

# PERFORMANCE OF WINDOWS MADE OF THERMALLY AND NON- MODIFIED NORWAY SPRUCE IN DIFFERENT CLIMATIC CONDITIONS

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# CHALLENGES BY NEW BUILDINGS





# BACKGROUND

Thermal conductivity coefficient  $\lambda$  of thermal modified Norway spruce wood is 20% lower than nature Norway spruce wood



In last few years an advantageous formulation prototype of innovative wood protective wax coating has been developed.

# GOALS

- Develop and test passive window, made of *Silvapro* thermally modified spruce, surface treated with *Silvacera* wax coating



# GOAL OF TEST CUBES

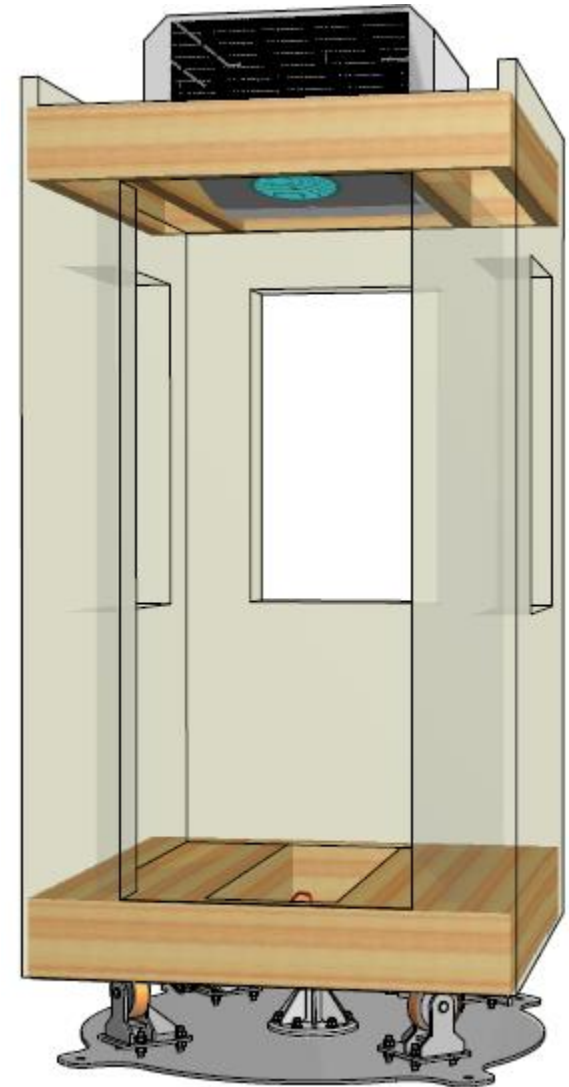
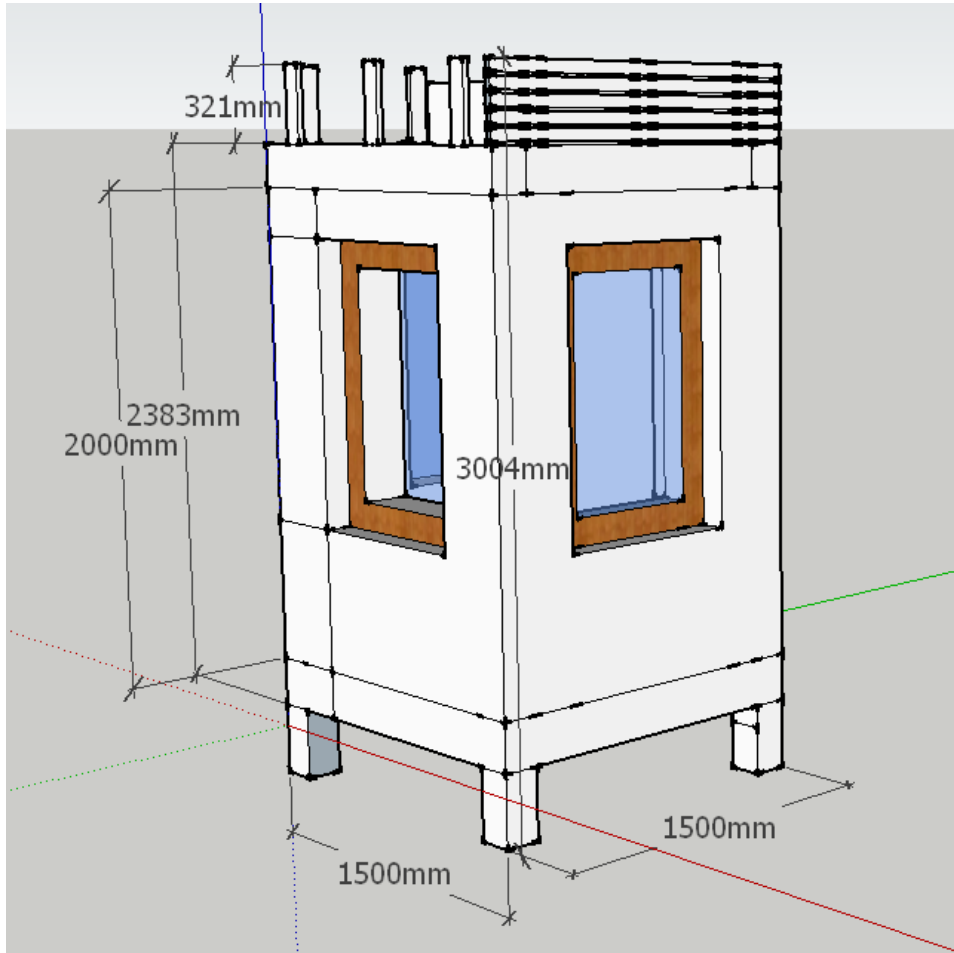
- Behaviour testing and modelling of windows and facades elements
- To test:
  - Colour measurement
  - Decay
  - Fungal disfigurement
  - Moisture content recordings



