POSTER 21

Impact of Temperature Change on the Voltinism of *Cnaphalocrocis medinalis* Guenée (Lepidoptera: Pyralidae) and *Naranga aenescens* Moore (Lepidoptera: Noctuidae)

J. J. Ahn*, K. S. Choi, and S. W. Kho

Reserach Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, RDA, Jeju, Ayeonno 281, Korea

I. Introduction

Climate change can affect population dynamics of insects in natural and agricultural systems. Temperature is one of important abiotic factors that influence development, survival, growth, movement and reproduction of insects. The change of surface temperature would cause to increase the number of generations (i.e. voltinism) per year for multivoltine insect species. The voltinism was determined by using the biological parameters (i.e. estimated lower developmental threshold and thermal constant of each species using linear regression) and climate data.

The rice leaf folder, *Cnaphalocrocis medinalis*, is one of insect pests of rice paddy field in Africa, Asia, Australia and Oceania. *C. medinalis* was a minor pest before the spread of high-yielding varieties of rice. Thereafter, it caused serious damage to rice growth and yield and sporadic resurgence of *C. medinalis* have occurred within the rice cropping area. The occurrence of *C. medinalis* have been highly variable by location and by year (Park *et al.*, 2010). It may considered that *C. medinalis* migrate from China to Korea and Japan using jet streams as the rice planthopper, *Nilaparvata lugens* Stål.

The rice green caterpillar *Naranga aenescens* Moore (Lepidoptera Noctuidae) is also an important insect pest of Poaceae including rice and corn, and has been distributed in Eastern and Middle East Asia (Fazeli-Dinan *et al*., 2012). The adults are active at night and inactive during the daytime. *N. aenescens* larvae scrape and feed on the leaf blades and edges of rice, resulting in the loss of rice yield. *N. aenescens* has three or four generations in a year, depending on local temperature conditions (Cho *et al*., 2014).

The phenology of multivoltine insects can be influenced by ambient temperatures. It will be possible that increasing temperature permits more rapid developmental rates of insects, with the consequence that multivoltine insects may be capable of increasing the number generations per year. We used the lower developmental threshold and thermal constant of *C. medinalis* and *N. aenescens* to examine the impact of temperature change on their voltinism.

* Correspondence to : j2ahn33@korea.kr

II. Materials and Methods

To estimate the voltinism of *C. medinalis* and *N. aenescens*, the climate data were obtained from the web site of the Korea Meterological Administration (www.kma.go.kr) from 1973 to 2015 at 60 locations in Korea, respectively. The lower developmental threshold and thermal constant for *C. medinalis* and *N. aenescens* from egg to adult emergence were 12.302 and 12.018°C, and 408.163 and 330.842DD (Degree-Days), respectively (Park *et al*., 2014, 2015). Degree-days were estimated by using simple cutoff method and cumulating degree-days (CDD) were calculated by summing estimated degree-days. The voltinism of each species was estimated by dividing CDD per specific period by the thermal constant requirement of each species from egg to adult emergence. The voltinism of *C. medinalis* was calculated based on the arrival time from China to Korea. We assumed that they arrived in Korea on June 1 every year. The local coordinates were adjusted by gTrans Ver 3.9 using 7 parameters. The maps were described by ArcGIS10. The interpolation of data was presented by IDW (Inverse Distantance Weighted) in ArcGIS10.

