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Aquatic Macroinvertebrates of the White River National Wildlife Refuge, Arkansas

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Abstract

The objectives of this study were to survey the diversity of the aquatic macroinvertebrates of the White River National Wildlife Refuge (WRNWR) and determine relative abundances and distributional and seasonal patterns. No comprehensive investigation of WRNWR aquatic macroinvertebrates had been conducted previously. Thirty sampling stations were established within WRNWR. Each station was sampled twice, providing 60 total samples, for 1.5 man hours with a Turtox Indestructible™ dip net. Three black light trap samples were taken to augment the species list. A total of 15,056 individuals representing 219 taxa was taken by dip net samples during the sampling period October 1989-September 1990. Insects comprised 76% of the organisms captured with Coleoptera being the dominant group. The most abundant organism for WRNWR was *Hydroporus vittatipennis*. Black light samples and literature records each revealed 21 additional taxa bringing the total taxa currently known from WRNWR to 261. Each of the 30 stations was assigned to one of four associations, which were defined by continuity of determined internal and external factors. The Climax-Isolation Association possessed the most stable and complex community structures; isolation by levees and natural boundaries and scarcity of human intervention probably accounted for this. The Congruent Lentic Association embraced communal structures of good quality but possessed factors limiting diversity. The Agriculturally Inflicted-White River Tributary Association supported relatively simple aquatic macroinvertebrate communities. Finally, the Restricted Association consisted of two stations containing significant limiting factors resulting in concomitantly depauperate aquatic macroinvertebrate communities.

Introduction

The White River National Wildlife Refuge (WRNWR), located in the floodplain of the lower White River approximately 8 km above its confluence with the Mississippi River, is the largest refuge in Arkansas (USDA Forest Service, undated). It covers 45,750 ha of land and is traversed by 95.5 km of the White River itself. WRNWR was established on 4 September 1935, primarily as a sanctuary for migratory waterfowl (Earngy, 1987). The majority of the refuge is concentrated in the eastern portion of Arkansas County, but extends into three adjoining counties (Fig. 1). WRNWR ranges from 4.4 to 14.7 km in width while its length extends approximately 48 km. It contains many km of streams, bayous and sloughs in addition to its 165 natural lakes. Mean annual rainfall on WRNWR is 128.30 cm with approximately 75% of the total rainfall occurring between the months of January and July. The mean annual temperature is 16.4°C (U.S. Department of Commerce National Oceanic and Atmospheric Administration, 1989 & 1990). The watershed of WRNWR is extremely flat bottomland of the Mississippi Alluvial Plain. Agriculture dominates the watershed outside of WRNWR boundaries while thriteen different forest types, containing 31 major tree species, dominate within its boundaries (USDA Forest Service, undated; Arkansas Department of Pollution Control and Ecology, 1975). Due to its proximity to the White and Mississippi Rivers, the refuge is subjected to flooding several months of the year. Flooding occurs, on average, in late winter and in spring lasting about two months (USDA Forest Service, undated).

WRNWR is best noted for its large number of overwintering waterfowl. Waterfowl start arriving in early fall and reach peak populations usually in late December. The majority of the ducks present on WRNWR are mallards. Peak waterfowl populations range from 150 to 350 thousand ducks (average around 225 thousand) and approximately 10 thousand Canada geese (USDA Forest Service, undated).

Agriculture is Arkansas' leading industry. The Mississippi Delta is the physiographic province that has been most intensely cultivated because of its rich alluvial deposits and flat topography. One result of agricultural activities here is that the native flora and fauna have been dramatically reduced in numbers and diversity, primarily through soil perturbation and subsequent degradation of soil, air and water quality. As a relatively undisturbed environment, WRNWR may still support invertebrate communities similar to those of the natural environment

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of the past.

The purposes of this study were to survey the diversity of the aquatic macroinvertebrates of WRNWR and determine their relative abundances and distributional and seasonal patterns. Recently Gordon et al. (1995) reported 54 species of aquatic Mollusca from WRNWR. Two other works (Kraemer and Gordon, 1981; Bates and Dennis, 1983) focused on aquatic Mollusca of the White River which included material from WRNWR. Comprehensive investigations of additional aquatic macroinvertebrate communities were lacking.

Methods and Materials

Thirty sampling stations were established within the boundaries of WRNWR (Fig. 1). Collections were initially made at a rate of five stations per month. Due to extensive flooding, only the first five sampling trips followed this pattern (October 1989-February 1990). The timing of all remaining sampling trips was dictated by site accessibility. Revisit collections were taken from June-September 1990, resulting in a total of 60 collections (two from each sample site). Each collection at each station was for 1.5 man hours with a Turtox Indestructible™ dip net with a mesh size of 1 mm^2. Specimens were preserved in 70% ethanol. Freshwater bivalve relics were collected by hand. The aquatic macroinvertebrates were identified in the laboratory, catalogued and placed in the Aquatic Macroinvertebrate Collection of the Arkansas State University Museum of Zoology (ASUMZ) as voucher specimens.

Three black light samples were taken to augment the species list. Samples were taken adjacent to sites 5, 11 and 30' (Fig. 1). The duration of these samples was one hour, starting approximately 15 minutes before dark and lasting 45 minutes after dark. Specimens were preserved in 70% ethanol. Specimens were sorted in the laboratory, and most were shipped to systematics specialists for identification.

