DVC® ANALYTICS INSTRUCTION MANUAL

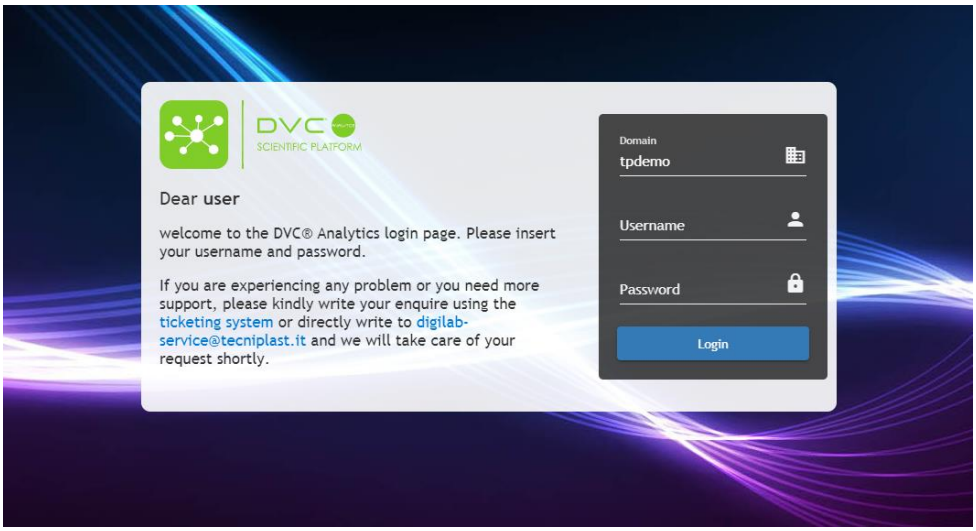
Summary

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 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

1 Login in page

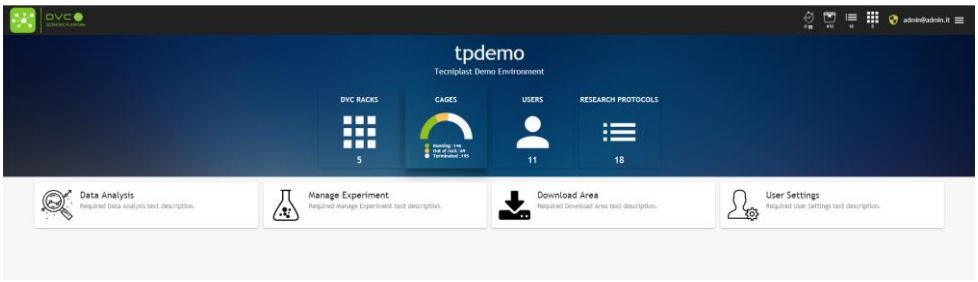
In order to login into the system, go to: https://analytics.dvc.tecniplast.it/login/XXX (XXX provided to you by Tecniplast) and enter your username and password that have been previously communicated.



2 Home Page

The top part of the home page (dark blue background) displays general information about the Facility (e.g. Facility name). The lower part of the home page (white background) displays the DVC® Analytics menu.

The home page varies based on the user role whether Facility Manager or Researcher (the User Setting button is hidden to the Researcher(s) that will have access only to the cages assigned previously by the Facility Manager)



DVC RACKS: how many DVC® Racks currently connected to the DVC® Analytics platform

CAGES: how many cages:

- **Running (green): #** of registered cages in the DVC® system currently inserted in the DVC® Rack
- **Out of Rack: (yellow): #** of registered cages in the DVC® system currently removed from the DVC® Rack (but still registered)
- **Terminated (grey): #** of cages properly terminated in the DVC® system

USERS: how many registered DVC® Analytics Users in the specific Facility

RESEARCH PROTOCOLS: how many DVC® Research Protocols have been currently received by the DVC® Analytics (sent by the DVC® System)

In The lower part of the home page shows different available buttons dependently upon your role (Facility/Researcher):

Through those buttons you can analyze data and set different Facility rules.

2.1 Facility Manager and Researcher Roles

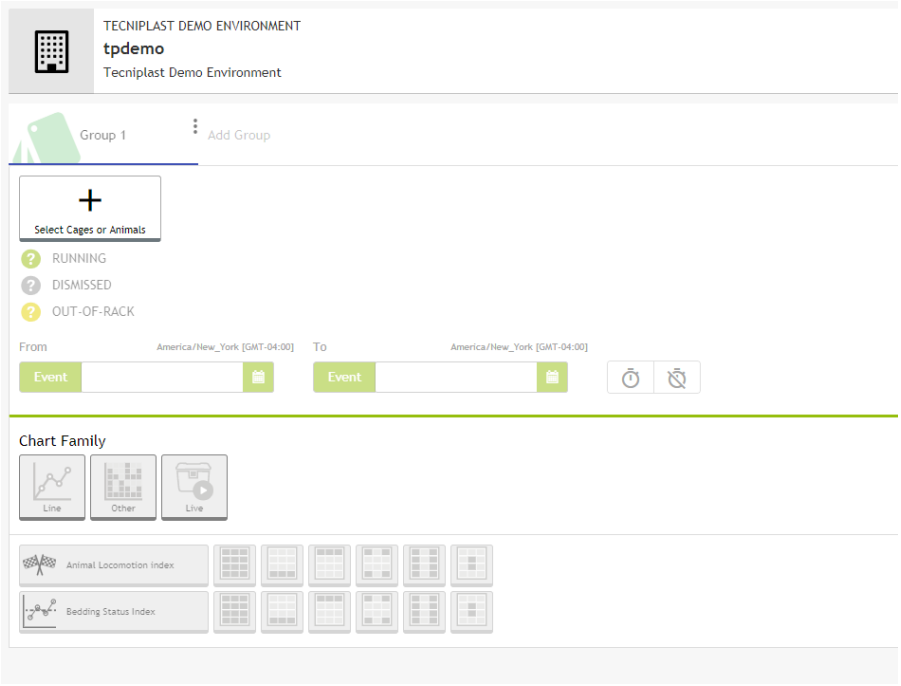
Facility Manager role has been designed in order to perform any task and have access to all functionalities of the DVC® Analytics system. Researcher role has been designed to provided limited access to only a subset of information (only to the Researcher's data) in order to increase privacy and limit any possibility of stolen data.

More specifically, these are the different enabled functionalities for the different roles:

FACILITY MANAGER (has full access to the DVC® Analytics menu)	**RESEARCHER** (limited access to the DVC® Analytics menu)
• is enabled to view all DVC® cages connected to the DVC® Analytics. • is enabled to register new DVC® Analytics users and associated them to DVC® cages. • is enabled to group together DVC® users and associate them to the DVC® cages. • is enabled to set and change the facility settings (e.g. dark hour).	• is enabled to view only DVC® cages that have been previously associated to her/him. • Is enabled to create cage and mice groups using only his/her cages

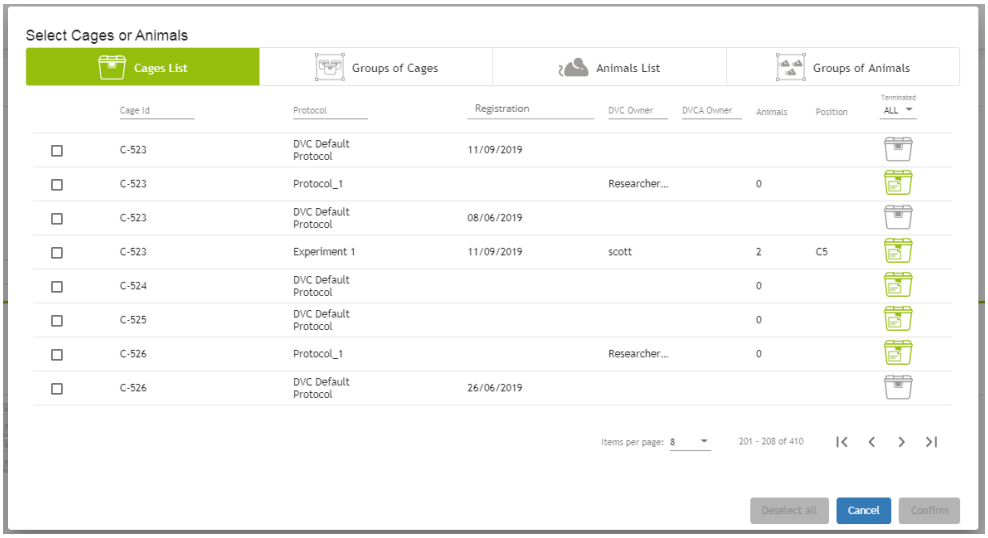
2.2 Data Analysis

In this section it is possible to analyze in depth an individual cage or group of cages selecting across multiple choices from temporal and data presentation perspective. Just clicking on the "Data Analysis" icon, you can enter in a menu section where multiple choices are available:



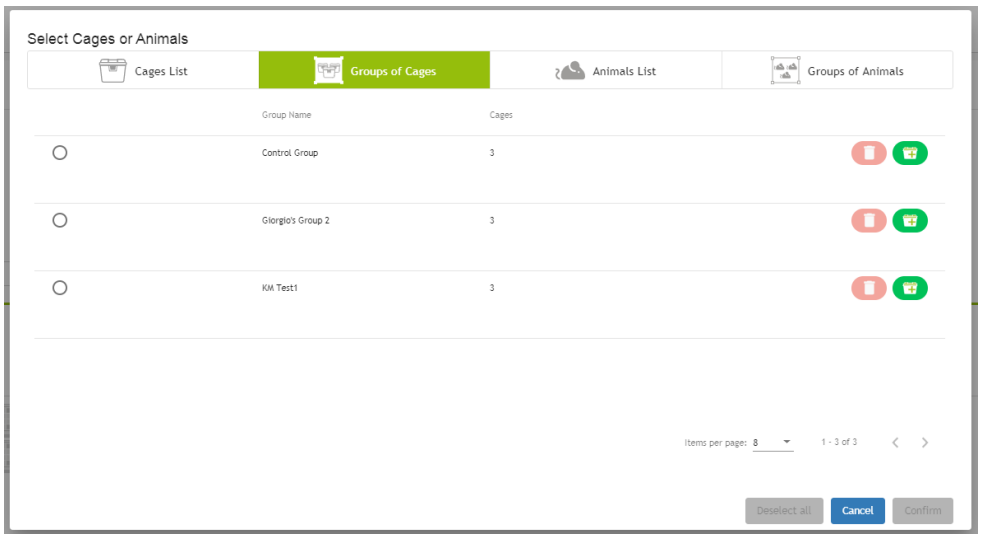
The first requested information is to select "Cages" or "Animals" by simply clicking on the corresponding button (all the other fields are disabled until this first selection is performed):

