THE BIOLOGY OF CORYTHUCHA AESCULI O. & D. (HEMIPTERA, TINGITIDAE) ON THE YELLOW BUCKEYE, AESCULUS OCTANDRA MARSH[1]

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INTRODUCTION AND ACKNOWLEDGMENTS

In May, 1932, the author noticed that the leaves of the yellow buckeye, *Aesculus octandra* Marsh., were literally covered by the tingitid, *Corythucha aesculi* O. & D., and showed considerable injury due to the feeding activities of this insect. Considerable numbers of various species of lady beetles were also present feeding upon the eggs and nymphs of the tingitid. With the assistance of four undergraduate students in entomology, a study of this association of insects has been carried on from the spring of 1932 until the end of June, 1936. Mr. John H. Hughes aided in the field work in 1932 and drew the figures of the life history of *C. aesculi*. Mr. Harry Bauman aided in the observations in 1933 and the spring of 1934; Mr. Dwight McKeown helped in the fall of 1934 and in 1935; and Mr. Harold S. McGinnis aided in 1936. The author has made observations and directed the study throughout. Acknowledgments are due Dr. C. J. Drake, of Iowa State College, for checking the identification of *C. aesculi* O. & D. and to Dr. Herbert Osborn, of Ohio State University, for determination of the leaf-hoppers mentioned in the paper.

THE LIFE HISTORY OF *Corythucha aesculi* O. & D.

C. aesculi O. & D. hibernates in the adult stage. It has been found under the bark of oak, hickory, and yellow buckeye, at a considerable distance above the ground. It has not been found on the lower part of tree trunks, stumps, logs, under debris or leaves, or in crevices. The number of this species found in hibernation is not a true indication of the number that appears on the leaves of buckeye in the spring, so there is probably still an undiscovered niche for hibernation in which large numbers spend the winter.

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The yellow buckeye is among the first of the forest trees of southeastern Ohio to acquire foliage in the spring and usually its leaves are quite well-developed before the leaf buds of most other trees open. Thus it becomes a concentration point for insects as they come out of hibernation. The adults of *C. aesculi* assemble on the buds of the yellow buckeye as soon as they begin to open. Often the opening buds will be literally covered by the tingitids before the leaves have a chance to spread. Feeding begins immediately and goes on continuously to the end of the season.

TABLE I

SEX RATIO of *C. aesculi* O. & D.

DATE	TOTAL SPECIMENS EXAMINED	MALES	FEMALES	SEX RATIO
April 26, '33	466	99	367	.79—
" 27, '33	435	95	340	.78+
" 29, '33	450	120	330	.70+
May 1, '33	414	94	320	.78—
" 3, '33	463	103	360	.78—
" 16, '33	85	14	71	.84+
June 10, '33	250	68	182	.73—
May 20, '35	200	61	139	.70—
June 15, '35	425	112	313	.71+
July 22, '35	346	81	265	.77—
June 26, '36	328	78	250	.76+
Totals	3,862	925	2,937	.76+

Females of *C. aesculi* greatly outnumber the males as is shown in Table I compiled from samples swept from the trees on various dates. The sex ratio is approximately .76. In cage experiments one male will mate with several females, and one female will mate with several males. This probably occurs in nature also.

When the weather is warm copulation is in progress in the field within two days after the emergence from hibernation and continues for several weeks. Oviposition commences about two days after copulation and continues about three weeks. The eggs are partially inserted in the tissues of the under side of the leaves along the principal veins. (Fig. 1). The numbers of eggs deposited per leaflet may be enormous. Counts of the eggs on 200 leaflets during the peak of the oviposition period gave an

average of 322 eggs per leaflet (one leaflet of the five of a leaf). Table II summarizes the results of these counts.

Five females in cages deposited an average of 178 eggs each over a period of ten days. The maximum number was 297, the minimum was 64. We have no record of the number laid per

Figure 1. Leaflet of yellow buckeye, *Aesculus octandra* Marsh., showing the position of eggs of *C. aesculi* O. & D.

female in the field, but judging from the number of eggs on the leaflets, it is quite large.

