Plant Protection Service
Ministry of Agriculture, Nature and Food Quality

Pest Risk Assessment Apriona *spp.*

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Pest Risk Assessment *Apriona spp.*

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Pest Risk Assessment Apriona species (A.germari, A.japonica & A.cinerea)

1. Reason for PRA

In 2008 and 2009 the NPPO of the Netherlands intercepted *Apriona* species three times. *Apriona germari* larvae were detected in wood packaging material from China. One *Apriona japonica* larva was detected in a consignment of *Enkianthus* (*Ericaceae*) from Japan.
The present PRA focuses mainly on the probability of establishment of *Apriona spp.* in the Netherlands.

2. Scientific names and taxonomy

There are 35 species described within the genus *Apriona* (see Appendix 1). The published information available on the ecology of *Apriona* species is limited. In this PRA, *A.germari, A.japonica* and*, A.cinerea* are considered, because they are reported to be the main *Apriona* species damaging trees in areas of origin (Esaki, 1995; Huang, 1996; Singh & Prasad, 1985). Also *A.germari* and *A.japonica* were intercepted in The Netherlands.

Class:	*Insecta*
Order:	*Coleoptera*
Family:	*Cerambycidae*
Subfamily:	*Lamiinae*
Tribe:	*Batocerini*
Genus:	*Apriona*
Species:	*germari* (Hope, 1831)
	japonica (Thomson, 1878)
	cinerea (Chevrolat, 1852)

<u>Common names and synonyms:</u>

Apriona germari: Brown Mulberry Longhorn (Duffy, 1968), Longhorn Stem Borer (Parc,2010), Jackfruit longhorn Beetle (Hill, 1983), Mulberry Longicorn Beetle (Yoon et *al*., 1997). Synonyms: *Apriona germarii*, *Apriona rugicollis* (CPC, 2008), *Lamia germari*, *Apriona plicicollis*, *Apriona deyrollei*, *Apriona cribata* (Huang et *al*., 2009).
Apriona japonica: Mulberry borer (Ohashi, 2005; Yamashita et *al*., 1999), Mulberry Longicorn Beetle (Esaki, 2001).
Apriona cinerea: Apple stem borer (Hill, 2008), Poplar Stem Borer (Singh & Verma, 1998), Apple tree borer (CBS, 2010).

3. PRA-area

The Netherlands.

4. Host plant range (Worldwide)

Apriona species are polyphagous and attack many plant species in their areas of origin, including species that are common and important in European forest, public green areas, and fruit tree plantations. The three species considered in this PRA have hosts in 62 different plant species, mostly trees, from the Moraceae, Salicaceae, Rosaceae and Fagaceae families. Detailed records of the host plant range can be found in Appendix 2.

5. Host plant range (NL)

In the PRA area, several host plants of *Apriona* spp. are present:

- Fruit crops: orchards of the fruit trees of *Pyrus* spp. (7.476 ha) and *Malus* spp. (9.302 ha) (CBS, 2010). Public green areas and forest plantations: *Fagus* sp., *Populus* sp., and *Salix* sp. are common trees in forests, public green and private areas. *Malus* is also present but less common.
- Nursery stocks: In 2008, 2.889 ha were occupied by forest plants and plant for hedges, 4.445 ha were occupied by ornamental trees, and 1.326 ha by nursery fruit trees (AIHP/UnionFleurs, 2009).
- Protected crops: In 2008, The Netherlands had 405 ha greenhouses for nursery stocks and hardy perennial plants (AIHP/unionFleurs, 2009).

The most important tree species attacked by the three species considered in this PRA are:
A. germari: *Morus* spp., *Populus* spp., *Pyrus* spp. and *Salix* spp.
A. japonica: *Celtis* spp., *Enkianthus* spp., *Fagus* spp., *Robinia* spp., and *Zelkova* spp.
A. cinerea: *Morus* spp., *Populus* spp., and *Pyrus* spp

6. What is the current area of distribution of the pest?

Apriona species are only present in Asia (see Appendix 3 for detailed records):

A. germari: Burma, China, Japan, Korea, Indochina (Vietnam, Laos and Cambodia), Malaysia, West Pakistan, North India, Taiwan, Thailand (Duffy, 1968), and Nepal (Huang et *al*., 2009). In China is found in the provinces Shangai (Qin et *al*., 1997), Liaoning, Hebei, Shandong, Shanxi, Shaanxi, Gansu, Jiangsu, Zhejiang, Hunan, Hubei, Anhui, Jiangxi, Fujian, Taiwan, Hainan, Guangdong, Guangxi, Guizhou, Sichuan, Yunnan, Xizang, Henan (Huang et *al*., 2009), and possibly in Heilongjiang (Li, 1996).

A. japonica: Japan in provinces Ishikawa (Esaki & Higuchi, 2006), Ibiraki (Yamanobe & Hosoda, 2002), Nagasaki (Yokomizo & Morita, 1980) and Nagano (Koyama & Okada, 2004)

A. cinerea: India in provinces Jammu and Kaschmir, Himachal Pradesh, Kumaon, Garhwal, Dehra Dun, Saharapur and Haladwani (Uttar Pradesh) (Bathia et *al*., 2007; Singh & Prasad, 1985), and in Pakistan in provinces Rawalpindi, Peshawar and Parachinar (Singh & Prasad, 1985)

7. Does it occur in the Netherlands?

No, pest status for the specified *Apriona* species is: absent, intercepted only.

8. Probability of entry

Apriona spp. can enter the Netherlands by:

1. Import of infested plants for planting from areas where the pest is present (China, Japan or India). In 2009 the NPPO of NL intercepted one larva of *Apriona japonica* on an *Enkianthus* tree imported from Japan.
2. In wood packaging material of the host plants (*Ficus*, *Morus*, *Populus*, *Salix*, *Malus*, *Pyrus*, etc.), infested with larvae.
   Apriona sp. 2 x intercepted in 2000 in Austria, originating from China (EPPO Reporting Service) and 2 x *Apriona* sp. intercepted by USDA between 1985 and 2000 (Haack, 2006); *Apriona* sp. (1x) and *Apriona germari* (1x) were intercepted in the Hamburg's harbour between 1991 and 2004 (Müller-Sanmann, 2004). In the Netherlands, one larvae (2008) and one adult (2009) were intercepted in wood packaging material from China.

A detailed pathway-analysis is not part of this short PRA.

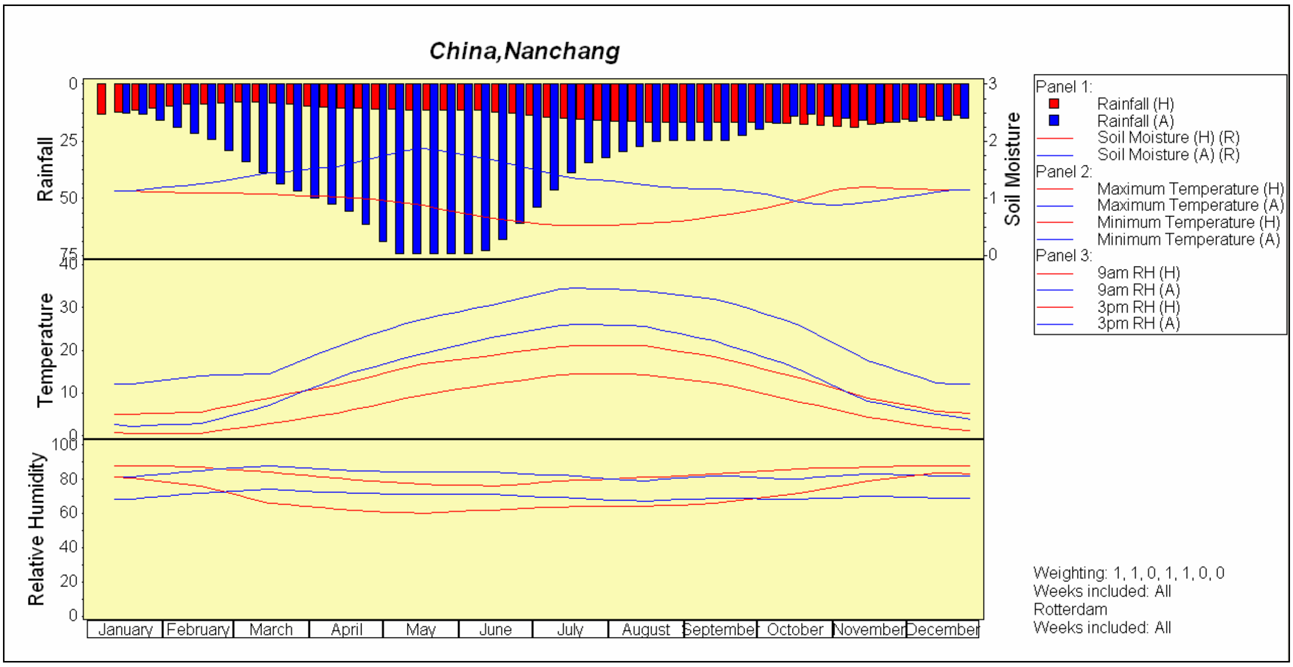
9. Probability of establishment

(a) Outdoors -

For a prediction of the length of the life cycle, and consequently the probability of establishment of *Apriona* species under the climatic conditions in the Netherlands, ideally information on the minimum development threshold and development time (egg-larva-pupa-adult) at different temperatures should be available. The biology aspects found in the literature about the *Apriona* spp. can be found in Appendix 4.