General, and some specific, aquatic macroinvertebrate identifications were made using keys by Holsinger (1976), Pennak (1978, 1989), Brigham et al. (1982), and Merritt and Cummins (1984). Other specific determinations were made using keys by Hungerford (1933, 1948), Drake and Chapman (1953), Truxal (1953), Young (1954, 1956), Wilson (1958), Froeschner (1962), Wood (1962), Zimmerman (1970), McCafferty (1975), Tarter et al. (1976), Gundersen (1978), Brigham (1979), Kittle (1980), Poulton and Stewart (1991) and Spangler (undated).

Shannon-Wiener Diversity (H'), Simpson Diversity, Simpson Dominance, H'max and Evenness values were calculated at base 2 logarithm using the **AQUATIC ECOLOGY-PC** program of Oakleaf Systems, Decorah,

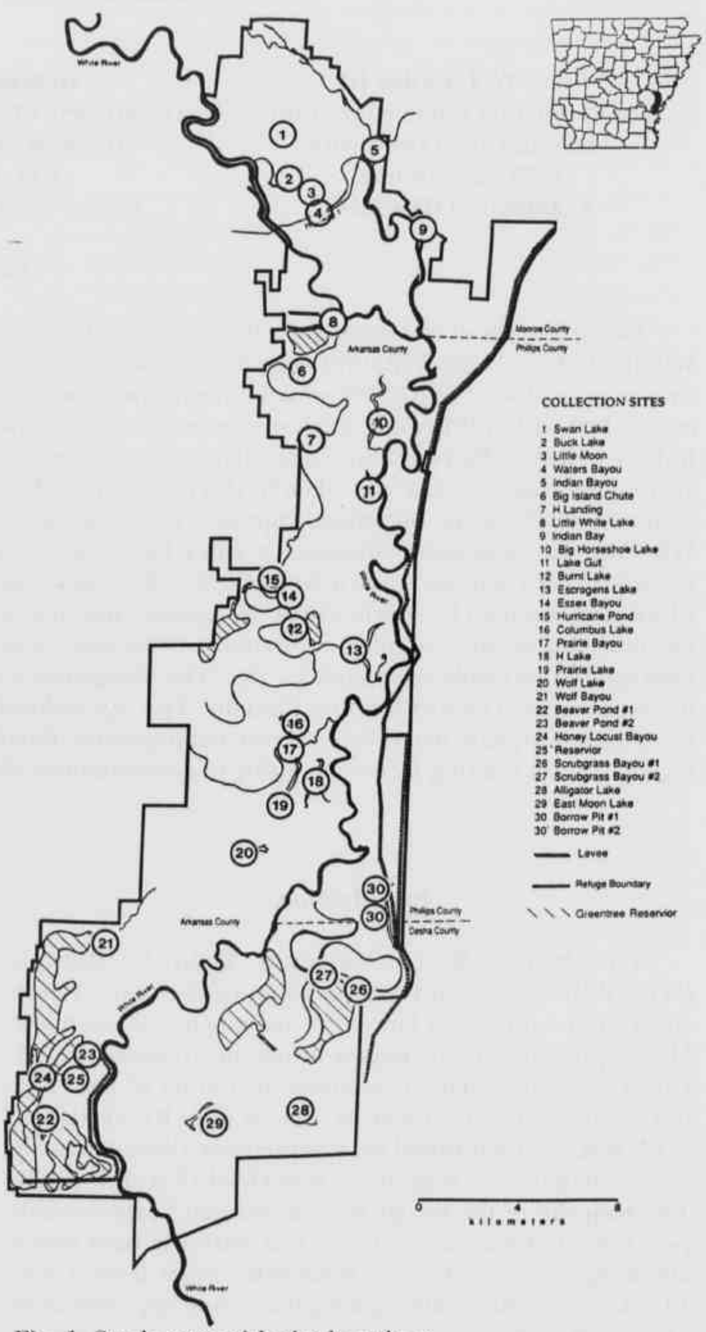

Fig. 1. Study area with site locations.

IA. Simpson Diversity and Simpson Dominance tend to be influenced by sample size. Conversely, H' is relatively independent of sample size (Poole, 1974). Due to this, H' is used as the representative parameter. H' represents the absolute diversity and is equated with the average degree of uncertainty of predicting the species of a given individual selected at random from a population (Schemnitz, 1980).

To characterize aquatic macroinvertebrate communities, the mean values for the numbers of taxa, numbers of individuals and diversity indices for the sample sites were analyzed to discern similarities. Where similarities existed, stations were clustered together. Associations were circumscribed from these clusters utilizing similarities among internal and external factors. Internal parameters included site location, habitat type, substrate, water level and current. External parameters included natural and man-made barriers (e.g. levees, forests), pollutants and watershed soils and vegetations.

Results

A total of 15,056 individuals representing 219 taxa was collected by dip net samples from WRNWR during 13 October 1989 through 30 September 1990. Insects comprised 76% of the organisms captured. Insecta orders represented include Coleoptera (61%), Hemiptera (18%), Odonata (8%), Diptera (6%), Megaloptera (4%), Ephemeroptera (2%), Trichoptera (2%), Collembola and Plecoptera (<1%). Of the non-insect fauna 6% of the individuals were decapod crustaceans, 6% were amphipods, 5% were molluscs and 5% were isopods. The following taxa each comprised less than one percent of the total: Bryozoa, Hydracarina, Mysidacea, Nematoda and

Table 1. Aquatic macroinvertebrates expressed as number collected per association. C-I, climax isolation association; AI-WRT, agriculturally inflicted-White River tributary association; C-L, congruent lentic association; RA, restricted association and TSA, totals for the study area.