The eggs hatch in from six to twelve days dependent upon the weather conditions and the young of each brood begin feeding in colonies on the under surface of the leaves. Sometimes three or four such aggregations will be found on a single

TABLE II

THE NUMBER OF EGGS OF *C. aesculi* O. & D. PER LEAFLET OF YELLOW BUCKEYE

DATE	NUMBER OF LEAFLETS EXAMINED	NUMBER OF EGGS PER LEAFLET
May 1, '33	10	186
May 2, '34	40	278
May 15, '36	150	342
Total	200	Average 322

leaf. The individuals of each aggregation are of the same instar although different aggregations may be in different instars. These aggregations of the same age remain together until they metamorphose into the adult stage. One may often find the exuviae of all instars of the group attached to the same leaf.

The number of individuals feeding on one leaf varies a great deal but may reach relatively large figures at times. Table III summarizes the counts of tingitids feeding upon the leaves of the buckeye at various times.

The length of time spent in the different instars varies with the weather conditions. High temperatures accelerate development, as is to be expected; low temperatures retard it. Warm dry weather is most favorable to the rapid and complete development of the broods. The spring months of 1932, '33, and '34, were warmer than those of 1935 and '36 in this area. Table IV

TABLE III

THE NUMBERS OF ADULTS AND NYMPHS OF *C. aesculi* O. & D. FEEDING PER LEAF (FIVE LEAFLETS) OF YELLOW BUCKEYE AT VARIOUS TIMES

(Each figure is the average of the counts on 100 leaves chosen at random.)

DATE	ADULTS	NYMPHS	TOTALS
May 7, '32	41	0	41
" 23, '32	28	136	164
June 27, '32	7	158	165
May 18, '33	36	140	176
" 31, '33	12	61	73
June 3, '34	27	96	123
May 19, '35	17	0	17
July 6, '35	4	48	52
June 26, '36	129	13	142

shows the effect of this difference distinctly upon the development of the tingitids. Heavy rains accompanied by strong winds frequently wash and blow large numbers of nymphs from the trees and thus reduce the populations materially. On May 25, 1933, for example, 2.77 inches of rain fell in the area within a few hours. Table III shows a population of 176 per leaf on May 18 and of 73 per leaf on May 31. A number of such instances when smaller numbers of leaves were counted appear in our records.

The total time from the deposition of eggs till the adult stage is reached is between six and seven weeks for the spring brood and slightly less for the summer brood. Table IV gives the dates of emergence from hibernation, the periods of copulation and oviposition, and the periods during which various instars were present in the field for both the spring and summer

broods. The dates are the first and last days on which the various stages were observed in the field. Since at times one or two days elapsed between observations, the actual appearance

TABLE IV

SEASONAL HISTORY OF *C. aesculi* O. & D. THE DATES REPRESENT THE FIRST AND LAST DAYS OF EACH YEAR UPON WHICH STAGES WERE OBSERVED IN THE FIELD

Year	Date of Emergence from Hibernation	Period of Copulation	Period of Oviposition	1st. Instar Present	2nd. Instar Present	3rd. Instar Present	4th. Instar Present	5th. Instar Present	Adult Present	Brood
1932	?	? to May 7	? to May 10	? to May 16	May 8 — May 23	May 14 — May 31	May 21 — June 6	May 26 — June 12	June 2 — July 5	SPRING
1933	Apr. 17	Apr. 18 — May 2	Apr. 20 — May 6	Apr. 26 — May 14	May 3 — May 22	May 9 — May 29	May 16 — June 8	May 22 — June 15	May 28 — July 8	
1934	Apr. 18	Apr. 20 — May 5	Apr. 21 — May 7	Apr. 30 — May 15	May 7 — May 23	May 13 — May 31	May 20 — June 6	May 28 — June 13	June 6 — July 6	
1935	Apr. 29	May 1 — May 20	May 4 — May 27	May 15 — June 4	May 24 — June 11	June 2 — June 26	June 11 — July 4	June 19 — July 11	June 26 — July 22	
1936	Apr. 23	Apr. 25 — May 16	Apr. 29 — May 24	May 12 — June 3	May 19 — June 11	May 27 — June 16	June 3 — June 21	June 10 — June 28	June 17 — ?	
1932		June 3 — June 11	June 4 — June 14	June 9 — June 20	June 14 — June 25	June 20 — July 2	June 28 — July 10	July 5 — July 18	July 12 — Sept. 17	SUMMER
1933		May 29 — June 10	May 31 — June 12	June 7 — June 19	June 13 — June 27	June 20 — July 5	June 27 — July 12	July 6 — July 20	July 13 — Sept. 23	
1934		June 8 — June 19	June 9 — June 22	June 16 — June 30	June 23 — July 8	June 30 — July 15	July 6 — July 23	July 12 — Aug. 1	July 17 — Oct. 2	
1935		June 27 — July 6	June 28 — July 9	July 5 — July 15	July 10 — July 23	July 16 — July 31	July 22 — ?	July 27 — ?	Aug. 3 — Sept. 25	
1936		June 19 — ?	June 20 — ?	June 26 — ?	Observations discontinued					

