

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

IMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. Un		1b. RESTRICTIVE MARKINGS	
2a. AD-A223 548		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.	
2b.			
4. PERFORMING ORGANIZATION REPORT NUMBER(S) USAFSAM-JA-90-31		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZATION USAF School of Aerospace Medicine (USAFSAM)	6b. OFFICE SYMBOL (If applicable) EKEN	7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State, and ZIP Code) Human Systems Division (AFSC) Brooks AFB TX 78235-5301		7b. ADDRESS (City, State, and ZIP Code)	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION USAF School of Aerospace Medicine	8b. OFFICE SYMBOL (If applicable) EKEN	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State, and ZIP Code) Human Systems Division (AFSC) Brooks AFB TX 78235-5301		10. SOURCE OF FUNDING NUMBERS	
		PROGRAM ELEMENT NO. N/A	PROJECT NO. N/A
		TASK NO. N/A	WORK UNIT ACCESSION NO. N/A
11. TITLE (Include Security Classification) Life histories of selected caddisflies (Trichoptera) in an Ozark stream, U.S.A.			
12. PERSONAL AUTHOR(S) Bowles, David E.; Allen, Robert T.			
13a. TYPE OF REPORT Interim	13b. TIME COVERED FROM 0885 TO 0490	14. DATE OF REPORT (Year, Month, Day) 1990, April	15. PAGE COUNT 20
16. SUPPLEMENTARY NOTATION N/A			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	Trichoptera, life histories, univoltine, bivoltine, Ozark stream	
06	13		
06	03		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Life histories for <i>Agapetus illini</i> , <i>Chimarra aterrima</i> , <i>C. obscura</i> , <i>Helicopsyche limnella</i> , <i>Polycentropus centralis</i> , <i>Wormaldia moesta</i> , and <i>Cheumatopsyche</i> spp. were estimated by determining the seasonal occurrence and relative abundance of larval instars and pupae and from adult collections. Head capsule width measurements revealed that all species studied had five larval instars. <i>Agapetus illini</i> and <i>W. moesta</i> were univoltine, but bivoltine life histories with overlapping generations were observed for <i>C. aterrima</i> , <i>C. obscura</i> , <i>H. limnella</i> , and <i>P. centralis</i> . Although four species of <i>Cheumatopsyche</i> were recognized in adult collections, immature stages were not differentiated. When considered at the generic level, <i>Cheumatopsyche</i> appears to be bivoltine, and data suggest that all four species are likely bivoltine. Adults of bivoltine species generally were prevalent from early spring through late autumn; adults of univoltine species (<i>A. illini</i> and <i>W. moesta</i>) were collected only during May. For the bivoltine species, larval recruitment from reproduction occurs throughout the adult flight period. Bivoltinism appears to be a common life-history pattern in warm water streams of southern latitudes in North America. <i>JES</i>			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL David E. Bowles, Capt, USAF, BSC		22b. TELEPHONE (Include Area Code) (512) 536-3471	22c. OFFICE SYMBOL USAFSAM/EKEN

Address correspondence to:
Capt. David E. Bowles
USAFSAM/EKEN
Brooks AFB, TX 78235
(512) 536-3471

Submitted to:
Journal of the North
American Benthological
Society

LIFE HISTORIES OF SELECTED CADDISFLIES (TRICHOPTERA)
IN AN OZARK STREAM, U. S. A. ¹

David E. Bowles ^{2,3} and Robert T. Allen

Department of Entomology, University of Arkansas,
Fayetteville, Arkansas 72701

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Special
A-1	

Running head: Life histories of Ozark caddisflies.

¹ Approved for publication by the Director, Arkansas Agricultural
Experiment Station, University of Arkansas, Fayetteville, Arkansas 72701.

² Present address: Medical Entomology Section, United States Air Force
School of Aerospace Medicine, Human Systems Division, Air Force Systems
Command, Brooks AFB, Texas 78235.

³ Opinions and assertions contained herein are those of the authors and are
not to be regarded as official or as reflecting the views of the United
States Air Force.

Abstract. Life histories for Agapetus illini, Chimarra aterrima, C. obscura, Helicopsyche limnella, Polycentropus centralis, Wormaldia moesta, and Cheumatopsyche spp. were estimated by determining the seasonal occurrence and relative abundance of larval instars and pupae and from adult collections. Head capsule width measurements revealed that all species studied had five larval instars. Agapetus illini and W. moesta were univoltine, but bivoltine life histories with overlapping generations were observed for C. aterrima, C. obscura, H. limnella, and P. centralis. Although four species of Cheumatopsyche were recognized in adult collections, immature stages were not differentiated. When considered at the generic level, Cheumatopsyche appears to be bivoltine, and data suggest that all four species are likely bivoltine. Adults of bivoltine species generally were prevalent from early spring through late autumn; adults of univoltine species (A. illini and W. moesta) were collected only during May. For the bivoltine species, larval recruitment from reproduction occurs throughout the adult flight period. Bivoltinism appears to be a common life-history pattern in warmwater streams of southern latitudes in North America.