Once you click, a pop-up menu appears with multiple choices:

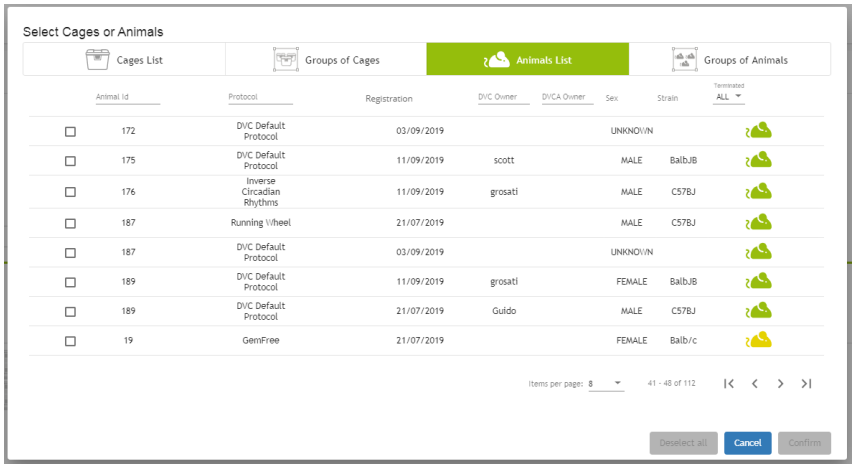


You can immediately select a cage (or multiple) searching for its Cage Id, you can filter by (research) Protocols (set in the DVC® system), time of Registration (when it has been registered in the DVC® system), DVC® Owner (set in the DVC® system). Moreover, there are other information like # animals in the cage ID and current rack position.

You can also select an already created “Group of Cages”



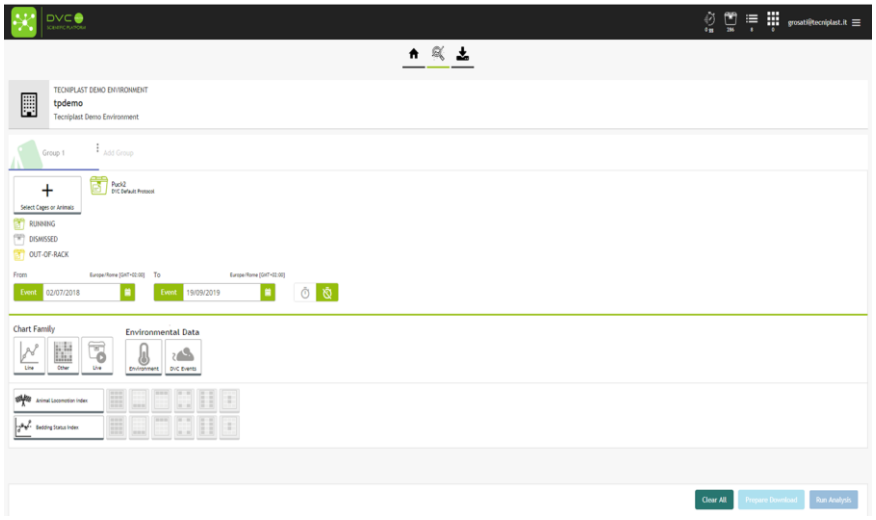
As well as you can select directly Animal IDs:



Or “Groups of Animals” if already created:

PLEASE NOTE: you can only select same type of elements (cages with cages or animals with animals, but not cages with animals at the same time).

Then, when at least one element (cage or animal ID) has been selected, other submenus become available.



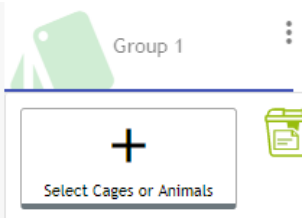
- **Group name and creation**: you can save this selection for further analysis.
- **From - To**: automatically filled with the date & Time of Registration and Termination (if any, otherwise the actual time if the cage(s) is still running).
- **Chart Family**: different available charts.

- **Environmental Data**: events generated in the DVC® system and environmental data (captured by REM if it is installed).
- **DVC® available metrics**: Animal Locomotion Index and Bedding Status Index

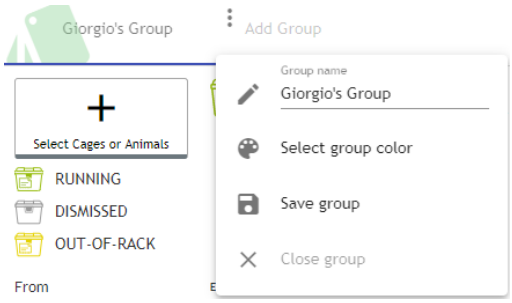
PLEASE NOTE: you cannot "Run Analysis" neither "Prepare Download" until all the selections have been performed.

2.2.1 Group name and creation

It is possible to quickly save the cage(s) or animal(s) selection just performed. Clicking on the small icon ⋮

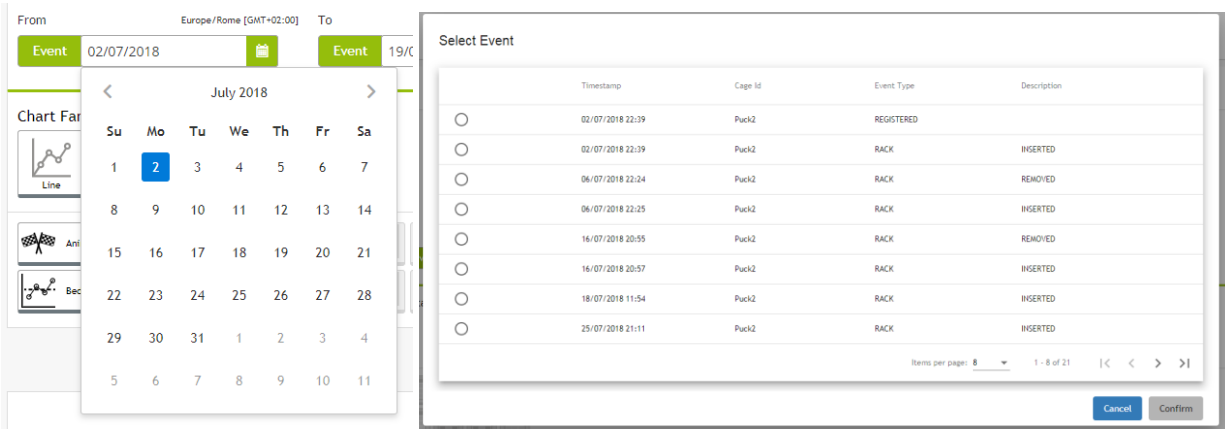


You can then change the name (by default it is Group 1), color in the graphs and finally save the group:



2.2.2 Selection by event

Any period (From - To) can be either selected clicking on the date (and a specific date pop-up appears) or clicking on the event button:



In this latter case, the entire (event) history of the selected element (cage(s) or animal(s)) appears in the chronological list. The currently managed events received from the usage of the DVC® systems are:

When the element is a Cage:

- **REGISTERED** (when the cage has been registered into the DVC® system)
- **INSERTED** (when the cage has been inserted into the DVC® rack)

- **REMOVED** (when the cage has been removed from the DVC® rack)
- **BEDDING_CHANGE** (when the cage bedding has been properly changed in the DVC® system)
- **CAGE_DISMISS** (when the cage has been properly terminated in the DVC® system).
- **RECONCILIATION** (when the cage has been reconciliated in the DVC® system, i.e. from cage missing to specific inserted cage. This is a functionality implemented in the DVC® system)

When the element is an Animal, it also has some extra events:

- **MOVED** (when the animal has been moved from a registered cage to the current under analysis)
- **CULLED** (when the animal is culled)
- **ADD** (when the animal is added for the first-time in the cage. It could be during the cage registration but also added from scratch in an already existing cage)

PLEASE NOTE: To disable the time selection click on the time disabling icon  and the time will be considered from 00:00

2.3 Select Chart Type

There are 3 different choices for you to start displaying data: Line, Other and Live.

2.3.1.1 Chart Family Line

Selecting “Line”, by default the interface proposes you the standard selection composed by the next selections:

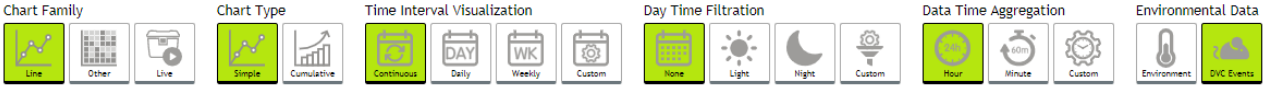


Chart Type:

- **Simple**: displays a continuous line in the selected time. Every point is the data collected by the DVC® system.
- **Cumulative**: all data are summed up and show a cumulative progression of the selected data along the selected time

Time Interval Visualization:

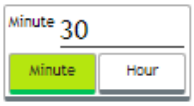
- **Continuous**: the line is continuously showing data along the selected time interval
- **Daily**: 7 different graphs corresponding to the 7 days of the week are displayed. If the time interval is longer than 1-week, multiple lines will be created for each day of the week.
- **Weekly**: one single weekly graph showing multiple lines corresponding to the multiple weeks (if any) in the selected period.
- **Custom**: multiple weekly graph based on number of selected weeks.

Day Time Filtration:

- **None**: no filtration applied. All day data are displayed.
- **Light**: Only light data are showed (light period based on Facility settings)
- **Night**: Only dark data are showed (night period based on Facility settings)
- **Custom**: it is possible to select days and hours to show data

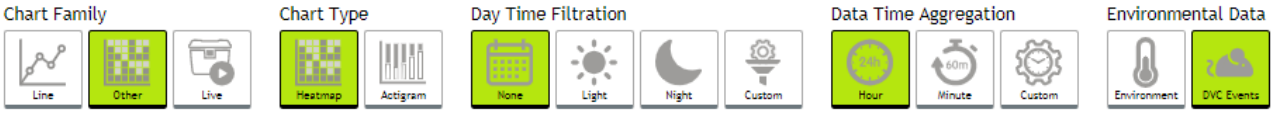
Data Time Aggregation:

- **Hour**: data are aggregated by hour
- **Minute**: data are aggregated by minute
- **Custom**: data can be aggregated by multiple minutes or multiple hours



2.3.1.2 Chart Family Other

Selecting "Other", by default the interface proposes you the standard selection composed by the next selections:



The only differences compared to the previous "Line" option is on the Chart Type selection that offers 2 different types of charts:

- **Heatmap**: data are aggregated day by day (each line is 24h data – from midnight to midnight) and every point is corresponding to the "Data Time Aggregation" selection (hour, minute, custom). The data are color-coded (blue is a low value, red is a high value)
- **Actigram**: data are aggregated day by day (each line is 24h data – from midnight to midnight) and every point is corresponding to minute aggregation (it is not possible to select other aggregation in this current version) and the magnitude of the line is corresponding to the data value collected.