III. Results

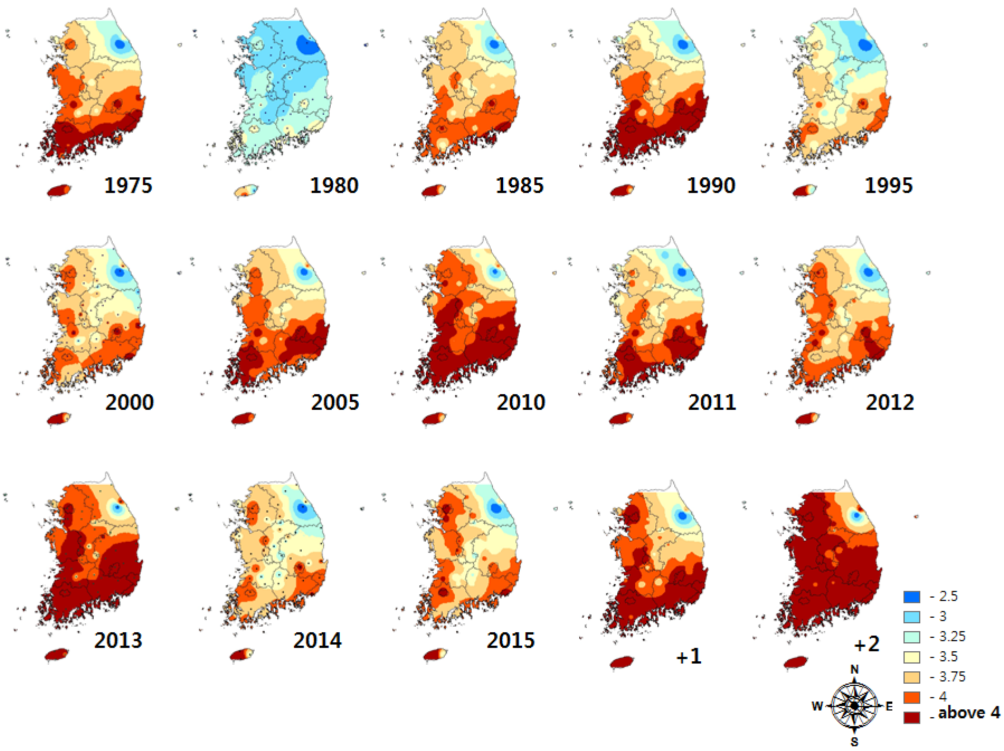

Fig. 1. Estimated the number of generation of *Cnaphalocrocis medinalis* using the lower developmental threshold and thermal constant from egg to adult emergence in each location. The “+1” means that the temperature is risen 1°C compared to the average temperature from 1980 to 2010. The “+2” means that the temperature is risen 2°C compared to the average temperature from 1980 to 2010.

Table 1. Average voltinism of *Cnaphalocrocis medinalis* per month from 1973 to 2015 using the lower developmental threshold and thermal constant from egg to adult emergence in each location

Locations	June	July	Aug.	Sep.	Oct.	Locations	June	July	Aug.	Sep.	Oct.
Boeun	0.65	0.92	0.94	0.52	0.12	Jecheon	0.64	0.89	0.92	0.50	0.10
Boryoung	0.65	0.95	1.02	0.64	0.24	Jejusi	0.68	1.04	1.11	0.78	0.44
Buan	0.70	1.01	1.05	0.65	0.23	Jeongeup	0.75	1.04	1.07	0.68	0.26
Busan	0.64	0.93	1.06	0.77	0.44	Jeonju	0.77	1.06	1.10	0.71	0.27
Buyeo	0.74	1.01	1.04	0.64	0.20	Jinju	0.72	1.00	1.06	0.69	0.27
Cheonan	0.71	0.98	1.01	0.60	0.18	Milyang	0.74	1.02	1.06	0.69	0.27
Cheongju	0.76	1.03	1.05	0.64	0.20	Mogpo	0.69	0.98	1.09	0.76	0.38
Chuncheon	0.72	0.96	0.98	0.56	0.15	Munkyoung	0.69	0.93	0.96	0.57	0.17
Chungju	0.73	0.98	1.00	0.59	0.16	Namhae	0.70	1.00	1.07	0.73	0.36
Chupungryoung	0.66	0.92	0.94	0.54	0.16	Namwon	0.73	1.00	1.04	0.65	0.20
