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RESEARCH ARTICLE

Light-Trap Catch of Moth Species of the Becse-Type Light Trap in Connection With the Height of the Tropopause

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ABSTRACT

In present study we examined the connection between height of tropopause and the light-trap catch moth species. The data of 8 Microlepidoptera and 26 Macrolepidoptera species were caught from the material of a Becse-type light-trap between1969 and 1973 Groups were made for data of the height of tropopause. The relative catch values of the examined species were categorised according to the characteristics of tropopause on each day, after it these values were summarised, averaged and depicted. We defined the parameters of the regression equations. Most species are collected in connection with the increasing the height of the tropopause, but decrease was observed only in case of three species. Often can be experienced the increase of the catch after the decrease of it if the values of the tropopause height is high. The different form of behaviour, however, is not linked to the taxonomic position.

Key Words: *Becse-type Light trap, Tropopause*

INTRODUCTION

The tropopause is a surface separating the lower layers of the atmosphere (troposphere) from the upper layers (stratosphere). It is of varying height. In the presence of very cold air masses from the Arctic it may be a mere 5 kilometres, while in the presence of sub-tropical air it may grow to 16 kilometres. Sometimes there are two or three tropopauses one above the other.

The former one, however, as investigations were carried out during the summer months, never occurred; even in the lower 9 km of the tropopause height was only very rarely observed. The incidence of subtropical air masses with a high tropopause was significantly more frequent.

We have demonstrated in our previous works that large regions prevailing weather conditions affect both the pheromone trapping (Károssy *et al.* 2009 Nowinszky and Puskás, 2003), and light trapping effectiveness (Károssy *et al.* 1990, Nowinszky et al . 1992, 1995, 1999, Nowinszky and Puskás, 2002, Keszthelyi *et al.* 2005, 2006).

We did not find any communications dealing with this topic in the literature apart from our own works. In recent years, some studies have already been published for different moth species, which could also prove the above hypothesis (Örményi *et al.*, 1997, Puskás and Nowinszky 2000, Puskás *et al.* 2,003, Nowinszky and Puskás 2013). We do not know any studies dealing with the contact of tropopause height and the light trapping only own papers.

MATERIAL AND METHODS

Data on the height of the tropopause were taken from the Year Books of National Weather Service of Budapest Central Meteorological Institute.

The light-trap operated by Varga and Mészáros (1973a, 1973b) between 1969 and 1973 on the territory of the Agricultural and Industrial Combine in Bečej, Serbia (Geographical coordinates are: 45°37'05"N 20°02'05"E) collects many more insects than the Hungarian Jermy-type traps do. The light source of the trap is an IPR WTF 220V, 250W mercury vapour

lamp 2 meters above the ground. There is a large collecting cage under the funnel of the trap. The cage contains two perpendicular separation walls made of plastic haircloth dividing the cage into four equal parts. This solution ensured that the tougher bodied and livelier beetles staying at the bottom of the cage couldn't damage the moths and other fragile insects that have climbed up on the separation walls. In the morning the cage was placed in a chest in which a few millilitres of carbon bisulphide had been burnt. The gases thus generated killed the insects quickly and effectively. The light-trap worked every night in the breeding season even in bad weather. Several of this type of traps collecting huge masses of insect material of good quality has been operating in Yugoslavia. Regarded to be dangerous, the use of this type of trap has not been permitted in Hungary.
The moth data of Becse-type light trap were processed and published (Vojnits *et al.*, 1971, Mészáros *et al.* 1971). This light-trap operated in Bečej Agricultural and Industrial Combine in the years 1969-1973. We process 8 Microlepidoptera and 26 Macrolepidoptera species from the total catching data. The names of the species, the years of collecting and the number of individuals are shown in Table 1.

