Supplementary material: Protection Analysis

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Introduction

The factors influencing the efficiency of a mosquito repellent is analysed in what follows. All analyses were performed using R Core Team (2018) and in particular, using the ANOVA functionality from the *car* package by Fox and Weisberg (2011).

Data

The following data were received (See Table at bottom):

```
'data.frame':   48 obs. of  11 variables:
 $ Product       : Factor w/ 8 levels "A","B","C","D",..: 1 1 1 1 1 1 2 2 2 2 ...
 $ Polymer       : Factor w/ 2 levels "EVA","LLDPE": 2 2 2 2 2 2 2 2 2 2 ...
 $ Repellent     : Factor w/ 2 levels "DEET","Icaridin": 1 1 1 1 1 1 1 1 1 1 ...
 $ Level         : int  20 20 20 20 20 20 30 30 30 30 ...
 $ Week          : int  1 3 5 7 9 11 1 3 5 7 ...
 $ Test.person   : Factor w/ 3 levels "AS","BM","RT": 2 1 1 1 3 3 1 1 2 2 ...
 $ Treated.foot  : Factor w/ 2 levels "L","R": 2 1 1 2 2 1 2 2 2 2 ...
 $ Time.1st.bite : int  10 23 48 103 30 54 20 21 62 79 ...
 $ Untreated.foot: int  49 39 16 20 11 26 26 98 7 40 ...
 $ Treated.foot.1: int  6 4 0 6 0 6 8 12 0 1 ...
```

```
 $ Protection    : num  0.78 0.81 1 0.54 1 0.63 0.53 0.78 1 0.95 ...


Summary statistics for the measurement variable:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.4600  0.7500  0.9000  0.8496  1.0000  1.0000
```

Protection

A parametric analysis of variance (ANOVA) is performed in order to detect significant factors that might have an influence on the protection measurement of the repellent. This insures that the effect of multiple testing is sufficiently dealt with, i.e. that the probability of detecting an effect do not increase, purely because more tests are performed. Following this, a non-parametric ANOVA is performed using the Kruskal-Wallis test, which makes no assumptions of the underlying data structure. Under all these tests, the null hypothesis is that there are no effect observed.

ANOVA Models

	Sum Sq	**Df**	**F value**	**Pr(>F)**
(Intercept)	0.98	1	36.39	0.0000
Polymer	0.05	1	1.70	0.1997
Repellent	0.08	1	2.83	0.1005
Level	0.01	1	0.50	0.4817
Week	0.11	1	4.05	0.0514
Test.person	0.01	2	0.13	0.8761
Treated.foot	0.00	1	0.01	0.9330
Time.1st.bite	0.02	1	0.61	0.4378
Residuals	1.02	38		

All the variables were tested simultaneously to minimize the effect of multiple testing. Product was not included as a variable, since it leads to a inversion problem of the hessian matrix. From this the following conclusions are possible: * Neither product, polymer, repellent, level, test person, treated foot, nor time to first bite had a significant effect on the level of protection. * The week seem to indicate a slight relation to the level of protection. This is damped somewhat by the addition of “time to 1st bite” which is not really an input variable to the model; and may be excluded.

These variables are now analysed separately in a nonparametric model.

Kruskal-Wallis Test

	Kruskal.Wallis.chi.squared	**df**	**p.value**
Product	7.05	7	0.42
Polymer	0.59	1	0.44
Repellent	2.10	1	0.15
Level	0.32	1	0.57
Week	18.90	11	0.06
Test Person	1.67	2	0.43
Treated Foot	0.51	1	0.47

These results confirm that of the ANOVA tests, and furthermore show that the “Week” effect is not significant at a 5% level of significance.

Analysing pre-post data

Since the foot being treated didn’t appear as a significant effect in the model, the untreated foot will be regarded as a control group. Here, the amount of probes were entered as dependent variable, and not the protection measurement.

```
Paired t-test


data:  Count by Group
t = 34.417, df = 47, p-value < 2.2e-16
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 0.8082174       Inf
sample estimates:
mean of the differences
               0.84964


 Wilcoxon signed rank test with continuity correction
data:  Count by Group
V = 1176, p-value = 6.335e-10
alternative hypothesis: true location shift is greater than 0
95 percent confidence interval:
 0.8125206       Inf
sample estimates:
(pseudo)median
     0.8729766
```

Therefore, although no significant effects could be detected between the different treatments, they all differed significantly from the untreated feet, indicating that being treated, differed significantly from not being treated, i.e. had significantly less probes.