Daegu	0.80	1.07	1.11	0.71	0.30	Pohang	0.68	0.99	1.04	0.69	0.34
Daegwanryoung	0.29	0.57	0.56	0.19	0.02	Sancheong	0.71	0.98	1.02	0.64	0.23
Daejeon	0.75	1.01	1.04	0.65	0.22	Seoguipo	0.69	1.02	1.13	0.86	0.54
Ganghwa	0.62	0.89	0.95	0.57	0.16	Seongsan	0.50	0.87	0.96	0.66	0.29
Gangreung	0.63	0.92	0.96	0.59	0.27	Seosan	0.67	0.95	1.00	0.62	0.20
Geochang	0.65	0.94	0.96	0.56	0.15	Seoul	0.75	0.98	1.04	0.67	0.25
Geoje	0.65	0.96	1.04	0.71	0.34	Sogcho	0.52	0.83	0.89	0.56	0.23
Geumsan	0.69	0.97	0.99	0.58	0.16	Suwoen	0.71	0.98	1.03	0.63	0.20
Goheung	0.67	0.98	1.05	0.70	0.30	Tongyoung	0.65	0.94	1.06	0.77	0.41
Gumi	0.74	1.00	1.02	0.62	0.20	Uiseong	0.68	0.97	1.00	0.58	0.15
Gunsan	0.69	0.99	1.05	0.69	0.27	Uljin	0.52	0.83	0.89	0.56	0.24
Gwangju	0.76	1.04	1.10	0.73	0.31	Ulreungdo	0.50	0.79	0.89	0.58	0.27
Haenam	0.69	0.99	1.05	0.69	0.27	Ulsan	0.68	0.99	1.06	0.70	0.33
Hapcheon	0.74	1.01	1.04	0.66	0.25	Wando	0.64	0.94	1.04	0.75	0.38
Hongcheon	0.70	0.96	0.98	0.56	0.14	Wonju	0.72	0.98	1.00	0.58	0.15
Icheon	0.71	0.97	0.99	0.58	0.16	Yangpyeong	0.72	0.98	1.00	0.59	0.16
Imsil	0.64	0.93	0.95	0.55	0.14	Yeosu	0.66	0.94	1.05	0.76	0.40
Incheon	0.65	0.92	1.01	0.66	0.25	Youngcheon	0.69	0.98	1.01	0.61	0.20
Inje	0.61	0.87	0.89	0.49	0.11	Youngdeok	0.60	0.91	0.96	0.59	0.24
Jangheung	0.67	0.98	1.04	0.68	0.26	Youngju	0.66	0.92	0.95	0.54	0.14

