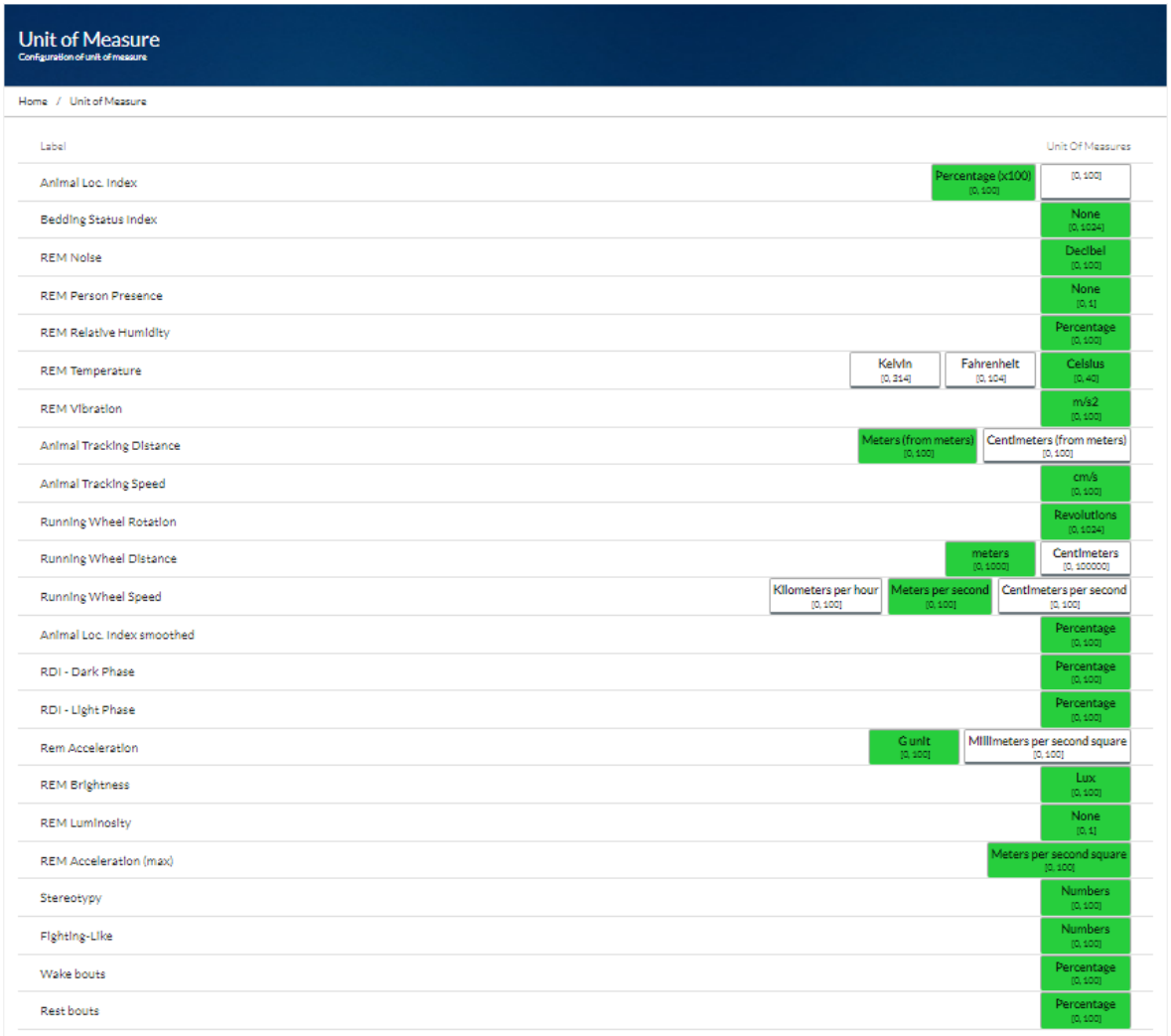
5 Settings

As described in section 2.1, this section is available only for the DVC® Analytics users registered as Facility Managers and not available to the users registered as Researchers. There are different options you can set.



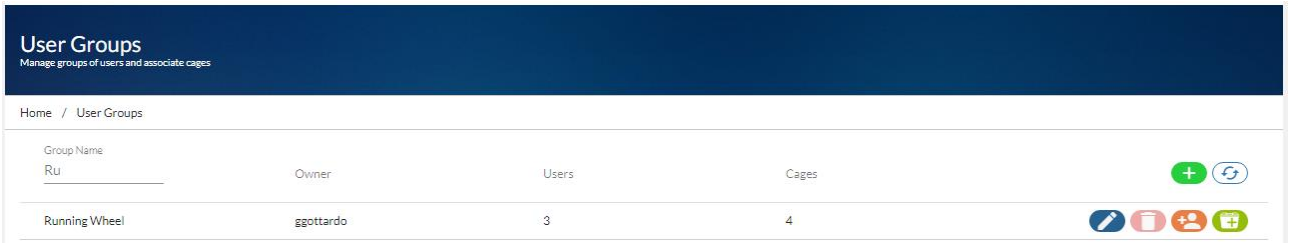
5.1 Unit of Measure

By clicking on the corresponding button, you can view your current settings, which are set by default, and change some of them if needed.

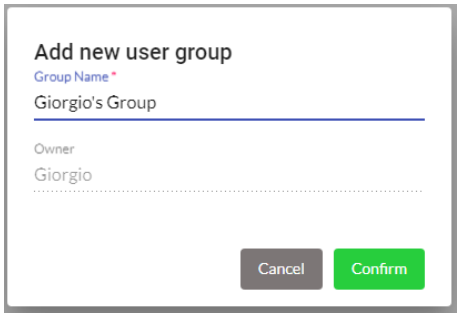


5.2 User Groups

This functionality allows a group of DVC® Analytics users to access a selected number of available cages.

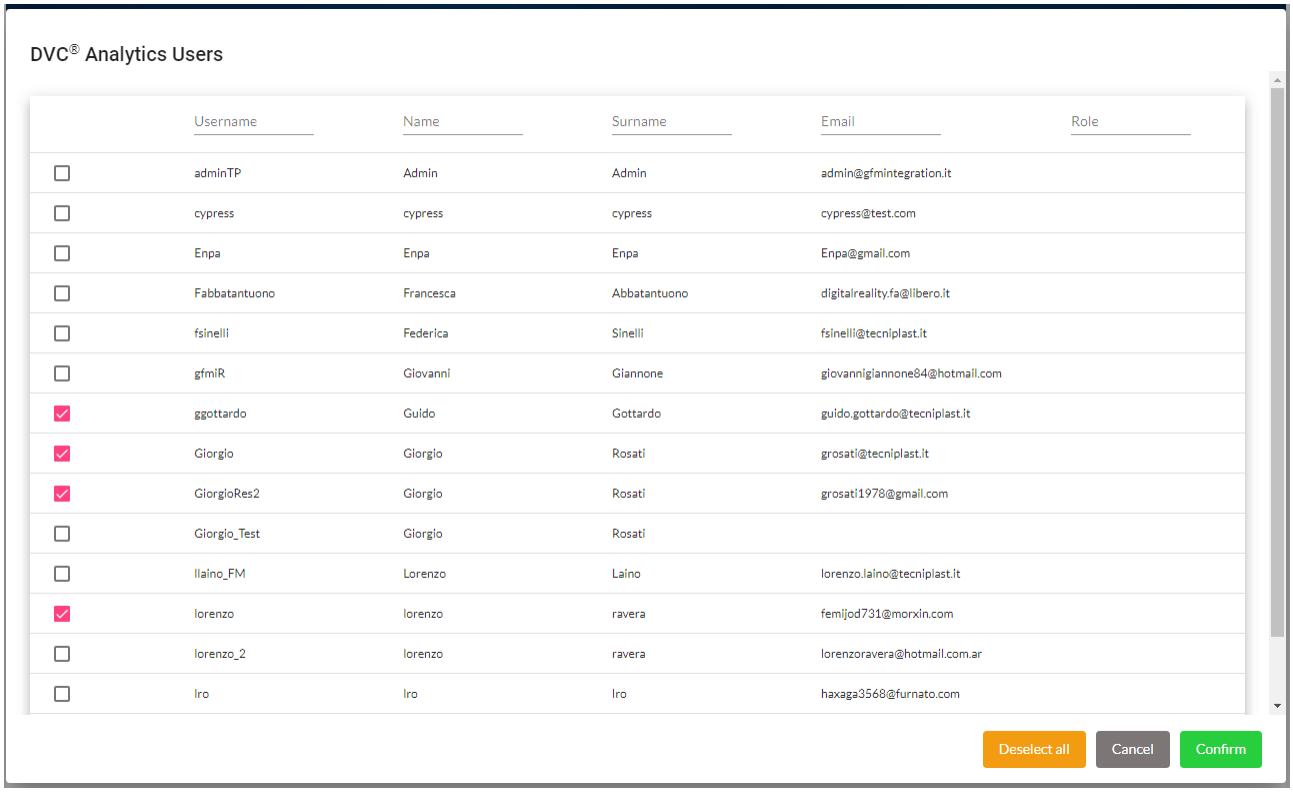


Everything starts by creating the new Group by assigning the name and the owner of this new group:



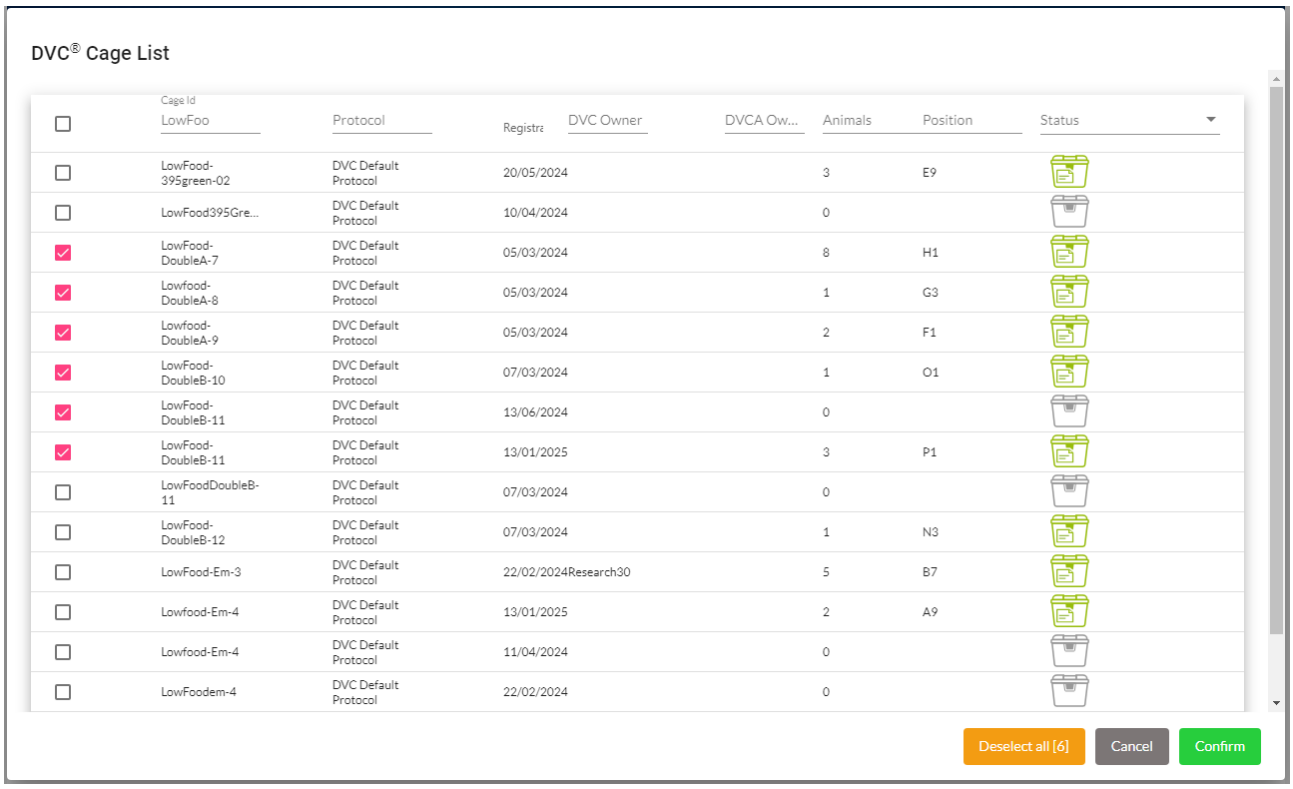
Then, by clicking the button 

, it is possible to add multiple existing users:



And finally, by clicking the icon 

, the cages become available to the group:

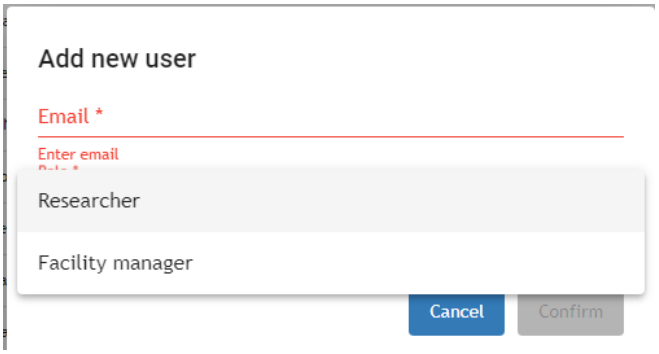


PLEASE NOTE: to delete a user group, you must deselect all the users and all the cages from the User group.

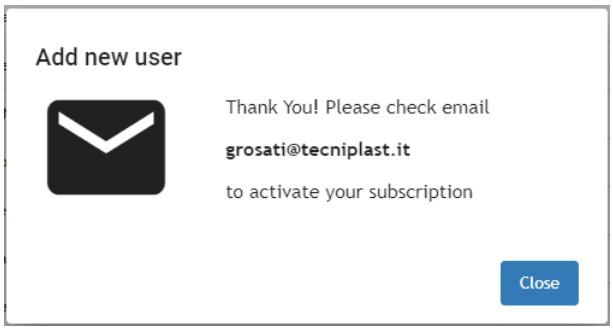
5.3 DVC® Analytics Users

Leveraging the already existing AMAZON cloud service, we implemented a critical package called Amazon COGNITO to manage user credentials securely.
(https://docs.aws.amazon.com/cognito/latest/developerguide/what-is-amazon-cognito.html).
Thanks to this functionality, now the process of a new user registration follows the below steps:
You can create unlimited users by clicking the corresponding icon  .

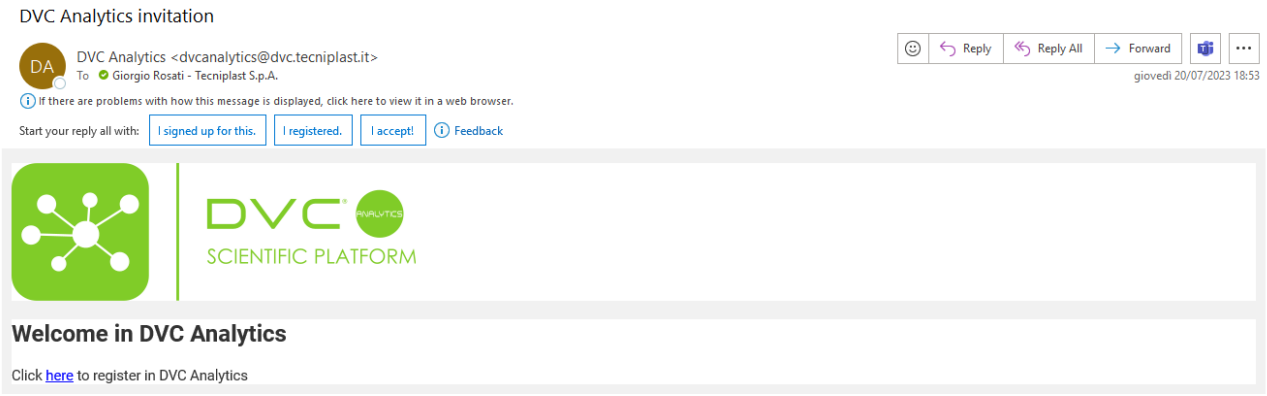
In this window, you must enter the email address of the new User and the "Role" ("Researcher" or "Facility manager"):



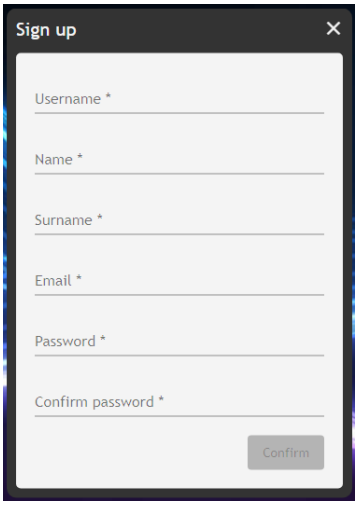
Once you "Confirm" the information, an invitation email is sent to the new User.



The new User receives the email and must click "here" to properly register in the DVC® Analytics.

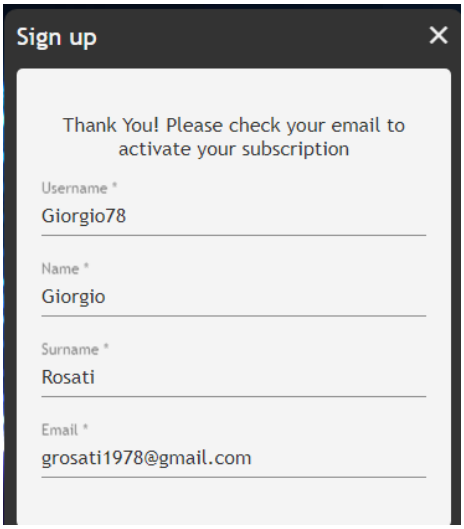


The new User is redirected to the DVC® Analytics registration page, where credential pieces of information are requested:



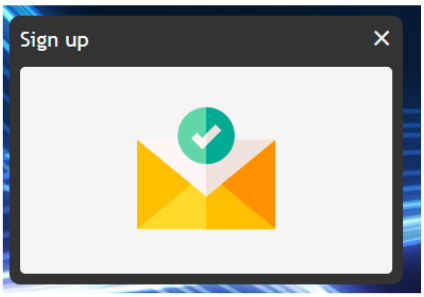
Remember that the password has some requirements: "**Use min 8 characters or more, minimum one number and one symbol and minimum one special symbol as [@$!%*?&~()_{}|:"<>,€]**"

Once all the information is inserted, you can click "Confirm", and a confirmation pop-up appears.



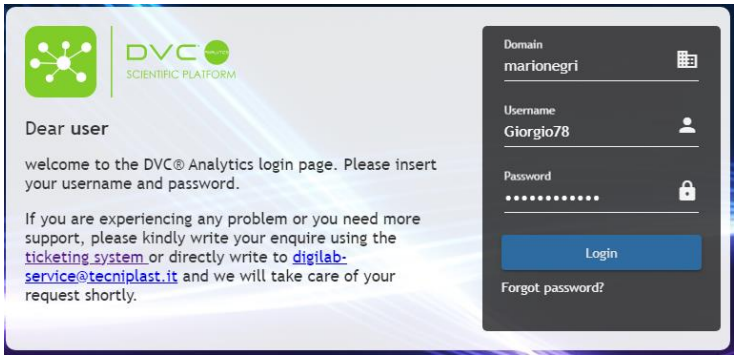
It is time to validate the email entered for the new User (that can be different compared to the invitation email). A confirmation email has been sent to the new User, who must accept it to confirm the email address (this is important for password recovery).

Clicking "here", the process of new user authentication is completed and confirmed.

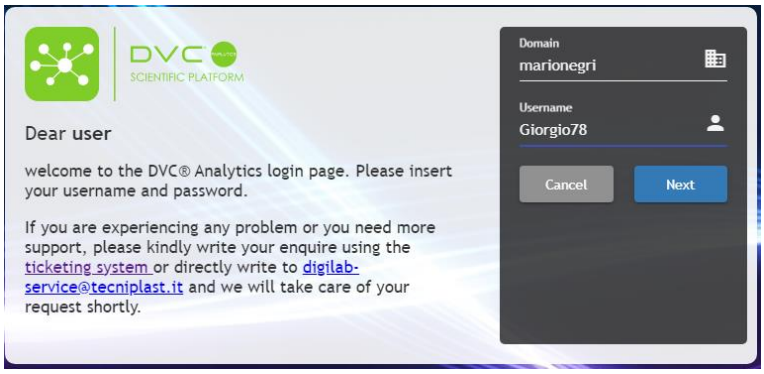


The new User can now finally log in to the DVC® Analytics platform.