# LOCATIONS OF TEST CUBES

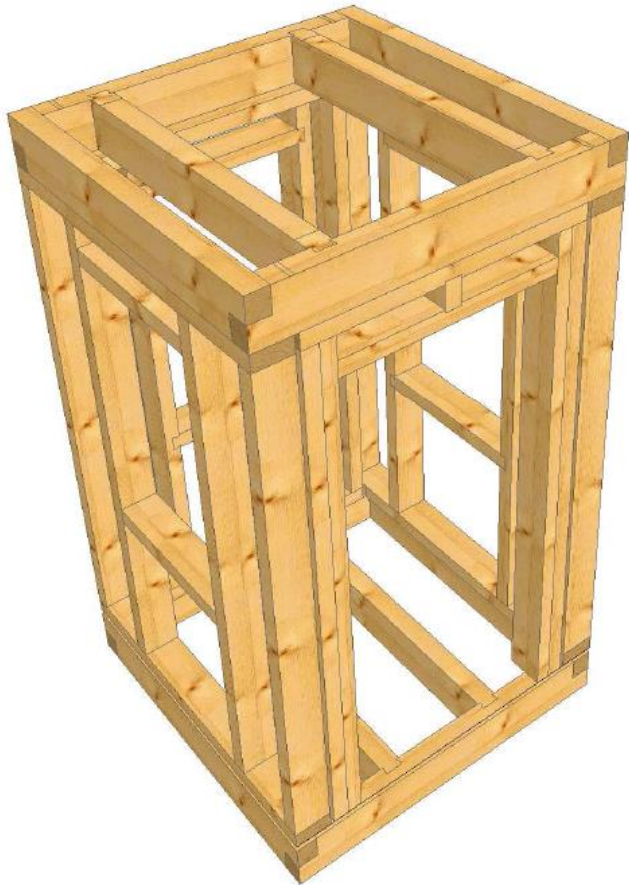


# SKETCH OF TEST CUBES





# ASSEMBLING TEST CUBES



# WAXING PROCESS



# MATERIALS ON THE FASSADE



Material number	Specimen number	Wood species	Thermal treatment	Surface treatment material	Surface treatment process	Additives
1	2-8	Norway spruce ( <i>Picea abies</i> )	-	-	-	-
2	9-15		-	Coating Silvanol B, No. 3	Brushing	-
3	16-22		-	Silvacera wax - conc. 1	Dip-coating I	-
4	23-30		-	Silvacera wax - conc. 2	Dip-coating I	-
5	31-37		Silvapro	-	-	-
6	39-44		Silvapro	-	-	-
7	45-52		Silvapro	Coating Silvanol B, No. 3	Brushing	-
8	53-59		Silvapro	Coating M SORA 03-08	Spraying	-
9	61-67		Silvapro	Silvacera wax - conc. 1	Dip-coating II	-
10	68-74		Silvapro	Silvacera wax - conc. 2	Dip-coating II	-
11	75-81		Silvapro	Silvacera wax - conc. 3	Dip-coating II	-
12	82-89		Silvapro	Silvacera wax - conc. 1	Dip-coating I	-
13	90-96		Silvapro	Silvacera wax - conc. 2	Dip-coating I	-
14	98-104		Silvapro	Silvacera wax - conc. 3	Dip-coating I	-
15	105-111		Silvapro	Reference wax - conc. 4	Dip-coating I	-
16	112-118		Silvapro	Reference wax - conc. 1	Dip-coating I	-
17	119-126		Silvapro	Reference wax - conc. 2	Dip-coating I	-
18	127-133		Silvapro (after surface treatment)	Silvacera wax - conc. 1	Dip-coating I	-
19	135-140		Silvapro (after surface treatment)	Silvacera wax - conc. 2	Dip-coating I	-
20	141-148		Silvapro (after surface treatment)	Silvacera wax - conc. 3	Dip-coating I	-
21	149-155		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment M SORA 03-08 I
22	157-163		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment M SORA 03-08 II
23	164-170		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment M SORA 03-08 III
24	171-177		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment M SORA 03-08 IV
25	178-185		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment Silvaproduct No. 3 I
26	186-192		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment Silvaproduct No. 3 II
27	194-200		Silvapro	Silvacera wax - conc. 2	Dip-coating I	M SORA UV-blocker I
28	201-207		Silvapro	Silvacera wax - conc. 2	Dip-coating I	M SORA UV-blocker II
29	208-214		Siberian larch ( <i>Larix sibirica</i> )	-	-	-
30	215-222	-		M SORA oil	Brushing	-
31	223-229	Silvapro	Silvacera wax - conc. 2	Dip-coating I	In-can preservative	
32	231-236	Norway spruce ( <i>Picea abies</i> )	Silvapro	Silvacera wax - conc. 1	Dip-coating I	In-can preservative
33	237-244	Silvapro	Silvacera wax - conc. 3	Dip-coating I	In-can preservative	
34	245-251	Beech ( <i>Fagus sylvatica</i> )	-	-	-	
35	253-259		Silvapro	-	-	-
36	260-267		Silvapro	Silvacera wax - conc. 2	Dip-coating I	-
37	268-274		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment M SORA 03-08 III
38	275-281	Poplar ( <i>Populus spp.</i> )	-	-	-	
39	282-288		Silvapro	-	-	-
40	289-295		Silvapro	Silvacera wax - conc. 2	Dip-coating I	-
41	296-302		Silvapro	Silvacera wax - conc. 2	Dip-coating I	Pigment M SORA 03-08 III
42	303-309	Pine sapwood ( <i>Pinus spp.</i> )	-	-	-	
Window 1	-	Norway spruce ( <i>Picea abies</i> )	Silvapro/-	Coating M SORA 03-08	Spraying	-
Window 2	-		Silvapro/-	M SORA oil	Brushing	-
Window 3	-		Silvapro/-	Silvacera wax - conc. 2	Dip-coating I	-
Door	-	Norway spruce ( <i>Picea abies</i> )/ Siberian larch ( <i>Larix sibirica</i> )	Silvapro/-	Silvacera wax - conc. 2	Dip-coating I	-



# WINDOWS

- Description of window samples:
  - 3 samples per cube: ½ spruce, ½ thermally modified spruce (TMS)
  - Surface treated with synthetic coating (W1), oil (W2) and wax (W3)



# WINDOW INSTALATION



9.3.2016



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# DOORS

- Made of TMS
- Pannels made of waxed surface TMS, spruce and larch



# MONUTING OF SENSORS

Measurements:

- Colour measuring
- Blue stain
- Decay
- Moisture content
- Temperature





# MOISTURE CONTENT AND TEMPERATURE MEASUREMENT

- Moisture content (MC)
  - Every 12 h
  - Resistance based measurement
  - Calibration curves
- Temperature
  - Every hour
  - Sensors on the inner and outer part of the windows and under some facade elements



# COLOURS MEASUREMENT

- Before exposure
- After 14 days
- 1, 3, 6, 12 months



# VISUAL ASSESSMENT OF BLUE STAINING

According to modified standard EN 152



Rating	Classification	Definition
0	No disfigurement	No surface disfigurement can be detected visually on the surface.
1	Slight disfigurement	The surface exhibits only a few individual small colonies none larger than 1.5 mm in width and 4 mm in length.
2	Moderate disfigurement	The surface is colonized up to a maximum of one third of the total area.
3	Severe disfigurement	More than one third of the surface area is colonised.
x	Grey surface	Surface disfigurement caused by blue stain fungi can not be resolved from greying caused by weathering

# TEST CUBES ON LOCATIONS



Žiri (Slovenia)



Ljubljana (Slovenia)



Hannover (Germany)



Skellefteå (Sweden)



Madrid (Spain)

WINTHERWAX TEST CUBES AROUND EUROPE



# CLIMATE DATA OF TEST SITES

		Madrid	Borås	Skellefteå	Ljubljana	Žiri	Hannover
Average temperature	[°C]	<b>13.7</b>	6.4	1.9	10.4	9.8	<b>8.8</b>
Av. January temperature	[°C]	5.0	-2.3	<b>-11.0</b>	-0.1	0.1	<b>0.3</b>
Av. July temperature	[°C]	<b>24.0</b>	16.0	15.5	20.4	19.4	<b>17.1</b>
Annual rain	[mm]	450	913	559	<b>1290</b>	1271	<b>666</b>
Scheffer Climate Index SCI	[ - ]	<b>21.4</b>	38.4	<b>23.5</b>	<b>50.8</b>	41.4	<b>50.9</b>
SCI relative	[ - ]	<b>0.61</b>	1.09	<b>0.67</b>	<b>1.44</b>	1.17	<b>1.44</b>
Dose (decay model)	[ - ]	<b>15.4</b>	47.1	<b>14.9</b>	<b>57.3</b>	48.1	41.4
Dose relative	[ - ]	<b>0.65</b>	1.99	<b>0.63</b>	<b>2.42</b>	2.03	1.75



# WINDOW – MAX MC

	Ljubljana	Ziri	madrid	hannover	Sweden
	MAX	MAX	MAX	MAX	MAX
window Spruce TMT Coating down	9,2	8,8	8,1	9,3	7,6
window Spruce TMT Coating up	9,4	9,0	8,2	9,1	7,4
window Spruce TMT oje up	8,3	8,5	8,9	8,5	7,4
window Spruce TMT oil down	8,2	8,7	7,6	8,4	8,5
window Spruce TMT wax up	8,1	8,2	8,2	8,2	7,7
window Spruce TMT wax down	8,4	9,0	7,9	8,6	7,5

	Ljubljana	Ziri	madrid	hannover	Sweden
	MAX	MAX	MAX	MAX	MAX
window Spruce Coating down	15,5	15,3	14,6	15,3	14,0
window Spruce Coating up	15,8	15,2	14,3	15,7	13,8
window Spruce oil up	15,5	15,4	14,8	15,7	14,7
window Spruce oil down	15,8	15,5	14,2	15,4	14,7
window Spruce wax up	15,2	15,0	15,0	15,5	13,8
window Spruce wax down	15,0	15,5	14,9	15,5	13,6



# WINDOW – MEDIAN MC

	Ljubljana	Ziri	Madrid	Hannover	Sweden
	median	median	median	median	median
window Spruce TMT Coating down	6,8	6,7	6,7	7,4	5,9
window Spruce TMT Coating up	7,2	6,5	6,5	7,4	5,8
window Spruce TMT oje up	6,9	6,6	7,1	7,4	5,2
window Spruce TMT oil down	6,7	6,6	5,9	7,5	6,1
window Spruce TMT wax up	7,2	6,3	6,3	7,5	5,9
window Spruce TMT wax down	7,0	6,5	5,9	7,8	5,2

	Ljubljana	Ziri	Madrid	Hannover	Sweden
	median	median	median	median	median
window Spruce Coating down	13,7	13,0	12,3	13,0	10,6
window Spruce Coating up	13,5	12,4	11,7	13,3	10,8
window Spruce oil up	13,2	12,3	12,2	13,9	10,5
window Spruce oil down	13,2	11,6	11,6	14,0	9,7
window Spruce wax up	13,4	12,4	12,3	14,4	10,1
window Spruce wax down	12,9	12,7	12,1	14,2	10,4

