Decision support system for fitting and mapping nonlinear functions with application to insect pest management in biological control context

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Table 1: Complete listing of Models in the DSS. The "Name" column give the name of the the model, the "Equation" column give the mathematical expression of the model, the "comment" column give the number of parameter of the model while the last column give the reference about the model.

ID	Name	Equation	Comment	Reference
1	Sharpe & DeMichele 1	$m(T)=\dfrac{p'.\dfrac{T}{T_0'}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0'}-\frac{1}{T}\right)\right]}}{1+e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L}-\frac{1}{T}\right)\right]}+e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H}-\frac{1}{T}\right)\right]}}$ $p'=a+b*T_o'$ $T_o'=\dfrac{\Delta H_L-\Delta H_H}{R*\log\left(-\dfrac{\Delta H_L}{\Delta H_H}\right)+\left(\dfrac{\Delta H_L}{T_L}\right)-\left(\dfrac{\Delta H_H}{T_L}\right)}$	5P	
2	Sharpe & DeMichele 2	$m(T)=\dfrac{p'.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}}{1+e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L}-\frac{1}{T}\right)\right]}+e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H}-\frac{1}{T}\right)\right]}}$ $p'=a+b*T_o$	6P	
3	Sharpe & DeMichele 3	$m(T)=\dfrac{p.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}}{1+e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L}-\frac{1}{T}\right)\right]}+e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H}-\frac{1}{T}\right)\right]}}$	7P	Sharpe and DeMichele 1977
4	Sharpe & DeMichele 4	$m(T)=p.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}$	3P	
5	Sharpe & DeMichele 5	$m(T)=\dfrac{p.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}}{1+e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L}-\frac{1}{T}\right)\right]}}$	5P	
6	Sharpe & DeMichele 6	$m(T)=\dfrac{p.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}}{1+e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H}-\frac{1}{T}\right)\right]}}$	5P	
7	Sharpe & DeMichele 7	$m(T)=p'.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}$ $p'=a+b*T_o'$	2P	

8	Sharpe & DeMichele 8	$m(T)=\dfrac{p'.\dfrac{T}{T_0}.e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0}-\frac{1}{T}\right)\right]}}{1+e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L}-\frac{1}{T}\right)\right]}}$	4P	

		$p' = a + b * T_o'$		
9	Sharpe & DeçMichele 9	$m(T) = \frac{p' . \frac{T}{T_0} . e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]}}{1 + e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H} - \frac{1}{T}\right)\right]}}$ $p' = a + b * T_o'$	4P	
10	Sharpe & DeMichele 10	$m(T) = \frac{p . \frac{T}{T_0'} . e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]}}{1 + e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L} - \frac{1}{T}\right)\right]} + e^{\left[\frac{\Delta H_H'}{R}\left(\frac{1}{T_H'} - \frac{1}{T}\right)\right]}}$ $H_H' = 1 \; T_H' = 1$	4P	Sporleder *et al.* (2004)
11	Sharpe & DeMichele 11	$m(T) = \frac{p * \frac{T}{T_0'} * e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]}}{1 + e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L} - \frac{1}{T}\right)\right]} + e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H} - \frac{1}{T}\right)\right]}}$	6P	
12	Sharpe & DeMichele 12	$m(T) = \frac{P' * \frac{T}{T_0} * e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]}}{1 + e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L} - \frac{1}{T}\right)\right]} + e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H} - \frac{1}{T}\right)\right]}}$ $P' = a + b * T_0$	5P	
13	Sharpe & DeMichele 13	$m(T) = \frac{P * \frac{T}{T_0} * e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]}}{1 + e^{\left[\frac{\Delta H_L}{R}\left(\frac{1}{T_L} - \frac{1}{T}\right)\right]}}$	4P	
14	Sharpe & DeMichele 14	$m(T) = \frac{P * \frac{T}{T_0} * e^{\left[\frac{\Delta H_A}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]}}{1 + e^{\left[\frac{\Delta H_H}{R}\left(\frac{1}{T_H} - \frac{1}{T}\right)\right]}}$	4P	