2.3.1.3 Chart Family Live

The DVC® Analytics features a very powerful opportunity related to "see" live data coming from selected elements (cage(s)/animal(s)).

Selecting "Live", by default the interface proposes to "see" the last 15min of the selected elements.

You can select other predefined time intervals (15-30-60min) as well as setting custom's ones simply clicking on the corresponding icon and then inputting your choices.

In this powerful feature, data are updated every minute.

PLEASE NOTE: this feature is available ONLY for RUNNING cages.

2.3.2 Select Metric Type

In your current version, there are 2 different DVC® metrics available:

- **Animal Locomotion Index**: it is expressed in arbitrary unit normalized between 0% and 100% representative of the animal activity performed in the cage by the animals (no activity = 0% - all electrodes simultaneously activated by the movements of the animals = 100%)
- **Bedding Status Index**: it is expressed in arbitrary unit representative of the dielectric (cage, bedding, moisture) materials immersed into the Electromagnetic Field (EMF) generated by the DVC® board.

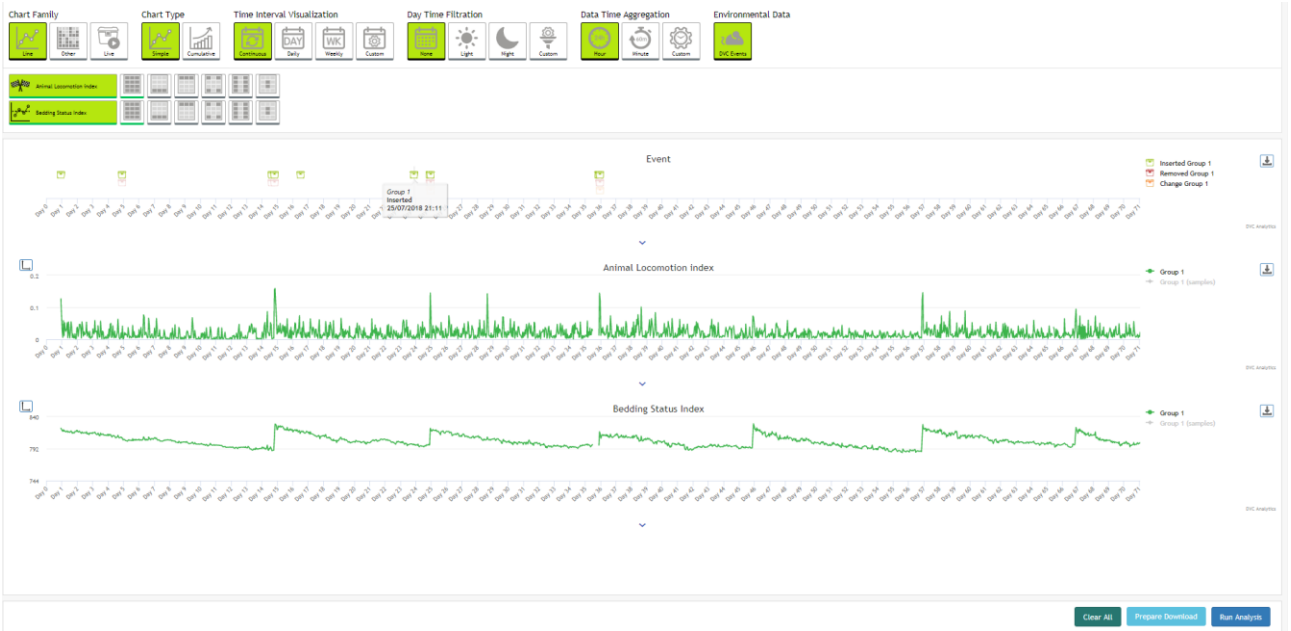
Moreover, it is possible to apply these metrics only to specific set of electrodes of the DVC® board simply selecting the proper icon representing the board next to animal locomotion index and Bedding status index button. The representation can be divided into: all, front, rear, corner, wall, center.

PLEASE NOTE: In this version of the DVC® Analytics you can select multiple metrics at once.

2.3.3 Run the analysis

Once all the selections have been made (elements, time intervals, charts, metrics), it is possible to start analyzing data (the buttons are now activated and they can be clicked).

Clicking on “Run Analysis”, dependently on your specific selections, the corresponding graphs appear.

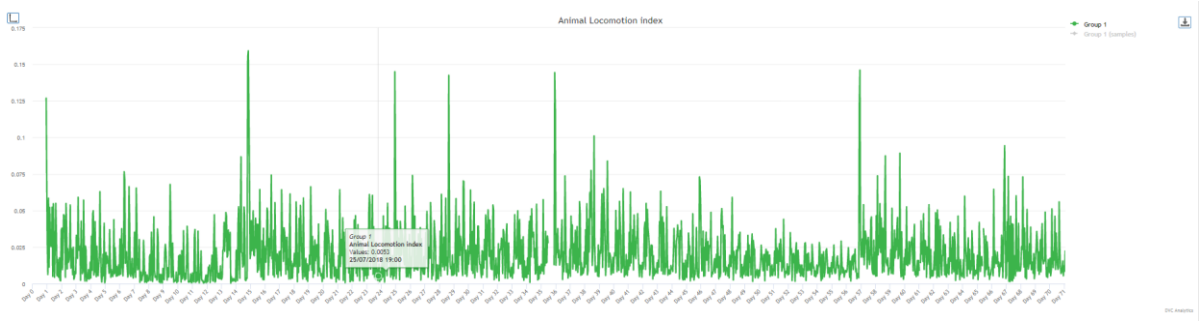


You can easily zoom any graph simply clicking in any position and keep pressed the left mouse button till the end of the area you want to zoom:

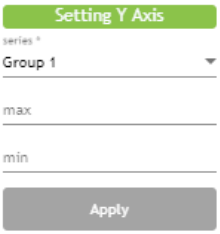
Releasing the button of the mouse, the graph is zooming in the selected area as well as all the other graphs are zoomed to show the corresponding data:

To reset the zoom, simply click on the corresponding icon of the zoomed graph Reset zoom .

Moreover, if you want to better analyze any graph, there is the opportunity to magnify it simply clicking on the corresponding icon ⌄ below the graph itself.

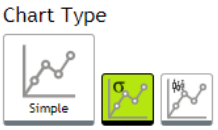


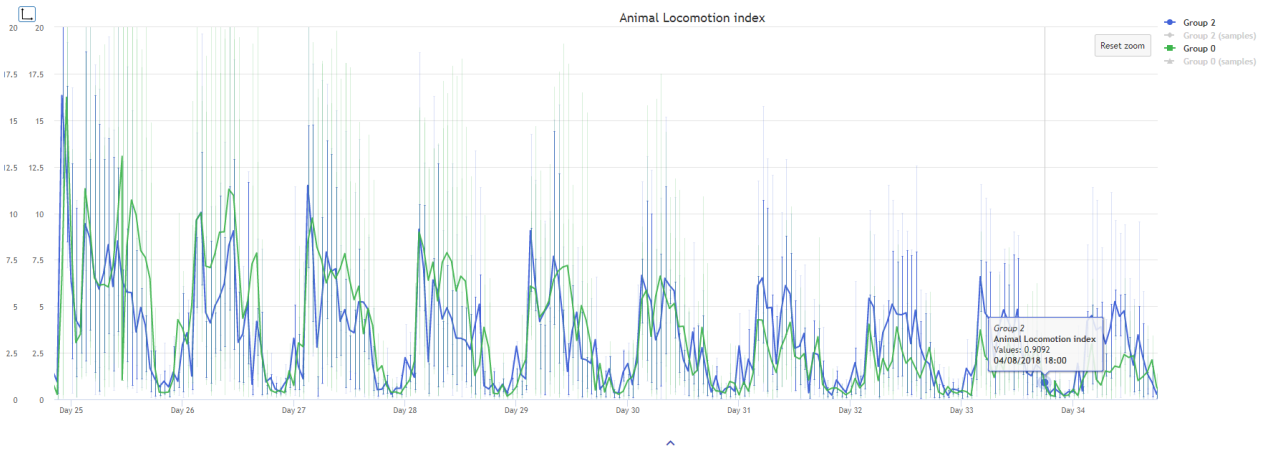
Furthermore, when you perform comparison between different groups, by default the y-axis autoscales on the highest value present in the selected time window. Otherwise, you can manually set the range of y-axis (minimum and maximum) accordingly to your need simply by clicking on this icon , located on the top-left side of the graph.



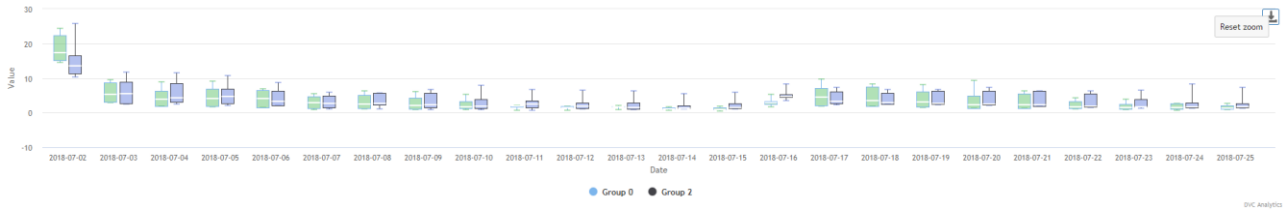
2.3.3.1 Multiple groups – SEM, INTERQUARTILE and BOX PLOT

Selecting multiple groups while performing the "Data Analysis" enables extra functionalities of the application. Selecting "Line", in the "Chart Type" is then possible to select also the Simple Line with Standard Error of the Mean (SEM) or INTERQUARTILE. In this case, extra vertical lines (SEM or INTERQUARTILE) are added to any extra point of the consequent graphs.