Apriona germari:
Data on field populations of *A. germari* show that the length of the life cycle in China varies between 1-3 years (see Appendix 5). The generation time of *A. germari* is 1 year in the relative warm area of Guangdong (Chen et *al*., 1959) and 2-3 years in the relative cooler area of Shandong (Yang et *al*., 2005). To predict the establishment probability and expected duration of the life cycle of *A. germari* in the Netherlands, three methods are used: (1) a comparison of local climate data, (2) a comparison with *Anoplophora chinensis*, another exotic wood borer, and (3) a climex model with the available biological data.

Comparison of climate data
In Nanchang (China) the life cycle of *A. germari* is reported to be 2 years (Shui et *al*., 2009). A comparison of the climatological data of Nanchang with Rotterdam (Climex version 3) shows that the average summer temperatures are 2 times higher in Nanchang compared to Rotterdam (see CLIMEX chart below (H: Home (Rotterdam), A: Abroad (Nangchang)). Therefore, the development time is roughly expected to be at least 2 times longer in Rotterdam, which corresponds to an expected development time of at least 4 years. This assumption is based on the fact that, the heat accumulation necessary for insect development, is twice as fast in Nanchang compared to Rotterdam.



Comparison with *Anoplophera chinensis*
The exotic wood borer *A. chinensis* has a life cycle of at least 3 years in the Netherlands (Van der Gaag et al., 2008). To compare the life cycle durations of *A. chinensis* and *A. germari* experimental data from laboratory experiments can be used.
Yoon et al. (1999) reported that the development time (egg to pupa) for *A. germari* was 270 days at a constant temperature of 25 ºC. In comparison with data for *A.chinensis*, a development time of 270 days seems very long. Adachi (1994) found that the development time (egg to pupa) of *A. chinensis* was 96 days at 25 ºC. However, these data were obtained for *A. chinensis* with a 1 year cycle. Adachi (1994) found that the development time for *A. chinensis* with a 2-year cycle was about twice as long as for *A. chinensis* with a 1-year cycle. This would indicate that the development time under laboratory conditions, for *A. chinensis* with a 2-year cycle, would have been 192 days at 25 ºC. Thus, *A. germari* develops 1,4 times slower compared to *A. chinensis.* This would indicate that the expected development time for *A. germari* is 4-5 years in the Netherlands (1,4x3-4).

Climex modelling
To predict the probability of establishment of *A. germari* in the Netherlands and other parts of the EU, a climex model was built. There is a limited availability of biological data for *A. germari* (see Appendix 4). The following biological data were used to set the parameters in the climex model:

Development times, measured at 25 °C by Yoon *et al.*(1999):
Egg to pupa: 270 days
Pupa: 19 days
Gravid female: 10 days

Total: 299 days (egg to ovipositing female)

Developmental temperature thresholds for *A. germari* could not be retrieved form the literature. An estimation was made with data available for *A. japonica*. For *A. japonica* Kitajima et *al*. (1997) reported that larvae stopped molting at 15 °C and that eggs did not hatch at 1o °C. As a conservative estimate the developmental threshold was set at 12 °C.
With a developmental threshold of 12 °C, the required Degree Days for development from egg to ovipositing female can be estimated: 299 days x (25-12 °C)= 3887 DD.
A literature review was conducted to assemble data on the geographical distribution of *A. germari* in South East Asia (see Appendix 3). Using these data, a graphical template was constructed, indicating the known distribution of *A. germari* in China . This template was used in Climex. The model parameters (e.g. cold stress) were adjusted in such a way that there was a good matching with the known distribution of *A. germari* in South East Asia (see appendix 8). Climex calculates the Ecoclimatic Index (EI), which gives an overall measure of the potential of a given location to support a permanent population. Because EI is calculated on an annual basis, the total required Degree Days was divided by *n* to visualize the EI for populations with a life cycle of *n* years.
The calculated generation times per year gave a good match with literature data (see figure), indicating that the Climex model produced good predictions (see appendix 9).
Running the model for the EU region shows that *A. germari* with a life cycle of 1-3 years can only establish in the Mediterranean region. According to this Climex model, the expected life cycle of *A. germari* in NL is estimated to be 5 years (see appendix 10&11).
To predict the situation in the Netherlands under climate change scenarios, the Climex model was run with two different scenarios. The results indicate that populations of *Apriona* spp. with a 3 year life cycle would be able to establish in the PRA area with a 2°C climate change scenario (see appendix 12).

Apriona japonica:
Data on field populations of *A. japonica* in Japan (see Appendix 6) show that the length of the life cycle varies between 2-3 years (Esaki, 2006). The average temperature in Tokyo is 1,4 times warmer compared to Rotterdam. Therefore, the development time is expected to be at least 1,4 times longer in Rotterdam, which corresponds to an expected development time of 3-4 years.
In laboratory experiments, Esaki 2001 found that the development time (hatched larvae to pupa) for *A. japonica* was 36 weeks (252 days) at a constant temperature of 25 ºC. Kitajima et *al*., 1997 reported that eggs at 25ºC hatched at 13 days on average. Thus, the development time at 25ºC for egg to pupa is 265 days for *A. japonica*, which is comparable to *A. germari* (270 days). This would indicate that, like in the case of *Apriona germari* above mentioned, the expected development time for *A. japonica* is 4-5 years in the Netherlands.

Apriona cinerea:
Data on field populations of *A. cinerea* in Pakistan show that the length of the life cycle is around 2 years (see table 5). The average temperature in Peshawar is 2,5 times warmer compared to Rotterdam. Therefore, the development time is expected to be 2,5 times longer in Rotterdam, which corresponds to an expected development time of 5 years.
There is no information available on the developmental threshold for *Apriona cinerea,* and therefore it is not possible to calculate the required Degree Days for successful development.

For all three species of *Apriona* it is uncertain if the temperature conditions in the summer months in NL are favourable for mating and ovipostion.

(b) In protected cultivation –

Climate conditions in glasshouses, where temperatures usually do not drop below 10°C and are usually around 20°C, are probably favourable for establishment. Suitable host plants are grown in Dutch commercial glasshouses on a limited scale (probably less than 20 ha). *Apriona* spp. are not known as a pest of glasshouse crops. Given the long generation time it is not to be expected that sustainable populations in glasshouse will occur.

Conclusion: Probability of establishment Low, Level of uncertainly Medium.

10. How likely is the pest to spread? (*naturally and by human assistance*)

Natural dispersal: Moderate likely
There is not much information available on natural dispersal (i.e. distances that can be flown by female) for *Apriona* spp. Given the similar biology of *Apriona spp.* with *Anoplophora spp*., the dispersal behaviour may be similar to *A. glabripennis* (which is about 1 cm smaller). *A. glabripennis* beetles usually stay near the place from which they emerged (within 400 m), but are probably capable of flying more than 2 km during one season (Dumouchel, 2004; Hérard et al., 2005; Smith et al., 2001, 2004; Sacco, 2004; Williams et al., 2004; Van der Gaag et *al*., 2008).

Human assistance: Moderately likely
Plants for planting and wood packaging material can be infested with larvae of *Apriona* spp. and import of these plants and materials may lead to the introduction and spread of the species, similar to *Anoplophora* spp.
The pest may be spread over larger distances by movement of infested plant material between glasshouse production sites in the Netherlands, and by introduction and movement of wood packaging material of the host plants (*Ficus*, *Morus*, *Salix*, *Malus*, *Pyrus*, etc.) infested with larvae (as shown by the interception in the Netherlands).

Conclusion: Probability of spread moderate. Level of uncertainly high.

11. What is the potential damage when the pest would become introduced?
(*without the use of control measures*)

a. Impact in its current area of distribution

Apriona spp. are mentioned in many reports as stemboring pests, but quantitative information about the damage and economic impact is generally lacking.

A. japonica

- Esaki (1995) reported that *A.japonica* is an important pest of mulberry (*Morus* sp.) trees and many broadleaved trees in Japan. Injuries caused by *A. japonica* occurred in a young plantation of *Zelkova serrata*, and approximately 3% of the trees were damaged by the borer.
- Esaki & Higuchi (2006) reported that *Apriona japonica* was found to be damaging a mixed forest of *Robinia pseudoacacia* and *Celtis sinensis*. No damage level mentioned.
- Yamanobe & Hosoda (2002) reported that all of 35 five-year-old beech (*Fagus crenata*) saplings planted in a lowland in a northern part of Ibaraki Prefecture (Japan) were damaged by the longicorn beetle *A. japonica*.