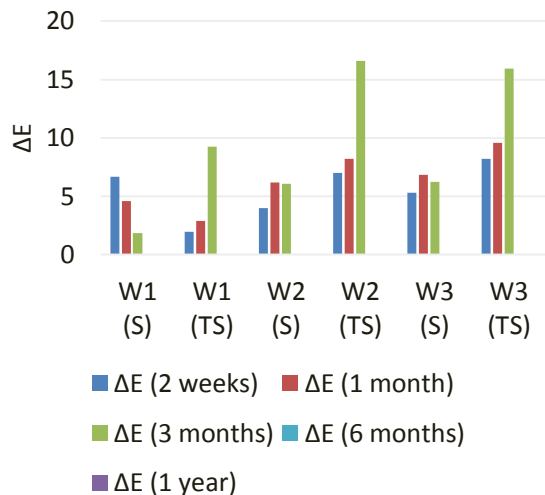
# COLOUR CHANGES

Windows

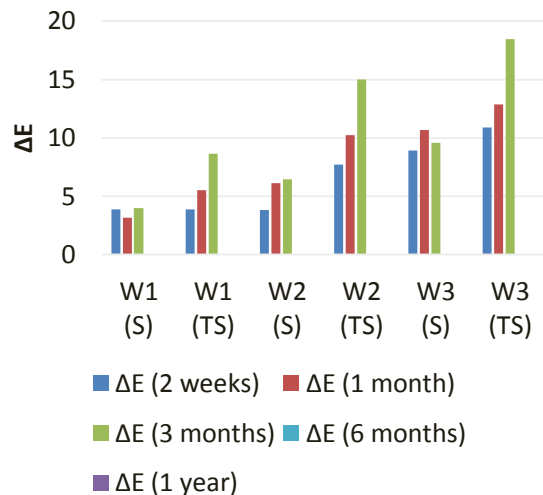




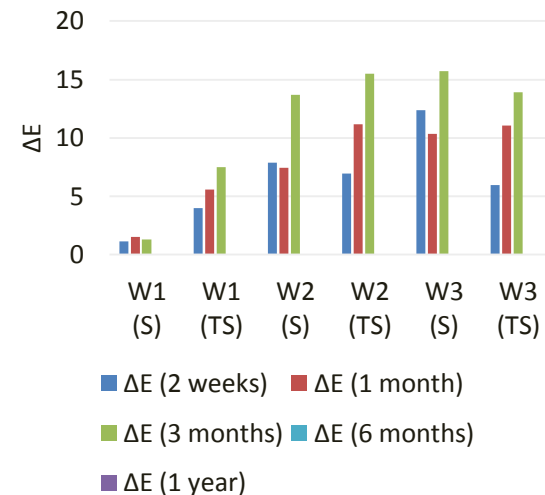
# ŽIRI



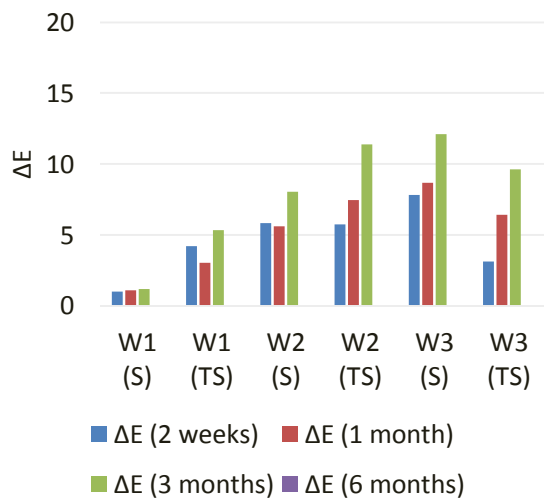
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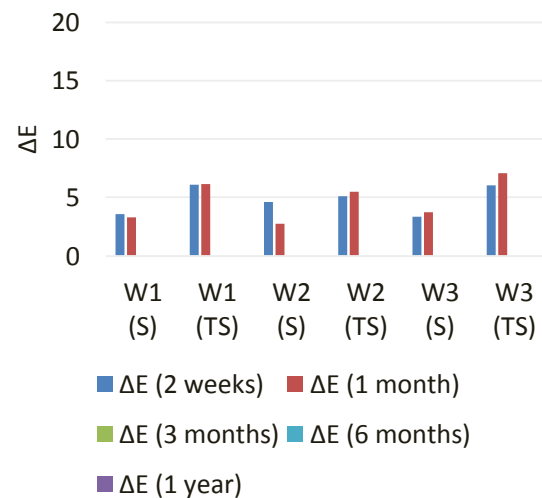
# MADRID