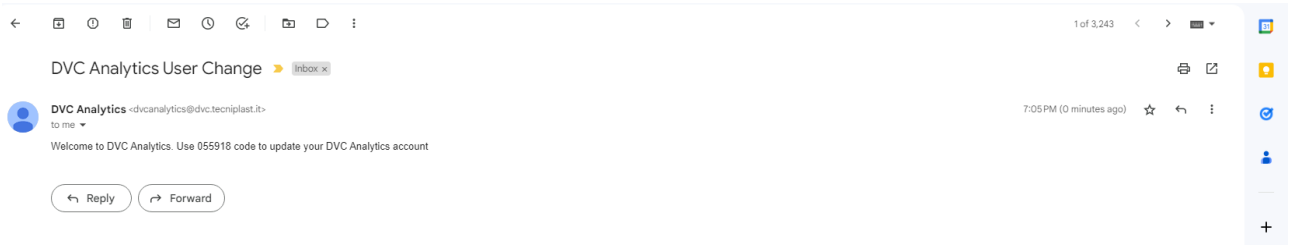
In case any user has lost credentials, it is possible to click on the corresponding section "Forgot password?" on the login page:



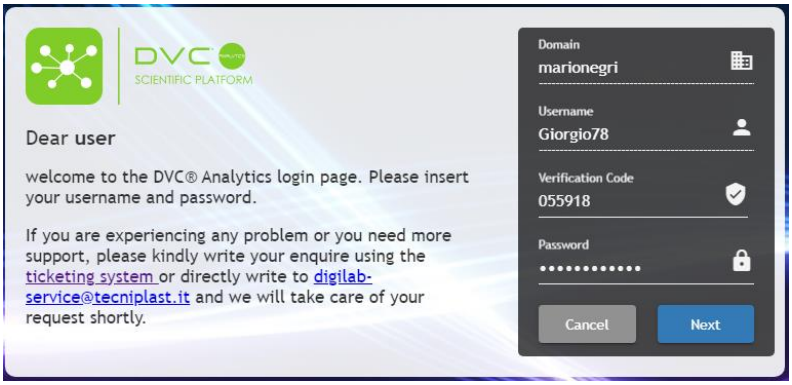
The User must enter the Username and then click "Next":



A "Verification Code" is sent to the email address of the User:

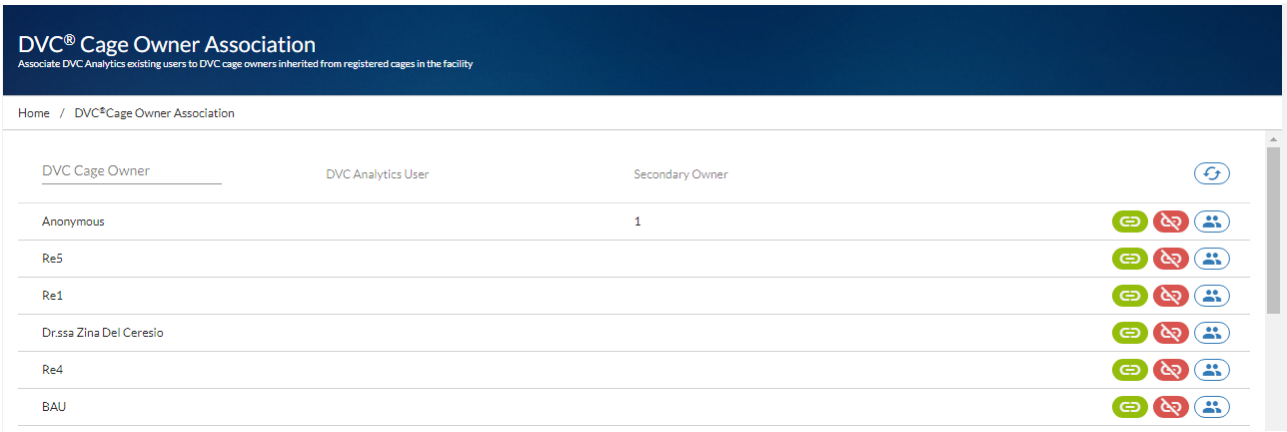


Inserting it in the corresponding field altogether with a new (valid) password, then clicking on "Next", the User can finally login again (with the new password):



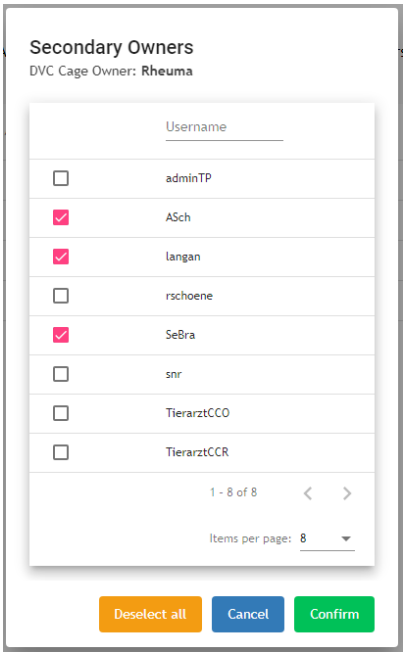
5.4 DVC® Cage Owner Association

This section is fundamental, especially if you have "Researcher users" because it is the only way to analyse cages using this profile.



Every cage prepared in the DVC® system can have a DVC® Owner associated (it is not mandatory but highly suggested when combined with DVC® Analytics – if not, it is defined as "Anonymous"). If so, this DVC® Owner is pushed to the DVC® Analytics and can be manually associated with existing DVC® Analytics users by clicking the icon. This will be set as the primary user.

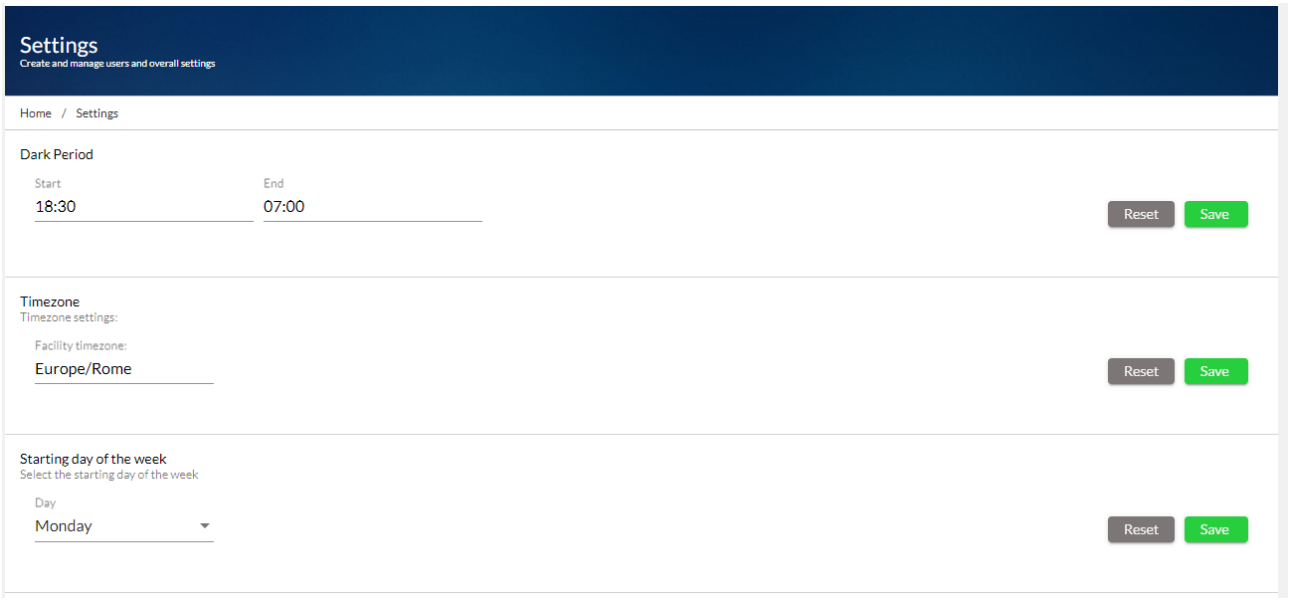
Then, by clicking the button, it is now possible to associate "secondary users" to the same cages created with this DVC® Owner:



The main difference between this feature and the "User Groups" described earlier is that, in this latter feature, any new cage created in the Animal room with the specific Cage Owner will become automatically available to all the primary and secondary users, while in the "User Groups" feature, only the selected ones are available to the entire group of users.

5.5 Settings

This button allows you to set different Facility information.



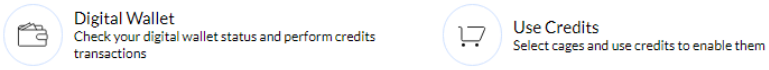
Essential to click the "Save" button.

6 DVC® Analytics Credits management

The DVC® Analytics platform can be enabled for the entire Facility (full), by Rack Level (serial number), or credits (cage/day). However, these functionalities cannot work simultaneously. Moreover, switching from any mode to credits mode makes the previous cages unavailable (unless credits are used to enable them).

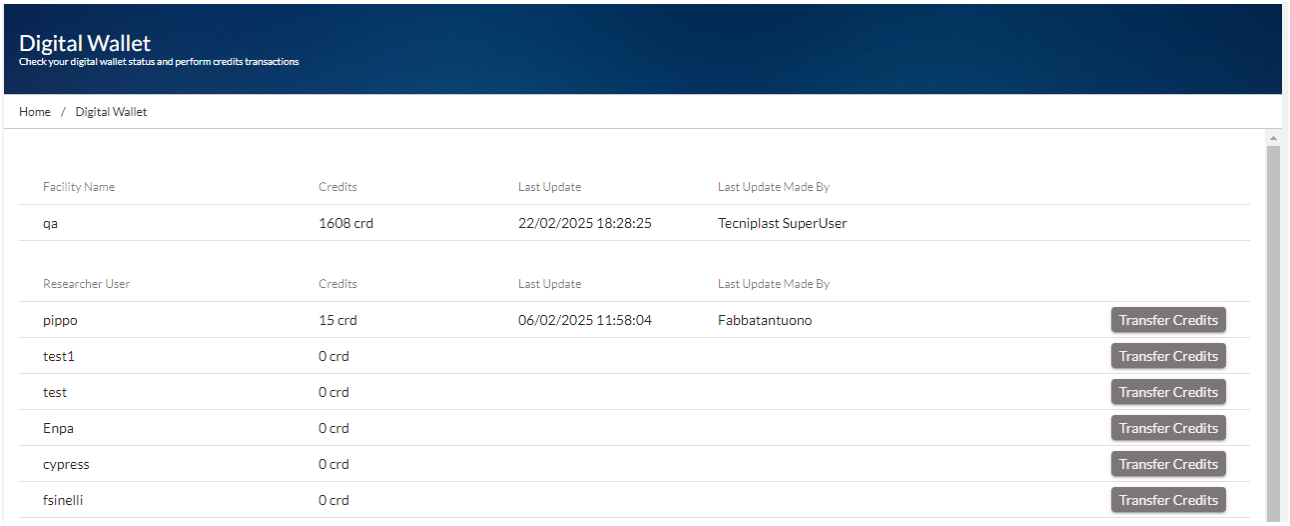
6.1 Home page

After the login, the home page shows specific sections where the credits are managed.

