Journal of the Arkansas Academy of Science

Volume 45 Article 36

1991

Synopsis of the Notonectidae of Arkansas

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and 1948b), and to information theory by Haynes (1957). These applications, in addition to the applications mentioned previously, suggest that physicists should become more familiar with the techniques of application of functional equations. The theorem derived in this paper is useful for calculating general results from measurements made on fixed amounts of materials. The methods developed in this paper allow the student to develop an understanding of the mathematical techniques used in the application of homogeneous functions; this allows these students to concentrate on the physics of critical point phenomena when they are first met, thus affording a deeper understanding.

ACKNOWLEDGMENTS

This paper was written to honor the teaching career of Dr. Robert E. Kelly, formerly of the University of Mississippi, and currently at Los Alamos Scientific Laboratories. It was in his classroom that I learned the axiomatic approach to thermodynamics and much else. The basic methods of this paper were taught by Dr. Kelly for many years, though the particular forms and proofs presented above are due to the present author.

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A SYNOPSIS OF THE NOTONECTIDAE OF ARKANSAS

There have been no studies pertaining specifically to the Notonectidae (back swimmers) of Arkansas. Pertinent information is either in taxonomic studies which include Arkansas material (Hungerford, 1933; Truxal, 1953) or aquatic macroinvertebrate lists from particular sites in the state (Harp and Hubbard, 1972; Harp and Harp, 1980; Farris and Harp, 1982; Huggins and Harp, 1983). The purposes of this paper are to present the first statewide species list, to delineate geographic distributions and to define preferred habitats for notonectid species in this state. Arkansas species may be identified by using Froeschner's (1962) key to Missouri species.

Most data presented have been synthesized from specimens in the Aquatic Macroinvertebrate Collection of the Arkansas State University Museum of Zoology; however contributions from museum collections from the Universities of Arkansas-Fayetteville and -Little Rock, along with literature records, are included. Supplemental collections were made by the authors to diminish distributional gaps in the data.

Two genera encompass the eight species of Notonectidae that occur in Arkansas. All species undergo five nymphal instars to reach adulthood and pass the winter as adults. Species of the two genera differ with respect to respiration, however. *Notonecta* species must surface frequently to replenish their oxygen supply. *Buenoa* individuals, however, have hemoglobin-filled abdominal sacs which greatly increase their capacity to store atmospheric oxygen (Truxal, 1953). This difference allows *Buenoa* to inhabit deeper water farther from shore and probably explains in part why fewer specimens of this genus are collected.

Buenoa confusa (Truxal) was first reported from Arkansas by Harp and Hubbard (1972). Distributionally, it is our least common notonectid, being represented by 35 specimens from 11 collections in three counties (Fig. 1). The collection in Monroe Co. contained three specimens taken by a black light trap. All other specimens were taken from the remaining two counties and were collected with a dipnet. Wilson (1958) reported this species in Mississippi from a single brackish pool filled with vegetation. In Arkansas, all collections were taken from clear, acid bauxite lakes, clear lakes or ponds with vegetation present. Arkansas collections thus far are from three ecoregions: Crowley's Ridge, the Ouachitas and the Mississippi Alluvial Plain. Truxal (1953) reported this species has been collected every month except February, March, October and December. Arkansas specimens have been collected during May and July-October.