# LJUBLJANA



# SKELLEFTEÅ

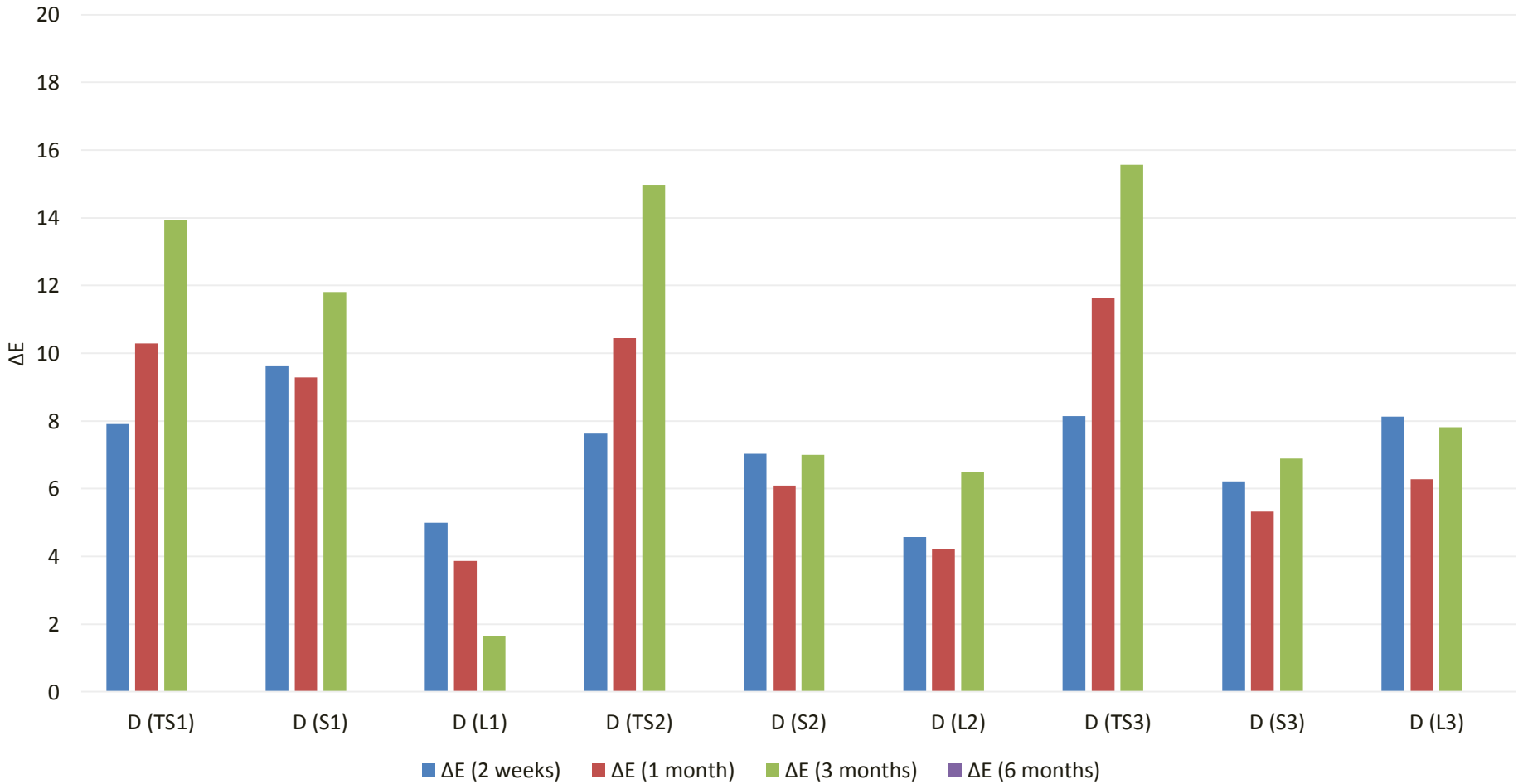


# COLOUR CHANGES

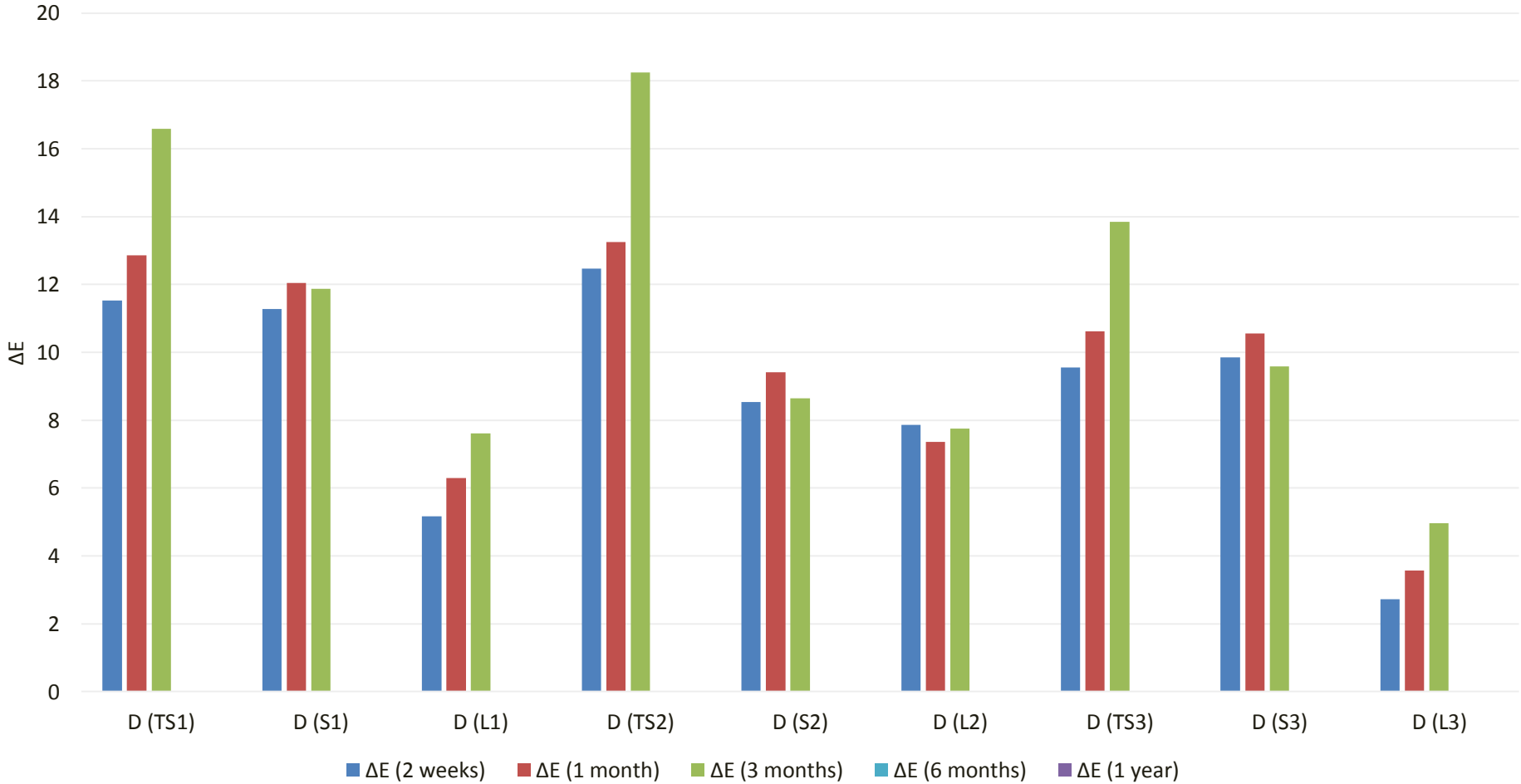
Door Ljubljana and Madrid