After arriving in Korea, *C. medinalis* survived more than three generations except Daegwanryoung. The number of generations varied depending on the season and locations. The average voltinism from 1973 to 2015 was highest at Seoguipo, and was followed by Jejusi, Daegu, Gwangju and Jeonju (Table 1 and Fig. 1). The number of generations varied depending on the season, with the lowest in February and the highest in August at each location in the case of *N. aenescens*. At least one generation per month would be possible from July to August. The average voltinism from 1973 to 2015 was highest at Seoguipo, and was followed by Jejusi, Daegu, Gwangju and Busan. The average voltinism from 1973 to 2015 was lowest at Daegwanryoung (Table 2 and Fig. 2).

Table 2. Average voltinism of *Naranga aenescens* per month from 1973 to 2015 using the lower developmental threshold and thermal constant from egg to adult emergence in each location

Locations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Boeun	0.00	0.00	0.00	0.09	0.42	0.82	1.16	1.19	0.67	0.17	0.01	0.00
Boryoung	0.00	0.00	0.00	0.09	0.42	0.83	1.20	1.28	0.82	0.31	0.03	0.00
Buan	0.00	0.00	0.00	0.11	0.48	0.88	1.28	1.32	0.83	0.30	0.03	0.00
Busan	0.00	0.00	0.02	0.20	0.55	0.82	1.18	1.34	0.97	0.57	0.14	0.01
Buyeo	0.00	0.00	0.01	0.13	0.53	0.94	1.27	1.31	0.82	0.27	0.02	0.00
Cheonan	0.00	0.00	0.00	0.12	0.51	0.90	1.24	1.27	0.77	0.24	0.02	0.00
Cheongju	0.00	0.00	0.01	0.16	0.59	0.97	1.29	1.32	0.82	0.27	0.02	0.00
Chuncheon	0.00	0.00	0.00	0.11	0.51	0.91	1.21	1.23	0.72	0.20	0.01	0.00
Chungju	0.00	0.00	0.00	0.12	0.51	0.92	1.24	1.27	0.76	0.22	0.01	0.00
Chupungryoung	0.00	0.00	0.00	0.12	0.48	0.84	1.16	1.19	0.70	0.21	0.01	0.00
Daegu	0.00	0.00	0.02	0.24	0.68	1.01	1.34	1.39	0.90	0.40	0.05	0.00
Daegwanryoung	0.00	0.00	0.00	0.02	0.14	0.38	0.72	0.72	0.25	0.02	0.00	0.00
Daejeon	0.00	0.00	0.01	0.17	0.57	0.95	1.28	1.31	0.83	0.29	0.02	0.00
Ganghwa	0.00	0.00	0.00	0.07	0.38	0.79	1.13	1.20	0.73	0.22	0.01	0.00
Gangreung	0.00	0.00	0.02	0.18	0.54	0.81	1.17	1.21	0.76	0.36	0.05	0.00
Geochang	0.00	0.00	0.00	0.11	0.46	0.83	1.18	1.21	0.72	0.21	0.01	0.00
Geoje	0.00	0.00	0.01	0.16	0.52	0.83	1.21	1.32	0.90	0.44	0.07	0.00
Geumsan	0.00	0.00	0.00	0.11	0.47	0.88	1.23	1.25	0.74	0.22	0.02	0.00
Goheung	0.00	0.00	0.01	0.14	0.51	0.86	1.24	1.32	0.89	0.39	0.05	0.00
Gumi	0.00	0.00	0.01	0.16	0.56	0.94	1.26	1.29	0.79	0.27	0.02	0.00
Gunsan	0.00	0.00	0.00	0.11	0.48	0.88	1.25	1.32	0.87	0.35	0.04	0.00
Gwangju	0.00	0.00	0.01	0.20	0.61	0.97	1.31	1.38	0.93	0.41	0.05	0.00
Haenam	0.00	0.00	0.01	0.12	0.50	0.88	1.25	1.32	0.88	0.36	0.05	0.00
Hapcheon	0.00	0.00	0.01	0.17	0.57	0.94	1.28	1.32	0.84	0.33	0.03	0.00
Hongcheon	0.00	0.00	0.00	0.10	0.46	0.89	1.21	1.23	0.72	0.19	0.01	0.00
Icheon	0.00	0.00	0.00	0.12	0.51	0.90	1.22	1.25	0.74	0.21	0.01	0.00
Imsil	0.00	0.00	0.00	0.08	0.40	0.82	1.17	1.20	0.71	0.19	0.01	0.00
Incheon	0.00	0.00	0.00	0.10	0.45	0.83	1.16	1.27	0.84	0.34	0.03	0.00
Inje	0.00	0.00	0.00	0.08	0.40	0.78	1.10	1.12	0.63	0.16	0.01	0.00
Jangheung	0.00	0.00	0.01	0.11	0.49	0.87	1.24	1.31	0.86	0.34	0.04	0.00
Jecheon	0.00	0.00	0.00	0.07	0.39	0.81	1.13	1.16	0.64	0.14	0.01	0.00
Jejusi	0.00	0.01	0.03	0.20	0.54	0.86	1.31	1.39	0.99	0.57	0.16	0.01
Jeongeup	0.00	0.00	0.01	0.16	0.56	0.94	1.31	1.35	0.87	0.35	0.04	0.00
Jeonju	0.00	0.00	0.01	0.19	0.61	0.98	1.34	1.38	0.90	0.36	0.04	0.00
Jinju	0.00	0.00	0.01	0.16	0.55	0.91	1.27	1.33	0.88	0.35	0.04	0.00
Milyang	0.00	0.00	0.01	0.16	0.56	0.93	1.29	1.34	0.87	0.35	0.04	0.00
Mogpo	0.00	0.00	0.01	0.15	0.54	0.88	1.24	1.37	0.97	0.49	0.08	0.00
Munkyoung	0.00	0.00	0.01	0.14	0.51	0.87	1.18	1.22	0.72	0.22	0.01	0.00
Namhae	0.00	0.00	0.01	0.19	0.57	0.89	1.26	1.35	0.93	0.46	0.07	0.00
Namwon	0.00	0.00	0.01	0.13	0.52	0.93	1.26	1.31	0.82	0.27	0.02	0.00
Pohang	0.00	0.00	0.02	0.21	0.59	0.87	1.25	1.32	0.88	0.44	0.08	0.00
Sancheong	0.00	0.00	0.01	0.16	0.54	0.90	1.24	1.29	0.82	0.31	0.03	0.00
Seoguipo	0.01	0.01	0.05	0.25	0.60	0.85	1.26	1.40	1.06	0.67	0.23	0.03
Seongsan	0.00	0.00	0.01	0.07	0.31	0.65	1.10	1.21	0.84	0.39	0.08	0.00
Seosan	0.00	0.00	0.00	0.09	0.44	0.85	1.19	1.26	0.79	0.27	0.02	0.00

Table 2. (continued)