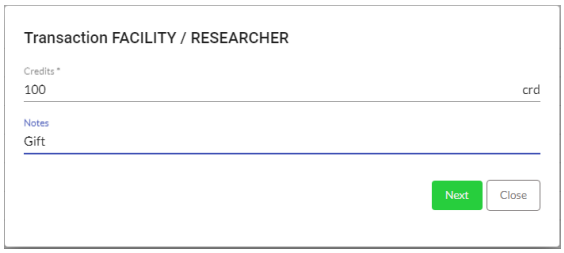


6.2 Digital wallet

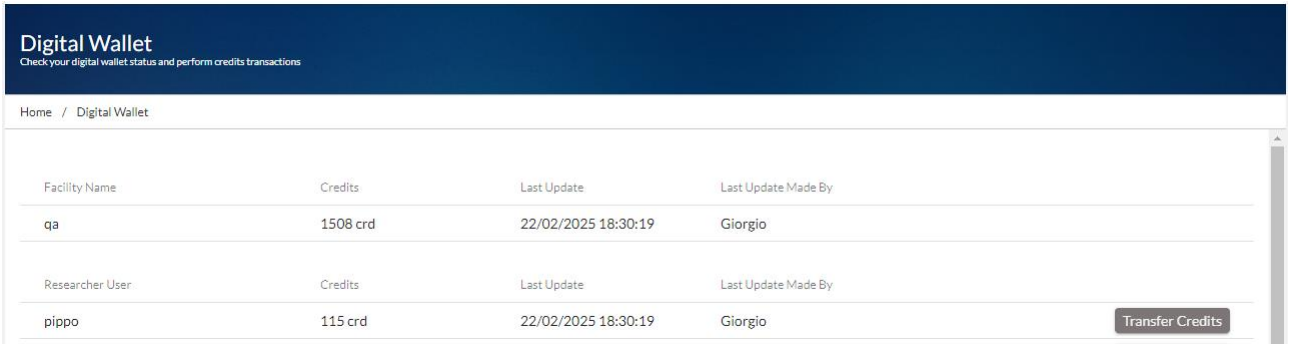
This section recaps the status of the credits at the Facility level (1.608 in this example). and how many credits are assigned to the different registered Researchers (15 to Pippo, in this example).



By clicking the button "Transfer Credits," credits can be moved from the Facility level to the specific selected Researcher by selecting the quantity and optionally leaving a comment.

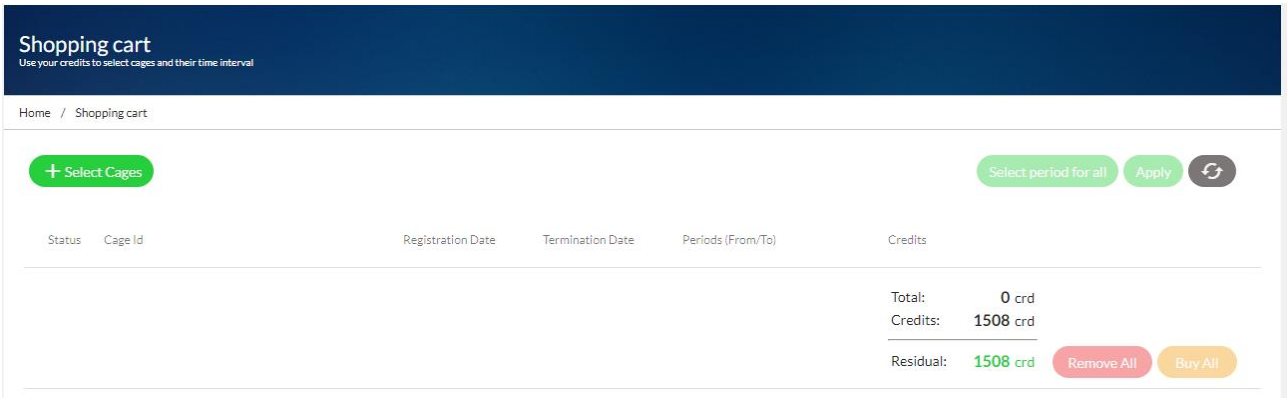


Once confirmed, the amounts of credits are updated, and the last transaction is tracked (performed by whom and when)

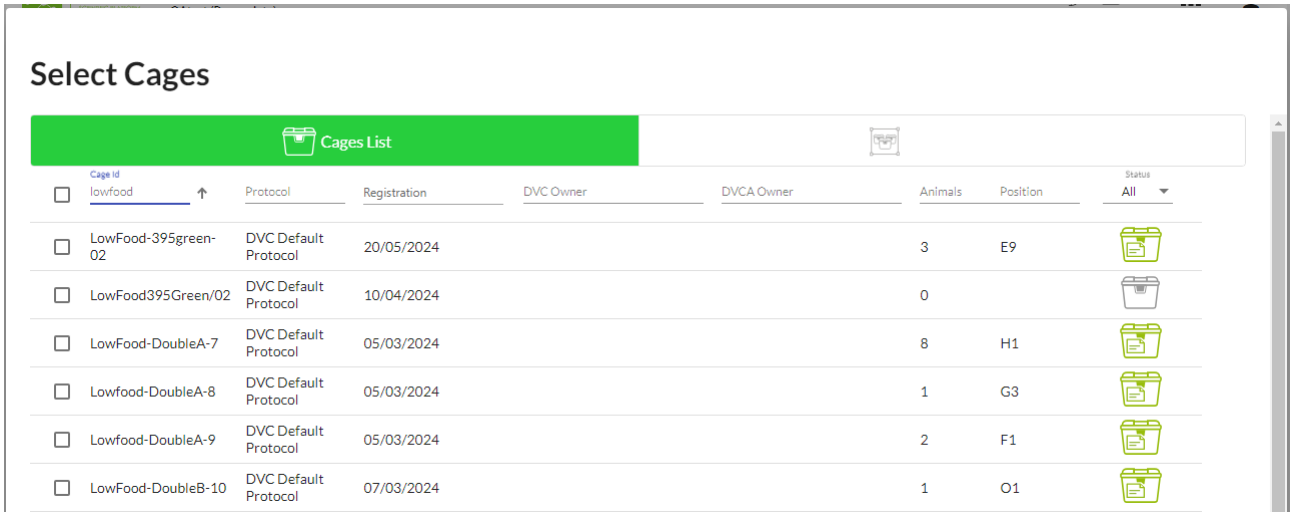


6.3 Use credits

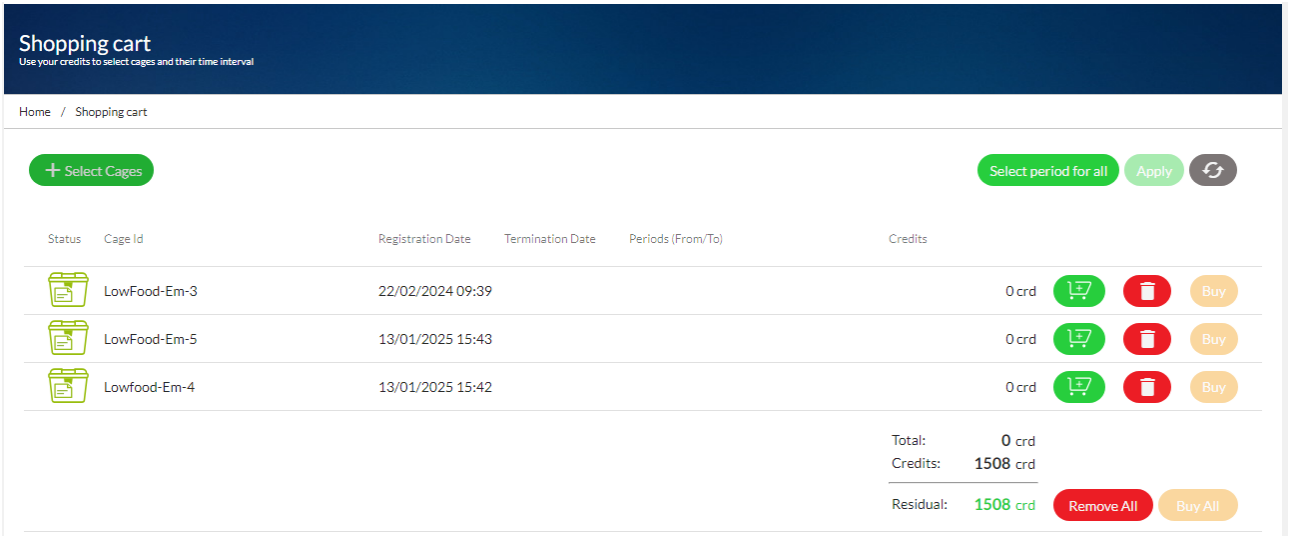
This section has been designed to support the selection of the cages to be enabled and the use of the corresponding credits:



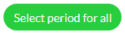
By clicking the button + Select Cages, you can select from all the registered cages (terminated, out of rack, running).



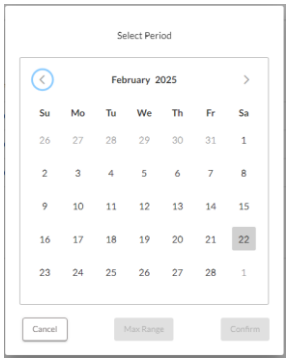
When you confirm the cages, it is time to select the dates (days) to enable the data.



