TABLES FOR THE CALCULATION OF THE PROBABILITY TO BE USED IN THE MODIFIED BONFERRONI'S TEST

Armando Conagin [1]

ABSTRACT

The present paper presents 8 tables to furnish P(F) values to be utilized in the calculation of BM and BMP to be used in comparison of means. Beside those we present Table 1 to show the performance of the BM and BMP tests proposed by Conagin (1998, 1999) as an improvement of Bonferroni's test.

RESUMO

O presente artigo apresenta 8 Tabelas (2 a 9) com vistas a fornecer o valor P(F) a ser utilizado em cálculo dos testes B_M e B_{MP}.

Apresenta também a tabela 1 com resultados que permitem sejam comparados os poderes discriminativos desses dois testes com os testes LSD, Duncan, SNK, Tukey, Bonferroni e Dunnett.

Palavras-chave: poder discriminativo de testes estatísticos, cálculo de BM e BMP, valores de P(F) em 8 Tabelas para utilização nesses cálculos.

INTRODUCTION

Conagin (1998 and 1999) has proposed a modification of Bonferroni's test to be used in the comparison among treatment means in

1. Agronomist and Applied Statistician, retired; Instituto Agronômico, Campinas, SP, Brazil.

experiments. The method was described in two articles published in **Revista de Agricultura** (Conagin, 1998 and 1999). He proved that his test has a higher discriminative power than other usual tests, as shows Table 1. But the calculation of the probability level to be used required the use of PROBF FUNCTION of the SAS Program (SAS, 1990).

Now he presents tables (2 to 9) to make easier the application of his test.

Example

Let us assume an experiment with t = 6 treatments in 3 randomized blocks, with observed $F_o = 9.72$, and 10 degrees of freedom (df) for the Residual. Assume also that k = 4 contrasts of 2 means are to be tested. The level of probability for the usual Bonferroni's test would be $\alpha' = \alpha/K = 0{,}05/4 = 0{,}0125$. But in Conagin's test this level is changed to

$$\delta_{BM} = \frac{\alpha}{K}\left[1 + P(F)\right] = \frac{0{,}05}{4}\left[1 + P(F)\right]$$

The values of P(F) are given for different values of **t** (number of treatments), of **r** (number of replications) and F_o/F_c = ratio of F obtained F_o and table value F_c at $\alpha = 5\%$ level of probability.

In the example shown we have t = 6 treatments, r = 3 replications, $F_o/F_c = 9.72/3.33 = 2.92$, where F_c refers to 5% probability, with 5 df for treatments, and 10 df for error.

Table 3, with t = 6 treatments, r = 3 replications, $F_o/F_c = 2{,}92$ gives:

$$\frac{F_o}{F_c} = 2.5 \rightarrow P(F) = 0.470$$

$$\frac{F_o}{F_c} = 3.0 \rightarrow P(F) = 0.478$$

Linear interpolation gives P(F) = 0.477.

So, we obtain:

$$\delta_{BM} = \alpha\,[1 + P(F)] / 4$$
$$= 0.05\,(1 + 0.477) / 4$$
$$= 0.0185$$

Now the usual t-test table gives for df = 10:

$\alpha = 1\% \rightarrow t = 3.17$

$\alpha = 2\% \rightarrow t = 2.76$

Linear interpolation gives t = 2.82. Thus the lsd for the test would be:

$$lsd = \frac{2.82 \times s}{\sqrt{3}} = 1.63\,s \quad ,$$

where **s** is the standard deviation. The usual Bonferroni's test would give lsd = 1.76 s, a higher value.