Key words: Trichoptera, life histories, univoltine, bivoltine, Ozark stream.

Caddisfly (Trichoptera) larvae are a common component of freshwater benthic communities with streams being the most common habitat (Wiggins 1977, Wiggins and Mackay 1978). Because of their abundance and diversity in aquatic habitats, caddisflies play major roles in energy transfer in these ecosystems. Despite the inclusion of caddisflies in a large number of ecological studies, much remains to be learned about these insects, particularly regarding their life histories.

Basic-life history information is an important, if not essential, element of ecological studies of aquatic insects (Resh 1979, Waters 1979). Failure to adequately consider life history in the design of ecological studies can seriously compromise the accuracy and validity of those studies. Oliver (1979) expressed the view that life-history studies also may benefit taxonomic studies by providing a wealth of information on biological aspects of a species such as reproductive isolation and associated life stages.

Although detailed life-history studies have been completed for a number of trichopteran species in North America (e.g., Beam and Wiggins 1987, Gotceitas and Clifford 1983, Krueger and Cook 1984, Mackay 1986, Martin 1985, Martinson and Ward 1982, Patterson and Vannote 1979, Singh et al. 1984, Winterbourn 1971), life histories of most species are yet to be determined. Also, little comparative information is available on life histories for a given species inhabiting different geographical regions.

The objective of this investigation was to study the life histories of selected caddisflies from an Ozark stream.

METHODS

Samples were collected from third-order reach of the Mulberry River, Johnson County, Arkansas from August 1985 to August 1986. The upper Mulberry River is a pristine stream having a well-developed riparian canopy. Substrate

at the study site was chiefly pebble and cobble (Wentworth 1922) and a few large boulders were scattered within the stream channel. Aquatic vegetation was sparse and dominated by water willow (Justicia americana (L.)), and algae, including Batrachospermum moniloforme Roth, Nostoc parmeloides Kutz, and Lemanea sp. Water temperatures ranged between 6.0 and 32.0°C; current velocities and point discharge ranged between 0.26-2.34 m/sec and 0.10-13.75 m³/sec, respectively. A more detailed description of the study area can be found in Bowles (1990).

Benthic samples were collected from riffles with a modified Hess sampler (0.1 m², 243 µm-mesh) (Waters and Knapp 1961). Samples were collected twice monthly May through October and monthly from November through March. No collections were made during April due to high water levels. On each sampling date, 24 samples were collected.

Samples were preserved in the field with 10% formalin and returned to the laboratory where they were sorted under 10X magnification. All trichopteran larvae and pupae were identified to the lowest possible taxonomic level and counted. Head capsule widths at the eyes were measured with a calibrated ocular micrometer for a selected number of species including, Agapetus illini Ross, Chimarra aterrima (Hagen), Chimarra obscura (Walker), Wormaldia moesta (Banks), Helicopsyche limnella Ross, and Polycentropus centralis Banks. Larvae and pupae of Cheumatopsyche were not identified to species, but these data were grouped to reconstruct the life history at the generic level.

For each species, larval instars were estimated by plotting head capsule widths against numbers collected, and life histories were estimated by plotting the proportion of each larval instar and pupae by sampling date. Adult flight periods were determined by intensive ultraviolet (UV)-light trapping during March through October. Adults were collected throughout the upper Mulberry River basin, but never from the precise study location in order

to avoid possible negative effects of adult removal on larval recruitment from reproduction. A voucher collection of immature and adult representatives of the species studied is deposited in the University of Arkansas Insect Collection.

RESULTS

All species studied had five distinct larval instars. Mean head capsule widths for each species and associated statistics for each larval instar are given in Table 1.

Chimarra aterrima and C. obscura, Helicopsyche limnella, and Polycentropus centralis had similar bivoltine life histories with overlapping generations (Figs. 1-4). The two generations are indicated by the large proportions of first-instar larvae of a given species relative to the other instars during spring and autumnal periods. All of these species had representatives of most larval instars present throughout the year. However, larvae of H. limnella were not collected from December through March. Adult emergence was most prevalent during the warmer months (i.e., April through October), and larval recruitment through reproduction generally paralleled adult flight periods.