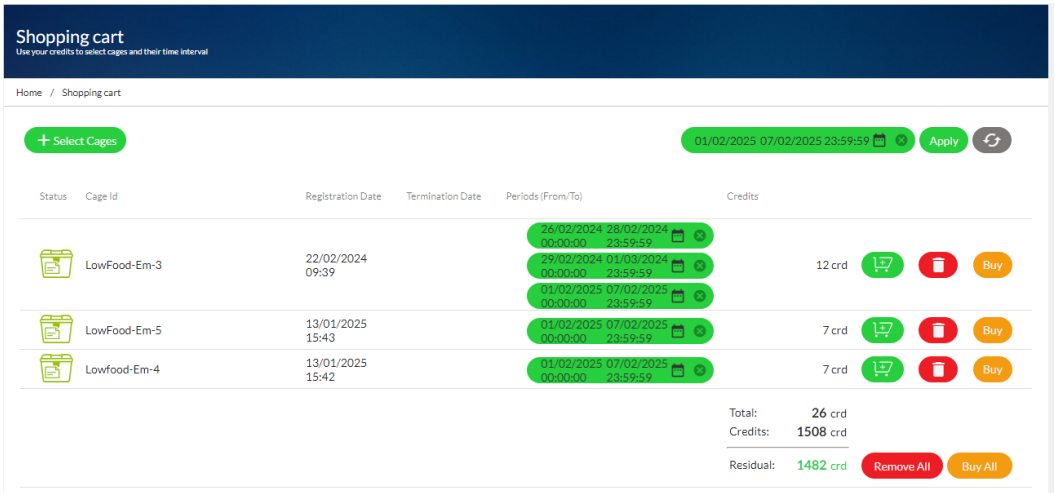
This is possible by clicking the corresponding icon 

for each individual cage or even applying the same period to all the cages by clicking the corresponding icon 

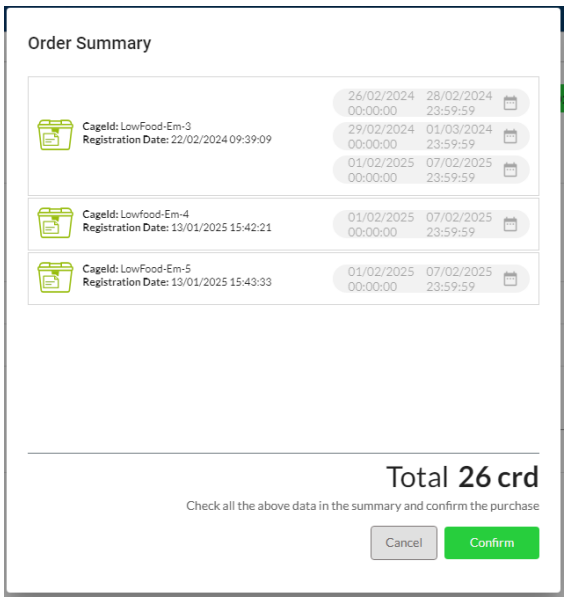
:



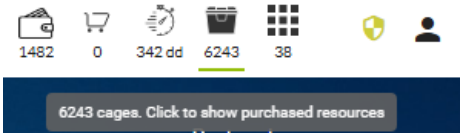
Please note that you can only select a valid period for which corresponding data are available. Moreover, you can select multiple periods for the same cage.



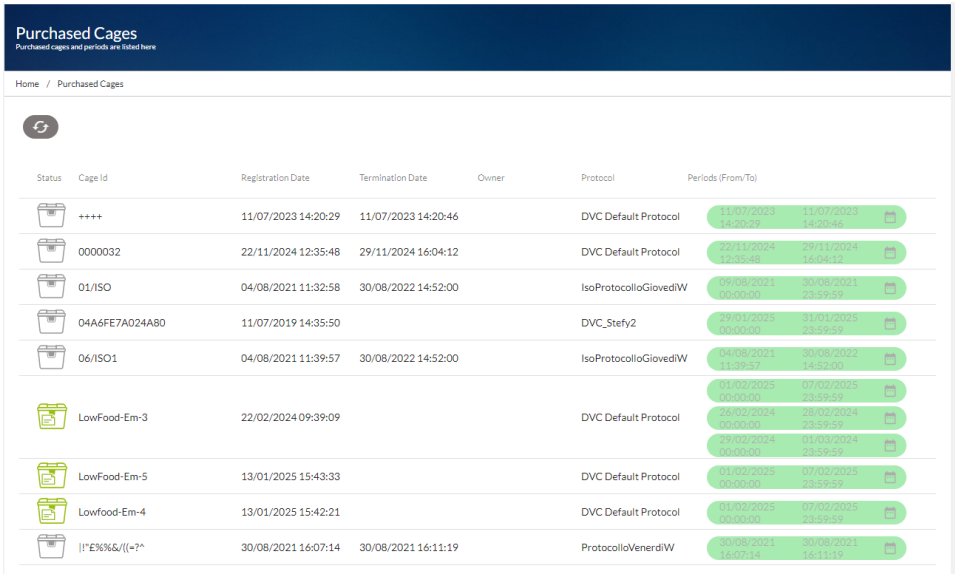
The total number of credits to be used for the specific selections is displayed, as well as the residuals. Clicking the button Buy All, the order is recapped and it needs your final approval before proceeding:



Finally, to see the "purchased" cages, click on the small icon placed on the top right side of the interface:



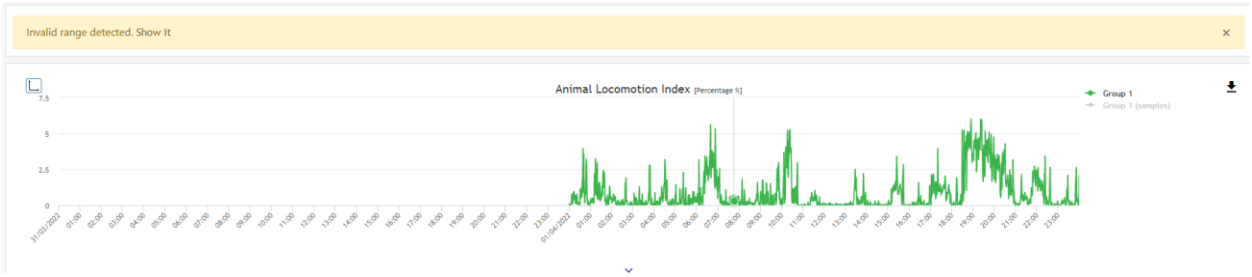
The entire list is shown with its correspondent periods:



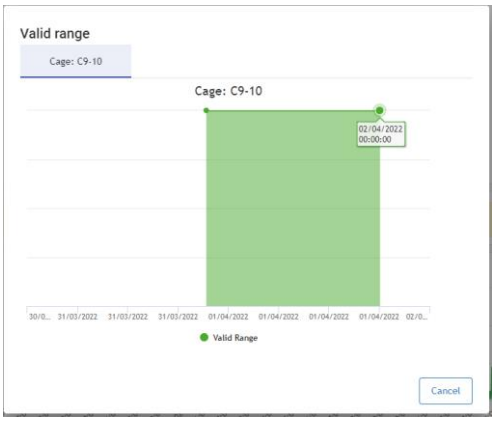
6.4 (Credit) Data Analysis

In the "Data Analysis" section, all cages are always visible as potential selections, but the availability of the corresponding data depends upon your purchases.

More specifically, if you select a wider temporal range than the one enabled by using the credits, only the corresponding purchased days are displayed (and downloadable), while the other period is not visible.



A specific "Invalid range detection" message appears. By clicking "Show it", you can quickly discover the missing days:



And only the purchased days (1st April in this example) are downloaded:

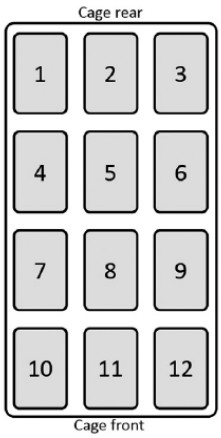
	A	B	C	D	E	F	G	H	I	J
1	day	hour	minute	relativeTime	Group_1_TIMESTAMP	Group_1_AVG	Group_1_SEM	Group_1_QRT	Group_1_SAMPLES	Group_1_C9_10
2	1	0	0	86400	2022-04-01T00:00:00.171+0200	0	NaN	[0.0,0.0,0.0,0.0,0.0]	225	0
3	1	0	1	86460	2022-04-01T00:01:00.104+0200	0,110619469	NaN	[0.11061946902654868,0.11061946902654868,0.11061946902654868,0.11061946902654868,0.11061946902654868]	226	0,110619469
4	1	0	2	86520	2022-04-01T00:02:00.196+0200	0,073746313	NaN	[0.07374631268436578,0.07374631268436578,0.07374631268436578,0.07374631268436578,0.07374631268436578]	226	0,073746313
5	1	0	3	86580	2022-04-01T00:03:00.209+0200	0,037037037	NaN	[0.037037037037037035,0.037037037037037035,0.037037037037037035,0.037037037037037035,0.037037037037037035]	225	0,037037037
6	1	0	4	86640	2022-04-01T00:04:00.036+0200	0	NaN	[0.0,0.0,0.0,0.0,0.0]	226	0
7	1	0	5	86700	2022-04-01T00:05:00.132+0200	0	NaN	[0.0,0.0,0.0,0.0,0.0]	226	0

7 Useful information

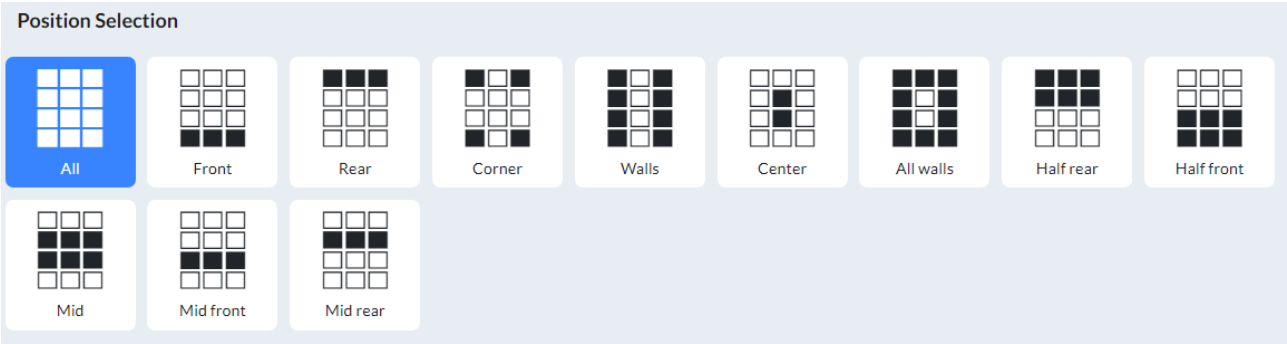
In this section, we would like to provide some tips and information to help you better understand how DVC Analytics works and maximise its benefits.