If you select "Other" in the Chart Family, a new graph becomes available "Box Plot":

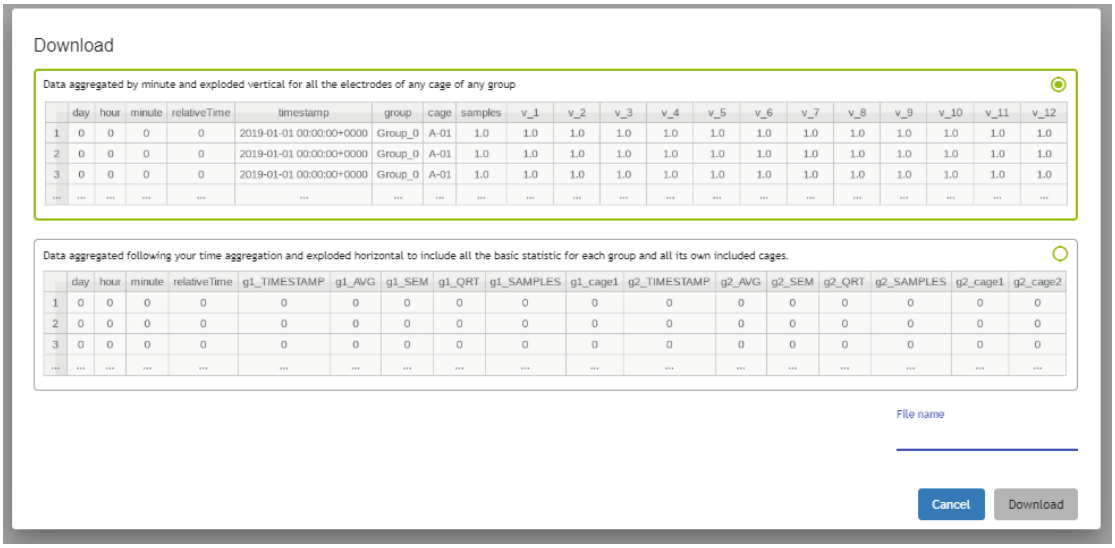


2.3.4 Prepare Download

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

Clicking on the icon 

it is then possible to choose between 2 different options:



Type 1 (upper choice):

Reporting data aggregated in rows by minute or by hour (or custom aggregation, dependently on your specific selection) for all the electrodes of any cage of any group In sequential order.

	day	hour	minute	relativeTime	timestamp	group	cage	samples	v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_10	v_11	v_12
1	0	0	0	0	2019-01-01 00:00:00+0000	Group_0	A-01	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0	0	0	0	2019-01-01 00:00:00+0000	Group_0	A-01	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	0	0	0	0	2019-01-01 00:00:00+0000	Group_0	A-01	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
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Day	Day from date selected in the observation time
Hour	Hour of that day 1-24
Minute	Minute of that hour 1-60
relative Time	Absolute value (in seconds) of the timing from the previous midnight of the starting date
Timestamp	Absolute Time Stamp in UTC time (https://en.wikipedia.org/wiki/Coordinated_Universal_Time)
Group	Name Group
Cage	Cage name within the selected cage group

Samples	Number of collected samples, detected in the specified time frame. Such information are useful to understand if the cage has been removed from the rack thus providing an estimation on how much data have been lost due to this event.
V_1/2/3/4/5/6/7/8/9/10/11/12	Value of activity detected on electrode 1/2/3/4/5/6/7/8/9/10/12 of the DVC® board

Type 2 (lower choice):

Reporting data aggregated in rows following your time aggregation (minute, hour or custom) and cage groups and cages by coloumns with some basic descriptive statistics (i.e. average, quartile, SEM)

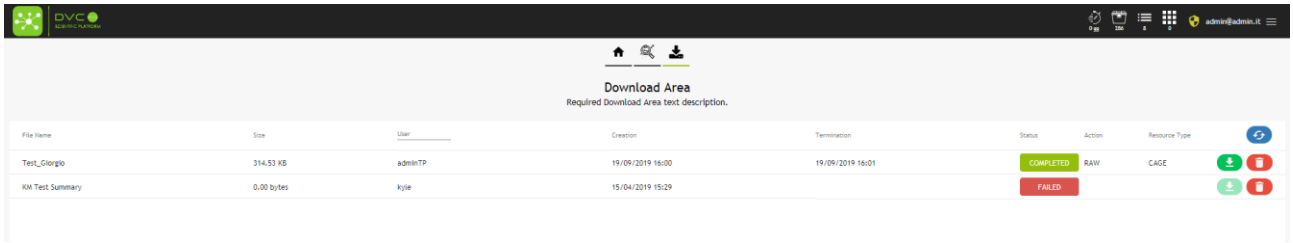
	day	hour	minute	relativeTime	g1_TIMESTAMP	g1_AVG	g1_SEM	g1_QRT	g1_SAMPLES	g1_cage1	g2_TIMESTAMP	g2_AVG	g2_SEM	g2_QRT	g2_SAMPLES	g2_cage1	g2_cage2
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

day	Day from date selected on the observation time
hour	Hour of that day 1-24
minute	Minute of that hour 1-60
relative Time	Absolute value (in seconds) of the timing from the previous midnight of the starting date
g1_TIMESTAMP	Absolute Time Stamp in UTC time for group 1 (https://en.wikipedia.org/wiki/Coordinated_Universal_Time)
g1_AVG	Metric Average of group 1
g1_SEM	SEM Group 1
g1_QRT	Quartile Group 1 [Minimum, Lower Quartile, Median, Upper Quartile, Maximum]
g1_SAMPLES	Collected samples, detected in the specified time frame and for the entire group. Such information are useful to understand if the cage has been removed from the rack thus providing an estimation on how much data have been lost due to this event.
g1_cage1	Metric Average of the first selected cage within group 1
g2_TIMESTAMP	Absolute Time Stamp group 2
g2_AVG	Metric Average of group 2
g2_SEM	Standard Error Group 2
g2_QRT	Quartile Group 2 [Minimum, Lower Quartile, Median, Upper Quartile, Maximum]
g2_SAMPLES	Amount of information, samples, detected in the specified time frame and for the entire group. Such information are useful to understand if the cage has been removed from the rack thus providing an estimation on how much data have been lost due to this event.
g2_cage1	Metric Average of the first selected cage within group 2
g2_cage2	Metric Average of the second selected cage within group 2

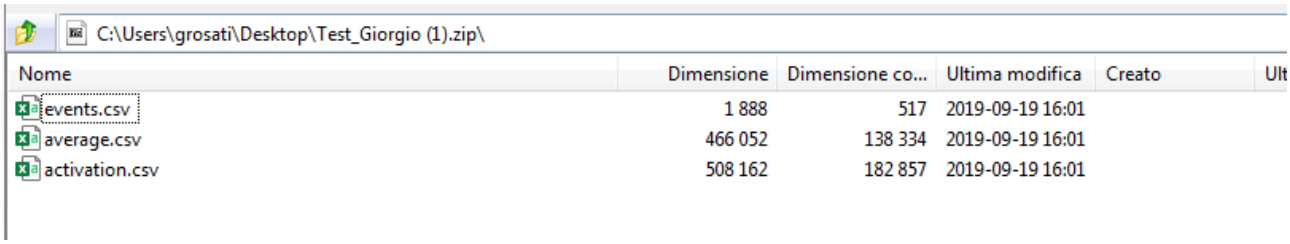
In order to start preparing the Download, it is mandatory to fill the File name section to activate the Download button

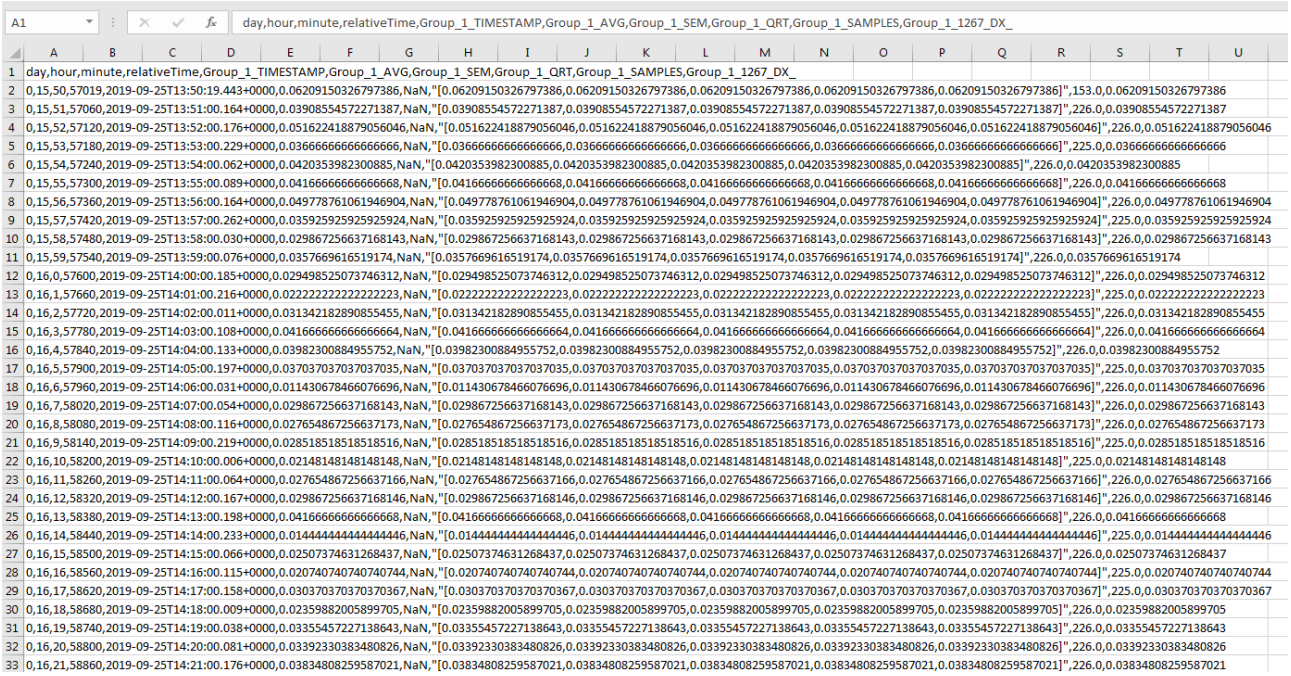
PLEASE NOTE: you find the "Downloaded data" in the dedicated section called Download Area

Where you can finally now really download on your PC the data simply clicking on the icon.