Table 1: Collection data of the examined moths (Lepidoptera) species

Families and scientific names	Common names	Collecting years	Number of Individuals	Number of Data
Tortricidae				
Aleimma loeflingiana Linnaeus, 1758	Yellow Oak Button	1969-72	2824	52
Crambidae				
Evergestis extimalis Scopoli, 1763	Marbled Yellow Pearl	1971-73	1149	86
Loxostege sticticalis Linnaeus, 1761	Beat Webworm Moth	170-73	1196	131
Sitochroa verticalis Linnaeus, 1758	Lesser Pearl	1970-73	3002	230
Ostrinia nubilalis Hübner, 1796	European Corn-borer	1970-73	38120	340
Nomophila noctuella Denis et Schiffermüller, 1775	Rush Veneer	1970-73	14374	243
Pyralidae				
Etiella zinckenella Treitschke, 1822	Lima Bean Pod Borer	1970-73	3141	129
Homeosoma nebulella Denis et et Schiffermüller, 1775	European Sunflower Moth	1969 and 71	6263	92
Geometridae				
Timandra comae Schmidt, 1931	Blood-vein	1970-73	4263	185
Chiasmia clathrata Linnaeus, 1758	Latticed Heath	1970-73	3478	258
Ascotis selenaria Denis et Schiffermüller, 1775	Luna Beauty	1970-71 and 1973	2159	161
Lymantriidae				
Leucoma salicis Linnaeus, 1758	White Satin Moth	1969-73	3255	255
Arctiidae				
Hxphantria cunea Drury, 1773	Fall Webworm	1970-73	4447	234
Spilosoma lubricipeda Linnaeus, 1758	White Ermine	1970-71	2644	84
Spilosoma urticae Esper, 1789	Water Ermine	1970-71 and 1973	4634	112
Phagmatobia fuliginosa L.	Ruby Tiger	1970-73	14374	243
Noctuidae				
Agrotis segetum Denis et Schiffermüller, 1775	Turnip Moth	1970-73	9895	301
Agrotis exclamationis Linnaeus, 1758	Heart & dart	1970-73	2348	177
Axylia putria Linnaeus, 1761	The Flamme	1969-73	2914	179
Noctua pronuba Linnaeus, 1758	Large Yellow Underwing	1970-73	1755	194
Xestia c-nigrum Linnaeus, 1758	Setaceous Hebrew Ch	1970-73	28999	326
Discestra trifolii Hfnufnagel, 1766	The Nutmeg	1970-73	11381	310
Mamestra brassicae Linnaeus, 1758.	Cabbage Moth	1970-71 and 1973	4187	92
Laconobia suasa Denis et Schiffer, 1775	Dog's Tooth	1970-73	4434	189
Laconobia oleracea Linnaeus, 1758	Bright-line Brown-eye	1970-73	7512	201
Mythimna turca Linnaeus, 1761	Double Line	1969-71 and 1973	1324	88
Mythimna vitellina Hübner, 1808	The Delicate	1970-73	3583	180
Mythimna pallens Linnaeus, 1758	Common Vainscot	1969-70 and 1972-73	3689	202
Heliothis maritima Graslin, 1855	Shoulder-striped Clover	1970-73	3563	215
Emmelia trabealis Scopoli, 1763	Spotted Sulphur	1970-73	18678	312
Macdunnoughia confusa Stephens, 1850	Dewick's Plusia	1969-73	1236	221
Autograha gamma Linnaeus, 1758	Silver Y	1970-73	6868	349
Autographa pulchrina Haworth, 1809	Beautiful Golden Y	1969 and 1972-73	1163	109
Tephrina arenacearia Denis et Schiffermüller, 1775	Lucerne Moth	1970-73	4457	227

From the catching data of the examined species, relative catch (RC) data were calculated for each night. The RC is the quotient of the number of individuals caught during a sampling time unit (1 night) per the average number of individuals of the same generation falling to the same time unit. In case of the expected average individual number, the RC value is 1. The introduction of RC enables us to carry out a joint evaluation of materials collected in different years and at different traps (Nowinszky, 2003).

Data on the height of the tropopause were arranged into classes according to Sturges' method (Odor and Iglódi 1987). The relative catch values were assigned into the classes of the tropopause belonging to the given day and then they were summarized and averaged.

RESULTS AND DISCUSSION

Based on our results, we proved that the light-trap catch of examined species is affected by the height of tropopause. However, some species may not react the same way. Most species are collected in connection with the increasing the height of the tropopause, but decrease was observed only in case of three species. Often can be experienced the increase of the catch after the decrease of it if the values of the tropopause height is high. The different form of behaviour, however, is not linked to the taxonomic position.