Larvae and pupae of Cheumatopsyche could not be distinguished reliably at the species level. However, adult collections revealed the presence of four species. These were: Cheumatopsyche aphantha Ross, May-September; C. campyla Ross, July-August; C. minuscula (Banks), April-May, July-September; and C. pettiti (Banks), June-July, September. The life history of Cheumatopsyche spp. also appeared to be bivoltine (Fig. 5). Larval recruitment through reproduction occurred May through October, and larvae overwintered (November through March) in instars II through V. Pupae were collected May through September.

Agapetus illini and Wormaldia moesta were found to have distinctly univoltine life histories (Figs. 6 and 7). Larvae of A. illini were

collected only from October through May; pupae and adults were collected only during May. First-instar larvae of A. illini were poorly represented in benthic collections.

Larvae of W. moesta were most prevalent during winter and early spring, but first-instar larvae were collected in small numbers throughout most of the year. Pupae of W. moesta were collected during May, but adults were not collected at the study site. However, adults were collected at nearby streams from April through early June (Bowles and Mathis 1989) most likely reflecting the emergence pattern of the Mulberry River population.

DISCUSSION

Bivoltinism, interpreted here to be the occurrence of two generations in approximately a one year period, was the most common life-history pattern for the species of caddisflies examined in this study. Although C. aterrma and C. obscura could possibly be trivoltine, the more conservative bivoltine life history is probable despite the appearance of multiple generations. For example, mature larvae of C. obscura (generation one) pupated and emerged in late spring, producing a second generation, as evidenced by the large proportion of first instar larvae collected in early June (Fig. 2). This second generation emerged during late summer. Bivoltine species with several overlapping cohorts superficially can resemble a trivoltine species, but, conversely, continuous larval recruitment can obscure a third generation (Parker and Voshe11 1982). The larvae of C. aterrma and C. obscura counted as first-instars during the winter months (December through February) may actually have been small second-instars, the small size being attributable to natural variation or a slower growth rate resulting from colder water temperatures. However, emergence (and possible reproduction) of adult Trichoptera during winter is not uncommon in northwest Arkansas (Bowles and

Mathis 1989, Unzicker et al. 1970). A similar situation was observed for P. centralis, (Fig. 4).

Life history information for C. aterrma and C. obscura from other geographical locations is scant. Williams and Hynes (1973) reported a population of C. aterrma from a Canadian stream to be univoltine. Similarly, Parker and Voshell (1983) reported a population of C. obscura from Virginia to be univoltine. However, Parker and Voshell (1982) found another population of C. obscura to be bivoltine with overlapping generations. Bivoltine life histories are more commonly reported than univoltine ones for Chimarra species from southern North America (Benke et al. 1984, Cudney and Wallace 1980).

The life history of H. limnella previously has not been reported and little is known about the biology of this Interior Highland endemic species. Univoltinism has been most commonly reported for other species of Helicopsyche. Jackson and Fisher (1986) reported a population of H. mexicana Ross from Arizona to be univoltine, and Williams et al. (1983) suggested that northern populations of H. borealis (Hagen) are univoltine. Vaughn (1985) found that H. borealis in Oklahoma was univoltine in a thermally fluctuating stream, but multivoltine with overlapping generations in a thermally constant stream. A California population of H. borealis was reported by Resh et al. (1984) to be univoltine with a single cohort, but larval instars could not be distinguished by head capsule measurements.

Although adults of P. centralis were collected from April through September, pupae were collected only during May, June, and September. This suggests that P. centralis either had delayed emergence or, perhaps more likely, that pupae were represented inadequately in benthic samples during periods of adult emergence. Polycentropus centralis overwintered as all larval instars, but first-instars were uncommon during the winter months,

being collected only during February. Information on life histories of Polycentropus is scant. Krueger and Waters (1983) found a population of an unidentified species in Minnesota to be univoltine.

Identification of larvae and pupae of Cheumatopsyche to the species level was a problem in this study as it is in other ecological studies as well (Benke et al. 1984, Freeman and Wallace 1984, Neves 1979, Parker and Voshell 1982). Although reconstructing life histories at the genus level encompasses greater error than that at the species level, a reasonable estimate still can be provided. The bivoltine life history reported here for the genus appears to be probable and likely reflects the life-history patterns of the individual species in the Mulberry River. Most of the four species identified as adults (i.e., C. aphantia, C. campyla, C. minuscula, C. pettiti) collected in UV-light samples at the Mulberry River, exhibited broad flight periods. The single exception was C. campyla, collected only during July and August. However, collections representing this species from other Ozark streams have ranged from March through October (Bowles and Mathis 1989).