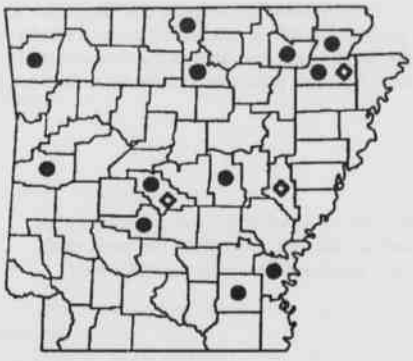

Fig. 1. B. confusa ◇
B. margaritacea ●

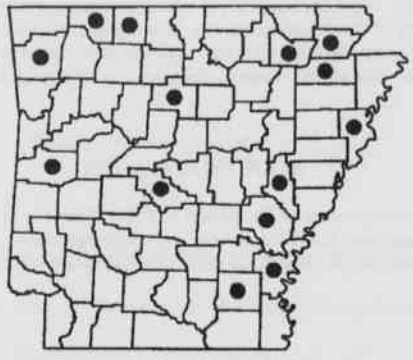

Fig. 2. B. scimitra

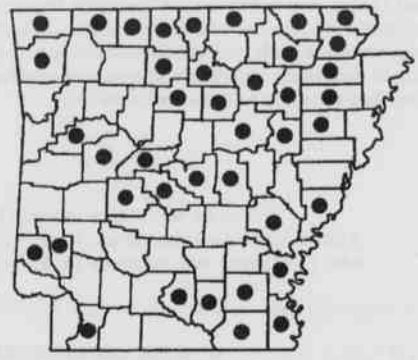

Fig. 3. N. indica

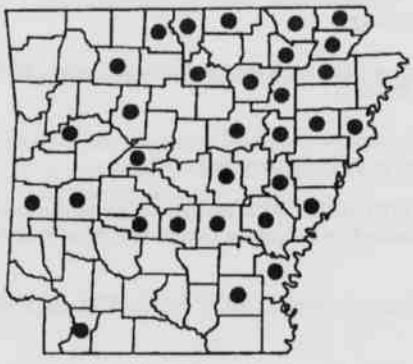

Fig. 4. N. irrorata

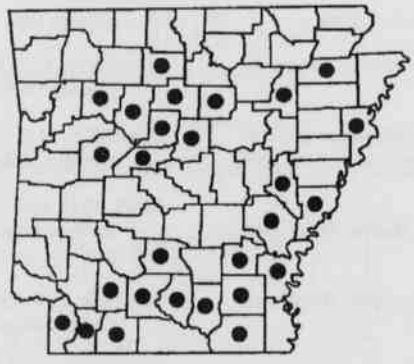

Fig. 5. N. raleighi

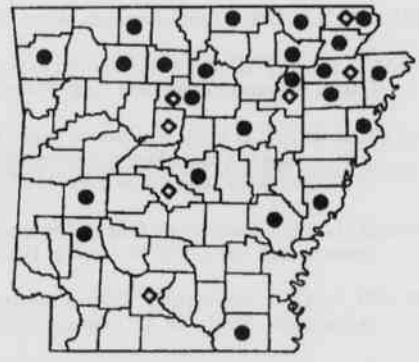

Fig. 6. N. uhleri ◇
N. undulata ●

Buenoa margaritacea (Torre-Bueno) was first reported from Arkansas by Truxal (1953). It is known from 35 specimens in 20 collections from 12 counties (Fig. 1). It has been taken in all of Arkansas' ecoregions except the Gulf Coastal Plain. Wilson (1958) reported that in Mississippi this species was most commonly collected from ponds. The only records for Missouri of this species came from Truxal's (1953) revisionary study (Froeschner, 1962). Most Arkansas specimens have been taken from ponds or lakes. However, specimens have also been taken from a pool area of Black River, a stream, roadside ditches and borrow-pits. Truxal (1953) reported collections of this species from every month of the year. Arkansas collections have been taken during February-May, July-September and November.

Buenoa scimitra (Bare) was first reported from Arkansas by Truxal (1953). It is the most common species of this genus in Arkansas, being known from 163 individuals in 29 collections from 14 counties (Fig. 2). Like *B. margaritacea*, *B. scimitra* has been collected from all five ecoregions of Arkansas except the Gulf Coastal Plain. Only in recent collections has this species been taken in large numbers in the state. Wilson (1958) and Froeschner (1962) reported this species to be the most common *Buenoa* in Mississippi and Missouri, respectively. Wilson (1958) reported this species to prefer sparsely vegetated, muddy, roadside pools, streams, small ponds and borrow-pits. Arkansas collections have been from these same habitat types. It is very commonly collected in black light trap samples. Truxal (1953) reported this species was collected every month of the year. Mississippi specimens have been taken from March to December (Wilson, 1958). Missouri specimens were taken during July, August and November (Froeschner, 1962). Arkansas collections occurred during January-May, July, September and November.

Notonecta indica (Linnaeus) was first reported from Arkansas by Hungerford (1933). It is our most common and most plastic notonectid species, being known from 519 individuals from 115 collections in 40 of Arkansas' 75 counties (Fig. 3). It has been collected from all five ecoregions of Arkansas. Froeschner (1962) reported this species to be uncommon in Missouri. Conversely, Wilson (1958) reported it to be very common and widespread in Mississippi. He also noted a wide range of color patterns for this species. Alexander (1982) observed eight hemelytral color patterns exhibited by specimens from Arkansas. We have seen the color patterns for this species range from completely white to almost completely black. Wilson (1958) reported this species to be commonly collected from ponds, borrow-pits, and small streams. Arkansas specimens have been taken from most every type of aquatic environment, including swimming pools. Froeschner (1962) reported that in Missouri this species was taken in March, June and November. Hungerford (1933) reported that this species had been collected, as it has in Arkansas, every month of the year.

Notonecta irrorata (Uhler), the largest notonectid in Arkansas, was first reported from the state by Hungerford (1933). It is a common and widespread species, being represented by 217 individuals from 69 collections in 31 counties throughout the five ecoregions of Arkansas (Fig. 4). Froeschner (1962) reported it to be known in Missouri from a few specimens taken in the southeast corner of the state. This species is common and widespread in Mississippi and occurs in a wide range of aquatic habitats (Wilson, 1958). Hungerford (1933) reported this species to be most common in water shaded by vegetation or overhanging limbs. Arkansas specimens were collected in a wide range of aquatic habitats but most often from habitats similar to those described by Hungerford. In Missouri, this

species was taken during March and June (Froeschner, 1962). Hungerford (1933) reported this species was collected every month except January and February, but noted that it was observed swimming under ice in Ithaca, N.Y., during early February. Arkansas specimens have been taken every month except May.