Taxa	C-I	AI-WRT	C-L	RA	TSA
NEMATODA	1	4	2	·	7
BRYOZOA					
Phylactolaemata					
Pectinatella magnifica Leidy	6	·	7	·	13
NEMATOMORPHA					
Gordioidea					
Gordioidea	1	·	·	·	1
Paragordius sp.	·	1	1	·	2
GASTROPODA					
Pulmonata					
Ferrissia fragilis (Tryon)	6	2	·	·	8
F. rivularis (Say)	15	1	5	·	21
Fossaria obrussa (Say)	·	1	·	·	1
Gyraulus parvus (Say)	1	·	·	·	1
Laevapex fuscus (Adams)	4	·	·	·	4
Micromenetus dilatatus (Gould)	2	2	·	·	4
Physella gyrina (Say)	7	1	3	·	11
P. heterostropha (Say)	88	30	51	·	169
Planorbella trivolvis (Say)	20	8	10	·	38
Prosobranchia					
Campeloma crassulum Rafinesque	5	23	4	5	37
Cincinnatia cincinnatiensis (Anthony)	109	·	·	·	109
Pleurocera canaliculatum (Say)	24	13	1	5	43
Valvata bicarinata Lea	1	·	·	·	1
V. tricarinata (Say)	1	·	·	·	1
Viviparus intertextus (Say)	8	5	2	·	15
V. subpurpureus (Say)	14	16	39	·	69
BIVALVIA					
Heterodonta					
Corbicula fluminea Muller	95	95	28	6	224
Sphaeriidae	3	23	3	·	29
Musculium transversum (Say)	9	10	8	2	29
M. securis (Prime)	2	2	1	·	5
Unionoidea					
Unionidae	1	·	·	·	1
Amblema plicata (Say)	·	·	©	·	·
Lampsilis teres (Rafinesque)	·	©	·	·	·
Leptodea fragilis (Rafinesque)	1	©	10	·	11
Ligumia subrostrate (Say)	©	·	1	1	2
Obliquaria reflexa Rafinesque	·	©	·	·	·
Plectomerus dombeyanus (Valenciennes)	·	·	1	·	1
Potamilus purpuratus (Lamarck)	·	·	©	·	·
Pyganodon grandis (Say)	©	·	·	·	·
Quadrula nodulata (Rafinesque)	·	·	1	·	1
Q. pustulosa (Lea)	.	.	©	.	.
Q. quadrula (Rafinesque)	·	·	©	·	·
Toxolasma parvus (Barnes)	1	·	5	·	6
T. texasensis (Lea)	·	·	1	·	1
Tritogonia verrucosa (Rafinesque)	·	·	1	·	1
OLIGOCHAETA					
Oligochaeta	9	15	22	2	48
HIRUDINEA					
Pharyngobdellida					
Erpobdellidae (immature)	4	·	·	·	4
Erpobdella punctata (Leidy)	·	1	3	·	4
Mooreobdella microstoma (Moore)	3	4	4	·	11
Rhynchobdellida					
Glossiphoniidae (immature)	·	1	·	·	1
Desserobdella phalera (Graf)	1	3	·	·	4
Helobdella sp. (immature)	·	8	1	·	9
Helobdella fusca Castle	2	·	·	·	2
H. stagnalis (Linnaeus)	5	2	25	1	33
H. triserialis (Blanchard)	4	4	1	·	9
Placobdella montifera Moore	1	·	3	·	4
P. papillifera (Verrill)	·	3	·	·	3
P. parasitica (Say)	1	·	·	·	1
CRUSTACEA					
Mysidacea					
Taphromysis louisianae Banner	·	11	·	·	11
Isopoda					
Caecidotea sp.	155	141	264	1	561
Lirceus sp.	15	34	73	1	123
Amphipoda					
Crangonyx sp.	221	250	160	1	632
Synurella bifurca (Hay)	·	3	·	·	3
Gammarus sp.	51	115	52	2	220