# LJUBLJANA



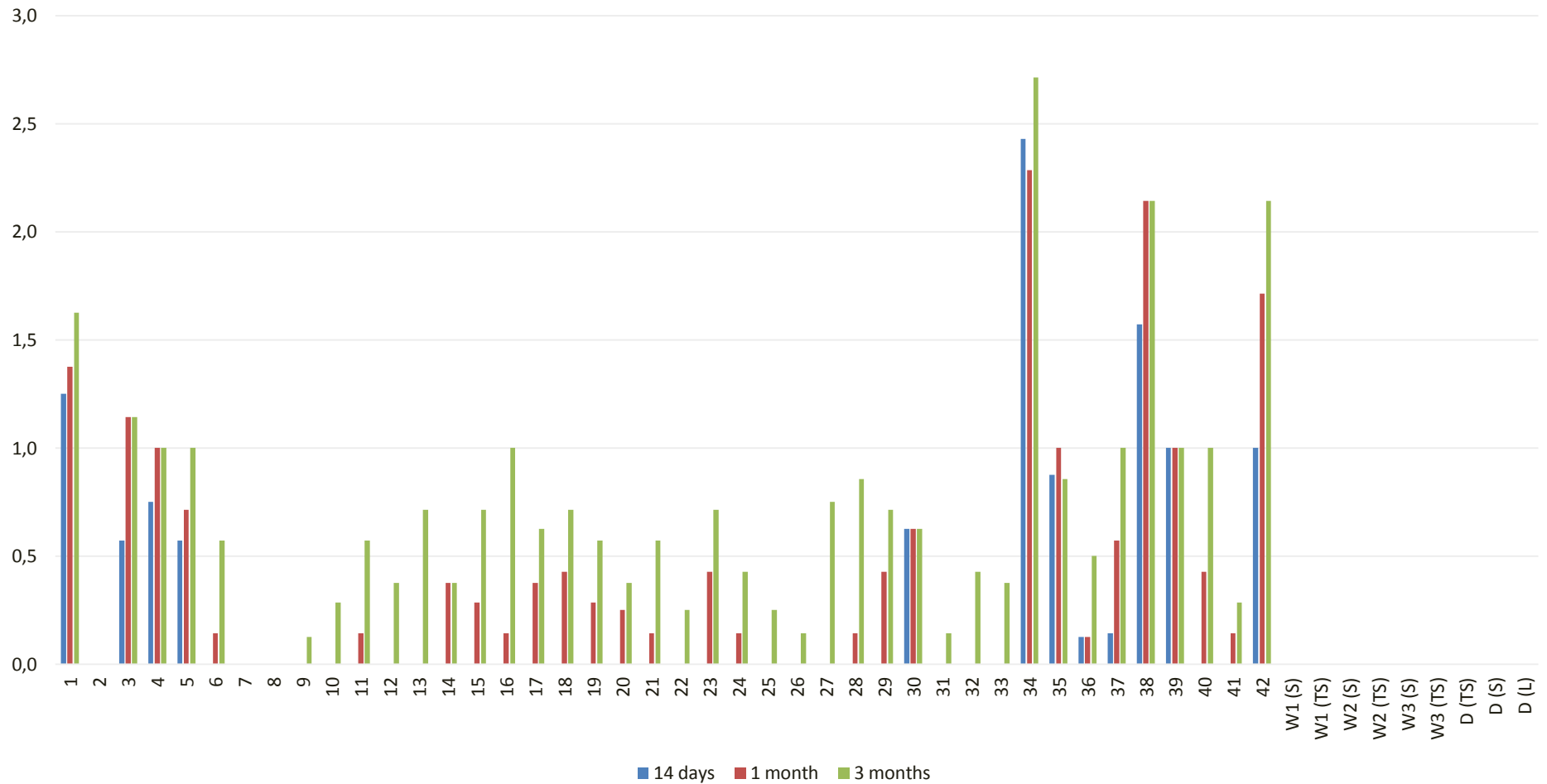
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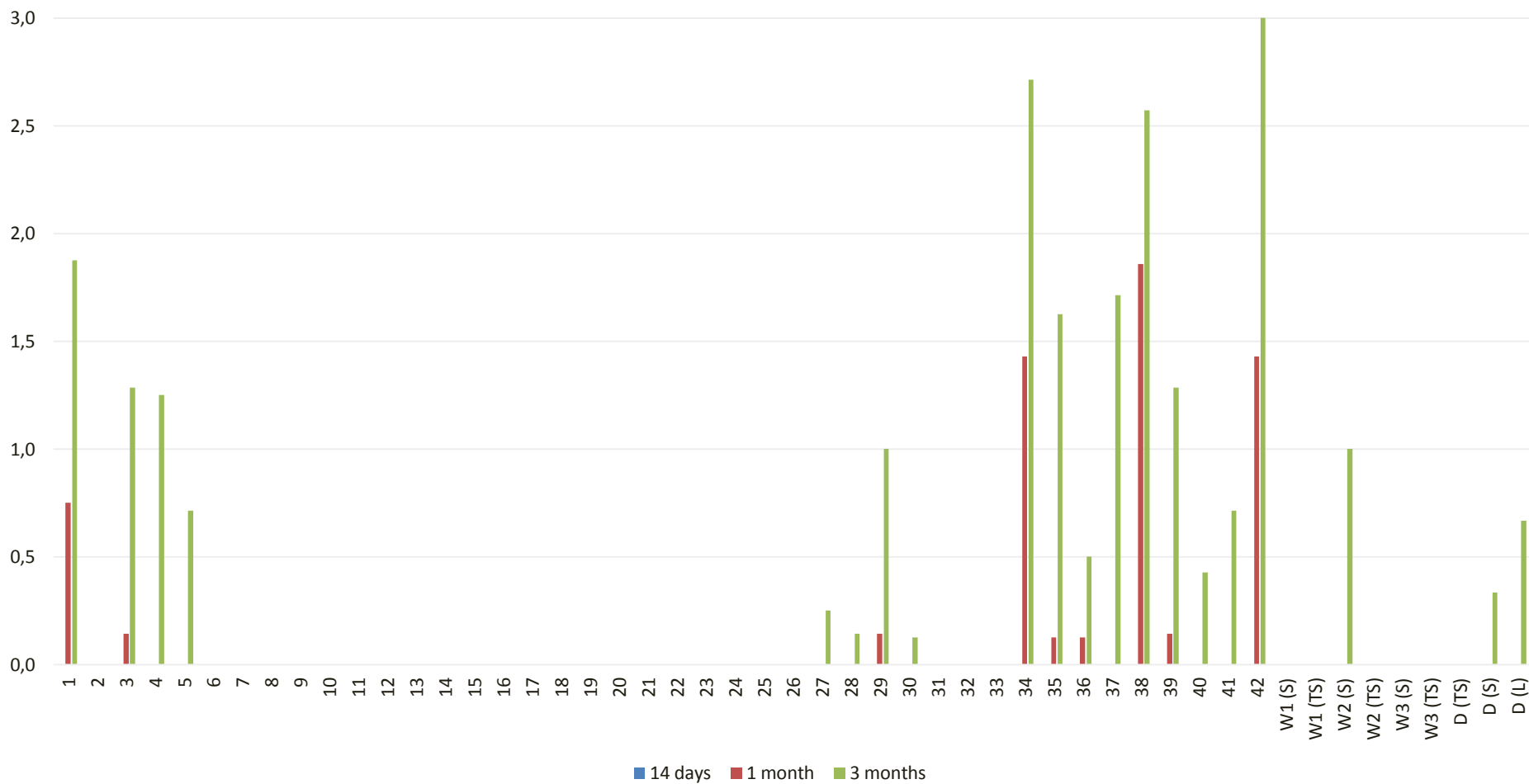
# BLUE STAIN