15	Deva 1	$m(T)=b(T-T_{min})$ T ≥ Tmax $m(T)=0$ T < Tmax	2P	Dallwits and Higgins 1992
16	Deva 2	$r(T)=b_1\left(10^{-v^2}\right)\left(1-b_5+b_5v^2\right)$ $v=\frac{\left(u+e^{b_4(u)}\right)}{c_2}$ $u=\frac{(T-b_3)}{(b_3-b_2)}-c_1$ $c_1=\frac{1}{1+0.28b_4+0.72\ln(1+b_4)}$ $c_2=\frac{1+b_4}{1+1.5b_4+0.39{b_4}^2}$	5P	Dallwits and Higgins 1992
17	Logan 1	$m(T)=Y*(e^{p*T}-e^{\left(p*T_{max}-\frac{(T_{max}-T)}{v}\right)})$	4P	Longan 1976
18	Logan 2	$m(T)=\alpha\left(\frac{1}{1+k*e^{-p*T}}-e^{-\frac{(T_{max}-T)}{v}}\right)$	5P	Longan 1976
19	Briere 1	$m(T)=a*T(T-T_o)\left(\sqrt{T_{max}-T}\right)$	3P T ≤ Tmax	Briere et al. 1999
20	Briere 2	$m(T)=a*T(T-T_o)(T_{max}-T)^d$	d Є Z→T Є R d∉ Z→T≤Tmax	Briere et al. 1999
21	Stinner 1	$m(T)=\frac{R_{max}\left(1+e^{k_1+k_2(T_{opc})}\right)}{1+e^{k_1+k_2(T)}}$	4P	Stinner et al. 1974
22	Hilber & logan 1	$m(T)=Y\left(\frac{T^2}{T^2+d^2}-e^{-\frac{(T_{max}-T)}{v}}\right)$	4P	Hilber and logan 1983
23	Lactin 1	$m(T)=e^{p*T}-e^{-\frac{(p*T_l-(T-T_l))}{dt}}+\lambda$	4P	Lactin et al. 1995
24	Linear	$m(T)=a+b*T$	2P	
25	Exponential simple	$m(T)=b_1*e^{b_2*T}$	2P	
26	Tb model	$m(T)=sy*e^{\left(b(T-T_b)-e^{\left(\frac{b(T-T_b)}{DT_b}\right)}\right)}$	4P	
27	Exponential model	$m(T)=sy*e^{b(T-T_b)}$	3P	
28	Exponential	$m(T)=e^{b(T-T_{min})}-1$	2P	
29	Ratkowsky 1	$m(T)=b(T-T_b)^2$	2P	Ratkowsky et al. 1982
30	Davidson	$m(T)=\frac{k}{1+e^{a-bT}}$	2P	Davidson 1942, 1944

31	Pradham	$m(T)=R_m e^{\left[\frac{-1}{2}\left(\frac{T-T_m}{T_\sigma}\right)^2\right]}$	3P	Pradham 1945
32	Angilletta Jr.	$m(T)=a*e^{\left[-\frac{1}{2}\left(\frac{\lvert T-b\rvert}{c}\right)^d\right]}$	4P	Angilletta Jr. 2006