G. fasciatus Say	7	26	13	1	47
Hyalella azteca (Saussure)	5	34	6	3	48
Decapoda					
Cambarellus (dirigicambarus) shufeldtii (Faxon)	20	3	2	·	25
C. (pandicambarus) sp.	3	·	·	·	3
Cambarus (Lacunicambarus) diogenes Girard	1	1	·	·	2
C. (L.) ludovicianus Faxon	1	·	·	·	1
Fallicambarus (Creaserinus) fodiens (Cottle)	1	·	·	·	1
Orconectes (Buannulificatus) palmeri palmeri (Faxon)	1	·	·	·	1
O. (tragulicambarus) lancifer (Hagen)	6	3	1	·	10
Procambaus (Ortmannicus) acutus acutus (Girard)	·	1	1	·	2
P. (O.) zonangulus Penn	1	·	1	·	2
P. (Pennides) ouachitae Penn	·	14	·	·	14
P. (Scapulicambarus) clarkii (Girard)	30	5	5	·	40
Palaeomonetes kadiakensis Rathbun	111	462	281	7	861
ARACHNOIDEA					
Hydracarina	4	4	·	1	9
INSECTA					
Collembola					
Isotoma sp.	·	4	·	3	7
Isotomurus sp.	·	1	·	·	1
Ephemeroptera					
Ephemeroptera (adult)	·	·	1	·	1
Baetis longipalpus	2	·	·	·	2
Callibaetis fluctuans (Walsh)	·	6	1	·	7
Brachycercus sp.	·	·	·	1	1
Caenis sp.	70	34	68	2	174
Ephemerella sp.	1	·	·	·	1
Hexagenia limbata (Serville)	3	40	·	1	44
Stenacron interpunctatum Say	1	·	1	·	2
Stenonema exiguum Traver	6	·	·	·	6
S. femoratum (Say)	·	1	·	·	1
Tortopus primus (McDunnough)	·	1	·	·	1
Odonata					
Zygoptera					
Lestes inaequalis Walsh	·	2	·	·	2
Argia sp.	4	22	1	·	27
Enallagma sp.	23	31	22	6	82
Ischnura sp.	65	52	1	·	118
Anisoptera					
Gomphus sp.	·	1	·	·	1
Arigomphus lentulus Needham	52	3	41	·	96
A. submedianus Williamson	18	·	3	·	21
Dromogomphus spinosus Selys	·	·	1	·	1
D. spoliatus Hagen	·	·	1	1	2
Stylurus plagiatus Selys	·	7	·	·	7
Nasiaeschna pentacantha Rambur	14	14	4	·	32
Macromia sp.	5	3	22	3	33
Epitheca (Epicordulia) princeps Hagen	32	3	86	1	122
E. (Tetragoneuria) cynosura (Say)	10	22	40	·	72
Celithemis verna Pritchard	·	1	·	·	1
Erythemis simplicicollis Say	17	2	·	·	19
Libellula cyanea Fabricius	1	·	·	·	1
L. incesta Hagen	·	·	3	·	3
L. luctuosa Burmeister	·	1	·	·	1
L. vibrans Fabricius	123	18	21	·	162
Pachydiplax longipennis Burmeister	28	29	·	·	57
Perithemis tenera Say	35	2	38	·	75
Plecoptera					
Acroneuria mela (Frison)	·	1	·	·	1
Hemiptera					
Belostoma (nymphs)	6	2	·	·	8
B. fluminea Say	4	·	·	·	4
B. lutarium (Stål)	2	1	2	·	5
Corixidae (nymphs)	190	6	57	·	253
Hesperocorixa lucida (Abbott)	·	2	·	·	2
H. nitida (Fieber)	3	1	·	·	4
Palmacorixa buenoi (Abbott)	394	24	130	·	548
Sigara sp.	·	1	·	·	1
Trichocorixa calva Say	311	11	31	1	354
T. kanza Sailer	244	11	148	·	403
T. sexcincta (Champion)	1	4	3	·	8
Gelastocoris oculatus oculatus (Fabricius)	3	3	15	6	27
Gerris (nymph)	7	·	·	·	7
G. argenticollis Parshley	4	1	·	·	5
G. nebularis Drake & Hottes	1	7	·	·	8
Limnoporus caniculatus (Say)	15	5	25	·	45
Neogerris hesione (Kirkaldy)	2	16	·	·	18
Trepobates pictus (Herrich-Schaeffer)	2	·	·	·	2
T. subnitidus Esaki	·	1	2	·	3
Hebrus consolidus Uhler	·	1	·	·	1
Merragata brunnea Drake	15	·	·	·	15
Hydrometra martini Kirkaldy	6	1	2	·	9
Mesovelia (nymphs)	24	15	·	·	39
M. mulsanti White	30	5	1	1	37
Pelocoris (nymph)	17	1	·	·	18
P. femoratus (Palisot-Beauvois)	17	·	·	·	17
Ranatra (nymph)	2	2	1	·	5
R. australis Hungerford	1	3	1	·	5
R. buenoi Hungerford	5	12	9	·	26
R. nigra Herrich-Schaeffer	4	·	5	·	9
Buenoa margaritacea Torre-Bueno	·	·	1	·	1
Notonecta (nymph)	7	·	·	·	7
N. irrorata Uhler	4	·	·	·	4
N. raleighi Torre-Bueno	3	3	·	·	6
Neoplea striola Ferber	70	12	·	·	82
Microvelia (nymph)	37	·	·	·	37
M. hinei Drake	4	·	·	·	4
Megaloptera					
Corydalus cornutus Linnaeus	26	1	·	·	27
Chauliodes rastricornis Rambur	7	2	·	·	9
Sialis sp.	14	21	358	3	396
Trichoptera					
Trichoptera (pupae)	·	·	1	·	1
Cheumatopsyche sp.	82	3	·	·	85
Hydropsyche sp.	57	1	·	·	58
Macrostemum sp.	17	·	·	·	17
Potamyia flava (Hagen)	3	2	·	·	5
Hydroptila sp.	2	·	·	·	2