A low tropopause is related the presence of cold and high tropopause the presence of warm types of air, while insect activity is increased by warm and reduced by cold air. An over 13 km height of the tropopause often indicates a subtropical air stream at a great height. This has a strong biological influence. These results may lead us to assume that the electric factors in the atmosphere also have an important role to play, mainly when a stream of subtropical air arrives at great height. On such occasions the 3Hz spherics impulse number shows a decrease, while cosmic radiation of the Sun will be on the increase (Örményi, 1984). The preponderance of negative ions in polar air reduces activity, while the preponderance of positive ions in subtropical maritime air may spur flight activity (Örményi, 1967).

Fig. 1: Light-trap catch of Setaceous Hebrew Character (*Xestia c-nigrum* L.) depending on the height of tropopause (Becse, 1970-1973)

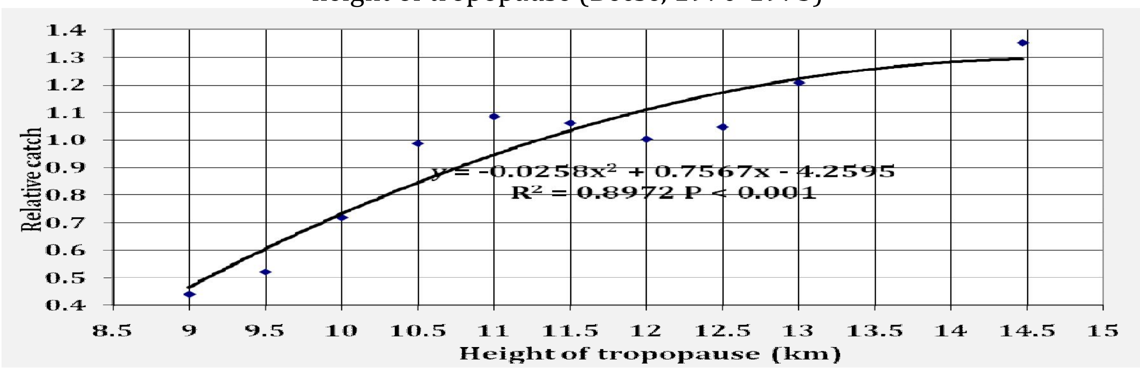

Fig. 2: Light-trap catch of Beet Webworm Moth (*Loxostege sticticalis* L.) depending on the height of tropopause (Becse, 1970-1973)

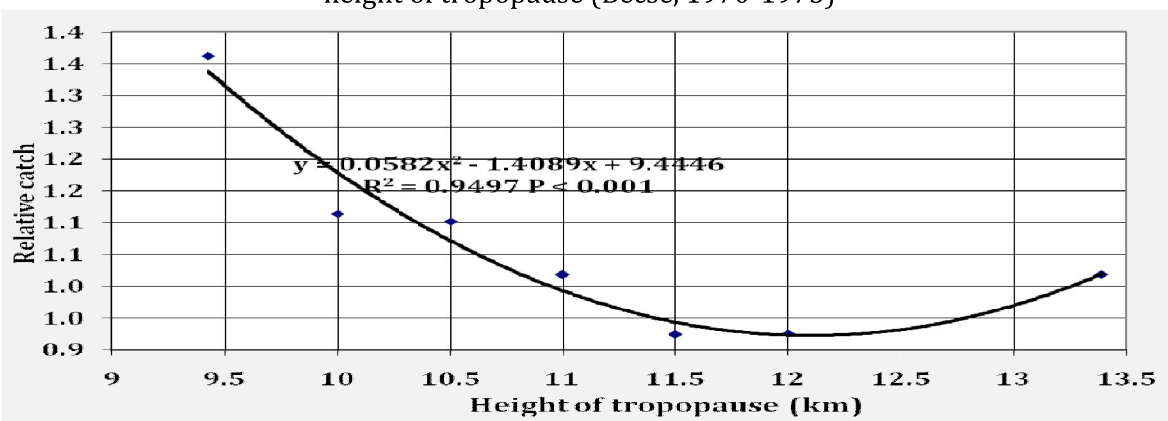

Fig. 3: Light-trap catch of Rush Veneer (*Nomophila noctuella* Den. et Schiff.) depending on the height of tropopause (Becse, 1970-1973)