33	Stinner 2	$m(T)=\frac{MaxDevRate*e^{k_1+k_2T_{opt}}}{1+e^{k_1+k_2T}}$	4P	Stinner 1974
34	Hilbert	$m(T)=\Psi\left[\frac{(T-T_b)^2}{((T-T_b)+D^2)}\right]-e^{-(\frac{T_m-(T-T_b)}{\Delta T})}$	5P	Hilbert and Logan 1983
35	Lactin 2	$m(T)=e^{\rho T}-e^{(\rho T_{Max}-\frac{T_{Max}-T}{\Delta})}$	• 5P	• Lactin et al. 1995
36	Anlytis 1	$m(T)=P\delta^n(1-\delta)^m \quad \delta=\frac{T-T_{mim}}{T_{\max}-T_{\min}}$	5P n Є Z→T Є R mЄ Z→T Є R n∉ Z→T≥Tmin m∉Z→T≤Tmx	Analysis 1977
37	Anlytis 2	$m(T)=[P\delta^n(1-\delta)]^m \quad \delta=\frac{T-T_{mim}}{T_{\max}-T_{\min}}$	5P n Є Z→T Є R mЄ Z→T Є R n∉ Z→T≥Tmin m∉Z→T≤Tmx	Analysis 1980
38	Anlytis 3	$m(T)=a(T-T_{\min})^n(T_{\max}-T)^m$	5P n Є Z→T Є R mЄ Z→T Є R n∉ Z→T≥Tmin m∉Z→T≤Tmx	Analysis 1977
39	Allahyari	$m(T)=P\delta^n(1-\delta^m) \quad \delta=\frac{T-T_{mim}}{T_{\max}-T_{\min}}$	5P n Є Z→T Є R mЄ Z→T Є R n∉ Z→T≥Tmin m∉Z→T≥Tmin	Allahyari 2005
40	Briere 3	$m(T)=a(T-T_b)(T_L-T)^{\frac{1}{2}}$	3P	Briere et al. 1999
41	Briere 4	$m(T)=a(T-T_b)(T_L-T)^{\frac{1}{n}}$ $T \le T_L$	3P	Briere et al. 1999

42	Kontodimas 1	$m(T)=a(T-T_{\min})^2(T_{\max}-T)$	3P	Kontodimas 2004
43	Kontodimas 2	$m(T)=\frac{2}{D_{\min}(e^{K(T-T_{opt})}+e^{-\lambda(T-T_{opt})})}$	4 P	Kontodimas 2004

44	Kontodimas 3	$m(T)=\frac{T*e^{\left(a-\frac{b}{T}\right)}}{1+e^{\left(c-\frac{d}{T}\right)}+e^{\left(f-\frac{g}{T}\right)}}$	6P	Kontodimas 2004
45	Ratkowsky 2	$m(T)=\left[a\left(T-T_{\min}\right)\left(1-e^{b(T-T_{\max})}\right)\right]^2$	4P	Ratkowsky et al. 1982
46	Janish 1	$m(T)=\frac{2}{D_{\min}(e^{K(T-T_{opt})}+e^{-K(T-T_{opt})})}$	3P	
47	Janish 2	$m(T)=\frac{2C}{a^{(T-Tm)}+b^{(T_m-T)}}$	3P	
48	Tanigoshi	$m(T)=a_0+a_1T+a_2T^2+a_3T^3$	4P	Tanigoshi and Browne 2004
49	Wang-Lan-Ding	$m(T)=k\frac{\left(1-e^{-a(T-T_{\min})}\right)\left(1-e^{b(T-T_{\max})}\right)}{1+e^{-r(T-c)}}$	7P	Wang et al. 1982
50	Stinner 3	$m(T)=\frac{c_1}{1+e^{(k_1+k_2*T)}}$	3P	
51	Stinner 4	$m(T)=\frac{c_1}{1+e^{(k_1+k_2*T)}}+\frac{c_2}{1+e^{(k_1+k_2(2*To-T))}}$	5P	
52	Logan 3	$m(T)=sy*e^{\left(b\left(T-T_{\min}\right)-e^{\left(b*T_{\max}-\frac{(T_{\max}-(T-T_{\min}))}{Dtb}\right)}\right)}$	5P	
53	Logan 4	$m(T)=\alpha\left(\frac{1}{1+k*e^{-b\left(T-T_{\min}\right)}}-e^{-\frac{(T_{\max}-(T-T_{\min}))}{Dt}}\right)$	5P	