References

Fox, John, and Sanford Weisberg. 2011. *An R Companion to Applied Regression*. Second. Thousand Oaks CA: Sage. http://socserv.socsci.mcmaster.ca/jfox/Books/Companion.

R Core Team. 2018. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Data

Product	Polymer	Repellent	Level	Ageing	Test person	Treated foot (L/R)	Time to 1st bite	Number of bites Untreated foot	Treated foot	Protection
			wt-%	weeks		L/R	s	#	#	
A	LLDPE	DEET	20	1	X	R	10	49	6	**0.78**
A	LLDPE	DEET	20	3	Z	L	23	39	4	**0.81**
A	LLDPE	DEET	20	5	Z	L	48	16	0	**1.00**
A	LLDPE	DEET	20	7	Z	R	103	20	6	**0.54**
A	LLDPE	DEET	20	9	Y	R	30	11	0	**1.00**
A	LLDPE	DEET	20	11	Y	L	54	26	6	**0.63**
B	LLDPE	DEET	30	1	Z	R	20	26	8	**0.53**
B	LLDPE	DEET	30	3	Z	R	21	98	12	**0.78**
B	LLDPE	DEET	30	5	X	R	62	7	0	**1.00**
B	LLDPE	DEET	30	7	X	R	79	40	1	**0.95**
B	LLDPE	DEET	30	9	Y	R	27	7	2	**0.56**
B	LLDPE	DEET	30	11	X	L	26	47	4	**0.84**
C	LLDPE	Icaridin	20	1	Z	L	13	47	1	**0.96**
C	LLDPE	Icaridin	20	3	X	R	10	24	3	**0.78**
C	LLDPE	Icaridin	20	5	X	L	51	45	0	**1.00**
C	LLDPE	Icaridin	20	7	Z	R	35	18	1	**0.89**
C	LLDPE	Icaridin	20	9	X	R	27	27	6	**0.64**
C	LLDPE	Icaridin	20	11	X	L	43	41	15	**0.46**
D	LLDPE	Icaridin	30	1	X	L	105	18	1	**0.89**
D	LLDPE	Icaridin	30	3	X	L	15	62	0	**1.00**
D	LLDPE	Icaridin	30	5	Z	L	29	24	0	**1.00**
D	LLDPE	Icaridin	30	7	Z	L	57	20	0	**1.00**
D	LLDPE	Icaridin	30	9	X	L	24	7	0	**1.00**
D	LLDPE	Icaridin	30	11	Y	L	54	48	1	**0.96**

E	EVA	DEET	20	2	Z	R	45	36	0	**1.00**
E	EVA	DEET	20	4	X	R	50	33	0	**1.00**
E	EVA	DEET	20	6	X	L	32	11	0	**1.00**
E	EVA	DEET	20	8	Z	L	115	65	13	**0.67**
E	EVA	DEET	20	10	X	L	57	28	8	**0.56**
E	EVA	DEET	20	12	X	R	21	29	2	**0.87**
F	EVA	DEET	30	2	X	L	25	21	0	**1.00**
F	EVA	DEET	30	4	Z	R	36	17	0	**1.00**
F	EVA	DEET	30	6	Z	L	25	11	1	**0.83**
F	EVA	DEET	30	8	X	R	90	20	1	**0.90**
F	EVA	DEET	30	10	Y	L	75	43	16	**0.46**
F	EVA	DEET	30	12	Y	R	13	55	8	**0.75**
G	EVA	Icaridin	20	2	Z	L	20	22	0	**1.00**
G	EVA	Icaridin	20	4	Z	L	115	7	1	**0.75**
G	EVA	Icaridin	20	6	Z	R	34	78	4	**0.90**
G	EVA	Icaridin	20	8	Z	L	28	24	0	**1.00**
G	EVA	Icaridin	20	10	Y	R	29	13	0	**1.00**
G	EVA	Icaridin	20	12	Y	L	6	62	6	**0.82**
H	EVA	Icaridin	30	2	X	L	40	23	0	**1.00**
H	EVA	Icaridin	30	4	X	L	170	7	0	**1.00**
H	EVA	Icaridin	30	6	X	R	40	57	3	**0.90**
H	EVA	Icaridin	30	8	X	R	51	50	0	**1.00**
H	EVA	Icaridin	30	10	X	R		24	5	**0.66**
H	EVA	Icaridin	30	12	X	L	6	71	12	**0.71**