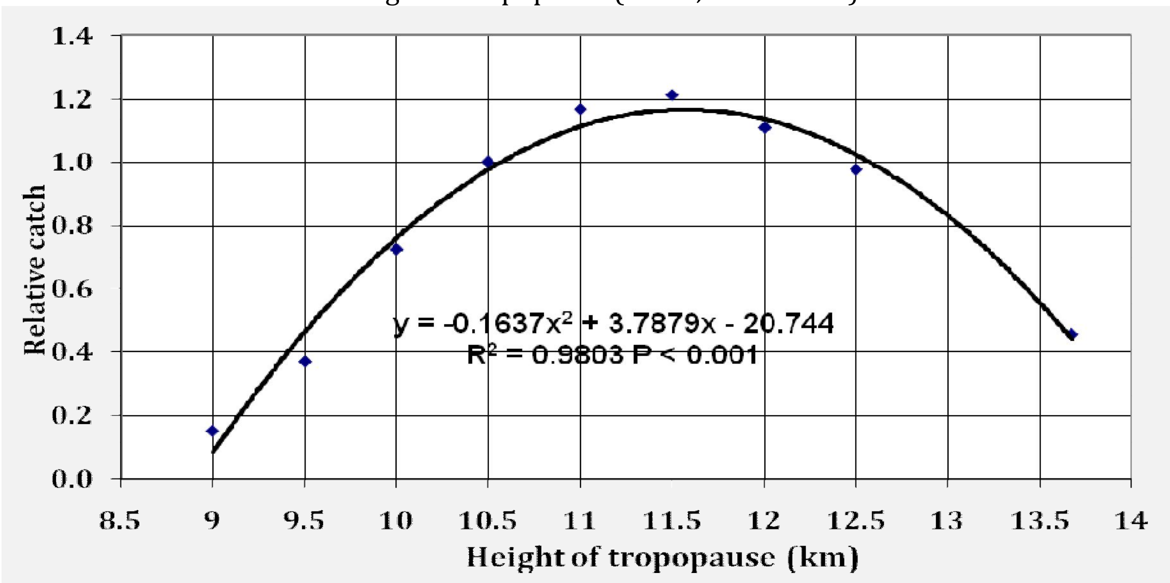

Table 2: The relative catch of the examined species depending on the height of tropopause, parameters of equations with the significance levels

Families — Species	Increasing or decreasing catch	Height of tropopause (km)											
		≤ 9	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14 ≤
		Parameters of equations and significance level											
Tortricidae													
Aleimma loeflingiana L.	Decreasing		1.07			1.00	0.98	0.99					
Yellow Oak Button		$y = 0.0242x^2 - 0.5666x + 4.2976$ $R^2 = 0.9886$ $P < 0.01$											
Crambidae													
Evergestis extimalis Scop.	Increasing	0.76	0.93		0.99	1.12	0.92	1.04		1.63			
Marbled Yellow Pearl		$y = 0.038x^3 - 1.257x^2 + 13.842x - 49.7$ $R^2 = 0.9033$ $P < 0.01$											
Loxostege sticticalis L.	Decreasing	1.36		1.11	1.10	1.02	0.92	0.93		1.02			
Beat Webworm Moth		$y = 0.0582x^2 - 1.4089x + 9.4446$ $R^2 = 0.9497$ $P < 0.001$											
Sitochroa verticalis L.	Increasing Decreasing	0.38		0.72	0.86	0.94	1.16	1.16			0.87		
Lesser Pearl		$y = -0.0895x^2 + 2.1744x - 12.073$ $R^2 = 0.9751$ $P < 0.001$											
Ostrinia nubilalis Hbn.	Increasing	0.07	0.19	0.86	0.73	0.83	1.00	1.17	1.33	1.18	1.34		1.55
European Corn-borer		$y = -0.0367x^2 + 1.1043x - 6.8226$ $R^2 = 0.924$ $P < 0.001$											
Nomophila noctuella Den. et Schiff.	Increasing Decreasing	0.15	0.37	0.73	1.00	1.17	1.22	1.11	0.98		0.76		
Rush Veneer		$y = -0.1637x^2 + 3.7879x - 20.744$ $R^2 = 0.9803$ $P < 0.001$											
Pyralidae													
Etiella zinckenella Tr.	Increasing		0.89		0.90	0.91	1.07	1.02	1.13		1.44		
Lima Bean Pod Borer		$y = 0.0307x^2 - 0.5906x + 3.7256$ $R^2 = 0.9565$ $P < 0.001$											
Homeosoma nebulella Den. et Schiff.	Increasing	0.23		0.81	0.98	1.16	1.05	1.03	1.05	1.26			
European Sunflower Moth		$y = 0.0499x^3 - 1.7551x^2 + 20.536x - 78.931$ $R^2 = 0.981$ $P < 0.001$											
Geometridae													
Timandra comae Schmidt	Increasing	0.47		0.79	1.13	1.09	1.03	0.94	1.05			1.13	
Blood-vein		$y = 0.034x^3 - 1.2227x^2 + 14.602x - 56.818$ $R^2 = 0.8967$ $P < 0.01$											
Chiasmia clathrata L.	Increasing Decreasing	0.35	0.59	0.97	1.16	1.17	1.05	0.95	0.90	0.92	0.90		0.89
Latticed Heath		$y = 0.0252x^3 - 0.9471x^2 + 11.735x - 46.854$ $R^2 = 0.903$ $P < 0.0 01$											
Ascotis selenaria Den. et Schiff.	Increasing Decreasing	0.29		0.86	1.26	1.36	1.09	0.89	0.81	0.86			0.80
Luna Beauty		$y = 0.0424x^3 - 1.5936x^2 + 19.677x - 78.807$ $R^2 = 0.8676$ $P < 0.001$											