A. germari

- Hussain et *al*. (2007) reported that *A. germari* is a major pest of mulberry plants in North India (Jammu and Kashmir).
- Huang (1996) *in* Shui et *al*. (2009) reported that damage caused by larvae of *Apriona germari* has resulted in serious economic losses in China. Shui et *al*. 2009 reported that *A. japonica* cause serious damage to trees and are difficult to control.
- Li Kezheng (1996) reported that *A. germari* is one of the main poplar stem-boring pests in North Forest in China.
- Qin et *al*. (1997) reported that *Apriona germari* was observed to be an important pest of *Ficus carica* in Shangai, China, with up to 89% of plants being damaged.

A. cinerea

- Singh & Prasad (1985) reported that *A. cinerea* is one of the pest which is a permanent threat to the future of poplar cultivation in the Himalaya, its foot hills and the adjoining plains region, and the pest

has assumed great importance with the cultivation of poplars on a large scale. Pruthi & Batra (1960) *in* Singh & Prasad (1985) reported that *A. cinerea* was known as a serious pest of apple orchards.
- Bathia (2004) reported that *Apriona cinerea* has been observed to be the most destructive pest of the woodborers in poplars in Jammu forests (India).

b. Potential impact in the PRA area

Assuming that *Apriona spp*. can establish outdoors, it can attack poplars, apples, beeches, willows and other crops and plants in the natural environment and urban areas. It is expected that the potential damage will be lower in the PRA area than in its current area of distribution because:
- *Apriona* spp. may need at least 4-5 years to complete one generation in the Netherlands (see question 9), and it is uncertain if summer conditions are favourable for mating and egg laying.
- It is uncertain if sustainable populations are able to establish in the PRA area. Given the climatic conditions, population levels are expected to be very low and hence also expected damage.

Conclusion: Level of Impact Low, Level of uncertainly: Medium

12. Which control measures are available?

In the literature, the following control measures in the current area of distribution are reported:
Chemical control:
- Yang et *al*. (2005) reported that spraying a 200x dilution of a 8% cypermethrin micro capsule solution on the trunk and large branches at the adult stage, and once again after 20 days could give good control of *Apriona germari*.
- In trials in China, larvae of *Apriona germari* in poplar trees (*Populus*) were controlled by injection of triazophos and omethoate or deltamethrin into the worm holes. These treatments achieved >90% control (Pan, 1999).
- Esaki (2007)reported that spraying fenitrotion should be effective in the management of *A. japonica* adults and that spraying of 0.44% fenitrotion twice at a 3 week interval can kill nearly 100% adults over a period of nine weeks.
- Shui et *al*. (2009) reported that inserting zinc phosphide sticks into the first hole of the tunnel from the bottom of the tree, is a feasible method to control *A. germari* larvae in triploid *Populus tomentosa* of pulpwood trees.
- Singh & Prasad (1985) reported that pruning of affected branches in September-October in poplars and fumigation with paradichlorobenzene or other fumigants successfully controls *A. cinerea* populations. Also, general purpose persistent insecticide, lindane, can be used for killing adults. Soil applications of Fudaran can protect nursery plants from the borer attack. Collateral host should be removed from the vicinity of poplar plantations.

Biological control, natural enemies, cultural practices:
- *Aprostocetus fukutai*, is an important natural enemy of *A. germari.* Rate of egg parasitism reached 50% in studies on the biology, ecology, conservation and utilization of the parasite carried out in 1988-1994 (Yan et *al*., 1996).
- Esaki & Higuchi (2006) reported that application of fungus-containing sheets (with *Beauveria brongniartii*) on trees where the adults congregated for feeding can kill *A. japonica* adults effectively.
- Esaki (2006) reported that *A. japonica* adults prefer to oviposit on host branches and stems covered with weeds and removing weeds deters *A. japonica* from ovipositing on exposed host tree parts.

The insecticides mentioned in the above reports are not registered for use in the semi-natural environment in NL. Therefore, chemical control is expected to be difficult. The mentioned biological control agents are not present or registered in the Netherlands.

13. What is the expected damage when the pest would become introduced?

(*with the use of available control measures; indicate efficacy of available pesticides and non-chemical methods; also discuss the availability of control measures in the future taking into account the possibility of resistance development against pesticides and possible withdrawal of pesticides*)

In general, the expected damage and impact is very low to low, because the organism has a long life cycle, given the climatic conditions in the Netherlands. The probability of establishment and significant population build-up is expected to be low. Therefore, there is low expected probability for the occurrence of sustainable populations which are able to induce significant economic damage.
Because there are virtually no insecticides registered for use in the natural environment, chemical control is expected to be difficult . However, damage is expected to be incidental and local. Control is probably not necessary.
Climex studies indicate that the expected life cycle duration in the Netherlands will be 4-5 years, compared to 2-3 years in its area of origin (see point 9). It should be noted that the same climex models indicate that in the Mediterranean region *A. germari* is expected to have the same life cycle as in its area of origin. Therefore, in contrast to the situation in NL, the expected damage and impact of *Apriona spp*. could be significant in the Mediterranean region.

14. Conclusion

Apriona spp. have a similar biology as Anoplophora species. Interceptions in the Netherlands on plants for planting (A. germari) and wood packaging material show that pathways exist. Apriona spp. are considered a pest with a low phytosanitary risk in the Netherlands for the following reasons:

- The climatic conditions in the Netherlands are less favourable for the pest than in its present area of distribution and, like in the case for A. chinensis, the climatic conditions will slow down the development and population build up.
- There is a low probability for the occurrence of sustainable populations which are able to induce significant economic damage. Damage is expected to be incidental and local.

Climex studies indicate that, in contrast to the situation in NL, Apriona spp. can establish permanently in the Mediterranean region.

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APPENDICES:

Appendix 1: Known *Apriona* spp.

	SPECIES	REFERENCE
1	*Apriona ammiralis* (Breuning, 1935)	http://www.eol.org/pages/10215
2	*Apriona aphetor* (Newman, 1842)	http://www.cerambycoidea.com/specie.asp?Id=32&Tipo=T
3	*Apriona bicolor* (Kriesche, 1919)	(Huang et *al*., 2009)
4	*Apriona buruensis* (Ritsema, 1898)	http://www.eol.org/pages/10215
5	*Apriona chemsaki* (Hua, 1986)	(Huang et *al*., 2009)
6	*Apriona cinerea* (Chevrolat, 1852)	(Duffy, 1968)
7	*Apriona cylindrica* (Thomson, 1857)	http://www.eol.org/pages/10215
8	*Apriona elsa* (Kriesche, 1919)	http://www.cerambycoidea.com/specie.asp?Id=32&Tipo=T
9	*Apriona flavescens* (Kaup, 1866)	(Duffy, 1968)
10	*Apriona germari* (Hope, 1831)	(Huang et *al*., 2009)
11	*Apriona gressitti* (Gilmour, 1958)	(Huang et *al*., 2009)
12	*Apriona grisescens* (Breuning, 1947)	http://www.eol.org/pages/10215
13	*Apriona hageni* (de Jong, 1936)	http://www.eol.org/pages/10215
14	*Apriona irma* (Kriesche, 1920)	http://www.eol.org/pages/10215
15	*Apriona japonica* (Thomson, 1878)	(Esaki, 2006)
16	*Apriona krieschei* (Gilmour, 1958)	http://www.eol.org/pages/10215
17	*Apriona marcusiana* (Kriesche, 1920)	http://www.cerambycoidea.com/specie.asp?Id=32&Tipo=T
18	*Apriona multigranula* (Thomson, 1878)	http://www.eol.org/pages/10215
19	*Apriona neglecta* (Ritsema, 1911)	http://www.eol.org/pages/10215
20	*Apriona neglectissima* (de Jong, 1936)	http://www.eol.org/pages/10215
21	*Apriona nobuoi* (Breuning & Ohbayashi 1966)	http://www.eol.org/pages/10215
22	*Apriona novaebritaniae* (Gilmour, 1958)	http://www.eol.org/pages/10215
23	*Apriona parvigranula* (Thomson, 1878)	(Huang et *al*., 2009)
24	*Apriona pascoei* (Gilmour, 1958)	http://www.eol.org/pages/10215
25	*Apriona paucigranula* (Thomson, 1878)	(Huang et *al*., 2009)
26	*Apriona punctatissima* (Kaup, 1866)	http://www.cerambycoidea.com/specie.asp?Id=32&Tipo=T
27	*Apriona rheinwartii* (Thomson, 1878)	http://www.eol.org/pages/10215
28	*Apriona rixator* (Newman, 1842)	http://www.cerambycoidea.com/specie.asp?Id=32&Tipo=T
29	*Apriona sublaevis* (Thomson, 1878)	http://www.eol.org/pages/10215
30	*Apriona subteruniformis* (Breuning, 1954)	http://www.eol.org/pages/10215
31	*Apriona swainsoni* (Hope, 1840)	(Huang et *al*., 2009)
32	*Apriona trilineata* (Chevrolat, 1852)	http://www.eol.org/pages/10215
33	*Apriona vagemaculata* (Breuning, 1948)	http://www.eol.org/pages/10215
34	*Apriona vivesi* (Breuning, 1981)	http://www.eol.org/pages/10215
35	*Apriona yayeyamai* (Breuning, 1976)	http://www.cerambycoidea.com/specie.asp?Id=32&Tipo=T

Appendix 2: Known Host-plants Apriona spp.