or disappearance of the stage may in a few cases be a day or two earlier or later than given. However, observations for the five years check rather closely with each other and it is believed

that the record as a whole is quite accurate. Figure 2 shows the life cycle diagrammatically for the year 1933.

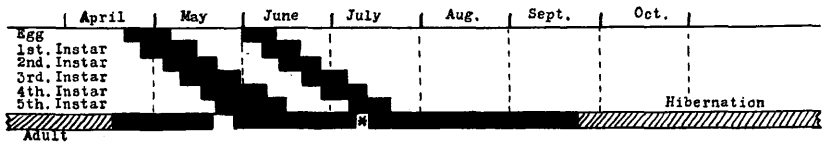

Figure 2. The stages of *C. aesculi* O. & D. present in the field at various times during a typical season. Based on the records of the year 1933. *Spring and summer brood possibly overlap at this time.

Table V gives the average duration of the various instars and Table VI gives their average length in millimeters. Figure 3 shows the egg, the five nymphal instars, and the adult of *C. aesculi*. These figures were all drawn to scale under a compound microscope by Mr. John Hughes. These tables and figures are self-explanatory and need no further discussion.

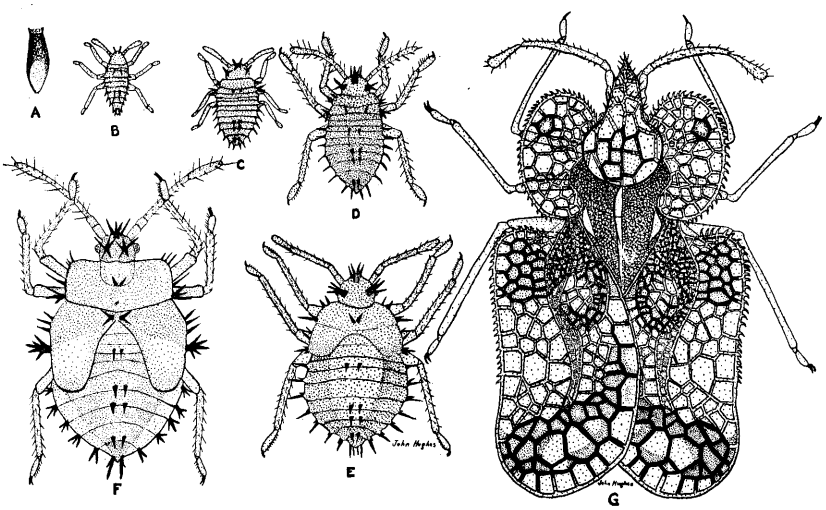

Figure 3. Various stages in the development of *C. aesculi* O. & D. A, egg; B, 1st instar; C, 2nd instar; D, 3rd instar; E, 4th instar; F, 5th instar; G, adult. All stages are drawn to the same scale.