Table 1. Result obtained when CV = 10%, for r = 3, df = 34(t=18), and r = 6 and df = 68(t = 18) when K = 4, of 40%, 30%, 20%, 10% of the respective treatment mean and the control mean. Values in the cells represent the *discriminative power* in percentage in 200 simulated experiments whith r = 3 and 100 experiments with r = 6.

	r = 3 , df = 34				r = 6 , df = 68			
Dif	**40%**	**30%**	**20%**	**10%**	**40%**	**30%**	**20%**	**10%**
LSD	100	96	70	23.5	100	99	95	40
Duncan	99.5	95	59	13	100	99	90	25
SNK	95	65.5	19.5	2	100	99	68	8
Tukey	89.5	53	13.5	1.5	100	96	50	6
Bonferroni	82.5	45.5	10.5	1	100	95	41	4
Dunnett	97	74	33.5	4.5	100	99	76	13
BM	99.5	90	56.5	7.5	100	99	87	26
BMP	98.5	88	55.5	11	100	99	88	25

r = number of replications;
t = number of treatments;
df = nunber of degrees of freedom;
LSD = least significant difference by t-test;
SNK = Student, Newman, Keuls test;
BM = Modified Bonferroni's test;
BMP = partial modified Bonferroni's test.

Table 2. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 2.

t	r	F_o/F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	2	0.004	0.064	0.092	0.117	0.140	0.171	0.197	0.228	0.252	0.282	-	-	-	
4	2	0.040	0.077	0.111	0.141	0.169	0.205	0.236	0.270	0.298	0.328	0.361	-	-	
5	2	0.046	0.087	0.126	0.159	0.190	0.230	0.264	0.301	0.329	0.359	0.389	-	-	
6	2	0.051	0.096	0.138	0.175	0.208	0.251	0.287	0.325	0.341	0.382	0.408	-	-	
8	2	0.057	0.110	0.157	0.201	0.238	0.281	0.321	0.360	0.387	0.413	0.432	-	-	
10	2	0.065	0.124	0.174	0.220	0.261	0.311	0.348	0.385	0.418	0.432	0.447	-	-	
13	2	0.073	0.139	0.197	0.248	0.290	0.341	0.378	0.412	0.434	0.451	0.459	-	-	
16	2	0.080	0.152	0.215	0.268	0.312	0.364	0.400	0.431	0.449	0.461	0.465	-	-	
20	2	0.090	0.167	0.239	0.293	0.339	0.318	0.422	0.449	0.462	0.471	0.471	-	-	
25	2	0.099	0.187	0.257	0.317	0.338	0.412	0.442	0.463	0.472	0.478	-	-	-	
30	2	0.109	0.200	0.279	0.337	0.384	0.429	0.455	0.472	0.479	0.522	-	-	-	
40	2	0.122	0.227	0.310	0.371	0.415	0.453	0.472	0.482	-	-	-	-	-	
55	2	0.144	0.262	0.345	0.405	0.444	0.473	0.484	-	-	-	-	-	-	
70	2	0.158	0.285	0.373	0.430	0.463	0.483	-	-	-	-	-	-	-	
100	2	0.194	0.328	0.416	0.442	-	-	-	-	-	-	-	-	-	
144	2	0.215	0.371	0.448	-	-	-	-	-	-	-	-	-	-	

Table 3. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 3.

