CONCORDIA STATION, DOME C, ANTARCTICA AS A GROUND-BASED ANALOG FOR SPACEFLIGHT/PLANETARY EXPLORATION:

The *CHOICE** Immunology Study

Final Data; NASA Assays - February, 2012

**Consequences of both long-term confinement ("Confinement Stress") and hypobaric hypoxia ("Hypoxic Stress") on Immunity ("Immune-Modulation/Suppression") in the Antarctic CONCORDIA Environment.*

Brian Crucian, Alexander Chouker, Satish Mehta, Raymond Stowe, Alex Salam, Ales Rybka, Heather Quiriarte, Duane Pierson and Clarence Sams


British Claim
Norwegian Claim
Indian Ocean
Scotia Sea
South Orkney Islands
Orcadas (Argentina)
Argentine Claim
Brazilian Zone of Interest
Weddell Sea
Bellingshausen Sea
Peter I Island
Ronne Ice Shelf
Fossil Bluff (U. K.)
Filchner (Germany)
Halley (U. K.)
Belgrano II (Argentina)
Druzhnaya-3 (Soviet Union)
Dresdner (Germany)
Georg von Neumayer (Germany)
Sanae (South Africa)
Maitri (India)
Dakshin Gangotri (India)
Georg Forster (Germany)
Novolazarevskaya (Soviet Union)
Troll (Norway)
Aboa (Finland)
Serie Marais (South Africa)
Wasa (Sweden)
Asuka (Japan)
Syowa (Japan)
Molodezhnaya (Soviet Union)
Mizuho (Japan)
Mawson (Australia)
Dovers (Australia)
Soyuz (Soviet Union)
Progress (Soviet Union)
Zhongshan (China)
Davis (Australia)
Law (Australia)
Mirnyy (Soviet Union)
Edgeworth David (Australia)
Oasis II (Soviet Union)
Vostok (Soviet Union)
Dome C
Casey (Australia)
Amundsen-Scott (U. S.)
South Pole
Byrd (U. S.)
Ross Ice Shelf
McMurdo (U. S.)
Vanda (New Zealand)
Scott (New Zealand)
Cape Bird (New Zealand)
World Park (Greenpeace)
Terra Nova Bay (Italy)
Gondwana (Germany)
Dumont d'Urville (France)
Leningradskaya (Soviet Union)
Lillie Marleen Hütte (Germany)
Commonwealth Bay (Australia)
Russkaya (Soviet Union)
Ross Sea
Balleny Islands
Antarctic Circle
New Zealand Claim
Australian Claim
Australian Claim
limit not defined
limit not defined
limit not defined
20° W
25° W
53° W
74° W
80° W
150° W
45° E
136° E
142° E
60°
70°
80°
90°

Environmental Factors

Difficult travel in/out

Extreme isolation, even greater than ISS

Altitude 3200m (10,500 ft)

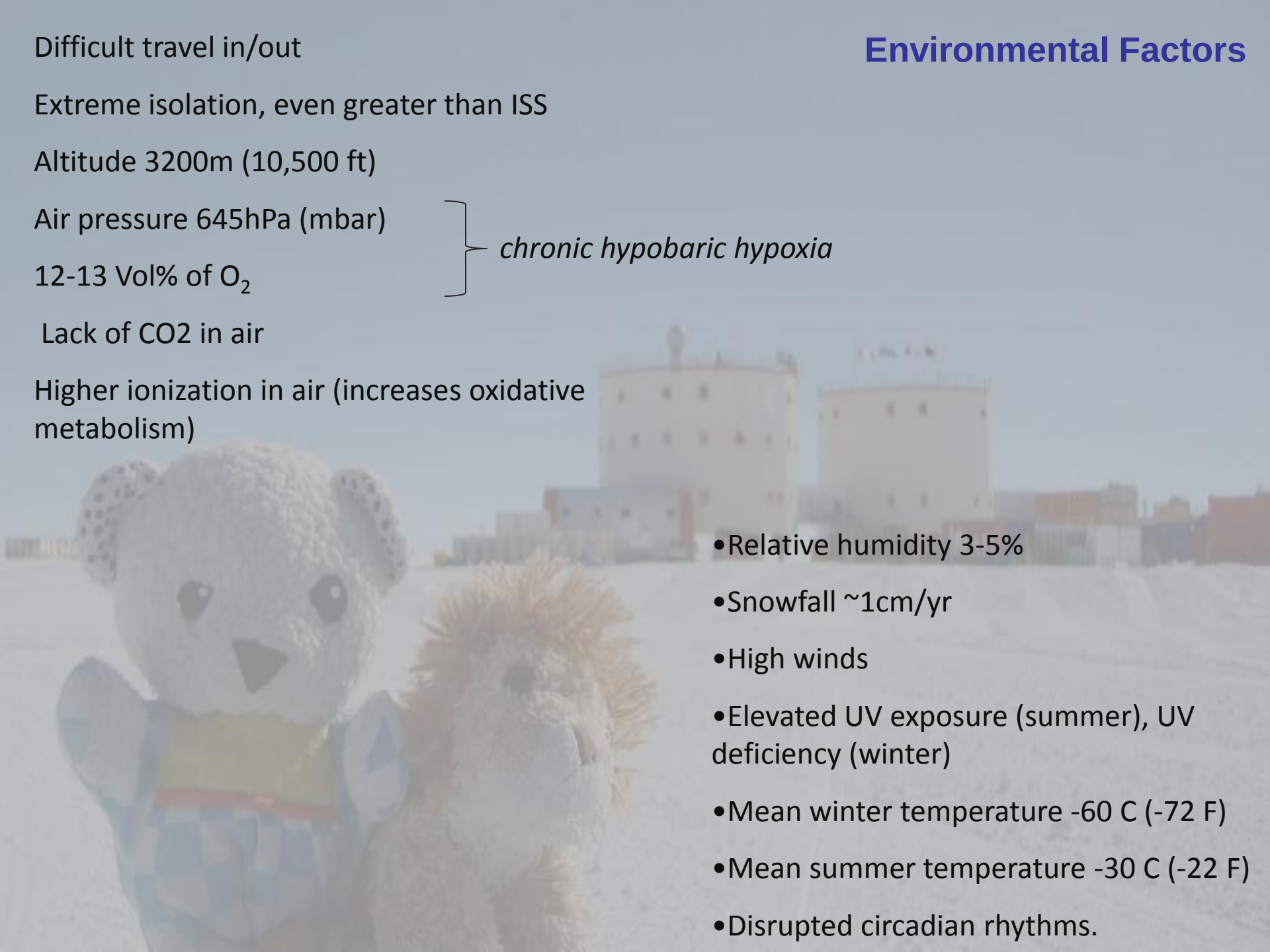
Air pressure 645hPa (mbar)

12-13 Vol% of O_2

} *chronic hypobaric hypoxia*

Lack of CO2 in air

Higher ionization in air (increases oxidative metabolism)