The spring brood develops in much greater numbers than the summer brood for several reasons. The food supply as a rule is much more abundant and succulent in the spring, whereas the summer brood appears at a time when the spring brood has already inflicted heavy injury upon the preferred

portions of the food plant. Many leaves become dry and drop from the trees carrying with them eggs and young nymphs of the summer brood. These usually do not get back to the host plants. Predators are also more abundant when the second brood appears and take a greater toll from it.

TABLE V

DURATION OF THE VARIOUS INSTARS IN THE DEVELOPMENT OF *C. aesculi* O. & D. IN DAYS; BASED ON FIVE-YEAR RECORDS

STAGE IN DEVELOPMENT			EGG	NYMPHAL INSTARS					ADULT
				1st.	2nd.	3rd.	4th.	5th.	
Length in Days	Spring Brood	Range.....	6–13	7–9	5–15	7–9	5–8*	6–9	26–42†
		Mean.....	8.8	7.6	7.7	7.7	6.8*	7.2	35†
	Summer Brood	Range.....	5–7	5–8	6–8	6–8	5–8	5–7	Overwinters
		Mean.....	6.8	6.5	7.0	7.1	7.1	6.3	

*The 4th instar of the spring brood is of shorter duration than any of the other instars of the brood. This does not hold for the summer brood.

†It may be that some individuals of the spring brood survive somewhat longer, for after the summer brood matures it is impossible to separate individuals of the two broods.

TABLE VI

MEASUREMENTS OF THE VARIOUS STAGES IN THE DEVELOPMENT OF *C. aesculi* O. & D. EACH FIGURE REPRESENTS THE AVERAGE OF TWENTY-FIVE INDIVIDUALS

STAGE	LENGTH IN MILLIMETERS
Egg	0.475–0.481
1st. instar nymph	0.64 –0.8
2nd. " "	0.88 –1.04
3rd. " "	1.2 –1.41
4th. " "	1.6 –1.84
5th. " "	2.24 –2.48
Adult	4.0 –4.4

Adults of the summer brood usually appear about the middle of July and remain in the environment in varying numbers until September or October when they go into hibernation upon the advent of cold weather.

EFFECTS ON THE HOST PLANT

The overwintering adult tingitids begin to feed upon the leaf buds of the yellow buckeye before they have a chance to open in the spring. Before long feeding scars become apparent on the under surface of the leaves. The bases of the eggs are inserted along the principal veins and a large number of scars result from this habit of oviposition. Fecal material is also deposited on the under surface of the leaves in the form of multitudinous flecks which block large numbers of the stomata. When the eggs hatch, the nymphs feed in aggregations on the under surface of the leaves and soon the entire areas where they are feeding turn yellowish and finally brown.

The spring brood feeds mainly on young trees and on the lower branches of older trees. Very few individuals are seen at

TABLE VII

MEASUREMENT OF GROWTH OF TWENTY YOUNG TREES, *Aesculus octandra* Marsh.

MEAN HEIGHT		MEAN CIRCUMFERENCE OF TRUNK TWO FEET ABOVE GROUND	
May 7, 1932	June 17, 1936	May 7, 1932	June 17, 1936
6 ft. 8 in.	7 ft. 5 in.	2.5 in.	2.7 in.

heights greater than twenty feet above the ground. By July 1 most of the leaves of the young trees and on the lower branches of older trees are turned brown and begin to fall off. By the middle of July many of the young trees are nearly bare. Many of the eggs of the spring brood deposited in these leaves perish when they hatch, for the nymphs usually do not again reach a food plant. The second or summer brood develops largely from eggs deposited on leaves higher on the older trees and from the few leaves that survive injury by the spring brood and remain on the younger trees.

The injury to the trees is evidently not severe enough to kill but it is probably sufficient to retard growth of the trees. Table VII gives measurements on the growth of twenty young trees in the areas studied.

THE RELATION OF *C. aesculi* TO OTHER INSECTS ON BUCKEYE

Both predators and competitors of *C. aesculi* O. & D. are present. The predators are more important and consist largely of beetles. Table VIII lists the predators, their comparative

TABLE VIII

THE PREDATORS OF *C. aesculi* O. & D. OBSERVED IN THE FIELD AND THE STAGES ATTACKED BY EACH

Abundance is rated as follows: (A) abundant, 1 or more per leaf; (C) common, 1 or more per 10 leaves; (F) frequent, 5 or more observed per trip; (S) scarce, less than 5 individuals seen per trip; (R) rare, less than 5 individuals seen altogether.