Leptoceridae (pupae)	1	·	·	·	1
Nectopsyche	·	3	·	·	3
Oecetis sp.	1	2	7	·	10
Limeiphilidae (adult)	1	·	·	·	1
Ironoquia sp.	2	·	·	·	2
Neureclipsis sp.	·	2	·	·	2
Ptilostomis sp.	·	·	2	·	2
Archips sp.	·	·	1	·	1
Coleoptera					
Curculionidae	29	3	·	·	32
Bidessonotus inconspicuous (LeConte)	16	4	2	·	22
Celina (larvae)	1	·	·	·	1
Coptotomus (larvae)	4	·	·	·	4
C. loticus Hilsenhoff	39	4	5	1	49
C. venustus Say	265	202	466	1	934
Desmopachria grana (LeConte)	6	·	·	·	6
Dytiscus (larvae)	·	7	·	·	7
Hydaticus sp.	1	·	·	·	1
Hydroporus (larvae)	·	12	·	·	12
H. clypealis Sharp	713	147	164	5	1029
H. hybridus Aube'	265	272	551	1	1089
H. rufilabris Sharp	4	1	1	·	6
H. signatus Mannerheim	2	·	·	·	2
H. undulatus Say	452	173	26	·	651
H. venustus LeConte	190	27	9	·	226
H. vittatipennis Gemminger & Harold	804	205	283	1	1293
Hydrovatus pustulatus pustulatus Melsh.	1	·	1	·	2
Laccophilus fasciatus rufus Melsh.	3	·	3	·	6
L. proximus proximus Say	24	2	4	·	30
Lioporius pilatei (Fall)	5	16	7	2	30
L. triangularis Fall	1	·	1	1	3
Neobidessus pullus (LeConte)	1	·	·	·	1
Thermonectus basillaris (Harris)	2	·	3	·	5
Uvarus granarius (Aubé)	5	·	·	·	5
U. lacustris (Say)	4	2	3	·	9
Dubiraphia sp.	13	1	29	1	44
Stenelmis sp.	2	5	·	·	7
Dineutus (larvae)	·	3	·	·	3
D. assimilis (Kirby)	10	25	27	·	62
D. carolinus LeConte	10	12	·	·	22
D. emarginatus (Say)	·	3	·	·	3
Gyretes compressus LeConte	·	40	·	1	41
Gyrinus sp.	47	93	22	1	163
Haliplus sp.	15	7	1	·	23
Peltodytes dunavani Young	22	30	7	·	59
P. sexmaculatus Roberts	163	21	15	1	200
Heteroceridae	1	·	·	·	1
Histeridae	·	2	·	·	2
Berosus sp.	276	35	22	7	540
Derallus altus (LeConte)	4	·	·	·	4
Enochrus consortus Green	1	·	·	·	1
E. ochraceus (Melsh.)	15	·	1	·	16
E. perplexus (LeConte)	2	·	·	·	2
E. sayi (Gundersen)	2	·	1	·	3
Helochares sp.	13	1	3	·	17
Helophorus (larvae)	·	·	2	·	2
Hydrobiomorpha casta (Say)	1	·	1	·	2
Hydrobius sp.	2	1	2	·	5
Hydrochara sp.	1	·	·	·	1
Hydrochus sp.	60	13	13	1	87
Tropisternus (larvae)	6	·	1	·	7
T. blatchleyi blatchleyi D'Orch	27	1	·	·	28
T. collaris mexicanus LaPorte	5	1	·	·	6
T. c. striolatus (LeConte)	66	·	1	·	67
T. lateralis nimbatus (Say)	7	·	·	·	7
Lampyridae	1	·	·	·	1
Hydrocanthus atripennis Say	7	1	·	·	8
Suphis inflatus (LeConte)	3	·	·	·	3
Suphisellus bicolor bicolor (Say)	11	·	2	·	13
Cyphon (Larvae)	12	10	8	·	30
Stenus sp.	1	·	·	·	1
Thinobius sp.	·	·	1	·	1
Diptera					
Tabanidae (pupae)	1	·	·	·	1
Chlorotabanus sp.	4	·	·	·	4
Tabanus sp.	1	·	·	1	2
Culicidae (pupae)	·	·	1	·	1
Culex erraticus	2	·	·	·	2
Sepedon sp.	2	·	·	·	2
Prionocera sp.	2	·	·	·	2
Tipula sp.	·	·	7	·	7
Limnoia sp.	1	·	·	·	1
Simulium sp.	5	·	·	·	5
Chrysops sp.	·	·	1	·	1
Chaoborus sp.	·	1	·	·	1
Chrionomidae	150	156	217	7	530
Ceratopogonidae	59	26	7	·	92
Stratiomyidae (pupae)	1	·	·	·	1
Odontomyia sp.	3	1	·	·	4
Stratiomys sp.	2	·	3	·	5
Total individuals	7,122	3,450	4,384	100	15,056
Total taxa	169	133	116	42	

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Nematomorpha (Table 1).

The taxa with the greatest number of organisms, listed in order of decreasing abundance, were *Hydroporus vittatipennis* (1293), *Hydroporus hybridus* (1089), *Hydroporus clypealis* (1029), *Coptotomus venustus* (934), *Palaemonetes kadiakensis* (861), *Hydroporus undulatus* (651), *Crangonyx* spp. (632), *Caecidotea* spp. (561), *Palmacorixa buenoi* (548), *Berosus* spp. (540), Chironomidae spp. (530), *Trichocorixa kanza* (403), *Sialis* spp. (396), *Trichocorixa calva* (354), *Hydroporus venustus* (226), *Corbicula fluminea* (224) and *Gammarus* spp. (220) (Table 1). These 17 taxa represented only 8% of the total number of taxa collected, yet they comprised 70% of the total number of organisms found in this study. Further, the genus *Hydroporus* represented 29% of the total number of individuals collected while representing only 3% of the total taxa.

The three supplemental black light samples revealed 21 additional taxa not taken in dip net samples (Table 2). Since the decision to use this method was made belatedly, these samples were all taken during September. Since the purpose of black light sampling was to augment the species list, organisms obtained were not utilized in diversity calculations and did not influence placement of sites within associations or the structure of defined associations. Although a multitude of organisms were captured, only those taxa not found by dip netting are reported (Table 2).

Table 2. Taxa taken exclusively from black light trap samples.