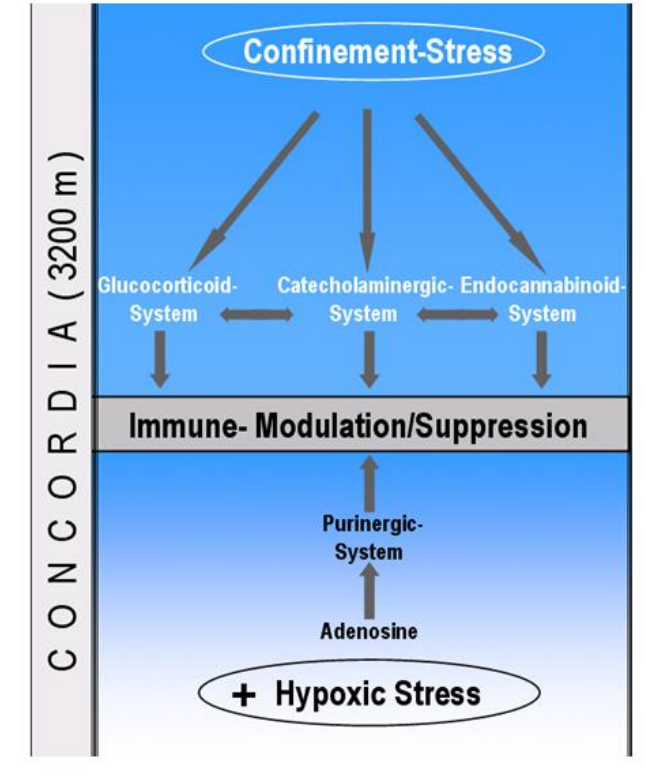


- Relative humidity 3-5%
- Snowfall ~1cm/yr
- High winds
- Elevated UV exposure (summer), UV deficiency (winter)
- Mean winter temperature -60 C (-72 F)
- Mean summer temperature -30 C (-22 F)
- Disrupted circadian rhythms.

Human Factors

- Isolation, confinement for prolonged duration
- Limited communication capability with outside world (more isolated than ISS!)
- International crew, multiple languages
- Realistic station lifestyle
- Sleep/wake cycles disrupted
- Actual extreme environment deployment w/ associated risks (not a mission analog!)
- Winter over crew: 12
- Summer crew: ~50

NASA Paradigm



Effects of Space Flight

Immune System Changes
(Status and Function)

Adverse clinical outcomes
(Latent Viral Reactivation)

Assays

BLOOD ASSAYS

Comprehensive immunophenotype

Intracellular cytokine profiles (T cell)