FAMILY AND SPECIES	ABUNDANCE	STAGES OF *C. aesculi* ATTACKED IN FIELD
LAMPHYRIDAE:		
Lucidota atra (Fabr.)	F	Nymph 1
Photinus pyralis (L.)	F	Nymph 2
" *scintillans* (Say)	R	Not observed feeding
Photuris pennsylvanica (DeG.)	F	Nymph 1, 2, 3
CANTHARIDAE:		
Chauliognathus marginatus Fab	F	Not observed feeding
Podabrus tricostatus (Say)	R	Nymph 1
" *basillaris* (Say)	F	Nymph 1, 2
" *modestus* (Say)	S	Not observed feeding
CLERIDAE:		
Enoclerus quadriguttatus Oliv	R	Nymph 1
COCCINELLIDAE:		
Hyperaspis binotata (Say)	F	Egg, Nymph 1, 2, 3, 4
Brachyacantha ursina (Fab.)	S	Not observed feeding
" *quadripunctata* (Melsh.)	S	Egg
Microweisea misella (Lec.)	S	Egg, Nymph 1
Stethorus punctum (Lec.)	S	Egg
Scymnus fraternus Lec	A	Egg, 1, 2, 3, 4, 5
" *rubricauda* Csy	C	Egg, 1, 2
" *collaris* Melsh	F	Egg
" *puncticollis* Lec	S	Egg
" *punctatus* Melsh	R	Egg
" *flavifrons* Melsh	S	Egg, 1
Delphastus pusillus (Lec.)	A	Egg
Psyllobora 20-maculata (Say)	A	Egg
Ceratomegilla fuscilabris (Muls.)	F	Egg, 1, 2, 3, 4, 5, Adult
Hippodamia convergens Guer	F	Egg, 1, 2, 3
Neoharmonia venusta (Melsh.)	R	Egg
Coccinella 9-notata Hbst	F	Nymph 1
Cycloneda munda (Say)	F	Nymph 1, 2, 3
Adalia bipunctata (L.)	F	Egg, 1, 2, 3, 4
Chilocorus bivulnerus Muls	S	Egg
ORTHOPERIDAE:		
Orthoperus glaber Lec	C	Faeces, Egg
CHRYSOPIDAE:		
Larvae, sp. not determined	C	Nymphs 1, 2, 3, 4, 5
HEMEROBIIDAE:		
Larvae, sp. undetermined	C	Nymphs 1, 2
PENTATOMIDAE:		
Brochymena arborea (Say)	S	Nymph 5, Adult
ANTHOCORIDAE:		
Lyctocoris stalii (Reuter)	S	Egg, Nymph 1
Xylocoris cursitans (Fallen)	F	Egg
MIRIDAE:		
Camptobrochus nebulosus Uhler	F	Egg, Nymph 1, 2
ARACHNIDA:		
Synemosyna formica Hentz	F	Egg, Nymph 1, 2, 3
Dictyna foliacea (Hentz)	F	Nymph 1, 2
Two other spiders undetermined	R	Nymph 1, 2

abundance, and the stages of *C. aesculi* attacked by them. Some species of beetles that are known to be predacious on other insects although not observed feeding on *C. aesculi*, were present on the trees and are listed in the table for it is very likely that most of them do feed on the tingitids.