54	Logan-5	$m(T)=\alpha\left(\frac{1}{1+k*e^{-b(T)}}-e^{-\frac{(T_{\max}-T)}{Dt}}\right)$	6P	
55	Hilber & logan 2	$m(T)=\psi\left(\frac{T^2}{T^2+D}-e^{-\frac{(T_{\max}-T)}{Dt}}\right)$	4P	
56	Hilber & logan 3	$m(T)=\psi\left(\frac{\left(T-T_{\min}\right)^2}{\left(T-T_{\min}\right)^2+D}-e^{-\frac{(T_{\max}-(T-T_{\min}))}{Dt}}\right)+\theta$	6P	
57	Taylor	$m(T)=r_m*e^{-\frac{1}{2}\left(-\frac{\left(T-T_{opt}\right)}{T_{roh}}\right)^2}$	3P	
58	Lactin 3	$m(T)=e^{\rho*T}-e^{(\rho*T_{Max}-\frac{T_{Max}-T}{\Delta})}+\lambda$	4P	

59	Sigmoid or Logistic	$m(T) = \frac{c_1}{1+e^{a+b*T}}$	3P	

60	MAIZSIM	$m(T) = \mathrm{Rmax}\left(\frac{\mathrm{Tceil} - \mathrm{T}}{\mathrm{Tceil} - \mathrm{Topc}}\right)\left(\left(\frac{T}{\mathrm{Topc}}\right)^{\frac{\mathrm{Topc}}{\mathrm{Tceil}-\mathrm{Topc}}}\right)$	3P	(Kim et al., 2012)
61	Enzymatic Response	$m(T) = \frac{51559240052.T.exp^{\left(\frac{-73900}{8.314.T}\right)}}{1+\left(exp^{\left(-73900/8.314T\right)}\right)^{\left(\frac{alpha*(1-T)}{To}\right)}}$	2P	
62	beta function	$m(T) = exp^{(k)}.\left((T-Tb)^{alpha}\right).\left((Tc-T)^{betas}\right)$	5P	
63	Wang et Engel	$m(T) = \frac{2\left((\mathrm{T}-\mathrm{Tmin})^{\left(\frac{\log(2)}{\log\left(\frac{\mathrm{Tmax}-\mathrm{Tmin}}{\mathrm{Topt}-\mathrm{Tmin}}\right)}\right)}\right)\left((\mathrm{Topt}-\mathrm{Tmin})^{\left(\frac{\log(2)}{\log\left(\frac{\mathrm{Tmax}-\mathrm{Tmin}}{\mathrm{Topt}-\mathrm{Tmin}}\right)}\right)}\right)-\left((\mathrm{T}-\mathrm{Tmin})^{\left(\frac{2*\log(2)}{\log\left(\frac{\mathrm{Tmax}-\mathrm{Tmin}}{\mathrm{Topt}-\mathrm{Tmin}}\right)}\right)}\right)}{\left((\mathrm{Topt}-\mathrm{Tmin})^{\left(\frac{2*\log(2)}{\log\left(\frac{\mathrm{Tmax}-\mathrm{Tmin}}{\mathrm{Topt}-\mathrm{Tmin}}\right)}\right)}\right)}$	3P	(Wang et Engel, 1998)
64	Richards	$m(T) = \frac{\mathrm{Yasym}}{\left(1+v.exp^{(-\mathrm{k}.(\mathrm{T}-\mathrm{Tm}))}\right)^{1/\mathrm{v}}}$	4P	Richards (1959)
65	Gompertz	$m(T) = Yasym * exp^{\left(-exp^{(-\mathrm{k}*(\mathrm{x}-\mathrm{Tm}))}\right)}$	3P	Gompertz (1825)
66	Beta 1	$m(T) = \mathrm{Rmax} * \left(1+\frac{Tmax-x}{Tmax-Topt}\right).\left(\frac{T}{Tmax}\right)^{\left(\frac{Tmax}{Tmax-Topt}\right)}$	3P	(Yin et al.,2003a)
67	Q10 function	$m(T) = Q10^{\left(\frac{\mathrm{T}-\mathrm{Tref}}{10}\right)}$	2P	
68	Ratkowsky 3	$m(T) = \frac{(T-Tmin)^2}{(Tref-Tmin)^2}$	2p	Ratkowsky et al.(1982)
69	Beta 2	$m(T) = Rmax.\left(\frac{\mathrm{Tmax}-\mathrm{T}}{\mathrm{Tmax}-\mathrm{Topt}}\right)\left(\frac{T}{Tmax}\right)^{\left(\frac{Tmax}{Tmax-Topt}\right)}$	3P	(Yin et al. 1995)
70	Bell curve	$m(T) = \mathrm{Yasym}.exp^{\left(a(\mathrm{T}-\mathrm{Topt})^2+b(\mathrm{T}-\mathrm{Topt})^3\right)}$	4P	
71	Gaussian function	$m(T) = \mathrm{Yasym}.exp^{\left(-0.5.\left(\frac{\mathrm{T}-\mathrm{Topt}}{b}\right)^2\right)}$	3P	
72	Beta 3	$m(T) = \mathrm{Rmax}.\left(\left(\frac{Tmax-T}{Tmax-Topt}\right) * \left(\left(\frac{T-\mathrm{Tmin}}{\mathrm{Topt}-\mathrm{Tmin}}\right)^{\left(\frac{\mathrm{Topt}-\mathrm{Tmin}}{Tmax-Topt}\right)}\right)\right)$	4P	(Yan et Hunt, 1999)
73	Expo first order plus logistic	$m(T) = \mathrm{Yo}.\left(1- exp^{(kT)}\right)+\mathrm{bT}$	3P	Gilles and price 2011)
74	Beta 4	$m(T) = Yb + (Rmax-Yb).\left(1+\frac{Tmax-T}{Tmax-Topt}\right) * \left(\left(\frac{T-\mathrm{Tmin}}{\mathrm{Tmax}-\mathrm{Tmin}}\right)^{\left(\frac{\mathrm{Tmax}-\mathrm{Tmin}}{Tmax-Topt}\right)}\right)$	5P	(Yin et al., 2003)
75	Beta 5	$m(T) = \mathrm{Rmax}\,\frac{(2.\mathrm{Tmax}-\mathrm{T}).T}{\mathrm{Tmax}^2}$	2P	(Yin et al., 2003)