t	r	F_o / F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	3	0.031	0.061	0.088	0.113	0.135	0.166	0.191	0.223	0.248	0.278	0.314	0.360	-	
3	3	0.042	0.079	0.115	0.148	0.178	0.217	0.251	0.288	0.318	0.352	0.386	0.416	0.417	
4	3	0.049	0.093	0.135	0.171	0.206	0.251	0.288	0.316	0.359	0.392	0.421	0.440	0.436	
5	3	0.054	0.105	0.149	0.191	0.227	0.276	0.315	0.357	0.387	0.417	0.442	0.452	0.447	
6	3	0.058	0.114	0.157	0.206	0.247	0.297	0.337	0.378	0.407	0.435	0.455	0.460	-	
8	3	0.068	0.128	0.185	0.233	0.277	0.330	0.371	0.410	0.435	0.457	0.470	0.469	-	
10	3	0.076	0.143	0.204	0.255	0.302	0.356	0.385	0.431	0.453	0.470	0.478	0.474	-	
13	3	0.085	0.161	0.228	0.284	0.332	0.387	0.423	0.454	0.471	0.481	0.484	-	-	
16	3	0.092	0.176	0.246	0.306	0.356	0.408	0.442	0.468	0.480	0.487	0.488	-	-	
20	3	0.104	0.192	0.270	0.333	0.381	0.430	0.449	0.480	0.488	0.491	0.491	-	-	
25	3	0.112	0.214	0.294	0.359	0.404	0.449	0.474	0.488	0.494	0.494	0.492	-	-	
30	3	0.127	0.228	0.315	0.379	0.424	0.464	0.483	0.494	0.496	0.496	-	-	-	
40	3	0.145	0.258	0.349	0.402	0.449	0.480	0.493	0.498	0.499	-	-	-	-	
55	3	0.167	0.291	0.384	0.441	0.474	0.493	0.500	0.500	-	-	-	-	-	
70	3	0.182	0.321	0.410	0.460	0.485	0.499	-	-	-	-	-	-	-	
100	3	0.222	0.364	0.448	0.483	0.497	-	-	-	-	-	-	-	-	
144	3	0.248	0.402	0.475	-	-	-	-	-	-	-	-	-	-	

Table 4. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 4.

t	r	F_o / F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	4	0.035	0.068	0.098	0.125	0.151	0.186	0.217	0.252	0.281	0.315	0.354	0.398	0.403	0.400
3	4	0.044	0.086	0.124	0.166	0.193	0.236	0.273	0.314	0.347	0.382	0.418	0.433	0.440	0.435
4	4	0.052	0.099	0.144	0.183	0.221	0.269	0.309	0.353	0.385	0.419	0.448	0.461	0.455	-
5	4	0.058	0.110	0.159	0.203	0.244	0.294	0.337	0.379	0.411	0.441	0.464	0.470	0.463	-
6	4	0.062	0.120	0.173	0.221	0.263	0.315	0.358	0.400	0.430	0.456	0.474	0.476	0.469	-
8	4	0.072	0.137	0.197	0.250	0.295	0.350	0.391	0.431	0.455	0.475	0.485	0.482	-	-
10	4	0.081	0.151	0.217	0.271	0.318	0.374	0.415	0.450	0.471	0.486	0.491	0.486	-	-
13	4	0.088	0.172	0.241	0.301	0.348	0.404	0.441	0.470	0.486	0.494	0.495	-	-	-
16	4	0.098	0.186	0.262	0.323	0.372	0.424	0.458	0.482	0.493	0.497	0.497	-	-	-
20	4	0.110	0.208	0.283	0.348	0.397	0.446	0.474	0.492	0.498	0.500	0.499	-	-	-
25	4	0.123	0.228	0.309	0.374	0.421	0.463	0.486	0.498	0.502	0.502	-	-	-	-
30	4	0.130	0.242	0.333	0.396	0.438	0.476	0.494	0.501	0.503	0.502	-	-	-	-
40	4	0.149	0.271	0.367	0.426	0.463	0.491	0.501	0.504	0.504	-	-	-	-	-
55	4	0.169	0.311	0.400	0.456	0.483	0.500	0.504	0.505	-	-	-	-	-	-
70	4	0.193	0.338	0.427	0.472	0.493	0.503	0.506	-	-	-	-	-	-	-
100	4	0.223	0.375	0.460	0.491	0.503	-	-	-	-	-	-	-	-	-
144	4	0.259	0.419	0.483	-	-	-	-	-	-	-	-	-	-	-

Table 5. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 5.