T cell function

Secreted cytokine profiles

Viral DNA - PBMC

Circulating viral-specific T cells

Viral-specific T cell function

Viral antibodies titers

Viral antibodies titers

Plasma stress hormones

SALIVA ASSAYS

Saliva stress hormones, Diurnal

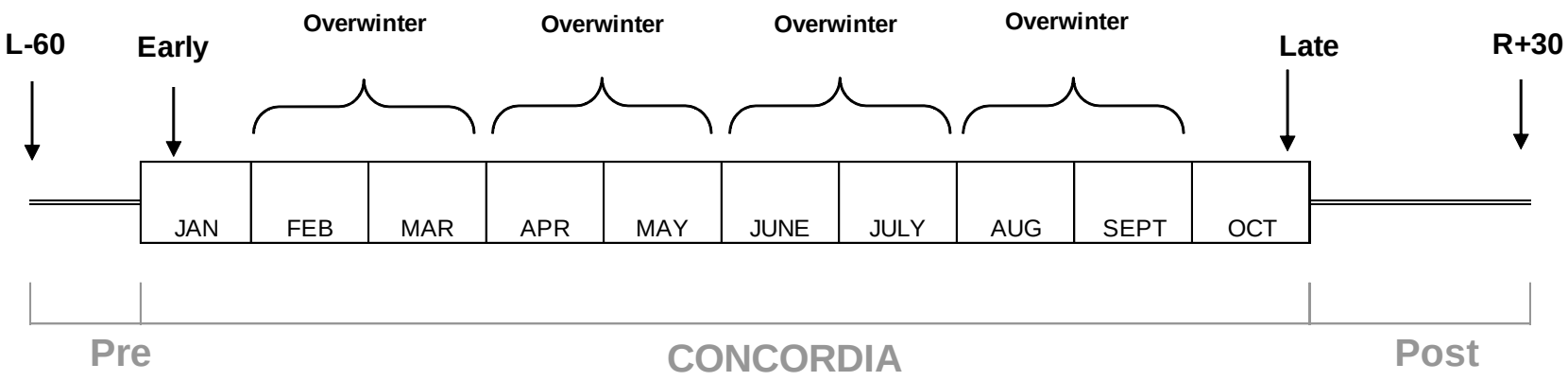
Viral DNA by PCR

URINE ASSAYS

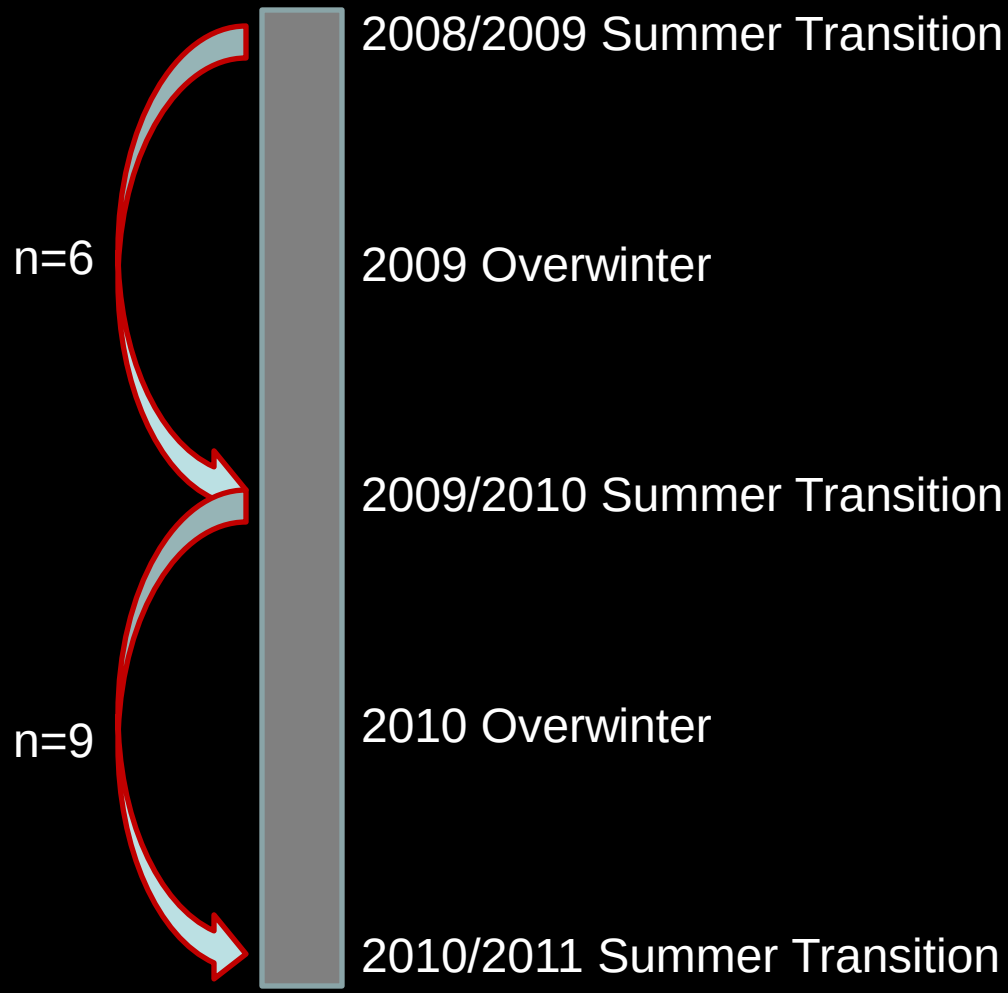
Viral DNA by PCR

Urine stress hormones

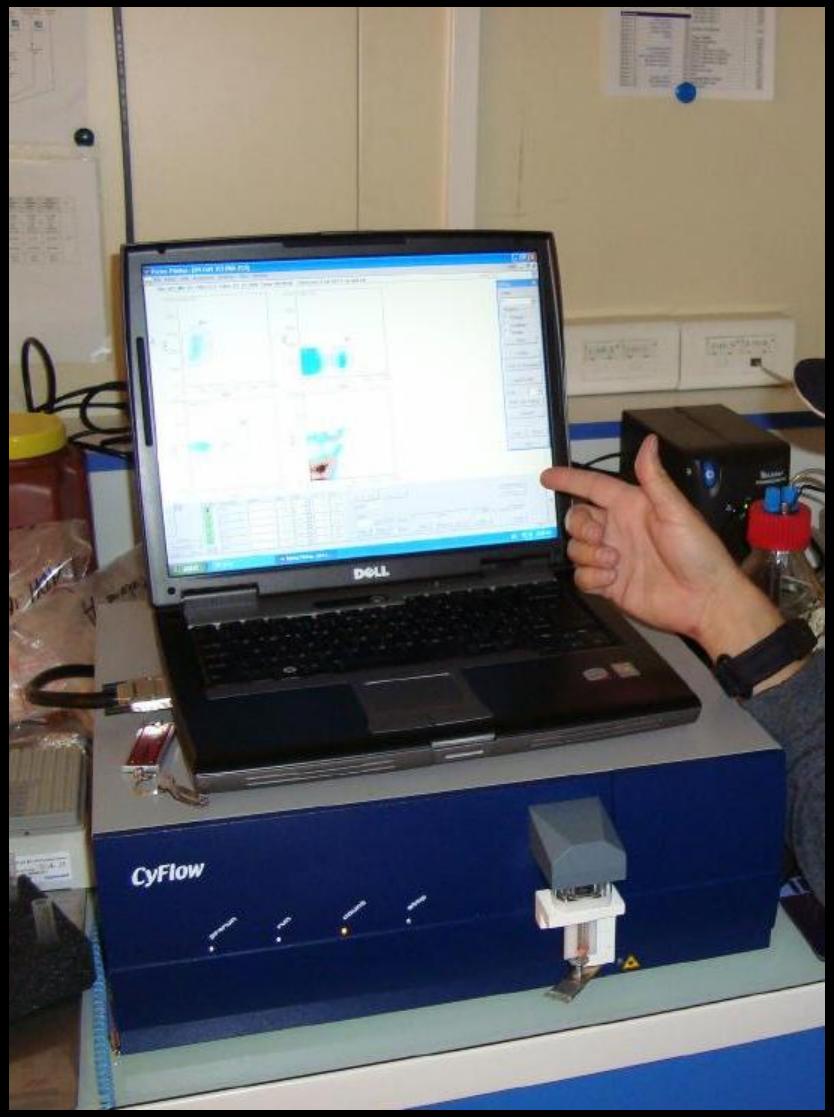
Sampling



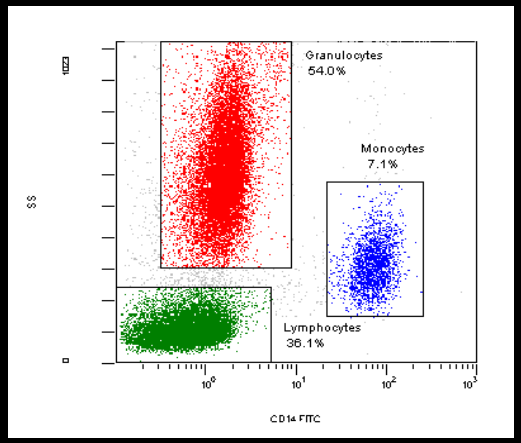
Subjects/Logistics

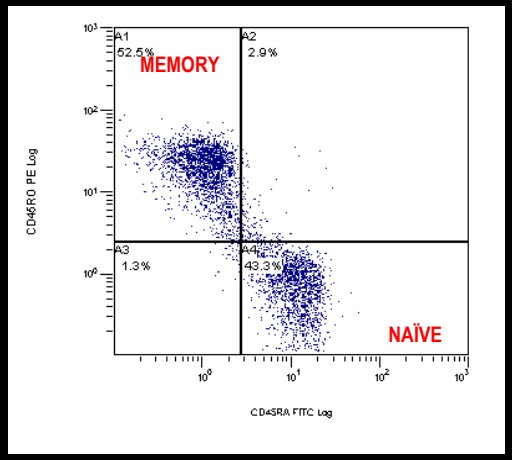


Overwinter Flow Cytometry



Overwinter Data: Phenotype





	L-30	Ear.	M2	M4	M6	Late	R+60
Granulocytes	52	44*	31*	37*	44*	46*	63
Lymphocytes	40	47*	49*	50*	45	44	32
Monocytes	5.0	5.0	10*	7*	5.0	5.0	3.0
T Cells	67	60*	65	55*	54*	56*	77
B Cells	7	13*	12*	11*	19*	13*	12
NK Cells	6	9	10*	12	5	11*	18
CD4+ T Cells	59	55*	50*	51*	50*	53*	61
CD8+ T Cells	33	32	29	26*	25*	30	27

	L-30	Ear.	M2	M4	M6	Late	R+60
Bulk Memory CD4+	54	59	56	59	62*	68*	49
Bulk Memory CD8+	37	59*	41	58*	59*	74*	32
CD8: Naïve/ctx	85	49*	65*	57*	62*	53*	92
CD8: Senescent	12	35*	24*	26*	21	27*	7
CD8: True Naïve	38	35	27	31	35	28	21
Central memory	6	10	5	13	10	13	34
Effector Memory	39	32*	37	33	32*	35	38
Term. Differentiated	17	23	31	22	24*	25	7

	L-30	Ear.	M2	M4	M6	Late	R+60
CD4/CD69	1	6*	1	2	2	2	0
CD8/CD69	2	9*	3	3	3	3	2
CD4/HLA-DR	2	3	3	2	1	1	2
CD8/HLA-DR	3	5*	2	2	1	1	3

2009/10 Summer Transition period – Incidence Rates

(mid-November to mid-January)

- Approx. 50% of summer participants contacted infectious disease

- Historically, extremely high incidence rate

- Three periods of epidemic viral infections:

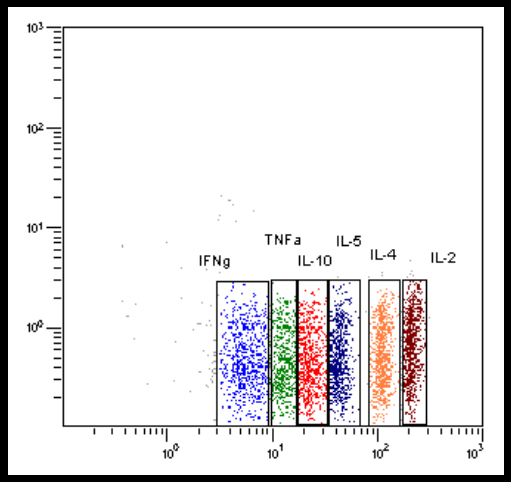
  Period 1: Flu-like (mid-Nov. to mid-Dec.)

