Life history of *Kermes quercus* (LINNAEUS) (Hemiptera: Kermesidae) in Poland

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ABSTRACT. This research complements the results of a study of the life cycle of *Kermes quercus* (L.) performed in Poland in 2008-2009. The latest observations were carried out in 2010 from the beginning of March until the end of November. They showed that *K. quercus* overwintered as 2nd-instar nymphs. These developed into adults at the beginning of May. Reproduction began at the beginning of June. The 1st-instar nymphs of the new generation appeared in mid-June. They then developed for about 5 months, after which they entered the winter diapause.

All the observations, carried out in 2008-2010, showed that, under the climatic conditions of Poland, *K. quercus* is not a univoltine species. One generation develops over two years. In the first year it overwinters as 1st-instar nymphs and in the second year as 2nd-instar nymphs.

KEY WORDS: Hemiptera, Kermesidae, *Kermes quercus* (LINNAEUS), life cycle, developmental stages.

INTRODUCTION

Kermes quercus (L.) is a Palaearctic species, widespread in many European countries (KOSZTARAB & KOZÁR 1988). In Poland it is very common, too (KAWECKI 1985, SIMON & HERCZEK 2010). It lives mainly in the bark crevices of tree trunks and on thick branches but, at high densities, it can also occur on thinner branches. Locally it can be a serious pest of oaks (NASONOV 1910, KOZÁR 1974, PODSIADŁO 2011). NASONOV was the first author to study the biology of *K. quercus*, in the region of St Petersburg in 1907 and 1908, but his description of the species' life cycle was not clear. Nevertheless, NASONOV's observations suggested that *K. quercus* was not a univoltine species. SAAKJAN-BARANOVA and MUZAFAROV (1972) described the life cycle of *K. quercus*, also from the region of St Petersburg. According to these latter authors, *K. quercus* was a univoltine

species, overwintering as 2nd-instar nymphs. These nymphs moulted in the spring and developed into adults. After mating, the adult females started to lay eggs. The 1st-instar nymphs hatched from the eggs and moulted into 2nd-instars in August. In the autumn the 2nd-instar nymphs entered the winter diapause. A similar description of the life cycle of *K. quercus* was given by SCHMUTTERER from Germany (1972).

Such a scheme of the life cycle of *K. quercus* is generally accepted and is even given on ScaleNet.

Observations carried out in Poland in 2008 and 2009 did not confirm the above version of the life cycle of *K. quercus* (PODSIADŁO 2011, 2012), however. The present research complements the results of those earlier studies.

Abbreviations

L₁ – 1st-instar nymph, L_{2♀} – 2nd-instar female, L_{2♂} – 2nd-instar male, L_{3♀} – 3rd-instar female, Pp – prepupa, P – pupa, ♀ – pre-reproductive female, ♀^o – reproductive female, ♂ – male.

MATERIAL AND METHODS

The observations were carried out between the beginning of March and the end of November in 2010. The material was collected on *Quercus robur* L. in the Bemowo woodland park, situated in the western part of Warsaw.

The mean monthly temperatures for Warsaw in 2010 are given in Table 1.

Table 1. Mean monthly temperatures (°C) in Warsaw in 2010 (from the Bulletin of the National Hydrological and Meteorological Service published by the Institute of Meteorology and Water Management in Warsaw, 2010).

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
-8.0	-1.7	4.0	9.5	13.7	17.5	21.9	20.0	12.8	6.4	6.0	-5.5

Pieces of bark or smaller branches were cut from the trees and all live individuals of *K. quercus* were picked off. In the laboratory they were preserved in 70% ethanol and the developmental stages were identified. In addition, the content of the brood chambers in females was inspected from mid-May onwards.

Sampling each month was divided into three ten-day periods: I – from the 1st to the 10th day of the month, II – from the 11th to the 20th day of the month and III – from the 21st to the 30th day of the month. The material was sampled at least once in each period.

The majority of specimens were identified under a stereomicroscope following their preliminary soaking in 10% aq. KOH for 24 hours. In case of doubt, the specimens were mounted in glycerine or in balsam and examined at a higher magnification. Tables 2a,b give the number of specimens of *K. quercus* examined. The number of adult males was based on the number of empty puparia.

RESULTS

Moulting began in the first third of April and proceeded rapidly (Table 3). The 2nd-instar females moulted into 3rd-instar females, and the 2nd-instar males into prepupae. The moulting of 3rd-instar females into adult females started in the first third of May. Prepupae started to moult into pupae in the last third of April. Males appeared in the first third of May. Mating was observed in the second third of May. During May the adult females produced large quantities of honeydew, which coated the surface of host plants and dribbled down the tree trunks. Eggs were laid in the first and second third of June.

Table 2a. Number of specimens of *K. quercus* (L.) collected on *Quercus robur* L. in Warsaw between March and June 2010.

[illegible]

Table 2b. Number of specimens of *K. quercus* (L.) collected on *Quercus robur* L. in Warsaw between July and November 2010.

Life st.	Month: 10 day periods														
	July			August			September			October			November		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
L ₁	210	290	300	100	130	225	427	670	875	650	600	350	560	764	769
L _{2♀}	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
L _{2♂}	0	0	0	0	0	0	0	1	1	2	0	0	1	2	1

Table 3. The development of a generation of *K. quercus* (L.) between March and June 2010 in Warsaw. The number of specimens is expressed as a percentage.