t	r	F_o / F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	5	0.035	0.070	0.101	0.132	0.159	0.196	0.225	0.268	0.299	0.337	0.377	0.421	0.424	0.419
3	5	0.046	0.088	0.129	0.165	0.200	0.245	0.285	0.329	0.362	0.400	0.436	0.460	0.455	0.449
4	5	0.053	0.103	0.149	0.191	0.228	0.280	0.321	0.366	0.399	0.433	0.462	0.475	0.467	0.462
5	5	0.059	0.114	0.164	0.211	0.252	0.305	0.349	0.392	0.424	0.455	0.477	0.482	0.474	-
6	5	0.064	0.124	0.179	0.227	0.272	0.326	0.370	0.413	0.442	0.469	0.486	0.486	0.478	-
8	5	0.075	0.142	0.203	0.256	0.300	0.359	0.403	0.442	0.465	0.486	0.495	0.496	-	-
10	5	0.083	0.156	0.224	0.281	0.329	0.384	0.426	0.461	0.481	0.494	0.498	0.493	-	-
13	5	0.094	0.174	0.249	0.310	0.359	0.413	0.451	0.478	0.493	0.501	0.501	0.492	-	-
16	5	0.099	0.193	0.269	0.338	0.383	0.435	0.467	0.490	0.500	0.504	0.503	-	-	-
20	5	0.116	0.212	0.297	0.358	0.408	0.456	0.481	0.498	0.504	0.505	0.503	-	-	-
25	5	0.123	0.232	0.319	0.384	0.430	0.471	0.492	0.503	0.506	0.506	0.504	-	-	-
30	5	0.140	0.250	0.341	0.403	0.447	0.483	0.499	0.506	0.507	0.506	0.504	-	-	-
40	5	0.157	0.283	0.371	0.433	0.470	0.496	0.505	0.507	0.507	0.506	-	-	-	-
55	5	0.177	0.315	0.411	0.462	0.489	0.504	0.508	0.508	-	-	-	-	-	-
70	5	0.206	0.340	0.435	0.478	0.498	0.507	0.508	-	-	-	-	-	-	-
100	5	0.234	0.388	0.466	0.496	0.506	-	-	-	-	-	-	-	-	-
144	5	0.270	0.430	0.489	-	-	-	-	-	-	-	-	-	-	-

Table 6. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 6.

t	r	F_o / F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	6	0.037	0.071	0.104	0.135	0.163	0.202	0.237	0.276	0.309	0.350	0.392	0.437	0.438	0.433
3	6	0.046	0.091	0.131	0.170	0.205	0.251	0.292	0.338	0.372	0.410	0.448	0.472	0.465	0.459
4	6	0.054	0.105	0.166	0.195	0.234	0.286	0.329	0.374	0.408	0.443	0.472	0.484	0.475	0.469
5	6	0.061	0.116	0.169	0.215	0.258	0.312	0.356	0.401	0.432	0.463	0.486	0.490	0.481	-
6	6	0.066	0.127	0.183	0.233	0.277	0.333	0.377	0.420	0.450	0.476	0.493	0.493	0.485	-
8	6	0.075	0.146	0.209	0.264	0.309	0.367	0.409	0.448	0.473	0.492	0.500	0.496	-	-
10	6	0.084	0.160	0.228	0.286	0.335	0.393	0.432	0.468	0.489	0.500	0.503	0.498	-	-
13	6	0.097	0.180	0.255	0.317	0.368	0.422	0.444	0.485	0.498	0.505	0.506	0.499	-	-
16	6	0.103	0.195	0.277	0.342	0.388	0.440	0.477	0.495	0.503	0.507	0.506	-	-	-
20	6	0.119	0.218	0.298	0.366	0.413	0.461	0.487	0.502	0.508	0.508	0.506	-	-	-
25	6	0.127	0.240	0.323	0.387	0.436	0.477	0.496	0.507	0.509	0.509	-	-	-	-
30	6	0.143	0.255	0.342	0.409	0.450	0.487	0.502	0.508	0.509	0.508	-	-	-	-
40	6	0.161	0.290	0.376	0.439	0.474	0.499	0.508	0.509	0.509	0.508	-	-	-	-
55	6	0.181	0.322	0.413	0.465	0.491	0.506	0.509	0.509	-	-	-	-	-	-
70	6	0.210	0.348	0.440	0.481	0.501	0.508	0.509	-	-	-	-	-	-	-
100	6	0.242	0.390	0.469	0.496	0.507	-	-	-	-	-	-	-	-	-
144	6	0.277	0.432	0.491	-	-	-	-	-	-	-	-	-	-	-

Table 7. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 8.