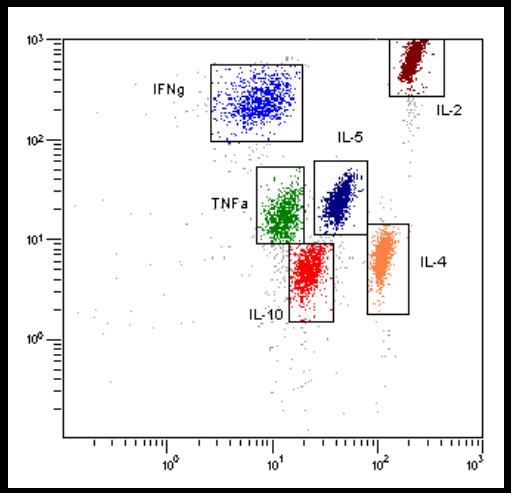
  Period 2: Rhinoparyngitis (mid-Dec. to early Jan.)

  Period 3: Gastro-enteritis (late-Dec. to early Jan.)

-Data from Concordia Station, Chief Medical Officer

Overwinter Data: Secreted Cytokine Profiles





T cells: CD3+CD28 - 48hr

	L-30	Ear.	F-M	A-M	J-J	A-S	Late	R+60
IFNg	74	58	100	104	116	138	59	2
TNFa	20	24	24	13	15	21	9	3
IL-10	6	16	5	8	8	9	3	2
IL-4	0	0	0	0	0	0	0	0
IL-5	4	2	7	8	9	5	3	1
IL-2	32	4	64	33	33	43	12	4

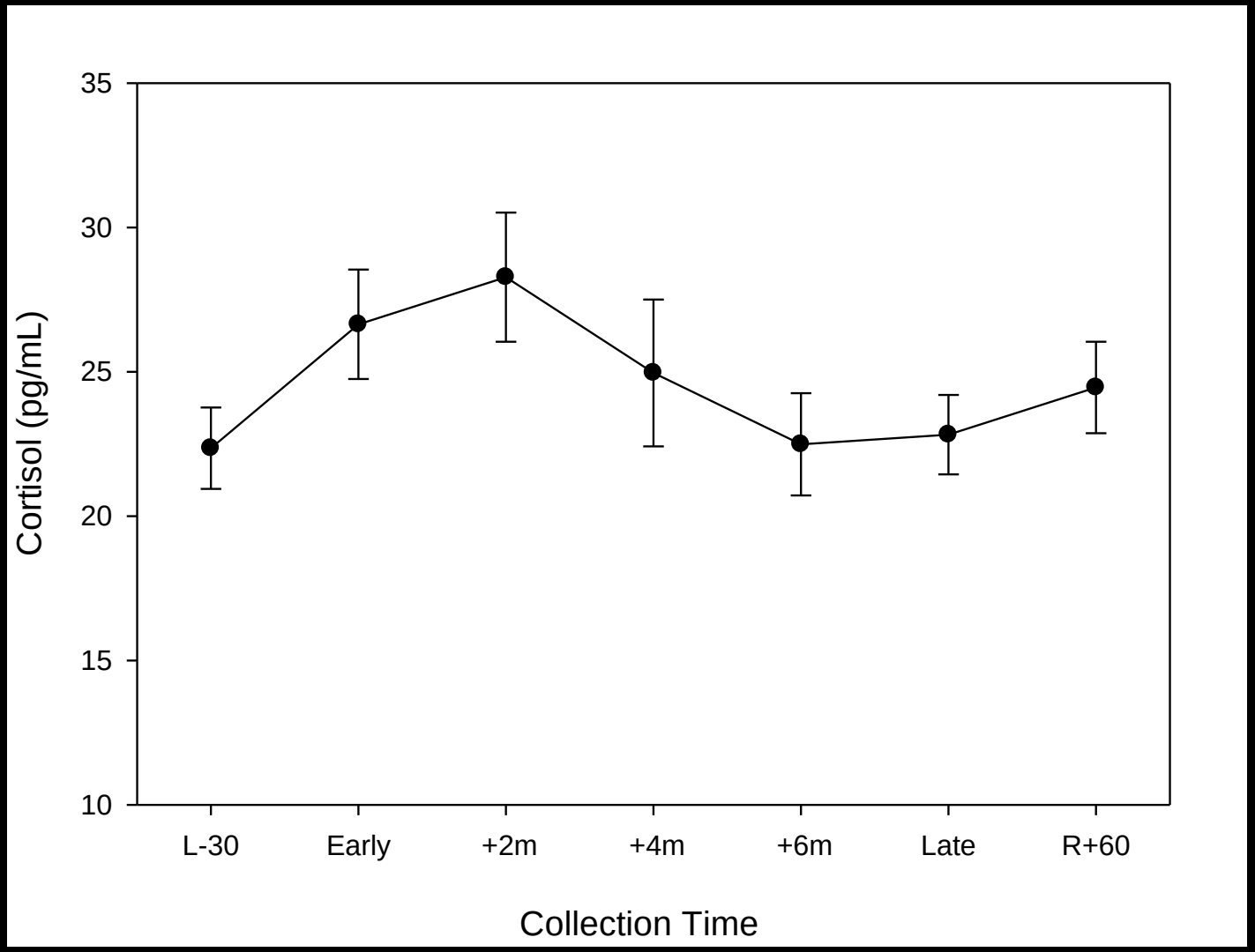
All Leukocytes: PMA+Ionomycin - 48hr

	L-30	Ear.	F-M	A-M	J-J	A-S	Late	R+60
IFNg	287	281	251	247	248	**238***	**220***	238
TNFa	51	**82***	**105***	**127***	**98***	**111***	**35***	52
IL-10	7	19*	16*	21*	19*	20*	5	5
IL-4	3	**5***	**4***	**5***	**5***	**6***	2	1
IL-5	15	19	17	**19***	18	20	11	4
IL-2	689	701	725	**764***	**764***	**736***	**526***	572