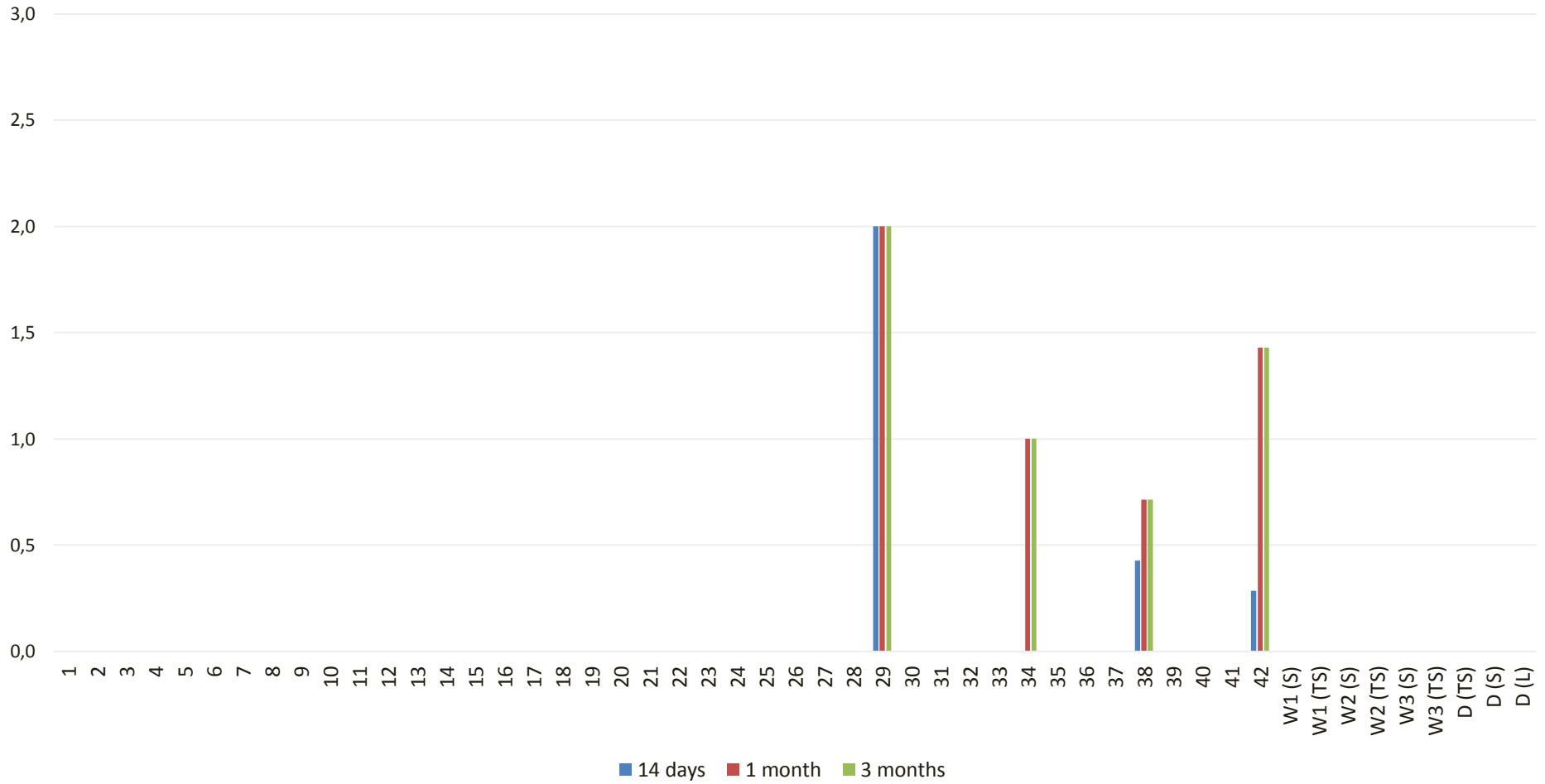
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# ŽIRI