	Host plant	Family	*A. germari*	*A. japonica*	*A. cinerea*
1	*Artocarpus chaplasha*	Moraceae	X		
2	*Artocarpus heterophyllus*	Moraceae	X		
3	*Artocarpus integra*	Moraceae	X		
4	*Bombax malabaricum*	Bombacaceae	X		
5	*Broussonetia papyrifera*	Moraceae	X		
6	*Cajanus cajan*	Fabaceae	X		
7	*Camellia oleifera*	Theaceae	X		
8	*Celtis sinensis*	Ulmaceae	X	X	
9	*Cinnamomum camphora*	Lauraceae	X		
10	*Citrus aurantium*	Rutaceae	X		
11	*Crataegus cordata*	Rosaceae	X		
12	*Cunninghamia lanceolata*	Pinaceae	X		
13	*Dalbergia sp.*	Fabaceae	X		
14	*Debregeasia hypoleuca*	Urticaceae			X
15	*Eriobotrya japonica*	Rosaceae	X	X	
16	*Enkianthus perulatus*	Ericaceae		X	
17	*Fagus crenata*	Fagaceae		X	
18	*Ficus carica*	Moraceae	X	X	X
19	*Ficus hispida*	Moraceae	X		
20	*Ficus infectoria*	Moraceae	X		
21	*Ficus retusa*	Moraceae	X		
22	*Juglans regia*	Juglandaceae	X		
23	*Lagerstroemia indica*	Lythraceae	X		
24	*Maclura pomifera*	Moraceae			X
25	*Malus domestica*	Rosaceae	X		X
26	*Malus asiatica*	Rosaceae	X		
27	*Malus pumilla*	Rosaceae	X		
28	*Malus sp.*	Rosaceae	X		
29	*Melia azedarach*	Meliaceae	X		
30	*Morus acidosa*	Moraceae	X		
31	*Morus alba*	Moraceae	X		
32	*Morus indica*	Moraceae			X
33	*Morus laevigata*	Moraceae	X		
34	*Morus sp.*	Moraceae	X	X	X
35	*Paulownia sp.*	Scrophulariaceae	X		
36	*Pinus massoniana*	Pinaceae	X		
37	*Pinus yunnanensis*	Pinaceae	X		
38	*Populus alba*	Salicaceae			X
39	*Populus casalae*	Salicaceae			X
40	*Populus ciliata*	Salicaceae			X
41	*Populus deltoides*	Salicaceae			X
42	*Populus nigra*	Salicaceae			X
43	*Populus x euramericana*	Salicaceae	X	X	X
44	*Populus sp.*	Salicaceae	X	X	X
45	*Populus tomentosa*	Salicaceae	X		
46	*Prunus persica*	Rosaceae			X
47	*Prunus pseudocerasus*	Rosaceae	X		
48	*Pterocarya stenoptera*	Juglandaceae	X		
49	*Pyrus baccata*	Rosaceae	X		
50	*Pyrus communis*	Rosaceae			X
51	*Quercus sp.*	Fagaceae	X		
52	*Robinia pseudoacacia*	Fagaceae	X	X	
53	*Salix babylonica*	Salicaceae	X		
54	*Salix sieboldiana*	Salicaceae	X		

55	*Salix* sp.	Salicaceae	X		X
56	*Salix tetrasperma*	Salicaceae	X		
57	*Sapium sebiferum*	Euphorbiaceae	X		
58	*Schima superba*	Theaceae	X		
59	*Trema amboinensis*	Ulmaceae	X		
60	*Ulmus sp.*	Ulmaceae	X		
61	*Vernicia fordii*	Euphorbiaceae	X		
62	*Zelkova serrata*	Ulmaceae		X	

Appendix 3: Recorded locations (Lands and Provinces) of *Apriona* spp. in Asia & references.

	Land	Region	References
A.japonica	Japan	Ishikawa	• Esaki, K.; Higuchi, T., 2006. Control of *Apriona japonica* (Coleoptrea: Cerambycidae) adults using nonwoven fabric sheet-formulations of an entomogenous fungus, *Beauveria brongniartii*, hung on feeding trees. *Journal of the Japanese Forest Society*, 88 (6): 441-445.
A.japonica	Japan	Nagasaki	• Yokomizo K.; Morita A., 1980. Oviposition behavior of the mulberry borer, *Apriona japonica* Thomson, on loquat trees [*Eriobotrya japonica*] in Nagasaki [Japan]. *Proceedings-of-the-Association-for-Plant-Protection-of-Kyushu (Japan)*, 26: 168-170.
A.japonica	Japan	Akita	• Kondo, K., 2008. Examples from practice: Occurrence of *Apriona japonica* (Coleoptera, Cerambycidae) in a *Fagus crenata* plantation at sea level, Akita Prefecture, Japan. *Tree and Forest health*, 12 (1): 20-22
A.japonica	Japan	Ibiraki	• Yamanobe, T., Hosoda, H., 2002. High survival rates for the longicorn beetle, *Apriona japonica* (Coleoptera, Cerambycidae) Thomson in beech trees (*Fagus crenata* Blume) planted in lowlands. *Japanese Journal of Applied Entomology and Zoology*, 46 (4): 256-258.
A.japonica	Japan	Nagano	• Koyama, Y.; Okada, M., 2004. Beech tree infestation by mulberry borer (*Apriona japonica* THOMSON) in northern Nagano Prefecture, central Japan. *Bulletin of Institute of Natural Education in Shiga Heights*, 41: 1-5
A.germari	China	Zhejang	• Chen, K.F., 1933. An Investigation on Cerambyeids attacking Mulberry in Kashing. *Entomology and Phytopathology*, September 1st. 1 (25):532-534.
A.germari	China	Hebei	• Li, H.P.; Huang, D.Z.; Wang, Z.G.; Yan, H.X.; Zheng, J.W., 2007. Screening test of highly virulent strains of entomopathogenic fungi *Beauveria bassiana* against *Apriona germari* larvae. *Scientia Silvae Sinicae*, 43(11): 66-71. • Huang D.Z.; Guan, H.Y.; Zhang, J.S.; Liu, J.X.; Wang, Z.X.; Zhang, J.Z., 1997. Control threshold for *Apriona germari*. *Journal of Northeast Forestry University*, 25(2): 78-82.
A.germari	China	Heilongjiang	• Li, K.Z., 1996. Poplar stem-boring pests and their control. *J. Northeast For. Univ.*, 7 (1).
A.germari	China	Shandong	• Shui S.Y.; Wen J.B.; Chen M.; Hu X.L., Liu F.; Li J., 2009. Chemical control of *Apriona germari* (Hope) larvae with zinc phosphide sticks. *Forestry Studies in China*, 11 (1): 9-13.
A.germari	China	Jiangsu	• Hu, J.J.; Han, Y.F.; Yin, W.L.; Augustin, S.; Villar, M., 2002. On resistance of progenies of *Populus deltoides* to a Cerambycidae borer: *Apriona germarii* Hope under artificial inoculation and natural infestation. *Scientia Silvae Sinicae*, 38 (1): 164-167. • Liu, S.Q. & Xu, H.Z., 2000. Integrated control and characteristics of the main poplar