Voltinism has been reported for numerous species of Cheumatopsyche, but detailed life-history studies generally are lacking. Other investigations have shown some species of Cheumatopsyche considered here to have both univoltine and bivoltine life histories, depending on geographical location. Cloud and Stewart (1974) reported a bivoltine life history for C. campyla in the Brazos River, Texas. Univoltine life histories have been reported for C. pettiti from Minnesota streams (MacFarlane and Waters 1982, Mackay and Waters 1986). However, most species of Cheumatopsyche from the warmwater streams of southern latitudes probably have two or more generations per year (Benke et al. 1984, Cudney and Wallace 1980, Freeman and Wallace 1984, Parker and Voshell 1982). The life histories of C. aphantia and C. minuscula previously have not been reported.

Life-history studies of Agapetus suggest that univoltinism is common for this genus. Anderson and Bourne (1974) reported A. bifidus Denning from an Oregon stream to be univoltine as did Neves (1979) for A. pinatus from Massachusetts. Georgian and Wallace (1983) found a North Carolina population of Agapetus (species undetermined) to have a univoltine life history. Ross (1944) noted that A. illini had one generation per year in the Ozarkian streams of southern Illinois, but few specific details of the life history were reported. The head capsule widths of the larval instars of A. bifidus reported by Anderson and Bourne (1974) mirrored those reported here for A. illini. Anderson and Bourne (1974) found that A. bifidus from an Oregon stream had an 8-9 month egg-diapause. Similarly, Wiggins (1977) suggested that the spring occurrence of A. illini in temporary streams of Illinois (based on Ross 1944) also might be due to a long egg-diapause. Although the Mulberry River is not a temporary stream, the long absence (Fig. 6) of A. illini from benthic collections may be the result of an egg-diapause which serves as a mechanism for avoiding unfavorably high water temperatures (up to 32°C) that occur during summer (see Beam and Wiggins 1987).

Poor representation of early instars, especially the first, in benthic collections when they are known to be present (e.g., the first-instar A. illini in this study) has been a common problem in life-history and other ecological studies of aquatic insects (Benke and Wallace 1980, Cudney and Wallace 1980, Freeman and Wallace 1984, Mackay and Waters 1986, Short et al. 1987, Waters and Crawford 1973). The reasons for such poor representation are unclear but may relate to sampling inadequacy (e.g., not sampling all available microhabitats), less time spent in earlier instars (Benke and Wallace 1980), or clumped distributions of first-instar larvae attributable to female ovipositional behaviors. The failure to adequately document the presence of first-instar larvae of A. illini in this study does not impact the

univoltine life-history interpretation.

The presence of first-instar larvae of W. moesta throughout the period following adult emergence until the following spring suggests an extended egg hatch period for this species in the Mulberry River. However, the absence of larger instars throughout much of this time cannot be explained readily, but may relate to increased mortality due to emergence during stressful or non-optimum periods. Singh et al. (1984) reported that first-instar larvae of W. moesta in a southern Ontario headwater stream were present for 10 weeks following adult emergence and instars III-V were present for only 2-4 months. Singh et al. (1984) reported finding W. moesta pupae over a 14-week period, in contrast to the approximately 4-week period observed in this study. Aside from that difference, the life histories appear to be similar for both geographical locations.

Trichopteran life histories reported from the warmwater streams of southern North America are principally bivoltine while those reported from the coolwater streams of the north are predominately univoltine. A given species (ex., C. aterrima, C. obscura) may have warmwater populations that are bivoltine and coolwater populations that are univoltine. However, other species (ex., A. illini, W. moesta) may be univoltine throughout their known range.

Life-history patterns may be influenced by a number of factors including water temperature, photoperiod, availability and quality of food resources (Anderson and Cummins 1979), geographic location, climatic conditions with associated ecological factors, and environmental disturbance (Lehinkuhl 1979). Also, the evolutionary history of taxa plays a significant role in life-history patterns. The relative contribution of each of these factors is difficult to interpret, but further investigation should serve to clarify this problem.

ACKNOWLEDGEMENTS

We thank Drs. Chris Carlton and Max Meisch (University of Arkansas) and Drs. Chad McHugh, Drew Pinkovsky, and Mr. Terry Carpenter (USAF School of Aerospace Medicine) for providing critical comments on this manuscript. Mike Mathis, University of Arkansas, also reviewed this paper and provided invaluable assistance with graphics.