The file you download is a .zip file that contains .csv files (comma separated file), one each metric you have previously selected (in this case average = Bedding Status Index, activation = Animal Locomotion Index, events = DVC events)



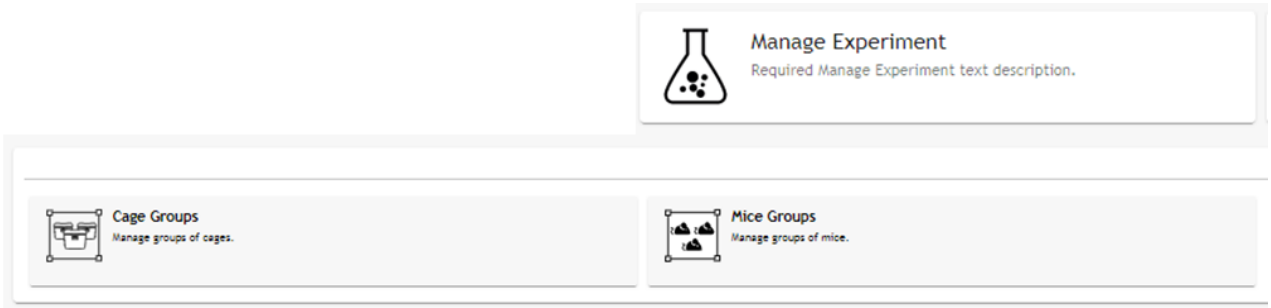


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	day,hour,minute,relativeTime,Group_1_TIMESTAMP,Group_1_AVG,Group_1_SEM,Group_1_QRT,Group_1_SAMPLES,Group_1_1267_DX_																				
2	0,15,50,57019,2019-09-25T13:50:19.443+0000,0.06209150326797386,NaN,"[0.06209150326797386,0.06209150326797386,0.06209150326797386,0.06209150326797386,0.06209150326797386]",153.0,0.06209150326797386																				
3	0,15,51,57060,2019-09-25T13:51:00.164+0000,0.03908554572271387,NaN,"[0.03908554572271387,0.03908554572271387,0.03908554572271387,0.03908554572271387,0.03908554572271387]",226.0,0.03908554572271387																				
4	0,15,52,57120,2019-09-25T13:52:00.176+0000,0.051622418879056046,NaN,"[0.051622418879056046,0.051622418879056046,0.051622418879056046,0.051622418879056046,0.051622418879056046]",226.0,0.051622418879056046																				
5	0,15,53,57180,2019-09-25T13:53:00.229+0000,0.03666666666666666,NaN,"[0.03666666666666666,0.03666666666666666,0.03666666666666666,0.03666666666666666,0.03666666666666666]",225.0,0.03666666666666666																				
6	0,15,54,57240,2019-09-25T13:54:00.062+0000,0.0420353982300885,NaN,"[0.0420353982300885,0.0420353982300885,0.0420353982300885,0.0420353982300885,0.0420353982300885]",226.0,0.0420353982300885																				
7	0,15,55,57300,2019-09-25T13:55:00.089+0000,0.04166666666666668,NaN,"[0.04166666666666668,0.04166666666666668,0.04166666666666668,0.04166666666666668,0.04166666666666668]",226.0,0.04166666666666668																				
8	0,15,56,57360,2019-09-25T13:56:00.164+0000,0.049778761061946904,NaN,"[0.049778761061946904,0.049778761061946904,0.049778761061946904,0.049778761061946904,0.049778761061946904]",226.0,0.049778761061946904																				
9	0,15,57,57420,2019-09-25T13:57:00.262+0000,0.03592592592925924,NaN,"[0.03592592592925924,0.03592592592925924,0.03592592592925924,0.03592592592925924,0.03592592592925924]",225.0,0.03592592592925924																				
10	0,15,58,57480,2019-09-25T13:58:00.030+0000,0.029867256637168143,NaN,"[0.029867256637168143,0.029867256637168143,0.029867256637168143,0.029867256637168143,0.029867256637168143]",226.0,0.029867256637168143																				
11	0,15,59,57540,2019-09-25T13:59:00.076+0000,0.0357669616519174,NaN,"[0.0357669616519174,0.0357669616519174,0.0357669616519174,0.0357669616519174,0.0357669616519174]",226.0,0.0357669616519174																				
12	0,16,0,57600,2019-09-25T14:00:00.185+0000,0.02949852073746312,NaN,"[0.02949852073746312,0.02949852073746312,0.02949852073746312,0.02949852073746312,0.02949852073746312]",226.0,0.02949852073746312																				
13	0,16,1,57660,2019-09-25T14:01:00.216+0000,0.022222222222222223,NaN,"[0.022222222222222223,0.022222222222222223,0.022222222222222223,0.022222222222222223,0.022222222222222223]",225.0,0.022222222222222223																				
14	0,16,2,57720,2019-09-25T14:02:00.011+0000,0.031342182890855455,NaN,"[0.031342182890855455,0.031342182890855455,0.031342182890855455,0.031342182890855455,0.031342182890855455]",226.0,0.031342182890855455																				
15	0,16,3,57780,2019-09-25T14:03:00.108+0000,0.041666666666666664,NaN,"[0.041666666666666664,0.041666666666666664,0.041666666666666664,0.041666666666666664,0.041666666666666664]",226.0,0.041666666666666664																				
16	0,16,4,57840,2019-09-25T14:04:00.133+0000,0.03982300884955752,NaN,"[0.03982300884955752,0.03982300884955752,0.03982300884955752,0.03982300884955752,0.03982300884955752]",226.0,0.03982300884955752																				
17	0,16,5,57900,2019-09-25T14:05:00.197+0000,0.037037037037037035,NaN,"[0.037037037037037035,0.037037037037037035,0.037037037037037035,0.037037037037037035,0.037037037037037035]",225.0,0.037037037037037035																				
18	0,16,6,57960,2019-09-25T14:06:00.031+0000,0.011430678466076696,NaN,"[0.011430678466076696,0.011430678466076696,0.011430678466076696,0.011430678466076696,0.011430678466076696]",226.0,0.011430678466076696																				
19	0,16,7,58020,2019-09-25T14:07:00.054+0000,0.029867256637168143,NaN,"[0.029867256637168143,0.029867256637168143,0.029867256637168143,0.029867256637168143,0.029867256637168143]",226.0,0.029867256637168143																				
20	0,16,8,58080,2019-09-25T14:08:00.116+0000,0.027654867256637173,NaN,"[0.027654867256637173,0.027654867256637173,0.027654867256637173,0.027654867256637173,0.027654867256637173]",226.0,0.027654867256637173																				
21	0,16,9,58140,2019-09-25T14:09:00.219+0000,0.028518518518518516,NaN,"[0.028518518518518516,0.028518518518518516,0.028518518518518516,0.028518518518518516,0.028518518518518516]",225.0,0.028518518518518516																				
22	0,16,10,58200,2019-09-25T14:10:00.006+0000,0.02148148148148148,NaN,"[0.02148148148148148,0.02148148148148148,0.02148148148148148,0.02148148148148148,0.02148148148148148]",225.0,0.02148148148148148																				
23	0,16,11,58260,2019-09-25T14:11:00.064+0000,0.027654867256637166,NaN,"[0.027654867256637166,0.027654867256637166,0.027654867256637166,0.027654867256637166,0.027654867256637166]",226.0,0.027654867256637166																				
24	0,16,12,58320,2019-09-25T14:12:00.167+0000,0.029867256637168146,NaN,"[0.029867256637168146,0.029867256637168146,0.029867256637168146,0.029867256637168146,0.029867256637168146]",226.0,0.029867256637168146																				
25	0,16,13,58380,2019-09-25T14:13:00.198+0000,0.04166666666666668,NaN,"[0.04166666666666668,0.04166666666666668,0.04166666666666668,0.04166666666666668,0.04166666666666668]",226.0,0.04166666666666668																				
26	0,16,14,58440,2019-09-25T14:14:00.233+0000,0.014444444444444446,NaN,"[0.014444444444444446,0.014444444444444446,0.014444444444444446,0.014444444444444446,0.014444444444444446]",225.0,0.014444444444444446																				
27	0,16,15,58500,2019-09-25T14:15:00.066+0000,0.02507374631268437,NaN,"[0.02507374631268437,0.02507374631268437,0.02507374631268437,0.02507374631268437,0.02507374631268437]",226.0,0.02507374631268437																				
28	0,16,16,58560,2019-09-25T14:16:00.115+0000,0.020740740740740744,NaN,"[0.020740740740740744,0.020740740740740744,0.020740740740740744,0.020740740740740744,0.020740740740740744]",225.0,0.020740740740740744																				
29	0,16,17,58620,2019-09-25T14:17:00.158+0000,0.030370370370370367,NaN,"[0.030370370370370367,0.030370370370370367,0.030370370370370367,0.030370370370370367,0.030370370370370367]",225.0,0.030370370370370367																				
30	0,16,18,58680,2019-09-25T14:18:00.009+0000,0.02359882005899705,NaN,"[0.02359882005899705,0.02359882005899705,0.02359882005899705,0.02359882005899705,0.02359882005899705]",226.0,0.02359882005899705																				
31	0,16,19,58740,2019-09-25T14:19:00.038+0000,0.03355457227138643,NaN,"[0.03355457227138643,0.03355457227138643,0.03355457227138643,0.03355457227138643,0.03355457227138643]",226.0,0.03355457227138643																				
32	0,16,20,58800,2019-09-25T14:20:00.081+0000,0.03392330383480826,NaN,"[0.03392330383480826,0.03392330383480826,0.03392330383480826,0.03392330383480826,0.03392330383480826]",226.0,0.03392330383480826																				
33	0,16,21,58860,2019-09-25T14:21:00.176+0000,0.03834808259587021,NaN,"[0.03834808259587021,0.03834808259587021,0.03834808259587021,0.03834808259587021,0.03834808259587021]",226.0,0.03834808259587021																				

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

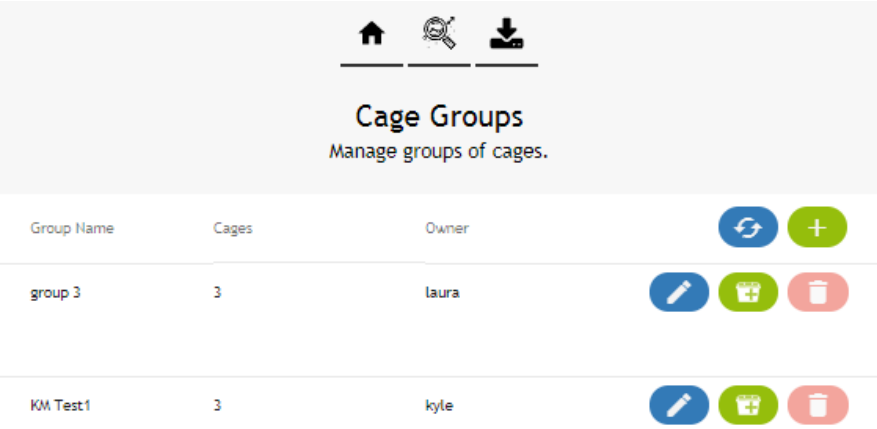
2.4 Manage Experiment

Clicking on the icon "Manage Experiment" other choices appear:

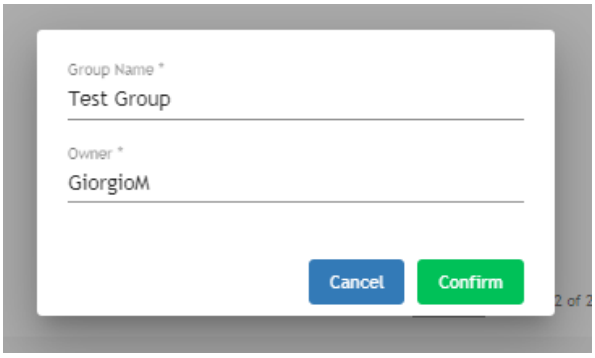


2.4.1 Cage Groups

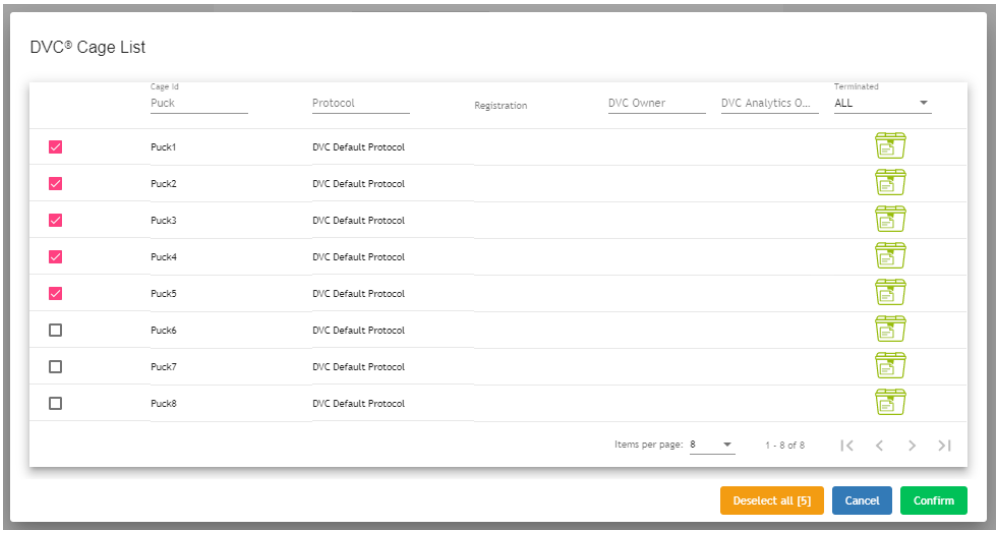
In this section it is possible to create specific groups of cages and assign to (already) existing DVC® Analytics users.



First step is to create the group, simply clicking on the corresponding icon  . A specific pop-up area appears and you are requested to insert the name of this group as well as the owner of the group.



Then, you can start adding cages to this group simply clicking on the icon  and then selecting the cages to be included in this group.

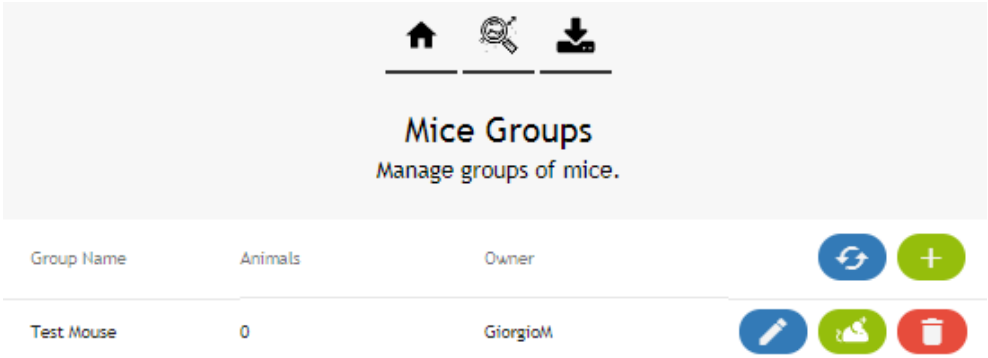


PLEASE NOTE: same cage(s) can be assigned to different groups.

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

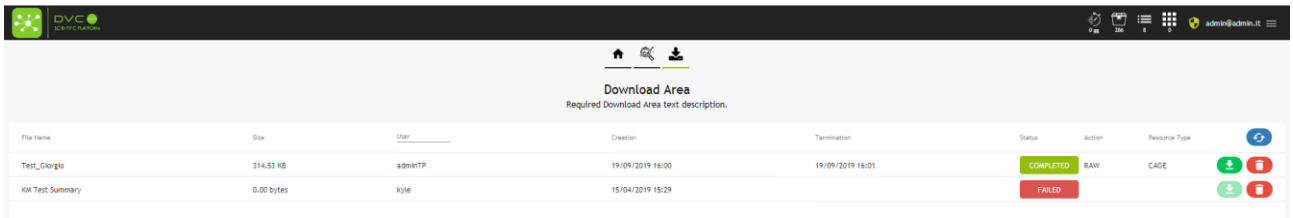
2.4.2 Mice groups

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



2.5 Download Area

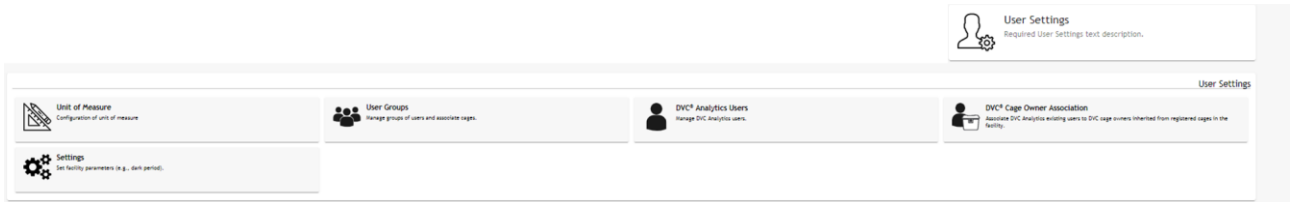
As already anticipated, in this section, you can immediately find all the requested-to-be-prepared data.



Additionally, you have other information such the status of the requested task (Running, Failed, Executed) as well as who requested it, the size of the file and the date of starting (Creation) and Termination.

2.6 User settings

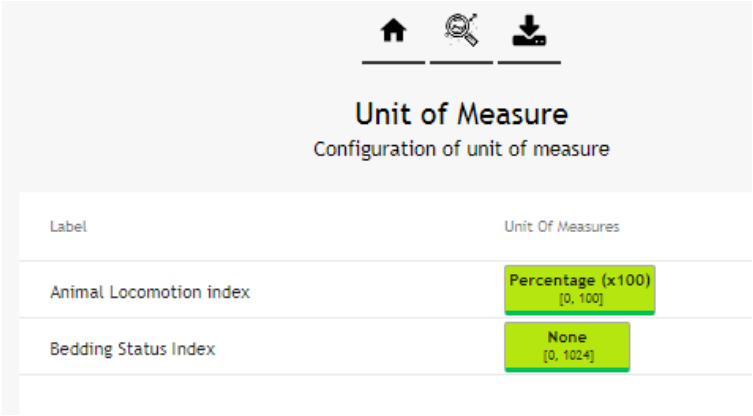
As described in section 2.1, this section is available only for the DVC® Analytics users registered as Facility Manager and not available to the users registered as Researchers.



There are different options you can set

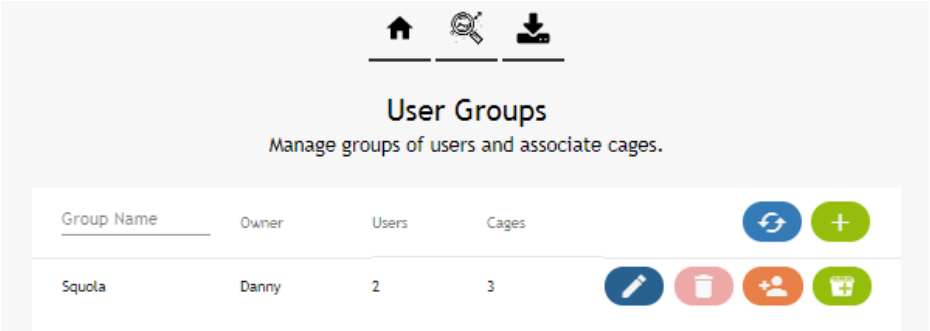
2.7 Unit of Measure

Clicking on the corresponding button, you can see which are your current settings set by Tecniplast

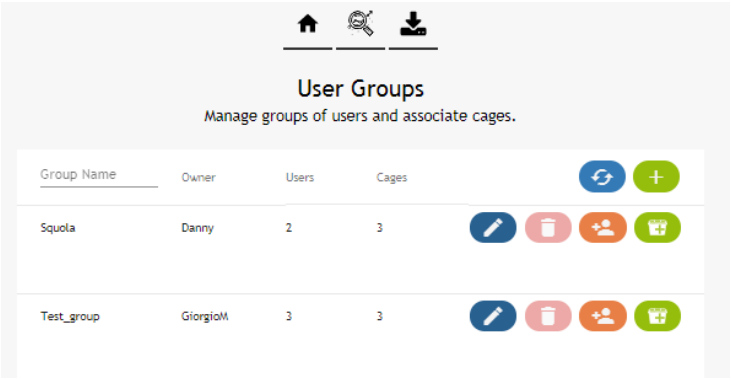


2.7.1 User Groups

You can create groups of users able to access to groups of cages.



This functionality is similar to the abovementioned Cage group (sect. 2.4.1) but with the difference that more users can now access to the same cages. You can simply add more users to the group clicking on the corresponding icon and then chose from the list, as well adding cages clicking on the icon and then choosing the selected ones from the list of available.

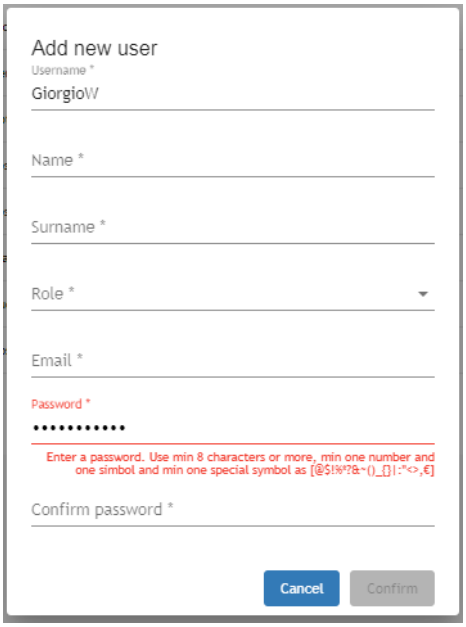


PLEASE NOTE: to delete a User group, you must deselect all the users and all the cages from the User group.