Species	
Enallagma vesperum Calvert	✲
Corisella edulis (Champion)	✲
Ramphocorixa accuminata (Uhler)	✲
Buenoa confusa Truxal	✲
B. scimitra Bare	✲
Cheumatopsyche burksi Ross	✲
C. campyla Ross	✲
C. pasella Ross	✲
Hydropsyche bidens Ross	✲
H. orris Ross	✲
H. rossi Flint, Voshell & Parker	✲
Macrostemum carolina Banks	✲
Orthotrichia aegerfasciella (Chambers)	✲
Ceraclea maculata (Banks)	✲
Nectopsyche candida (Hagen)	✲
Oecetis avara (Banks)	✲
O. cinerascens (Hagen)	✲
O. ditissa Ross	✲
O. inconspicua (Walker)	✲
O. nocturna Ross	✲
Cyrnellus fraternus (Banks)	✲
Neureclipsis crepuscularis (Walker)	✲
Copelatus chevrolati renovatus Guignot	✲
Enochrus pygmaeus nebulosus (Say)	✲
Ptiliidae	✲
Scirtes ovalis Blatchley	✲
Anopheles crucians Wiedemann	✲
A. punctipennis (Say)	✲

✲ = Taxa which represent an augmentation to the species list.

The mean number of taxa taken per collection during this study was 27.3 (range 8 - 48) and the mean number of individuals taken per collection was 251.6 (range 8 - 626). The mean H' value per station was 3.408 with a range of 1.020 - 4.840. Severe flooding prevented collection during the months of March and May 1990. These collections were subsequently taken during September 1990. As a result, no monthly data or six-month fluctuations of data could be discerned.

Mean number of taxa, number of individuals and calculated diversity values for the sample sites tended towards sectional clustering throughout the study area (Chordas, 1992). Four distinct associations were established which depicted sectional zonation within WRNWR.

Discussion

Four associations recognized in this study include the Climax-Isolation Association, Congruent Lentic Association, Agriculturally Inflicted-White River Triutary Association and the Restricted Association. No single association was confined to one area of WRNWR. This study established four new state records and produced two second occurrences for recently reported state records.

Climax-Isolation Association (C-I).--This association consisted of 10 stations, 1-5 and 26-30, which were located in the most northern and southeastern portions of WRNWR (Fig. 1). Stations located in these areas were isolated by natural and or man-made barriers and possess the greatest wealth of taxa, greatest diversity values and the largest number of individuals per station (Fig. 2). Isolation of habitat, by levees, forestation and the White River itself, allowed climax communities to persist in these areas. Both portions of this association were accessible only by a single dirt road. This limited accessibility decreased potential perturbations resulting from anthropogenic activity. A combination of lentic and lotic stations made up this association. Clear water, comparable substrate types, moderate amounts of aquatic vegetation and relatively stable water levels during the initial and revisit series typified this association.

In this association, the mean number of taxa per station (34.2) was 20% higher than the mean for the study (27.3) while the mean number of individuals per station (356.2) was 29% higher than the study mean of 251.6 (Fig. 2). The mean H' value per station (3.666) was 8% higher than the study mean 3.408. Figure 2 illustrates the continuity of parameters in this association. Values for all parameters are clearly greater than those for other associations and plainly exceed the study means (Fig. 2). All four state records that were captured during this study were taken in this association, and two of the four were taken exclusively in this association.

Forty-six percent of all molluscs and 63% of the Mollusca taxa, representing 94% of the Gastropoda but only 35% of the Pelecypoda taxa, were taken within this association. Regardless of its size, virtually every aquatic habitat could contain pelecypods (Harris and Gordon, 1990). Since the basic technique used for collecting pelecypods was gathering relics by hand, this group, repre-

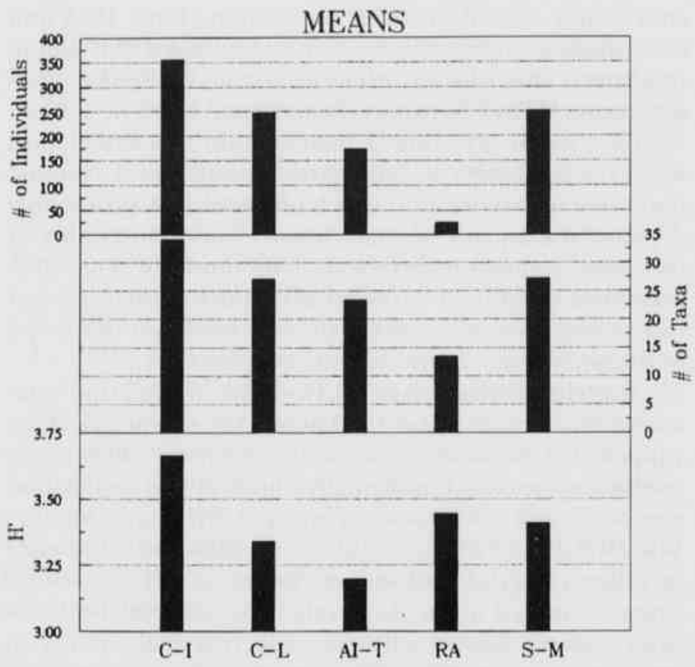

Fig. 2. Mean values for number of individuals, number of taxa and H' for each association. C-I, climax isolation association; C-L, congruent lentic association; AI-T, agriculturally inflicted-White River tributary association; RA, restricted association and S-M, study area.

sented by 14 total taxa, was underrepresented as evident by the 16 additional pelecypod taxa reported from WRNWR by Gordon et al. (1995). Table 3 lists 21 additional literature records for aquatic Mollusca taxa known from WRNWR.

Of the Hirudinea collected in this study, 22% of the individuals and seven of the nine taxa were collected in this association. One taxon, *Helobdella fusca*, a state road, was collected exclusively in this association (Table 1). Although this species is newly reported for Arkansas, Pennak (1989) lists this species as "widely distributed and common". One specimen of the species *Placobdella parasitica*, also only found here, was collected. This species is considered to be a semipermanent parasite and remains on its host except during breeding when they leave the host briefly for egg deposition (Pennak, 1989).