			diseases and insect outbreaks in Siyang County. *Journal of Jiangsu Forestry Science and Technology*, 27(6): 33-35.
A.germari	China	Shangai	• Qin, H.Z.; Ju, Y.M.; Wang, W,Z,, 1997. A study on control of damage of *Apriona germari* (Hope) on *Ficus carica*. *Journal of Shanghai Agricultural College*, 15: 3, 239-242.
A.germari	China	Taiwan	• Cheng, C.J., Chang, S.C., 1974. Three new records of species of longicorn beetles destructive to chestnut trees in Taiwan. *Journal of Agriculture and Forestry*, 23: 109-120.
A.germari	China	Hong-Kong	• www.cabicompendium.org
A.germari	South Korea	Kyunggi, Kyungbuk, Kyungnam, Chunbuk, Chunnam	• Yoon, H.J.; Park, I.G.; Mah, Y.I.; Seol, K.Y., 1997. Larval development of mulberry longicorn beetle, *Apriona germari* Hope, on the artificial diet. *Korean Journal of Applied Entomology*, 36 (4): 317-322.
A.germari	India	Jammu and Kaschmir	• Hussain, A.; Chishti, M.Z.; Buhroo, A.A.; Khan, M.A., 2007. Adult population of *Apriona germari* Hope (Coleoptera: Cerambycidae) in mulberry farms of Jammu and Kashmir State (India). *Pakistan Entomologist*, 29 (1): 15-17.
A.germari	Laos Vietnam		• www.cabicompendium.org
A.germari	China	Jiangxi	• (Zhang and Shen, 1965; Huang et al., 1997) *in* Shui S.Y.; Wen J.B.; Chen M.; Hu X.L., Liu F.; Li J., 2009. Chemical control of *Apriona germari* (Hope) larvae with zinc phosphide sticks. *Forestry Studies in China*, 11 (1): 9-13.
A.germari	China Vietnam, Burma, India, Laos, Nepal, Korea, Japan	China provinces: Liaoning, Hebei, Shandong, Shanxi, Shaanxi, Gansu, Jiangsu, Zhejiang, Hunan, Hubei, Anhui, Jiangxi, Fujian, Taiwan, Hainan, Guangdong, Guangxi, Guizhou, Sichuan, Yunnan, Xizang, Henan (material examined)	• Huang, J. ; Wang, W. ; Zhou, S.; Wang, S., 2009. Review of the Chinese species of *Apriona* Chevrolat, 1852, with proposal of new synomyms (Coleoptera, Cerambicidae, Lamiinae, Batocerini). *Les Cahiers Magallanes*, 94 : 1-23.
A.swainsoni	China	Anhui	• Tang, Y.P., Liu, G.H., 2000. Study on forecasting the occurrence of oviposition in *Apriona swainsoni*. *Scientia Silvae Sinicae*, 36 (6): 86-89.
A.swainsoni	China, Vietnam, Burma, Laos, India	China provinces: Henan, Jiangsu, Fujian, Hubei, Guangxi, Guizhou, Sichuan, Hunan (material examined)	• Huang, J.; Wang, W.; Zhou, S.; Wang, S., 2009. Review of the Chinese species of *Apriona* Chevrolat, 1852, with proposal of new synomyms (Coleoptera, Cerambicidae, Lamiinae, Batocerini). *Les Cahiers Magallanes*, 94 : 1-23.
A.cinerea	India & Pakistan	India: Jammu & Kaschmir, Himachal Pradesh, Uttar Pradesh Pakistan: Rawalpindi, Peshawar, Parachinar	• Singh, P., Prasad, G., 1985. Poplar stem borer, *Apriona cinere*a Chevrolat (*Coleoptera: Cerambycidae*) its biology, ecology and control. *Indian forester*, 111(7): 517-524.

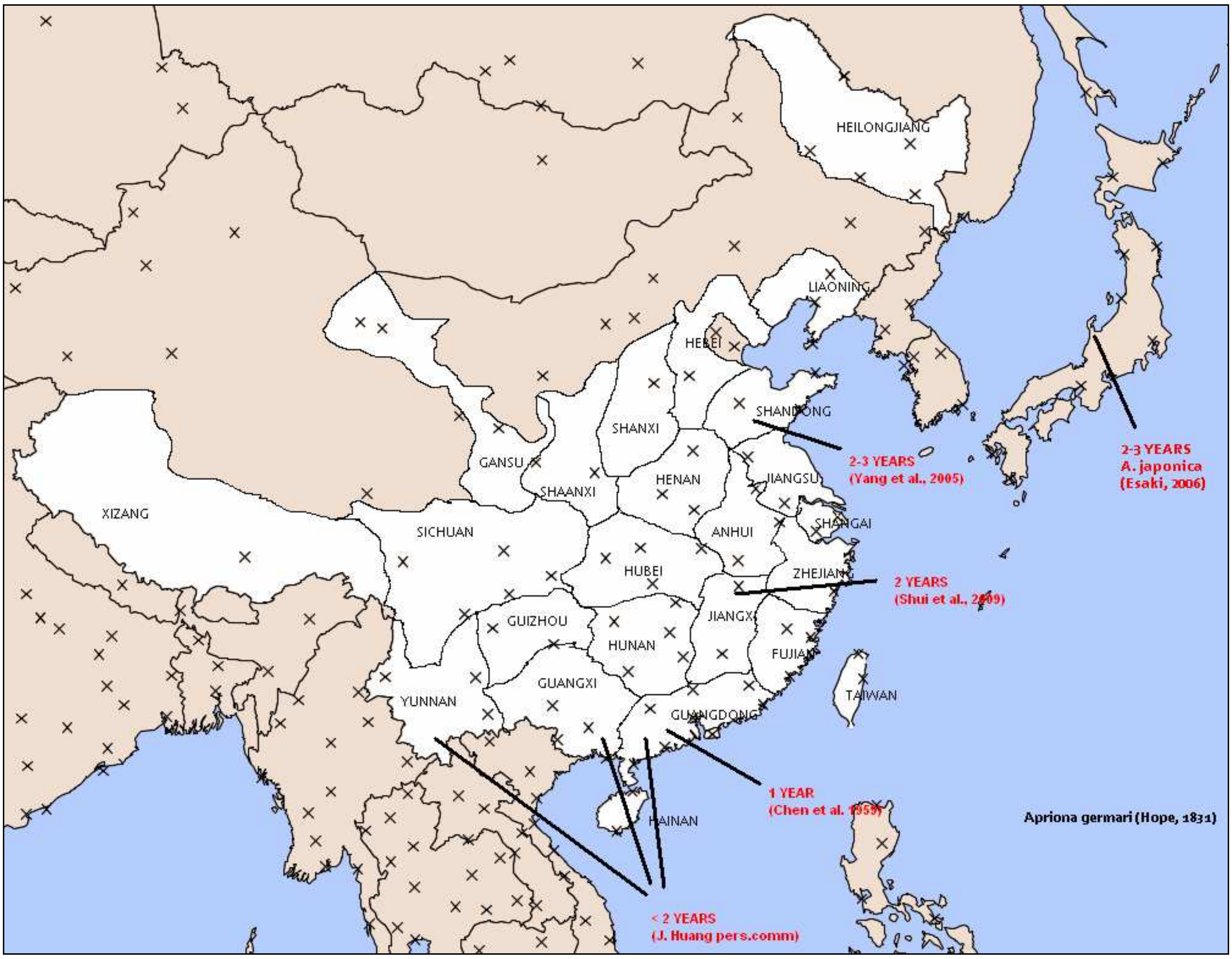
Appendix 4 : Biology aspects of *Apriona* spp., location and references

Species	Development time	Locatie	Publicatie
A. japonica	• 36 weeks for hatched larvae to pupate at 25° C under a 16 h light-8 h dark photoperiod • larvae exposed to 10 degrees C in the dark for 30 days from 16-18 weeks after hatching pupated 30-32 weeks later • 30-day low-temperature treatment in darkness terminated larval diapause	Artificial breeding	Esaki, K., 2001. Artificial diet rearing and termination of larval diapause in the mulberry longicorn beetle, *Apriona japonica* Thomson (Coleoptera: Cerambycidae). *Japanese Journal of Applied Entomology and Zoology*, 45 (3): 149-151.
	A generation requires **two or more years** in *Z. serrata* trees	Sika, Ishikawa Prefecture	(Esaki, 1999; Ohashi, 2001) *in* Esaki, K., 2006. Deterrent effect of weed removal in *Zelkova serrata* on oviposition of *Apriona japonica* Thomson (Coleoptera, Cerambycidae). *Japanese Entomology and Zoology*, 41 (1): 83-86.
	Capability of flight for adult. The capability could not be clear because their recapture rates were very low (6.6%) in some investigate forests. (e-mail from Kojiro Esaki)	Uchinada, Ishikawa Prefecture	Esaki, K.; Higuchi, T., 2006. Control of *Apriona japonica* (Coleoptrea: Cerambycidae) adults using nonwoven fabric sheet-formulations of an entomogenous fungus, *Beauveria brongniartii*, hung on feeding trees. *Journal of the Japanese Forest Society*, 88 (6): 441-445.
	Adults of A. japonica are present from beginning July and oviposited from late July until early September with a peak in early August in young Zelkova plantation. A generation of A. japonica requires two or three years in Ischikawa-ken Forest Experimentation	Sika, Ishikawa Prefecture	Esaki, K., 2007. Life cycle, damage analysis and control of *Apriona japonica* Thomson (Coleoptera, Cerambycidae) in young *Zelkova serrata* plantation. *Bulletin of the Ishikawa-ken Forest Experimentation*, 39: 44 pp.