76	Beta 6	$m(T) = \text{Rmax}\,\frac{(3.\text{Tmax} - 2.\text{T}).T^2}{\text{Tmax}^3}$	2P	(Yin et al., 2003)
77	Beta 7	$m(T) = \text{Rmax}.\left(1 - \left(1 + \left(\frac{Tmax - T}{Tmax - Topt}\right)\right) * \left(\left(\frac{T}{Tmax}\right)^{\left(\frac{Tmax}{Tmax-Topt}\right)}\right)\right)$	3P	(Yin et al., 2009)
78	Modified exponential	$m(T) = exp(a + bT.(1 - 0.5T/Topt))$	3P	(O'Connell 1990)
79	Lorentzian 3-parameter	$m(T) = \frac{a}{\left(1 + \left(\frac{\text{T} - \text{Topt}}{b}\right)^2\right)}$	3P	
80	Lorentzian 4-parameter	$m(T) = \frac{\text{Yopt} + a}{\left(1 + \left(\frac{\text{T} - \text{Topt}}{b}\right)^2\right)}$	4P	
81	Log normal 3-parameter	$m(T) = a.exp^{\left(-0.5*\left(\frac{\log\left(\frac{T}{\text{Topt}}\right)}{b}\right)^2\right)}$	3P	
82	Pseudo-voigt 4 parameter	$m(T) = a.\left(\left(\frac{k}{1 + \left(\frac{T - Topt}{b}\right)^2}\right) + (1 - k).exp^{\left(-0.5*\left(\frac{(T-\text{Topt})}{b}\right)^2\right)}\right)$	4P	

- *T* temperature in Degree Celcius

- *m(T)* mortality at temperature *T*

R= 1987 cal degree (-1) mol(-1)