2.7.2 DVC® Analytics Users

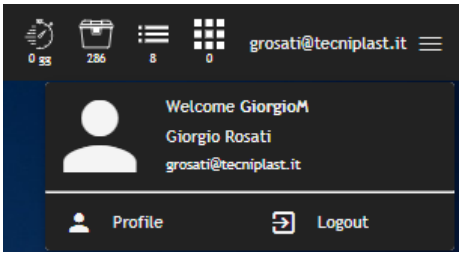
In this section you can create unlimited users simply clicking on the corresponding icon .

You must enter different information for any user:

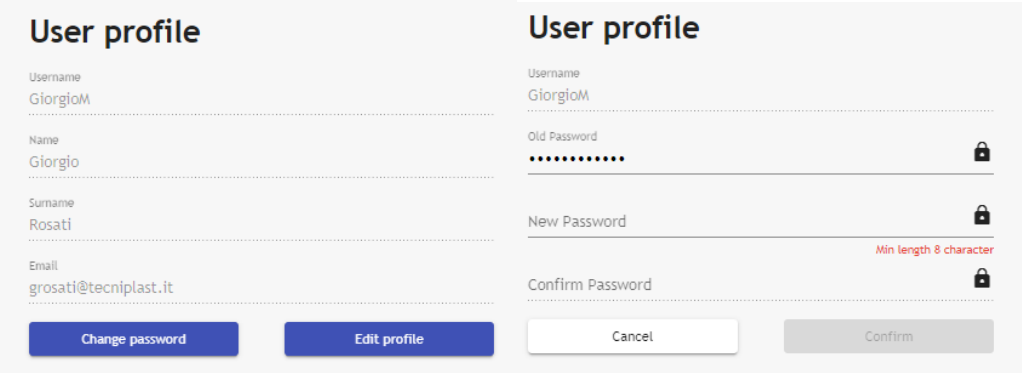


PLEASE NOTE: The minimum requirements to create your password are: 8 characters or more, one number and one symbol and one special symbol as [@$!%*?&~()_{}|:"<>,€]

Any new user must have an initial password that can be easily changed when entering for the first time in the application and clicking on the top right area ☰

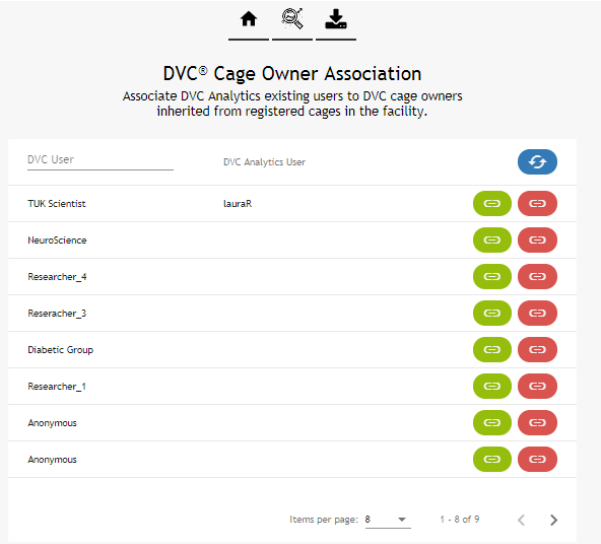


And then “Profile” and finally “Change Password” where the (new) user is requested to insert OLD password and new one.



2.7.3 DVC® Cage Owner Association

This section is fundamental especially if you are (or have) Researcher users, because it is the only way to analyze cages when using this profile.

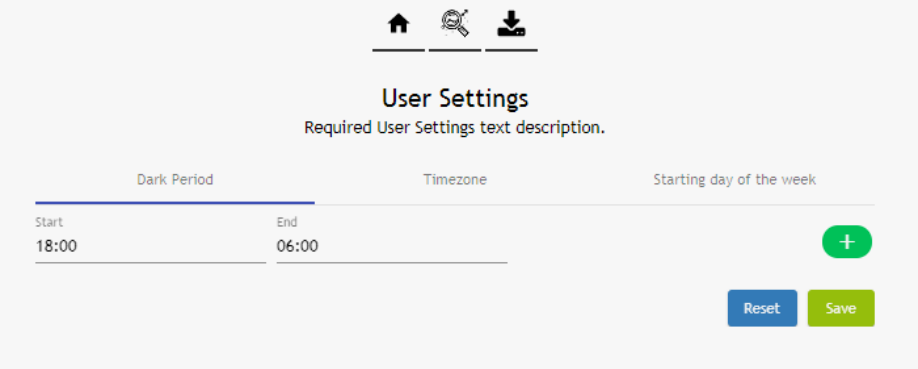


Every cage prepared in the DVC® system can have a DVC® Owner associated to it (it is not mandatory but highly suggested when used in combination with DVC® Analytics). If so, this DVC® Owner is pushed to the DVC® Analytics and it is called DVC User and can be associated to already existing DVC® Analytics users simply clicking on the  icon.

PLEASE NOTE: only 1 DVC® Analytics user can be associate to the DVC User (it is not possible to associate multiple DVC® Analytics users to the same cages – you can manage this situation using.

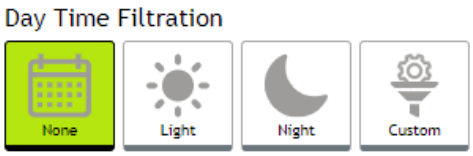
2.7.4 Settings

This button allows you to set different Facility information

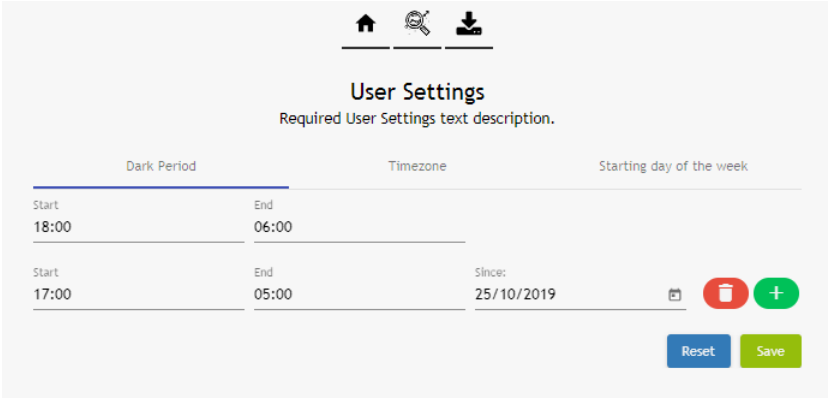


2.7.4.1 Dark Period

This section is fundamental to properly set your official night period in the Facility. This setting is used in the “Day Time Filtration” section.



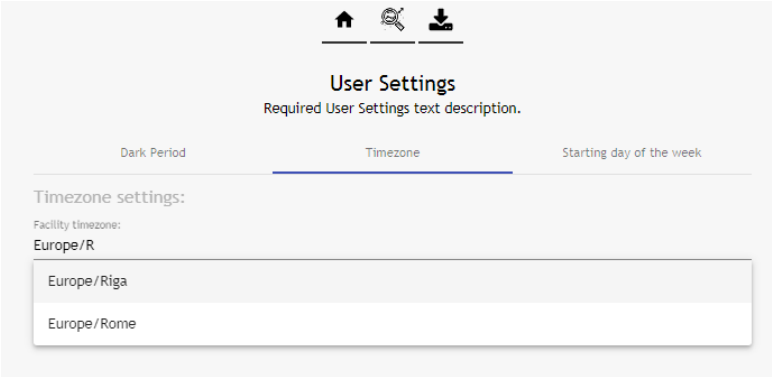
If you manage time-shift in your facility because of summer-winter time, you can click on the + and then select the new time interval and the date of start from this interval



PLEASE NOTE: you can change/delete this time interval and original data are not affected.

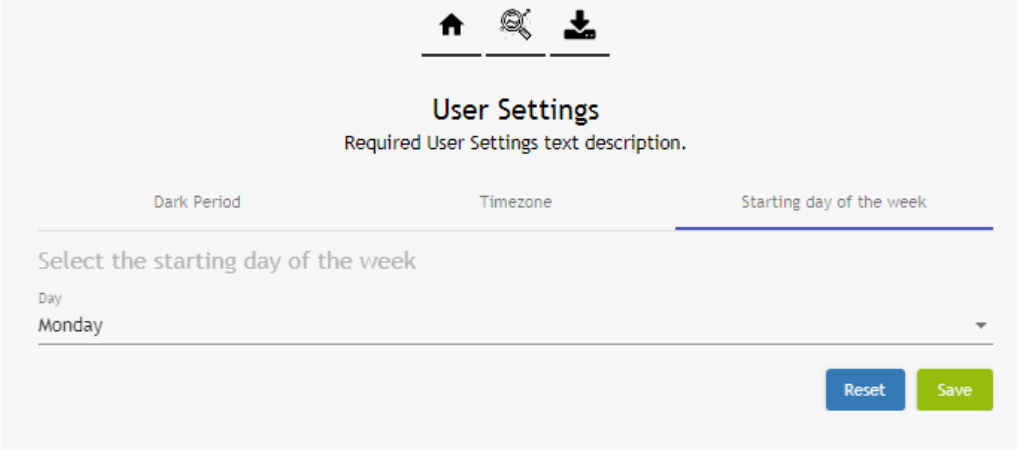
2.7.4.2 Time Zone

This is also important to “see” your data in the graph/charts considering your Facility Time zone. Simply start typing in the corresponding area and the field will autocomplete with your timezone



2.7.4.3 Starting of the week

In order to allow you maximum flexibility, it is possible to set the “first” day of the week that will be then used to display data especially in the daily and weekly graph selection:



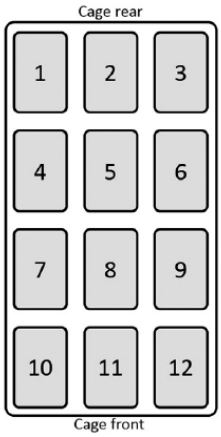
PLEASE NOTE: Sunday and Monday are currently the available “first” days of the week.

3 Useful information

In this section, we would like to provide you some tips and information that would be important to know in order to better understand how the DVC® Analytics works and get the most from it.