A. germari	At 25° C: • Egg: 18 days • Larva: 252 days • Pupa: 19 days • Adult: 40-44 days To terminate larval diapause: • 5° C for 60 days Total life-cycle: from 197 –331 days	Artificial breeding. Larvae from Kyunggi province, South Korea	Yoon, H.J.; Mah Y.I., 1999. Life cycle of the mulberry longicorn beetle, *Apriona germari* Hope on an artificial diet. *Journal of Asia-Pacific Entomology*, 2 (2): 169-173.
	In Shandong province, its generation cycle takes **2 or 3 years**	Shandong province	Yang, Q.L.; Zhang, M.C.; Wang, G.M.; Zhang, H.P., 2005. Effectiveness of using 8% cypermethrin for control of *Apriona germarii*. *China Fruits*, 1: 54.
	Larval duration was extended compared to that of the 1st- to 9th- or 12th-instar, requiring 186.03 and 304.58 days, respectively (**less 1 year** artificial breeding)	Artificial breeding in South Korea	Yoon, H. J.; Park, I. G.; Mah, Y. I.; Lee, S. B; Yang, S. Y., 1997. Ecological characteristics of mulberry longicorn beetle, *Apriona germari* Hope, at the hibernation stage in mulberry fields. *Korean Journal of Applied Entomology*, 36 (1): 67-72.
	According to Nakagawa (1900) and Maki (1916), the duration of the life-cycle of this beetle is **one year in Formosa** and **two years in Japan**. A captive adult continued oviposition for 79 days, laying less than five eggs a day and 116 in all throughout. The eggs, dormant during winter (when laid in the autumn) usually hatch in about 14 days. The duration of the larval period is 349 –397 days.	Taiwan Japan	Duffy, E.A.J., 1968. A monograph of the immature stages of Oriental timber beetles (Cerambycidae). *British Museum (Natural History) London*, p. 268-270.
	One generation per year in Guangdong Province (S. China), and **2-3 years** for one generation in northern China.	Guandong Province	Chen, S.X.; Xie, Y.Z.; Deng, G, 1959. Economic insect fauna of China. Fasc. 1. Coleoptera. Cerambycidae. *Science Press,* Beijing, China: p.84.
	In most provinces of China, *A. germari* needs **2 years** to finish its development. A few southern provinces, for example south part of Guangdong, Guangxi and Yunnan: **less than 2 years** Possibly it will take **three years** to finish a complete life circle in Heilongjiang because of the extremely colder climate than south China.	South of provinces Guangdong, Guangxi and Yunnan	Huang, J. ; Wang, W. ; Zhou, S.; Wang, S., 2009. Review of the Chinese species of *Apriona* Chevrolat, 1852, with proposal of new synomyms (Coleoptera, Cerambicidae, Lamiinae, Batocerini). *Les Cahiers Magallanes*, 94 : 1-23. (answer email Jianhua Huang)
	The larval period is **22-23 months** in Nangchang city, Jianxi Province. Experimental site: located at Gaotang , Shandong Province. This site is in a temperate continental monsoon semi-arid climate zone.	Nangchang city, Jianxi Province Gaotang, Shandong Province	Shui S.Y.; Wen J.B.; Chen M.; Hu X.L., Liu F.; Li J., 2009. Chemical control of *Apriona germari* (Hope) larvae with zinc phosphide sticks. *Forestry Studies in China*, 11 (1): 9-13.

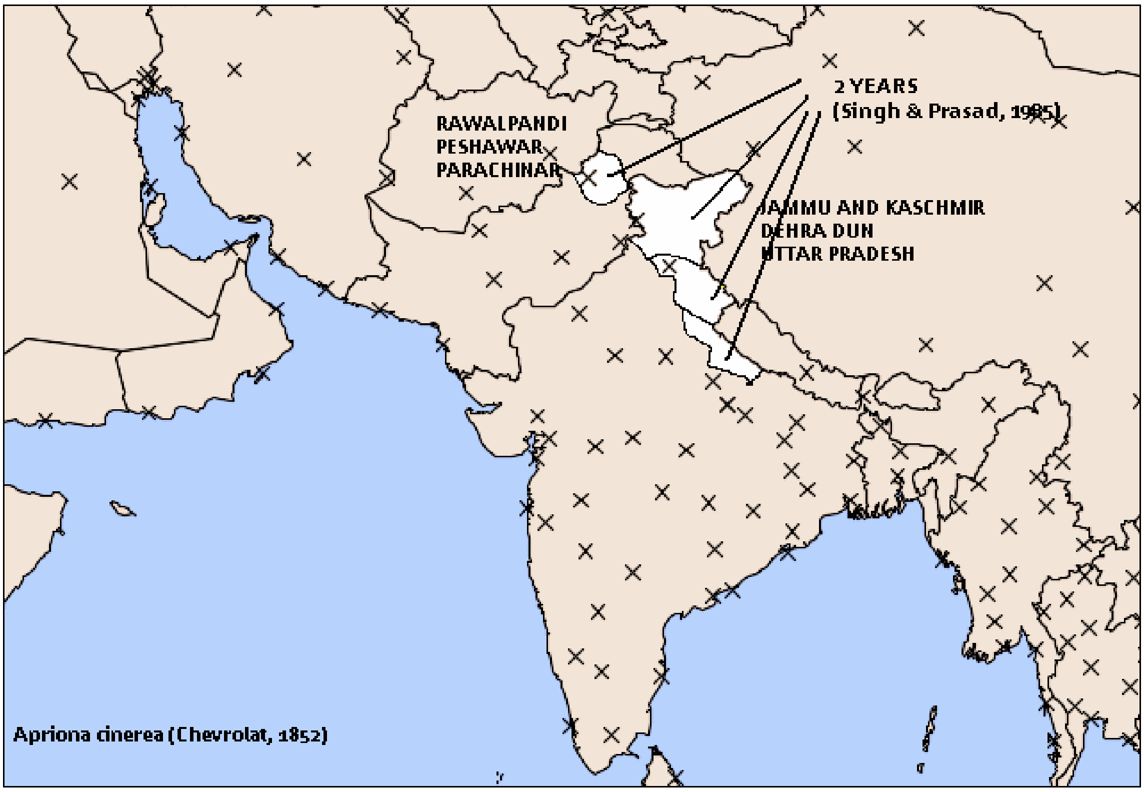
	A.germari emerged over a period of four moths. In subtropical region (Jammu province), mass emergence of beetles took place in mid July while in temperate region (Kashmir province), peak of emergence occurred in mid August.	Miransahib (Jammu province) and Bimyar Uri (Kashmir province)	Hussain, A.; Chishti, M.Z.; Buhroo, A.A.; Khan, M.A., 2007. Adult population of *Apriona germari* Hope (Coleoptera: Cerambycidae) in mulberry farms of Jammu and Kashmir State (India). *Pakistan Entomologist*, 29 (1): 15-17.
	Apriona germari produces 1 generation per three years. It overwinters as a larva in the stems. Adults lay eggs inside the stems of the host trees.	China (every provinces)	Tree Fruit Technical Advisory Council (Tree TAC), July 22, 2003. Facsimile 703.790.0845. Vienna, Virginia.
A.cinerea	Life cycle of the borer takes **two years**. The borer continues feeding up to October, but stops doing so in November in hills and December in Dehra Dun and remains quiescent throughout winter. Diapauses as mature larva in the second winter.	India: Jammu and Kaschmir Himachal Pradesh Uttar Pradesh Pakistan: Rawalpindi Peshawar Parachinar	Singh, P., Prasad, G., 1985. Poplar stem borer, *Apriona cinere*a Chevrolat (*Coleoptera: Cerambycidae*) its biology, ecology and control. *Indian forester*, 111(7): 517-524.

Appendix 5. Distribution of *Apriona germari* in provinces of China (in white) with duration of the life-cycle. (X: Meteorological stations used by CLIMEX)



Appendix 6. Distribution of *Apriona japonica* in Prefectures of Japan (in white) with duration of the life-cycle. (X: Meteorological stations used by CLIMEX)

Appendix 7. Distribution of *Apriona cinerea* in provinces of India and Pakistan (in white) with duration of the life-cycle. (X: Meteorological stations used by CLIMEX)