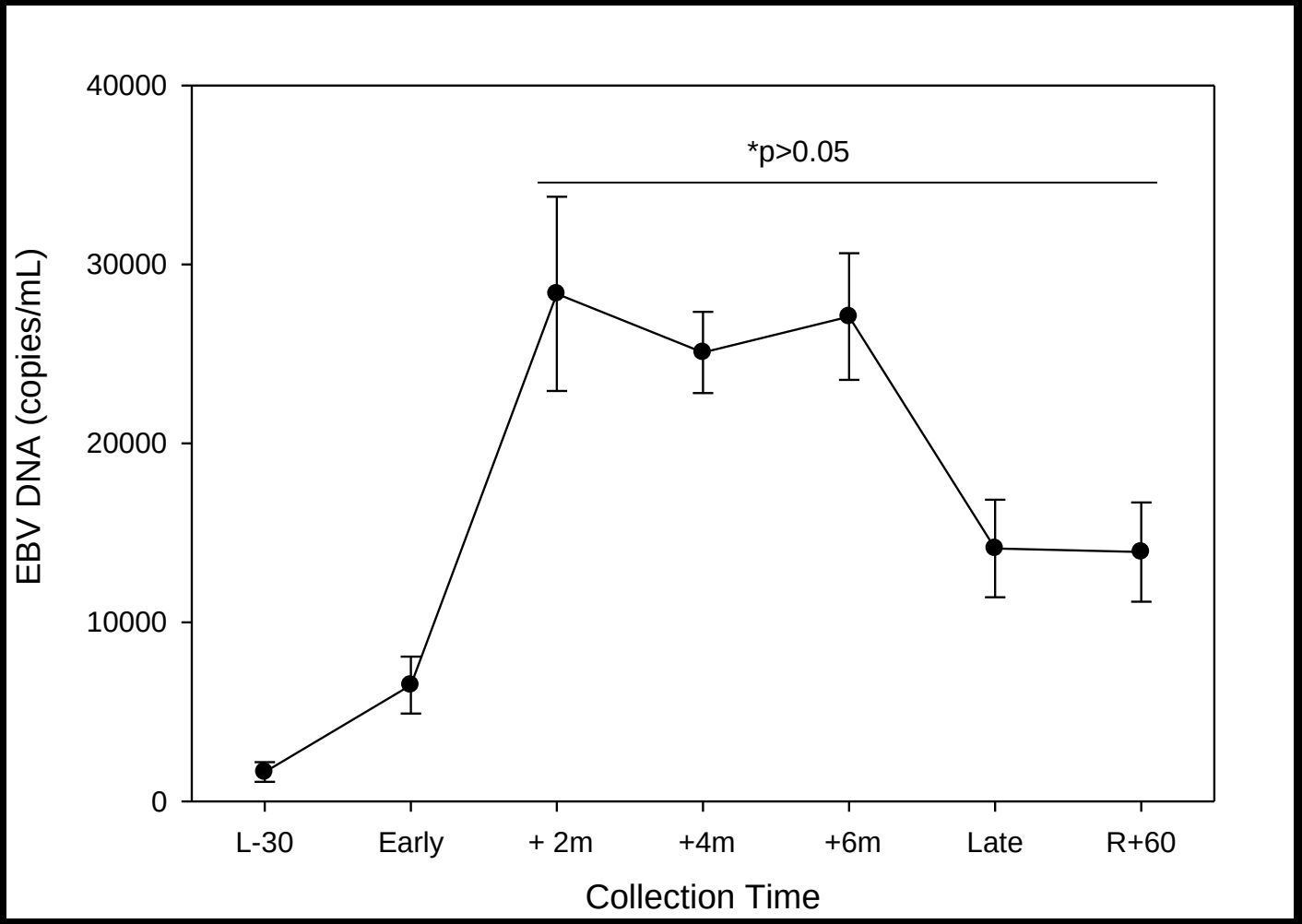
Monocytes: LPS - 48hr

	L-30	Ear.	F-M	A-M	J-J	A-S	Late	R+60
IL-12	0	0	0	0	0	0	0	0
TNFa	9	**20***	**17***	**18***	**21***	**17***	12	33
IL-10	14	**27***	**43***	**37***	**37***	**42***	6	11
IL-6	432	431	498	494	506	477	232	502
IL-1b	51	**95***	50	54	57	39	110	175
IL-8	610	583	529	591	600	577	408	636