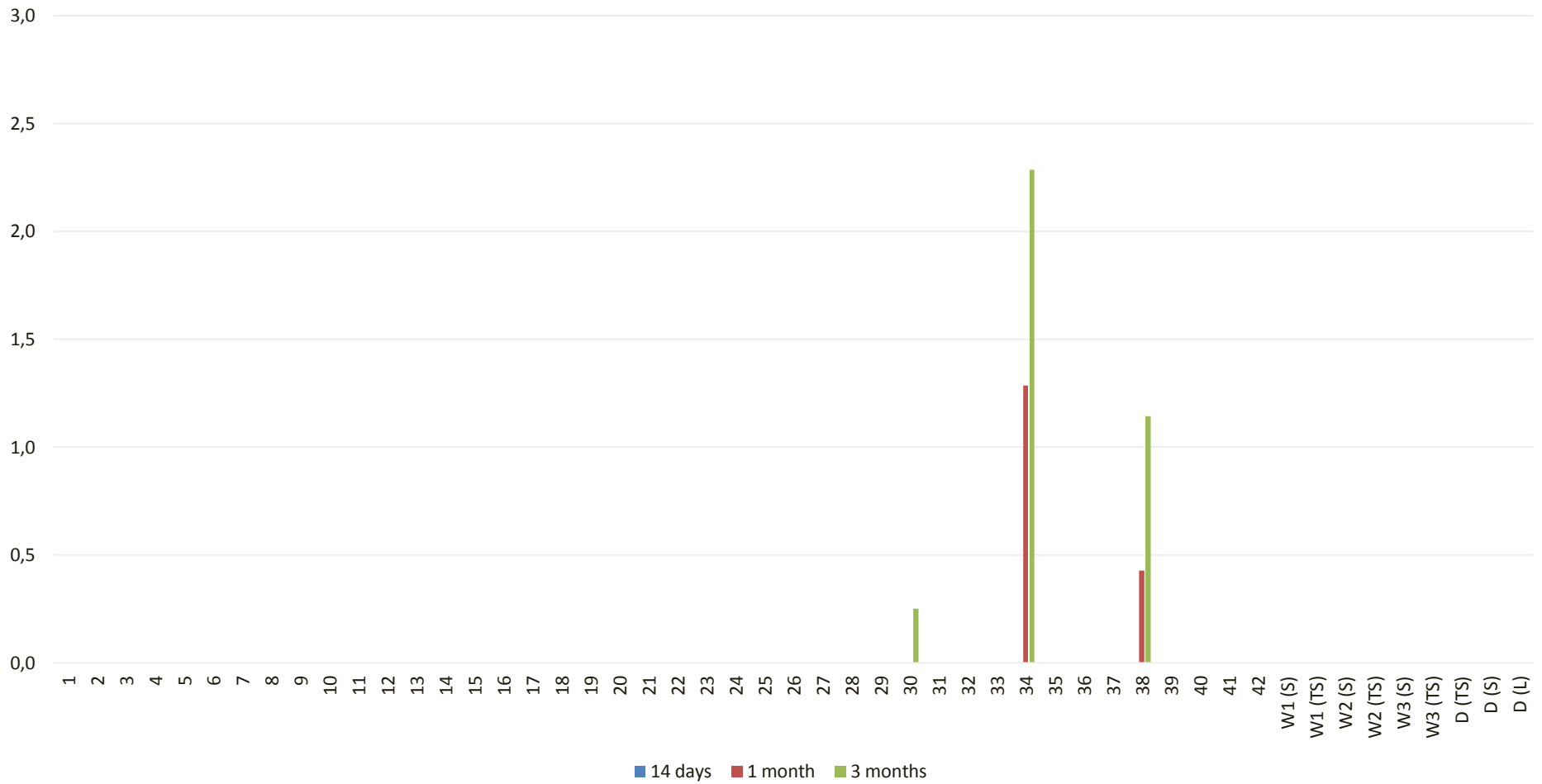


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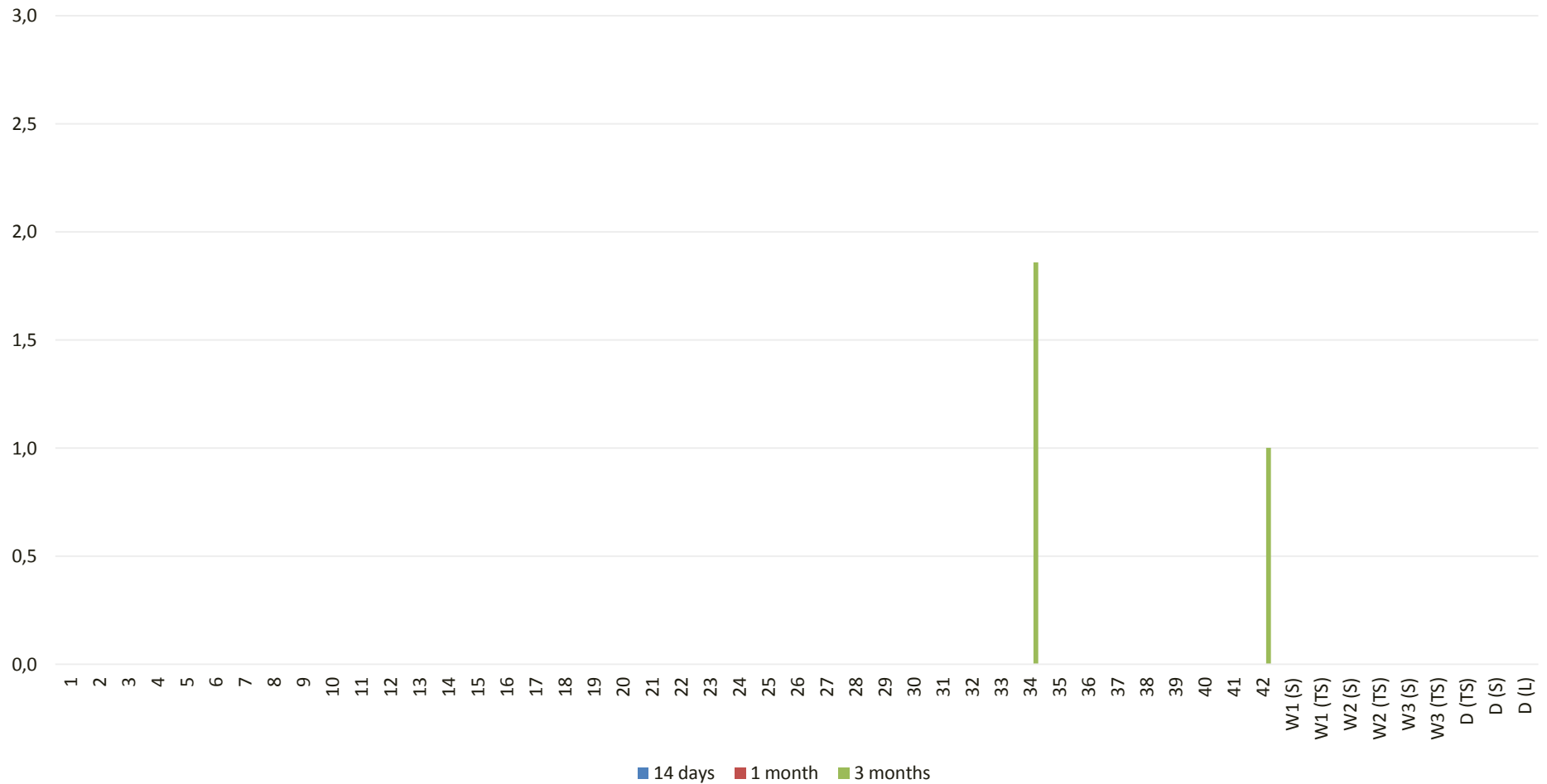




# MADRID



# SKELLEFTEÅ





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M SORA



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# THANK YOU