Table 3: The relative catch of the examined species depending on the height of tropopause, parameters of equations with the significance levels

Families — Species	Increasing or decreasing catch	Height of tropopause (km)											
		≤ 9	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14 ≤
		Parameters of equations and significance level											
Lymantriidae													
Leucoma salicis L.	Increasing	0.60		0.79	0.97	1.02	1.05	1.00	1.03	1.25			
White Satin Moth		$y = 0.0308x^3 - 1.0755x^2 + 12.527x - 47.695$ $R^2 = 0.9714$ $P < 0.001$											
Arctiidae													
Hxphantria cunea Drury	Increasing		0.96		1.00	1.01	1.06	1.04	0.94		0.72		
Fall Webworm	Decreasing	$y = -0.0451x^2 + 1.0059x - 4.5747$ $R^2 = 0.9488$ $P < 0.001$											
Spilosoma lubricipeda L.	Increasing			0.69		0.86	0.96	1.16			1.35		
White Ermine		$y = 2.369Ln(x) - 4.8002$ $R^2 = 0.9737$ $P < 0.001$											
Spilosoma urticae Esper	Increasing		0.78		0.87	0.90	1.04	1.14		1.25			
Water Ermine		$y = 0.1409x - 0.6054$ $R^2 = 0.9739$ $P < 0.001$											
Phagmatobia fuliginosa L.	Increasing	0.08	0.37	0.73	1.00	1.17	1.22	1.11	0.96		0.46		
Ruby Tiger	Decreasing	$y = -0.1675x^2 + 3.8818x - 21.326$ $R^2 = 0.9844$ $P < 0.001$											
Noctuidae													
Agrotis segetum Den. et Schiff.	Increasing	0.20	0.63	0.77	1.00	0.99	1.07	1.08	1.20	1.11		0.60	
Turnip Moth	Decreasing	$y = -0.0925x^2 + 2.227x - 12.247$ $R^2 = 0.9644$ $P < 0.001$											
Agrotis exclamationis L.	Increasing	1.00		0.98	1.04	1.13	1.08	1.03	0.86	0.76	0.77		0.80
Heart & dart	Decreasing	$y = 0.0164x^3 - 0.6026x^2 + 7.2508x - 27.537$ $R^2 = 0.8224$ $P < 0.001$											
Axylia putria L.	Increasing	0.69		0.86	0.88	1.10	1.09	1.21	0.96			0.90	
The Flamme	Decreasing	$y = 0.0038x^3 - 0.185x^2 + 2.8128x - 12.511$ $R^2 = 0.7839$ $P < 0.01$											
Noctua pronuba L.	Increasing		0.94		1.19	1.17	1.15	0.98	0.85		0.49		
Large Yellow Underwing	Decreasing	$y = -0.0935x^2 + 2.0309x - 9.8692$ $R^2 = 0.971$ $P < 0.001$											
Xestia c-nigrum L.	Increasing	0.44	0.52	0.72	0.99	1.09	1.06	1.03	1.05	1.21		1.35	
Setaceous Hebrew Character		$y = -0.0258x^2 + 0.7567x - 4.2595$ $R^2 = 0.8972$ $P < 0.001$											
Discestra trifolii Hfn.	Increasing	0.37		1.08	0.96	0.97	0.90	0.97	1.03	1.24			1.72
The Nutmeg		$y = 0.0352x^3 - 1.2356x^2 + 14.437x - 55.167$ $R^2 = 0.9072$ $P < 0.001$											