LITERATURE CITED

- Anderson, N. H., and J. R. Bourne. 1974. Bionomics of three species of glossosomatid caddis flies (Trichoptera: Glossosomatidae) in Oregon. *Canadian Journal of Zoology* 52:405-411.
- Anderson, N. H., and K. W. Cummins. 1979. Influences of diet on the life histories of aquatic insects. *Journal of the Fisheries Research Board of Canada* 36:335-342.
- Beam, B. D., and G. B. Wiggins. 1987. A comparative study of the biology of five species of Neophylax (Trichoptera: Limnephilidae) in southern Ontario. *Canadian Journal of Zoology* 65:1741-1754.
- Benke, A. C., T. V. Van Arsdall, Jr., and D. M. Gillespie. 1984. Invertebrate productivity in a subtropical blackwater river: the importance of habitat and life history. *Ecological Monographs* 54:25-63.
- Benke, A. C., and J. B. Wallace. 1980. Trophic basis of production among net spinning caddisflies in a southern Appalachian stream. *Ecology* 61:108-118.
- Bowles, D. E. 1990. Life history and variability in secondary production estimates for Corydalis cornutus (Megaloptera: Corydalidae) in an Ozark stream. *Journal of Agricultural Entomology* 7:61-70.
- Bowles, D. E., and M. L. Mathis. 1989. Caddisflies (Insecta: Trichoptera) of mountainous regions in Arkansas, with new state records for the order. *Journal of the Kansas Entomological Society* 62:234-244.
- Cloud, T. J., and K. W. Stewart. 1974. Seasonal fluctuations and periodicity in the drift of caddisfly larvae (Trichoptera) in the Brazos River, Texas. *Annals of the Entomological Society of America* 67:805-811.
- Cudney, M. D., and J. B. Wallace. 1980. Life cycles, microdistribution and production dynamics of six species of net-spinning caddisflies in a large southeastern (U.S.A.) river. *Holarctic Ecology* 3:169-182.

- Freeman, M. C., and J. B. Wallace. 1984. Production of net-spinning caddisflies (Hydropsychidae) and black flies (Simuliidae) on rock outcrop substrate in a small southeastern Piedmont stream. *Hydrobiologia* 112:3-15.
- Georgian, T., and J. B. Wallace. 1983. Seasonal production dynamics in a guild of periphyton-grazing insects in a southern appalachian stream. *Ecology* 64:1236-1248.
- Gotceitas, V., and H. F. Clifford. 1983. The life history of Dicosmoecus atripes (Hagen) (Limnephilidae: Trichoptera) in a Rocky Mountain stream of Alberta, Canada. *Canadian Journal of Zoology* 61:586-596.
- Jackson, J. K., and S. G. Fisher. 1986. Secondary production, emergence, and export of aquatic insects of a Sonoran Desert stream. *Ecology* 67:629-638.
- Krueger, C. C., and E. F. Cook. 1984. Life cycles and drift of Trichoptera from a woodland stream in Minnesota. *Canadian Journal of Zoology* 62:1479-1484.
- Krueger, C. C., and T. F. Waters. 1983. Annual production of macroinvertebrates in three streams of different water quality. *Ecology* 64:840-850.
- Lehmkuhl, D. M. 1979. Environmental disturbance and life histories: principles and examples. *Journal of the Fisheries Research Board of Canada* 36:329-334.
- MacFarlane, R. J. and T. F. Waters. 1982. Annual production by caddisflies and mayflies in a western Minnesota plains stream. *Canadian Journal of Fisheries and Aquatic Sciences* 39:1628-1635.
- Mackay, R. J. 1986. Life cycles of Hydropsyche riola, H. slossonae, and Cheumatopsyche pettiti (Trichoptera: Hydropsychidae) in a spring-fed stream in Minnesota. *American Midland Naturalist* 115:19-25.

- Mackay, R. J., and T. F. Waters. 1986. Effects of small impoundments on hydropsychid caddisfly production in Valley Creek, Minnesota. *Ecology* 67:1680-1686.
- Martin, I. D. 1985. Microhabitat selection and life cycle patterns of two Rhyacophila species (Trichoptera: Rhyacophilidae) in southern Ontario streams. *Freshwater Biology* 15:1-14.
- Martinson, R. J., and J. V. Ward. 1982. Life history and ecology of Hesperophylax occidentalis (Banks) (Trichoptera: Limnephilidae) from three springs in the Piceance Basin, Colorado. *Freshwater Invertebrate Biology* 1:41-47.
- Neves, R. J. 1979. Secondary production of epilithic fauna in a woodland stream. *American Midland Naturalist* 102:209-224.
- Oliver, D. R. 1979. Contribution of life history information to taxonomy of aquatic insects. *Journal of the Fisheries Research Board of Canada* 36:318-321.
- Parker, C. R., and J. R. Voshell, Jr. 1982. Life histories of some filter-feeding Trichoptera in Virginia. *Canadian Journal of Zoology* 60:1732-1742.
- Parker, C. R., and J. R. Voshell, Jr. 1983. Production of filter-feeding Trichoptera in an impounded and a free-flowing river. *Canadian Journal of Zoology* 61:70-87.
- Patterson, J. W., and R. L. Vannote. 1979. Life history and population dynamics of Heteroplectron americanum. *Environmental Entomology* 8:665-669.
- Resh, V. H. 1979. Sampling variability and life history features: basic considerations in the design of aquatic insect studies. *Journal of the Fisheries Research Board of Canada* 36:290-311.