		F_o / F_c													
t	r	1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	8	0.037	0.072	0.106	0.138	0.166	0.207	0.243	0.286	0.322	0.364	0.429	0.452	0.458	0.451
3	8	0.047	0.092	0.134	0.174	0.210	0.259	0.300	0.347	0.383	0.424	0.462	0.487	0.479	0.472
4	8	0.056	0.106	0.155	0.200	0.241	0.293	0.337	0.384	0.419	0.455	0.484	0.495	0.487	0.480
5	8	0.061	0.119	0.172	0.220	0.264	0.319	0.365	0.410	0.443	0.473	0.495	0.500	0.491	0.485
6	8	0.067	0.130	0.188	0.240	0.286	0.342	0.386	0.430	0.460	0.486	0.502	0.501	0.493	-
8	8	0.077	0.148	0.212	0.268	0.316	0.376	0.418	0.458	0.482	0.500	0.508	0.503	0.496	-
10	8	0.084	0.165	0.233	0.293	0.343	0.400	0.440	0.475	0.494	0.507	0.510	0.503	-	-
13	8	0.097	0.185	0.258	0.321	0.373	0.428	0.463	0.491	0.504	0.511	0.511	0.505	-	-
16	8	0.108	0.201	0.280	0.346	0.396	0.448	0.479	0.500	0.508	0.511	0.510	0.504	-	-
20	8	0.119	0.224	0.294	0.371	0.420	0.466	0.492	0.507	0.512	0.512	0.510	-	-	-
25	8	0.131	0.244	0.331	0.397	0.442	0.482	0.501	0.510	0.513	0.512	0.510	-	-	-
30	8	0.138	0.263	0.352	0.418	0.458	0.492	0.506	0.512	0.513	0.511	0.509	-	-	-
40	8	0.165	0.290	0.385	0.445	0.480	0.503	0.511	0.511	0.511	0.510	-	-	-	-
55	8	0.189	0.333	0.418	0.470	0.495	0.509	0.511	0.511	-	-	-	-	-	-
70	8	0.207	0.356	0.442	0.486	0.503	0.510	0.511	-	-	-	-	-	-	-
100	8	0.248	0.396	0.473	0.500	0.508	-	-	-	-	-	-	-	-	-
144	8	0.289	0.437	0.493	-	-	-	-	-	-	-	-	-	-	-

Table 8. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 10.