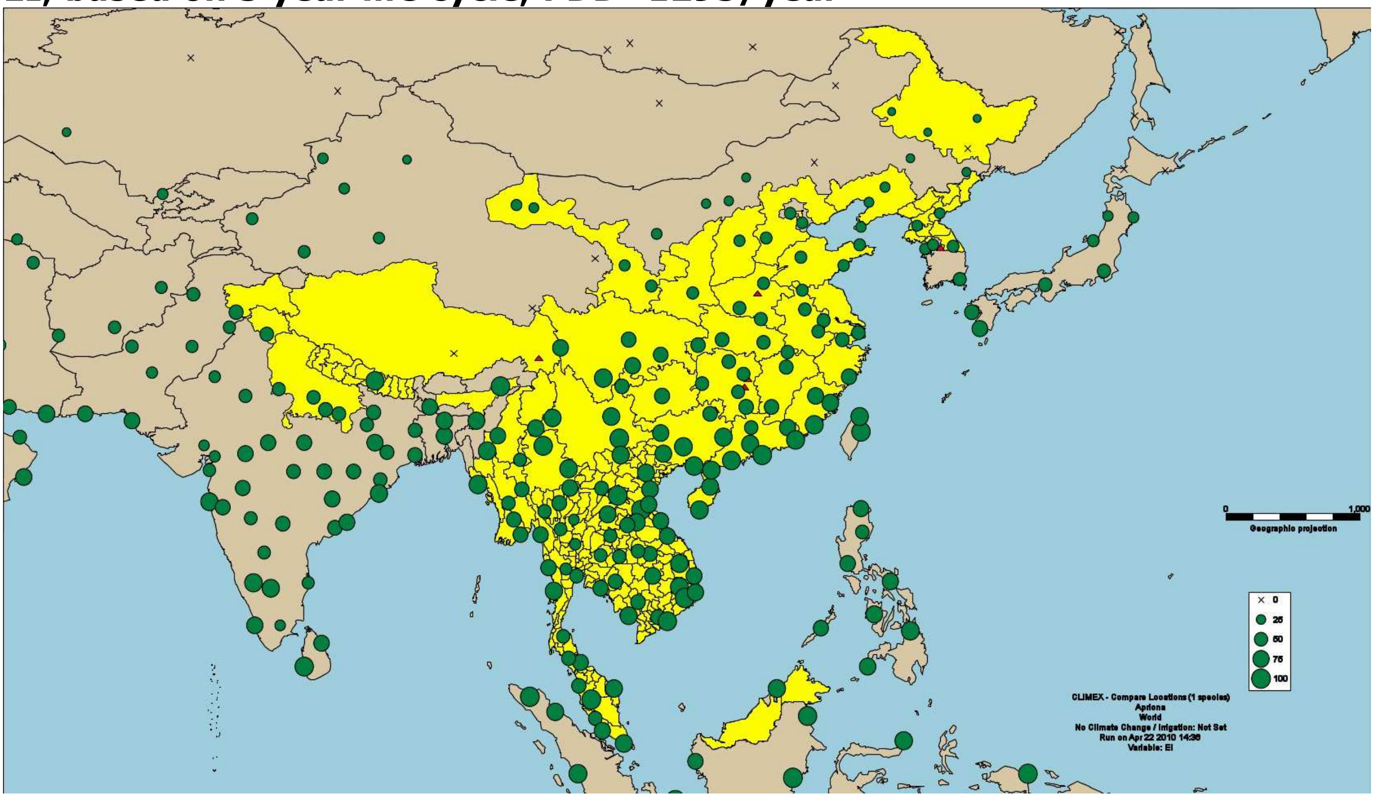


Appendix 8. Distribution of *Apriona germari* as predicted by Climex model. Locations (provinces) where A. germari is reported are indicated in yellow.

Climex model parameters:

☐ Moisture Index					
☑ Temperature Index					
DV0	DV1	DV2	DV3		
10	12	30	35		
☐ Light Index					
☐ Diapause Index					
☑ Cold Stress					
TTCS	THCS	DTCS	DHCS	TTCSA	THCSA
0	0	12	-0.0001	0	0
☐ Heat Stress					
☐ Dry Stress					
☐ Wet Stress					
☐ Cold-Dry Stress					
☐ Cold-Wet Stress					
☐ Hot-Dry Stress					
☐ Hot-Wet Stress					
Day-degree accumulation above DV0					
DV0	DV3	MTS			
10	35	7			
Day-degree accumulation above DVCS					
DVCS	*DV4	MTS			
8	100	7			
Day-degree accumulation above DVHS					
DVHS	*DV4	MTS			
28	100	7			
Degree-days per Generation					
PDD					
1295					

EI, based on 3 year life cycle, PDD=1295/year

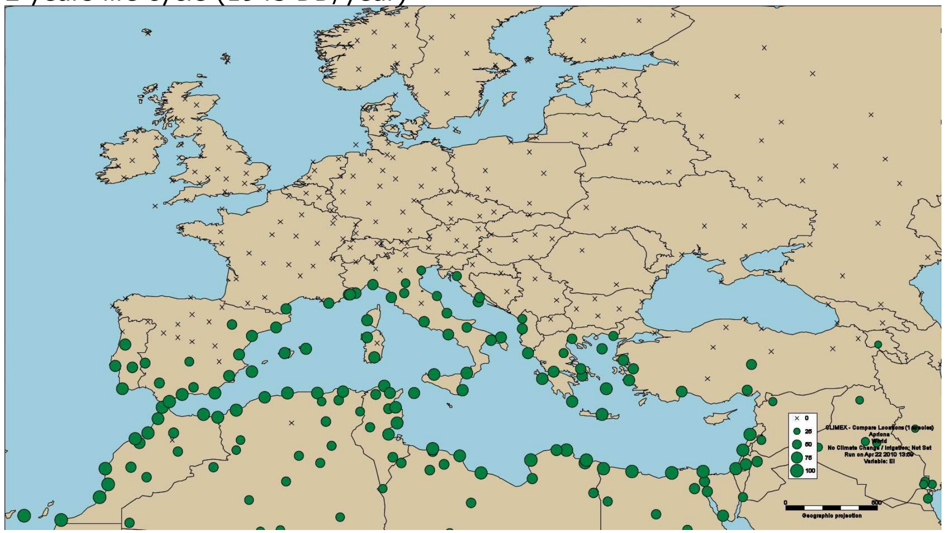


Appendix 9. Number of generations per year of *Apriona germari* according to Climex model (same parameters as in appendix 7).

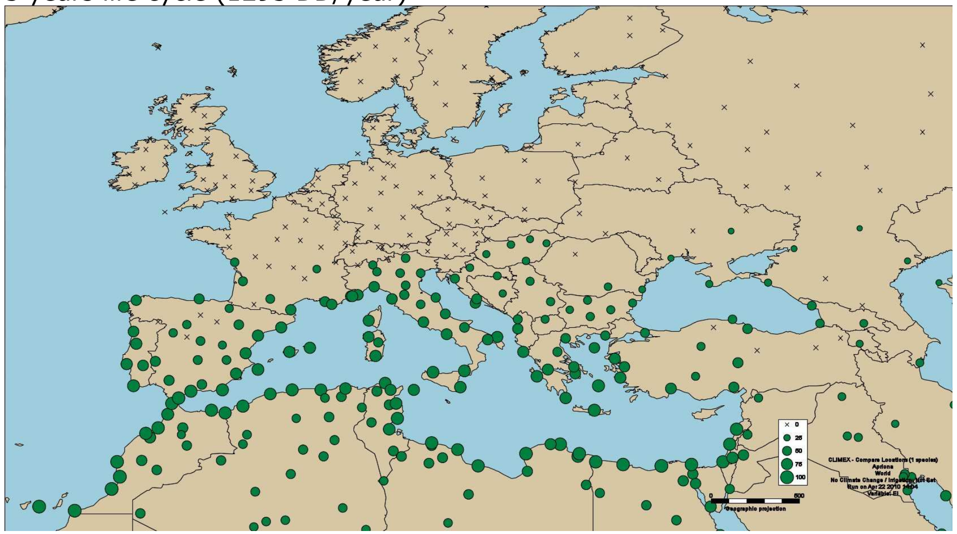
Appendix 10. Potential distribution of *Apriona germari* in Europe.

Ecoclimatic index (EI) indicating suitability of areas. Crosses indicate unsuitable location (EI=0). Threshold temperature in all models was 12 °C.

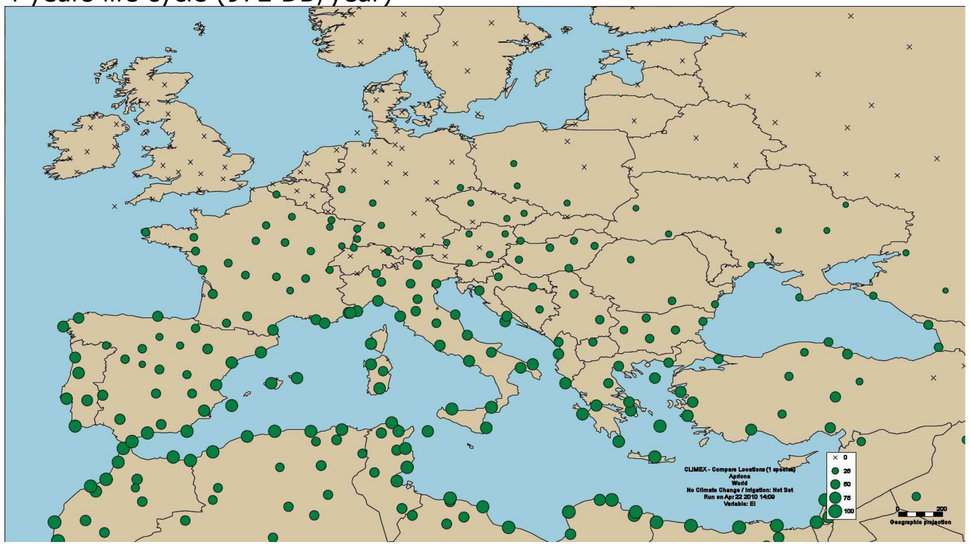
2 years life cycle (1943 DD/year)