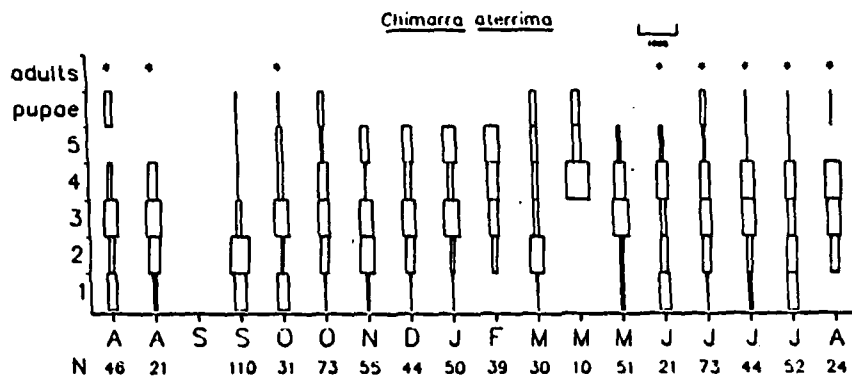
- Resh, V. H., G. A. Lamberti, and J. R. Wood. 1984. Biology of the caddisfly Helicopsyche borealis (Hagen): A comparison of North American populations. *Freshwater Invertebrate Biology* 3:172-180.
- Ross, H. H. 1944. The caddis flies, or Trichoptera, of Illinois. *Bulletin of the Illinois Natural History Survey* 23:1-326.
- Short, R. A., E. H. Stanley, J. W. Harrison, and C. R. Epperson. 1987. Production of Corydalis cornutus (Megaloptera) in four streams differing in size, flow, and temperature. *Journal of the North American Benthological Society* 6:105-114.
- Singh, M. P., S. M. Smith, and A. D. Harrison. 1984. Life cycles, microdistribution, and food of two species of caddisflies (Trichoptera) in a wooded stream in southern Ontario. *Canadian Journal of Zoology* 62:2582-2588.
- Unzicker, J. D., L. Aggus, and L. O. Warren. 1970. A preliminary list of the Arkansas Trichoptera. *Journal of the Georgia Entomological Society* 5:167-174.
- Vaughn, C. C. 1985. Life history of Helicopsyche borealis (Hagen) (Trichoptera: Helicopsychidae) in Oklahoma. *American Midland Naturalist* 113:76-83.
- Waters, T. F. 1979. Benthic life histories: summary and future needs. *Journal of the Fisheries Research Board of Canada* 36:342-345.
- Waters, T. F., and G. W. Crawford. 1973. Annual production of a stream mayfly population: a comparison of methods. *Limnology and Oceanography* 18:286-296.
- Waters, T. F., and R. J. Knapp. 1961. An improved stream bottom sampler. *Transactions of the American Fisheries Society* 90:225-226.
- Wentworth, C. K. 1922. A grade scale and class terms for clastic sediments. *Journal of Geology* 30:377-392.

- Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press: Toronto.
- Wiggins, G. B., and R. J. Mackay. 1978. Some relationships between systematics and trophic ecology in nearctic aquatic insects with special reference to Trichoptera. *Ecology* 59:1211-1220.
- Williams, D. D., A. T. Reed, and K. A. Moore. 1983. The distribution and zoogeography of Helicopsyche borealis (Trichoptera: Helicopsychidae): a nearctic representative of a tropical genus. *Canadian Journal of Zoology* 61:2288-2299.
- Williams, N. E., and H. B. N. Hynes. 1973. Microdistribution and feeding of the net-spinning caddisflies (Trichoptera) of a Canadian stream. *Oikos* 24:73-84.
- Winterbourn, M. J. 1971. An ecological study of Banksiola crotchi Banks (Trichoptera: Phryganeidae) in Marion Lake, British Columbia. *Canadian Journal of Zoology* 49:637-645.