t	r	F_o / F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	10	0.037	0.072	0.106	0.138	0.169	0.210	0.248	0.292	0.328	0.372	0.421	0.472	0.471	0.464
3	10	0.049	0.093	0.136	0.176	0.213	0.262	0.305	0.353	0.390	0.431	0.470	0.496	0.488	0.481
4	10	0.057	0.108	0.157	0.202	0.243	0.296	0.343	0.390	0.425	0.461	0.491	0.503	0.494	0.487
5	10	0.061	0.121	0.174	0.224	0.268	0.325	0.372	0.417	0.449	0.480	0.502	0.505	0.496	0.490
6	10	0.068	0.133	0.190	0.242	0.287	0.346	0.391	0.436	0.466	0.491	0.507	0.506	0.498	-
8	10	0.079	0.150	0.216	0.272	0.321	0.378	0.426	0.463	0.488	0.504	0.512	0.507	0.500	-
10	10	0.086	0.165	0.238	0.295	0.348	0.404	0.446	0.479	0.499	0.510	0.513	0.508	-	-
13	10	0.101	0.186	0.264	0.326	0.377	0.432	0.468	0.495	0.507	0.514	0.513	0.508	-	-
16	10	0.111	0.204	0.287	0.351	0.399	0.452	0.482	0.504	0.511	0.515	0.513	0.508	-	-
20	10	0.122	0.222	0.310	0.377	0.426	0.471	0.495	0.509	0.511	0.515	0.512	-	-	-
25	10	0.131	0.246	0.335	0.402	0.448	0.486	0.504	0.513	0.514	0.514	0.511	-	-	-
30	10	0.142	0.268	0.357	0.419	0.462	0.494	0.508	0.514	0.514	0.513	0.511	-	-	-
40	10	0.166	0.300	0.393	0.444	0.482	0.505	0.512	0.514	0.513	-	-	-	-	-
55	10	0.193	0.329	0.423	0.474	0.498	0.510	0.513	0.512	-	-	-	-	-	-
70	10	0.208	0.358	0.445	0.488	0.505	0.511	0.512	-	-	-	-	-	-	-
100	10	0.251	0.400	0.476	0.502	0.510	-	-	-	-	-	-	-	-	-
144	10	0.294	0.440	0.496	0,499	-	-	-	-	-	-	-	-	-	-

Table 9. Values of P(F) encountered in the cells for different values t, and Fo / Fc when r = 15.

t	r	F_o / F_c 1.1	1.2	1.3	1.4	1.5	1.65	1.8	2.0	2.2	2.5	3.0	4.5	7.0	10
2	15	0.037	0.073	0.108	0.141	0.171	0.214	0.253	0.298	0.336	0.383	0.435	0.491	0.491	0.482
3	15	0.048	0.095	0.138	0.179	0.216	0.267	0.311	0.361	0.399	0.441	0.482	0.509	0.501	0.493
4	15	0.056	0.111	0.160	0.206	0.248	0.304	0.349	0.398	0.434	0.471	0.501	0.512	0.504	0.497
5	15	0.064	0.122	0.180	0.228	0.271	0.330	0.377	0.424	0.457	0.488	0.509	0.513	0.505	0.499
6	15	0.070	0.134	0.194	0.246	0.294	0.351	0.399	0.443	0.473	0.499	0.515	0.513	0.506	-
8	15	0.079	0.152	0.221	0.278	0.326	0.386	0.430	0.469	0.493	0.510	0.518	0.513	0.506	-
10	15	0.090	0.168	0.241	0.300	0.352	0.410	0.452	0.485	0.504	0.515	0.518	0.513	-	-
13	15	0.098	0.188	0.269	0.332	0.382	0.437	0.473	0.499	0.512	0.518	0.516	0.512	-	-
16	15	0.109	0.209	0.290	0.357	0.405	0.457	0.487	0.508	0.515	0.518	0.516	-	-	-
20	15	0.124	0.227	0.315	0.383	0.432	0.476	0.500	0.513	0.517	0.517	0.515	-	-	-
25	15	0.139	0.252	0.342	0.408	0.448	0.489	0.507	0.515	0.517	0.516	0.514	-	-	-
30	15	0.146	0.268	0.360	0.424	0.467	0.498	0.511	0.516	0.517	0.515	0.513	-	-	-
40	15	0.166	0.302	0.393	0.453	0.485	0.507	0.514	0.516	0.515	0.514	-	-	-	-
55	15	0.183	0.338	0.426	0.478	0.500	0.512	0.514	0.514	0.513	-	-	-	-	-
70	15	0.213	0.368	0.451	0.493	0.507	0.513	0.514	-	-	-	-	-	-	-
100	15	0.251	0.410	0.478	0.512	0.511	-	-	-	-	-	-	-	-	-
144	15	0.299	-	-	-	-	-	-	-	-	-	-	-	-	-

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