Six of the 10 taxa and 35% of the Ephemeroptera individuals were collected in this Association. Three taxa (*Baetis longipalpus*, *Ephemerella* sp. and *Stenonema exiguum*) were exclusively found here. Odonates in this Association composed 64% of the taxa and 46% of the number found in the study. Hemipteran diversity was high in this association with 83% of the taxa and 57% of the individuals captured in the study being found here. Coleoptera diversity in this association was also high. They composed 88% of the total taxa and 47% of the total individuals found in this study. Thirteen taxa were found only in this association, one of these, *Suphis inflatus*, is a new state record.

Trichopteran larvae were numerous in this association (Table 1). Twenty-six of the 27 specimens of the dobsonfly, *Corydalus cornutus*, collected in this study were found in this association. High Diptera diversity occurred in this association with 79% of the total taxa represented.

Table 3. Literature records of aquatic Mollusca from WRNWR.

Species	
Anodonta suborbiculata Say[2]	*Megalonaias nervosa* (Rafinesque)[3]
Arcidens confragosus (Say)[3]	*Obovaria jacksoniana* Frierson[3]
Ellipsaria lineolata (Rafinesque)[3]	*O. olivaria* (Rafinesque)[3]
Elliptio dilatata (Rafinesque)[3]	*Potamilus ohiensis* (Rafinesque)[3]
Fusconaia undata (Barnes)[3]	*Probythinella lacustris* (Baker)[1]
F. ebena (Lea)[3]	*Quadrula cylindrica* (Say)[3]
Lampsilis cardium Rafinesqsue[3]	*Q. metanevera* (Rafinesque)[2]
L. hydiana (Lea)[3]	*Somatogyrus* sp.[1]
L. siliquoidea (Barnes)[1]	*Truncilla truncata* Rafinesque[3]
Lasmigona complanata (Barnes)[3]	*Uniomerus tetralasmus* (Say)[3]
Ligumia recta (Lamarck)[3]	

[1]Kraemer and Gordon (1981)
[2]Bates and Dennis (1983)
[3]Gordon et al. (1995)

Congruent Lentic Association (C-L).--Eight stations (11-13, 15-16 and 18-20), located through the center of WRNWR, comprised this association (Fig. 1). The mean number of taxa and individuals per station as well as the mean H' value approximated the study means of 27,252 and 3.408, respectively (Fig. 2). These values were considerably lower than the Climax-Isolation Association's values (Fig. 2). All stations in this association were lentic, contained large amounts of leaf litter and/or detritus, possessed soft substrates and had slightly to moderately turbid water.

Most groups of organisms in this association were represented by approximately 50% of the total taxa and individuals taken during this study. One exception to this was the pelecypods. This group was represented by 82% of the taxa taken in the study. All the species taken in this association are characteristically plastic species capable of inhabiting a wide array of habitats (Table 1). Upon comparing this population to the number of pelecypod taxa reported from WRNWR by Gordon et al. (1995), the percent represented in this association drops to 45. Thus the true representation of the pelecypods in this association is similar to that of other groups with approximately 50% of the taxa present.

The only megalopteran collected in this association was *Sialis* spp. Larval sialids always occur in areas containing muddy, silty deposits and accumulated debris (Brigham et al., 1982). This habitat type occurred throughout the Congruent Lentic Association. The sialids captured here made up 90% of all sialids and 82% of all megalopterans captured during the study. This group was the only group to deviate from the typical 50% representation characteristic of groups in this association (Table 1).

Ephemeroptera and Trichoptera were poorly represented in this association. This was due to the absence of appropriate habitat.

Agriculturally Inflicted-White River Tributary Association (AI-T).--Ten stations (6-8, 14, 17 and 21-25) made up this association. These stations were located either on the periphery of WRNWR or along tributaries. The mean number of taxa per station was 23.4 which was 14% and 32% lower than the means for the study and Climax-Isolation Association, respectively (Fig. 2). The mean number of individuals per station (174.2) was 31% lower than the means of the study, 51% lower than the mean for the Climax-Isolation Association and 36% lower than the mean for the Congruent Lentic Association (Fig. 2). The H' value (3.199) was also lower than the means for the study and all other associations (Fig. 2).

The tributary stations in this association were physically quite similar. All contained steep mudy banks, turbid water and little or no detritus, debris or vegetation. To the contrary, the stations located on the periphery of WRNWR differed greatly in their physical characteristics. All peripherally located stations were very easily accessed by humans and had a preponderance of agricultural activity ongoing throughout their watersheds.

The only organisms occurring in large numbers here were the amphipods, representing 43% of all amphipods collected and *Palaemonetes kadiakensis*, which represented 54% of all freshwater shrimp collected. Those organisms occurring in a moderate abundance were the Hirudinea, ephemeropterans and isopods, which constituted 29%, 32% and 25% of their respective totals for the study. A large population of *Hexagenia limbata*, occurring mostly in the tributaries, accounted for 86% of the mayflies taken in this association and 91% of the individuals of this species taken during this study. The presence of soft banks in these tributaries accounted for this burrowing mayfly's abundance. In general, the aquatic macroinvertebrate communities of this association had good diversity but low numerical standing crops (Table 1), indicating possible instability.

All of the specimens of *Taphromysis louisanae* collected from the WRNWR were taken from two tributaries within this association. This species is listed as occurring in roadside ditches in Louisiana and Texas (Pennak, 1989), but Cochran and Harp (1990) reported the first record of this species from Arkansas.