Locations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Seoul	0.00	0.00	0.01	0.16	0.57	0.95	1.24	1.31	0.85	0.33	0.03	0.00
Sogcho	0.00	0.00	0.01	0.11	0.41	0.67	1.05	1.12	0.71	0.31	0.04	0.00
Suwoen	0.00	0.00	0.00	0.11	0.49	0.90	1.23	1.29	0.81	0.26	0.02	0.00
Tongyoung	0.00	0.00	0.01	0.17	0.53	0.83	1.18	1.33	0.97	0.54	0.11	0.00
Uiseong	0.00	0.00	0.00	0.11	0.46	0.87	1.23	1.26	0.74	0.20	0.01	0.00
Uljin	0.00	0.00	0.01	0.13	0.40	0.66	1.05	1.13	0.72	0.32	0.04	0.00
Ulreungdo	0.00	0.00	0.00	0.08	0.36	0.64	1.00	1.13	0.74	0.36	0.06	0.00
Ulsan	0.00	0.00	0.02	0.18	0.56	0.87	1.25	1.34	0.88	0.43	0.07	0.00
Wando	0.00	0.00	0.01	0.14	0.50	0.82	1.19	1.32	0.95	0.49	0.09	0.00
Wonju	0.00	0.00	0.00	0.13	0.51	0.92	1.23	1.26	0.74	0.21	0.01	0.00
Yangpyeong	0.00	0.00	0.00	0.11	0.50	0.92	1.23	1.26	0.75	0.22	0.01	0.00
Yeosu	0.00	0.00	0.01	0.17	0.55	0.84	1.18	1.32	0.96	0.52	0.10	0.00
Youngcheon	0.00	0.00	0.01	0.14	0.51	0.88	1.24	1.27	0.78	0.27	0.02	0.00
Youngdeok	0.00	0.00	0.01	0.14	0.46	0.77	1.15	1.21	0.75	0.32	0.04	0.00
Youngju	0.00	0.00	0.00	0.10	0.46	0.85	1.16	1.20	0.69	0.19	0.01	0.00

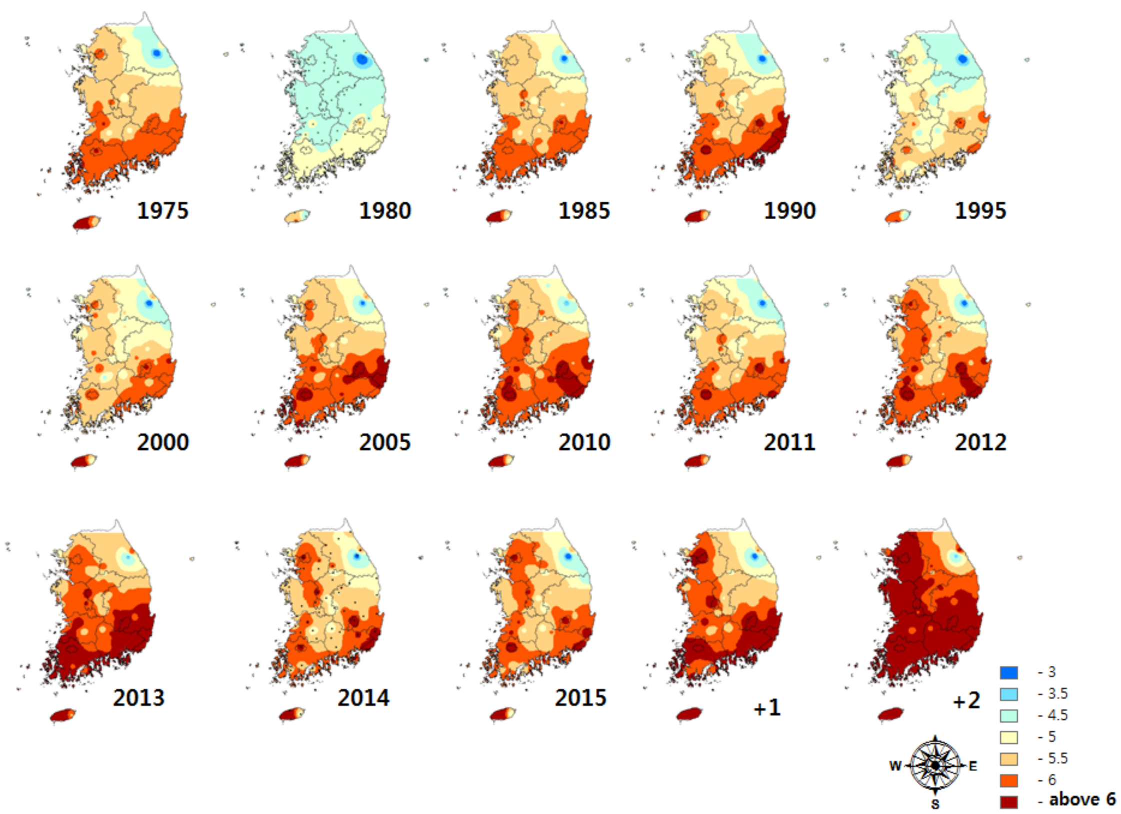

Fig. 2. Estimated the number of generation of *Naranga aenescens* using the lower developmental threshold and thermal constant from egg to adult emergence in each location. The "+1" means that the temperature is risen 1°C compared to the average temperature from 1980 to 2010. The "+2" means that the temperature is risen 2°C compared to the average temperature from 1980 to 2010.

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