Life stage	Month: 10 day periods											
	March			April			May			June		
	I	II	III	I	II	III	I	II	III	I	II	III
L ₁	<1	<1	<1	0	0	0	0	0	0	0	0	0
L _{2♀}	64	79	81	35	4	4	0	0	0	0	0	0
L _{3♀}	0	0	0	38	48	59	9	0	0	0	0	0
♀	0	0	0	0	0	0	49	57	100	37	0	0
♀°	0	0	0	0	0	0	0	0	0	63	100	100
L _{2♂}	35	20	19	22	8	4	0	0	0	0	0	0
Pp	0	0	0	5	40	17	0	0	0	0	0	0
P	0	0	0	0	0	16	20	0	0	0	0	0
♂	0	0	0	0	0	0	22	43	0	0	0	0

The 1st-instar nymphs hatched in the second and last third of June. They developed for about 5 months, after which they entered the winter diapause (Table 2b). In the autumn sporadic moulting of 1st-instar nymphs into 2nd-instar nymphs was observed, but these made up less than 1% of the individuals collected. Nearly all the nymphs overwintered as 1st-instars.

DISCUSSION

Tables 4a-e illustrate the development of a generation of *K. quercus* in 2008-2010. As can be seen, adult females started to lay eggs in the first third of June 2008.

The egg phase lasted about one week. The 1st-instar nymphs appeared in the second third of June. They developed for about 5 months, then entered the winter diapause. In autumn 2008 a few 1st-instar nymphs moulted into 2nd-instars (unpublished data). As later observations showed, these 2nd-instar nymphs survived the winter 2008/2009 and even moulted in spring 2009, but died without reaching sexual maturity. However, as they made up only about 1% of the individuals collected, nearly all the nymphs overwintered as 1st-instars.

In the spring 2009 the 1st-instar nymphs became active and continued their development until the last third of August, when they started to moult into the 2nd-instar. Hence, the 1st nymphal stage lasted about 14 months. The 2nd-instar nymphs developed for about three months before entering the winter diapause. About 1-2% of the 1st-instar nymphs stopped growing and entered the winter diapause in the 1st stage. Most of them died during the winter 2009/2010, although single individuals did survive (see Tables 2a and 3). However, they subsequently became infected by fungi and died. Hence, nearly all the nymphs overwintered as 2nd-instars. They did not moult until the end of March, although they were visibly active: for example, 2nd-instar males produced puparia. The 2nd-instar stage lasted about 7 months.

Moulting started in the first third of April. The 2nd-instar females moulted into 3rd-instar females, and the 2nd-instar males into prepupae. The 3rd-instar stage lasted for about one month, mainly during April. The prepupae lasted about 3 weeks and were found in April. The pupae lasted about 2 weeks, being found mainly during the last third of April and the first third of May. Adult males emerged in the first third of May but were hardly noticeable after leaving the puparia except for mating. Their presence was manifested only by the empty puparia. The adult females appeared in the first third of May. They started to lay eggs in the first third of June, thus initiating the development of new generation.

Materials collected sporadically in 2011, 2012 and 2013 confirmed the above life cycle of *K. quercus* in Poland.

Each life stage of *K. quercus* appeared every two years. Adults occurred in even-numbered years: 2008, 2010, 2012.

Dead post-reproductive females can be found attached to the trunks and branches for more than one year and can therefore be collected every year on oaks infested by this species. Likewise, dead nymphs from previous years remain in bark crevices for a long time.

Live females of *K. quercus* produce a viscous honeydew and are therefore easily distinguishable in the field from dead ones.

K. quercus – the northern kermes – probably belongs to the European-Siberian fauna (BORCHSENIUS 1960). It does not occur in southern Europe. Perhaps the proper development of both 1st-instar nymphs and 2nd-instar nymphs requires both stages to hibernate.

Table 4a. The development of a generation of *Kermes quercus* (L.) in Poland between March and June in 2008 (according to PODSIADŁO 2012).

Month: 10 day periods															
January		February		March			April			May			June		
Winter diapause				I	II	III	I	II	III	I	II	III	I	II	III
Development of the previous generation													♀°	♀°	♀°
														L ₁	L ₁

Table 4b. The development of a generation of *Kermes quercus* (L.) in Poland between July and December in 2008 (according to PODSIADŁO 2012).

July			August			September			October			November			December		
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	Winter diapause		
L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁			

Table 4c. The development of a generation of *Kermes quercus* (L.) in Poland between March and June in 2009 (according to PODSIADŁO 2011).

Month: 10 day periods													
January	February	March			April			May			June		
Winter diapause		I	II	III	I	II	III	I	II	III	I	II	III
		L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁

Table 4d. The development of a generation of *Kermes quercus* (L.) in Poland between July and December in 2009 (according to PODSIADŁO 2011).

July			August			September			October			November			December		
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	Winter diapause		
L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁	L ₁								
					L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}			
					L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}			

Table 4e. The development of a generation of *Kermes quercus* (L.) in Poland between March and June in 2010.

Month: 10 day periods													
January	February	March			April			May			June		
Winter diapause		I	II	III	I	II	III	I	II	III	I	II	III
		L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}	L _{2♀}						
					L _{3♀}	L _{3♀}	L _{3♀}	L _{3♀}					
								♀	♀	♀	♀		
											♀°	♀°	♀°
		L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}	L _{2♂}				Development of the next generation		
					Pp	Pp	Pp						
							P	P					
								♂	♂				

CONCLUSIONS

- (1) Under the climatic conditions of Poland, *Kermes quercus* (L.) is not a univoltine species.
- (2) Each generation develops over two years. In the first year it overwinters in the 1st nymphal stage and in the second year in the 2nd nymphal stage.
- (3) Each life stage of *K. quercus* appears every two years.
- (4) In the study area reproduction took place in the June of even-numbered years.

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Received: 6 June, 2013

Accepted: 4 July, 2013