7.1 DVC® board

The DVC® board is the core of the DVC® system. Twelve different electrodes map the entire base of the cage. These electrodes are numbered in the following way:



For some metrics (Animal Activity Index and Bedding Status Index), selecting ONLY some electrodes (corners, walls, etc.) can help analyse specific patterns deeply.

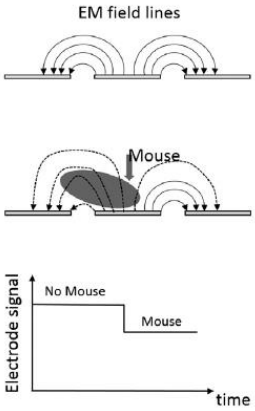


For some other metrics, such as Running Wheel or Animal Tracking, it is impossible to select specific electrodes because the data are calculated using the Running Wheel or the entire DVC® board.

7.2 DVC® working principle and derived metrics.

The working principle of the DVC® system is based on an electrical capacitance sensing technology (CTS). The DVC® board comprises twelve electrodes connected to an integrated circuit, continuously measuring their electrical capacitance every 250 msec (roughly). Since the matter influences capacitance in each electrode's surroundings, its measurements are affected by the presence of, e.g., water and animals. Note that materials with high water content are characterised by large values of relative permittivity (concerning air), which directly affects capacitance (high relative permittivity means higher capacitance). Since mice are characterised by high water content, their movements are performed. At the same time, close to an electrode induces significant capacitance changes, and thus, by properly tracking these changes over time, it is possible to monitor animal activity. Note that capacitance remains unchanged when material compositions around an electrode are unvaried.

Additionally, the capacitance readings are affected by the presence of water (due to, e.g., bottle leakage) or urine. However, animal activity occurs on a time scale different than water leakage or urine; thus, the two variables can be easily distinguished. Furthermore, the system's capability to discern animal movements is unchanged even when water/urine is present in an electrode surrounding (not a flooded cage, but a typical amount of water/urine in a dirty cage). Water/urine can change absolute capacitance readings but not capacitance variations due to animal movements.



Keeping this working principle in mind, some important metrics can be applied. The currently available metrics in the DVC® Analytics systems are:

- Animal Locomotion Index
- Animal Locomotion Index (smoothed)
- Bedding Status Index
- Animal Tracking Distance
- Animal Tracking Speed
- RDI Dark Phase
- RDI Light Phase
- Running Wheel Rotation
- Running Wheel Distance
- Running Wheel Speed
- Rest Bouts
- Wake Bouts
- Fighting-like
- Stereotypy

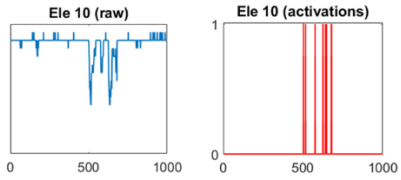
PLEASE NOTE: Every element (cage or animal) has specific capabilities assigned by the DVC® system that enable or disable the correspondent DVC® metrics (e.g., a cage without a Running Wheel does not enable the Running Wheel metric).

7.2.1 Animal Locomotion Index

This DVC® metric is highly robust because it uses the so-called "Activation Density" metric that has been extensively validated in the field across different experiments and validation processes (you can find detailed information in this publication: https://www.heliyon.com/article/e01454).

An electrode is activated when its measurements are significantly perturbed over a limited time interval, occurring when a mouse performs activity sufficiently close to an electrode (see below). Density indicates that the total number of activations is divided by the duration of the time interval and the number of electrodes of interest (up to twelve).

Any drop/increase of the signal higher than the electronic noise (1 count) is considered accurate activation.



$$ACT_e = |e_k(t) - e_k(t\text{-}1)| > 1 \rightarrow 1 \text{ (activation), otherwise 0}$$

Where $e_k(t)$ is the kth electrode at time t

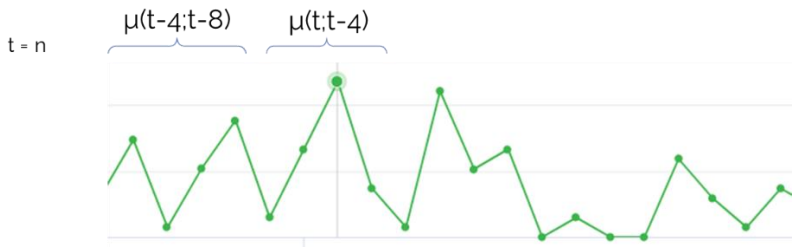
The Animal Locomotion Index is expressed in % of arbitrary units, and it is normalised between 0% and 100%

$$\sum_{e=1}^{12} ACTe/\#Electrodes/\#samples$$

7.2.2 Animal Locomotion Index (smoothed)

This is an improved version of the historical metric "Animal Locomotion Index" (ALI). The statistical reason is that the smoothed process increases robustness to noise and provides more sensitivity to the intensity of mice movements.

More specifically, to calculate the minute data aggregation, instead of performing a sample-by-sample difference (remember that every sample is collected every 250 msec), the $ALI_{smoothed}$ considers the moving difference between two groups of 4 consecutive samples each. If the module of this difference is above a minimum threshold, the current group of samples is counted as a valid activation.



$$ACT_{smoot}=|\mu(e_k(t;t\text{-}4))-\mu(e_k(t\text{-}4;t\text{-}8))| \geq 1{,}25 \rightarrow 1 \text{ (activation), otherwise 0}$$

Where **$\mu(e_k(t;t\text{-}4))$** is the average of 4 consecutive samples of the kth electrode.

$$\sum_{e=1}^{12} ACTsmoot/\#Electrodes/\#samples$$

The Animal Locomotion Smoothed Index is expressed in % of arbitrary units, and it is normalised between 0% and 100%

The main benefits of this (smoothed) metric are:

- **Electrode 2** of the DVC® board was considered generally "less sensitive" because the RFID antenna uses part of its area to read the below cage. Applying this new mathematical method and a dedicated threshold (1.01) allows us to assess its activity better for up to 50% more activations. This helps to evaluate activity, e.g., in the rear of the cage, with a better resolution.
- It reduces "**background noisy baseline activity**" and emphasises "**spikes in activity**" over a longer time window. Since the primary behaviour of mice, especially at baseline levels, does not change in

time windows below 1 second, this new metric calculation will not affect the behaviours identified via DVC®-based algorithms to date.

7.2.3 Animal Tracking Distance and Speed

The distance walked accounts for the total distance covered by the mouse within a given time interval, while the average speed is the distance walked divided by the duration of the time interval considered. We assume that the mouse position on the cage floor is identified in terms of its centroid, while the distance walked is computed via the sum of the Euclidean distances of the mouse centroid in successive frames within the time interval of interest. The distance walked is defined as follows. Let $\mathbf{p}(t) = [p_x(t), p_y(t)]$ be a 2 ×1 vector of coordinates on the plane (cage floor) representing the position of the centroid of the mouse at time t. Then, the distance walked within the time interval t_1, and t_2 can be computed as:

$$S(t_1, t_2) = \sum_{t=t_1+1}^{t_2} d(t)$$

Where:

$$d(t) = \sqrt{(p_x(t) - p_x(t-1))^2 + (p_y(t) - p_y(t-1))^2}$$

is the Euclidean distance between two positions in adjacent frames.

The average speed is instead defined as the ratio between the cumulative walked distance and the duration of the time interval:

$$V(t_1, t_2) = \frac{1}{t_2 - t_1} S(t_1, t_2)$$

7.2.4 Bedding Status Index

This metric was initially designed to evaluate the level of moisture in bedding. Indeed, it is the core metric of the DVC® Bedding Algorithm and the DVC® water flooding algorithm.

Its mathematical formula is straightforward and robust. It considers the absolute values (i.e., the capacity-related measurements or arbitrary Units) of each electrode and performs an average of these values among the selected time interval:

$$\sum_{e=1}^{12} \frac{\boldsymbol{El\ value}}{\boldsymbol{\#\ Electrodes}}$$

Where $\boldsymbol{El_{value}}$ is the absolute value of the electrode.

7.2.5 Fighting-like index

This metric value is derived from a Convolutional Neural Network (CNN) that has been extensively trained on several thousand examples of fighting and non-fighting events. Every minute of data is ingested in the CNN and continuously evaluated to produce the outcome.

7.2.6 RDI (Regularity Disturbance Index)

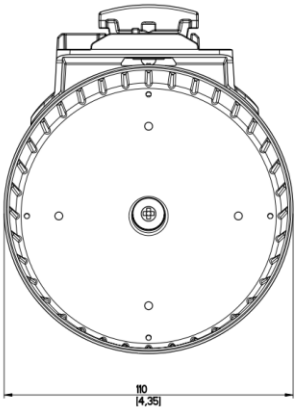
This is a derived metric based on the ALI_{smoot}. RDI has been developed to capture irregular patterns of animal activity. To quantitatively capture these patterns, we designed this metric based on the sample entropy mathematical formula (Richman and Moorman, 2000), which serves as the core metric.

RDI is a metric that measures irregularities of a time series (e.g., home cage activity), and the absolute amount of the activity itself does not influence it.

Currently, the DVC® analytics provides one data point per light or dark period (i.e., 12 hours).

7.2.7 Running Wheel Rotation, Distance and Speed

Using the DVC Running Wheel product, it is possible to automate several metrics. The diameter of the plastic DVC® Running wheel is 110.4 mm (4.35 inches), which corresponds to a perimeter of approximately 33.75 cm (13.3 inches).



The minimum time resolution is the minute, and the metrics are expressed in:

- **Running Wheel rotation:** # Complete rotations in the selected time resolution (minute, hour, custom)
- **Running Wheel distance**: # complete rotations * 33,75 cm (13,3 inch) in the selected time resolution
- **Running Wheel Speed**: expressed in cm/min (inch/min) or m/min (feet/min)

7.2.8 Rest-Wake Bouts

This is a derived metric based on the ALI_{smoot}. It has been designed to work only in combination with its Rest-Wake Chart, which displays the quantity of rest and wake bouts in the selected period divided into system-specific bins (see later in the corresponding chart section)

7.2.9 Stereotypy

This metric value is derived from a Convolutional Neural Network (CNN) that has been extensively trained on several thousand examples of stereotypic and non-stereotypic events. Every minute, data is ingested into the CNN and continuously evaluated to produce the outcome.

7.3 How data are calculated and aggregated

Considering the various data and charts, it is essential to understand how they are calculated.