Table 4: The relative catch of the examined species depending on the height of tropopause, parameters of equations with the significance levels

Families — Species	Increasing or decreasing catch	Height of tropopause (km)											
		≤ 9	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14 ≤
		Parameters of equations and significance level											
Noctuidae													
Mamestra brassicae L.	Increasing	0.40		0.58	0.74	1.03	1.23	1.18	1.15				1.33
Cabbage Moth		$y = -0.0512x^2 + 1.4055x - 8.3002$ $R^2 = 0.9425$ $P < 0.001$											
Laconobia suasa Den. et Schiff.	Increasing	0.18		1.00	0.95	1.08	1.01	1.11	0.95	0.96			1.28
Dog's Tooth		$y = 0.0412x^3 - 1.5217x^2 + 18.587x - 74.076$ $R^2 = 0.932$ $P < 0.001$											
Laconobia oleracea L.	Increasing	0.68		1.00	1.16	1.23	1.05	0.92		0.77			
Bright-line Brown-eye	Decreasing	$y = 0.0531x^3 - 1.9012x^2 + 22.441x - 86.333$ $R^2 = 0.9579$ $P < 0.001$											
Mythimna turca L.	Increasing		0.76		0.77	1.06	1.13	1.24	1.09	0.70	0.55		0.69
Double Line	Decreasing	$y = 0.0311x^3 - 1.1961x^2 + 15.104x - 61.703$ $R^2 = 0.6078$ $P < 0.05$											
Mythimna vitellina Hbn.	Increasing	0.56	0.72	0.81	0.92	0.98	0.95	1.05	1.04	1.41		1.42	
The Delicate		$y = -0.0012x^2 + 0.1858x - 0.9612$ $R^2 = 0.9085$ $P < 0.001$											
Mythimna pallens L.	Increasing	0.59		0.70	0.81	0.83	1.03	1.12	1.26		1.55		
Common Vainscot		$y = 0.2272x - 1.584$ $R^2 = 0.9847$ $P < 0.001$											
Heliothis maritima Graslin	Increasing	0.26		0.73	0.82	0.84	0.96	1.04	1.21	1.45	1.52		
Shoulder-striped Clover		$y = -0.0237x^2 + 0.7922x - 4.9714$ $R^2 = 0.9402$ $P < 0.001$											
Emmelia trabealis Scop.	Increasing	0.06	0.29	0.69	0.71	0.94	1.07	1.14	1.11	0.82	1.19	1.75	2.85
Spotted Sulphur		$y = 0.0297x^3 - 1.0562x^2 + 12.587x - 49.342$ $R^2 = 0.9606$ $P < 0.001$											
Macdunnoughia confusa Steph.	Increasing	0.64		0.99	1.19	1.29	1.03	0.93	0.92		0.80		
Dewick's Plusia	Decreasing	$y = 0.0338x^3 - 1.2264x^2 + 14.657x - 56.652$ $R^2 = 0.9397$ $P < 0.001$											
Autograha gamma L.	Increasing	0.54	0.68	1.01	1.10	0.95	1.01	0.99	1.12	1.07		1.25	
Silver Y		$y = 0.0185x^3 - 0.6695x^2 + 8.0473x - 31.14$ $R^2 = 0.8748$ $P < 0.001$											
Autographa pulchrina Haw.	Increasing	0.35		0.71	0.94	1.07	1.12	1.10		1.15			
Beautiful Golden Y		$y = -0.097x^2 + 2.3747x - 13.346$ $R^2 = 0.9773$ $P < 0.001$											
Tephrina arenacearia Den. et Schiff.	Increasing	0.23		0.79	0.85	0.86	0.96	1.05	1.29	1.39			1.77
Lucerne Moth		$y = 0.2526x - 1.9103$ $R^2 = 0.942$ $P < 0.001$											

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