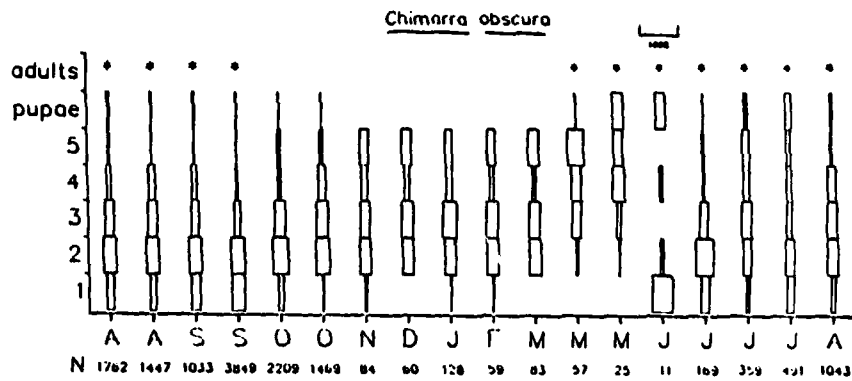
Table 1. Mean head capsule widths and associated statistics for selected caddisfly larvae collected from the Mulberry River, Arkansas.

Species	Instar	N	Head Capsule Width (nm)	
			\bar{X}	Range
<u>Agapetus illini</u>	I	3	0.12	0.11-0.12
	II	36	0.16	0.14-0.18
	III	237	0.24	0.20-0.30
	IV	205	0.34	0.31-0.40
	V	158	0.45	0.41-0.47
<u>Chimarra aterrima</u>	I	104	0.27	0.25-0.34
	II	204	0.44	0.36-0.54
	III	224	0.66	0.56-0.75
	IV	131	0.82	0.76-0.95
	V	134	1.00	0.96-1.11
<u>C. obscura</u>	I	98	0.27	0.24-0.34
	II	353	0.45	0.38-0.51
	III	293	0.68	0.57-0.75
	IV	87	0.88	0.78-0.93
	V	132	0.99	0.96-1.14
<u>Helicopsyche limnella</u>	I	90	0.13	0.09-0.15
	II	177	0.19	0.16-0.24
	III	85	0.27	0.26-0.34
	IV	31	0.41	0.36-0.45
	V	15	0.50	0.48-0.60
<u>Polycentropus centralis</u>	I	181	0.27	0.21-0.33
	II	309	0.44	0.36-0.51
	III	119	0.64	0.57-0.81
	IV	59	1.02	0.93-1.08
	V	40	1.12	1.11-1.20
<u>Wormaldia moesta</u>	I	80	0.16	0.14-0.25
	II	36	0.29	0.26-0.40
	III	51	0.50	0.46-0.60
	IV	38	0.67	0.62-0.75
	V	26	0.79	0.76-0.87
<u>Cheumatopsyche spp.</u>	I	59	0.21	0.18-0.25
	II	203	0.31	0.29-0.39
	III	160	0.48	0.42-0.60
	IV	99	0.71	0.63-0.78
	V	16	0.92	0.81-1.02

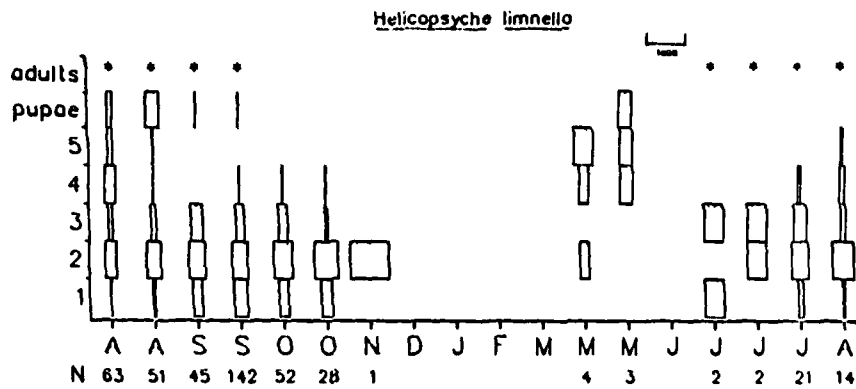
Figs. 1-7. Life histories of selected caddisflies collected from the Mulberry River, Arkansas. 1. Chimarra aterrima. 2. C. obscura. 3. Helicopsyche limnella. 4. Polycentropus centralis. 5. Cheumatopsyche spp. 6. Agapetus illini. 7. Wormaldia moesta.