Considering all the available DVC® metrics, below you can find the recap of the aggregations:

Metric	***Aggregation in the selected time interval***
Animal Locomotion Index	Average
Animal Locomotion Index (smoothed)	Average
Animal Tracking Distance	Sum

Animal Tracking Speed	Average
Bedding Status Index	Average
Rest Disturbance Index during Dark	Average
Rest Disturbance Index during Light	Average
Running Wheel Distance	Sum
Running Wheel Rotation	Sum
Running Wheel Speed	Average
Rest-Wake	Time-weighted
Fighting-like	Sum
Stereotypy	Sum

7.4 Chart visualisation

Multiple charts are available, designed to help users better and clearer understand the behaviour and phenomena under analysis. The availability of a chart depends on the previous metric selection.

7.4.1 Line Chart Simple

Every point of the line is calculated in the following way:

SPATIAL AGGREGATION: average of the selected DVC® boards electrodes (by default, the twelve electrodes). The result is one single data point (if you select only the corners, the data point is the average of the four electrodes).

TEMPORAL AGGREGATION: The default temporal window (minute and hour) is automatically calculated by the DVC system as it occurs. On the other hand, if you have selected a custom temporal window, the result is the average of all the minutes included in the customised temporal interval if the time is not a multiple of the hour.

Activation (3min) = [activation (min 1°) + activation (min 2°) + activation (min 3°)] / 3

If the custom temporal interval is a multiple of the hour:

Activation (3h) = [activation (hour 1°) + activation (hour 2°) + activation (hour 3°)] / 3

GROUP AGGREGATION: the data point in the graph is calculated as the average of the single calculated metric.

Activation (3 cages) = [activation (cage 1°) + activation (cage 2°) + activation (cage 3°)] / 3

7.4.2 Line chart with SEM

As explained previously, SEM is enabled by selecting multiple cages in the same group. Everything is calculated the same as above in terms of spatial and temporal aggregation, and then, the SEM (Standard Error of the Mean) is calculated as:

$$SEM = \frac{SD}{\sqrt{\#samples}}$$

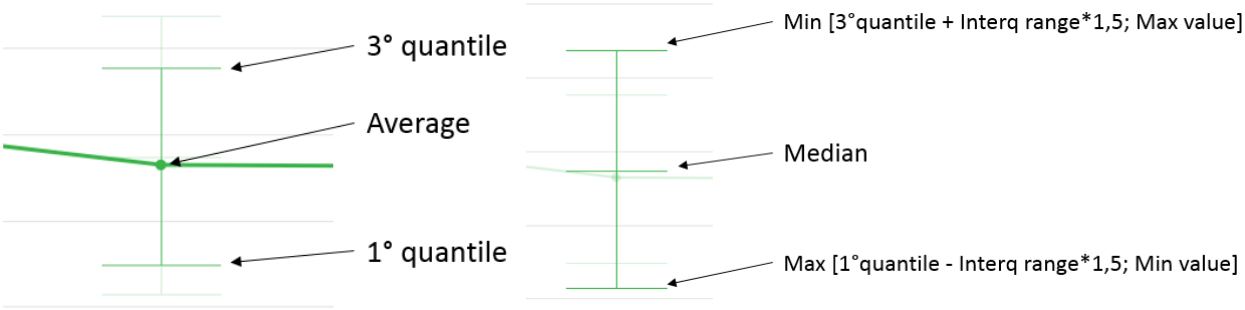
Where SD is the Standard Deviation.

The corresponding Line chart is the average (central data point) ± SEM.

7.4.3 Line chart with Interquartile

As explained previously, the INTERQUARTILE is enabled by selecting multiple cages in the same group. Everything is calculated the same as above in terms of spatial and temporal aggregation, and then, the INTERQUANTILE feature enables six different points per data sample:

- Average
- Median
- Quantile
- 3* Quantile
- Interquartile min range
- Interquartile max range



7.4.4 Line chart cumulative

Spatial and temporal aggregation follow the abovementioned scheme, and in this specific case, every data point is the sum of the previous ones:

d(0) = A(0)

d(1) = A(0) + A(1)

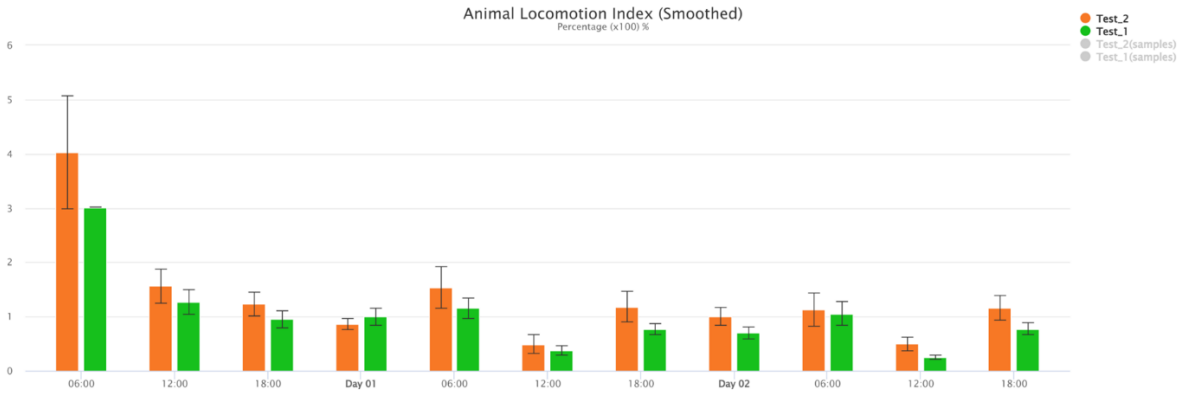
d(2) = A(0) + A(1) + A(2)

d(n) = A(0) + A(1) + A(2) + ... + A(n)

7.4.5 Bar plot

In the Bar plot chart, each rectangular bar represents the value of the selected metric in the aggregated time interval.

The height of the bar is proportional to the value of the metric.

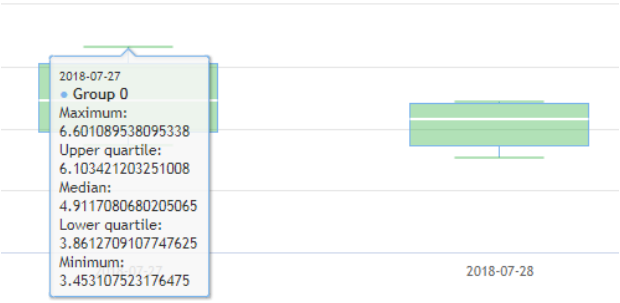


7.4.6 Box Plot

Spatial aggregation is similar to the Line Chart. Temporal aggregation must be calculated within 24 hours (you must select between "start of the day" or "Lights-on"). The result is a single data point for each selected element (cage or animal). The Box Plot chart is available only when multiple elements (cages or animals) are selected.

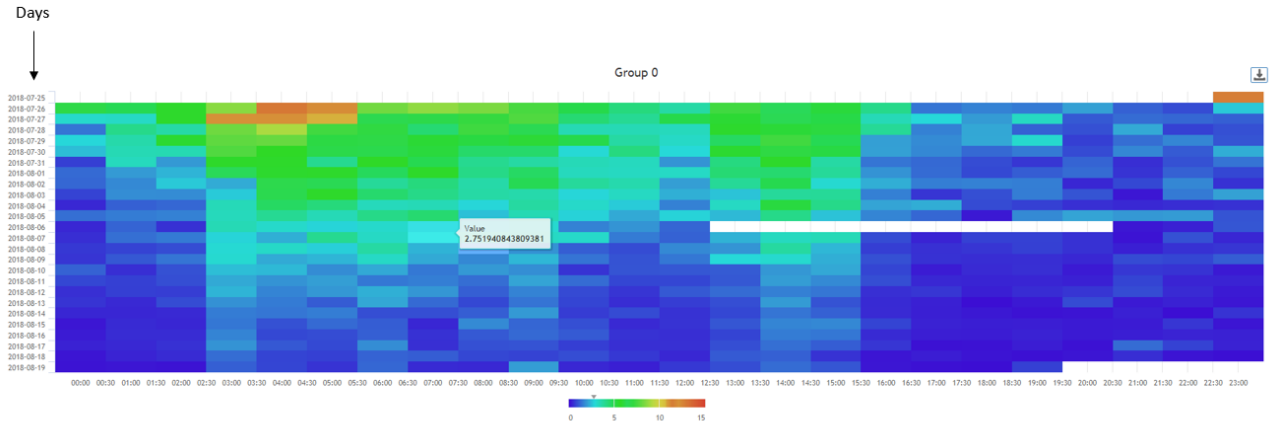
The BOX PLOT feature enables five different points per data sample:

- Median
- 1st Quantile
- 3rd Quantile
- Min
- Max



7.4.7 Heatmap

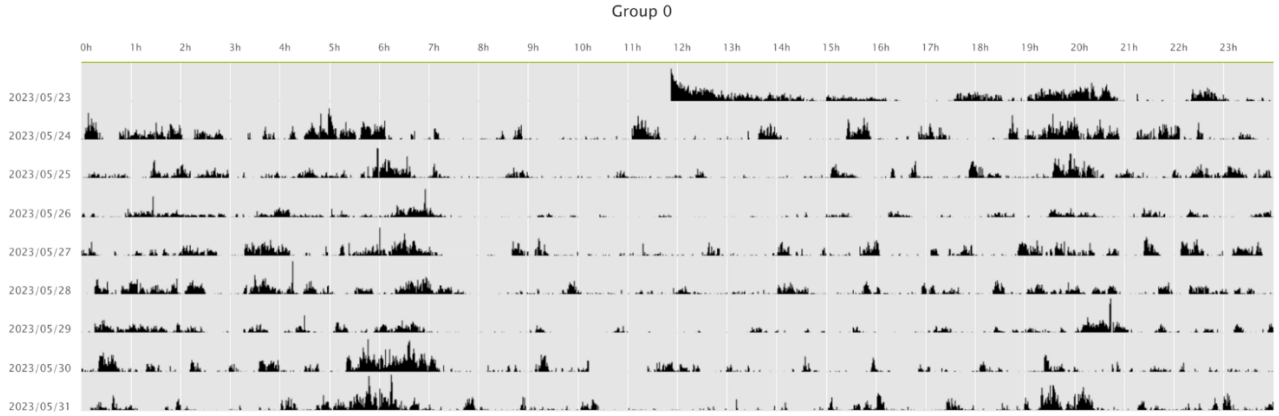
Spatial, temporal and group aggregation are precisely calculated as above. The only difference with the Line Chart is the chromatic visualisation (from blue as a lower value to red as a higher value). Every block is representative of the Data Time Aggregation chosen.