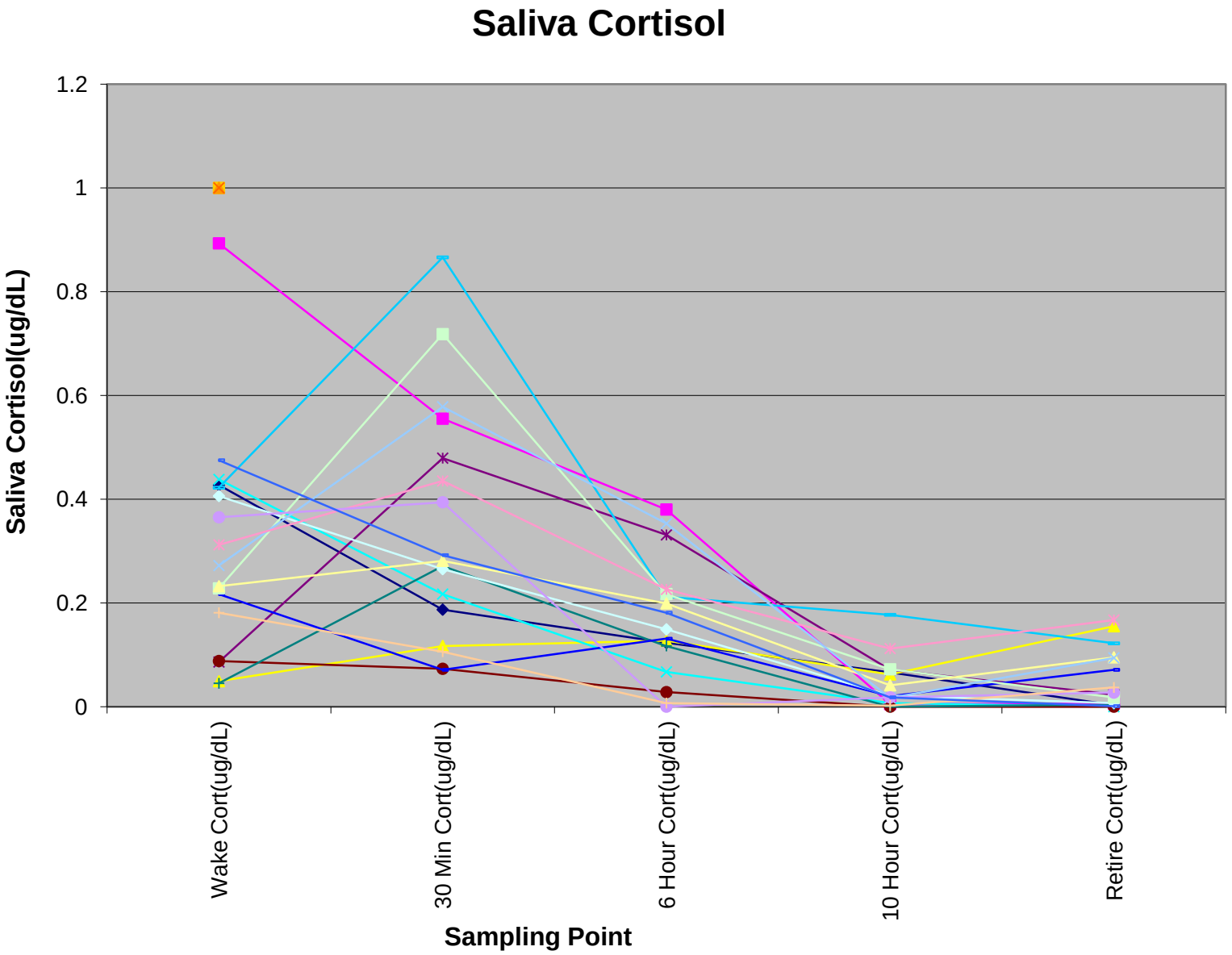
Overwinter Data: Plasma Cortisol



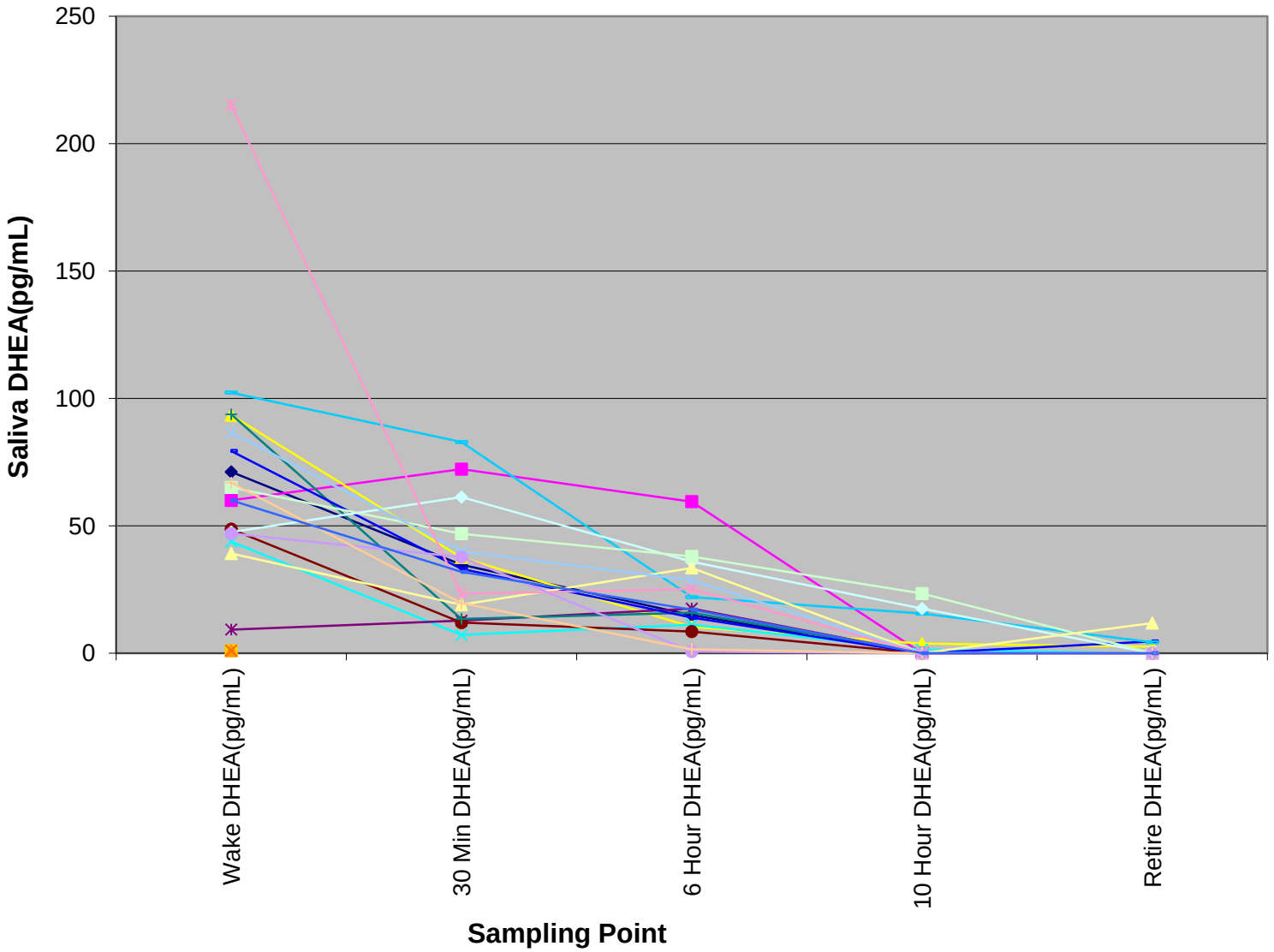
Overwinter Data: Plasma EBV DNA



Overwinter Data: Salivary Cortisol



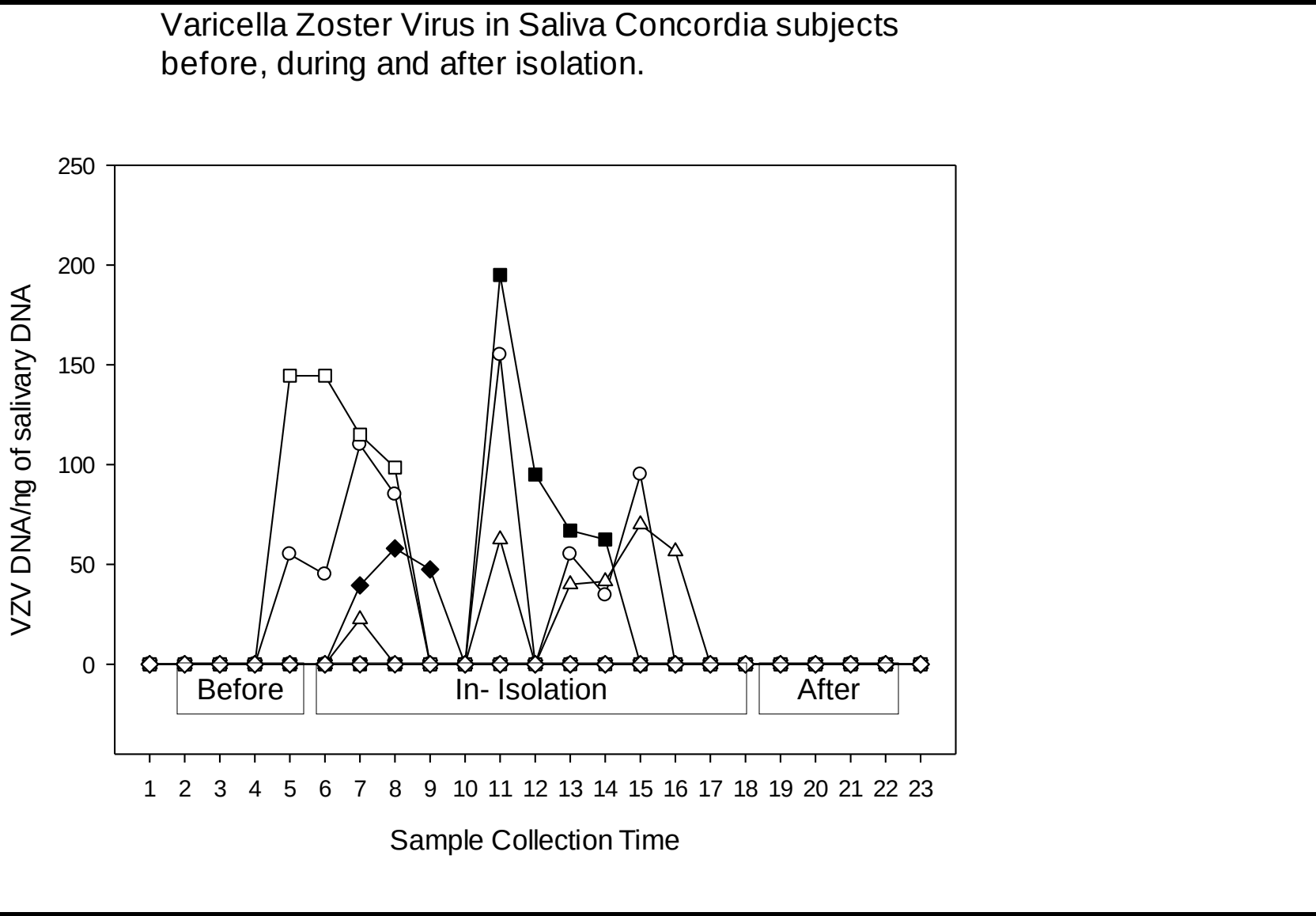
Overwinter Data: Salivary DHEA



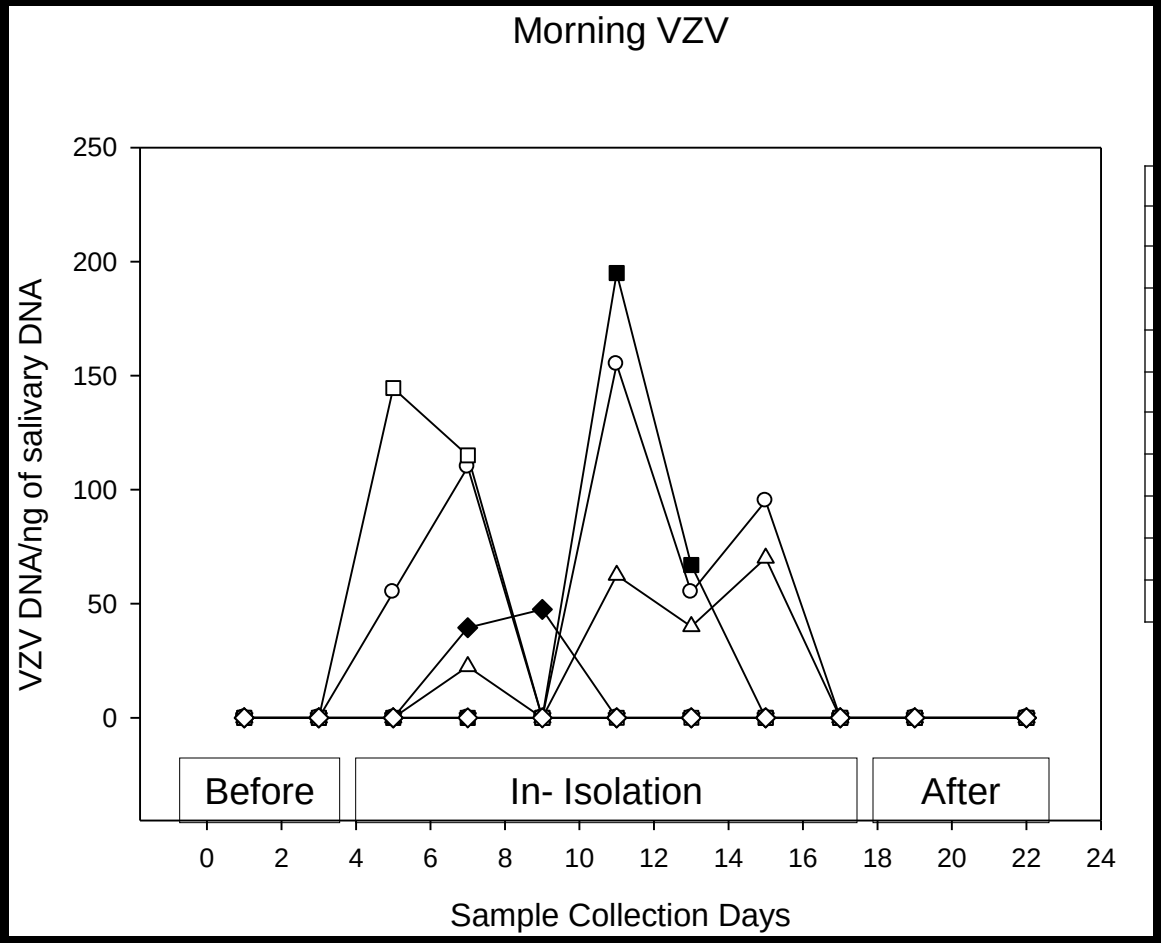
Overwinter Data: VZV Reactivation

		Before		In Isolation							After
		Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	
G		-	-	-	-	-	-	-	-	-	-
~~H~~		-	NA	NA	NA	NA	NA	NA	NA	NA	NA
~~J~~		-	-	+	+	-	+	+	+	-	-
K		-	-	-	-	-	-	-	-	-	-
L		-	-	-	+	-	+	+	+	-	-
M		-	-	-	-	-	+	+	-	-	-
N		-	-	+	+	-	-	-	-	-	-
O		-	-	-	+	+	-	-	-	-	-
P		-	-	-	-	-	-	-	-	-	-
J		-	-	-	-	-	-	-	-	-	-
		-	-					-	-	-	-
		-	-					-	-	-	-