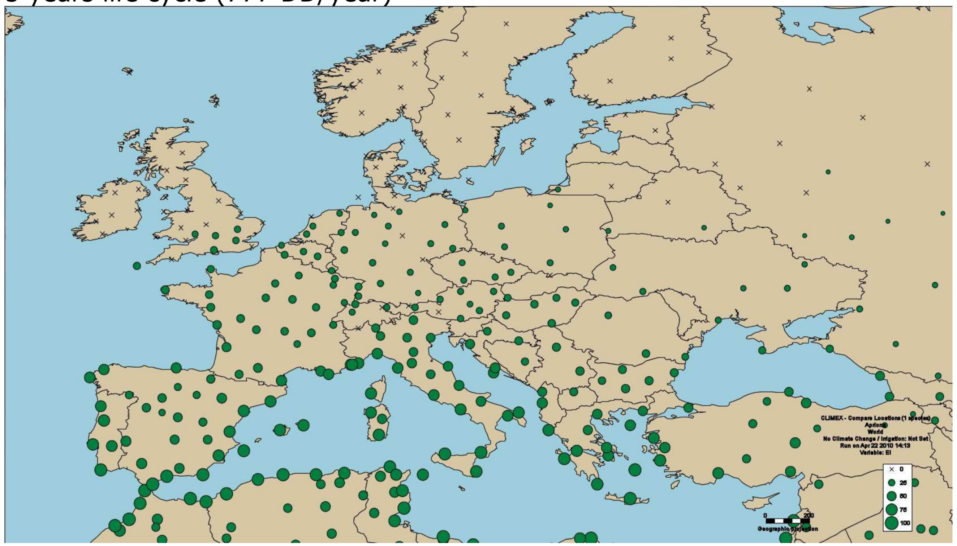
3 years life cycle (1295 DD/year)



4 years life cycle (972 DD/year)

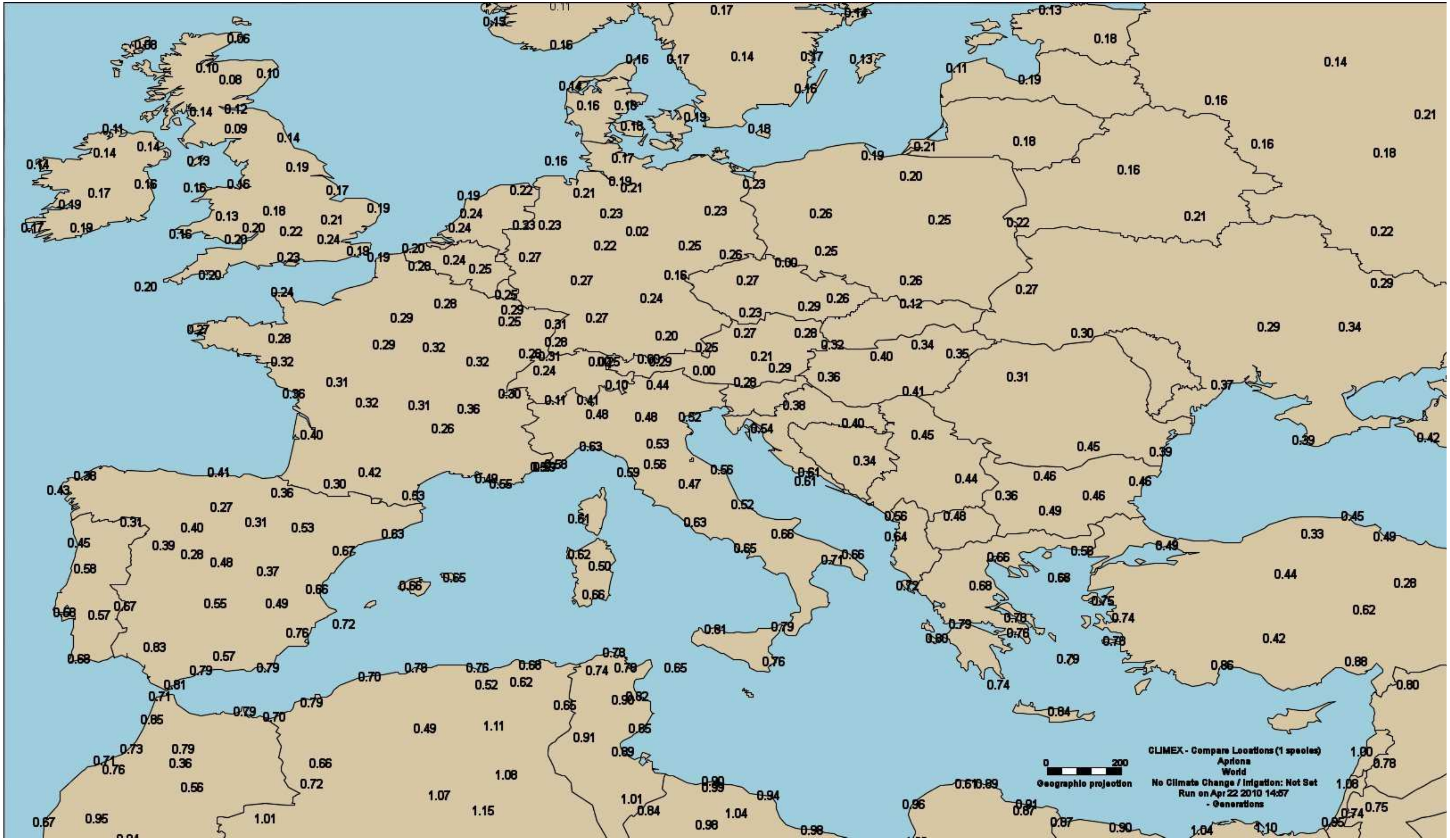


5 years life cycle (777 DD/year)



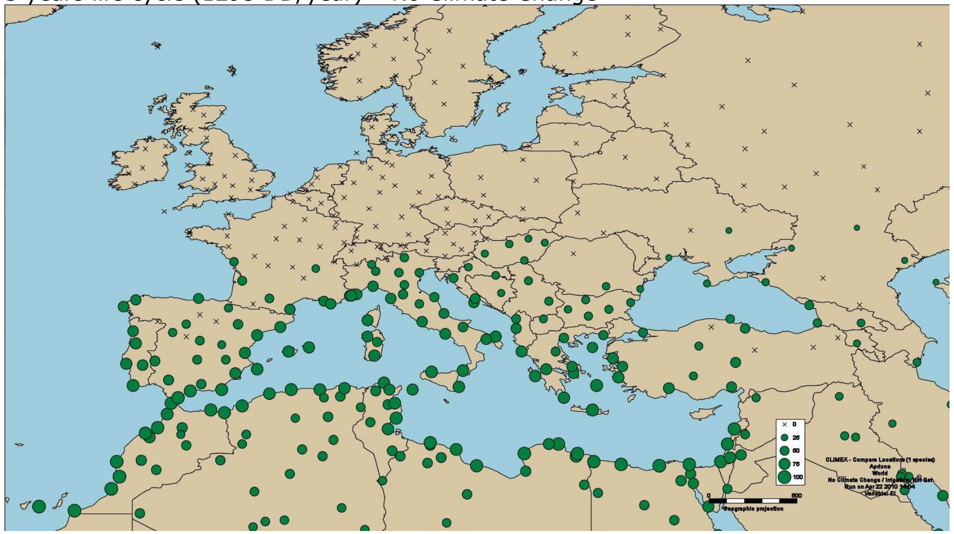
Appendix 11. Potential number of generations per year of *Apriona germari* in Europe.

Based on development threshold temperature of 12 °C and 4212 DD necessary for egg to gravid female development..

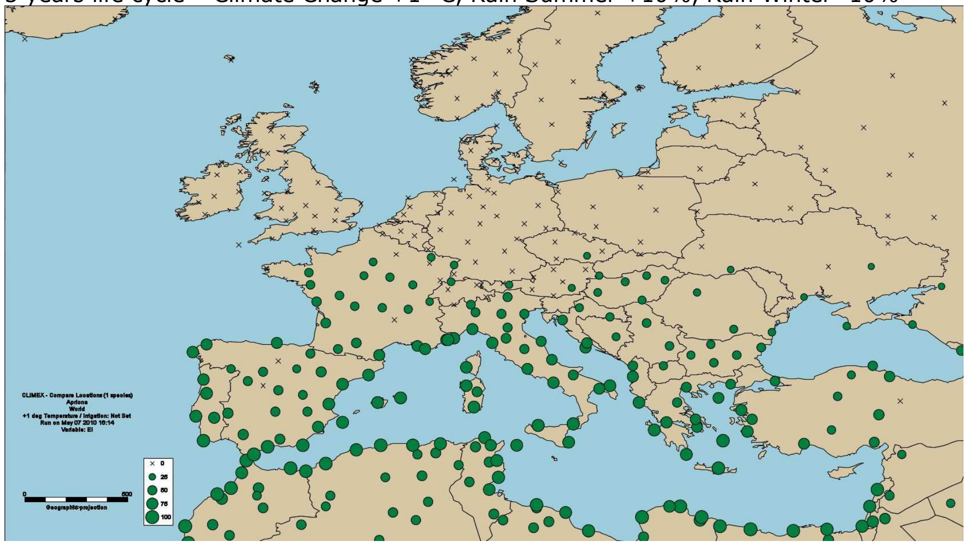


Appendix 12. Potential distribution of *Apriona germari* in Europe with Climate Change Scenarios.

3 years life cycle (1295 DD/year) – No Climate Change



3 years life cycle – Climate Change +1 °C, Rain Summer +10%, Rain Winter -10%



3 years life cycle – Climate Change +2 °C, Rain Summer +15%, Rain Winter -15%