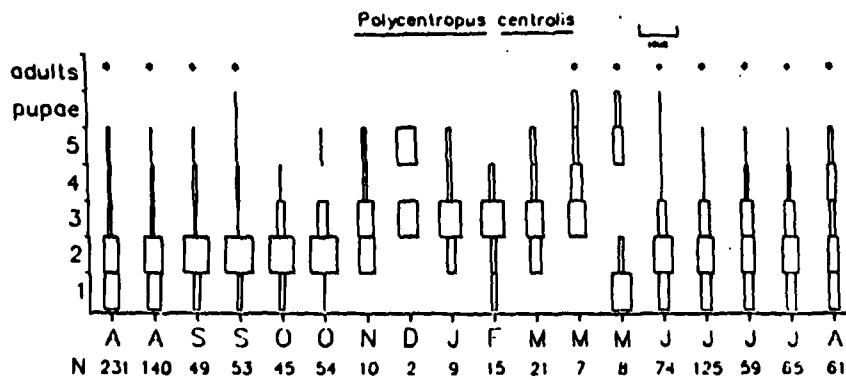
1



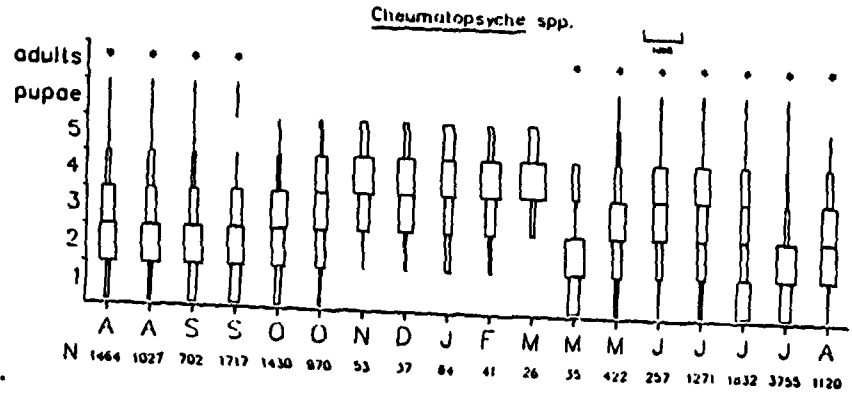
2



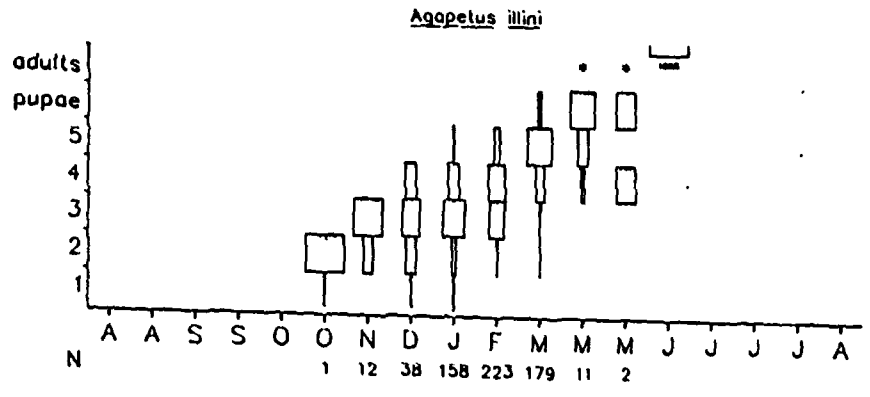
3



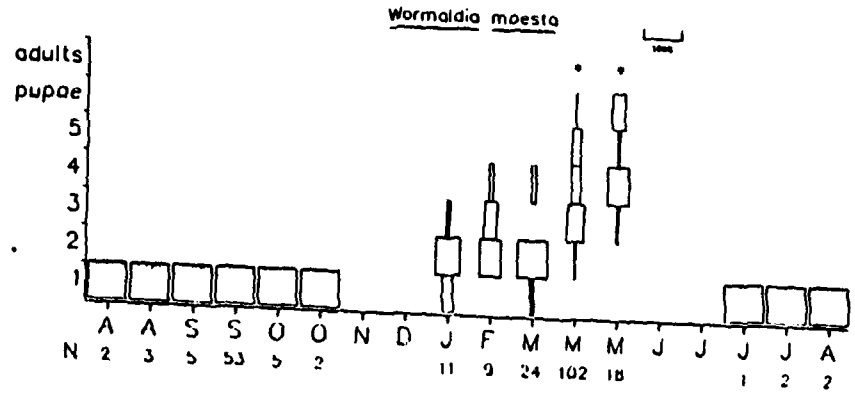
4



5



6



7