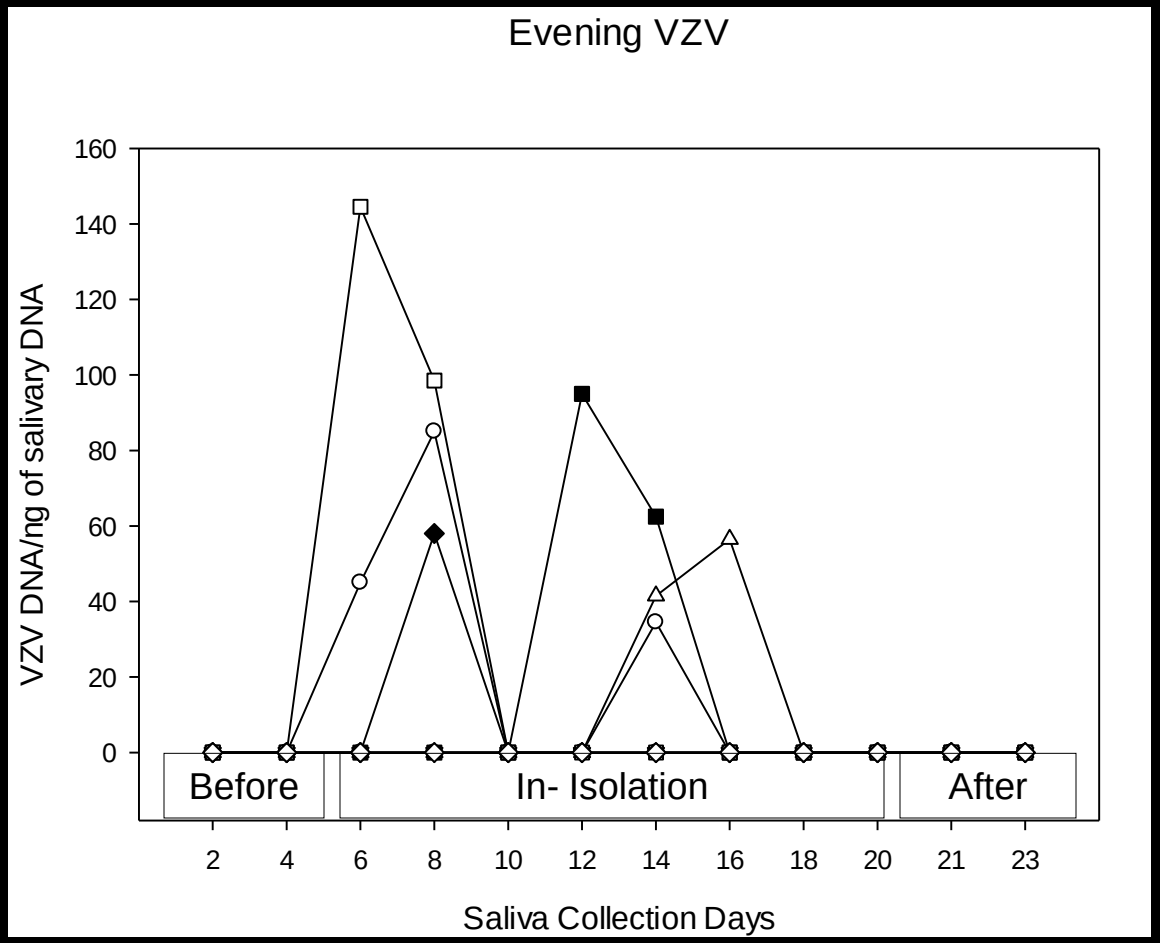
Overwinter Data: VZV Reactivation



Overwinter Data: VZV Reactivation (AM)



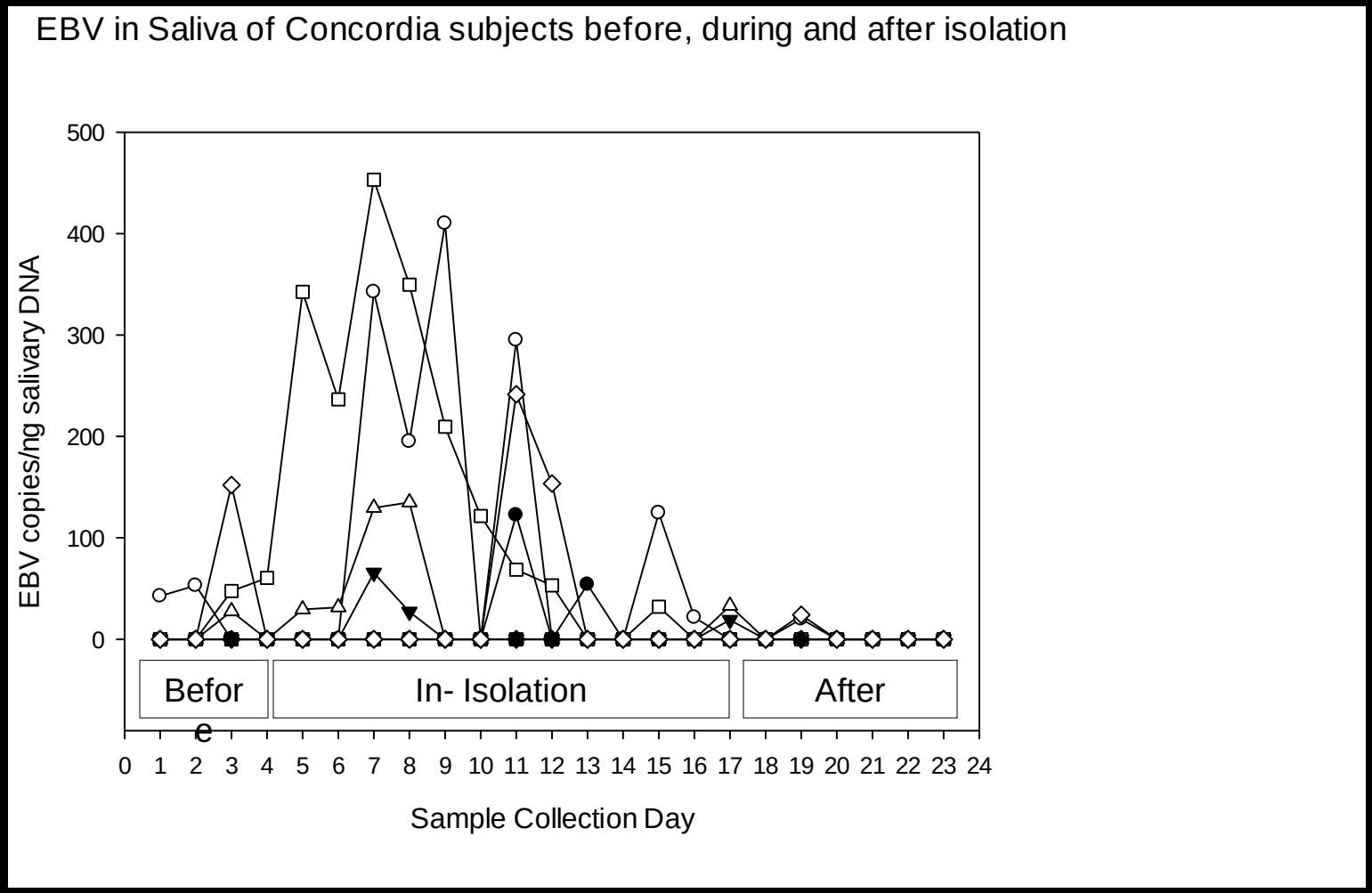
Overwinter Data: VZV Reactivation (PM)



Overwinter Data: EBV Reactivation

		Before		In Isolation							After
		Feb (M)	Mar (M)	Apr (M)	May (M)	June (M)	July (M)	Aug (M)	Sept (M)	Oct (M)	
G	JFV	-	-	-	-	-	+	+	-	-	-
~~H~~	~~DM~~	-	NA	NA	NA	NA	NA	NA	NA	NA	NA
~~J~~	~~JMM~~	+	-	-	+	+	+	-	+	-	+
K	CR	-	-	-	+	-	-	-	-	+	-
L	GD	-	+	+	+	-	-	-	-	-	-
M	AB	-	-	-	-	-	-	-	-	-	-
N	LM	-	+	+	+	+	+	-	+	-	-
O	KA	-	-	-	-	-	-	-	-	-	-
P	AR	-	+	-	-	-	+	-	-	-	0
J	AL*	-	-	-	-	-	-	-	-	-	-
	MF	-	-					-	-	-	-
	AC'	-	-					-	-	-	-

Overwinter Data: EBV Reactivation



Questions?