24 hours of the day, starting from midnight to midnight

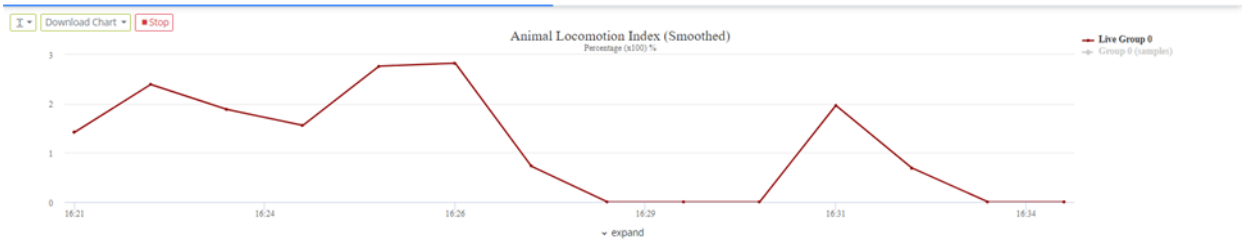
7.4.8 Actogram

This chart is a simple graph showing the selected metric over a given period, day after day. The vertical line's length determines the metric's magnitude in a specific aggregated time.



7.4.9 Live data

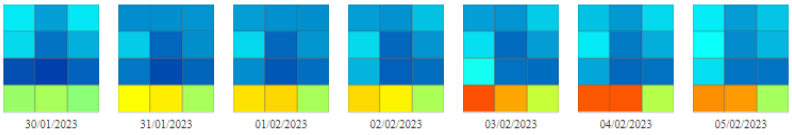
This chart can be applied only to "running" cage(s) (or animal(s)). You can visualise the last minutes of data (15-30-60 min) of the selected metric through a simple line chart. The data are updated every minute.



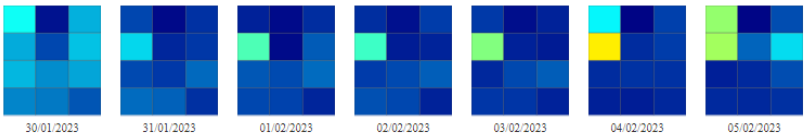
7.4.10 Board Heatmap

This chart can be applied to those metrics that consider the 12-electrodes as a data source (i.e., the ALI, the ALI smoothed and the Bedding Status Index). It is a colour-code representation of the DVC board with its 12 electrodes. The standard granularity of the data aggregation is the day.

It can be helpful to discriminate, for instance, the latrine preference (by selecting the Bedding Status Index as a metric):



And the corresponding Animal Activity preference (by selecting the "ALI smoothed" as metric):

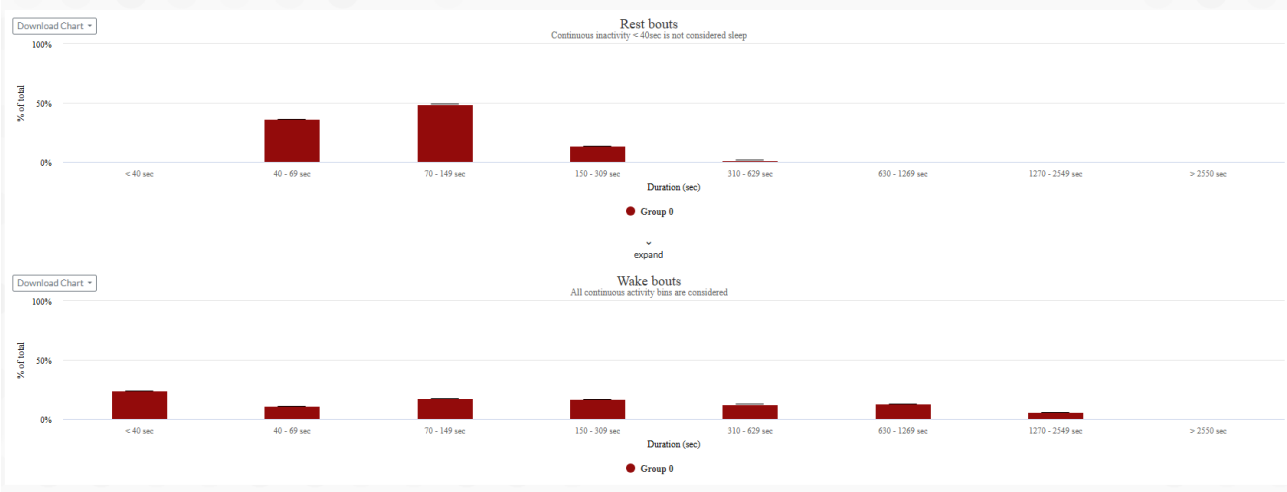


The minimum granularity is the minute. By clicking over one DVC board, it is possible to drill it down to the below granularity if available (i.e., starting from the day aggregation, clicking on a specific date, it is possible to explore the 24 hrs of that day, and so on, clicking on a specific hour of the day, you can explore the below 60 min of that hour).

7.4.11 Rest Awake

The selection process yields two independent charts, each representing a time-weighted frequency histogram with distinct interval bins. The bins are defined as follows:

- < 40 sec
- 40 – 69 sec
- 70 – 149 sec
- 150 – 309 sec
- 310 – 629 sec
- 630 – 1269 sec
- 1270 – 2549 sec
- > 2549 sec

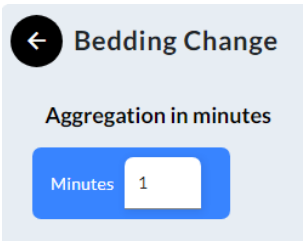


For any given analysis period, the duration of each resting (or waking) event is measured and assigned to the appropriate bin. The final output is normalised to facilitate comparisons.

For the Rest chart, please consider that any continuous inactivity < 40 sec is removed because it is not considered sleep (https://wellcomeopenresearch.org/articles/1-2/v2).

7.4.12 Bedding Change (response)

This chart is a modified Simple Line chart applied to the Bedding Change event. It shows the 300-minute response to the event. Data are aggregated by the minute, but there is the opportunity to increase the aggregation interval:

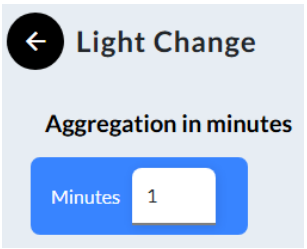


This visualisation helps interpret the impact of bedding changes on animal activity. If multiple bedding change events occur within the analysis period, their average is calculated and displayed.

Please note there is a limitation in data analysis: any bedding change task performed outside the light period will result in the event (and its data) being discarded..

7.4.13 Light Change

This chart is a modified Simple Line chart applied to the Lights On and Lights Off events, as defined in the Facility Settings section. It shows the 60 minutes before and after the response to the event.

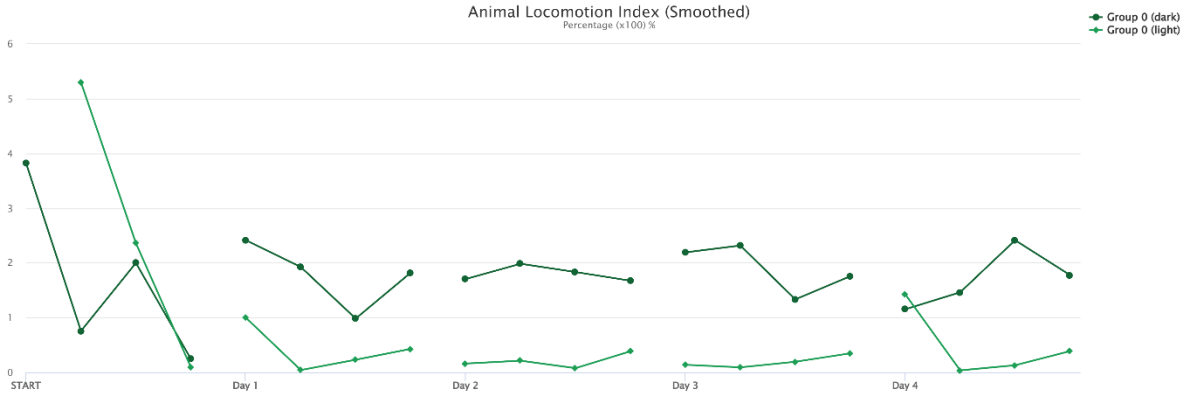


This visualisation helps analyse the impact of light changes on animal activity. Their average is calculated and displayed if multiple light change events occur during the analysis period.

Two dedicated Simple Line charts are provided: one for Lights On events and another for Lights Off events.

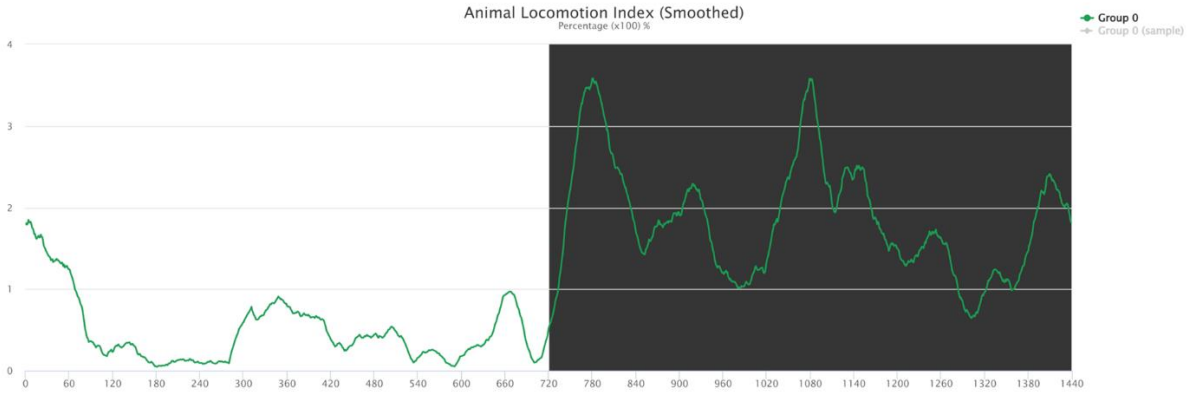
7.4.14 Dark Light

This is a simple Line plot chart showing light and dark data simultaneously for each selected analysis day.



7.4.15 Daily Rhythm

This chart is calculated by averaging and smoothing, minute by minute, all the data points of the 24-hour cycle of each selected interval day.

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