3.1 DVC® board

The DVC® board is the core of the DVC® system. There are 12 different electrodes that are mapping the entire base of the cage. These electrodes are numbered in the next way:

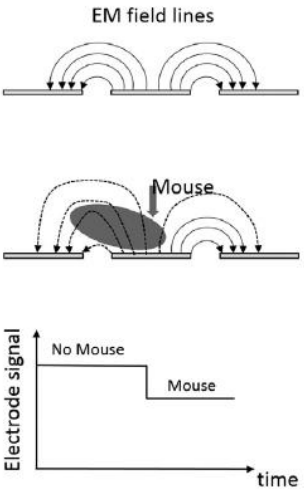


For some metrics (Animal Activity Index and Bedding Status Index) it is possible to select ONLY some electrodes (corners, walls, center, etc) if you want to deeply analyze specific patterns.

For some other metrics, such as Running Wheel or Animal Tracking for instance, it is not possible to select specific electrodes because the data are calculated using the Running Wheel or the entire DVC® board respectively.

3.2 DVC® working principle and derived metrics

Basically, the working principle of the DVC® system is based on an electrical capacitance sensing technology (CTS). As said, the DVC® board is composed of 12 electrodes connected to an integrated circuit that continuously measures their electrical capacitance every 250msec (roughly). Since capacitance is influenced by the matter present in each electrode's surrounding, its measurements are affected by the presence of, e.g., water and animals. Note that, materials with high water content are characterized by large values of relative permittivity (with respect to air), which in turns has a direct effect on capacitance (high relative permittivity means higher capacitance). Since mice are characterized by high water content, their movements performed while close to an electrode induce significant capacitance changes, and thus, by properly tracking these changes over time it is possible to monitor animal activity. Note that, capacitance remains substantially unchanged when material compositions around an electrode is 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 substantially different than that of water leakage or urine and thus the two variables can be easily distunguished. Furthermore, even when water/urine are present in an electrode surrounding (clearly not a flooded cage, but common amount of water/urine in a dirty cage) the capability of the system to discern animal movements is substantially unchanged. In fact, the presence of water/urine can change absolute capacitance readings, but not capacitance variations due to animal movements.



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

- **Animal Activity Index**
- **Bedding Status Index**
- **Animal Tracking Distance**
- **Animal Tracking Speed**
- **Running Wheel Rotation**
- **Running Wheel Distance**
- **Running Wheel Speed**

PLEASE NOTE: every element (cage or animal) has specific capabilities assigned by the DVC® system that enable or not correspondent DVC® metrics (a cage without Running Wheel doesn't enable the Running Wheel metric).

3.2.1 Animal Activity Index

This DVC® metric is extremely 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 considered activated when its measurements are perturbed significantly over a limited time interval, which generally occurs when a mouse performs activity while sufficiently close to an electrode (see below). Density indicates that the total number of activations are divided by the duration of the time interval considered and the number of electrodes of interest (up to twelve). A sketch of the Capacity Sensing Technology activation density metric is the following. Recall that the Capacity Sensing Technology board provides measurements related to electrode capacitance every 250ms and let $c_k(t)$ be the (filtered) capacitance measurements from the kth electrode at time t. Then, we compare the difference between two adjacent capacitance measurements as

$$\Delta_k(t) = c_k(t) - c_k(t-1).$$

The rationale behind this is that when no animal movements occur the difference Δk(t) is approximately zero as there are no variations in electrode capacitance, while absolute values $|\Delta k(t)|>0$ indicate capacitance variations that are generally caused by animal movements. According to these observations, we consider that an electrode is activated when we observe a change in adjacent measurements larger than a fixed threshold λ. The threshold is conveniently chosen to separate noise induced capacitance variations from animal movements. Finally, the binary information indicating whether the electrode is activated at time t is given by:

$$a_k(t) = 1[|\Delta_k(t)| \geq \lambda]$$

where 1[x] is the indicator function for the event x, with 1[x]=1 if event x is true and 1[x]=0 otherwise. Finally, one is generally interested in measuring the average amount of activations, occurring across a given set of electrodes (i.e., area of the cage) and within a given time interval. To do so, the CST activation density within time periods t1 and t2, across set of electrode S, can be computed as

$$A_{CST}(t_1, t_2) = \frac{1}{|S|\,(t_2 - t_1)} \sum_{k \in S} \sum_{t=t_1}^{t_2-1} a_k(t)$$

where |S| indicates the cardinality (i.e., number of electrodes) of set S. Note that, the CST activation density does not indicate the type of movement performed, but it only accounts whether activity occurred close to an electrode.

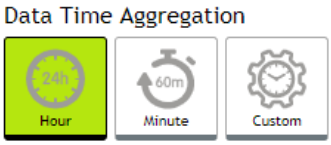
This Animal Activity Index is expressed in % arbitrary unit and it is normalized between 0% and 100%.

3.2.2 Bedding Status Index

This DVC® metric has been developed in order to provide the possibility to determine and analyze the status of the bedding. There are basically 2 different events that affect bedding status:

- **Growing moisture due to latrine creation**
- **Water flooding due to water bottle leakage and/or Automatic Watering System valve failure**

In both cases, this DVC® metric is calculated starting from the absolute value collected by the CST and applied a specific-time-interval average function (minute, hour, custom)



PLEASE NOTE: this DVC® metric lends itself well to use the different mapping electrodes opportunity

3.2.3 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:

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

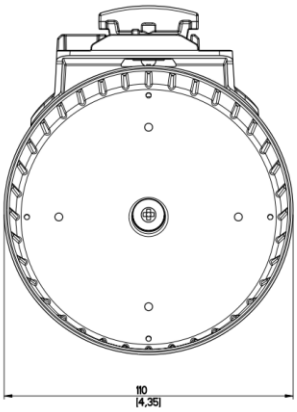
is the Euclidean distance between two positions in adjacent frames.

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

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

3.2.4 Running Wheel Rotation, Distance and Speed

Using the product DVC® Running wheel, it is possible to automate several metrics. The diameter of the plastic DVC® Running wheel is 110,4 mm (4,35 inch) that corresponds to a perimeter of about 34,54 cm (13,6 inch).



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 * 34,54 cm (13,6 inch) in the selected time-resolution
- **Running Wheel Speed**: expressed in cm/min or m/min

3.3 How data are calculated and aggregated

Considering the different data and the different charts, it is fundamental to understand how these are calculated.

3.3.1 Line Chart

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

SPATIAL AGGREGATION: average of the selected DVC® boards electrodes (by default the 12 electrodes). The result is one single data point (if you select only the corners, the data point is the average of the 4 electrodes).

TEMPORAL AGGREGATION: the default temporal window (minute and hour) are automatically calculated by the DVC® system while they are occurring. Vice versa, if you have selected a custom temporal window, the result is the average of all the minutes included into the custom 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 the calculated as the average of the single calculated metric.

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

3.3.2 Line chart with SEM

As explained in section 2.3.3.1, the 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), it is simply calculated as (where SD = Standard Deviation):

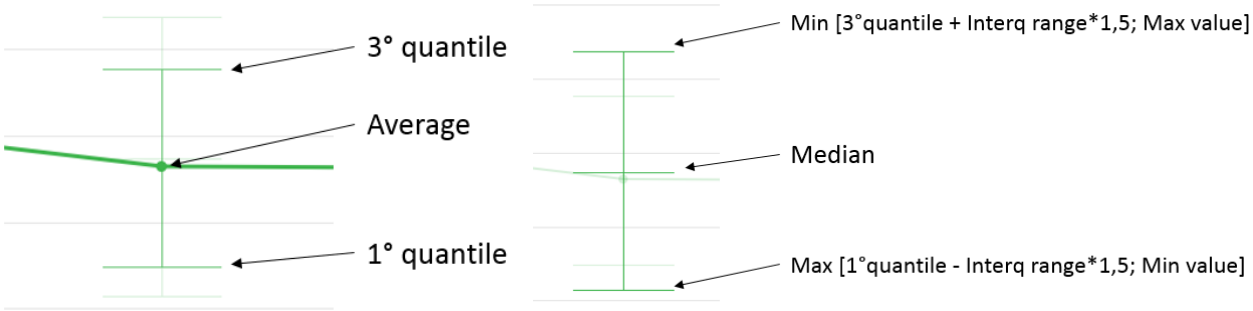
$$\mathbf{SEM = SD / \sqrt{(\#samples)}}$$

In the correspondent Linechart it is shown as average (central data point) ± SEM.

3.3.3 Line chart with Interquantile

As explained in section 2.3.3.1, the INTERQUANTILE 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 6 different points per data sample:

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



3.3.4 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:

$$d(0) = A(0)$$

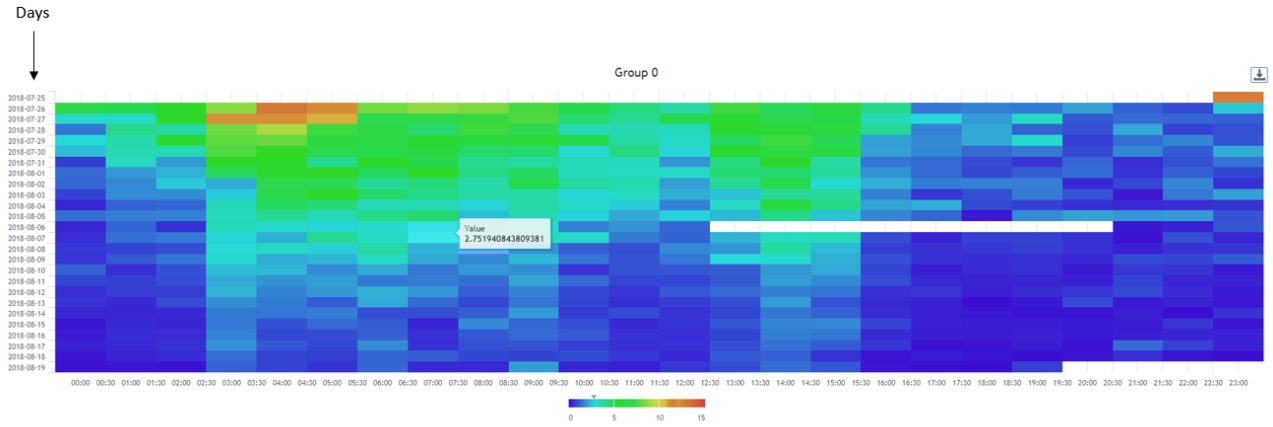
$$d(1) = A(0) + A(1)$$

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

$$d(n) = A(0) + A(1) + A(2) + \dots + A(n)$$

3.3.5 Heatmap

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



24 hours of the day, starting from midnight to midnight

3.3.6 Box Plot

Spatial aggregation is the same of the Line Chart. Temporal aggregation is forced to be calculated on 24 hours (the day). 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 5 different points per data sample:

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