Of the forms studied the lady beetles form by far the most important group of predators upon *C. aesculi*, and among them *Scymnus fraternus*, *Scymnus rubricauda*, *Delphastus pusillus*, *Psyllobora 20-maculata*, and *Adalia bipunctata* are the most effective. The predators destroy large numbers of young of *C. aesculi* in all stages from the egg to the fourth instar and smaller numbers of the older stages. The toll taken from the summer brood is greater in proportion than that taken from the

TABLE IX

EGGS OF *C. aesculi* O. & D. DEVOURED BY PREDATORS IN CAPTIVITY IN FOUR, FIVE, OR SIX DAYS

PREDATORS	NUMBER OF INDIVIDUALS	TOTAL EGGS CONSUMED	EGGS CONSUMED PER DAY
Scymnus fraternus Lec.	4	292	14.6
Scymnus rubricauda Csy.	8	500	12.5
Delphastus pusillus (Lec.)	10	470	8.7
Ceratomegilla fuscilabris (Muls.)	3	350	25.
Psyllobora 20-maculata (Say)	15	1407	17.8
Adalia bipunctata (L.)	7	851	23.

spring brood. The numbers destroyed are not sufficient, however, to keep the tingitid from becoming exceedingly abundant as has been shown in the preceding sections of this paper.

A few experiments were carried out to determine the number of tingitid eggs destroyed by some of the lady beetle predators. Table IX gives the results of these.

Various parasitic Hymenoptera were observed on the foliage frequently but no oviposition was noted and no parasites were reared from any of the eggs or nymphs that were caged.

There are certain insects that attack the buckeye leaves and thus serve as competitors of *C. aesculi*. Some of these became fairly abundant at times, but at no time was their influence

great enough to bring about a shortage of food for the tingitids. Table X gives a list of those observed feeding on buckeye leaves.

Another tingitid, *Gargaphia tiliae* Walsh, sometimes occurs abundantly on the yellow buckeye during the mating season. It has never been observed to feed upon the leaves. Many other species of insects were observed on the foliage occasionally but since they were few in numbers and no feeding activity was observed, they are omitted from this discussion.

TABLE X

INSECTS FOUND FEEDING ON THE LEAVES OF THE YELLOW BUCKEYE, *Aesculus octandra* MARSH., IN COMPETITION WITH *C. aesculi* O. & D.

FAMILY AND SPECIES	ABUNDANCE
HOMOPTERA:	
Cicadellidae.	
Graphocephala versuta (Say)	F
Erythroneura vulnerata (Fitch)	A
Erythroneura basilaris (Say)	F
LEPIDOPTERA:	
Geometridae.	
Larvae, sp. undetermined	F
COLEOPTERA:	
Scarabaeidae.	
Dichelonyx subvittata Lec	R
Chrysomelidae.	
Syneta ferruginea (Germ.)	S
Nodonota puncticollis (Say)	S
Paria canella (Fab.) and var	C
Diabrotica 12-punctata (Fab.)	F
Diabrotica vittata (Fab.)	F
Luperodes cyanellus Lec	S
Crepidodera erythropus Melsh	A
Epitrix fuscula Cr	S
Epitrix cucumeris Har	C
Chaetocnema minuta Melsh	C
Baliosus ruber (Web.)	R
Chiridia guttata (Oliv.)	F
Metriona bicolor (Fab.)	F
Mylabridae.	
Mylabris mimus (Say)	C
Curculionidae.	
Two sp. undetermined	F

SUMMARY

1. The life history of *Corythucha aesculi* O. & D. on yellow buckeye, *Aesculus octandra* Marsh., has been studied for five years and the data summarized for each stage of development.

2. The sex ratio of *C. aesculi* is approximately .76.

3. The spring brood confines its attack largely to young trees and the lower branches of older trees.

4. The summer brood develops mainly in older trees twenty or more feet above the ground.

5. Many eggs and young of the summer brood never develop because the leaves on which the eggs are laid drop from the trees and the young do not get back to their food plant.

6. Forty predators, mainly insects, were found on the buckeye trees. Most of these were observed to attack one or more stages of *C. aesculi* and thus reduce the populations of both broods. They are not effective enough to control the tingitid.

7. Six species of lady beetles have been fed upon the eggs of *C. aesculi* while in captivity.

8. Twenty-one insects have been observed feeding upon the leaves of the yellow buckeye in competition with *C. aesculi*. None of them were ever abundant enough to cause a shortage of food for the tingitid.

9. Injury to leaves of young buckeye trees causes them to drop their leaves in midsummer. This results in slow growth of the trees. Older trees seemingly suffer little injury since only the lower leaves are severely injured.

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