Notonecta raleighi (Bueno) was first reported from Arkansas by Harp and Harp (1980). Materials at hand show 116 individuals in 48 collections in 27 counties (Fig. 5). It has been collected in all five ecoregions of Arkansas, but seems to be most common in the southern portion of the state. Foreschner (1962) reported this species to be uncommon in Missouri, being collected only from large ponds and a pool area of a nearly dry stream bed. Wilson (1958) reported this species to be fairly common in Mississippi, being taken from a wide range of aquatic habitats except for running streams and borrow-pits. Collections in Arkansas are from habitats similar to those reported by Wilson (1958). Missouri specimens of this species were taken during March, June and October (Froeschner, 1962). Arkansas specimens of this species have been collected every month except April, July and December.

Notonecta uhleri (Kirkaldy) has not previously been reported from Arkansas. It is the least common notonectid species in the state, being now known from only 12 individuals having been taken in eight collections from seven counties (Fig. 6). Of the eight collections, three were from the Ouachita Mountains, two were from Crowley's Ridge, and one each from the Mississippi Alluvial Plain and Gulf Coastal Plain. Wilson (1958) reported this species to be very uncommon in Mississippi, being collected from a roadside borrow-pit and a deep stream, neither of which had vegetation, but Froeschner (1962), while listing it, had no record of its occurrence. Arkansas specimens have been collected from a farm pond, pool areas of rivers or creeks and a lake. All collection sites contained turbid water; vegetation was present in all habitats except the lake. Hungerford (1933) reported this species to have been collected during the months of July-October. Wilson (1958) reported taking it in August and October. Arkansas specimens were taken during March, April and October-December.

Notonecta undulata (Say) was first reported from Arkansas by Hungerford (1933). It is a common and widespread species in Arkansas, being represented by 205 individuals in 54 collections from 23 counties throughout the five natural divisions of Arkansas (Fig. 6). The majority of the collections of this species have been taken from the eastern portion of the state. Hungerford (1933) thought this species to be "the most common species in the United States". This species is similar in size and color pattern to *N. indicia*, and therefore these two species are often confused for each other (Hungerford, 1933). Further, causing even greater confusion, these two species are often collected together in the same sample. Froeschner (1962) reported this species to be very common in Missouri. Conversely, Wilson (1958) listed this species but had no record of its occurrence in Mississippi. Missouri specimens were collected from ponds and quiet sections of rivers (Froeschner, 1962). Arkansas specimens have been taken from most aquatic habitats, including swimming pools. Missouri specimens of the species were collected from January to July (Froeschner, 1962). Hungerford (1933) reported collections of this species for every month of the year. Arkansas specimens of this species have been taken during all months except July.

From present knowledge, it is probable that all eight notonectid species can be collected during any month of the year in Arkansas. Most should be found in any of the state's ecoregions. *B. confusa* and *N. uhleri* may be restricted in their habitat preference, however. The former appears to prefer clear well-vegetated waters, whereas the latter prefers turbid water with mud substrates.

ACKNOWLEDGMENTS

We thank Ed J. Bacon (UA-Monticello), Harvey E. Barton (ASU Entomological Museum), Chris Carlton (UA-Fayetteville Entomological Museum) and Robert Watson (UA-Little Rock Entomological Museum) for providing specimens.

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EVALUATION OF PARTICULATE AIR FILTERS FOR INDOOR AIR CLEANING

Indoor Air Quality is a growing health concern. Efforts are currently being made to reduce pollutants and to prevent illnesses resulting from inhalation of allergens and pathogens at home and in the workplace. Without adequate air filtration in the heating, ventilation, and air conditioning (HVAC) system, air pollutants may distribute through the house or building, or the HVAC system may become a source of allergens and pathogens.

In this study several types of filter were evaluated for their effectiveness in removing airborne particles in the size range of 0.2 to 1.0 μm in diameter and for the energy requirements associated with the filtration. Tested were: (1) a pleated paper type filter, (2) a 7.5 cm thick, medium efficiency pleated electret filter, (3) a 15 cm thick, High Efficiency Particulate Air (HEPA) electret filter, and (4) a standard fiberglass HVAC filter. The electret filter material consists of fibers having a semi-permanent charge which enhances collection efficiency through electrostatic attraction of the aerosol particles. Each of the filters was about 0.37 m^2 in cross section with the actual filter surface area varying depending on the thickness and number of pleats.