The only plecopteran specimen obtained during the entire study was taken in this association (Table 1). A limited, shallow rocky substrate area contained this single specimen. This species, *Acroneuria mela*, is listed as present in the WRNWR region (Poulton and Stewart, 1991).

One factor affecting habitats within this association was extreme artificial and natural water level fluctuations. These fluctuations, which intermittently profoundly depleted the aquatic habitat, directly caused instability in the aquatic macroinvertebrate communities. This phenomenon combined with intense human activities and intervention into these areas directly hindered the scope of the aquatic macroinvertebrate communities.

Restricted Association (RA).--This association contains only stations 9 and 10. These were characterized by supporting the fewest taxa and organisms. The mean number of taxa and individuals found in this association was 50% and 90% lower, respectively, than that for WRNWR (Fig. 2). Figure 2 illustrates the vast difference in values of certain parameters found in this association when compared to the three other associations. Both stations contain factors adversely affecting their ability to support larger communities of aquatic macroinvertebrates. The biota at station 9 were limited by frequent anthropogenic perturbation and possible point source organic pollution. This station was located immediately downstream from several houseboats which were thought to release untreated effluent into the water. The substrate was composed of soft mud only. The other major limiting factor, found at station 10, was the presence of a sandy substrate. A nutrient base of aquatic vegetation, leaf litter and detritus was completely absent from both stations. Most taxa taken in this association were characteristically generalists that were commonly encountered throughout WRNWR. The exception to this was the presence of organisms like *Brachycercus* sp. which was found exclusively in this association. Members of this genus occur most commonly where sandy substrates exist (Brigham et al., 1982).

Conclusions

Prior to this study, two aquatic macroinvertebrate studies had been conducted in the bottomlands of the Mississippi Alluvial Plain. Cochran and Harp (1990) reported 243 taxa from the St. Francis Sunken Lands in northeast Arkansas, and Harp and Harp (1980) reported 163 taxa from Wapanocca National Wildlife Refuge. WRNWR lies south-southwest of these two areas. Some similarities, including a few habitat types and about 50% of the taxa, were manifested through the three study areas. However, due to wide variations of aquatic habitat, WRNWR contains community and habitat structures, as well as taxa, that were not found in the other two investigations.

Our hypothesis that WRNWR would support invertebrate communities similar to those of the past is supported by this study. Four species taken during this study are newly reported for Arkansas. Two of these four are leech species, *Desserobdella phalera* and *Helobdella fusca*. Both species were collected in the C-I, while additional *D. phalera* occurrences were noted in the AI-T (Table 1). Three specimens of the species *Suphis inflatus*, historically known from the southeastern United States (Spangler and Folkerts, 1973), were taken from one site within the C-I (Table 1). Finally, a single larval specimen of the species *Tortopus primus* was taken from WRNWR in a dip net sample from one site in the AI-T (Table 1), and adults were taken in a black light sample within the C-I (Station 5, Figure 1; Table 1). This species also represents the first occurrence of the family Polymitarcyidae in Arkansas. The reported range of the genus *Tortopus* (Merritt and Cummins, 1984) suggested that inevitably it would be taken in Arkansas.

The occurrence of two other organisms in WRNWR that have recently been reported as new state records further indicate the ecological soundness of this refuge. Eleven specimens of the species *Taphromysis louisanae*, first reported from Arkansas by Cochran and Harp (1990), were collected in the AI-T (Table 1). Gordon et al. (1995) reported *Valvata bicarinata* as a new Arkansas record. This species was found in the C-I in this study.

Summary

A total of 15,056 individuals representing 219 taxa was taken by dip net sampling from WRNWR. Forty-two additional taxa were noted from literature records and black light samples, bringing the total taxa currently known from WRNWR to 261. The most abundant organism from WRNWR was *Hydroporus vittatipennis*, with 1293 individuals.

Aquatic macroinvertebrate communities were defined by using the mean values for the numbers of taxa, numbers of individuals and diversity indices for the sample sites to discern similarities. Where similarities existed, stations were clustered. Associations were circumscribed from these clusters utilizing similarities among internal and external factors.

The C-I possessed the most complex, and therefore the most stable, community structures; isolation by levees and other natural boundaries and the general lack of anthropogenic perturbations probably accounted for this. The diversity and large populations of aquatic macroinvertebrates taken from this association were indicative of climax communities.

Lentic stations located through the center of WRNWR formed the C-L. Number of taxa, individuals and H' values were all close to their respective mean values for the study. Aquatic macroinvertebrate communities of these stations reflected a relatively undisturbed and healthy lentic ecosystem.

The AI-T contained stations which all had agriculture activity on-going in their watersheds and/or were flowing tributaries to the White River. While several taxa were present, populations were exceedingly small. The habitats in this association were easily accessible by humans and consequently subject to their activities. The instability of these communities can be related to the condition and activities in their watersheds.

Two stations located in areas containing significant limiting factors formed the RA. Aquatic macroinvertebrate communities, due to these limiting factors, were concomitantly depauperate.

Our hypothesis that WRNWR was acting as a refugium was supported by the diverse aquatic macroinvertebrate communities present and exemplified by the presence of four aquatic macroinvertebrate species new to the state: *Desserobdella phalera, Helobdella fusca, Suphis inflatus* and *Tortopus primus*. Further supporting this contention was the occurrence of two recently reported state records in WRNWR: *Taphromysis louisanae* and *Valvata bicarinata*.

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